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## ***Ultra-Low Power Stereo CODEC with Audio Enhancement DSP, 2W Stereo Class D Speaker Drivers and Ground Referenced Headphone Drivers***

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### **DESCRIPTION**

The WM8962B is a low power, high performance stereo CODEC designed for portable digital audio applications.

An integrated charge pump provides a ground referenced output which removes the need for DC-blocking capacitors on the headphone outputs, and uses the Wolfson 'Class-W' amplifier techniques - incorporating an innovative dual-mode charge pump architecture - to optimise efficiency and power consumption during playback. A DC Servo is used to reduce DC ground offsets. This improves power consumption and minimises pops and clicks.

Stereo class D speaker drivers provide 2W per channel into 4Ω BTL loads, with a 5V supply. Low leakage, excellent PSRR and pop/click suppression mechanisms also allow direct battery connection to the speaker supply. Flexible speaker boost settings allow speaker output power to be maximised while minimising other analogue supply currents.

Control sequences for audio path setup can be pre-loaded and executed by an integrated sequencer to reduce software driver development and eliminate pops and clicks via Wolfson's SilentSwitch™ technology.

Flexible input configuration: four stereo inputs or eight mono inputs on Left or Right ADC, with a complete analogue (four single-ended stereo inputs) and digital microphone interface. External component requirements are drastically reduced as no separate microphone, speaker or headphone amplifiers are required. Advanced on-chip digital signal processing performs automatic level control for the microphone or line input.

Stereo 24-bit sigma-delta ADCs and DACs are used with low power over-sampling digital interpolation and decimation filters and a flexible digital audio interface.

A programmable audio enhancement DSP is included with multiple preset algorithms. Virtual Surround Sound widens the stereo speaker audio image, HD Bass enhances low frequencies, and ReTune™ flattens the frequency response of the speaker or microphone path. A configurable DSP includes additional functions such as 3D widening for recording, a 5-band parametric EQ and Dynamic Range Controller.

Two high performance PLLs and one Frequency Locked Loop (FLL) are integrated to enable the user to clock a full audio system.

The WM8962B operates at analogue supply voltages down to 1.7V, although the digital supplies can operate at voltages down to 1.62V to save power. The speaker supply can operate at up to 5.5V. Unused functions can be disabled using software control to save power.

The WM8962B is supplied in a very small W-CSP package, ideal for use in hand-held and portable systems.

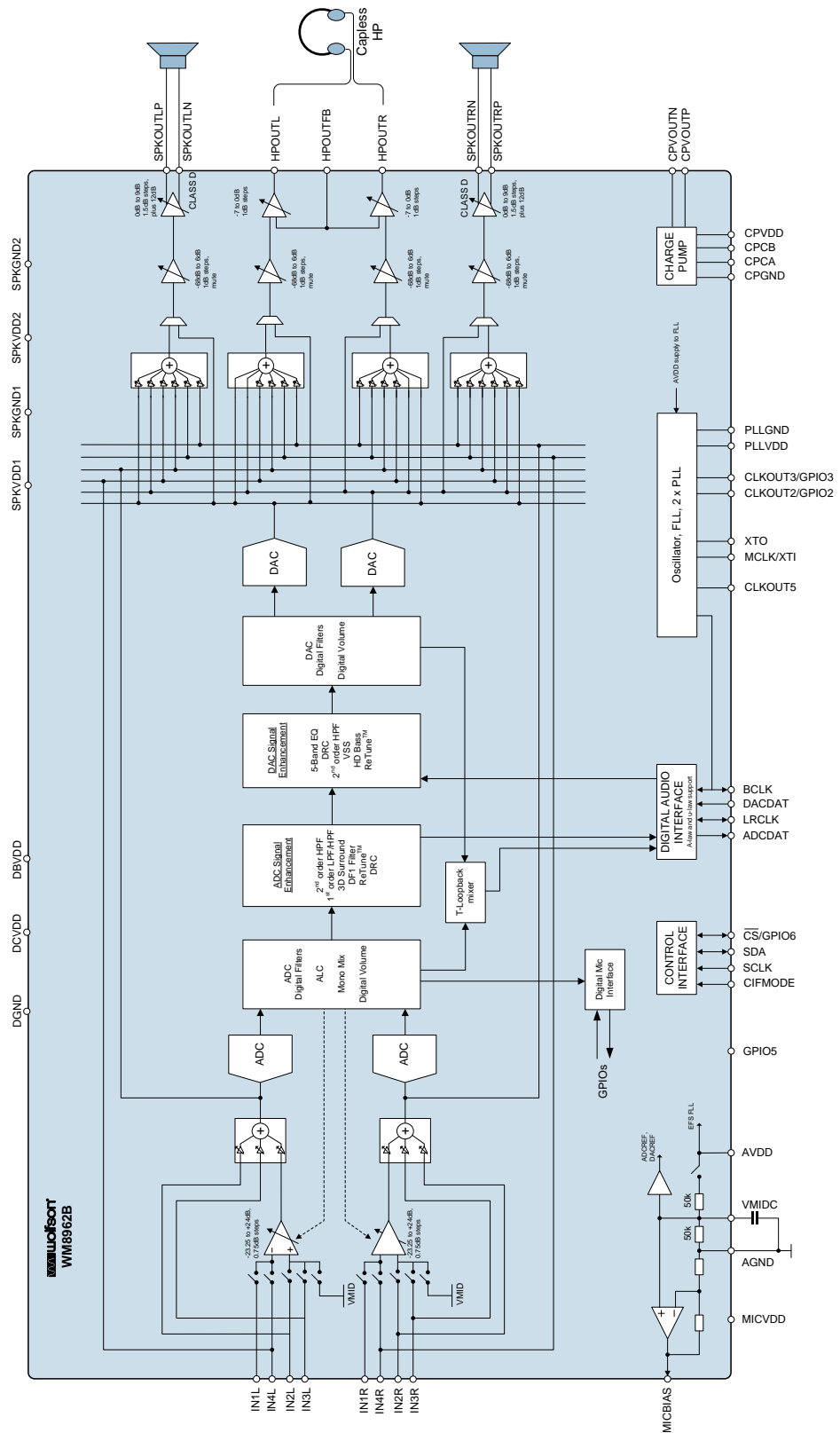
### **FEATURES**

- DAC SNR 98dB ('A' weighted), THD -84dB at 48kHz, 1.8V
- ADC SNR 94dB ('A' weighted), THD -85dB at 48kHz, 1.8V
- Stereo Class D Speaker Driver
  - 2W per channel into 4Ω BTL speakers
  - 2W mono (for improved THD)
  - Flexible internal switching clock
- Wolfson 'Class-W' ultra-low power headphone driver
  - Up to 31mW per channel output power at 1% THD+N into 16Ω at 1.8V
  - Ground Referenced
  - Low offset (+/- 1.2mV)
  - Pop and click suppression
  - Control sequencer for pop-minimised power-up/down
  - Single register write for default start-up sequence
- Microphone Interface
  - Single ended four stereo analogue input
  - Integrated low noise MICBIAS
  - Digital microphone interface
  - Programmable ALC / Limiter and Noise Gate
- Programmable Audio Enhancement DSP with Presets
  - Virtual Surround Sound
  - HD Bass
  - ReTune™
- Fixed Audio Processing DSP
  - 3D stereo widening
  - 5-band Parametric EQ
  - Dynamic range controller
  - Beep generator
- Two integrated PLLs enable clocking of full audio system
- Low Power Consumption
  - 7.7mW headphone playback
  - 8.3mW analogue record mode
- Low Supply Voltages
  - Analogue 1.7V to 2.0V (Speaker supply up to 5.5V)
  - Charge pump 1.7V to 2.0V
  - MIC bias amp supply 1.7V to 3.6V
  - Digital 1.62V to 2.0V
- 2-wire I2C and 3- or 4-wire SPI serial control interface
- Standard sample rates from 8kHz to 96kHz
- W-CSP, 3.6x3.9mm 49-pin

### **APPLICATIONS**

- Portable gaming
- Mobile multimedia
- Voice recorders and Stereo DSC-Camcorder

## BLOCK DIAGRAM



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**PIN CONFIGURATION**

**ORDERING INFORMATION**

| ORDER CODE    | TEMPERATURE RANGE | PACKAGE                                                | MOISTURE SENSITIVITY LEVEL | PEAK SOLDERING TEMPERATURE |
|---------------|-------------------|--------------------------------------------------------|----------------------------|----------------------------|
| WM8962BECSN/R | -40°C to +85°C    | 49-ball CSP<br>(3.6x3.9mm)<br>(Pb-free, Tape and reel) | MSL1                       | 260°C                      |

**Note:**

Reel quantity = 5,000

**PIN DESCRIPTION**

| PIN NO | NAME          | TYPE                   | DESCRIPTION                                                                                                     |
|--------|---------------|------------------------|-----------------------------------------------------------------------------------------------------------------|
| A1     | SPKOUTLP      | Analogue Output        | Left speaker positive output                                                                                    |
| A2     | SPKVDD1       | Supply                 | Supply for left speaker drivers                                                                                 |
| A3     | MICVDD        | Supply                 | Microphone bias amp supply                                                                                      |
| A4     | MICBIAS       | Reference              | Microphone bias                                                                                                 |
| A5     | HPOUTR        | Analogue Output        | Right output (Line or headphone)                                                                                |
| A6     | CPVOUTP       | Supply                 | Charge pump positive supply (powers HPOUTL, HPOUTR)                                                             |
| A7     | CPVOUTN       | Supply                 | Charge pump negative supply (powers HPOUTL, HPOUTR)                                                             |
| B1     | SPKGND1       | Supply                 | Ground for left speaker drivers                                                                                 |
| B2     | SPKOUTRP      | Analogue Output        | Right speaker positive output                                                                                   |
| B3     | SPKOUTLN      | Analogue Output        | Left speaker negative output                                                                                    |
| B4     | HPOUTFB       | Analogue Input         | HPOUTL/R ground loop noise rejection feedback                                                                   |
| B5     | HPOUTL        | Analogue Output        | Left output (Line or headphone)                                                                                 |
| B6     | CPCA          | Analogue Input         | Charge pump fly-back capacitor pin                                                                              |
| B7     | CPCB          | Analogue Input         | Charge pump fly-back capacitor pin                                                                              |
| C1     | SPKGND2       | Supply                 | Ground for right speaker drivers                                                                                |
| C2     | SPKVDD2       | Supply                 | Supply for right speaker drivers                                                                                |
| C3     | SPKOUTRN      | Analogue Output        | Right speaker negative output                                                                                   |
| C4     | IN1L          | Analogue Input         | Left channel single-ended input 1                                                                               |
| C5     | VMIDC         | Reference              | Mid-rail voltage (AVDD/2) - (requires decoupling capacitor)                                                     |
| C6     | CPVDD         | Supply                 | Charge pump power supply                                                                                        |
| C7     | CPGND         | Supply                 | Charge pump ground (return path for CPVDD)                                                                      |
| D1     | DACDAT        | Digital Input          | DAC digital audio data                                                                                          |
| D2     | ADCDAT        | Digital Output         | ADC digital audio data                                                                                          |
| D3     | LRCLK         | Digital Input / Output | Audio interface left / right clock                                                                              |
| D4     | IN1R          | Analogue Input         | Right channel single-ended input 1                                                                              |
| D5     | IN2L          | Analogue Input         | Left channel single-ended input 2                                                                               |
| D6     | AVDD          | Supply                 | Analogue supply                                                                                                 |
| D7     | AGND          | Supply                 | Analogue ground (return path for AVDD and MICVDD)                                                               |
| E1     | BCLK          | Digital Input / Output | Audio interface bit clock                                                                                       |
| E2     | SDA           | Digital Input / Output | Control interface data input / 2-wire acknowledge output                                                        |
| E3     | CS/GPIO6      | Digital Input / Output | CS input / Digital Microphone input / General purpose input / output                                            |
| E4     | CLKOUT2/GPIO2 | Digital Output         | PLL2 Clock output / General purpose input / output                                                              |
| E5     | IN2R          | Analogue Input         | Right channel single-ended input 2                                                                              |
| E6     | IN4L          | Analogue Input         | Left channel single-ended input 4                                                                               |
| E7     | IN4R          | Analogue Input         | Right channel single-ended input 4                                                                              |
| F1     | SCLK          | Digital Input          | Control interface clock input                                                                                   |
| F2     | CIFMODE       | Digital Input          | Selects 2-wire or 3 / 4-wire control wire interface                                                             |
| F3     | DGND          | Supply                 | Digital ground                                                                                                  |
| F4     | CLKOUT3/GPIO3 | Digital Output         | PLL3 / FLL Clock output / GPIO                                                                                  |
| F5     | IN3L          | Analogue Input         | Left channel single-ended input 3                                                                               |
| F6     | IN3R          | Analogue Input         | Right channel single-ended input 3                                                                              |
| F7     | XTO           | Analogue Output        | xtal output                                                                                                     |
| G1     | GPIO5         | Digital Input / Output | Digital Microphone Input / General purpose input / output<br>Important: See page 179 for start-up requirements. |
| G2     | DCVDD         | Supply                 | Digital Core Supply                                                                                             |
| G3     | DBVDD         | Supply                 | Digital Buffer Supply                                                                                           |
| G4     | PLLVD         | Supply                 | PLL Supply                                                                                                      |
| G5     | PLLGND        | Supply                 | PLL Ground                                                                                                      |
| G6     | CLKOUT5       | Analogue Output        | FLL / Oscillator Clock output                                                                                   |
| G7     | MCLK / XT1    | Digital Input          | Master clock input / xtal input                                                                                 |



## ABSOLUTE MAXIMUM RATINGS

Absolute Maximum Ratings are stress ratings only. Permanent damage to the device may be caused by continuously operating at or beyond these limits. Device functional operating limits and guaranteed performance specifications are given under Electrical Characteristics at the test conditions specified.



ESD Sensitive Device. This device is manufactured on a CMOS process. It is therefore generically susceptible to damage from excessive static voltages. Proper ESD precautions must be taken during handling and storage of this device.

Cirrus tests its package types according to IPC/JEDEC J-STD-020 for Moisture Sensitivity to determine acceptable storage conditions prior to surface mount assembly. These levels are:

MSL1 = unlimited floor life at <30°C / 85% Relative Humidity. Not normally stored in moisture barrier bag.

MSL2 = out of bag storage for 1 year at <30°C / 60% Relative Humidity. Supplied in moisture barrier bag.

MSL3 = out of bag storage for 168 hours at <30°C / 60% Relative Humidity. Supplied in moisture barrier bag.

The Moisture Sensitivity Level for each package type is specified in Ordering Information.

| CONDITION                                       | MIN         | MAX         |
|-------------------------------------------------|-------------|-------------|
| DCVDD, AVDD, PLLVDD                             | -0.3V       | +2.5V       |
| MICVDD, DBVDD                                   | -0.3V       | +4.5V       |
| SPKVDD1, SPKVDD2                                | -0.3V       | +7.0V       |
| CPVDD                                           | -0.3V       | +2.2V       |
| Voltage range digital inputs                    | DGND -0.3V  | DBVDD +0.3V |
| Voltage range analogue inputs                   | AGND -0.3V  | AVDD +0.3V  |
| Voltage range analogue outputs (HPOUTL, HPOUTR) | -CPVDD-0.3V | +CPVDD+0.3V |
| Temperature Range, T <sub>A</sub>               | -40°C       | +85°C       |
| Junction Temperature, T <sub>J</sub>            | -40°C       | +150°C      |
| Storage temperature after soldering             | -65°C       | +150°C      |

### Notes:

1. Analogue, digital and speaker grounds must always be within 0.3V of each other.
2. All digital and analogue supplies are completely independent from each other (i.e. not internally connected).
3. AVDD must be less than or equal to MICVDD.
4. AVDD must be less than or equal to SPKVDD1 and SPKVDD2.

## RECOMMENDED OPERATING CONDITIONS

| PARAMETER                                        | SYMBOL                                      | MIN  | TYP | MAX | UNIT |
|--------------------------------------------------|---------------------------------------------|------|-----|-----|------|
| Digital core supply range                        | DCVDD                                       | 1.62 | 1.8 | 2.0 | V    |
| Digital buffer supply range                      | DBVDD                                       | 1.62 | 1.8 | 3.6 | V    |
| Microphone bias supply range                     | MICVDD                                      | 1.7  | 2.5 | 3.6 | V    |
| Analogue supplies range                          | AVDD                                        | 1.7  | 1.8 | 2.0 | V    |
| PLL supply range                                 | PLLVDD                                      | 1.7  | 1.8 | 2.0 | V    |
| Charge pump supply range (1.8V supply operation) | CPVDD                                       | 1.7  | 1.8 | 2.0 | V    |
| Speaker supply range                             | SPKVDD1, SPKVDD2                            | 1.7  | 5.0 | 5.5 | V    |
| Ground                                           | DGND, AGND, CPGND, SPKGND1, SPKGND2, PLLGND |      | 0   |     | V    |
| Operating temperature range                      | T <sub>A</sub>                              | -40  |     | 85  | °C   |
| Operating junction temperature                   | T <sub>J</sub>                              | -40  |     | 85  | °C   |

### Notes:

1. SPKVDD1 and SPKVDD2 must be high enough to support the peak output voltage when using CLASSD\_VOL function, to avoid output waveform clipping. Peak output voltage is AVDD\*CLASSD\_VOL.
2. The AGND and PLLGND pins must be tied together as close as possible to the WM8962B.
3. The WM8962B can operate with PLLVDD tied to 0V; device power consumption may be reduced, but the crystal oscillator, PLLs and CLKOUT functions will not be supported.

**ELECTRICAL CHARACTERISTICS**
**Test Conditions**

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

 T<sub>A</sub> = +25°C, 1kHz signal, fs = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                                                               | SYMBOL            | TEST CONDITIONS        | MIN | TYP                             | MAX | UNIT         |
|-------------------------------------------------------------------------|-------------------|------------------------|-----|---------------------------------|-----|--------------|
| <b>Analogue Inputs (IN1L, IN1R, IN4L, IN4R) to Input PGA</b>            |                   |                        |     |                                 |     |              |
| Full-scale Input Signal Level – note this changes in proportion to AVDD | V <sub>INFS</sub> | Single-ended PGA input |     | 500<br>-6.02                    |     | mVrms<br>dBV |
| Input resistance                                                        |                   | +24dB PGA gain         |     | 3.6                             |     | kΩ           |
|                                                                         |                   | 0dB PGA gain           |     | 30.0                            |     |              |
|                                                                         |                   | -23.25dB PGA gain      |     | 56.5                            |     |              |
| Input capacitance                                                       | C <sub>in</sub>   |                        |     | 65                              |     | pF           |
| <b>Analogue Inputs (IN2L, IN2R, IN3L, IN3R) to Input PGA</b>            |                   |                        |     |                                 |     |              |
| Full-scale Input Signal Level – note this changes in proportion to AVDD | V <sub>INFS</sub> | Single-ended PGA input |     | 500<br>-6.02                    |     | mVrms<br>dBV |
| Input resistance                                                        |                   | All gain settings      |     | 60                              |     | kΩ           |
| <b>Input Programmable Gain Amplifier (PGA)</b>                          |                   |                        |     |                                 |     |              |
| Minimum programmable gain                                               |                   |                        |     | -23.25                          |     | dB           |
| Maximum programmable gain                                               |                   |                        |     | 24                              |     | dB           |
| Programmable Gain Step Size                                             |                   | Guaranteed monotonic   |     | 0.75                            |     | dB           |
| PGA Noise (referred to input) (A-weighted)                              |                   | IN1 and IN4            |     | -113                            |     | dBV          |
| PGA Noise (referred to input) (A-weighted)                              |                   | IN2 and IN3            |     | -113                            |     | dBV          |
| Mute Attenuation                                                        |                   |                        |     | 100                             |     | dB           |
| <b>Selectable Input Gain Boost (From Input PGA)</b>                     |                   |                        |     |                                 |     |              |
| Gain Boost Steps                                                        |                   | Input from PGA         |     | 0, 6, 13, 18,<br>20, 24, 27, 29 |     | dB           |
| Mute Attenuation                                                        |                   |                        |     | 95                              |     | dB           |
| <b>Selectable Input Gain to ADC Mixer (From IN2, IN3)</b>               |                   |                        |     |                                 |     |              |
| Gain Boost Steps                                                        |                   | Input from IN2 / IN3   |     | -12, -9, -6, -3,<br>0, 3, 6     |     | dB           |
| Mute Attenuation                                                        |                   |                        |     | 95                              |     | dB           |

**Test Conditions**

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

 T<sub>A</sub> = +25°C, 1kHz signal, fs = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                                                                         | SYMBOL | TEST CONDITIONS                                          | MIN | TYP    | MAX | UNIT |
|-----------------------------------------------------------------------------------|--------|----------------------------------------------------------|-----|--------|-----|------|
| <b>Analogue Inputs (IN1L, IN1R) to ADC out via Input PGA and Input Gain Boost</b> |        |                                                          |     |        |     |      |
| Signal to Noise Ratio (A-weighted)                                                | SNR    | ADC_HP=0<br>MIXIN_BIAS=100<br>INPGA_BIAS=100             |     | 91     |     | dB   |
| Total Harmonic Distortion Plus Noise (-1dBFS input)                               | THD+N  | 'Option 1' (low power) bias settings - see Note 2.       |     | -70    |     | dB   |
| Signal to Noise Ratio (A-weighted)                                                | SNR    | ADC_HP=0<br>MIXIN_BIAS=011<br>INPGA_BIAS=100             |     | 91     |     | dB   |
| Total Harmonic Distortion Plus Noise (-1dBFS input)                               | THD+N  | 'Option 2' bias settings - see Note 2.                   |     | -75    |     | dB   |
| Signal to Noise Ratio (A-weighted)                                                | SNR    | ADC_HP=0<br>MIXIN_BIAS=000<br>INPGA_BIAS=100             | 81  | 91     |     | dB   |
| Total Harmonic Distortion Plus Noise (-1dBFS input)                               | THD+N  | 'Option 3' bias settings - see Note 2.                   |     | -82    | -72 | dB   |
| Signal to Noise Ratio (A-weighted)                                                | SNR    | ADC_HP=1<br>MIXIN_BIAS=000<br>INPGA_BIAS=000             |     | 93     |     | dB   |
| Total Harmonic Distortion Plus Noise (-1dBFS input)                               | THD+N  | Option 4' (high performance) bias settings - see Note 2. |     | -82    |     | dB   |
| ADC Channel Separation                                                            |        | 1kHz                                                     |     | 95     |     | dB   |
|                                                                                   |        | 10kHz                                                    |     | 97     |     |      |
| PSRR (AVDD)                                                                       |        | 100mV(peak-peak) 1kHz                                    |     | 60     |     | dB   |
|                                                                                   |        | 100mV(peak-peak) 20kHz                                   |     | 40     |     |      |
| Channel Matching                                                                  |        | 1kHz signal                                              |     | +/-0.5 |     | dB   |

### Test Conditions

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

T<sub>A</sub> = +25°C, 1kHz signal, f<sub>s</sub> = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                                                                                                                                   | SYMBOL | TEST CONDITIONS                                           | MIN | TYP | MAX | UNIT |
|---------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------------------------------------------------|-----|-----|-----|------|
| <b>Analogue Inputs (IN2L, IN2R) to ADC out via Input Gain (Input PGA Bypassed)</b>                                                          |        |                                                           |     |     |     |      |
| Signal to Noise Ratio (A-weighted)                                                                                                          | SNR    | ADC_HP=0<br>MIXIN_BIAS=100<br>INPGA_BIAS=100              |     | 91  |     | dB   |
| Total Harmonic Distortion Plus Noise (-1dBFS input)                                                                                         | THD+N  | 'Option 1' (low power) bias settings - see Note 2.        |     | -70 |     | dB   |
| Signal to Noise Ratio (A-weighted)                                                                                                          | SNR    | ADC_HP=0<br>MIXIN_BIAS=011<br>INPGA_BIAS=100              |     | 91  |     | dB   |
| Total Harmonic Distortion Plus Noise (-1dBFS input)                                                                                         | THD+N  | 'Option 2' bias settings - see Note 2.                    |     | -75 |     | dB   |
| Signal to Noise Ratio (A-weighted)                                                                                                          | SNR    | ADC_HP=0<br>MIXIN_BIAS=000<br>INPGA_BIAS=100              |     | 91  |     | dB   |
| Total Harmonic Distortion Plus Noise (-1dBFS input)                                                                                         | THD+N  | 'Option 3' bias settings - see Note 2.                    |     | -85 |     | dB   |
| Signal to Noise Ratio (A-weighted)                                                                                                          | SNR    | ADC_HP=1<br>MIXIN_BIAS=000<br>INPGA_BIAS=000              |     | 94  |     | dB   |
| Total Harmonic Distortion Plus Noise (-1dBFS input)                                                                                         | THD+N  | 'Option 4' (high performance) bias settings - see Note 2. |     | -85 |     | dB   |
| ADC Channel Separation                                                                                                                      |        | 1kHz                                                      |     | 95  |     | dB   |
|                                                                                                                                             |        | 10kHz                                                     |     | 87  |     |      |
| PSRR (AVDD)                                                                                                                                 |        | 100mV(peak-peak) 1kHz                                     |     | 60  |     | dB   |
|                                                                                                                                             |        | 100mV(peak-peak) 20kHz                                    |     | 40  |     |      |
| <b>Analogue Inputs (IN4L, IN4R) to HPOUTL/R (used as Line output) with 10kΩ / 50pF load:<br/>Low Power headphone playback mode (Note 3)</b> |        |                                                           |     |     |     |      |
| Input Resistance                                                                                                                            |        | +6dB PGA gain                                             |     | 10  |     | kΩ   |
|                                                                                                                                             |        | 0dB PGA gain                                              |     | 17  |     |      |
|                                                                                                                                             |        | -15dB PGA gain                                            |     | 80  |     |      |
| Signal to Noise Ratio (A-weighted)                                                                                                          | SNR    |                                                           |     | 97  |     | dB   |
| Total Harmonic Distortion Plus Noise                                                                                                        | THD+N  | 10kΩ, 50pF load                                           |     | -80 |     | dB   |

**Test Conditions**

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

 T<sub>A</sub> = +25°C, 1kHz signal, f<sub>s</sub> = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                                                                                                                                                                                                                                         | SYMBOL | TEST CONDITIONS | MIN | TYP | MAX | UNIT |
|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------|-----------------|-----|-----|-----|------|
| <b>ADC Input Path Crosstalk</b>                                                                                                                                                                                                                   |        |                 |     |     |     |      |
| IN1 / IN4 ADC input path crosstalk                                                                                                                                                                                                                |        | 1kHz            |     | -98 |     | dB   |
|                                                                                                                                                                                                                                                   |        | 10kHz           |     | -79 |     |      |
| IN2 / IN3 ADC input path crosstalk                                                                                                                                                                                                                |        | 1kHz            |     | -85 |     | dB   |
|                                                                                                                                                                                                                                                   |        | 10kHz           |     | -65 |     |      |
| IN2 / IN4 ADC input path crosstalk                                                                                                                                                                                                                |        | 1kHz            |     | -90 |     | dB   |
|                                                                                                                                                                                                                                                   |        | 10kHz           |     | -69 |     |      |
| IN3 / IN4 ADC input path crosstalk                                                                                                                                                                                                                |        | 1kHz            |     | -75 |     | dB   |
|                                                                                                                                                                                                                                                   |        | 10kHz           |     | -55 |     |      |
| The ADC path is enabled from one input pin; -6dBV test signal applied to the other input; crosstalk measured at ADC output. The test is repeated with the two input pins swapped; the crosstalk figure is the worst case of the two measurements. |        |                 |     |     |     |      |

**Test Conditions**

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

 T<sub>A</sub> = +25°C, 1kHz signal, fs = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                                                                                                             | SYMBOL | TEST CONDITIONS         | MIN | TYP  | MAX    | UNIT             |
|-----------------------------------------------------------------------------------------------------------------------|--------|-------------------------|-----|------|--------|------------------|
| <b>HPOUTL/R_VOL</b>                                                                                                   |        |                         |     |      |        |                  |
| Minimum programmable gain                                                                                             |        |                         |     | -68  |        | dB               |
| Maximum programmable gain                                                                                             |        |                         |     | 6    |        | dB               |
| Volume Gain Step Size                                                                                                 |        | Guaranteed monotonic    |     | 1    |        | dB               |
| Mute Attenuation                                                                                                      |        |                         |     | 94   |        | dB               |
| <b>HP1L/R_VOL</b>                                                                                                     |        |                         |     |      |        |                  |
| Minimum programmable gain                                                                                             |        |                         |     | -7   |        | dB               |
| Maximum programmable gain                                                                                             |        |                         |     | 0    |        | dB               |
| Volume Gain Step Size                                                                                                 |        | Guaranteed monotonic    |     | 1    |        | dB               |
| <b>DAC to HPOUTL/R (used as Line output) with 10kΩ / 50pF load: Low Power headphone playback mode (Note 3)</b>        |        |                         |     |      |        |                  |
| Full scale output voltage                                                                                             |        | HPOUTL/R_VOL = 0dB      |     | 0.96 |        | V <sub>rms</sub> |
| Signal to Noise Ratio (A-weighted)                                                                                    | SNR    |                         | 87  | 97   |        | dB               |
| Total Harmonic Distortion Plus Noise                                                                                  | THD+N  | 10kΩ load               |     | -84  | -74    | dB               |
| Channel Separation                                                                                                    |        | 1kHz full scale signal  |     | 93   |        | dB               |
|                                                                                                                       |        | 10kHz full scale signal |     | 86   |        |                  |
| PSRR (AVDD)                                                                                                           |        | 100mV(peak-peak) 1kHz   |     | 70   |        | dB               |
|                                                                                                                       |        | 100mV(peak-peak) 20kHz  |     | 65   |        |                  |
| DC offset                                                                                                             |        | DC servo is enabled     | 0   |      | +/-1.2 | mV               |
| <b>DAC to HPOUTL/R (used as Line output) with 10kΩ / 50pF load: High Performance headphone playback mode (Note 3)</b> |        |                         |     |      |        |                  |
| Signal to Noise Ratio (A-weighted)                                                                                    | SNR    |                         | 87  | 98   |        | dB               |
| Total Harmonic Distortion Plus Noise                                                                                  | THD+N  | 10kΩ load               |     | -84  | -74    | dB               |

**Test Conditions**

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

 T<sub>A</sub> = +25°C, 1kHz signal, f<sub>s</sub> = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                                                                              | SYMBOL         | TEST CONDITIONS                                                 | MIN | TYP           | MAX    | UNIT    |
|----------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------|-----|---------------|--------|---------|
| <b>DAC to HPOUTL/R with headphone load: Low Power headphone playback mode (Note 3)</b> |                |                                                                 |     |               |        |         |
| Output Power at 1% THD+N                                                               | P <sub>O</sub> | R <sub>L</sub> =32Ω                                             |     | 26            |        | mW      |
|                                                                                        |                | R <sub>L</sub> =16Ω                                             |     | 31            |        |         |
| Total Harmonic Distortion Plus Noise                                                   | THD+N          | R <sub>L</sub> =32Ω, P <sub>O</sub> =2mW                        |     | -79<br>0.011  |        | dB<br>% |
|                                                                                        |                | R <sub>L</sub> =32Ω, P <sub>O</sub> =3.5mW                      |     | -79<br>0.011  |        |         |
|                                                                                        |                | R <sub>L</sub> =32Ω, P <sub>O</sub> =12mW                       |     | -78<br>0.013  |        |         |
|                                                                                        |                | R <sub>L</sub> =16Ω, P <sub>O</sub> =2mW                        |     | -81<br>0.0089 |        |         |
|                                                                                        |                | R <sub>L</sub> =16Ω, P <sub>O</sub> =22mW                       |     | -80<br>0.010  |        |         |
| Output Noise Level                                                                     |                |                                                                 |     | -97           | -87    | dBV     |
| DC offset                                                                              |                | DC servo is enabled                                             | 0   |               | +/-1.2 | mV      |
| Channel Separation                                                                     |                | 1kHz test signal,<br>R <sub>L</sub> =16Ω, P <sub>O</sub> =22mW  |     | 95            |        | dB      |
|                                                                                        |                | 10kHz test signal,<br>R <sub>L</sub> =16Ω, P <sub>O</sub> =22mW |     | 84            |        |         |
| <b>DAC to HPOUTL/R with headphone load: High Performance playback mode (Note 3)</b>    |                |                                                                 |     |               |        |         |
| Total Harmonic Distortion Plus Noise                                                   | THD+N          | R <sub>L</sub> =32Ω, P <sub>O</sub> =12mW                       |     | -84<br>0.0063 |        | dB<br>% |
|                                                                                        |                | R <sub>L</sub> =16Ω, P <sub>O</sub> =22mW                       |     | -81<br>0.0089 |        |         |
| Output Noise Level                                                                     |                |                                                                 |     | -98           | -87    | dBV     |

### Test Conditions

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

T<sub>A</sub> = +25°C, 1kHz signal, f<sub>s</sub> = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                                                                                                            | SYMBOL         | TEST CONDITIONS                                                                                     | MIN | TYP          | MAX | UNIT    |
|----------------------------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------------------------------------------|-----|--------------|-----|---------|
| <b>SPKOUTL/R_VOL</b>                                                                                                 |                |                                                                                                     |     |              |     |         |
| Minimum programmable gain                                                                                            |                |                                                                                                     |     | -68          |     | dB      |
| Maximum programmable gain                                                                                            |                |                                                                                                     |     | 6            |     | dB      |
| Volume Gain Step Size                                                                                                |                | Guaranteed monotonic                                                                                |     | 1            |     | dB      |
| Mute Attenuation                                                                                                     |                |                                                                                                     |     | 92           |     | dB      |
| <b>DAC to Stereo Speaker Outputs (DAC to SPKOUTLP, SPKOUTLN, SPKOUTRP, SPKOUTRN with 8Ω + 22μH bridge tied load)</b> |                |                                                                                                     |     |              |     |         |
| Output Power                                                                                                         | P <sub>O</sub> | 1% THD+N, R <sub>L</sub> = 8Ω,<br>SPKVDD1=SPKVDD2=5.5V                                              |     | 1.26         |     | W       |
|                                                                                                                      |                | 1% THD+N, R <sub>L</sub> = 8Ω,<br>SPKVDD1=SPKVDD2=1.7V                                              |     | 0.08         |     |         |
| Total Harmonic Distortion Plus Noise                                                                                 | THD+N          | P <sub>O</sub> =200mW, R <sub>L</sub> = 8Ω,<br>SPKVDD1=SPKVDD2=3.3V                                 |     | -68<br>0.040 |     | dB<br>% |
|                                                                                                                      |                | P <sub>O</sub> =320mW, R <sub>L</sub> = 8Ω,<br>SPKVDD1=SPKVDD2=3.3V                                 |     | -72<br>0.025 |     |         |
|                                                                                                                      |                | P <sub>O</sub> =320mW, R <sub>L</sub> = 8Ω,<br>SPKVDD1=SPKVDD2=5V                                   |     | -67<br>0.045 | -55 |         |
|                                                                                                                      |                | P <sub>O</sub> =1W, R <sub>L</sub> = 8Ω,<br>SPKVDD1=SPKVDD2=5V,<br>CLASSD_VOL=110<br>DACL/R_VOL=C1h |     | -61<br>0.089 |     |         |
| Signal to Noise Ratio<br>(A-weighted)<br>(DAC to speaker outputs)                                                    | SNR            | SPKVDD1=SPKVDD2=3.3V,<br>R <sub>L</sub> = 8Ω,<br>Output signal =2.0Vrms                             |     | 90           |     | dB      |
|                                                                                                                      |                | SPKVDD1=SPKVDD2=5V,<br>R <sub>L</sub> = 8Ω,<br>Output signal=2.8Vrms                                | 83  | 93           |     |         |
| PSRR (SPKVDD1/SPKVDD2)                                                                                               | PSRR           | 100mV(peak-peak) 217Hz                                                                              |     | 78           |     | dB      |
|                                                                                                                      |                | 100mV(peak-peak) 1kHz                                                                               |     | 78           |     |         |
| <b>DAC to Stereo Speaker Outputs (DAC to SPKOUTLP, SPKOUTLN, SPKOUTRP, SPKOUTRN with 4Ω + 22μH bridge tied load)</b> |                |                                                                                                     |     |              |     |         |
| Output Power                                                                                                         | P <sub>O</sub> | 1% THD+N, R <sub>L</sub> = 4Ω,<br>SPKVDD1=SPKVDD2=5V                                                |     | 1.75         |     | W       |
|                                                                                                                      |                | 10% THD+N, R <sub>L</sub> = 4Ω,<br>SPKVDD1=SPKVDD2=5V                                               |     | 2.20         |     |         |
| Total Harmonic Distortion Plus Noise                                                                                 | THD+N          | P <sub>O</sub> =1W, R <sub>L</sub> = 4Ω,<br>SPKVDD1=SPKVDD2=5V                                      |     | -67<br>0.045 |     | dB<br>% |
|                                                                                                                      |                | P <sub>O</sub> =2W, R <sub>L</sub> = 4Ω,<br>SPKVDD1=SPKVDD2=5V                                      |     | -25<br>5.5   |     |         |
| Signal to Noise Ratio<br>(A-weighted)<br>(DAC to speaker outputs)                                                    | SNR            | SPKVDD1=SPKVDD2=3.3V,<br>R <sub>L</sub> = 4Ω,<br>Output signal=2.0Vrms                              |     | 90           |     | dB      |
|                                                                                                                      |                | SPKVDD1=SPKVDD2=5V,<br>R <sub>L</sub> = 4Ω,<br>Output signal=2.8Vrms                                |     | 93           |     |         |



**Test Conditions**

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

 T<sub>A</sub> = +25°C, 1kHz signal, f<sub>s</sub> = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                                                                                                       | SYMBOL         | TEST CONDITIONS                                                                                     | MIN | TYP          | MAX | UNIT    |
|-----------------------------------------------------------------------------------------------------------------|----------------|-----------------------------------------------------------------------------------------------------|-----|--------------|-----|---------|
| <b>DAC to Mono Speaker Output (DAC to SPKOUTLP/RP, SPKOUTLN/RN with 4Ω + 22μH bridge tied load, SPK_MONO=1)</b> |                |                                                                                                     |     |              |     |         |
| Output Power                                                                                                    | P <sub>O</sub> | 1% THD+N, R <sub>L</sub> = 4Ω,<br>SPKVDD1=SPKVDD2=5.5V                                              |     | 2.45         |     | W       |
|                                                                                                                 |                | 1% THD+N, R <sub>L</sub> = 4Ω,<br>SPKVDD1=SPKVDD2=1.7V                                              |     | 0.15         |     |         |
| Total Harmonic Distortion Plus Noise                                                                            | THD+N          | P <sub>O</sub> =400mW, R <sub>L</sub> = 4Ω,<br>SPKVDD1=SPKVDD2=3.3V                                 |     | -64<br>0.063 |     | dB<br>% |
|                                                                                                                 |                | P <sub>O</sub> =640mW, R <sub>L</sub> = 4Ω,<br>SPKVDD1=SPKVDD2=3.3V                                 |     | -63<br>0.071 |     |         |
|                                                                                                                 |                | P <sub>O</sub> =640mW, R <sub>L</sub> = 4Ω,<br>SPKVDD1=SPKVDD2=5V                                   |     | -67<br>0.044 |     |         |
|                                                                                                                 |                | P <sub>O</sub> =2W, R <sub>L</sub> = 4Ω,<br>SPKVDD1=SPKVDD2=5V,<br>CLASSD_VOL=110<br>DACL/R_VOL=C1h |     | -61<br>0.089 |     |         |
| Signal to Noise Ratio<br>(A-weighted)<br>(DAC to speaker outputs)                                               | SNR            | SPKVDD1=SPKVDD2=3.3V,<br>R <sub>L</sub> = 4Ω,<br>Output signal=2.0Vrms                              |     | 90           |     | dB      |
|                                                                                                                 |                | SPKVDD1=SPKVDD2=5V,<br>R <sub>L</sub> = 4Ω,<br>Output signal=2.8Vrms                                |     | 93           |     |         |

### Test Conditions

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

T<sub>A</sub> = +25°C, 1kHz signal, f<sub>s</sub> = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                                                                                   | SYMBOL               | TEST CONDITIONS                                                       | MIN  | TYP          | MAX  | UNIT   |
|---------------------------------------------------------------------------------------------|----------------------|-----------------------------------------------------------------------|------|--------------|------|--------|
| <b>Analogue Reference Levels</b>                                                            |                      |                                                                       |      |              |      |        |
| Mid-rail Reference Voltage                                                                  | VMIDC                |                                                                       | -3%  | AVDD/2       | +3%  | V      |
| <b>Microphone Bias</b>                                                                      |                      |                                                                       |      |              |      |        |
| Bias Voltage<br>(Note that MICVDD must be at least 300mV higher than V <sub>MICBIAS</sub> ) | V <sub>MICBIAS</sub> | MICVDD=2.5V,<br>2mA load current,<br>MICBIAS_EVR=00,<br>MICBIAS_LVL=0 | -4%  | 0.828 × AVDD | +4%  | V      |
|                                                                                             |                      | MICVDD=2.5V,<br>2mA load current,<br>MICBIAS_EVR=00,<br>MICBIAS_LVL=1 | -4%  | 1.156 × AVDD | +4%  |        |
|                                                                                             |                      | MICVDD=3.3V,<br>2mA load current,<br>MICBIAS_EVR=10                   |      | 1.33 × AVDD  |      |        |
|                                                                                             |                      | MICVDD=3.3V,<br>2mA load current,<br>MICBIAS_EVR=01                   |      | 1.59 × AVDD  |      |        |
| PSRR (MICVDD)                                                                               | PSRR                 | 100mV (peak-peak) 1kHz,<br>MICBIAS_EVR=00,<br>MICBIAS_LVL=1           |      | 74           |      | dB     |
| PSRR (AVDD)                                                                                 | PSRR                 | 100mV (peak-peak) 1kHz,<br>MICBIAS_EVR=00,<br>MICBIAS_LVL=1           |      | 52           |      | dB     |
| Maximum Bias Current Source                                                                 | I <sub>MICBIAS</sub> |                                                                       |      | 2            |      | mA     |
| Output Noise spectral density<br>@ 1kHz                                                     | V <sub>st</sub>      | MICBIAS_EVR=00,<br>MICBIAS_LVL=0                                      |      | 63           |      | nV/√Hz |
|                                                                                             |                      | MICBIAS_EVR=00,<br>MICBIAS_LVL=1                                      |      | 85           |      |        |
|                                                                                             |                      | MICBIAS_EVR=10                                                        |      | 96           |      |        |
|                                                                                             |                      | MICBIAS_EVR=01                                                        |      | 116          |      |        |
| <b>MICBIAS Current Detect Function (see Note 1)</b>                                         |                      |                                                                       |      |              |      |        |
| Current Detect Threshold                                                                    |                      | MICDET_THR = 000                                                      | 38   | 64           | 90   | μA     |
|                                                                                             |                      | MICDET_THR = 001                                                      | -25% | 166          | +25% |        |
|                                                                                             |                      | MICDET_THR = 010                                                      | -20% | 375          | +20% |        |
|                                                                                             |                      | MICDET_THR = 011                                                      | -20% | 475          | +20% |        |
|                                                                                             |                      | MICDET_THR = 100                                                      | -20% | 575          | +20% |        |
|                                                                                             |                      | MICDET_THR = 101                                                      | -20% | 680          | +20% |        |
|                                                                                             |                      | MICDET_THR = 110                                                      | -20% | 885          | +20% |        |
|                                                                                             |                      | MICDET_THR = 111                                                      | -20% | 990          | +20% |        |
| Delay Time for Current Detect Interrupt                                                     | t <sub>DET</sub>     |                                                                       |      | 1.6          |      | ms     |
| <b>MICBIAS Short Circuit (Hook Switch) Detect Function (see Note 1)</b>                     |                      |                                                                       |      |              |      |        |
| Short Circuit Detect Threshold                                                              |                      | MICSHORT_THR = 00                                                     | -18% | 515          | +18% | μA     |
|                                                                                             |                      | MICSHORT_THR = 01                                                     | -15% | 680          | +15% |        |
|                                                                                             |                      | MICSHORT_THR = 10                                                     | -15% | 1050         | +15% |        |
|                                                                                             |                      | MICSHORT_THR = 11                                                     | -15% | 1215         | +15% |        |
| Delay Time for Short Circuit Detect Interrupt                                               | t <sub>SHORT</sub>   |                                                                       |      | 47           |      | ms     |

**Test Conditions**

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

 T<sub>A</sub> = +25°C, 1kHz signal, f<sub>s</sub> = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                                                  | SYMBOL             | TEST CONDITIONS                                                                                                                           | MIN   | TYP   | MAX    | UNIT |
|------------------------------------------------------------|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------|-------|-------|--------|------|
| <b>Charge Pump</b>                                         |                    |                                                                                                                                           |       |       |        |      |
| Maximum Charge Pump switching frequency                    | CP <sub>FREQ</sub> |                                                                                                                                           |       | 1     |        | MHz  |
| Flyback capacitor (between CPCA and CPCB pins)             | C <sub>FB</sub>    | at 2V                                                                                                                                     | 1     |       |        | μF   |
| VPOS capacitor                                             |                    | at 2V                                                                                                                                     | 2     |       |        | μF   |
| VNEG capacitor                                             |                    | at 2V                                                                                                                                     | 2     |       |        | μF   |
| Charge pump start-up time                                  |                    |                                                                                                                                           |       | 190   |        | μs   |
| <b>Crystal Oscillator</b>                                  |                    |                                                                                                                                           |       |       |        |      |
| External crystal frequency                                 |                    |                                                                                                                                           |       | 24    |        | MHz  |
| Oscillator load capacitance                                |                    | XTI and XTO Pins                                                                                                                          |       | 10.5  |        | pF   |
| Start-up time                                              |                    | measured from time when:<br>PLLVDD ≥ 1.7V,<br>AVDD ≥ 1.7V and<br>DVDD ≥ 1.62V,<br>until crystal output is stable<br>and in specification. |       | 1.5   |        | ms   |
| <b>Phase Locked Loops (PLLs)</b>                           |                    |                                                                                                                                           |       |       |        |      |
| Output frequency                                           | F <sub>OUT</sub>   |                                                                                                                                           | 22.5  |       | 50     | MHz  |
| Output duty cycle                                          |                    |                                                                                                                                           | 40    | 50    | 60     | %    |
| Start-up time (including Crystal Oscillator start-up time) |                    | measured from time when:<br>PLLVDD ≥ 1.7V,<br>AVDD ≥ 1.7V and<br>DVDD ≥ 1.62V,<br>until PLL outputs are stable<br>and in specification.   |       | 1.5   |        | ms   |
| Frequency synthesis error                                  |                    |                                                                                                                                           |       | 0     |        | ppm  |
| Absolute clock period jitter (peak)                        |                    | Input Clock = 24MHz,<br>5pF load                                                                                                          |       | 500   |        | ps   |
| Short term jitter (peak, cycle to cycle)                   |                    | N=1, 1000 samples,<br>Input Clock = 24MHz,<br>5pF load. (see Note 4)                                                                      |       | 150   |        | ps   |
| Long term jitter (peak)                                    |                    | N=1000, 1000 samples,<br>Input Clock = 24MHz,<br>5pF load. (see Note 4)                                                                   |       | 500   |        | ps   |
| MCLK / XTI input frequency range                           |                    |                                                                                                                                           | 14    |       | 40     | MHz  |
| <b>Frequency Locked Loop (FLL)</b>                         |                    |                                                                                                                                           |       |       |        |      |
| Input frequency                                            | F <sub>REF</sub>   | FLL_REFCLK_DIV = 00                                                                                                                       | 0.032 |       | 13.5   | MHz  |
|                                                            |                    | FLL_REFCLK_DIV = 01                                                                                                                       | 0.064 |       | 27     |      |
|                                                            |                    | FLL_REFCLK_DIV = 10                                                                                                                       | 0.128 |       | 36.864 |      |
| Output frequency                                           | F <sub>OUT</sub>   |                                                                                                                                           | 1.875 |       | 50     | MHz  |
| Start-Up time                                              |                    | VMID enabled; measured from FLL_ENA=1 to clock signal present on CLKOUTn.                                                                 |       | 220   |        | μs   |
| Frequency synthesis error                                  |                    |                                                                                                                                           |       | 0     |        | ppm  |
| Start-Up time (free-running mode)                          |                    | VMID enabled; measured from FLL_ENA=1 to clock signal present on CLKOUTn.                                                                 |       | 0.75  |        | μs   |
| Frequency accuracy (free-running mode)                     |                    | Reference clock supplied initially                                                                                                        |       | +/-10 |        | %    |
|                                                            |                    | No reference clock provided                                                                                                               |       | +/-30 |        | %    |

### Test Conditions

MICVDD = DCVDD = DBVDD = CPVDD = AVDD = PLLVDD = 1.8V, SPKVDD1 = SPKVDD2 = 5V.

T<sub>A</sub> = +25°C, 1kHz signal, fs = 48kHz, PGA gain = 0dB, 24-bit audio data unless otherwise stated.

| PARAMETER                     | SYMBOL               | TEST CONDITIONS                                                           | MIN       | TYP | MAX       | UNIT |
|-------------------------------|----------------------|---------------------------------------------------------------------------|-----------|-----|-----------|------|
| <b>Digital Input / Output</b> |                      |                                                                           |           |     |           |      |
| Input HIGH Level              | V <sub>IH</sub>      |                                                                           | 0.7×DBVDD |     |           | V    |
| Input LOW Level               | V <sub>IL</sub>      |                                                                           |           |     | 0.3×DBVDD | V    |
| Output HIGH Level             | V <sub>OH</sub>      | I <sub>OH</sub> =1mA                                                      | 0.9×DBVDD |     |           | V    |
| Output LOW Level              | V <sub>OL</sub>      | I <sub>OL</sub> =-1mA                                                     |           |     | 0.1×DBVDD | V    |
| Input capacitance             |                      |                                                                           |           | 15  |           | pF   |
| Input leakage                 |                      |                                                                           | -0.9      |     | 0.9       | μA   |
| CLKOUTn output impedance      |                      |                                                                           |           | 160 |           | Ω    |
| <b>Current Consumption</b>    |                      |                                                                           |           |     |           |      |
| AVDD                          | I <sub>AVDD</sub>    | OFF: power applied,<br>all clocks stopped,<br>thermal shut-down enabled   |           | 40  | 75        | μA   |
| DCVDD                         | I <sub>DCVDD</sub>   |                                                                           |           | 3   | 25        | μA   |
| DBVDD                         | I <sub>DBVDD</sub>   |                                                                           |           | 0   | 10        | μA   |
| CPVDD                         | I <sub>CPVDD</sub>   |                                                                           |           | 0.5 | 10        | μA   |
| SPKVDD1                       | I <sub>SPKVDD1</sub> |                                                                           |           | 1   | 5         | μA   |
| SPKVDD2                       | I <sub>SPKVDD2</sub> |                                                                           |           | 1   | 5         | μA   |
| MICVDD                        | I <sub>MICVDD</sub>  |                                                                           |           | 0.2 | 5         | μA   |
| PLLVDD                        | I <sub>PLLVDD1</sub> |                                                                           | 7         | 30  | μA        |      |
| MICVDD                        | I <sub>MICVDD</sub>  | SPKVDD1=SPKVDD2=5V,<br>MICVDD=2.5V,<br>All other supplies<br>disconnected |           | 0.2 | 5         | μA   |
| SPKVDD1                       | I <sub>SPKVDD1</sub> |                                                                           |           | 0.2 | 5         | μA   |
| SPKVDD2                       | I <sub>SPKVDD2</sub> |                                                                           |           | 0.2 | 5         | μA   |
| MICVDD                        | I <sub>MICVDD</sub>  | SPKVDD1=SPKVDD2=5V,<br>MICVDD=2.5V,<br>All other supplies 0V              |           | 0.2 | 5         | μA   |
| SPKVDD1                       | I <sub>SPKVDD1</sub> |                                                                           |           | 0.2 | 5         | μA   |
| SPKVDD2                       | I <sub>SPKVDD2</sub> |                                                                           |           | 0.2 | 5         | μA   |

### Note:

1. If AVDD ≠ 1.8, current threshold values should be multiplied by (AVDD/1.8)
2. Four different bias configurations are supported for ADC input paths; these are defined in the “Reference Voltages and Bias Control” section.
3. Two different bias configurations are supported for the DAC / Headphone output paths; these are defined in the “Reference Voltages and Bias Control” section.
4. N = number of clock periods in one sample.

## TERMINOLOGY

1. Signal-to-Noise Ratio (dB) – SNR is a measure of the difference in level between the maximum full scale output signal and the output with no input signal applied.
2. Total Harmonic Distortion (dB) – THD is the level of the rms value of the sum of harmonic distortion products relative to the amplitude of the measured output signal.
3. Total Harmonic Distortion plus Noise (dB) – THD+N is the level of the rms value of the sum of harmonic distortion products plus noise in the specified bandwidth relative to the amplitude of the measured output signal.
4. Channel Separation (L/R) (dB) – left-to-right and right-to-left channel separation is the measured signal level in the idle channel at the test signal frequency relative to the signal level at the output of the active channel. The active channel is configured and supplied with an appropriate input signal to drive a full scale output, with signal measured at the output of the associated idle channel.
5. Mute Attenuation – This is a measure of the difference in level between the full scale output signal and the output with mute applied.
6. All performance measurements carried out with 20kHz low pass filter, and where noted an A-weighted filter. Failure to use such a filter will result in higher THD and lower SNR readings than are found in the Electrical Characteristics. The low pass filter removes out of band noise; although it is not audible it may affect dynamic specification values.

## THERMAL CHARACTERISTICS

The WM8962B thermal performance is characterised by the  $\Theta_{JA}$  and  $\Theta_{JB}$  parameters, as noted below.

Note that the thermal characteristics are based upon simulations in accordance with the JEDEC thermal testing standards, JESD51-9. These test conditions may be very different to the application conditions, so these parameters should be used with caution.

Theta-JA ( $\Theta_{JA}$ ) is the junction-to-air thermal resistance. It is determined by the following equation:

$$\Theta_{JA} = \frac{T_J - T_A}{P_A}$$

where

$T_J$  = Junction temperature (the maximum temperature on the die)

$T_A$  = Ambient temperature (the temperature of the surrounding environment)

$P_A$  = Power dissipated from the device to the surrounding air

Theta-JB ( $\Theta_{JB}$ ) is the junction-to-board thermal resistance. It is determined by the following equation:

$$\Theta_{JB} = \frac{T_J - T_B}{P_B}$$

where

$T_J$  = Junction temperature (the maximum temperature on the die)

$T_B$  = Board temperature (the temperature of the printed circuit board)

$P_B$  = Power dissipated from the device to the circuit board

See "Recommended Operating Conditions" for the recommended  $T_J$  and  $T_A$  operating limits.

| PARAMETER                     | SYMBOL        | TYP | UNIT |
|-------------------------------|---------------|-----|------|
| Thermal resistance (Theta-JA) | $\Theta_{JA}$ | 50  | °C/W |
| Thermal resistance (Theta-JB) | $\Theta_{JB}$ | 20  | °C/W |

**TYPICAL POWER CONSUMPTION**

| <b>Analogue Input (IN1L, IN1R) to ADC out via Input PGA and Input Gain boost</b>                    |                       |                       |                        |                      |                        |                       |                        |              |
|-----------------------------------------------------------------------------------------------------|-----------------------|-----------------------|------------------------|----------------------|------------------------|-----------------------|------------------------|--------------|
| Quiescent input, default register conditions unless otherwise stated.                               |                       |                       |                        |                      |                        |                       |                        |              |
| MCLK = 12.288MHz, fs = 48kHz, MCLK rate = 256fs, 24-bit I2S, Slave mode,                            |                       |                       |                        |                      |                        |                       |                        |              |
| INL_ENA = 1, INR_ENA = 1,                                                                           |                       |                       |                        |                      |                        |                       |                        |              |
| INPGAL_MUTE = 0, INPGAR_MUTE = 0,                                                                   |                       |                       |                        |                      |                        |                       |                        |              |
| ADCL_ENA = 1, ADCR_ENA = 1                                                                          |                       |                       |                        |                      |                        |                       |                        |              |
| VMID_SEL = 01, BIAS_ENA = 1                                                                         |                       |                       |                        |                      |                        |                       |                        |              |
| See "Reference Voltages and Bias Control" for details of the bias configuration registers.          |                       |                       |                        |                      |                        |                       |                        |              |
|                                                                                                     | <b>DCVDD<br/>1.8V</b> | <b>DBVDD<br/>1.8V</b> | <b>MICVDD<br/>2.5V</b> | <b>AVDD<br/>1.8V</b> | <b>PLLVDD<br/>1.8V</b> | <b>CPVDD<br/>1.8V</b> | <b>SPKVDD<br/>5.0V</b> | <b>TOTAL</b> |
| Quiescent input,<br>Option 1 bias settings                                                          | 2.4mA                 | 0.0mA                 | 0.0mA                  | 2.5mA                | 0.0mA                  | 0.0mA                 | 0.0mA                  | 8.8mW        |
| Quiescent input,<br>Option 2 bias settings                                                          | 2.4mA                 | 0.0mA                 | 0.0mA                  | 2.7mA                | 0.0mA                  | 0.0mA                 | 0.0mA                  | 9.2mW        |
| Quiescent input,<br>Option 3 bias settings (default)                                                | 2.4mA                 | 0.0mA                 | 0.0mA                  | 3.3mA                | 0.0mA                  | 0.0mA                 | 0.0mA                  | 10.3mW       |
| Quiescent input,<br>Option 4 bias settings                                                          | 2.6mA                 | 0.0mA                 | 0.0mA                  | 5.4mA                | 0.0mA                  | 0.0mA                 | 0.0mA                  | 14.4mW       |
| -1dBFS ADC output                                                                                   | 2.4mA                 | 0.0mA                 | 0.0mA                  | 3.3mA                | 0.0mA                  | 0.0mA                 | 0.0mA                  | 10.4mW       |
| MICBIAS enabled                                                                                     | 2.4mA                 | 0.0mA                 | 0.4mA                  | 3.3mA                | 0.0mA                  | 0.0mA                 | 0.0mA                  | 11.3mW       |
| Quiescent input,<br>fs = 8kHz, MCLK = 2.048MHz                                                      | 0.3mA                 | 0.0mA                 | 0.0mA                  | 3.0mA                | 0.0mA                  | 0.0mA                 | 0.0mA                  | 6.0mW        |
| Quiescent input,<br>fs = 96kHz, MCLK = 24.576MHz                                                    | 4.1mA                 | 0.0mA                 | 0.0mA                  | 3.3mA                | 0.0mA                  | 0.0mA                 | 0.0mA                  | 13.3mW       |
| Quiescent input,<br>fs = 48kHz, MCLK = 24.576MHz,<br>MCLK = 512fs,<br>DSP Sound Enhancement enabled | 14.5mA                | 0.2mA                 | 0.0mA                  | 3.2mA                | 0.0mA                  | 0.0mA                 | 0.0mA                  | 32.4mW       |

**Analogue Input (IN2L, IN2R) to ADC out via Input PGA and Input Gain boost**  
 Quiescent input, default register conditions unless otherwise stated.  
 MCLK = 12.288MHz, fs = 48kHz, MCLK rate = 256fs, 24-bit I2S, Slave mode,  
 MIXINL\_ENA = 1, MIXINR\_ENA = 1, IN2L\_TO\_MIXINL = 1, IN2R\_TO\_MIXINR = 1,  
 ADCL\_ENA = 1, ADCR\_ENA = 1,  
 VMID\_SEL = 01, BIAS\_ENA = 1.  
 See "Reference Voltages and Bias Control" for details of the bias configuration registers.

|                                                                                                     | DCVDD<br>1.8V | DBVDD<br>1.8V | MICVDD<br>2.5V | AVDD<br>1.8V | PLLVDD<br>1.8V | CPVDD<br>1.8V | SPKVDD<br>5.0V | TOTAL  |
|-----------------------------------------------------------------------------------------------------|---------------|---------------|----------------|--------------|----------------|---------------|----------------|--------|
| Quiescent input,<br>Option 1 bias settings                                                          | 2.4mA         | 0.0mA         | 0.0mA          | 2.2mA        | 0.0mA          | 0.0mA         | 0.0mA          | 8.3mW  |
| Quiescent input,<br>Option 2 bias settings                                                          | 2.4mA         | 0.0mA         | 0.0mA          | 2.4mA        | 0.0mA          | 0.0mA         | 0.0mA          | 8.7mW  |
| Quiescent input,<br>Option 3 bias settings (default)                                                | 2.4mA         | 0.0mA         | 0.0mA          | 3.0mA        | 0.0mA          | 0.0mA         | 0.0mA          | 9.8mW  |
| Quiescent input,<br>Option 4 bias settings                                                          | 2.6mA         | 0.0mA         | 0.0mA          | 4.5mA        | 0.0mA          | 0.0mA         | 0.0mA          | 12.9mW |
| -1dBFS ADC output                                                                                   | 2.4mA         | 0.0mA         | 0.0mA          | 3.0mA        | 0.0mA          | 0.0mA         | 0.0mA          | 9.9mW  |
| MICBIAS enabled                                                                                     | 2.4mA         | 0.0mA         | 0.4mA          | 3.0mA        | 0.0mA          | 0.0mA         | 0.0mA          | 10.7mW |
| Quiescent input,<br>fs = 8kHz, MCLK = 2.048MHz                                                      | 0.3mA         | 0.0mA         | 0.0mA          | 2.7mA        | 0.0mA          | 0.0mA         | 0.0mA          | 5.4mW  |
| Quiescent input,<br>fs = 96kHz, MCLK = 24.576MHz                                                    | 4.1mA         | 0.0mA         | 0.0mA          | 3.0mA        | 0.0mA          | 0.0mA         | 0.0mA          | 12.8mW |
| Quiescent input,<br>fs = 48kHz, MCLK = 24.576MHz,<br>MCLK = 512fs,<br>DSP Sound Enhancement enabled | 14.5mA        | 0.2mA         | 0.0mA          | 3.0mA        | 0.0mA          | 0.0mA         | 0.0mA          | 32.0mW |

**Stereo DAC Playback to Headphone (HPOUTL, HPOUTR) - Low Power headphone playback mode, 16Ω load.**  
 Default register conditions unless otherwise stated.  
 Default DAC to Headphone Power Up sequence completed.  
 CP\_DYN\_PWR = 1  
 MCLK = 12.288MHz, fs = 48kHz, MCLK rate = 256fs, 24-bit I2S, Slave mode,  
 Input signal level = 0dBFS, HP1x\_VOL = 111b (0dB),  
 Note that Low Power headphone playback mode is selected by default.

|                                                                                                                        | DCVDD<br>1.8V | DBVDD<br>1.8V | MICVDD<br>2.5V | AVDD<br>1.8V | PLLVDD<br>1.8V | CPVDD<br>1.8V | SPKVDD<br>5.0V | TOTAL   |
|------------------------------------------------------------------------------------------------------------------------|---------------|---------------|----------------|--------------|----------------|---------------|----------------|---------|
| Quiescent output                                                                                                       | 2.0mA         | 0.0mA         | 0.0mA          | 1.7mA        | 0.0mA          | 0.5mA         | 0.0mA          | 7.7mW   |
| 0.1mW/channel output<br>HPOUTx_VOL = 5Dh (-28dB)                                                                       | 1.9mA         | 0.0mA         | 0.0mA          | 1.7mA        | 0.0mA          | 2.7mA         | 0.0mA          | 11.4mW  |
| 2mW/channel output<br>HPOUTx_VOL = 69h (-15dB)                                                                         | 2.0mA         | 0.0mA         | 0.0mA          | 1.7mA        | 0.0mA          | 10.1mA        | 0.0mA          | 25.0mW  |
| 16mW/channel output<br>HPOUTx_VOL = 73h (-6dB)                                                                         | 2.0mA         | 0.0mA         | 0.0mA          | 1.7mA        | 0.0mA          | 53.7mA        | 0.0mA          | 103.4mW |
| Quiescent output,<br>fs = 48kHz, MCLK = 24.576MHz,<br>MCLK = 512fs,<br>DSP Sound Enhancement enabled<br>CP_DYN_PWR = 0 | 14.3mA        | 0.0mA         | 0.0mA          | 1.8mA        | 0.0mA          | 1.8mA         | 0.0mA          | 32.2mW  |

**Stereo DAC Playback to Headphone (HPOUTL, HPOUTR) - High Performance headphone playback mode, 16Ω load.**

Default register conditions unless otherwise stated.

Default DAC to Headphone Power Up sequence completed.

DAC\_HP = 1, HP\_PGAS\_BIAS = 000, HP\_BIAS\_BOOST = 000. (These must be set after running the DAC power-up sequence.)

CP\_DYN\_PWR = 1

MCLK = 12.288MHz, fs = 48kHz, MCLK rate = 256fs, 24-bit I2S, Slave mode,

Input signal level = 0dBFS, HP1x\_VOL = 000b (-7dB),

See "Reference Voltages and Bias Control" for details of the High Performance headphone playback mode.

|                                                                                                                        | DCVDD<br>1.8V | DBVDD<br>1.8V | MICVDD<br>2.5V | AVDD<br>1.8V | PLLVDD<br>1.8V | CPVDD<br>1.8V | SPKVDD<br>5.0V | TOTAL   |
|------------------------------------------------------------------------------------------------------------------------|---------------|---------------|----------------|--------------|----------------|---------------|----------------|---------|
| Quiescent output                                                                                                       | 2.0mA         | 0.0mA         | 0.0mA          | 2.5mA        | 0.0mA          | 0.5mA         | 0.0mA          | 8.9mW   |
| 0.1mW/channel output<br>HPOUTx_VOL = 65h (-20dB)                                                                       | 2.1mA         | 0.0mA         | 0.0mA          | 2.5mA        | 0.0mA          | 2.9mA         | 0.0mA          | 13.3mW  |
| 2mW/channel output<br>HPOUTx_VOL = 72h (-7dB)                                                                          | 2.1mA         | 0.0mA         | 0.0mA          | 2.5mA        | 0.0mA          | 22.5mA        | 0.0mA          | 48.7mW  |
| 16mW/channel output<br>HPOUTx_VOL = 79h (-0dB)<br>HP1x_VOL = 2h (-5dB)                                                 | 2.1mA         | 0.0mA         | 0.0mA          | 2.5mA        | 0.0mA          | 59.6mA        | 0.0mA          | 115.6mW |
| Quiescent output,<br>fs = 48kHz, MCLK = 24.576MHz,<br>MCLK = 512fs,<br>DSP Sound Enhancement enabled<br>CP_DYN_PWR = 0 | 14.4mA        | 0.0mA         | 0.0mA          | 2.5mA        | 0.0mA          | 1.8mA         | 0.0mA          | 33.8mW  |

**Stereo DAC Playback to Speaker (SPKOUTLP, SPKOUTLN, SPKOUTRP, SPKOUTRN) - 8.2Ω, 2.2μH load.**

Default register conditions unless otherwise stated.

Default DAC to Headphone Power Up sequence completed.

DAC\_MUTE = 0, DACL\_ENA = 1, DACR\_ENA = 1,

SPKOUTL\_ENA = 1, SPKOUTL\_PGA\_ENA = 1, SPKOUTL\_PGA\_MUTE = 1,

SPKOUTR\_ENA = 1, SPKOUTR\_PGA\_ENA = 1, SPKOUTR\_PGA\_MUTE = 1,

CLASSD\_VOL = 111 (+12dB),

VMID\_SEL = 01, BIAS\_ENA = 1,

MCLK = 12.288MHz, fs = 48kHz, MCLK rate = 256fs, 24-bit I2S, Slave mode,

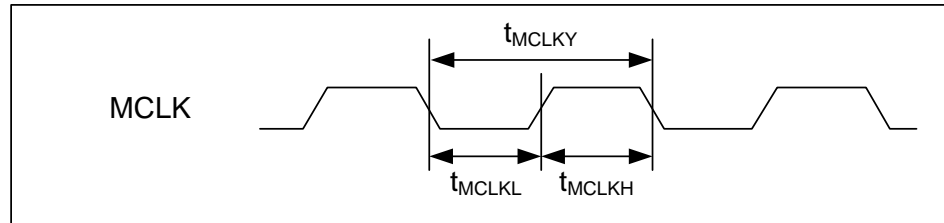
|                                                                                                      | DCVDD<br>1.8V | DBVDD<br>1.8V | MICVDD<br>2.5V | AVDD<br>1.8V | PLLVDD<br>1.8V | CPVDD<br>1.8V | SPKVDD<br>5.0V | TOTAL    |
|------------------------------------------------------------------------------------------------------|---------------|---------------|----------------|--------------|----------------|---------------|----------------|----------|
| Quiescent output                                                                                     | 2.4mA         | 0.0mA         | 0.0mA          | 2.7mA        | 0.0mA          | 0.0mA         | 7.3mA          | 45.7mW   |
| 200mW/channel output                                                                                 | 2.4mA         | 0.0mA         | 0.0mA          | 2.7mA        | 0.0mA          | 0.0mA         | 91.8mA         | 468.2mW  |
| 1W/channel output                                                                                    | 2.3mA         | 0.0mA         | 0.0mA          | 2.6mA        | 0.0mA          | 0.0mA         | 532.7mA        | 2672.3mW |
| Quiescent output,<br>fs = 48kHz, MCLK = 24.576MHz,<br>MCLK = 512fs,<br>DSP Sound Enhancement enabled | 14.3mA        | 0.0mA         | 0.0mA          | 2.9mA        | 0.0mA          | 0.0mA         | 7.1mA          | 66.6mW   |



| <b>Clocking Configurations</b>                                                                        |                       |                       |                        |                      |                        |                       |                        |              |
|-------------------------------------------------------------------------------------------------------|-----------------------|-----------------------|------------------------|----------------------|------------------------|-----------------------|------------------------|--------------|
| Default register conditions unless otherwise stated.                                                  |                       |                       |                        |                      |                        |                       |                        |              |
|                                                                                                       | <b>DCVDD<br/>1.8V</b> | <b>DBVDD<br/>1.8V</b> | <b>MICVDD<br/>2.5V</b> | <b>AVDD<br/>1.8V</b> | <b>PLLVDD<br/>1.8V</b> | <b>CPVDD<br/>1.8V</b> | <b>SPKVDD<br/>5.0V</b> | <b>TOTAL</b> |
| PLL3 enabled,<br>24MHz crystal oscillator reference,<br>PLL3 output = 24.576MHz,<br>MCLK = 12.288MHz. | 0.680mA               | 0.160mA               | 0.0mA                  | 0.056mA              | 2.278mA                | 0.0mA                 | 0.001mA                | 5.718mW      |
| FLL enabled,<br>24MHz crystal oscillator reference,<br>FLL output = 12.288MHz,<br>MCLK = 12.288MHz.   | 1.756mA               | 0.086mA               | 0.0mA                  | 0.451mA              | 1.691mA                | 0.0mA                 | 0.001mA                | 7.175mW      |

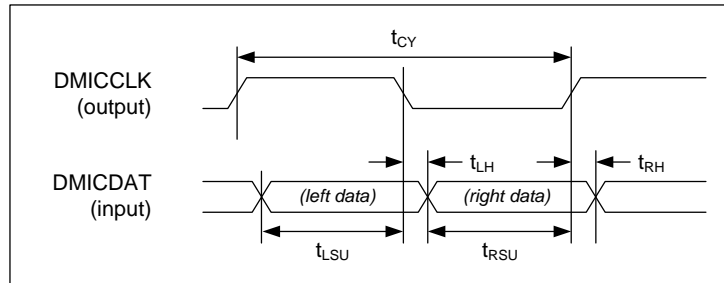
**Notes:**

1. SPKVDD = SPKVDD1 = SPKVDD2.
2.  $I_{SPKVDD} = I_{SPKVDD1} + I_{SPKVDD2}$ .
3. Speaker load inductance will affect the power consumption; reduced inductance will increase power consumption.

**SIGNAL TIMING REQUIREMENTS**
**MASTER CLOCK**

**Figure 1 Master Clock Timing**
**Test Conditions**

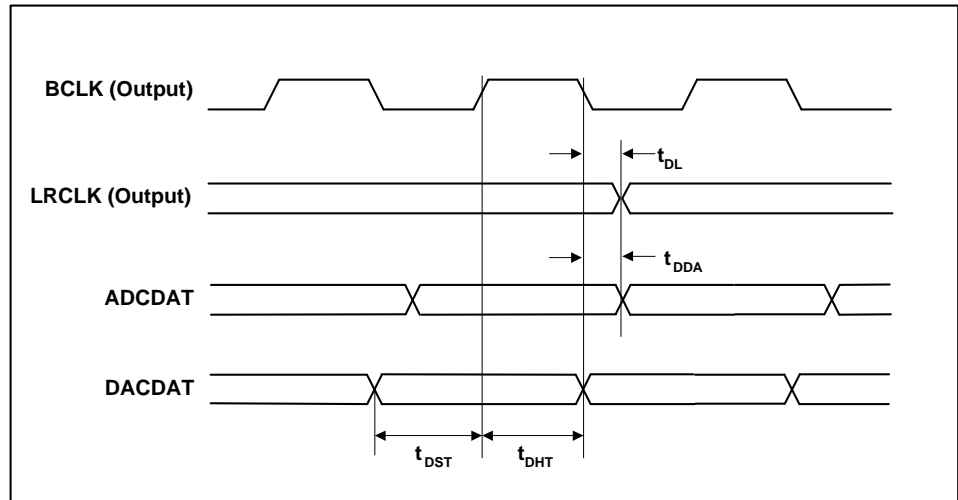
MICVDD=2.5V, DCVDD = CPVDD=AVDD =1.8V SPKVDD1 = SPKVDD2 = 5V,  
 DGND=AGND=CPGND=SPKGND1=SPKGND2=0V,  $T_A = +25^\circ\text{C}$

| PARAMETER                  | SYMBOL                  | CONDITIONS | MIN    | TYP | MAX   | UNIT |
|----------------------------|-------------------------|------------|--------|-----|-------|------|
| <b>Master Clock Timing</b> |                         |            |        |     |       |      |
| MCLK cycle time            | $T_{MCLKY}$             |            | 20.345 |     |       | ns   |
| MCLK duty cycle            | $T_{MCLKH} : T_{MCLKL}$ |            | 60:40  |     | 40:60 |      |

**AUDIO INTERFACE TIMING**
**DIGITAL MICROPHONE (DMIC) INTERFACE TIMING**

**Figure 2 Digital Microphone Interface Timing**
**Test Conditions**

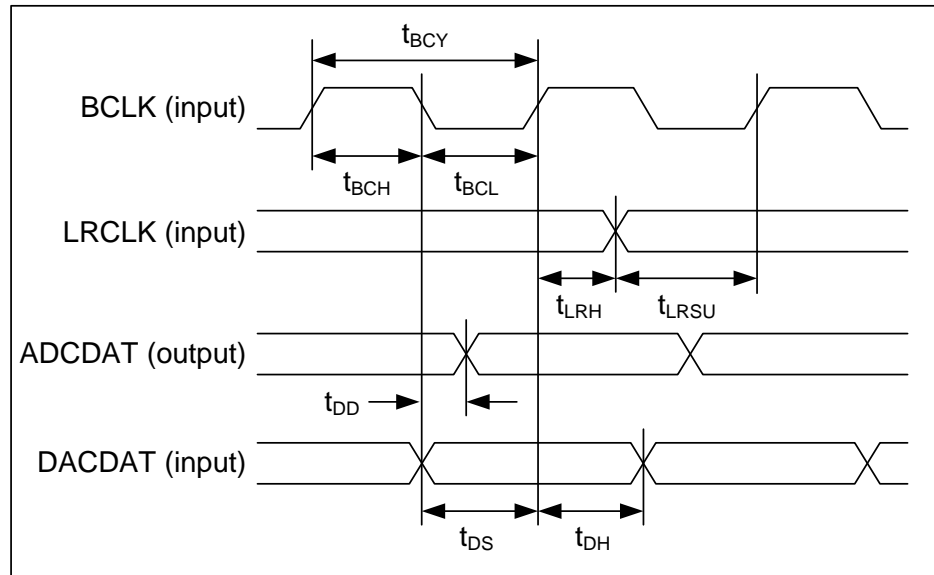
The following timing information is valid across the full range of recommended operating conditions.

| PARAMETER                                          | SYMBOL    | MIN   | TYP | MAX   | UNIT |
|----------------------------------------------------|-----------|-------|-----|-------|------|
| <b>Digital Microphone Interface Timing</b>         |           |       |     |       |      |
| DMICCLK cycle time                                 | $t_{CY}$  | 320   |     |       | ns   |
| DMICCLK duty cycle                                 |           | 45:55 |     | 55:45 |      |
| DMICDAT (Left) setup time to falling DMICCLK edge  | $t_{LSU}$ | 15    |     |       | ns   |
| DMICDAT (Left) hold time from falling DMICCLK edge | $t_{LH}$  | 0     |     |       | ns   |
| DMICDAT (Right) setup time to rising DMICCLK edge  | $t_{RSU}$ | 15    |     |       | ns   |
| DMICDAT (Right) hold time from rising DMICCLK edge | $t_{RH}$  | 0     |     |       | ns   |

**DIGITAL AUDIO INTERFACE - MASTER MODE**

**Figure 3 Audio Interface Timing - Master Mode**
**Test Conditions**

The following timing information is valid across the full range of recommended operating conditions.

| PARAMETER                                       | SYMBOL    | MIN | TYP | MAX | UNIT |
|-------------------------------------------------|-----------|-----|-----|-----|------|
| <b>Audio Interface Timing - Master Mode</b>     |           |     |     |     |      |
| LRCLK propagation delay from BCLK falling edge  | $t_{DL}$  |     |     | 10  | ns   |
| ADCDAT propagation delay from BCLK falling edge | $t_{DDA}$ |     |     | 14  | ns   |
| DACDAT setup time to BCLK rising edge           | $t_{DST}$ | 10  |     |     | ns   |
| DACDAT hold time from BCLK rising edge          | $t_{DHT}$ | 10  |     |     | ns   |

**DIGITAL AUDIO INTERFACE - SLAVE MODE**

**Figure 4 Audio Interface Timing – Slave Mode**
**Test Conditions**

The following timing information is valid across the full range of recommended operating conditions.

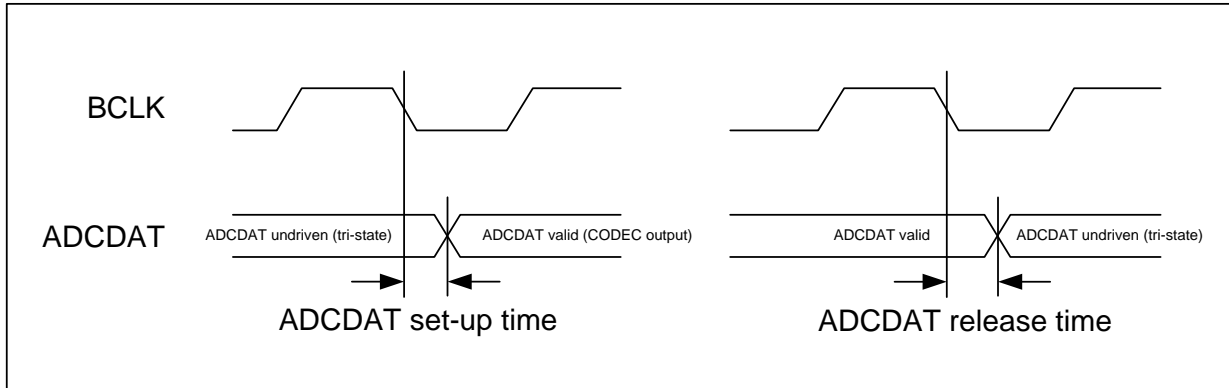
| PARAMETER                                       | SYMBOL     | MIN | TYP | MAX | UNIT |
|-------------------------------------------------|------------|-----|-----|-----|------|
| <b>Audio Interface Timing - Slave Mode</b>      |            |     |     |     |      |
| BCLK cycle time                                 | $t_{BCY}$  | 50  |     |     | ns   |
| BCLK pulse width high                           | $t_{BCH}$  | 20  |     |     | ns   |
| BCLK pulse width low                            | $t_{BCL}$  | 20  |     |     | ns   |
| LRCLK set-up time to BCLK rising edge           | $t_{LRSU}$ | 16  |     |     | ns   |
| LRCLK hold time from BCLK rising edge           | $t_{LRH}$  | 10  |     |     | ns   |
| DACDAT hold time from BCLK rising edge          | $t_{DH}$   | 10  |     |     | ns   |
| ADCDAT propagation delay from BCLK falling edge | $t_{DD}$   |     |     | 14  | ns   |
| DACDAT set-up time to BCLK rising edge          | $t_{DS}$   | 10  |     |     | ns   |

**Note:**

BCLK period should always be greater than or equal to MCLK period.

**DIGITAL AUDIO INTERFACE - TDM MODE**

In TDM mode, it is important that two devices do not attempt to drive the ADCDAT pin simultaneously. The timing of the WM8962B ADCDAT pin tri-stating at the start and end of the data transmission is described below.

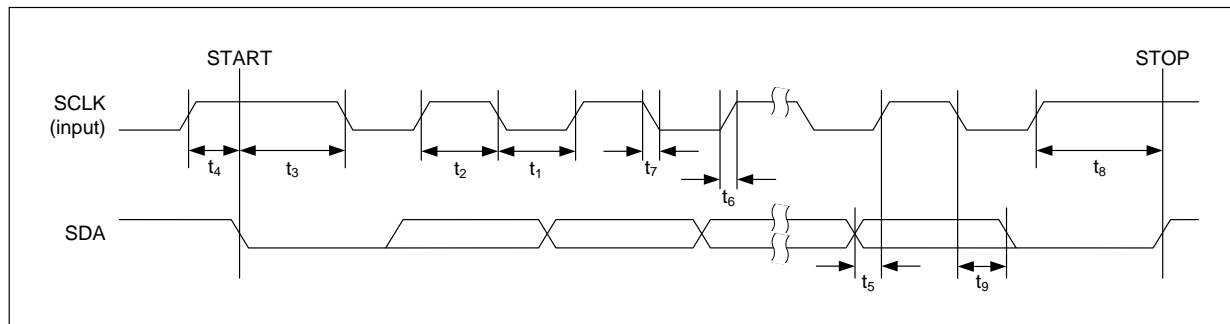


**Figure 5 Audio Interface Timing – TDM Mode**

**Test Conditions**

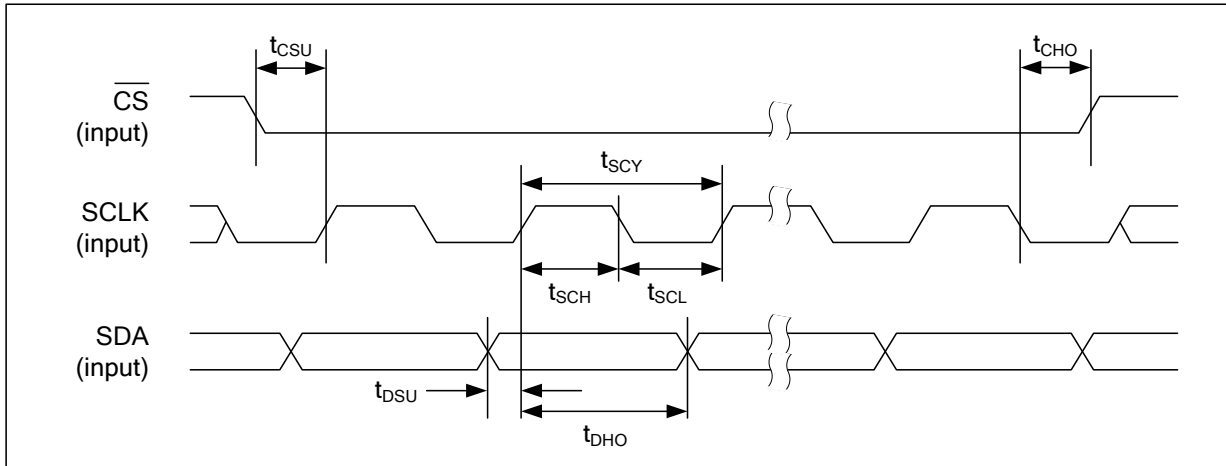
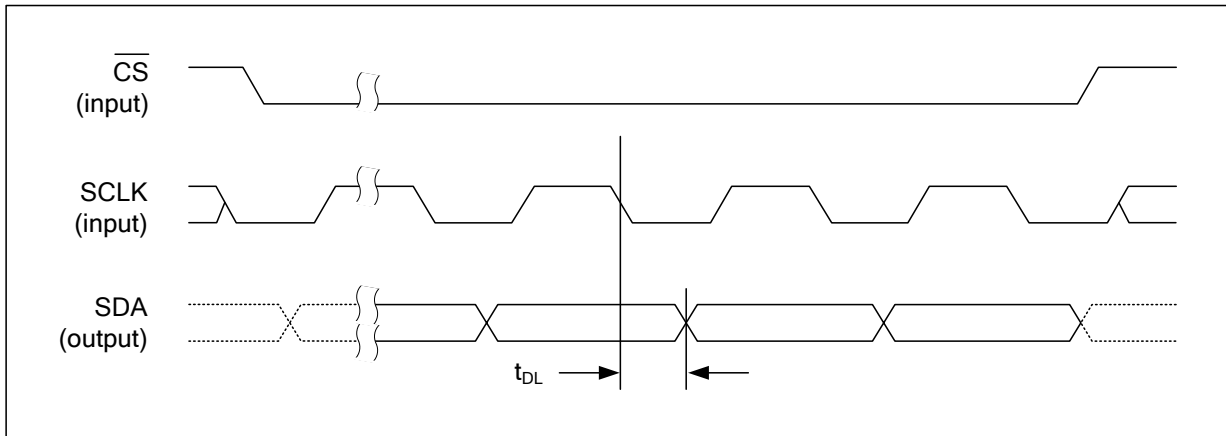
The following timing information is valid across the full range of recommended operating conditions.

| PARAMETER                                  | SYMBOL | MIN | TYP | MAX | UNIT |
|--------------------------------------------|--------|-----|-----|-----|------|
| <b>Audio Interface Timing - TDM Mode</b>   |        |     |     |     |      |
| ADCDAT setup time from BCLK falling edge   |        |     | 4   |     | ns   |
| ADCDAT release time from BCLK falling edge |        |     | 25  |     | ns   |

**CONTROL INTERFACE TIMING**
**2-WIRE (I2C) CONTROL MODE**

**Figure 6 Control Interface Timing**
**Test Conditions**

The following timing information is valid across the full range of recommended operating conditions.

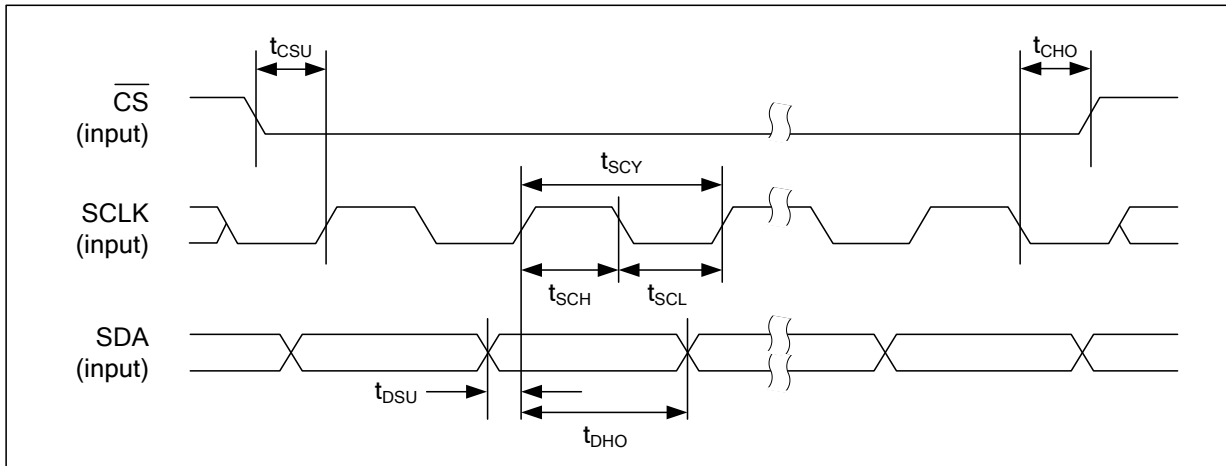
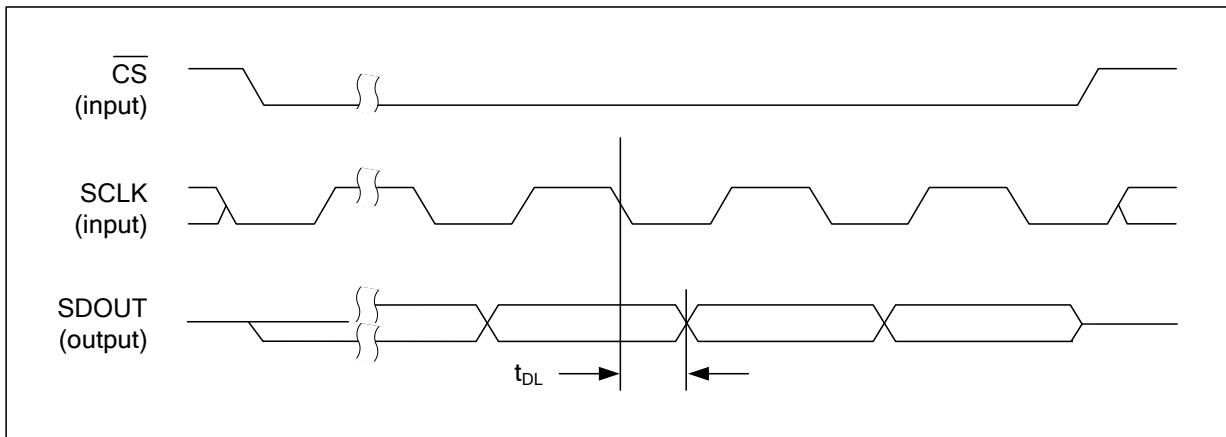
| PARAMETER                                     | SYMBOL   | MIN | TYP | MAX | UNIT |
|-----------------------------------------------|----------|-----|-----|-----|------|
| <b>Program Register Input Information</b>     |          |     |     |     |      |
| SCLK Frequency                                |          |     |     | 526 | kHz  |
| SCLK Low Pulse-Width                          | $t_1$    | 1.3 |     |     | us   |
| SCLK High Pulse-Width                         | $t_2$    | 600 |     |     | ns   |
| Hold Time (Start Condition)                   | $t_3$    | 600 |     |     | ns   |
| Setup Time (Start Condition)                  | $t_4$    | 600 |     |     | ns   |
| Data Setup Time                               | $t_5$    | 100 |     |     | ns   |
| SDA, SCLK Rise Time                           | $t_6$    |     |     | 300 | ns   |
| SDA, SCLK Fall Time                           | $t_7$    |     |     | 300 | ns   |
| Setup Time (Stop Condition)                   | $t_8$    | 600 |     |     | ns   |
| Data Hold Time                                | $t_9$    |     |     | 900 | ns   |
| Pulse width of spikes that will be suppressed | $t_{ps}$ | 0   |     | 5   | ns   |

**3-WIRE (SPI) CONTROL MODE**

**Figure 7 Control Interface Timing - 3-wire (SPI) Control Mode (Write Cycle)**

**Figure 8 Control Interface Timing - 3-wire (SPI) Control Mode (Read Cycle)**
**Test Conditions**

The following timing information is valid across the full range of recommended operating conditions.

| PARAMETER                                     | SYMBOL    | MIN | TYP | MAX | UNIT |
|-----------------------------------------------|-----------|-----|-----|-----|------|
| CS falling edge to SCLK rising edge           | $t_{CSU}$ | 40  |     |     | ns   |
| SCLK falling edge to CS rising edge           | $t_{CHO}$ | 10  |     |     | ns   |
| SCLK pulse cycle time                         | $t_{SCY}$ | 200 |     |     | ns   |
| SCLK pulse width low                          | $t_{SCL}$ | 80  |     |     | ns   |
| SCLK pulse width high                         | $t_{SCH}$ | 80  |     |     | ns   |
| SDA to SCLK set-up time                       | $t_{DSU}$ | 40  |     |     | ns   |
| SDA to SCLK hold time                         | $t_{DHO}$ | 10  |     |     | ns   |
| Pulse width of spikes that will be suppressed | $t_{ps}$  | 0   |     | 5   | ns   |
| SCLK falling edge to SDA output transition    | $t_{DL}$  |     |     | 40  | ns   |



**4-WIRE (SPI) CONTROL MODE**

**Figure 9 Control Interface Timing - 4-wire (SPI) Control Mode (Write Cycle)**

**Figure 10 Control Interface Timing - 4-wire (SPI) Control Mode (Read Cycle)**
**Test Conditions**

The following timing information is valid across the full range of recommended operating conditions.

| PARAMETER                                     | SYMBOL    | MIN | TYP | MAX | UNIT |
|-----------------------------------------------|-----------|-----|-----|-----|------|
| CS falling edge to SCLK rising edge           | $t_{CSU}$ | 40  |     |     | ns   |
| SCLK falling edge to CS rising edge           | $t_{CHO}$ | 10  |     |     | ns   |
| SCLK pulse cycle time                         | $t_{SCY}$ | 200 |     |     | ns   |
| SCLK pulse width low                          | $t_{SCL}$ | 80  |     |     | ns   |
| SCLK pulse width high                         | $t_{SCH}$ | 80  |     |     | ns   |
| SDA to SCLK set-up time                       | $t_{DSU}$ | 40  |     |     | ns   |
| SDA to SCLK hold time                         | $t_{DHO}$ | 10  |     |     | ns   |
| Pulse width of spikes that will be suppressed | $t_{ps}$  | 0   |     | 5   | ns   |
| SCLK falling edge to SDOUT transition         | $t_{DL}$  |     |     | 40  | ns   |

**POWER ON RESET TIMING**

The WM8962B includes an internal Power-On-Reset (POR) circuit, which is used to reset the digital logic into a default state after power up. The POR circuit is powered from AVDD and monitors DCVDD. The internal POR signal is asserted low when AVDD and DCVDD are below minimum thresholds.

A secondary reset circuit is associated with the PLLVDD supply. The PLLs are disabled and the associated registers are undefined when PLLVDD is below its minimum threshold. Full device functionality is not possible until AVDD, DCVDD and PLLVDD are above their respective reset thresholds. The WM8962B can operate with PLLVDD tied to 0V, but the crystal oscillator, PLLs and CLKOUT functions will not be supported.

The specific behaviour of the circuit will vary, depending on the relative timing of the supply voltages. Typical scenarios are illustrated in Figure 11 and Figure 12.

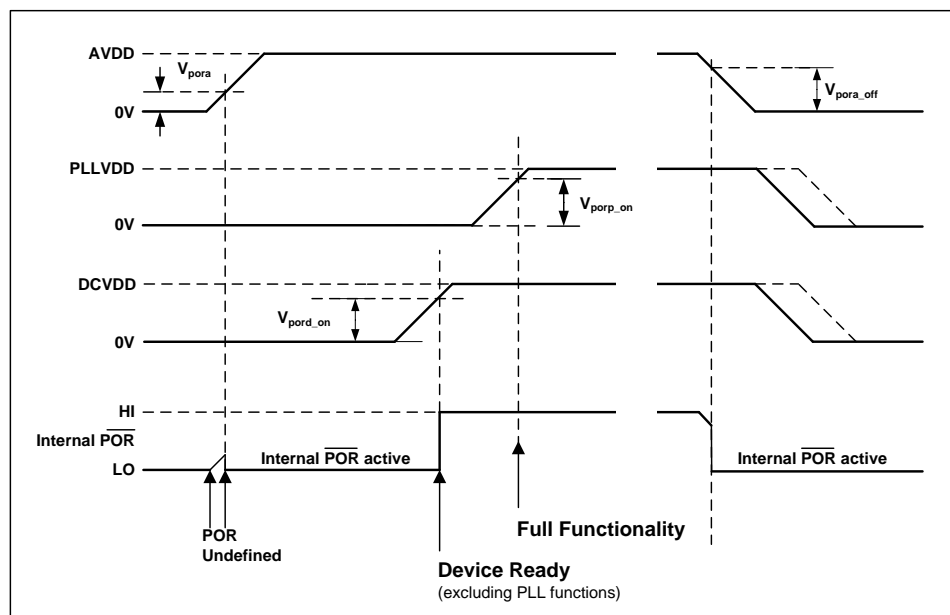
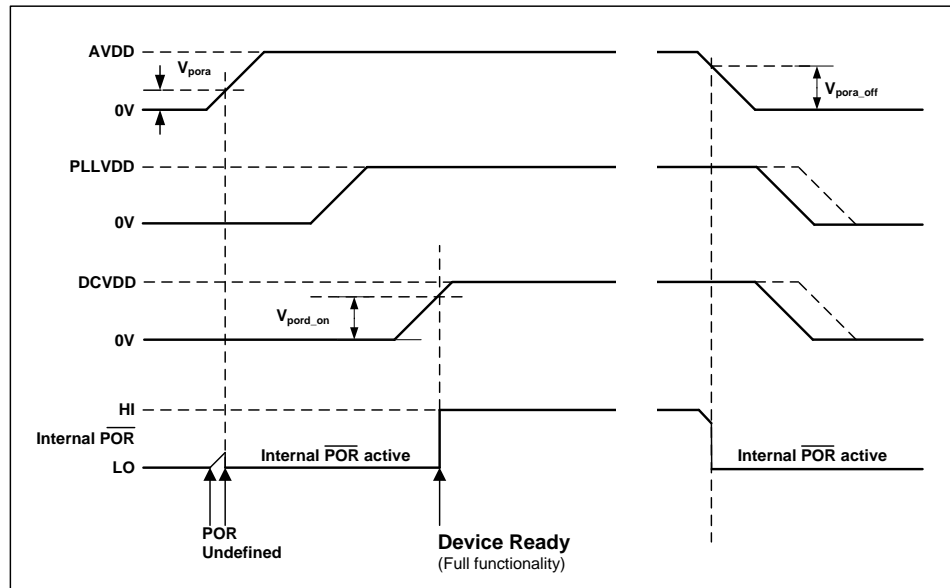


Figure 11 Power On Reset Timing - AVDD Enabled First

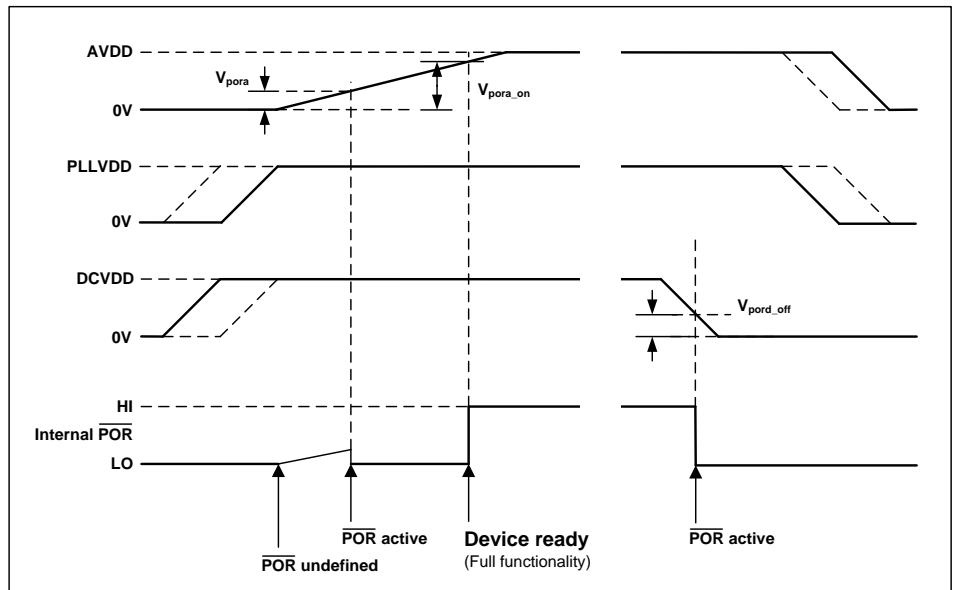
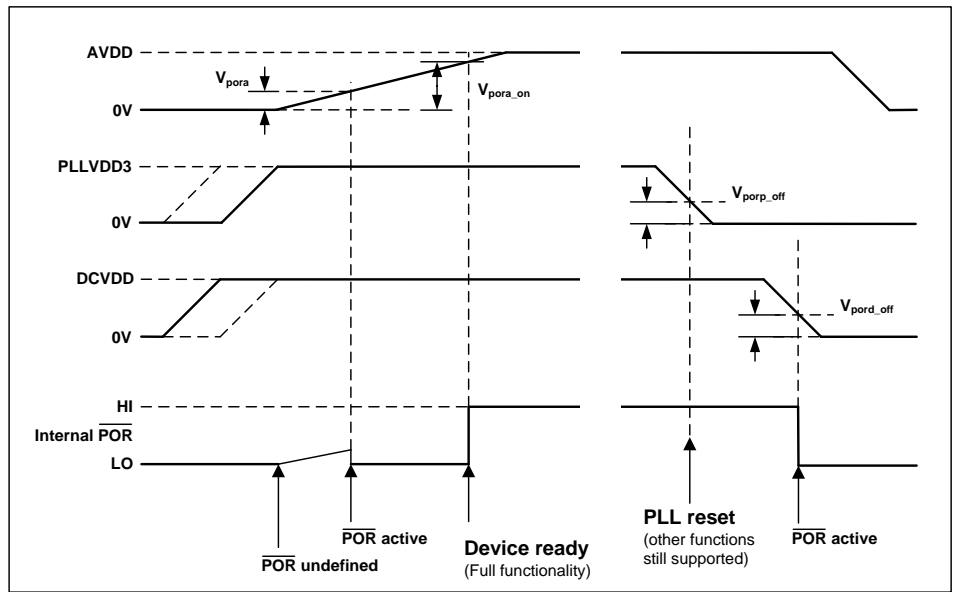


Figure 12 Power On Reset Timing - DCVDD Enabled First

The POR signal is undefined until AVDD has exceeded the minimum threshold,  $V_{pora}$ . Once this threshold has been exceeded, POR is asserted low and the chip is held in reset. In this condition, all writes to the control interface are ignored. Once AVDD and DCVDD have reached their respective power on thresholds, POR is released high, all registers are in their default state, and writes to the control interface may take place.

A secondary reset circuit is associated with the PLLVDD supply. The PLLs are disabled and the associated registers are undefined when PLLVDD is below its minimum threshold.

Note that a minimum power-on reset period,  $T_{POR}$ , applies even if AVDD and DCVDD have zero rise time. (This specification is guaranteed by design rather than test.)

On power down, POR is asserted low when any of AVDD or DCVDD falls below their respective power-down thresholds.

Typical Power-On Reset parameters for the WM8962B are defined in Table 1.

| SYMBOL          | DESCRIPTION                                 | TYP  | UNIT    |
|-----------------|---------------------------------------------|------|---------|
| $V_{pora}$      | AVDD threshold below which POR is undefined | 0.5  | V       |
| $V_{pora\_on}$  | Power-On threshold (AVDD)                   | 1.1  | V       |
| $V_{pora\_off}$ | Power-Off threshold (AVDD)                  | 1.1  | V       |
| $V_{pord\_on}$  | Power-On threshold (DCVDD)                  | 0.9  | V       |
| $V_{pord\_off}$ | Power-Off threshold (DCVDD)                 | 0.65 | V       |
| $V_{porp\_on}$  | PLL start-up threshold (PLLVDD)             | 1.1  | V       |
| $V_{porp\_off}$ | PLL reset threshold (PLLVDD)                | 1.1  | V       |
| $T_{POR}$       | Minimum Power-On Reset period               | 9.5  | $\mu$ s |

**Table 1 Typical Power-On Reset Parameters**

**Notes:**

1. If AVDD and DCVDD suffer a brown-out (i.e. drop below the minimum recommended operating level but do not go below  $V_{pora\_off}$  or  $V_{pord\_off}$ ), then the chip does not reset and resumes normal operation when the voltage is back to the recommended level again.
2. The chip enters reset at power down when AVDD or DCVDD falls below  $V_{pora\_off}$  or  $V_{pord\_off}$ . This may be important if the supply is turned on and off frequently by a power management system.
3. The minimum  $T_{POR}$  period is maintained even if DCVDD and AVDD have zero rise time. This specification is guaranteed by design rather than test.
4. The WM8962B can operate with PLLVDD tied to 0V, but the crystal oscillator, PLLs and CLKOUT functions will not be supported.

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## DEVICE DESCRIPTION

### INTRODUCTION

The WM8962B is a low power audio CODEC offering a combination of high quality audio, advanced features, low power and small size. These characteristics make it ideal for portable digital audio applications with stereo speaker and headphone outputs such as games consoles, portable media players and multimedia phones.

A flexible input configuration supports a single-ended stereo microphone interface and a digital microphone interface. A boost amplifier is available for additional gain on the microphone inputs. A programmable gain amplifier (PGA) with an automatic level control (ALC) function can be used to maintain a constant microphone recording volume.

Stereo class D speaker drivers can provide up to 2W per channel into 4Ω BTL loads. It is also possible to configure the speaker drivers as a mono output, giving enhanced performance.

Highly flexible output speaker boost settings provide fully internal level-shifting of analogue output signals, allowing speaker output power to be maximised while minimising other analogue supply currents, and requiring no additional components.

A dual mode (Level Shifting or Inverting Mode) charge pump generates split supplies for the headphone output amplifiers allowing these to be ground referenced.

A DC servo to remove offsets from the headphone outputs, low leakage and a user controlled power-up/power-down Control Sequencer provides powerful pop and click suppression mechanisms which enable direct battery connection. These anti-pop/click mechanisms, and no requirement for any external DC blocking capacitors to the headphone, result in a reduced external component count and reduced power consumption in portable battery-powered applications.

The hi-fi quality stereo ADC and DAC uses a 24-bit, low-order over-sampling architecture to deliver optimum performance. ADC and DAC operate at the same sample rate.

An audio enhancement DSP provides powerful benefits in audio processing. Three algorithms are pre-programmed in the DSP. ReTune™ flattens the frequency response of the full record and/or playback path, including microphone, speaker and housing. Virtual Surround Sound widens the stereo speaker audio image. High Definition Bass enhances low frequencies, improving the performance of small speakers. Further audio enhancements are provided in a fix function DSP – 3D enhancement, a 5-band parametric equaliser, and a Dynamic Range Controller.

The WM8962B has a highly flexible digital audio interface, supporting a number of protocols, including I2S, DSP, MSB-first left/right justified, and can operate in master or slave modes. PCM operation is supported in the DSP mode. A-law and  $\mu$ -law companding are also supported. Time division multiplexing (TDM) is available to allow multiple devices to stream data simultaneously on the same bus, saving space and power.

The WM8962B provides two integrated PLLs and one FLL to generate internal and external clock signals. The SYSCLK (internal system clock) provides clocking for all internal functions. SYSCLK can be derived directly from the MCLK pin, or else using one of the PLLs or the FLL. All MCLK frequencies typically used in portable systems are supported for sample rates between 8 kHz and 96 kHz. The ADC and DAC must be configured to operate at the same sample rate. A flexible switching clock for the class D speaker drivers (synchronous with the audio DSP clocks for best performance) is also derived from SYSCLK.

To allow full software control over all its features, the WM8962B supports 2-wire (I2C) and 3- or 4-wire (SPI) serial control interface modes, with full read-back capability on all registers. The WM8962B is fully compatible with, and an ideal partner to, a wide range of industry standard microprocessors, controllers and DSPs. Unused functions can be disabled via software to save power, while low leakage currents extend standby and off time in portable battery-powered applications.

**INPUT SIGNAL PATH**

The WM8962B has many analogue input channels, configurable in combinations of up to eight mono inputs or four stereo inputs.

Any of the analogue inputs may be connected to the input PGA on the associated left or right channel. (Note that only one analogue input can be connected to the PGA at any time; the PGA does not perform any signal mixing.)

The left and right analogue inputs IN2 and IN3 can be connected to the input boost mixer on the associated left or right channel, bypassing the input PGA.

Note that the input signal path audio performance is affected by the choice of signal path. Best performance is achieved using analogue inputs IN2 or IN3 connected directly to the input boost mixer. The performance of the input signal paths are ranked as described in the list below (best performance first).

- IN2 or IN3 connected directly to the input boost mixer
- IN1 or IN4 connected via the input PGA
- IN2 or IN3 connected via the input PGA

The left and right analogue inputs IN4 can be connected directly to the output signal mixers, which drive the headphone or speaker outputs.

The input signal paths and the control registers are shown in Figure 13.

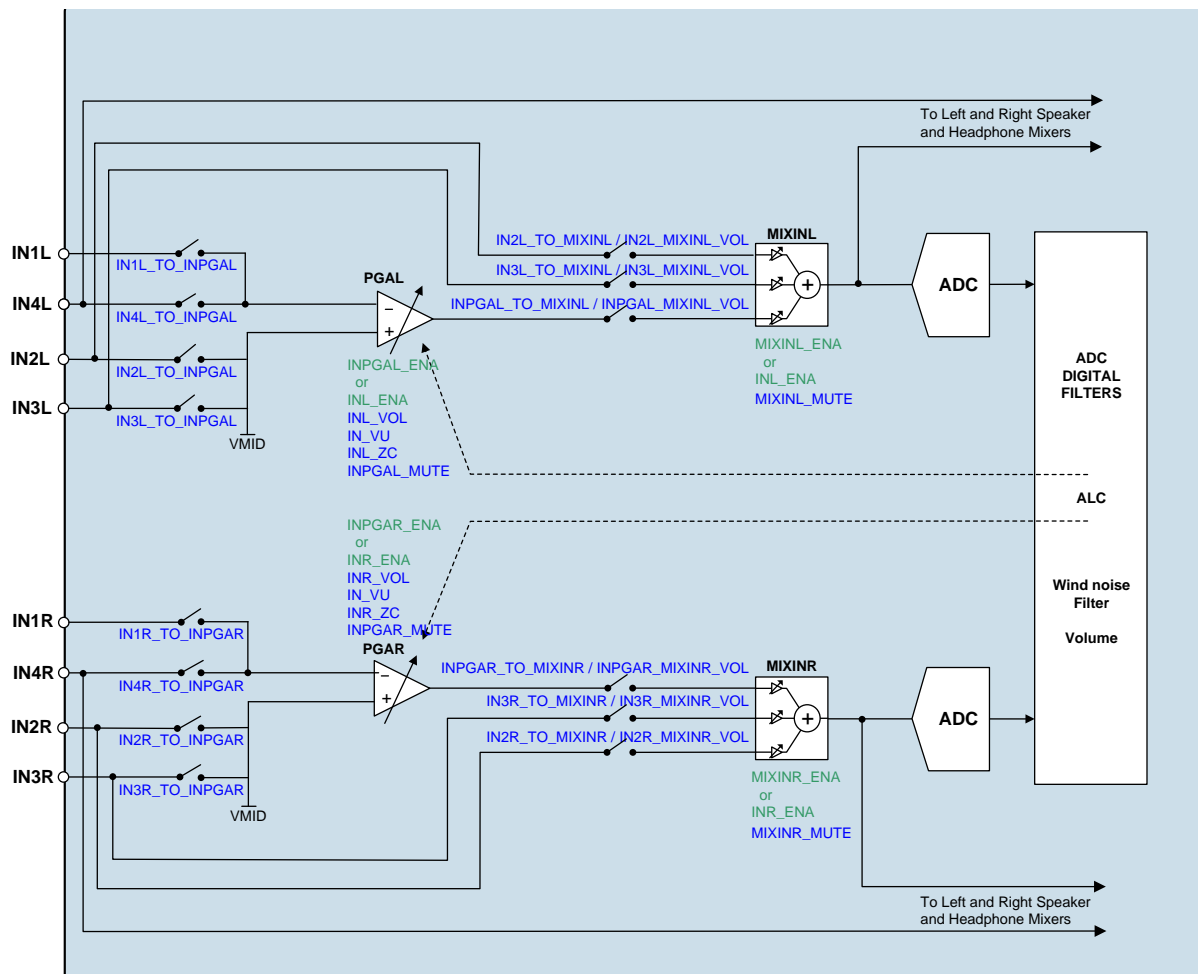


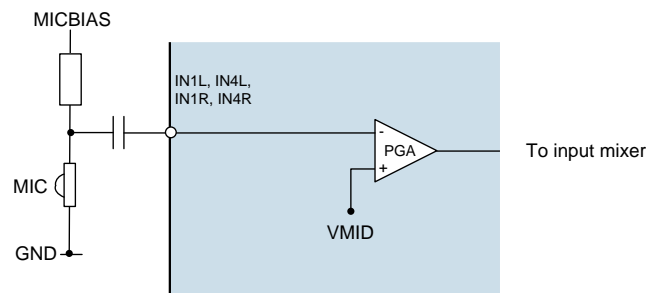
Figure 13 Analogue Input Signal Path

### MICROPHONE INPUT CONNECTION

The WM8962B supports analogue and digital microphone input. Refer to the “Digital Microphone Interface” section for details of the digital microphone input.

The input PGAs can support a single-ended analogue microphone input. A microphone bias generator is also provided, suitable for powering electret condenser microphones.

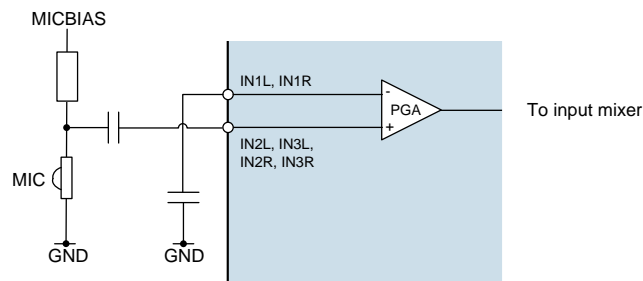
Single-ended analogue microphone input using IN1L, IN1R, IN4L or IN4R is configured as shown in Figure 14.



**Figure 14 Microphone Input IN1 or IN4**

When using IN2L, IN2R, IN3L or IN3R as an input to the PGA, the respective IN1 pin (IN1L or IN1R) must be connected to ground via an external capacitor, as shown in Figure 15.

Note that when IN2L, IN2R, IN3L or IN3R is selected as input to the PGA (using the register bits described in Table 6), the respective IN1 pin (IN1L or IN1R) is automatically connected to the PGA in order to support the capacitor requirement described above.



**Figure 15 Microphone Input IN2 or IN3**

### LINE INPUT CONNECTION

Single-ended line inputs may be connected to the left or right channel analogue inputs IN1, IN2, IN3 or IN4, and routed to the input mixers or output signal paths as illustrated in Figure 14.

If IN2L, IN2R, IN3L or IN3R is used as an input to the PGA, then the respective IN1 pin (IN1L or IN1R) must be connected to ground via an external capacitor, as shown in Figure 15.

Note that when IN2L, IN2R, IN3L or IN3R is selected as input to the PGA (using the register bits described in Table 6), the respective IN1 pin (IN1L or IN1R) is automatically connected to the PGA in order to support the capacitor requirement described above.

### MICROPHONE BIAS CONTROL

There is one MICBIAS generator which provides low noise reference voltages suitable for biasing electret condenser (ECM) type microphones via an external resistor.

Note that an external decoupling capacitor is required on the MICBIAS output. A suitable capacitor must be connected whenever the MICBIAS output is enabled. Additional filtering of the MICBIAS output, to reduce noise and interference, may be implemented as described in the “Applications Information” section, if required.

The MICBIAS output is enabled using the MICBIAS\_ENA register bit. The MICBIAS voltage is selected using the MICBIAS\_LVL and MICBIAS\_EVR register fields, as detailed in Table 2.

| REGISTER ADDRESS             | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                    |
|------------------------------|-----|----------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R25 (19h)<br>Pwr Mgmt<br>(1) | 1   | MICBIAS_ENA          | 0       | Microphone Bias Enable<br>0 = OFF (high impedance output)<br>1 = ON                                                                                                                                            |
| R29 (1Dh)<br>Pwr Mgmt<br>(3) | 1:0 | MICBIAS_EVR<br>[1:0] | 00      | Microphone Bias Voltage Control<br>00 = Controlled by MICBIAS_LVL<br>01 = 1.63 x AVDD (approx.)<br>10 = 1.34 x AVDD (approx.)<br>11 = 1.63 x AVDD (approx.)                                                    |
| R48 (30h)<br>MICBIAS         | 0   | MICBIAS_LVL          | 1       | Microphone Bias Voltage Control<br>0 = 0.828 x AVDD (approx.)<br>1 = 1.156 x AVDD (approx.)<br>Only valid when MICBIAS_EVR=00. In other cases, the Microphone Bias voltage is controlled by MICBIAS_EVR alone. |

**Table 2 Microphone Bias Control**

Note that the maximum source current capability for MICBIAS is 2.0mA. The external biasing resistance must be large enough to limit the MICBIAS current to 2.0mA across the full microphone impedance range.

Note that the MICVDD supply voltage must be at least 300mV higher than the desired MICBIAS output voltage.

### MICBIAS CURRENT DETECT

A MICBIAS Current Detect function is provided for external accessory detection. This is provided in order to detect the insertion/removal of a microphone or the pressing/releasing of the microphone ‘hook’ switch; these events will cause a significant change in MICBIAS current flow, which can be detected and used to generate a signal to the host processor.

The MICBIAS current detect function is enabled by setting the MICDET\_ENA register bit. When this function is enabled, two current thresholds can be defined, using the MICDET\_THR and MICSHORT\_THR registers. When a change in MICBIAS current which crosses either threshold is detected, then an interrupt event can be generated. In a typical application, accessory insertion would be detected when the MICBIAS current exceeds MICDET\_THR, and microphone hookswitch operation would be detected when the MICBIAS current exceeds MICSHORT\_THR.

The current detect threshold functions are both inputs to the Interrupt control circuit and can be used to trigger an Interrupt event when either threshold is crossed. Both events can also be indicated as an output on a GPIO pin - see “General Purpose Input/Output (GPIO)”. The status flags MICDET\_STS or MICSHORT\_STS are also asserted whenever the relevant current threshold is exceeded.

The current detect thresholds are enabled and controlled using the registers described in Table 3 Performance parameters for this circuit block can be found in the “Electrical Characteristics” section.

Filtering is also provided in both current detect circuits to improve reliability in conditions where AC current spikes are present due to ambient noise conditions. This feature is described in the following section. Further guidance on the usage of the MICBIAS current monitoring features is also described in the following pages.



| REGISTER ADDRESS                    | BIT   | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                               |
|-------------------------------------|-------|--------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R48 (30h)<br>Additional Control (4) | 14:12 | MICDET_THR [2:0]   | 000     | MICBIAS Current Detect Threshold (AVDD = 1.8V)<br>000 = 64uA<br>001 = 166uA<br>010 = 375uA<br>011 = 475uA<br>100 = 575uA<br>101 = 680uA<br>110 = 885uA<br>111 = 990uA<br>Note that the value scales with AVDD. The value quoted is correct for AVDD=1.8V. |
|                                     | 11:10 | MICSHORT_THR [1:0] | 00      | MICBIAS Short Circuit Threshold (AVDD = 1.8V)<br>00 = 515uA<br>01 = 680uA<br>10 = 1050uA<br>11 = 1215uA<br>Note that the value scales with AVDD. The value quoted is correct for AVDD=1.8V.                                                               |
|                                     | 9     | MICDET_ENA         | 0       | MICBIAS Current and Short Circuit Detect Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                            |
|                                     | 7     | MICDET_STS         | 0       | MICBIAS Current Detection status<br>0 = Current Detect threshold not exceeded<br>1 = Current Detect threshold exceeded                                                                                                                                    |
|                                     | 6     | MICSHORT_STS       | 0       | MICBIAS Short Circuit status<br>0 = Short Circuit threshold not exceeded<br>1 = Short Circuit threshold exceeded                                                                                                                                          |

**Table 3 MICBIAS Current Detect**

### MICBIAS CURRENT DETECT FILTERING

The function of the filtering is to ensure that AC current spikes caused by ambient noise conditions near the microphone do not lead to incorrect signalling of the microphone insertion/removal status or the microphone hookswitch status.

Digital filtering of the hookswitch status ensures that the MICBIAS Short Circuit detection event is only signalled if the MICSHORT\_THR threshold condition has been met for 10 consecutive measurements.

In a typical application, microphone insertion would be detected when the MICBIAS current exceeds the Current Detect threshold set by MICDET\_THR.

When the MICD\_IRQ\_POL interrupt polarity bit is set to 0, then microphone insertion detection will cause the MICD\_EINT interrupt status register to be set. (See "Interrupts" for details of these register bits.)

For detection of microphone removal, the MICD\_IRQ\_POL bit should be set to 1. When the MICD\_IRQ\_POL interrupt polarity bit is set to 1, then microphone removal detection will cause the MICD\_EINT interrupt status register to be set.

The detection of these events is bandwidth limited for best noise rejection, and is subject to detection delay time  $t_{DET}$ , as specified in the “Electrical Characteristics” section. Provided that the MICDET\_THR field has been set appropriately, each insertion or removal event will be detected within the delay time  $t_{DET}$ .

It is likely that the microphone socket contacts will have mechanical “bounce” when a microphone is inserted or removed, and hence the resultant control signal will not be a clean logic level transition. Since  $t_{DET}$  has a range of values, it is possible that the interrupt will be generated before the mechanical “bounce” has ceased. Hence after a mic insertion or removal has been detected, a time delay should be applied before re-configuring the MICD\_IRQ\_POL bit. The maximum possible mechanical bounce times for mic insertion and removal must be understood by the software programmer.

Utilising a GPIO pin to monitor the steady state of the microphone detection function does not change the timing of the detection mechanism, so there will also be a delay  $t_{DET}$  before the signal changes state. It may be desirable to implement de-bounce in the host processor when monitoring the state of the GPIO signal.

Microphone hook switch operation is detected when the MICBIAS current exceeds the Short Circuit Detect threshold set by MICSHORT\_THR. Using the digital filtering, the hook switch detection event is only signalled if the MICSHORT\_THR threshold condition has been met for 10 consecutive measurements.

When the MICSCD\_IRQ\_POL interrupt polarity bit is set to 0, then hook switch operation will cause the MICSCD\_EINT interrupt status register to be set. (See “Interrupts” for details of these register bits.)

For detection of microphone removal, the MICSCD\_IRQ\_POL bit should be set to 1. When the MICSCD\_IRQ\_POL interrupt polarity bit is set to 1, then hook switch release will cause the MICSCD\_EINT interrupt status register to be set.

The hook switch detection measurement frequency and the detection delay time  $t_{SHORT}$  are detailed in the “Electrical Characteristics” section.

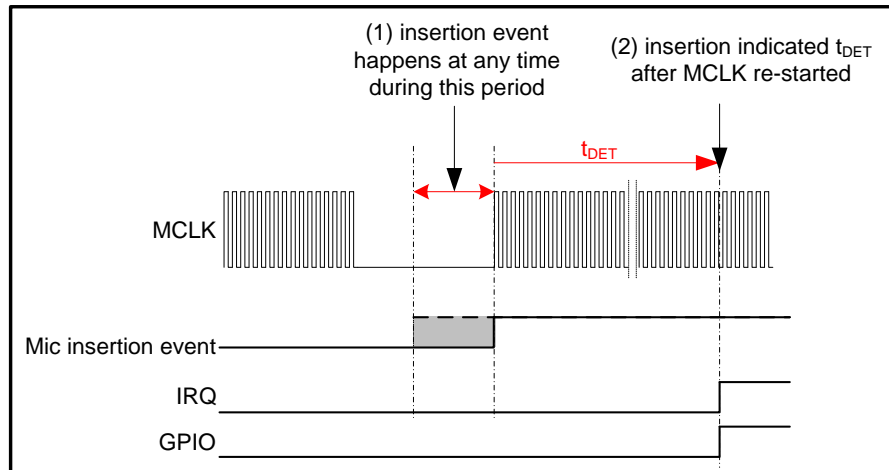
The WM8962B Interrupt function is described in the “Interrupts” section. Example control sequences for configuring the Interrupts functions for MICBIAS current detection events are described in the “Applications Information” section.

A clock is required for the digital filtering function. This requires:

- MCLK is present or the FLL is selected as the SYSCLK source in free-running mode
- SYSCLK\_ENA = 1

Any MICBIAS Current Detect event (accessory insertion/removal or hookswitch press/release) which happens while one or more of the clocking criteria is not satisfied (for example during a low power mode where the CPU has disabled MCLK) will still be detected, but only after the clocking conditions are met. An example is illustrated in Figure 16, where the mic is inserted while MCLK is stopped.

Note that the interrupts and digital filtering can be supported in the absence of an external clock by using the FLL in free-running mode and selecting the FLL as the clock source, as described in “Clocking and Sample Rates”.



**Figure 16 MICBIAS Detection Events without MCLK**

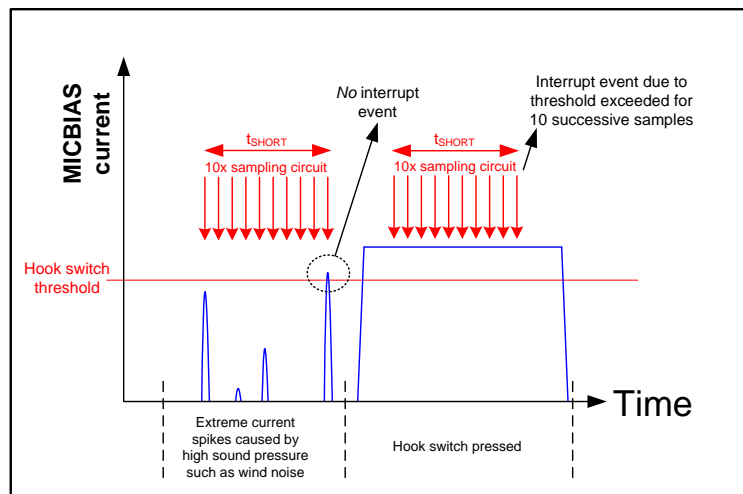
### MICROPHONE HOOK SWITCH DETECTION

The possibility of spurious hook switch interrupts due to ambient noise conditions can be removed by detailed understanding of microphone behaviour under extremely high sound pressure levels or during mechanical shock, and by correct selection of the MICBIAS resistor value; these factors will affect the level of the MICBIAS AC current spikes.

In applications where the Current Detect threshold is close to the level of the current spikes, the probability of false detections is reduced by the digital filtering described above.

Note that the filtering algorithm provides only limited rejection of very high current spikes at frequencies less than or equal to the hook switch detect measurement frequency, or at frequencies equal to harmonics of the hook switch detect measurement frequency.

The MICBIAS Hook Switch detection filtering is illustrated in Figure 17. Example control sequences for configuring the Interrupts functions for MICBIAS current detection events are described in the “Applications Information” section.



**Figure 17 MICBIAS Hook Switch Detection Filtering**

**MULTIPLE PUSH BUTTON DETECTION**

The MICDET\_THR and MICSHORT\_THR current detection thresholds can be used to detect accessory insertion and hook switch status as described above. The WM8962B can also be configured to support multiple button detection, as illustrated in Figure 18.

Multiple push button detection is supported using carefully chosen resistors to distinguish one push button from another, and by using the WM8962B Analogue to Digital Converter (ADC) to measure the potential divider formed between the MICBIAS resistor and the push button resistors.

The push buttons are connected in parallel, each with a uniquely-valued series resistor. Assertion of any of the push buttons will result in a different voltage measurement, depending on which button has been pressed.

The resistor values must be carefully selected to ensure that each push button can be reliably and uniquely recognised. It must also be ensured that the DC connection (to pin IN4L as illustrated in Figure 18) does not exceed the maximum input voltage for that pin. Note that the MICBIAS voltage may need to be reduced as a result.

In order to meet the maximum input voltage limit described above, it is required that MICBIAS\_EVR=00 under the circuit configuration shown.

Note that the IN1L and IN4L input paths should not be enabled simultaneously as inputs to the PGA. As a result, it should be noted that the microphone/line audio input path to the PGA cannot be supported at the same time as DC measurement via the same PGA.

In a typical application, the MICBIAS short circuit detect feature should be used to detect a push button operation in the first instance. When this event has been detected, then IN1L should be disabled, and IN4L should then be enabled to allow the ADC measurement to determine which button has been pressed.

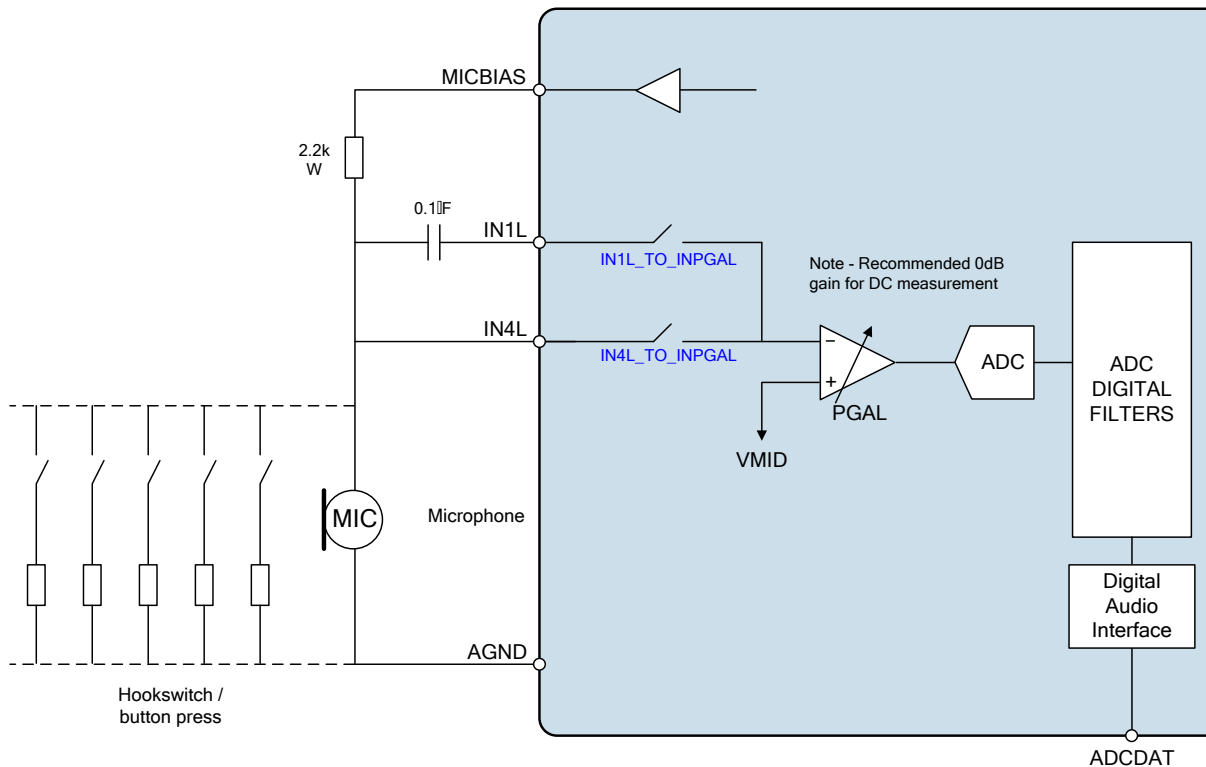
The push button detection mechanism described here can be implemented using the IN4L pin or the IN4R pin. It is not recommended to use any other input pin for push button detection.

When using the DC voltage measurement function, the IN4 pins must be configured using the register sequence described in Table 4, in order to disconnect these pins from the internal voltage reference.

| REGISTER ADDRESS | VALUE |
|------------------|-------|
| FDh              | 0001h |
| CCh              | 0040h |
| FDh              | 0000h |

**Table 4 Input Pins IN4L and IN4R Configuration for Push Button Detection**

When using the ADC to perform DC voltage measurement for push button detection, the ADC High Pass Filter must be disabled. See “ADC Signal Path Enhancements” for details of the ADC\_HPF\_DIS register bit to control this filter. It is recommended to set the PGA gain to 0dB for DC measurement.



**Figure 18 Multiple Hook Switch Detection**

### INPUT PGA ENABLE

The WM8962B has two input PGAs (Programmable Gain Amplifiers), which provide adjustable gain on the applicable input signal paths.

The input PGAs are enabled using register bits INL\_ENA, INR\_ENA, INPGAR\_ENA and INPGAL\_ENA, as described in Table 5.

| REGISTER ADDRESS                     | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                                |
|--------------------------------------|-----|------------|---------|----------------------------------------------------------------------------------------------------------------------------|
| R25 (19h)<br>Pwr Mgmt (1)            | 5   | INL_ENA    | 0       | Left Input PGA and Mixer Enable.<br>0 = Disabled<br>1 = Enabled                                                            |
|                                      | 4   | INR_ENA    | 0       | Right Input PGA and Mixer Enable.<br>0 = Disabled<br>1 = Enabled                                                           |
| R37 (25h)<br>Left Input PGA Control  | 4   | INPGAL_ENA | 0       | Left Input PGA Enable<br>0 = Disabled<br>1 = Enabled<br>Note that the Left Input PGA is also enabled when INL_ENA is set   |
| R38 (26h)<br>Right Input PGA Control | 4   | INPGAR_ENA | 0       | Right Input PGA Enable<br>0 = Disabled<br>1 = Enabled<br>Note that the Right Input PGA is also enabled when INR_ENA is set |

**Table 5 Input PGA Enable**

To enable the input PGAs, the reference voltage VMID and the bias current must also be enabled. See "Reference Voltages and Bias Control" for details of the associated controls VMID\_SEL and BIAS\_ENA.

**INPUT PGA CONFIGURATION**

Each of the PGAs operates in a single-ended mode. Configuration of the PGA inputs to the WM8962B input pins is controlled using the register bits shown in Table 6.

The maximum available attenuation on any of these input paths is achieved by using register bits shown in Table 6 to disconnect the input pins from the applicable PGA.

| REGISTER ADDRESS                        | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                      |
|-----------------------------------------|-----|--------------------|---------|----------------------------------------------------------------------------------|
| R37 (25h)<br>Left input<br>PGA control  | 3   | IN1L_TO_INPGAL     | 1       | Selects the IN1L pin as an input to the Left PGA<br>0 = Disabled<br>1 = Enabled  |
|                                         | 2   | IN2L_TO_INPGAL     | 0       | Selects the IN2L pin as an input to the Left PGA<br>0 = Disabled<br>1 = Enabled  |
|                                         | 1   | IN3L_TO_INPGAL     | 0       | Selects the IN3L pin as an input to the Left PGA<br>0 = Disabled<br>1 = Enabled  |
|                                         | 0   | IN4L_TO_INPGAL     | 0       | Selects the IN4L pin as an input to the Left PGA<br>0 = Disabled<br>1 = Enabled  |
| R38 (26h)<br>Right input<br>PGA control | 3   | IN1R_TO_INPGA<br>R | 1       | Selects the IN1R pin as an input to the Right PGA<br>0 = Disabled<br>1 = Enabled |
|                                         | 2   | IN2R_TO_INPGA<br>R | 0       | Selects the IN2R pin as an input to the Right PGA<br>0 = Disabled<br>1 = Enabled |
|                                         | 1   | IN3R_TO_INPGA<br>R | 0       | Selects the IN3R pin as an input to the Right PGA<br>0 = Disabled<br>1 = Enabled |
|                                         | 0   | IN4R_TO_INPGA<br>R | 0       | Selects the IN4R pin as an input to the Right PGA<br>0 = Disabled<br>1 = Enabled |

**Table 6 Input PGA Configuration**

**INPUT PGA VOLUME CONTROL**

Each of the two Input PGAs has an independently controlled gain range of -23.25dB to +24dB in 0.75dB steps. Each Input PGA can be independently muted using the PGA mute bits as described in Table 7, with maximum mute attenuation achieved by simultaneously disabling the corresponding inputs described in Table 6.

To prevent "zipper noise", a zero-cross function is provided on the input paths. When this feature is enabled, volume updates will not take place until a zero-crossing is detected. In the case of a long period without zero-crossings, a timeout function is provided. When the zero-cross function is enabled, the volume will update after the timeout period if no earlier zero-cross has occurred. The timeout clock is enabled using TOCLK\_ENA, the timeout period is set by TOCLK\_DIV. See "Clocking and Sample Rates" for more information on these fields.

The IN\_VU bits control the loading of the input PGA volume data and the PGA mute functions. When IN\_VU is set to 0, the PGA volume data will be loaded into the respective control register, but will not actually change the gain setting. The INL and INR volume settings are both updated when a 1 is written to either IN\_VU bit. Similarly, the INPGAL\_MUTE and INPGAR\_MUTE settings are only effective when a 1 is written to either IN\_VU bit. This makes it possible to update the gain/mute of the left and right signal paths simultaneously.

Note that the Input PGA control has a dependency on the correct sequencing of the ALC and ADC Enable control registers; if the correct sequences are not followed, then the Input PGA gain settings may become fixed. See "Automatic Level Control (ALC)" for further details.

The Input PGA Volume Control register fields are described in Table 7 and Table 8.

| REGISTER ADDRESS              | BIT | LABEL         | DEFAULT       | DESCRIPTION                                                                                                                                  |
|-------------------------------|-----|---------------|---------------|----------------------------------------------------------------------------------------------------------------------------------------------|
| R0 (0h)<br>Left input volume  | 8   | IN_VU         | N/A           | Input PGA Volume and Mute Update<br>Writing a 1 to this bit will cause the INL and INR volume and mute settings to be updated simultaneously |
|                               | 7   | INPGAL_MUTE   | 1             | Left input PGA Mute<br>0 = Unmuted<br>1 = Muted                                                                                              |
|                               | 6   | INL_ZC        | 0             | INL PGA Zero Cross Detector<br>0 = Change gain immediately<br>1 = Change gain on zero cross only                                             |
|                               | 5:0 | INL_VOL [5:0] | 011111 (0dB)  | Left input PGA Volume<br>-23.25dB to +24.00dB in 0.75dB steps.<br>See Table 8 for volume range.                                              |
| R1 (1h)<br>Right input volume | 8   | IN_VU         | N/A           | Input PGA Volume and Mute Update<br>Writing a 1 to this bit will cause the INL and INR volume and mute settings to be updated simultaneously |
|                               | 7   | INPGAR_MUTE   | 1             | Right input PGA Mute<br>0 = Unmuted<br>1 = Muted                                                                                             |
|                               | 6   | INR_ZC        | 0             | INR PGA Zero Cross Detector<br>0 = Change gain immediately<br>1 = Change gain on zero cross only                                             |
|                               | 5:0 | INR_VOL [5:0] | 01_1111 (0dB) | Right input PGA Volume<br>-23.25dB to +24.00dB in 0.75dB steps.<br>See Table 8 for volume range.                                             |

**Table 7 Input PGA Volume Control**

| INL_VOL[5:0], INR_VOL[5:0] | VOLUME (dB) | INL_VOL[5:0], INR_VOL[5:0] | VOLUME (dB) |
|----------------------------|-------------|----------------------------|-------------|
| 00_0000                    | -23.25      | 10_0000                    | 0.75        |
| 00_0001                    | -22.50      | 10_0001                    | 1.50        |
| 00_0010                    | -21.75      | 10_0010                    | 2.25        |
| 00_0011                    | -21.00      | 10_0011                    | 3.00        |
| 00_0100                    | -20.25      | 10_0100                    | 3.75        |
| 00_0101                    | -19.50      | 10_0101                    | 4.50        |
| 00_0110                    | -18.75      | 10_0110                    | 5.25        |
| 00_0111                    | -18.00      | 10_0111                    | 6.00        |
| 00_1000                    | -17.25      | 10_1000                    | 6.75        |
| 00_1001                    | -16.50      | 10_1001                    | 7.50        |
| 00_1010                    | -15.75      | 10_1010                    | 8.25        |
| 00_1011                    | -15.00      | 10_1011                    | 9.00        |
| 00_1100                    | -14.25      | 10_1100                    | 9.75        |
| 00_1101                    | -13.50      | 10_1101                    | 10.50       |
| 00_1110                    | -12.75      | 10_1110                    | 11.25       |
| 00_1111                    | -12.00      | 10_1111                    | 12.00       |
| 01_0000                    | -11.25      | 11_0000                    | 12.75       |
| 01_0001                    | -10.50      | 11_0001                    | 13.50       |
| 01_0010                    | -9.75       | 11_0010                    | 14.25       |
| 01_0011                    | -9.00       | 11_0011                    | 15.00       |
| 01_0100                    | -8.25       | 11_0100                    | 15.75       |
| 01_0101                    | -7.50       | 11_0101                    | 16.50       |
| 01_0110                    | -6.75       | 11_0110                    | 17.25       |
| 01_0111                    | -6.00       | 11_0111                    | 18.00       |
| 01_1000                    | -5.25       | 11_1000                    | 18.75       |
| 01_1001                    | -4.50       | 11_1001                    | 19.50       |
| 01_1010                    | -3.75       | 11_1010                    | 20.25       |
| 01_1011                    | -3.00       | 11_1011                    | 21.00       |
| 01_1100                    | -2.25       | 11_1100                    | 21.75       |
| 01_1101                    | -1.50       | 11_1101                    | 22.50       |
| 01_1110                    | -0.75       | 11_1110                    | 23.25       |
| 01_1111                    | 0.00        | 11_1111                    | 24.00       |

**Table 8 Input PGA Volume Range**



**INPUT MIXER ENABLE**

The WM8962B has two analogue input mixers, which provide mixing and signal boost functions for the analogue input paths.

The input mixers MIXINL and MIXINR are enabled by the MIXINL\_ENA and MIXINR\_ENA register bits, as described in Table 9. Note that the input mixers can also be controlled by INL\_ENA and INR\_ENA, as described in Table 5.

| REGISTER ADDRESS                     | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                                    |
|--------------------------------------|-----|------------|---------|--------------------------------------------------------------------------------------------------------------------------------|
| R31 (1Fh)<br>Input mixer control (1) | 1   | MIXINL_ENA | 0       | Left Input Mixer Enable<br>0 = Disabled<br>1 = Enabled<br>Note that the Left Input Mixer is also enabled when INL_ENA is set   |
|                                      | 0   | MIXINR_ENA | 0       | Right Input Mixer Enable<br>0 = Disabled<br>1 = Enabled<br>Note that the Right Input Mixer is also enabled when INR_ENA is set |

**Table 9 Input Mixer Enable**

**INPUT MIXER CONFIGURATION AND VOLUME CONTROL**

The analogue input mixers MIXINL and MIXINR can be configured to take input from the input PGAs and also directly from the IN2 and IN3 inputs pins.

The Input Boost Mixer configuration and volume controls are described in Table 10 for the Left input boost-mixer (MIXINL) and Table 11 for the Right input boost-mixer (MIXINR).

Note that the available mixer gain settings for the IN2 and IN3 paths are different to the input PGA signal paths. The IN2 and IN3 signal paths can be controlled from -12dB to +6dB. The input PGA signal paths can be controlled from 0dB to +29dB.

To prevent pop noise, it is recommended that gain and mute controls for the input boost mixers are not modified while the signal paths are active. If volume control is required on these signal paths, it is recommended that this is implemented using the input PGA volume controls or the ADC volume controls. The ADC volume controls are described in the "Analogue To Digital Converter (ADC)" section.

| REGISTER ADDRESS                     | BIT | LABEL                 | DEFAULT | DESCRIPTION                                                                                                                                                     |
|--------------------------------------|-----|-----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R31 (1Fh)<br>Input mixer control (1) | 3   | MIXINL_MUTE           | 0       | Left input boost-mixer mute<br>0 = Un-mute<br>1 = Mute                                                                                                          |
| R32 (20h)<br>Left input mixer volume | 8:6 | IN2L_MIXINL_VOL [2:0] | 101     | Left input IN2L to Left input Boost-Mixer Gain<br>000 = -12dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |

| REGISTER ADDRESS                     | BIT | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                        |
|--------------------------------------|-----|-------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                      | 5:3 | INPGAL_MIXINL_VOL [2:0] | 000     | Left input PGA to Left input Boost-Mixer Gain<br>000 = 0dB<br>001 = +6dB<br>010 = +13dB<br>011 = +18dB<br>100 = +20dB<br>101 = +24dB<br>110 = +27dB<br>111 = +29dB |
|                                      | 2:0 | IN3L_MIXINL_VOL [2:0]   | 101     | Left input IN3L to Left input Boost-Mixer Gain<br>000 = -12dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB    |
| R34 (22h)<br>Input mixer control (2) | 5   | IN2L_TO_MIXINL          | 0       | Left Input IN2L to Left input Boost-Mixer Select<br>0 = Disabled<br>1 = Enabled                                                                                    |
|                                      | 4   | IN3L_TO_MIXINL          | 0       | Left Input IN3L to Left input Boost-Mixer Select<br>0 = Disabled<br>1 = Enabled                                                                                    |
|                                      | 3   | INPGAL_TO_MIXINL        | 1       | Left Input PGA to Left input Boost-Mixer Select<br>0 = Disabled<br>1 = Enabled                                                                                     |

**Table 10 Left Input Mixer (MIXINL) Volume Control**

| REGISTER ADDRESS                      | BIT | LABEL                 | DEFAULT | DESCRIPTION                                                                                                                                                       |
|---------------------------------------|-----|-----------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R31 (1Fh)<br>Input mixer control (1)  | 2   | MIXINR_MUTE           | 0       | Right input boost-mixer mute<br>0 = Un-mute<br>1 = Mute                                                                                                           |
| R33 (21h)<br>Right input mixer volume | 8:6 | IN2R_MIXINR_VOL [2:0] | 101     | Right input IN2R to Right input Boost-Mixer Gain<br>000 = -12dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |

| REGISTER ADDRESS                     | BIT | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                          |
|--------------------------------------|-----|-------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                      | 5:3 | INPGAR_MIXINR_VOL [2:0] | 000     | Right input PGA to Right input Boost-Mixer Gain<br>000 = 0dB<br>001 = +6dB<br>010 = +13dB<br>011 = +18dB<br>100 = +20dB<br>101 = +24dB<br>110 = +27dB<br>111 = +29dB |
|                                      | 2:0 | IN3R_MIXINR_VOL [2:0]   | 101     | Right input IN3R to Right input Boost-Mixer Gain<br>000 = -12dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB    |
| R34 (22h)<br>Input mixer control (2) | 2   | IN2R_TO_MIXINR          | 0       | Right input IN2R to Right input Boost-Mixer Select<br>0 = Disabled<br>1 = Enabled                                                                                    |
|                                      | 1   | IN3R_TO_MIXINR          | 0       | Right input IN3R to Right input Boost-Mixer Select<br>0 = Disabled<br>1 = Enabled                                                                                    |
|                                      | 0   | INPGAR_TO_MIXINR        | 1       | Right input PGA to Right input Boost-Mixer Select<br>0 = Disabled<br>1 = Enabled                                                                                     |

**Table 11 Right Input Mixer (MIXINR) Volume Control**

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## AUTOMATIC LEVEL CONTROL (ALC)

The WM8962B has an automatic PGA gain control circuit that keeps a constant recording volume irrespective of the input signal level. This is achieved by continuously adjusting the input PGA gain so that the signal level at the ADC input remains constant.

A digital peak detector monitors the ADC output and changes the PGA gain if necessary.

The ALC has two modes selected by the ALC\_MODE register. See the “Limiter Mode” section for further details on the ALC Modes.

The ALC also has a Noise Gate function, which provides additional control of low level input signals. This means that the signal path is quiet when no signal is present, giving an improvement in background noise level.

The Automatic Level Control (ALC) can be enabled on either the left channel, or the right channel, or on both channels, using the ALCL\_ENA and ALCR\_ENA fields respectively. Note that the ALC (Left) function requires the Left and Right ADCs to be enabled; the ALC (Right) function only requires the Right ADC to be enabled.

Note that, when disabling the input signal path, the ALC must be disabled before the respective ADCs are disabled. If this sequence is not followed, then the Input PGA gain settings may become fixed.

The ALC should not be enabled when using the IN2 or IN3 inputs connected directly to the input boost mixer; this is because these paths will bypass the PGAs where the ALC gain adjustment is performed.

ALC can be set to Active Mode or to Monitor Mode. When ALC is in Active Mode (ALC\_INACTIVE\_ENA = 0), the gain of the analogue PGAs is controlled by the ALC bit settings, and not by the INL\_VOL or the INR\_VOL fields. When ALC is in Monitor Mode (ALC\_INACTIVE\_ENA=1), ALC monitors the signal levels without doing any of the level control that it would otherwise perform. Details on readback of the ALC status are in the “ALC Status Readback” section.

When the ALC is enabled, a target level for the analogue input signal at the ADC is determined by the ALC\_LVL setting. There are two ranges (high or low) from which the ALC\_LVL target value can be taken. The target values in each of these ranges are shown in Table 13. Two ranges can be selected using ALC\_LVL\_MODE. Set ALC\_LVL\_MODE to 0 to use the low range (-28.5dBFS to -6dBFS), or set ALC\_LVL\_MODE to 1 to use the higher range (-22.5dBFS to -1.5dBFS).

| REGISTER ADDRESS  | BIT | LABEL            | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------------|-----|------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R17 (11h)<br>ALC1 | 10  | ALC_INACTIVE_ENA | 0       | Select whether the ALC is in Active Mode (that is, ALC is controlling the PGA gain) or in Monitor Mode (the analogue controls are disabled). Note that at least one of ALCL_ENA and ALCR_ENA must also be enabled<br>0 = ALC is in Active Mode<br>1 = ALC is in Monitor Mode                                                                                                                                       |
|                   | 9   | ALC_LVL_MODE     | 0       | Select the range of the ALC target level.<br>0 = -28.5dBFS to -6dBFS in 1.5dB steps<br>1 = -22.5dBFS to -1.5dBFS in 1.5dB steps                                                                                                                                                                                                                                                                                    |
|                   | 8   | ALCL_ENA         | 0       | Select ALC on the Left channel<br>0 = Disabled (PGA gain set by INL_VOL)<br>1 = Enabled<br>Note that in stereo mode, the left and right PGA volumes, and left and right boost mixer volumes, must be the same before setting ALCL_ENA = 1 and ALCR_ENA = 1                                                                                                                                                         |
|                   | 7   | ALCR_ENA         | 0       | Select ALC on the Right channel<br>0 = Disabled (PGA gain set by INR_VOL)<br>1 = Enabled<br>Note that in stereo mode, the left and right PGA volumes, and left and right boost mixer volumes, must be the same before setting ALCL_ENA = 1 and ALCR_ENA = 1                                                                                                                                                        |
|                   | 3:0 | ALC_LVL [3:0]    | 1011    | Set the Target signal level at the ADC input.<br>Note that the target level is also determined by ALC_LVL_MODE.<br><br>ALC_LVL_MODE = 0<br>0000 = -28.5dBFS<br>0001 = -27.0dBFS<br>...in 1.5dB steps to...<br>1111 = -6dBFS<br><br>ALC_LVL_MODE = 1<br>0000 = -22.5dBFS<br>0001 = -21.0dBFS<br>...in 1.5dB steps to...<br>1110 = -1.5dBFS<br>1111 = -1.5dBFS<br><br>See Table 13 for the range of possible values. |

**Table 12 Automatic Level Control**

| ALC_LVL | ALC_LVL_MODE = 0<br>(dBFS) | ALC_LVL_MODE = 1<br>(dBFS) |
|---------|----------------------------|----------------------------|
| 0000    | -28.5                      | -22.5                      |
| 0001    | -27.0                      | -21.0                      |
| 0010    | -25.5                      | -19.5                      |
| 0011    | -24.0                      | -18.0                      |
| 0100    | -22.5                      | -16.5                      |
| 0101    | -21.0                      | -15.0                      |
| 0110    | -19.5                      | -13.5                      |
| 0111    | -18.0                      | -12.0                      |
| 1000    | -16.5                      | -10.5                      |
| 1001    | -15.0                      | -9.0                       |
| 1010    | -13.5                      | -7.5                       |
| 1011    | -12.0                      | -6.0                       |
| 1100    | -10.5                      | -4.5                       |
| 1101    | -9.0                       | -3.0                       |
| 1110    | -7.5                       | -1.5                       |
| 1111    | -6.0                       | -1.5                       |

**Table 13 ALC Target Level Values**
**LIMITER MODE**

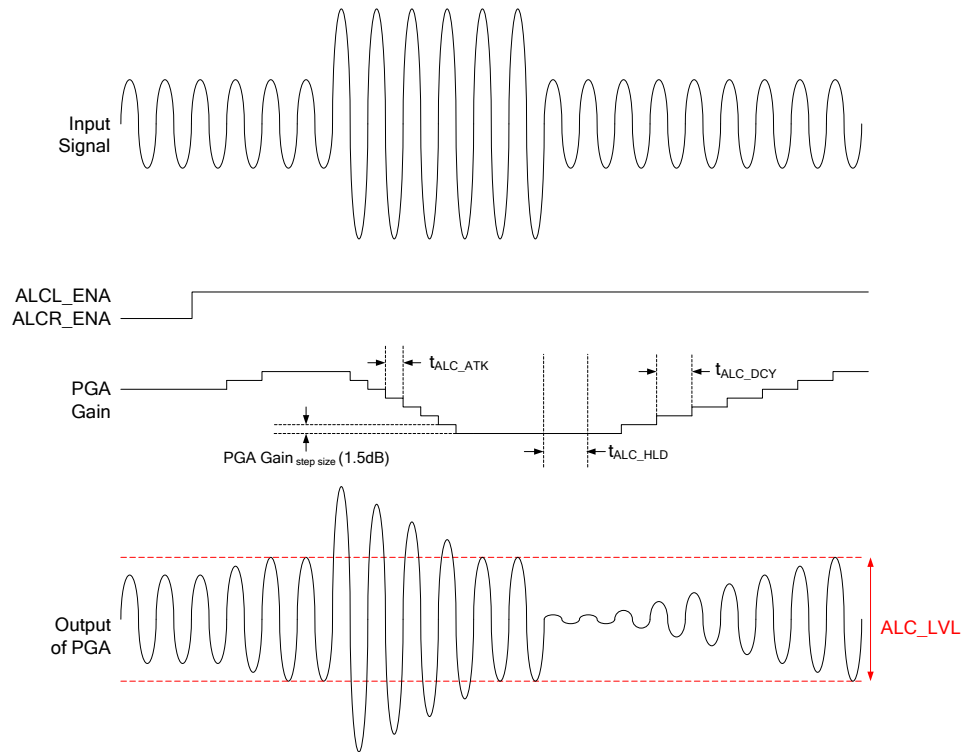
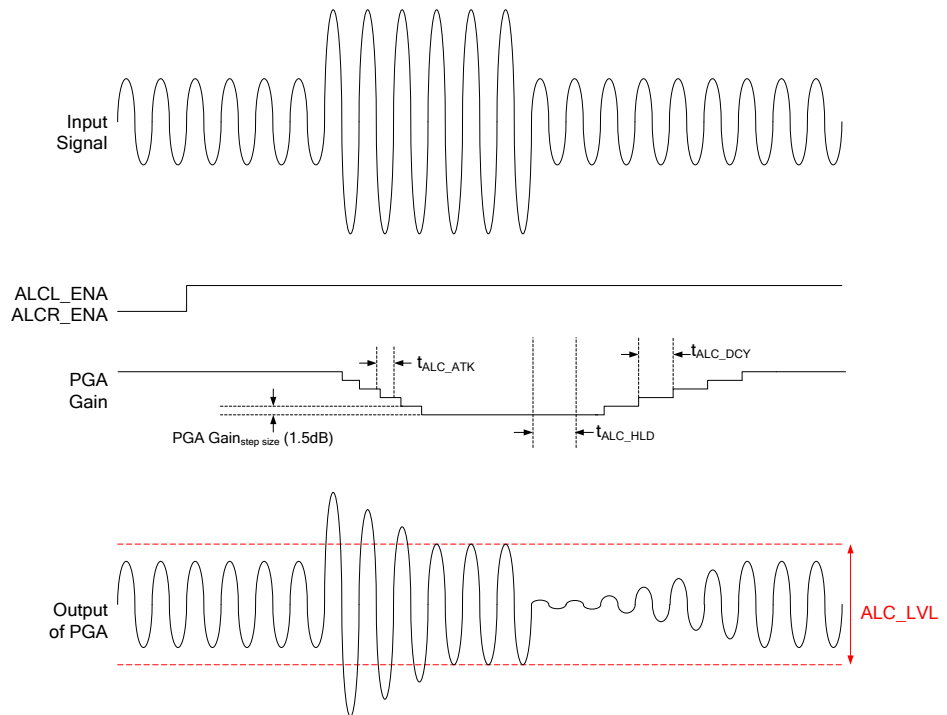
In Normal Mode (ALC\_MODE = 0), the ALC will attempt to maintain a constant signal level by increasing or decreasing the gain of the PGA. This is illustrated in Figure 19.

In Limiter Mode (ALC\_MODE = 1), the ALC will reduce peaks that go above the threshold level, but will not increase the PGA gain beyond the starting level. (The starting level is defined as the gain setting of the PGA at the time when the ALC is enabled.) This is illustrated in Figure 20.

Note that ALC\_MODE should not be changed while the ALC is active. ALCL\_ENA and ALCR\_ENA must both be set to 0 before changing ALC\_MODE.

| REGISTER ADDRESS  | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                                       |
|-------------------|-----|----------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R19 (13h)<br>ALC3 | 8   | ALC_MODE | 0       | ALC Mode<br>0 = Normal ALC Mode<br>1 = Limiter Mode<br>Note that ALCL_ENA and ALCR_ENA must both be set to 0 before changing ALC_MODE, otherwise unexpected behaviour may result. |

**Table 14 ALC Mode Switch (ALC\_MODE)**


**Figure 19 ALC Normal Mode Operation**

**Figure 20 ALC Limiter Mode Operation**

**ALC GAIN CONTROL**

The minimum and maximum gain applied by the ALC is set by register fields ALC\_MINGAIN and ALC\_MAXGAIN respectively. These limits can be used to alter the ALC response from that illustrated in Figure 19 and Figure 20. If the range between maximum and minimum gain is reduced, then the extent of the automatic level control is reduced.

Note that, when the ALC is first enabled, the PGA gain (in dB) must be less than the ALC\_MAXGAIN setting. The PGA gain is controlled by the INL\_VOL and INR\_VOL registers, as described in Table 7.

The minimum gain in the ALC response is set by ALC\_MINGAIN. The minimum gain limit can be used to prevent excessive attenuation of the signal path.

The maximum gain limit set by ALC\_MAXGAIN can be used to prevent quiet signals (or silence) from being excessively amplified. Note that the Noise Gate function also affects quiet signals. See the “ALC Noise Gate” section (below) for further details on the Noise Gate.

To prevent “zipper noise”, a zero-cross function is provided within the ALC. When this feature is enabled, volume updates will not take place until a zero-crossing is detected. In the case of a long period without zero-crossings, a timeout function is provided. When the zero-cross function is enabled, the volume will update after the timeout period if no earlier zero-cross has occurred. The timeout clock is enabled using TOCLK\_ENA. See “Clocking and Sample Rates” for the definition of this bit. Note that the zero-cross function can be supported without TOCLK enabled, but the timeout function will not be provided in this case.

When operating in stereo, the peak detector takes the maximum of left and right channel peak values, and any new gain setting is applied equally to both left and right PGAs so that the stereo image is preserved. The input PGA and Input Mixer gain settings should be identical when entering ALC stereo mode in order for gain updates to be applied correctly.

The ALC function can also be enabled on one channel only. In this case, only one PGA is controlled by the ALC mechanism, while the other channel runs independently with its PGA gain set through the control register.

When one ALC channel is unused, the peak detector disregards that channel.

| REGISTER ADDRESS  | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                   |
|-------------------|-----|----------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R17 (11h)<br>ALC1 | 6:4 | ALC_MAXGAIN<br>[3:0] | 111     | Maximum ALC gain<br>000 = -18dB<br>001 = -12dB<br>010 = -6dB<br>011 = 0dB<br>100 = +6dB<br>101 = +12dB<br>110 = +18dB<br>111 = +24dB                          |
| R18 (12h)<br>ALC2 | 7   | ALC_ZC               | 0       | ALC Zero Cross Detector<br>0 = Change gain immediately<br>1 = Change gain on zero cross only                                                                  |
|                   | 6:4 | ALC_MINGAIN<br>[3:0] | 000     | Minimum ALC gain<br>000 = -23.25dB<br>001 = -17.25dB<br>010 = -11.25dB<br>011 = -5.25dB<br>100 = +0.75dB<br>101 = +6.75dB<br>110 = +12.75dB<br>111 = +18.75dB |

**Table 15 ALC Gain Limits**



**ALC DYNAMIC CHARACTERISTICS**

The dynamic behaviour determines how quickly the ALC responds to changing signal levels. Note that the ALC responds to the average (RMS) signal amplitude over a period of time.

The ALC\_HLD field selects a delay between the detection of a peak signal level that is below the ALC target level, and the start of the PGA gain ramping up. ALC\_HLD can be set to any of the times shown in Table 16. ALC\_HLD only affects the gain ramp-up on a low level signal. There is no delay in ramping the gain down when the signal level is above the target level. Note that it is only the start of the gain ramp-up that is affected by the ALC\_HLD setting; once the ramp-up has started, it proceeds at the pace dictated by the ALC\_DCY setting.

The ALC\_DCY field determines how quickly the ALC gain increases when the signal amplitude is low. The times specified are for the time taken per step of applied gain. The actual time taken for the recording level to return to its target level therefore depends on both the decay rate and the gain adjustment required. If the required gain change is small, then the total decay time will be shorter than when a larger gain change is required.

The ALC\_ATK field determines how quickly the ALC gain decreases when the signal amplitude is high. The times specified are for the time taken per step of applied attenuation. The actual time taken for the recording level to return to its target level therefore depends on both the attack rate and the gain adjustment required. If the required gain change is small, then the total decay time will be shorter than when a larger gain change is required.

These register fields are described in Table 16.

The SAMPLE\_RATE register field must be set correctly to ensure that the ALC attack, decay and hold times are correct for the chosen sample rate. See the "Clocking and Sample Rates" section for further details of this register.

| REGISTER ADDRESS  | BIT | LABEL         | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                         |
|-------------------|-----|---------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R18 (12h)<br>ALC2 | 3:0 | ALC_HLD [3:0] | 0000    | ALC Hold time before the gain ramp-up starts<br>0000 = 0.00ms<br>0001 = 2.67ms<br>0010 = 5.33ms<br>0011 = 10.7ms<br>0100 = 21.3ms<br>0101 = 42.7ms<br>0110 = 85.3ms<br>0111 = 171ms<br>1000 = 341ms<br>1001 = 683ms<br>1010 = 1.37s<br>1011 = 2.73s<br>1100 = 5.46s<br>1101 = 10.9s<br>1110 = 21.8s<br>1111 = 43.7s |

| REGISTER ADDRESS  | BIT | LABEL         | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------|-----|---------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R19 (13h)<br>ALC3 | 7:4 | ALC_DCY [3:0] | 0011    | <p>Sets the Gain Decay Rate (measured in time per 1.5dB step).<br/>If ALC_MODE = 0<br/>0000 = 0.41ms / step<br/>0001 = 0.82ms / step<br/>...doubling with each step to...<br/>1010 = 420ms / step<br/>1011 = 840ms / step<br/>1100 to 1111 = Reserved</p> <p>If ALC_MODE = 1<br/>0000 = 0.082ms / step<br/>0001 = 0.164ms / step<br/>...doubling with each step to...<br/>1010 = 83.9ms / step<br/>1011 = 168ms / step<br/>1100 to 1111 = Reserved</p> <p>Note that when 88.2kHz or 96kHz sample rate is selected, the Gain Decay time is defined as for the ALC_MODE=0 case above.<br/>See Table 17 for further details.</p> |
|                   | 3:0 | ALC_ATK [3:0] | 0010    | <p>Sets the Gain Attack Rate (measured in time per 1.5dB step).<br/>If ALC_MODE = 0<br/>0000 = 0.104ms / step<br/>0001 = 0.208ms / step<br/>...doubling with each step to...<br/>1010 = 106ms / step<br/>1011 to 1111 = Reserved</p> <p>If ALC_MODE = 1<br/>0000 = 0.020ms / step<br/>0001 = 0.041ms / step<br/>...doubling with each step to...<br/>1010 = 21.0ms / step<br/>1011 to 1111 = Reserved</p> <p>Note that when 88.2kHz or 96kHz sample rate is selected, the Gain Attack time is defined as for the ALC_MODE=0 case above.<br/>See Table 18 for further details.</p>                                             |

**Table 16 ALC Time Constants**

| ALC_DCY,<br>ALC_NGATE_DCY | ALC_MODE = 0 | ALC_MODE = 1,<br>SAMPLE_RATE ≤ 48kHz | ALC_MODE = 1,<br>SAMPLE_RATE > 48kHz |
|---------------------------|--------------|--------------------------------------|--------------------------------------|
| 0000                      | 0.41ms       | 0.082ms                              | 0.41ms                               |
| 0001                      | 0.82ms       | 0.164ms                              | 0.82ms                               |
| 0010                      | 1.64ms       | 0.328ms                              | 1.64ms                               |
| 0011                      | 3.28ms       | 0.655ms                              | 3.28ms                               |
| 0100                      | 6.56ms       | 1.31ms                               | 6.56ms                               |
| 0101                      | 13.1ms       | 2.62ms                               | 13.1ms                               |
| 0110                      | 26.2ms       | 5.24ms                               | 26.2ms                               |
| 0111                      | 52.5ms       | 10.5ms                               | 52.5ms                               |
| 1000                      | 105ms        | 21.0ms                               | 105ms                                |
| 1001                      | 210ms        | 41.9ms                               | 210ms                                |
| 1010                      | 420ms        | 83.9ms                               | 420ms                                |
| 1011                      | 840ms        | 168ms                                | 840ms                                |

**Table 17 ALC Decay Rate (Time per 1.5dB Gain Step)**

| ALC_ATK,<br>ALC_NGATE_ATK | ALC_MODE = 0 | ALC_MODE = 1,<br>SAMPLE_RATE ≤ 48kHz | ALC_MODE = 1,<br>SAMPLE_RATE > 48kHz |
|---------------------------|--------------|--------------------------------------|--------------------------------------|
| 0000                      | 0.104ms      | 0.020ms                              | 0.104ms                              |
| 0001                      | 0.208ms      | 0.041ms                              | 0.208ms                              |
| 0010                      | 0.416ms      | 0.082ms                              | 0.416ms                              |
| 0011                      | 0.832ms      | 0.164ms                              | 0.832ms                              |
| 0100                      | 1.66ms       | 0.328ms                              | 1.66ms                               |
| 0101                      | 3.33ms       | 0.655ms                              | 3.33ms                               |
| 0110                      | 6.66ms       | 1.31ms                               | 6.66ms                               |
| 0111                      | 13.3ms       | 2.62ms                               | 13.3ms                               |
| 1000                      | 26.6ms       | 5.24ms                               | 26.6ms                               |
| 1001                      | 53.2ms       | 10.5ms                               | 53.2ms                               |
| 1010                      | 106ms        | 21.0ms                               | 106ms                                |

**Table 18 ALC Attack Rate (Time per 1.5dB Gain Step)**

### PEAK LIMITER

To prevent clipping when a large signal occurs just after a period of quiet, the ALC circuit includes a limiter function. If the ADC input signal exceeds 87.5% of full scale (−1.16dBFS), the PGA gain is ramped down at the maximum attack rate (as when ALC\_ATK = 0000), until the signal level falls below 87.5% of full scale. This function is automatically enabled whenever the ALC is in Active Mode, but has no effect when ALC is in Monitor Mode.

Note that if ALC\_ATK = 0000, then the peak limiter makes no difference to the operation of the ALC; ALC\_ATK is already at 0000 and the ALC is therefore already ramping down at its maximum rate. The Peak Limiter is designed to prevent clipping when long attack times are used.

### ALC NOISE GATE

To avoid 'noise pumping' when the signal is very quiet and consists mainly of noise, the ALC function has a noise gate function. This prevents noise pumping by comparing the signal level at the input pins against a noise gate threshold, ALC\_NGATE\_THR. The noise gate cuts in when:

$$\text{Signal level at ADC [dB]} < \text{ALC\_NGATE\_THR [dB]} + \text{PGA gain [dB]} + \text{Input Mixer gain [dB]}$$

This is equivalent to:

$$\text{Signal level at input pin [dB]} < \text{ALC\_NGATE\_THR [dB]}$$

Whenever the signal level at the input pins drops below the Noise Gate Threshold (ALC\_NGATE\_THR), the ALC Noise Gate is activated in one of three modes. The Noise Gate Mode is selected by ALC\_NGATE\_MODE. As soon as the peak input signal level drops below the Noise Gate Threshold, control of the PGA gain is passed from the ALC to the Noise Gate system.

The Noise Gate modes are:

- Mode 00: The PGA Gain remains static while the input signal is below the ALC Noise Gate Threshold (ALC\_NGATE\_THR) level.

As soon as the input signal rises back above the ALC Noise Gate Threshold, PGA gain is once again controlled by the ALC.

- Mode 01: The PGA Gain is muted while the input signal is below the ALC Noise Gate Threshold (ALC\_NGATE\_THR) level. The muting of the PGA Gain is immediate (a hard mute), and is performed by setting ADCL\_VOL or ADCR\_VOL or both to zero. Note that with Mode 01, it is the ADCL\_VOL and ADCR\_VOL registers that are muted, and not the INL\_VOL and INR\_VOL registers that are changed in the other modes.

As soon as the input signal rises back above the ALC Noise Gate Threshold, ADCL\_VOL and ADCR\_VOL are restored to their previous values. Again this is immediate (a hard unmute).

- Mode 10: The PGA Gain is either ramped down to the ALC\_NGATE\_GAIN at a rate determined by ALC\_NGATE\_ATK, or ramped up to the ALC\_NGATE\_GAIN level at a rate determined by ALC\_NGATE\_DCY.

As soon as the input signal rises back above the ALC Noise Gate Threshold, PGA gain is once again controlled by the ALC. The PGA gain is ramped up (or down) at a rate determined by ALC\_DCY (or ALC\_ATK).

The noise gate control register is described in Table 19. The ALC\_NGATE\_THR variable sets the Noise Gate threshold with respect to the ADC full-scale range. The threshold is adjusted in 1.5dB steps. Levels at the extremes of the range may cause inappropriate operation, so care should be taken with set-up of the function. Note that the Noise Gate only works in conjunction with the ALC function, and always operates on the same channel(s) as the ALC (left, right, both, or none).

| REGISTER ADDRESS        | BIT   | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|-------------------------|-------|-------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R19 (13h)<br>ALC3       | 12:10 | ALC_NGATE_GAIN<br>[2:0] | 111     | Noise Gate Gain level. This is the PGA gain level used within the ALC Noise Gate function.<br>000 = -23.25dB<br>001 = -18dB<br>010 = -12dB<br>011 = -6dB<br>100 = 0dB<br>101 = +6dB<br>110 = +12dB<br>111 = +18dB                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| R20 (14h)<br>Noise Gate | 15:12 | ALC_NGATE_DCY<br>[3:0]  | 0011    | Sets the Noise Gate Gain Decay Rate (time taken to ramp up to the ALC_NGATE_GAIN level), measured in time per 1.5dB step.<br><br>If ALC_MODE = 0<br>0000 = 0.41ms / step<br>0001 = 0.82ms / step<br>...doubling with each step to...<br>1010 = 420ms / step<br>1011 = 840ms / step<br>1100 to 1111 = Reserved<br><br>If ALC_MODE = 1<br>0000 = 0.082ms / step<br>0001 = 0.164ms / step<br>...doubling with each step to...<br>1010 = 83.9ms / step<br>1011 = 168ms / step<br>1100 to 1111 = Reserved<br><br>Note that when 88.2kHz or 96kHz sample rate is selected, the Noise Gate Gain Decay time is defined as for the ALC_MODE=0 case above.<br>See Table 17 for further details. |

| REGISTER ADDRESS | BIT  | LABEL                | DEFAULT            | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|------------------|------|----------------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  | 11:8 | ALC_NGATE_ATK [3:0]  | 0010               | <p>Sets the Gain Attack Rate (time taken to ramp down to the ALC_NGATE_GAIN level), measured in time per 1.5dB step.</p> <p>If ALC_MODE = 0<br/>           0000 = 0.10ms / step<br/>           0001 = 0.21ms / step<br/>           ...doubling with each step to...<br/>           1010 = 106ms / step<br/>           1011 to 1111 = Reserved</p> <p>If ALC_MODE = 1<br/>           0000 = 0.020ms / step<br/>           0001 = 0.041ms / step<br/>           ...doubling with each step to...<br/>           1010 = 21.0ms / step<br/>           1011 to 1111 = Reserved</p> <p>Note that when 88.2kHz or 96kHz sample rate is selected, the Noise Gain Attack time is defined as for the ALC_MODE=0 case above. See Table 18 for further details.</p> |
|                  | 7:3  | ALC_NGATE_THR [4:0]  | 0_0000 (-76.5dBFS) | Noise Gate Threshold. If the input signal falls below this level, the Noise Gate function is triggered. -76.5dB to -30dB in 1.5dB steps. See Table 20 for further details.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  | 2:1  | ALC_NGATE_MODE [1:0] | 00                 | <p>Noise gate mode</p> <p>00 = Hold PGA gain static when noise gate triggers</p> <p>01 = Mute ADC output immediately when noise gate triggers.</p> <p>10 = Ramp PGA Gain to ADC_NGATE_GAIN level when Noise Gate triggers.</p> <p>11 = Reserved</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                  | 0    | ALC_NGATE_ENA        | 0                  | Noise Gate function enable<br>0 = Disable<br>1 = Enable                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

**Table 19 ALC Noise Gate Control**

| ALC_NGATE_THR [4:0] | THRESHOLD (dBFS) |
|---------------------|------------------|
| 0_0000              | -76.5            |
| 0_0001              | -75.0            |
| 0_0010              | -73.5            |
| 0_0011              | -72.0            |
| 0_0100              | -70.5            |
| 0_0101              | -69.0            |
| 0_0110              | -67.5            |
| 0_0111              | -66.0            |
| 0_1000              | -64.5            |
| 0_1001              | -63.0            |
| 0_1010              | -61.5            |
| 0_1011              | -60.0            |
| 0_1100              | -58.5            |
| 0_1101              | -57.0            |
| 0_1110              | -55.5            |
| 0_1111              | -54.0            |
| 1_0000              | -52.5            |
| 1_0001              | -51.0            |
| 1_0010              | -49.5            |
| 1_0011              | -48.0            |
| 1_0100              | -46.5            |
| 1_0101              | -45.0            |
| 1_0110              | -43.5            |
| 1_0111              | -42.0            |
| 1_1000              | -40.5            |
| 1_1001              | -39.0            |
| 1_1010              | -37.5            |
| 1_1011              | -36.0            |
| 1_1100              | -34.5            |
| 1_1101              | -33.0            |
| 1_1110              | -31.5            |
| 1_1111              | -30.0            |

**Table 20 ALC Noise Gate Threshold (ALC\_NGATE\_THR) Settings**

**ALC STATUS READBACK**

There are five ALC status registers that provide monitoring of the Automatic Level Control (ALC). These are particularly useful when ALC is in Monitor Mode (ALC\_INACTIVE\_ENA = 1), and the PGA Gains are not being changed by the ALC.

These five Register bits and their settings are summarised in Table 21.

| REGISTER ADDRESS  | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                                          |
|-------------------|-----|----------------|---------|--------------------------------------------------------------------------------------------------------------------------------------|
| R18 (12h)<br>ALC2 | 15  | ALC_LOCK_STS   | 0       | Readback of the ALC Lock Status. Set when ADC signal = ALC_LVL                                                                       |
|                   | 14  | ALC_THRESH_STS | 0       | Readback of the ALC Threshold Level status (when ALC_LOCK_STS = 0)<br>0 = ADC signal < ALC_LVL<br>1 = ADC signal > ALC_LVL           |
|                   | 13  | ALC_SAT_STS    | 0       | Readback of the ALC saturation status.<br>0 = ADC signal = ALC_LVL<br>1 = ADC signal < ALC_LVL but maximum ALC Gain has been reached |
|                   | 12  | ALC_PKOVR_STS  | 0       | Readback of the ALC Peak Limiter Overload status. Set when ADC input signal exceeds -1.16dBFS                                        |
|                   | 11  | ALC_NGATE_STS  | 0       | Readback of the ALC Noise Gate status.<br>0 = ADC input signal level > ALC_NGATE_THR<br>1 = ADC input signal level < ALC_NGATE_THR   |

**Table 21 ALC Status Readback**



## DIGITAL MICROPHONE INTERFACE

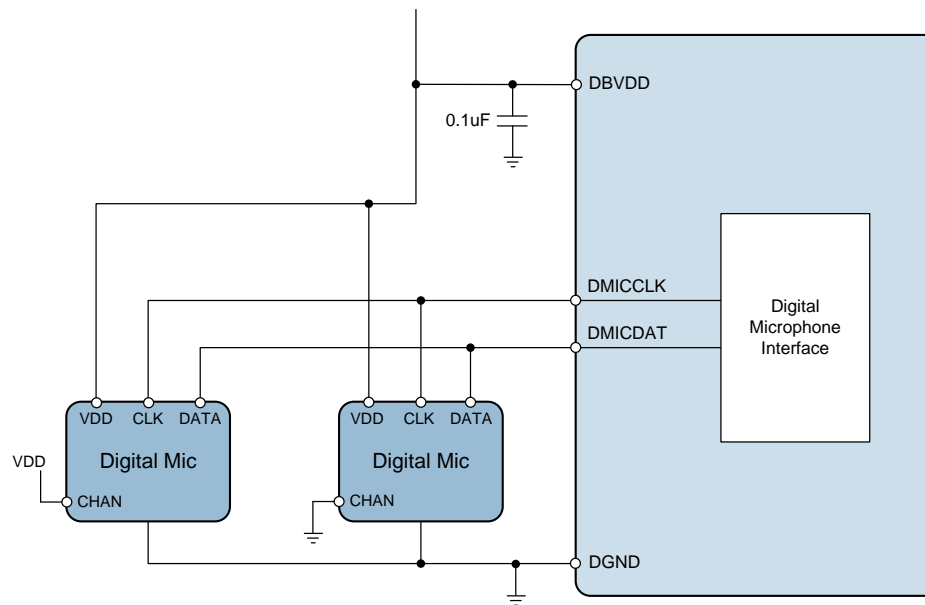
The WM8962B supports a stereo digital microphone interface. Two channels of audio data are multiplexed on a GPIO pin configured for digital microphone input.

The digital microphone data input (DMICDAT) is provided on GPIO5 or GPIO6 by setting the respective GPN\_FN register to 1\_0100. The associated clock (DMICCLK) is provided on a separate GPIO pin by setting the respective GPN\_FN register to 1\_0011. See “General Purpose Input/Output (GPIO)” section for details on these registers.

Note that care must be taken to ensure that the respective digital logic levels of the microphone are compatible with the digital input thresholds of the WM8962B. The digital input thresholds are referenced to DBVDD, as defined in “Electrical Characteristics”. It is recommended to power the digital microphones from DBVDD.

When digital microphone input is enabled, the WM8962B outputs a clock signal (DMICCLK) on the Digital Microphone Clock Output pin (this must be configured on one of the GPIO pins). The clock frequency for all supported digital microphone clocking modes is described later in this section.

A pair of digital microphones is connected as illustrated in Figure 21. The microphones must be configured to ensure that the Left mic transmits a data bit when DMICCLK is high, and the Right mic transmits a data bit when DMICCLK is low. The WM8962B samples the digital microphone data at the end of each DMICCLK phase. Each microphone must tri-state its data output when the other microphone is transmitting.

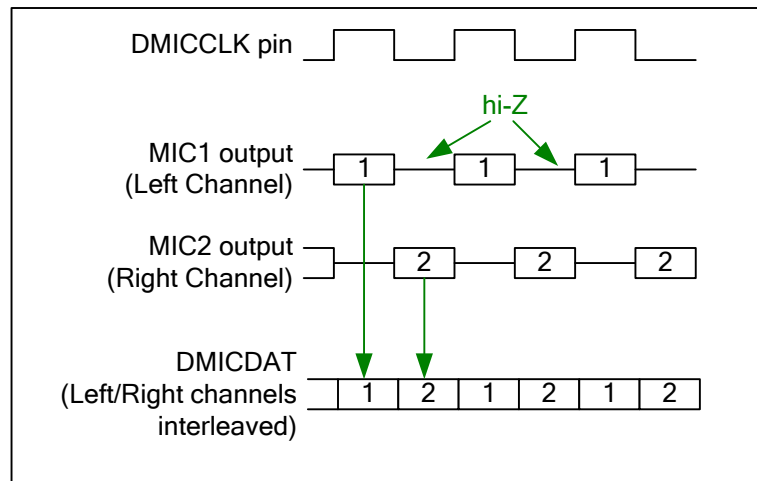


DMICCLK is available on GPIO2, GPIO3, GPIO5 and GPIO6  
DMICDAT is supported on GPIO5 and GPIO6

**Figure 21 Digital Microphone Input**

The digital microphone signal paths are enabled using the DMIC\_ENA register. When DMIC\_ENA is set, the ADC path is disconnected and the digital microphone data is routed to the digital core, as illustrated in “Digital Mixing”.

Two microphone channels are interleaved on DMICDAT; the timing is illustrated in Figure 22. Each microphone must tri-state its data output when the other microphone is transmitting.



**Figure 22 Digital Microphone Interface Timing**

The digital microphone interface control fields are described in Table 22. Note that the ADC and Record Path filters must be enabled and the sample rate must be set in order to ensure correct operation of all DSP functions associated with the digital microphone. Volume control for the Digital Microphone Interface signals is provided using the ADC Volume Control.

See “Analogue To Digital Converter (ADC)” for details of the ADC Enable and ADC digital volume control functions. See “General Purpose Input/Output (GPIO)” for details of configuring the DMICCLK and DMICDAT functions. See “Clocking and Sample Rates” for details of the sample rate control.

| REGISTER ADDRESS          | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                      |
|---------------------------|-----|----------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R25 (19h)<br>Pwr Mgmt (1) | 10  | DMIC_ENA | 0       | Enables Digital Microphone mode.<br>0 = Audio DSP input is from ADC<br>1 = Audio DSP input is from digital microphone interface<br><br>Note that, when the digital microphone interface is selected, the ADCL_ENA and ADCR_ENA registers must also be set to enable the left and right digital microphone channels respectively. |
|                           | 3   | ADCL_ENA | 0       | Left ADC Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                                                   |
|                           | 2   | ADCR_ENA | 0       | Right ADC Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                                                  |

**Table 22 Digital Microphone Interface Control**

Note that, in addition to setting the DMIC\_ENA bit as described in Table 22, the pins GPIO2, GPIO3, GPIO5 or GPIO6 must also be configured to provide the digital microphone interface function. See “General Purpose Input/Output (GPIO)” for details.

Clocking for the digital microphone interface is derived from SYSCLK. The DMICCLK frequency is configured automatically, according to the SAMPLE\_RATE, MCLK\_RATE, and ADC\_HP registers. (See “Clocking and Sample Rates” for further details of the system clocks and control registers.)

The DMICCLK is enabled whenever a digital microphone input path is enabled on the GPIO2 or GPIO3 pins. Note that the SYSCLK\_ENA register must also be set.

The DMICCLK frequency is as described in Table 23 (for ADC\_HP=0) and Table 24 (for ADC\_HP=1). The ADC\_HP bit is set to 0 by default, giving reduced power consumption. Note that the only valid DMICCLK configurations are the ones listed in Table 23 and Table 24.

Note that the system clock, SYSCLK, must be present and enabled when using the digital microphone interface.

| SAMPLE RATE<br>(kHz) | MCLK RATE (MCLK / fs ratio) |        |        |        |        |        |        |       |
|----------------------|-----------------------------|--------|--------|--------|--------|--------|--------|-------|
|                      | 256                         | 384    | 512    | 768    | 1024   | 1536   | 3072   | 6144  |
| 8                    | 1.024                       |        | 1.024  | 1.024  | 1.024  | 1.024  | 1.024  | 1.024 |
| 11.025               | 1.4112                      |        | 1.4112 | 1.4112 | 1.4112 | 1.4112 | 1.4112 |       |
| 12                   | 1.536                       |        | 1.536  | 1.536  | 1.536  | 1.536  | 1.536  |       |
| 16                   | 1.024                       | 1.024  | 1.024  | 1.024  | 1.024  | 1.024  | 1.024  |       |
| 22.05                | 1.4112                      | 1.4112 | 1.4112 | 1.4112 | 1.4112 | 1.4112 |        |       |
| 24                   | 1.536                       | 1.536  | 1.536  | 1.536  | 1.536  | 1.536  |        |       |
| 32                   | 2.048                       | 2.048  | 2.048  | 2.048  | 2.048  | 2.048  |        |       |
| 44.1                 | 2.8224                      | 1.4112 | 2.8224 | 1.4112 | 2.8224 |        |        |       |
| 48                   | 3.072                       | 1.536  | 3.072  | 1.536  | 3.072  |        |        |       |
| 88.2                 | 2.8224                      |        | 2.8224 |        |        |        |        |       |
| 96                   | 3.072                       |        | 3.072  |        |        |        |        |       |

When ADC\_HP=0, digital microphone operation is only supported for the above configurations. Digital microphone operation is not supported for 64fs, 128fs or 192fs MCLK ratios.

**Table 23 DMICCLK Frequency (MHz) - ADC\_HP = 0 (Default)**

| SAMPLE RATE<br>(kHz) | MCLK RATE (MCLK / fs ratio) |     |        |       |        |       |       |       |
|----------------------|-----------------------------|-----|--------|-------|--------|-------|-------|-------|
|                      | 256                         | 384 | 512    | 768   | 1024   | 1536  | 3072  | 6144  |
| 8                    | 1.024                       |     | 2.048  |       | 2.048  | 2.048 | 2.048 | 2.048 |
| 11.025               | 1.4112                      |     | 2.8224 |       | 2.8224 |       |       |       |
| 12                   | 1.536                       |     | 3.072  |       | 3.072  |       |       |       |
| 16                   | 2.048                       |     |        | 2.048 | 2.048  | 2.048 | 2.048 |       |
| 22.05                | 2.8224                      |     | 2.8224 |       | 2.8224 |       |       |       |
| 24                   | 3.072                       |     | 3.072  |       | 3.072  |       |       |       |
| 32                   | 2.048                       |     | 2.048  |       | 2.048  |       |       |       |
| 44.1                 | 2.8224                      |     | 2.8224 |       | 2.8224 |       |       |       |
| 48                   | 3.072                       |     | 3.072  |       | 3.072  |       |       |       |
| 88.2                 | 2.8224                      |     | 2.8224 |       |        |       |       |       |
| 96                   | 3.072                       |     | 3.072  |       |        |       |       |       |

When ADC\_HP=1, digital microphone operation is only supported for the above configurations. Digital microphone operation is not supported for 64fs, 128fs or 192fs MCLK ratios.

**Table 24 DMICCLK Frequency (MHz) - ADC\_HP = 1**

**ANALOGUE TO DIGITAL CONVERTER (ADC)**

The WM8962B uses stereo 24-bit, 128x oversampled sigma-delta ADCs. The use of multi-bit feedback and high oversampling rates reduces the effects of jitter and high frequency noise. The ADC full scale input level is proportional to AVDD - see "Electrical Characteristics". Any input signal greater than full scale may overload the ADC and cause distortion.

The ADCs are enabled by the ADCL\_ENA and ADCR\_ENA register bits. Note that when disabling the ADC, the digital volume controls ADCL\_VOL and ADCR\_VOL should be muted before clearing ADCL\_ENA or ADCR\_ENA to 0. This ensures that the last ADC code does not appear at the Audio Interface (ADCDAT) pin when ADCL\_ENA or ADCR\_ENA are cleared.

| REGISTER ADDRESS          | BIT | LABEL    | DEFAULT | DESCRIPTION                                     |
|---------------------------|-----|----------|---------|-------------------------------------------------|
| R25 (19h)<br>Pwr Mgmt (1) | 3   | ADCL_ENA | 0       | Left ADC Enable<br>0 = Disabled<br>1 = Enabled  |
|                           | 2   | ADCR_ENA | 0       | Right ADC Enable<br>0 = Disabled<br>1 = Enabled |

**Table 25 ADC Enable Control**

**ADC CLOCKING CONTROL**

Clocking for the ADCs is derived from SYSCLK. The required clock is enabled when the SYSCLK\_ENA register is set.

The ADC clock rate is configured automatically, according to the SAMPLE\_RATE and MCLK\_RATE registers. See "Clocking and Sample Rates" for further details of the system clocks and associated control registers.

Note that the ADC and the ADC signal path enhancements functions are only supported under specific clocking configurations. The valid clocking ratios for ADC operation are identified in Table 96. See also Table 97 for details of the supported functions for different MCLK / fs ratios.

**ADC DIGITAL VOLUME CONTROL**

The output of the ADCs can be digitally amplified or attenuated over a range from -71.625dB to +23.625dB in 0.375dB steps. The volume of each channel can be controlled separately. The gain for a given eight-bit code X is given by:

$$0.375 \times (X-192) \text{ dB for } 1 \leq X \leq 255; \quad \text{MUTE for } X = 0$$

The ADC\_VU bit controls the loading of digital volume control data. When ADC\_VU is set to 0, the ADCL\_VOL or ADCR\_VOL control data will be loaded into the respective control register, but will not actually change the digital gain setting. Both left and right gain settings are updated when a 1 is written to ADC\_VU. This makes it possible to update the gain of both channels simultaneously.

| REGISTER ADDRESS              | BIT | LABEL          | DEFAULT   | DESCRIPTION                                                                                                                                                                         |
|-------------------------------|-----|----------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R21 (15h)<br>Left ADC Volume  | 8   | ADC_VU         | N/A       | ADC Volume Update<br>Writing a 1 to this bit will cause left and right ADC volume to be updated simultaneously                                                                      |
|                               | 7:0 | ADCL_VOL [7:0] | C0h (0dB) | Left ADC Digital Volume<br>00h = mute<br>01h = -71.625dB<br>02h = -71.250dB<br>...0.375dB steps<br>C0h = 0dB (default)<br>...<br>FFh = 23.625dB<br>(See Table 27 for volume range)  |
| R22 (16h)<br>Right ADC Volume | 8   | ADC_VU         | N/A       | ADC Volume Update<br>Writing a 1 to this bit will cause left and right ADC volume to be updated simultaneously                                                                      |
|                               | 7:0 | ADCR_VOL [7:0] | C0h (0dB) | Right ADC Digital Volume<br>00h = mute<br>01h = -71.625dB<br>02h = -71.250dB<br>...0.375dB steps<br>C0h = 0dB (default)<br>...<br>FFh = 23.625dB<br>(See Table 27 for volume range) |

**Table 26 ADC Digital Volume Control**

| ADCL_VOL or<br>ADCR_VOL | Volume (dB) | ADCL_VOL or<br>ADCR_VOL | Volume (dB) | ADCL_VOL or<br>ADCR_VOL | Volume (dB) | ADCL_VOL or<br>ADCR_VOL | Volume (dB) |
|-------------------------|-------------|-------------------------|-------------|-------------------------|-------------|-------------------------|-------------|
| 00                      | MUTE        | 40                      | -48.000     | 80                      | -24.000     | C0                      | 0.000       |
| 01                      | -71.625     | 41                      | -47.625     | 81                      | -23.625     | C1                      | 0.375       |
| 02                      | -71.250     | 42                      | -47.250     | 82                      | -23.250     | C2                      | 0.750       |
| 03                      | -70.875     | 43                      | -46.875     | 83                      | -22.875     | C3                      | 1.125       |
| 04                      | -70.500     | 44                      | -46.500     | 84                      | -22.500     | C4                      | 1.500       |
| 05                      | -70.125     | 45                      | -46.125     | 85                      | -22.125     | C5                      | 1.875       |
| 06                      | -69.750     | 46                      | -45.750     | 86                      | -21.750     | C6                      | 2.250       |
| 07                      | -69.375     | 47                      | -45.375     | 87                      | -21.375     | C7                      | 2.625       |
| 08                      | -69.000     | 48                      | -45.000     | 88                      | -21.000     | C8                      | 3.000       |
| 09                      | -68.625     | 49                      | -44.625     | 89                      | -20.625     | C9                      | 3.375       |
| 0A                      | -68.250     | 4A                      | -44.250     | 8A                      | -20.250     | CA                      | 3.750       |
| 0B                      | -67.875     | 4B                      | -43.875     | 8B                      | -19.875     | CB                      | 4.125       |
| 0C                      | -67.500     | 4C                      | -43.500     | 8C                      | -19.500     | CC                      | 4.500       |
| 0D                      | -67.125     | 4D                      | -43.125     | 8D                      | -19.125     | CD                      | 4.875       |
| 0E                      | -66.750     | 4E                      | -42.750     | 8E                      | -18.750     | CE                      | 5.250       |
| 0F                      | -66.375     | 4F                      | -42.375     | 8F                      | -18.375     | CF                      | 5.625       |
| 10                      | -66.000     | 50                      | -42.000     | 90                      | -18.000     | D0                      | 6.000       |
| 11                      | -65.625     | 51                      | -41.625     | 91                      | -17.625     | D1                      | 6.375       |
| 12                      | -65.250     | 52                      | -41.250     | 92                      | -17.250     | D2                      | 6.750       |
| 13                      | -64.875     | 53                      | -40.875     | 93                      | -16.875     | D3                      | 7.125       |
| 14                      | -64.500     | 54                      | -40.500     | 94                      | -16.500     | D4                      | 7.500       |
| 15                      | -64.125     | 55                      | -40.125     | 95                      | -16.125     | D5                      | 7.875       |
| 16                      | -63.750     | 56                      | -39.750     | 96                      | -15.750     | D6                      | 8.250       |
| 17                      | -63.375     | 57                      | -39.375     | 97                      | -15.375     | D7                      | 8.625       |
| 18                      | -63.000     | 58                      | -39.000     | 98                      | -15.000     | D8                      | 9.000       |
| 19                      | -62.625     | 59                      | -38.625     | 99                      | -14.625     | D9                      | 9.375       |
| 1A                      | -62.250     | 5A                      | -38.250     | 9A                      | -14.250     | DA                      | 9.750       |
| 1B                      | -61.875     | 5B                      | -37.875     | 9B                      | -13.875     | DB                      | 10.125      |
| 1C                      | -61.500     | 5C                      | -37.500     | 9C                      | -13.500     | DC                      | 10.500      |
| 1D                      | -61.125     | 5D                      | -37.125     | 9D                      | -13.125     | DD                      | 10.875      |
| 1E                      | -60.750     | 5E                      | -36.750     | 9E                      | -12.750     | DE                      | 11.250      |
| 1F                      | -60.375     | 5F                      | -36.375     | 9F                      | -12.375     | DF                      | 11.625      |
| 20                      | -60.000     | 60                      | -36.000     | A0                      | -12.000     | E0                      | 12.000      |
| 21                      | -59.625     | 61                      | -35.625     | A1                      | -11.625     | E1                      | 12.375      |
| 22                      | -59.250     | 62                      | -35.250     | A2                      | -11.250     | E2                      | 12.750      |
| 23                      | -58.875     | 63                      | -34.875     | A3                      | -10.875     | E3                      | 13.125      |
| 24                      | -58.500     | 64                      | -34.500     | A4                      | -10.500     | E4                      | 13.500      |
| 25                      | -58.125     | 65                      | -34.125     | A5                      | -10.125     | E5                      | 13.875      |
| 26                      | -57.750     | 66                      | -33.750     | A6                      | -9.750      | E6                      | 14.250      |
| 27                      | -57.375     | 67                      | -33.375     | A7                      | -9.375      | E7                      | 14.625      |
| 28                      | -57.000     | 68                      | -33.000     | A8                      | -9.000      | E8                      | 15.000      |
| 29                      | -56.625     | 69                      | -32.625     | A9                      | -8.625      | E9                      | 15.375      |
| 2A                      | -56.250     | 6A                      | -32.250     | AA                      | -8.250      | EA                      | 15.750      |
| 2B                      | -55.875     | 6B                      | -31.875     | AB                      | -7.875      | EB                      | 16.125      |
| 2C                      | -55.500     | 6C                      | -31.500     | AC                      | -7.500      | EC                      | 16.500      |
| 2D                      | -55.125     | 6D                      | -31.125     | AD                      | -7.125      | ED                      | 16.875      |
| 2E                      | -54.750     | 6E                      | -30.750     | AE                      | -6.750      | EE                      | 17.250      |
| 2F                      | -54.375     | 6F                      | -30.375     | AF                      | -6.375      | EF                      | 17.625      |
| 30                      | -54.000     | 70                      | -30.000     | B0                      | -6.000      | F0                      | 18.000      |
| 31                      | -53.625     | 71                      | -29.625     | B1                      | -5.625      | F1                      | 18.375      |
| 32                      | -53.250     | 72                      | -29.250     | B2                      | -5.250      | F2                      | 18.750      |
| 33                      | -52.875     | 73                      | -28.875     | B3                      | -4.875      | F3                      | 19.125      |
| 34                      | -52.500     | 74                      | -28.500     | B4                      | -4.500      | F4                      | 19.500      |
| 35                      | -52.125     | 75                      | -28.125     | B5                      | -4.125      | F5                      | 19.875      |
| 36                      | -51.750     | 76                      | -27.750     | B6                      | -3.750      | F6                      | 20.250      |
| 37                      | -51.375     | 77                      | -27.375     | B7                      | -3.375      | F7                      | 20.625      |
| 38                      | -51.000     | 78                      | -27.000     | B8                      | -3.000      | F8                      | 21.000      |
| 39                      | -50.625     | 79                      | -26.625     | B9                      | -2.625      | F9                      | 21.375      |
| 3A                      | -50.250     | 7A                      | -26.250     | BA                      | -2.250      | FA                      | 21.750      |
| 3B                      | -49.875     | 7B                      | -25.875     | BB                      | -1.875      | FB                      | 22.125      |
| 3C                      | -49.500     | 7C                      | -25.500     | BC                      | -1.500      | FC                      | 22.500      |
| 3D                      | -49.125     | 7D                      | -25.125     | BD                      | -1.125      | FD                      | 22.875      |
| 3E                      | -48.750     | 7E                      | -24.750     | BE                      | -0.750      | FE                      | 23.250      |
| 3F                      | -48.375     | 7F                      | -24.375     | BF                      | -0.375      | FF                      | 23.625      |

**Table 27 ADC Digital Volume Range**

**ADC OVERSAMPLING RATIO (OSR)**

The ADC oversampling rate is programmable to allow power consumption versus audio performance trade-offs. The default oversampling rate is low for reduced power consumption; using the higher OSR setting improves the DAC signal-to-noise performance.

See the “Reference Voltages and Bias Control” section for details of the supported bias control settings for the input signal paths.

| REGISTER ADDRESS                    | BIT | LABEL  | DEFAULT | DESCRIPTION                                                                                              |
|-------------------------------------|-----|--------|---------|----------------------------------------------------------------------------------------------------------|
| R23 (17h)<br>Additional control (1) | 5   | ADC_HP | 0       | ADC Oversampling Ratio<br>0 = Low Power (typically 64 x fs)<br>1 = High Performance (typically 128 x fs) |

**Table 28 ADC Oversampling Ratio**
**ADC MONOMIX**

A mono mix of the Left and Right channels can be created by setting the ADC\_MONOMIX register bit, as described in Table 29. When ADC\_MONOMIX is set, 3D Surround must be disabled (THREED\_ENA = 0, as described Table 34) for the ADC\_MONOMIX setting to be effective. An attenuation of -6dB is applied to the sum of the Left and Right channels in order to avoid clipping.

| REGISTER ADDRESS        | BIT | LABEL       | DEFAULT | DESCRIPTION                                                                                                                                |
|-------------------------|-----|-------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------|
| R268 (010Ch)<br>THREED1 | 6   | ADC_MONOMIX | 0       | ADC Monomix enable<br>0 = Disabled<br>1 = Enabled<br>Note that THREED_ENA (see Table 34) must be disabled for ADC_MONOMIX to be effective. |

**Table 29 ADC Monomix**

## DSP SIGNAL ENHANCEMENTS

The WM8962B incorporates several advanced signal enhancement features within the digital audio signal paths, as illustrated in Figure 23.

The ADC signal path incorporates a 2<sup>nd</sup> order High-Pass Filter (HPF), 1<sup>st</sup> order Low/High-Pass Filter (LPF/HPF), 3D surround, DF1 Filter, ReTune™ and Dynamic Range Control (DRC).

The DAC signal path incorporates a 5-Band EQ, Dynamic Range Control (DRC), 2<sup>nd</sup> order High-Pass Filter (HPF), Virtual Surround Sound (VSS), HD Bass and ReTune™.

Note that ReTune™ can be enabled on the ADC or DAC signal paths; it can also be enabled on both paths at the same time, with unique coefficient sets on each path.

Dynamic Range Control (DRC) can be enabled on either the ADC path or on the DAC path, but not on both at the same time.

Note that specific sequences must be followed when enabling or configuring ADC ReTune, DAC ReTune, DAC 2<sup>nd</sup> order HPF, VSS, and HD Bass sound enhancement functions. Different control sequences are applicable, depending on whether any of the advanced signal enhancements is initially enabled or not.

The configuration parameters in registers R16896 (4200h) to R21139 (5293h) are 24-bit words, arranged within the 16-bit register address space. Each 24-bit word must be written to the register map in full, MSBs first, before attempting to read back the value. Failure to do this may give incorrect read/write behaviour.

When updating the configuration parameters for any DSP feature(s), it is recommended to write all of the associated registers, in incremental address order, before reading back any values.

### ENABLE SEQUENCE - ENHANCEMENTS INITIALLY DISABLED

When enabling any of ADC ReTune, DAC ReTune, DAC 2<sup>nd</sup> order HPF, VSS, or HD Bass, the following sequence is required.

Note that this sequence assumes that, under initial conditions, all of these enhancement functions are disabled. A separate sequence is described for use when sound enhancement is initially enabled.

1. MCLK must be present and configured at  $\geq 512$  fs (see Table 99)
2. Set ADCL\_VOL = 00h in Register R21 (15h), and ADCR\_VOL = 00h in Register R22 (16h) (see Table 26)
3. Set ADCL\_ENA = 0 and ADCR\_ENA = 0 in Register R25 (19h) (see Table 25)
4. Set DAC\_MUTE = 1 in Register R5 (5h) (see Table 63)
5. Set DACL\_ENA = 0 and DACR\_ENA = 0 in Register R26 (1Ah) (see Table 60)
6. Set DSP2\_ENA = 1 in Register R768 (300h) (see Table 30)
7. Set the configuration parameters in registers R16896 (4200h) to R21139 (5293h)
8. Readback the configuration parameters in registers R16896 (4200h) to R21139 (5293h)
9. Set DSP2\_RUNR = 1 in Register R1037 (40Dh) (see Table 30)
10. Set the enable bits in Register R16389 (4005h) for any required sound enhancement

RTN\_ADC\_ENA

RTN\_DAC\_ENA

HDBASS\_ENA

HPF1\_ENA (see note below)

HPF2\_ENA (see note below)

VSS\_ENA

11. Set ADCL\_ENA = 1 and ADCR\_ENA = 1 in Register R25 (19h), if required (see Table 25)
12. Set ADCL\_VOL in Register R21 (15h), and ADCR\_VOL in Register R22 (16h), to their previous values
13. Set DACL\_ENA = 1 and DACR\_ENA = 1 in Register R26 (1Ah), if required (see Table 60)



14. Set DAC\_MUTE = 0 in Register R5 (5h) (see Table 63)

Note that the DAC high pass filters cannot be enabled unless one or more other sound enhancement functions is enabled. If HPF1\_ENA = 1 or HPF2\_ENA = 1, then at least one other of the enable bits in Register R16389 must also be set (ie. RTN\_ADC\_ENA, RTN\_DAC\_ENA, HDBASS\_ENA or VSS\_ENA).

Note that DSP2\_ENA in Register R768 (300h) must remain asserted whenever any of the sound enhancement functions listed above is being used.

#### ENABLE / DISABLE SEQUENCE - ENHANCEMENTS INITIALLY ENABLED

When enabling or disabling any of ADC ReTune, DAC ReTune, DAC 2<sup>nd</sup> order HPF, VSS, or HD Bass, the following sequence is required.

Note that this sequence assumes that, under initial conditions, one or more of these enhancement functions is enabled. A separate sequence is described for use when the sound enhancements are initially disabled.

Note that this sequence assumes that the applicable enhancement functions have already been configured (using default settings or otherwise). This sequence is only for enabling/disabling the selected functions. Separate sequences are described for configuring any of the sound enhancement functions.

1. Set ADCL\_VOL = 00h in Register R21 (15h), and ADCR\_VOL = 00h in Register R22 (16h) (see Table 26)
2. Set DAC\_MUTE = 1 in Register R5 (5h) (see Table 63)
3. Set the enable bits in Register R16389 (4005h) for any required sound enhancement
  - RTN\_ADC\_ENA
  - RTN\_DAC\_ENA
  - HDBASS\_ENA
  - HPF1\_ENA (see note below)
  - HPF2\_ENA (see note below)
  - VSS\_ENA
4. Set ADCL\_VOL in Register R21 (15h), and ADCR\_VOL in Register R22 (16h), to their previous values
5. Set DAC\_MUTE = 0 in Register R5 (5h) (see Table 63)

Note that the DAC high pass filters cannot be enabled unless one or more other sound enhancement functions is enabled. If HPF1\_ENA = 1 or HPF2\_ENA = 1, then at least one other of the enable bits in Register R16389 must also be set (ie. RTN\_ADC\_ENA, RTN\_DAC\_ENA, HDBASS\_ENA or VSS\_ENA).

Note that DSP2\_ENA in Register R768 (300h) must remain asserted whenever any of the sound enhancement functions listed above is being used.

To disable all sound enhancement functions, refer to the control sequence described in the next section ("Disable All Sound Enhancements").

**DISABLE ALL SOUND ENHANCEMENTS SEQUENCE**

When disabling all of the sound enhancement functions (ADC ReTune, DAC ReTune, DAC 2<sup>nd</sup> order HPF, VSS, and HD Bass), the following sequence is required:

1. Set ADCL\_VOL = 00h in Register R21 (15h), and ADCR\_VOL = 00h in Register R22 (16h) (see Table 26)
2. Set DAC\_MUTE = 1 in Register R5 (5h) (see Table 63)
3. Set the enable bits in Register R16389 (4005h) to 0 for all sound enhancements
  - RTN\_ADC\_ENA = 0
  - RTN\_DAC\_ENA = 0
  - HDBASS\_ENA = 0
  - HPF1\_ENA = 0
  - HPF2\_ENA = 0
  - VSS\_ENA = 0
4. Set ADCL\_VOL in Register R21 (15h), and ADCR\_VOL in Register R22 (16h), to their previous values
5. Set DAC\_MUTE = 0 in Register R5 (5h) (see Table 63)
6. Set DSP2\_STOP = 1 in Register R1037 (40Dh) (see Table 30)
7. Set DSP2\_ENA = 0 in Register R768 (300h) (see Table 30).

**UPDATE / READBACK SEQUENCE - ENHANCEMENTS INITIALLY ENABLED**

The required control sequence to update or read back the configuration parameters differs according to whether one or more of the sound enhancements is enabled under the initial conditions.

If ADC ReTune, DAC ReTune, DAC 2<sup>nd</sup> order HPF, VSS, or HD Bass is already enabled, then the following sequence is required when updating or reading back the configuration parameters:

1. Set ADCL\_VOL = 00h in Register R21 (15h), and ADCR\_VOL = 00h in Register R22 (16h) (see Table 26)
2. Set ADCL\_ENA = 0 and ADCR\_ENA = 0 in Register R25 (19h) (see Table 25)
3. Set DAC\_MUTE = 1 in Register R5 (5h) (see Table 63)
4. Set DACL\_ENA = 0 and DACR\_ENA = 0 in Register R26 (1Ah) (see Table 60)
5. Disable all sound enhancement registers in Register R16389 (4005h)
  - RTN\_ADC\_ENA = 0
  - RTN\_DAC\_ENA = 0
  - HDBASS\_ENA = 0
  - HPF2\_ENA = 0
  - HPF1\_ENA = 0
  - VSS\_ENA = 0
6. Set DSP2\_STOP = 1 in Register R1037 (40Dh) (see Table 30)
7. Set the configuration parameters in registers R16896 (4200h) to R21139 (5293h)
8. Readback the configuration parameters in registers R16896 (4200h) to R21139 (5293h)
9. Set DSP2\_RUNR = 1 in Register R1037 (40Dh) (see Table 30)
10. Set the enable bits in Register R16389 (4005h) for any required sound enhancement
  - RTN\_ADC\_ENA
  - RTN\_DAC\_ENA
  - HDBASS\_ENA
  - HPF1\_ENA
  - HPF2\_ENA
  - VSS\_ENA
11. Set ADCL\_ENA = 1 and ADCR\_ENA = 1 in Register R25 (19h), if required (see Table 25)
12. Set ADCL\_VOL in Register R21 (15h), and ADCR\_VOL in Register R22 (16h), to their previous values
13. Set DACL\_ENA = 1 and DACR\_ENA = 1 in Register R26 (1Ah), if required (see Table 60)
14. Set DAC\_MUTE = 0 in Register R5 (5h) (see Table 63)

**UPDATE / READBACK SEQUENCE - ENHANCEMENTS INITIALLY DISABLED**

The required control sequence to update or read back the configuration parameters differs according to whether one or more of the sound enhancements is enabled under the initial conditions.

If ADC ReTune, DAC ReTune, DAC 2<sup>nd</sup> order HPF, VSS, or HD Bass are all disabled, then the following sequence is required when updating or reading back the configuration parameters:

1. MCLK must be present and configured at  $\geq 512$  fs (see Table 99)
2. Set ADCL\_VOL = 00h in Register R21 (15h), and ADCR\_VOL = 00h in Register R22 (16h) (see Table 26)
3. Set ADCL\_ENA = 0 and ADCR\_ENA = 0 in Register R25 (19h) (see Table 25)
4. Set DAC\_MUTE = 1 in Register R5 (5h) (see Table 63)
5. Set DACL\_ENA = 0 and DACR\_ENA = 0 in Register R26 (1Ah) (see Table 60)
6. Set DSP2\_ENA = 1 in Register R768 (300h) (see Table 30)
7. Set the configuration parameters in registers R16896 (4200h) to R21139 (5293h)
8. Readback the configuration parameters in registers R16896 (4200h) to R21139 (5293h)
9. Set DSP2\_ENA = 0 in Register R768 (300h) (see Table 30)
10. Set ADCL\_ENA = 1 and ADCR\_ENA = 1 in Register R25 (19h), if required (see Table 25)
11. Set ADCL\_VOL in Register R21 (15h), and ADCR\_VOL in Register R22 (16h), to their previous values
12. Set DACL\_ENA = 1 and DACR\_ENA = 1 in Register R26 (1Ah), if required (see Table 60)
13. Set DAC\_MUTE = 0 in Register R5 (5h) (see Table 63)

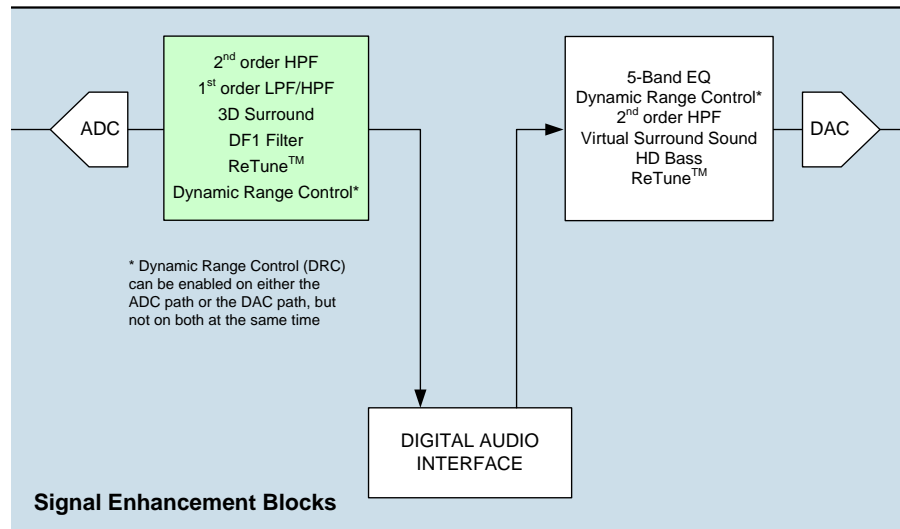
The DSP2 audio processor control registers are described in Table 30. Other registers associated with ADC ReTune, DAC ReTune, DAC 2<sup>nd</sup> order HPF, VSS, or HD Bass are described in the respective sections in the following pages.

| REGISTER ADDRESS                      | BIT | LABEL     | DEFAULT | DESCRIPTION                                                                                                                                                                                                                  |
|---------------------------------------|-----|-----------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R768 (R300h)<br>DSP2 Power Management | 0   | DSP2_ENA  | 0       | DSP2 Audio Processor Enable.<br>0 = Disabled<br>1 = Enabled<br>This bit must be set before any of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass is enabled. It must remain set whenever any of these functions is enabled. |
| R1037 (40Dh)<br>DSP2_ExecC onrol      | 2   | DSP2_STOP | N/A     | Stop the DSP2 audio processor<br>Writing a 1 to this bit will cause the DSP2 processor to stop processing audio data                                                                                                         |
|                                       | 1   | DSP2_RUNR | N/A     | Start the DSP2 audio processor<br>Writing a 1 to this bit will cause the DSP2 processor to start processing audio data                                                                                                       |

**Table 30 DSP Signal Enhancement Control**

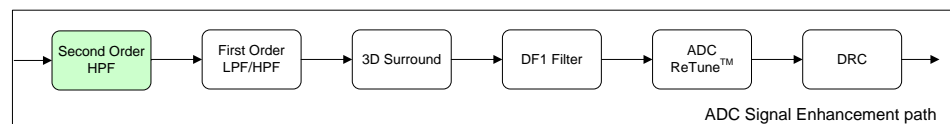
## ADC SIGNAL PATH ENHANCEMENTS

The ADC signal path incorporates a number of sound enhancement features, as illustrated in Figure 23. These features are described more fully in the following sections.



**Figure 23 ADC Signal Path Enhancements**

### ADC SECOND ORDER HIGH-PASS FILTER



A digital high-pass filter is enabled by default in the ADC path to remove DC offsets. This filter can also be used to remove low frequency noise in voice applications (e.g. wind noise or mechanical vibration). The filter can be disabled by setting the ADC\_HPF\_DIS register bit.

The filter operates in one of two modes, selected by ADC\_HPF\_MODE.

The ADC\_HPF\_SR register should be set according to the selected ADC sample rate. See “Clocking and Sample Rates” for details of the ADC sample rate.

In Hi-Fi mode, the high-pass filter is optimised for removing DC offsets without degrading the bass response and has a cut-off frequency of 3.5Hz when the sample rate (fs) = 44.1kHz.

In Application mode, the HPF cut-off frequency is set using ADC\_HPF\_CUT. This mode is intended for voice communication; it is recommended to set the cut-off frequency below 300Hz (e.g. ADC\_HPF\_CUT = 101 when fs = 8kHz or ADC\_HPF\_CUT = 101 when fs = 16kHz).

| REGISTER ADDRESS                   | BIT   | LABEL            | DEFAULT | DESCRIPTION                                                                                                                                                                                                       |
|------------------------------------|-------|------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R5 (05h)<br>ADC & DAC<br>Control 1 | 0     | ADC_HPF_DIS      | 0       | ADC High-Pass Filter Disable<br>0 = Enable<br>1 = Disable                                                                                                                                                         |
| R6 (06h)<br>ADC & DAC<br>Control 2 | 13:12 | ADC_HPF_SR [1:0] | 10      | ADC High-Pass Filter Sample rate<br>00 = 8k, 11.025k, 12k<br>01 = 16k, 22.025k, 24k<br>10 = 32k, 44.1, 48k<br>11 = 88.2k, 96k<br>This field is for read-back only; it is set automatically and cannot be adjusted |
|                                    | 10    | ADC_HPF_MODE     | 0       | ADC High-Pass Filter Mode select<br>0 = Hi-Fi mode (1 <sup>st</sup> order)<br>1 = Application mode (2 <sup>nd</sup> order)                                                                                        |
|                                    | 9:7   | ADC_HPF_CUT[2:0] | 000     | ADC High-Pass Filter Cutoff<br>Note that the cut-off frequency scales with sample rate. See Table 32 for cut-off frequencies at all supported sample rates                                                        |

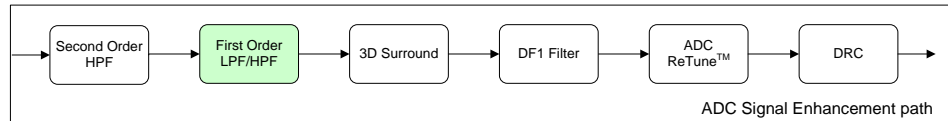
**Table 31 ADC High-Pass Filter**

| SAMPLE FREQUENCY (kHz) | CUT-OFF FREQUENCY (Hz) |                                     |       |       |       |       |       |       |       |
|------------------------|------------------------|-------------------------------------|-------|-------|-------|-------|-------|-------|-------|
|                        | HI-FI MODE             | APPLICATION MODE / ADC_HPF_CUT[2:0] |       |       |       |       |       |       |       |
|                        |                        | 000                                 | 001   | 010   | 011   | 100   | 101   | 110   | 111   |
| 8.000                  | 3.0                    | 80.5                                | 100.5 | 129.0 | 160.5 | 200.5 | 256.5 | 320.5 | 400.5 |
| 11.025                 | 4.5                    | 111.0                               | 138.5 | 177.5 | 221.0 | 276.5 | 353.0 | 442.0 | 551.5 |
| 12.000                 | 4.5                    | 120.5                               | 151.0 | 193.0 | 240.5 | 300.5 | 384.5 | 481.0 | 600.5 |
| 16.000                 | 3.0                    | 80.0                                | 101.0 | 129.0 | 161.0 | 200.5 | 256.5 | 321.0 | 401.0 |
| 22.050                 | 4.5                    | 110.5                               | 139.0 | 177.5 | 221.5 | 276.0 | 353.5 | 442.0 | 552.5 |
| 24.000                 | 4.5                    | 120.5                               | 151.5 | 193.5 | 241.5 | 300.5 | 385.0 | 481.5 | 601.0 |
| 32.000                 | 2.5                    | 80.0                                | 101.5 | 129.0 | 160.5 | 200.0 | 257.5 | 320.0 | 401.0 |
| 44.100                 | 3.5                    | 110.0                               | 139.5 | 177.5 | 221.0 | 275.5 | 355.0 | 441.0 | 552.5 |
| 48.000                 | 4.0                    | 119.5                               | 152.0 | 193.0 | 240.5 | 300.0 | 386.5 | 480.0 | 601.0 |
| 88.200                 | 3.5                    | 112.5                               | 139.0 | 177.0 | 220.0 | 274.0 | 355.0 | 442.0 | 551.0 |
| 96.000                 | 4.0                    | 122.5                               | 151.5 | 192.5 | 239.5 | 298.0 | 386.5 | 481.0 | 600.0 |

**Note:** 'Hi-Fi Mode' refers to the mode when ADC\_HPF\_MODE = 0 (first order filtering and a cut-off frequency of 3.5Hz at a sample rate of 44.1kHz); 'Application Mode' refers to the mode when ADC\_HPF\_MODE = 1 (second order filtering and the cut-off frequency set by ADC\_HPF\_CUT)

**Table 32 ADC High-Pass Filter Cut-Off Frequencies**

The high-pass filter characteristics are shown in the "Digital Filter Characteristics" section.

**LOW-PASS / HIGH-PASS FILTER (LPF/HPF)**


The Low-Pass / High-Pass filter is part of the ADC Signal Enhancement path.

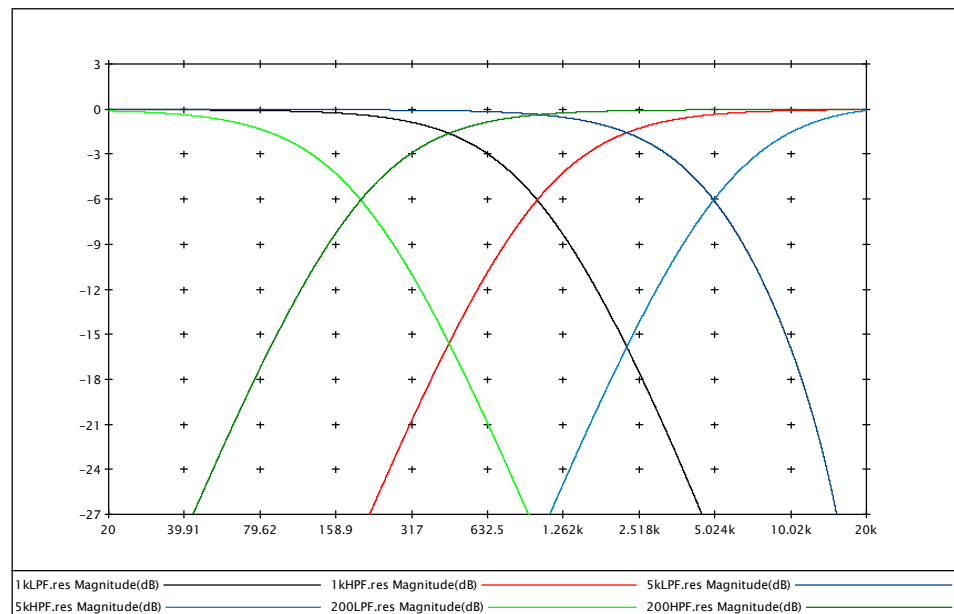
This first-order filter can be configured to be high-pass or low-pass. It can be used to removed unwanted 'out of band' noise from the ADC signal path. The filter is enabled using the LHPF\_ENA register bit defined in Table 33. The default setting is bypass (OFF). The High-Pass or Low-Pass configuration is selected using the LHPF\_MODE register bit.

The filter can be programmed using the LHPF\_COEFF register field (R265). For the derivation of this parameter, refer to the WISCE™ configuration tool supplied with the WM8962B Evaluation Kit.

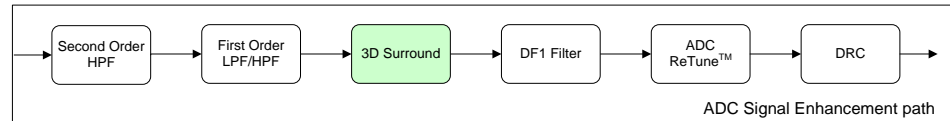
| REGISTER ADDRESS      | BIT | LABEL     | DEFAULT | DESCRIPTION                                                       |
|-----------------------|-----|-----------|---------|-------------------------------------------------------------------|
| R264 (0108h)<br>LHPF1 | 1   | LHPF_MODE | 0       | Low/High-Pass Filter mode select<br>0 = Low-Pass<br>1 = High-Pass |
|                       | 0   | LHPF_ENA  | 0       | Low/High-Pass Filter<br>0 = Disable<br>1 = Enable                 |

**Table 33 Low-Pass / High-Pass Filter Control**

Example plots of the Low-pass / High-pass filter response are shown in Figure 24.



**Figure 24 Low-pass / High-pass Filter Responses**

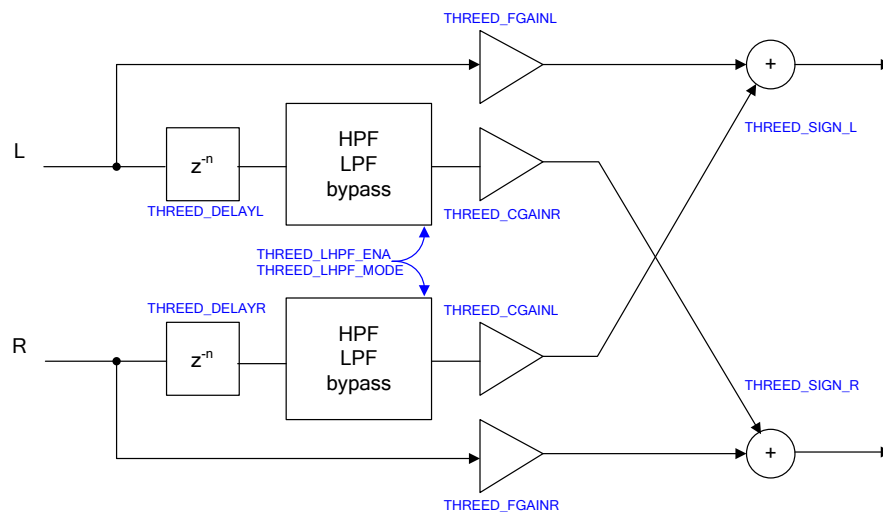
**3D SURROUND**


The 3D Surround function is part of the ADC Signal Enhancement path.

The 3D Surround processing can be used in ADC record applications to select between a directional or wide-angle microphone response. Depending on the target application, the stereo widening capability could be selected manually, or else could be configured automatically for different operational modes, for example.

Note that the stereo widening is most effective at frequencies above 2kHz; lower frequencies may be attenuated by the phase cancellation process employed by the 3D Surround function. The DF1 filter (also part of the the ADC Signal Enhancement path) can be used to compensate for the attenuation of low frequencies; a low-shelf filter can be implemented in the DF1, as described later.

The 3D Surround effect is programmable; it uses time delays and controlled cross-talk mechanisms to adjust the depth or width of the stereo audio. The 3D Surround effect includes programmable high-pass or low-pass filtering to limit the effect to specific frequency bands if required. The structure of the 3D Surround processing is illustrated in Figure 25.



**Figure 25 3D Surround Processing**

The 3D Surround effect is enabled using the THREED\_ENA register. Note that enabling 3D Surround will cause any ADC\_MONOMIX settings to be ignored.

When 3D Surround is enabled, the left and right audio channels connect to the outputs using forward (same channel) paths and cross-feed (opposite channel) paths. The forward gain levels are determined by the THREED\_FGAINL and THREED\_FGAINR registers; the cross-feed gain levels are set by THREED\_CGAINL (for right-to-left cross-feed) and THREED\_CGAINR (for left-to-right cross-feed).

The polarity of the cross-feed mixing is controlled by the THREED\_SIGN\_L and THREED\_SIGN\_R register bits. If THREED\_SIGN\_L = 1 or THREED\_SIGN\_R = 1, then the respective cross-feed signal is subtracted from the main signal. If THREED\_SIGN\_L = 0 or THREED\_SIGN\_R = 0, then the respective cross-feed signal is added to the forward path signal.

A time delay can be applied to the cross-feed signals; this is selected using the THREED\_DELAYL and THREED\_DELAYR registers for the left and right channels respectively. The signals can be delayed up to a maximum of 8 samples.

High-Pass or Low-Pass filtering can be applied to the cross-feed signals. This is enabled by the THREED\_LHPF\_ENA register. The High-Pass or Low-Pass configuration is selected using the



THREED\_LHPF\_MODE register bit. This is typically used to filter out fixed-frequency noise or resonances.

The 3D Surround High-Pass / Low-Pass filter can be programmed using the THREED\_LHPF\_COEFF register field (R270). For the derivation of this parameter, refer to the WISCE™ configuration tool supplied with the WM8962B Evaluation Kit.

| REGISTER ADDRESS        | BIT   | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                         |
|-------------------------|-------|-------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R268 (010Ch)<br>THREED1 | 5     | THREED_SIGNL            | 0       | 3D Left Cross mixing polarity (from the right channel to the left)<br>0 = Positive<br>1 = Negative                                                                                                                                                                  |
|                         | 4     | THREED_SIGNR            | 0       | 3D Right Cross mixing polarity (from the left channel to the right)<br>0 = Positive<br>1 = Negative                                                                                                                                                                 |
|                         | 2     | THREED_LHPF_MODE        | 0       | 3D Low/High-Pass filter mode<br>0 = Low-Pass<br>1 = High-Pass                                                                                                                                                                                                       |
|                         | 1     | THREED_LHPF_ENA         | 0       | 3D Low/High-Pass filter enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                       |
|                         | 0     | THREED_ENA              | 0       | 3D Surround Sound enable<br>0 = Disabled<br>1 = Enabled<br>Note that setting THREED_ENA will cause any ADC_MONOMIX setting to be ignored                                                                                                                            |
| R269 (010Dh)<br>THREED2 | 15:11 | THREED_FGAIN<br>L [4:0] | 00000   | 3D Left Forward Gain<br>00000 = Mute<br>00001 = -11.25dB<br>00010 = -10.875dB<br>(...in steps of -0.375dB)<br>11110 = -0.375dB<br>11111 = 0.0dB<br>See Table 35 for a full list of gain settings                                                                    |
|                         | 10:6  | THREED_CGAIN<br>L [4:0] | 00000   | 3D Left Cross Gain (from the right channel to the left)<br>00000 = Mute<br>00001 = -11.25dB<br>00010 = -10.875dB<br>(...in steps of -0.375dB)<br>11110 = -0.375dB<br>11111 = 0.0dB<br>See Table 35 for a full list of gain settings                                 |
|                         | 5:2   | THREED_DELAY<br>L [3:0] | 0000    | 3D Left Filter Delay (measured from the sample rate)<br>0000 = 0 samples<br>0001 = 1 samples<br>0010 = 2 samples<br>0011 = 3 samples<br>0100 = 4 samples<br>0101 = 5 samples<br>0110 = 6 samples<br>0111 = 7 samples<br>1000 = 8 samples<br>1001 to 1111 = Reserved |

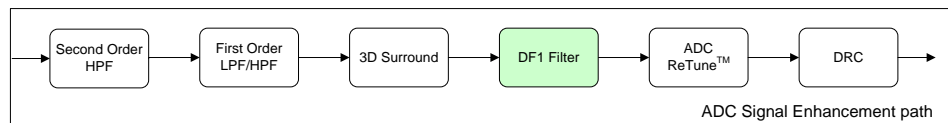
| REGISTER ADDRESS        | BIT   | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                    |
|-------------------------|-------|-------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R271 (010Fh)<br>THREED4 | 15:11 | THREED_FGAIN<br>R [4:0] | 00000   | 3D Right Forward Gain<br>00000 = Mute<br>00001 = -11.25dB<br>00010 = -10.875dB<br>(...in steps of -0.375dB)<br>11110 = -0.375dB<br>11111 = 0.0dB<br>See Table 35 for a full list of gain settings                                                              |
|                         | 10:6  | THREED_CGAIN<br>R [4:0] | 00000   | 3D Right Cross Gain (from the left channel to the right)<br>00000 = Mute<br>00001 = -11.25dB<br>00010 = -10.875dB<br>(...in steps of -0.375dB)<br>11110 = -0.375dB<br>11111 = 0.0dB<br>See Table 35 for a full list of gain settings                           |
|                         | 5:2   | THREED_DELAY<br>R [3:0] | 0000    | 3D Filter Delay (measured from the sample rate)<br>0000 = 0 samples<br>0001 = 1 samples<br>0010 = 2 samples<br>0011 = 3 samples<br>0100 = 4 samples<br>0101 = 5 samples<br>0110 = 6 samples<br>0111 = 7 samples<br>1000 = 8 samples<br>1001 to 1111 = Reserved |

**Table 34 3D Surround Processing**

| THREED_FGAINL [4:0],<br>THREED_CGAINL [4:0],<br>THREED_FGAINR [4:0]<br>OR<br>THREED_CGAINR [4:0] | GAIN (dB) | THREED_FGAINL [4:0],<br>THREED_CGAINL [4:0],<br>THREED_FGAINR [4:0]<br>OR<br>THREED_CGAINR [4:0] | GAIN (dB) |
|--------------------------------------------------------------------------------------------------|-----------|--------------------------------------------------------------------------------------------------|-----------|
| 0_0000                                                                                           | Mute      | 1_0000                                                                                           | -5.625    |
| 0_0001                                                                                           | -11.250   | 1_0001                                                                                           | -5.250    |
| 0_0010                                                                                           | -10.875   | 1_0010                                                                                           | -4.875    |
| 0_0011                                                                                           | -10.500   | 1_0011                                                                                           | -4.500    |
| 0_0100                                                                                           | -10.125   | 1_0100                                                                                           | -4.125    |
| 0_0101                                                                                           | -9.750    | 1_0101                                                                                           | -3.750    |
| 0_0110                                                                                           | -9.375    | 1_0110                                                                                           | -3.375    |
| 0_0111                                                                                           | -9.000    | 1_0111                                                                                           | -3.000    |
| 0_1000                                                                                           | -8.625    | 1_1000                                                                                           | -2.625    |
| 0_1001                                                                                           | -8.250    | 1_1001                                                                                           | -2.250    |
| 0_1010                                                                                           | -7.875    | 1_1010                                                                                           | -1.875    |
| 0_1011                                                                                           | -7.500    | 1_1011                                                                                           | -1.500    |
| 0_1100                                                                                           | -7.125    | 1_1100                                                                                           | -1.125    |
| 0_1101                                                                                           | -6.750    | 1_1101                                                                                           | -0.750    |
| 0_1110                                                                                           | -6.375    | 1_1110                                                                                           | -0.375    |
| 0_1111                                                                                           | -6.000    | 1_1111                                                                                           | 0.000     |

**Table 35 3D Surround Forward Gain and Cross Gain Range**

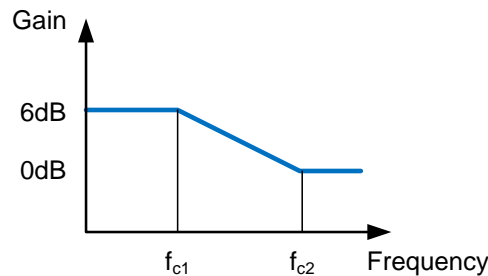
### DF1 FILTER



The DF1 Filter function is implemented in the ADC Signal Enhancement path.

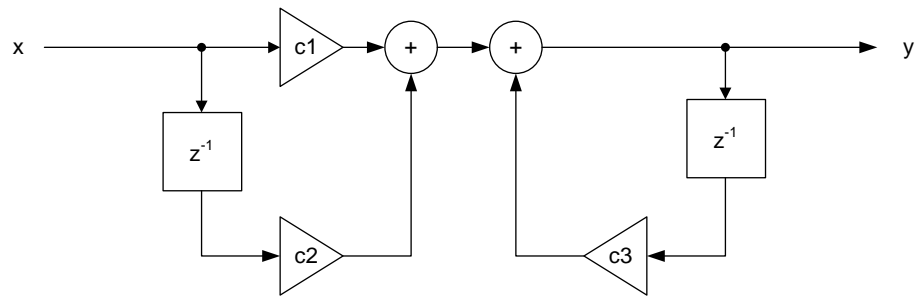
The Direct-Form 1 (DF1) filter can be used to implement a wide variety of user-defined algorithms. Typical applications of this function include low-shelf, high-shelf or all-pass filters. (A low-shelf filter boosts or attenuates low frequencies; a high-shelf filter boosts or attenuates high frequencies. All-pass filters can be defined which pass all frequencies, but adjust the phase response of the signal.)

One of the recommended uses for the DF1 filter is as a low-shelf filter compensating for low frequency effects in the 3D Surround function. In this case, the DF1 filter should provide gain at low frequencies (eg. below 2kHz). An example low-shelf filter response is illustrated in Figure 26.



**Figure 26 DF1 Low Shelf Filter Response**

The Direct-Form 1 (DF1) standard filter is illustrated in Figure 27. All of the filter coefficients are programmable for the left and right channels independently, but DF1 can also be configured for both channels to share the filter coefficients from one or other of the channels. The default coefficients give a transparent filter response.


**Figure 27 Direct-Form 1 Standard Filter Structure**

The DF1 response is defined by the following equations:

$$y[n] = c_1x[n] + c_2x[n-1] + c_3y[n-1]$$

$$H = \frac{y}{x} = \frac{c_1 + c_2z^{-1}}{1 - c_3z^{-1}}$$

The DF1 filter is enabled on the ADC signal path using the DF1\_ENA register bit defined in Table 36.

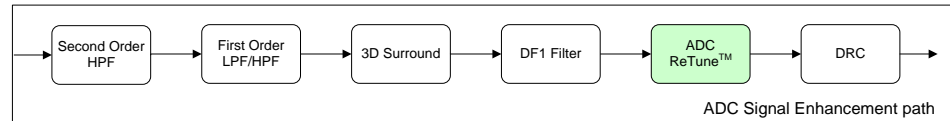
The DF1 filter can be configured for both channels to use the same filter coefficients; this is selected by setting the DF1\_SHARED\_COEFF register bit. When this bit is set, then the applicable coefficients are selected using DF1\_SHARED\_COEFF\_SEL; it is possible to select either the left or right channel coefficients.

The DF1 filter can be used to implement very complex response patterns, with specific phase and gain responses at different frequencies. Typical applications of this type of filter include refinements or compensations to the 3D Surround, or other user-selected filters.

For the derivation of the DF1 Filter coefficients (registers R257 to R259 and for the left channel, R260 to R262 for the right channel), refer to the WISCE™ configuration tool supplied with the WM8962B Evaluation Kit.

| REGISTER ADDRESS    | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                           |
|---------------------|-----|----------------------|---------|-----------------------------------------------------------------------------------------------------------------------|
| R256 (0100h)<br>DF1 | 2   | DF1_SHARED_COEFF     | 0       | DF1 Shared Coefficients Enable<br>0 = Disabled<br>1 = Enabled                                                         |
|                     | 1   | DF1_SHARED_COEFF_SEL | 0       | DF1 Shared Coefficients Select<br>0 = Both channels use left coefficients<br>1 = Both channels use right coefficients |
|                     | 0   | DF1_ENA              | 0       | DF1 Enable in ADC path<br>0 = Disabled<br>1 = Enabled                                                                 |

**Table 36 Direct Form 1 (DF1) Filtering**

**ADC RETUNE**


The ReTune function is part of both the ADC and the DAC Signal Enhancement paths. It can be enabled on either path independently. Unique coefficient sets are supported for each path.

ReTune™ is an advanced feature that is intended to perform frequency linearisation according to the particular needs of the application microphone, loudspeaker or housing. The ReTune algorithms can provide acoustic equalisation and selective phase (delay) control of specific frequency bands. In a typical application, ReTune™ is used to flatten the response across the audio frequency band. ReTune™ can also be configured to achieve other response patterns if required.

Note that, when using ReTune™ to boost any frequency band, it is recommended to take care not to introduce distortion, taking into account the gain that may be applied by other audio enhancement functions.

Before ReTune™ is enabled, it must be initialised and configured using the DSP2\_ENA bit described in Table 37. Note that this bit only needs to be enabled once before using any or all of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass.

Note that specific sequences must be followed when enabling or configuring ADC ReTune, DAC ReTune, DAC HPF, VSS, and HD Bass sound enhancement functions (see “Enable Sequence - Enhancements Initially Disabled”).

The ReTune function is enabled on the ADC path using the RTN\_ADC\_ENA register bit as described in Table 37. Under default conditions, the Left and Right channels each use unique tuning coefficients. When the ADC\_RETUNE\_SCV register is set, then both channels are controlled by the Right channel coefficients.

For the derivation of ADC ReTune configuration parameters in registers R17920 to R19007, the Cirrus WISCE™ software must be used to analyse the requirements of the application (refer to WISCE™ for further information.) If desired, one or more sets of register coefficients might be derived for different operating scenarios, and these may be recalled and written to the CODEC registers as required in the target application. The ADC ReTune configuration procedure involves the generation and analysis of test signals as outlined below. Note that DSP2\_ENA must be enabled before there is any type of access of any of the parameters associated with ADC ReTune.

To determine the characteristics of the microphone in an application, a test signal is applied to a loudspeaker that is in the acoustic path to the microphone. The received signal through the application microphone is analysed and compared with the received signal from a reference microphone in order to determine the characteristics of the application microphone.

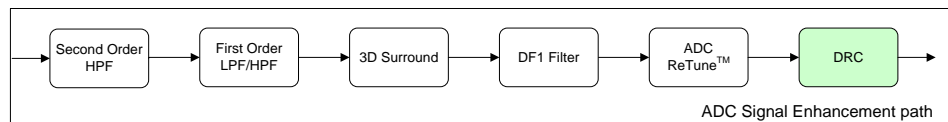
Note that the ReTune configuration coefficients are specific to a particular speaker or microphone; it is therefore required that the part-to-part variation in these components is small.

ADC ReTune is controlled using the register bits as described in Table 37.

| REGISTER ADDRESS                           | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                                                                                                                                  |
|--------------------------------------------|-----|----------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R768 (R300h)<br>DSP2 Power Management      | 0   | DSP2_ENA       | 0       | DSP2 Audio Processor Enable.<br>0 = Disabled<br>1 = Enabled<br>This bit must be set before any of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass is enabled. It must remain set whenever any of these functions is enabled. |
| R16384 (4000h)<br>RETUNEADC_SHARED_COEFF_1 | 7   | ADC_RETUNE_SCV | 0       | ADC ReTune Coefficient sharing<br>0 = Left and Right channels each use unique coefficients<br>1 = Both channels use the Right Channel coefficients                                                                           |
| R16389 (4005h)<br>SOUNDSTAGE_ENABLES_0     | 5   | RTN_ADC_ENA    | 0       | ADC ReTune enable<br>0 = disabled<br>1 = enabled                                                                                                                                                                             |

**Table 37 ADC ReTune Enable**

#### DYNAMIC RANGE CONTROL (DRC)



The dynamic range controller (DRC) is a circuit that can be enabled in either the digital record (ADC) or the digital playback (DAC) path of the WM8962B. Note that the DRC cannot be enabled in both signal paths at the same time.

The function of the DRC is to adjust the signal gain in conditions where the input amplitude is unknown or varies over a wide range, e.g. when recording from microphones built into a handheld system.

The DRC can apply Compression and Automatic Level Control to the signal path. It incorporates 'anti-clip' and 'quick release' features for handling transients in order to improve intelligibility in the presence of loud impulsive noises.

The DRC also incorporates a Noise Gate function, which provides additional attenuation of very low-level input signals. This means that the signal path is quiet when no signal is present, giving an improvement in background noise level under these conditions.

The DRC is enabled using DRC\_ENA, as described in Table 38. The DRC is selected in the ADC signal path by setting DRC\_MODE = 0.

| REGISTER ADDRESS      | BIT | LABEL    | DEFAULT | DESCRIPTION                                     |
|-----------------------|-----|----------|---------|-------------------------------------------------|
| R276 (0114h)<br>DRC 1 | 1   | DRC_MODE | 0       | DRC path select<br>0 = ADC path<br>1 = DAC path |
|                       | 0   | DRC_ENA  | 0       | DRC Enable<br>0 = Disabled<br>1 = Enabled       |

**Table 38 DRC Mode and Enable**

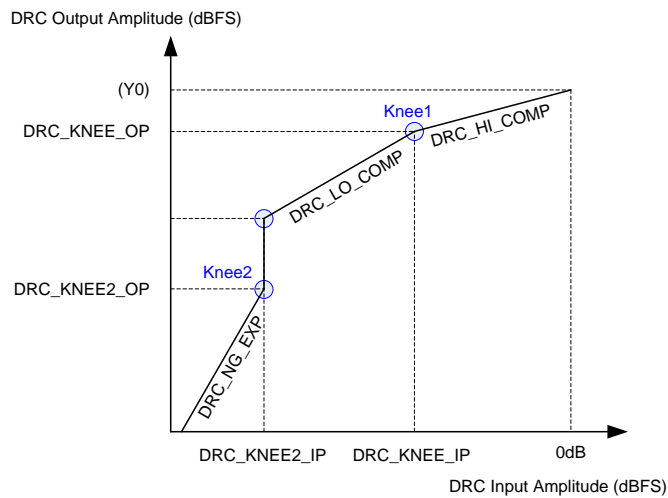
**DRC COMPRESSION / EXPANSION / LIMITING**

The DRC supports two different compression regions, separated by a “Knee” at a specific input amplitude. In the region above the knee, the compression slope DRC\_HI\_COMP applies; in the region below the knee, the compression slope DRC\_LO\_COMP applies.

The DRC also supports a noise gate region, where low-level input signals are heavily attenuated. This function can be enabled or disabled according to the application requirements. The DRC response in this region is defined by the expansion slope DRC\_NG\_EXP.

For additional attenuation of signals in the noise gate region, an additional “knee” can be defined (shown as “Knee2” in Figure 28). When this knee is enabled, this introduces an infinitely steep drop-off in the DRC response pattern between the DRC\_LO\_COMP and DRC\_NG\_EXP regions.

The overall DRC compression characteristic in “steady state” (i.e. where the input amplitude is near-constant) is illustrated in Figure 28.



**Figure 28 DRC Response Characteristic**

The slope of the DRC response is determined by register fields DRC\_HI\_COMP and DRC\_LO\_COMP. A slope of 1 indicates constant gain in this region. A slope less than 1 represents compression (i.e. a change in input amplitude produces only a smaller change in output amplitude). A slope of 0 indicates that the target output amplitude is the same across a range of input amplitudes; this is infinite compression.

When the noise gate is enabled, the DRC response in this region is determined by the DRC\_NG\_EXP register. A slope of 1 indicates constant gain in this region. A slope greater than 1 represents expansion (i.e. a change in input amplitude produces a larger change in output amplitude).

When the DRC\_KNEE2\_OP knee is enabled (“Knee2” in Figure 28), this introduces the vertical line in the response pattern illustrated, resulting in infinitely steep attenuation at this point in the response.

The DRC parameters are listed in Table 39.

| REF | PARAMETER    | DESCRIPTION                   |
|-----|--------------|-------------------------------|
| 1   | DRC_KNEE_IP  | Input level at Knee1 (dB)     |
| 2   | DRC_KNEE_OP  | Output level at Knee2 (dB)    |
| 3   | DRC_HI_COMP  | Compression ratio above Knee1 |
| 4   | DRC_LO_COMP  | Compression ratio below Knee1 |
| 5   | DRC_KNEE2_IP | Input level at Knee2 (dB)     |
| 6   | DRC_NG_EXP   | Expansion ratio below Knee2   |
| 7   | DRC_KNEE2_OP | Output level at Knee2 (dB)    |

**Table 39 DRC Response Parameters**

The noise gate is enabled when the DRC\_NG\_ENA register is set. When the noise gate is disabled, parameters 5, 6, and 7 above are ignored, and the DRC\_LO\_COMP slope applies to all input signal levels below Knee1.

The DRC\_KNEE2\_OP knee is enabled when the DRC\_KNEE2\_OP\_ENA register is set. When this bit is not set, then parameter 7 above is ignored, and the Knee2 position always coincides with the low end of the DRC\_LO\_COMP region.

The “Knee1” point in Figure 28 is determined by register fields DRC\_KNEE\_IP and DRC\_KNEE\_OP.

Parameter Y0, the output level for a 0dB input, is not specified directly, but can be calculated from the other parameters, using the equation:

$$Y0 = DRC\_KNEE\_OP - (DRC\_KNEE\_IP \times DRC\_HI\_COMP)$$

The DRC Compression / Expansion / Limiting parameters are defined in Table 40.

| REGISTER ADDRESS      | BIT | LABEL             | DEFAULT | DESCRIPTION                                                                                                                                                                          |
|-----------------------|-----|-------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R276 (0114h)<br>DRC1  | 7   | DRC_NG_ENA        | 0       | DRC Noise Gate Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                 |
|                       | 4   | DRC_KNEE2_OP_ENA  | 0       | DRC_KNEE2_OP Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                   |
| R278 (0116h)<br>DRC 3 | 7:6 | DRC_NG_EXP [1:0]  | 00      | Noise Gate slope<br>00 = 1 (no expansion)<br>01 = 2<br>10 = 4<br>11 = 8                                                                                                              |
|                       | 5:3 | DRC_HI_COMP [2:0] | 011     | Compressor slope (upper region)<br>000 = 1 (no compression)<br>001 = 1/2<br>010 = 1/4<br>011 = 1/8 (default)<br>100 = 1/16<br>101 = 0 (ALC Mode)<br>110 = Reserved<br>111 = Reserved |
|                       | 2:0 | DRC_LO_COMP [2:0] | 000     | Compressor slope (lower region)<br>000 = 1 (no compression)<br>001 = 1/2<br>010 = 1/4<br>011 = 1/8<br>100 = 0<br>101 to 111 = Reserved                                               |



| REGISTER ADDRESS      | BIT  | LABEL                 | DEFAULT | DESCRIPTION                                                                                                                                                                                                        |
|-----------------------|------|-----------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R279 (0117h)<br>DRC 4 | 10:5 | DRC_KNEE_IP<br>[5:0]  | 000000  | Input signal level at the Compressor 'Knee'.<br>000000 = 0dB<br>000001 = -0.75dB<br>000010 = -1.5dB<br>... (-0.75dB steps)<br>111100 = -45dB<br>111101 to 111111 = Reserved                                        |
|                       | 4:0  | DRC_KNEE_OP<br>[4:0]  | 00000   | Output signal at the Compressor 'Knee'.<br>00000 = 0dB<br>00001 = -0.75dB<br>00010 = -1.5dB<br>... (-0.75dB steps)<br>11110 = -22.5dB<br>11111 = Reserved                                                          |
| R280 (0117h)<br>DRC 4 | 9:5  | DRC_KNEE2_IP<br>[4:0] | 00000   | Input signal level at the Noise Gate threshold 'Knee2'.<br>00000 = -36dB<br>00001 = -37.5dB<br>00010 = -39dB<br>... (-1.5dB steps)<br>11110 = -81dB<br>11111 = -82.5dB<br>Only applicable when<br>DRC_NG_ENA = 1.  |
|                       | 4:0  | DRC_KNEE2_OP<br>[4:0] | 00000   | Output signal at the Noise Gate threshold 'Knee2'.<br>00000 = -30dB<br>00001 = -31.5dB<br>00010 = -33dB<br>... (-1.5dB steps)<br>11110 = -75dB<br>11111 = -76.5dB<br>Only applicable when<br>DRC_KNEE2_OP_ENA = 1. |

**Table 40 DRC Control Registers**

**DRC GAIN LIMITS**

The minimum and maximum gain applied by the DRC is set by register fields DRC\_MINGAIN, DRC\_MAXGAIN and DRC\_NG\_MINGAIN. These limits can be used to alter the DRC response from that illustrated in Figure 28. If the range between maximum and minimum gain is reduced, then the extent of the dynamic range control is reduced.

The minimum gain in the Compression regions of the DRC response is set by DRC\_MINGAIN. The minimum gain in the Noise Gate region is set by DRC\_NG\_MINGAIN. The minimum gain limit prevents excessive attenuation of the signal path.

The maximum gain limit set by DRC\_MAXGAIN prevents quiet signals (or silence) from being excessively amplified.

| REGISTER ADDRESS      | BIT   | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                              |
|-----------------------|-------|----------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R277 (0115h)<br>DRC 2 | 4:2   | DRC_MINGAIN [2:0]    | 001     | Minimum gain the DRC can use to attenuate audio signals<br>000 = 0dB<br>001 = -12dB (default)<br>010 = -18dB<br>011 = -24dB<br>100 = -36dB<br>101to 111 = Reserved                                                                                                                                       |
|                       | 1:0   | DRC_MAXGAIN [1:0]    | 01      | Maximum gain the DRC can use to boost audio signals (dB)<br>00 = 12dB<br>01 = 18dB (default)<br>10 = 24dB<br>11 = 36dB                                                                                                                                                                                   |
| R278 (0116h)<br>DRC 3 | 15:12 | DRC_NG_MINGAIN [3:0] | 0000    | Minimum gain the DRC can use to attenuate audio signals when the noise gate is active.<br>0000 = -36dB<br>0001 = -30dB<br>0010 = -24dB<br>0011 = -18dB<br>0100 = -12dB<br>0101 = -6dB<br>0110 = 0dB<br>0111 = 6dB<br>1000 = 12dB<br>1001 = 18dB<br>1010 = 24dB<br>1011 = 30dB<br>1100 to 1111 = Reserved |

**Table 41 DRC Gain Limits**

**DRC DYNAMIC CHARACTERISTICS**

The dynamic behaviour determines how quickly the DRC responds to changing signal levels. Note that the DRC responds to the average (RMS) signal amplitude over a period of time.

The DRC\_ATK determines how quickly the DRC gain decreases when the signal amplitude is high. The DRC\_DCY determines how quickly the DRC gain increases when the signal amplitude is low.

These register fields are described in Table 16. Note that the register defaults are suitable for general purpose microphone use.

| REGISTER ADDRESS              | BIT  | LABEL         | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                    |
|-------------------------------|------|---------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R277 (0115h)<br>DRC Control 2 | 12:9 | DRC_ATK [3:0] | 0100    | Gain attack rate (seconds/6dB)<br>0000 = Reserved<br>0001 = 181us<br>0010 = 363us<br>0011 = 726us<br>0100 = 1.45ms<br>0101 = 2.9ms<br>0110 = 5.8ms<br>0111 = 11.6ms<br>1000 = 23.2ms<br>1001 = 46.4ms<br>1010 = 92.8ms<br>1011 = 185.6ms<br>1100-1111 = Reserved                                               |
|                               | 8:5  | DRC_DCY [3:0] | 1001    | Gain decay rate (seconds/6dB)<br>0000 = 1.45ms<br>0001 = 2.9ms<br>0010 = 5.8ms<br>0011 = 11.6ms<br>0100 = 23.25ms<br>0101 = 46.5ms<br>0110 = 93ms<br>0111 = 186ms<br>1000 = 372ms<br>1001 = 743ms (default)<br>1010 = 1.49s<br>1011 = 2.97s<br>1100 = 5.94s<br>1101 = 11.89s<br>1110 = 23.78s<br>1111 = 47.56s |

**Table 42 DRC Time Constants**

**DRC ANTI-CLIP CONTROL**

The DRC includes an Anti-Clip feature to avoid signal clipping when the input amplitude rises very quickly. This feature uses a feed-forward technique for early detection of a rising signal level. Signal clipping is avoided by dynamically increasing the gain attack rate when required. The Anti-Clip feature is enabled using the DRC\_ANTICLIP bit.

Note that the feed-forward processing increases the latency in the input signal path. The DRC Anti-Clip control is described in Table 43.

| REGISTER ADDRESS              | BIT | LABEL        | DEFAULT | DESCRIPTION                                         |
|-------------------------------|-----|--------------|---------|-----------------------------------------------------|
| R276 (0114h)<br>DRC Control 1 | 2   | DRC_ANTICLIP | 1       | DRC Anti-clip Enable<br>0 = Disabled<br>1 = Enabled |

**Table 43 DRC Anti-Clip Control**

Note that the Anti-Clip feature operates entirely in the digital domain. It cannot be used to prevent signal clipping in the analogue domain nor in the source signal. Analogue clipping can only be prevented by reducing the analogue signal gain or by adjusting the source signal.

**DRC QUICK-RELEASE CONTROL**

The DRC includes a Quick-Release feature to handle short transient peaks that are not related to the intended source signal. For example, in handheld microphone recording, transient signal peaks sometimes occur due to user handling, key presses or accidental tapping against the microphone. The Quick Release feature ensures that these transients do not cause the intended signal to be masked by the longer time constants of DRC\_DCY.

The Quick-Release feature is enabled by setting the DRC\_QR bit. When this bit is enabled, the DRC measures the crest factor (peak to RMS ratio) of the input signal. A high crest factor is indicative of a transient peak that may not be related to the intended source signal. If the crest factor exceeds the level set by DRC\_QR\_THR, then the normal decay rate (DRC\_DCY) is ignored and a faster decay rate (DRC\_QR\_DCY) is used instead.

The DRC Quick-Release control bits are described in Table 44.

| REGISTER ADDRESS      | BIT   | LABEL               | DEFAULT | DESCRIPTION                                                                                              |
|-----------------------|-------|---------------------|---------|----------------------------------------------------------------------------------------------------------|
| R276 (0114h)<br>DRC 1 | 3     | DRC_QR              | 1       | DRC Quick-release Enable<br>0 = Disabled<br>1 = Enabled                                                  |
| R278 (0116h)<br>DRC 3 | 11:10 | DRC_QR_THR<br>[1:0] | 00      | DRC Quick-release threshold (crest factor in dB)<br>00 = 12dB<br>01 = 18dB<br>10 = 24dB<br>11 = 30dB     |
|                       | 9:8   | DRC_QR_DCY<br>[1:0] | 00      | DRC Quick-release decay rate (seconds/6dB)<br>00 = 0.725ms<br>01 = 1.45ms<br>10 = 5.8ms<br>11 = reserved |

**Table 44 DRC Quick-Release Control**

**DRC SIGNAL ACTIVITY DETECT**

The DRC incorporates a configurable signal detect function, allowing the signal level at the DRC input to be monitored and to be used to trigger other events. This can be used to detect the presence of a microphone signal on an ADC channel, or can be used to detect an audio signal received over the digital audio interface.

The Peak signal level or the RMS signal level of the DRC input can be selected as the detection threshold. When the threshold condition is exceeded, an interrupt or GPIO output can be generated. See “General Purpose Input/Output (GPIO)” and “Interrupts” for further details.

When the DRC is enabled, then signal activity detection can be enabled by setting the DRC\_SIG\_DET register bit. The applicable threshold can be defined either as a Peak level (Crest Factor) or an RMS level, depending on the DRC\_SIG\_DET\_MODE register bit. When Peak level is selected, the threshold is determined by DRC\_SIG\_DET\_PK, which defines the applicable Crest Factor (Peak to RMS ratio) threshold. If RMS level is selected, then the threshold is set using DRC\_SIG\_DET\_RMS. These register fields are described in Table 45.

| REGISTER ADDRESS     | BIT   | LABEL                 | DEFAULT | DESCRIPTION                                                                                                                                                                                                            |
|----------------------|-------|-----------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R276 (0114h)<br>DRC1 | 14:10 | DRC_SIG_DET_RMS [4:0] | 00000   | DRC Signal Detect RMS Threshold. This is the RMS signal level for signal detect to be indicated when DRC_SIG_DET_MODE=1.<br>00000 = -27dB<br>00001 = -28.5dB<br>.... (1.5dB steps)<br>11110 = -72dB<br>11111 = -73.5dB |
|                      | 9:8   | DRC_SIG_DET_PK [1:0]  | 00      | DRC Signal Detect Peak Threshold. This is the Peak/RMS ratio, or Crest Factor, level for signal detect to be indicated when DRC_SIG_DET_MODE=0.<br>00 = 14dB<br>01 = 20dB<br>10 = 26dB<br>11 = 32dB                    |
|                      | 6     | DRC_SIG_DET_MODE      | 0       | DRC Signal Detect Mode<br>0 = Peak threshold mode<br>1 = RMS threshold mode                                                                                                                                            |
|                      | 5     | DRC_SIG_DET           | 0       | DRC Signal Detect Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                |

**Table 45 DRC Signal Activity Detect GPIO/Interrupt Control**

**DIGITAL MIXING**

The ADC and DAC data can be combined in various ways to support a range of different usage modes.

Under default conditions, data from the Left and Right ADCs is routed to the Left and Right channels respectively of the digital audio interface. The channels can be swapped if required and digital inversion of either signal is also possible. See “Digital Audio Interface” for more information on the audio interface.

By default, the Left and Right input channels of the digital audio interface are routed to the Left and Right DACs respectively on the WM8962B. The channels can be swapped if required and digital inversion of either signal is also possible.

A mono mix of the two audio channels into a single DAC can be selected, as described in the “Digital-to-Analogue Converter (DAC)” section.

Digital sidetone from the ADCs can also be selectively mixed into the DAC output path, as described later in this section.

**DIGITAL MIXING PATHS**

Figure 29 shows the digital mixing paths available in the WM8962B digital core.

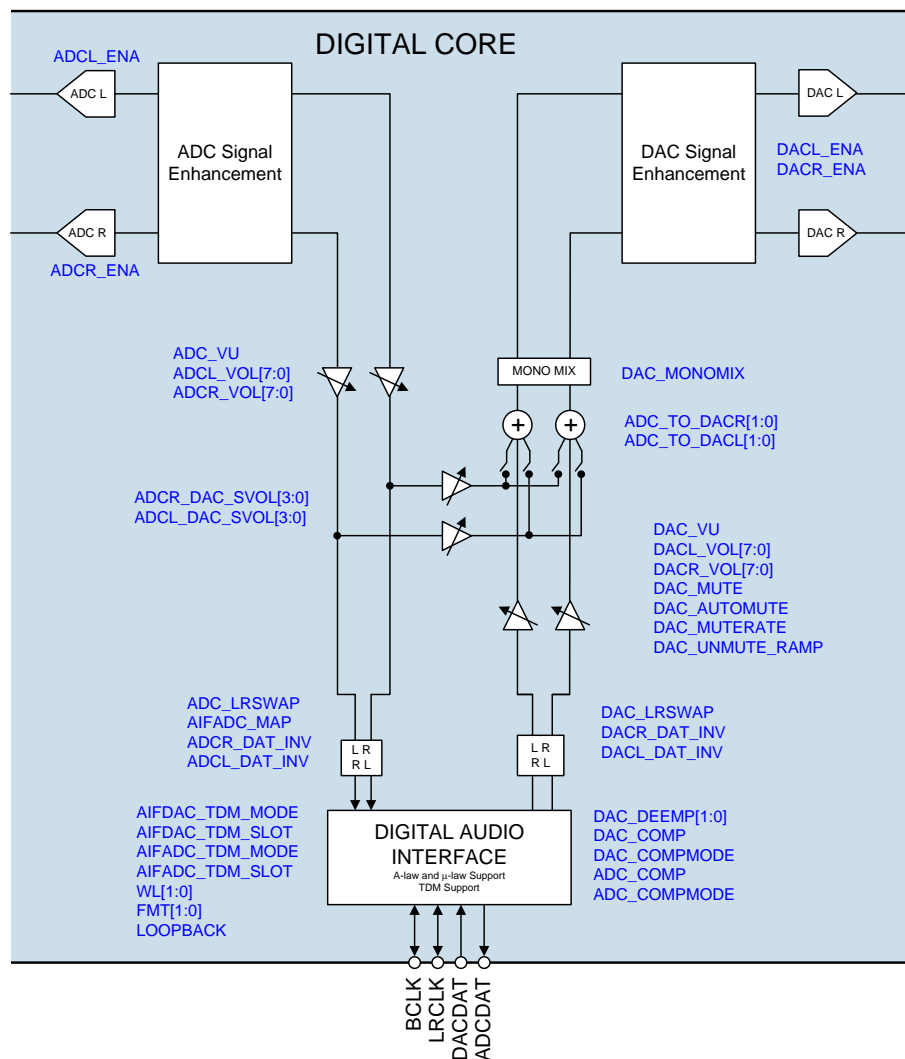


Figure 29 Digital Mixing Paths

The polarity of each ADC output signal can be changed under software control using the ADCR\_DAT\_INV and ADCL\_DAT\_INV register bits. The ADC\_LRSWAP register bit may be used to swap the left and right digital audio interface data. These register bits are described in Table 46.

| REGISTER ADDRESS                   | BIT | LABEL        | DEFAULT | DESCRIPTION                                                                            |
|------------------------------------|-----|--------------|---------|----------------------------------------------------------------------------------------|
| R5 (05h)<br>ADC & DAC<br>Control 1 | 6   | ADCR_DAT_INV | 0       | Right ADC Invert<br>0 = Right ADC output not inverted<br>1 = Right ADC output inverted |
|                                    | 5   | ADCL_DAT_INV | 0       | Left ADC Invert<br>0 = Left ADC output not inverted<br>1 = Left ADC output inverted    |
| R7 (07h)<br>Audio<br>Interface 0   | 8   | ADC_LRSWAP   | 0       | Swap left/right ADC data on the interface<br>0 = Normal<br>1 = ADCDAT channels swapped |

**Table 46 ADC Routing and Control**

The input data source for each DAC can be controlled using the DAC\_LRSWAP register bit; this swaps the left and right channel input data within the digital audio interface. The polarity of each DAC input may also be modified using register bits DACR\_DAT\_INV and DACL\_DAT\_INV. These register bits are described in Table 47.

| REGISTER ADDRESS                   | BIT | LABEL        | DEFAULT | DESCRIPTION                                                                            |
|------------------------------------|-----|--------------|---------|----------------------------------------------------------------------------------------|
| R6 (06h)<br>ADC & DAC<br>Control 2 | 6   | DACR_DAT_INV | 0       | Right DAC Invert<br>0 = Right DAC input not inverted<br>1 = Right DAC input inverted   |
|                                    | 5   | DACL_DAT_INV | 0       | Left DAC Invert<br>0 = Left DAC input not inverted<br>1 = Left DAC input inverted      |
| R7 (07h)<br>Audio<br>Interface 0   | 5   | DAC_LRSWAP   | 0       | Swap left/right DAC data on the interface<br>0 = Normal<br>1 = DACDAT channels swapped |

**Table 47 DAC Routing and Control**

### DIGITAL SIDETONE

Digital sidetone mixing (from ADC output into DAC input) is available. Digital data from either left or right ADC can be mixed with the audio interface data on the left and right DAC channels. Sidetone data is taken from the ADC high-pass filter output, to reduce low frequency noise in the sidetone (e.g. wind noise or mechanical vibration).

When using the digital sidetone, it is recommended that the ADCs are enabled before un-muting the DACs to prevent pop noise. The DAC volumes and sidetone volumes should be set to an appropriate level to avoid clipping at the DAC input.

When digital sidetone is used, it is recommended that the Charge Pump operates in Register Control mode only (CP\_DYN\_PWR = 0). If Dynamic Control mode (CP\_DYN\_PWR = 1) is used, the headphone output may be clipped. See "Charge Pump" for details.

The digital sidetone is controlled as shown in Table 48.

| REGISTER ADDRESS                   | BIT | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                          |
|------------------------------------|-----|-------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------|
| R57 (39h)<br>DAC DSP<br>Mixing (1) | 7:4 | ADCR_DAC_SV<br>OL [3:0] | 0000    | Right ADC Digital Sidetone Volume<br>0000 = -36dB<br>0001 = -33dB<br>(... 3dB steps)<br>1011 = -3dB<br>11XX = 0dB<br>(See Table 49 for volume range) |
|                                    | 3:2 | ADC_TO_DACR<br>[1:0]    | 00      | Right DAC Digital Sidetone Source<br>00 = No sidetone<br>01 = Left ADC<br>10 = Right ADC<br>11 = No sidetone                                         |
| R58 (3Ah)<br>DAC DSP<br>Mixing (2) | 7:4 | ADCL_DAC_SV<br>OL [3:0] | 0000    | Left ADC Digital Sidetone Volume<br>0000 = -36dB<br>0001 = -33dB<br>(... 3dB steps)<br>1011 = -3dB<br>11XX = 0dB<br>(See Table 49 for volume range)  |
|                                    | 3:2 | ADC_TO_DACL<br>[1:0]    | 00      | Left DAC Digital Sidetone Source<br>00 = No sidetone<br>01 = Left ADC<br>10 = Right ADC<br>11 = No sidetone                                          |

**Table 48 Digital Sidetone Control**

The digital sidetone volume settings are shown in Table 49.

| ADCR_DAC_SVOL<br>OR<br>ADCL_DAC_SVOL | SIDETONE VOLUME |
|--------------------------------------|-----------------|
| 0000                                 | -36             |
| 0001                                 | -33             |
| 0010                                 | -30             |
| 0011                                 | -27             |
| 0100                                 | -24             |
| 0101                                 | -21             |
| 0110                                 | -18             |
| 0111                                 | -15             |
| 1000                                 | -12             |
| 1001                                 | -9              |
| 1010                                 | -6              |
| 1011                                 | -3              |
| 1100                                 | 0               |
| 1101                                 | 0               |
| 1110                                 | 0               |
| 1111                                 | 0               |

**Table 49 Digital Sidetone Volume**



**T-LOOPBACK**

The T-Loopback function provides a specialised mode for use in communications applications such as VOIP handset configurations. The T-Loopback configuration provides a mono ADC and mono DAC signal to be output via the Digital Audio Interface transmit path. This allows Acoustic Echo Cancellation to be performed using difference algorithms implemented on an external processor.

T-Loopback is enabled by setting the TLB\_ENA register bit, as described in Table 51.

When T-Loopback is enabled, the Digital Audio Interface outputs are configured according to the TLB\_MODE bit, as described below.

| DESCRIPTION  | LEFT AIF OUTPUT          | RIGHT AIF OUTPUT         |
|--------------|--------------------------|--------------------------|
| TLB_MODE = 0 | Left ADC                 | (Left DAC + Right DAC)/2 |
| TLB_MODE = 1 | (Left DAC + Right DAC)/2 | Right ADC                |

**Table 50 T-Loopback Mode Select**

Note that the Left ADC and Right ADC signals can be digitally mixed, if required. This enables the sum of the Left and Right ADC channels to be output in T-Loopback. The ADC Monomix feature is described in the “ADC Monomix” section.

Note that the Left DAC and Right DAC signals used in the T-Loopback are also controlled by the DAC Digital Volume controls (see “Digital-to-Analogue Converter (DAC)”). It is possible to output just a single DAC channel in T-Loopback mode by setting the Digital Volume to zero in the unwanted channel.

The register bits associated with T-Loopback are described in Table 51.

| REGISTER ADDRESS          | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                                             |
|---------------------------|-----|----------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R285 (011Dh)<br>Tloopback | 1   | TLB_ENA  | 0       | T-Loopback Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                        |
|                           | 0   | TLB_MODE | 0       | T-Loopback Mode Select<br>0: Left AIF Output = Left ADC; Right AIF Output = (Left DAC + Right DAC) / 2<br>1: Left AIF Output = (Left DAC + Right DAC) / 2; Right AIF Output = Right ADC |

**Table 51 T-Loopback Control**

The signal paths when T-Loopback is enabled (TLB\_ENA = 1) are illustrated in Figure 30.

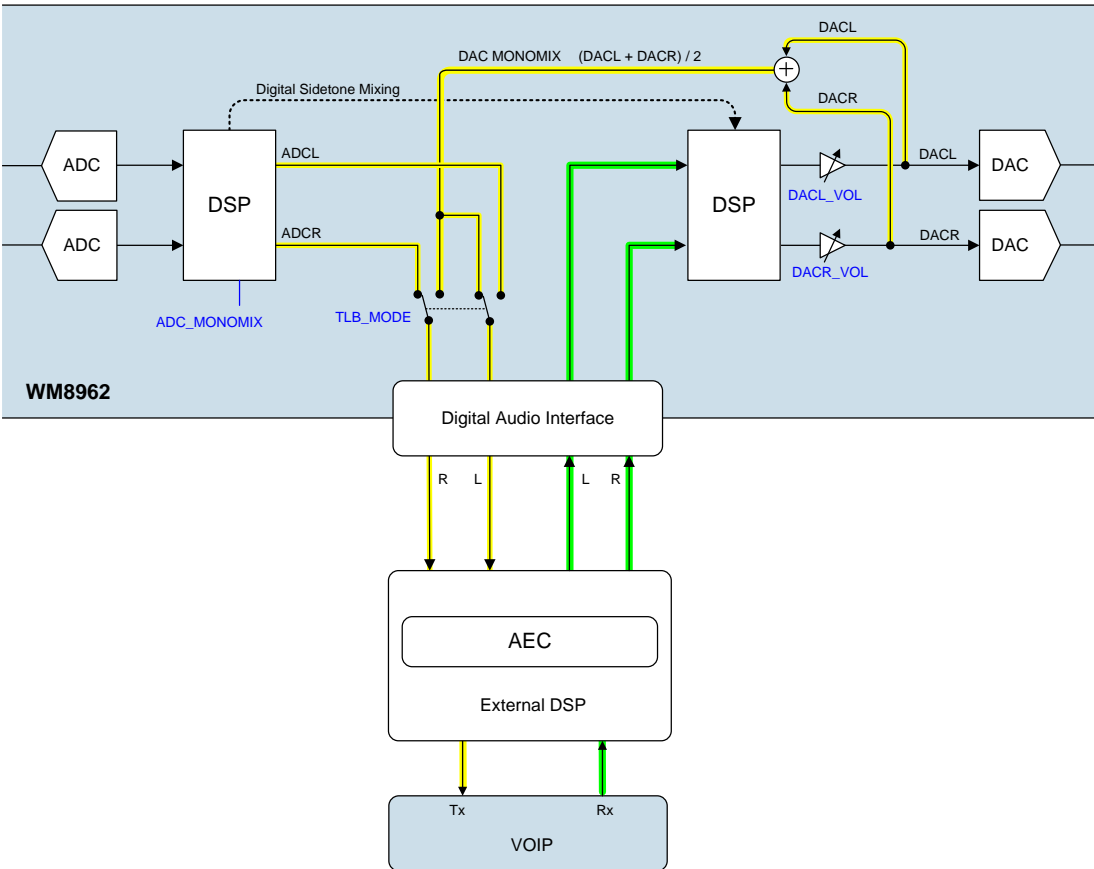
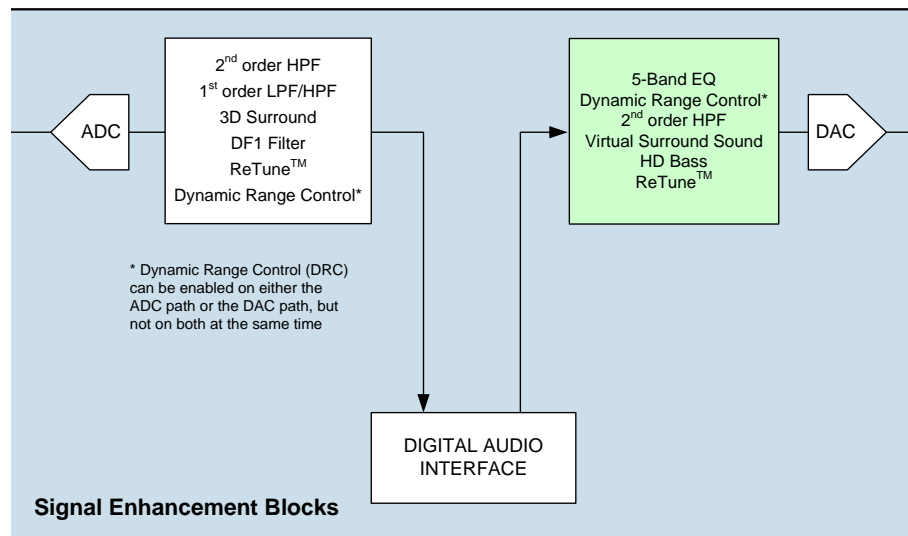


Figure 30 T-Loopback Signal Paths

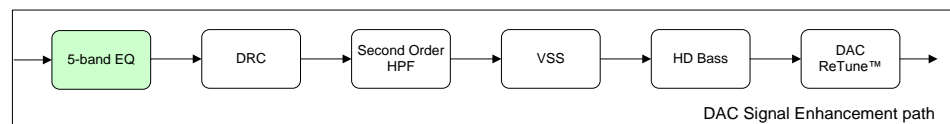
## DAC SIGNAL PATH ENHANCEMENTS

The DAC signal path incorporates a number of sound enhancement features, as illustrated in Figure 31. These features are described more fully in the following sections.



**Figure 31 DAC Signal Enhancements**

### 5-BAND EQ



The 5-band EQ function is implemented in the DAC Signal Enhancement path.

The 5-band EQ can be used to support user preferences for different music types, such as allowing selection of 'rock', 'dance', 'classical' or other user-defined EQ profiles. The 5-band EQ can also be used to provide compensation for imperfect characteristics of other components in the audio chain, such as the loudspeaker in portable applications in particular.

Note that the functionality of the 5-band EQ has similarities to some of the other DAC signal enhancements; it is important to select the most appropriate processing block for each requirement. The 5-band EQ provides a basic level of signal control, whilst the other enhancements can provide superior performance in many cases.

Frequency compensation of loudspeakers and other components can be implemented using the DAC ReTune function, which provides a more powerful capability to normalise the frequency response; this is achieved through the use of calibrated measurement procedures. The 5-band EQ provides a simpler and coarser type of signal control.

Reduction of bass frequencies (removing signal content that the speaker is unable to reproduce) can be implemented using the 2<sup>nd</sup> order High Pass Filter (DAC HPF); this provides greater attenuation of the bass frequencies, without affecting the desired pass-band.

Enhancement of bass frequencies (compensation for poor sensitivity in headphones or loudspeakers at low frequencies) can be implemented using the HD Bass function; this is a more intelligent and adaptive audio enhancement than the 5-band EQ.

Note that, when using the 5-band EQ to boost any frequency band, it is recommended to take care not to introduce distortion, taking into account the gain that may be applied by other audio enhancement functions.

The 5-band EQ allows the gain within five frequency bands to be controlled. The upper and lower frequency bands are controlled by low-pass and high-pass filters respectively. The middle three frequency bands are notch filters.

The 5-band EQ is enabled by setting the EQ\_ENA register as described in Table 53.

In default mode, the cut-off / centre frequencies are fixed as described in Table 52. The filter bandwidths are also fixed in this mode. The gain of the individual bands (-12dB to +12dB) can be controlled as described in Table 54.

The cut-off / centre frequencies noted in Table 52 are applicable to a sample rate of 48kHz. Note that, when using other sample rates, these frequencies will be scaled in proportion to the selected sample rate (see “Clocking and Sample Rates”).

| EQ BAND | CUT-OFF/CENTRE FREQUENCY |
|---------|--------------------------|
| 1       | 100 Hz                   |
| 2       | 300 Hz                   |
| 3       | 875 Hz                   |
| 4       | 2400 Hz                  |
| 5       | 6900 Hz                  |

**Table 52 EQ Band Cut-off / Centre Frequencies**

The gain for each of the five EQ bands on each of the channels is individually programmable using the register bits described in Table 53. The gain in each band on each channel is controllable in 1dB steps from -12dB to +12dB.

The 5-band EQ can be configured for both channels to use the same configuration settings; this is selected by setting the EQ\_SHARED\_COEFF register bit. When this bit is set, then the applicable coefficients are selected using EQ\_SHARED\_COEFF\_SEL; it is possible to select either the left or right channel coefficients.

It is also possible for the user to define the cut-off/centre frequencies and the filter bandwidth for each EQ band, in addition to the gain controls already defined. This enables the EQ to be accurately customised for a specific transducer characteristic or desired sound profile.

For the derivation of the 5-Band EQ configuration parameters in registers R338 to R355 (Left channel) and R358 to R375 (Right channel), refer to the WISCE™ configuration tool supplied with the WM8962B Evaluation Kit.

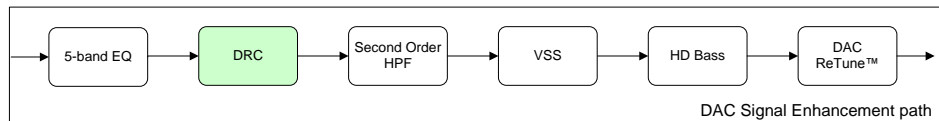
| REGISTER ADDRESS    | BIT   | LABEL               | DEFAULT | DESCRIPTION                                                                                                                                                          |
|---------------------|-------|---------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R335 (014Fh)<br>EQ1 | 2     | EQ_SHARED_COEFF     | 1       | 5-Band EQ Shared Coefficient enable<br>0 = Right and Left channels use unique coefficients<br>1 = Left and right channels share filter coefficients                  |
|                     | 1     | EQ_SHARED_COEFF_SEL | 0       | 5-Band EQ Shared Coefficient select<br>0 = Both channels use the left channel filter coefficients<br>1 = Both channels use the right channel filter coefficients     |
|                     | 0     | EQ_ENA              | 0       | 5-Band EQ Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                      |
| R336 (0150h)<br>EQ2 | 15:11 | EQL_B1_GAIN[4:0]    | 01100   | Left Channel Band 1 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved<br>See Table 54 for the full range |
|                     | 10:6  | EQL_B2_GAIN[4:0]    | 01100   | Left Channel Band 2 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved<br>See Table 54 for the full range |

| REGISTER ADDRESS    | BIT   | LABEL            | DEFAULT | DESCRIPTION                                                                                                                                                           |
|---------------------|-------|------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                     | 5:1   | EQL_B3_GAIN[4:0] | 01100   | Left Channel Band 3 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved<br>See Table 54 for the full range  |
| R337 (0151h)<br>EQ2 | 15:11 | EQL_B4_GAIN[4:0] | 01100   | Left Channel Band 4 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved<br>See Table 54 for the full range  |
|                     | 10:6  | EQL_B5_GAIN[4:0] | 01100   | Left Channel Band 5 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved<br>See Table 54 for the full range  |
| R356 (0164h)<br>EQ2 | 15:11 | EQR_B1_GAIN[4:0] | 01100   | Right Channel Band 1 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved<br>See Table 54 for the full range |
|                     | 10:6  | EQR_B2_GAIN[4:0] | 01100   | Right Channel Band 2 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved<br>See Table 54 for the full range |
|                     | 5:1   | EQR_B3_GAIN[4:0] | 01100   | Right Channel Band 3 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved<br>See Table 54 for the full range |
| R357 (0165h)<br>EQ2 | 15:11 | EQR_B4_GAIN[4:0] | 01100   | Right Channel Band 4 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved<br>See Table 54 for the full range |
|                     | 10:6  | EQR_B5_GAIN[4:0] | 01100   | Right Channel Band 5 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved<br>See Table 54 for the full range |

**Table 53 5-Band EQ Control**

| 5-BAND EQ GAIN | GAIN (dB) | 5-BAND EQ GAIN   | GAIN (dB) |
|----------------|-----------|------------------|-----------|
| 0_0000         | -12       | 0_1101           | +1        |
| 0_0001         | -11       | 0_1110           | +2        |
| 0_0010         | -10       | 0_1111           | +3        |
| 0_0011         | -9        | 1_0000           | +4        |
| 0_0100         | -8        | 1_0001           | +5        |
| 0_0101         | -7        | 1_0010           | +6        |
| 0_0110         | -6        | 1_0011           | +7        |
| 0_0111         | -5        | 1_0100           | +8        |
| 0_1000         | -4        | 1_0101           | +9        |
| 0_1001         | -3        | 1_0110           | +10       |
| 0_1010         | -2        | 1_0111           | +11       |
| 0_1011         | -1        | 1_1000           | +12       |
| 0_1100         | 0         | 1_1001 to 1_1111 | Reserved  |

**Table 54 5-Band EQ Gain Range**

**DYNAMIC RANGE CONTROL (DRC)**


The dynamic range controller (DRC) is a circuit that can be enabled in either the digital record (ADC) or the digital playback (DAC) path of the WM8962B. Note that the DRC cannot be enabled in both signal paths at the same time.

The function of the DRC is to adjust the signal gain in conditions where the input amplitude is unknown or varies over a wide range, e.g. when recording from microphones built into a handheld system.

The DRC can apply Compression and Automatic Level Control to the signal path. It incorporates 'anti-clip' and 'quick release' features for handling transients in order to improve intelligibility in the presence of loud impulsive noises.

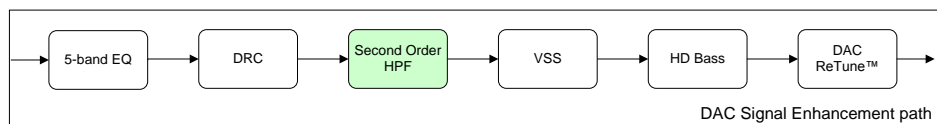
The DRC also incorporates a Noise Gate function, which provides additional attenuation of very low-level input signals. This means that the signal path is quiet when no signal is present, giving an improvement in background noise level under these conditions.

The DRC is enabled using DRC\_ENA, as described in Table 55. The DRC is selected in the DAC signal path by setting DRC\_MODE = 1.

Additional registers for configuring the DRC are described in the "ADC Signal Path Enhancements" section.

| REGISTER ADDRESS      | BIT | LABEL    | DEFAULT | DESCRIPTION                                     |
|-----------------------|-----|----------|---------|-------------------------------------------------|
| R276 (0114h)<br>DRC 1 | 1   | DRC_MODE | 0       | DRC path select<br>0 = ADC path<br>1 = DAC path |
|                       | 0   | DRC_ENA  | 0       | DRC Enable<br>0 = Disabled<br>1 = Enabled       |

**Table 55 DRC Mode and Enable**

**DAC SECOND ORDER HIGH-PASS FILTER**


The 2<sup>nd</sup> order High-Pass Filter (HPF) is part of the DAC Signal Enhancement path.

The DAC High-Pass filter is provided to remove DC offsets and low frequencies from the DAC signal path. This is an important function as DC offsets in the audio signal will reduce the signal headroom and increase power consumption. DC offsets and low frequency signals that are outside the capabilities of the loudspeaker will result in audible distortion and can cause damage to speakers or headphones.

The cut-off frequency of the DAC High-Pass filter should be set to attenuate the frequencies that the speaker cannot reproduce, but without unnecessarily removing higher frequencies that can be supported. The 2<sup>nd</sup> order cut-off slope of 12dB per octave provides good selectivity between the frequencies to be cut and the frequencies to be retained.

The DAC High-Pass filter is particularly recommended for use with the VSS, HD Bass and DAC ReTune functions in order to prevent distortion and speaker damage.

Before the DAC High-Pass filter is enabled, it must be initialised and configured using the DSP2\_ENA bit described in Table 56. Note that this bit only needs to be enabled once before using any or all of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass.

Note that specific sequences must be followed when enabling or configuring ADC ReTune, DAC ReTune, DAC HPF, VSS, and HD Bass sound enhancement functions (see “Enable Sequence - Enhancements Initially Disabled”).

The 2<sup>nd</sup> order High Pass Filter comprises two 1<sup>st</sup> order filters, which are enabled using the HPF1\_ENA and HPF2\_ENA register bits as described in Table 56. Either one of the filters, or both filters, may be enabled. Each filter provides a cut-off slope of 6dB per octave; when both filters are enabled together, the combined effect is a second-order filter, with a cut-off slope of 12dB per octave.

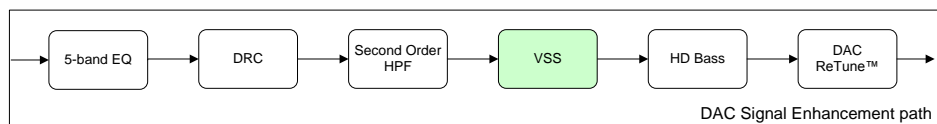
Note that the DAC high pass filters cannot be enabled unless one or more other sound enhancement functions is enabled. If HPF1\_ENA = 1 or HPF2\_ENA = 1, then at least one other of the enable bits in Register R16389 must also be set (ie. RTN\_ADC\_ENA, RTN\_DAC\_ENA, HDBASS\_ENA or VSS\_ENA).

For the derivation of the High-Pass Filter configuration parameters in registers R17408 and R17409, refer to the WISCE™ configuration tool supplied with the WM8962B Evaluation Kit. Note that both filters (HPF1 and HPF2) use the same configuration parameters.

| REGISTER ADDRESS                           | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                                                                                  |
|--------------------------------------------|-----|----------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R768 (R300h)<br>DSP2 Power Management      | 0   | DSP2_ENA | 0       | DSP2 Audio Processor Enable.<br>0 = Disabled<br>1 = Enabled<br>This bit must be set before any of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass is enabled. It must remain set whenever any of these functions is enabled. |
| R16389 (4005h)<br>SOUNDSTAGE<br>_ENABLES_0 | 2   | HPF2_ENA | 0       | High-Pass Filter (HPF2) enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                |
|                                            | 1   | HPF1_ENA | 0       | High Pass Filter (HPF1) enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                |

**Table 56 DAC High Pass Filter Enable**



**VIRTUAL SURROUND SOUND (VSS)**


The Virtual Surround Sound (VSS) function is part of the DAC Signal Enhancement path.

Virtual Sound Sound (VSS) is a digital processing function that creates a perception of wider speaker separation, generating a rich and immersive listening experience. It is aimed at portable applications, but is effective on larger systems also. Note that VSS is not suited to single-speaker systems, nor to headphone outputs.

Portable applications, where the speaker separation is small, suffer from significant acoustic crosstalk, where the Right speaker output is heard strongly in the Left ear, and vice versa. The VSS algorithms are designed to minimise these crosstalk effects, thus increasing the stereo experience. The VSS process is finely tuned to produce a compelling three-dimensional experience, but without the listening fatigue associated with some other stereo enhancement systems.

The VSS algorithms (and the user perception) are most effective at high frequencies; low frequency content is therefore configured to bypass the VSS crosstalk processing. The crossover frequency (for the low-frequency bypass) is adjustable, enabling the user to trade-off the stereo widening effect against the required degree of integrity in the original audio.

The VSS algorithms are programmable and can be optimised for specific application or user geometries. It is recommended to use the DAC HPF in conjunction with VSS in order to prevent distortion and speaker damage.

Before VSS is enabled, it must be initialised and configured using the DSP2\_ENA bit described in Table 57. Note that this bit only needs to be enabled once before using any or all of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass.

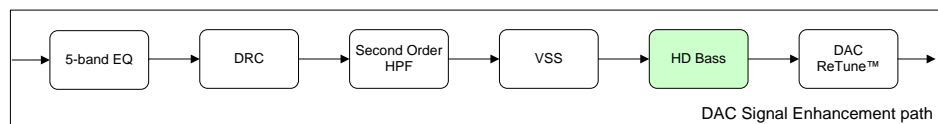
Note that specific sequences must be followed when enabling or configuring ADC ReTune, DAC ReTune, DAC HPF, VSS, and HD Bass sound enhancement functions (see “Enable Sequence - Enhancements Initially Disabled”).

VSS is enabled using the VSS\_ENA register bit as described in Table 57.

It is possible to configure the VSS function to create a stereo effect that is optimised and tailored specifically for a particular application. For the derivation of the VSS configuration parameters in registers R20992 to R21139, refer to the WISCE configuration tool supplied with the WM8962B Evaluation Kit. Note that DSP2\_ENA must be enabled before there is any type of access of any of the parameters associated with VSS.

| REGISTER ADDRESS                       | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                                                                                  |
|----------------------------------------|-----|----------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R768 (R300h)<br>DSP2 Power Management  | 0   | DSP2_ENA | 0       | DSP2 Audio Processor Enable.<br>0 = Disabled<br>1 = Enabled<br>This bit must be set before any of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass is enabled. It must remain set whenever any of these functions is enabled. |
| R16389 (4005h)<br>SOUNDSTAGE_ENABLES_0 | 0   | VSS_ENA  | 0       | Virtual Surround Sound (VSS) enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                           |

**Table 57 Virtual Surround Sound (VSS) Enable**

**HD BASS**


The HD Bass function is part of the DAC Signal Enhancement path.

HD Bass is a dynamic bass boost enhancement which is designed to improve the bass response of small speakers for portable applications in particular. It is also effective on larger speaker systems and on headphones if desired.

HD Bass provides an adaptive gain control of a narrow frequency band towards the low end of the audio spectrum. At low frequencies, where the loudspeaker response is poor, the HD Bass function applies gain in order to increase the bass content of the loudspeaker output. The amount of gain is controlled adaptively, to ensure that distortion is not introduced.

Note that fixed gain can be applied to bass frequencies using the 5-band EQ. The DRC can also apply gain to the DAC signal path. If these enhancements are used in conjunction with HD Bass, then it is important to limit the maximum gain of the 5-band EQ or DRC, to ensure that sufficient headroom is allowed for the HD Bass dynamic boost function.

It is recommended to use the DAC HPF in conjunction with HD Bass in order to prevent distortion and speaker damage.

Before HD Bass is enabled, it must be initialised and configured using the DSP2\_ENA bit described in Table 58. Note that this bit only needs to be enabled once before using any or all of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass.

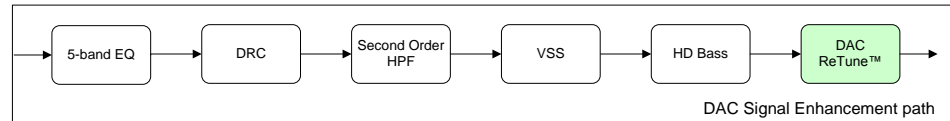
Note that specific sequences must be followed when enabling or configuring ADC ReTune, DAC ReTune, DAC HPF, VSS, and HD Bass sound enhancement functions (see “Enable Sequence - Enhancements Initially Disabled”).

HD Bass is enabled using the HDBASS\_ENA register bit as described in Table 58. HD Bass is pre-configured with a default set of parameters, but it is possible to select alternative settings.

For the derivation of the HD Bass configuration parameters in registers R16896 to R16925, refer to the WISCE configuration tool supplied with the WM8962B Evaluation Kit. Note that DSP2\_ENA must be enabled before there is any type of access of any of the parameters associated with HD Bass.

| REGISTER ADDRESS                       | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                                                                                                                                  |
|----------------------------------------|-----|------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R768 (R300h)<br>DSP2 Power Management  | 0   | DSP2_ENA   | 0       | DSP2 Audio Processor Enable.<br>0 = Disabled<br>1 = Enabled<br>This bit must be set before any of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass is enabled. It must remain set whenever any of these functions is enabled. |
| R16389 (4005h)<br>SOUNDSTAGE_ENABLES_0 | 3   | HDBASS_ENA | 0       | HD Bass enable<br>0 = HD Bass disabled<br>1 = HD Bass enabled                                                                                                                                                                |

**Table 58 HD Bass Control**

**DAC RETUNE**


The ReTune function is part of both the ADC and the DAC Signal Enhancement paths. It can be enabled on either path independently. Unique coefficient sets are supported for each path.

ReTune™ is an advanced feature that is intended to perform frequency linearisation according to the particular needs of the application microphone, loudspeaker or housing. The ReTune algorithms can provide acoustic equalisation and selective phase (delay) control of specific frequency bands. In a typical application, ReTune™ is used to flatten the response across the audio frequency band. ReTune™ can also be configured to achieve other response patterns if required.

It is particularly recommended to use ReTune™ to flatten the DAC signal path response when using the VSS or HD Bass functions. The signal processing algorithms of the VSS and HD Bass functions assume a flat system response, and the performance of these enhancements will be compromised if the speaker response is poor or uncalibrated.

Note that, when using ReTune™ to boost any frequency band, it is recommended to take care not to introduce distortion, taking into account the gain that may be applied by other audio enhancement functions.

It is recommended to use the DAC HPF in conjunction with DAC ReTune in order to prevent distortion and speaker damage.

Before ReTune™ is enabled, it must be initialised and configured using the DSP2\_ENA bit described in Table 59. Note that this bit only needs to be enabled once before using any or all of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass.

Note that specific sequences must be followed when enabling or configuring ADC ReTune, DAC ReTune, DAC HPF, VSS, and HD Bass sound enhancement functions (see “Enable Sequence - Enhancements Initially Disabled”).

The ReTune function is enabled on the DAC path using the RTN\_DAC\_ENA register bit as described in Table 59. Under default conditions, the Left and Right channels each use unique tuning coefficients. When the DAC\_RETUNE\_SCV register is set, then both channels are controlled by the Right channel coefficients.

For the derivation of DAC ReTune configuration parameters in registers R19456 to R20543, the Cirrus WISCE™ software must be used to analyse the requirements of the application (refer to WISCE for further information.) If desired, one or more sets of register coefficients might be derived for different operating scenarios, and these may be recalled and written to the CODEC registers as required in the target application. The DAC ReTune configuration procedure involves the generation and analysis of test signals as outlined below. Note that DSP2\_ENA must be enabled before there is any type of access of any of the parameters associated with DAC ReTune.

To determine the characteristics of the loudspeaker in an application, a test signal is applied to the target application. A reference microphone is positioned in the normal acoustic path of the loudspeaker, and the received signal is analysed to determine how accurately the loudspeaker has reproduced the test signal.

Note that the ReTune configuration coefficients are specific to a particular speaker or microphone; it is therefore required that the part-to-part variation in these components is small.

DAC ReTune is controlled using the register bits as described in Table 59.

| REGISTER ADDRESS                           | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                                                                                                                                  |
|--------------------------------------------|-----|----------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R768 (R300h)<br>DSP2 Power Management      | 0   | DSP2_ENA       | 0       | DSP2 Audio Processor Enable.<br>0 = Disabled<br>1 = Enabled<br>This bit must be set before any of ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass is enabled. It must remain set whenever any of these functions is enabled. |
| R16386 (4002h)<br>RETUNEDAC_SHARED_COEFF_1 | 7   | DAC_RETUNE_SCV | 0       | DAC ReTune Coefficient sharing<br>0 = Left and Right channels each use unique coefficients<br>1 = Both channels use the Right Channel coefficients                                                                           |
| R16389 (4005h)<br>SOUNDSTAGE_ENABLES_0     | 4   | RTN_DAC_ENA    | 0       | DAC ReTune enable<br>0 = disabled<br>1 = enabled                                                                                                                                                                             |

**Table 59 DAC ReTune Enable**

## DIGITAL-TO-ANALOGUE CONVERTER (DAC)

The WM8962B DACs receive digital input data from the digital audio interface. The digital audio data is converted to oversampled bit-streams in the on-chip, true 24-bit digital interpolation filters. The bit-stream data enters two multi-bit, sigma-delta DACs, which convert them to high quality analogue audio signals.

The DACs provide digital volume control with soft mute / un-mute. Digital mono mix and de-emphasis filtering is also supported.

The DACs are enabled by the DACL\_ENA and DACR\_ENA register bits.

| REGISTER ADDRESS          | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                       |
|---------------------------|-----|----------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R26 (1Ah)<br>Pwr Mgmt (2) | 8   | DACL_ENA | 0       | Left DAC Enable<br>0 = Disabled<br>1 = Enabled<br>Note that DACL_ENA must be set to 1 when processing left channel data from the DAC or Digital Beep Generator.   |
|                           | 7   | DACR_ENA | 0       | Right DAC Enable<br>0 = Disabled<br>1 = Enabled<br>Note that DACR_ENA must be set to 1 when processing right channel data from the DAC or Digital Beep Generator. |

**Table 60 DAC Enable Control**

### DAC CLOCKING CONTROL

Clocking for the DACs is derived from SYSCLK. The required clock is enabled when the SYSCLK\_ENA register is set.

The DAC clock rate is configured automatically, according to the SAMPLE\_RATE and MCLK\_RATE registers. See "Clocking and Sample Rates" for further details of the system clocks and associated control registers.

Note that the DAC and the DAC signal path enhancements functions are only supported under specific clocking configurations. The valid clocking ratios for DAC operation are identified in Table 96. See also Table 97 for details of the supported functions for different MCLK / fs ratios.

### DAC DIGITAL VOLUME CONTROL

The output level (digital volume) of each DAC can be controlled digitally over a range from -71.625dB to +23.625dB in 0.375dB steps. The level of attenuation for an eight-bit code X is given by:

$$0.375 \times (X-192) \text{ dB for } 1 \leq X \leq 255; \quad \text{MUTE for } X = 0$$

The DAC\_VU bit controls the loading of digital volume control data. When DAC\_VU is set to 0, the DACL\_VOL or DACR\_VOL control data will be loaded into the respective control register, but will not actually change the digital gain setting. Both left and right gain settings are updated when a 1 is written to DAC\_VU. This makes it possible to update the gain of both channels simultaneously.

See "DAC Digital Volume Control" section for a description of the volume update function, the zero cross function and the timeout operation.

| REGISTER ADDRESS              | BIT | LABEL          | DEFAULT   | DESCRIPTION                                                                                                                                                                                                 |
|-------------------------------|-----|----------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R10 (0Ah)<br>Left DAC volume  | 8   | DAC_VU         | N/A       | DAC Volume Update<br>Writing a 1 to this bit will cause left and right DAC volume to be updated simultaneously                                                                                              |
|                               | 7:0 | DACL_VOL [7:0] | C0h (0dB) | Left DAC Digital Volume Control<br>00h = Digital Mute<br>01h = -71.625dB<br>02h = -71.250dB<br>... 0.375dB steps up to<br>C0h = 0dB (default)<br>....<br>FFh = 23.625dB<br>(See Table 62 for volume range)  |
| R11 (0Bh)<br>Right DAC volume | 8   | DAC_VU         | N/A       | DAC Volume Update<br>Writing a 1 to this bit will cause left and right DAC volume to be updated simultaneously                                                                                              |
|                               | 7:0 | DACR_VOL [7:0] | C0h (0dB) | Right DAC Digital Volume Control<br>00h = Digital Mute<br>01h = -71.625dB<br>02h = -71.250dB<br>... 0.375dB steps up to<br>C0h = 0dB (default)<br>....<br>FFh = 23.625dB<br>(See Table 62 for volume range) |

**Table 61 Digital Volume Control**

| DACL_VOL or<br>DACR_VOL    Volume (dB) |         | DACL_VOL or<br>DACR_VOL    Volume (dB) |         | DACL_VOL or<br>DACR_VOL    Volume (dB) |         | DACL_VOL or<br>DACR_VOL    Volume (dB) |        |
|----------------------------------------|---------|----------------------------------------|---------|----------------------------------------|---------|----------------------------------------|--------|
| 00                                     | MUTE    | 40                                     | -48.000 | 80                                     | -24.000 | C0                                     | 0.000  |
| 01                                     | -71.625 | 41                                     | -47.625 | 81                                     | -23.625 | C1                                     | 0.375  |
| 02                                     | -71.250 | 42                                     | -47.250 | 82                                     | -23.250 | C2                                     | 0.750  |
| 03                                     | -70.875 | 43                                     | -46.875 | 83                                     | -22.875 | C3                                     | 1.125  |
| 04                                     | -70.500 | 44                                     | -46.500 | 84                                     | -22.500 | C4                                     | 1.500  |
| 05                                     | -70.125 | 45                                     | -46.125 | 85                                     | -22.125 | C5                                     | 1.875  |
| 06                                     | -69.750 | 46                                     | -45.750 | 86                                     | -21.750 | C6                                     | 2.250  |
| 07                                     | -69.375 | 47                                     | -45.375 | 87                                     | -21.375 | C7                                     | 2.625  |
| 08                                     | -69.000 | 48                                     | -45.000 | 88                                     | -21.000 | C8                                     | 3.000  |
| 09                                     | -68.625 | 49                                     | -44.625 | 89                                     | -20.625 | C9                                     | 3.375  |
| 0A                                     | -68.250 | 4A                                     | -44.250 | 8A                                     | -20.250 | CA                                     | 3.750  |
| 0B                                     | -67.875 | 4B                                     | -43.875 | 8B                                     | -19.875 | CB                                     | 4.125  |
| 0C                                     | -67.500 | 4C                                     | -43.500 | 8C                                     | -19.500 | CC                                     | 4.500  |
| 0D                                     | -67.125 | 4D                                     | -43.125 | 8D                                     | -19.125 | CD                                     | 4.875  |
| 0E                                     | -66.750 | 4E                                     | -42.750 | 8E                                     | -18.750 | CE                                     | 5.250  |
| 0F                                     | -66.375 | 4F                                     | -42.375 | 8F                                     | -18.375 | CF                                     | 5.625  |
| 10                                     | -66.000 | 50                                     | -42.000 | 90                                     | -18.000 | D0                                     | 6.000  |
| 11                                     | -65.625 | 51                                     | -41.625 | 91                                     | -17.625 | D1                                     | 6.375  |
| 12                                     | -65.250 | 52                                     | -41.250 | 92                                     | -17.250 | D2                                     | 6.750  |
| 13                                     | -64.875 | 53                                     | -40.875 | 93                                     | -16.875 | D3                                     | 7.125  |
| 14                                     | -64.500 | 54                                     | -40.500 | 94                                     | -16.500 | D4                                     | 7.500  |
| 15                                     | -64.125 | 55                                     | -40.125 | 95                                     | -16.125 | D5                                     | 7.875  |
| 16                                     | -63.750 | 56                                     | -39.750 | 96                                     | -15.750 | D6                                     | 8.250  |
| 17                                     | -63.375 | 57                                     | -39.375 | 97                                     | -15.375 | D7                                     | 8.625  |
| 18                                     | -63.000 | 58                                     | -39.000 | 98                                     | -15.000 | D8                                     | 9.000  |
| 19                                     | -62.625 | 59                                     | -38.625 | 99                                     | -14.625 | D9                                     | 9.375  |
| 1A                                     | -62.250 | 5A                                     | -38.250 | 9A                                     | -14.250 | DA                                     | 9.750  |
| 1B                                     | -61.875 | 5B                                     | -37.875 | 9B                                     | -13.875 | DB                                     | 10.125 |
| 1C                                     | -61.500 | 5C                                     | -37.500 | 9C                                     | -13.500 | DC                                     | 10.500 |
| 1D                                     | -61.125 | 5D                                     | -37.125 | 9D                                     | -13.125 | DD                                     | 10.875 |
| 1E                                     | -60.750 | 5E                                     | -36.750 | 9E                                     | -12.750 | DE                                     | 11.250 |
| 1F                                     | -60.375 | 5F                                     | -36.375 | 9F                                     | -12.375 | DF                                     | 11.625 |
| 20                                     | -60.000 | 60                                     | -36.000 | A0                                     | -12.000 | E0                                     | 12.000 |
| 21                                     | -59.625 | 61                                     | -35.625 | A1                                     | -11.625 | E1                                     | 12.375 |
| 22                                     | -59.250 | 62                                     | -35.250 | A2                                     | -11.250 | E2                                     | 12.750 |
| 23                                     | -58.875 | 63                                     | -34.875 | A3                                     | -10.875 | E3                                     | 13.125 |
| 24                                     | -58.500 | 64                                     | -34.500 | A4                                     | -10.500 | E4                                     | 13.500 |
| 25                                     | -58.125 | 65                                     | -34.125 | A5                                     | -10.125 | E5                                     | 13.875 |
| 26                                     | -57.750 | 66                                     | -33.750 | A6                                     | -9.750  | E6                                     | 14.250 |
| 27                                     | -57.375 | 67                                     | -33.375 | A7                                     | -9.375  | E7                                     | 14.625 |
| 28                                     | -57.000 | 68                                     | -33.000 | A8                                     | -9.000  | E8                                     | 15.000 |
| 29                                     | -56.625 | 69                                     | -32.625 | A9                                     | -8.625  | E9                                     | 15.375 |
| 2A                                     | -56.250 | 6A                                     | -32.250 | AA                                     | -8.250  | EA                                     | 15.750 |
| 2B                                     | -55.875 | 6B                                     | -31.875 | AB                                     | -7.875  | EB                                     | 16.125 |
| 2C                                     | -55.500 | 6C                                     | -31.500 | AC                                     | -7.500  | EC                                     | 16.500 |
| 2D                                     | -55.125 | 6D                                     | -31.125 | AD                                     | -7.125  | ED                                     | 16.875 |
| 2E                                     | -54.750 | 6E                                     | -30.750 | AE                                     | -6.750  | EE                                     | 17.250 |
| 2F                                     | -54.375 | 6F                                     | -30.375 | AF                                     | -6.375  | EF                                     | 17.625 |
| 30                                     | -54.000 | 70                                     | -30.000 | B0                                     | -6.000  | F0                                     | 18.000 |
| 31                                     | -53.625 | 71                                     | -29.625 | B1                                     | -5.625  | F1                                     | 18.375 |
| 32                                     | -53.250 | 72                                     | -29.250 | B2                                     | -5.250  | F2                                     | 18.750 |
| 33                                     | -52.875 | 73                                     | -28.875 | B3                                     | -4.875  | F3                                     | 19.125 |
| 34                                     | -52.500 | 74                                     | -28.500 | B4                                     | -4.500  | F4                                     | 19.500 |
| 35                                     | -52.125 | 75                                     | -28.125 | B5                                     | -4.125  | F5                                     | 19.875 |
| 36                                     | -51.750 | 76                                     | -27.750 | B6                                     | -3.750  | F6                                     | 20.250 |
| 37                                     | -51.375 | 77                                     | -27.375 | B7                                     | -3.375  | F7                                     | 20.625 |
| 38                                     | -51.000 | 78                                     | -27.000 | B8                                     | -3.000  | F8                                     | 21.000 |
| 39                                     | -50.625 | 79                                     | -26.625 | B9                                     | -2.625  | F9                                     | 21.375 |
| 3A                                     | -50.250 | 7A                                     | -26.250 | BA                                     | -2.250  | FA                                     | 21.750 |
| 3B                                     | -49.875 | 7B                                     | -25.875 | BB                                     | -1.875  | FB                                     | 22.125 |
| 3C                                     | -49.500 | 7C                                     | -25.500 | BC                                     | -1.500  | FC                                     | 22.500 |
| 3D                                     | -49.125 | 7D                                     | -25.125 | BD                                     | -1.125  | FD                                     | 22.875 |
| 3E                                     | -48.750 | 7E                                     | -24.750 | BE                                     | -0.750  | FE                                     | 23.250 |
| 3F                                     | -48.375 | 7F                                     | -24.375 | BF                                     | -0.375  | FF                                     | 23.625 |

**Table 62 DAC Digital Volume Range**

### DAC SOFT MUTE AND UN-MUTE

A signal can be muted and unmuted using the DAC\_MUTE register. The type of muting or unmuting performed (hard or soft) is controlled by the DAC\_MUTE\_RAMP and DAC\_UNMUTE\_RAMP registers.

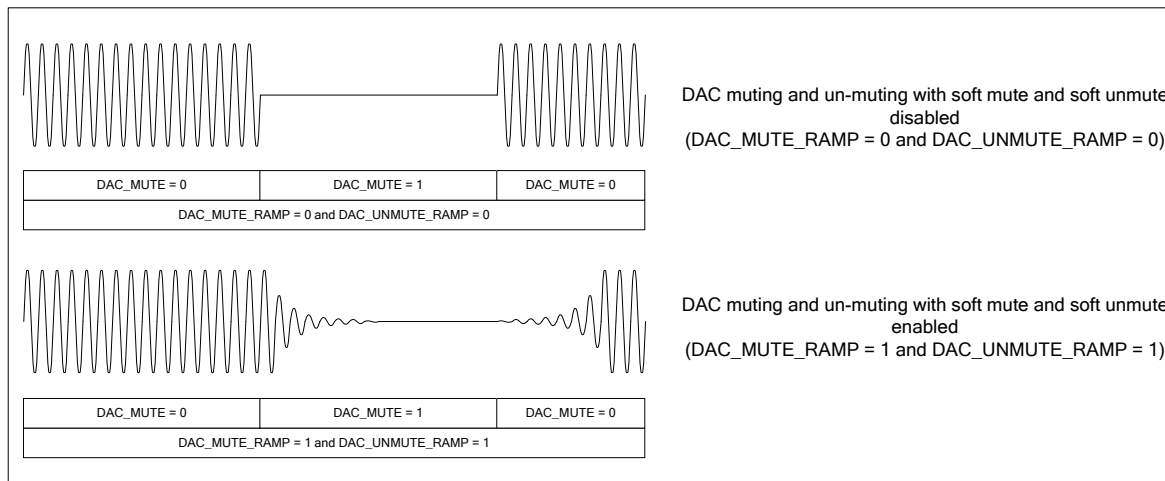
Note that the DAC is muted by default. To play back an audio signal, this function must first be disabled by setting the DAC\_MUTE bit to zero.

If DAC\_MUTE\_RAMP = 0 when a signal is muted, any muting of the output volume is instantaneous (a 'hard' mute). If DAC\_MUTE\_RAMP = 1 ('soft' mute), the signal is gradually attenuated until the volume of the digital signal reaches zero, as illustrated in Figure 32.

Similarly, the hard and soft unmute functions are controlled by the DAC\_UNMUTE\_RAMP register. If DAC\_UNMUTE\_RAMP = 0, the signal gain returns instantaneously to the current PGA gain setting. If DAC\_UNMUTE\_RAMP = 1, the signal is gradually boosted until the volume of the digital signal reaches the current PGA gain setting. This is illustrated in Figure 32.

DAC\_UNMUTE\_RAMP would typically be enabled when using soft mute during playback of audio data so that when mute is then disabled, the sudden volume increase will not create pop noise by jumping immediately to the previous volume level (e.g. resuming playback after pausing during a track).

DAC\_UNMUTE\_RAMP would typically be disabled when un-muting at the start of a digital music file, so that the first part of the track is not attenuated (e.g. when starting playback of a new track, or resuming playback after pausing between tracks).



**Figure 32 DAC Mute Control**

The volume ramp rate during soft mute and un-mute is controlled by the DAC\_MUTERATE bit as shown in Table 63.

| REGISTER ADDRESS                   | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                              |
|------------------------------------|-----|-----------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R5 (05h)<br>ADC & DAC<br>Control 1 | 4   | DAC_MUTE_RAMP   | 1       | DAC Soft Mute Control<br>0 = Muting the DAC<br>(DAC_MUTE = 1) will cause the volume to change immediately to mute.<br>1 = Muting the DAC<br>(DAC_MUTE = 1) will cause the volume to ramp down gradually to mute.                                                         |
|                                    | 3   | DAC_MUTE        | 1       | Digital DAC Mute<br>0 = Un-mute<br>1 = Mute<br><br>Note that this bit also exists in R49. Reading or writing to either location has the same effect.                                                                                                                     |
| R49 (31h)                          | 4   | DAC_MUTE        | 1       | Digital DAC Mute<br>0 = Un-mute<br>1 = Mute<br><br>Note that this bit also exists in R5. Reading or writing to either location has the same effect.                                                                                                                      |
| R6 (06h)<br>ADC & DAC<br>Control 2 | 3   | DAC_UNMUTE_RAMP | 1       | DAC Soft Unmute Control<br>0 = Unmuting the DAC<br>(DAC_MUTE = 0) will cause the volume to change immediately to the DACL_VOL/DACR_VOL settings.<br>1 = Unmuting the DAC<br>(DAC_MUTE = 0) will cause the volume to ramp up gradually to the DACL_VOL/DACR_VOL settings. |
|                                    | 2   | DAC_MUTERATE    | 0       | DAC Soft Mute Ramp Rate<br>0 = Fast ramp (maximum ramp time 10.7ms)<br>1 = Slow ramp (maximum ramp time 171ms).<br><br>Note that the ramp rate scales with sample rate (fs). Quoted values are correct for fs = 48kHz.                                                   |

**Table 63 DAC Soft-Mute Control**



### DAC AUTO-MUTE

The DAC digital mute and volume controls are described earlier in Table 61 and Table 63.

The DAC also incorporates a digital auto-mute monitor, which is enabled by setting DAC\_AUTOMUTE. When the auto-mute is enabled, and a number (DAC\_AUTOMUTE\_SAMPLES) of consecutive zero-samples is detected, the AUTOMUTE\_STS flag is asserted.

The WM8962B supports the option to automatically power-down the speaker path when the DAC Auto-Mute is triggered, and to re-enable the speaker path when audio data is detected. This feature has been designed to work around the Write Sequencer, which mutes and unmutes the speakers in a controlled manner using the Speaker Sleep (see Table 129) and Speaker Wake (see Table 130) write sequences. Auto-mute is enabled by setting the WSEQ\_AUTOSEQ\_ENA bit in Register R87. See Table 64 for details of this and other Auto-mute register bits.

The status of DAC Auto-Mute can be read back from the AUTOMUTE\_STS bit.

| REGISTER ADDRESS                       | BIT | LABEL                      | DEFAULT | DESCRIPTION                                                                                                                                                                  |
|----------------------------------------|-----|----------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R9 (09h)<br>Audio Interface 0          | 11  | AUTOMUTE_STS               | 0       | Readback of the DAC Automute status<br>0 = Automute not detected<br>1 = Automute detected                                                                                    |
|                                        | 9:8 | DAC_AUTOMUTE_SAMPLES [1:0] | 11      | Selects the number of consecutive zero DAC samples that will be interpreted as an Automute.<br>00 = 128 samples<br>01 = 256 samples<br>10 = 512 samples<br>11 = 1024 samples |
|                                        | 7   | DAC_AUTOMUTE               | 0       | DAC Auto-Mute Control<br>0 = Disabled<br>1 = Enabled                                                                                                                         |
| R87 (57h)<br>Write Sequencer Control 1 | 7   | WSEQ_AUTOSEQ_ENA           | 0       | Write Sequencer Auto-Sequence Enable (controls the Class D driver via DAC Auto-Mute function)<br>0 = Disabled<br>1 = Enabled                                                 |

**Table 64 DAC Auto Mute**

### DAC MONO MIX

A DAC digital mono-mix mode can be enabled using the DAC\_MONOMIX register bit. This mono mix will be output on whichever DAC is enabled. To prevent clipping, a -6dB attenuation is automatically applied to the mono mix.

The mono mix is only supported when one or other DAC is disabled. When the mono mix is selected, then the mono mix is output on the enabled DAC only; there is no output from the disabled DAC. If DACL\_ENA and DACR\_ENA are both set, then stereo operation applies.

| REGISTER ADDRESS               | BIT | LABEL       | DEFAULT | DESCRIPTION                                                                                                                                                                                       |
|--------------------------------|-----|-------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R57(39h)<br>DAC DSP Mixing (1) | 9   | DAC_MONOMIX | 0       | DAC Mono Mix<br>0 = Stereo<br>1 = Mono (Mono mix output on enabled DAC)<br>Mono Mix is only supported when one or other DAC is disabled.<br>When Mono mix is enabled, 6dB attenuation is applied. |

**Table 65 DAC Mono Mix**

**DAC DE-EMPHASIS**

Digital de-emphasis can be applied to the DAC playback data (e.g. when the data comes from a CD with pre-emphasis used in the recording). De-emphasis filtering is available for sample rates of 48kHz, 44.1kHz and 32kHz.

| REGISTER ADDRESS                   | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                                    |
|------------------------------------|-----|--------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R5 (05h)<br>ADC & DAC<br>Control 1 | 2:1 | DAC_DEEMP<br>[1:0] | 00      | De-Emphasis Control<br><br>00 = No de-emphasis<br>01 = De-emphasis for 32kHz sample rate<br>10 = De-emphasis for 44.1kHz sample rate<br>11 = De-emphasis for 48kHz sample rate |

**Table 66 DAC De-Emphasis Control**
**DAC OVERSAMPLING RATIO (OSR)**

The DAC oversampling rate is programmable to allow power consumption versus audio performance trade-offs. The default oversampling rate is low for reduced power consumption; using the higher OSR setting improves the DAC signal-to-noise performance.

See the “Reference Voltages and Bias Control” section for details of the supported bias control settings for the output signal paths.

| REGISTER ADDRESS                   | BIT | LABEL  | DEFAULT | DESCRIPTION                                                                                              |
|------------------------------------|-----|--------|---------|----------------------------------------------------------------------------------------------------------|
| R6 (06h)<br>ADC & DAC<br>Control 2 | 0   | DAC_HP | 0       | DAC Oversampling Ratio<br>0 = Low Power (typically 64 x fs)<br>1 = High Performance (typically 128 x fs) |

**Table 67 DAC Oversampling Control**

**DIGITAL BEEP GENERATOR**

The WM8962B provides a digital signal generator which can be used to inject an audio tone (beep) into the DAC signal path. The output of the beep generator is digitally mixed with the DAC outputs, after the DAC digital volume.

The beep is enabled using BEEP\_ENA. The beep function creates an approximation of a Sine wave. The audio frequency is set using BEEP\_RATE, and is dependent on the SAMPLE\_RATE\_INT\_MODE and the SAMPLE\_RATE settings (see “Clocking and Sample Rates” section). The beep volume is set using BEEP\_GAIN. Note that the volume of the digital beep generator is not affected by the DAC volume or DAC mute controls.

The digital beep generator control fields are described in Table 68.

| REGISTER ADDRESS                 | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                         |
|----------------------------------|-----|-----------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R110 (6Eh)<br>Beep Generator (1) | 7:4 | BEEP_GAIN [3:0] | 0000    | Digital Beep Volume Control<br>0000 = mute<br>0001 = -90dB<br>0010 = -84dB<br>... (6dB steps)<br>1111 = -6dB                                                                                                                                        |
|                                  | 2:1 | BEEP_RATE [1:0] | 01      | Digital Beep Waveform Control<br>If SAMPLE_RATE_INT_MODE = 1<br>00 = 500Hz<br>01 = 1000Hz<br>10 = 2000Hz<br>11 = 4000Hz<br>If SAMPLE_RATE_INT_MODE = 0<br>00 = 499Hz – 502Hz<br>01 = 999Hz – 1003Hz<br>10 = 1998Hz – 2005Hz<br>11 = 3997Hz – 4009Hz |
|                                  | 0   | BEEP_ENA        | 0       | Digital Beep Enable<br>0 = Disabled<br>1 = Enabled<br>Note that the DAC and associated signal path needs to be enabled when using the digital beep.                                                                                                 |

**Table 68 Digital Beep Generator**

## OUTPUT SIGNAL PATH

The WM8962B input routing and mixers provide a high degree of flexibility, allowing operation of many simultaneous signal paths through the device to the output devices. The analogue output devices are a pair of stereo Headphone Output drivers and a pair of Speaker Output drivers. Support for mono signal output is also provided.

The output signal paths and associated control registers are illustrated in Figure 33.

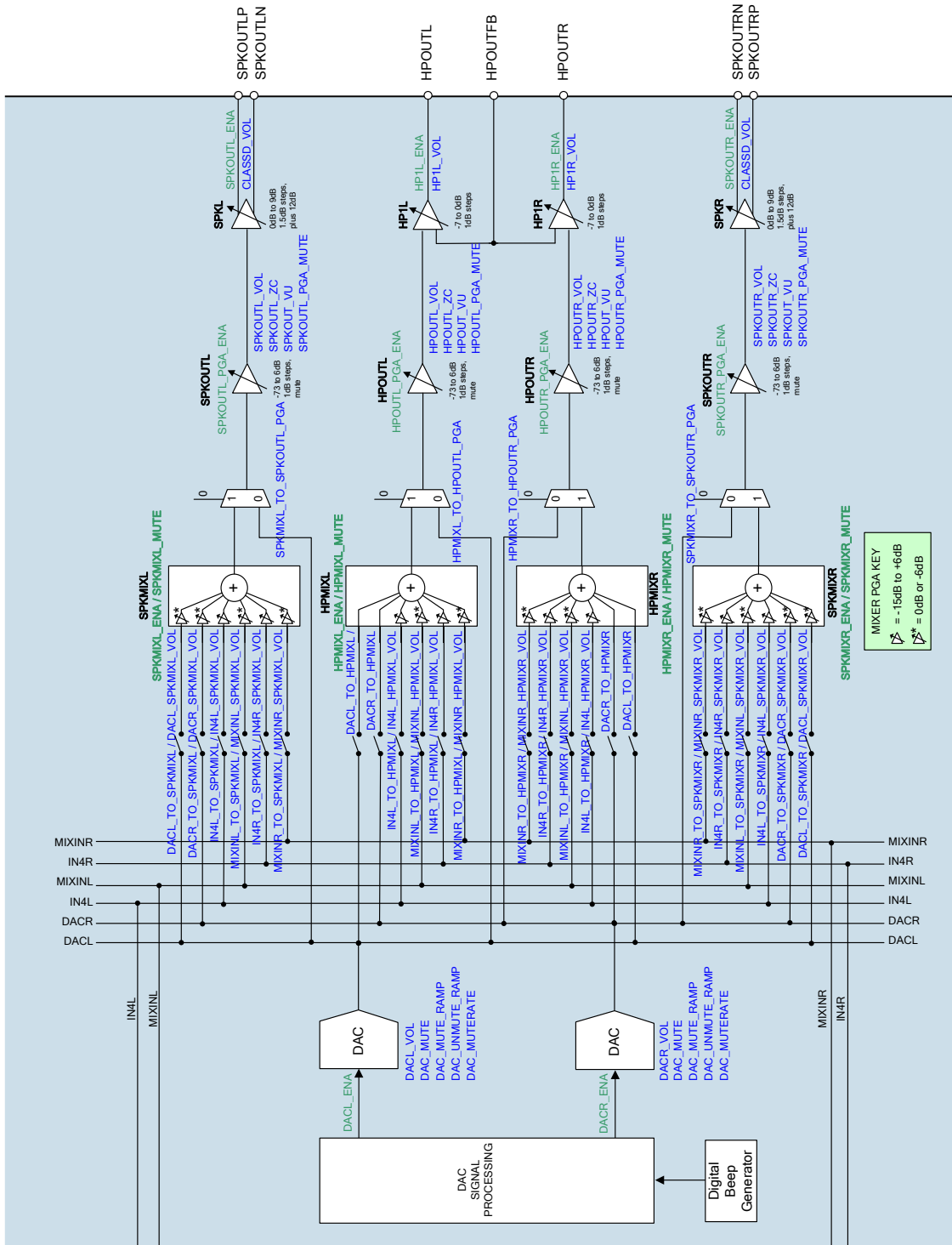


Figure 33 Output Signal Paths

**OUTPUT SIGNAL PATHS ENABLE**

The four output mixers, and each analogue output pin and associated PGA, can be independently enabled or disabled using the register bits described in Table 69.

The Class D speaker drivers are controlled using SPKOUTL\_ENA and SPKOUTR\_ENA. The headphone drivers are controlled by HP1L\_ENA and HP1R\_ENA.

To enable the output PGAs, the reference voltage VMID and the bias current must also be enabled. See "Reference Voltages and Bias Control" for details of the associated controls VMID\_SEL and BIAS\_ENA.

Note that the Speaker and Headphone outputs, the Speaker and Headphone PGAs, and the Speaker and headphone mixers are all disabled by default. The required signal paths must be enabled and unmuted using the control bits described in the respective tables below.

| REGISTER ADDRESS                    | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                             |
|-------------------------------------|-----|-----------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| R26 (1Ah)<br>Pwr Mgmt (2)           | 6   | HPOUTL_PGA_ENA  | 0       | Headphone Left PGA enable<br>0 = Disabled<br>1 = Enabled                                                                                                |
|                                     | 5   | HPOUTR_PGA_ENA  | 0       | Headphone Right PGA enable<br>0 = Disabled<br>1 = Enabled                                                                                               |
|                                     | 4   | SPKOUTL_PGA_ENA | 0       | Speaker Left PGA enable<br>0 = Disabled<br>1 = Enabled                                                                                                  |
|                                     | 3   | SPKOUTR_PGA_ENA | 0       | Speaker Right PGA enable<br>0 = Disabled<br>1 = Enabled                                                                                                 |
| R49 (31h)<br>Class D<br>Control (1) | 7   | SPKOUTR_ENA     | 0       | Right channel class D Speaker Enable<br>0 = Disabled<br>1 = Enabled                                                                                     |
|                                     | 6   | SPKOUTL_ENA     | 0       | Left channel class D Speaker Enable<br>0 = Disabled<br>1 = Enabled                                                                                      |
| R69 (45h)<br>Analogue HP<br>0       | 4   | HP1L_ENA        | 0       | Enables HP1L input stage<br>0 = Disabled<br>1 = Enabled<br>For normal operation, this bit should be set as the final stage of the HP1L Enable sequence. |
|                                     | 0   | HP1R_ENA        | 0       | Enables HP1R input stage<br>0 = Disabled<br>1 = Enabled<br>For normal operation, this bit should be set as the final stage of the HP1R Enable sequence. |
| R99 (63h)<br>Mixer Enables          | 3   | HPMIXL_ENA      | 0       | Left Headphone Mixer Enable<br>0 = Disabled<br>1 = Enabled                                                                                              |
|                                     | 2   | HPMIXR_ENA      | 0       | Right Headphone Mixer Enable<br>0 = Disabled<br>1 = Enabled                                                                                             |
|                                     | 1   | SPKMIXL_ENA     | 0       | Left Speaker Mixer Enable<br>0 = Disabled<br>1 = Enabled                                                                                                |
|                                     | 0   | SPKMIXR_ENA     | 0       | Right Speaker Mixer Enable<br>0 = Disabled<br>1 = Enabled                                                                                               |

**Table 69 Output Signal Paths Enable**

## SPEAKER OUTPUT PATHS

The following sections describe all the speaker output paths and controls. For information on the headphone output paths and controls, refer to the “Headphone Output Paths” section.

### SPEAKER MIXER CONTROL

The two speaker mixers - SPKMIXL and SPKMIXR – can each have any combination of the six available input paths enabled as described in Table 70 (left speaker mixer) and Table 71 (right speaker mixer). The six input signal paths are two from the DACs (DACL and DACR), two from the input mixers (MIXINL and MIXINR) and two bypass paths direct from the IN4 input pins (IN4L and IN4R). The speaker mixers are muted by default.

The two signal paths from the left and right DACs to each of the two speaker mixers SPKMIXL and SPKMIXR are enabled using the register bits DACL\_TO\_SPKMIXL, DACL\_TO\_SPKMIXR, DACR\_TO\_SPKMIXL and DACR\_TO\_SPKMIXR. A selectable -6dB control is available on each of these paths to help avoid signal clipping.

The two DAC output signals can also be configured to bypass the speaker mixers using the SPKMIXL\_TO\_SPKOUTL\_PGA and SPKMIXR\_TO\_SPKOUTR\_PGA register bits. Note that the DAC output signals bypass the mixers by default.

The direct signal paths from each of the input mixers MIXINL and MIXINR to each of the speaker mixers SPKMIXL and SPKMIXR are enabled using the MIXINL\_TO\_SPKMIXL, MIXINL\_TO\_SPKMIXR, MIXINR\_TO\_SPKMIXL and MIXINR\_TO\_SPKMIXR register bits. A selectable -6dB control is available on each of these paths to help avoid signal clipping.

The direct signal paths from the IN4L and IN4R input pins to the speaker mixers SPKMIXL and SPKMIXR are enabled using the IN4L\_TO\_SPKMIXL, IN4L\_TO\_SPKMIXR, IN4R\_TO\_SPKMIXL, and IN4R\_TO\_SPKMIXR register bits. Each input signal path from IN4 also has an associated PGA with a gain range from -15dB to +6dB.

| REGISTER ADDRESS                   | BIT | LABEL                  | DEFAULT | DESCRIPTION                                                                   |
|------------------------------------|-----|------------------------|---------|-------------------------------------------------------------------------------|
| R105 (69h)<br>Speaker Mixer<br>(1) | 7   | SPKMIXL_TO_SPKOUTL_PGA | 0       | Left Speaker PGA Path Select<br>0 = DACL Output<br>1 = SPKMIXL Output         |
|                                    | 5   | DACL_TO_SPKMIXL        | 0       | Left DAC to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled          |
|                                    | 4   | DACR_TO_SPKMIXL        | 0       | Right DAC to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled         |
|                                    | 3   | MIXINL_TO_SPKMIXL      | 0       | Left Input Mixer to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled  |
|                                    | 2   | MIXINR_TO_SPKMIXL      | 0       | Right Input Mixer to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled |
|                                    | 1   | IN4L_TO_SPKMIXL        | 0       | Input IN4L to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled        |
|                                    | 0   | IN4R_TO_SPKMIXL        | 0       | Input IN4R to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled        |

| REGISTER ADDRESS                   | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                      |
|------------------------------------|-----|--------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R107 (6Bh)<br>Speaker Mixer<br>(3) | 8   | SPKMIXL_MUTE       | 1       | Left Speaker Mixer Mute<br>0 = Unmuted<br>1 = Muted                                                                                                              |
|                                    | 7   | MIXINL_SPKMIXL_VOL | 0       | Left Input Mixer to Left Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                             |
|                                    | 6   | MIXINR_SPKMIXL_VOL | 0       | Right Input Mixer to Left Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                            |
|                                    | 5:3 | IN4L_SPKMIXL_VOL   | 111     | Input IN4L to Left Speaker Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |
|                                    | 2:0 | IN4R_SPKMIXL_VOL   | 111     | Input IN4R to Left Speaker Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |
| R109 (6Dh)<br>Speaker Mixer<br>(5) | 7   | DACL_SPKMIXL_VOL   | 0       | Left DAC to Left Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                                     |
|                                    | 6   | DACR_SPKMIXL_VOL   | 0       | Right DAC to Left Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                                    |

**Table 70 Left Speaker Mixer Control**

| REGISTER ADDRESS                   | BIT | LABEL                  | DEFAULT | DESCRIPTION                                                            |
|------------------------------------|-----|------------------------|---------|------------------------------------------------------------------------|
| R106 (6Ah)<br>Speaker Mixer<br>(2) | 7   | SPKMIXR_TO_SPKOUTR_PGA | 0       | Right Speaker PGA Path Select<br>0 = DACR Output<br>1 = SPKMIXR Output |
|                                    | 5   | DACL_TO_SPKMIXR        | 0       | Left DAC to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled  |
|                                    | 4   | DACR_TO_SPKMIXR        | 0       | Right DAC to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled |

| REGISTER ADDRESS             | BIT | LABEL               | DEFAULT | DESCRIPTION                                                                                                                                                       |
|------------------------------|-----|---------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                              | 3   | MIXINL_TO_SPK MIXR  | 0       | Left Input Mixer to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled                                                                                     |
|                              | 2   | MIXINR_TO_SPK MIXR  | 0       | Right Input Mixer to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled                                                                                    |
|                              | 1   | IN4L_TO_SPKMI XR    | 0       | Input IN4L to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled                                                                                           |
|                              | 0   | IN4R_TO_SPKMI XR    | 0       | Input IN4R to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled                                                                                           |
| R108 (6Ch) Speaker Mixer (4) | 8   | SPKMIXR_MUTE        | 1       | Right Speaker Mixer Mute<br>0 = Unmuted<br>1 = Muted                                                                                                              |
|                              | 7   | MIXINL_SPKMIX R_VOL | 0       | Left Input Mixer to Right Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                             |
|                              | 6   | MIXINR_SPKMIX R_VOL | 0       | Right Input Mixer to Right Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                            |
|                              | 5:3 | IN4L_SPKMIXR_VOL    | 111     | Input IN4L to Right Speaker Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |
|                              | 2:0 | IN4R_SPKMIXR_VOL    | 111     | Input IN4R to Right Speaker Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |
| R109 (6Dh) Speaker Mixer (5) | 5   | DACL_SPKMIXR_VOL    | 0       | Left DAC to Right Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                                     |
|                              | 4   | DACR_SPKMIXR_VOL    | 0       | Right DAC to Right Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                                    |

**Table 71 Right Speaker Mixer Control**



### SPEAKER OUTPUT PGA CONTROL

There are four speaker output PGAs – two primary (SPKOUTL and SPKOUTR), and two secondary (SPKL, SPKR). The speaker outputs are each controlled by a primary PGA and a secondary PGA in series.

The SPKOUTL and SPKOUTR PGAs give a high degree of control from -68dB to +6dB in 1dB steps. A detailed table of all SPKOUTL and SPKOUTR gain settings is shown in Table 73. Dedicated secondary PGAs are provided for each of the SPKOUT output pins. The secondary PGAs provide control from 0dB to +9dB in 1.5dB steps, and +12dB, on each channel. See Figure 33 for a representation of this layout.

The direct signal paths from the IN4L and IN4R input pins to the speaker mixers SPKMIXL and SPKMIXR are enabled using the IN4L\_TO\_SPKMIXL, IN4L\_TO\_SPKMIXR, IN4R\_TO\_SPKMIXL, and IN4R\_TO\_SPKMIXR register bits. Each input signal path from IN4 also has an associated PGA with a gain range from -15dB to +6dB.

To minimise pop and zipper noise, it is recommended that only SPKOUTL PGA and SPKOUTR PGA are modified while the output signal path is active as these are the only Speaker PGAs with Zero Cross. In the case of a long period without zero-crossings, a timeout function is provided. When the zero-cross function is enabled, the volume will update after the timeout period if no earlier zero-cross has occurred. The timeout clock is enabled using TOCLK\_ENA; the timeout period is set by TOCLK\_DIV. See "Clocking and Sample Rates" for more information on these fields. It is recommended that the other gain controls on the signal paths should not be modified while the signal path is active.

The left and right channels on the SPKOUT pins can be boosted using the CLASSD\_VOL register. Note that both left and right channels are updated simultaneously with the CLASSD\_VOL register.

The speaker output signal can be muted using the SPKOUTL\_PGA\_MUTE and SPKOUTR\_PGA\_MUTE registers. The speaker outputs are un-muted by default.

The SPKOUT\_VU bits control the loading of the speaker PGA volume data. When SPKOUT\_VU is set to 0, the volume control data will be loaded into the respective control register, but will not actually change the gain setting. The left and right Speaker PGA volume settings are both updated when a 1 is written to any of the SPKOUT\_VU bits. This makes it possible to update the gain of the left and right output paths simultaneously.

The Speaker PGA volume control register fields are described in Table 72.

| REGISTER ADDRESS               | BIT | LABEL             | DEFAULT       | DESCRIPTION                                                                                                                                                                                                                                |
|--------------------------------|-----|-------------------|---------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R40 (28h)<br>SPKOUTL<br>volume | 8   | SPKOUT_VU         | N/A           | Speaker Output PGA Volume Update<br>Writing a 1 to this bit will update SPKOUTL_VOL and SPKOUTR_VOL volumes simultaneously.                                                                                                                |
|                                | 7   | SPKOUTL_ZC        | 0             | SPKOUTL_VOL (Left Speaker Output PGA) Zero Cross Enable<br>0 = Zero cross disabled<br>1 = Zero cross enabled                                                                                                                               |
|                                | 6:0 | SPKOUTL_VOL [6:0] | 00h<br>(Mute) | Left Speaker Output PGA Volume<br>000_0000 to 010_1111 = Mute<br>011_0000 to 011_0101 = -68dB<br>011_0110 = -67dB<br>...in 1dB steps<br>111_1001 = 0dB<br>...<br>111_1111 = +6dB<br><br>(See Table 73 for output PGA volume control range) |

| REGISTER ADDRESS                  | BIT | LABEL             | DEFAULT       | DESCRIPTION                                                                                                                                                                                                                                 |
|-----------------------------------|-----|-------------------|---------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R41 (29h)<br>SPKOUTR<br>volume    | 8   | SPKOUT_VU         | N/A           | Speaker Output PGA Volume Update<br>Writing a 1 to this bit will update SPKOUTL_VOL and SPKOUTR_VOL volumes simultaneously.                                                                                                                 |
|                                   | 7   | SPKOUTR_ZC        | 0             | SPKOUTR_VOL (Right Speaker Output PGA) Zero Cross Enable<br>0 = Zero cross disabled<br>1 = Zero cross enabled                                                                                                                               |
|                                   | 6:0 | SPKOUTR_VOL [6:0] | 00h<br>(Mute) | Right Speaker Output PGA Volume<br>000_0000 to 010_1111 = Mute<br>011_0000 to 011_0101 = -68dB<br>011_0110 = -67dB<br>...in 1dB steps<br>111_1001 = 0dB<br>...<br>111_1111 = +6dB<br><br>(See Table 73 for output PGA volume control range) |
| R49 (31h)<br>Class D<br>Control 1 | 2   | SPKOUT_VU         | N/A           | Speaker Output PGA Volume Update<br>Writing a 1 to this bit will update SPKOUTL_VOL and SPKOUTR_VOL volumes simultaneously.                                                                                                                 |
|                                   | 1   | SPKOUTL_PGA_MUTE  | 0             | SPKOUTL_VOL (Left Speaker Output PGA) Mute<br>0 = Un-mute<br>1 = Mute                                                                                                                                                                       |
|                                   | 0   | SPKOUTR_PGA_MUTE  | 0             | SPKOUTR_VOL (Right Speaker Output PGA) Mute<br>0 = Un-mute<br>1 = Mute                                                                                                                                                                      |

**Table 72 Speaker Output PGA (SPKOUTL\_VOL, SPKOUTR\_VOL) Control**

| HPOUTL_VOL [6:0],<br>HPOUTR_VOL [6:0],<br>SPKOUTL_VOL [6:0] or<br>SPKOUTR_VOL [6:0] | VOLUME (dB) | HPOUTL_VOL [6:0],<br>HPOUTR_VOL [6:0],<br>SPKOUTL_VOL [6:0] or<br>SPKOUTR_VOL [6:0] | VOLUME (dB) |
|-------------------------------------------------------------------------------------|-------------|-------------------------------------------------------------------------------------|-------------|
| 000_0000 to 010_1111                                                                | Mute        | 101_1010                                                                            | -31         |
| 011_0000 to 011_0101                                                                | -68         | 101_1011                                                                            | -30         |
| 011_0110                                                                            | -67         | 101_1100                                                                            | -29         |
| 011_0111                                                                            | -66         | 101_1101                                                                            | -28         |
| 011_1000                                                                            | -65         | 101_1110                                                                            | -27         |
| 011_1001                                                                            | -64         | 101_1111                                                                            | -26         |
| 011_1010                                                                            | -63         | 110_0000                                                                            | -25         |
| 011_1011                                                                            | -62         | 110_0001                                                                            | -24         |
| 011_1100                                                                            | -61         | 110_0010                                                                            | -23         |
| 011_1101                                                                            | -60         | 110_0011                                                                            | -22         |
| 011_1110                                                                            | -59         | 110_0100                                                                            | -21         |
| 011_1111                                                                            | -58         | 110_0101                                                                            | -20         |
| 100_0000                                                                            | -57         | 110_0110                                                                            | -19         |
| 100_0001                                                                            | -56         | 110_0111                                                                            | -18         |
| 100_0010                                                                            | -55         | 110_1000                                                                            | -17         |
| 100_0011                                                                            | -54         | 110_1001                                                                            | -16         |
| 100_0100                                                                            | -53         | 110_1010                                                                            | -15         |
| 100_0101                                                                            | -52         | 110_1011                                                                            | -14         |
| 100_0110                                                                            | -51         | 110_1100                                                                            | -13         |
| 100_0111                                                                            | -50         | 110_1101                                                                            | -12         |
| 100_1000                                                                            | -49         | 110_1110                                                                            | -11         |
| 100_1001                                                                            | -48         | 110_1111                                                                            | -10         |
| 100_1010                                                                            | -47         | 111_0000                                                                            | -9          |
| 100_1011                                                                            | -46         | 111_0001                                                                            | -8          |
| 100_1100                                                                            | -45         | 111_0010                                                                            | -7          |
| 100_1101                                                                            | -44         | 111_0011                                                                            | -6          |
| 100_1110                                                                            | -43         | 111_0100                                                                            | -5          |
| 100_1111                                                                            | -42         | 111_0101                                                                            | -4          |
| 101_0000                                                                            | -41         | 111_0110                                                                            | -3          |
| 101_0001                                                                            | -40         | 111_0111                                                                            | -2          |
| 101_0010                                                                            | -39         | 111_1000                                                                            | -1          |
| 101_0011                                                                            | -38         | 111_1001                                                                            | 0           |
| 101_0100                                                                            | -37         | 111_1010                                                                            | +1          |
| 101_0101                                                                            | -36         | 111_1011                                                                            | +2          |
| 101_0110                                                                            | -35         | 111_1100                                                                            | +3          |
| 101_0111                                                                            | -34         | 111_1101                                                                            | +4          |
| 101_1000                                                                            | -33         | 111_1110                                                                            | +5          |
| 101_1001                                                                            | -32         | 111_1111                                                                            | +6          |

**Table 73 Headphone PGA and Speaker PGA Volume Range**

### SPEAKER OUTPUT CONFIGURATIONS

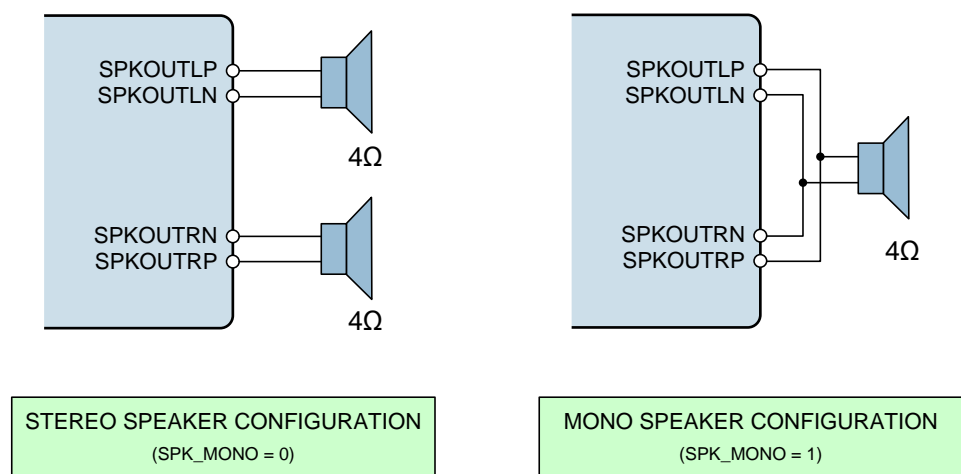
The speaker outputs SPKOUT are driven by the two speaker PGAs SPKOUTL and SPKOUTR. Fine volume control is available on the speaker paths using the SPKOUTL\_VOL and SPKOUTR\_VOL PGAs. A volume boost function (CLASSD\_VOL) is available on both the speaker paths.

The speaker outputs SPKOUTL and SPKOUTR operate in a BTL configuration in Class D amplifier mode.

The speaker outputs can be configured as a pair of stereo outputs, or as a single mono output. Note that, for applications requiring only a single speaker output, it is possible to improve the THD performance by configuring the speaker outputs in mono mode. See “Electrical Characteristics” for further details.

The mono configuration is selected using the SPK\_MONO register bit, as described in Table 74. In mono mode, the P channels, SPKOUTLP and SPKOUTRP should be connected together on the PCB, and similarly with the N channels, SPKOUTLN and SPKOUTRN, as illustrated in Figure 34. In this configuration both left and right speaker drivers should be enabled (SPKOUTL\_ENA=1 and SPKOUTR\_ENA=1), but both drivers will output the left speaker path signal only.

The connections for stereo and mono speaker configurations are shown in Figure 34.

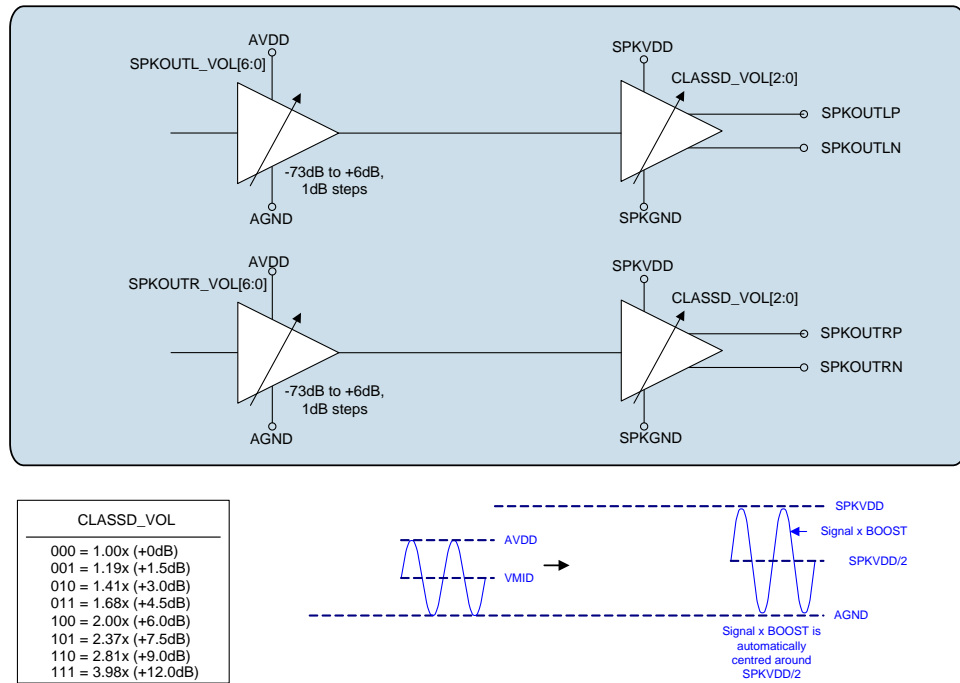


**Figure 34 Mono and Stereo Speaker Output Configuration**

Eight levels of AC signal boost are provided in order to deliver maximum output power for many commonly-used SPKVDD/AVDD combinations. The AC boost levels from 0dB to +12dB are selected using register bit CLASSD\_VOL, which boosts left and right channels equally. To prevent pop noise, CLASSD\_VOL should not be modified while the speaker outputs are enabled. Figure 35 illustrates the speaker outputs and gain/boost options available.

Ultra-low leakage and high PSRR allow the speaker supply SPKVDD to be directly connected to a lithium battery. Note that an appropriate SPKVDD supply voltage must be provided to prevent waveform clipping when speaker boost is used.

DC gain is applied automatically with a shift from VMID to SPKVDD/2. This provides optimum signal swing for maximum output power.


**Figure 35 Speaker Output Configuration and AC Boost Operation**

| REGISTER ADDRESS                  | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                      |
|-----------------------------------|-----|------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R51 (33h)<br>Class D<br>Control 2 | 6   | SPK_MONO   | 0       | Mono Speaker Configuration enable<br>0 = Default (stereo)<br>1 = Mono mode<br>When SPK_MONO is set to '1', both speakers output the signal from the left channel.<br>Note that the user must tie the outputs together for mono use                                                                                               |
|                                   | 2:0 | CLASSD_VOL | 011     | AC Speaker Gain Boost. Note that both left and right channels are boosted equally<br>000 = 1.00x boost (+0dB)<br>001 = 1.19x boost (+1.5dB)<br>010 = 1.41x boost (+3.0dB)<br>011 = 1.68x boost (+4.5dB)<br>100 = 2.00x boost (+6.0dB)<br>101 = 2.37x boost (+7.5dB)<br>110 = 2.81x boost (+9.0dB)<br>111 = 3.98x boost (+12.0dB) |

**Table 74 Class D Speaker Driver Control**

## HEADPHONE OUTPUT PATHS

The following sections describe all the headphone output paths and controls. For information on the speaker output paths and controls, refer to the earlier “Speaker Output Paths” section.

### HEADPHONE SIGNAL PATHS ENABLE

The WM8962B headphone drivers incorporate Wolfson’s SilentSwitch technology which enables pops normally associated with Start-Up, Shut-Down or signal path control to be suppressed. To achieve maximum benefit from these features, careful attention is required to the sequence and timing of these controls. Note that, under the recommended usage conditions of the WM8962B, these features will be configured by running the default Start-Up and Shut-Down sequences as described in the “Control Write Sequencer” section. In these cases, the user does not need to set these register fields directly.

The Headphone output drivers can be actively switched to AGND through internal resistors if desired. This is desirable at start-up in order to achieve a known condition prior to enabling the output. This is also desirable in shutdown to prevent the external connections from being affected by the internal circuits. The HPOUTL and HPOUTR outputs are shorted to AGND by default; the short circuit is removed on each of these paths by setting the applicable fields HP1L\_RMV\_SHORT and HP1R\_RMV\_SHORT.

The ground-referenced Headphone output drivers are designed to suppress pops and clicks when enabled or disabled. However, it is necessary to control the drivers in accordance with a defined sequence in start-up and shut-down to achieve the pop suppression. It is also necessary to schedule the DC Servo offset correction at the appropriate point in the sequence (see “DC Servo”). Table 75 and Table 76 describe the recommended sequences for enabling and disabling these output drivers.

| SEQUENCE | HPOUT ENABLE                             |
|----------|------------------------------------------|
| Step 1   | HP1L_ENA = 1<br>HP1R_ENA = 1             |
| Step 2   | 20 $\mu$ s delay                         |
| Step 3   | HP1L_ENA_DLY = 1<br>HP1R_ENA_DLY = 1     |
| Step 4   | DC offset correction                     |
| Step 5   | HP1L_ENA_OUTP = 1<br>HP1R_ENA_OUTP = 1   |
| Step 6   | 20 $\mu$ s delay                         |
| Step 7   | HP1L_RMV_SHORT = 1<br>HP1R_RMV_SHORT = 1 |

**Table 75 Headphone Output Enable Sequence**

| SEQUENCE | HPOUT DISABLE                                                                                                  |
|----------|----------------------------------------------------------------------------------------------------------------|
| Step 1   | HP1L_RMV_SHORT = 0<br>HP1R_RMV_SHORT = 0                                                                       |
| Step 2   | 20 $\mu$ s delay                                                                                               |
| Step 3   | HP1L_ENA = 0<br>HP1L_ENA_DLY = 0<br>HP1L_ENA_OUTP = 0<br>HP1R_ENA = 0<br>HP1R_ENA_DLY = 0<br>HP1R_ENA_OUTP = 0 |

**Table 76 Headphone Output Disable Sequence**

The register bits relating to pop suppression control are defined in Table 77.

| REGISTER ADDRESS              | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                   |
|-------------------------------|-----|----------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R69 (45h)<br>Analogue<br>HP 0 | 7   | HP1L_RMV_SHORT | 0       | Removes HP1L short<br>0 = HP1L short enabled<br>1 = HP1L short removed<br>For pop-free operation, this bit should be set to 1 as the final step in the HP1L Enable sequence.                                                                                                                  |
|                               | 6   | HP1L_ENA_OUTP  | 0       | Enables HP1L output stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set to 1 after the DC offset cancellation has been performed.                                                                                                                          |
|                               | 5   | HP1L_ENA_DLY   | 0       | Enables HP1L intermediate stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set to 1 after the output signal path has been configured, and before the DC Offset cancellation is scheduled<br>This bit should be set with at least 20us delay after HP1L_ENA. |
|                               | 4   | HP1L_ENA       | 0       | Enables HP1L input stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set as the first stage of the HP1L Enable sequence.                                                                                                                                     |
|                               | 3   | HP1R_RMV_SHORT | 0       | Removes HP1R short<br>0 = HP1R short enabled<br>1 = HP1R short removed<br>For pop-free operation, this bit should be set to 1 as the final step in the HP1R Enable sequence.                                                                                                                  |
|                               | 2   | HP1R_ENA_OUTP  | 0       | Enables HP1R output stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set to 1 after the DC offset cancellation has been performed.                                                                                                                          |
|                               | 1   | HP1R_ENA_DLY   | 0       | Enables HP1R intermediate stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set to 1 after the output signal path has been configured, and before the DC Offset cancellation is scheduled<br>This bit should be set with at least 20us delay after HP1R_ENA. |
|                               | 0   | HP1R_ENA       | 0       | Enables HP1R input stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set as the first stage of the HP1R Enable sequence.                                                                                                                                     |

**Table 77 Headphone Output Signal Paths Control**

**HEADPHONE MIXER CONTROL**

The two headphone mixers - HPMIXL and HPMIXR – can each have any combination of the six available input paths enabled as described in Table 78 (left headphone mixers) and Table 79 (right headphone mixers). The six input signal paths are two from the DACs (DACL and DACR), two from the input mixers (MIXINL and MIXINR) and two bypass paths direct from the IN4 input pins (IN4L and IN4R). The headphone mixers are muted by default.

The two signal paths from the left and right DACs to each of the two headphone mixers HPMIXL and HPMIXR are enabled using the register bits DACL\_TO\_HPMIXL, DACL\_TO\_HPMIXR, DACR\_TO\_HPMIXL and DACR\_TO\_HPMIXR. There is no selectable gain associated with these mixer paths.

The two DAC output signals can also be configured to bypass the headphone mixers using the HPMIXL\_TO\_HPOUTL\_PGA and HPMIXR\_TO\_HPOUTR\_PGA register bits. Note that the DAC output signals bypass the mixers by default.

The direct signal paths from each of the input mixers MIXINL and MIXINR to each of the headphone mixers HPMIXL and HPMIXR are enabled using the MIXINL\_TO\_HPMIXL, MIXINL\_TO\_HPMIXR, MIXINR\_TO\_HPMIXL and MIXINR\_TO\_HPMIXR register bits. A selectable -6dB control is available on each of these paths to help avoid signal clipping.

The direct signal paths from the IN4L and IN4R input pins to the headphone mixers HPMIXL and HPMIXR are enabled using the IN4L\_TO\_HPMIXL, IN4L\_TO\_HPMIXR, IN4R\_TO\_HPMIXL, and IN4R\_TO\_HPMIXR register bits. Each input signal path from IN4 also has an associated PGA with a gain range from -15dB to +6dB.

| REGISTER ADDRESS                  | BIT | LABEL                    | DEFAULT | DESCRIPTION                                                                        |
|-----------------------------------|-----|--------------------------|---------|------------------------------------------------------------------------------------|
| R100 (64h)<br>Headphone Mixer (1) | 7   | HPMIXL_TO_HP<br>OUTL_PGA | 0       | Left Headphone PGA Path Select<br>0 = DACL Output<br>1 = HPMIXL Output             |
|                                   | 5   | DACL_TO_HPMI<br>XL       | 0       | Left DAC to Left Headphone Mixer<br>select<br>0 = Disabled<br>1 = Enabled          |
|                                   | 4   | DACR_TO_HPMI<br>XL       | 0       | Right DAC to Left Headphone Mixer<br>select<br>0 = Disabled<br>1 = Enabled         |
|                                   | 3   | MIXINL_TO_HPM<br>IXL     | 0       | Left Input Mixer to Left Headphone<br>Mixer select<br>0 = Disabled<br>1 = Enabled  |
|                                   | 2   | MIXINR_TO_HP<br>MIXL     | 0       | Right Input Mixer to Left Headphone<br>Mixer select<br>0 = Disabled<br>1 = Enabled |
|                                   | 1   | IN4L_TO_HPMIX<br>L       | 0       | Input IN4L to Left Headphone Mixer<br>select<br>0 = Disabled<br>1 = Enabled        |
|                                   | 0   | IN4R_TO_HPMIX<br>L       | 0       | Input IN4R to Left Headphone Mixer<br>select<br>0 = Disabled<br>1 = Enabled        |
| R102 (66h)<br>Headphone Mixer (3) | 8   | HPMIXL_MUTE              | 1       | Left Headphone Mixer Mute<br>0 = Unmuted<br>1 = Muted                              |
|                                   | 7   | MIXINL_HPMIXL_<br>VOL    | 0       | Left Input Mixer to Left Headphone<br>Mixer volume<br>0 = 0dB<br>1 = -6dB          |



| REGISTER ADDRESS | BIT | LABEL             | DEFAULT | DESCRIPTION                                                                                                                                                        |
|------------------|-----|-------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  | 6   | MIXINR_HPMIXL_VOL | 0       | Right Input Mixer to Left Headphone Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                            |
|                  | 5:3 | IN4L_HPMIXL_VOL   | 111     | Input IN4L to Left Headphone Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |
|                  | 2:0 | IN4R_HPMIXL_VOL   | 111     | Input IN4R to Left Headphone Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |

**Table 78 Left Headphone Mixer Control**

| REGISTER ADDRESS                  | BIT | LABEL                 | DEFAULT | DESCRIPTION                                                                      |
|-----------------------------------|-----|-----------------------|---------|----------------------------------------------------------------------------------|
| R101 (65h)<br>Headphone Mixer (2) | 7   | HPMIXR_TO_HP_OUTR_PGA | 0       | Right Headphone PGA Path Select<br>0 = DACR Output<br>1 = HPMIXR Output          |
|                                   | 5   | DACL_TO_HP MIXR       | 0       | Left DAC to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled          |
|                                   | 4   | DACR_TO_HP MIXR       | 0       | Right DAC to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled         |
|                                   | 3   | MIXINL_TO_HP MIXR     | 0       | Left Input Mixer to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled  |
|                                   | 2   | MIXINR_TO_HP MIXR     | 0       | Right Input Mixer to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled |
|                                   | 1   | IN4L_TO_HP MIXR       | 0       | Input IN4L to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled        |
|                                   | 0   | IN4R_TO_HP MIXR       | 0       | Input IN4R to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled        |

| REGISTER ADDRESS                  | BIT | LABEL             | DEFAULT | DESCRIPTION                                                                                                                                                         |
|-----------------------------------|-----|-------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R103 (67h)<br>Headphone Mixer (4) | 8   | HPMIXR_MUTE       | 1       | Right Headphone Mixer Mute<br>0 = Unmuted<br>1 = Muted                                                                                                              |
|                                   | 7   | MIXINL_HPMIXR_VOL | 0       | Left Input Mixer to Right Headphone Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                             |
|                                   | 6   | MIXINR_HPMIXR_VOL | 0       | Right Input Mixer to Right Headphone Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                            |
|                                   | 5:3 | IN4L_HPMIXR_VOL   | 111     | Input IN4L to Right Headphone Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |
|                                   | 2:0 | IN4R_HPMIXR_VOL   | 111     | Input IN4R to Right Headphone Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |

**Table 79 Right Headphone Mixer Control**

**HEADPHONE OUTPUT PGA CONTROL**

There are four headphone output PGAs – two primary (HPOUTL and HPOUTR), and two secondary (HP1L, HP1R). The headphone outputs are each controlled by a primary PGA and a secondary PGA in series.

The HPOUTL and HPOUTR PGAs give a high degree of control from -68dB to +6dB in 1dB steps. A detailed table of all HPOUTL and HPOUTR gain settings is shown in Table 73. Secondary PGAs for HPOUTL and HPOUTR provide control from -7dB to 0dB in 1dB steps on each channel. See Figure 33 for a representation of this layout.

The HPOUT PGAs are controlled using the HPOUTL\_VOL and HPOUTR\_VOL registers, providing fine volume control to HPOUTL and HPOUTR.

To prevent "zipper noise", a zero-cross function is provided on the HPOUTL and HPOUTR output PGAs. When this feature is enabled, volume updates will not take place until a zero-crossing is detected. In the case of a long period without zero-crossings, a timeout function is provided. When the zero-cross function is enabled, the volume will update after the timeout period if no earlier zero-cross has occurred. The timeout clock is enabled using TOCLK\_ENA; the timeout period is set by TOCLK\_DIV. See "Clocking and Sample Rates" for more information on these fields.

It is recommended that only HPOUTL PGA and HPOUTR PGA are modified while the output signal path is active as these are the only Headphone PGAs with the zero-cross function. It is recommended that the other gain controls on the signal paths should not be modified while the signal path is active.

The left and right channels can also be attenuated independently using the HP1L\_VOL and HP1R\_VOL registers. Note that there is no zero-cross function associated with these registers.

The headphone output signal can be muted using the HPOUTL\_PGA\_MUTE and HPOUTR\_PGA\_MUTE registers. The headphone outputs are un-muted by default.

The HPOUT\_VU bits control the loading of the Headphone Output PGA volume data and the PGA mute functions. When HPOUT\_VU is set to 0, the volume control data will be loaded into the respective control register, but will not actually change the gain setting. The left and right Headphone Output PGA volume settings are both updated when a 1 is written to any of the HPOUT\_VU bits. Similarly, the HPOUTL\_PGA\_MUTE and HPOUTR\_PGA\_MUTE settings are only effective when a 1 is written to either HPOUT\_VU bit. This makes it possible to update the gain of the left and right output paths simultaneously.

Note that the HP1L\_VOL and HP1R\_VOL registers are effective immediately when updated; the HPOUT\_VU bits have no control over the Secondary PGA volume registers. For best performance, the Secondary PGA volume registers should be set to 000b (-7dB). See "Reference Voltages and Bias Control" for further details of the High Performance headphone playback configuration.

| REGISTER ADDRESS            | BIT | LABEL            | DEFAULT     | DESCRIPTION                                                                                                                                                                                                                            |
|-----------------------------|-----|------------------|-------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R2 (2h)<br>HPOUTL<br>volume | 8   | HPOUT_VU         | N/A         | Headphone Output PGA Volume and Mute Update.<br>Writing 1 to this bit will cause the HPOUTL and HPOUTR volume and mute settings to be updated simultaneously.                                                                          |
|                             | 7   | HPOUTL_ZC        | 0           | Left Headphone Output PGA Zero Cross Enable<br>0 = Zero cross disabled<br>1 = Zero cross enabled                                                                                                                                       |
|                             | 6:0 | HPOUTL_VOL [6:0] | 0<br>(Mute) | Left Headphone Output PGA Volume<br>000_0000 to 010_1111 = Mute<br>011_0000 to 011_0101 = -68dB<br>011_0110 = -67dB<br>...in 1dB steps<br>111_1001 = 0dB<br>...<br>111_1111 = +6dB<br><br>(See Table 73 for full volume control range) |

| REGISTER ADDRESS              | BIT | LABEL            | DEFAULT     | DESCRIPTION                                                                                                                                                                                                                             |
|-------------------------------|-----|------------------|-------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R3 (2h)<br>HPOUTR<br>volume   | 8   | HPOUT_VU         | N/A         | Headphone Output PGA Volume and Mute Update<br>Writing 1 to this bit will cause the HPOUTL and HPOUTR volume and mute settings to be updated simultaneously.                                                                            |
|                               | 7   | HPOUTR_ZC        | 0           | Right Headphone Output PGA Zero Cross Enable<br>0 = Zero cross disabled<br>1 = Zero cross enabled                                                                                                                                       |
|                               | 6:0 | HPOUTR_VOL [6:0] | 0<br>(Mute) | Right Headphone Output PGA Volume<br>000_0000 to 010_1111 = Mute<br>011_0000 to 011_0101 = -68dB<br>011_0110 = -67dB<br>...in 1dB steps<br>111_1001 = 0dB<br>...<br>111_1111 = +6dB<br><br>(See Table 73 for full volume control range) |
| R26 (1A) Pwr<br>Mgmt (2)      | 1   | HPOUTL_PGA_MUTE  | 0           | HPOUTL_VOL (Left Headphone Output PGA) Mute<br>0 = Un-mute<br>1 = Mute                                                                                                                                                                  |
|                               | 0   | HPOUTR_PGA_MUTE  | 0           | HPOUTR_VOL (Right Headphone Output PGA) Mute<br>0 = Un-mute<br>1 = Mute                                                                                                                                                                 |
| R71 (47h)<br>Analogue HP<br>2 | 8:6 | HP1L_VOL [2:0]   | 111         | Headphone 1 Left Secondary PGA volume.<br>000 = -7dB<br>001 = -6dB<br>010 = -5dB<br>011 = -4dB<br>100 = -3dB<br>101 = -2dB<br>110 = -1dB<br>111 = 0dB (default)                                                                         |
|                               | 5:3 | HP1R_VOL [2:0]   | 111         | Headphone 1 Right Secondary PGA volume.<br>000 = -7dB<br>001 = -6dB<br>010 = -5dB<br>011 = -4dB<br>100 = -3dB<br>101 = -2dB<br>110 = -1dB<br>111 = 0dB (default)                                                                        |

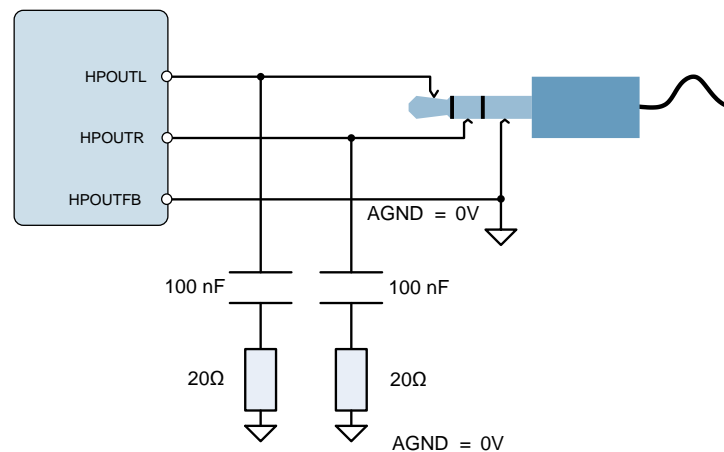
**Table 80 Headphone Output PGA (HPOUTL\_VOL, HPOUTR\_VOL, HP1L\_VOL, HP1R\_VOL) Control**

### HEADPHONE OUTPUT CONFIGURATIONS

The headphone output driver is capable of driving up to 25mW into a 16Ω or 32Ω load such as a stereo headset or headphones. The outputs are ground-referenced, eliminating any requirement for AC coupling capacitors. This is achieved by having separate positive and negative supply rails powered by an on-chip charge pump. A DC Servo circuit removes any DC offset from the headphone outputs, suppressing 'pop' noise and minimising power consumption. The Charge Pump and DC Servo are described separately (see "Charge Pump" and "DC Servo" respectively).

It is recommended to connect a zobel network to the headphone output pins HPOUTL and HPOUTR for best audio performance in all applications. The components of the zobel network have the effect of dampening high frequency oscillations or instabilities that can arise outside the audio band under certain conditions. Possible sources of these instabilities include the inductive load of a headphone coil or an active load in the form of an external line amplifier. The capacitance of lengthy cables or PCB tracks can also lead to amplifier instability. The zobel network should comprise of a 20Ω resistor and 100nF capacitor in series with each other, as illustrated in Figure 36.

Note that the zobel network may be unnecessary in some applications; it depends upon the characteristics of the connected load. It is recommended to include these components for best audio quality and amplifier stability in all cases.

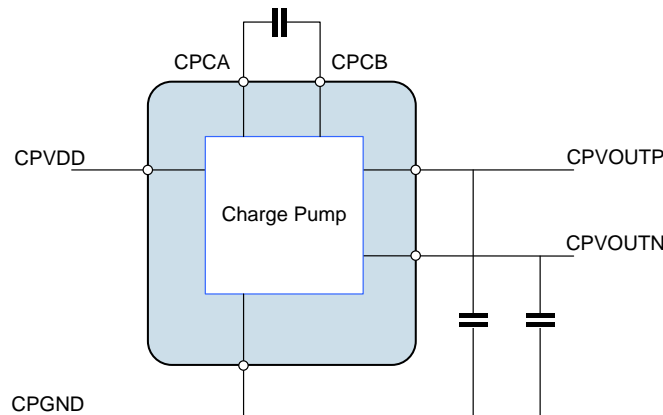


**Figure 36 Zobel Network Components for HPOUTL and HPOUTR**

The headphone output incorporates a common mode, or ground loop, feedback path which provides rejection of system-related ground noise. The return path is via HPOUTFB. This pin must be connected to ground for normal operation of the headphone output. No register configuration is required.

**CHARGE PUMP**

The WM8962B incorporates a dual-mode Charge Pump which generates the supply rails for the headphone output drivers, HPOUTL and HPOUTR. The Charge Pump has a single supply input, CPVDD, and generates split rails CPVOUTP and CPVOUTN according to the selected mode of operation. The Charge Pump connections are illustrated in Figure 37 (see “Electrical Characteristics” for external component values). An input decoupling capacitor may also be required at CPVDD, depending upon the system configuration.



**Figure 37 Charge Pump External Connections**

The Charge Pump is enabled by setting the CP\_ENA bit. When enabled, the charge pump adjusts the output voltages (CPVOUTP and CPVOUTN) as well as the switching frequency in order to optimise the power consumption according to the operating conditions. This can take two forms, which are selected using the CP\_DYN\_PWR register bit.

- Register control (CP\_DYN\_PWR = 0)
- Dynamic control (CP\_DYN\_PWR = 1)

Under Register control, the HPOUTL\_VOL and HPOUTR\_VOL register settings are used to control the charge pump mode of operation.

Under Dynamic control, the audio signal level in the DAC is also used to control the charge pump mode of operation. This is the Wolfson ‘Class W’ mode, which allows the power consumption to be optimised in real time.

When selecting Register control (CP\_DYN\_PWR = 0), a ‘1’ must be written to the HPOUT\_VU bit to complete the mode change. HPOUT\_VU is defined in the “Headphone Output Paths” section (Table 80).

Note that, when selecting Dynamic control (CP\_DYN\_PWR = 1), the Charge Pump mode change is implemented immediately when CP\_DYN\_PWR is updated.

When digital sidetone is used (see “Digital Mixing”), it is recommended that the Charge Pump operates in Register Control mode only (CP\_DYN\_PWR = 0). This is because the Dynamic Control mode (Class W) does not measure the sidetone signal level and hence the Charge Pump configuration cannot be optimised for all signal conditions when digital sidetone is enabled; this could lead to signal clipping.

When Virtual Surround Sound (VSS), HD Bass or DAC ReTune is used (see “DAC Signal Path Enhancements”), it is recommended that the Charge Pump operates in Register Control mode only (CP\_DYN\_PWR = 0). This is because the Dynamic Control mode (Class W) does not measure the DSP Signal Enhancements level and hence the Charge Pump cannot be optimised for all signal conditions when VSS, HD Bass or DAC ReTune is enabled; this could lead to signal clipping.

Under the recommended usage conditions of the WM8962B, the Charge Pump will be enabled by running the default headphone Start-Up sequence as described in the “Control Write Sequencer” section. (Similarly, it will be disabled by running the Shut-Down sequence.) In these cases, the user does not need to write to the CP\_ENA bit. The Charge Pump operating mode defaults to Register control; Dynamic control may be selected by setting the CP\_DYN\_PWR register bit, if appropriate.

The SYSCLK signal must be present for the charge pump to function. The clock division from MCLK (or the internal oscillator) is handled transparently by the WM8962B without user intervention, as long as SYSCLK and sample rates are set correctly (see “Clocking and Sample Rates” section). The clock divider ratio depends on the SAMPLE\_RATE[2:0] and MCLK\_RATE[3:0] register settings.

The Charge Pump control fields are described in Table 81.

| REGISTER ADDRESS           | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                     |
|----------------------------|-----|------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R72 (48h)<br>Charge Pump 1 | 0   | CP_ENA     | 0       | Enable charge-pump digits<br>0 = disable<br>1 = enable                                                                                                                                                                                                                                                                                                          |
| R82 (52h)<br>Charge Pump B | 0   | CP_DYN_PWR | 0       | Enable dynamic charge pump power control<br>0 = Charge pump controlled by volume register settings (Class G)<br>1 = Charge pump controlled by real-time audio level (Class W)<br>Class W is recommended for lowest power consumption<br>When selecting CP_DYN_PWR=0, a '1' must be written to the HPOUT_VU bit (Register R2 or R3) to complete the mode change. |

**Table 81 Charge Pump Control**

## DC SERVO

The WM8962B provides four DC servo circuits - two on the headphone outputs HPOUTL and HPOUTR, and two on the analogue input paths INL and INR. The DC servo circuits remove offset from these signal paths.

Removal of DC offset on the headphone outputs is important because any deviation from GND at the output pin will cause current to flow through the load under quiescent conditions, resulting in increased power consumption. Additionally, the presence of DC offsets can result in audible pops and clicks at power up and power down. The DC servo ensures that the DC level on the headphone outputs is within 1.2mV of GND.

Removal of DC offset on the input paths is important because any deviation from VMID at the ADC input will prevent correct operation of the zero-cross detection and may also restrict the maximum analogue input signal level. (Zero-cross detection is available for PGA volume updates, including when the PGA is controlled by the ALC control.)

The recommended usage of the DC Servo is initialised by running the default Start-Up sequence as described in the “Control Write Sequencer” section. The default Start-Up sequence executes a series of DC offset corrections, after which the measured offset correction is maintained on the headphone output channels.

Updates to the DC Servo correction can also be scheduled using register writes, including during audio playback. The relevant control fields are described in the following paragraphs and are defined in Table 82.

### DC SERVO ENABLE AND START-UP

The DC Servo circuits are enabled on HPOUTL and HPOUTR by setting HP1L\_DCS\_ENA and HP1R\_DCS\_ENA respectively. Equivalent registers are provided for the analogue input paths INL and INR. When the DC Servo is enabled, the DC offset correction can be commanded in different ways, as described below.

Writing a logic 1 to HP1L\_DCS\_STARTUP initiates a series of DC offset measurements and applies the necessary correction to the HPOUTL output. On completion, the output will be within 1.2mV of AGND. This is the DC Servo mode selected by the default Start-Up sequence. Completion of this DC offset correction is indicated by the DCS\_STARTUP\_DONE\_HP1L, as described in Table 82.

The DC Servo Start-Up function is supported on all four DC Servo channels; individual register control is provided for each channel. The DC Servo Start-Up can be commanded on multiple channels simultaneously if required. Typically, this operation takes 24ms per channel.

The DC Servo control fields associated with start-up operation are described in Table 82. For Headphone output DC offset correction, it is important to note that the DC Servo Start-Up mode should be commanded as part of a control sequence which includes muting and shorting of the headphone outputs; a suitable sequence is defined in the default Start-Up sequence (see “Control Write Sequencer”). See also the “Headphone Output Paths” section for the details of the recommended Headphone Enable/Disable sequence.

Note that, once the DC offset correction has been performed, the measured offset will be maintained in memory, even when the associated signal path is disabled. This means that, if required, the DC offset correction can be performed on all channels during start-up, and each channel may then be disabled or enabled when required, without having to re-schedule the DC offset correction.

The DC Servo circuit uses the Charge Pump power supply. The Charge Pump must be enabled by setting the CP\_ENA register bit and ensuring that a suitable clock (eg. MCLK) is present. If these conditions are not met, then DC offset correction cannot be performed. See “Charge Pump” and “Clocking and Sample Rates” for details of the associated controls.

| REGISTER ADDRESS        | BIT | LABEL                 | DEFAULT | DESCRIPTION                                                                      |
|-------------------------|-----|-----------------------|---------|----------------------------------------------------------------------------------|
| R60 (3Ch)<br>DC Servo 0 | 7   | INL_DCS_ENA           | 0       | DC Servo enable for Left input signal path<br>0 = Disabled<br>1 = Enabled        |
|                         | 6   | INL_DCS_STARTUP       | 0       | Writing 1 to this bit selects Start-Up DC Servo mode for Left input signal path  |
|                         | 3   | INR_DCS_ENA           | 0       | DC Servo enable for Right input signal path<br>0 = Disabled<br>1 = Enabled       |
|                         | 2   | INR_DCS_STARTUP       | 0       | Writing 1 to this bit selects Start-Up DC Servo mode for Right input signal path |
| R61 (3Dh)<br>DC Servo 1 | 7   | HP1L_DCS_ENA          | 0       | DC Servo enable for HPOUTL<br>0 = Disabled<br>1 = Enabled                        |
|                         | 6   | HP1L_DCS_STARTUP      | 0       | Writing 1 to this bit selects Start-Up DC Servo mode for HPOUTL                  |
|                         | 3   | HP1R_DCS_ENA          | 0       | DC Servo enable for HPOUTR<br>0 = Disabled<br>1 = Enabled                        |
|                         | 2   | HP1R_DCS_STARTUP      | 0       | Writing 1 to this bit selects Start-Up DC Servo mode for HPOUTR                  |
| R66 (42h)<br>DC Servo 6 | 10  | DCS_STARTUP_DONE_IN1L | 0       | DC Servo Start-Up Status (Left Input)<br>0 = Not complete<br>1 = Complete        |
|                         | 9   | DCS_STARTUP_DONE_IN1R | 0       | DC Servo Start-Up Status (Right Input)<br>0 = Not complete<br>1 = Complete       |
|                         | 8   | DCS_STARTUP_DONE_HP1L | 0       | DC Servo Start-Up Status (HPOUTL)<br>0 = Not complete<br>1 = Complete            |
|                         | 7   | DCS_STARTUP_DONE_HP1R | 0       | DC Servo Start-Up Status (HPOUTR)<br>0 = Not complete<br>1 = Complete            |

**Table 82 DC Servo Enable and Start-Up Modes**



**DC SERVO ACTIVE MODES**

The DC Servo Start-Up mode described above is suitable for initialising the DC offset correction circuit on the input or output signal paths as part of a controlled start-up sequence which is executed before the signal path is fully enabled. The WM8962B also supports DC offset measurement and correction on the HP output paths whilst the signal path is active; this may be of benefit following a large change in signal gain, which can lead to a change in DC offset level.

Writing a logic 1 to HP1L\_DCS\_SYNC initiates a series of DC offset measurements and applies the necessary correction to the HPOUTL output. Writing a logic 1 to HP1R\_DCS\_SYNC initiates a series of DC offset measurements and applies the necessary correction to the HPOUTR output.

The number of DC Servo operations performed is determined by HP1\_DCS\_SYNC\_STEP. A maximum of 127 operations may be selected, though a much lower value will be sufficient in most applications. The DC Servo uses filtering to measure the DC offset in the presence of any audio that may be present; this requires a longer time to perform the correction process than in the Start-Up mode, and means that the DC Servo may be operating for several seconds after the process was initiated.

The DC Servo Sync mode described above is supported on the HPOUT DC Servo channels; individual register control is provided for each channel. It is recommended that the DC Servo Sync mode is scheduled whenever a large change in signal gain (eg. >6dB) is applied in the output signal path. Note that the DC Servo Sync mode is not required on the input signal paths as the DC offset in these paths does not change with gain, and only the Start-Up correction is necessary.

The DC Servo control fields associated with Sync mode (suitable for use on a signal path that is in active use) are described in Table 83.

| REGISTER ADDRESS        | BIT  | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                |
|-------------------------|------|-------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R61 (3Dh)<br>DC Servo 1 | 4    | HP1L_DCS_SYNC           | 0       | Writing 1 to this bit selects a series of DC offset corrections for HPOUTL                                                                                 |
|                         | 0    | HP1R_DCS_SYNC           | 0       | Writing 1 to this bit selects a series of DC offset corrections for HPOUTR                                                                                 |
| R64 (40h)<br>DC Servo 4 | 13:7 | HP1_DCS_SYNC_STEP [6:0] | 10h     | Number of DC Servo updates to perform in a series event (HPOUTL and HPOUTR)<br>00h to 0Fh = Reserved<br>10h = 16 (default)<br>11h = 17<br>...<br>7Fh = 127 |

**Table 83 DC Servo Active Modes**

## REFERENCE VOLTAGES AND BIAS CONTROL

This section describes the analogue reference voltage and bias current controls. It also describes the VMID soft-start circuit for pop suppressed start-up and shut-down. Note that, under the recommended usage conditions of the WM8962B, these features will be configured by running the default Start-Up and Shut-Down sequences as described in the “Control Write Sequencer” section. In these cases, the user does not need to set these register fields directly.

### ANALOGUE REFERENCE AND MASTER BIAS

The analogue circuits in the WM8962B require a mid-rail analogue reference voltage, VMID. This reference is generated from AVDD via a programmable resistor chain. The VMID reference generator requires a bias current, which is enabled by STARTUP\_BIAS\_ENA. Together with the external VMID decoupling capacitor, the programmable VMID resistor chain results in a slow, normal or fast charging characteristic on VMID. This is controlled by the VMID\_SEL register, and can be used to optimise the reference for normal operation, low power standby or for fast start-up as described in Table 84. For normal operation, the VMID\_SEL field should be set to 01.

A soft-start circuit is provided in order to control the switch-on of the VMID reference; this is enabled by setting VMID\_RAMP. When the soft-start circuit is enabled prior to enabling VMID\_SEL, the VMID reference rises smoothly, without any step change that could otherwise occur.

The analogue circuits in the WM8962B require a bias current. The normal bias current is enabled by setting BIAS\_ENA. Note that the normal bias current source requires VMID to be enabled also.

The analogue inputs to the WM8962B are biased to VMID in normal operation. In order to avoid audible pops caused by a disabled signal path dropping to AGND, the WM8962B can maintain these connections at VMID when the relevant input stage is disabled. This is achieved by connecting a buffered VMID reference to the input or output. The buffered VMID reference is enabled by setting VMID\_BUF\_ENA.

| REGISTER ADDRESS             | BIT | LABEL             | DEFAULT | DESCRIPTION                                                                                                                                                                                                    |
|------------------------------|-----|-------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R25 (19h)<br>Pwr Mgmt<br>(1) | 8:7 | VMID_SEL<br>[1:0] | 00      | VMID Divider Enable and Select<br>00 = VMID disabled (for OFF mode)<br>01 = 2 x 50k divider (for normal operation)<br>10 = 2 x 250k divider (for low power standby)<br>11 = 2 x 5k divider (for fast start-up) |
|                              | 6   | BIAS_ENA          | 0       | Enables the Normal bias current generator (for all analogue functions)<br>0 = Disabled<br>1 = Enabled                                                                                                          |
| R28 (1Ch)<br>Anti-pop        | 4   | STARTUP_BIAS_ENA  | 0       | Enables the Start-Up bias current generator<br>0 = Disabled<br>1 = Enabled                                                                                                                                     |
|                              | 3   | VMID_BUF_ENA      | 0       | VMID Buffer Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                              |
|                              | 2   | VMID_RAMP         | 0       | Enables VMID soft ramp-up<br>0 = Disabled<br>1 = Enabled                                                                                                                                                       |

**Table 84 Reference Voltages and Master Bias Enable**

**INPUT SIGNAL PATH BIAS CONTROL SETTINGS**

All the analogue circuits of the WM8962B require a bias current. The bias current in the input signal path circuits can be controlled using the register bits described in Table 85.

When adjusting the bias settings, there is always a trade-off between performance and power. Selecting a lower bias can be used to reduce power consumption, but may have a marginal impact on audio performance in some usage modes. Selecting a higher bias offers a performance improvement, but also an increase in power consumption.

| REGISTER ADDRESS                    | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                                                         |
|-------------------------------------|-----|------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| R23 (17h)<br>Additional Control (1) | 5   | ADC_HP     | 0       | ADC Oversampling Ratio<br>0 = Low Power (typically 64 x fs)<br>1 = High Performance (typically 128 x fs)                                            |
| R35 (23h)<br>Input bias control     | 5:3 | MIXIN_BIAS | 000     | Input Boost-Mixer Bias Control<br>000 = x 2.0 (default)<br>001 = Reserved<br>010 = Reserved<br>011 = x 1.0<br>100 = x 0.67<br>101 to 111 = Reserved |
|                                     | 2:0 | INPGA_BIAS | 100     | Input PGA Bias Control<br>000 = x 2.0<br>001 = Reserved<br>010 = Reserved<br>011 = Reserved<br>100 = x 0.67 (default)<br>101 to 111 = Reserved      |

**Table 85 Input Signal Path Bias Control Settings**

It is recommended that the input signal path bias control settings are selected only from the supported combinations listed in Table 86.

| DESCRIPTION        | ADC_HP | MIXIN_BIAS | INPGA_BIAS | NOTES                    |
|--------------------|--------|------------|------------|--------------------------|
| Option 1           | 0      | 100        | 100        | Lowest power consumption |
| Option 2           | 0      | 011        | 100        |                          |
| Option 3 (default) | 0      | 000        | 100        |                          |
| Option 4           | 1      | 000        | 000        | Highest performance      |

**Table 86 Recommended Bias Control Settings (Input Signal Path)**

**OUTPUT SIGNAL PATH BIAS CONTROL SETTINGS**

All the analogue circuits of the WM8962B require a bias current. The bias current in the output signal path circuits can be controlled using the register bits described in Table 87.

When adjusting the bias settings, there is always a trade-off between performance and power. Selecting a lower bias can be used to reduce power consumption, but may have a marginal impact on audio performance in some usage modes. Selecting a higher bias offers a performance improvement, but also an increase in power consumption.

| REGISTER ADDRESS                      | BIT | LABEL                  | DEFAULT | DESCRIPTION                                                                                                                      |
|---------------------------------------|-----|------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------|
| R6 (06h)<br>ADC &<br>DAC<br>Control 2 | 0   | DAC_HP                 | 0       | DAC Oversampling Ratio<br>0 = Low Power (typically 64 x fs)<br>1 = High Performance (typically 128 x fs)                         |
| R68 (44h)<br>Analogue<br>PGA Bias     | 2:0 | HP_PGAS_BIAS<br>[2:0]  | 011     | Headphone PGA Boost Bias<br>000 = x 2.0<br>001 = Reserved<br>010 = Reserved<br>011 = x 1.0 (default)<br>100 to 111 = Reserved    |
| R71 (47h)<br>Analogue<br>HP 2         | 2:0 | HP_BIAS_BOOST<br>[2:0] | 011     | Headphone Driver Boost Bias<br>000 = x 2.0<br>001 = Reserved<br>010 = Reserved<br>011 = x 1.0 (default)<br>100 to 111 = Reserved |

**Table 87 Output Signal Path Bias Control Settings**

It is recommended that the output signal path bias control settings are selected only from the supported combinations listed in Table 88.

Note that, for the specified performance in 'High Performance' mode, the headphone output secondary PGAs must be set to -7dB attenuation. See "Headphone Output Paths" for details of the associated registers.

| DESCRIPTION                              | DAC_HP | HP_PGAS_BIAS | HP_BIAS_BOOST | HP1L_VOL,<br>HP1R_VOL |
|------------------------------------------|--------|--------------|---------------|-----------------------|
| Low Power headphone playback mode        | 0      | 011          | 011           | XXX                   |
| High Performance headphone playback mode | 1      | 000          | 000           | 000                   |

**Table 88 Recommended Bias Control Settings (Output Signal Path)**

Note that power consumption in the WM8962B can be optimised in real time using the adaptive Charge Pump that provides the supply rails to the headphone driver. The Dynamic control mode of the Charge Pump provides lowest power consumption, and may be selected in Low Power or High Performance headphone playback modes.

Note that there are some operating conditions in which the Dynamic control mode should not be selected; these are described in the "Charge Pump" section.

## DIGITAL AUDIO INTERFACE

The digital audio interface is used for inputting DAC data to the WM8962B and outputting ADC data from it. The digital audio interface uses four pins:

- ADCDAT: ADC data output
- DACDAT: DAC data input
- LRCLK: Left/Right data alignment clock
- BCLK: Bit clock, for synchronisation

The clock signals BCLK and LRCLK can be outputs when the WM8962B operates as a master, or inputs when it is a slave (see “Master and Slave Mode Operation”, below).

Four different audio data formats are supported:

- Left justified
- Right justified
- I<sup>2</sup>S
- DSP mode

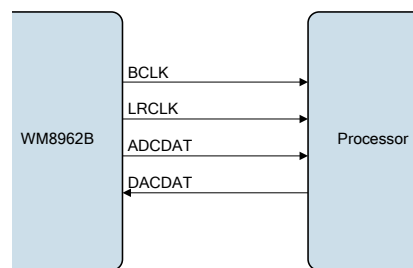
All four of these modes are MSB first. They are described in “Audio Data Formats (Normal Mode)” below. Refer to the “Signal Timing Requirements” section for timing information.

Time Division Multiplexing (TDM) is available in all four data format modes. The WM8962B can be programmed to send and receive data in one of two time slots.

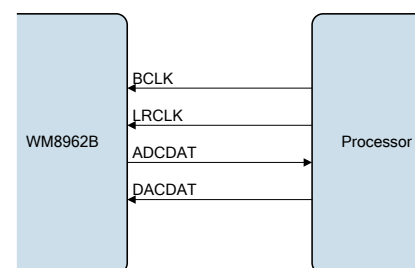
PCM operation is supported using the DSP mode.

### MASTER AND SLAVE MODE OPERATION

The WM8962B digital audio interface can operate as a master or slave as shown in Figure 38 and Figure 39.



**Figure 38 Master Mode**



**Figure 39 Slave Mode**

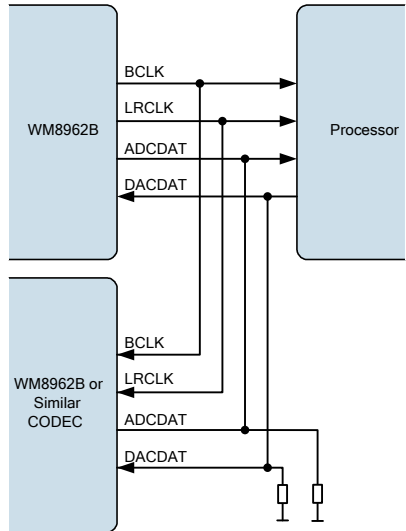
The Audio Interface output control is illustrated above. The MSTR control register determines whether the WM8962B generates the clock signals. The MSTR register field is defined in Table 89.

| REGISTER ADDRESS              | BIT | LABEL | DEFAULT | DESCRIPTION                                                      |
|-------------------------------|-----|-------|---------|------------------------------------------------------------------|
| R7 (07h)<br>Audio Interface 0 | 6   | MSTR  | 0       | Audio Interface Mode Select<br>0 = Slave mode<br>1 = Master mode |

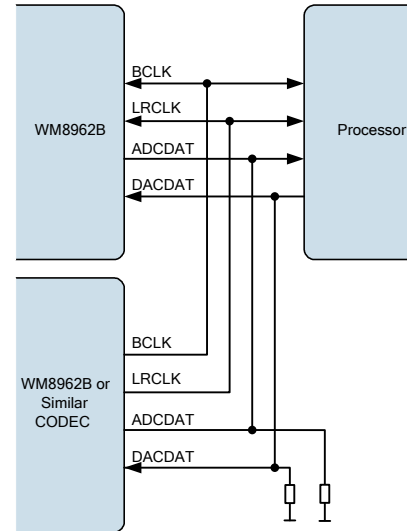
**Table 89 Audio Interface Master/Slave Control**

## OPERATION WITH TDM

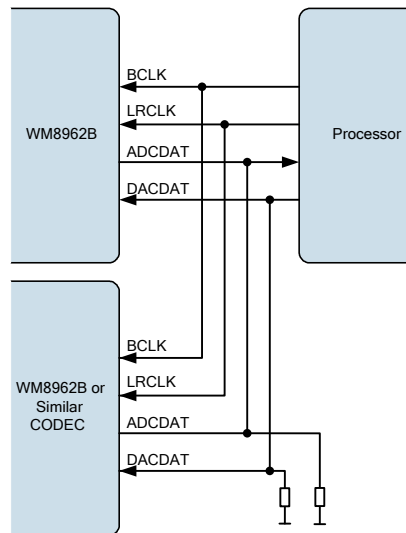
Time division multiplexing (TDM) allows multiple devices to transfer data simultaneously on the same bus. The WM8962B ADCs and DACs support TDM in master and slave modes for all data formats and word lengths. TDM is enabled and configured using register bits defined in the "Digital Audio Interface Control" section.



**Figure 40 TDM with WM8962B as Master**



**Figure 41 TDM with Other CODEC as Master**



**Figure 42 TDM with Processor as Master**

**Note:** The WM8962B is a 24-bit device. If the user operates the WM8962B in 32-bit mode then the 8 LSBs will be ignored on the receiving side and not driven on the transmitting side. It is therefore recommended to add a pull-down resistor, if necessary, to the DACDAT line and the ADCDAT line in TDM mode.

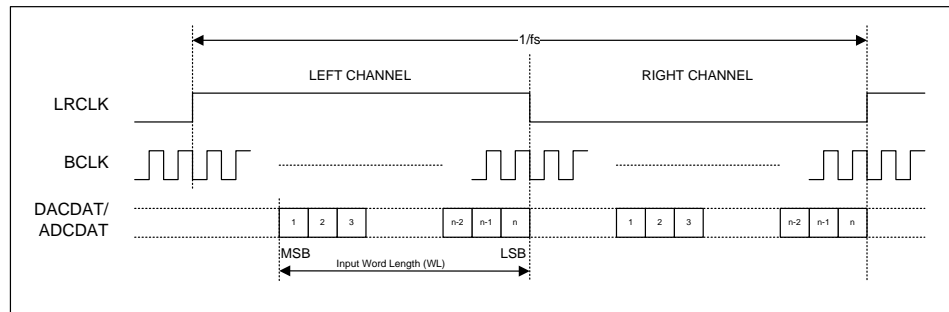
**BCLK FREQUENCY**

The BCLK frequency is controlled relative to SYSCLK by the BCLK\_DIV divider. Internal clock divide and phase control mechanisms ensure that the BCLK and LRCLK edges will occur in a predictable and repeatable position relative to each other and relative to the data for a given combination of DAC/ADC sample rate and BCLK\_DIV settings.

BCLK\_DIV is defined in the “Digital Audio Interface Control” section. See also “Clocking and Sample Rates” section for more information.

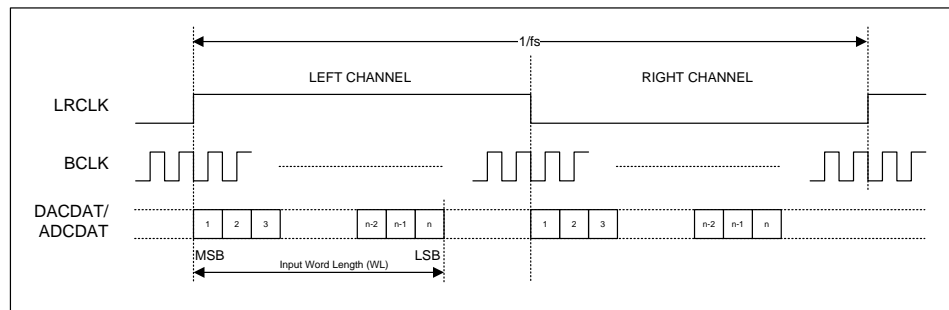
**AUDIO DATA FORMATS (NORMAL MODE)**

In Right Justified mode, the LSB is available on the last rising edge of BCLK before a LRCLK transition. All other bits are transmitted before (MSB first). Depending on word length, BCLK frequency and sample rate, there may be unused BCLK cycles after each LRCLK transition.



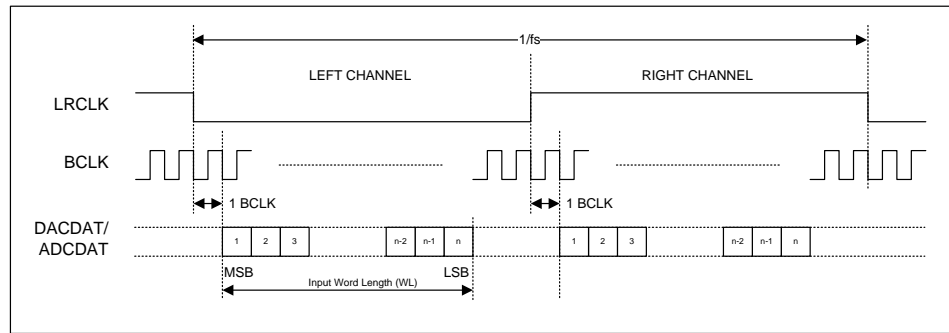
**Figure 43 Right Justified Audio Interface (assuming n-bit word length)**

In Left Justified mode, the MSB is available on the first rising edge of BCLK following a LRCLK transition. The other bits up to the LSB are then transmitted in order. Depending on word length, BCLK frequency and sample rate, there may be unused BCLK cycles before each LRCLK transition.



**Figure 44 Left Justified Audio Interface (assuming n-bit word length)**

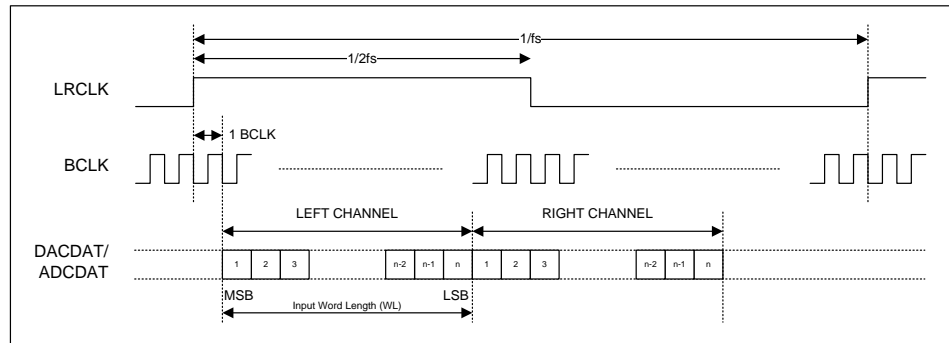
In I<sup>2</sup>S mode, the MSB is available on the second rising edge of BCLK following a LRCLK transition. The other bits up to the LSB are then transmitted in order. Depending on word length, BCLK frequency and sample rate, there may be unused BCLK cycles between the LSB of one sample and the MSB of the next.



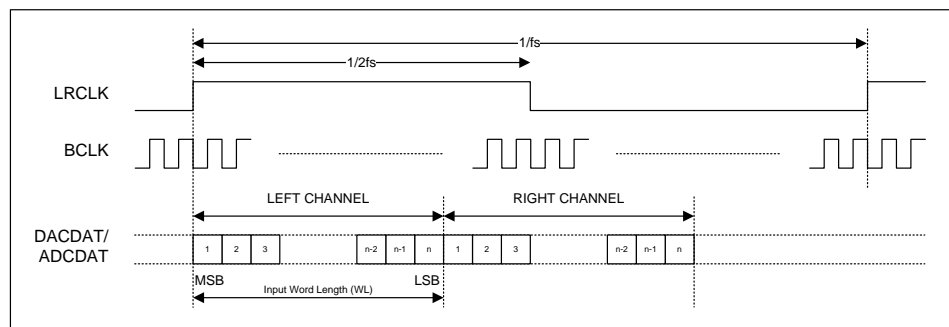
**Figure 45 I2S Justified Audio Interface (assuming n-bit word length)**

In DSP mode, the left channel MSB is available on either the 1<sup>st</sup> (mode B) or 2<sup>nd</sup> (mode A) rising edge of BCLK (selectable by LRCLK\_INV) following a rising edge of LRCLK. Right channel data immediately follows left channel data. Depending on word length, BCLK frequency and sample rate, there may be unused BCLK cycles between the LSB of the right channel data and the next sample.

In device master mode, the LRCLK output will resemble the frame pulse shown in Figure 46 and Figure 47. In device slave mode, Figure 48 and Figure 49, it is possible to use any length of frame pulse less than  $1/f_s$ , providing the falling edge of the frame pulse occurs greater than one BCLK period before the rising edge of the next frame pulse.

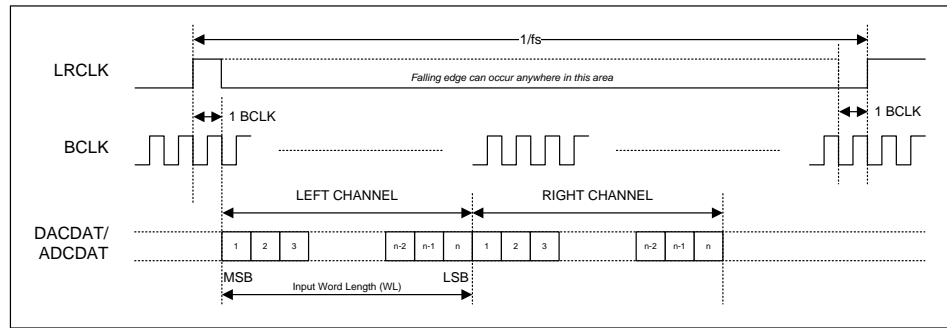


**Figure 46 DSP Mode Audio Interface (mode A, LRCLK\_INV=0, Master)**

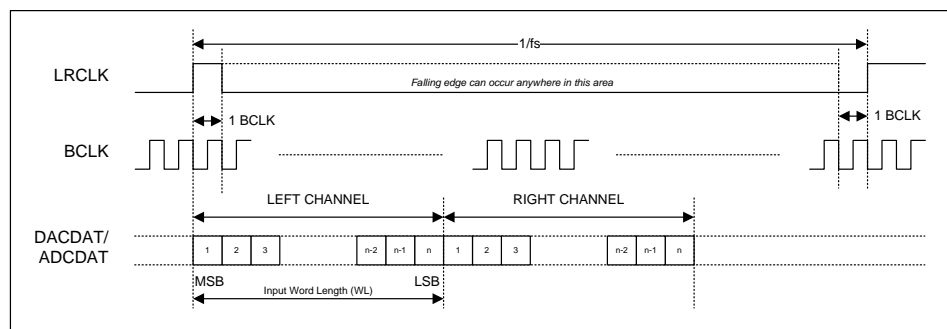


**Figure 47 DSP Mode Audio Interface (mode B, LRCLK\_INV=1, Master)**





**Figure 48 DSP Mode Audio Interface (mode A, LRCLK\_INV=0, Slave)**



**Figure 49 DSP Mode Audio Interface (mode B, LRCLK\_INV=1, Slave)**

PCM operation is supported in DSP interface mode. WM8962B ADC data that is output on the Left Channel will be read as mono PCM data by the receiving equipment. Mono PCM data received by the WM8962B will be treated as Left Channel data. This data may be routed to the Left/Right DACs as described in the “Digital Mixing” section.

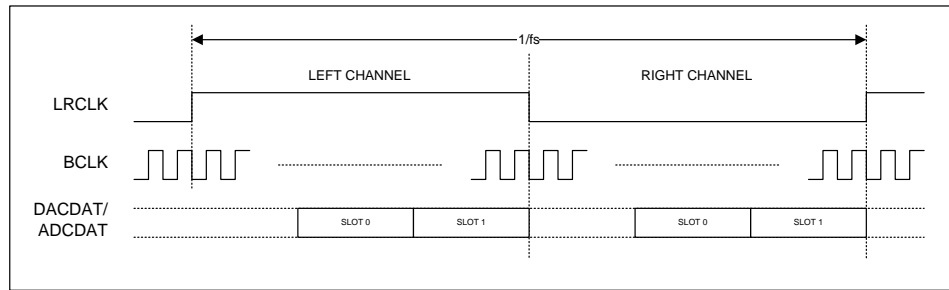
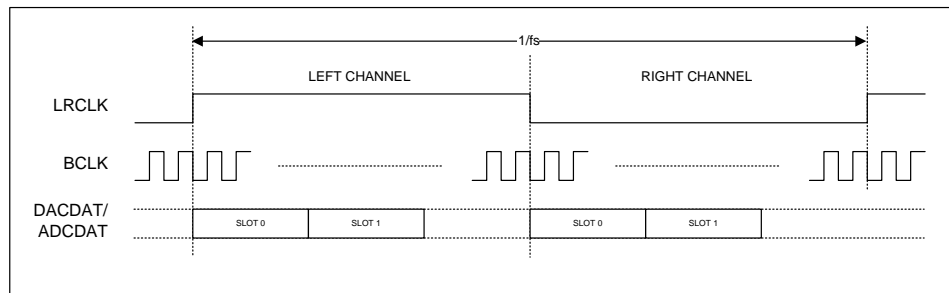
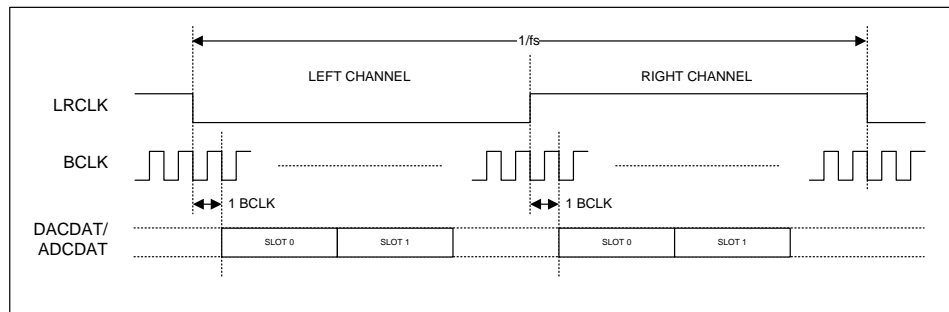
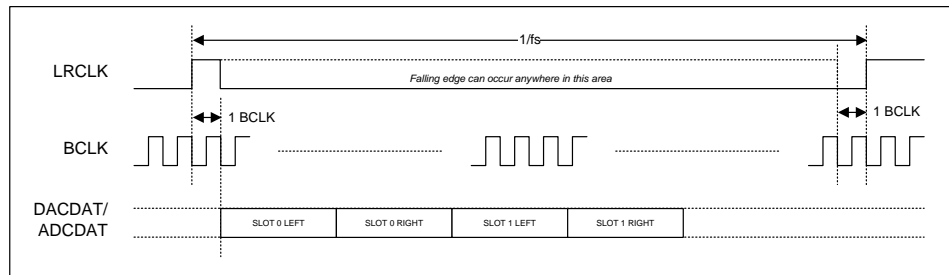
### AUDIO DATA FORMATS (TDM MODE)

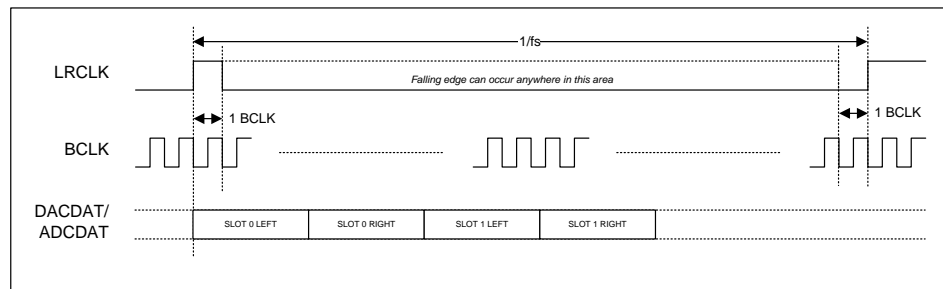
TDM is supported in master and slave mode and is enabled by register bits AIFADC\_TDM\_MODE and AIFDAC\_TDM\_MODE. All audio interface data formats support time division multiplexing (TDM) for ADC and DAC data.

Two time slots are available (Slot 0 and Slot 1), selected by register bits AIFADC\_TDM\_SLOT and AIFDAC\_TDM\_SLOT which control time slots for the ADC data and the DAC data.

When TDM is enabled, the ADCDAT pin will be tri-stated immediately before and immediately after data transmission, to allow another ADC device to drive this signal line for the remainder of the sample period. Note that it is important that two ADC devices do not attempt to drive the data pin simultaneously. A short circuit may occur if the transmission time of the two ADC devices overlap with each other. See “Audio Interface Timing” for details of the ADCDAT output relative to BCLK signal. Note that it is possible to ensure a gap exists between transmissions by setting the transmitted word length to a value higher than the actual length of the data. For example, if 32-bit word length is selected where only 24-bit data is available, then the WM8962B interface will tri-state after transmission of the 24-bit data, ensuring a gap after the WM8962B’s TDM slot.

When TDM is enabled, BCLK frequency must be high enough to allow data from both time slots to be transferred. The relative timing of Slot 0 and Slot 1 depends upon the selected data format as shown in Figure 50 to Figure 54.


**Figure 50 TDM in Right-Justified Mode**

**Figure 51 TDM in Left-Justified Mode**

**Figure 52 TDM in I²S Mode**

**Figure 53 TDM in DSP Mode A**


**Figure 54 TDM in DSP Mode B**

## DIGITAL AUDIO INTERFACE CONTROL

The register bits controlling audio data format, word length, left/right channel data configuration and TDM are summarised in Table 90.

| REGISTER ADDRESS                      | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                      |
|---------------------------------------|-----|-----------------|---------|------------------------------------------------------------------------------------------------------------------|
| R5 (05h)<br>ADC &<br>DAC<br>Control 1 | 6   | ADCR_DAT_INV    | 0       | Right ADC Invert<br>0 = Right ADC output not inverted<br>1 = Right ADC output inverted                           |
|                                       | 5   | ADCL_DAT_INV    | 0       | Left ADC Invert<br>0 = Left ADC output not inverted<br>1 = Left ADC output inverted                              |
| R6 (06h)<br>ADC &<br>DAC<br>Control 2 | 6   | DACR_DAT_INV    | 0       | Right DAC Invert<br>0 = Right DAC input not inverted<br>1 = Right DAC input inverted                             |
|                                       | 5   | DACL_DAT_INV    | 0       | Left DAC Invert<br>0 = Left DAC input not inverted<br>1 = Left DAC input inverted                                |
| R7 (07h)<br>Audio<br>Interface<br>0   | 12  | AIFDAC_TDM_MODE | 0       | DAC TDM Mode Select<br>0 = Normal DACDAT operation (1 stereo slot)<br>1 = TDM enabled on DACDAT (2 stereo slots) |
|                                       | 11  | AIFDAC_TDM_SLOT | 0       | DACDAT TDM Slot Select<br>0 = DACDAT data input on slot 0<br>1 = DACDAT data input on slot 1                     |
|                                       | 10  | AIFADC_TDM_MODE | 0       | ADC TDM Mode Select<br>0 = Normal ADCDAT operation (1 stereo slot)<br>1 = TDM enabled on ADCDAT (2 stereo slots) |
|                                       | 9   | AIFADC_TDM_SLOT | 0       | ADCDAT TDM Slot Select<br>0 = ADCDAT data input on slot 0<br>1 = ADCDAT data input on slot 1                     |
|                                       | 8   | ADC_LRSWAP      | 0       | Swap left/right ADC data on the interface<br>0 = Normal<br>1 = ADCDAT channels swapped                           |
|                                       | 7   | BCLK_INV        | 0       | BCLK Invert<br>0 = BCLK not inverted<br>1 = BCLK inverted                                                        |
|                                       | 5   | DAC_LRSWAP      | 0       | Swap left/right DAC data on the interface<br>0 = Normal<br>1 = DACDAT channels swapped                           |

| REGISTER ADDRESS | BIT | LABEL     | DEFAULT | DESCRIPTION                                                                                                                                                                                  |
|------------------|-----|-----------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  | 4   | LRCLK_INV | 0       | Right, left and I <sup>2</sup> S modes – LRCLK polarity<br>0 = normal LRCLK polarity<br>1 = invert LRCLK polarity                                                                            |
|                  |     |           |         | DSP Mode – mode A/B select<br>0 = MSB is available on 2nd BCLK rising edge after LRCLK rising edge (mode A)<br>1 = MSB is available on 1st BCLK rising edge after LRCLK rising edge (mode B) |
|                  | 3:2 | WL [1:0]  | 10      | Digital Audio Interface Word Length<br>00 = 16 bits<br>01 = 20 bits<br>10 = 24 bits<br>11 = 32 bits<br>Note - see “Companding” for the selection of 8-bit mode.                              |
|                  | 1:0 | FMT [1:0] | 10      | Digital Audio Interface Format<br>00 = Right justified<br>01 = Left justified<br>10 = I <sup>2</sup> S Format<br>11 = DSP Mode                                                               |

**Table 90 Digital Audio Interface Data Control**

#### AUDIO INTERFACE TRI-STATE

Register bit AIF\_TRI can be used to tri-state the audio interface pins as described in Table 91. All digital audio interface pins will be tri-stated by this function, regardless of the state of other registers which control these pin configurations.

| REGISTER ADDRESS                    | BIT | LABEL   | DEFAULT | DESCRIPTION                                                                                                                       |
|-------------------------------------|-----|---------|---------|-----------------------------------------------------------------------------------------------------------------------------------|
| R24 (18h)<br>Additional Control (2) | 3   | AIF_TRI | 0       | Audio Interface Tristate<br>0 = Audio interface pins operate normally<br>1 = ADCDAT is tri-stated; BCLK & LRCLK are set as inputs |

**Table 91 Digital Audio Interface Tri-State Control**

#### BCLK AND LRCLK CONTROL

The audio interface can be programmed to operate in master mode or slave mode using the MSTR register bit.

In master mode, the BCLK and LRCLK signals are generated by the WM8962B when any of the ADCs or DACs is enabled. In slave mode, the BCLK and LRCLK clock outputs are disabled by default to allow another digital audio interface to drive these pins. Refer to “Clocking and Sample Rates” for specific operating constraints in this configuration.

| REGISTER ADDRESS               | BIT  | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                   |
|--------------------------------|------|--------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R7 (07h)<br>Audio Interface 0  | 6    | MSTR               | 0       | Audio Interface Mode Select<br>0 = Slave mode<br>1 = Master mode                                                                                                                                                                                                                                                                                              |
| R8 (08h)<br>Clocking2          | 3:0  | BCLK_DIV           | 0100    | BCLK Rate<br>0000 = DSPCLK<br>0001 = Reserved<br>0010 = DSPCLK / 2<br>0011 = DSPCLK / 3<br>0100 = DSPCLK / 4 (default)<br>0101 = Reserved<br>0110 = DSPCLK / 6<br>0111 = DSPCLK / 8<br>1000 = Reserved<br>1001 = DSPCLK / 12<br>1010 = DSPCLK / 16<br>1011 = DSPCLK / 24<br>1100 = Reserved<br>1101 = DSPCLK / 32<br>1110 = DSPCLK / 32<br>1111 = DSPCLK / 32 |
| R14 (0Eh)<br>Audio Interface 2 | 10:0 | AIF_RATE<br>[10:0] | 040h    | LRCLK Rate<br>LRCLK clock output =<br>BCLK / AIF_RATE<br><br>Integer (LSB = 1)<br>Valid from 4..2047<br><br>Default (040h) = 64 BCLKs per LRCLK                                                                                                                                                                                                               |

**Table 92 Digital Audio Interface Clock Control**

### COMPANDING

The WM8962B supports A-law and  $\mu$ -law companding on both transmit (ADC) and receive (DAC) sides as shown in Table 93.

| REGISTER ADDRESS              | BIT | LABEL        | DEFAULT | DESCRIPTION                                          |
|-------------------------------|-----|--------------|---------|------------------------------------------------------|
| R9 (09h)<br>Audio Interface 1 | 4   | DAC_COMP     | 0       | DAC Companding Enable<br>0 = disabled<br>1 = enabled |
|                               | 3   | DAC_COMPMODE | 0       | DAC Companding Type<br>0 = $\mu$ -law<br>1 = A-law   |
|                               | 2   | ADC_COMP     | 0       | ADC Companding Enable<br>0 = disabled<br>1 = enabled |
|                               | 1   | ADC_COMPMODE | 0       | ADC Companding Type<br>0 = $\mu$ -law<br>1 = A-law   |

**Table 93 Companding Control**

Companding involves using a piecewise linear approximation of the following equations (as set out by ITU-T G.711 standard) for data compression:

$\mu$ -law (where  $\mu=255$  for the U.S. and Japan):

$$F(x) = \ln(1 + \mu|x|) / \ln(1 + \mu) \quad -1 \leq x \leq 1$$

A-law (where  $A=87.6$  for Europe):

$$F(x) = A|x| / (1 + \ln A) \quad x \leq 1/A$$

$$F(x) = (1 + \ln A|x|) / (1 + \ln A) \quad 1/A \leq x \leq 1$$

The companded data is also inverted as recommended by the G.711 standard (all 8 bits are inverted for  $\mu$ -law, all even data bits are inverted for A-law). The data will be transmitted as the first 8 MSBs of data.

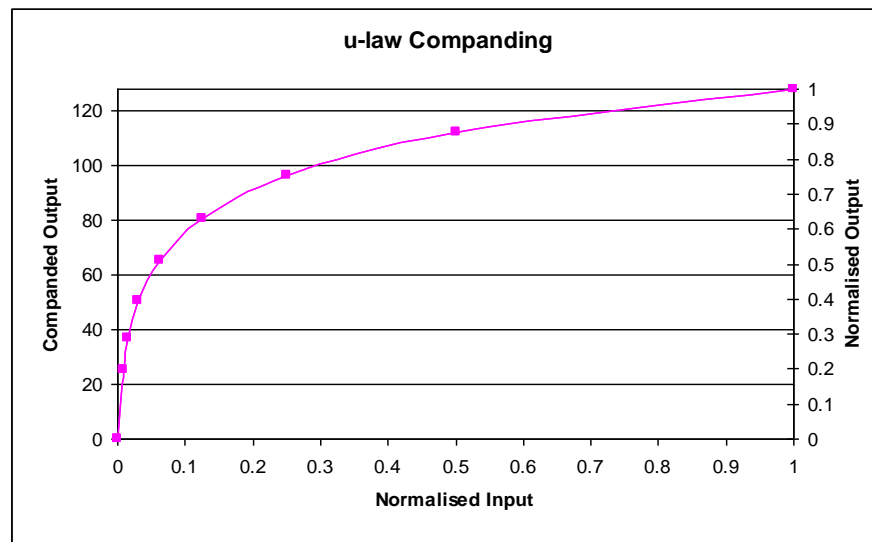
Companding converts 13 bits ( $\mu$ -law) or 12 bits (A-law) to 8 bits using non-linear quantization. This provides greater precision for low amplitude signals than for high amplitude signals, resulting in a greater usable dynamic range than 8 bit linear quantization. The companded signal is an 8-bit word comprising sign (1 bit), exponent (3 bits) and mantissa (4 bits).

8-bit mode is selected whenever  $DAC\_COMP=1$  or  $ADC\_COMP=1$ . The use of 8-bit data allows samples to be passed using as few as 8 BCLK cycles per LRCLK frame. When using DSP mode B, 8-bit data words may be transferred consecutively every 8 BCLK cycles.

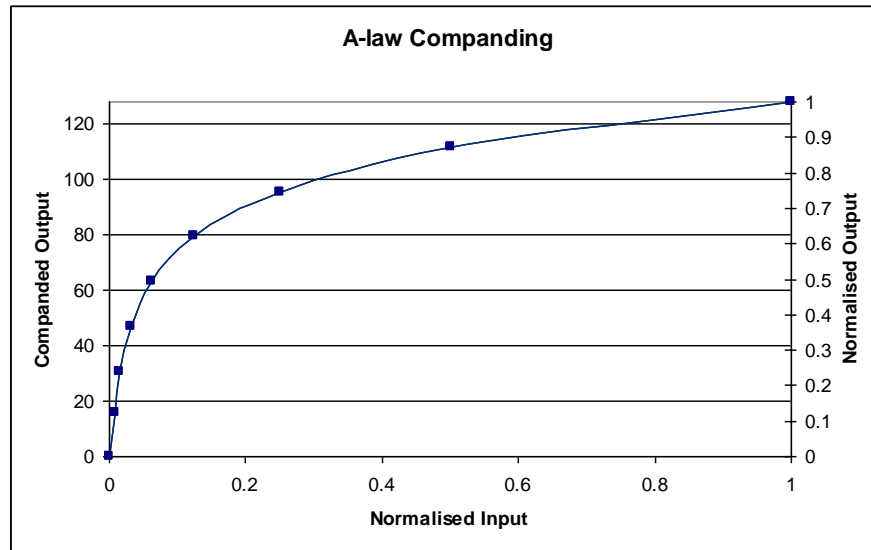
8-bit mode (without Companding) may be enabled by setting  $DAC\_COMPMODE=1$  or  $ADC\_COMPMODE=1$ , when  $DAC\_COMP=0$  and  $ADC\_COMP=0$ .

| BIT7 | BIT[6:4] | BIT[3:0] |
|------|----------|----------|
| SIGN | EXPONENT | MANTISSA |

**Table 94 8-bit Companded Word Composition**



**Figure 55  $\mu$ -Law Companding**



**Figure 56 A-Law Companding**

**LOOPBACK**

Setting the LOOPBACK register bit enables digital loopback. When this bit is set, the ADC digital data output is routed to the DAC digital data input path. The digital audio interface input (DACDAT) is not used when LOOPBACK is enabled.

| REGISTER ADDRESS                | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                 |
|---------------------------------|-----|----------|---------|-----------------------------------------------------------------------------------------------------------------------------|
| R9 (09h)<br>Audio Interface (2) | 0   | LOOPBACK | 0       | Digital Loopback Function<br>0 = No loopback<br>1 = Loopback enabled (ADC data output is directly input to DAC data input). |

**Table 95 Loopback Control**

**Note:** When the digital sidetone is enabled, ADC data will also be added to DAC digital data input path within the Digital Mixing circuit. This applies regardless of whether LOOPBACK is enabled.

## CLOCKING AND SAMPLE RATES

The internal clocks for the WM8962B are all derived from a common internal clock source, SYSCLK. This clock is the reference for the ADCs, DACs, DSP core functions, digital audio interface, Class D switching amplifier, DC servo control and other internal functions.

SYSCLK can either be derived directly from MCLK, or may be generated from the Frequency Locked Loop (FLL) or Phase Locked Loop (PLL). Many commonly-used audio sample rates can be derived directly from typical MCLK frequencies; the FLL and PLL provide additional flexibility for a wide range of reference frequencies. To avoid audible glitches, all clock configurations must be set up before enabling playback. The FLL can be used to generate a free-running clock in the absence of an external reference source; see “Free-Running FLL Clock” for further details. See “Internal / External Clock Generation” for further details of the PLL and FLL circuits.

The WM8962B supports automatic clocking configuration. The programmable dividers associated with the ADCs, DACs, DSP core functions, Class D switching and DC servo are configured automatically, with values determined from the MCLK\_RATE and SAMPLE\_RATE fields. The user must also configure the OPCLK (if required), the TOCLK (if required) and the digital audio interface.

ADC/DAC oversample rates of 64fs or 128fs are supported (based on a 48kHz sample rate).

A 256kHz clock, supporting a number of internal functions, is derived from SYSCLK.

The Class D switching amplifier and DC servo control circuits are clocked from SYSCLK.

A GPIO Clock, OPCLK, can be derived from SYSCLK and output on a GPIO pin to provide clocking to other devices. This clock is enabled by OPCLK\_ENA and controlled by OPCLK\_DIV.

A slow clock, TOCLK, is used to set the timeout period for volume updates when zero-cross detect is used. This clock is enabled by TOCLK\_ENA and controlled by TOCLK\_DIV. A de-bounce clock, DBCLK, is used to control the de-bouncing of button/accessory detect GPIO inputs and selected interrupt inputs. This clock is enabled automatically whenever GPIO or interrupt de-bouncing is selected. The de-bounce clock frequency is controlled by DBCLK\_DIV.

In master mode, BCLK is derived from DSPCLK via a programmable divider set by BCLK\_DIV. In master mode, the LRCLK is derived from BCLK via a programmable divider AIF\_RATE.

In Slave mode, BCLK and LRCLK are inputs to the WM8962B, allowing another digital audio interface to drive these pins. See the “BCLK and LRCLK Control” sub-section for specific operating constraints in this configuration.

The control registers associated with Clocking and Sample Rates are shown in Table 98 to Table 103.

The overall clocking scheme for the WM8962B is illustrated in Figure 57.



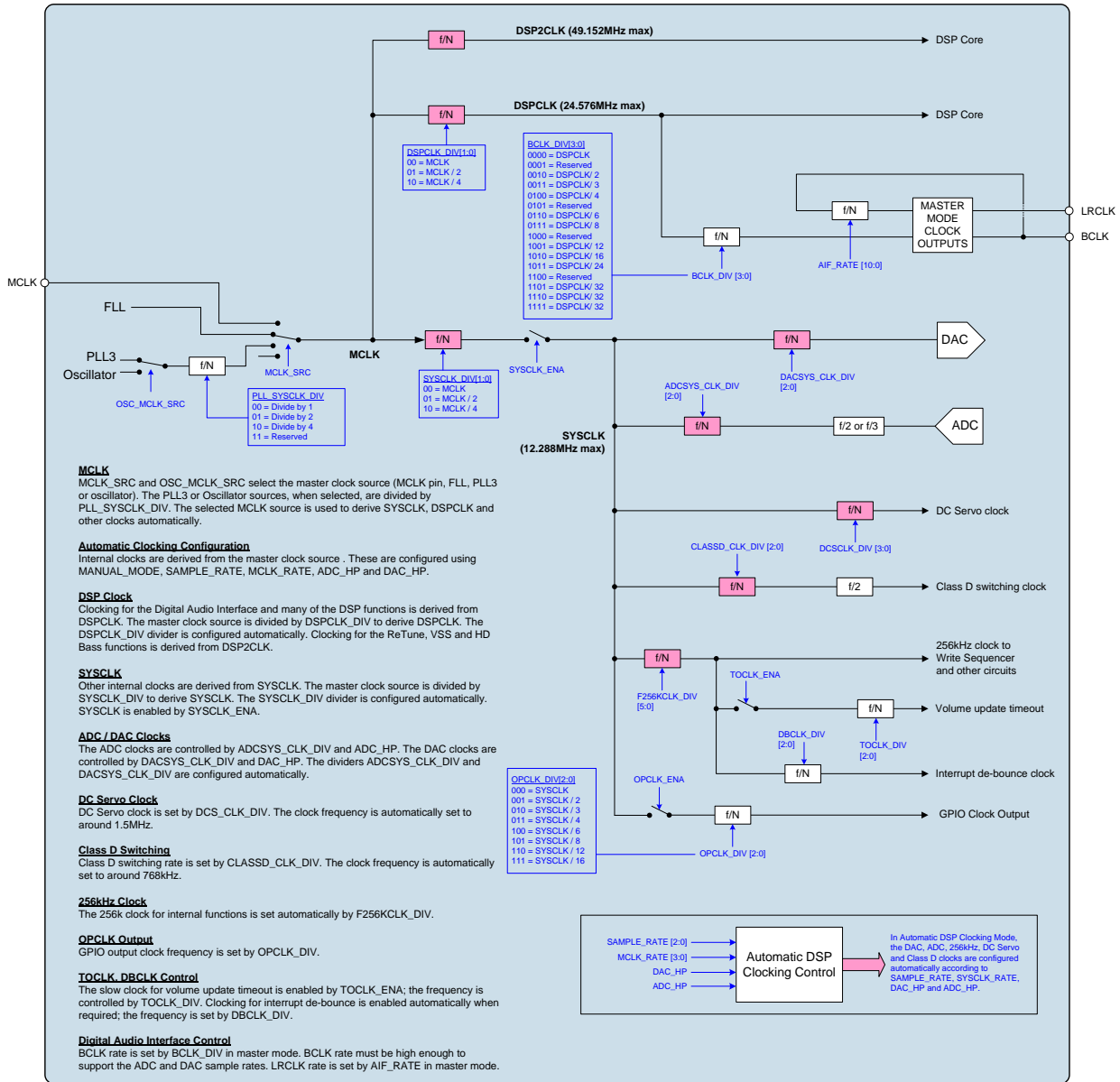


Figure 57 SYSCLK and Internal Clocking Scheme

## SYSCLK CONTROL

The MCLK\_SRC and OSC\_MCLK\_SRC registers are used to select the source for MCLK. The source may be either the MCLK pin, FLL, PLL3 or Oscillator. The PLL3 or Oscillator sources, when selected, are controlled by the PLL\_SYSCLK\_DIV divider.

The selected source may be adjusted by the programmable divider SYSCLK\_DIV; this is configured automatically by the WM8962B to ensure that SYSCLK <= 12.288MHz. (Note that the SYSCLK\_DIV divider is a read-only register; it cannot be written to.)

The MCLK\_SRC register is controlled automatically under certain circumstances, as described below. The associated control register, CLKREG\_OVD, is defined in the following section ("Automatic Clocking Configuration").

When a logic 1 is applied on the GPIO5 pin, the MCLK\_SRC register is set to 01b, selecting FLL as the source. In this case, the MCLK\_SRC register is locked to prevent accidental writes to this register. The MCLK\_SRC register can be unlocked by setting the CLKREG\_OVD bit.

When a logic 0 is applied on the GPIO5 pin, the MCLK\_SRC register defaults to 00b, selecting MCLK as the source. In this case, the default (00b) is selected on the falling edge of GPIO5; other settings can then be selected by writing to the MCLK\_SRC register as normal.

Note that it is important that the GPIO5 input is held in a defined logic state (logic '0' or logic '1') during start-up; it must not be left floating. If normal GPIO functionality is required on the GPIO5 pin, then the CLKREG\_OVD bit must be set to '1' in order to select normal read/write control of all the clocking registers, and to permit GPIO functions. The GPIO5 pin must be held in a defined logic state (logic '0' or logic '1') whenever the pin is configured as an input, including whenever CLKREG\_OVD = 0 (default).

See “Internal / External Clock Generation” for more details of the FLL and PLL clock generators.

The SYSCLK signal is enabled by register bit SYSCLK\_ENA. This bit should be set to 0 when reconfiguring clock sources.

The following operating frequency limits are recommended when configuring SYSCLK. Failure to observe these limits may result in degraded noise performance.

- MCLK ≥ 3MHz
- If DAC\_HP = 1 or ADC\_HP = 1, then MCLK ≥ 6MHz

The valid clocking ratios for DAC and/or ADC operation are identified in Table 96. See also Table 97 for details of the supported functions for each combination of Sample Rate and MCLK / fs ratio.

| SAMPLE RATE (kHz) | MCLK RATE (MCLK / fs ratio) |     |     |     |     |     |     |      |      |      |      |
|-------------------|-----------------------------|-----|-----|-----|-----|-----|-----|------|------|------|------|
|                   | 64                          | 128 | 192 | 256 | 384 | 512 | 768 | 1024 | 1536 | 3072 | 6144 |
| 8                 | 1                           | 2   | 3   | 4   | 5   | 6   | 6   | 6    | 6    | 6    | 6    |
| 11.025            | 1                           | 2   | 3   | 4   | 5   | 6   | 6   | 6    | 6    | 6    |      |
| 12                | 1                           | 2   | 3   | 4   | 5   | 6   | 6   | 6    | 6    | 6    |      |
| 16                | 1                           | 2   | 3   | 4   | 5   | 6   | 6   | 6    | 6    | 6    |      |
| 22.05             | 1                           | 2   | 3   | 4   | 5   | 6   | 6   | 6    | 6    |      |      |
| 24                | 1                           | 2   | 3   | 4   | 5   | 6   | 6   | 6    | 6    |      |      |
| 32                | 1                           | 2   | 3   | 4   | 5   | 6   | 6   | 6    | 6    |      |      |
| 44.1              | 1                           | 2   | 3   | 4   | 5   | 6   | 5   | 6    |      |      |      |
| 48                | 1                           | 2   | 3   | 4   | 5   | 6   | 5   | 6    |      |      |      |
| 88.2              | 1                           | 2   | 3   | 4   | 3   | 4   |     |      |      |      |      |
| 96                | 1                           | 2   | 3   | 4   | 3   | 4   |     |      |      |      |      |

**Table 96 MCLK / Sample Rate Availability**

| CODE | DAC/ADC Configuration | ADC Signal Path Enhancements                                       |         | DAC Signal Path Enhancements |           |                                                       |
|------|-----------------------|--------------------------------------------------------------------|---------|------------------------------|-----------|-------------------------------------------------------|
|      |                       | HPF, LPF/HPF, DF1 Filter, 3D Surround, Dynamic Range Control (DRC) | ReTune™ | Dynamic Range Control (DRC)  | 5-band EQ | Virtual Surround Sound (VSS), ReTune HD Bass, DAC HPF |
| 1    | Mono DAC              |                                                                    |         |                              |           |                                                       |
| 2    | Stereo DAC            |                                                                    |         |                              |           |                                                       |
| 3    | Stereo DAC            |                                                                    |         | ✓                            | ✓         |                                                       |
| 4    | Stereo CODEC          | ✓                                                                  |         | ✓                            |           |                                                       |
|      | or Stereo DAC         |                                                                    |         | ✓                            | ✓         |                                                       |
| 5    | Stereo CODEC          | ✓                                                                  |         | ✓                            | ✓         |                                                       |
| 6    | Stereo CODEC          | ✓                                                                  | ✓       | ✓                            | ✓         | ✓                                                     |

**Table 97 DAC/ADC and Audio Enhancements Availability**

The supported MCLK frequency range is defined in the “Signal Timing Requirements”.

The MCLK / fs ratio is set using the MCLK\_RATE register. See “Automatic Clocking Configuration” for details of this register.

The MCLK and SYSCLK control register fields are defined in Table 98.

| REGISTER ADDRESS                     | BIT  | LABEL          | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------------------------|------|----------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R4 (04h)<br>Clocking1                | 2:1  | SYSClk_DIV     | 00      | SYSClk Divider<br>00 = MCLK<br>01 = MCLK / 2<br>10 = MCLK / 4<br>11 = Reserved<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br>Note that the division is applied to the selected MCLK source, including FLL / PLL when applicable.                                                                                                                                                                                                                                                                                                   |
| R8 (08h)<br>Clocking2                | 10:9 | MCLK_SRC       | 00      | MCLK source select<br>00 = MCLK pin<br>01 = FLL output<br>10 = PLL3 or Oscillator (selected by OSC_MCLK_SRC)<br>11 = Reserved<br>If CLKREG_OVD = 0, then MCLK_SRC is controlled by the GPIO5 pin.<br>If CLKREG_OVD = 0 and GPIO5 = 1, then MCLK_SRC = 01 (FLL) and MCLK_SRC cannot be changed by the Control Interface.<br>If CLKREG_OVD = 0 and GPIO5 = 0, then MCLK_SRC = 00 (MCLK) by default, but the value can be changed via the Control Interface.<br>If CLKREG_OVD = 1 then MCLK_SRC = 00 (MCLK) by default, but the value can be changed via the Control Interface. |
|                                      | 5    | SYSClk_ENA     | 1       | SYSClk enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| R125 (7Dh)<br>Analogue<br>Clocking2  | 4:3  | PLL_SYSClk_DIV | 01      | PLL3 / Oscillator to MCLK divider<br>00 = Divide by 1<br>01 = Divide by 2<br>10 = Divide by 4<br>11 = Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| R152 (98h)<br>Analogue<br>Clocking 4 | 4    | OSC_MCLK_SRC   | 0       | PLL3 / Oscillator to MCLK source<br>0 = PLL3<br>1 = Oscillator<br>This field selects the MCLK source, when MCLK_SRC = 10.                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

**Table 98 MCLK and SYSClk Control**

**AUTOMATIC CLOCKING CONFIGURATION**

The WM8962B supports a wide range of standard audio sample rates from 8kHz to 96kHz. The Automatic Clocking Configuration mode simplifies the configuration of the clock dividers in the WM8962B by deriving most of the necessary parameters from a minimum number of user registers.

In Automatic mode, the SAMPLE\_RATE field selects the sample rate, fs, of the ADC and DAC. The SAMPLE\_RATE\_INT\_MODE bit should be set according to the selected SAMPLE\_RATE, as described in Table 99. Note that, in Automatic mode, the same sample rate always applies to the ADC and DAC.

In Automatic mode, the MCLK\_RATE field must be set according to the ratio of MCLK to fs. (Note that the MCLK source is selected by MCLK\_SRC - see Table 98.)

Selectable modes of ADC / DAC operation are available using the ADC\_HP and DAC\_HP register bits. The automatic clocking configuration uses these bits to determine the applicable clock divider settings.

The WM8962B is designed to support specific internal and external clocking configurations. Under default conditions, the GPIO5 pin has control over selected clocking registers, and normal read/write access to some registers is not supported. When the CLKREG\_OVD register is set to 1, the affected clocking registers are controlled as normal via the Control Interface. The registers that are affected by CLKREG\_OVD are noted in Table 99.

| REGISTER ADDRESS                       | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                        |
|----------------------------------------|-----|----------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R6 (06h)<br>ADC & DAC<br>Control 2     | 0   | DAC_HP               | 0       | DAC Oversampling Ratio<br>0 = Low Power (typically 64 x fs)<br>1 = High Performance (typically 128 x fs)                                                                                                                                                                                                                                                           |
| R8 (08h)<br>Clocking2                  | 11  | CLKREG_OVD           | 0       | Clock Configuration Override<br>0 = MCLK_SRC, OSC_ENA and CLKOUT5_SEL registers are controlled by the GPIO5 pin; PLL2_ENA, PLL3_ENA, CLKOUT2_DIV, CLKOUT5_DIV and CLKOUT3_SEL registers are locked to fixed values.<br>1 = Clocking registers are controlled as normal via Control Interface.<br>This bit must be set to 1 to support GPIO functionality on GPIO5. |
| R23 (17h)<br>Additional<br>Control (1) | 5   | ADC_HP               | 0       | ADC Oversampling Ratio<br>0 = Low Power (typically 64 x fs)<br>1 = High Performance (typically 128 x fs)                                                                                                                                                                                                                                                           |
| R27 (1Bh)<br>Additional<br>Control (3) | 4   | SAMPLE_RATE_INT_MODE | 1       | Selects the Integer or Fractional value of the SAMPLE_RATE register.<br>0 = 11.025k, 22.05k, 44.1k or 88.2kHz<br>1 = 8k, 12k, 16k, 24k, 32k, 48k or 96kHz                                                                                                                                                                                                          |
|                                        | 2:0 | SAMPLE_RATE [2:0]    | 000     | Selects the Sample Rate (fs)<br>000 = 44.1kHz, 48kHz<br>001 = 32kHz<br>010 = 22.05kHz, 24kHz<br>011 = 16kHz<br>100 = 11.025kHz, 12kHz<br>101 = 8kHz<br>110 = 88.2kHz, 96kHz<br>111 = Reserved                                                                                                                                                                      |

| REGISTER ADDRESS        | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------|-----|--------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R56 (38h)<br>Clocking 4 | 4:1 | MCLK_RATE<br>[3:0] | 0011    | <p>Selects the MCLK / fs ratio.<br/>(Note that the MCLK source is selected by MCLK_SRC.)</p> <p>0000 = 64<br/>0001 = 128<br/>0010 = 192<br/>0011 = 256 (default)<br/>0100 = 384<br/>0101 = 512<br/>0110 = 768<br/>0111 = 1024<br/>1000 = Reserved<br/>1001 = 1536<br/>1010 = 3072<br/>1011 = 6144</p> <p>If ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass is enabled, then MCLK_RATE must be 512 or higher.</p> |

**Table 99 Automatic Clocking Configuration Control**

**DSP, ADC, DAC CLOCK CONTROL**

The clocking of the DSP is derived from MCLK. The clocking of the ADC and DAC circuits is derived from SYSCLK. The associated dividers are configured automatically by the WM8962B.

The DSP clocking rate is controlled by DSPCLK\_DIV. In automatic clocking mode, this is configured automatically by the WM8962B to ensure  $DSPCLK \leq 24.576MHz$ . (Note that the DSPCLK\_DIV divider is a read-only register; it cannot be written to.)

The ADC clocking rate is controlled by ADCSYS\_CLK\_DIV. In automatic clocking mode, the WM8962B uses this divider to derive the most suitable  $SYSCLK / fs$  ratio, where  $fs$  is the ADC sampling rate.

The DAC clocking rate is controlled by DACSYS\_CLK\_DIV. In automatic clocking mode, the WM8962B uses this divider to derive the most suitable  $SYSCLK / fs$  ratio, where  $fs$  is the DAC sampling rate.

| REGISTER ADDRESS       | BIT  | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                        |
|------------------------|------|----------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R4 (04h)<br>Clocking 1 | 10:9 | DSPCLK_DIV [1:0]     | 00      | DSP Clock Divider<br>00 = MCLK<br>01 = MCLK / 2<br>10 = MCLK / 4<br>11 = Reserved<br>This field is for read-back only; it is set automatically and cannot be adjusted.                                                                                             |
|                        | 8:6  | ADCSYS_CLK_DIV [2:0] | 000     | ADC Sample Rate Divider<br>000 = SYSCLK<br>001 = Reserved<br>010 = SYSCLK / 2<br>011 = SYSCLK / 3<br>100 = SYSCLK / 4<br>101 = Reserved<br>110 = SYSCLK / 6<br>111 = Reserved<br>This field is for read-back only; it is set automatically and cannot be adjusted. |
|                        | 5:3  | DACSYS_CLK_DIV [2:0] | 100     | DAC Sample Rate Divider<br>000 = SYSCLK<br>001 = Reserved<br>010 = SYSCLK / 2<br>011 = SYSCLK / 3<br>100 = SYSCLK / 4<br>101 = Reserved<br>110 = SYSCLK / 6<br>111 = Reserved<br>This field is for read-back only; it is set automatically and cannot be adjusted. |

**Table 100 DSP, ADC, DAC Clock Control**

**CLASS D, 256K, DC SERVO CLOCK CONTROL**

The clocking of the Class D amplifier, DC Servo and other functions is derived from SYSCLK. The associated dividers are configured automatically by the WM8962B.

The Class D amplifier switching frequency is controlled by CLASSD\_CLK\_DIV. In automatic clocking mode, the WM8962B uses this divider to generate a Class D clock that is approximately 768kHz. (Note that there is an additional divide by two in the output stage producing a 384kHz switching frequency.)

A 256kHz clock is required for other circuits, including the Control Write Sequencer. In automatic clocking mode, the WM8962B uses F256KCLK\_DIV to generate a clock that is approximately 256kHz.

The DC Servo clock frequency is controlled by DCSCCLK\_DIV. In automatic clocking mode, the WM8962B uses this divider to generate a clock that is approximately 1.5MHz.

| REGISTER ADDRESS        | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                           |
|-------------------------|-----|----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R8 (08h)<br>Clocking2   | 8:6 | CLASSD_CLK_DIV [2:0] | 111     | Class D Clock Divider<br>000 = SYSCLK<br>001 = SYSCLK / 2<br>010 = SYSCLK / 3<br>011 = SYSCLK / 4<br>100 = SYSCLK / 6<br>101 = SYSCLK / 8<br>110 = SYSCLK / 12<br>111 = SYSCLK / 16<br>This field is for read-back only; it is set automatically and cannot be adjusted.                                              |
| R30 (1Eh)<br>Clocking 3 | 6:1 | F256KCLK_DIV [5:0]   | 2Fh     | 256kHz Clock Divider<br>0d = SYSCLK<br>1d = SYSCLK / 2<br>2d = SYSCLK / 3<br>....<br>63d = SYSCLK / 64<br>This field is for read-back only; it is set automatically and cannot be adjusted.                                                                                                                           |
| R56 (38h)<br>Clocking 4 | 8:5 | DCSCCLK_DIV [3:0]    | 1000    | DC Servo Clock Divider<br>0000 = SYSCLK<br>0001 = SYSCLK / 1.5<br>0010 = SYSCLK / 2<br>0011 = Reserved<br>0100 = SYSCLK / 3<br>0101 = SYSCLK / 4<br>0110 = Reserved<br>0111 = SYSCLK / 6<br>1000 = SYSCLK / 8<br>1001 to 1111 = Reserved<br>This field is for read-back only; it is set automatically by the WM8962B. |

**Table 101 Class D, 256k, DC Servo Clock Control**

**OPCLK CONTROL**

A clock output (OPCLK) derived from SYSCLK may be output on a GPIO pin. This clock is enabled by register bit OPCLK\_ENA, and its frequency is controlled by OPCLK\_DIV.

This output of this clock is also dependent upon the GPIO register settings described in the General Purpose Input/Output (GPIO)" section.

| REGISTER ADDRESS             | BIT   | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                                                                  |
|------------------------------|-------|--------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R25 (19h)<br>Pwr Mgmt<br>(1) | 9     | OPCLK_ENA          | 0       | GPIO Clock Output Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                      |
| R30 (1Eh)<br>Clocking 3      | 12:10 | OPCLK_DIV<br>[2:0] | 000     | GPIO Output Clock Divider<br>000 = SYSCLK<br>001 = SYSCLK / 2<br>010 = SYSCLK / 3<br>011 = SYSCLK / 4<br>100 = SYSCLK / 6<br>101 = SYSCLK / 8<br>110 = SYSCLK / 12<br>111 = SYSCLK / 16<br>000 = SYSCLK / 16 |

**Table 102 OPCLK Control**
**TOCLK, DBCLK CONTROL**

A slow clock (TOCLK) is derived from the internally generated 256kHz clock to enable input de-bouncing and volume update timeout functions. This clock is enabled by register bit TOCLK\_ENA, and its frequency is controlled by TOCLK\_DIV.

A de-bounce clock, DBCLK, is used to control the de-bouncing of GPIO inputs and selected interrupt inputs. This clock is enabled automatically whenever GPIO or interrupt de-bouncing is selected. The de-bounce clock frequency is controlled by DBCLK\_DIV.

| REGISTER ADDRESS                      | BIT   | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                      |
|---------------------------------------|-------|--------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R23 (17h)<br>Additional<br>Control(1) | 0     | TOCLK_ENA          | 0       | TOCLK Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                                      |
| R30 (1Eh)<br>Clocking 3               | 15:13 | DBCLK_DIV<br>[2:0] | 000     | DBCLK Rate Divider<br>(divides the 256kHz clock; nominal frequency is quoted in brackets)<br>000 = f / 256 (1kHz)<br>001 = f / 2048 (125Hz)<br>010 = f / 4096 (62.5Hz)<br>011 = f / 8192 (31.2Hz)<br>100 = f / 16384 (15.6Hz)<br>101 = f / 32768 (7.8Hz)<br>110 = f / 64536 (3.9Hz)<br>111 = f / 131072 (1.95Hz) |
|                                       | 9:7   | TOCLK_DIV<br>[2:0] | 000     | TOCLK Rate Divider<br>(divides the 256kHz clock; nominal frequency is quoted in brackets)<br>000 = f / 256 (1kHz)<br>001 = f / 512 (500Hz)<br>010 = f / 1024 (250Hz)<br>011 = f / 2048 (125Hz)<br>100 = f / 4096 (62.5Hz)<br>101 = f / 8192 (31.2Hz)<br>110 = f / 16384 (15.6Hz)<br>111 = f / 32768 (7.8Hz)      |

**Table 103 TOCLK, DBCLK Control**



### BCLK AND LRCLK CONTROL

In master mode, BCLK is derived from DSPCLK via a programmable division set by BCLK\_DIV.

In master mode, LRCLK is derived from BCLK via a programmable division set by AIF\_RATE.

See “Digital Audio Interface Control” for details of these fields.

In Slave mode, BCLK/LRCLK should not be stopped whilst a DAC to Speaker playback path is active unless SYSCLK is also stopped. Failure to meet this requirement may result in a DC output at the speaker outputs, and possible speaker damage.

In Slave mode, if BCLK/LRCLK may stop during DAC to Speaker playback then it is recommended to use a SYSCLK source that will also stop at the same time as BCLK/LRCLK. It is important to note that the FLL will continue to run even when its input reference is removed; if the FLL is selected as the SYSCLK source, then SYSCLK will not stop if BCLK/LRCLK is stopped.

If SYSCLK is stopped whenever BCLK/LRCLK is stopped, or if the audio interface is operating in Master mode, then no specific action is required in relation to BCLK/LRCLK stopping.

If BCLK/LRCLK may stop during DAC to Speaker playback, with SYSCLK still running, then it is recommended to disable the Speaker output (see “Output Signal Path”) or to disable the DAC to Speaker Mixer paths (see “Speaker Output Paths”) before stopping BCLK/LRCLK.

If it is not possible to change the WM8962B settings before BCLK/LRCLK are stopped (ie. the BCLK/LRCLK inputs may stop unpredictably), then the DAC 2<sup>nd</sup> order HPF should be enabled in order to remove DC offsets in the output signal. See “DAC Signal Path Enhancements” for details of this feature.

### CONTROL INTERFACE CLOCKING

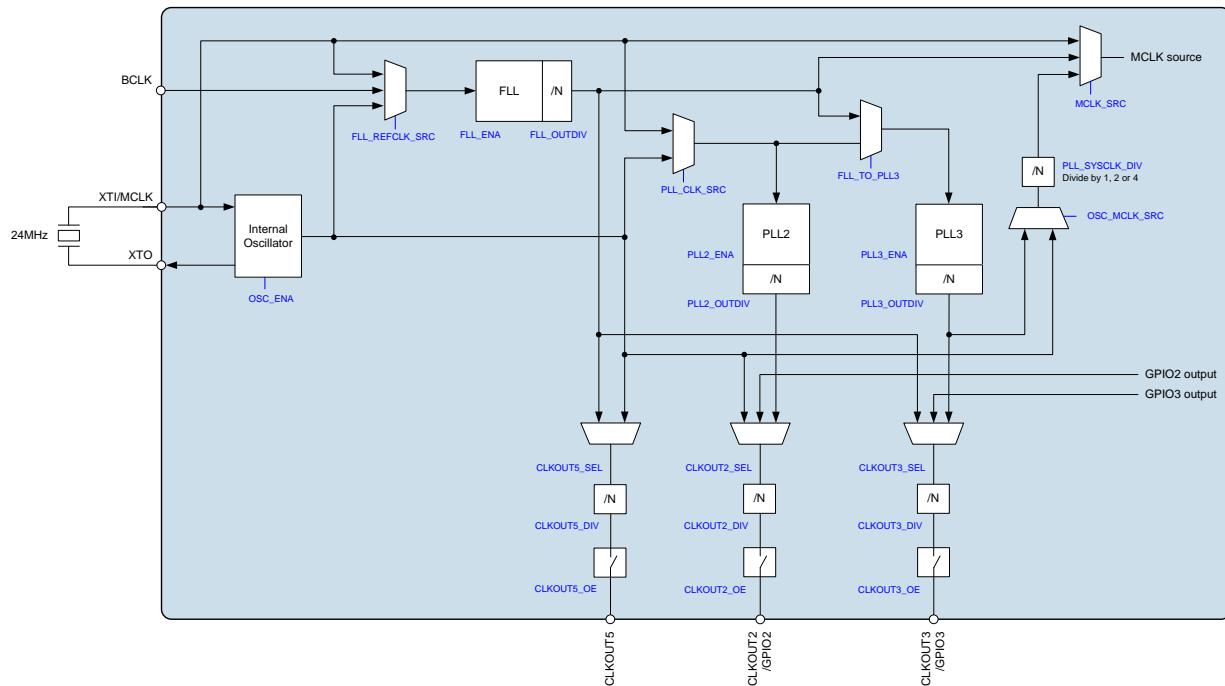
Register map access is possible with or without a system clock (SYSCLK). The source for SYSCLK may be either the MCLK pin, FLL or PLL3, as described above in the “SYSCLK Control” section.

When SYSCLK\_ENA = 1, then an active clock source for SYSCLK must be present for control interface clocking. If the SYSCLK source is stopped, then SYSCLK\_ENA must be set to 0 for control register access.

**INTERNAL / EXTERNAL CLOCK GENERATION**

The WM8962B provides many features to generate clocks for internal and external use. The internal SYSCLK is either generated from MCLK directly, or can be generated using the FLL or using PLL3.

The WM8962B Clock Generation options are illustrated in Figure 58.



**Figure 58 Clock Generation Block Diagram**

The MCLK pin supports clock input from external source; this provides a reference for clocking the WM8962B internal circuits via SYSCLK. The WM8962B also provides an internal oscillator circuit, using an external crystal connected to the MCLK pin.

The output of the oscillator can be output directly on the CLKOUT2 or CLKOUT5 pins.

The WM8962B incorporates a Frequency Locked Loop (FLL). The input reference to the FLL is selectable; it can be either the MCLK or BCLK pin directly, or else the internal oscillator. The FLL can be used to generate SYSCLK; it can also be configured to provide an input reference to PLL3.

The WM8962B incorporates two Phase Locked Loop (PLL) circuits. The input reference to these PLLs is selectable; it can either be the MCLK pin directly, or else the internal oscillator. The FLL output can be selected as the input reference for PLL3 if required.

The PLLs can be used to generate a variety of clock signals from the available reference inputs. These are configurable circuits which perform frequency multiplication and frequency division to suit the application requirements. The PLLs are tolerant of jitter on the input reference and can therefore be used to generate a stable output from a less stable input.

The signals generated by PLL2 and PLL3 can be output on the CLKOUT2 and CLKOUT3 pins respectively. If any PLL output is not required, then the respective CLKOUT pin(s) can alternatively be used for GPIO functions.

**START-UP OPTIONS FOR INTERNAL / EXTERNAL CLOCK GENERATION**

The default (start-up) conditions of the WM8962B can be selected using the GPIO5 pin as a hardware control input. The logic state of the GPIO5 pin during start-up determines the initial value of the clocking control registers, causing different functionality to be selected for each logic state.

Under specific conditions, some of the registers that are controlled by the GPIO5 pin are locked to prevent accidental writes to the affected bit(s). In some cases, the GPIO5 pin determines the initial condition, but the register can still be updated via the Control Interface.

It is possible to unlock all of the clocking control registers, giving full flexibility of the clocking configuration and to enable GPIO functionality on the GPIO5 pin.

The start-up options for the WM8962B are summarised below. The behaviour of the associated clocking control registers is summarised in Table 104.

The WM8962B can be configured to generate a CLKOUT5 output as a default start-up condition. Under default register conditions, with a logic '1' applied to the GPIO5 pin, the CLKOUT5 pin will default to a Clock output that is derived from the Crystal Oscillator. In this configuration, the Oscillator is enabled by default, and the CLKOUT5 frequency is the oscillator frequency divided by 2.

Under default register conditions, with a logic '0' applied to the GPIO5 pin, the crystal oscillator is disabled by default, and no clocks will be present on any of the CLKOUT $n$  pins on start-up.

For full configuration flexibility of the WM8962B Clocking functions, the CLKREG\_OVD bit must be set to '1' in order to select normal read/write access to all clocking control registers.

Note that the GPIO5 pin must be held in a defined logic state (logic '0' or logic '1') during start-up; it must not be left floating. Normal GPIO5 functionality can be enabled after start-up, after setting the CLKREG\_OVD bit to '1'. The GPIO5 pin must be held in a defined logic state (logic '0' or logic '1') whenever the pin is configured as an input, including whenever CLKREG\_OVD = 0.

| REGISTER                                                                                            | CLKREG_OVD=0      |                | CLKREG_OVD=1    |
|-----------------------------------------------------------------------------------------------------|-------------------|----------------|-----------------|
|                                                                                                     | GPIO5=0           | GPIO5=1        |                 |
| MCLK_SRC                                                                                            | 00 (MCLK)         | 01 (FLL) *     | 00 (MCLK)       |
| OSC_ENA                                                                                             | 0 (Disabled) *    | 1 (Enabled)    | 1 (Enabled)     |
| CLKOUT3_SEL                                                                                         | 10 (FLL) *        |                | 00 (PLL3)       |
| CLKOUT5_SEL                                                                                         | 1 (FLL) *         | 0 (Oscillator) | 0 (Oscillator)  |
| CLKOUT2_DIV                                                                                         | 1 (Divide by 2) * |                | 0 (Divide by 1) |
| CLKOUT5_DIV                                                                                         | 1 (Divide by 2) * |                | 0 (Divide by 1) |
| PLL2_ENA                                                                                            | 0 (Disabled) *    |                | 1 (Enabled)     |
| PLL3_ENA                                                                                            | 0 (Disabled) *    |                | 1 (Enabled)     |
| Note - The register settings marked (*) are locked to prevent accidental writes to these registers. |                   |                |                 |

**Table 104 Start-Up Options for Internal / External Clock Generation**

The register settings described in Table 104 are the initial/default values corresponding to each GPIO5 condition and each CLKREG\_OVD condition. (Note that other clocking configuration registers, which have no dependency on GPIO5 or CLKREG\_OVD, are not listed in Table 104.)

When CLKREG\_OVD=0, then the register settings marked (\*) are locked to prevent accidental writes to the associated registers.

When CLKREG\_OVD=1, then all of the clocking control fields can be written via the Control Interface.

The MCLK\_SRC register is described in the "Clocking and Sample Rates" section. The other registers referenced above are described later in this section.

**INTERNAL OSCILLATOR CONTROL**

The internal oscillator is enabled by OSC\_ENA. The oscillator is suitable for operation at 24MHz, using a suitable external crystal. The oscillator should be enabled when an external crystal is connected to MCLK to provide clocking; it should be disabled when an external clock is connected to MCLK.

The OSC\_ENA register is controlled automatically under certain circumstances, as described below. The associated control register, CLKREG\_OVD, is defined in the “Automatic Clocking Configuration” section, (see “Clocking and Sample Rates”).

When a logic 0 is applied on the GPIO5 pin, the OSC\_ENA register is set 0. In this case, the OSC\_ENA register is locked to prevent accidental writes to this register. The OSC\_ENA register can be unlocked by setting the CLKREG\_OVD bit.

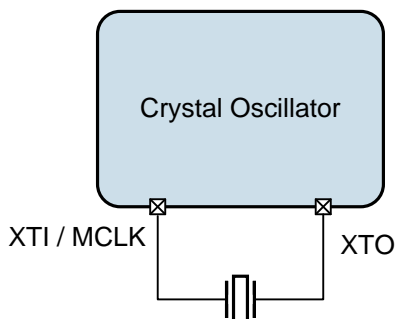
When a logic 1 is applied on the GPIO5 pin, the OSC\_ENA register defaults to 1. In this case, the default (1) is selected on the rising edge of GPIO5; other settings can then be selected by writing to the OSC\_ENA register as normal.

Note that, if GPIO functionality is required on the GPIO5 pin, then the CLKREG\_OVD bit must be set to ‘1’ in order to select normal read/write control of the OSC\_ENA register.

| REGISTER ADDRESS    | BIT | LABEL   | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|---------------------|-----|---------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R129 (81h)<br>PLL 2 | 7   | OSC_ENA | 0       | Internal Oscillator Enable<br>0 = Disabled<br>1 = Enabled<br>If CLKREG_OVD = 0, then OSC_ENA is controlled by the GPIO5 pin.<br>If CLKREG_OVD = 0 and GPIO5 = 0, then OSC_ENA = 0 and cannot be changed by the Control Interface.<br>If CLKREG_OVD = 0 and GPIO5 = 1, then OSC_ENA = 1 by default, but the value can be changed via the Control Interface.<br>If CLKREG_OVD = 1, then OSC_ENA = 1 by default, but the value can be changed via the Control Interface. |

**Table 105 Internal Oscillator Enable**

The crystal oscillator requires an external crystal on the XTI and XTO pins. The WM8962B provides internal loading capacitors for the crystal, removing the need for any external capacitors, as shown in Figure 59.



**Figure 59 Crystal Oscillator**

The internal loading capacitance is detailed in the “Electrical Characteristics”. Selection of the correct crystal component is important to ensure best accuracy and stability of the oscillator.

In cases where the internal loading capacitance differs from the required value (eg. due to characteristics of the chosen crystal, or due to additional capacitive effects of PCB tracks), it is possible to compensate for this within the WM8962B, using the control registers described below.

The compensation in internal loading capacitance (with respect to the default value) must be configured on the XTI and XTO pins individually. The combined effect of the compensation is as per series-connected capacitors; therefore, if the overall difference required is -1pF, then an adjustment of -2pF must be made on each of the XTI and XTO pins. Note that this sum assumes that the difference is the same for both pins.

To apply the capacitive correction, the combined difference (-2pF in the above example) should be applied to XTI\_CAP\_SEL and XTO\_CAP\_SEL registers.

It is necessary to ensure that the values written to the XTI\_CAP\_SEL and XTO\_CAP\_SEL registers do not cause internal limits to be exceeded; this requires the oscillator trim registers to be read, in order to confirm the amount of calibration already configured to match the specified Electrical Characteristics.

The value written to XTI\_CAP\_SEL, when summed with the trim value OSC\_TRIM\_XTI, must not result in a value outside the limits of OSC\_TRIM\_XTI. The sum of the XTI\_CAP\_SEL and OSC\_TRIM\_XTI settings must be between 8pF and 23.5pF.

The value written to XTO\_CAP\_SEL, when summed with the trim value OSC\_TRIM\_XTO, must not result in a value outside the limits of OSC\_TRIM\_XTO. The sum of the XTO\_CAP\_SEL and OSC\_TRIM\_XTO settings must be between 8pF and 23.5pF.

As an example, if the read value of OSC\_TRIM\_XTI is 21.5pF, then it is not possible to increase the XTI capacitance by more than 2pF - a larger value would exceed the 23.5pF limit.

Note that the description provided here assumes that the difference in capacitance (with respect to the recommended value) is the same for both pins (XTI and XTO).

The relevant registers are described in Table 106.

| REGISTER ADDRESS                  | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                                                                                        |
|-----------------------------------|-----|--------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R115 (73h)<br>Oscillator Trim (3) | 4:0 | OSC_TRIM_XTI [4:0] |         | Trimmed Oscillator XTI capacitance<br>00h = 8pF<br>01h = 8.5pF<br>... 0.5pF steps<br>1Eh = 23pF<br>1Fh = 23.5pF<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br>see Table 107 for details. |
| R116 (74h)<br>Oscillator Trim (4) | 4:0 | OSC_TRIM_XTO [4:0] |         | Trimmed Oscillator XTO capacitance<br>00h = 8pF<br>01h = 8.5pF<br>... 0.5pF steps<br>1Eh = 23pF<br>1Fh = 23.5pF<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br>see Table 107 for details. |
| R119 (77h)<br>Oscillator Trim (7) | 7:4 | XTO_CAP_SEL [3:0]  | 0000    | XTO load capacitance adjustment<br>Two's complement format,<br>LSB = 0.5pF<br>Range is -4.0pF to +3.5pF<br>see Table 108 for details                                                                                               |
|                                   | 3:0 | XTI_CAP_SEL [3:0]  | 0000    | XTI load capacitance adjustment<br>Two's complement format,<br>LSB = 0.5pF<br>Range is -4.0pF to +3.5pF<br>see Table 108 for details                                                                                               |

**Table 106 Oscillator Trim Control**

| OSC_TRIM_XTI,<br>OSC_TRIM_XTO | DESCRIPTION | OSC_TRIM_XTI,<br>OSC_TRIM_XTO | DESCRIPTION |
|-------------------------------|-------------|-------------------------------|-------------|
| 00000                         | 14.0pF      | 10000                         | 22.0pF      |
| 00001                         | 14.5pF      | 10001                         | 22.5pF      |
| 00010                         | 15.0pF      | 10010                         | 23.0pF      |
| 00011                         | 15.5pF      | 10011                         | 23.5pF      |
| 00100                         | 16.0pF      | 10100                         | 24.0pF      |
| 00101                         | 16.5pF      | 10101                         | 24.5pF      |
| 00110                         | 17.0pF      | 10110                         | 25.0pF      |
| 00111                         | 17.5pF      | 10111                         | 25.5pF      |
| 01000                         | 18.0pF      | 11000                         | 25.5pF      |
| 01001                         | 18.5pF      | 11001                         | 25.5pF      |
| 01010                         | 19.0pF      | 11010                         | 25.5pF      |
| 01011                         | 19.5pF      | 11011                         | 25.5pF      |
| 01100                         | 20.0pF      | 11100                         | 25.5pF      |
| 01101                         | 20.5pF      | 11101                         | 25.5pF      |
| 01110                         | 21.0pF      | 11110                         | 25.5pF      |
| 01111                         | 21.5pF      | 11111                         | 25.5pF      |

**Table 107 Oscillator Trim Register Readback**

| XTI_CAP_SEL,<br>XTO_CAP_SEL | DESCRIPTION | XTI_CAP_SEL,<br>XTO_CAP_SEL | DESCRIPTION |
|-----------------------------|-------------|-----------------------------|-------------|
| 0000                        | 0.0pF       | 1000                        | -4.0pF      |
| 0001                        | +0.5pF      | 1001                        | -3.5pF      |
| 0010                        | +1.0pF      | 1010                        | -3.0pF      |
| 0011                        | +1.5pF      | 1011                        | -2.5pF      |
| 0100                        | +2.0pF      | 1100                        | -2.0pF      |
| 0101                        | +2.5pF      | 1101                        | -1.5pF      |
| 0110                        | +3.0pF      | 1110                        | -1.0pF      |
| 0111                        | +3.5pF      | 1111                        | -0.5pF      |

**Table 108 Oscillator Trim Adjustment Settings**

### CLKOUT CONTROL

The WM8962B provides three CLKOUT pins for FLL / PLL output.

The selected function of each is determined by the CLKOUT $n$ \_SEL registers, where  $n$  represents the applicable pin. The available options are indicated in the register descriptions shown in Table 109.

The CLKOUT3\_SEL register is controlled automatically under certain circumstances, as noted in Table 109. The associated control register, CLKREG\_OVD, is defined in the “Automatic Clocking Configuration” section, (see “Clocking and Sample Rates”).

The CLKOUT5\_SEL register is controlled automatically under certain circumstances, as described below. The associated control register, CLKREG\_OVD, is defined in the “Automatic Clocking Configuration” section, (see “Clocking and Sample Rates”).

When a logic 0 is applied on the GPIO5 pin, the CLKOUT5\_SEL register is set 1, selecting the FLL as the source. In this case, the CLKOUT5\_SEL register is locked to prevent accidental writes to this register. The CLKOUT5\_SEL register can be unlocked by setting the CLKREG\_OVD bit.

When a logic 1 is applied on the GPIO5 pin, the CLKOUT5\_SEL register defaults to 0, selecting the Oscillator as the source. In this case, the default (0) is selected on the rising edge of GPIO5; other settings can then be selected by writing to the CLKOUT5\_SEL register as normal.

Note that, if GPIO functionality is required on the GPIO5 pin, then the CLKREG\_OVD bit must be set to ‘1’ in order to select normal read/write control of the CLKOUT5\_SEL register.

Each of the CLKOUT pins can be enabled or tri-stated using the CLKOUT<sub>n</sub>\_OE registers. When a pin is tri-stated, it does not support either the PLL/FLL output or the GPIO function. See “General Purpose Input/Output (GPIO)” for more details of the GPIO functions.

A selectable divider is available on each of the CLKOUT pins. When the CLKOUT<sub>n</sub>\_DIV bit is set, then the respective Clock output is divided by two. Note that, when the selected function is GPIO, then the CLKOUT<sub>n</sub>\_DIV bit should be set to 0.

The CLKOUT2\_DIV and CLKOUT5\_DIV registers are controlled automatically under certain circumstances, as noted in Table 109. The associated control register, CLKREG\_OVD, is defined in the “Automatic Clocking Configuration” section, (see “Clocking and Sample Rates”).

| REGISTER ADDRESS                    | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------------------------------|-----|----------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R124 (7Ch)<br>Analogue<br>Clocking1 | 6:5 | CLKOUT2_SEL<br>[1:0] | 00      | CLKOUT2 Output Select<br>00 = PLL2<br>01 = GPIO2<br>10 = Internal oscillator<br>11 = Reserved                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                                     | 4:3 | CLKOUT3_SEL<br>[1:0] | 10      | CLKOUT3 Output Select<br>00 = PLL3<br>01 = GPIO3<br>10 = FLL<br>11 = Reserved<br>If CLKREG_OVD = 0, then<br>CLKOUT3_SEL = 10 (FLL) and cannot<br>be changed by the Control Interface.<br>If CLKREG_OVD = 1, then<br>CLKOUT3_SEL = 00 (PLL3) by default,<br>but the value can be changed via the<br>Control Interface.                                                                                                                                                                                                                                   |
|                                     | 0   | CLKOUT5_SEL          | 1       | CLKOUT5 Output Select<br>0 = Internal oscillator<br>1 = FLL<br>If CLKREG_OVD = 0, then<br>CLKOUT5_SEL is controlled by the<br>GPIO5 pin.<br>If CLKREG_OVD = 0 and GPIO5 = 0,<br>then CLKOUT5_SEL = 1 (FLL) and<br>cannot be changed by the Control<br>Interface.<br>If CLKREG_OVD = 0 and GPIO5 = 1,<br>then CLKOUT5_SEL = 0 (Oscillator) by<br>default, but the value can be changed<br>via the Control Interface.<br>If CLKREG_OVD = 1 then<br>CLKOUT5_SEL = 0 (Oscillator) by<br>default, but the value can be changed<br>via the Control Interface. |
| R125 (7Dh)<br>Analogue<br>Clocking2 | 2   | CLKOUT3_DIV          | 0       | CLKOUT3 Output Divide<br>0 = Divide by 1<br>1 = Divide by 2                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|                                     | 1   | CLKOUT2_DIV          | 1       | CLKOUT2 Output Divide<br>0 = Divide by 1<br>1 = Divide by 2<br>If CLKREG_OVD = 0, then<br>CLKOUT2_DIV = 1 (Divide by 2) and<br>cannot be changed by the Control<br>Interface.<br>If CLKREG_OVD = 1, then<br>CLKOUT2_DIV = 0 by default, but the<br>value can be changed via the Control<br>Interface.                                                                                                                                                                                                                                                   |

| REGISTER ADDRESS                    | BIT | LABEL       | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                         |
|-------------------------------------|-----|-------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                     | 0   | CLKOUT5_DIV | 1       | CLKOUT5 Output Divide<br>0 = Divide by 1<br>1 = Divide by 2<br>If CLKREG_OVD = 0, then CLKOUT5_DIV = 1 (Divide by 2) and cannot be changed by the Control Interface.<br>If CLKREG_OVD = 1, then CLKOUT5_DIV = 0 by default, but the value can be changed via the Control Interface. |
| R126 (7Eh)<br>Analogue<br>Clocking3 | 3   | CLKOUT2_OE  | 1       | CLKOUT2 Output Enable<br>0 = Disabled (tri-state)<br>1 = Enabled                                                                                                                                                                                                                    |
|                                     | 2   | CLKOUT3_OE  | 1       | CLKOUT3 Output Enable<br>0 = Disabled (tri-state)<br>1 = Enabled                                                                                                                                                                                                                    |
|                                     | 0   | CLKOUT5_OE  | 1       | CLKOUT5 Output Enable<br>0 = Disabled (tri-state)<br>1 = Enabled                                                                                                                                                                                                                    |

**Table 109 CLKOUT Control**

### FREQUENCY LOCKED LOOP (FLL)

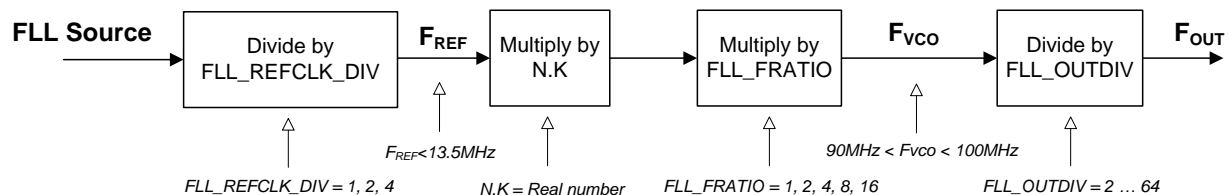
The WM8962B incorporates a Frequency Locked Loop (FLL) circuit. The FLL uses a highly accurate and configurable circuit to generate SYSCLK from a wide variety of different reference sources and frequencies.

The FLL input reference may be a high frequency (eg. 36.864MHz) or low frequency (eg. 32,768kHz). The FLL is tolerant of jitter and may be used to generate a stable SYSCLK from a less stable input signal. The FLL characteristics are summarised in “Electrical Characteristics”.

Note that the FLL can be used to generate a free-running clock in the absence of an external reference source. This is described in the “Free-Running FLL Clock” section below. This feature enables clocked functions (such as microphone/accessory detection interrupts) to be supported when the external reference clock or crystal oscillator is not enabled.

The input reference to the FLL is selected by FLL\_REFCLK\_SRC. The available options are MCLK, BCLK or the internal oscillator.

The FLL control registers are illustrated in Figure 60.


**Figure 60 FLL Configuration**

The FLL is enabled using the FLL\_ENA register bit. Note that, when changing FLL settings, it is recommended that the digital circuit be disabled via FLL\_ENA and then re-enabled after the other register settings have been updated. When changing the input reference frequency F<sub>REF</sub>, it is recommended the FLL be reset by setting FLL\_ENA to 0.

The field FLL\_REFCLK\_DIV provides the option to divide the input reference (MCLK, BCLK or Internal Oscillator) by 1, 2 or 4. This field should be set to bring the reference down to 13.5MHz or below. For best performance, it is recommended that the highest possible frequency - within the 13.5MHz limit - should be selected.



The FLL output frequency is directly determined from FLL\_FRATIO, FLL\_OUTDIV and the real number represented by N.K.

The integer value, N, is held in the FLL\_N register field, and is used in both Integer and Fractional Modes. The fractional portion, K, is only valid in Fractional Mode when enabled by the field FLL\_FRAC. The value of K is determined by the ratio FLL\_THETA / FLL\_LAMBDA.

It is recommended that FLL Fractional mode is enabled at all times (FLL\_FRAC = 1). Power consumption in the FLL is reduced in integer mode (FLL\_FRAC = 0). However, the performance may also be reduced, with increased noise or jitter on the output.

The FLL output frequency is generated according to the following equation:

$$F_{OUT} = (F_{VCO} / FLL\_OUTDIV)$$

The FLL operating frequency,  $F_{VCO}$  is set according to the following equation:

$$F_{VCO} = (F_{REF} \times N.K \times FLL\_FRATIO)$$

$F_{REF}$  is the input frequency, as determined by FLL\_REFCLK\_DIV.

$F_{VCO}$  must be in the range 90-100 MHz. Frequencies outside this range cannot be supported.

Note that the output frequencies that do not lie within the ranges quoted above cannot be guaranteed across the full range of device operating temperatures.

In order to follow the above requirements for  $F_{VCO}$ , the value of FLL\_OUTDIV should be selected according to the desired output  $F_{OUT}$ . The FLL\_OUTDIV register must be set so that  $F_{VCO}$  is in the range 90-100MHz. The available ratios are integers from 2 to 64. Some typical settings of FLL\_OUTDIV are noted in Table 110.

| OUTPUT FREQUENCY $F_{OUT}$ | FLL_OUTDIV                           |
|----------------------------|--------------------------------------|
| 1.875 MHz - 2.0833 MHz     | 101111 ( $F_{OUT}$ clock ratio = 48) |
| 2.8125 MHz - 3.125 MHz     | 011111 ( $F_{OUT}$ clock ratio = 32) |
| 3.75 MHz - 4.1667 MHz      | 010111 ( $F_{OUT}$ clock ratio = 24) |
| 5.625 MHz - 6.25 MHz       | 001111 ( $F_{OUT}$ clock ratio = 16) |
| 11.25 MHz - 12.5 MHz       | 000111 ( $F_{OUT}$ clock ratio = 8)  |
| 18 MHz - 20 MHz            | 000100 ( $F_{OUT}$ clock ratio = 5)  |
| 22.5 MHz - 25 MHz          | 000011 ( $F_{OUT}$ clock ratio = 4)  |
| 40 MHz - 50 MHz            | 000001 ( $F_{OUT}$ clock ratio = 2)  |

**Table 110 Selection of FLL\_OUTDIV**

The value of FLL\_FRATIO should be selected as described in Table 111.

| REFERENCE FREQUENCY $F_{REF}$ | FLL_FRATIO                       |
|-------------------------------|----------------------------------|
| 1MHz - 13.5MHz                | 0h ( $F_{VCO}$ clock ratio = 1)  |
| 256kHz - 1MHz                 | 1h ( $F_{VCO}$ clock ratio = 2)  |
| 128kHz - 256kHz               | 2h ( $F_{VCO}$ clock ratio = 4)  |
| 64kHz - 128kHz                | 3h ( $F_{VCO}$ clock ratio = 8)  |
| Less than 64kHz               | 4h ( $F_{VCO}$ clock ratio = 16) |

**Table 111 Selection of FLL\_FRATIO**

In order to determine the remaining FLL parameters, the FLL operating frequency,  $F_{VCO}$ , must be calculated, as given by the following equation:

$$F_{VCO} = (F_{OUT} \times FLL\_OUTDIV)$$

The value of N.K can then be determined as follows:

$$N.K = F_{VCO} / (FLL\_FRATIO \times F_{REF})$$

Note that, in the above equations:

FLL\_OUTDIV is the F<sub>OUT</sub> clock ratio (2...64).

F<sub>REF</sub> is the input frequency, after division by FLL\_REFCLK\_DIV, where applicable.

FLL\_FRATIO is the F<sub>VCO</sub> clock ratio (1, 2, 4, 8 or 16).

The value of N is held in the FLL\_N register field.

The value of K is determined by the ratio FLL\_THETA / FLL\_LAMBDA.

The FLL\_N, FLL\_THETA and FLL\_LAMBDA fields are all coded as integers (LSB = 1).

Note that FLL\_LAMBDA must be set to a non-zero value in Integer and Fractional modes.

In Fractional Mode (FLL\_FRAC = 1), the register fields FLL\_THETA and FLL\_LAMBDA can be calculated as follows:

Calculate GCD(FLL) using the greatest common denominator function:

$$GCD(FLL) = GCD(FLL\_FRATIO \times F_{REF}, F_{VCO})$$

where GCD(x, y) is the greatest common denominator of x and y

Next, calculate FLL\_THETA and FLL\_LAMBDA using the following equations:

$$FLL\_THETA = (F_{VCO} - (FLL\_N \times FLL\_FRATIO \times F_{REF})) / GCD(FLL)$$

$$FLL\_LAMBDA = (FLL\_FRATIO \times F_{REF}) / GCD(FLL)$$

Note that, in Fractional Mode, the values of FLL\_THETA and FLL\_LAMBDA must be co-prime (ie. not divisible by any common integer). The calculation above ensures that the values will be co-prime.

The value of K must be a fraction less than 1 (ie. FLL\_THETA must be less than FLL\_LAMBDA).

For best performance, a non-integer value of N.K must be used. If necessary, it is recommended to adjust FLL<sub>n</sub>\_OUTDIV in order to obtain a non-integer value of N.K. Care must always be taken to ensure that the FLL operating frequency, F<sub>VCO</sub>, is within its recommended limits of 90-100 MHz.

The FLL control registers are described in Table 112. An example FLL calculation is shown on the following page.

| REGISTER ADDRESS              | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                           |
|-------------------------------|-----|----------|---------|---------------------------------------------------------------------------------------------------------------------------------------|
| R155 (9Bh)<br>FLL Control (1) | 3   |          | 1       | Reserved - Do not change                                                                                                              |
|                               | 2   | FLL_FRAC | 1       | FLL Fractional Mode enable<br>0 = Integer Mode<br>1 = Fractional Mode<br><br>Fractional Mode (FLL_FRAC=1) is recommended in all cases |
|                               | 0   | FLL_ENA  | 0       | FLL Enable<br>0 = Disabled<br>1 = Enabled                                                                                             |

| REGISTER ADDRESS                 | BIT  | LABEL                    | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                  |
|----------------------------------|------|--------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R156 (9Ch)<br>FLL Control<br>(2) | 8:3  | FLL_OUTDIV<br>[5:0]      | 000111  | FLL F <sub>OUT</sub> clock ratio<br>000000 = Reserved<br>000001 = 2<br>000010 = 3<br>000011 = 4<br>000100 = 5<br>000101 = 6<br>...<br>111110 = 63<br>111111 = 64<br>(F <sub>OUT</sub> = F <sub>VCO</sub> / FLL_OUTDIV)                                                                       |
|                                  | 1:0  | FLL_REFCLK_D<br>IV [1:0] | 01      | FLL Clock Reference Divider<br>00 = MCLK / 1<br>01 = MCLK / 2<br>10 = MCLK / 4<br>11 = Reserved<br><br>MCLK (or other input reference) must be divided down to <=13.5MHz.<br>For lower power operation, the reference clock can be divided down further if desired.                          |
| R157 (9Dh)<br>FLL Control<br>(3) | 8:4  |                          | 11000   | Reserved - Do not change                                                                                                                                                                                                                                                                     |
|                                  | 2:0  | FLL_FRATIO<br>[2:0]      | 000     | FLL F <sub>VCO</sub> clock ratio<br>000 = 1<br>001 = 2<br>010 = 4<br>011 = 8<br>1XX = 16<br><br>000 recommended for F <sub>REF</sub> > 1MHz<br>011 recommended for F <sub>REF</sub> < 64kHz                                                                                                  |
| R158 (9Eh)<br>FLL Control<br>(4) | 3:0  |                          | 0000    | Reserved - Do not change                                                                                                                                                                                                                                                                     |
| R160 (A0h)<br>FLL Control<br>(6) | 15:0 | FLL_THETA<br>[15:0]      | 0018h   | FLL Fractional multiply for F <sub>REF</sub> .<br>Only valid when FLL_FRAC = 1.<br>This field sets the numerator (multiply) part of the FLL_THETA / FLL_LAMBDA ratio. It is coded as LSB = 1.                                                                                                |
| R161 (A1h)<br>FLL Control<br>(7) | 15:0 | FLL_LAMBDA<br>[15:0]     | 007Dh   | FLL Fractional multiply for F <sub>REF</sub> .<br>Only valid when FLL_FRAC = 1.<br>This field sets the denominator (dividing) part of the FLL_THETA / FLL_LAMBDA ratio. It is coded as LSB = 1.<br>Note that it is required that FLL_LAMBDA > 0 in all cases (Integer and Fractional modes). |
| R162 (A2h)<br>FLL Control<br>(8) | 9:0  | FLL_N [9:0]              | 008h    | FLL Integer multiply for F <sub>REF</sub><br>(LSB = 1)                                                                                                                                                                                                                                       |

**Table 112 FLL Register Controls**

**FREE-RUNNING FLL CLOCK**

The Frequency Locked Loop (FLL) can generate a clock signal even when no external reference is available. However, it should be noted that the accuracy of this clock is reduced, and an external reference source should always be used where possible. Note that, in free-running modes, the FLL is not sufficiently accurate for hi-fi ADC or DAC applications. However, the free-running modes are suitable for clocking most other functions, including the Write Sequencer, Charge Pump, DC Servo and Class D loudspeaker driver. Note that the free-running FLL mode enables microphone/accessory detection interrupts to be supported without external clocking.

If an accurate reference clock is initially available, then the FLL should be configured as described above. The FLL will continue to generate a stable output clock after the reference input is stopped or disconnected.

If no reference clock is available at the time of starting up the FLL, then an internal clock frequency of approximately 12MHz can be generated by implementing the following sequence:

- Enable the FLL Analogue Oscillator (FLL\_OSC\_ENA = 1)
- Set the F<sub>OUT</sub> clock divider to divide by 8 (FLL\_OUTDIV = 000111)
- Configure the oscillator frequency by setting FLL\_FRC\_NCO = 1 and FLL\_FRC\_NCO\_VAL = 19h

Note that the free-running FLL mode is not suitable for hi-fi CODEC applications. In the absence of any reference clock, the FLL output is subject to a very wide tolerance; see “Electrical Characteristics” for details of the FLL accuracy.

Note that the free-running FLL clock is selected as SYSCLK using the registers noted in Figure 58.

The free-running FLL clock may be used to support analogue functions, for which the digital audio interface is not used, and there is no applicable Sample Rate (fs). When SYSCLK is required for circuits such as the Class D, DC Servo, Control Write Sequencer or Charge Pump, then valid Sample Rate register settings (SAMPLE\_RATE and MCLK\_RATE) are still required, even though the digital audio interface is not active.

| REGISTER ADDRESS                   | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                                           |
|------------------------------------|-----|-----------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R155 (009Bh)<br>FLL Control<br>(1) | 1   | FLL_OSC_ENA     | 0       | FLL Oscillator enable<br>0 = Disabled<br>1 = Enabled<br>(Note that this field is required for free-running FLL modes only)                                            |
| R159 (009Fh)<br>FLL Control<br>(5) | 6:1 | FLL_FRC_NCO_VAL | 19h     | FLL Forced oscillator value<br>Valid range is 000000 to 111111<br>0x19h (011001) = 12MHz approx<br>(Note that this field is required for free-running FLL modes only) |
|                                    | 0   | FLL_FRC_NCO     | 0       | FLL Forced control select<br>0 = Normal<br>1 = FLL oscillator controlled by FLL_FRC_NCO_VAL<br>(Note that this field is required for free-running FLL modes only)     |

**Table 113 FLL Free-Running Mode**

**EXAMPLE FLL CALCULATION**

The following example illustrates how to derive the FLL registers to generate 12.288 MHz output ( $F_{OUT}$ ) from a 13.000 MHz reference clock ( $F_{REF}$ ):

- Set FLL\_REFCLK\_DIV in order to generate  $F_{REF} \leq 13.5\text{MHz}$ :  
FLL\_REFCLK\_DIV = 00 (divide by 1)
- Set FLL\_OUTDIV for the required output frequency as shown in Table 110:-  
 $F_{OUT} = 12.288\text{ MHz}$ , therefore FLL\_OUTDIV = 07h ( $F_{OUT}$  clock ratio = 8)
- Set FLL\_FRATIO for the given reference frequency as shown in Table 111:  
 $F_{REF} = 13\text{MHz}$ , therefore FLL\_FRATIO = 0h ( $F_{VCO}$  clock ratio = 1)
- Calculate  $F_{VCO}$  as given by  $F_{VCO} = F_{OUT} \times FLL\_OUTDIV$ :-  
 $F_{VCO} = 12.288 \times 8 = 98.304\text{MHz}$
- Calculate N.K as given by  $N.K = F_{VCO} / (FLL\_FRATIO \times F_{REF})$ :  
 $N.K = 98.304 / (1 \times 13) = 7.561846$
- Determine FLL\_N from the integer portion of N.K:-  
FLL\_N = 7.
- Determine GCD(FLL), as given by  $GCD(FLL) = GCD(FLL\_FRATIO \times F_{REF}, F_{VCO})$ :  
 $GCD(FLL) = GCD(1 \times 13000000, 98304000) = 8000$
- Determine FLL\_THETA, as given by  
 $FLL\_THETA = (F_{VCO} - (FLL\_N \times FLL\_FRATIO \times F_{REF})) / GCD(FLL)$ :  
 $FLL\_THETA = (98304000 - (7 \times 1 \times 13000000)) / 8000$   
FLL\_THETA = 913 (0391h)
- Determine FLL\_LAMBDA, as given by  
 $FLL\_LAMBDA = (FLL\_FRATIO \times F_{REF}) / GCD(FLL)$ :  
 $FLL\_LAMBDA = (1 \times 13000000) / 8000$   
FLL\_LAMBDA = 1625 (0659h)

### PHASE LOCKED LOOP (PLL)

The WM8962B incorporates two PLLs. These are enabled using the respective  $PLL_n\_ENA$  register bits.

The  $PLL2\_ENA$  and  $PLL3\_ENA$  registers are controlled automatically under certain circumstances, as noted in Table 117.

The input reference to the PLLs is selected by  $PLL\_CLK\_SRC$ . The available options are MCLK or the internal oscillator. Under default conditions, the internal oscillator is selected as the reference for all of the PLLs.

In the case of PLL3, the FLL may be selected as the input reference, using  $FLL\_TO\_PLL3$ . When this bit is set, the FLL output is selected as the input reference to PLL3.

The input reference source(s) for the PLLs is selected as defined in Table 114.

| REGISTER ADDRESS    | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                                                  |
|---------------------|-----|-----------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R131 (83h)<br>PLL 4 | 1   | $PLL\_CLK\_SRC$ | 0       | PLL Clock Source<br>0 = Internal oscillator<br>1 = MCLK<br>Note that the $SEQ\_ENA$ bit (Register R150, 96h) must be set to 0 when MCLK is selected as the PLL Clock Source. |
|                     | 0   | $FLL\_TO\_PLL3$ | 0       | PLL3 Clock Source<br>0 = Selected by $PLL\_CLK\_SRC$<br>1 = FLL                                                                                                              |

**Table 114 PLL Reference Select**

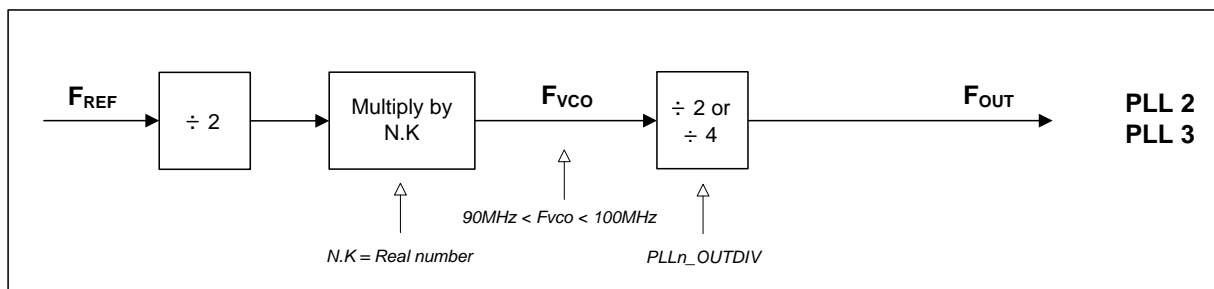
An internal sequencer ensures correct synchronisation of the PLL circuits; this is enabled by default. Note that, if MCLK is selected as the PLL Clock Source, then the internal sequencer must be disabled.

The PLL Control Sequencer is controlled using the  $SEQ\_ENA$  register as described in Table 115.

| REGISTER ADDRESS      | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                                             |
|-----------------------|-----|------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------|
| R150 (96h)<br>PLL DLL | 1   | $SEQ\_ENA$ | 1       | PLL Control Sequencer Enable<br>0 = Disabled<br>1 = Enabled<br>This bit must be set to 0 when MCLK is selected as the PLL Clock Source. |

**Table 115 PLL Control Sequencer**

The PLLs can be configured to derive a wide range of output frequencies from the internal 24MHz crystal oscillator (or external reference). The PLLs can be configured using the control fields in Register R136 through to R143, described below. The PLL configurations are illustrated in Figure 61.



**Figure 61 PLL Frequency Control**

The output frequency of each PLL is directly determined from PLL<sub>n</sub>\_OUTDIV and the real numbers represented by the N.K value applicable to each PLL. (Note that *n* is 2 or 3 depending on the applicable PLL.)

For each PLL, the integer value, N, is held in the PLL<sub>n</sub>\_N register fields, and is used in both Integer and Fractional Modes. The fractional portion, K, is only valid in Fractional Mode when enabled by the field PLL<sub>n</sub>\_FRAC. The value of K is held in the PLL<sub>n</sub>\_K register fields.

It is recommended that PLL Fractional mode is enabled at all times (PLL<sub>n</sub>\_FRAC = 1). Power consumption in the PLL is reduced in integer mode (PLL<sub>n</sub>\_FRAC = 0). However, the performance may also be reduced, with increased noise or jitter on the output.

The FLL output frequency is generated according to the following equation:

$$F_{OUT} = F_{VCO} / (2 \times PLLn\_OUTDIV)$$

The PLL operating frequency, F<sub>VCO</sub>, is set according to the following equation:

$$F_{VCO} = (F_{REF} \times N.K / 2)$$

F<sub>REF</sub> is the input frequency (typically 24MHz on the WM8962B).

F<sub>VCO</sub> must be in the range 90-100 MHz. Note that frequencies that do not lie within this range cannot be guaranteed across the full range of device operating temperatures.

The value of the PLL<sub>n</sub>\_OUTDIV registers must be set depending on the required output frequency, ensuring that the respective F<sub>VCO</sub> frequency is within the recommended operating limits. The supported configurations are noted in Table 116.

Note that the CLKOUT<sub>n</sub> output frequencies can also be controlled by the CLKOUT<sub>n</sub>\_DIV registers, as defined in Table 109; these dividers extend the range of clock frequencies that can be output on the CLKOUT pins.

Note that, when PLL3 is selected as the SYSCLK source, the frequency can also be controlled by the PLL\_SYSCLK\_DIV register, as described in Table 98; this divider provides flexibility in generating the necessary internal and external clock frequencies.

| OUTPUT FREQUENCY F <sub>OUT</sub> | PLL <sub>n</sub> _OUTDIV (PLL2, 3, 4)      |
|-----------------------------------|--------------------------------------------|
| 45 MHz - 50 MHz                   | PLL <sub>n</sub> _OUTDIV = 1 (divide by 2) |
| 22.5 MHz - 25 MHz                 | PLL <sub>n</sub> _OUTDIV = 2 (divide by 4) |

**Table 116 Selection of PLL<sub>n</sub>\_OUTDIV**

In order to determine the remaining PLL parameters, the PLL operating frequency, F<sub>VCO</sub>, must be calculated, as given by the following equation:

$$F_{VCO} = (F_{OUT} \times 2 \times PLLn\_OUTDIV)$$

The PLL frequency ratio N.K can then be determined as follows:

$$N.K = F_{VCO} \times 2 / F_{REF}$$

The PLL frequency ratio N.K is the real number represented by the register fields PLL<sub>n</sub>\_N and PLL<sub>n</sub>\_K (where *n* is 2 or 3, depending on the applicable PLL). The field PLL<sub>n</sub>\_N is an integer (LSB = 1); PLL<sub>n</sub>\_K is the fractional portion of the number (MSB = 0.5). The fractional portion is only valid in Fractional Mode, when enabled by the field PLL<sub>n</sub>\_FRAC.

If N.K is an integer (PLL<sub>n</sub>\_K = 0), then PLL integer mode should be selected, ie. PLL<sub>n</sub>\_FRAC = 0. Power consumption in the PLL is reduced in integer mode.

In N.K is not an integer (PLL<sub>n</sub>\_K > 0), the PLL fractional mode must be selected, ie. PLL<sub>n</sub>\_FRAC = 1.

For PLL stability, input frequencies and divisions must be chosen so that  $5 \leq N \leq 13$ . Best performance is achieved for  $7 \leq N \leq 9$ . Also, the PLL performs best when  $F_{VCO}$  is set between 90MHz and 100MHz.

In PLL Fractional Mode, the fractional portion of the N.K multiplier is held in the PLL<sub>n</sub>\_K register field. This field is coded as a fixed point quantity, where the MSB has a weighting of 0.5. Note that, if desired, the value of this field may be calculated by multiplying K by  $2^{24}$  and treating PLL<sub>n</sub>\_K as an integer value, as illustrated in the following example:

If  $N.K = 7.11111111$ , then  $K = 0.11111111$

Multiplying K by  $2^{24}$  gives  $0.11111111 \times 16777216 = 1864134.92$  (decimal)

Apply rounding to the nearest integer = 1864135 (decimal) = 1C71C7 (hex)

PLL<sub>n</sub>\_N = 07h

PLL<sub>n</sub>\_K = 1C71C7h

The PLL Control registers described in Table 117 allow the default output frequencies to be enabled.

| REGISTER ADDRESS    | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                               |
|---------------------|-----|----------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R129 (81h)<br>PLL 2 | 5   | PLL2_ENA | 0       | PLL2 Enable<br>0 = Disabled<br>1 = Enabled<br>If CLKREG_OVD = 0, then PLL2_ENA = 0 (Disabled) and cannot be changed by the Control Interface.<br>If CLKREG_OVD = 1, then PLL2_ENA = 1 by default, but the value can be changed via the Control Interface. |
|                     | 4   | PLL3_ENA | 0       | PLL3 Enable<br>0 = Disabled<br>1 = Enabled<br>If CLKREG_OVD = 0, then PLL3_ENA = 0 (Disabled) and cannot be changed by the Control Interface.<br>If CLKREG_OVD = 1, then PLL3_ENA = 1 by default, but the value can be changed via the Control Interface. |
|                     | 0   |          | 1       | Reserved - Do not change                                                                                                                                                                                                                                  |

**Table 117 PLL Control**



The PLL Control registers are described in Table 118. Example PLL calculations are shown on the following page, suitable for generating 12MHz or 24.576MHz clocks from the 24MHz reference.

| REGISTER ADDRESS                     | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                     |
|--------------------------------------|-----|----------------|---------|---------------------------------------------------------------------------------|
| R125 (7Dh)<br>Analogue<br>Clocking 2 | 7   | PLL2_OUTDIV    | 0       | PLL2 Output Divider<br>0 = Divide by 2<br>1 = Divide by 4                       |
|                                      | 6   | PLL3_OUTDIV    | 1       | PLL3 Output Divider<br>0 = Divide by 2<br>1 = Divide by 4                       |
| R136 (88h)<br>PLL 9                  | 6   | PLL2_FRAC      | 1       | PLL2 Fractional enable<br>0 = Integer Mode<br>1 = Fractional Mode (recommended) |
|                                      | 4:0 | PLL2_N [4:0]   | 0_0111  | Integer Multiply for PLL2<br>(LSB = 1)                                          |
| R137 (89h)<br>PLL 10                 | 7:0 | PLL2_K [23:16] | 1Ch     | Fractional Multiply for PLL2<br>(MSB = 0.5)                                     |
| R138 (8Ah)<br>PLL 11                 | 7:0 | PLL2_K [15:8]  | 71h     |                                                                                 |
| R139 (8Bh)<br>PLL 12                 | 7:0 | PLL2_K [7:0]   | C7h     |                                                                                 |
| R140 (8Ch)<br>PLL 13                 | 6   | PLL3_FRAC      | 1       | PLL3 Fractional enable<br>0 = Integer Mode<br>1 = Fractional Mode (recommended) |
|                                      | 4:0 | PLL3_N [4:0]   | 0_0111  | Integer Multiply for PLL3<br>(LSB = 1)                                          |
| R141 (8Dh)<br>PLL 14                 | 7:0 | PLL3_K [23:16] | 48h     | Fractional Multiply for PLL3<br>(MSB = 0.5)                                     |
| R142 (8Eh)<br>PLL 15                 | 7:0 | PLL3_K [15:8]  | 22h     |                                                                                 |
| R143 (8Fh)<br>PLL 16                 | 7:0 | PLL3_K [7:0]   | 97h     |                                                                                 |

**Table 118 PLL Frequency Ratio Control**

### EXAMPLE PLL CALCULATION

A typical application may require a 12MHz clock output and a 24.576MHz clock output from the WM8962B.

In this case, it is recommended that PLL2 should be configured for 24MHz output. Under default conditions, the CLKOUT2\_DIV function will apply further division, enabling 12MHz output on the CLKOUT2 pin.

The CLKOUT3 pin is suitable for 24.576MHz output, using the default values of the CLKOUT3\_DIV and PLL3\_OUTDIV registers.

The following example illustrates how to derive the PLL registers to generate 24.000MHz output ( $F_{OUT}$ ) from a 24.000 MHz reference clock ( $F_{REF}$ ).

- Set PLLn\_OUTDIV to ensure  $F_{VCO}$  is in the range 90MHz to 100MHz.  
 $F_{OUT} = 24.000\text{MHz}$ , therefore PLLn\_OUTDIV = 1 (divide by 4)
- Calculate  $F_{VCO}$  as given by  $F_{VCO} = F_{OUT} \times \text{PLLn\_OUTDIV}$ :-  
 $F_{VCO} = 24.000 \times 4 = 96.000\text{MHz}$
- Calculate N.K as given by  $N.K = (F_{VCO} \times 2) / F_{REF}$ :-  
 $N.K = (96.000 \times 2) / 24 = 8.0$
- Determine PLLn\_N and PLLn\_K from the integer and fractional portions of N.K:-  
PLLn\_N = 8. PLLn\_K = 0.0
- N.K is an integer; set PLLn\_FRAC = 0.

The following example illustrates how to derive the PLL registers to generate 24.576MHz output ( $F_{OUT}$ ) from a 24.000 MHz reference clock ( $F_{REF}$ ).

- Set PLLn\_OUTDIV to ensure  $F_{VCO}$  is in the range 90MHz to 100MHz.  
 $F_{OUT} = 24.576\text{MHz}$ , therefore PLLn\_OUTDIV = 1 (divide by 4)
- Calculate  $F_{VCO}$  as given by  $F_{VCO} = F_{OUT} \times \text{PLLn\_OUTDIV}$ :-  
 $F_{VCO} = 24.576 \times 4 = 98.304\text{MHz}$
- Calculate N.K as given by  $N.K = (F_{VCO} \times 2) / F_{REF}$ :-  
 $N.K = (98.304 \times 2) / 24 = 8.192$
- Determine PLLn\_N and PLLn\_K from the integer and fractional portions of N.K:-  
PLLn\_N = 8. PLLn\_K = 0.192
- Confirm that N.K is a fractional quantity and set PLLn\_FRAC:  
N.K is fractional. Set PLLn\_FRAC = 1.
- Convert PLL\_K into integer format:  
 $0.192 \times 16777216 = 3221225.472$  (decimal).
- Round off to 3221225 (decimal) = 3126E9h  
PLLn\_K [23:16] = 31h  
PLLn\_K [15:8] = 26h  
PLLn\_K [7:0] = E9h

## GENERAL PURPOSE INPUT/OUTPUT (GPIO)

The WM8962B provides four multi-function pins which can be configured to provide a number of different functions. There are two digital output pins on the DBVDD power domain. PLLVDD must also be present for correct functionality. The GPIO pins are:

- CLKOUT2/GPIO2
- CLKOUT3/GPIO3

There are two digital input/output pins on the DBVDD power domain. DCVDD must also be present for correct functionality. The GPIO pins are:

- GPIO5
- CS / GPIO6

Note that, under default conditions, the GPIO5 pin is used as an input to the clocking control functions. The affected registers are described in the “Clocking and Sample Rates” and “Internal / External Clock Generation” sections. It is important that this input is held in a defined logic state (logic ‘0’ or logic ‘1’) during start-up; it must not be left floating. Normal GPIO5 functionality can be enabled after start-up, as described below.

If GPIO functionality is required on the GPIO5 pin, then the CLKREG\_OVD bit must be set to ‘1’ in order to select normal read/write control of all the clocking registers, and to permit GPIO functions.

If the CLKREG\_OVD bit is set to ‘0’ (default), then the GPIO5 control register (R516) must not be changed from the default value. The GPIO5 pin must be held in a defined logic state (logic ‘0’ or logic ‘1’) whenever the pin is configured as an input, including whenever CLKREG\_OVD = 0.

Under default conditions, the GPIO2 pin is configured as the CLKOUT2 function, supporting the PLL2 output. For GPIO2 functionality, set CLKREG\_OVD=1, CLKOUT2\_SEL=01, CLKOUT2\_DIV=0 and CLKOUT2\_OE=1. The CLKREG\_OVD register must be set to 1 before writing to the other registers.

Under default conditions, the GPIO3 pin is configured as the CLKOUT3 function, supporting the FLL output. For GPIO3 functionality, set CLKREG\_OVD=1, CLKOUT3\_SEL=01, CLKOUT3\_DIV=0 and CLKOUT3\_OE=1. The CLKREG\_OVD register must be set to 1 before writing to the other registers.

See “Internal / External Clock Generation” for details of the CLKOUT<sub>n</sub>\_SEL, CLKOUT<sub>n</sub>\_DIV and CLKOUT<sub>n</sub>\_OE registers. The CLKREG\_OVD register is defined in Table 99 (see “Clocking and Sample Rates”).

For pins GPIO5 and GPIO6, the pin direction, set by GP<sub>n</sub>\_DIR, must be set according to the function selected by GP5\_FN or GP6\_FN.

The characteristics of pins GPIO5 or GPIO6, if selected as an output, may be controlled by setting GP<sub>n</sub>\_OP\_CFG - an output pin may be either CMOS or Open-Drain. When a pin is configured as a GPIO output, its level can be set to logic 0 or logic 1 using the GP<sub>n</sub>\_LVL field.

GPIO5 and GPIO6 pins can be configured as GPIO inputs can be used to trigger an Interrupt event. This input may be configured as active high or active low using the IRQ\_POL field. De-bouncing of this input may be enabled using the GP<sub>n</sub>\_DB field. Internal pull-up and pull-down resistors may be enabled using the GP<sub>n</sub>\_PU and GP<sub>n</sub>\_PD fields. (Note that if GP<sub>n</sub>\_PU and GP<sub>n</sub>\_PD are both set for any GPIO pin, then the pull-up and pull-down will be disabled.)

The register fields that control the GPIO pins are described in Table 119.

For each GPIO pin, the selected function is determined by the GP<sub>n</sub>\_FN field, where ‘n’ identifies the GPIO pin (2, 3, 5 or 6). The polarity of the GPIO outputs can be selected using the GP<sub>n</sub>\_POL register bits.

When a pin is configured as a Logic Level output (GP<sub>n</sub>\_DIR = 0, GP<sub>n</sub>\_FN = 01h), its level can be set to logic 0 or logic 1 using the GP<sub>n</sub>\_LVL field.

When the GPIO5 or GPIO6 pin is configured as a Logic Level input (GP<sub>n</sub>\_DIR = 1, GP<sub>n</sub>\_FN = 01h), its level can be read using the GP<sub>n</sub>\_LVL field.

Note that for PLL / FLL / oscillator output on GPIO2 and GPIO3, the CLKOUT<sub>n</sub>\_SEL registers must be set to the appropriate values (see Table 109). Setting GP<sub>n</sub>\_FN = 00h is recommended in this case, but it should be noted that the PLL / FLL / oscillator output is only possible using the CLKOUT<sub>n</sub>\_SEL registers.

| REGISTER ADDRESS       | BIT | LABEL       | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|------------------------|-----|-------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R513 (0201h)<br>GPIO 2 | 10  | GP2_POL     | 0       | GPIO 2 Polarity<br>0 = Not inverted<br>1 = Inverted                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                        | 6   | GP2_LVL     | 0       | GPIO 2 Output Level<br>(when GP2_FN = 00001)<br>0 = Logic 0<br>1 = Logic 1<br>Note that this is a Write-Only register;<br>the Readback value is undefined.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |
|                        | 4:0 | GP2_FN[4:0] | 0_0000  | GPIO 2 Pin Function select<br>0_0000 = CLKOUT (PLL2 / Oscillator) -<br>see note below<br>0_0001 = Logic 0 or Logic 1<br>(depending on GP2_LVL)<br>0_0010 = SDOUT<br>0_0011 = IRQ<br>0_0100 = Temperature shutdown<br>0_0101 = Reserved<br>0_0110 = PLL2 Lock<br>0_0111 = PLL3 Lock<br>0_1000 = Reserved<br>0_1001 = FLL Lock<br>0_1010 = DRC Activity detect<br>0_1011 = Write Sequencer done<br>0_1100 = ALC Noise Gate active<br>0_1101 = ALC Peak Limiter overload<br>0_1110 = ALC Saturation<br>0_1111 = ALC level threshold<br>1_0000 = ALC Level lock<br>1_0001 = FIFO error indicator<br>1_0010 = OPCLK<br>1_0011 = Digital Microphone Clock<br>Output<br>1_0100 = Reserved<br>1_0101 = Mic Detect flag<br>1_0110 = Mic Short Circuit flag<br>1_0111 to 1_1111 = Reserved<br>Note that PLL2 or the internal oscillator<br>CLKOUT is enabled using<br>CLKOUT2_SEL. Setting GP2_FN =<br>00h is recommended in this case. |
| R514 (0202h)<br>GPIO 3 | 10  | GP3_POL     | 0       | GPIO 3 Polarity<br>0 = Not inverted<br>1 = Inverted                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|                        | 6   | GP3_LVL     | 0       | GPIO 3 Output Level<br>(when GP3_FN = 00001)<br>0 = Logic 0<br>1 = Logic 1<br>Note that this is a Write-Only register;<br>the Readback value is undefined.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

| REGISTER ADDRESS       | BIT | LABEL       | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|------------------------|-----|-------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                        | 4:0 | GP3_FN[4:0] | 0_0000  | GPIO 3 Pin Function select<br>0_0000 = CLKOUT (PLL3 / FLL) - see note below<br>0_0001 = Logic 0 or Logic 1 (depending on GP3_LVL)<br>0_0010 = SDOUT<br>0_0011 = IRQ<br>0_0100 = Temperature shutdown<br>0_0101 = Reserved<br>0_0110 = PLL2 Lock<br>0_0111 = PLL3 Lock<br>0_1000 = Reserved<br>0_1001 = FLL Lock<br>0_1010 = DRC Activity detect<br>0_1011 = Write Sequencer done<br>0_1100 = ALC Noise Gate active<br>0_1101 = ALC Peak Limiter overload<br>0_1110 = ALC Saturation<br>0_1111 = ALC level threshold<br>1_0000 = ALC Level lock<br>1_0001 = FIFO error indicator<br>1_0010 = OPCLK<br>1_0011 = Digital Microphone Clock Output<br>1_0100 = Reserved<br>1_0101 = Mic Detect flag<br>1_0110 = Mic Short Circuit flag<br>1_0111 to 1_1111 = Reserved<br>Note that PLL3 or FLL CLKOUT is enabled using CLKOUT3_SEL. Setting GP3_FN = 00h is recommended in this case. |
| R516 (0204h)<br>GPIO 5 | 15  | GP5_DIR     | 1       | GPIO5 Direction<br>0 = Output<br>1 = Input                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|                        | 14  | GP5_PU      | 0       | GPIO5 pull-up resistor enable<br>0 = pull-up disabled<br>1 = pull-up enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                        | 13  | GP5_PD      | 0       | GPIO5 pull-down resistor enable<br>0 = pull-up disabled<br>1 = pull-down enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|                        | 10  | GP5_POL     | 0       | GPIO5 Polarity<br>0 = Not inverted<br>1 = Inverted                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|                        | 9   | GP5_OP_CFG  |         | GPIO5 Output pin configuration<br>0 = CMOS<br>1 = Open-drain                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                        | 8   | GP5_DB      |         | GPIO5 input de-bounce<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |

| REGISTER ADDRESS       | BIT | LABEL       | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------|-----|-------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                        | 6   | GP5_LVL     | 0       | <p>GPIO 5 Level<br/>(when GP5_FN = 00001)<br/>0 = Logic 0<br/>1 = Logic 1</p> <p>Write to this bit to set the GPIO5 output. Read from this bit to read GPIO input level.</p> <p>Note that, when GPIO5 is configured as an output (GP5_DIR=0), this is a Write-Only register; the Readback value is undefined.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|                        | 4:0 | GP5_FN[4:0] | 0_0000  | <p>GPIO5 Pin Function select</p> <p>0_0000 = Unused<br/>0_0001 = Logic 0 or Logic 1 (depending on GP5_LVL)<br/>0_0010 = SDOUT<br/>0_0011 = IRQ<br/>0_0100 = Temperature shutdown<br/>0_0101 = Reserved<br/>0_0110 = PLL2 Lock<br/>0_0111 = PLL3 Lock<br/>0_1000 = Reserved<br/>0_1001 = FLL Lock<br/>0_1010 = DRC Activity detect<br/>0_1011 = Write Sequencer done<br/>0_1100 = ALC Noise Gate active<br/>0_1101 = ALC Peak Limiter overload<br/>0_1110 = ALC Saturation<br/>0_1111 = ALC level threshold<br/>1_0000 = ALC Level lock<br/>1_0001 = FIFO error indicator<br/>1_0010 = OPCLK<br/>1_0011 = Digital Microphone Clock Output<br/>1_0100 = Digital Microphone Data Input<br/>1_0100 = Reserved<br/>1_0101 = Mic Detect flag<br/>1_0110 = Mic Short Circuit flag<br/>1_0111 to 1_1111 = Reserved</p> <p>Note that GPIO5 functions are only supported when CLKREG_OVD=1. When CLKREG_OVD=0, the contents of Register R516 must not be changed from the default value.</p> |
| R517 (0205h)<br>GPIO 6 | 15  | GP6_DIR     | 1       | <p>GPIO6 Direction<br/>0 = Output<br/>1 = Input</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|                        | 14  | GP6_PU      | 0       | <p>GPIO6 pull-up resistor enable<br/>0 = pull-up disabled<br/>1 = pull-up enabled</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                        | 13  | GP6_PD      | 0       | <p>GPIO6 pull-down resistor enable<br/>0 = pull-up disabled<br/>1 = pull-down enabled</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                        | 10  | GP6_POL     | 0       | <p>GPIO6 Polarity<br/>0 = Not inverted<br/>1 = Inverted</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |

| REGISTER ADDRESS | BIT | LABEL       | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|------------------|-----|-------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  | 9   | GP6_OP_CFG  |         | GPIO6 Output pin configuration<br>0 = CMOS<br>1 = Open-drain                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
|                  | 8   | GP6_DB      |         | GPIO6 input de-bounce<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|                  | 6   | GP6_LVL     | 0       | GPIO 6 Level<br>(when GP6_FN = 00001)<br>0 = Logic 0<br>1 = Logic 1<br>Write to this bit to set the GPIO6 output. Read from this bit to read GPIO input level.<br>Note that, when GPIO6 is configured as an output (GP6_DIR=0), this is a Write-Only register; the Readback value is undefined.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                  | 4:0 | GP6_FN[4:0] | 0_0000  | GPIO6 Pin Function select<br>0_0000 = CSB Input<br>0_0001 = Logic 0 or Logic 1 (depending on GP6_LVL)<br>0_0010 = Reserved<br>0_0011 = IRQ<br>0_0100 = Temperature shutdown<br>0_0101 = Reserved<br>0_0110 = PLL2 Lock<br>0_0111 = PLL3 Lock<br>0_1000 = Reserved<br>0_1001 = FLL Lock<br>0_1010 = DRC Activity detect<br>0_1011 = Write Sequencer done<br>0_1100 = ALC Noise Gate active<br>0_1101 = ALC Peak Limiter overload<br>0_1110 = ALC Saturation<br>0_1111 = ALC level threshold<br>1_0000 = ALC Level lock<br>1_0001 = FIFO error indicator<br>1_0010 = OPCLK<br>1_0011 = Digital Microphone Clock Output<br>1_0100 = Digital Microphone Data Input<br>1_0100 = Reserved<br>1_0101 = Mic Detect flag<br>1_0110 = Mic Short Circuit flag<br>1_0111 to 1_1111 = Reserved |

**Table 119 GPIO Control**

## INTERRUPTS

The Interrupt Controller has multiple inputs, including the GPIO input, ALC status, PLL lock and FLL lock. Any combination of these inputs can be used to trigger an Interrupt (IRQ) event.

There is an Interrupt Status field associated with each of the IRQ inputs. These are contained in the Interrupt Status Registers (R560 and R561), as described in Table 120. The status of the IRQ inputs can be read from this register at any time, or else in response to the Interrupt Output being signalled via a GPIO pin.

Each of the IRQ inputs can be individually masked or enabled as an input to the Interrupt function, using the bits contained in the Interrupt Status Mask registers (R568 and R569). Note that the

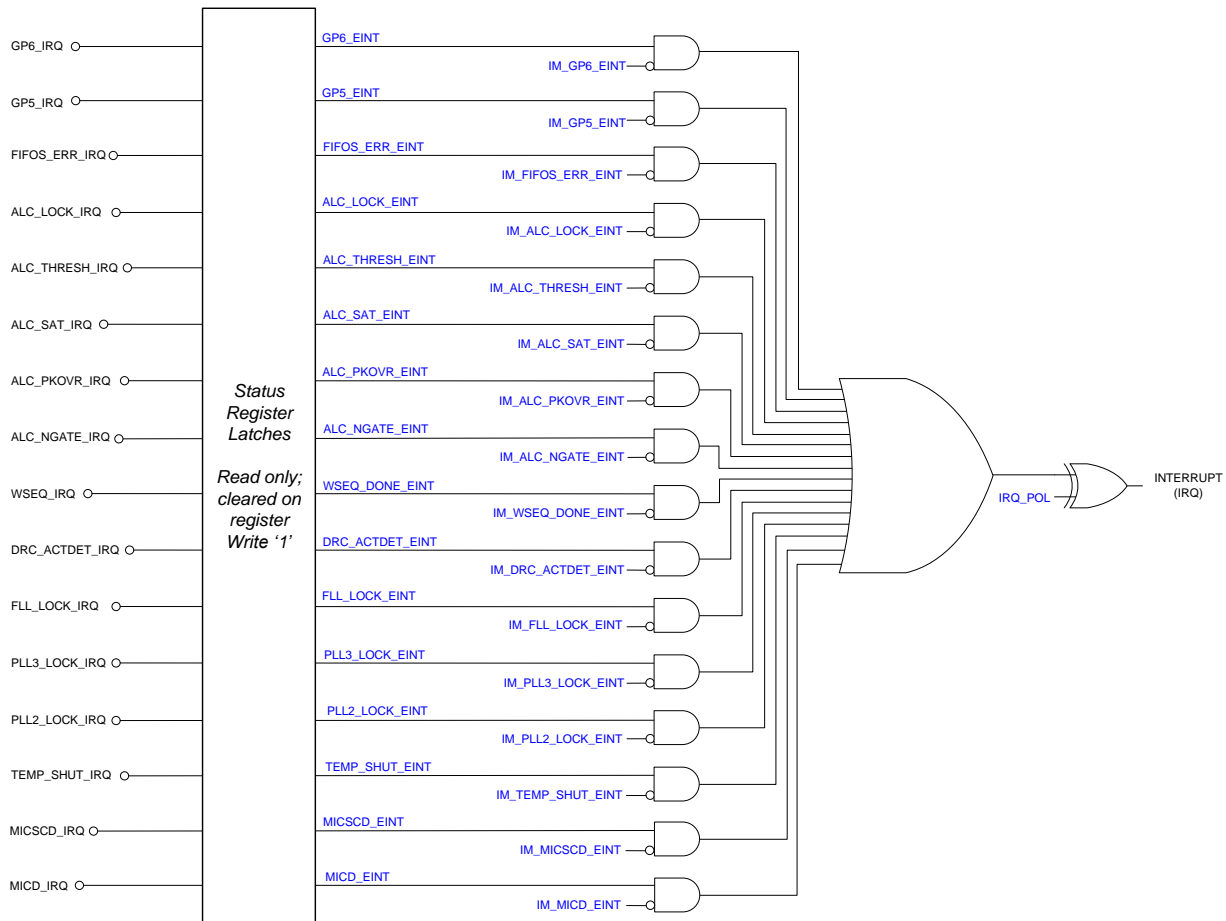
Interrupt Status fields remain valid, even when masked, but the masked bits will not cause the Interrupt Output to be asserted.

The Interrupt Output represents the logical 'OR' of all the unmasked IRQ inputs, as illustrated in Figure 62. The bits within the Interrupt Status register (R560 and R561) are latching fields and, once they are set, they are not reset until a '1' is written to the respective register bit in the Interrupt Status registers. The Interrupt (IRQ) output is not reset until each of the unmasked IRQ inputs has been reset. Note that, if the condition that caused the IRQ input to be asserted is still valid, then the Interrupt Output will remain set even after the Status register has been written to.

The PLL<sub>n</sub>\_LOCK\_EINT, FLL\_LOCK\_EINT and TEMP\_SHUT\_EINT inputs to the Interrupt Controller can be de-bounced to avoid false detections. The timeout clock (TOCLK) is required for this function. The de-bounce is enabled on these inputs using the bits in Register R584. The de-bounce clock is enabled automatically whenever interrupt de-bouncing is selected. The de-bounce clock frequency is controlled by DBCLK\_DIV as described in "Clocking and Sample Rates".

By default, the Interrupt Output is Active High. The polarity can be inverted using IRQ\_POL.

The WM8962B Interrupt Controller circuit is illustrated in Figure 54. The associated control fields are described in Table 120.



**Figure 62** Interrupt Controller



| REGISTER ADDRESS                   | BIT           | LABEL           | DEFAULT                                                                                                        | DESCRIPTION                                                                                                                                                |
|------------------------------------|---------------|-----------------|----------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R560 (0230h)<br>Interrupt Status 1 | 5             | GP6_EINT        | 0                                                                                                              | GPIO6 IRQ status<br>0 = GPIO6 IRQ not set<br>1 = GPIO6 IRQ set<br>Note: cleared when a '1' is written                                                      |
|                                    | 4             | GP5EINT         | 0                                                                                                              | GPIO5 IRQ status<br>0 = GPIO5 IRQ not set<br>1 = GPIO5 IRQ set<br>Note: cleared when a '1' is written                                                      |
| R561 (0231h)<br>Interrupt Status 2 | 15            | MICSCD_EINT     | 0                                                                                                              | Mic Short Circuit Interrupt Status<br>0 = MICSCD IRQ not set<br>1 = MICSCD IRQ set<br>Note: cleared when a '1' is written                                  |
|                                    | 14            | MICD_EINT       | 0                                                                                                              | Mic Detect Interrupt Status<br>0 = MICD IRQ not set<br>1 = MICD IRQ set<br>Note: cleared when a '1' is written                                             |
|                                    | 13            | FIFOS_ERR_EINT  | 0                                                                                                              | FIFO error IRQ status<br>0 = FIFO error IRQ not set<br>1 = FIFO error IRQ set<br>Note: cleared when a '1' is written                                       |
|                                    | 12            | ALC_LOCK_EINT   | 0                                                                                                              | ALC level lock IRQ status<br>0 = ALC level lock IRQ not set<br>1 = ALC level lock IRQ set<br>Note: cleared when a '1' is written                           |
|                                    | 11            | ALC_THRESH_EINT | 0                                                                                                              | ALC level threshold IRQ status<br>0 = ALC level threshold IRQ not set<br>1 = ALC level threshold IRQ set<br>Note: cleared when a '1' is written            |
|                                    | 10            | ALC_SAT_EINT    | 0                                                                                                              | ALC saturation IRQ status<br>0 = ALC saturation IRQ not set<br>1 = ALC saturation IRQ set<br>Note: cleared when a '1' is written                           |
|                                    | 9             | ALC_PKOVR_EINT  | 0                                                                                                              | ALC peak overload detector IRQ status<br>0 = ALC pk. overload det. IRQ not set<br>1 = ALC pk. Overload det. IRQ set<br>Note: cleared when a '1' is written |
|                                    | 8             | ALC_NGATE_EINT  | 0                                                                                                              | ALC Noise Gate active IRQ status<br>0 = ALC Noise Gate IRQ not set<br>1 = ALC Noise Gate IRQ set<br>Note: cleared when a '1' is written                    |
|                                    | 7             | WSEQ_DONE_EINT  | 0                                                                                                              | Write Sequencer done IRQ status<br>0 = Write Sequencer IRQ not set<br>1 = Write Sequencer IRQ set<br>Note: cleared when a '1' is written                   |
|                                    | 6             | DRC_ACTDET_EINT | 0                                                                                                              | DRC Activity IRQ status<br>0 = DRC Activity IRQ not set<br>1 = DRC Activity IRQ set<br>Note: cleared when a '1' is written                                 |
| 5                                  | FLL_LOCK_EINT | 0               | FLL lock IRQ status<br>0 = FLL lock IRQ not set<br>1 = FLL lock IRQ set<br>Note: cleared when a '1' is written |                                                                                                                                                            |

| REGISTER ADDRESS                           | BIT | LABEL                  | DEFAULT | DESCRIPTION                                                                                                                                        |
|--------------------------------------------|-----|------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------|
|                                            | 3   | PLL3_LOCK_EI<br>NT     | 0       | PLL3 Lock IRQ status<br>0 = PLL3 Lock IRQ not set<br>1 = PLL3 Lock IRQ set<br>Note: cleared when a '1' is written                                  |
|                                            | 2   | PLL2_LOCK_EI<br>NT     | 0       | PLL2 Lock IRQ status<br>0 = PLL2 Lock IRQ not set<br>1 = PLL2 Lock IRQ set<br>Note: cleared when a '1' is written                                  |
|                                            | 0   | TEMP_SHUT_EI<br>NT     | 0       | Temperature Shutdown IRQ status<br>0 = Temperature Shutdown IRQ not set<br>1 = Temperature Shutdown IRQ set<br>Note: cleared when a '1' is written |
| R568 (0238h)<br>Interrupt<br>Status 1 Mask | 5   | IM_GP6_EINT            | 1       | Interrupt mask for GPIO6<br>0 = Not masked<br>1 = Masked                                                                                           |
|                                            | 4   | IM_GP5_EINT            | 1       | Interrupt mask for GPIO5<br>0 = Not masked<br>1 = Masked                                                                                           |
| R569 (0239h)<br>Interrupt<br>Status 2 Mask | 15  | IM_MICSCD_EI<br>NT     | 0       | Interrupt mask for Mic Short Circuit<br>0 = Not masked<br>1 = Masked                                                                               |
|                                            | 14  | IM_MICD_EINT           | 0       | Interrupt mask for Mic Detect<br>0 = Not masked<br>1 = Masked                                                                                      |
|                                            | 13  | IM_FIFOS_ERR<br>_EINT  | 1       | Interrupt mask for FIFOS Error<br>0 = Not masked<br>1 = Masked                                                                                     |
|                                            | 12  | IM_ALC_LOCK_<br>EINT   | 1       | Interrupt mask for ALC Lock<br>0 = Not masked<br>1 = Masked                                                                                        |
|                                            | 11  | IM_ALC_THRES<br>H_EINT | 1       | Interrupt mask for ALC Threshold<br>0 = Not masked<br>1 = Masked                                                                                   |
|                                            | 10  | IM_ALC_SAT_EI<br>NT    | 1       | Interrupt mask for ALC Saturation<br>0 = Not masked<br>1 = Masked                                                                                  |
|                                            | 9   | IM_ALC_PKOV<br>R_EINT  | 1       | Interrupt mask for ALC Peak<br>Detector overload<br>0 = Not masked<br>1 = Masked                                                                   |
|                                            | 8   | IM_ALC_NGATE<br>_EINT  | 1       | Interrupt mask for ALC Noise Gate<br>active<br>0 = Not masked<br>1 = Masked                                                                        |
|                                            | 7   | IM_WSEQ_DON<br>E_EINT  | 1       | Interrupt mask for Write Sequencer<br>done<br>0 = Not masked<br>1 = Masked                                                                         |
|                                            | 6   | IM_DRC_ACTD<br>ET_EINT | 1       | Interrupt mask for DRC Activity<br>detect<br>0 = Not masked<br>1 = Masked                                                                          |
|                                            | 5   | IM_FLL_LOCK_<br>EINT   | 1       | Interrupt mask for FLL Lock<br>0 = Not masked<br>1 = Masked                                                                                        |

| REGISTER ADDRESS                  | BIT | LABEL             | DEFAULT | DESCRIPTION                                                                                                                                                          |
|-----------------------------------|-----|-------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                   | 3   | IM_PLL3_LOCK_EINT | 1       | Interrupt mask for PLL3 Lock<br>0 = Not masked<br>1 = Masked                                                                                                         |
|                                   | 2   | IM_PLL2_LOCK_EINT | 1       | Interrupt mask for PLL2 Lock<br>0 = Not masked<br>1 = Masked                                                                                                         |
|                                   | 0   | IM_TEMP_SHUT_EINT | 1       | Interrupt mask for Temperature Shutdown<br>0 = Not masked<br>1 = Masked                                                                                              |
| R576 (0240h)<br>Interrupt Control | 0   | IRQ_POL           | 0       | Interrupt Output polarity<br>0 = Active high<br>1 = Active low                                                                                                       |
| R584 (0248h)<br>IRQ Debounce      | 5   | FLL_LOCK_DB       | 1       | Debounce Enable on FLL Lock<br>0 = Disabled<br>1 = Enabled                                                                                                           |
|                                   | 3   | PLL3_LOCK_DB      | 1       | Debounce Enable on PLL3 Lock<br>0 = Disabled<br>1 = Enabled                                                                                                          |
|                                   | 2   | PLL2_LOCK_DB      | 1       | Debounce Enable on PLL2 Lock<br>0 = Disabled<br>1 = Enabled                                                                                                          |
|                                   | 0   | TEMP_SHUT_DB      | 1       | Debounce Enable on Temperature Shutdown<br>0 = Disabled<br>1 = Enabled                                                                                               |
| R586 (024Ah)<br>MICINT Source Pol | 15  | MICSCD_IRQ_POL    | 0       | Mic Short Circuit Interrupt Polarity<br>0 = Active high (IRQ asserted when MICSHORT_THR is exceeded)<br>1 = Active low (IRQ asserted when MICSHORT_THR not exceeded) |
|                                   | 14  | MICD_IRQ_POL      | 0       | Mic Detect Interrupt Polarity<br>0 = Active high (IRQ asserted when MICDET_THR is exceeded)<br>1 = Active low (IRQ asserted when MICDET_THR not exceeded)            |

**Table 120 Interrupt Control**

## CONTROL INTERFACE

The WM8962B is controlled by writing to its control registers. Readback is available for all registers. The Control Interface can operate as either a 2-, 3- or 4-wire interface:

- 2-wire (I2C) mode uses pins SCLK and SDA
- 3-wire (SPI) mode uses pins CS/GPIO6, SCLK and SDA
- 4-wire (SPI) mode uses the CS/GPIO6, SCLK and SDA pins; the SDOOUT function is provided on a GPIO pin

Readback is provided on the bi-directional pin SDA in 2-/3-wire modes. In 4-wire mode, the SDOOUT readback function must be enabled on one of the GPIO pins - see "General Purpose Input/Output (GPIO)".

In 3-wire and 4-wire SPI modes, the CS function is provided using the CS/GPIO6 pin. In these control interface modes, GPIO6 must be configured as CS by setting GP6\_FN = 00h and GP6\_DIR = 1. Note that this is the default setting of GPIO6.

The WM8962B uses 16-bit register addresses and 16-bit data in 2-wire (I2C) mode; the WM8962B uses 15-bit register addresses in 3-wire and 4-wire (SPI) modes.

The configuration parameters in registers R16896 (4200h) to R21139 (5293h) are 24-bit words, arranged within the 16-bit register address space. Each 24-bit word must be written to the register map in full, MSBs first, before attempting to read back the value. Failure to do this may give incorrect read/write behaviour.

When updating the configuration parameters for any DSP feature(s), it is recommended to write all of the associated registers, in incremental address order, before reading back any values.

Note that the Control Interface function can be supported with or without system clocking. Where possible, the register map access is synchronised with SYSCLK in order to ensure predictable operation of cross-domain functions. See "Clocking and Sample Rates" for further details of Control Interface clocking.

### SELECTION OF CONTROL INTERFACE MODE

The WM8962B Control Interface Mode is determined by the logic level on the CIFMODE pin, as shown in Table 121.

| CIFMODE | INTERFACE FORMAT          |
|---------|---------------------------|
| Low     | 2 wire (I2C) Mode         |
| High    | 3- or 4- wire (SPI) Modes |

**Table 121 Control Interface Mode Selection**

In 2-wire (I2C) Control Interface mode, Auto-Increment mode may be selected. This enables multiple write and multiple read operations to be scheduled faster than is possible with single register operations, and is illustrated in Figure 67, Figure 68 and Figure 69. The auto-increment option is enabled when the AUTO\_INC register bit is set. This bit is defined in Table 122. Auto-increment is enabled by default.

In SPI modes, 3-wire or 4-wire operation may be selected using the SPI\_4WIRE register bit.

In SPI modes, the Continuous Read mode may be selected using the SPI\_CONTRD bit. This enables multiple register read operations to be scheduled faster than is possible with single register operations. When SPI\_CONTRD is set, the WM8962B will readback from incremental register addresses as long as CS is held low and SCLK is toggled.

In 3-wire (SPI) mode, register readback is provided using the bi-directional pin SDA. During data output, the SDA pin can be configured as CMOS or Open Drain, using the SPI\_CFG register bit.

In 4-wire (SPI) mode, register readback is provided using SDOOUT, which must be configured on one of the GPIO pins.

When GPIO5 is configured as SDOOUT, it may be configured as CMOS or as 'Wired OR' using the SPI\_CFG bit. In CMOS mode, SDOOUT is driven low when not outputting register data. In 'Wired OR' mode, SDOOUT is un-driven (high impedance) when not outputting register data bits. Note that the

SDOUT function on GPIO2 and GPIO3 is not configurable using SPI\_CFG; on these pins, SDOUT is a CMOS output at all times.

The Control Interface configuration bits are described in Table 122.

| REGISTER ADDRESS                 | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                       |
|----------------------------------|-----|------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R94 (005Eh)<br>Control Interface | 6   | SPI_CONTRD | 0       | Enable continuous read mode in SPI (3-wire/4-wire) modes<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                           |
|                                  | 5   | SPI_4WIRE  | 0       | SPI control mode select<br>0 = 3-wire using bidirectional SDA<br>1 = 4-wire using SDOUT                                                                                                                                                                                                                                           |
|                                  | 4   | SPI_CFG    | 0       | SDA/SDOUT pin configuration<br><br>In 3-wire mode (SPI_4WIRE=0):<br>0 = SDA output is CMOS<br>1 = SDA output is Open Drain<br><br>In 4-wire mode (SPI_4WIRE=1):<br>0 = SDOUT output is CMOS<br>1 = SDOUT output is Wired 'OR'.<br>Note that only GPIO5 can be configured as Wired 'OR'. This bit has no effect on GPIO2 or GPIO3. |
| R252 (00FFh)                     | 0   | AUTO_INC   | 1       | Enables address auto-increment (applies to 2-wire I2C mode only)<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                   |

**Table 122 Control Interface Configuration**

## 2-WIRE (I2C) CONTROL MODE

In 2-wire (I2C) mode, the WM8962B is a slave device on the control interface; SCLK is a clock input, while SDA is a bi-directional data pin. To allow arbitration of multiple slaves (and/or multiple masters) on the same interface, the WM8962B transmits logic 1 by tri-stating the SDA pin, rather than pulling it high. An external pull-up resistor is required to pull the SDA line high so that the logic 1 can be recognised by the master.

In order to allow many devices to share a single 2-wire control bus, every device on the bus has a unique 8-bit device ID (this is not the same as the address of each register in the WM8962B). The WM8962B device ID is 0011\_0100 (34h). The LSB of the device ID is the Read/Write bit; this bit is set to logic 1 for "Read" and logic 0 for "Write".

Important - in addition to the I2C address noted above (34h), the WM8962B also incorporates test functionality via I2C addresses 94h and D2h, and may respond to I2C operations at these addresses. It is a requirement that no other device on the same I2C bus makes use of address 94h or D2h.

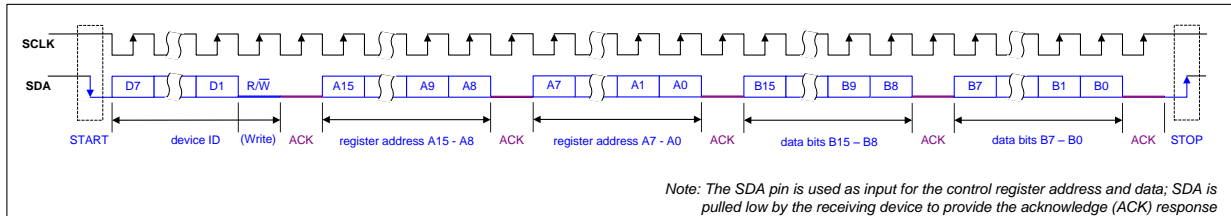
The WM8962B operates as a slave device only. The controller indicates the start of data transfer with a high to low transition on SDA while SCLK remains high. This indicates that a device ID, register address and data will follow. The WM8962B responds to the start condition and shifts in the next eight bits on SDA (8-bit device ID, including Read/Write bit, MSB first). If the device ID received matches the device ID of the WM8962B, then the WM8962B responds by pulling SDA low on the next clock pulse (ACK). If the device ID is not recognised or the R/W bit is '1' when operating in write only mode, the WM8962B returns to the idle condition and waits for a new start condition and valid address.

If the device ID matches the device ID of the WM8962B, the data transfer continues as described below. The controller indicates the end of data transfer with a low to high transition on SDA while SCLK remains high. After receiving a complete address and data sequence the WM8962B returns to the idle state and waits for another start condition. If a start or stop condition is detected out of sequence at any point during data transfer (i.e. SDA changes while SCLK is high), the device returns to the idle condition.

The WM8962B supports the following read and write operations:

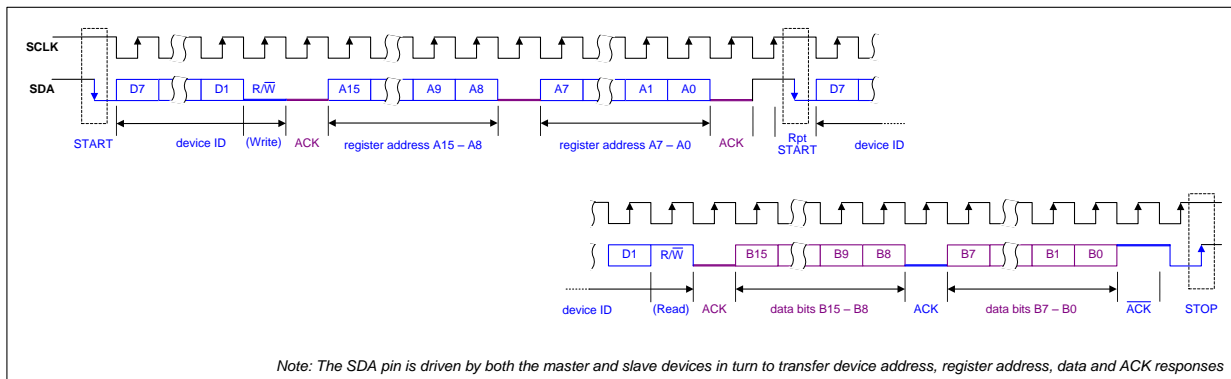
- Single write
- Single read
- Multiple write using auto-increment
- Multiple read using auto-increment

The sequence of signals associated with a single register write operation is illustrated in Figure 63.



**Figure 63 Control Interface 2-wire (I2C) Register Write**

The sequence of signals associated with a single register read operation is illustrated in Figure 64.



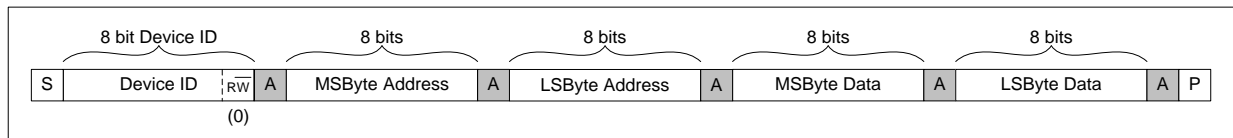
**Figure 64 Control Interface 2-wire (I2C) Register Read**

The Control Interface also supports other register operations, as listed above. The interface protocol for these operations is summarised below. The terminology used in the following figures is detailed in Table 123.

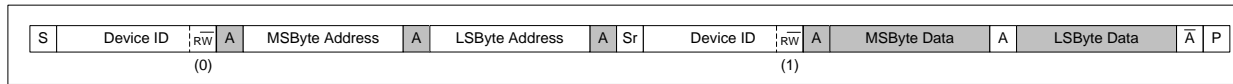
Note that, for multiple write and multiple read operations, the auto-increment option must be enabled. This feature is enabled by default, as noted in Table 122.

| TERMINOLOGY   | DESCRIPTION                          |                       |
|---------------|--------------------------------------|-----------------------|
| S             | Start Condition                      |                       |
| Sr            | Repeated start                       |                       |
| A             | Acknowledge (SDA Low)                |                       |
| $\bar{A}$     | Not Acknowledge (SDA High)           |                       |
| P             | Stop Condition                       |                       |
| R/W           | ReadNotWrite                         | 0 = Write<br>1 = Read |
| [White field] | Data flow from bus master to WM8962B |                       |
| [Grey field]  | Data flow from WM8962B to bus master |                       |

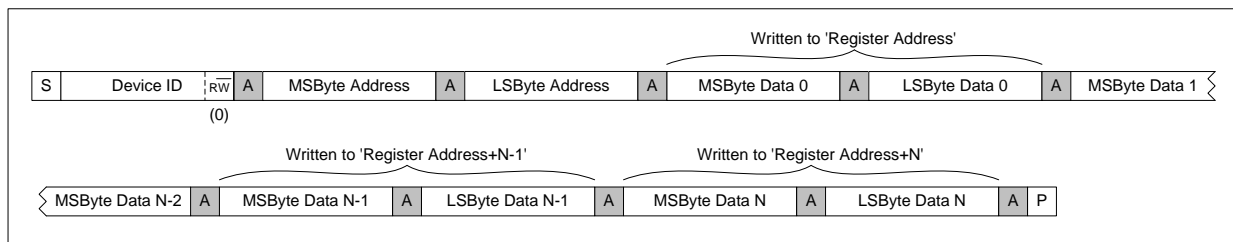
**Table 123 Control Interface Terminology**



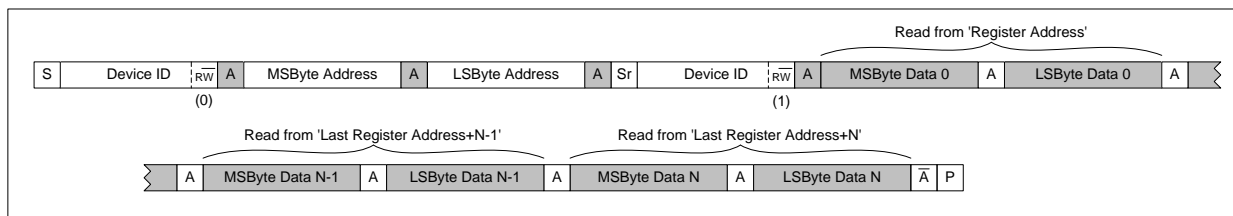
**Figure 65 Single Register Write to Specified Address**



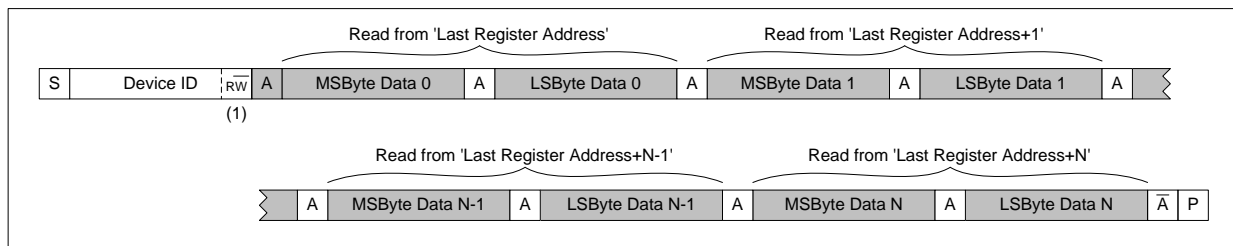
**Figure 66 Single Register Read from Specified Address**



**Figure 67 Multiple Register Write to Specified Address using Auto-increment**



**Figure 68 Multiple Register Read from Specified Address using Auto-increment**



**Figure 69 Multiple Register Read from Last Address using Auto-increment**

Multiple Write and Multiple Read operations enable the host processor to access sequential blocks of the data in the WM8962B register map faster than is possible with single register operations. The auto-increment option is enabled when the AUTO\_INC register bit is set. This bit is defined in Table 122. Auto-increment is enabled by default.

### 3-WIRE (SPI) CONTROL MODE

The 3-wire control interface uses the CS, SCLK and SDA pins.

In 3-wire control mode, a control word consists of 32 bits. The first bit is the read/write bit (R/W), which is followed by 15 address bits (A14 to A0) that determine which control register is accessed. The remaining 16 bits (B15 to B0) are data bits, corresponding to the 16 bits in each control register.

In 3-wire mode, every rising edge of SCLK clocks in one data bit from the SDA pin. A rising edge on CS latches in a complete control word consisting of the last 32 bits.

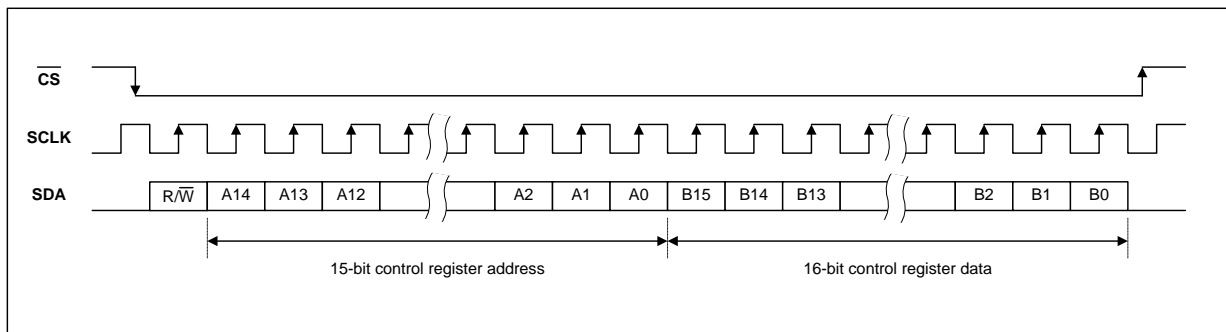
In Write operations (R/W=0), all SDA bits are driven by the controlling device.

In Read operations (R/W=1), the SDA pin is driven by the controlling device to clock in the register address, after which the WM8962B drives the SDA pin to output the applicable data bits.

During data output, the SDA pin can be configured as CMOS or Open Drain, using the SPI\_CFG register bit, as described in Table 122. In Open Drain configuration, an external pull-up resistor is required to pull the SDA line high so that the logic 1 can be recognised by the master.

When SPI Continuous Read mode is enabled (SPI\_CONTRD = 1), the WM8962B will readback from incremental register addresses as long as CS is held low and SCLK is toggled. In this mode, the WM8962B will increment the readback address after the first 32 clock cycles, and will output data from the next register address, and successive register addresses, MSB first, for as long as CS is held low and SCLK is toggled.

The 3-wire control mode timing is illustrated in Figure 70.



**Figure 70 3-Wire Serial Control Interface**



### 4-WIRE (SPI) CONTROL MODE

The 4-wire control interface uses the CS, SCLK, SDA and SDOUT pins.

The SDOUT function must be enabled on one of the GPIO pins - see "General Purpose Input/Output (GPIO)".

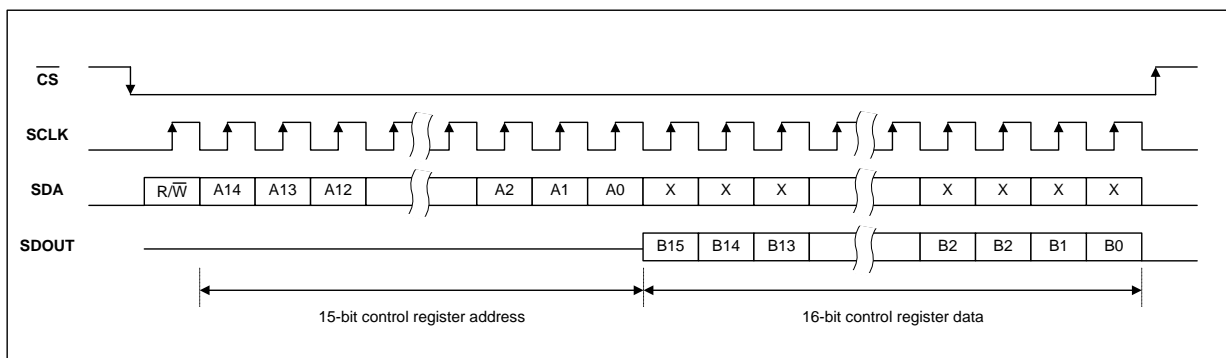
When GPIO5 is configured as the Data Output pin, SDOUT, it can be configured as CMOS or 'Wired OR', as described in Table 122. In CMOS mode, SDOUT is driven low when not outputting register data bits. In 'Wired OR' mode, SDOUT is undriven (high impedance) when not outputting register data bits. Note that the SDOUT function on GPIO2 and GPIO3 is not configurable using SPI\_CFG; on these pins, SDOUT is a CMOS output at all times

In Write operations (R/W=0), this mode is the same as 3-wire mode described above.

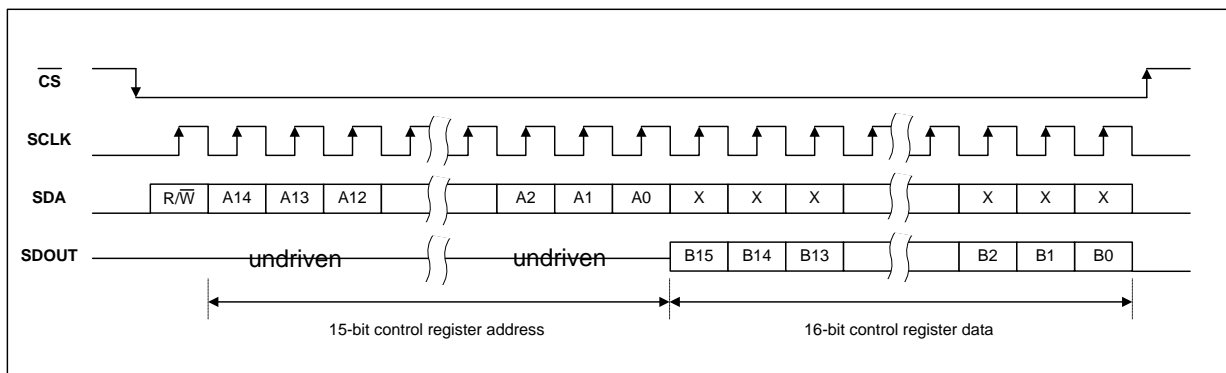
In Read operations (R/W=1), the SDA pin is ignored following receipt of the valid register address. SDOUT is driven by the WM8962B.

When SPI Continuous Read mode is enabled (SPI\_CONTRD = 1), the WM8962B will readback from incremental register addresses as long as CS is held low and SCLK is toggled. In this mode, the WM8962B will increment the readback address after the first 32 clock cycles, and will output data from the next register address, and successive register addresses, MSB first, for as long as CS is held low and SCLK is toggled.

The 4-wire control mode timing is illustrated in Figure 71 and Figure 72.



**Figure 71 4-Wire Readback (CMOS)**



**Figure 72 4-Wire Readback (Wired-'OR')**

## CONTROL WRITE SEQUENCER

The Control Write Sequencer is a programmable unit that forms part of the WM8962B control interface logic. It provides the ability to perform a sequence of register write operations with the minimum of demands on the host processor - the sequence may be initiated by a single operation from the host processor and then left to execute independently.

Default sequences for Start-Up of each output driver and Shut-Down are provided (see “Default Sequences” section). It is recommended that these default sequences are used unless changes become necessary.

When a sequence is initiated, the sequencer performs a series of pre-defined register writes. The host processor informs the sequencer of the start index of the required sequence within the sequencer’s memory. At each step of the sequence, the contents of the selected register fields are read from the sequencer’s memory and copied into the WM8962B control registers. This continues sequentially through the sequencer’s memory until an “End of Sequence” bit is encountered; at this point, the sequencer stops and an Interrupt status flag is asserted. For cases where the timing of the write sequence is important, a programmable delay can be set for specific steps within the sequence.

Note that the Control Write Sequencer’s internal clock is derived from the internal clock SYSCLK which must be enabled as described in “Clocking and Sample Rates”. The clock division from SYSCLK is handled transparently by the WM8962B without user intervention, provided that SYSCLK is configured as specified in “Clocking and Sample Rates”.

### INITIATING A SEQUENCE

The Register fields associated with running the Control Write Sequencer are described in Table 124. Note that the operation of the Control Write Sequencer also requires the internal clock SYSCLK to be configured as described in “Clocking and Sample Rates”.

The Write Sequencer is enabled by setting the WSEQ\_ENA bit. The start index of the required sequence must be written to the WSEQ\_START\_INDEX field.

The Write Sequencer stores up to 128 register write commands. These are defined in Registers R4096 to R4607. There are 4 registers used to define each of the 128 possible commands. The value of WSEQ\_START\_INDEX selects the registers applicable to the first write command in the selected sequence.

Setting the WSEQ\_START bit initiates the sequencer at the given start index. The Write Sequencer can be interrupted by writing a logic 1 to the WSEQ\_ABORT bit.

The current status of the Write Sequencer can be read using two further register fields - when the WSEQ\_BUSY bit is asserted, this indicates that the Write Sequencer is busy. Note that, whilst the Control Write Sequencer is running a sequence (indicated by the WSEQ\_BUSY bit), full read/write operations to the Control Registers cannot be supported. (Register access to the Control Write Sequencer registers, Software Reset registers, PLL/CLKOUT control registers is still supported while the Control Write Sequencer is running. Unsuccessful I2C interface commands will be indicated to the host processor by the WM8962B failing to provide the acknowledge, ‘ACK’, indication.)

The index of the current step in the Write Sequencer can be read from the WSEQ\_CURRENT\_INDEX field; this is an indicator of the sequencer’s progress. On completion of a sequence, this field holds the index of the last step within the last commanded sequence.

When the Write Sequencer reaches the end of a sequence, it asserts the WSEQ\_DONE\_EINT flag in Register R561 (see “Interrupts”). This flag can be used to generate an Interrupt Event on completion of the sequence. Note that the WSEQ\_DONE\_EINT flag is asserted to indicate that the WSEQ is NOT Busy.

The WM8962B supports the option to automatically power-down the Class D speaker drivers when the DAC Auto-Mute is triggered, and to re-enable the speaker drivers when audio data is detected. This is implemented using the Control Write Sequencer, and enabled by setting the WSEQ\_AUTOSEQ\_ENA bit. When this bit is set, and the conditions for DAC Auto-Mute are satisfied, the default “Speaker Sleep” sequence is triggered. When the DAC is un-muted following an Auto-Mute event, the “Speaker Wake” sequence is triggered. See “Default Sequences” for details of these sequences.

| REGISTER ADDRESS                       | BIT | LABEL                                | DEFAULT  | DESCRIPTION                                                                                                                                                                                                                                                                           |
|----------------------------------------|-----|--------------------------------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R87 (57h)<br>Write Sequencer Control 1 | 7   | WSEQ_AUTOS EQ_ENA                    | 0        | Write Sequencer Auto-Sequence Enable (controls the Class D driver via DAC Auto-Mute function)<br>0 = Disabled<br>1 = Enabled                                                                                                                                                          |
|                                        | 5   | WSEQ_ENA                             | 0        | Write Sequencer Enable.<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                |
| R90 (5Ah)<br>Write Sequencer Control 2 | 8   | WSEQ_ABORT                           | 0        | Writing a 1 to this bit aborts the current sequence and returns control of the device back to the serial control interface.                                                                                                                                                           |
|                                        | 7   | WSEQ_START                           | 0        | Writing a 1 to this bit starts the write sequencer at the index location selected by WSEQ_START_INDEX. The sequence continues until it reaches an "End of sequence" flag. At the end of the sequence, this bit will be reset by the Write Sequencer.                                  |
|                                        | 6:0 | WSEQ_START_INDEX [6:0]               | 000_0000 | Sequence Start Index. This field determines the memory location of the first command in the selected sequence. There are 127 Write Sequencer RAM addresses:<br>00h = WSEQ_ADDR0 (R4096)<br>01h = WSEQ_ADDR1 (R4100)<br>02h = WSEQ_ADDR2 (R4104)<br>....<br>7Fh = WSEQ_ADDR127 (R4604) |
| R93 (5Dh)<br>Write Sequencer Control 3 | 9:3 | WSEQ_CURRENT_INDEX [6:0] (read only) | 000_0000 | Sequence Current Index. This indicates the memory location of the most recently accessed command in the write sequencer memory. Coding is the same as WSEQ_START_INDEX.                                                                                                               |
|                                        | 0   | WSEQ_BUSY (read only)                | 0        | Sequencer Busy flag (Read Only).<br>0 = Sequencer idle<br>1 = Sequencer busy<br>Note: it is not possible to write to control registers via the control interface while the Sequencer is Busy.                                                                                         |

**Table 124 Write Sequencer Control - Initiating a Sequence**

### PROGRAMMING A SEQUENCE

A sequence consists of write operations to data bits (or groups of bits) within the control registers. Each write operation is defined by a block of 4 registers, which contain 6 fields as described in this section.

The block of 4 registers is the same for up to 128 steps held in the sequencer memory. Multiple sequences can be held in the memory at the same time; each sequence occupies its own range within the 128 available register blocks.

The following 6 fields are replicated 128 times - one for each of the sequencer's 128 steps. In the following descriptions, the term 'n' is used to denote the step number, from 0 to 127.

WSEQ\_ADDRn is a 14-bit field containing the Control Register Address in which the data should be written. Note that the Control Write Sequencer cannot be used to access the Software Reset registers, PLL/CLKOUT control registers or the Write Sequencer registers R87, R90 and R93.

WSEQ\_DATA $n$  is an 8-bit field which contains the data to be written to the selected Control Register. The WSEQ\_DATA\_WIDTH $n$  field determines how many of these bits are written to the selected register; the most significant bits (above the number indicated by WSEQ\_DATA\_WIDTH $n$ ) are ignored.

WSEQ\_DATA\_START $n$  is a 4-bit field which identifies the LSB position within the selected Control Register to which the data should be written. For example, setting WSEQ\_DATA\_START $n$  = 0100 will select bit 4 as the LSB position; in this case, 4-bit data would be written to bits 7:4.

WSEQ\_DATA\_WIDTH $n$  is a 3-bit field which identifies the width of the data block to be written. This enables selected portions of a Control Register to be updated without any concern for other bits within the same register, eliminating the need for read-modify-write procedures. Values of 0 to 7 correspond to data widths of 1 to 8 respectively. For example, setting WSEQ\_DATA\_WIDTH $n$  = 010 will cause a 3-bit data block to be written. Note that the maximum value of this field corresponds to an 8-bit data block; writing to register fields greater than 8 bits wide must be performed using two separate operations of the Control Write Sequencer.

WSEQ\_DELAY $n$  is a 4-bit field which controls the waiting time between the current step and the next step in the sequence i.e. the delay occurs after the write in which it was called. The total delay time per step (including execution) is defined below, giving a useful range of execution/delay times from approximately 562 $\mu$ s up to 2.048s per step:

$$T = k \times (2^{WSEQ\_DELAY} + 8)$$

where  $k = 62.5\mu\text{s}$  (if SAMPLE\_RATE\_INT\_MODE = 1)

and  $k = 68.1\mu\text{s}$  (if SAMPLE\_RATE\_INT\_MODE = 0)

Note that the sequencer execution/delay time varies between integer and fractional values of the SAMPLE\_RATE register; see "Clocking and Sample Rates" for details of the associated registers.

WSEQ\_EOS $n$  is a 1-bit field which indicates the End of Sequence. If this bit is set, then the Control Write Sequencer will automatically stop after this step has been executed.

The register definitions for Step 0 are described in Table 125. The equivalent definitions also apply to Step 1 through to Step 127, in the subsequent register address locations.

| REGISTER ADDRESS                      | BIT  | LABEL                  | DEFAULT | DESCRIPTION                                                                                                                                                                                   |
|---------------------------------------|------|------------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R4096<br>(1000h)<br>Write Sequencer 0 | 13:0 | WSEQ_ADDR<br>0 [13:0]  | 001Ch   | Control Register Address to be written to in this sequence step.                                                                                                                              |
| R4097<br>(1001h)<br>Write Sequencer 1 | 7:0  | WSEQ_DATA<br>0 [7:0]   | 03h     | Data to be written in this sequence step. When the data width is less than 8 bits, then one or more of the MSBs of WSEQ_DATA $n$ are ignored. It is recommended that unused bits be set to 0. |
| R4098<br>(1002h)<br>Write Sequencer 2 | 10:8 | WSEQ_DATA_WIDTH0 [2:0] | 001     | Width of the data block written in this sequence step.<br>000 = 1 bit<br>001 = 2 bits<br>010 = 3 bits<br>011 = 4 bits<br>100 = 5 bits<br>101 = 6 bits<br>110 = 7 bits<br>111 = 8 bits         |
|                                       | 3:0  | WSEQ_DATA_START0 [3:0] | 0011    | Bit position of the LSB of the data block written in this sequence step.<br>0000 = Bit 0<br>...<br>1111 = Bit 15                                                                              |

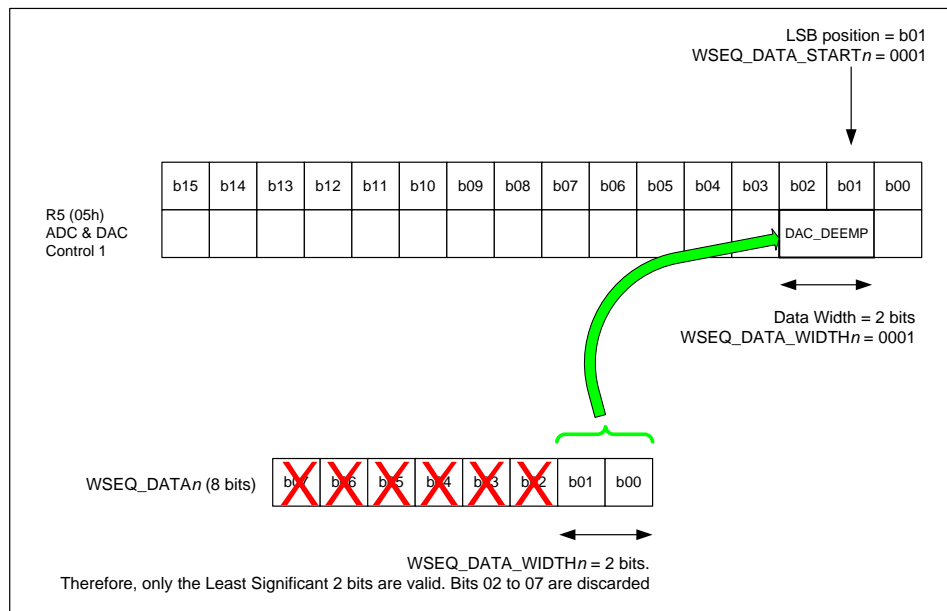
| REGISTER ADDRESS                      | BIT | LABEL             | DEFAULT | DESCRIPTION                                                                                                                                                                                                        |
|---------------------------------------|-----|-------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R4099<br>(1003h)<br>Write Sequencer 3 | 8   | WSEQ_EOS0         | 0       | End of Sequence flag. This bit indicates whether the Control Write Sequencer should stop after executing this step.<br>0 = Not end of sequence<br>1 = End of sequence (Stop the sequencer after this step).        |
|                                       | 3:0 | WSEQ_DELAY0 [3:0] | 0000    | Time delay after executing this step. Total time per step (including execution) = $k \times (2^{WSEQ\_DELAY} + 8)$ .<br>$k = 62.5\mu s$ (SAMPLE_RATE_INT_MODE = 1),<br>$k = 68.1\mu s$ (SAMPLE_RATE_INT_MODE = 0), |

**Table 125 Write Sequencer Control - Programming a Sequence**

Note that a 'Dummy' write can be inserted into a control sequence by commanding the sequencer to write a value of 0 to bit 0 of Register R254 (00FEh). This is effectively a write to a non-existent register location. This can be used in order to create placeholders ready for easy adaptation of a control sequence. For example, a sequence could be defined to power-up a mono signal path from DACL to headphone, with a 'dummy' write included to leave space for easy modification to a stereo signal path configuration. Dummy writes can also be used in order to implement additional time delays between register writes.

In summary, the Control Register to be written is set by the WSEQ\_ADDR $n$  field. The data bits that are written are determined by a combination of WSEQ\_DATA\_START $n$ , WSEQ\_DATA\_WIDTH $n$  and WSEQ\_DATA $n$ . This is illustrated below for an example case of writing to the DAC\_DEEMP field within Register R5 (0005h).

In this example, the Start Position is bit 01 (WSEQ\_DATA\_START $n$  = 0001b) and the Data width is 2 bits (WSEQ\_DATA\_WIDTH $n$  = 0001b). With these settings, the Control Write Sequencer would update the Control Register R5 [2:1] with the contents of WSEQ\_DATA $n$  [1:0].


**Figure 73 Control Write Sequencer Example**

## DEFAULT SEQUENCES

When the WM8962B is powered up, a number of Control Write Sequences are available through default settings in the sequencer memory locations. The pre-programmed default settings include Start-Up and Shut-Down sequences for each of the output drivers. Note that the default sequences do not include audio signal path or gain setting configuration; this must be implemented prior to scheduling any of the default Start-Up sequences.

The entire sequencer memory may be programmed to users' own settings at any time, as described in "Programming a Sequence". Users' own settings remain in memory regardless of WSEQ\_ENA, and are not affected by software resets (i.e. writing to Register R15). However, any non-default sequences are lost when the device is powered down.

The following default control sequences are provided:

1. DAC to Headphone Power Up - This sequence powers up the HPOUT headphone driver and charge pump. It commands the DC Servo to perform offset correction. It enables the master bias required for analogue functions. This sequence is intended for enabling the headphone output after initial power-on.
2. Analogue Input Power Up - This sequence powers up the analogue input (IN1L and IN1R) signal paths to the ADC output. The MICBIAS is enabled for powering electret condenser microphones connected to IN1L and IN1R. The DC Servo performs offset correction on the input signal paths. The intended usage of this sequence assumes that the "DAC to Headphone 1 Power Up" sequence has been run previously.
3. Chip Power Down - This sequence shuts down all of the WM8962B input paths, output drivers, DC Servo, charge pump and analogue bias circuits.
4. Speaker Sleep - This sequence mutes the DAC output and Class D speaker output, and disabled the Class D output driver. This is intended for use as a power saving feature during quiescent DAC conditions. When the WSEQ\_AUTOSEQ\_ENA register bit is set, this sequence is automatically triggered whenever quiescent DAC playback conditions are detected.
5. Speaker Wake - This sequence enables the Class D speaker driver output and un-mutes the DAC output and Class D speaker path. When the WSEQ\_AUTOSEQ\_ENA register bit is set, this sequence is automatically triggered whenever a non-zero DAC sample is detected following an AUTOMUTE event.

Specific details of each of these sequences is provided below.

**DAC to Headphone Power Up**

The DAC to Headphone Power Up sequence is initiated by writing 0080h to Register 90 (5Ah). This single operation starts the Control Write Sequencer at Index Address 0 (00h).

This sequence takes up to 93ms to run.

| WSEQ INDEX | REGISTER ADDRESS | WIDTH  | START | DATA | DELAY | EOS | DESCRIPTION                                                                                                       |
|------------|------------------|--------|-------|------|-------|-----|-------------------------------------------------------------------------------------------------------------------|
| 0 (00h)    | R28 (1Ch)        | 2 bits | Bit 3 | 03h  | 0h    | 0b  | STARTUP_BIAS_ENA = 1b<br>VMID_BUF_ENA = 1b                                                                        |
| 1 (01h)    | R25 (19h)        | 3 bits | Bit 6 | 07h  | 0h    | 0b  | VMID_SEL [1:0] = 11b<br>BIAS_ENA = 1b                                                                             |
| 2 (02h)    | R72 (48h)        | 1 bit  | Bit 0 | 01b  | 6h    | 0b  | CP_ENA = 1b<br>(time delay inserted)                                                                              |
| 3 (03h)    | R26 (1Ah)        | 4 bits | Bit 5 | 0Fh  | 0h    | 0b  | DACL_ENA = 1b<br>DACR_ENA = 1b<br>HPOUTL_PGA_ENA = 1b<br>HPOUTR_PGA_ENA = 1b                                      |
| 4 (04h)    | R69 (45h)        | 5 bits | Bit 0 | 11h  | 0h    | 0b  | HP1L_ENA = 1b<br>HP1R_ENA = 1b                                                                                    |
| 5 (05h)    | R69 (45h)        | 5 bits | Bit 1 | 19h  | 0h    | 0b  | HP1L_ENA_DLY = 1b<br>HP1R_ENA_DLY = 1b                                                                            |
| 6 (06h)    | R2 (2h)          | 7 bits | Bit 0 | 30h  | 0h    | 0b  | HPOUTL_VOL [6:0] = 30h                                                                                            |
| 7 (07h)    | R3 (3h)          | 7 bits | Bit 0 | 30h  | 0h    | 0b  | HPOUTR_VOL [6:0] = 30h                                                                                            |
| 8 (08h)    | R3 (3h)          | 1 bit  | Bit 8 | 01h  | 0h    | 0b  | HPOUT_VU = 1b                                                                                                     |
| 9 (09h)    | R61 (3Dh)        | 6 bits | Bit 2 | 33h  | Ah    | 0b  | HP1L_DCS_ENA = 1b<br>HP1L_DCS_STARTUP = 1b<br>HP1R_DCS_ENA = 1b<br>HP1R_DCS_STARTUP = 1b<br>(time delay inserted) |
| 10 (0Ah)   | R254 (FEh)       | 1 bit  | Bit 0 | 00h  | 0h    | 0b  | Dummy Write for expansion                                                                                         |
| 11 (0Bh)   | R7 (7h)          | 2 bits | Bit 2 | 00h  | 0h    | 0b  | WL [1:0] = 00                                                                                                     |
| 12 (0Ch)   | R69 (45h)        | 5 bits | Bit 2 | 1Dh  | 0h    | 0b  | HP1L_ENA_OUTP = 1<br>HP1R_ENA_OUTP = 1                                                                            |
| 13 (0Dh)   | R69 (45h)        | 5 bits | Bit 3 | 1Fh  | 0h    | 0b  | HP1L_RMV_SHORT = 1<br>HP1R_RMV_SHORT = 1                                                                          |
| 14 (0Eh)   | R254 (FEh)       | 1 bit  | Bit 0 | 00h  | 0h    | 0b  | Dummy Write for expansion                                                                                         |
| 15 (0Fh)   | R5 (5h)          | 1 bit  | Bit 3 | 00h  | 7h    | 1b  | DAC_MUTE = 0<br>(time delay inserted)                                                                             |

**Table 126 DAC to Headphone 1 Power Up Sequence**

**Analogue Input Power Up**

The Analogue Input Power Up sequence is initiated by writing 0092h to Register 90 (5Ah). This single operation starts the Control Write Sequencer at Index Address 18 (12h).

This sequence takes up to 75ms to run.

| WSEQ INDEX | REGISTER ADDRESS | WIDTH  | START | DATA | DELAY | EOS | DESCRIPTION                                   |
|------------|------------------|--------|-------|------|-------|-----|-----------------------------------------------|
| 18 (12h)   | R32 (20h)        | 3 bits | Bit 3 | 07h  | 0h    | 0b  | INPGAL_MIXINL_VOL [2:0] = 111b                |
| 19 (13h)   | R33 (21h)        | 3 bits | Bit 3 | 07h  | 0h    | 0b  | INPGAR_MIXINR_VOL [2:0] = 111b                |
| 20 (14h)   | R25 (19h)        | 5 bits | Bit 1 | 19h  | 0h    | 0b  | INL_ENA = 1<br>INR_ENA = 1<br>MICBIAS_ENA = 1 |

| WSEQ INDEX | REGISTER ADDRESS | WIDTH  | START | DATA | DELAY | EOS | DESCRIPTION                                                                                               |
|------------|------------------|--------|-------|------|-------|-----|-----------------------------------------------------------------------------------------------------------|
| 21 (15h)   | R60 (3Ch)        | 6 bits | Bit 2 | 33h  | Ah    | 0b  | INL_DCS_ENA = 1<br>INL_DCS_STARTUP = 1<br>INR_DCS_ENA = 1<br>INR_DCS_STARTUP = 1<br>(time delay inserted) |
| 22 (16h)   | R254 (FEh)       | 1 bit  | Bit 0 | 00h  | 0h    | 0b  | Dummy Write for expansion                                                                                 |
| 23 (17h)   | R25 (19h)        | 2 bits | Bit 2 | 03h  | 0h    | 0b  | ADCL_ENA = 1<br>ADCR_ENA = 1                                                                              |
| 24 (18h)   | R32 (20h)        | 3 bits | Bit 3 | 00h  | 0h    | 0b  | INPGAL_MIXINL_VOL [2:0] = 000                                                                             |
| 25 (19h)   | R33 (21h)        | 3 bits | Bit 3 | 00h  | 0h    | 1b  | INPGAR_MIXINR_VOL [2:0] = 000                                                                             |

**Table 127 Analogue Input Power Up Sequence**
**Chip Power Down**

The Chip Power Down sequence is initiated by writing 009Bh to Register 90 (5Ah). This single operation starts the Control Write Sequencer at Index Address 27 (1Bh).

This sequence takes up to 32ms to run.

| WSEQ INDEX | REGISTER ADDRESS | WIDTH  | START | DATA | DELAY | EOS | DESCRIPTION                                                                                                          |
|------------|------------------|--------|-------|------|-------|-----|----------------------------------------------------------------------------------------------------------------------|
| 27 (1Bh)   | R5 (5h)          | 1 bit  | Bit 3 | 01h  | 8h    | 0b  | DAC_MUTE = 1b<br>(time delay inserted)                                                                               |
| 28 (1Ch)   | R0 (0h)          | 1 bit  | Bit 7 | 01h  | 0h    | 0b  | INPGAL_MUTE = 1b                                                                                                     |
| 29 (1Dh)   | R1 (1h)          | 2 bits | Bit 7 | 03h  | 0h    | 0b  | INVU = 1b<br>INPGAR_MUTE = 1b                                                                                        |
| 30 (1Eh)   | R69 (45h)        | 5 bits | Bit 3 | 0Eh  | 0h    | 0b  | HP1L_RMV_SHORT = 0b<br>HP1R_RMV_SHORT = 0b                                                                           |
| 31 (1Fh)   | R96 (60h)        | 5 bits | Bit 3 | 0Eh  | 0h    | 0b  |                                                                                                                      |
| 32 (20h)   | R2 (2h)          | 7 bits | Bit 0 | 00h  | 0h    | 0b  | HPOUTL_VOL [6:0] = 00h                                                                                               |
| 33 (21h)   | R3 (3h)          | 7 bits | Bit 0 | 00h  | 0h    | 0b  | HPOUTR_VOL [6:0] = 00h                                                                                               |
| 34 (22h)   | R3 (3h)          | 1 bit  | Bit 8 | 01h  | 0h    | 0b  | HPOUTVU = 1b                                                                                                         |
| 35 (23h)   | R40 (28h)        | 7 bits | Bit 0 | 00h  | 0h    | 0b  | SPKOUTL_VOL [6:0] = 00h                                                                                              |
| 36 (24h)   | R41 (29h)        | 7 bits | Bit 0 | 00h  | 0h    | 0b  | SPKOUTR_VOL [6:0] = 00h                                                                                              |
| 37 (25h)   | R41 (29)         | 1 bit  | Bit 8 | 01h  | 0h    | 0b  | SPKOUT_VU = 1b                                                                                                       |
| 38 (26h)   | R60 (3Ch)        | 5 bits | Bit 3 | 00h  | 0h    | 0b  | INL_DCS_ENA = 0b<br>INR_DCS_ENA = 0b                                                                                 |
| 39 (27h)   | R61 (3Dh)        | 5 bits | Bit 3 | 00h  | 0h    | 0b  | HP1L_DCS_ENA = 0b<br>HP1R_DCS_ENA = 0b                                                                               |
| 40 (28h)   | R62 (3Eh)        | 5 bits | Bit 3 | 00h  | 0h    | 0b  |                                                                                                                      |
| 41 (29h)   | R69 (45h)        | 8 bits | Bit 0 | 00h  | 0h    | 0b  | HP1L_ENA_OUTP = 0b<br>HP1L_ENA_DLY = 0b<br>HP1L_ENA = 0b<br>HP1R_ENA_OUTP = 0b<br>HP1R_ENA_DLY = 0b<br>HP1R_ENA = 0b |
| 42 (2Ah)   | R96 (60h)        | 8 bits | Bit 0 | 00h  | 0h    | 0b  |                                                                                                                      |
| 43 (2Bh)   | R49 (31h)        | 2 bits | Bit 6 | 00h  | 0h    | 0b  | SPKOUTR_ENA = 0b<br>SPKOUTL_ENA = 0b                                                                                 |
| 44 (2Ch)   | R99 (63h)        | 4 bits | Bit 0 | 00h  | 0h    | 0b  | HPMIXL_ENA = 0b<br>HPMIXR_ENA = 0b<br>SPKMIXL_ENA = 0b<br>SPKMIXR_ENA = 0b                                           |



| WSEQ INDEX | REGISTER ADDRESS | WIDTH  | START | DATA | DELAY | EOS | DESCRIPTION                                                                                                                  |
|------------|------------------|--------|-------|------|-------|-----|------------------------------------------------------------------------------------------------------------------------------|
| 45 (2Dh)   | R26 (1Ah)        | 6 bits | Bit 3 | 00h  | 0h    | 0b  | DACL_ENA = 0b<br>DACR_ENA = 0b<br>HPOUTL_PGA_ENA = 0b<br>HPOUTR_PGA_ENA = 0b<br>SPKOUTL_PGA_ENA = 0b<br>SPKOUTR_PGA_ENA = 0b |
| 46 (2Eh)   | R72 (48h)        | 1 bit  | Bit 0 | 00h  | 0h    | 0b  | CP_ENA = 0b                                                                                                                  |
| 47 (2Fh)   | R25 (19h)        | 6 bits | Bit 1 | 00h  | 0h    | 0b  | BIAS_ENA = 0b<br>INL_ENA = 0b<br>INR_ENA = 0b<br>ADCL_ENA = 0b<br>ADCR_ENA = 0b<br>MICBIAS_ENA = 0b                          |
| 48 (30h)   | R28 (1Ch)        | 2 bits | Bit 3 | 00h  | 0h    | 0b  | STARTUP_BIAS_ENA = 0b<br>VMID_BUF_ENA = 0b                                                                                   |
| 49 (31h)   | R25 (19h)        | 2 bits | Bit 7 | 00h  | 0h    | 1b  | VMID_SEL [1:0] = 00b                                                                                                         |

**Table 128 Chip Power Down Sequence**
**Speaker Sleep**

The Speaker Sleep sequence is initiated by writing 00E4h to Register 90 (5Ah). This single operation starts the Control Write Sequencer at Index Address 100 (64h).

This sequence takes up to 2ms to run.

| WSEQ INDEX | REGISTER ADDRESS | WIDTH  | START | DATA | DELAY | EOS | DESCRIPTION                                                   |
|------------|------------------|--------|-------|------|-------|-----|---------------------------------------------------------------|
| 100 (64h)  | R49 (31h)        | 1 bit  | Bit 4 | 01h  | 0h    | 0b  | DAC_MUTE = 1                                                  |
| 101 (65h)  | R49 (31h)        | 3 bits | Bit 0 | 07h  | 0h    | 0b  | SPKOUT_VU = 1<br>SPKOUTL_PGA_MUTE = 1<br>SPKOUTR_PGA_MUTE = 1 |
| 102 (66h)  | R49 (31h)        | 2 bits | Bit 6 | 00h  | 0h    | 1b  | SPKOUTR_ENA = 0<br>SPKOUTL_ENA = 0                            |

**Table 129 Speaker Sleep Sequence**
**Speaker Wake**

The Speaker Wake sequence is initiated by writing 00E8h to Register 90 (5Ah). This single operation starts the Control Write Sequencer at Index Address 104 (68h).

This sequence takes up to 2ms to run.

| WSEQ INDEX | REGISTER ADDRESS | WIDTH  | START | DATA | DELAY | EOS | DESCRIPTION                                                   |
|------------|------------------|--------|-------|------|-------|-----|---------------------------------------------------------------|
| 104 (68h)  | R49 (31h)        | 2 bits | Bit 6 | 03h  | 0h    | 0b  | SPKOUTR_ENA = 1<br>SPKOUTL_ENA = 1                            |
| 105 (69h)  | R49 (31h)        | 3 bits | Bit 0 | 04h  | 0h    | 0b  | SPKOUT_VU = 1<br>SPKOUTL_PGA_MUTE = 0<br>SPKOUTR_PGA_MUTE = 0 |
| 106 (6Ah)  | R49 (31h)        | 1 bit  | Bit 4 | 00h  | 0h    | 1b  | DAC_MUTE = 0                                                  |

**Table 130 Speaker Wake Sequence**

**THERMAL SHUTDOWN**

The WM8962B incorporates a temperature sensor on each of the headphone circuit and the speaker circuit. These detect when the device temperature is within normal limits, or the device is approaching a hazardous temperature condition (above 125°C and below 145°C), or if the device has exceeded a hazardous temperature condition (>145°C). The temperature sensors can be configured to automatically disable the audio outputs of the WM8962B in response to an over-temperature condition (approximately 145°C) on either the headphone or the speaker circuits.

The temperature status can be output directly on a GPIO pin, as described in the “General Purpose Input/Output (GPIO)” section. The temperature sensor can also be used to generate Interrupt events, as described in the “Interrupts” section.

The temperature sensors are enabled on the headphone and the speaker circuits by setting the TEMP\_ENA\_HP and the TEMP\_ENA\_SPK register bits respectively.

Temperature warnings are flagged at 125°C by asserting the TEMP\_WARN\_HP (headphones) and TEMP\_WARN\_SPK (speakers) register bits. Potentially hazardous over-temperature conditions are flagged by the setting of the TEMP\_ERR\_HP (headphones) and TEMP\_ERR\_SPK (speakers) registers.

When the THERR\_ACT register is also set, then a device over-temperature condition in either sensor (TEMP\_ERR\_HP or TEMP\_ERR\_SPK asserted) will cause the speaker outputs (SPKOUTL and SPKOUTR) to be disabled by setting SPKL\_ENA and SPKR\_ENA to 0, and the headphone outputs to be disabled by setting CP\_ENA to 0. This response is likely to prevent any damage to the device attributable to the large currents of the output drivers. Note that headphone and speaker audio outputs are both disabled when either of the TEMP\_ERR\_HP or TEMP\_ERR\_SPK register bits is set.

When the audio circuits are disabled by THERR\_ACT after reaching a temperature of 145°C, they will be reset to their previous setting once the temperature drops again.

| REGISTER ADDRESS                     | BIT | LABEL            | DEFAULT | DESCRIPTION                                                                                                                                                                            |
|--------------------------------------|-----|------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R23 (17h)<br>Additional control(1)   | 8   | THERR_ACT [15:0] | 1       | Speaker and Headphone over-temperature shutdown enable.<br>0 = Disabled<br>1 = Enabled<br>Note that TEMP_ENA_HP or TEMP_ENA_SPK or both must be enabled for Automatic Shutdown to work |
| R47 (2Fh)<br>Thermal Shutdown Status | 3   | TEMP_ERR_HP      | 0       | Headphone temperature error status (triggered at 145°C)<br>0 = Not triggered<br>1 = Triggered<br>Note that this is a Read Only field                                                   |
|                                      | 2   | TEMP_WARN_HP     | 0       | Headphone temperature warning status (triggered at 125°C)<br>0 = Not triggered<br>1 = Triggered<br>Note that this is a Read Only field                                                 |
|                                      | 1   | TEMP_ERR_SPK     | 0       | Speaker temperature error status (triggered at 145°C)<br>0 = Not triggered<br>1 = Triggered<br>Note that this is a Read Only field                                                     |
|                                      | 0   | TEMP_WARN_SPK    | 0       | Speaker temperature warning status (triggered at 125°C)<br>0 = Not triggered<br>1 = Triggered<br>Note that this is a Read Only field                                                   |
| R48 (30h)                            | 2   | TEMP_ENA_HP      | 1       | Headphone temperature sensor enable<br>0 = Disabled<br>1 = Enabled                                                                                                                     |

| REGISTER ADDRESS | BIT | LABEL            | DEFAULT | DESCRIPTION                                                      |
|------------------|-----|------------------|---------|------------------------------------------------------------------|
|                  | 1   | TEMP_ENA_S<br>PK | 1       | Speaker temperature sensor enable<br>0 = Disabled<br>1 = Enabled |

**Table 131 Temperature Sensor Control**

## SOFTWARE RESET AND CHIP ID

A Software Reset can be commanded by writing to Register R15. This is a read-only register field and the contents will not be affected by writing to this Register. Note that the PLL Registers (R114 through to R152) are not affected by this Software Reset; these registers can be reset separately.

A PLL Software Reset can be commanded by writing to Register R127. This is a read-only register field and the contents will not be affected by writing to this Register. The PLL Software Reset causes the contents of the PLL Registers (R114 through to R152) to be reset to their default states.

The Customer ID and Chip Revision ID can be read back from Register R1 (01h), as described in Table 132.

| REGISTER ADDRESS                    | BIT   | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                      |
|-------------------------------------|-------|----------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R1 (01h)<br>Right Input<br>volume   | 15:12 | CUST_ID [3:0]        | 0000b   | Reading from this register will indicate the Customer ID.                                                                                                                                                        |
|                                     | 11:9  | CHIP_REV [2:0]       |         | Reading from this register will indicate the Chip Revision ID.<br>000 = Rev A<br>001 = Rev B<br>010 = Rev C<br>011 = Rev D                                                                                       |
| R15 (0Fh)<br>Software<br>Reset      | 15:0  | SW_RESET [15:0]      | 6243h   | Writing to this register resets all non-PLL registers to their default state. Registers R114 (72h) through to R152 (98h) are not affected by this Reset. Reading from this register will indicate Chip ID 6243h. |
| R127 (7Fh)<br>PLL Software<br>Reset | 15:0  | SW_RESET_ PLL [15:0] |         | Writing to this register resets all PLL registers to their default state. This affects registers R114 (72h) through to R152 (98h).                                                                               |

**Table 132 Software Reset and Chip ID**

**REGISTER MAP**

The WM8962B control registers are listed below. Note that only the register addresses described here should be accessed; writing to other addresses may result in undefined behaviour. Register bits that are not documented should not be changed from the default values.

| REG       | NAME                  | 15                  | 14              | 13                   | 12                   | 11               | 10                   | 9                          | 8                        | 7              | 6                        | 5             | 4                    | 3            | 2               | 1            | 0           | DEFAULT |
|-----------|-----------------------|---------------------|-----------------|----------------------|----------------------|------------------|----------------------|----------------------------|--------------------------|----------------|--------------------------|---------------|----------------------|--------------|-----------------|--------------|-------------|---------|
| R0 (0h)   | Left Input volume     | 0                   | 0               | 0                    | 0                    | 0                | 0                    | 0                          | IN_VU                    | INPGA_L_MUTE   | INL_ZC                   | INL_VOL [5:0] |                      |              |                 |              | 009Fh       |         |
| R1 (1h)   | Right Input volume    | CUST_ID [3:0]       |                 |                      | CHIP_REV [2:0]       |                  |                      | IN_VU                      | INPGA_R_MUTE             | INR_ZC         | INR_VOL [5:0]            |               |                      |              |                 | 069Fh        |             |         |
| R2 (2h)   | HPOUTL volume         | 0                   | 0               | 0                    | 0                    | 0                | 0                    | 0                          | HPOUT_VU                 | HPOUT_L_ZC     | HPOUTL_VOL [6:0]         |               |                      |              |                 | 0000h        |             |         |
| R3 (3h)   | HPOUTR volume         | 0                   | 0               | 0                    | 0                    | 0                | 0                    | 0                          | HPOUT_VU                 | HPOUT_R_ZC     | HPOUTR_VOL [6:0]         |               |                      |              |                 | 0000h        |             |         |
| R4 (4h)   | Clocking1             | 0                   | 0               | 0                    | 0                    | 0                | DSPCLK_DIV [1:0] (K) |                            | ADCSYS_CLK_DIV [2:0] (K) |                | DACSYS_CLK_DIV [2:0] (K) |               | SYSCLK_DIV [1:0] (K) |              | 0               | 0020h        |             |         |
| R5 (5h)   | ADC & DAC Control 1   | 0                   | 0               | 0                    | 0                    | 0                | 0                    | 0                          | 0                        | 0              | ADCR_DAT_I NV            | ADCL_DAT_I NV | DAC_MUTE_R AMP       | DAC_MUTE     | DAC_DEEMP [1:0] |              | ADC_HPF_DIS | 0018h   |
| R6 (6h)   | ADC & DAC Control 2   | 0                   | 0               | ADC_HPF_SR [1:0] (K) |                      | 0                | ADC_HPF_MODE         | ADC_HPF_CUT [2:0]          |                          | DACR_DAT_I NV  | DACL_DAT_I NV            | 0             | DAC_UNMUTE_RAM P     | DAC_MUTE     | 0               | DAC_HP       | 2008h       |         |
| R7 (7h)   | Audio Interface 0     | 0                   | 0               | 0                    | AIFDACC_TDM_MOD E    | AIFDACC_TDM_SLOT | AIFDACC_TDM_MOD E    | AIFDACC_TDM_SLOT           | ADC_LRSWA P              | BCLK_I NV      | MSTR                     | DAC_LRSWA P   | LRCLK_INV            | WL [1:0]     |                 | FMT [1:0]    |             | 000Ah   |
| R8 (8h)   | Clocking2             | 0                   | 0               | 0                    | 0                    | CLKREG_OVD       | MCLK_SRC [1:0]       |                            | CLASSD_CLK_DIV [2:0] (K) |                | SYSCLK_ENA               | 0             | BCLK_DIV [3:0]       |              |                 | 01E4h        |             |         |
| R9 (9h)   | Audio Interface 1     | 0                   | 0               | 0                    | 0                    | AUTOMUTE_STS     | 0                    | DAC_AUTOMUTE_SAMPLES [1:0] |                          | DAC_AUTOMUTE   | 0                        | 0             | DAC_COMP             | DAC_COMP ODE | ADC_COMP        | ADC_COMP ODE | LOOPBACK    | 0300h   |
| R10 (Ah)  | Left DAC volume       | 0                   | 0               | 0                    | 0                    | 0                | 0                    | 0                          | DAC_VU                   | DACL_VOL [7:0] |                          |               |                      |              |                 |              | 00C0h       |         |
| R11 (Bh)  | Right DAC volume      | 0                   | 0               | 0                    | 0                    | 0                | 0                    | 0                          | DAC_VU                   | DACR_VOL [7:0] |                          |               |                      |              |                 |              | 00C0h       |         |
| R14 (Eh)  | Audio Interface 2     | 0                   | 0               | 0                    | 0                    | 0                | AIF_RATE [10:0]      |                            |                          |                |                          |               |                      |              |                 |              | 0040h       |         |
| R15 (Fh)  | Software Reset        | SW_RESET [15:0]     |                 |                      |                      |                  |                      |                            |                          |                |                          |               |                      |              |                 |              |             | 0000h   |
| R17 (11h) | ALC1                  | 0                   | 0               | 0                    | 0                    | 0                | ALC_INACTIV E_ENA    | ALC_LVL_M ODE              | ALC_L_ENA                | ALC_R_ENA      | ALC_MAXGAIN [2:0]        |               | ALC_LVL [3:0]        |              |                 | 007Bh        |             |         |
| R18 (12h) | ALC2                  | ALC_LOCK_S TS       | ALC_THRESH _STS | ALC_SAT_ST S         | ALC_PKOVR_ STS       | ALC_NGATE_ STS   | 0                    | 0                          | 0                        | ALC_ZC         | ALC_MINGAIN [2:0]        |               | ALC_HLD [3:0]        |              |                 | 0000h        |             |         |
| R19 (13h) | ALC3                  | 0                   | 0               | 0                    | ALC_NGATE_GAIN [2:0] |                  |                      | 0                          | ALC_M ODE                | ALC_DCY [3:0]  |                          | ALC_ATK [3:0] |                      |              | 1C32h           |              |             |         |
| R20 (14h) | Noise Gate            | ALC_NGATE_DCY [3:0] |                 |                      | ALC_NGATE_ATK [3:0]  |                  |                      | ALC_NGATE_THR [4:0]        |                          |                | ALC_NGATE_M ODE [1:0]    |               | ALC_NGATE_ ENA       | 3200h        |                 |              |             |         |
| R21 (15h) | Left ADC volume       | 0                   | 0               | 0                    | 0                    | 0                | 0                    | 0                          | ADC_VU                   | ADCL_VOL [7:0] |                          |               |                      |              |                 |              | 00C0h       |         |
| R22 (16h) | Right ADC volume      | 0                   | 0               | 0                    | 0                    | 0                | 0                    | 0                          | ADC_VU                   | ADCR_VOL [7:0] |                          |               |                      |              |                 |              | 00C0h       |         |
| R23 (17h) | Additional control(1) | 0                   | 0               | 0                    | 0                    | 0                | 0                    | 0                          | THERR_ACT                | 0              | 0                        | ADC_HP        | 0                    | 0            | 0               | 0            | TOCLK_ENA   | 0100h   |

| REG       | NAME                     | 15              | 14               | 13 | 12              | 11                 | 10       | 9               | 8                     | 7                   | 6                       | 5                | 4                     | 3                | 2                 | 1                 | 0                 | DEFAULT |
|-----------|--------------------------|-----------------|------------------|----|-----------------|--------------------|----------|-----------------|-----------------------|---------------------|-------------------------|------------------|-----------------------|------------------|-------------------|-------------------|-------------------|---------|
| R24 (18h) | Additional control(2)    | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | 0                       | 0                | 0                     | AIF_TR1          | 0                 | 0                 | 0                 | 0000h   |
| R25 (19h) | Pwr Mgmt (1)             | 0               | 0                | 0  | 0               | 0                  | DMIC_ENA | OPCLK_ENA       | VMID_SEL [1:0]        |                     | BIAS_ENA                | INL_ENA          | INR_ENA               | ADCL_ENA         | ADCR_ENA          | MICBIAS_ENA       | 0                 | 0000h   |
| R26 (1Ah) | Pwr Mgmt (2)             | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | DACL_ENA              | DACR_ENA            | HPOUTL_PGA_ENA          | HPOUTR_PGA_ENA   | SPKOUTL_PG_A_ENA      | SPKOUTR_PG_A_ENA | 0                 | HPOUTL_PGA_MUTE   | HPOUTR_PGA_MUTE   | 0000h   |
| R27 (1Bh) | Additional Control (3)   | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | 0                       | 0                | SAMPLE_RATE_INT_MODE  | 0                | SAMPLE_RATE [2:0] |                   | 0010h             |         |
| R28 (1Ch) | Anti-pop                 | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | 0                       | 0                | STARTUP_BIAS_ENA      | VMID_BUF_ENA     | VMID_RAMP         | 0                 | 0                 | 0000h   |
| R29 (1Dh) | Pwr Mgmt (3)             | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | 0                       | 0                | 0                     | 0                | 0                 | MICBIAS_EVR [1:0] |                   | 0000h   |
| R30 (1Eh) | Clocking 3               | DBCLK_DIV [2:0] |                  |    | OPCLK_DIV [2:0] |                    |          | TOCLK_DIV [2:0] |                       |                     | F256KCLK_DIV [5:0] (K)  |                  |                       |                  |                   | 0                 | 005Eh             |         |
| R31 (1Fh) | Input mixer control (1)  | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | 0                       | 0                | 0                     | MIXINL_MUTE      | MIXINR_MUTE       | MIXINL_ENA        | MIXINR_ENA        | 0000h   |
| R32 (20h) | Left input mixer volume  | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | IN2L_MIXINL_VOL [2:0] |                     | INPGAL_MIXINL_VOL [2:0] |                  | IN3L_MIXINL_VOL [2:0] |                  |                   |                   | 0145h             |         |
| R33 (21h) | Right input mixer volume | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | IN2R_MIXINR_VOL [2:0] |                     | INPGAR_MIXINR_VOL [2:0] |                  | IN3R_MIXINR_VOL [2:0] |                  |                   |                   | 0145h             |         |
| R34 (22h) | Input mixer control (2)  | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | 0                       | IN2L_TO_MIXINL   | IN3L_TO_MIXINL        | INPGA_TO_MIXINL  | IN2R_TO_MIXINR    | IN3R_TO_MIXINR    | INPGA_TO_MIXINR   | 0009h   |
| R35 (23h) | Input bias control       | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | 0                       | MIXIN_BIAS [2:0] |                       |                  | INPGA_BIAS [2:0]  |                   |                   | 0004h   |
| R37 (25h) | Left input PGA control   | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | 0                       | INPGA_L_ENA      | IN1L_TO_INPGAL        | IN2L_TO_INPGAL   | IN3L_TO_INPGAL    | IN4L_TO_INPGAL    | 0008h             |         |
| R38 (26h) | Right input PGA control  | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | 0                       | INPGA_R_ENA      | IN1R_TO_INPGAR        | IN2R_TO_INPGAR   | IN3R_TO_INPGAR    | IN4R_TO_INPGAR    | 0008h             |         |
| R40 (28h) | SPKOUTL volume           | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | SPKOUTL_VU            | SPKOUTL_ZC          | SPKOUTL_VOL [6:0]       |                  |                       |                  |                   |                   | 0000h             |         |
| R41 (29h) | SPKOUTR volume           | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | SPKOUTR_VU            | SPKOUTR_ZC          | SPKOUTR_VOL [6:0]       |                  |                       |                  |                   |                   | 0000h             |         |
| R47 (2Fh) | Thermal Shutdown Status  | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | 0                       | 0                | TEMP_ERR_HP           | TEMP_WARN_HP     | TEMP_ERR_SPK      | TEMP_WARN_SPK     | 0000h             |         |
| R48 (30h) | Additional Control (4)   | 1               | MICDET_THR [2:0] |    |                 | MICSHORT_THR [1:0] |          | MICDET_ENA      | 0                     | MICDET_STS          | MICSHORT_STS            | 1                | 0                     | 0                | TEMP_ENA_HP       | TEMP_ENA_SPK      | MICBIAS_LVL       | 8027h   |
| R49 (31h) | Class D Control 1        | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | SPKOUTR_ENA         | SPKOUTL_ENA             | 0                | DAC_MUTE              | 0                | SPKOUTL_VU        | SPKOUTL_PG_A_MUTE | SPKOUTR_PG_A_MUTE | 0010h   |
| R51 (33h) | Class D Control 2        | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | 0                   | SPK_MONO                | 0                | 0                     | 0                | CLASSD_VOL [2:0]  |                   |                   | 0003h   |
| R56 (38h) | Clocking 4               | 0               | 0                | 0  | 0               | 0                  | 1        | 0               | 1                     | 0                   | 0                       | 0                | MCLK_RATE [3:0]       |                  |                   |                   | 0                 | 0506h   |
| R57 (39h) | DAC DSP Mixing (1)       | 0               | 0                | 0  | 0               | 0                  | 0        | DAC_MONOMIX     | 0                     | ADCR_DAC_SVOL [3:0] |                         |                  | ADC_TO_DACR [1:0]     |                  | 0                 | 0                 | 0000h             |         |
| R58 (3Ah) | DAC DSP Mixing (2)       | 0               | 0                | 0  | 0               | 0                  | 0        | 0               | 0                     | ADCL_DAC_SVOL [3:0] |                         |                  | ADC_TO_DACL [1:0]     |                  | 0                 | 0                 | 0000h             |         |

| REG        | NAME                      | 15 | 14 | 13                       | 12 | 11 | 10                               | 9                                | 8                                     | 7                                     | 6                             | 5                      | 4                      | 3                        | 2                            | 1                      | 0                      | DEFAULT |       |
|------------|---------------------------|----|----|--------------------------|----|----|----------------------------------|----------------------------------|---------------------------------------|---------------------------------------|-------------------------------|------------------------|------------------------|--------------------------|------------------------------|------------------------|------------------------|---------|-------|
| R60 (3Ch)  | DC Servo 0                | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | INL_D<br>CS_EN<br>A                   | INL_D<br>CS_ST<br>ARTUP       | 0                      | 0                      | INR_D<br>CS_EN<br>A      | INR_D<br>CS_ST<br>ARTUP      | 0                      | 0                      | 0000h   |       |
| R61 (3Dh)  | DC Servo 1                | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | HP1L_<br>DCS_E<br>NA                  | HP1L_<br>DCS_S<br>TARTU<br>P  | 0                      | HP1L_<br>DCS_S<br>YNC  | HP1R_<br>DCS_E<br>NA     | HP1R_<br>DCS_S<br>TARTU<br>P | 0                      | HP1R_<br>DCS_S<br>YNC  | 0000h   |       |
| R64 (40h)  | DC Servo 4                | 0  | 0  | HP1_DCS_SYNC_STEPS [6:0] |    |    |                                  |                                  |                                       |                                       | 0                             | 0                      | 1                      | 0                        | 0                            | 0                      | 0                      | 0       | 0810h |
| R66 (42h)  | DC Servo 6                | 0  | 0  | 0                        | 0  | 0  | DCS_S<br>TARTU<br>P_DON<br>E_INL | DCS_S<br>TARTU<br>P_DON<br>E_INR | DCS_S<br>TARTU<br>P_DON<br>E_HP1<br>L | DCS_S<br>TARTU<br>P_DON<br>E_HP1<br>R | 0                             | 0                      | 0                      | 0                        | 0                            | 0                      | 0                      | 0       | 0000h |
| R68 (44h)  | Analogue PGA Bias         | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | 0                                     | 0                             | 0                      | 1                      | 1                        | HP_PGAS_BIAS [2:0]           |                        | 001Bh                  |         |       |
| R69 (45h)  | Analogue HP 0             | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | HP1L_<br>RMV_S<br>HORT                | HP1L_<br>ENA_O<br>UTP         | HP1L_<br>ENA_D<br>LY   | HP1L_<br>ENA           | HP1R_<br>RMV_S<br>HORT   | HP1R_<br>ENA_O<br>UTP        | HP1R_<br>ENA_D<br>LY   | HP1R_<br>ENA           | 0000h   |       |
| R71 (47h)  | Analogue HP 2             | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | HP1L_VOL [2:0]                        |                                       | HP1R_VOL [2:0]                |                        | HP_BIAS_BOOST [2:0]    |                          | 0                            | 0                      | 0                      | 01FBh   |       |
| R72 (48h)  | Charge Pump 1             | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | 0                                     | 0                             | 0                      | 0                      | 0                        | 0                            | 0                      | CP_EN<br>A             | 0000h   |       |
| R82 (52h)  | Charge Pump B             | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | 0                                     | 0                             | 0                      | 0                      | 1                        | 0                            | 0                      | CP_DY<br>N_PW<br>R     | 0004h   |       |
| R87 (57h)  | Write Sequencer Control 1 | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | WSEQ<br>_AUTO<br>SEQ_E<br>NA          | 0                             | WSEQ<br>_ENA           | 0                      | 0                        | 0                            | 0                      | 0                      | 0000h   |       |
| R90 (5Ah)  | Write Sequencer Control 2 | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | WSEQ<br>_ABOR<br>T                    | WSEQ<br>_STAR<br>T                    | WSEQ_START_INDEX [6:0]        |                        |                        |                          |                              |                        | 0000h                  |         |       |
| R93 (5Dh)  | Write Sequencer Control 3 | 0  | 0  | 0                        | 0  | 0  | 0                                | WSEQ_CURRENT_INDEX [6:0]         |                                       |                                       |                               |                        |                        | 0                        | 0                            | 0                      | WSEQ<br>_BUSY          | 0000h   |       |
| R94 (5Eh)  | Control Interface         | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | SPI_C<br>ONTR<br>D                    | SPI_4<br>WIRE                 | SPI_CF<br>G            | 0                      | 0                        | 0                            | 0                      | 0                      | 0000h   |       |
| R99 (63h)  | Mixer Enables             | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | 0                                     | 0                             | 0                      | HPMIX<br>L_ENA         | HPMIX<br>R_ENA           | SPKMI<br>XL_EN<br>A          | SPKMI<br>XR_EN<br>A    | 0000h                  |         |       |
| R100 (64h) | Headphone Mixer (1)       | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | HPMIX<br>L_TO_<br>HPOUT<br>L_PGA      | 0                             | DACL_<br>TO_HP<br>MIXL | DACR_<br>TO_HP<br>MIXL | MIXINL<br>_TO_H<br>PMIXL | MIXINR<br>_TO_H<br>PMIXL     | IN4L_T<br>O_HP<br>MIXL | IN4R_T<br>O_HP<br>MIXL | 0000h   |       |
| R101 (65h) | Headphone Mixer (2)       | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | 0                                     | HPMIX<br>R_TO_<br>HPOUT<br>R_PGA      | 0                             | DACL_<br>TO_HP<br>MIXR | DACR_<br>TO_HP<br>MIXR | MIXINL<br>_TO_H<br>PMIXR | MIXINR<br>_TO_H<br>PMIXR     | IN4L_T<br>O_HP<br>MIXR | IN4R_T<br>O_HP<br>MIXR | 0000h   |       |
| R102 (66h) | Headphone Mixer (3)       | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | HPMIX<br>L_MUT<br>E                   | MIXINL<br>_HPMI<br>XL_VO<br>L         | MIXINR<br>_HPMI<br>XL_VO<br>L | IN4L_HPMIXL_VOL [2:0]  |                        | IN4R_HPMIXL_VOL [2:0]    |                              | 013Fh                  |                        |         |       |
| R103 (67h) | Headphone Mixer (4)       | 0  | 0  | 0                        | 0  | 0  | 0                                | 0                                | HPMIX<br>R_MUT<br>E                   | MIXINL<br>_HPMI<br>XR_VO<br>L         | MIXINR<br>_HPMI<br>XR_VO<br>L | IN4L_HPMIXR_VOL [2:0]  |                        | IN4R_HPMIXR_VOL [2:0]    |                              | 013Fh                  |                        |         |       |

| REG        | NAME                | 15                  | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7                        | 6                   | 5                      | 4                      | 3                 | 2                      | 1               | 0               | DEFAULT |
|------------|---------------------|---------------------|----|----|----|----|----|---|---|--------------------------|---------------------|------------------------|------------------------|-------------------|------------------------|-----------------|-----------------|---------|
| R105 (69h) | Speaker Mixer (1)   | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | SPKMI_XL_TO_SPKO_UTL_PGA | 0                   | DAACL_TO_SPKMIXL       | DACR_TO_SPKMIXL        | MIXINL_TO_SPKMIXL | MIXINR_TO_SPKMIXL      | IN4L_TO_SPKMIXL | IN4R_TO_SPKMIXL | 0000h   |
| R106 (6Ah) | Speaker Mixer (2)   | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | SPKMI_XR_TO_SPKOUTR_PGA  | 0                   | DAACL_TO_SPKMIXR       | DACR_TO_SPKMIXR        | MIXINL_TO_SPKMIXR | MIXINR_TO_SPKMIXR      | IN4L_TO_SPKMIXR | IN4R_TO_SPKMIXR | 0000h   |
| R107 (6Bh) | Speaker Mixer (3)   | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | SPKMI_XL_MUTE            | MIXINL_SPKMI_XL_VOL | MIXINR_SPKMI_XL_VOL    | IN4L_SPKMIXL_VOL [2:0] |                   | IN4R_SPKMIXL_VOL [2:0] |                 | 013Fh           |         |
| R108 (6Ch) | Speaker Mixer (4)   | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | SPKMI_XR_MUTE            | MIXINL_SPKMI_XR_VOL | MIXINR_SPKMI_XR_VOL    | IN4L_SPKMIXR_VOL [2:0] |                   | IN4R_SPKMIXR_VOL [2:0] |                 | 013Fh           |         |
| R109 (6Dh) | Speaker Mixer (5)   | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | DAACL_SPKMI_XL_VOL       | DACR_SPKMI_XR_VOL   | DAACL_SPKMI_XR_VOL     | DACR_SPKMI_XR_VOL      | 0                 | 0                      | 1               | 1               | 0003h   |
| R110 (6Eh) | Beep Generator (1)  | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | BEEP_GAIN [3:0]          |                     |                        | 0                      | BEEP_RATE [1:0]   |                        | BEEP_ENA        | 0002h           |         |
| R115 (73h) | Oscillator Trim (3) | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0                        | 0                   | 0                      | OSC_TRIM_XTI [4:0] (K) |                   |                        |                 | 0000h           |         |
| R116 (74h) | Oscillator Trim (4) | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0                        | 1                   | OSC_TRIM_XTO [4:0] (K) |                        |                   |                        | 0020h           |                 |         |
| R119 (77h) | Oscillator Trim (7) | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | XTO_CAP_SEL [3:0]        |                     |                        | XTI_CAP_SEL [3:0]      |                   |                        | 0000h           |                 |         |
| R124 (7Ch) | Analogue Clocking1  | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0                        | CLKOUT2_SEL [1:0]   | CLKOUT3_SEL [1:0]      | 0                      | 0                 | CLKOUT5_SEL            | 0011h           |                 |         |
| R125 (7Dh) | Analogue Clocking2  | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | PLL2_OUTDIV              | PLL3_OUTDIV         | 0                      | PLL_SYSCLK_DIV [1:0]   | CLKOUT3_DIV       | CLKOUT2_DIV            | CLKOUT5_DIV     | 004Bh           |         |
| R126 (7Eh) | Analogue Clocking3  | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0                        | 0                   | 1                      | CLKOUT2_OE             | CLKOUT3_OE        | 1                      | CLKOUT5_OE      | 001Fh           |         |
| R127 (7Fh) | PLL Software Reset  | SW_RESET_PLL [15:0] |    |    |    |    |    |   |   |                          |                     |                        |                        |                   |                        |                 |                 | 0000h   |
| R129 (81h) | PLL2                | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | OSC_ENA                  | 0                   | PLL2_ENA               | PLL3_ENA               | 0                 | 0                      | 0               | 1               | 0001h   |
| R131 (83h) | PLL 4               | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0                        | 0                   | 0                      | 1                      | 0                 | 0                      | PLL_CLK_SRC     | FLL_T_OPLL3     | 0010h   |
| R136 (88h) | PLL 9               | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0                        | PLL2_FRAC           | 1                      | PLL2_N [4:0]           |                   |                        |                 | 0067h           |         |
| R137 (89h) | PLL 10              | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | PLL2_K [7:0]             |                     |                        |                        |                   |                        |                 | 001Ch           |         |
| R138 (8Ah) | PLL 11              | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | PLL2_K [7:0]             |                     |                        |                        |                   |                        |                 | 0071h           |         |
| R139 (8Bh) | PLL 12              | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | PLL2_K [7:0]             |                     |                        |                        |                   |                        |                 | 00C7h           |         |
| R140 (8Ch) | PLL 13              | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | 0                        | PLL3_FRAC           | 1                      | PLL3_N [4:0]           |                   |                        |                 | 0067h           |         |
| R141 (8Dh) | PLL 14              | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | PLL3_K [7:0]             |                     |                        |                        |                   |                        |                 | 0048h           |         |
| R142 (8Eh) | PLL 15              | 0                   | 0  | 0  | 0  | 0  | 0  | 0 | 0 | PLL3_K [7:0]             |                     |                        |                        |                   |                        |                 | 0022h           |         |

| REG         | NAME               | 15                       | 14                    | 13 | 12 | 11                  | 10                   | 9           | 8                | 7                     | 6                    | 5                 | 4               | 3              | 2                    | 1                      | 0           | DEFAULT |       |
|-------------|--------------------|--------------------------|-----------------------|----|----|---------------------|----------------------|-------------|------------------|-----------------------|----------------------|-------------------|-----------------|----------------|----------------------|------------------------|-------------|---------|-------|
| R143 (8Fh)  | PLL 16             | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | 0                | PLL3_K [7:0]          |                      |                   |                 |                |                      |                        | 0097h       |         |       |
| R150 (96h)  | PLL DLL            | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | 0                | 0                     | 0                    | 0                 | 0               | 0              | 0                    | SEQ_ENA                | 1           | 0003h   |       |
| R152 (98h)  | Analogue Control 4 | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | 0                | 1                     | 1                    | 0                 | OSC_MCLK_SRC    | 0              | 0                    | 0                      | 0           | 00C0h   |       |
| R155 (9Bh)  | FLL Control (1)    | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | 0                | 0                     | FLL_REFCLK_SRC [1:0] |                   | 0               | 1              | FLL_F RAC            | FLL_O SC_ENA           | FLL_E NA    | 000Ch   |       |
| R156 (9Ch)  | FLL Control (2)    | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | FLL_OUTDIV [5:0] |                       |                      |                   |                 | 0              | FLL_REFCLK_DIV [1:0] |                        | 0039h       |         |       |
| R157 (9Dh)  | FLL Control (3)    | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | 1                | 1                     | 0                    | 0                 | 0               | 0              | FLL_FRATIO [2:0]     |                        |             | 0180h   |       |
| R159 (9Fh)  | FLL Control (5)    | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | 0                | FLL_FRC_NCO_VAL [5:0] |                      |                   |                 |                |                      | FLL_F RC_NCO           | 0032h       |         |       |
| R160 (A0h)  | FLL Control (6)    | FLL_THETA [15:0]         |                       |    |    |                     |                      |             |                  |                       |                      |                   |                 |                |                      |                        |             | 0018h   |       |
| R161 (A1h)  | FLL Control (7)    | FLL_LAMBDA [15:0]        |                       |    |    |                     |                      |             |                  |                       |                      |                   |                 |                |                      |                        |             | 007Dh   |       |
| R162 (A2h)  | FLL Control (8)    | 0                        | 0                     | 0  | 0  | 0                   | 0                    | FLL_N [9:0] |                  |                       |                      |                   |                 |                |                      |                        | 0008h       |         |       |
| R252 (FCh)  | General test 1     | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | 0                | 0                     | 0                    | 0                 | 0               | 0              | 1                    | 0                      | AUTO_INC    | 0005h   |       |
| R256 (100h) | DF1                | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | 0                | 0                     | 0                    | 0                 | 0               | 0              | DF1_S HARED_COEF F   | DF1_S HARED_COEF F_SEL | DF1_E NA    | 0000h   |       |
| R257 (101h) | DF2                | DF1_COEFF_L0 [15:0]      |                       |    |    |                     |                      |             |                  |                       |                      |                   |                 |                |                      |                        |             | 0000h   |       |
| R258 (102h) | DF3                | DF1_COEFF_L1 [15:0]      |                       |    |    |                     |                      |             |                  |                       |                      |                   |                 |                |                      |                        |             | 0000h   |       |
| R259 (103h) | DF4                | DF1_COEFF_L2 [15:0]      |                       |    |    |                     |                      |             |                  |                       |                      |                   |                 |                |                      |                        |             | 0000h   |       |
| R260 (104h) | DF5                | DF1_COEFF_R0 [15:0]      |                       |    |    |                     |                      |             |                  |                       |                      |                   |                 |                |                      |                        |             | 0000h   |       |
| R261 (105h) | DF6                | DF1_COEFF_R1 [15:0]      |                       |    |    |                     |                      |             |                  |                       |                      |                   |                 |                |                      |                        |             | 0000h   |       |
| R262 (106h) | DF7                | DF1_COEFF_R2 [15:0]      |                       |    |    |                     |                      |             |                  |                       |                      |                   |                 |                |                      |                        |             | 0000h   |       |
| R264 (108h) | LHPF1              | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | 0                | 0                     | 0                    | 0                 | 0               | 0              | LHPF_MODE            | LHPF_ENA               | 0000h       |         |       |
| R265 (109h) | LHPF2              | LHPF_COEFF [15:0]        |                       |    |    |                     |                      |             |                  |                       |                      |                   |                 |                |                      |                        |             | 0000h   |       |
| R268 (10Ch) | THREED1            | 0                        | 0                     | 0  | 0  | 0                   | 0                    | 0           | 0                | 0                     | ADC_M ONOMI X        | THREE D_SIG N_L   | THREE D_SIG N_R | 0              | THREE D_LHP F_MODE   | THREE D_LHP F_ENA      | THREE D_ENA | 0000h   |       |
| R269 (10Dh) | THREED2            | THREED_FGAINL [4:0]      |                       |    |    | THREED_CGAINL [4:0] |                      |             |                  | THREED_DELAYL [3:0]   |                      |                   | 0               | 0              |                      |                        |             | 0000h   |       |
| R270 (10Eh) | THREED3            | THREED_LHPF_COEFF [15:0] |                       |    |    |                     |                      |             |                  |                       |                      |                   |                 |                |                      |                        |             | 0000h   |       |
| R271 (10Fh) | THREED4            | THREED_FGAINR [4:0]      |                       |    |    | THREED_CGAINR [4:0] |                      |             |                  | THREED_DELAYR [3:0]   |                      |                   | 0               | 0              |                      |                        |             | 0000h   |       |
| R276 (114h) | DRC 1              | 0                        | DRC_SIG_DET_RMS [4:0] |    |    |                     | DRC_SIG_DET_PK [1:0] |             | DRC_N G_ENA      | DRC_S IG_DE T_MOD E   | DRC_S IG_DE T        | DRC_K NEE2_OP_ENA | DRC_Q R         | DRC_A NTCI LIP | DRC_MODE             | DRC_ENA                |             |         | 000Ch |



| REG            | NAME      | 15                   | 14 | 13 | 12               | 11                | 10                 | 9             | 8                | 7                 | 6                  | 5 | 4                 | 3 | 2               | 1                   | 0        | DEFAULT |
|----------------|-----------|----------------------|----|----|------------------|-------------------|--------------------|---------------|------------------|-------------------|--------------------|---|-------------------|---|-----------------|---------------------|----------|---------|
| R277<br>(115h) | DRC 2     | 0                    | 0  | 0  | DRC_ATK [3:0]    |                   |                    | DRC_DCY [3:0] |                  |                   | DRC_MINGAIN [2:0]  |   | DRC_MAXGAIN [1:0] |   |                 |                     | 0925h    |         |
| R278<br>(116h) | DRC 3     | DRC_NG_MINGAIN [3:0] |    |    | DRC_QR_THR [1:0] |                   | DRC_QR_DCY [1:0]   |               | DRC_NG_EXP [1:0] |                   | DRC_HI_COMP [2:0]  |   | DRC_LO_COMP [2:0] |   |                 |                     | 0000h    |         |
| R279<br>(117h) | DRC 4     | 0                    | 0  | 0  | 0                | 0                 | DRC_KNEE_IP [5:0]  |               |                  |                   | DRC_KNEE_OP [4:0]  |   |                   |   | 0000h           |                     |          |         |
| R280<br>(118h) | DRC 5     | 0                    | 0  | 0  | 0                | 0                 | DRC_KNEE2_IP [4:0] |               |                  |                   | DRC_KNEE2_OP [4:0] |   |                   |   | 0000h           |                     |          |         |
| R285<br>(11Dh) | Tloopback | 0                    | 0  | 0  | 0                | 0                 | 0                  | 0             | 0                | 0                 | 0                  | 0 | 0                 | 0 | 0               | TLB_ENA             | TLB_MODE | 0000h   |
| R335<br>(14Fh) | EQ1       | 0                    | 0  | 0  | 0                | 0                 | 0                  | 0             | 0                | 0                 | 0                  | 0 | 0                 | 0 | EQ_SHARED_COEFF | EQ_SHARED_COEFF_SEL | EQ_ENA   | 0004h   |
| R336<br>(150h) | EQ2       | EQL_B1_GAIN [4:0]    |    |    |                  | EQL_B2_GAIN [4:0] |                    |               |                  | EQL_B3_GAIN [4:0] |                    |   |                   | 0 |                 | 6318h               |          |         |
| R337<br>(151h) | EQ3       | EQL_B4_GAIN [4:0]    |    |    |                  | EQL_B5_GAIN [4:0] |                    |               |                  | 0                 | 0                  | 0 | 0                 | 0 | 0               | 0                   | 0        | 6300h   |
| R338<br>(152h) | EQ4       | EQL_B1_A [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 0FCAh   |
| R339<br>(153h) | EQ5       | EQL_B1_B [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 0400h   |
| R340<br>(154h) | EQ6       | EQL_B1_PG [15:0]     |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 00D8h   |
| R341<br>(155h) | EQ7       | EQL_B2_A [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 1EB5h   |
| R342<br>(156h) | EQ8       | EQL_B2_B [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | F145h   |
| R343<br>(157h) | EQ9       | EQL_B2_C [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 0B75h   |
| R344<br>(158h) | EQ10      | EQL_B2_PG [15:0]     |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 01C5h   |
| R345<br>(159h) | EQ11      | EQL_B3_A [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 1C58h   |
| R346<br>(15Ah) | EQ12      | EQL_B3_B [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | F373h   |
| R347<br>(15Bh) | EQ13      | EQL_B3_C [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 0A54h   |
| R348<br>(15Ch) | EQ14      | EQL_B3_PG [15:0]     |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 0558h   |
| R349<br>(15Dh) | EQ15      | EQL_B4_A [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 168Eh   |
| R350<br>(15Eh) | EQ16      | EQL_B4_B [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | F829h   |
| R351<br>(15Fh) | EQ17      | EQL_B4_C [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 07ADh   |
| R352<br>(160h) | EQ18      | EQL_B4_PG [15:0]     |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 1103h   |
| R353<br>(161h) | EQ19      | EQL_B5_A [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 0564h   |
| R354<br>(162h) | EQ20      | EQL_B5_B [15:0]      |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 0559h   |
| R355<br>(163h) | EQ21      | EQL_B5_PG [15:0]     |    |    |                  |                   |                    |               |                  |                   |                    |   |                   |   |                 |                     |          | 4000h   |
| R356<br>(164h) | EQ22      | EQR_B1_GAIN [4:0]    |    |    |                  | EQR_B2_GAIN [4:0] |                    |               |                  | EQR_B3_GAIN [4:0] |                    |   |                   | 0 |                 | 6318h               |          |         |

| REG            | NAME                       | 15                     | 14                   | 13                            | 12                           | 11                             | 10                      | 9                             | 8                             | 7                             | 6                              | 5                        | 4               | 3                             | 2                             | 1 | 0                             | DEFAULT |
|----------------|----------------------------|------------------------|----------------------|-------------------------------|------------------------------|--------------------------------|-------------------------|-------------------------------|-------------------------------|-------------------------------|--------------------------------|--------------------------|-----------------|-------------------------------|-------------------------------|---|-------------------------------|---------|
| R357<br>(165h) | EQ23                       | EQR_B4_GAIN [4:0]      |                      |                               |                              |                                | EQR_B5_GAIN [4:0]       |                               |                               |                               |                                | 0                        | 0               | 0                             | 0                             | 0 | 0                             | 6300h   |
| R358<br>(166h) | EQ24                       | EQR_B1_A [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 0FCAh   |
| R359<br>(167h) | EQ25                       | EQR_B1_B [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 0400h   |
| R360<br>(168h) | EQ26                       | EQR_B1_PG [15:0]       |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 00D8h   |
| R361<br>(169h) | EQ27                       | EQR_B2_A [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 1EB5h   |
| R362<br>(16Ah) | EQ28                       | EQR_B2_B [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | F145h   |
| R363<br>(16Bh) | EQ29                       | EQR_B2_C [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 0B75h   |
| R364<br>(16Ch) | EQ30                       | EQR_B2_PG [15:0]       |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 01C5h   |
| R365<br>(16Dh) | EQ31                       | EQR_B3_A [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 1C58h   |
| R366<br>(16Eh) | EQ32                       | EQR_B3_B [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | F373h   |
| R367<br>(16Fh) | EQ33                       | EQR_B3_C [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 0A54h   |
| R368<br>(170h) | EQ34                       | EQR_B3_PG [15:0]       |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 0558h   |
| R369<br>(171h) | EQ35                       | EQR_B4_A [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 168Eh   |
| R370<br>(172h) | EQ36                       | EQR_B4_B [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | F829h   |
| R371<br>(173h) | EQ37                       | EQR_B4_C [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 07ADh   |
| R372<br>(174h) | EQ38                       | EQR_B4_PG [15:0]       |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 1103h   |
| R373<br>(175h) | EQ39                       | EQR_B5_A [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 0564h   |
| R374<br>(176h) | EQ40                       | EQR_B5_B [15:0]        |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 0559h   |
| R375<br>(177h) | EQ41                       | EQR_B5_PG [15:0]       |                      |                               |                              |                                |                         |                               |                               |                               |                                |                          |                 |                               |                               |   |                               | 4000h   |
| R513<br>(201h) | GPIO 2                     | 0                      | 0                    | 0                             | 0                            | 0                              | GP2_P<br>OL             | 0                             | 0                             | 0                             | GP2_L<br>VL                    | 0                        | GP2_FN [4:0]    |                               |                               |   | 0000h                         |         |
| R514<br>(202h) | GPIO 3                     | 0                      | 0                    | 0                             | 0                            | 0                              | GP3_P<br>OL             | 0                             | 0                             | 0                             | GP3_L<br>VL                    | 0                        | GP3_FN [4:0]    |                               |                               |   | 0000h                         |         |
| R516<br>(204h) | GPIO 5                     | GP5_D<br>IR            | GP5_P<br>U           | GP5_P<br>D                    | 0                            | 0                              | GP5_P<br>OL             | GP5_O<br>P_CFG                | GP5_D<br>B                    | 0                             | GP5_L<br>VL                    | 0                        | GP5_FN [4:0]    |                               |                               |   | 8100h                         |         |
| R517<br>(205h) | GPIO 6                     | GP6_D<br>IR            | GP6_P<br>U           | GP6_P<br>D                    | 0                            | 0                              | GP6_P<br>OL             | GP6_O<br>P_CFG                | GP6_D<br>B                    | 0                             | GP6_L<br>VL                    | 0                        | GP6_FN [4:0]    |                               |                               |   | 8100h                         |         |
| R560<br>(230h) | Interrupt Status<br>1      | 0                      | 0                    | 0                             | 0                            | 0                              | 0                       | 0                             | 0                             | 0                             | 0                              | GP6_EI<br>NT             | GP5_EI<br>NT    | 0                             | 0                             | 0 | 0                             | 0000h   |
| R561<br>(231h) | Interrupt Status<br>2      | MICSC<br>D_EIN<br>T    | MICD_<br>EINT        | FIFOS_<br>ERR_E<br>INT        | ALC_L<br>OCK_E<br>INT        | ALC_T<br>HRESH<br>_EINT        | ALC_S<br>AT_EIN<br>T    | ALC_P<br>KOV<br>R_EINT        | ALC_N<br>GATE_<br>EINT        | WSEQ_<br>DONE<br>_EINT        | DRC_A<br>CTDET<br>_EINT        | FLL_L<br>OCK_E<br>INT    | 0               | PLL3_L<br>OCK_E<br>INT        | PLL2_L<br>OCK_E<br>INT        | 0 | TEMP_<br>SHUT_<br>EINT        | 0000h   |
| R568<br>(238h) | Interrupt Status<br>1 Mask | 0                      | 0                    | 0                             | 0                            | 0                              | 0                       | 0                             | 0                             | 0                             | 0                              | IM_GP<br>6_EINT          | IM_GP<br>5_EINT | 0                             | 0                             | 0 | 0                             | 0030h   |
| R569<br>(239h) | Interrupt Status<br>2 Mask | IM_MIC<br>SCD_E<br>INT | IM_MIC<br>D_EIN<br>T | IM_FIF<br>OS_ER<br>R_EIN<br>T | IM_AL<br>C_LOC<br>K_EIN<br>T | IM_AL<br>C_THR<br>ESH_E<br>INT | IM_AL<br>C_SAT<br>_EINT | IM_AL<br>C_PKO<br>VR_EI<br>NT | IM_AL<br>C_NGA<br>TE_EIN<br>T | IM_WS<br>EQ_DO<br>NE_EI<br>NT | IM_DR<br>C_ACT<br>DET_EI<br>NT | IM_FLL<br>_LOCK<br>_EINT | 1               | IM_PLL<br>3_LOC<br>K_EIN<br>T | IM_PLL<br>2_LOC<br>K_EIN<br>T | 1 | IM_TE<br>MP_SH<br>UT_EI<br>NT | FFFFh   |

| REG               | NAME                             | 15                                                                                          | 14                   | 13                  | 12 | 11 | 10                           | 9 | 8                   | 7                              | 6                                  | 5                   | 4                   | 3                        | 2                    | 1             | 0                    | DEFAULT     |       |
|-------------------|----------------------------------|---------------------------------------------------------------------------------------------|----------------------|---------------------|----|----|------------------------------|---|---------------------|--------------------------------|------------------------------------|---------------------|---------------------|--------------------------|----------------------|---------------|----------------------|-------------|-------|
| R576<br>(240h)    | Interrupt Control                | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | 0                   | 0                              | 0                                  | 0                   | 0                   | 0                        | 0                    | 0             | 0                    | IRQ_P<br>OL | 0000h |
| R584<br>(248h)    | IRQ Debounce                     | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | 0                   | 0                              | 0                                  | FLL_L<br>OCK_D<br>B | 1                   | PLL3_L<br>OCK_D<br>B     | PLL2_L<br>OCK_D<br>B | 1             | TEMP_<br>SHUT_<br>DB | 003Fh       |       |
| R586<br>(24Ah)    | MICINT Source<br>Pol             | MICSC<br>D_IRQ<br>_POL                                                                      | MICD_I<br>RQ_PO<br>L | 0                   | 0  | 0  | 0                            | 0 | 0                   | 0                              | 0                                  | 0                   | 0                   | 0                        | 0                    | 0             | 0                    | 0000h       |       |
| R768<br>(300h)    | DSP2 Power<br>Management         | 0                                                                                           | 0                    | 0                   | 1  | 1  | 1                            | 0 | 0                   | 0                              | 0                                  | 0                   | 0                   | 0                        | 0                    | 0             | DSP2_<br>ENA         | 1C00h       |       |
| R1037<br>(40Dh)   | DSP2_ExecCon<br>trol             | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | 0                   | 0                              | 0                                  | DSP2_<br>STOPC      | DSP2_<br>STOPS      | DSP2_<br>STOPI           | DSP2_<br>STOP        | DSP2_<br>RUNR | DSP2_<br>RUN         | 0000h       |       |
| R4096<br>(1000h)  | Write<br>Sequencer 0             | 0                                                                                           | 0                    | WSEQ_ADDR0 [13:0]   |    |    |                              |   |                     |                                |                                    |                     |                     |                          |                      |               | 001Ch                |             |       |
| R4097<br>(1001h)  | Write<br>Sequencer 1             | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | 0                   | WSEQ_DATA0 [7:0]               |                                    |                     |                     |                          |                      |               |                      | 0003h       |       |
| R4098<br>(1002h)  | Write<br>Sequencer 2             | 0                                                                                           | 0                    | 0                   | 0  | 0  | WSEQ_DATA_WIDTH0<br>[2:0]    |   |                     | 0                              | 0                                  | 0                   | 0                   | WSEQ_DATA_START0 [3:0]   |                      |               | 0103h                |             |       |
| R4099<br>(1003h)  | Write<br>Sequencer 3             | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | WSEQ<br>_EOS0       | 0                              | 0                                  | 0                   | 0                   | WSEQ_DELAY0 [3:0]        |                      |               | 0000h                |             |       |
| R4100<br>(1004h)  | Write<br>Sequencer 4             | 0                                                                                           | 0                    | WSEQ_ADDR1 [13:0]   |    |    |                              |   |                     |                                |                                    |                     |                     |                          |                      |               | 0019h                |             |       |
| R4101<br>(1005h)  | Write<br>Sequencer 5             | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | 0                   | WSEQ_DATA1 [7:0]               |                                    |                     |                     |                          |                      |               |                      | 0007h       |       |
| R4102<br>(1006h)  | Write<br>Sequencer 6             | 0                                                                                           | 0                    | 0                   | 0  | 0  | WSEQ_DATA_WIDTH1<br>[2:0]    |   |                     | 0                              | 0                                  | 0                   | 0                   | WSEQ_DATA_START1 [3:0]   |                      |               | 0206h                |             |       |
| R4103<br>(1007h)  | Write<br>Sequencer 7             | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | WSEQ<br>_EOS1       | 0                              | 0                                  | 0                   | 0                   | WSEQ_DELAY1 [3:0]        |                      |               | 0000h                |             |       |
| R4104<br>(1008h)  | Write<br>Sequencer 8             |                                                                                             |                      |                     |    |    |                              |   |                     |                                |                                    |                     |                     |                          |                      |               |                      |             |       |
| R4603<br>(11FBh)  | Write<br>Sequencer 507           | Register Addresses R4104 (1008h) to contain R4603 (11FBh) Write Sequencer Control Registers |                      |                     |    |    |                              |   |                     |                                |                                    |                     |                     |                          |                      |               |                      |             |       |
| R4604<br>(11FCh)  | Write<br>Sequencer 508           | 0                                                                                           | 0                    | WSEQ_ADDR127 [13:0] |    |    |                              |   |                     |                                |                                    |                     |                     |                          |                      |               | 0000h                |             |       |
| R4605<br>(11FDh)  | Write<br>Sequencer 509           | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | 0                   | WSEQ_DATA127 [7:0]             |                                    |                     |                     |                          |                      |               |                      | 0000h       |       |
| R4606<br>(11FEh)  | Write<br>Sequencer 510           | 0                                                                                           | 0                    | 0                   | 0  | 0  | WSEQ_DATA_WIDTH12<br>7 [2:0] |   |                     | 0                              | 0                                  | 0                   | 0                   | WSEQ_DATA_START127 [3:0] |                      |               | 0000h                |             |       |
| R4607<br>(11FFh)  | Write<br>Sequencer 511           | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | WSEQ<br>_EOS1<br>27 | 0                              | 0                                  | 0                   | 0                   | WSEQ_DELAY127 [3:0]      |                      |               | 0000h                |             |       |
| R16384<br>(4000h) | RETUNEADC_<br>SHARED_COE<br>FF_1 | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | 0                   | ADC_R<br>ETUNE<br>_SCV         | RETUNEADC_SHARED_COEFF_22_16 [6:0] |                     |                     |                          |                      |               | 0000h                |             |       |
| R16385<br>(4001h) | RETUNEADC_<br>SHARED_COE<br>FF_0 | RETUNEADC_SHARED_COEFF_15_00 [15:0]                                                         |                      |                     |    |    |                              |   |                     |                                |                                    |                     |                     |                          | 0000h                |               |                      |             |       |
| R16386<br>(4002h) | RETUNEDAC_<br>SHARED_COE<br>FF_1 | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | 0                   | ADC_R<br>ETUNE<br>_SCV         | RETUNEDAC_SHARED_COEFF_23_16 [6:0] |                     |                     |                          |                      |               | 0000h                |             |       |
| R16387<br>(4003h) | RETUNEDAC_<br>SHARED_COE<br>FF_0 | RETUNEDAC_SHARED_COEFF_15_00 [15:0]                                                         |                      |                     |    |    |                              |   |                     |                                |                                    |                     |                     |                          | 0000h                |               |                      |             |       |
| R16388<br>(4004h) | SOUNDSTAGE<br>_ENABLES_1         | 0                                                                                           | 0                    | 0                   | 0  | 0  | 0                            | 0 | 0                   | SOUNDSTAGE_ENABLES_23_16 [7:0] |                                    |                     |                     |                          |                      |               |                      | 0000h       |       |
| R16389<br>(4005h) | SOUNDSTAGE<br>_ENABLES_0         | SOUNDSTAGE_ENABLES_15_06 [9:0]                                                              |                      |                     |    |    |                              |   |                     |                                |                                    | RTN_A<br>DC_EN<br>A | RTN_D<br>AC_EN<br>A | HDBAS<br>S_ENA           | HPF2_<br>ENA         | HPF1_<br>ENA  | VSS_E<br>NA          | 0000h       |       |

| REG               | NAME                  | 15                                                                                                 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7 | 6 | 5 | 4 | 3 | 2 | 1 | 0 | DEFAULT |
|-------------------|-----------------------|----------------------------------------------------------------------------------------------------|----|----|----|----|----|---|---|---|---|---|---|---|---|---|---|---------|
| R16896<br>(4200h) | HDBASS_AI_1           |                                                                                                    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | 0002h   |
| R16925<br>(421Dh) | HDBASS_PG_0           | Register Addresses R16896 (4200h) to R16925 (421Dh) contain HD Bass Control Registers              |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | 999Ah   |
| R17408<br>(4400h) | HPF_C_1               |                                                                                                    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | 0083h   |
| R17409<br>(4401h) | HPF_C_0               | Register Addresses R17408 (4400h) to R17409 (4401h) contain DAC High Pass Filter Control Registers |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | 98ADh   |
| R17920<br>(4600h) | ADCL_RETUNE<br>_C1_1  |                                                                                                    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | 007Fh   |
| R19007<br>(4A3Fh) | ADCR_RETUN<br>E_C32_0 | Register Addresses R17920 (4600h) to R19007 (4A3Fh) contain ADC ReTune Control Registers           |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | 0000h   |
| R19456<br>(4C00h) | DACL_RETUNE<br>_C1_1  |                                                                                                    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | 007Fh   |
| R20543<br>(503Fh) | DACR_RETUN<br>E_C32_0 | Register Addresses R19456 (4C00h) to R20543 (503Fh) contain DAC ReTune Control Registers           |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | 0000h   |
| R20992<br>(5200h) | VSS_XHD2_1            |                                                                                                    |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | 008Ch   |
| R21139<br>(5293h) | VSS_XTS32_0           | Register Addresses R20992 (5200h) to R21139 (5293h) contain VSS Control Registers                  |    |    |    |    |    |   |   |   |   |   |   |   |   |   |   | 8580h   |

**REGISTER BITS BY ADDRESS**

| REGISTER ADDRESS           | BIT | LABEL         | DEFAULT | DESCRIPTION                                                                                                                                  |
|----------------------------|-----|---------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------|
| R0 (00h) Left Input volume | 8   | IN_VU         | 0       | Input PGA Volume and Mute Update<br>Writing a 1 to this bit will cause the INL and INR volume and mute settings to be updated simultaneously |
|                            | 7   | INPGAL_MUTE   | 1       | Left input PGA Mute<br>0 = Unmuted<br>1 = Muted                                                                                              |
|                            | 6   | INL_ZC        | 0       | INL PGA Zero Cross Detector<br>0 = Change gain immediately<br>1 = Change gain on zero cross only                                             |
|                            | 5:0 | INL_VOL [5:0] | 01_1111 | Left input PGA Volume<br>-23.25dB to +24.00dB in 0.75dB steps.                                                                               |

**Register 00h** Left Input volume

| REGISTER ADDRESS            | BIT   | LABEL          | DEFAULT | DESCRIPTION                                                                                                                                  |
|-----------------------------|-------|----------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------|
| R1 (01h) Right Input volume | 15:12 | CUST_ID [3:0]  | 0000    | Reading from this register will indicate the Customer ID.                                                                                    |
|                             | 11:9  | CHIP_REV [2:0] | 011     | Reading from this register will indicate the Chip Revision ID.<br>000 = Rev A<br>001 = Rev B<br>010 = Rev C<br>011 = Rev D                   |
|                             | 8     | IN_VU          | 0       | Input PGA Volume and Mute Update<br>Writing a 1 to this bit will cause the INL and INR volume and mute settings to be updated simultaneously |
|                             | 7     | INPGAR_MUTE    | 1       | Right input PGA Mute<br>0 = Unmuted<br>1 = Muted                                                                                             |
|                             | 6     | INR_ZC         | 0       | INR PGA Zero Cross Detector<br>0 = Change gain immediately<br>1 = Change gain on zero cross only                                             |
|                             | 5:0   | INR_VOL [5:0]  | 01_1111 | Right input PGA Volume<br>-23.25dB to +24.00dB in 0.75dB steps.                                                                              |

**Register 01h** Right Input volume

| REGISTER ADDRESS       | BIT | LABEL            | DEFAULT  | DESCRIPTION                                                                                                                                                                        |
|------------------------|-----|------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R2 (02h) HPOUTL volume | 8   | HPOUT_VU         | 0        | Headphone Output PGA Volume and Mute Update.<br>Writing 1 to this bit will cause the HPOUTL and HPOUTR volume and mute settings to be updated simultaneously.                      |
|                        | 7   | HPOUTL_ZC        | 0        | HPOUTL_VOL (Left Headphone Output PGA) Zero Cross Enable<br>0 = Zero cross disabled<br>1 = Zero cross enabled                                                                      |
|                        | 6:0 | HPOUTL_VOL [6:0] | 000_0000 | Left Headphone Output PGA Volume<br>000_0000 to 010_1111 = Mute<br>011_0000 to 011_0101 = -68dB<br>011_0110 = -67dB<br>...in 1dB steps<br>111_1001 = 0dB<br>...<br>111_1111 = +6dB |

**Register 02h** HPOUTL volume

| REGISTER ADDRESS          | BIT | LABEL            | DEFAULT  | DESCRIPTION                                                                                                                                                                         |
|---------------------------|-----|------------------|----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R3 (03h)<br>HPOUTR volume | 8   | HPOUT_VU         | 0        | Headphone Output PGA Volume and Mute Update. Writing 1 to this bit will cause the HPOUTL and HPOUTR volume and mute settings to be updated simultaneously.                          |
|                           | 7   | HPOUTR_ZC        | 0        | HPOUTR_VOL (Right Headphone Output PGA) Zero Cross Enable<br>0 = Zero cross disabled<br>1 = Zero cross enabled                                                                      |
|                           | 6:0 | HPOUTR_VOL [6:0] | 000_0000 | Right Headphone Output PGA Volume<br>000_0000 to 010_1111 = Mute<br>011_0000 to 011_0101 = -68dB<br>011_0110 = -67dB<br>...in 1dB steps<br>111_1001 = 0dB<br>...<br>111_1111 = +6dB |

**Register 03h** HPOUTR volume

| REGISTER ADDRESS      | BIT  | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                             |
|-----------------------|------|----------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R4 (04h)<br>Clocking1 | 10:9 | DSPCLK_DIV [1:0]     | 00      | DSP Clock Divider<br>00 = MCLK<br>01 = MCLK / 2<br>10 = MCLK / 4<br>11 = Reserved<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br><i>Protected by security key.</i>                                                                                             |
|                       | 8:6  | ADCSYS_CLK_DIV [2:0] | 000     | ADC Sample Rate Divider<br>000 = SYSCLK<br>001 = Reserved<br>010 = SYSCLK / 2<br>011 = SYSCLK / 3<br>100 = SYSCLK / 4<br>101 = Reserved<br>110 = SYSCLK / 6<br>111 = Reserved<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br><i>Protected by security key.</i> |
|                       | 5:3  | DACSYS_CLK_DIV [2:0] | 100     | DAC Sample Rate Divider<br>000 = SYSCLK<br>001 = Reserved<br>010 = SYSCLK / 2<br>011 = SYSCLK / 3<br>100 = SYSCLK / 4<br>101 = Reserved<br>110 = SYSCLK / 6<br>111 = Reserved<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br><i>Protected by security key.</i> |
|                       | 2:1  | SYSClk_DIV [1:0]     | 00      | SYSClk Divider<br>00 = MCLK<br>01 = MCLK / 2<br>10 = MCLK / 4                                                                                                                                                                                                                                           |

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                    |
|------------------|-----|-------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     |       |         | 11 = Reserved<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br>Note that the division is applied to the selected MCLK source, including FLL / PLL when applicable.<br><i>Protected by security key.</i> |

**Register 04h** Clocking1

| REGISTER ADDRESS                   | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                                                                                |
|------------------------------------|-----|-----------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R5 (05h)<br>ADC & DAC<br>Control 1 | 6   | ADCR_DAT_INV    | 0       | Right ADC Invert<br>0 = Right ADC output not inverted<br>1 = Right ADC output inverted                                                                                                                     |
|                                    | 5   | ADCL_DAT_INV    | 0       | Left ADC Invert<br>0 = Left ADC output not inverted<br>1 = Left ADC output inverted                                                                                                                        |
|                                    | 4   | DAC_MUTE_RAMP   | 1       | DAC Soft Mute Control<br>0 = Muting the DAC (DAC_MUTE = 1) will cause the volume to change immediately to mute.<br>1 = Muting the DAC (DAC_MUTE = 1) will cause the volume to ramp down gradually to mute. |
|                                    | 3   | DAC_MUTE        | 1       | Digital DAC Mute<br>0 = Un-mute<br>1 = Mute<br>Note that this bit also exists in R49. Reading or writing to either location has the same effect.                                                           |
|                                    | 2:1 | DAC_DEEMP [1:0] | 00      | De-Emphasis Control<br><br>00 = No de-emphasis<br>01 = De-emphasis for 32kHz sample rate<br>10 = De-emphasis for 44.1kHz sample rate<br>11 = De-emphasis for 48kHz sample rate                             |
|                                    | 0   | ADC_HPF_DIS     | 0       | ADC High-Pass Filter Disable<br>0 = Enable<br>1 = Disable                                                                                                                                                  |

**Register 05h** ADC & DAC Control 1

| REGISTER ADDRESS                   | BIT   | LABEL             | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                             |
|------------------------------------|-------|-------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R6 (06h)<br>ADC & DAC<br>Control 2 | 13:12 | ADC_HPF_SR [1:0]  | 10      | ADC High-Pass Filter Sample rate<br>00 = 8k, 11.025k, 12k<br>01 = 16k, 22.025k, 24k<br>10 = 32k, 44.1, 48k<br>11 = 88.2k, 96k<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br><i>Protected by security key.</i> |
|                                    | 10    | ADC_HPF_MODE      | 0       | ADC High-Pass Filter Mode select<br>0 = Hi-Fi mode (1st order)<br>1 = Application mode (2nd order)                                                                                                                                                      |
|                                    | 9:7   | ADC_HPF_CUT [2:0] | 000     | ADC High-Pass Filter Cutoff<br>Note that the cut-off frequency scales with sample rate.                                                                                                                                                                 |
|                                    | 6     | DACR_DAT_INV      | 0       | Right DAC Invert                                                                                                                                                                                                                                        |

| REGISTER ADDRESS | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                        |
|------------------|-----|-----------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     | V               |         | 0 = Right DAC input not inverted<br>1 = Right DAC input inverted                                                                                                                                                                                                   |
|                  | 5   | DACL_DAT_INV    | 0       | Left DAC Invert<br>0 = Left DAC input not inverted<br>1 = Left DAC input inverted                                                                                                                                                                                  |
|                  | 3   | DAC_UNMUTE_RAMP | 1       | DAC Soft Unmute Control<br>0 = Unmuting the DAC (DAC_MUTE = 0) will cause the volume to change immediately to the DACL_VOL/DACR_VOL settings.<br>1 = Unmuting the DAC (DAC_MUTE = 0) will cause the volume to ramp up gradually to the DACL_VOL/DACR_VOL settings. |
|                  | 2   | DAC_MUTERATE    | 0       | DAC Soft Mute Ramp Rate<br>0 = Fast ramp (maximum ramp time 10.7ms)<br>1 = Slow ramp (maximum ramp time 171ms).<br>Note that the ramp rate scales with sample rate (fs). Quoted values are correct for fs = 48kHz.                                                 |
|                  | 0   | DAC_HP          | 0       | DAC Oversampling Ratio<br>0 = Low Power (typically 64 x fs)<br>1 = High Performance (typically 128 x fs)                                                                                                                                                           |

**Register 06h ADC & DAC Control 2**

| REGISTER ADDRESS              | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                                                                                             |
|-------------------------------|-----|-----------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R7 (07h)<br>Audio Interface 0 | 12  | AIFDAC_TDM_MODE | 0       | DAC TDM Mode Select<br>0 = Normal DACDAT operation (1 stereo slot)<br>1 = TDM enabled on DACDAT (2 stereo slots)                                                                                                        |
|                               | 11  | AIFDAC_TDM_SLOT | 0       | DACDAT TDM Slot Select<br>0 = DACDAT data input on slot 0<br>1 = DACDAT data input on slot 1                                                                                                                            |
|                               | 10  | AIFADC_TDM_MODE | 0       | ADC TDM Mode Select<br>0 = Normal ADCDAT operation (1 stereo slot)<br>1 = TDM enabled on ADCDAT (2 stereo slots)                                                                                                        |
|                               | 9   | AIFADC_TDM_SLOT | 0       | ADCDAT TDM Slot Select<br>0 = ADCDAT data input on slot 0<br>1 = ADCDAT data input on slot 1                                                                                                                            |
|                               | 8   | ADC_LRSWAP      | 0       | Swap left/right ADC data on the interface<br>0 = Normal<br>1 = ADCDAT channels swapped                                                                                                                                  |
|                               | 7   | BCLK_INV        | 0       | BCLK Invert<br>0 = BCLK not inverted<br>1 = BCLK inverted                                                                                                                                                               |
|                               | 6   | MSTR            | 0       | Audio Interface Mode Select<br>0 = Slave mode<br>1 = Master mode                                                                                                                                                        |
|                               | 5   | DAC_LRSWAP      | 0       | Swap left/right DAC data on the interface<br>0 = Normal<br>1 = DACDAT channels swapped                                                                                                                                  |
|                               | 4   | LRCLK_INV       | 0       | Right, left and I2S modes – LRCLK polarity<br>0 = normal LRCLK polarity<br>1 = invert LRCLK polarity<br><br>DSP Mode – mode A/B select<br>0 = MSB is available on 2nd BCLK rising edge after LRCLK rising edge (mode A) |



| REGISTER ADDRESS | BIT | LABEL     | DEFAULT | DESCRIPTION                                                                                                       |
|------------------|-----|-----------|---------|-------------------------------------------------------------------------------------------------------------------|
|                  |     |           |         | 1 = MSB is available on 1st BCLK rising edge after LRCLK rising edge (mode B)                                     |
|                  | 3:2 | WL [1:0]  | 10      | Digital Audio Interface Word Length<br>00 = 16 bits<br>01 = 20 bits<br>10 = 24 bits<br>11 = 32 bits               |
|                  | 1:0 | FMT [1:0] | 10      | Digital Audio Interface Format<br>00 = Right justified<br>01 = Left justified<br>10 = I2S Format<br>11 = DSP Mode |

**Register 07h** Audio Interface 0

| REGISTER ADDRESS      | BIT  | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|-----------------------|------|----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R8 (08h)<br>Clocking2 | 11   | CLKREG_OVD           | 0       | Clock Configuration Override<br>0 = MCLK_SRC, OSC_ENA and CLKOUT5_SEL registers are controlled by the GPIO5 pin; PLL2_ENA, PLL3_ENA, CLKOUT2_DIV, CLKOUT5_DIV and CLKOUT3_SEL registers are locked to fixed values.<br>1 = Clocking registers are controlled as normal via Control Interface.<br>This bit must be set to 1 to support GPIO functionality on GPIO5.                                                                                                                                                                                                          |
|                       | 10:9 | MCLK_SRC [1:0]       | 00      | MCLK source select<br>00 = MCLK pin<br>01 = FLL output<br>10 = PLL3 or Oscillator (selected by OSC_MCLK_SRC)<br>11 = Reserved<br>If CLKREG_OVD = 0, then MCLK_SRC is controlled by the GPIO5 pin.<br>If CLKREG_OVD = 0 and GPIO5 = 1, then MCLK_SRC = 01 (FLL) and MCLK_SRC cannot be changed by the Control Interface.<br>If CLKREG_OVD = 0 and GPIO5 = 0, then MCLK_SRC = 00 (MCLK) by default, but the value can be changed via the Control Interface.<br>If CLKREG_OVD = 1 then MCLK_SRC= 00 (MCLK) by default, but the value can be changed via the Control Interface. |
|                       | 8:6  | CLASSD_CLK_DIV [2:0] | 111     | Class D Clock Divider<br>000 = SYSCLK<br>001 = SYSCLK / 2<br>010 = SYSCLK / 3<br>011 = SYSCLK / 4<br>100 = SYSCLK / 6<br>101 = SYSCLK / 8<br>110 = SYSCLK / 12<br>111 = SYSCLK / 16<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br><i>Protected by security key.</i>                                                                                                                                                                                                                                                               |
|                       | 5    | SYSCLK_ENA           | 1       | SYSCLK enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |

| REGISTER ADDRESS | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                   |
|------------------|-----|----------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  | 3:0 | BCLK_DIV [3:0] | 0100    | BCLK Rate<br>0000 = DSPCLK<br>0001 = Reserved<br>0010 = DSPCLK / 2<br>0011 = DSPCLK / 3<br>0100 = DSPCLK / 4 (default)<br>0101 = Reserved<br>0110 = DSPCLK / 6<br>0111 = DSPCLK / 8<br>1000 = Reserved<br>1001 = DSPCLK / 12<br>1010 = DSPCLK / 16<br>1011 = DSPCLK / 24<br>1100 = Reserved<br>1101 = DSPCLK / 32<br>1110 = DSPCLK / 32<br>1111 = DSPCLK / 32 |

**Register 08h** Clocking2

| REGISTER ADDRESS              | BIT | LABEL                      | DEFAULT | DESCRIPTION                                                                                                                                                                  |
|-------------------------------|-----|----------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R9 (09h)<br>Audio Interface 1 | 11  | AUTOMUTE_STATUS            | 0       | Readback of the DAC automute status<br>0 = Automute not detected<br>1 = Automute detected                                                                                    |
|                               | 9:8 | DAC_AUTOMUTE_SAMPLES [1:0] | 11      | Selects the number of consecutive zero DAC samples that will be interpreted as an Automute.<br>00 = 128 samples<br>01 = 256 samples<br>10 = 512 samples<br>11 = 1024 samples |
|                               | 7   | DAC_AUTOMUTE               | 0       | DAC Auto-Mute Control<br>0 = Disabled<br>1 = Enabled                                                                                                                         |
|                               | 4   | DAC_COMP                   | 0       | DAC Companding Enable<br>0 = disabled<br>1 = enabled                                                                                                                         |
|                               | 3   | DAC_COMPMODE               | 0       | DAC Companding Type<br>0 = $\mu$ -law<br>1 = A-law                                                                                                                           |
|                               | 2   | ADC_COMP                   | 0       | ADC Companding Enable<br>0 = disabled<br>1 = enabled                                                                                                                         |
|                               | 1   | ADC_COMPMODE               | 0       | ADC Companding Type<br>0 = $\mu$ -law<br>1 = A-law                                                                                                                           |
|                               | 0   | LOOPBACK                   | 0       | Digital Loopback Function<br>0 = No loopback<br>1 = Loopback enabled (ADC data output is directly input to DAC data input).                                                  |

**Register 09h** Audio Interface 1

| REGISTER ADDRESS             | BIT | LABEL          | DEFAULT   | DESCRIPTION                                                                                                                                                             |
|------------------------------|-----|----------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R10 (0Ah)<br>Left DAC volume | 8   | DAC_VU         | 0         | DAC Volume Update<br>Writing a 1 to this bit will cause left and right DAC volume to be updated simultaneously                                                          |
|                              | 7:0 | DACL_VOL [7:0] | 1100_0000 | Left DAC Digital Volume Control<br>00h = Digital Mute<br>01h = -71.625dB<br>02h = -71.250dB<br>... 0.375dB steps up to<br>C0h = 0dB (default)<br>....<br>FFh = 23.625dB |

**Register 0Ah** Left DAC volume

| REGISTER ADDRESS              | BIT | LABEL          | DEFAULT   | DESCRIPTION                                                                                                                                                              |
|-------------------------------|-----|----------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R11 (0Bh)<br>Right DAC volume | 8   | DAC_VU         | 0         | DAC Volume Update<br>Writing a 1 to this bit will cause left and right DAC volume to be updated simultaneously                                                           |
|                               | 7:0 | DACR_VOL [7:0] | 1100_0000 | Right DAC Digital Volume Control<br>00h = Digital Mute<br>01h = -71.625dB<br>02h = -71.250dB<br>... 0.375dB steps up to<br>C0h = 0dB (default)<br>....<br>FFh = 23.625dB |

**Register 0Bh** Right DAC volume

| REGISTER ADDRESS               | BIT  | LABEL           | DEFAULT       | DESCRIPTION                                                                                                                                     |
|--------------------------------|------|-----------------|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| R14 (0Eh)<br>Audio Interface 2 | 10:0 | AIF_RATE [10:0] | 000_0100_0000 | LRCLK Rate<br>LRCLK clock output =<br>BCLK / AIF_RATE<br><br>Integer (LSB = 1)<br>Valid from 4..2047<br><br>Default (040h) = 64 BCLKs per LRCLK |

**Register 0Eh** Audio Interface 2

| REGISTER ADDRESS            | BIT  | LABEL           | DEFAULT                  | DESCRIPTION                                                                                                                                                                                                            |
|-----------------------------|------|-----------------|--------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R15 (0Fh)<br>Software Reset | 15:0 | SW_RESET [15:0] | 0000_0000_0000_0000<br>0 | Writing to this register resets all non-PLL registers to their default state.<br>Registers R114 (72h) through to R152 (98h) are not affected by this reset.<br>Reading from this register will indicate Chip ID 6243h. |

**Register 0Fh** Software Reset

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION |
|------------------|-----|-------|---------|-------------|
|------------------|-----|-------|---------|-------------|

| REGISTER ADDRESS  | BIT | LABEL             | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                  |
|-------------------|-----|-------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R17 (11h)<br>ALC1 | 10  | ALC_INACTIVE_ENA  | 0       | Select whether the ALC is in Active Mode (that is, ALC is controlling the PGA gain) or in Monitor Mode (the analogue controls are disabled). Note that at least one of ALCL_ENA and ALCR_ENA must also be enabled<br>0 = ALC is in Active Mode<br>1 = ALC is in Monitor Mode                                                                                 |
|                   | 9   | ALC_LVL_MODE      | 0       | Select the range of the ALC target level.<br>0 = -28.5dBFS to -6dBFS in 1.5dB steps<br>1 = -22.5dBFS to -1.5dBFS in 1.5dB steps                                                                                                                                                                                                                              |
|                   | 8   | ALCL_ENA          | 0       | Select ALC on the Left channel<br>0 = Disabled (PGA gain set by INL_VOL)<br>1 = Enabled<br><br>Note that in stereo mode, the left and right PGA volumes, and left and right boost mixer volumes, must be the same before setting ALCL_ENA = 1 and ALCR_ENA = 1                                                                                               |
|                   | 7   | ALCR_ENA          | 0       | Select ALC on the Right channel<br>0 = Disabled (PGA gain set by INR_VOL)<br>1 = Enabled<br><br>Note that in stereo mode, the left and right PGA volumes, and left and right boost mixer volumes, must be the same before setting ALCL_ENA = 1 and ALCR_ENA = 1                                                                                              |
|                   | 6:4 | ALC_MAXGAIN [2:0] | 111     | Maximum ALC gain<br>000 = -18dB<br>001 = -12dB<br>010 = -6dB<br>011 = 0dB<br>100 = +6dB<br>101 = +12dB<br>110 = +18dB<br>111 = +24dB                                                                                                                                                                                                                         |
|                   | 3:0 | ALC_LVL [3:0]     | 1011    | Set the Target signal level at the ADC input.<br>Note that the target level is also determined by ALC_LVL_MODE.<br><br>ALC_LVL_MODE = 0<br>0000 = -28.5dBFS<br>0001 = -27.0dBFS<br>...in 1.5dB steps to...<br>1111 = -6dBFS<br><br>ALC_LVL_MODE = 1<br>0000 = -22.5dBFS<br>0001 = -21.0dBFS<br>...in 1.5dB steps to...<br>1110 = -1.5dBFS<br>1111 = -1.5dBFS |

**Register 11h ALC1**

| REGISTER ADDRESS  | BIT | LABEL             | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                         |
|-------------------|-----|-------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R18 (12h)<br>ALC2 | 15  | ALC_LOCK_STS      | 0       | Readback of the ALC Lock Status.<br>Set when ADC signal = ALC_LVL                                                                                                                                                                                                                                                   |
|                   | 14  | ALC_THRESH_STS    | 0       | Readback of the ALC Threshold Level status (when ALC_LOCK_STS = 0)<br>0 = ADC signal < ALC_LVL<br>1 = ADC signal > ALC_LVL                                                                                                                                                                                          |
|                   | 13  | ALC_SAT_STS       | 0       | Readback of the ALC saturation status.<br>0 = ADC signal = ALC_LVL<br>1 = ADC signal < ALC_LVL but maximum ALC Gain has been reached                                                                                                                                                                                |
|                   | 12  | ALC_PKOVR_STS     | 0       | Readback of the ALC Peak Limiter Overload status.<br>Set when ADC input signal exceeds -1.16dBFS                                                                                                                                                                                                                    |
|                   | 11  | ALC_NGATE_STS     | 0       | Readback of the ALC Noise Gate status.<br>0 = ADC input signal level > ALC_NGATE_THR<br>1 = ADC input signal level < ALC_NGATE_THR                                                                                                                                                                                  |
|                   | 7   | ALC_ZC            | 0       | ALC Zero Cross Detector<br>0 = Change gain immediately<br>1 = Change gain on zero cross only                                                                                                                                                                                                                        |
|                   | 6:4 | ALC_MINGAIN [2:0] | 000     | Minimum ALC gain<br>000 = -23.25dB<br>001 = -17.25dB<br>010 = -11.25dB<br>011 = -5.25dB<br>100 = +0.75dB<br>101 = +6.75dB<br>110 = +12.75dB<br>111 = +18.75dB                                                                                                                                                       |
|                   | 3:0 | ALC_HLD [3:0]     | 0000    | ALC Hold time before the gain ramp-up starts<br>0000 = 0.00ms<br>0001 = 2.67ms<br>0010 = 5.33ms<br>0011 = 10.7ms<br>0100 = 21.3ms<br>0101 = 42.7ms<br>0110 = 85.3ms<br>0111 = 171ms<br>1000 = 341ms<br>1001 = 683ms<br>1010 = 1.37s<br>1011 = 2.73s<br>1100 = 5.46s<br>1101 = 10.9s<br>1110 = 21.8s<br>1111 = 43.7s |

**Register 12h ALC2**

| REGISTER ADDRESS  | BIT   | LABEL                    | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                         |
|-------------------|-------|--------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R19 (13h)<br>ALC3 | 12:10 | ALC_NGATE_G<br>AIN [2:0] | 111     | Noise Gate Gain level. This is the PGA gain level used within the ALC Noise Gate function.<br>000 = -23.25dB<br>001 = -18dB<br>010 = -12dB<br>011 = -6dB<br>100 = 0dB<br>101 = +6dB<br>110 = +12dB<br>111 = +18dB                                                                                                                                                                                                                                                                                                                                                   |
|                   | 8     | ALC_MODE                 | 0       | ALC Mode<br>0 = Normal ALC Mode<br>1 = Limiter Mode<br>Note that ALCL_ENA and ALCR_ENA must both be set to 0 before changing ALC_MODE, otherwise unexpected behaviour may result.                                                                                                                                                                                                                                                                                                                                                                                   |
|                   | 7:4   | ALC_DCY [3:0]            | 0011    | Sets the Gain Decay Rate (measured in time per 1.5dB step).<br>If ALC_MODE = 0<br>0000 = 0.41ms / step<br>0001 = 0.82ms / step<br>...doubling with each step to...<br>1010 = 420ms / step<br>1011 = 840ms / step<br>1100 to 1111 = Reserved<br><br>If ALC_MODE = 1<br>0000 = 0.082ms / step<br>0001 = 0.164ms / step<br>...doubling with each step to...<br>1010 = 83.9ms / step<br>1011 = 168ms / step<br>1100 to 1111 = Reserved<br><br>Note that when 88.2kHz or 96kHz sample rate is selected, the Gain Decay time is defined as for the ALC_MODE=0 case above. |
|                   | 3:0   | ALC_ATK [3:0]            | 0010    | Sets the Gain Attack Rate (measured in time per 1.5dB step).<br>If ALC_MODE = 0<br>0000 = 0.104ms / step<br>0001 = 0.208ms / step<br>...doubling with each step to...<br>1010 = 106ms / step<br>1011 to 1111 = Reserved<br><br>If ALC_MODE = 1<br>0000 = 0.020ms / step<br>0001 = 0.041ms / step<br>...doubling with each step to...<br>1010 = 21.0ms / step<br>1011 to 1111 = Reserved<br><br>Note that when 88.2kHz or 96kHz sample rate is selected, the Gain Attack time is defined as for the ALC_MODE=0 case above.                                           |

**Register 13h ALC3**

| REGISTER ADDRESS        | BIT   | LABEL                    | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|-------------------------|-------|--------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R20 (14h)<br>Noise Gate | 15:12 | ALC_NGATE_D<br>CY [3:0]  | 0011    | <p>Sets the Noise Gate Gain Decay Rate (time taken to ramp up to the ALC_NGATE_GAIN level), measured in time per 1.5dB step.</p> <p>If ALC_MODE = 0<br/>           0000 = 0.41ms / step<br/>           0001 = 0.82ms / step<br/>           ...doubling with each step to...<br/>           1010 = 420ms / step<br/>           1011 = 840ms / step<br/>           1100 to 1111 = Reserved</p> <p>If ALC_MODE = 1<br/>           0000 = 0.082ms / step<br/>           0001 = 0.164ms / step<br/>           ...doubling with each step to...<br/>           1010 = 83.9ms / step<br/>           1011 = 168ms / step<br/>           1100 to 1111 = Reserved</p> <p>Note that when 88.2kHz or 96kHz sample rate is selected, the Noise Gate Gain Decay time is defined as for the ALC_MODE=0 case above.</p> |
|                         | 11:8  | ALC_NGATE_A<br>TK [3:0]  | 0010    | <p>Sets the Gain Attack Rate (time taken to ramp down to the ALC_NGATE_GAIN level), measured in time per 1.5dB step.</p> <p>If ALC_MODE = 0<br/>           0000 = 0.10ms / step<br/>           0001 = 0.21ms / step<br/>           ...doubling with each step to...<br/>           1010 = 106ms / step<br/>           1011 to 1111 = Reserved</p> <p>If ALC_MODE = 1<br/>           0000 = 0.020ms / step<br/>           0001 = 0.041ms / step<br/>           ...doubling with each step to...<br/>           1010 = 21.0ms / step<br/>           1011 to 1111 = Reserved</p> <p>Note that when 88.2kHz or 96kHz sample rate is selected, the Noise Gain Attack time is defined as for the ALC_MODE=0 case above.</p>                                                                                   |
|                         | 7:3   | ALC_NGATE_T<br>HR [4:0]  | 0_0000  | <p>Noise Gate Threshold. If the input signal falls below this level, the Noise Gate function is triggered.<br/>           -76.5dB to -30dB in 1.5dB steps.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
|                         | 2:1   | ALC_NGATE_M<br>ODE [1:0] | 00      | <p>Noise gate mode<br/>           00 = Hold PGA gain static when noise gate triggers<br/>           01 = Mute ADC output immediately when noise gate triggers.<br/>           10 = Ramp PGA Gain to ADC_NGATE_GAIN level when Noise Gate triggers.<br/>           11 = Reserved</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
|                         | 0     | ALC_NGATE_E<br>NA        | 0       | <p>Noise Gate function enable<br/>           0 = Disable<br/>           1 = Enable</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |

**Register 14h Noise Gate**

| REGISTER ADDRESS             | BIT | LABEL          | DEFAULT   | DESCRIPTION                                                                                                                                     |
|------------------------------|-----|----------------|-----------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| R21 (15h)<br>Left ADC volume | 8   | ADC_VU         | 0         | ADC Volume Update<br>Writing a 1 to this bit will cause left and right ADC volume to be updated simultaneously                                  |
|                              | 7:0 | ADCL_VOL [7:0] | 1100_0000 | Left ADC Digital Volume<br>00h = mute<br>01h = -71.625dB<br>02h = -71.250dB<br>...0.375dB steps<br>C0h = 0dB (default)<br>...<br>FFh = 23.625dB |

**Register 15h** Left ADC volume

| REGISTER ADDRESS              | BIT | LABEL          | DEFAULT   | DESCRIPTION                                                                                                                                      |
|-------------------------------|-----|----------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------|
| R22 (16h)<br>Right ADC volume | 8   | ADC_VU         | 0         | ADC Volume Update<br>Writing a 1 to this bit will cause left and right ADC volume to be updated simultaneously                                   |
|                               | 7:0 | ADCR_VOL [7:0] | 1100_0000 | Right ADC Digital Volume<br>00h = mute<br>01h = -71.625dB<br>02h = -71.250dB<br>...0.375dB steps<br>C0h = 0dB (default)<br>...<br>FFh = 23.625dB |

**Register 16h** Right ADC volume

| REGISTER ADDRESS                   | BIT | LABEL     | DEFAULT | DESCRIPTION                                                                                                                                                                            |
|------------------------------------|-----|-----------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R23 (17h)<br>Additional control(1) | 8   | THERR_ACT | 1       | Speaker and Headphone over temperature shutdown enable.<br>0 = Disabled<br>1 = Enabled<br>Note that TEMP_ENA_HP or TEMP_ENA_SPK or both must be enabled for Automatic Shutdown to work |
|                                    | 5   | ADC_HP    | 0       | ADC Oversampling Ratio<br>0 = Low Power (typically 64 x fs)<br>1 = High Performance (typically 128 x fs)                                                                               |
|                                    | 0   | TOCLK_ENA | 0       | TOCLK Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                            |

**Register 17h** Additional control(1)

| REGISTER ADDRESS                   | BIT | LABEL   | DEFAULT | DESCRIPTION                                                                                                                       |
|------------------------------------|-----|---------|---------|-----------------------------------------------------------------------------------------------------------------------------------|
| R24 (18h)<br>Additional control(2) | 3   | AIF_TRI | 0       | Audio Interface Tristate<br>0 = Audio interface pins operate normally<br>1 = ADCDAT is tri-stated; BCLK & LRCLK are set as inputs |

**Register 18h** Additional control(2)



| REGISTER ADDRESS          | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                  |
|---------------------------|-----|----------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R25 (19h)<br>Pwr Mgmt (1) | 10  | DMIC_ENA       | 0       | Enables Digital Microphone mode.<br>0 = Audio DSP input is from ADC<br>1 = Audio DSP input is from digital microphone interface<br>Note that, when the digital microphone interface is selected, the ADCL_ENA and ADCR_ENA registers must also be set to enable the left and right digital microphone channels respectively. |
|                           | 9   | OPCLK_ENA      | 0       | GPIO Clock Output Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                                      |
|                           | 8:7 | VMID_SEL [1:0] | 00      | VMID Divider Enable and Select<br>00 = VMID disabled (for OFF mode)<br>01 = 2 x 50k divider (for normal operation)<br>10 = 2 x 250k divider (for low power standby)<br>11 = 2 x 5k divider (for fast start-up)                                                                                                               |
|                           | 6   | BIAS_ENA       | 0       | Enables the Normal bias current generator (for all analogue functions)<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                        |
|                           | 5   | INL_ENA        | 0       | Left Input PGA and Mixer Enable.<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                              |
|                           | 4   | INR_ENA        | 0       | Right Input PGA and Mixer Enable.<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                             |
|                           | 3   | ADCL_ENA       | 0       | Left ADC Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                                               |
|                           | 2   | ADCR_ENA       | 0       | Right ADC Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                                              |
|                           | 1   | MICBIAS_ENA    | 0       | Microphone Bias Enable<br>0 = OFF (high impedance output)<br>1 = ON                                                                                                                                                                                                                                                          |

**Register 19h Pwr Mgmt (1)**

| REGISTER ADDRESS          | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                                                                       |
|---------------------------|-----|----------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R26 (1Ah)<br>Pwr Mgmt (2) | 8   | DACL_ENA       | 0       | Left DAC Enable<br>0 = Disabled<br>1 = Enabled<br>Note that DACL_ENA must be set to 1 when processing left channel data from the DAC or Digital Beep Generator.   |
|                           | 7   | DACR_ENA       | 0       | Right DAC Enable<br>0 = Disabled<br>1 = Enabled<br>Note that DACR_ENA must be set to 1 when processing right channel data from the DAC or Digital Beep Generator. |
|                           | 6   | HPOUTL_PGA_ENA | 0       | Headphone Left PGA enable<br>0 = Disabled<br>1 = Enabled                                                                                                          |
|                           | 5   | HPOUTR_PGA_ENA | 0       | Headphone Right PGA enable<br>0 = Disabled<br>1 = Enabled                                                                                                         |

| REGISTER ADDRESS | BIT | LABEL           | DEFAULT | DESCRIPTION                                                             |
|------------------|-----|-----------------|---------|-------------------------------------------------------------------------|
|                  | 4   | SPKOUTL_PGA_ENA | 0       | Speaker Left PGA enable<br>0 = Disabled<br>1 = Enabled                  |
|                  | 3   | SPKOUTR_PGA_ENA | 0       | Speaker Right PGA enable<br>0 = Disabled<br>1 = Enabled                 |
|                  | 1   | HPOUTL_PGA_MUTE | 0       | HPOUTL_VOL (Left Headphone Output PGA) Mute<br>0 = Un-mute<br>1 = Mute  |
|                  | 0   | HPOUTR_PGA_MUTE | 0       | HPOUTR_VOL (Right Headphone Output PGA) Mute<br>0 = Un-mute<br>1 = Mute |

**Register 1Ah** Pwr Mgmt (2)

| REGISTER ADDRESS                    | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                   |
|-------------------------------------|-----|----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R27 (1Bh)<br>Additional Control (3) | 4   | SAMPLE_RATE_INT_MODE | 1       | Selects the Integer or Fractional value of the SAMPLE_RATE register.<br>0 = 11.025k, 22.05k, 44.1k or 88.2kHz<br>1 = 8k, 12k, 16k, 24k, 32k, 48k or 96kHz                                     |
|                                     | 2:0 | SAMPLE_RATE [2:0]    | 000     | Selects the Sample Rate (fs)<br>000 = 44.1kHz, 48kHz<br>001 = 32kHz<br>010 = 22.05kHz, 24kHz<br>011 = 16kHz<br>100 = 11.025kHz, 12kHz<br>101 = 8kHz<br>110 = 88.2kHz, 96kHz<br>111 = Reserved |

**Register 1Bh** Additional Control (3)

| REGISTER ADDRESS      | BIT | LABEL            | DEFAULT | DESCRIPTION                                                                |
|-----------------------|-----|------------------|---------|----------------------------------------------------------------------------|
| R28 (1Ch)<br>Anti-pop | 4   | STARTUP_BIAS_ENA | 0       | Enables the Start-Up bias current generator<br>0 = Disabled<br>1 = Enabled |
|                       | 3   | VMID_BUF_ENA     | 0       | VMID Buffer Enable<br>0 = Disabled<br>1 = Enabled                          |
|                       | 2   | VMID_RAMP        | 0       | Enables VMID soft ramp-up<br>0 = Disabled<br>1 = Enabled                   |

**Register 1Ch** Anti-pop

| REGISTER ADDRESS          | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                 |
|---------------------------|-----|----------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R29 (1Dh)<br>Pwr Mgmt (3) | 1:0 | MICBIAS_EVR<br>[1:0] | 00      | Microphone Bias Voltage Control<br>00 = Controlled by MICBIAS_LVL<br>01 = 1.63 x AVDD (approx.)<br>10 = 1.34 x AVDD (approx.)<br>11 = 1.63 x AVDD (approx.) |

**Register 1Dh Pwr Mgmt (3)**

| REGISTER ADDRESS        | BIT   | LABEL                 | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                      |
|-------------------------|-------|-----------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R30 (1Eh)<br>Clocking 3 | 15:13 | DBCLK_DIV<br>[2:0]    | 000     | DBCLK Rate Divider<br>(divides the 256kHz clock; nominal frequency is quoted in brackets)<br>000 = f / 256 (1kHz)<br>001 = f / 2048 (125Hz)<br>010 = f / 4096 (62.5Hz)<br>011 = f / 8192 (31.2Hz)<br>100 = f / 16384 (15.6Hz)<br>101 = f / 32768 (7.8Hz)<br>110 = f / 64536 (3.9Hz)<br>111 = f / 131072 (1.95Hz) |
|                         | 12:10 | OPCLK_DIV<br>[2:0]    | 000     | GPIO Output Clock Divider<br>000 = SYSCLK<br>001 = SYSCLK / 2<br>010 = SYSCLK / 3<br>011 = SYSCLK / 4<br>100 = SYSCLK / 6<br>101 = SYSCLK / 8<br>110 = SYSCLK / 12<br>111 = SYSCLK / 16<br>000 = SYSCLK / 16                                                                                                     |
|                         | 9:7   | TOCLK_DIV<br>[2:0]    | 000     | TOCLK Rate Divider<br>(divides the 256kHz clock; nominal frequency is quoted in brackets)<br>000 = f / 256 (1kHz)<br>001 = f / 512 (500Hz)<br>010 = f / 1024 (250Hz)<br>011 = f / 2048 (125Hz)<br>100 = f / 4096 (62.5Hz)<br>101 = f / 8192 (31.2Hz)<br>110 = f / 16384 (15.6Hz)<br>111 = f / 32768 (7.8Hz)      |
|                         | 6:1   | F256KCLK_DIV<br>[5:0] | 10_1111 | 256kHz Clock Divider<br>0d = SYSCLK<br>1d = SYSCLK / 2<br>2d = SYSCLK / 3<br>....<br>63d = SYSCLK / 64<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br><i>Protected by security key.</i>                                                                                 |

**Register 1Eh Clocking 3**

| REGISTER ADDRESS                     | BIT | LABEL       | DEFAULT | DESCRIPTION                                                                                                                    |
|--------------------------------------|-----|-------------|---------|--------------------------------------------------------------------------------------------------------------------------------|
| R31 (1Fh)<br>Input mixer control (1) | 3   | MIXINL_MUTE | 0       | Left input boost mixer mute<br>0 = Un-mute<br>1 = Mute                                                                         |
|                                      | 2   | MIXINR_MUTE | 0       | Right input boost mixer mute<br>0 = Un-mute<br>1 = Mute                                                                        |
|                                      | 1   | MIXINL_ENA  | 0       | Left Input Mixer Enable<br>0 = Disabled<br>1 = Enabled<br>Note that the Left Input Mixer is also enabled when INL_ENA is set   |
|                                      | 0   | MIXINR_ENA  | 0       | Right Input Mixer Enable<br>0 = Disabled<br>1 = Enabled<br>Note that the Right Input Mixer is also enabled when INR_ENA is set |

**Register 1Fh** Input mixer control (1)

| REGISTER ADDRESS                     | BIT | LABEL                       | DEFAULT | DESCRIPTION                                                                                                                                                        |
|--------------------------------------|-----|-----------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R32 (20h)<br>Left input mixer volume | 8:6 | IN2L_MIXINL_V<br>OL [2:0]   | 101     | Left input IN2L to Left input Boost Mixer Gain<br>000 = -12dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB    |
|                                      | 5:3 | INPGAL_MIXIN<br>L_VOL [2:0] | 000     | Left input PGA to Left input Boost Mixer Gain<br>000 = 0dB<br>001 = +6dB<br>010 = +13dB<br>011 = +18dB<br>100 = +20dB<br>101 = +24dB<br>110 = +27dB<br>111 = +29dB |
|                                      | 2:0 | IN3L_MIXINL_V<br>OL [2:0]   | 101     | Left input IN3L to Left input Boost Mixer Gain<br>000 = -12dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB    |

**Register 20h** Left input mixer volume

| REGISTER ADDRESS                      | BIT | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                          |
|---------------------------------------|-----|-------------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R33 (21h)<br>Right input mixer volume | 8:6 | IN2R_MIXINR_VOL [2:0]   | 101     | Right input IN2R to Right input Boost Mixer Gain<br>000 = -12dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB    |
|                                       | 5:3 | INPGAR_MIXINR_VOL [2:0] | 000     | Right input PGA to Right input Boost Mixer Gain<br>000 = 0dB<br>001 = +6dB<br>010 = +13dB<br>011 = +18dB<br>100 = +20dB<br>101 = +24dB<br>110 = +27dB<br>111 = +29dB |
|                                       | 2:0 | IN3R_MIXINR_VOL [2:0]   | 101     | Right input IN3R to Right input Boost Mixer Gain<br>000 = -12dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB    |

**Register 21h** Right input mixer volume

| REGISTER ADDRESS                     | BIT | LABEL            | DEFAULT | DESCRIPTION                                                                       |
|--------------------------------------|-----|------------------|---------|-----------------------------------------------------------------------------------|
| R34 (22h)<br>Input mixer control (2) | 5   | IN2L_TO_MIXINL   | 0       | Left Input IN2L to Left input Boost Mixer Select<br>0 = Disabled<br>1 = Enabled   |
|                                      | 4   | IN3L_TO_MIXINL   | 0       | Left Input IN3L to Left input Boost Mixer Select<br>0 = Disabled<br>1 = Enabled   |
|                                      | 3   | INPGAL_TO_MIXINL | 1       | Left Input PGA to Left input Boost Mixer Select<br>0 = Disabled<br>1 = Enabled    |
|                                      | 2   | IN2R_TO_MIXINR   | 0       | Right input IN2R to Right input Boost Mixer Select<br>0 = Disabled<br>1 = Enabled |
|                                      | 1   | IN3R_TO_MIXINR   | 0       | Right input IN3R to Right input Boost Mixer Select<br>0 = Disabled<br>1 = Enabled |
|                                      | 0   | INPGAR_TO_MIXINR | 1       | Right input PGA to Right input Boost Mixer Select<br>0 = Disabled<br>1 = Enabled  |

**Register 22h** Input mixer control (2)

| REGISTER ADDRESS                | BIT | LABEL            | DEFAULT | DESCRIPTION                                                                                                                                         |
|---------------------------------|-----|------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------|
| R35 (23h)<br>Input bias control | 5:3 | MIXIN_BIAS [2:0] | 000     | Input Boost-Mixer Bias Control<br>000 = x 2.0 (default)<br>001 = Reserved<br>010 = Reserved<br>011 = x 1.0<br>100 = x 0.67<br>101 to 111 = Reserved |
|                                 | 2:0 | INPGA_BIAS [2:0] | 100     | Input PGA Bias Control<br>000 = x 2.0<br>001 = Reserved<br>010 = Reserved<br>011 = Reserved<br>100 = x 0.67 (default)<br>101 to 111 = Reserved      |

**Register 23h** Input bias control

| REGISTER ADDRESS                    | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                               |
|-------------------------------------|-----|----------------|---------|---------------------------------------------------------------------------------------------------------------------------|
| R37 (25h)<br>Left input PGA control | 4   | INPGAL_ENA     | 0       | Left Input PGA Enable.<br>0 = Disabled<br>1 = Enabled<br>Note that the Left Input PGA is also enabled when INL_ENA is set |
|                                     | 3   | IN1L_TO_INPGAL | 1       | Selects the IN1L pin as an input to the left PGA<br>0 = Disabled<br>1 = Enabled                                           |
|                                     | 2   | IN2L_TO_INPGAL | 0       | Selects the IN2L pin as an input to the left PGA<br>0 = Disabled<br>1 = Enabled                                           |
|                                     | 1   | IN3L_TO_INPGAL | 0       | Selects the IN3L pin as an input to the left PGA<br>0 = Disabled<br>1 = Enabled                                           |
|                                     | 0   | IN4L_TO_INPGAL | 0       | Selects the IN4L pin as an input to the left PGA<br>0 = Disabled<br>1 = Enabled                                           |

**Register 25h** Left input PGA control

| REGISTER ADDRESS                     | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                                |
|--------------------------------------|-----|----------------|---------|----------------------------------------------------------------------------------------------------------------------------|
| R38 (26h)<br>Right input PGA control | 4   | INPGAR_ENA     | 0       | Right Input PGA Enable<br>0 = Disabled<br>1 = Enabled<br>Note that the Right Input PGA is also enabled when INR_ENA is set |
|                                      | 3   | IN1R_TO_INPGAR | 1       | Selects the IN1R pin as an input to the right PGA<br>0 = Disabled<br>1 = Enabled                                           |
|                                      | 2   | IN2R_TO_INPGAR | 0       | Selects the IN2R pin as an input to the right PGA<br>0 = Disabled<br>1 = Enabled                                           |
|                                      | 1   | IN3R_TO_INPGAR | 0       | Selects the IN3R pin as an input to the right PGA<br>0 = Disabled<br>1 = Enabled                                           |

| REGISTER ADDRESS | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                      |
|------------------|-----|----------------|---------|----------------------------------------------------------------------------------|
|                  | 0   | IN4R_TO_INPGAR | 0       | Selects the IN4R pin as an input to the right PGA<br>0 = Disabled<br>1 = Enabled |

**Register 26h** Right input PGA control

| REGISTER ADDRESS               | BIT | LABEL             | DEFAULT  | DESCRIPTION                                                                                                                                                                      |
|--------------------------------|-----|-------------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R40 (28h)<br>SPKOUTL<br>volume | 8   | SPKOUT_VU         | 0        | Speaker Output PGA Volume Update<br>Writing a 1 to this bit will update SPKOUTL_VOL and SPKOUTR_VOL volumes simultaneously.                                                      |
|                                | 7   | SPKOUTL_ZC        | 0        | SPKOUTL_VOL (Left Speaker Output PGA) Zero Cross Enable<br>0 = Zero cross disabled<br>1 = Zero cross enabled                                                                     |
|                                | 6:0 | SPKOUTL_VOL [6:0] | 000_0000 | Left Speaker Output PGA Volume<br>000_0000 to 010_1111 = Mute<br>011_0000 to 011_0101 = -68dB<br>011_0110 = -67dB<br>...in 1dB steps<br>111_1001 = 0dB<br>...<br>111_1111 = +6dB |

**Register 28h** SPKOUTL volume

| REGISTER ADDRESS               | BIT | LABEL             | DEFAULT  | DESCRIPTION                                                                                                                                                                       |
|--------------------------------|-----|-------------------|----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R41 (29h)<br>SPKOUTR<br>volume | 8   | SPKOUT_VU         | 0        | Speaker Output PGA Volume Update<br>Writing a 1 to this bit will update SPKOUTL_VOL and SPKOUTR_VOL volumes simultaneously.                                                       |
|                                | 7   | SPKOUTR_ZC        | 0        | SPKOUTR_VOL (Right Speaker Output PGA) Zero Cross Enable<br>0 = Zero cross disabled<br>1 = Zero cross enabled                                                                     |
|                                | 6:0 | SPKOUTR_VOL [6:0] | 000_0000 | Right Speaker Output PGA Volume<br>000_0000 to 010_1111 = Mute<br>011_0000 to 011_0101 = -68dB<br>011_0110 = -67dB<br>...in 1dB steps<br>111_1001 = 0dB<br>...<br>111_1111 = +6dB |

**Register 29h** SPKOUTR volume

| REGISTER ADDRESS                     | BIT | LABEL         | DEFAULT | DESCRIPTION                                                                                                                            |
|--------------------------------------|-----|---------------|---------|----------------------------------------------------------------------------------------------------------------------------------------|
| R47 (2Fh)<br>Thermal Shutdown Status | 3   | TEMP_ERR_HP   | 0       | Headphone temperature error status (triggered at 145°C)<br>0 = Not triggered<br>1 = Triggered<br>Note that this is a Read Only field   |
|                                      | 2   | TEMP_WARN_HP  | 0       | Headphone temperature warning status (triggered at 125°C)<br>0 = Not triggered<br>1 = Triggered<br>Note that this is a Read Only field |
|                                      | 1   | TEMP_ERR_SPK  | 0       | Speaker temperature error status (triggered at 145°C)<br>0 = Not triggered<br>1 = Triggered<br>Note that this is a Read Only field     |
|                                      | 0   | TEMP_WARN_SPK | 0       | Speaker temperature warning status (triggered at 125°C)<br>0 = Not triggered<br>1 = Triggered<br>Note that this is a Read Only field   |

**Register 2Fh** Thermal Shutdown Status

| REGISTER ADDRESS                    | BIT   | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                              |
|-------------------------------------|-------|--------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R48 (30h)<br>Additional Control (4) | 15    | Reserved           | 1       | Reserved - do not change                                                                                                                                                                                                                                 |
|                                     | 14:12 | MICDET_THR [2:0]   | 000     | MICBIAS Current Detect Threshold (AVDD = 1.8V)<br>000 = 64uA<br>001 = 166uA<br>010 = 375uA<br>011 = 475uA<br>100 = 575uA<br>101 = 680uA<br>110 = 885uA<br>111 = 990uA<br>Note that the value scales with AVDD. The value quoted is correct for AVDD=1.8V |
|                                     | 11:10 | MICSHORT_THR [1:0] | 00      | MICBIAS Short Circuit Threshold (AVDD = 1.8V)<br>00 = 515uA<br>01 = 680uA<br>10 = 1050uA<br>11 = 1215uA<br>Note that the value scales with AVDD. The value quoted is correct for AVDD=1.8V                                                               |
|                                     | 9     | MICDET_ENA         | 0       | MICBIAS Current and Short Circuit Detect Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                           |
|                                     | 7     | MICDET_STS         | 0       | MICBIAS Current Detection status<br>0 = Current Detect threshold not exceeded<br>1 = Current Detect threshold exceeded                                                                                                                                   |
|                                     | 6     | MICSHORT_STS       | 0       | MICBIAS Short Circuit status<br>0 = Short Circuit threshold not exceeded<br>1 = Short Circuit threshold exceeded                                                                                                                                         |
|                                     | 5     | Reserved           | 1       | Reserved - do not change                                                                                                                                                                                                                                 |
|                                     | 2     | TEMP_ENA_HP        | 1       | Headphone temperature sensor enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                       |



| REGISTER ADDRESS | BIT | LABEL        | DEFAULT | DESCRIPTION                                                                                                                                                                                                    |
|------------------|-----|--------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  | 1   | TEMP_ENA_SPK | 1       | Speaker temperature sensor enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                               |
|                  | 0   | MICBIAS_LVL  | 1       | Microphone Bias Voltage Control<br>0 = 0.828 x AVDD (approx.)<br>1 = 1.156 x AVDD (approx.)<br>Only valid when MICBIAS_EVR=00. In other cases, the Microphone Bias voltage is controlled by MICBIAS_EVR alone. |

**Register 30h** Additional Control (4)

| REGISTER ADDRESS                  | BIT | LABEL            | DEFAULT | DESCRIPTION                                                                                                                                     |
|-----------------------------------|-----|------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| R49 (31h)<br>Class D<br>Control 1 | 7   | SPKOUTR_ENA      | 0       | Right channel class D Speaker Enable<br>0 = Disabled<br>1 = Enabled                                                                             |
|                                   | 6   | SPKOUTL_ENA      | 0       | Left channel class D Speaker Enable<br>0 = Disabled<br>1 = Enabled                                                                              |
|                                   | 4   | DAC_MUTE         | 1       | Digital DAC Mute<br>0 = Un-mute<br>1 = Mute<br>Note that this bit also exists in R5. Reading or writing to either location has the same effect. |
|                                   | 2   | SPKOUT_VU        | 0       | Speaker Output PGA Volume Update<br>Writing a 1 to this bit will update SPKOUTL_VOL and SPKOUTR_VOL volumes simultaneously.                     |
|                                   | 1   | SPKOUTL_PGA_MUTE | 0       | SPKOUTL_VOL (Left Speaker Output PGA) Mute<br>0 = Un-mute<br>1 = Mute                                                                           |
|                                   | 0   | SPKOUTR_PGA_MUTE | 0       | SPKOUTR_VOL (Right Speaker Output PGA) Mute<br>0 = Un-mute<br>1 = Mute                                                                          |

**Register 31h** Class D Control 1

| REGISTER ADDRESS                  | BIT | LABEL            | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                      |
|-----------------------------------|-----|------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R51 (33h)<br>Class D<br>Control 2 | 6   | SPK_MONO         | 0       | Mono Speaker Configuration enable<br>0 = Default (stereo)<br>1 = Mono mode<br>When SPK_MONO is set to '1', both speakers output the signal from the left channel.<br>Note that the user must tie the outputs together for mono use                                                                                               |
|                                   | 2:0 | CLASSD_VOL [2:0] | 011     | AC Speaker Gain Boost. Note that both left and right channels are boosted equally<br>000 = 1.00x boost (+0dB)<br>001 = 1.19x boost (+1.5dB)<br>010 = 1.41x boost (+3.0dB)<br>011 = 1.68x boost (+4.5dB)<br>100 = 2.00x boost (+6.0dB)<br>101 = 2.37x boost (+7.5dB)<br>110 = 2.81x boost (+9.0dB)<br>111 = 3.98x boost (+12.0dB) |

**Register 33h** Class D Control 2

| REGISTER ADDRESS        | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                      |
|-------------------------|-----|--------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R56 (38h)<br>Clocking 4 | 4:1 | MCLK_RATE<br>[3:0] | 0011    | Selects the MCLK / fs ratio.<br>(Note that the MCLK source is selected by MCLK_SRC.)<br>0000 = 64<br>0001 = 128<br>0010 = 192<br>0011 = 256 (default)<br>0100 = 384<br>0101 = 512<br>0110 = 768<br>0111 = 1024<br>1000 = Reserved<br>1001 = 1536<br>1010 = 3072<br>1011 = 6144<br>1100 to 1111 = Reserved<br>If ADC ReTune, DAC ReTune, DAC HPF, VSS or HD Bass is enabled, then MCLK_RATE must be 512 or higher |

**Register 38h** Clocking 4

| REGISTER ADDRESS                   | BIT | LABEL               | DEFAULT | DESCRIPTION                                                                                                                                                                                       |
|------------------------------------|-----|---------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R57 (39h)<br>DAC DSP<br>Mixing (1) | 9   | DAC_MONOMIX         | 0       | DAC Mono Mix<br>0 = Stereo<br>1 = Mono (Mono mix output on enabled DAC)<br>Mono Mix is only supported when one or other DAC is disabled.<br>When Mono mix is enabled, 6dB attenuation is applied. |
|                                    | 7:4 | ADCR_DAC_SVOL [3:0] | 0000    | Right ADC Digital Sidetone Volume<br>0000 = -36dB<br>0001 = -33dB<br>(... 3dB steps)<br>1011 = -3dB<br>11XX = 0dB                                                                                 |
|                                    | 3:2 | ADC_TO_DACR [1:0]   | 00      | Right DAC Digital Sidetone Source<br>00 = No sidetone<br>01 = Left ADC<br>10 = Right ADC<br>11 = No sidetone                                                                                      |

**Register 39h** DAC DSP Mixing (1)

| REGISTER ADDRESS                   | BIT | LABEL               | DEFAULT | DESCRIPTION                                                                                                      |
|------------------------------------|-----|---------------------|---------|------------------------------------------------------------------------------------------------------------------|
| R58 (3Ah)<br>DAC DSP<br>Mixing (2) | 7:4 | ADCL_DAC_SVOL [3:0] | 0000    | Left ADC Digital Sidetone Volume<br>0000 = -36dB<br>0001 = -33dB<br>(... 3dB steps)<br>1011 = -3dB<br>11XX = 0dB |
|                                    | 3:2 | ADC_TO_DACL [1:0]   | 00      | Left DAC Digital Sidetone Source<br>00 = No sidetone<br>01 = Left ADC                                            |

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                        |
|------------------|-----|-------|---------|------------------------------------|
|                  |     |       |         | 10 = Right ADC<br>11 = No sidetone |

**Register 3Ah** DAC DSP Mixing (2)

| REGISTER ADDRESS        | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                      |
|-------------------------|-----|-----------------|---------|----------------------------------------------------------------------------------|
| R60 (3Ch)<br>DC Servo 0 | 7   | INL_DCS_ENA     | 0       | DC Servo enable for Left input signal path<br>0 = Disabled<br>1 = Enabled        |
|                         | 6   | INL_DCS_STARTUP | 0       | Writing 1 to this bit selects Start-Up DC Servo mode for Left input signal path  |
|                         | 3   | INR_DCS_ENA     | 0       | DC Servo enable for Right input signal path<br>0 = Disabled<br>1 = Enabled       |
|                         | 2   | INR_DCS_STARTUP | 0       | Writing 1 to this bit selects Start-Up DC Servo mode for Right input signal path |

**Register 3Ch** DC Servo 0

| REGISTER ADDRESS        | BIT | LABEL            | DEFAULT | DESCRIPTION                                                                |
|-------------------------|-----|------------------|---------|----------------------------------------------------------------------------|
| R61 (3Dh)<br>DC Servo 1 | 7   | HP1L_DCS_ENA     | 0       | DC Servo enable for HPOUTL<br>0 = Disabled<br>1 = Enabled                  |
|                         | 6   | HP1L_DCS_STARTUP | 0       | Writing 1 to this bit selects Start-Up DC Servo mode for HPOUTL            |
|                         | 4   | HP1L_DCS_SYNC    | 0       | Writing 1 to this bit selects a series of DC offset corrections for HPOUTL |
|                         | 3   | HP1R_DCS_ENA     | 0       | DC Servo enable for HPOUTR<br>0 = Disabled<br>1 = Enabled                  |
|                         | 2   | HP1R_DCS_STARTUP | 0       | Writing 1 to this bit selects Start-Up DC Servo mode for HPOUTR            |
|                         | 0   | HP1R_DCS_SYNC    | 0       | Writing 1 to this bit selects a series of DC offset corrections for HPOUTR |

**Register 3Dh** DC Servo 1

| REGISTER ADDRESS        | BIT  | LABEL                    | DEFAULT  | DESCRIPTION                                                                                                                                                |
|-------------------------|------|--------------------------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R64 (40h)<br>DC Servo 4 | 13:7 | HP1_DCS_SYNC_STEPS [6:0] | 001_0000 | Number of DC Servo updates to perform in a series event (HPOUTL and HPOUTR)<br>00h to 0Fh = Reserved<br>10h = 16 (default)<br>11h = 17<br>...<br>7Fh = 127 |

**Register 40h** DC Servo 4

| REGISTER ADDRESS | BIT | LABEL       | DEFAULT | DESCRIPTION                           |
|------------------|-----|-------------|---------|---------------------------------------|
| R66 (42h)        | 10  | DCS_STARTUP | 0       | DC Servo Start-Up Status (Left Input) |

| REGISTER ADDRESS | BIT | LABEL                 | DEFAULT | DESCRIPTION                                                                |
|------------------|-----|-----------------------|---------|----------------------------------------------------------------------------|
| DC Servo 6       |     | _DONE_INL             |         | 0 = Not complete<br>1 = Complete                                           |
|                  | 9   | DCS_STARTUP_DONE_INR  | 0       | DC Servo Start-Up Status (Right Input)<br>0 = Not complete<br>1 = Complete |
|                  | 8   | DCS_STARTUP_DONE_HP1L | 0       | DC Servo Start-Up Status (HPOUTL)<br>0 = Not complete<br>1 = Complete      |
|                  | 7   | DCS_STARTUP_DONE_HP1R | 0       | DC Servo Start-Up Status (HPOUTR)<br>0 = Not complete<br>1 = Complete      |

**Register 42h** DC Servo 6

| REGISTER ADDRESS                  | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                                                                   |
|-----------------------------------|-----|--------------------|---------|-------------------------------------------------------------------------------------------------------------------------------|
| R68 (44h)<br>Analogue<br>PGA Bias | 4   | Reserved           | 1       | Reserved - do not change                                                                                                      |
|                                   | 3   | Reserved           | 1       | Reserved - do not change                                                                                                      |
|                                   | 2:0 | HP_PGAS_BIAS [2:0] | 011     | Headphone PGA Boost Bias<br>000 = x 2.0<br>001 = Reserved<br>010 = Reserved<br>011 = x 1.0 (default)<br>100 to 111 = Reserved |

**Register 44h** Analogue PGA Bias

| REGISTER ADDRESS              | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                 |
|-------------------------------|-----|-----------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R69 (45h)<br>Analogue HP<br>0 | 7   | HP1L_RMV_SHORT  | 0       | Removes HP1L short<br>0 = HP1L short enabled<br>1 = HP1L short removed<br>For pop-free operation, this bit should be set to 1 as the final step in the HP1L Enable sequence.                                                                                                                |
|                               | 6   | HP1L_ENA_OUTPUT | 0       | Enables HP1L output stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set to 1 after the DC offset cancellation has been performed.                                                                                                                        |
|                               | 5   | HP1L_ENA_DELAY  | 0       | Enables HP1L intermediate stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set to 1 after the output signal path has been configured, and before the DC Offset cancellation is scheduled. This bit should be set with at least 20us delay after HP1L_ENA. |
|                               | 4   | HP1L_ENA        | 0       | Enables HP1L input stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set as the first stage of the HP1L Enable sequence.                                                                                                                                   |
|                               | 3   | HP1R_RMV_SHORT  | 0       | Removes HP1R short<br>0 = HP1R short enabled<br>1 = HP1R short removed<br>For pop-free operation, this bit should be set to 1 as the                                                                                                                                                        |

| REGISTER ADDRESS | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                |
|------------------|-----|----------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     |                |         | final step in the HP1R Enable sequence.                                                                                                                                                                                                                                                    |
|                  | 2   | HP1R_ENA_OUTP  | 0       | Enables HP1R output stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set to 1 after the DC offset cancellation has been performed.                                                                                                                       |
|                  | 1   | HP1R_ENA_DELAY | 0       | Enables HP1R intermediate stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set to 1 after the output signal path has been configured, and before the DC Offset cancellation is scheduled This bit should be set with at least 20us delay after HP1R_ENA. |
|                  | 0   | HP1R_ENA       | 0       | Enables HP1R input stage<br>0 = Disabled<br>1 = Enabled<br>For pop-free operation, this bit should be set as the first stage of the HP1R Enable sequence.                                                                                                                                  |

**Register 45h** Analogue HP 0

| REGISTER ADDRESS           | BIT | LABEL               | DEFAULT | DESCRIPTION                                                                                                                                                      |
|----------------------------|-----|---------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R71 (47h)<br>Analogue HP 2 | 8:6 | HP1L_VOL [2:0]      | 111     | Headphone 1 Left Secondary PGA volume.<br>000 = -7dB<br>001 = -6dB<br>010 = -5dB<br>011 = -4dB<br>100 = -3dB<br>101 = -2dB<br>110 = -1dB<br>111 = 0dB (default)  |
|                            | 5:3 | HP1R_VOL [2:0]      | 111     | Headphone 1 Right Secondary PGA volume.<br>000 = -7dB<br>001 = -6dB<br>010 = -5dB<br>011 = -4dB<br>100 = -3dB<br>101 = -2dB<br>110 = -1dB<br>111 = 0dB (default) |
|                            | 2:0 | HP_BIAS_BOOST [2:0] | 011     | Headphone Driver Boost Bias<br>000 = x 2.0<br>001 = Reserved<br>010 = Reserved<br>011 = x 1.0 (default)<br>100 to 111 = Reserved                                 |

**Register 47h** Analogue HP 2

| REGISTER ADDRESS           | BIT | LABEL  | DEFAULT | DESCRIPTION                                            |
|----------------------------|-----|--------|---------|--------------------------------------------------------|
| R72 (48h)<br>Charge Pump 1 | 0   | CP_ENA | 0       | Enable charge-pump digits<br>0 = disable<br>1 = enable |

**Register 48h** Charge Pump 1

| REGISTER ADDRESS           | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                     |
|----------------------------|-----|------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R82 (52h)<br>Charge Pump B | 0   | CP_DYN_PWR | 0       | Enable dynamic charge pump power control<br>0 = Charge pump controlled by volume register settings (Class G)<br>1 = Charge pump controlled by real-time audio level (Class W)<br>Class W is recommended for lowest power consumption<br>When selecting CP_DYN_PWR=0, a '1' must be written to the HPOUT_VU bit (Register R2 or R3) to complete the mode change. |

**Register 52h** Charge Pump B

| REGISTER ADDRESS                       | BIT | LABEL             | DEFAULT | DESCRIPTION                                                                                                                  |
|----------------------------------------|-----|-------------------|---------|------------------------------------------------------------------------------------------------------------------------------|
| R87 (57h)<br>Write Sequencer Control 1 | 7   | WSEQ_AUTOS EQ_ENA | 0       | Write Sequencer Auto-Sequence Enable (controls the Class D driver via DAC Auto-Mute function)<br>0 = Disabled<br>1 = Enabled |
|                                        | 5   | WSEQ_ENA          | 0       | Write Sequencer Enable.<br>0 = Disabled<br>1 = Enabled                                                                       |

**Register 57h** Write Sequencer Control 1

| REGISTER ADDRESS                       | BIT | LABEL                  | DEFAULT  | DESCRIPTION                                                                                                                                                                                                                                                                           |
|----------------------------------------|-----|------------------------|----------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R90 (5Ah)<br>Write Sequencer Control 2 | 8   | WSEQ_ABORT             | 0        | Writing a 1 to this bit aborts the current sequence and returns control of the device back to the serial control interface.                                                                                                                                                           |
|                                        | 7   | WSEQ_START             | 0        | Writing a 1 to this bit starts the write sequencer at the index location selected by WSEQ_START_INDEX. The sequence continues until it reaches an "End of sequence" flag. At the end of the sequence, this bit will be reset by the Write Sequencer.                                  |
|                                        | 6:0 | WSEQ_START_INDEX [6:0] | 000_0000 | Sequence Start Index. This field determines the memory location of the first command in the selected sequence. There are 127 Write Sequencer RAM addresses:<br>00h = WSEQ_ADDR0 (R4096)<br>01h = WSEQ_ADDR1 (R4100)<br>02h = WSEQ_ADDR2 (R4104)<br>....<br>7Fh = WSEQ_ADDR127 (R4604) |

**Register 5Ah** Write Sequencer Control 2

| REGISTER ADDRESS                       | BIT | LABEL                    | DEFAULT  | DESCRIPTION                                                                                                                                                                |
|----------------------------------------|-----|--------------------------|----------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R93 (5Dh)<br>Write Sequencer Control 3 | 9:3 | WSEQ_CURRENT_INDEX [6:0] | 000_0000 | Sequence Current Index. This indicates the memory location of the most recently accessed command in the write sequencer memory.<br>Coding is the same as WSEQ_START_INDEX. |
|                                        | 0   | WSEQ_BUSY                | 0        | Sequencer Busy flag (Read Only).<br>0 = Sequencer idle<br>1 = Sequencer busy<br>Note: it is not possible to write to non-PLL control registers                             |

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                            |
|------------------|-----|-------|---------|--------------------------------------------------------|
|                  |     |       |         | via the control interface while the Sequencer is Busy. |

**Register 5Dh** Write Sequencer Control 3

| REGISTER ADDRESS               | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                             |
|--------------------------------|-----|------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R94 (5Eh)<br>Control Interface | 6   | SPI_CONTRD | 0       | Enable continuous read mode in SPI (3-wire/4-wire) modes<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                                 |
|                                | 5   | SPI_4WIRE  | 0       | SPI control mode select<br>0 = 3-wire using bidirectional SDA<br>1 = 4-wire using SDOOUT                                                                                                                                                                                                                                                |
|                                | 4   | SPI_CFG    | 0       | SDA/SDOOUT pin configuration<br><br>In 3-wire mode (SPI_4WIRE=0):<br>0 = SDA output is CMOS<br>1 = SDA output is Open Drain<br><br>In 4-wire mode (SPI_4WIRE=1):<br>0 = SDOOUT output is CMOS<br>1 = SDOOUT output is Wired 'OR'.<br>Note that only GPIO5 can be configured as Wired 'OR'.<br>This bit has no effect on GPIO2 or GPIO3. |

**Register 5Eh** Control Interface

| REGISTER ADDRESS           | BIT | LABEL       | DEFAULT | DESCRIPTION                                                 |
|----------------------------|-----|-------------|---------|-------------------------------------------------------------|
| R99 (63h)<br>Mixer Enables | 3   | HPMIXL_ENA  | 0       | Left Headphone Mixer Enable<br>0 = Disabled<br>1 = Enabled  |
|                            | 2   | HPMIXR_ENA  | 0       | Right Headphone Mixer Enable<br>0 = Disabled<br>1 = Enabled |
|                            | 1   | SPKMIXL_ENA | 0       | Left Speaker Mixer Enable<br>0 = Disabled<br>1 = Enabled    |
|                            | 0   | SPKMIXR_ENA | 0       | Right Speaker Mixer Enable<br>0 = Disabled<br>1 = Enabled   |

**Register 63h** Mixer Enables

| REGISTER ADDRESS                  | BIT | LABEL                    | DEFAULT | DESCRIPTION                                                             |
|-----------------------------------|-----|--------------------------|---------|-------------------------------------------------------------------------|
| R100 (64h)<br>Headphone Mixer (1) | 7   | HPMIXL_TO_H<br>POUTL_PGA | 0       | Left Headphone PGA Path Select<br>0 = DACL Output<br>1 = HPMIXL Output  |
|                                   | 5   | DACL_TO_HPMIXL           | 0       | Left DAC to Left Headphone Mixer select<br>0 = Disabled<br>1 = Enabled  |
|                                   | 4   | DACR_TO_HPMIXL           | 0       | Right DAC to Left Headphone Mixer select<br>0 = Disabled<br>1 = Enabled |

| REGISTER ADDRESS | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                     |
|------------------|-----|----------------------|---------|---------------------------------------------------------------------------------|
|                  | 3   | MIXINL_TO_HP<br>MIXL | 0       | Left Input Mixer to Left Headphone Mixer select<br>0 = Disabled<br>1 = Enabled  |
|                  | 2   | MIXINR_TO_HP<br>MIXL | 0       | Right Input Mixer to Left Headphone Mixer select<br>0 = Disabled<br>1 = Enabled |
|                  | 1   | IN4L_TO_HPMI<br>XL   | 0       | Input IN4L to Left Headphone Mixer select<br>0 = Disabled<br>1 = Enabled        |
|                  | 0   | IN4R_TO_HPMI<br>XL   | 0       | Input IN4R to Left Headphone Mixer select<br>0 = Disabled<br>1 = Enabled        |

**Register 64h** Headphone Mixer (1)

| REGISTER ADDRESS                     | BIT | LABEL                    | DEFAULT | DESCRIPTION                                                                      |
|--------------------------------------|-----|--------------------------|---------|----------------------------------------------------------------------------------|
| R101 (65h)<br>Headphone<br>Mixer (2) | 7   | HPMIXR_TO_H<br>POUTR_PGA | 0       | Right Headphone PGA Path Select<br>0 = DACR Output<br>1 = HPMIXR Output          |
|                                      | 5   | DACL_TO_HP<br>IXR        | 0       | Left DAC to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled          |
|                                      | 4   | DACR_TO_HP<br>MIXR       | 0       | Right DAC to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled         |
|                                      | 3   | MIXINL_TO_HP<br>MIXR     | 0       | Left Input Mixer to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled  |
|                                      | 2   | MIXINR_TO_HP<br>MIXR     | 0       | Right Input Mixer to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled |
|                                      | 1   | IN4L_TO_HPMI<br>XR       | 0       | Input IN4L to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled        |
|                                      | 0   | IN4R_TO_HPMI<br>XR       | 0       | Input IN4R to Right Headphone Mixer select<br>0 = Disabled<br>1 = Enabled        |

**Register 65h** Headphone Mixer (2)

| REGISTER ADDRESS                     | BIT | LABEL                     | DEFAULT | DESCRIPTION                                                             |
|--------------------------------------|-----|---------------------------|---------|-------------------------------------------------------------------------|
| R102 (66h)<br>Headphone<br>Mixer (3) | 8   | HPMIXL_MUTE               | 1       | Left Headphone Mixer Mute<br>0 = Unmuted<br>1 = Muted                   |
|                                      | 7   | MIXINL_HPMIX<br>L_VOL     | 0       | Left Input Mixer to Left Headphone Mixer volume<br>0 = 0dB<br>1 = -6dB  |
|                                      | 6   | MIXINR_HPMIX<br>L_VOL     | 0       | Right Input Mixer to Left Headphone Mixer volume<br>0 = 0dB<br>1 = -6dB |
|                                      | 5:3 | IN4L_HPMIXL_<br>VOL [2:0] | 111     | Input IN4L to Left Headphone Mixer Volume control<br>000 = -15dB        |



| REGISTER ADDRESS | BIT | LABEL                 | DEFAULT | DESCRIPTION                                                                                                                                                        |
|------------------|-----|-----------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     |                       |         | 001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB                                                                     |
|                  | 2:0 | IN4R_HPMIXL_VOL [2:0] | 111     | Input IN4R to Left Headphone Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |

**Register 66h** Headphone Mixer (3)

| REGISTER ADDRESS                  | BIT | LABEL                 | DEFAULT | DESCRIPTION                                                                                                                                                         |
|-----------------------------------|-----|-----------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R103 (67h)<br>Headphone Mixer (4) | 8   | HPMIXR_MUTE           | 1       | Right Headphone Mixer Mute<br>0 = Unmuted<br>1 = Muted                                                                                                              |
|                                   | 7   | MIXINL_HPMIXR_VOL     | 0       | Left Input Mixer to Right Headphone Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                             |
|                                   | 6   | MIXINR_HPMIXR_VOL     | 0       | Right Input Mixer to Right Headphone Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                            |
|                                   | 5:3 | IN4L_HPMIXR_VOL [2:0] | 111     | Input IN4L to Right Headphone Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |
|                                   | 2:0 | IN4R_HPMIXR_VOL [2:0] | 111     | Input IN4R to Right Headphone Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |

**Register 67h** Headphone Mixer (4)

| REGISTER ADDRESS      | BIT | LABEL                  | DEFAULT | DESCRIPTION                                     |
|-----------------------|-----|------------------------|---------|-------------------------------------------------|
| R105 (69h)<br>Speaker | 7   | SPKMIXL_TO_SPKOUTL_PGA | 0       | Left Speaker PGA Path Select<br>0 = DACL Output |

| REGISTER ADDRESS | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                   |
|------------------|-----|--------------------|---------|-------------------------------------------------------------------------------|
| Mixer (1)        |     |                    |         | 1 = SPKMIXL Output                                                            |
|                  | 5   | DACL_TO_SPK MIXL   | 0       | Left DAC to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled          |
|                  | 4   | DACR_TO_SPK MIXL   | 0       | Right DAC to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled         |
|                  | 3   | MIXINL_TO_SP KMIXL | 0       | Left Input Mixer to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled  |
|                  | 2   | MIXINR_TO_SP KMIXL | 0       | Right Input Mixer to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled |
|                  | 1   | IN4L_TO_SPKM IXL   | 0       | Input IN4L to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled        |
|                  | 0   | IN4R_TO_SPK MIXL   | 0       | Input IN4R to Left Speaker Mixer select<br>0 = Disabled<br>1 = Enabled        |

**Register 69h** Speaker Mixer (1)

| REGISTER ADDRESS                | BIT | LABEL                  | DEFAULT | DESCRIPTION                                                                    |
|---------------------------------|-----|------------------------|---------|--------------------------------------------------------------------------------|
| R106 (6Ah)<br>Speaker Mixer (2) | 7   | SPKMIXR_TO_SPKOUTR_PGA | 0       | Right Speaker PGA Path Select<br>0 = DACR Output<br>1 = SPKMIXR Output         |
|                                 | 5   | DACL_TO_SPK MIXR       | 0       | Left DAC to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled          |
|                                 | 4   | DACR_TO_SPK MIXR       | 0       | Right DAC to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled         |
|                                 | 3   | MIXINL_TO_SP KMIXR     | 0       | Left Input Mixer to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled  |
|                                 | 2   | MIXINR_TO_SP KMIXR     | 0       | Right Input Mixer to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled |
|                                 | 1   | IN4L_TO_SPKM IXR       | 0       | Input IN4L to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled        |
|                                 | 0   | IN4R_TO_SPK MIXR       | 0       | Input IN4R to Right Speaker Mixer select<br>0 = Disabled<br>1 = Enabled        |

**Register 6Ah** Speaker Mixer (2)

| REGISTER ADDRESS                | BIT | LABEL        | DEFAULT | DESCRIPTION                                         |
|---------------------------------|-----|--------------|---------|-----------------------------------------------------|
| R107 (6Bh)<br>Speaker Mixer (3) | 8   | SPKMIXL_MUTE | 1       | Left Speaker Mixer Mute<br>0 = Unmuted<br>1 = Muted |
|                                 | 7   | MIXINL_SPKMI | 0       | Left Input Mixer to Left Speaker Mixer volume       |

| REGISTER ADDRESS | BIT | LABEL                      | DEFAULT | DESCRIPTION                                                                                                                                                      |
|------------------|-----|----------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     | XL_VOL                     |         | 0 = 0dB<br>1 = -6dB                                                                                                                                              |
|                  | 6   | MIXINR_SPKMI<br>XL_VOL     | 0       | Right Input Mixer to Left Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                            |
|                  | 5:3 | IN4L_SPKMIXL<br>_VOL [2:0] | 111     | Input IN4L to Left Speaker Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |
|                  | 2:0 | IN4R_SPKMIXL<br>_VOL [2:0] | 111     | Input IN4R to Left Speaker Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |

**Register 6Bh Speaker Mixer (3)**

| REGISTER ADDRESS                   | BIT | LABEL                      | DEFAULT | DESCRIPTION                                                                                                                                                       |
|------------------------------------|-----|----------------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R108 (6Ch)<br>Speaker<br>Mixer (4) | 8   | SPKMIXR_MUT<br>E           | 1       | Right Speaker Mixer Mute<br>0 = Unmuted<br>1 = Muted                                                                                                              |
|                                    | 7   | MIXINL_SPKMI<br>XR_VOL     | 0       | Left Input Mixer to Right Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                             |
|                                    | 6   | MIXINR_SPKMI<br>XR_VOL     | 0       | Right Input Mixer to Right Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB                                                                                            |
|                                    | 5:3 | IN4L_SPKMIXR<br>_VOL [2:0] | 111     | Input IN4L to Right Speaker Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |
|                                    | 2:0 | IN4R_SPKMIXR<br>_VOL [2:0] | 111     | Input IN4R to Right Speaker Mixer Volume control<br>000 = -15dB<br>001 = -12dB<br>010 = -9dB<br>011 = -6dB<br>100 = -3dB<br>101 = 0dB<br>110 = +3dB<br>111 = +6dB |

**Register 6Ch Speaker Mixer (4)**

| REGISTER ADDRESS                | BIT | LABEL             | DEFAULT | DESCRIPTION                                                    |
|---------------------------------|-----|-------------------|---------|----------------------------------------------------------------|
| R109 (6Dh)<br>Speaker Mixer (5) | 7   | DACL_SPKMIX_L_VOL | 0       | Left DAC to Left Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB   |
|                                 | 6   | DACR_SPKMIX_L_VOL | 0       | Right DAC to Left Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB  |
|                                 | 5   | DACL_SPKMIX_R_VOL | 0       | Left DAC to Right Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB  |
|                                 | 4   | DACR_SPKMIX_R_VOL | 0       | Right DAC to Right Speaker Mixer volume<br>0 = 0dB<br>1 = -6dB |
|                                 | 1   | Reserved          | 1       | Reserved - do not change                                       |
|                                 | 0   | Reserved          | 1       | Reserved - do not change                                       |

**Register 6Dh Speaker Mixer (5)**

| REGISTER ADDRESS                 | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                 |
|----------------------------------|-----|-----------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R110 (6Eh)<br>Beep Generator (1) | 7:4 | BEEP_GAIN [3:0] | 0000    | Digital Beep Volume Control<br>0000 = mute<br>0001 = -90dB<br>0010 = -84dB<br>... (6dB steps)<br>1111 = -6dB                                                                                                                                |
|                                  | 2:1 | BEEP_RATE [1:0] | 01      | Digital Beep Waveform Control<br>If SAMPLE_RATE_INT_MODE = 1<br>00 = 500Hz<br>01 = 1000Hz<br>10 = 2000Hz<br>11 = 4000Hz<br>If SAMPLE_RATE_INT_MODE = 0<br>00 = 499 – 502Hz<br>01 = 999 – 1003Hz<br>10 = 1998 – 2005Hz<br>11 = 3997 – 4009Hz |
|                                  | 0   | BEEP_ENA        | 0       | Digital Beep Enable<br>0 = Disabled<br>1 = Enabled<br>Note that the DAC and associated signal path needs to be enabled when using the digital beep.                                                                                         |

**Register 6Eh Beep Generator (1)**

| REGISTER ADDRESS                  | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                                                          |
|-----------------------------------|-----|--------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R115 (73h)<br>Oscillator Trim (3) | 4:0 | OSC_TRIM_XTI [4:0] | 0_0000  | Trimmed Oscillator XTI capacitance<br>00h = 8pF<br>01h = 8.5pF<br>... 0.5pF steps<br>1Eh = 23pF<br>1Fh = 23.5pF<br>This field is for read-back only; it is set automatically and cannot be adjusted. |

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                       |
|------------------|-----|-------|---------|-----------------------------------|
|                  |     |       |         | <i>Protected by security key.</i> |

**Register 73h** Oscillator Trim (3)

| REGISTER ADDRESS                  | BIT | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                                                                                               |
|-----------------------------------|-----|-------------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R116 (74h)<br>Oscillator Trim (4) | 4:0 | OSC_TRIM_XTO<br>O [4:0] | 0_0000  | Trimmed Oscillator XTO capacitance<br>00h = 8pF<br>01h = 8.5pF<br>... 0.5pF steps<br>1Eh = 23pF<br>1Fh = 23.5pF<br>This field is for read-back only; it is set automatically and cannot be adjusted.<br><i>Protected by security key.</i> |

**Register 74h** Oscillator Trim (4)

| REGISTER ADDRESS                  | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                             |
|-----------------------------------|-----|----------------------|---------|---------------------------------------------------------------------------------------------------------|
| R119 (77h)<br>Oscillator Trim (7) | 7:4 | XTO_CAP_SEL<br>[3:0] | 0000    | XTO load capacitance adjustment<br>Two's complement format,<br>LSB = 0.5pF<br>Range is -4.0pF to +3.5pF |
|                                   | 3:0 | XTI_CAP_SEL<br>[3:0] | 0000    | XTI load capacitance adjustment<br>Two's complement format,<br>LSB = 0.5pF<br>Range is -4.0pF to +3.5pF |

**Register 77h** Oscillator Trim (7)

| REGISTER ADDRESS                 | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                            |
|----------------------------------|-----|----------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R124 (7Ch)<br>Analogue Clocking1 | 6:5 | CLKOUT2_SEL<br>[1:0] | 00      | CLKOUT2 Output Select<br>00 = PLL2<br>01 = GPIO2<br>10 = Internal oscillator<br>11 = Reserved                                                                                                                                                                                                          |
|                                  | 4:3 | CLKOUT3_SEL<br>[1:0] | 10      | CLKOUT3 Output Select<br>00 = PLL3<br>01 = GPIO3<br>10 = FLL<br>11 = Reserved<br>If CLKREG_OVD = 0, then CLKOUT3_SEL = 10 (FLL) and cannot be changed by the Control Interface.<br>If CLKREG_OVD = 1, then CLKOUT3_SEL = 00 (PLL3) by default, but the value can be changed via the Control Interface. |
|                                  | 0   | CLKOUT5_SEL          | 1       | CLKOUT5 Output Select<br>0 = Internal oscillator<br>1 = FLL<br>If CLKREG_OVD = 0, then CLKOUT5_SEL is controlled by the GPIO5 pin.<br>If CLKREG_OVD = 0 and GPIO5 = 0, then CLKOUT5_SEL = 1 (FLL) and cannot be changed by the Control Interface.                                                      |

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                       |
|------------------|-----|-------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     |       |         | If CLKREG_OVD = 0 and GPIO5 = 1, then CLKOUT5_SEL = 0 (Oscillator) by default, but the value can be changed via the Control Interface.<br>If CLKREG_OVD = 1 then CLKOUT5_SEL = 0 (Oscillator) by default, but the value can be changed via the Control Interface. |

**Register 7Ch** Analogue Clocking1

| REGISTER ADDRESS                    | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                         |
|-------------------------------------|-----|----------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R125 (7Dh)<br>Analogue<br>Clocking2 | 7   | PLL2_OUTDIV          | 0       | PLL2 Output Divider<br>0 = Divide by 2<br>1 = Divide by 4                                                                                                                                                                                                                           |
|                                     | 6   | PLL3_OUTDIV          | 1       | PLL3 Output Divider<br>0 = Divide by 2<br>1 = Divide by 4                                                                                                                                                                                                                           |
|                                     | 4:3 | PLL_SYSCLK_DIV [1:0] | 01      | PLL3 / Oscillator to MCLK divider<br>00 = Divide by 1<br>01 = Divide by 2<br>10 = Divide by 4<br>11 = Reserved                                                                                                                                                                      |
|                                     | 2   | CLKOUT3_DIV          | 0       | CLKOUT3 Output Divide<br>0 = Divide by 1<br>1 = Divide by 2                                                                                                                                                                                                                         |
|                                     | 1   | CLKOUT2_DIV          | 1       | CLKOUT2 Output Divide<br>0 = Divide by 1<br>1 = Divide by 2<br>If CLKREG_OVD = 0, then CLKOUT2_DIV = 1 (Divide by 2) and cannot be changed by the Control Interface.<br>If CLKREG_OVD = 1, then CLKOUT2_DIV = 0 by default, but the value can be changed via the Control Interface. |
|                                     | 0   | CLKOUT5_DIV          | 1       | CLKOUT5 Output Divide<br>0 = Divide by 1<br>1 = Divide by 2<br>If CLKREG_OVD = 0, then CLKOUT5_DIV = 1 (Divide by 2) and cannot be changed by the Control Interface.<br>If CLKREG_OVD = 1, then CLKOUT5_DIV = 0 by default, but the value can be changed via the Control Interface. |

**Register 7Dh** Analogue Clocking2

| REGISTER ADDRESS                    | BIT | LABEL      | DEFAULT | DESCRIPTION                                                      |
|-------------------------------------|-----|------------|---------|------------------------------------------------------------------|
| R126 (7Eh)<br>Analogue<br>Clocking3 | 4   | Reserved   | 1       | Reserved - do not change                                         |
|                                     | 3   | CLKOUT2_OE | 1       | CLKOUT2 Output Enable<br>0 = Disabled (tri-state)<br>1 = Enabled |
|                                     | 2   | CLKOUT3_OE | 1       | CLKOUT3 Output Enable<br>0 = Disabled (tri-state)<br>1 = Enabled |
|                                     | 1   | Reserved   | 1       | Reserved - do not change                                         |
|                                     | 0   | CLKOUT5_OE | 1       | CLKOUT5 Output Enable<br>0 = Disabled (tri-state)<br>1 = Enabled |

**Register 7Eh Analogue Clocking3**

| REGISTER ADDRESS                 | BIT  | LABEL                   | DEFAULT                     | DESCRIPTION                                                                                                                          |
|----------------------------------|------|-------------------------|-----------------------------|--------------------------------------------------------------------------------------------------------------------------------------|
| R127 (7Fh)<br>PLL Software Reset | 15:0 | SW_RESET_PL<br>L [15:0] | 0000_0000<br>_0000_000<br>0 | Writing to this register resets all PLL registers to their default state.<br>This affects registers R114 (72h) through to R152 (98h) |

**Register 7Fh PLL Software Reset**

| REGISTER ADDRESS   | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                    |
|--------------------|-----|----------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R129 (81h)<br>PLL2 | 7   | OSC_ENA  | 0       | Internal Oscillator Enable<br>0 = Disabled<br>1 = Enabled<br>If CLKREG_OVD = 0 and GPIO5 = 0, then OSC_ENA = 0 and cannot be changed by the Control Interface<br>If CLKREG_OVD = 0 and GPIO5 = 1, then OSC_ENA = 1 by default, but the value can be changed via the Control Interface<br>If CLKREG_OVD = 1 then OSC_ENA = 1 by default, but the value can be changed via the Control Interface |
|                    | 5   | PLL2_ENA | 0       | PLL2 Enable<br>0 = Disabled<br>1 = Enabled<br>If CLKREG_OVD = 0, then PLL2_ENA = 0 (Disabled) and cannot be changed by the Control Interface.<br>If CLKREG_OVD = 1, then PLL2_ENA = 1 by default, but the value can be changed via the Control Interface.                                                                                                                                      |
|                    | 4   | PLL3_ENA | 0       | PLL3 Enable<br>0 = Disabled<br>1 = Enabled<br>If CLKREG_OVD = 0, then PLL3_ENA = 0 (Disabled) and cannot be changed by the Control Interface.<br>If CLKREG_OVD = 1, then PLL3_ENA = 1 by default, but the value can be changed via the Control Interface.                                                                                                                                      |
|                    | 0   | Reserved | 1       | Reserved - do not change                                                                                                                                                                                                                                                                                                                                                                       |

**Register 81h PLL2**

| REGISTER ADDRESS    | BIT | LABEL       | DEFAULT | DESCRIPTION                                                                                                                                                               |
|---------------------|-----|-------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R131 (83h)<br>PLL 4 | 4   | Reserved    | 1       | Reserved - do not change                                                                                                                                                  |
|                     | 1   | PLL_CLK_SRC | 0       | PLL Clock Source<br>0 = Internal oscillator<br>1 = MCLK<br>Note that the SEQ_ENA bit (Register R150, 96h) must be set to 0 when MCLK is selected as the PLL Clock Source. |
|                     | 0   | FLL_TO_PLL3 | 0       | PLL3 Clock Source<br>0 = Selected by PLL_CLK_SRC<br>1 = FLL                                                                                                               |

**Register 83h PLL 4**

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION |
|------------------|-----|-------|---------|-------------|
|------------------|-----|-------|---------|-------------|

| REGISTER ADDRESS    | BIT | LABEL        | DEFAULT | DESCRIPTION                                                                     |
|---------------------|-----|--------------|---------|---------------------------------------------------------------------------------|
| R136 (88h)<br>PLL 9 | 6   | PLL2_FRAC    | 1       | PLL2 Fractional enable<br>0 = Integer Mode<br>1 = Fractional Mode (recommended) |
|                     | 4:0 | PLL2_N [4:0] | 0_0111  | Integer Multiply for PLL2<br>(LSB = 1)                                          |

**Register 88h PLL 9**

| REGISTER ADDRESS     | BIT | LABEL        | DEFAULT   | DESCRIPTION                                                                         |
|----------------------|-----|--------------|-----------|-------------------------------------------------------------------------------------|
| R137 (89h)<br>PLL 10 | 7:0 | PLL2_K [7:0] | 0001_1100 | Fractional Multiply for PLL2<br>(MSB = 0.5)<br>This is bits 23:16 of a 24-bit field |

**Register 89h PLL 10**

| REGISTER ADDRESS     | BIT | LABEL        | DEFAULT   | DESCRIPTION                                                                        |
|----------------------|-----|--------------|-----------|------------------------------------------------------------------------------------|
| R138 (8Ah)<br>PLL 11 | 7:0 | PLL2_K [7:0] | 0111_0001 | Fractional Multiply for PLL2<br>(MSB = 0.5)<br>This is bits 15:8 of a 24-bit field |

**Register 8Ah PLL 11**

| REGISTER ADDRESS     | BIT | LABEL        | DEFAULT   | DESCRIPTION                                                                       |
|----------------------|-----|--------------|-----------|-----------------------------------------------------------------------------------|
| R139 (8Bh)<br>PLL 12 | 7:0 | PLL2_K [7:0] | 1100_0111 | Fractional Multiply for PLL2<br>(MSB = 0.5)<br>This is bits 7:0 of a 24-bit field |

**Register 8Bh PLL 12**

| REGISTER ADDRESS     | BIT | LABEL        | DEFAULT | DESCRIPTION                                                                     |
|----------------------|-----|--------------|---------|---------------------------------------------------------------------------------|
| R140 (8Ch)<br>PLL 13 | 6   | PLL3_FRAC    | 1       | PLL3 Fractional enable<br>0 = Integer Mode<br>1 = Fractional Mode (recommended) |
|                      | 4:0 | PLL3_N [4:0] | 0_0111  | Integer Multiply for PLL3<br>(LSB = 1)                                          |

**Register 8Ch PLL 13**

| REGISTER ADDRESS     | BIT | LABEL        | DEFAULT   | DESCRIPTION                                                                         |
|----------------------|-----|--------------|-----------|-------------------------------------------------------------------------------------|
| R141 (8Dh)<br>PLL 14 | 7:0 | PLL3_K [7:0] | 0100_1000 | Fractional Multiply for PLL3<br>(MSB = 0.5)<br>This is bits 23:16 of a 24-bit field |

**Register 8Dh PLL 14**

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION |
|------------------|-----|-------|---------|-------------|
|------------------|-----|-------|---------|-------------|



| REGISTER ADDRESS     | BIT | LABEL        | DEFAULT   | DESCRIPTION                                                                        |
|----------------------|-----|--------------|-----------|------------------------------------------------------------------------------------|
| R142 (8Eh)<br>PLL 15 | 7:0 | PLL3_K [7:0] | 0010_0010 | Fractional Multiply for PLL3<br>(MSB = 0.5)<br>This is bits 15:8 of a 24-bit field |

**Register 8Eh PLL 15**

| REGISTER ADDRESS     | BIT | LABEL        | DEFAULT   | DESCRIPTION                                                                       |
|----------------------|-----|--------------|-----------|-----------------------------------------------------------------------------------|
| R143 (8Fh)<br>PLL 16 | 7:0 | PLL3_K [7:0] | 1001_0111 | Fractional Multiply for PLL3<br>(MSB = 0.5)<br>This is bits 7:0 of a 24-bit field |

**Register 8Fh PLL 16**

| REGISTER ADDRESS      | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                             |
|-----------------------|-----|----------|---------|-----------------------------------------------------------------------------------------------------------------------------------------|
| R150 (96h)<br>PLL DLL | 1   | SEQ_ENA  | 1       | PLL Control Sequencer Enable<br>0 = Disabled<br>1 = Enabled<br>This bit must be set to 0 when MCLK is selected as the PLL Clock Source. |
|                       | 0   | Reserved | 1       | Reserved - do not change                                                                                                                |

**Register 96h PLL DLL**

| REGISTER ADDRESS                     | BIT | LABEL        | DEFAULT | DESCRIPTION                                                                                                               |
|--------------------------------------|-----|--------------|---------|---------------------------------------------------------------------------------------------------------------------------|
| R152 (98h)<br>Analogue<br>Clocking 4 | 7   |              | 1       | Reserved - do not change                                                                                                  |
|                                      | 6   |              | 1       | Reserved - do not change                                                                                                  |
|                                      | 4   | OSC_MCLK_SRC | 0       | PLL3 / Oscillator to MCLK source<br>0 = PLL3<br>1 = Oscillator<br>This field selects the MCLK source, when MCLK_SRC = 10. |

**Register 98h Analogue Clocking 4**

| REGISTER ADDRESS                 | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                           |
|----------------------------------|-----|----------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------|
| R155 (9Bh)<br>FLL Control<br>(1) | 6:5 | FLL_REFCLK_SRC [1:0] | 00      | FLL Clock Source<br>00 = MCLK<br>01 = BCLK<br>10 = Internal oscillator<br>11 = Reserved                                               |
|                                  | 3   | Reserved             | 1       | Reserved - do not change                                                                                                              |
|                                  | 2   | FLL_FRAC             | 1       | FLL Fractional Mode enable<br>0 = Integer Mode<br>1 = Fractional Mode<br><br>Fractional Mode (FLL_FRAC=1) is recommended in all cases |
|                                  | 1   | FLL_OSC_ENA          | 0       | FLL Oscillator enable<br>0 = Disabled<br>1 = Enabled<br>(Note that this field is required for free-running FLL modes)                 |

| REGISTER ADDRESS | BIT | LABEL   | DEFAULT | DESCRIPTION                               |
|------------------|-----|---------|---------|-------------------------------------------|
|                  |     |         |         | only)                                     |
|                  | 0   | FLL_ENA | 0       | FLL Enable<br>0 = Disabled<br>1 = Enabled |

**Register 9Bh** FLL Control (1)

| REGISTER ADDRESS              | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                         |
|-------------------------------|-----|----------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R156 (9Ch)<br>FLL Control (2) | 8:3 | FLL_OUTDIV [5:0]     | 00_0111 | FLL FOUT clock ratio<br>000000 = Reserved<br>000001 = 2<br>000010 = 3<br>000011 = 4<br>000100 = 5<br>000101 = 6<br>...<br>111110 = 63<br>111111 = 64<br>(FOUT = FVCO / FLL_OUTDIV)                                                                                  |
|                               | 1:0 | FLL_REFCLK_DIV [1:0] | 01      | FLL Clock Reference Divider<br>00 = MCLK / 1<br>01 = MCLK / 2<br>10 = MCLK / 4<br>11 = Reserved<br><br>MCLK (or other input reference) must be divided down to <=13.5MHz.<br>For lower power operation, the reference clock can be divided down further if desired. |

**Register 9Ch** FLL Control (2)

| REGISTER ADDRESS              | BIT | LABEL            | DEFAULT | DESCRIPTION                                                                                                                                             |
|-------------------------------|-----|------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------|
| R157 (9Dh)<br>FLL Control (3) | 8   | Reserved         | 1       | Reserved - do not change                                                                                                                                |
|                               | 7   | Reserved         | 1       | Reserved - do not change                                                                                                                                |
|                               | 2:0 | FLL_FRATIO [2:0] | 000     | FLL FVCO clock ratio<br>000 = 1<br>001 = 2<br>010 = 4<br>011 = 8<br>1XX = 16<br><br>000 recommended for FREF > 1MHz<br>011 recommended for FREF < 64kHz |

**Register 9Dh** FLL Control (3)

| REGISTER ADDRESS              | BIT | LABEL                 | DEFAULT | DESCRIPTION                                                                                                                                                      |
|-------------------------------|-----|-----------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R159 (9Fh)<br>FLL Control (5) | 6:1 | FLL_FRC_NCO_VAL [5:0] | 01_1001 | FLL Forced oscillator value<br>Valid range is 000000 to 111111<br>0x19h (011001) = 12MHz approx<br>(Note that this field is required for free-running FLL modes) |

| REGISTER ADDRESS | BIT | LABEL       | DEFAULT | DESCRIPTION                                                                                                                                                       |
|------------------|-----|-------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     |             |         | only)                                                                                                                                                             |
|                  | 0   | FLL_FRC_NCO | 0       | FLL Forced control select<br>0 = Normal<br>1 = FLL oscillator controlled by FLL_FRC_NCO_VAL<br>(Note that this field is required for free-running FLL modes only) |

**Register 9Fh** FLL Control (5)

| REGISTER ADDRESS                 | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                                                                                                                                                                      |
|----------------------------------|------|---------------------|-----------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R160 (A0h)<br>FLL Control<br>(6) | 15:0 | FLL_THETA<br>[15:0] | 0000_0000<br>_0001_100<br>0 | FLL Fractional multiply for FREF.<br>Only valid when FLL_FRAC = 1.<br>This field sets the numerator (multiply) part of the FLL_THETA / FLL_LAMBDA ratio. It is coded as LSB = 1. |

**Register A0h** FLL Control (6)

| REGISTER ADDRESS                 | BIT  | LABEL                | DEFAULT                     | DESCRIPTION                                                                                                                                                                                                                                                                     |
|----------------------------------|------|----------------------|-----------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R161 (A1h)<br>FLL Control<br>(7) | 15:0 | FLL_LAMBDA<br>[15:0] | 0000_0000<br>_0111_110<br>1 | FLL Fractional multiply for FREF.<br>Only valid when FLL_FRAC = 1.<br>This field sets the denominator (dividing) part of the FLL_THETA / FLL_LAMBDA ratio. It is coded as LSB = 1.<br>Note that it is required that FLL_LAMBDA > 0 in all cases (Integer and Fractional modes). |

**Register A1h** FLL Control (7)

| REGISTER ADDRESS                 | BIT | LABEL       | DEFAULT          | DESCRIPTION                                |
|----------------------------------|-----|-------------|------------------|--------------------------------------------|
| R162 (A2h)<br>FLL Control<br>(8) | 9:0 | FLL_N [9:0] | 00_0000_1<br>000 | FLL Integer multiply for FREF<br>(LSB = 1) |

**Register A2h** FLL Control (8)

| REGISTER ADDRESS                | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                        |
|---------------------------------|-----|----------|---------|----------------------------------------------------------------------------------------------------|
| R252 (FCh)<br>General test<br>1 | 2   | Reserved | 1       | Reserved - do not change                                                                           |
|                                 | 0   | AUTO_INC | 1       | Enables address auto-increment<br>(applies to 2-wire I2C mode only)<br>0 = Disabled<br>1 = Enabled |

**Register FCh** General test 1

| REGISTER ADDRESS    | BIT | LABEL                | DEFAULT | DESCRIPTION                                                               |
|---------------------|-----|----------------------|---------|---------------------------------------------------------------------------|
| R256 (0100h)<br>DF1 | 2   | DF1_SHARED_COEFF     | 0       | DF1 Shared Coefficients Enable<br>0 = Disabled<br>1 = Enabled             |
|                     | 1   | DF1_SHARED_COEFF_SEL | 0       | DF1 Shared Coefficients Select<br>0 = Both channels use left coefficients |

| REGISTER ADDRESS | BIT | LABEL   | DEFAULT | DESCRIPTION                                           |
|------------------|-----|---------|---------|-------------------------------------------------------|
|                  |     |         |         | 1 = Both channels use right coefficients              |
|                  | 0   | DF1_ENA | 0       | DF1 Enable in ADC path<br>0 = Disabled<br>1 = Enabled |

**Register 0100h DF1**

| REGISTER ADDRESS    | BIT  | LABEL                  | DEFAULT                     | DESCRIPTION                   |
|---------------------|------|------------------------|-----------------------------|-------------------------------|
| R257 (0101h)<br>DF2 | 15:0 | DF1_COEFF_L0<br>[15:0] | 0000_0000<br>_0000_000<br>0 | DF1 Filter Coefficient Left 0 |

**Register 0101h DF2**

| REGISTER ADDRESS    | BIT  | LABEL                  | DEFAULT                     | DESCRIPTION                   |
|---------------------|------|------------------------|-----------------------------|-------------------------------|
| R258 (0102h)<br>DF3 | 15:0 | DF1_COEFF_L1<br>[15:0] | 0000_0000<br>_0000_000<br>0 | DF1 Filter Coefficient Left 1 |

**Register 0102h DF3**

| REGISTER ADDRESS    | BIT  | LABEL                  | DEFAULT                     | DESCRIPTION                   |
|---------------------|------|------------------------|-----------------------------|-------------------------------|
| R259 (0103h)<br>DF4 | 15:0 | DF1_COEFF_L2<br>[15:0] | 0000_0000<br>_0000_000<br>0 | DF1 Filter Coefficient Left 2 |

**Register 0103h DF4**

| REGISTER ADDRESS    | BIT  | LABEL                   | DEFAULT                     | DESCRIPTION                    |
|---------------------|------|-------------------------|-----------------------------|--------------------------------|
| R260 (0104h)<br>DF5 | 15:0 | DF1_COEFF_R<br>0 [15:0] | 0000_0000<br>_0000_000<br>0 | DF1 Filter Coefficient Right 0 |

**Register 0104h DF5**

| REGISTER ADDRESS    | BIT  | LABEL                   | DEFAULT                     | DESCRIPTION                    |
|---------------------|------|-------------------------|-----------------------------|--------------------------------|
| R261 (0105h)<br>DF6 | 15:0 | DF1_COEFF_R<br>1 [15:0] | 0000_0000<br>_0000_000<br>0 | DF1 Filter Coefficient Right 1 |

**Register 0105h DF6**

| REGISTER ADDRESS    | BIT  | LABEL                   | DEFAULT                     | DESCRIPTION                    |
|---------------------|------|-------------------------|-----------------------------|--------------------------------|
| R262 (0106h)<br>DF7 | 15:0 | DF1_COEFF_R<br>2 [15:0] | 0000_0000<br>_0000_000<br>0 | DF1 Filter Coefficient Right 2 |

**Register 0106h DF7**

| REGISTER ADDRESS      | BIT | LABEL     | DEFAULT | DESCRIPTION                                                       |
|-----------------------|-----|-----------|---------|-------------------------------------------------------------------|
| R264 (0108h)<br>LHPF1 | 1   | LHPF_MODE | 0       | Low/High-Pass Filter mode select<br>0 = Low-Pass<br>1 = High-Pass |
|                       | 0   | LHPF_ENA  | 0       | Low/High-Pass Filter<br>0 = Disable<br>1 = Enable                 |

**Register 0108h LHPF1**

| REGISTER ADDRESS      | BIT  | LABEL                | DEFAULT                     | DESCRIPTION      |
|-----------------------|------|----------------------|-----------------------------|------------------|
| R265 (0109h)<br>LHPF2 | 15:0 | LHPF_COEFF<br>[15:0] | 0000_0000<br>_0000_000<br>0 | LHPF Coefficient |

**Register 0109h LHPF2**

| REGISTER ADDRESS           | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                 |
|----------------------------|-----|----------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------|
| R268<br>(010Ch)<br>THREED1 | 6   | ADC_MONOMI<br>X      | 0       | ADC Monomix enable<br>0 = Disabled<br>1 = Enabled<br>Note that THREED_ENA must be disabled for<br>ADC_MONOMIX to be effective.              |
|                            | 5   | THREED_SIGN<br>_L    | 0       | 3D Left Cross mixing polarity (from the right channel to the<br>left)<br>0 = Positive<br>1 = Negative                                       |
|                            | 4   | THREED_SIGN<br>_R    | 0       | 3D Right Cross mixing polarity (from the left channel to the<br>right)<br>0 = Positive<br>1 = Negative                                      |
|                            | 2   | THREED_LHPF<br>_MODE | 0       | 3D Low/High-Pass filter mode<br>0 = Low-Pass<br>1 = High-Pass                                                                               |
|                            | 1   | THREED_LHPF<br>_ENA  | 0       | 3D Low/High-Pass filter enable<br>0 = Disabled<br>1 = Enabled                                                                               |
|                            | 0   | THREED_ENA           | 0       | 3D Surround Sound enable<br>0 = Disabled<br>1 = Enabled<br>Note that setting THREED_ENA will cause any<br>ADC_MONOMIX setting to be ignored |

**Register 010Ch THREED1**

| REGISTER ADDRESS           | BIT   | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                         |
|----------------------------|-------|-------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R269<br>(010Dh)<br>THREED2 | 15:11 | THREED_FGAI<br>NL [4:0] | 0_0000  | 3D Left Forward Gain<br>00000 = Mute<br>00001 = -11.25dB<br>00010 = -10.875dB<br>(...in steps of -0.375dB)<br>11110 = -0.375dB<br>11111 = 0.0dB                                                                                                                     |
|                            | 10:6  | THREED_CGAI<br>NL [4:0] | 0_0000  | 3D Left Cross Gain (from the right channel to the left)<br>00000 = Mute<br>00001 = -11.25dB<br>00010 = -10.875dB<br>(...in steps of -0.375dB)<br>11110 = -0.375dB<br>11111 = 0.0dB                                                                                  |
|                            | 5:2   | THREED_DELA<br>YL [3:0] | 0000    | 3D Left Filter Delay (measured from the sample rate)<br>0000 = 0 samples<br>0001 = 1 samples<br>0010 = 2 samples<br>0011 = 3 samples<br>0100 = 4 samples<br>0101 = 5 samples<br>0110 = 6 samples<br>0111 = 7 samples<br>1000 = 8 samples<br>1001 to 1111 = Reserved |

**Register 010Dh THREED2**

| REGISTER ADDRESS           | BIT  | LABEL                        | DEFAULT                      | DESCRIPTION         |
|----------------------------|------|------------------------------|------------------------------|---------------------|
| R270<br>(010Eh)<br>THREED3 | 15:0 | THREED_LHPF<br>_COEFF [15:0] | 0000_0000<br>_0000_0000<br>0 | 3D LHPF coefficient |

**Register 010Eh THREED3**

| REGISTER ADDRESS           | BIT   | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                                         |
|----------------------------|-------|-------------------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R271<br>(010Fh)<br>THREED4 | 15:11 | THREED_FGAI<br>NR [4:0] | 0_0000  | 3D Right Forward Gain<br>00000 = Mute<br>00001 = -11.25dB<br>00010 = -10.875dB<br>(...in steps of -0.375dB)<br>11110 = -0.375dB<br>11111 = 0.0dB                                    |
|                            | 10:6  | THREED_CGAI<br>NR [4:0] | 0_0000  | 3D Right Cross Gain (from the left channel to the right)<br>00000 = Mute<br>00001 = -11.25dB<br>00010 = -10.875dB<br>(...in steps of -0.375dB)<br>11110 = -0.375dB<br>11111 = 0.0dB |
|                            | 5:2   | THREED_DELA<br>YR [3:0] | 0000    | 3D Filter Delay (measured from the sample rate)<br>0000 = 0 samples<br>0001 = 1 samples<br>0010 = 2 samples                                                                         |

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                     |
|------------------|-----|-------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     |       |         | 0011 = 3 samples<br>0100 = 4 samples<br>0101 = 5 samples<br>0110 = 6 samples<br>0111 = 7 samples<br>1000 = 8 samples<br>1001 to 1111 = Reserved |

**Register 010Fh THREED4**

| REGISTER ADDRESS      | BIT   | LABEL                 | DEFAULT | DESCRIPTION                                                                                                                                                                                                               |
|-----------------------|-------|-----------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R276 (0114h)<br>DRC 1 | 14:10 | DRC_SIG_DET_RMS [4:0] | 0_0000  | DRC Signal Detect RMS Threshold.<br>This is the RMS signal level for signal detect to be indicated when DRC_SIG_DET_MODE=1.<br>00000 = -27dB<br>00001 = -28.5dB<br>.... (1.5dB steps)<br>11110 = -72dB<br>11111 = -73.5dB |
|                       | 9:8   | DRC_SIG_DET_PK [1:0]  | 00      | DRC Signal Detect Peak Threshold.<br>This is the Peak/RMS ratio, or Crest Factor, level for signal detect to be indicated when DRC_SIG_DET_MODE=0.<br>00 = 14dB<br>01 = 20dB<br>10 = 26dB<br>11 = 32dB                    |
|                       | 7     | DRC_NG_ENA            | 0       | DRC Noise Gate Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                      |
|                       | 6     | DRC_SIG_DET_MODE      | 0       | DRC Signal Detect Mode<br>0 = Peak threshold mode<br>1 = RMS threshold mode                                                                                                                                               |
|                       | 5     | DRC_SIG_DET           | 0       | DRC Signal Detect Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                   |
|                       | 4     | DRC_KNEE2_OP_ENA      | 0       | DRC_KNEE2_OP Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                        |
|                       | 3     | DRC_QR                | 1       | DRC Quick-release Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                   |
|                       | 2     | DRC_ANTICLIP          | 1       | DRC Anti-clip Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                       |
|                       | 1     | DRC_MODE              | 0       | DRC path select<br>0 = ADC path<br>1 = DAC path                                                                                                                                                                           |
|                       | 0     | DRC_ENA               | 0       | DRC Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                 |

**Register 0114h DRC 1**

| REGISTER ADDRESS      | BIT  | LABEL             | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                    |
|-----------------------|------|-------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R277 (0115h)<br>DRC 2 | 12:9 | DRC_ATK [3:0]     | 0100    | Gain attack rate (seconds/6dB)<br>0000 = Reserved<br>0001 = 181us<br>0010 = 363us<br>0011 = 726us<br>0100 = 1.45ms<br>0101 = 2.9ms<br>0110 = 5.8ms<br>0111 = 11.6ms<br>1000 = 23.2ms<br>1001 = 46.4ms<br>1010 = 92.8ms<br>1011 = 185.6ms<br>1100-1111 = Reserved                                               |
|                       | 8:5  | DRC_DCY [3:0]     | 1001    | Gain decay rate (seconds/6dB)<br>0000 = 1.45ms<br>0001 = 2.9ms<br>0010 = 5.8ms<br>0011 = 11.6ms<br>0100 = 23.25ms<br>0101 = 46.5ms<br>0110 = 93ms<br>0111 = 186ms<br>1000 = 372ms<br>1001 = 743ms (default)<br>1010 = 1.49s<br>1011 = 2.97s<br>1100 = 5.94s<br>1101 = 11.89s<br>1110 = 23.78s<br>1111 = 47.56s |
|                       | 4:2  | DRC_MINGAIN [2:0] | 001     | Minimum gain the DRC can use to attenuate audio signals<br>000 = 0dB<br>001 = -12dB (default)<br>010 = -18dB<br>011 = -24dB<br>100 = -36dB<br>101to 111 = Reserved                                                                                                                                             |
|                       | 1:0  | DRC_MAXGAIN [1:0] | 01      | Maximum gain the DRC can use to boost audio signals (dB)<br>00 = 12dB<br>01 = 18dB (default)<br>10 = 24dB<br>11 = 36dB                                                                                                                                                                                         |

**Register 0115h DRC 2**

| REGISTER ADDRESS      | BIT   | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                         |
|-----------------------|-------|----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R278 (0116h)<br>DRC 3 | 15:12 | DRC_NG_MINGAIN [3:0] | 0000    | Minimum gain the DRC can use to attenuate audio signals when the noise gate is active.<br>0000 = -36dB<br>0001 = -30dB<br>0010 = -24dB<br>0011 = -18dB<br>0100 = -12dB<br>0101 = -6dB<br>0110 = 0dB |



| REGISTER ADDRESS | BIT   | LABEL                  | DEFAULT | DESCRIPTION                                                                                                                                                                          |
|------------------|-------|------------------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |       |                        |         | 0111 = 6dB<br>1000 = 12dB<br>1001 = 18dB<br>1010 = 24dB<br>1011 = 30dB<br>1100 to 1111 = Reserved                                                                                    |
|                  | 11:10 | DRC_QR_THR<br>[1:0]    | 00      | DRC Quick-release threshold (crest factor in dB)<br>00 = 12dB<br>01 = 18dB<br>10 = 24dB<br>11 = 30dB                                                                                 |
|                  | 9:8   | DRC_QR_DCY<br>[1:0]    | 00      | DRC Quick-release decay rate (seconds/6dB)<br>00 = 0.725ms<br>01 = 1.45ms<br>10 = 5.8ms<br>11 = reserved                                                                             |
|                  | 7:6   | DRC_NG_EXP<br>[1:0]    | 00      | Noise Gate slope<br>00 = 1 (no expansion)<br>01 = 2<br>10 = 4<br>11 = 8                                                                                                              |
|                  | 5:3   | DRC_HI_COMP<br>[2:0]   | 000     | Compressor slope (upper region)<br>000 = 1 (no compression)<br>001 = 1/2<br>010 = 1/4<br>011 = 1/8 (default)<br>100 = 1/16<br>101 = 0 (ALC Mode)<br>110 = Reserved<br>111 = Reserved |
|                  | 2:0   | DRC_LO_COMP<br>P [2:0] | 000     | Compressor slope (lower region)<br>000 = 1 (no compression)<br>001 = 1/2<br>010 = 1/4<br>011 = 1/8<br>100 = 0<br>101 to 111 = Reserved                                               |

**Register 0116h DRC 3**

| REGISTER ADDRESS      | BIT  | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                 |
|-----------------------|------|----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R279 (0117h)<br>DRC 4 | 10:5 | DRC_KNEE_IP<br>[5:0] | 00_0000 | Input signal level at the Compressor 'Knee'.<br>000000 = 0dB<br>000001 = -0.75dB<br>000010 = -1.5dB<br>... (-0.75dB steps)<br>111100 = -45dB<br>111101 to 111111 = Reserved |
|                       | 4:0  | DRC_KNEE_OP<br>[4:0] | 0_0000  | Output signal at the Compressor 'Knee'.<br>000000 = 0dB<br>000001 = -0.75dB<br>000010 = -1.5dB<br>... (-0.75dB steps)<br>111110 = -22.5dB<br>111111 = Reserved              |

**Register 0117h DRC 4**

| REGISTER ADDRESS      | BIT | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                                                                     |
|-----------------------|-----|-------------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R280 (0118h)<br>DRC 5 | 9:5 | DRC_KNEE2_IP<br>[4:0]   | 0_0000  | Input signal level at the Noise Gate threshold 'Knee2'.<br>00000 = -36dB<br>00001 = -37.5dB<br>00010 = -39dB<br>... (-1.5dB steps)<br>11110 = -81dB<br>11111 = -82.5dB<br>Only applicable when DRC_NG_ENA = 1.  |
|                       | 4:0 | DRC_KNEE2_OP<br>P [4:0] | 0_0000  | Output signal at the Noise Gate threshold 'Knee2'.<br>00000 = -30dB<br>00001 = -31.5dB<br>00010 = -33dB<br>... (-1.5dB steps)<br>11110 = -75dB<br>11111 = -76.5dB<br>Only applicable when DRC_KNEE2_OP_ENA = 1. |

**Register 0118h DRC 5**

| REGISTER ADDRESS             | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                                             |
|------------------------------|-----|----------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R285<br>(011Dh)<br>Tloopback | 1   | TLB_ENA  | 0       | T-Loopback Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                                        |
|                              | 0   | TLB_MODE | 0       | T-Loopback Mode Select<br>0: Left AIF Output = Left ADC; Right AIF Output = (Left DAC + Right DAC) / 2<br>1: Left AIF Output = (Left DAC + Right DAC) / 2; Right AIF Output = Right ADC |

**Register 011Dh Tloopback**

| REGISTER ADDRESS    | BIT | LABEL                   | DEFAULT | DESCRIPTION                                                                                                                                                      |
|---------------------|-----|-------------------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R335<br>(014Fh) EQ1 | 2   | EQ_SHARED_C<br>OEFF     | 1       | 5-Band EQ Shared Coefficient enable<br>0 = Right and Left channels use unique coefficients<br>1 = Left and right channels share filter coefficients              |
|                     | 1   | EQ_SHARED_C<br>OEFF_SEL | 0       | 5-Band EQ Shared Coefficient select<br>0 = Both channels use the left channel filter coefficients<br>1 = Both channels use the right channel filter coefficients |
|                     | 0   | EQ_ENA                  | 0       | 5-Band EQ Enable<br>0 = Disabled<br>1 = Enabled                                                                                                                  |

**Register 014Fh EQ1**

| REGISTER ADDRESS    | BIT   | LABEL                | DEFAULT | DESCRIPTION                                                                                                                       |
|---------------------|-------|----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------|
| R336 (0150h)<br>EQ2 | 15:11 | EQL_B1_GAIN<br>[4:0] | 0_1100  | Left Channel Band 1 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved |
|                     | 10:6  | EQL_B2_GAIN<br>[4:0] | 0_1100  | Left Channel Band 2 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved |
|                     | 5:1   | EQL_B3_GAIN<br>[4:0] | 0_1100  | Left Channel Band 3 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved |

**Register 0150h EQ2**

| REGISTER ADDRESS    | BIT   | LABEL                | DEFAULT | DESCRIPTION                                                                                                                       |
|---------------------|-------|----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------|
| R337 (0151h)<br>EQ3 | 15:11 | EQL_B4_GAIN<br>[4:0] | 0_1100  | Left Channel Band 4 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved |
|                     | 10:6  | EQL_B5_GAIN<br>[4:0] | 0_1100  | Left Channel Band 5 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved |

**Register 0151h EQ3**

| REGISTER ADDRESS    | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|---------------------|------|--------------------|-----------------------------|--------------------------------|
| R338 (0152h)<br>EQ4 | 15:0 | EQL_B1_A<br>[15:0] | 0000_1111<br>_1100_101<br>0 | 5 Band EQ Band 1 coefficient A |

**Register 0152h EQ4**

| REGISTER ADDRESS    | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|---------------------|------|--------------------|-----------------------------|--------------------------------|
| R339 (0153h)<br>EQ5 | 15:0 | EQL_B1_B<br>[15:0] | 0000_0100<br>_0000_000<br>0 | 5 Band EQ Band 1 coefficient B |

**Register 0153h EQ5**

| REGISTER ADDRESS    | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                     |
|---------------------|------|---------------------|-----------------------------|---------------------------------|
| R340 (0154h)<br>EQ6 | 15:0 | EQL_B1_PG<br>[15:0] | 0000_0000<br>_1101_100<br>0 | 5 Band EQ Band 1 coefficient PG |

**Register 0154h EQ6**

| REGISTER ADDRESS    | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|---------------------|------|--------------------|-----------------------------|--------------------------------|
| R341 (0155h)<br>EQ7 | 15:0 | EQL_B2_A<br>[15:0] | 0001_1110<br>_1011_010<br>1 | 5 Band EQ Band 2 coefficient A |

**Register 0155h EQ7**

| REGISTER ADDRESS    | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|---------------------|------|--------------------|-----------------------------|--------------------------------|
| R342 (0156h)<br>EQ8 | 15:0 | EQL_B2_B<br>[15:0] | 1111_0001<br>_0100_010<br>1 | 5 Band EQ Band 2 coefficient B |

**Register 0156h EQ8**

| REGISTER ADDRESS    | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|---------------------|------|--------------------|-----------------------------|--------------------------------|
| R343 (0157h)<br>EQ9 | 15:0 | EQL_B2_C<br>[15:0] | 0000_1011<br>_0111_010<br>1 | 5 Band EQ Band 2 coefficient C |

**Register 0157h EQ9**

| REGISTER ADDRESS     | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                     |
|----------------------|------|---------------------|-----------------------------|---------------------------------|
| R344 (0158h)<br>EQ10 | 15:0 | EQL_B2_PG<br>[15:0] | 0000_0001<br>_1100_010<br>1 | 5 Band EQ Band 2 coefficient PG |

**Register 0158h EQ10**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R345 (0159h)<br>EQ11 | 15:0 | EQL_B3_A<br>[15:0] | 0001_1100<br>_0101_100<br>0 | 5 Band EQ Band 3 coefficient A |

**Register 0159h EQ11**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R346 (015Ah)<br>EQ12 | 15:0 | EQL_B3_B<br>[15:0] | 1111_0011<br>_0111_001<br>1 | 5 Band EQ Band 3 coefficient B |

**Register 015Ah EQ12**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R347 (015Bh)<br>EQ13 | 15:0 | EQL_B3_C<br>[15:0] | 0000_1010<br>_0101_010<br>0 | 5 Band EQ Band 3 coefficient C |

**Register 015Bh EQ13**

| REGISTER ADDRESS     | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                     |
|----------------------|------|---------------------|-----------------------------|---------------------------------|
| R348 (015Ch)<br>EQ14 | 15:0 | EQL_B3_PG<br>[15:0] | 0000_0101<br>_0101_100<br>0 | 5 Band EQ Band 3 coefficient PG |

**Register 015Ch EQ14**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R349 (015Dh)<br>EQ15 | 15:0 | EQL_B4_A<br>[15:0] | 0001_0110<br>_1000_111<br>0 | 5 Band EQ Band 4 coefficient A |

**Register 015Dh EQ15**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R350 (015Eh)<br>EQ16 | 15:0 | EQL_B4_B<br>[15:0] | 1111_1000<br>_0010_100<br>1 | 5 Band EQ Band 4 coefficient B |

**Register 015Eh EQ16**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R351 (015Fh)<br>EQ17 | 15:0 | EQL_B4_C<br>[15:0] | 0000_0111<br>_1010_110<br>1 | 5 Band EQ Band 4 coefficient C |

**Register 015Fh EQ17**

| REGISTER ADDRESS     | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                     |
|----------------------|------|---------------------|-----------------------------|---------------------------------|
| R352 (0160h)<br>EQ18 | 15:0 | EQL_B4_PG<br>[15:0] | 0001_0001<br>_0000_001<br>1 | 5 Band EQ Band 2 coefficient PG |

**Register 0160h EQ18**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R353 (0161h)<br>EQ19 | 15:0 | EQL_B5_A<br>[15:0] | 0000_0101<br>_0110_010<br>0 | 5 Band EQ Band 5 coefficient A |

**Register 0161h EQ19**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R354 (0162h)<br>EQ20 | 15:0 | EQL_B5_B<br>[15:0] | 0000_0101<br>_0101_100<br>1 | 5 Band EQ Band 5 coefficient B |

**Register 0162h EQ20**

| REGISTER ADDRESS     | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                     |
|----------------------|------|---------------------|-----------------------------|---------------------------------|
| R355 (0163h)<br>EQ21 | 15:0 | EQL_B5_PG<br>[15:0] | 0100_0000<br>_0000_000<br>0 | 5 Band EQ Band 5 coefficient PG |

**Register 0163h EQ21**

| REGISTER ADDRESS     | BIT   | LABEL                | DEFAULT | DESCRIPTION                                                                                                                        |
|----------------------|-------|----------------------|---------|------------------------------------------------------------------------------------------------------------------------------------|
| R356 (0164h)<br>EQ22 | 15:11 | EQR_B1_GAIN<br>[4:0] | 0_1100  | Right Channel Band 1 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved |
|                      | 10:6  | EQR_B2_GAIN<br>[4:0] | 0_1100  | Right Channel Band 2 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved |
|                      | 5:1   | EQR_B3_GAIN<br>[4:0] | 0_1100  | Right Channel Band 3 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved |

**Register 0164h EQ22**

| REGISTER ADDRESS     | BIT   | LABEL                | DEFAULT | DESCRIPTION                                                                                                                        |
|----------------------|-------|----------------------|---------|------------------------------------------------------------------------------------------------------------------------------------|
| R357 (0165h)<br>EQ23 | 15:11 | EQR_B4_GAIN<br>[4:0] | 0_1100  | Right Channel Band 4 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved |
|                      | 10:6  | EQR_B5_GAIN<br>[4:0] | 0_1100  | Right Channel Band 5 EQ Gain<br>0_0000 = -12dB<br>0_0001 = -11dB<br>...1dB steps to<br>1_1000 = +12dB<br>1_1001 to 1_1111 reserved |

**Register 0165h EQ23**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R358 (0166h)<br>EQ24 | 15:0 | EQR_B1_A<br>[15:0] | 0000_1111<br>_1100_101<br>0 | 5 Band EQ Band 1 coefficient A |

**Register 0166h EQ24**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R359 (0167h)<br>EQ25 | 15:0 | EQR_B1_B<br>[15:0] | 0000_0100<br>_0000_000<br>0 | 5 Band EQ Band 1 coefficient B |

**Register 0167h EQ25**

| REGISTER ADDRESS     | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                     |
|----------------------|------|---------------------|-----------------------------|---------------------------------|
| R360 (0168h)<br>EQ26 | 15:0 | EQR_B1_PG<br>[15:0] | 0000_0000<br>_1101_100<br>0 | 5 Band EQ Band 1 coefficient PG |

**Register 0168h EQ26**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R361 (0169h)<br>EQ27 | 15:0 | EQR_B2_A<br>[15:0] | 0001_1110<br>_1011_010<br>1 | 5 Band EQ Band 2 coefficient A |

**Register 0169h EQ27**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R362 (016Ah)<br>EQ28 | 15:0 | EQR_B2_B<br>[15:0] | 1111_0001<br>_0100_010<br>1 | 5 Band EQ Band 2 coefficient B |

**Register 016Ah EQ28**

| REGISTER ADDRESS        | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|-------------------------|------|--------------------|-----------------------------|--------------------------------|
| R363<br>(016Bh)<br>EQ29 | 15:0 | EQR_B2_C<br>[15:0] | 0000_1011<br>_0111_010<br>1 | 5 Band EQ Band 2 coefficient C |

**Register 016Bh EQ29**

| REGISTER ADDRESS        | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                     |
|-------------------------|------|---------------------|-----------------------------|---------------------------------|
| R364<br>(016Ch)<br>EQ30 | 15:0 | EQR_B2_PG<br>[15:0] | 0000_0001<br>_1100_010<br>1 | 5 Band EQ Band 2 coefficient PG |

**Register 016Ch EQ30**

| REGISTER ADDRESS        | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|-------------------------|------|--------------------|-----------------------------|--------------------------------|
| R365<br>(016Dh)<br>EQ31 | 15:0 | EQR_B3_A<br>[15:0] | 0001_1100<br>_0101_100<br>0 | 5 Band EQ Band 3 coefficient A |

**Register 016Dh EQ31**

| REGISTER ADDRESS        | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|-------------------------|------|--------------------|-----------------------------|--------------------------------|
| R366<br>(016Eh)<br>EQ32 | 15:0 | EQR_B3_B<br>[15:0] | 1111_0011<br>_0111_001<br>1 | 5 Band EQ Band 3 coefficient B |

**Register 016Eh EQ32**

| REGISTER ADDRESS        | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|-------------------------|------|--------------------|-----------------------------|--------------------------------|
| R367<br>(016Fh)<br>EQ33 | 15:0 | EQR_B3_C<br>[15:0] | 0000_1010<br>_0101_010<br>0 | 5 Band EQ Band 3 coefficient C |

**Register 016Fh EQ33**

| REGISTER ADDRESS     | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                     |
|----------------------|------|---------------------|-----------------------------|---------------------------------|
| R368 (0170h)<br>EQ34 | 15:0 | EQR_B3_PG<br>[15:0] | 0000_0101<br>_0101_100<br>0 | 5 Band EQ Band 3 coefficient PG |

**Register 0170h EQ34**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R369 (0171h)<br>EQ35 | 15:0 | EQR_B4_A<br>[15:0] | 0001_0110<br>_1000_111<br>0 | 5 Band EQ Band 4 coefficient A |

**Register 0171h EQ35**



| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R370 (0172h)<br>EQ36 | 15:0 | EQR_B4_B<br>[15:0] | 1111_1000<br>_0010_100<br>1 | 5 Band EQ Band 4 coefficient B |

**Register 0172h EQ36**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R371 (0173h)<br>EQ37 | 15:0 | EQR_B4_C<br>[15:0] | 0000_0111<br>_1010_110<br>1 | 5 Band EQ Band 4 coefficient C |

**Register 0173h EQ37**

| REGISTER ADDRESS     | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                     |
|----------------------|------|---------------------|-----------------------------|---------------------------------|
| R372 (0174h)<br>EQ38 | 15:0 | EQR_B4_PG<br>[15:0] | 0001_0001<br>_0000_001<br>1 | 5 Band EQ Band 2 coefficient PG |

**Register 0174h EQ38**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R373 (0175h)<br>EQ39 | 15:0 | EQR_B5_A<br>[15:0] | 0000_0101<br>_0110_010<br>0 | 5 Band EQ Band 5 coefficient A |

**Register 0175h EQ39**

| REGISTER ADDRESS     | BIT  | LABEL              | DEFAULT                     | DESCRIPTION                    |
|----------------------|------|--------------------|-----------------------------|--------------------------------|
| R374 (0176h)<br>EQ40 | 15:0 | EQR_B5_B<br>[15:0] | 0000_0101<br>_0101_100<br>1 | 5 Band EQ Band 5 coefficient B |

**Register 0176h EQ40**

| REGISTER ADDRESS     | BIT  | LABEL               | DEFAULT                     | DESCRIPTION                     |
|----------------------|------|---------------------|-----------------------------|---------------------------------|
| R375 (0177h)<br>EQ41 | 15:0 | EQR_B5_PG<br>[15:0] | 0100_0000<br>_0000_000<br>0 | 5 Band EQ Band 5 coefficient PG |

**Register 0177h EQ41**

| REGISTER ADDRESS       | BIT | LABEL   | DEFAULT | DESCRIPTION                                                                |
|------------------------|-----|---------|---------|----------------------------------------------------------------------------|
| R513 (0201h)<br>GPIO 2 | 10  | GP2_POL | 0       | GPIO 2 Polarity<br>0 = Not inverted<br>1 = Inverted                        |
|                        | 6   | GP2_LVL | 0       | GPIO 2 Output Level<br>(when GP2_FN = 00001)<br>0 = Logic 0<br>1 = Logic 1 |

| REGISTER ADDRESS | BIT | LABEL        | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
|------------------|-----|--------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     |              |         | Note that this is a Write-Only register; the Readback value is undefined.                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|                  | 4:0 | GP2_FN [4:0] | 0_0000  | GPIO 2 Pin Function select<br>0_0000 = CLKOUT (PLL2 / Oscillator) - see note below<br>0_0001 = Logic 0 or Logic 1 (depending on GP2_LVL)<br>0_0010 = SDOUT<br>0_0011 = IRQ<br>0_0100 = Temperature shutdown<br>0_0101 = Reserved<br>0_0110 = PLL2 Lock<br>0_0111 = PLL3 Lock<br>0_1000 = Reserved<br>0_1001 = FLL Lock<br>0_1010 = DRC Activity detect<br>0_1011 = Write Sequencer done<br>0_1100 = ALC Noise Gate active<br>0_1101 = ALC Peak Limiter overload<br>0_1110 = ALC Saturation<br>0_1111 = ALC level threshold<br>1_0000 = ALC Level lock<br>1_0001 = FIFO error indicator<br>1_0010 = OPCLK<br>1_0011 = Digital Microphone Output Clock<br>1_0100 = Reserved<br>1_0101 = Mic Detect flag<br>1_0110 = Mic Short Circuit flag<br>1_0111 to 1_1111 = Reserved<br>Note that PLL2 or the internal oscillator CLKOUT is enabled using CLKOUT2_SEL. Setting GP2_FN = 00h is recommended in this case. |

**Register 0201h GPIO 2**

| REGISTER ADDRESS       | BIT | LABEL        | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------------|-----|--------------|---------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R514 (0202h)<br>GPIO 3 | 10  | GP3_POL      | 0       | GPIO 3 Polarity<br>0 = Not inverted<br>1 = Inverted                                                                                                                                                                                                                                                                                                                                                                |
|                        | 6   | GP3_LVL      | 0       | GPIO 3 Output Level<br>(when GP3_FN = 00001)<br>0 = Logic 0<br>1 = Logic 1<br>Note that this is a Write-Only register; the Readback value is undefined.                                                                                                                                                                                                                                                            |
|                        | 4:0 | GP3_FN [4:0] | 0_0000  | GPIO 3 Pin Function select<br>0_0000 = CLKOUT (PLL3 / FLL) - see note below<br>0_0001 = Logic 0 or Logic 1 (depending on GP3_LVL)<br>0_0010 = SDOUT<br>0_0011 = IRQ<br>0_0100 = Temperature shutdown<br>0_0101 = Reserved<br>0_0110 = PLL2 Lock<br>0_0111 = PLL3 Lock<br>0_1000 = Reserved<br>0_1001 = FLL Lock<br>0_1010 = DRC Activity detect<br>0_1011 = Write Sequencer done<br>0_1100 = ALC Noise Gate active |

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|------------------|-----|-------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     |       |         | 0_1101 = ALC Peak Limiter overload<br>0_1110 = ALC Saturation<br>0_1111 = ALC level threshold<br>1_0000 = ALC Level lock<br>1_0001 = FIFO error indicator<br>1_0010 = OPCLK<br>1_0011 = Digital Microphone Output Clock<br>1_0100 = Reserved<br>1_0101 = Mic Detect flag<br>1_0110 = Mic Short Circuit flag<br>1_0111 to 1_1111 = Reserved<br>Note that PLL3 or FLL CLKOUT is enabled using CLKOUT3_SEL. Setting GP3_FN = 00h is recommended in this case. |

**Register 0202h GPIO 3**

| REGISTER ADDRESS       | BIT | LABEL        | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                     |
|------------------------|-----|--------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R516 (0204h)<br>GPIO 5 | 15  | GP5_DIR      | 1       | GPIO5 Direction<br>0 = Output<br>1 = Input                                                                                                                                                                                                                                                      |
|                        | 14  | GP5_PU       | 0       | GPIO5 pull-up resistor enable<br>0 = pull-up disabled<br>1 = pull-up enabled                                                                                                                                                                                                                    |
|                        | 13  | GP5_PD       | 0       | GPIO5 pull-down resistor enable<br>0 = pull-up disabled<br>1 = pull-down enabled                                                                                                                                                                                                                |
|                        | 10  | GP5_POL      | 0       | GPIO5 Polarity<br>0 = Not inverted<br>1 = Inverted                                                                                                                                                                                                                                              |
|                        | 9   | GP5_OP_CFG   | 0       | GPIO5 Output pin configuration<br>0 = CMOS<br>1 = Open-drain                                                                                                                                                                                                                                    |
|                        | 8   | GP5_DB       | 1       | GPIO5 input de-bounce<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                            |
|                        | 6   | GP5_LVL      | 0       | GPIO 5 Level<br>(when GP5_FN = 00001)<br>0 = Logic 0<br>1 = Logic 1<br>Write to this bit to set the GPIO5 output. Read from this bit to read GPIO input level.<br>Note that, when GPIO5 is configured as an output (GP5_DIR=0), this is a Write-Only register; the Readback value is undefined. |
|                        | 4:0 | GP5_FN [4:0] | 0_0000  | GPIO5 Pin Function select<br>0_0000 = Unused<br>0_0001 = Logic 0 or Logic 1 (depending on GP5_LVL)<br>0_0010 = SDOUT<br>0_0011 = IRQ<br>0_0100 = Temperature shutdown<br>0_0101 = Reserved<br>0_0110 = PLL2 Lock<br>0_0111 = PLL3 Lock<br>0_1000 = Reserved<br>0_1001 = FLL Lock                |

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
|------------------|-----|-------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     |       |         | 0_1010 = DRC Activity detect<br>0_1011 = Write Sequencer done<br>0_1100 = ALC Noise Gate active<br>0_1101 = ALC Peak Limiter overload<br>0_1110 = ALC Saturation<br>0_1111 = ALC level threshold<br>1_0000 = ALC Level lock<br>1_0001 = FIFO error indicator<br>1_0010 = OPCLK<br>1_0011 = Digital Microphone Output Clock<br>1_0100 = Digital Microphone Input Data<br>1_0101 = Mic Detect flag<br>1_0110 = Mic Short Circuit flag<br>1_0111 to 1_1111 = Reserved<br>Note that GPIO5 functions are only supported when CLKREG_OVD=1.<br>When CLKREG_OVD=0, the contents of Register R516 must not be changed from the default value. |

**Register 0204h GPIO 5**

| REGISTER ADDRESS       | BIT | LABEL        | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                     |
|------------------------|-----|--------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R517 (0205h)<br>GPIO 6 | 15  | GP6_DIR      | 1       | GPIO6 Direction<br>0 = Output<br>1 = Input                                                                                                                                                                                                                                                      |
|                        | 14  | GP6_PU       | 0       | GPIO6 pull-up resistor enable<br>0 = pull-up disabled<br>1 = pull-up enabled                                                                                                                                                                                                                    |
|                        | 13  | GP6_PD       | 0       | GPIO6 pull-down resistor enable<br>0 = pull-up disabled<br>1 = pull-down enabled                                                                                                                                                                                                                |
|                        | 10  | GP6_POL      | 0       | GPIO6 Polarity<br>0 = Not inverted<br>1 = Inverted                                                                                                                                                                                                                                              |
|                        | 9   | GP6_OP_CFG   | 0       | GPIO6 Output pin configuration<br>0 = CMOS<br>1 = Open-drain                                                                                                                                                                                                                                    |
|                        | 8   | GP6_DB       | 1       | GPIO6 input de-bounce<br>0 = Disabled<br>1 = Enabled                                                                                                                                                                                                                                            |
|                        | 6   | GP6_LVL      | 0       | GPIO 6 Level<br>(when GP6_FN = 00001)<br>0 = Logic 0<br>1 = Logic 1<br>Write to this bit to set the GPIO6 output. Read from this bit to read GPIO input level.<br>Note that, when GPIO6 is configured as an output (GP6_DIR=0), this is a Write-Only register; the Readback value is undefined. |
|                        | 4:0 | GP6_FN [4:0] | 0_0000  | GPIO6 Pin Function select<br>0_0000 = CSB Input<br>0_0001 = Logic 0 or Logic 1 (depending on GP6_LVL)<br>0_0010 = Reserved<br>0_0011 = IRQ<br>0_0100 = Temperature shutdown<br>0_0101 = Reserved<br>0_0110 = PLL2 Lock                                                                          |

| REGISTER ADDRESS | BIT | LABEL | DEFAULT | DESCRIPTION                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|------------------|-----|-------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  |     |       |         | 0_0111 = PLL3 Lock<br>0_1000 = Reserved<br>0_1001 = FLL Lock<br>0_1010 = DRC Activity detect<br>0_1011 = Write Sequencer done<br>0_1100 = ALC Noise Gate active<br>0_1101 = ALC Peak Limiter overload<br>0_1110 = ALC Saturation<br>0_1111 = ALC level threshold<br>1_0000 = ALC Level lock<br>1_0001 = FIFO error indicator<br>1_0010 = OPCLK<br>1_0011 = Digital Microphone Output Clock<br>1_0100 = Digital Microphone Input Data<br>1_0101 = Mic Detect flag<br>1_0110 = Mic Short Circuit flag<br>1_0111 to 1_1111 = Reserved |

**Register 0205h** GPIO 6

| REGISTER ADDRESS                   | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                           |
|------------------------------------|-----|----------|---------|-------------------------------------------------------------------------------------------------------|
| R560 (0230h)<br>Interrupt Status 1 | 5   | GP6_EINT | 0       | GPIO6 IRQ status<br>0 = GPIO6 IRQ not set<br>1 = GPIO6 IRQ set<br>Note: cleared when a '1' is written |
|                                    | 4   | GP5_EINT | 0       | GPIO5 IRQ status<br>0 = GPIO5 IRQ not set<br>1 = GPIO5 IRQ set<br>Note: cleared when a '1' is written |

**Register 0230h** Interrupt Status 1

| REGISTER ADDRESS                   | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                     |
|------------------------------------|-----|-----------------|---------|-------------------------------------------------------------------------------------------------------------------------------------------------|
| R561 (0231h)<br>Interrupt Status 2 | 15  | MICSCD_EINT     | 0       | Mic Short Circuit Interrupt Status<br>0 = MICSCD IRQ not set<br>1 = MICSCD IRQ set<br>Note: cleared when a '1' is written                       |
|                                    | 14  | MICD_EINT       | 0       | Mic Detect Interrupt Status<br>0 = MICD IRQ not set<br>1 = MICD IRQ set<br>Note: cleared when a '1' is written                                  |
|                                    | 13  | FIFOS_ERR_EINT  | 0       | FIFO error IRQ status<br>0 = FIFO error IRQ not set<br>1 = FIFO error IRQ set<br>Note: cleared when a '1' is written                            |
|                                    | 12  | ALC_LOCK_EINT   | 0       | ALC level lock IRQ status<br>0 = ALC level lock IRQ not set<br>1 = ALC level lock IRQ set<br>Note: cleared when a '1' is written                |
|                                    | 11  | ALC_THRESH_EINT | 0       | ALC level threshold IRQ status<br>0 = ALC level threshold IRQ not set<br>1 = ALC level threshold IRQ set<br>Note: cleared when a '1' is written |

| REGISTER ADDRESS | BIT | LABEL           | DEFAULT | DESCRIPTION                                                                                                                                                |
|------------------|-----|-----------------|---------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                  | 10  | ALC_SAT_EINT    | 0       | ALC saturation IRQ status<br>0 = ALC saturation IRQ not set<br>1 = ALC saturation IRQ set<br>Note: cleared when a '1' is written                           |
|                  | 9   | ALC_PKOVR_EINT  | 0       | ALC peak overload detector IRQ status<br>0 = ALC pk. overload det. IRQ not set<br>1 = ALC pk. Overload det. IRQ set<br>Note: cleared when a '1' is written |
|                  | 8   | ALC_NGATE_EINT  | 0       | ALC Noise Gate active IRQ status<br>0 = ALC Noise Gate IRQ not set<br>1 = ALC Noise Gate IRQ set<br>Note: cleared when a '1' is written                    |
|                  | 7   | WSEQ_DONE_EINT  | 0       | Write Sequencer done IRQ status<br>0 = Write Sequencer IRQ not set<br>1 = Write Sequencer IRQ set<br>Note: cleared when a '1' is written                   |
|                  | 6   | DRC_ACTDET_EINT | 0       | DRC Activity IRQ status<br>0 = DRC Activity IRQ not set<br>1 = DRC Activity IRQ set<br>Note: cleared when a '1' is written                                 |
|                  | 5   | FLL_LOCK_EINT   | 0       | FLL lock IRQ status<br>0 = FLL lock IRQ not set<br>1 = FLL lock IRQ set<br>Note: cleared when a '1' is written                                             |
|                  | 3   | PLL3_LOCK_EINT  | 0       | PLL3 Lock IRQ status<br>0 = PLL3 Lock IRQ not set<br>1 = PLL3 Lock IRQ set<br>Note: cleared when a '1' is written                                          |
|                  | 2   | PLL2_LOCK_EINT  | 0       | PLL2 Lock IRQ status<br>0 = PLL2 Lock IRQ not set<br>1 = PLL2 Lock IRQ set<br>Note: cleared when a '1' is written                                          |
|                  | 0   | TEMP_SHUT_EINT  | 0       | Temperature Shutdown IRQ status<br>0 = Temperature Shutdown IRQ not set<br>1 = Temperature Shutdown IRQ set<br>Note: cleared when a '1' is written         |

**Register 0231h** Interrupt Status 2

| REGISTER ADDRESS                        | BIT | LABEL       | DEFAULT | DESCRIPTION                                              |
|-----------------------------------------|-----|-------------|---------|----------------------------------------------------------|
| R568 (0238h)<br>Interrupt Status 1 Mask | 5   | IM_GP6_EINT | 1       | Interrupt mask for GPIO6<br>0 = Not masked<br>1 = Masked |
|                                         | 4   | IM_GP5_EINT | 1       | Interrupt mask for GPIO5<br>0 = Not masked<br>1 = Masked |

**Register 0238h** Interrupt Status 1 Mask

| REGISTER ADDRESS                        | BIT                   | LABEL                         | DEFAULT                                                                 | DESCRIPTION                                                                   |
|-----------------------------------------|-----------------------|-------------------------------|-------------------------------------------------------------------------|-------------------------------------------------------------------------------|
| R569 (0239h)<br>Interrupt Status 2 Mask | 15                    | IM_MICSCD_EINT                | 1                                                                       | Interrupt mask for Mic Short Circuit<br>0 = Not masked<br>1 = Masked          |
|                                         | 14                    | IM_MICD_EINT                  | 1                                                                       | Interrupt mask for Mic Detect<br>0 = Not masked<br>1 = Masked                 |
|                                         | 13                    | IM_FIFOS_ERR_EINT             | 1                                                                       | Interrupt mask for FIFOS Error<br>0 = Not masked<br>1 = Masked                |
|                                         | 12                    | IM_ALC_LOCK_EINT              | 1                                                                       | Interrupt mask for ALC Lock<br>0 = Not masked<br>1 = Masked                   |
|                                         | 11                    | IM_ALC_THRESHOLD_EINT         | 1                                                                       | Interrupt mask for ALC Threshold<br>0 = Not masked<br>1 = Masked              |
|                                         | 10                    | IM_ALC_SAT_EINT               | 1                                                                       | Interrupt mask for ALC Saturation<br>0 = Not masked<br>1 = Masked             |
|                                         | 9                     | IM_ALC_PKOVER_EINT            | 1                                                                       | Interrupt mask for ALC Peak Detector overload<br>0 = Not masked<br>1 = Masked |
|                                         | 8                     | IM_ALC_NOISE_GATE_ACTIVE_EINT | 1                                                                       | Interrupt mask for ALC Noise Gate active<br>0 = Not masked<br>1 = Masked      |
|                                         | 7                     | IM_WRITE_SEQUENCER_DONE_EINT  | 1                                                                       | Interrupt mask for Write Sequencer done<br>0 = Not masked<br>1 = Masked       |
|                                         | 6                     | IM_DRC_ACTIVITY_DETECT_EINT   | 1                                                                       | Interrupt mask for DRC Activity detect<br>0 = Not masked<br>1 = Masked        |
|                                         | 5                     | IM_FLL_LOCK_EINT              | 1                                                                       | Interrupt mask for FLL Lock<br>0 = Not masked<br>1 = Masked                   |
|                                         | 4                     | Reserved                      | 1                                                                       | Reserved - do not change                                                      |
|                                         | 3                     | IM_PLL3_LOCK_EINT             | 1                                                                       | Interrupt mask for PLL3 Lock<br>0 = Not masked<br>1 = Masked                  |
|                                         | 2                     | IM_PLL2_LOCK_EINT             | 1                                                                       | Interrupt mask for PLL2 Lock<br>0 = Not masked<br>1 = Masked                  |
|                                         | 1                     | Reserved                      | 1                                                                       | Reserved - do not change                                                      |
| 0                                       | IM_TEMP_SHUTDOWN_EINT | 1                             | Interrupt mask for Temperature Shutdown<br>0 = Not masked<br>1 = Masked |                                                                               |

**Register 0239h** Interrupt Status 2 Mask

| REGISTER ADDRESS                  | BIT | LABEL   | DEFAULT | DESCRIPTION                                                    |
|-----------------------------------|-----|---------|---------|----------------------------------------------------------------|
| R576 (0240h)<br>Interrupt Control | 0   | IRQ_POL | 0       | Interrupt Output polarity<br>0 = Active high<br>1 = Active low |

**Register 0240h** Interrupt Control

| REGISTER ADDRESS                | BIT | LABEL            | DEFAULT | DESCRIPTION                                                            |
|---------------------------------|-----|------------------|---------|------------------------------------------------------------------------|
| R584 (0248h)<br>IRQ<br>Debounce | 5   | FLL_LOCK_DB      | 1       | Debounce Enable on FLL Lock<br>0 = Disabled<br>1 = Enabled             |
|                                 | 4   | Reserved         | 1       | Reserved - do not change                                               |
|                                 | 3   | PLL3_LOCK_D<br>B | 1       | Debounce Enable on PLL3 Lock<br>0 = Disabled<br>1 = Enabled            |
|                                 | 2   | PLL2_LOCK_D<br>B | 1       | Debounce Enable on PLL2 Lock<br>0 = Disabled<br>1 = Enabled            |
|                                 | 1   | Reserved         | 1       | Reserved - do not change                                               |
|                                 | 0   | TEMP_SHUT_D<br>B | 1       | Debounce Enable on Temperature Shutdown<br>0 = Disabled<br>1 = Enabled |

**Register 0248h** IRQ Debounce

| REGISTER ADDRESS                        | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                                          |
|-----------------------------------------|-----|--------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R586<br>(024Ah)<br>MICINT<br>Source Pol | 15  | MICSCD_IRQ_P<br>OL | 0       | Mic Short Circuit Interrupt Polarity<br>0 = Active high (IRQ asserted when MICSHORT_THR is exceeded)<br>1 = Active low (IRQ asserted when MICSHORT_THR not exceeded) |
|                                         | 14  | MICD_IRQ_POL       | 0       | Mic Detect Interrupt Polarity<br>0 = Active high (IRQ asserted when MICDET_THR is exceeded)<br>1 = Active low (IRQ asserted when MICDET_THR not exceeded)            |

**Register 024Ah** MICINT Source Pol

| REGISTER ADDRESS                         | BIT | LABEL    | DEFAULT | DESCRIPTION                                                                                                                                                                                                                     |
|------------------------------------------|-----|----------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R768 (0300h)<br>DSP2 Power<br>Management | 0   | DSP2_ENA | 0       | DSP2 Audio Processor Enable.<br>0 = Disabled<br>1 = Enabled<br><br>This bit must be set before any of ADC ReTune, DAC ReTune, DAC HPF, VSS or HDBass is enabled. It must remain set whenever any of these functions is enabled. |

**Register 0300h** DSP2 Power Management



| REGISTER ADDRESS                     | BIT | LABEL      | DEFAULT | DESCRIPTION                                                                                                            |
|--------------------------------------|-----|------------|---------|------------------------------------------------------------------------------------------------------------------------|
| R1037<br>(040Dh)<br>DSP2_ExecControl | 5   | DSP2_STOPC | 0       | [No description available]                                                                                             |
|                                      | 4   | DSP2_STOPS | 0       | [No description available]                                                                                             |
|                                      | 3   | DSP2_STOPI | 0       | [No description available]                                                                                             |
|                                      | 2   | DSP2_STOP  | 0       | Stop the DSP2 audio processor. Writing a 1 to this bit will cause the DSP2 processor to stop processing audio data.    |
|                                      | 1   | DSP2_RUNR  | 0       | Start the DSP2 audio processor<br>Writing a 1 to this bit will cause the DSP2 processor to start processing audio data |
|                                      | 0   | DSP2_RUN   | 0       | [No description available]                                                                                             |

**Register 040Dh** DSP2\_ExecControl

| REGISTER ADDRESS                   | BIT  | LABEL                | DEFAULT               | DESCRIPTION                                                      |
|------------------------------------|------|----------------------|-----------------------|------------------------------------------------------------------|
| R4096<br>(1000h) Write Sequencer 0 | 13:0 | WSEQ_ADDR0<br>[13:0] | 00_0000_0<br>001_1100 | Control Register Address to be written to in this sequence step. |

**Register 1000h** Write Sequencer 0

| REGISTER ADDRESS                   | BIT | LABEL               | DEFAULT   | DESCRIPTION                                                                                                                                                                                |
|------------------------------------|-----|---------------------|-----------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R4097<br>(1001h) Write Sequencer 1 | 7:0 | WSEQ_DATA0<br>[7:0] | 0000_0011 | Data to be written in this sequence step. When the data width is less than 8 bits, then one or more of the MSBs of WSEQ_DATA0 are ignored. It is recommended that unused bits be set to 0. |

**Register 1001h** Write Sequencer 1

| REGISTER ADDRESS                   | BIT  | LABEL                  | DEFAULT | DESCRIPTION                                                                                                                                                                           |
|------------------------------------|------|------------------------|---------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R4098<br>(1002h) Write Sequencer 2 | 10:8 | WSEQ_DATA_WIDTH0 [2:0] | 001     | Width of the data block written in this sequence step.<br>000 = 1 bit<br>001 = 2 bits<br>010 = 3 bits<br>011 = 4 bits<br>100 = 5 bits<br>101 = 6 bits<br>110 = 7 bits<br>111 = 8 bits |
|                                    | 3:0  | WSEQ_DATA_START0 [3:0] | 0011    | Bit position of the LSB of the data block written in this sequence step.<br>0000 = Bit 0<br>...<br>1111 = Bit 15                                                                      |

**Register 1002h** Write Sequencer 2

| REGISTER ADDRESS                   | BIT | LABEL                | DEFAULT | DESCRIPTION                                                                                                                                                                                                                             |
|------------------------------------|-----|----------------------|---------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| R4099<br>(1003h) Write Sequencer 3 | 8   | WSEQ_EOS0            | 0       | End of Sequence flag. This bit indicates whether the Control Write Sequencer should stop after executing this step.<br>0 = Not end of sequence<br>1 = End of sequence (Stop the sequencer after this step).                             |
|                                    | 3:0 | WSEQ_DELAY0<br>[3:0] | 0000    | Time delay after executing this step.<br>Total time per step (including execution)<br>= $k \times (2^{\text{WSEQ\_DELAY}} + 8)$<br>$k = 62.5\mu\text{s}$ (SAMPLE_RATE_INT_MODE = 1)<br>$k = 68.1\mu\text{s}$ (SAMPLE_RATE_INT_MODE = 0) |

**Register 1003h** Write Sequencer 3

| REGISTER ADDRESS                                                                            | BIT | LABEL | DEFAULT | DESCRIPTION                         |
|---------------------------------------------------------------------------------------------|-----|-------|---------|-------------------------------------|
| R4100<br>(1004h) Write Sequencer 4<br><br>To<br><br>R4607<br>(11FFh)<br>Write Sequencer 511 |     |       |         | [Write Sequencer Control Registers] |

**Register 1004h** Write Sequencer 4 to **Register 11FFh** Write Sequencer 511

| REGISTER ADDRESS                              | BIT | LABEL          | DEFAULT | DESCRIPTION                                                                                                                                        |
|-----------------------------------------------|-----|----------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| R16384<br>(4000h)<br>RETUNEADC_SHARED_COEFF_1 | 7   | ADC_RETUNE_SCV | 0       | ADC ReTune Coefficient sharing<br>0 = Left and Right channels each use unique coefficients<br>1 = Both channels use the Right Channel coefficients |
|                                               | 6:0 |                |         | [ADC ReTune Control Registers]                                                                                                                     |

**Register 4000h** RETUNEADC\_SHARED\_COEFF\_1

| REGISTER ADDRESS                              | BIT  | LABEL | DEFAULT | DESCRIPTION                    |
|-----------------------------------------------|------|-------|---------|--------------------------------|
| R16385<br>(4001h)<br>RETUNEADC_SHARED_COEFF_0 | 15:0 |       |         | [ADC ReTune Control Registers] |

**Register 4001h** RETUNEADC\_SHARED\_COEFF\_0

| REGISTER ADDRESS                                      | BIT | LABEL              | DEFAULT | DESCRIPTION                                                                                                                                        |
|-------------------------------------------------------|-----|--------------------|---------|----------------------------------------------------------------------------------------------------------------------------------------------------|
| R16386<br>(4002h)<br>RETUNEDA<br>C_SHARED_<br>COEFF_1 | 7   | DAC_RETUNE_<br>SCV | 0       | DAC ReTune Coefficient sharing<br>0 = Left and Right channels each use unique coefficients<br>1 = Both channels use the Right Channel coefficients |
|                                                       | 6:0 |                    |         | [DAC ReTune Control Registers]                                                                                                                     |

**Register 4002h** RETUNEDAC\_SHARED\_COEFF\_1

| REGISTER ADDRESS                                      | BIT  | LABEL | DEFAULT | DESCRIPTION                    |
|-------------------------------------------------------|------|-------|---------|--------------------------------|
| R16387<br>(4003h)<br>RETUNEDA<br>C_SHARED_<br>COEFF_0 | 15:0 |       |         | [DAC ReTune Control Registers] |

**Register 4003h** RETUNEDAC\_SHARED\_COEFF\_0

| REGISTER ADDRESS                                  | BIT | LABEL                                  | DEFAULT   | DESCRIPTION                |
|---------------------------------------------------|-----|----------------------------------------|-----------|----------------------------|
| R16388<br>(4004h)<br>SOUNDSTA<br>GE_ENABLE<br>S_1 | 7:0 | SOUNDSTAGE<br>_ENABLES_23_<br>16 [7:0] | 0000_0000 | [No description available] |

**Register 4004h** SOUNDSTAGE\_ENABLES\_1

| REGISTER ADDRESS                                  | BIT  | LABEL                                  | DEFAULT          | DESCRIPTION                                                        |
|---------------------------------------------------|------|----------------------------------------|------------------|--------------------------------------------------------------------|
| R16389<br>(4005h)<br>SOUNDSTA<br>GE_ENABLE<br>S_0 | 15:6 | SOUNDSTAGE<br>_ENABLES_15_<br>06 [9:0] | 00_0000_0<br>000 | [No description available]                                         |
|                                                   | 5    | RTN_ADC_ENA                            | 0                | ADC ReTune enable<br>0 = Disabled<br>1 = Enabled                   |
|                                                   | 4    | RTN_DAC_ENA                            | 0                | DAC ReTune enable<br>0 = Disabled<br>1 = Enabled                   |
|                                                   | 3    | HDBASS_ENA                             | 0                | HD Bass enable<br>0 = HD Bass disabled<br>1 = HD Bass enabled      |
|                                                   | 2    | HPF2_ENA                               | 0                | High-Pass Filter (HPF2) enable<br>0 = Disabled<br>1 = Enabled      |
|                                                   | 1    | HPF1_ENA                               | 0                | High-Pass Filter (HPF1) enable<br>0 = Disabled<br>1 = Enabled      |
|                                                   | 0    | VSS_ENA                                | 0                | Virtual Surround Sound (VSS) enable<br>0 = Disabled<br>1 = Enabled |

**Register 4005h** SOUNDSTAGE\_ENABLES\_0

| REGISTER ADDRESS                                                                   | BIT | LABEL | DEFAULT | DESCRIPTION                 |
|------------------------------------------------------------------------------------|-----|-------|---------|-----------------------------|
| R16896<br>(4200h)<br>HDBASS_AI_0<br><br>To<br><br>R16925<br>(421Dh)<br>HDBASS_PG_0 |     |       |         | [HD Bass Control Registers] |

**Register 4201h HDBASS\_AI\_0 to Register 421Dh HDBASS\_PG\_0**

| REGISTER ADDRESS                                                           | BIT | LABEL | DEFAULT | DESCRIPTION                              |
|----------------------------------------------------------------------------|-----|-------|---------|------------------------------------------|
| R17408<br>(4400h)<br>HPF_C_1<br><br>To<br><br>R17409<br>(4401h)<br>HPF_C_0 |     |       |         | [DAC High Pass Filter Control Registers] |

**Register 4400h HPF\_C\_1 to Register 4401h HPF\_C\_0**

| REGISTER ADDRESS                                                                              | BIT | LABEL | DEFAULT | DESCRIPTION                    |
|-----------------------------------------------------------------------------------------------|-----|-------|---------|--------------------------------|
| R17920<br>(4600h)<br>ADCL_RETUNE_C1_1<br><br>To<br><br>R19007<br>(4A3Fh)<br>ADCR_RETUNE_C32_0 |     |       |         | [ADC ReTune Control Registers] |

**Register 4600h ADCL\_RETUNE\_C1\_1 to Register 4A3Fh ADCR\_RETUNE\_C32\_0**

| REGISTER ADDRESS                                                                                      | BIT | LABEL | DEFAULT | DESCRIPTION                    |
|-------------------------------------------------------------------------------------------------------|-----|-------|---------|--------------------------------|
| R19456<br>(4C00h)<br>DACL_RETU<br>NE_C1_1<br><br>To<br><br>R20543<br>(503Fh)<br>DACR_RETU<br>NE_C32_0 |     |       |         | [DAC ReTune Control Registers] |

**Register 4C00h DACL\_RETUNE\_C1\_1 to Register 503Fh DACR\_RETUNE\_C32\_0**

| REGISTER ADDRESS                                                                          | BIT | LABEL | DEFAULT | DESCRIPTION             |
|-------------------------------------------------------------------------------------------|-----|-------|---------|-------------------------|
| R20992<br>(5200h)<br>VSS_XHD2_<br>1<br><br>To<br><br>R21139<br>(5293h)<br>VSS_XTS32<br>_0 |     |       |         | [VSS Control Registers] |

**Register 5200h VSS\_XHD2\_1 to Register 5293h VSS\_XTS32\_0**

**DIGITAL FILTER CHARACTERISTICS**

| PARAMETER                          | TEST CONDITIONS                          | MIN      | TYP    | MAX      | UNIT |
|------------------------------------|------------------------------------------|----------|--------|----------|------|
| <b>ADC Filter</b>                  |                                          |          |        |          |      |
| Passband                           |                                          |          |        | 0.454 fs |      |
|                                    | -3dB                                     |          | 0.5 fs |          |      |
| Passband Ripple                    | $f < 0.454 \text{ fs}$                   |          |        | +/- 0.05 | dB   |
| Stopband                           |                                          | 0.546 fs |        |          |      |
| Stopband Attenuation               | $f > 0.546 \text{ fs}$                   | -60      |        |          | dB   |
| <b>DAC Normal Filter</b>           |                                          |          |        |          |      |
| Passband                           |                                          |          |        | 0.454 fs |      |
|                                    | -6dB                                     |          | 0.5 fs |          |      |
| Passband Ripple                    | $f < 0.454 \text{ fs}$                   |          |        | +/- 0.05 | dB   |
| Stopband                           |                                          | 0.546 fs |        |          |      |
| Stopband Attenuation               | $0.546 \text{ fs} < f < 30 \text{ fs}$   | -50      |        |          | dB   |
| <b>DAC Sloping Stopband Filter</b> |                                          |          |        |          |      |
| Passband                           |                                          |          |        | 0.454 fs |      |
|                                    | -9dB                                     |          | 0.5 fs |          |      |
| Passband Ripple                    | $f < 0.25 \text{ fs}$                    |          |        | +/- 0.05 | dB   |
|                                    | $0.25 \text{ fs} < f < 0.454 \text{ fs}$ |          |        | +/- 1    |      |
| Stopband 1                         |                                          | 0.546 fs |        | 0.7 fs   |      |
| Stopband 1 Attenuation             | $f > 0.546 \text{ fs}$                   | -60      |        |          | dB   |
| Stopband 2                         |                                          | 0.7 fs   |        | 1.4 fs   |      |
| Stopband 2 Attenuation             | $f > 0.7 \text{ fs}$                     | -85      |        |          | dB   |
| Stopband 3                         |                                          | 1.4 fs   |        |          |      |
| Stopband 3 Attenuation             | $1.4 \text{ fs} < f < 30 \text{ fs}$     | -53      |        |          | dB   |

| DAC FILTERS      |             | ADC FILTERS |             |
|------------------|-------------|-------------|-------------|
| Mode             | Group Delay | Mode        | Group Delay |
| Normal           | 16.5 / fs   | Normal      | 15 / fs     |
| Sloping Stopband | 18 / fs     |             |             |

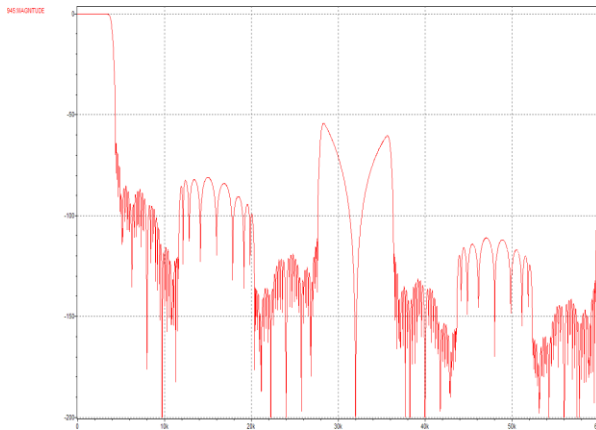
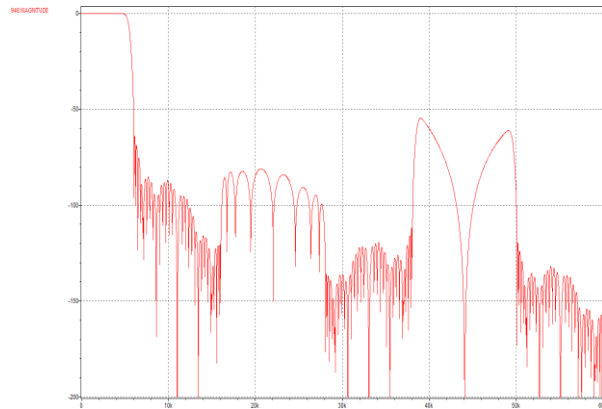
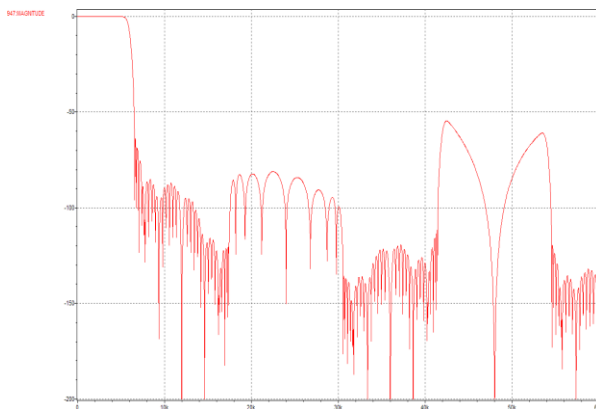
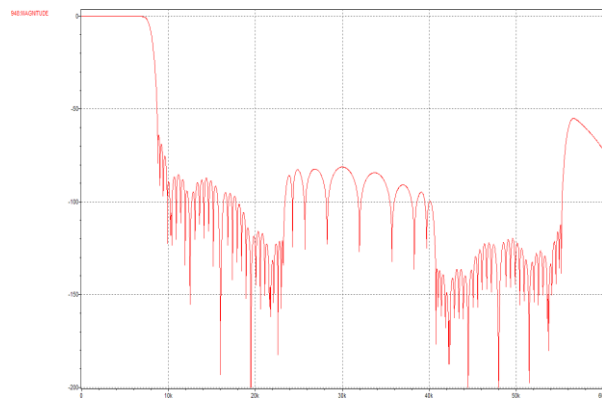
**TERMINOLOGY**

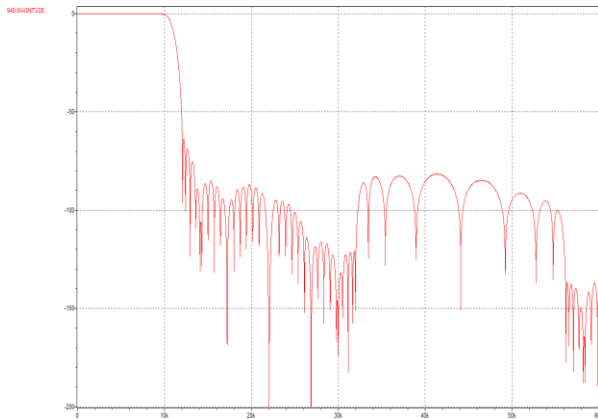
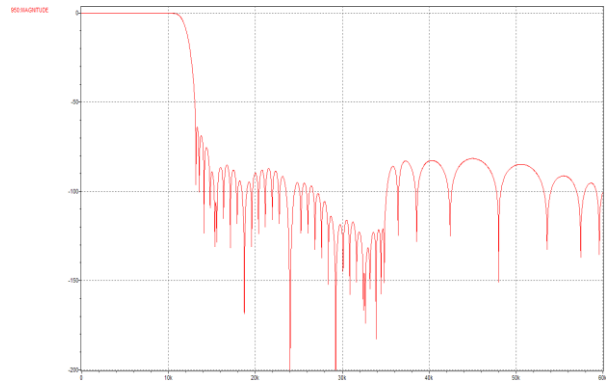
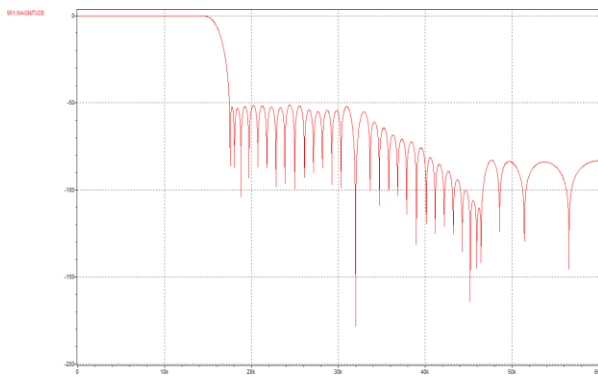
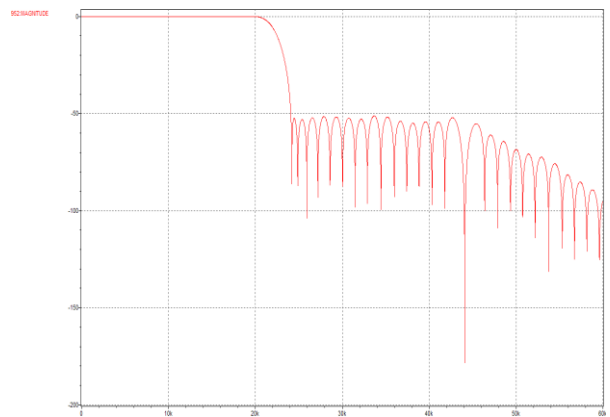
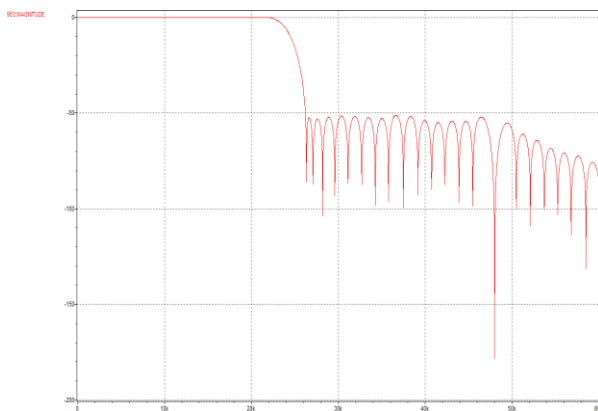
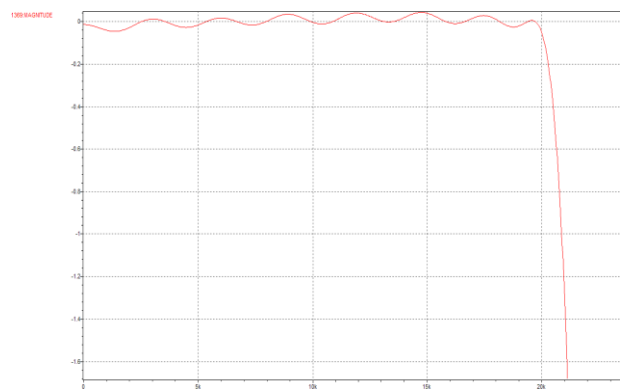
1. Stop Band Attenuation (dB) – the degree to which the frequency spectrum is attenuated (outside audio band)
2. Pass-band Ripple – any variation of the frequency response in the pass-band region

**DAC FILTER RESPONSES**

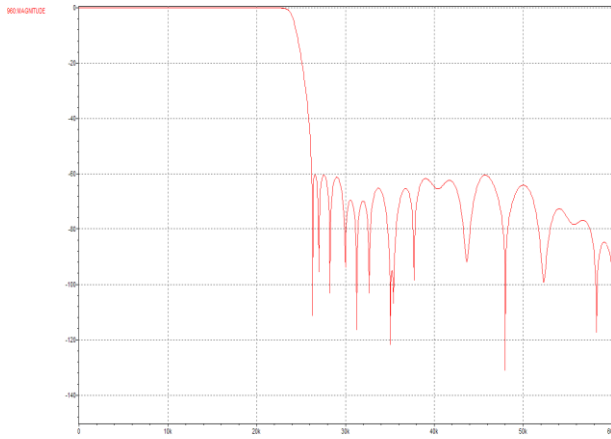
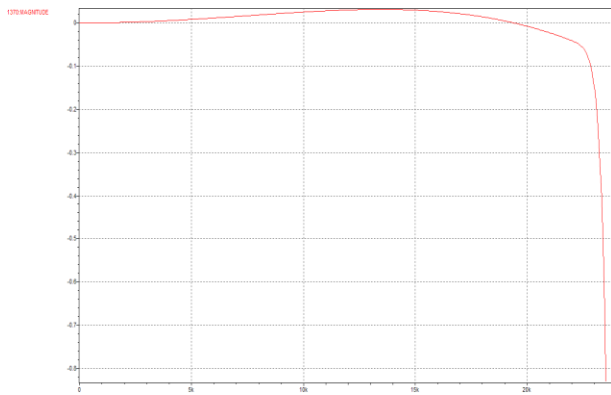
This series of plots shows the filter response for the entire DAC channel for different signal rates. The full path, has a nominal gain of 3.01dB (1V input, 1.414V output), this means that the highest nodes in the 48kHz case are at 47.5dB (rather than below the 50dB specification).

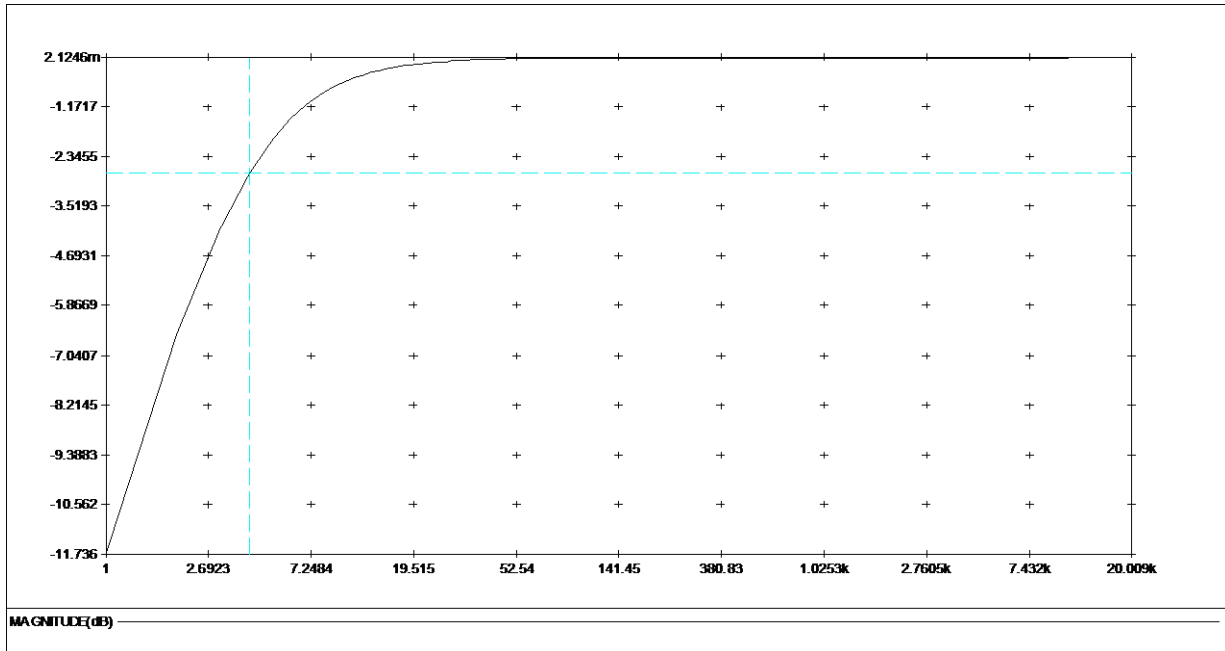
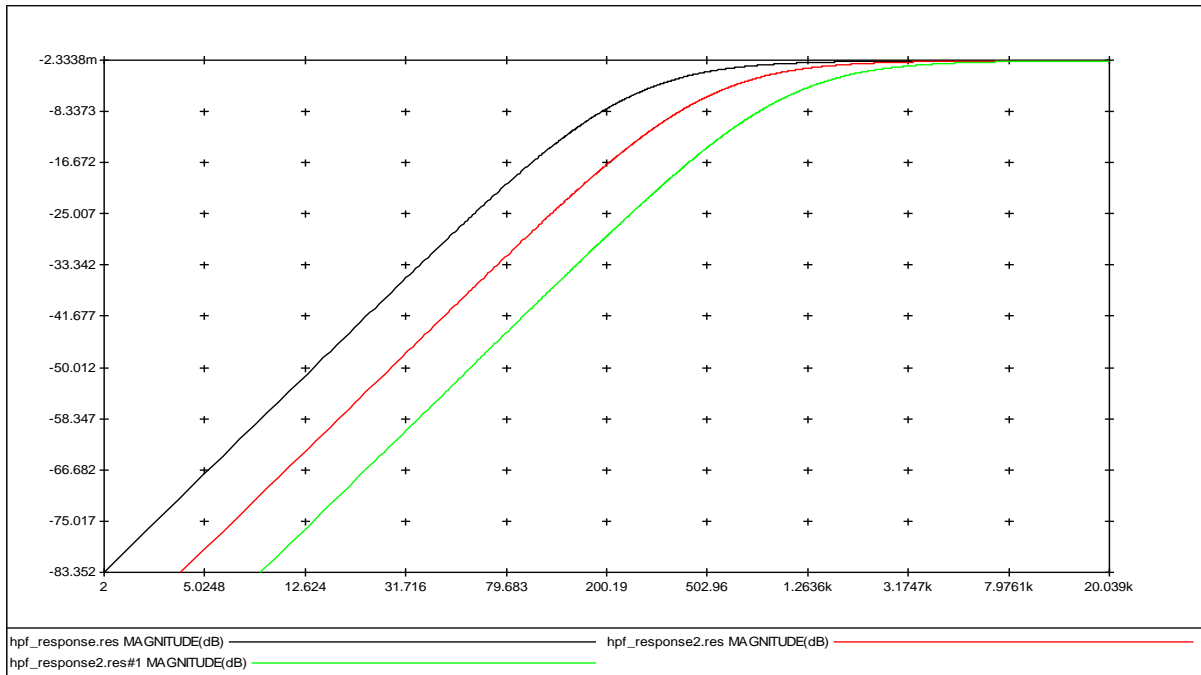
| Sample Rate (kHz) | Sloping Stop-band | MCLK recommended rate for DAC only playback (CODEC mode) (Hz) |
|-------------------|-------------------|---------------------------------------------------------------|
| 8                 | Yes               | 3072000 (3072000)                                             |
| 11.025            | Yes               | 2822400 (2822400)                                             |
| 12                | Yes               | 3072000 (3072000)                                             |
| 16                | Yes               | 2048000 (6144000)                                             |
| 22.05             | Yes               | 2822400 (5644800)                                             |
| 24                | Yes               | 3072000 (6144000)                                             |
| 32                | No                | 2048000 (8192000)                                             |
| 44.1              | No                | 2822400 (11289600)                                            |
| 48                | No                | 3072000 (12288000)                                            |

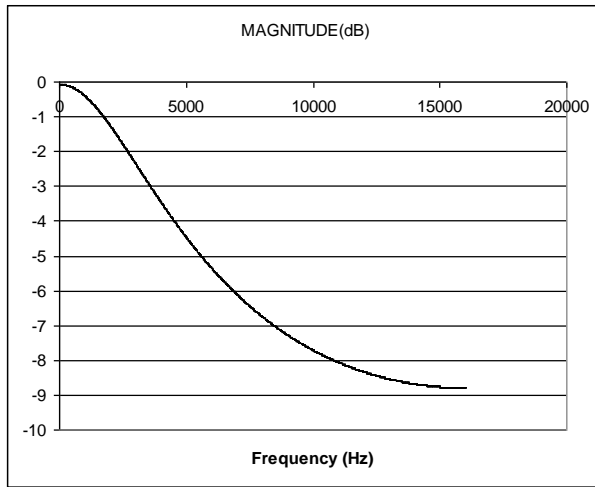
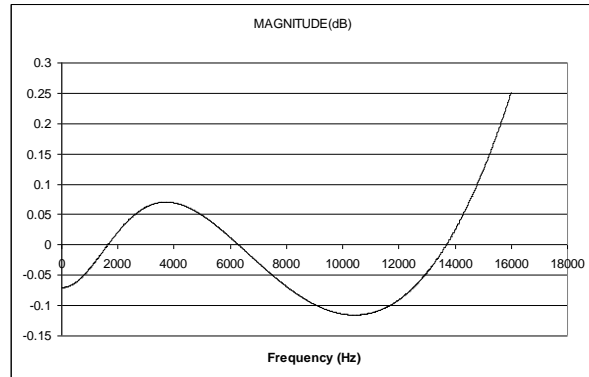
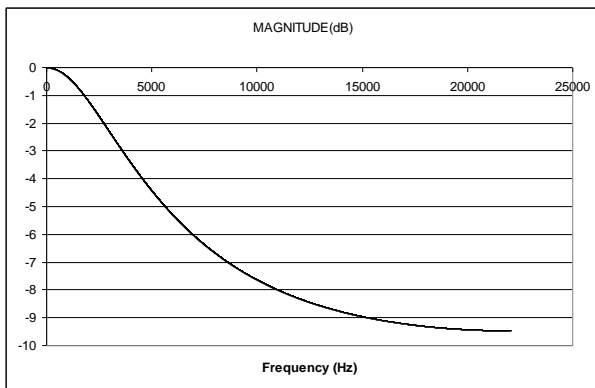
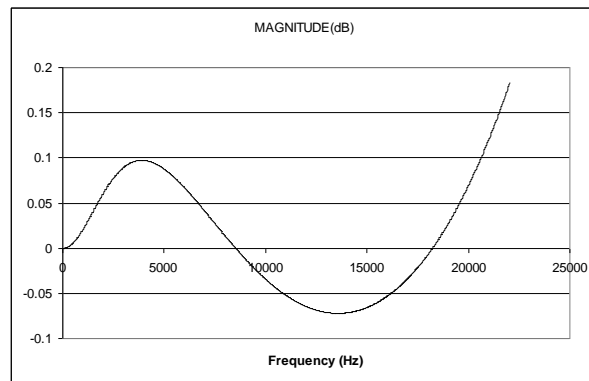
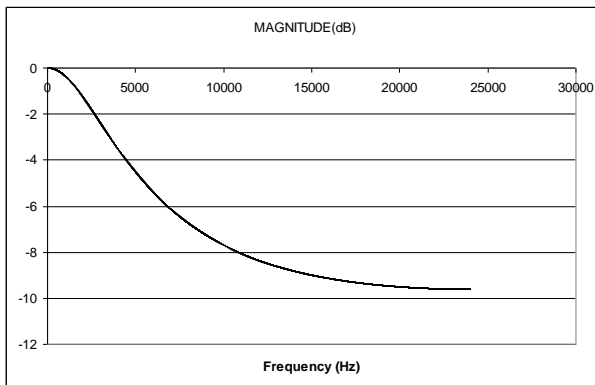
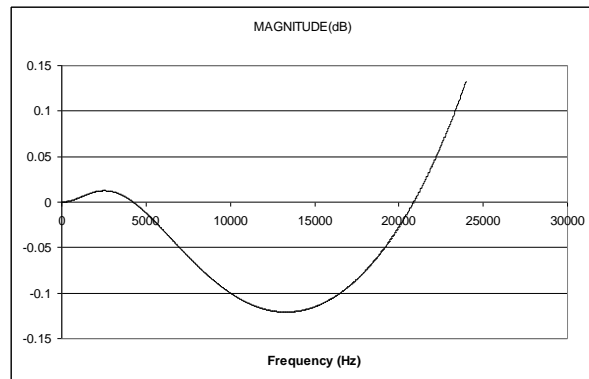
**Table 133 Recommended Filter Configurations for Supported Sample Rates**

**Figure 74 DAC Filter Response 8k Sampling Rate**

**Figure 75 DAC Filter Response for 11.025k Sample Rate**

**Figure 76 DAC Filter Response for 12k Sample Rate**

**Figure 77 DAC Filter Response for 16k Sample Rate**


**Figure 78 DAC Filter Response 22.05k Sample Rate**

**Figure 79 DAC Playback Filter Response for 24k Sample Rate**

**Figure 80 DAC Playback Filter Response for 32k Sample Rate**

**Figure 81 DAC Playback Filter Response for 44.1k Sample Rate**

**Figure 82 DAC Playback Filter Response for 48k Sample Rate**

**Figure 83 DAC Playback Filter Passband Ripple for 44.1k Sample Rate (MCLK=11.2896MHZ)**



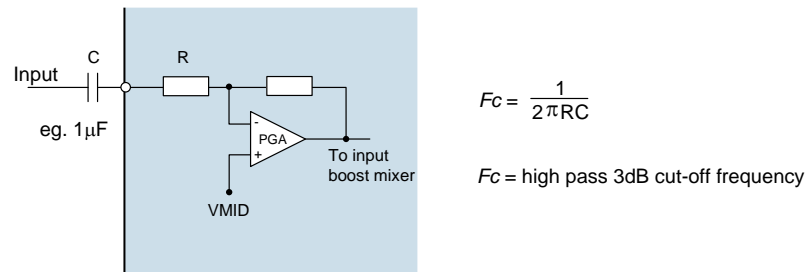
**ADC FILTER RESPONSES**

**Figure 84 ADC Digital Filter Frequency Response (128OSR)**

**Figure 85 ADC Digital Filter Passband Ripple (128OSR)**

**ADC HIGH PASS FILTER RESPONSES**

**Figure 86 ADC Digital High Pass Filter Frequency Response (48kHz, Hi-Fi Mode, ADC\_HPF\_CUT[1:0]=00)**

**Figure 87 ADC Digital High Pass Filter Ripple (48kHz, Voice Mode, ADC\_HPF\_CUT=01, 10 and 11)**

**DE-EMPHASIS FILTER RESPONSES**

**Figure 88 De-Emphasis Digital Filter Response (32kHz)**

**Figure 89 De-Emphasis Error (32kHz)**

**Figure 90 De-Emphasis Digital Filter Response (44.1kHz)**

**Figure 91 De-Emphasis Error (44.1kHz)**

**Figure 92 De-Emphasis Digital Filter Response (48kHz)**

**Figure 93 De-Emphasis Error (48kHz)**

**APPLICATIONS INFORMATION**
**ANALOGUE INPUT PATHS**

The WM8962B provides up to 8 analogue audio input paths. Each of these inputs is referenced to the internal DC reference, VMID. A DC blocking capacitor is required for each analogue input pin used in the target application. The choice of capacitor is determined by the filter that is formed between that capacitor and the impedance of the input pin. The circuit is illustrated in Figure 94.



**Figure 94 Audio Input Path DC Blocking Capacitor**

In accordance with the WM8962B input pin resistance, it is recommended that a 1µF capacitance will give good results in most cases. Note that the input impedance, R, changes with the PGA gain setting, as described in the “Electrical Characteristics”.

A single capacitor is required for line or microphone input connection. Tantalum electrolytic capacitors are particularly suitable as they offer high stability in a small package size.

Ceramic equivalents are a cost effective alternative to the superior tantalum packages, but care must be taken to ensure the desired capacitance is maintained at the AVDD operating voltage. Also, ceramic capacitors may show microphonic effects, where vibrations and mechanical conditions give rise to electrical signals. This is particularly problematic for microphone input paths where a large signal gain is required.

The external connections for electret condenser microphones, incorporating the WM8962B microphone bias circuit, are shown later in the “Microphone Bias Circuit” section below.

**MICROPHONE BIAS CIRCUIT**

The WM8962B is designed to interface easily with analogue microphones. An electret condenser microphone (ECM) requires a bias current; this can be provided by the MICBIAS output on the WM8962B.

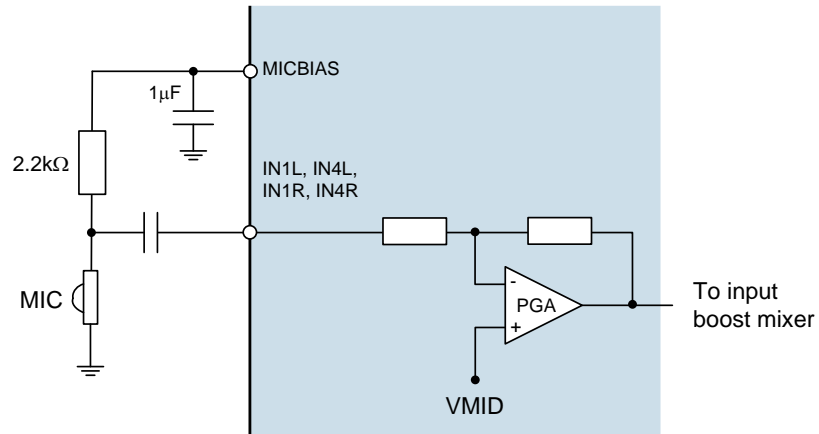
An electret condenser microphone may be connected in single-ended configuration, as illustrated in Figure 95.

A decoupling capacitor is required on the MICBIAS output. A suitable capacitor must be connected whenever the MICBIAS output is enabled.

A current-limiting resistor is also required for the ECM; the resistance should be chosen according to the minimum operating impedance of the microphone and MICBIAS voltage so that the maximum bias current of the WM8962B is not exceeded.

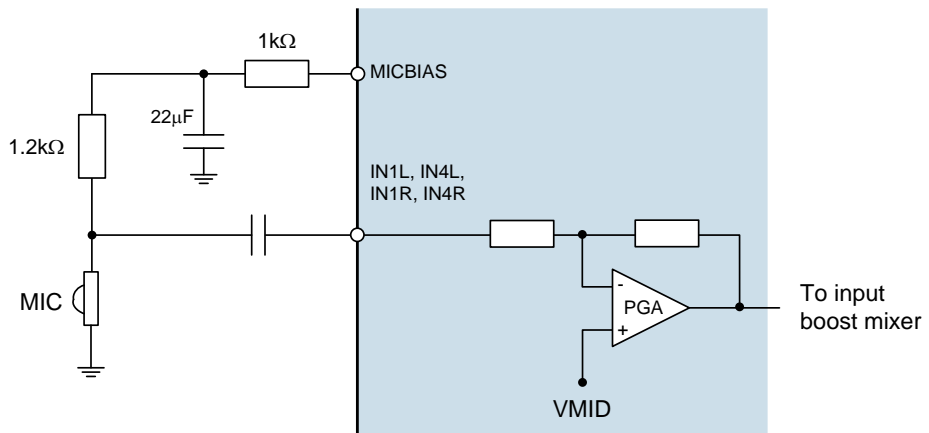
A 2.2kΩ current-limiting resistor is recommended; this provides compatibility with a wide range of microphone components.

Note that the MICBIAS output can also be used to power an analogue silicon microphone. In this case, the MICBIAS connects directly to the VDD pin of the microphone - a current-limiting resistor is not required in this case.



**Figure 95 Single Ended Microphone Connection**

Additional filtering of the MICBIAS output, to reduce noise and interference, may be implemented using the configuration illustrated in Figure 96.



**Figure 96 Microphone Connection, with MICBIAS filter components**

**CHARGE PUMP COMPONENTS**

The WM8962B incorporates a Charge Pump circuit, which generates the CPVOUTP and CPVOUTN supply rails for the ground-referenced headphone drivers.

Decoupling capacitors are required on each of the Charge Pump outputs. A fly-back capacitor is also required. The recommended Charge Pump capacitors for WM8962B are detailed below in Table 134.

| DESCRIPTION                                             | CAPACITOR                                                                               |
|---------------------------------------------------------|-----------------------------------------------------------------------------------------|
| CPVOUTP decoupling                                      | Required capacitance is 2.0 $\mu$ F at 2V.<br>Suitable component typically 4.7 $\mu$ F. |
| CPVOUTN decoupling                                      | Required capacitance is 2.0 $\mu$ F at 2V.<br>Suitable component typically 4.7 $\mu$ F. |
| Charge Pump fly-back<br>(connect between C1CA and C1CB) | Required capacitance is 1.0 $\mu$ F at 2V.<br>Suitable component typically 2.2 $\mu$ F. |

**Table 134 Charge Pump External Capacitors**

Ceramic capacitors are recommended for these Charge Pump requirements. Note that, due to the wide tolerance of many types of ceramic capacitors, care must be taken to ensure that the selected components provide the required capacitance across the required temperature and voltage ranges in the intended application. Ceramic capacitors with X5R dielectric are recommended.

The positioning of the Charge Pump capacitors is important, particularly the fly-back capacitors. These capacitors should be placed as close as possible to the WM8962B.

## RECOMMENDED EXTERNAL COMPONENTS DIAGRAM

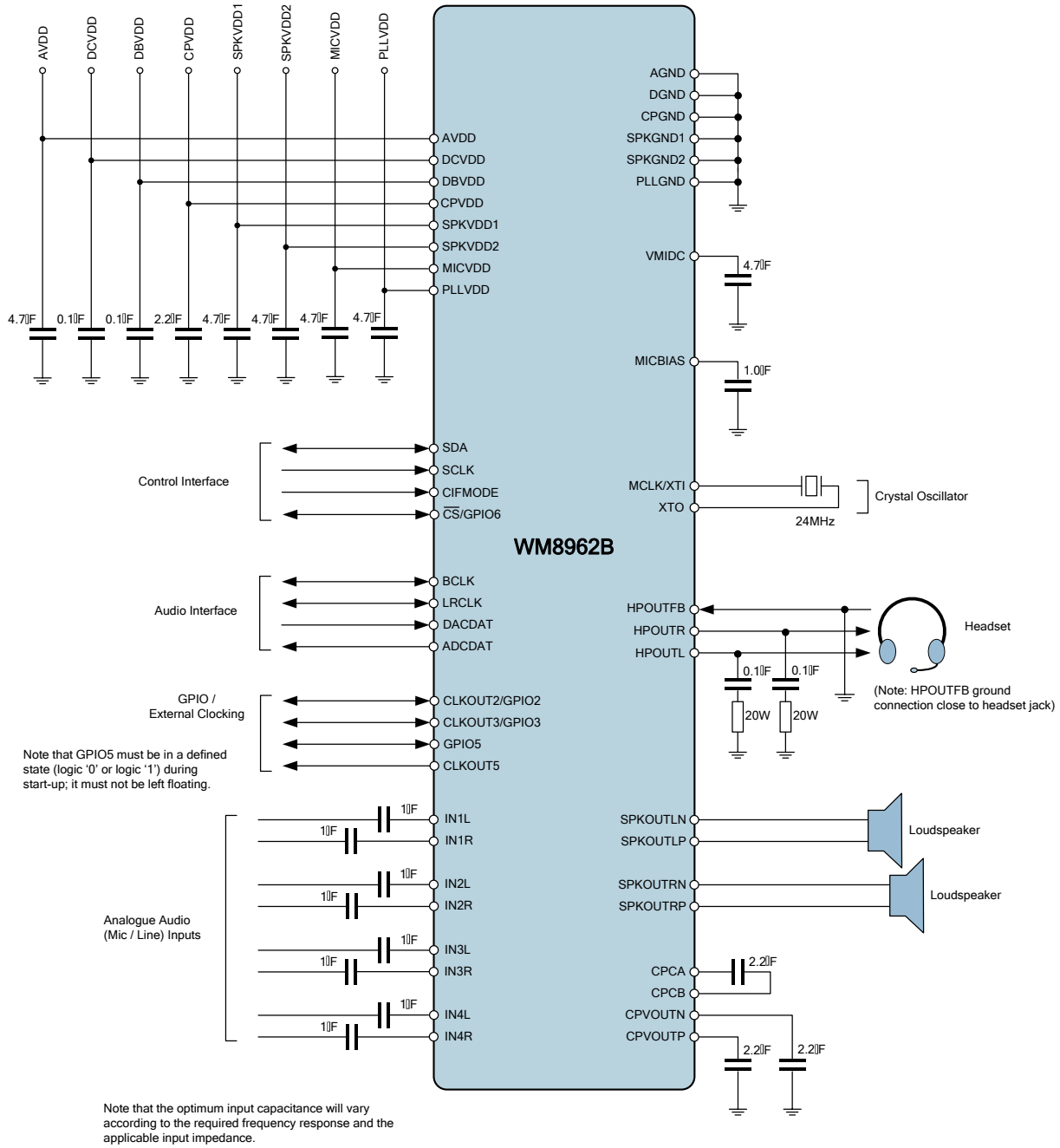


Figure 97 WM8962B Recommended External Components

**Notes:**
**1. Power Supply Decoupling Capacitors**

X5R ceramic capacitor is recommended for the power supply decoupling capacitors.

The decoupling capacitors on VMIDC, MICBIAS, CPVOUTP and CPVOUTN should be as close to the WM8962B as possible.

**2. Charge Pump Capacitors**

Specific recommendations for Charge Pump capacitors are provided in Table 135. Note that two different recommendations are provided for CPVOUTP and CPVOUTN; either of these components is suitable, depending upon size requirements and availability.

The positioning of the flyback capacitor is very important - this should be as close to the WM8962B as possible.

It is important to select a suitable capacitor type for the Charge Pump. Note that the capacitance may vary with DC voltage; care is required to ensure that required capacitance is achieved at the applicable operating voltage, as specified in Figure 97. The capacitor datasheet should be consulted for this information.

| COMPONENT                              | REQUIRED CAPACITANCE        | VALUE             | PART NUMBER               | VOLTAGE | TYPE | SIZE |
|----------------------------------------|-----------------------------|-------------------|---------------------------|---------|------|------|
| Charge Pump Flyback (CPCA to CPCB)     | $\geq 1\mu\text{F}$ at 2VDC | 2.2 $\mu\text{F}$ | Kemet C0402C225M9PAC      | 6.3v    | X5R  | 0402 |
| CPVOUTN decoupling, CPVOUTP decoupling | $\geq 2\mu\text{F}$ at 2VDC | 2.2 $\mu\text{F}$ | MuRata GRM188R61A225KE34D | 10v     | X5R  | 0603 |
|                                        |                             | 4.7 $\mu\text{F}$ | MuRata GRM155R60J475M_EIA | 6.3v    | X5R  | 0402 |

**Table 135 Charge Pump Capacitors**

**3. Zobel Networks**

The Zobel network shown in Figure 97 is required on HPOUTL and HPOUTR whenever that output is enabled. Stability of these ground-referenced outputs across all process corners cannot be guaranteed without the Zobel network components. (Note that, if any ground-referenced output pin is not required, the Zobel network components can be omitted from the output pin, and the pin can be left floating.) The Zobel network requirement is detailed further in the applications note WAN\_0212 "Class W Headphone Impedance Compensation".

Zobel networks should be positioned reasonably close to the WM8962B.

**4. Crystal Oscillator**

The WM8962B supports device clocking from either a digital clock source (compatible with timing and voltage threshold requirements) or from a crystal oscillator.

**5. PLLGND Connection**

The AGND and PLLGND pins must be tied together as close as possible to the WM8962B.



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**PCB LAYOUT CONSIDERATIONS**

Poor PCB layout will degrade the performance and be a contributory factor in EMI, ground bounce and resistive voltage losses. All external components should be placed as close to the WM8962B device as possible, with current loop areas kept as small as possible.

The following layout priorities should be observed. (All these components should be as close to the WM8962B as possible; item 1. is the highest priority).

1. Crystal
2. Charge pump capacitors
3. AVDD, DCVDD, DBVDD decoupling
4. VMIDC, MICBIAS decoupling
5. Other decoupling
6. Zobel network components
7. CLKOUTn termination resistors

**MIC DETECTION SEQUENCE USING MICBIAS CURRENT**

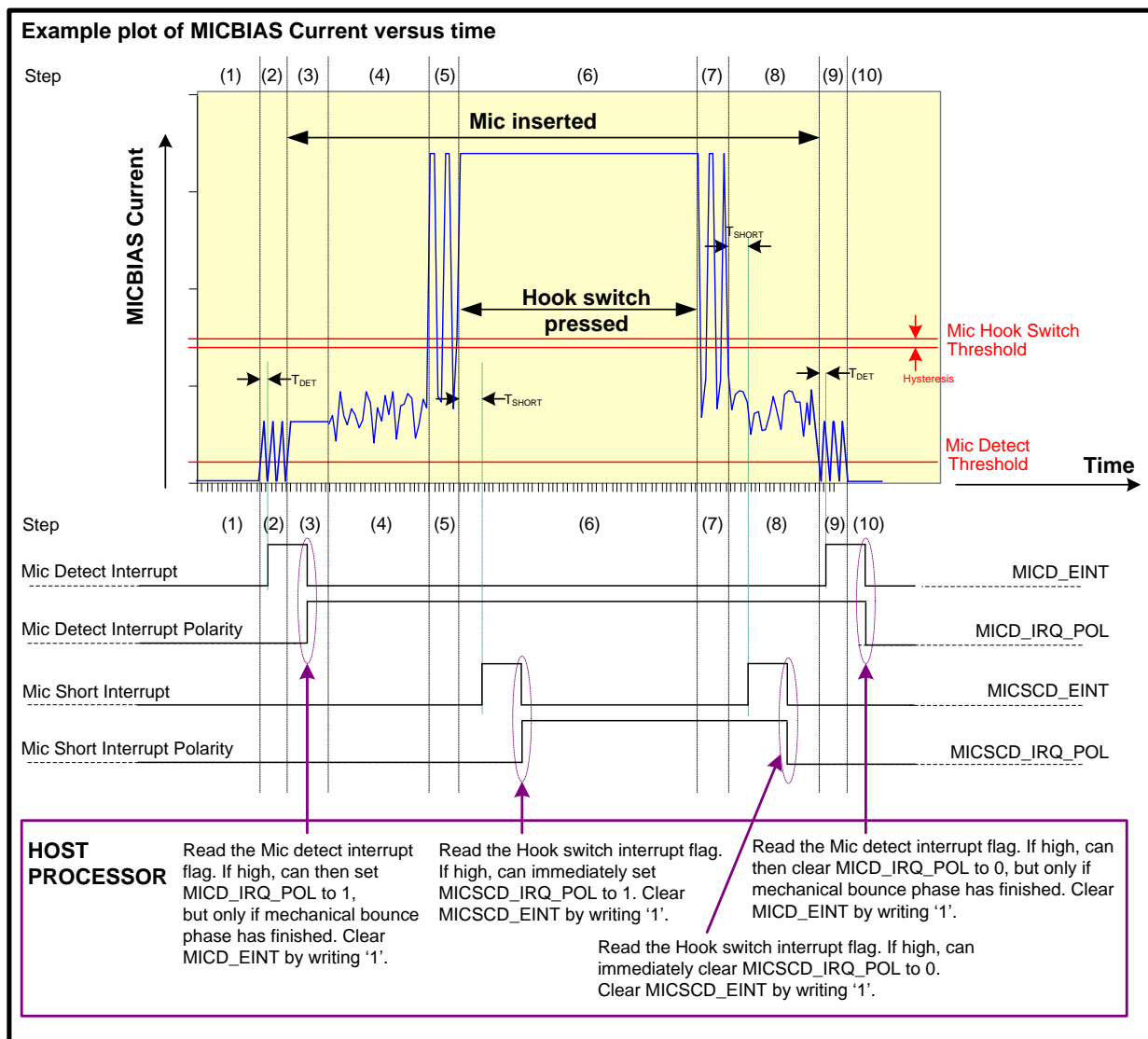
This section details an example sequence which summarises how the host processor can configure and detect the events supported by the MICBIAS current detect function (see "MICBIAS Current Detect"):

- Mic insertion/removal
- Hook switch press/release

Figure 98 shows an example of how the MICBIAS current flow varies versus time, during mic insertion and hook switch events. The Y axis is annotated with the Mic detection thresholds, and the X axis is annotated with the stages of an example sequence as detailed in Table 136, to illustrate how the host processor can implement mic insertion and hook switch detection.

The sequence assumes that the microphone insertion and hook switch detection functions are monitored by polling the interrupt flags using the control interface. Note that the maximum mechanical bounce times for mic insertion and removal must be fully understood by the software programmer.

A GPIO pin could be used as an alternative mechanism to monitor the MICBIAS detection functions. This enables the host processor to detect mechanical bounce at any time.

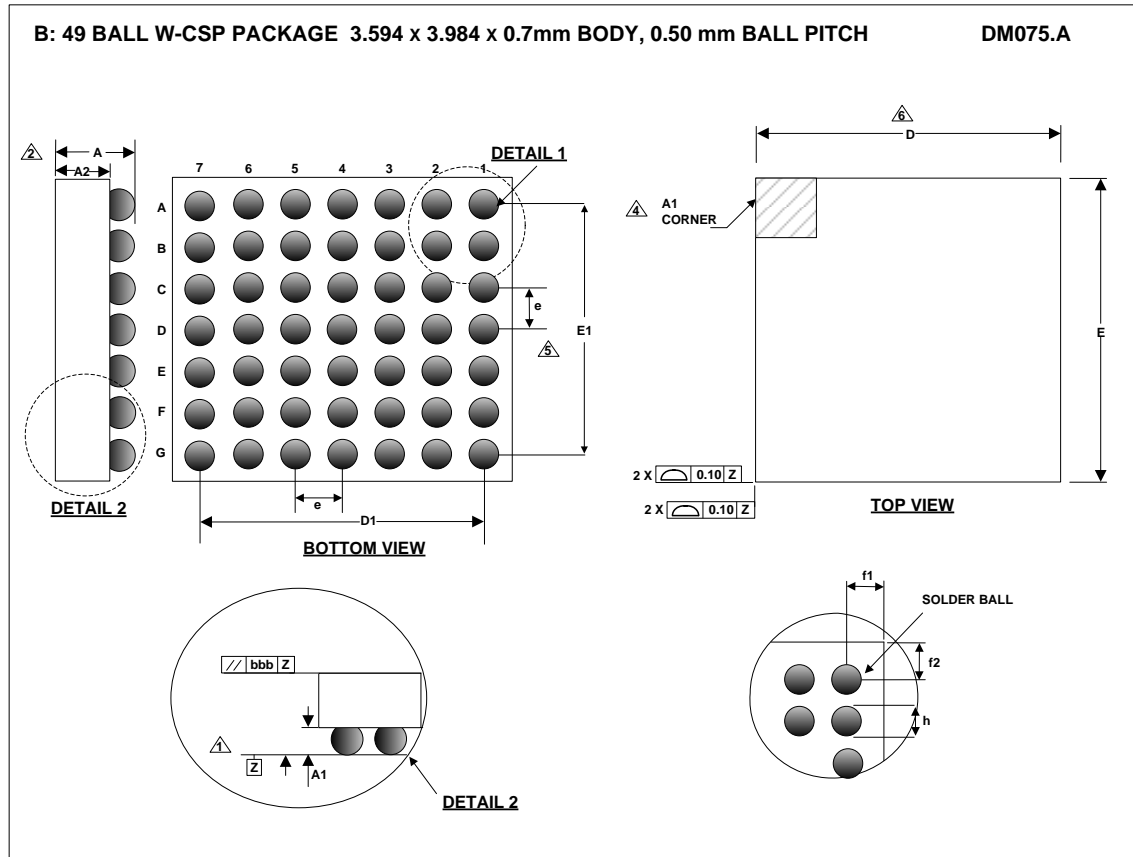


**Figure 98 Mic Insert and Hook Switch Detect: Example MICBIAS Current Plot**

|    |                                                                                                                                                                                                                                                                                                                                                                                      |
|----|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1  | Mic not inserted. To detect mic insertion, Host processor must initialise interrupts and clear MICD_IRQ_POL = 0. At every step, the host processor should poll the interrupt status register.<br>Note that Mic Insertion de-bounce circuitry is automatically enabled.                                                                                                               |
| 2  | Mechanical bounce of jack socket during Mic insertion. Host processor may already detect a mic insertion interrupt (MICD_EINT) during this step. Once detected, the host processor can set MICD_IRQ_POL = 1 and then clear the interrupt, unless mechanical bounce can last longer than the shortest possible $T_{DET}$ , in which case the host processor should wait until step 3. |
| 3  | Mic fully inserted. If not already set, the host processor must now set MICD_IRQ_POL = 1. If not already cleared, the host processor must now clear the MICD_EINT interrupt. To detect Hook switch press, the host processor must clear MICSCD_IRQ_POL = 0. At this step, the diagram shows no AC current swing, due to a very low ambient noise level.                              |
| 4  | Mic fully inserted. Diagram shows AC current swing due to high levels of background noise (such as wind).                                                                                                                                                                                                                                                                            |
| 5  | Mechanical bounce during hook switch press. The hook switch interrupt is unlikely to be set during this step, because 10 successive samples of the MICBIAS current exceeding the hook switch threshold have not yet been sampled.<br>Note that Hook Switch de-bounce circuitry is automatically enabled.                                                                             |
| 6  | Hook switch is fully pressed down. After $T_{SHORT}$ , 10 successive samples of the MICBIAS current exceeding the hook switch threshold have been detected, hence a hook switch interrupt (MISCDC_EINT) will be generated. Once detected, the host processor can immediately set MICSCD_IRQ_POL = 1 and then clear the MISCDC_EINT interrupt.                                        |
| 7  | Mechanical bounce during hook switch release. The hook switch interrupt is unlikely to be set during this step, because 10 successive samples of the MICBIAS current lower than the hook switch threshold have not yet been sampled.                                                                                                                                                 |
| 8  | Hook switch fully released. After $T_{SHORT}$ , 10 successive samples of the MICBIAS current lower than the hook switch threshold have been detected, hence a hook switch interrupt (MISCDC_EINT) will be generated. Once detected, the host processor can immediately clear MICSCD_IRQ_POL = 0 and then clear the MISCDC_EINT interrupt.                                            |
| 9  | Mechanical bounce of jack socket during Mic removal. Host processor may already detect a mic removal interrupt (MICD_EINT) during this step. Once detected, the host processor can clear MICD_IRQ_POL = 0 and then clear the interrupt, unless mechanical bounce can last longer than the shortest possible $T_{DET}$ , in which case the host processor should wait until step 10.  |
| 10 | Mic fully removed. If not already cleared, the host processor must now clear MICD_IRQ_POL = 0. If not already cleared, the host processor must now clear the MICD_EINT interrupt.                                                                                                                                                                                                    |

**Table 136 Mic Insert and Hook Switch Detect: Example Sequence**

Alternatively, utilising a GPIO pin to monitor the MICBIAS current detect functionality permits the host processor to monitor the steady state of microphone detection or hook switch press functions. Because the GPIO shows the steady state condition, software de-bounce may be easier to implement in the host processor, dependant on the processor performance characteristics, hence use of the GPIO is likely to simplify the rejection of mechanical bounce. Changes of state in the GPIO pin are also subject to the time delays  $t_{DET}$  and  $t_{SHORT}$ .

**PACKAGE DIMENSIONS**


| Symbols   | Dimensions (mm) |           |       | NOTE |
|-----------|-----------------|-----------|-------|------|
|           | MIN             | NOM       | MAX   |      |
| <b>A</b>  | 0.650           | 0.7       | 0.750 |      |
| <b>A1</b> | 0.219           | 0.244     | 0.269 |      |
| <b>A2</b> | 0.431           | 0.456     | 0.481 |      |
| <b>D</b>  | 3.564           | 3.594     | 3.624 |      |
| <b>D1</b> |                 | 3.00 BSC  |       |      |
| <b>E</b>  | 3.954           | 3.984     | 4.014 |      |
| <b>E1</b> |                 | 3.00 BSC  |       |      |
| <b>e</b>  |                 | 0.50 BSC  |       | 5    |
| <b>f1</b> | 0.282           |           |       |      |
| <b>f2</b> | 0.477           |           |       |      |
| <b>h</b>  |                 | 0.314 BSC |       |      |

**NOTES:**

1. PRIMARY DATUM -Z- AND SEATING PLANE ARE DEFINED BY THE SPHERICAL CROWNS OF THE SOLDER BALLS.
2. THIS DIMENSION INCLUDES STAND-OFF HEIGHT 'A1' AND BACKSIDE COATING.
3. A1 CORNER IS IDENTIFIED BY INK/LASER MARK ON TOP PACKAGE.
4. BILATERAL TOLERANCE ZONE IS APPLIED TO EACH SIDE OF THE PACKAGE BODY.
5. 'e' REPRESENTS THE BASIC SOLDER BALL GRID PITCH.
6. THIS DRAWING IS SUBJECT TO CHANGE WITHOUT NOTICE.
7. FOLLOWS JEDEC DESIGN GUIDE MO-211-C.

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## IMPORTANT NOTICE

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**REVISION HISTORY**

| DATE     | REV | DESCRIPTION OF CHANGES                                                                                                                                                                                                                                                                                                                                                                                                           | PAGE                                        | CHANGED BY |
|----------|-----|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------|------------|
| 19/12/11 | 1.0 | First Release                                                                                                                                                                                                                                                                                                                                                                                                                    |                                             |            |
| 16/04/12 | 2.0 | MICBIAS_EVR definition updated                                                                                                                                                                                                                                                                                                                                                                                                   |                                             |            |
| 10/05/12 | 2.0 | Thermal characteristics updated, and more details added                                                                                                                                                                                                                                                                                                                                                                          |                                             |            |
| 11/05/12 | 2.0 | Product status changed to Preliminary Technical Data                                                                                                                                                                                                                                                                                                                                                                             |                                             |            |
| 11/05/12 | 2.0 | 1W changed to 2W in title, p1                                                                                                                                                                                                                                                                                                                                                                                                    |                                             |            |
| 25/05/12 | 3.0 | Update to comments regarding MICBIAS filtering components                                                                                                                                                                                                                                                                                                                                                                        |                                             |            |
| 25/06/12 | 3.0 | Speaker Supply Leakage Current moved to the Current Consumption section of the Electrical Characteristics.<br>Added new section in Electrical Characteristics for DAC to Stereo 4ohm Speaker performance.<br>Updated typical values for MICBIAS voltages.<br>Added typical Output Noise values for each available MICBIAS level.                                                                                                 |                                             |            |
| 25/06/12 | 3.0 | Product status updated to pre-production.                                                                                                                                                                                                                                                                                                                                                                                        |                                             |            |
| 30/08/12 | 4.0 | Product status updated to production data<br>Updates to the Electrical Characteristics<br>Updated ADC oversampling rate description.                                                                                                                                                                                                                                                                                             |                                             |            |
| 04/04/13 | 4.1 | Noted that I2C addresses 94h and D2h are reserved, and must not be used on the same bus as WM8962B.                                                                                                                                                                                                                                                                                                                              |                                             |            |
| 30/01/14 | 4.2 | Additions to the recommended DSP control sequences.<br>Additional requirements for writing 24-bit DSP configuration registers.<br>Correction to the inconsistent descriptions of the SPKOUTL/R_PGA_MUTE bits.<br>Digital Core block diagram updated, consistent with ADC Enhancements functions (Second Order Filter is included within ADC Enhancements).<br>Correction to control sequence for multiple push-button detection. | 72-76<br>72, 188<br>122<br><br>94<br><br>44 | PH         |
| 22/07/14 | 4.2 | DF1 filter as input to DRC is deleted                                                                                                                                                                                                                                                                                                                                                                                            | 84, 86                                      | PH         |

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