Medical Applications Guide

Amplifiers, Clocks, Data Converters, Digital Signal Processors,
Digital Temperature Sensors, Interface, Logic, Microcontrollers, Power Management, RF ICs

2Q 2007

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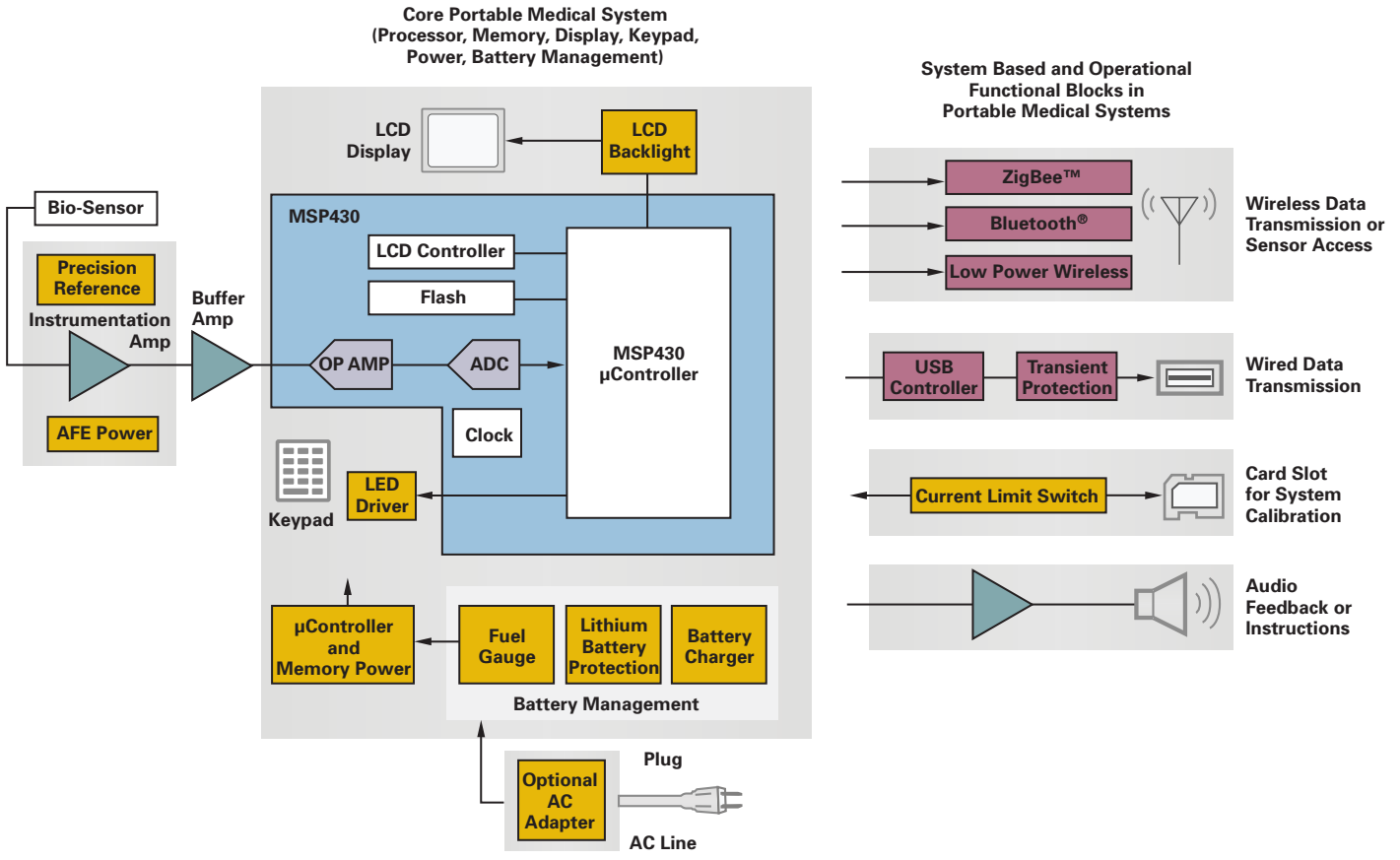
Portable Medical Applications

Whether developing a blood glucose meter, digital blood pressure meter, blood gas meter, digital pulse/heart rate monitor or even a digital thermometer, there are five system level blocks that are common to each one: Power/Battery Management, Control and Data Processing, Amplification and A/D Conversion of the sensor input, some type of display and the sensor element(s) itself. In general, these are all battery-operated, microcontroller-controlled handheld devices that take measurements using various bio-sensors. Obviously, the actual implementation topology of these blocks will differ greatly with the sensing, processing and information display demands of the meter type and feature set.

Key design considerations are ultra-low power consumption and high efficiency driven by the need for extended battery life, and high precision with a fast response time driven by the user's need to quickly know their health status. Additional requirements may drive needs for additional memory to allow for historical profiling, cabled or wireless interfaces for data upload to a computer at home or in the doctor's office or even for access to the sensor, and possibly audio feedback for simple good/not good indication or more complex step-by-step utilization instructions. Adding these features without increasing power consumption is a significant challenge. Texas Instruments offers a broad portfolio of high-performance Microcontrollers, Digital Signal Processors (DSPs), Instrumentation, Operational and Buffer Amplifiers, Data Converters, Power and Battery Management, Audio Amplifiers, and both Wired and Wireless Interface components.



General block diagram for typical portable medical devices.

Blood Pressure and Heart Rate Monitors

Blood Pressure Monitor

The system uses either Korotkoff, Oscillometry, or Pulse Transit Time methods to measure blood pressure. It employs a pressure cuff and pump, plus a transducer to measure blood pressure and heart rate in three phases: Inflation, Measurement, and Deflation. It includes an LCD, selection buttons, memory recall, power management and USB interface.

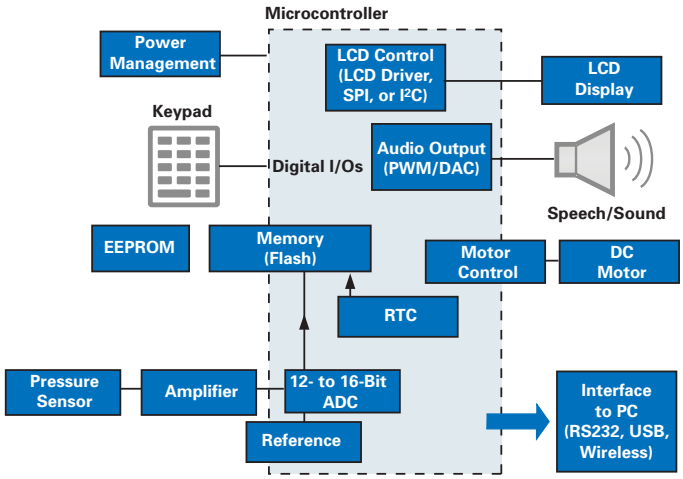
The core subsystems include:

Processor/Memory — The digital pressure measurement and heart rate are performed by the microprocessor. Measurement results are stored in Flash memory as a data log that can be uploaded to a PC via USB.

User Interface — Allows the user to control the pressure measurement process and read the results on a LCD display.

Sensor Interface — Allows the processor to control the cuff inflation/deflation and sense blood pressure which is amplified by instrumentation amplifiers and digitized by the ADC.

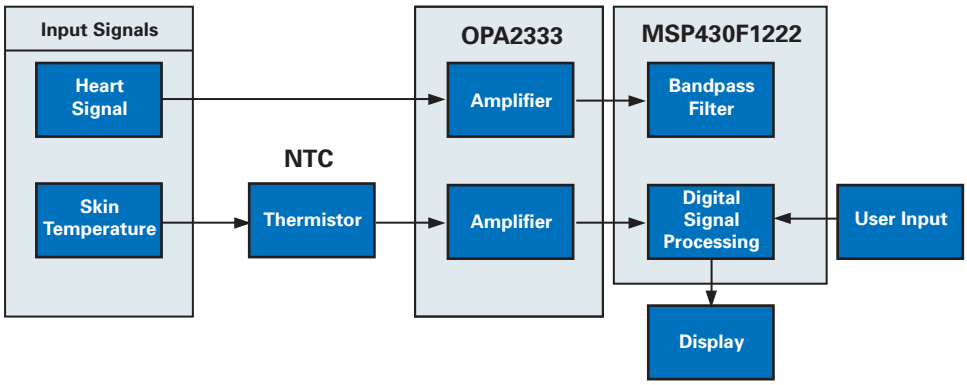
Power Conversion — Converts input power from the alkaline battery to run various functional blocks.



Example application block diagram – blood pressure monitor.

Heart Rate Monitor

The heart generates an electro-chemical impulse that spreads out in the heart in such a fashion as to cause the cells to contract and relax in a timely order and thus give the heart a pumping characteristic. This sequence is initiated by a group of nerve cells called the sinoatrial (SA) node resulting in a polarization and depolarization of the cells of the heart. Because this action is electrical in nature and because the body is conductive with its fluid content, this electrochemical action can be measured at the surface of the body.



The graphics illustrates a multifunction system to measure heart rate and skin temperature using OPA2333 and MSP430.

Note:

"Heart Rate and EKG Monitor using the MSP430FG439" (slaa280)
www-s.ti.com/sc/techlit/slaa280

Blood Analyzer

New innovations in blood analyzers are making it easier than ever to test quickly for any of a number of critical care assays in blood such as blood gases, glucose, electrolytes, coagulation, chemistries, hematology and cardiac markers (cTnI). Also with the advent of new digital technologies, invasive blood analyzers have become portable and are used to measure the two major assays of metabolic disorders in blood system: glucose and cholesterol.

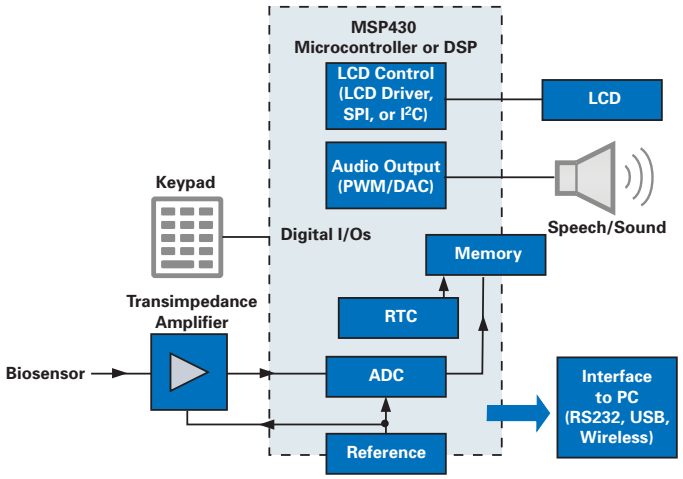
The two methods used for blood measurement are the color reflectance method and the electromechanical sensor technology (amperometric method).

The analog front-end of the reflectance method uses optical sensors (LED, photo transistors) and a transimpedance amplifier. Measurements made using color reflectance method are based upon the intensity of the reaction color in the reaction layer of the test strip by reflectance photometry. The analyzer quantifies the color change and generates a numerical value representative of the concentration of the cholesterol/glucose level in blood.

In the amperometric method, the biosensor (test strip) is directly connected with the transimpedance amplifier. Cholesterol/glucose present in the blood while undergoing chemical reaction with the test strip generates charge, which is measured by the amperometric method. Especially for the amperometric method, an ambient temperature measurement is also necessary for compensation of test strip characteristics.

The measurement sequence is usually controlled by a microcontroller (MCU). The MCU also takes care of processing of the conversion results, storing the measurements in an EEPROM or Flash memory, and controlling other functions such as the keypad, real-time clock, sound/speech compression and serial communication to a connected PC.

The audio output is provided by either a PWM circuit or from the DAC. Both can be used to generate beeping sounds to signal when the measurement results are available as well as to generate voice instructions from the speech-synthesizer software using, for example, ADPCM compression algorithms. Measurement results are stored together with the measurement time and date to the EEPROM or Flash memory as a data log that can be uploaded to a PC via RS-232 or USB interface.



Example application block diagram – blood analyzer.

Digital Thermometers

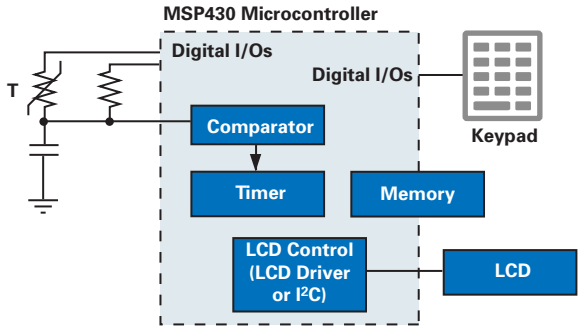
Digital Thermometers

Digital thermometers are quickly replacing traditional mercury thermometers. Digital thermometers are fast, accurate and effective. With newer technologies, different types of digital fever thermometers may be classified on the basis of the location where they are used such as oral, rectal, underarm, ear, etc. The ear thermometer measures the infrared heat of the eardrum, which reflects the temperature of the hypothalamus — the temperature-controlling system of the brain. Infrared sensors are used in ear thermometers for measurement, while thermopiles or thermistors may be used in other types.

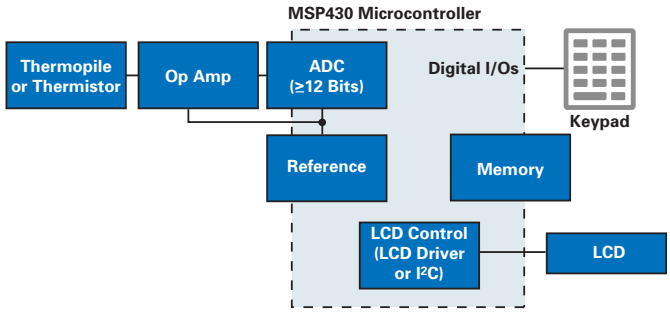
Depending on cost considerations, different types of digital thermometers are available. High-end thermometers have a number of thermopiles or thermistors, whose resistance changes with temperature. The change in resistance is measured as a change in voltage. This analog voltage is converted digitally by an analog-to-digital converter (ADC). The speed and resolution of this ADC depends on the accuracy and time at which information is needed. However, if an ADC module is not available, then it is possible to digitize the analog signal by using a comparator and a timer, using slope A/D conversion. This method is generally used in low-cost versions of digital thermometers. The single slope conversion is a simple method for measuring temperature. Capacitance, supply voltage and frequency changes caused by aging or temperature drift can be compensated by using a ratio metric measurement principle. Detailed information about the slope conversion principle can be found in the application note *"Implementing an Ultra-Low-Power Thermostat with Slope A/D Conversion"* (SLAA129).

The block diagrams at right show both the low-end general-purpose and high-end versions of digital thermometers. Typical ADC resolution used in general-purpose digital thermometers may be 12-bit and above depending on the accuracy level required. A good reference for the ADC is also required for better accuracy. A microcontroller may be used for control purposes. Low-cost solutions employ a low-cost, low-power microcontroller like the MSP430, which has the integrated comparator and timer to digitize the analog signal using the slope A/D conversion technique.

Other additional features like high temperature alarm, beep after measurement, auto shut-off and data log of previous temperatures may also be featured in thermometers. Most thermometers have easy-to-read displays, usually a LCD display and low-battery indicator. Other peripherals include digital I/Os and LCD drivers.



A general block diagram of a low-cost digital thermometer.



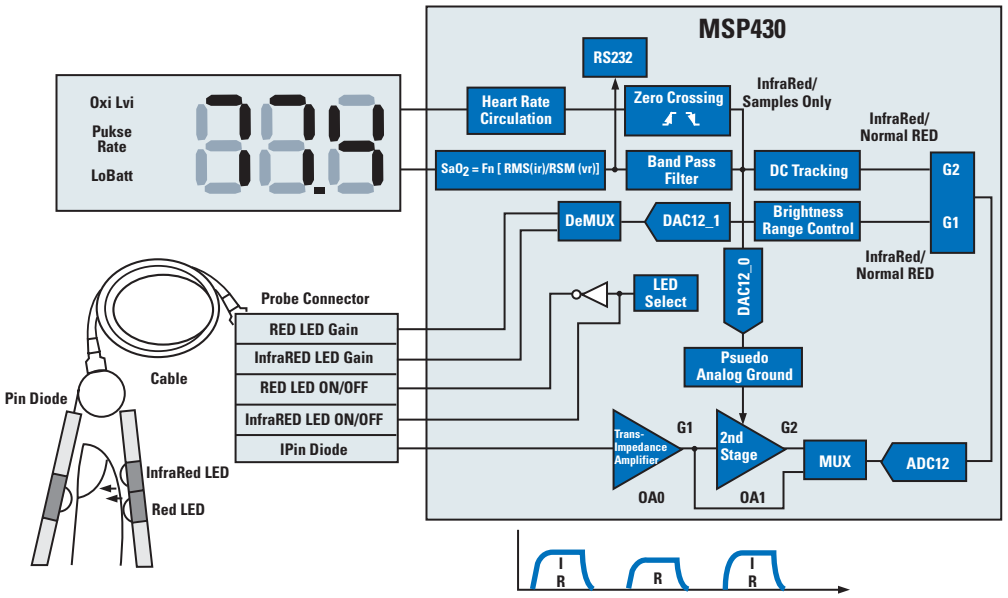
A general block diagram of a digital thermometer with high accuracy.

Pulse Oximetry

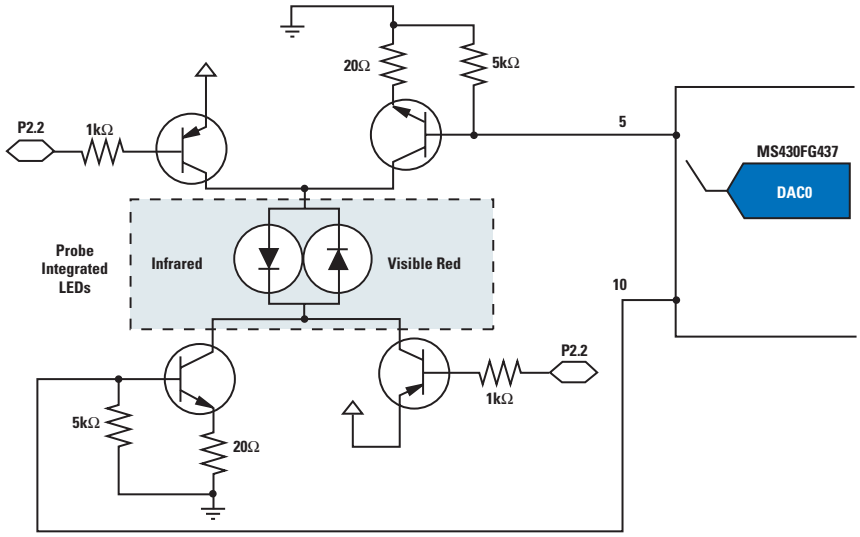
The pulseoximeter is a medical instrument for monitoring the blood oxygenation of a patient. By measuring the oxygen level and heart rate, the instrument can sound an alarm if these drop below a pre-determined level. This type of monitoring is especially useful for newborn infants and during surgery.

The design of a non-invasive optical pulseoximeter using the MSP430FG437 microcontroller (MCU) consists of a peripheral probe combined with the MCU displaying the oxygen saturation and pulse rate on a LCD glass. The same sensor is used for both heart-rate detection and pulseoximetering in this application. The probe is placed on a peripheral point of the body such as a finger tip, ear lobe or the nose. The probe includes two light emitting diodes (LEDs), one in the visible red spectrum (660nm) and the other in the infrared spectrum (940nm). The percentage of oxygen in the body is determined by measuring the intensity from each frequency of light after it is transmitted through the body and then the ratio between these two intensities is calculated.

The diagram at right demonstrates the implementation of a single-chip, portable pulseoximeter using the ultra-low-power capability of the MSP430 MCU. Because of the high level of analog integration, the external components are kept to a minimum. Furthermore, by keeping ON time to a minimum and power cycling the two light sources, power consumption is reduced.



Apart from the MCU and four transistors, only passive components are needed for this design.



LED drive circuit.

For More Information About Single-Chip Pulseoximeter Design Using the MSP430, Visit:

www-s.ti.com/sc/techlit/slaa274

Portable Medical

MSP430FG461x Offers Complete System-on-Chip for High-Precision, Portable Instrumentation

MSP430FG4616, MSP430FG4617, MSP430FG4618, MSP430FG4619

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/PARTnumber
(Replace **PARTnumber** with **MSP430FG4616**, **MSP430FG4617**, **MSP430FG4618** or **MSP430FG4619**)

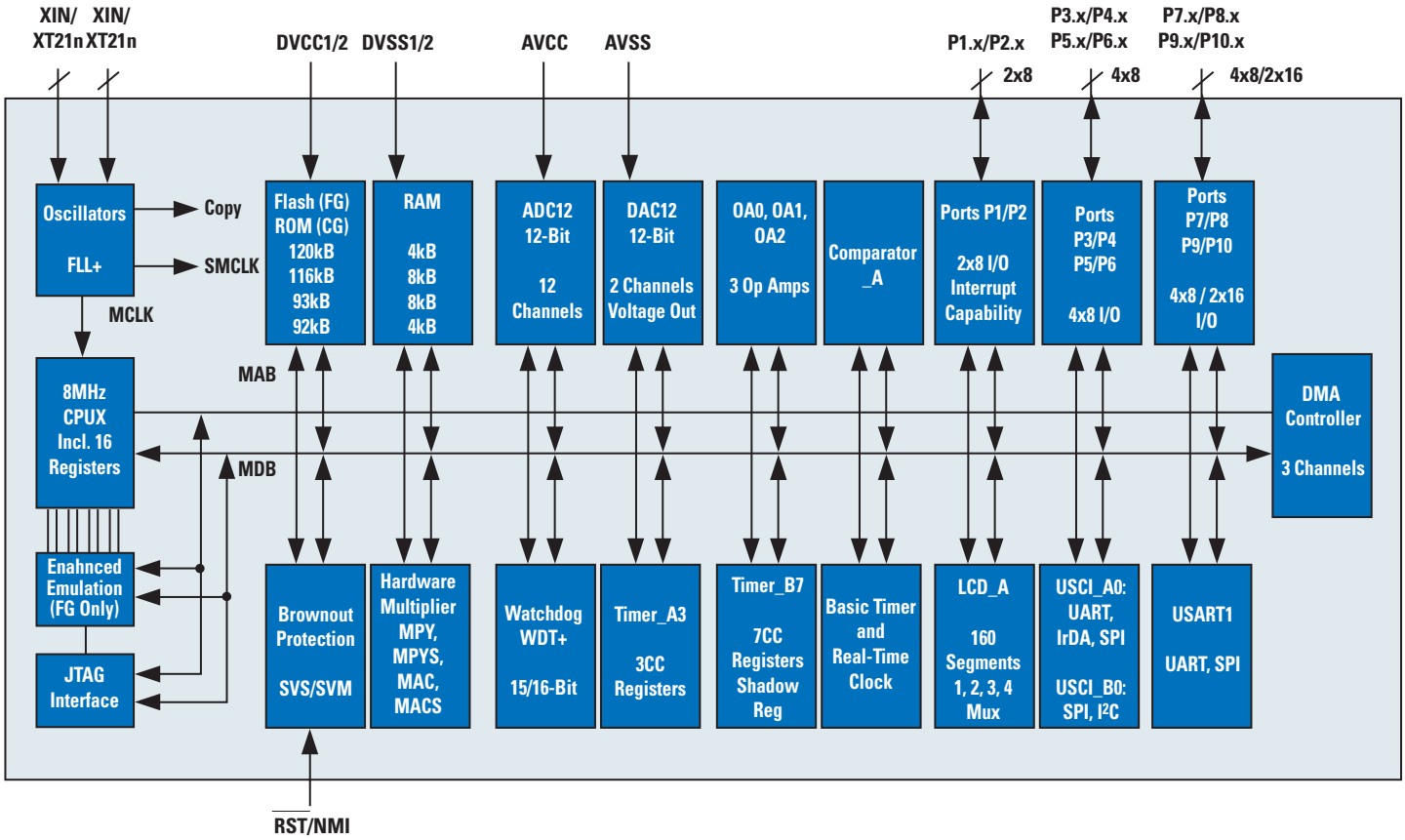
The MSP430FG461x microcontroller (MCU) series is designed for high-precision, real-time portable applications that require highly integrated intelligent peripherals and larger memory options on a single chip. The MCU's extended 1MB memory model enables faster code execution that results in up to 50% reduction in cycles for a full context store and up to 25% when addressing peripherals, Flash or RAM. The MCU configurations are complete with two 16-bit timers, a high-performance 12-bit A/D converter, dual 12-bit D/A converters, three configurable operational amplifiers, one universal serial communication interface (USCI), one universal synchronous/asynchronous communication interface (USART), DMA, 80 I/O pins and a liquid crystal display (LCD) driver with regulated charge pump.

Key Features

- Up to 120kB Flash/8kB RAM
- Ultra-low-power RTC operation
- Zero-power brown-out reset
- Complete system-on-chip:
  - UART, SPI, I^2C, IrDA
  - OPA-ADC-MDA-DAC-OPA
- Voltage-programmable LCD driver
- Trace buffer on chip
- Easy to use

Applications

- High-precision, battery-powered applications such as:
  - Portable medical
  - Portable industrial
  - Low-power RF



MPS430FG461x functional block diagram.

15ppm/°C (max), 100µA, SOT23-3 Series Voltage References

REF3112, REF3120, REF3125, REF3130, REF3133, REF3140

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/PARTnumber
(Replace **PARTnumber** with **REF3112**, **REF3120**, **REF3125**, **REF3130**, **REF3133** or **REF3140**)

The REF31xx is a family of precision, low-power, low-dropout series voltage references. The REF31xx does not require a load capacitor, but is stable with any capacitive load and can sink/source up to 10mA of output current. Unloaded, the REF31xx can be operated on supplies down to 5mV above the output voltage.

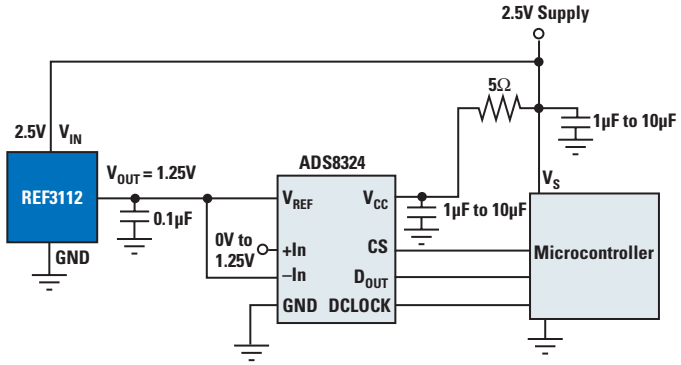
Product	Voltage (V)
REF3112	1.25
REF3120	2.048
REF3125	2.5
REF3130	3.0
REF3133	3.3
REF3140	4.096

Key Features

- Low dropout: 5mV
- High output current: ±10mA
- High accuracy: 0.2% (max)
- Low I_Q: 115µA (max)
- Excellent specified drift performance:
  - 15ppm/°C (max) from 0°C to +70°C
  - 20ppm/°C (max) from –40°C to +125°C

Applications

- Medical equipment
- Data acquisition systems
- Portable, battery-powered equipment
- Handheld test equipment



Basic data acquisition system.

1.8V, microPower CMOS Operational Amplifier Zerø-Drift Series

OPA333, OPA2333

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/OPA333 or **www.ti.com/sc/device/OPA2333**

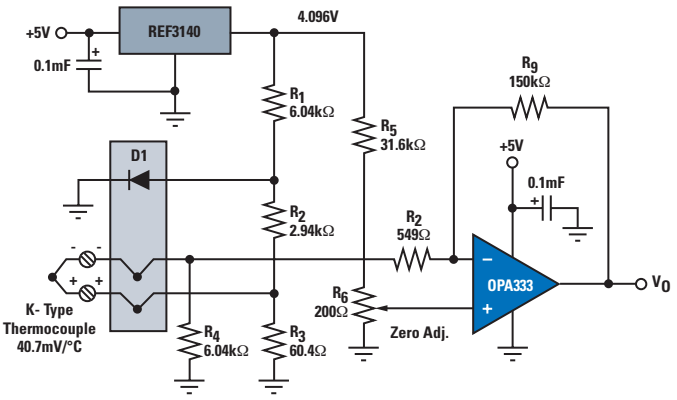
The OPA333 series of CMOS operational amplifiers uses a proprietary auto-calibration technique to simultaneously provide very low offset voltage (10µV max) and near-zero drift over time and temperature. These miniature, high-precision, low quiescent current amplifiers offer high-impedance inputs that have a common-mode range 100mV beyond the rails and rail-to-rail output that swings within 50mV of the rails. Single or dual supplies as low as +1.8V (±0.9V) and up to +5.5V (±2.75V) may be used. The OPA333 family offers excellent CMRR without the crossover associated with traditional complementary input stages. This design results in superior performance for driving analog-to-digital converters (ADCs) without degradation of differential linearity.

Key Features

- Low offset voltage: 10µV (max)
- Zero drift: 0.05µV/°C (max)
- 0.01Hz to 10Hz noise: 1.1μV_{PP}
- Quiescent current: 17µA
- Supply voltage: 1.8V to 5.5V
- Rail-to-rail input/output
- Packaging: SC70, SOT23

Applications

- Medical instrumentation
- Temperature measurements
- Battery-powered instruments
- Electronic scales
- Handheld equipment



OPA333 in temperature measurement circuit.

System Support Products

Voltage Level Translation

As operating voltage levels in microcontrollers continue to drop, a void may be created between peripheral devices and processors that disrupts interfacing between the devices. TI's translators enable communication between incompatible I/Os with level translation between the 1.2V, 1.5V, 1.8V, 2.5V and 3V nodes. The MSP430 microcontroller shown in many applications within this guide, has a 3.6V (max) I/O tolerance: thus, translators can be used to protect the inputs and to interface to higher voltage peripherals.

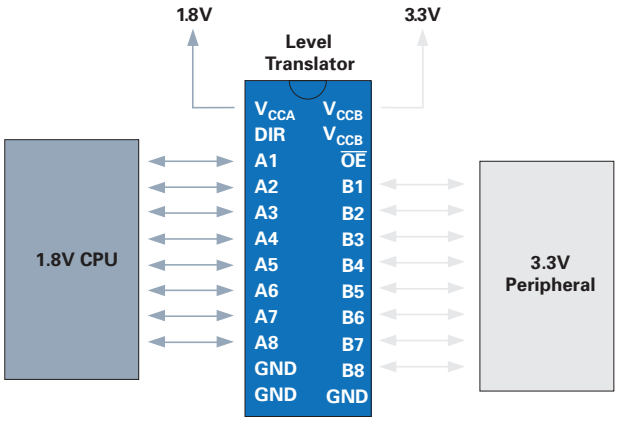
Applications

- LCD interface
- Interface devices with different supply voltages

Suggested Components

Component	Description	V_{CC} Range (V)	Power Max I_{CC} (µA)	Smallest Footprint Pins/Packages
SN74AVC1T45*	Single-bit Dual-Supply Bus Transceiver	1.2 to 3.6	10	6/WCSP (NanoStar™)
SN74LVC1T45	Single-bit Dual-Supply Bus Transceiver	1.65 to 5.5	4	6/WCSP (NanoStar)
SN74AVC2T45*	Dual-bit Dual-Supply Transceiver	1.2 to 3.6	10	8/WCSP (NanoStar)
SN74LVC2T45	Dual-bit Dual-Supply Transceiver	1.65 to 5.5	10	8/WCSP (NanoStar)
SN74AUP1T57	Single-Supply Voltage Translator	2.3 to 3.6	0.9	6/WCSP (NanoStar)
SN74AUP1T58	Single-Supply Voltage Translator	2.3 to 3.6	0.9	6/WCSP (NanoStar)
SN74AUP1T97	Single-Supply Voltage Translator	2.3 to 3.6	0.9	6/WCSP (NanoStar)
SN74AUP1T98	Single-Supply Voltage Translator	2.3 to 3.6	0.9	6/WCSP (NanoStar)
PCA9306	Dual Bidirectional I²C-bus and SMBus Voltage-Level Translator	—	—	8/US, WCSP

** Bus-hold option available.*



Example application block diagram.

I²C Bus I/O Expansion

Often there are not enough GPIOs available on the microcontroller to control all the desired peripherals, such as controlling LEDs or interfacing to a keypad. An I²C bus expander can increase the number of GPIOs while taking up minimal board space with the 8-pin WCSP.

Key Features

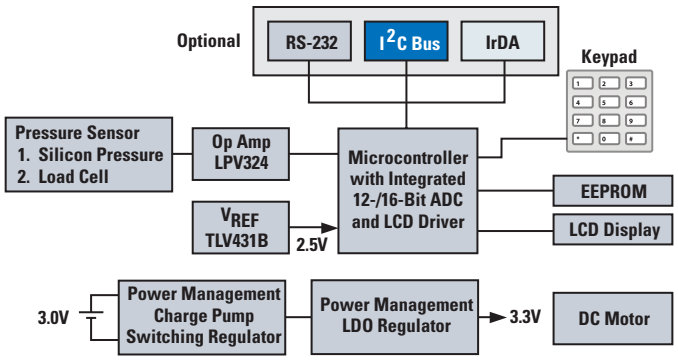
- Processor pin savings
- Improved board routing
- Reduced board space

Applications

- Keypad control
- LED control
- Temperature sensing

Suggested Components

Component	Frequency (Max) (kHz)	I²C Address	V_{CC} Range (V)	-bit Width
PCA9536	400	1000 001	2.3 to 5.5	4
PCF8574	100	0100 xxx	2.5 to 6.0	8
PCF8574A	100	0111 xxx	2.5 to 6.0	8
PCA9554	400	0011 xxx	2.3 to 5.5	8
PCA9557	400	0011 xxx	2.3 to 5.5	8
PCA6107	400	0011 xxx	2.3 to 5.5	8
PCF8575	400	0100 xxx	2.5 to 5.5	16
PCF8575C	400	0100 xxx	4.5 to 5.5	16
PCA9535	400	0100 xxx	2.3 to 5.5	16
PCA9539	400	1110 1xx	2.3 to 5.5	16
PCA9555	400	0100 xxx	2.3 to 5.5	16



Example application block diagram.

Audio Signal Routing

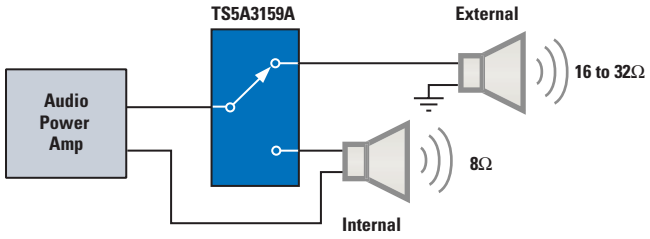
One of the most common applications for analog switches is signal routing. This may be routing from one source to multiple destinations or from several sources to a single destination. A single-pole, double-throw analog switch can be used for either situation. For example, the switch could be used to reroute the output of the audio power amplifier to two different speakers. Another common application is switching from an audio amplifier in the baseband of a mobile to an audio power amplifier for higher power output.

Applications

- DeMUX internal/external speakers
- MUX audio power amplifier
- Low-power routing (<100mA)
- Amplifier gain adjustment

Suggested Components

Component	Configuration	V+ (V)	r_{on} (Ω)	Smallest Footprint Pins/Packages
TS5A3159A	1 x SPDT	1.65 to 5.5	0.9	6/WCSP
TS5A3166	1 x SPST	1.65 to 5.5	0.9	6/WCSP
TS5A23166	2 x SPST	1.65 to 5.5	0.9	6/WCSP
TS5A3153	1 x SPDT	1.65 to 5.5	0.9	8/WCSP
TS5A6542	1 x SPDT	1.65 to 5.5	0.75	8/WCSP
TS5A23159	2 x SPDT	1.65 to 5.5	0.9	10/Micro QFN
TS5A26542	2 x SPDT	1.65 to 5.5	0.75	12/WCSP
TS5A3359	1 x SP3T	1.65 to 5.5	0.9	8/WCSP



Example application block diagram.

USB-to-Serial Bridge
TUSB3410

Get samples, datasheets, app reports and evaluation modules at:
www.ti.com/sc/device/TUSB3410

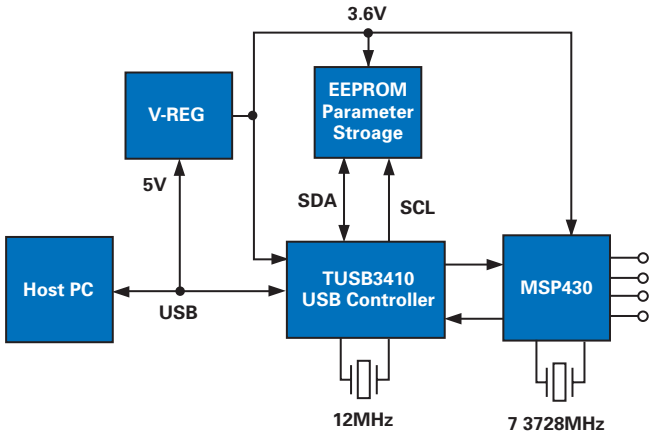
The TUSB3410 and TUSBWINVCP Software provide an easy way to move your serial-based legacy device to a fast, flexible USB interface by bridging between a USB port and an enhanced UART serial port. The TUSB3410 contains all the necessary logic to communicate with the host computer using the USB bus. The TUSBWINVCP software package enables the TUSB3410 to act as a Virtual COM Port and appear like the legacy COM ports on the back of your old PCs. This enables you to use your existing devices and application software without any changes to either of them.

Key Features

- USB full-speed (12Mbps) compliant
- Integrated 8052 microcontroller with 16Kbytes of RAM that can be loaded from the host or from external onboard memory via an I^2C bus
- Integrated, enhanced UART features including:
  - Programmable software/hardware flow control
  - Automatic RS-485 bus transceiver control, with and without echo
  - Software-selectable baud rate from 50 to 921.6 kbaud
  - Built-in, 2-channel DMA controller for USB/UART bulk I/O
- TUSB3410UARTPDK product development kit can jump-start your USB-to-serial development

Applications

- Handheld meters
- Health metrics/monitors
- Legacy-free PC COM port replacement



TUSB3410/MSP430 implementation block diagram.

Wireless Interface, RFID and Tag-it™

Radio Frequency Identification (RFID)

TI's high frequency RFID product family consists of 13.56MHz high-frequency (HF) transponders and low-power RFID readers, which are compliant with the ISO/IEC 15693 and ISO/IEC 18000-3 global open standards. Typical RFID implementations can include applications such as asset tracking, access control, blood bag tracking, medical supply tracking, patient/staff authentication, pharmaceutical authentication, medical imaging, product authentication, and remote digital healthcare management – as well as many non-medical related applications.

Tag-it HF-I Transponder Inlays

TI's Tag-it HF-I family of transponder inlays consist of 13.56MHz high-frequency (HF) transponders that are compliant with the ISO/IEC 15693 and ISO/IEC 18000-3 global open standards. These products are available in six different antenna shapes with frequency offset for integration into paper, PVC or other substrates manufactured with TI's patented laser-tuning process to provide consistent read performance. Prior to delivery, the transponders undergo complete functional and parametric testing in order to provide the high quality customers have come to expect.

Tag-it HF-I Family Product Specifications

Supported Standards	ISO/IEC 15693-2, -3; ISO/IEC18000-3
Recommended Operating Frequency	13.56MHz
Factory Programmed Read Only Numbers	64-bits
Typical Programming Cycles (at +25°C)	100,000
Data Retention Time (at +55°C)	>10 years

Key Features

- ISO/IEC 15693-2, -3; ISO/IEC18000-3
- User and factory lock per block
- Application Family Identifier (AFI)

Standard

- 256-bit user memory, 8 x 32-bit
- FastSID

Pro

- 256-bit user memory, 8 x 32-bit
- Password-protected write command
- Command to disable IC functionality
- FastSID

Plus

- 2k-bit user memory, 64 x 32 6-bit
- Data Storage Format Identifier (DSFID)
- Combined inventory read block

Tag-it™ HF-I Plus Inlay Shapes

Part Number	RI-I11-112A	RI-I11-112B	RI-I02-112A	RI-I02-112B	RI-I03-112A	RI-I15-112B	RI-I16-112A	RI-I17-112A
Available Memory	2k-bits organized in 64 x 32-bit blocks							
Antenna size (mm)	45 x 45	45 x 45	45 x 76	45 x 76	22.5 x 38	34 x 65	θ 24.2	θ 32.5
Foil Pitch (mm)	50.8 + 0.1/ –0.4 (2 in)	50.8 + 0.1/ –0.4 (2 in)	96 + 0.1/ –0.4 (~3.78 in)	96 + 0.1/ –0.4 (~3.78 in)	58 +0.1/ –0.4 (~1.89 in)	101.6 +0.1/ –0.4 (4 in)	50.8 +0.1/ –0.4 (2 in)	50.8 +0.1/ –0.4 (2 in)
Frequency Offset for Lamination Material	Paper	PVC	Paper	PVC	Paper/PVC	PVC	Paper/PVC	Paper/PVC
Delivery	Single tape row with 48mm foil width wound on cardboard reel							

Tag-it™ HF-I Pro Transponder Inlays

Part Number	RI-I11-114A-S1	RI-I11-114B-S1	RI-I02-114A-S1	RI-I02-114B-S1	RI-I03-114-S1	RI-I16-114-S1	RI-I17-114-S1
Available Memory	256-bits organized in 8 x 32-bit blocks						
Foil Width (mm)	48mm ±0.5mm						
Antenna size (mm)	45 x 45	45 x 45	45 x 76	45 x 76	22.5 x 38	θ 24.2	θ 32.5
Foil Pitch (mm)	50.8 +0.1/–0.4 (2 in)	50.8 +0.1/–0.4 (2 in)	96 +0.1/–0.4 (~3.78 in)	96 +0.1/–0.4 (~3.78 in)	48 +0.1/–0.4 (~1.89 in)	50.8 +0.1/–0.4 (2 in)	50.8 +0.1/–0.4 (2 in)
Frequency Offset for Lamination Material	Paper	PVC	Paper	PVC	Paper/PVC	Paper/PVC	Paper/PVC
Delivery	Single row tape Wound on cardboard reel						

Tag-it™ HF-I Standard Transponder Inlays

Part Number	RI-I11-114A-01	RI-I11-114B-01	RI-I02-114A-01	RI-I02-114B-01	RI-I03-114-01	RI-I16-114-01	RI-I17-114-01
Available Memory	256-bits organized in 8 x 32-bit blocks						
Foil Width (mm)	48mm ±0.5mm						
Antenna size (mm)	45 x 45	45 x 45	45 x 76	45 x 76	22.5 x 38	θ 24.2	θ 32.5
Foil Pitch (mm)	50.8 +0.1/–0.4 (2 in)	50.8 +0.1/–0.4 (2 in)	96 +0.1/–0.4 (~3.78 in)	96 +0.1/–0.4 (~3.78 in)	48 +0.1/–0.4 (~1.89 in)	50.8 +0.1/–0.4 (2 in)	50.8 +0.1/–0.4 (2 in)
Frequency Offset for Lamination Material	Paper	PVC	Paper	PVC	Paper/PVC	Paper/PVC	Paper/PVC
Delivery	Single row tape wound on cardboard reel						

Low-Power, Multi-Standard HF RFID Readers
TRF7960,TRF7961

Get samples and datasheets at:

www.ti.com/sc/device/TRF7960 or **www.ti.com/sc/device/TRF7961**

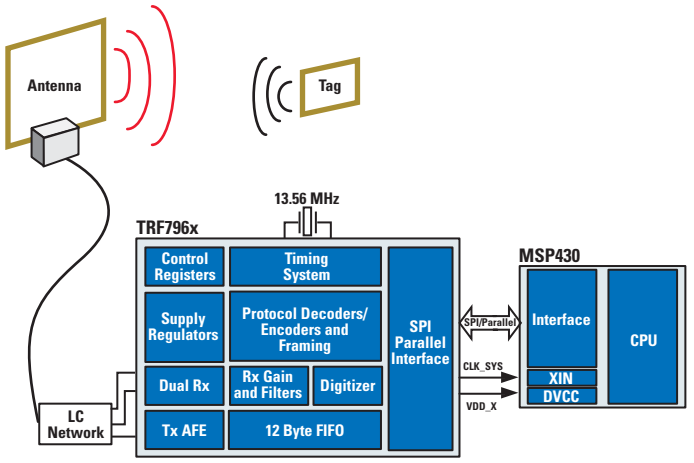
Complementing the Tag-it™ HF-I family of transponder inlays, is the TRF7960; a highly integrated analog front end and data framing system for any 13.56MHz RFID reader system. Built-in programming options make it useful for a wide range of applications both in proximity and vicinity RFID systems. Its high level of integration, excellent performance, miniature size and multiple low power modes allows the TRF7960 to be used for battery power-constrained medical applications.

Key Features

- Supports ISO14443A/B, ISO15693 and Tag-it
- Completely integrated protocol handling (OSI Model Layer 3 and below)
- Programmable output power: (100mW or 200mW)
- Wide operating voltage range: 2.7V to 5.5 V
- Separate, internal high-PSRR LDOs for analog, digital and PA sections provide noise isolation for superior read range and reliability
- Parallel 8-bit or Serial 4-pin SPI interface with 12-byte FIFO
- Seven, user selectable, ultra-low power modes
  - Power down: <1mA
  - Standby: 120mA
  - Active:10mA (Rx only)
- High integration reduces total BOM and board area
  - Integrated LDO supply regulator for MCU
  - Single Xtal system with available output clock for MCU
- MSP430 software libraries with Software Licensing Agreement are available at no cost
- 11 user-accessible and programmable registers
- Package: Ultra-small 32-pin QFN (5mm x 5mm)

Applications

- Asset tracking
- Access control
- Blood bag tracking
- Medical supply tracking
- Patient and staff authentication
- Pharmaceutical authentication
- Medical imaging and data tracking
- Product authentication and calibration
- Remote digital healthcare management
- And many other non-medical related applications



Functional block diagram.

TRF7960 and TRF7961 Evaluation Modules (EVMs)

The TRF7960 and TRF7961 EVMs evaluate the performance of the TRF7960 and TRF7961 multiple-protocol RFID transceivers. The component incorporates an analog front end, protocol handling, framing, error checking, and multiple integrated voltage regulators with other features that allow the reader to be customized/configurable for the end application.

The TRF7961 EVM features include:

- Supports the ISO 15693 standard
- Supports the Texas Instruments Tag-it™ standard
- Self contained – has an on-board 13.56MHz loop antenna and interface
- Communicates with host software on a Windows®-based PC through a standard USB cable

The TRF7960 EVM has all the features of the TRF7961 EVM, but adds:

- Support for both the ISO 14443A standard and the ISO 14443B standard (layer 3)
- Protocol indication LEDs – no computer is required to indicate detection of a tag.

Low-Power RF Products

Low-Power Multi-Channel Sub-1GHz RF Transceiver
CC1100

Get samples and datasheets at: **www.ti.com/sc/device/CC1100**

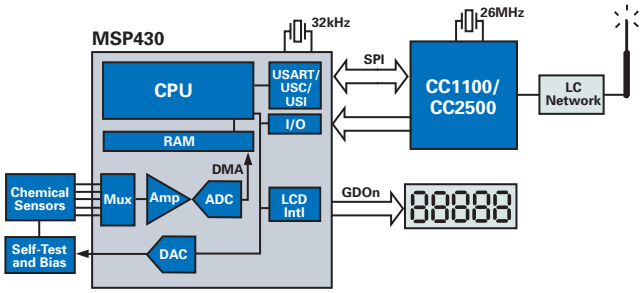
The CC1100 is a low-cost, single-chip UHF transceiver designed for very low-power wireless applications. Due to its small size, low power consumption and excellent radio performance, the CC1100 can be used for small, battery-operated medical applications in the sub-1GHz ISM (Industrial, Scientific and Medical) bands.

Key Features

- Low current consumption: 14.5mA in Rx at 1.2kbps, 433MHz, 15.5mA in Tx at 0dBm, 433MHz
- High sensitivity: –110dBm at 1.2kbps, 1% packet error rate
- Frequency bands: 300 - 348MHz, 400 - 464MHz and 800 - 928MHz
- Supply voltage: 1.8V to 3.6V
- Excellent receiver selectivity and blocking performance
- Many powerful digital features allow a high-performance RF system to be made using an inexpensive microcontroller
- Packaging: small QLP-20 (4mm x 4mm)

Applications

- Personal and portable measurement products
- Handheld medical diagnostics
- Battery-powered instruments
- Medical equipment



Example application block diagram – wireless blood gas analyzer.

See also the CC2500 — a low-power, 2.4GHz RF transceiver.

Sub-1GHz System-on-Chip RF Solution
CC1110/F8/F16/F32

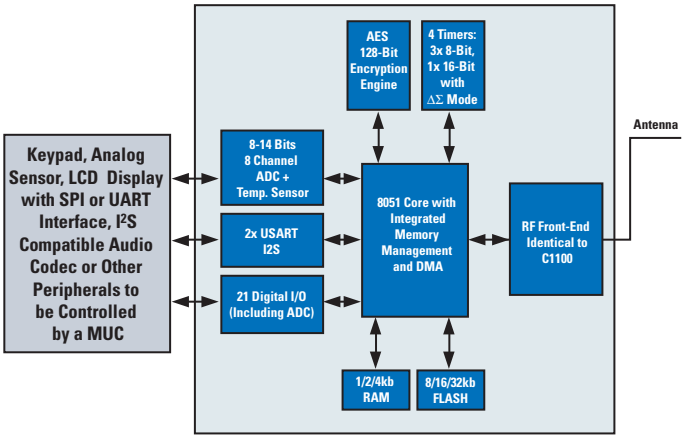
PREVIEW*

Get samples and datasheets at: **www.ti.com/sc/device/CC1110**

The CC1110 is a low-cost system-on-chip (SoC) IC designed for low-power and low-voltage wireless communication applications. The CC1110 combines the excellent performance of the CC1100 RF transceiver with an industry-standard enhanced MCU, 8/16/32kB of in-system programmable Flash memory, 1/2/4kB of RAM and many other useful peripherals. Because of several advanced low-power operating modes, the CC1110 is designed for systems where very low power consumption is required.

Key Features

- Low current consumption
- High-performance RF transceiver core (same as in the CC1100)
- 8- to14-bit ADC with up to eight inputs
- 21 general I/O pins
- Real-time clock and several timers
- 8/16/32kB in-system programmable Flash
- 1/2/4kB RAM
- Packaging: 6mm x 6mm QLP-36



General-purpose medical device using CC1110. Supports secure RF link with embedded 128-bit AES hardware encryption.

See also the CC2510 and CC2511 — 2.4GHz, system-on-a-chip RF solutions.

**Product release scheduled for 3Q 2007.*

ZigBee for Medical Applications

The world is going wireless and medical applications are no exception. More and more medical devices, especially patient monitoring, can benefit from wireless ZigBee technology. With the use of wireless sensors, the patients can move around in the hospital, or even in their homes, and the sensors will still monitor and send critical health data to the hospital or doctor. Being independent of a patient's exact geographical location has a positive impact on both the patient and the hospital.

The ZigBee standard enables companies to have a simple, reliable, low-cost and low-power standard-based wireless platform for their application development. TI's low-power RF portfolio of high-performance RF ICs offers robust and cost-effective solutions for a variety of medical devices.

RF-ICs Compliant with IEEE 802.15.4/ZigBee Specifications

- CC2420: Industry-leading RF transceiver provides maximum flexibility as it can be combined with microcontroller
- CC2430: True System-on-Chip (SoC) with integrated microcontroller
- CC2431: SoC with integrated location capabilities
- Hardware development kits
- High-performance and robust reference designs
- Free Z-Stack ZigBee 2006 compliant stack
- Free IEEE 802.15.4 MAC software

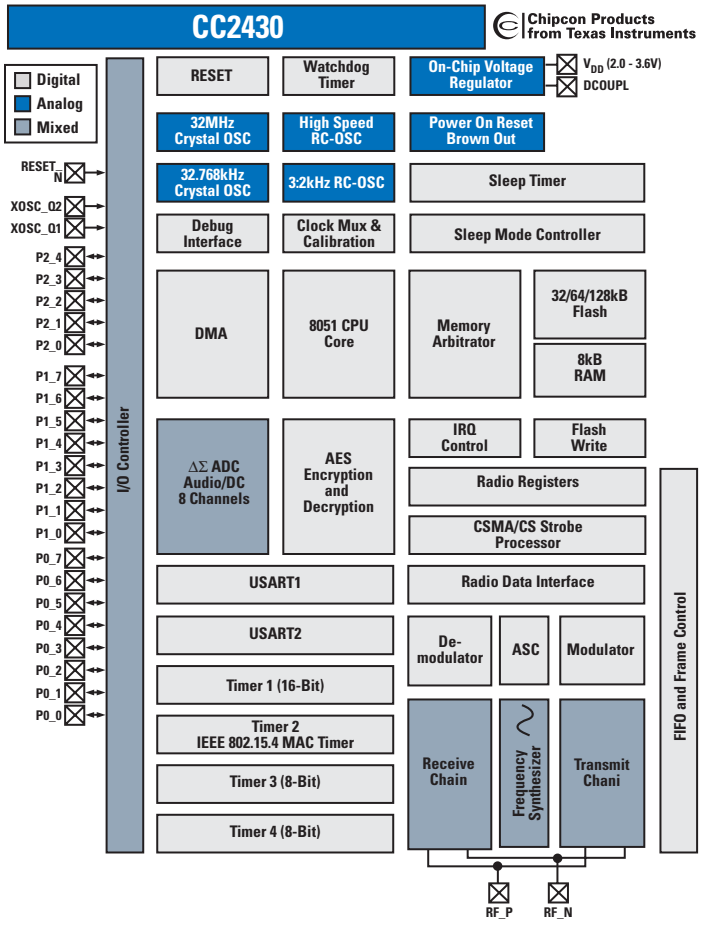
ZigBee Software Development Suite

- Z-Stack: Industry-leading ZigBee protocol stack from TI
- Z-Stack: Protocol stack extensions
- Z-Tool (debug tool)

Applications

- Patient monitoring
- Hospital equipment tracking

For more information visit: **www.ti.com/zigbee**



CC2430 functional block diagram.

Power Management for Portable Devices

High PSRR LDOs in Ultra-Small Packages
TPS71710

Get samples and datasheets at: **www.ti.com/sc/device/TPS71710**

The TPS717xx family of low-dropout (LDO), low-power linear regulators offer very high power supply rejection (PSRR) while maintaining very low 50µA ground current in an ultra-small 5-pin SC70 package. The family achieves fast start-up, very low noise, and excellent transient response. The TPS717xx is stable with a 1.0µF ceramic output capacitor and uses a precision voltage reference and feedback loop to achieve a worst-case overall accuracy of 3%.

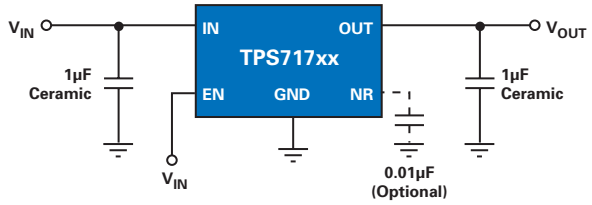
Key Features

- Input voltage range: 2.5V to 6.5V
- Fixed output voltages: 0.9V to 3.3V
- Adjustable output voltages: 0.9V to 5.0V
- Rated output current: 150mA
- Low quiescent current: 50µA
- Stable with 1µF ceramic output capacitor
- 30µV_{RMS} output noise, 100Hz to 100kHz
- 3% accuracy over load/line/temp
- Very high PSRR: 70dB at 100Hz, 1kHz
  - 67dB at 10kHz, 100kHz
  - 45dB at 1MHz
- Package: SC70-5 and 6-pin 2mm x 2mm SON, 1.5mm x 1.5mm SON

Applications

- RF applications
- Low noise applications
- Camera modules
- PLL power supplies
- VCO power supplies

Component	I_{OUT} (mA)	V_{DO} (mV)	I_Q (µA)	PSRR at 1MHz (dB)
TPS717xx	150	170	50	45



Typical application circuit for fixed voltage variations.

600mA Switch, Low V_{IN} Boost DC/DC In TSOT-23
TPS61070

Get samples and datasheets at: **www.ti.com/sc/device/TPS61070**

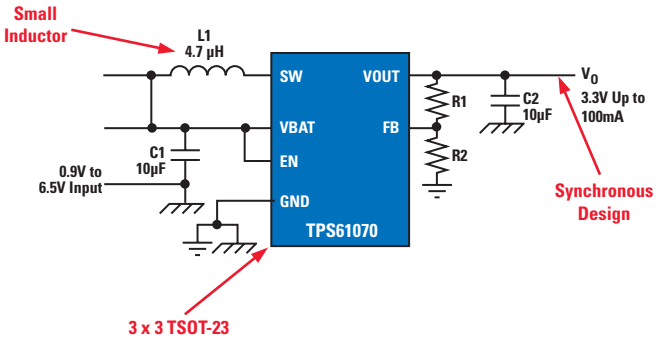
The TPS6107x is a synchronous DC/DC converter with integrated FETs providing a peak power conversion efficiency of >90% over a very wide load range and a quiescent current of 19µA. 1-cell to 3-cell Alkaline/NiMH and 1-cell Li-Ion battery-powered equipment benefit from the 0.9V to 5.5V input voltage range. The 600mA switch current limit allows an output current of up to 75mA at 3.3V from a 0.9V input.

Key Features

- Input voltage range: 0.9V to 5.5V
- 75mA at 3.3V V_{OUT} and 0.9V V_{IN}
- Switch current limit: 600mA
- Up to 90% efficient over wide load range
- Quiescent current: 19µA (typ)
- Shutdown current: 0.05µA (typ)
- Load disconnect during shutdown
- Adjustable output voltage up to 5.5V
- 1.2MHz switching frequency, synchronous
- Package: 3mm x 3mm x 1mm^2 TSOT-23

Applications

- Portable medical devices needing a higher voltage than supplied by battery
- Simple LED backlighting for LCD



Functional block diagram.

Low-Cost, 1-Cell Li-Ion Charger with FET and Current Sense in QFN-10

bq24081 bqTINY™

Get samples and datasheets at: **www.ti.com/sc/device/bq24081**

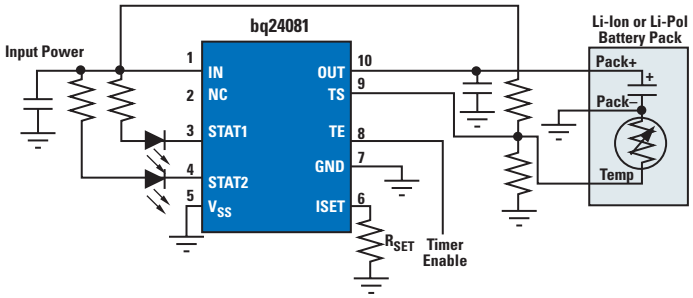
The bq2408x are highly integrated linear Li-Ion charge management ICs optimized for USB and AC wall adapter charging of single-cell Li-Ion and Li-Polymer batteries. These highly integrated, single-cell Li-Ion battery charge management ICs can be used for low-dropout charger designs in space-limited, portable applications. They require a minimal set of external components by integrating a 1A charge FET, reverse-blocking circuitry and current sense along with other battery management features.

Key Features

- Integration: 1A FET, reverse-current protection, current sense, thermal shutdown, 3mm x 3mm^2 QFN-10
- Battery management: 4.2V, ±0.5% voltage regulation, charge termination, safety timer, optional temperature monitoring
- Autonomous power-source selection
- Battery pre-conditioning with safety timer
- bq24080 offers Charge Enable (CE) and Power Good (PG) functions, bq24081 offers Timer Enable (TE) and Temp Sense (TS) functions

Applications

- Any portable medical device powered by 1-cell Li-Ion and charged from a USB port



Functional block diagram.

Li-Ion and Li-Pol Battery Gas Gauge IC for Portable Applications

bq27010

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/bq27010

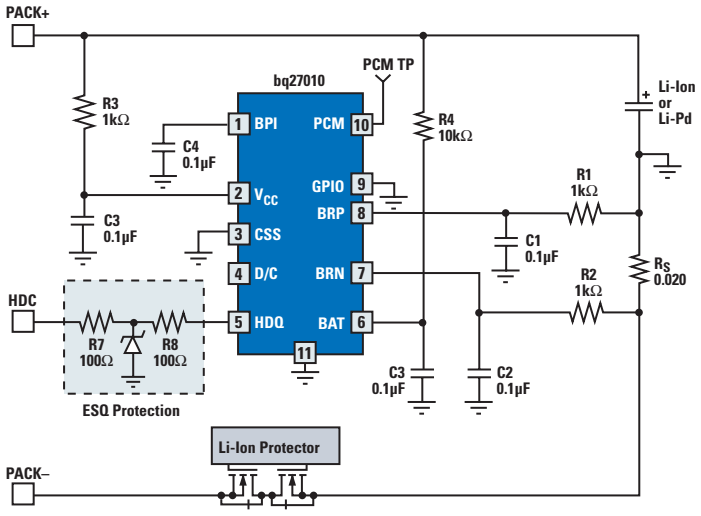
The bq27010 (bqJUNIOR™) series are highly accurate, stand-alone, single-cell, Li-Ion and Li-Pol battery capacity monitoring and reporting components targeted at space-limited, portable applications. Compensation for battery age, temperature, self-discharge and discharge rate are applied to the capacity measurements to provide available time-to empty information across a wide range of operating conditions. The component can operate directly from a single-cell and communicates to the system over a HDQ one-wire (bq27010) or I^{2}C serial interface (bq27210).

Key Features

- Reports accurate time-to-empty at both measured and host-requested load values
- Automatic capacity reduction with age
- Reports temperature, voltage and current
- Requires no user calibration
- Programmable input/output port
- Dynamic end-of-discharge detection delay to allow use in a high-dynamic load environment

Applications

- Portable medical
- Handheld devices



Functional block diagram.

Component Recommendations for Portable Medical Applications

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
INA122	Instrumentation Amp	±50µV (max) input offset, 83dB CMRR, 0.06mA (typ) I_Q		
INA126	Instrumentation Amp	±250µV (max) input offset, 83dB CMRR, 0.175mA (typ) I_Q		
INA321	Instrumentation Amp	±500µV (max) input offset, 90dB CMRR, 0.04mA (typ) I_Q		
INA331	Instrumentation Amp	±500µV (max) input offset, 90dB CMRR, 0.415mA (typ) I_Q		
OPA333	Precision Op Amp	1.8V (min) V_S, 0.017mA (max)/ch I_Q		
OPA364	CMOS Amplifier	1.8V, 7MHz, 90dB CMRR, 5V/µs slew rate, 750µA/ch I_Q	Sensor amplification in battery-powered systems	OPA363, OPA2363, OPA2364, OPA4364
TLV276x	microPower Op Amp	1.8V, RRIO, 500µV input offset voltage, 500kHz BW	Available in S, D, Q, 20µA/ch I_Q	
TPA6203A	Class-AB Audio Amp	2.5V to 5.5V supply, 1.25W output, 1.17mA/ch I_Q, 8Ω (min) load	Speaker amplifier, mono, fully differential	
TPA741	Class-AB Audio Amp	2.5V to 5.5V supply, 0.7mW output, 1.35mA/ch I_Q, 8Ω (min) load	Speaker amplifier, mono, active high shutdown, depop	
TPA751	Class-AB Audio Amp	2.5V to 5.5V supply, 0.7mW output, 1.25mA/ch I_Q, 8Ω (min) load	Speaker amplifier, mono, active low shutdown	
Data Converters				
ADS7866	SAR ADC, Serial	1.2V, 12-bit, 200kSPS (max), 85dB SFDR	Very small, low power	ADS7886
ADS7867	SAR ADC, Serial	1.2V, 10-bit, 240kSPS (max), 80dB SFDR	Very small, low power	ADS7887
ADS7868	SAR ADC, Serial	1.2V, 8-bit, 280kSPS (max), 67dB SFDR	Very small, low power	ADS7888
DAC7551	V_{OUT} DAC	12-bit, 500kSPS, ±0.5LSB DNL, ±1LSB INL, 0.27mW power	Ultra-low glitch	DAC7554
DAC8534	V_{OUT} DAC	16-bit, 0.093MSPS, ±1LSB DNL, ±64LSB INL, 2.7mW power	Quad	
DAC8551	V_{OUT} DAC	16-bit, 0.2MSPS, ±1LSB DNL, ±8LSB INL, 1mW power		DAC8554
DAC8560	V_{OUT} DAC	16-bit, 0.15nV-s glitch, ±10µs to 0.003%FSR settling time	Small with internal 2ppm/°C reference	DAC8554, DAC8551, DAC8552
References				
REF2912	Series Voltage	100ppm/°C (max) temp coeff, 50µA I_Q, 2% accuracy		REF29xx
REF3012	Series Voltage	50ppm/°C (max) temp coeff, 50µA I_Q, 0.2% accuracy		REF30xx
REF3140	Voltage Reference	15ppm/°C (max) drift, 5mV low dropout, 115µA (max) I_Q, 0.2% (max) accuracy	No load capacitor required	REF3130, REF3120 REF32xy, REF33xy
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q	Multiple output voltages, SOT23-6	
REF33xx	microPower Bandgap	0.1% (max) accuracy, 30ppm/°C (max) drift, 0.005mA (max) I_Q	Multiple output voltages, MSOP-8, SO-8	
REF50xx	Precision Reference	0.05% accuracy, 3ppm/°C (max) drift, 6µV_{PP} low noise	Multiple output voltages, SC71	
Processors				
MSP430F20xx	Ultra Low Power 16-bit MCU	2 KB Flash, 128 B RAM, SPI+I^2C	8 ch. 12-bit ADC or 4 ch. 16-bit SD ADC, 4x4 mm package	
MSP430F22x4	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + I^2C + UART/LIN + IrDA	12 ch. 10-bit ADC, 2 op.amps	
MSP430F23x0	Ultra Low Power 16-bit MCU	32 KB Flash, 2 KB RAM, SPI + I^2C + UART/LIN + IrDA	Analog comparator, HW multiplier	
MSP430F15x	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comparator	
MSP430F16x	Ultra Low Power 16-bit MCU	60 KB Flash, 2 KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comp, HW multiplier	
MSP430F16xx	Ultra Low Power 16-bit MCU	55 KB Flash, 10 KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comp, HW multiplier	
MSP430F41x	Ultra Low Power 16-bit MCU	4 KB Flash, 256 B RAM, SVS, 96 segment LCD	Analog comparator	
MSP430F42x0	Ultra Low Power 16-bit MCU	32 KB Flash, 256 B RAM, 56 segment LCD	5 ch. 16-bit SD ADC, 12-bit DAC	
MSP430F42x	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + UART, SVS, 128 segment LCD	3 x 16-bit SD ADC	
MSP430F43x	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, analog comparator	
MSP430FG43x	Ultra Low Power 16-bit MCU	60 KB Flash, 2 KB RAM, SPI + UART, SVS, 128 segment LCD	12 ch. 12-bit ADC, 2 ch. 12-bit DAC, DMA, 3 op amps	

*Preview components are listed in **bold blue**.*

*New products are listed in **bold red**.*

Component Recommendations for Portable Medical Applications

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Processors (Continued)				
MSP430F44x	Ultra Low Power 16-bit MCU	60 KB Flash, 2 KB RAM, 2x SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, HW multiplier	
MSP430FG461x	Ultra Low Power 16-bit MCU	120 KB Flash, 8 KB RAM, SPI + I^2C + UART/LIN + IrDA, 160 LCD	12 ch.12-bit ADC, 2 ch.12-bit DAC, A-comp, 3 op amp, HW multiplier	
Interface				
SN65220	USB Transient Suppressor	1 USB port, 3.3V supply, –40°C to +85°C temp range		
TPD4E002	Low Capacitance Array	±15kV ESD protection, 11pF at 0V low I/O capacitance, VBR - 6.1V (min) I/O breakdown voltage	High ESD protection level, high integration	TPD4E001
TUSB3410	USB 2.0 Full-Speed to Enhanced Serial Port Bridge	USB 2.0 compliance, enhanced UART port		
Power Management Products				
bq2406x	Battery Charger	Linear 1-Cell Li-Ion charger with thermal regulation, 6.5V OVP, temp sense	Good for space-limited designs with need for battery safety	bq2410x
bq27010	Battery Fuel Gauge	Li-Ion and Li-Pol battery gas gauge	Reports accurate time-to-empty of battery	bq27200, bq27500
TPS2041B	USB Power Switches	USB compliant power source, short circuit protection	Single chip power source solution for USB and memory cards	TPS2051B, TPS2061
TPS61081	LED Boost Converter	Input to output isolation	Protection from short between any pins and between any pin to ground	TPS61042
TPS61100	Dual Boost Converter	High efficient, dual boost converter	Long battery life, space savings, works over entire battery range	TPS61020
TPS61200	Boost Converter	High efficient, operates down to 0.3V	Supper efficient boost that works over entire battery range	TPS61010
TPS62300	Step-Down Converter	500mA, 3MHz synchronous step-down converter	Very small inductor and high efficiency	TPS62040
TPS63000	Buck Boost Converter	Automatic transition between step down and boost mode	Produce mid-range voltage out over entire range of battery	TPS621130
TPS71710	Low-Noise Single-Channel LDO	High bandwidth, very high rejection of power source noise	Low-noise power rails for sensitive analog components	TPS759xx, TPS739xx
UCC3804	PWM Controller	12.5/8.3V on/off UVLO thresholds, 1MHz (max) frequency	Buck, boost, flyback, forward, current mode control	UCC3809

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

ECG/Portable ECG and EEG

In This Section

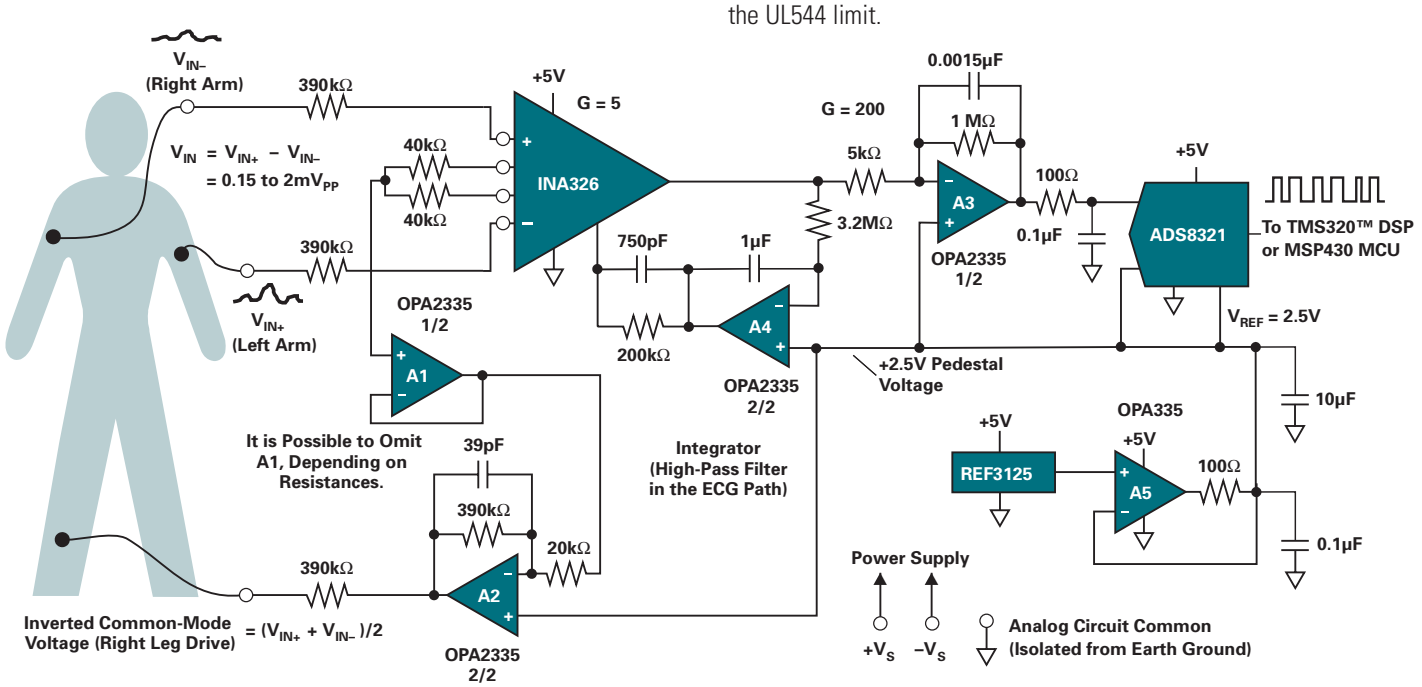
Biophysical Monitoring Overview

The human medical data acquisition system, in particular the patient monitoring system, presents the challenge to designers of measuring very small electrical signals in the presence of much larger common-mode voltages and noise. Front-end amplifiers perform the essential conditioning that complements downstream digital processing, which in turn refines the measurement and communicates with other systems. Biophysical measurements include electrical and mechanical signals for general monitoring, diagnostic and scientific purposes both in clinic and non-clinic environments. Successfully meeting the signal acquisition challenge requires system designers to have knowledge of the signal source, good design practice and ICs with appropriate characteristics, features and performance.

Signal Acquisition Challenges

The action potential created by heart wall contraction spreads electrical currents from the heart throughout the body. The spreading electrical currents create different potentials at different points on the body, which can be sensed by electrodes on the skin surface using biological transducers made of metals and salts. This electrical potential is an AC signal with bandwidth of 0.05Hz to 100Hz, sometimes up to 1kHz. It is generally around 1mV peak-to-peak in the presence of much larger external high frequency noise plus 50/60Hz interference normal-mode (mixed with the electrode signal) and common-mode voltages (common to all electrode signals).

The common-mode is comprised of two parts: 50 or 60Hz interference and DC electrode offset potential. Other noise or higher frequencies within the biophysical bandwidth come from movement artifacts that change the skin-electrode interface, muscle contraction or electromyographic spikes, respiration (which may be rhythmic or sporadic), electromagnetic interference (EMI), and noise from other electronic components that couple into the input. Some of the noise can be cancelled with a high-input-impedance instrumentation amplifier (INA), like the INA326 or INA118, which removes the AC line noise common to both inputs and amplifies the remaining unequal signals present on the inputs; higher INA common-mode rejection (CMR) will result in greater rejection. Because they originate at different points on the body, the left-arm and right-arm ECG signals are at different voltage levels and are amplified by the INA. To further reject 50 and 60Hz noise, an operational amplifier deriving common-mode voltage is used to invert the common-mode signal and drive it back into the patient through the right leg using amplifier A2. Only a few microamps or less are required to achieve significant CMR improvement and stay within the UL544 limit.



Three ECG electrodes connected to patient using CMOS components with 5V single supply. This circuit will operate on a 3.3V supply.

Supply Voltage

As in most other applications, the system supply voltage in biophysical monitoring continues the trend toward low, single-supply levels. While bipolar supplies are still used, 5V systems are now common and trending to single 3.3V supplies. This trend presents a significant challenge for the designer faced with at least a 300mV DC electrode potential and emphasizes the need for a precision signal-conditioning solution. While the following discussion concentrates on the single supply design, the principles involved apply to bipolar designs as well. A list of recommended single and bipolar supply components can be found below.

Frequency Response

Standard –3dB frequency bandwidth for patient monitoring is 0.05Hz to 30Hz, while diagnostic grade monitoring requires 0.05Hz to 100Hz or more. The analog front end must be AC coupled to remove artifacts from the electrode offset potential.

Electrode Potential

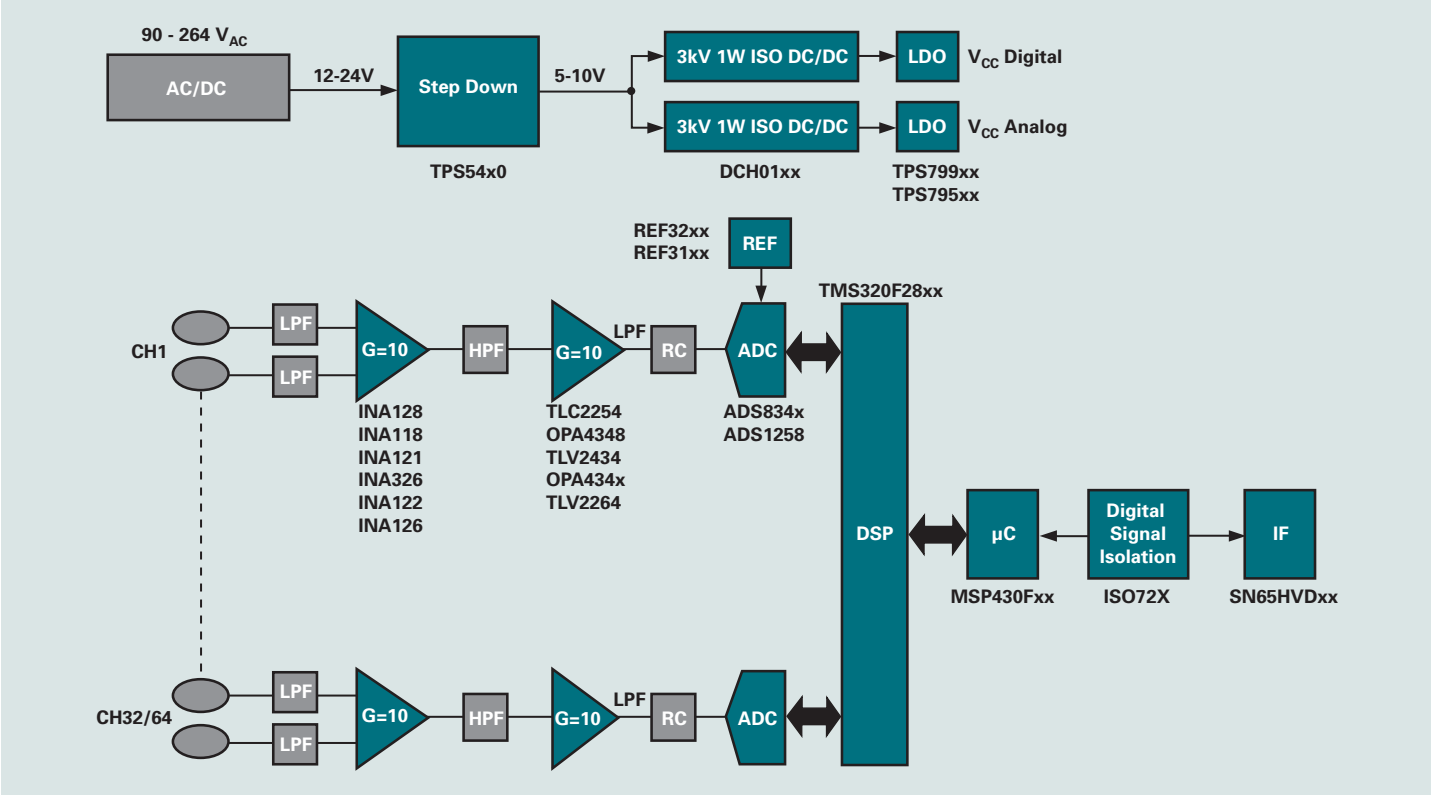
Because electrode potential can in practice reach ±500mV, eliminating the effects of electrode potential by AC coupling is essential. ADC restorator amplifier in a feedback configuration nulls out the DC offset. If the left arm DC offset is +300mV and the right arm electrode is 0V DC, the differential input voltage is 300mV. Because the instrumentation amp has a gain of 5, 1.5V appears at the output of the instrumentation amp. With a gain of 50 or more, the output amplifier would try to drive the signal up to 75V but never does because a feedback integrator applies an equal negative voltage to the reference point. Using this linear summing effect, the electrode offset is cancelled. The result of this DC restorator is to turn the original DC-coupled amplifier into an AC-coupled amplifier. With the DC normal-mode voltage removed, the output stage can amplify the AC ECG signal without becoming saturated.

Instrumentation Amplifier Requirements

- Stability in low gain (Gain = 1 to 10)
- High common-mode rejection
- Low input bias current (I_B)
- Good swing to the output rail
- Very low offset and drift

Operational Amplifier Requirements

- Low noise in high gain (Gain = 10 to 1000)
- Rail-to-rail output
- Very low offset and drift



ECG/EEG block diagram.

ECG/Portable ECG and EEG

24-Bit, Fast Channel Cycling ADC
ADS1258

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/ADS1258

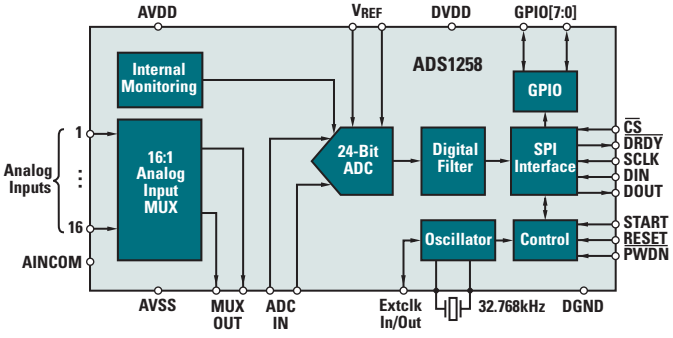
TI's ADS1258 components have been used in high-precision, multi-channel applications such as patient monitoring and ECG systems. It can sequentially cycle through all 16-channels in less than 675µs. Even though this is a low-noise, delta-sigma ADC architecture, its single-cycle (zero-latency) high-speed conversion can be programmed from 1.8k to 23.7kSPS per channel with no loss in performance. The flexible input multiplexer accepts combinations of 8 differential or 16 single-ended inputs with a full-scale differential range of 5V, or true-bipolar input range of ±2.5V. The differential output of the multiplexer is accessible to allow common input signal conditioning, such as scaling or filtering, prior to the input to the ADC. Additional internal system monitor registers provide supply voltage, temperature, reference voltage, gain and offset measurement.

Key Features

- 24-bits, no missing codes
- Fixed or automatic channel scan
- Fixed-channel data rate: 125kSPS
- Auto-scan data rate: 23.7kSPS
  - 16-channel data in <675µs
- Single-conversion settled data
- 16 single-ended or 8 differential inputs
- Low 2.8μV_{RMS} noise at 1.8kSPS
- Excellent AC and DC performance
  - 0.0003% INL
  - 0.02µV/°C offset drift
  - 0.4ppm/°C gain drift
  - 8 GPIOs
  - 32.768kHz PLL crystal oscillator or external clock
- Packaging: QFN-48

Applications

- Patient monitoring
- ECG
- Test and measurement systems
- Fast scan multi-channel instrumentation



ADS1258 functional block diagram.

TMS320C28x™ Controller Generation, Fixed-Point MCU Control, DSP Performance
TMS320C28x

Get samples, datasheets, tools and app reports at:
www.ti.com/sc/device/TMS320C2802

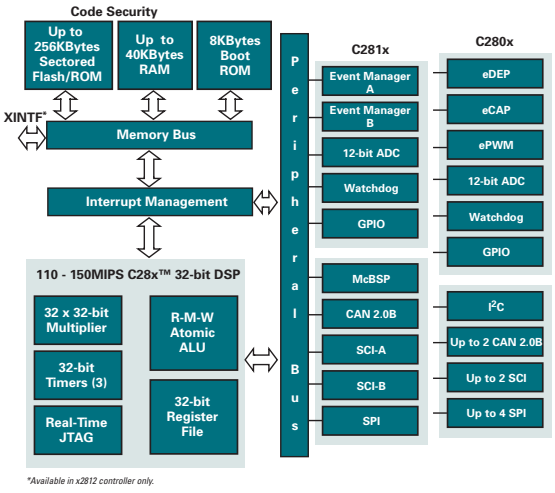
The TMS320C28x digital signal processor (DSP) has a 32-bit, fixed-point C28x™ DSP core and up to 150MIPS operation. It features a 1.8/1.9V core, 3.3V peripherals and easy-to-use software and development tools that speed time-to-market.

Key Features

- Ultra-fast 20-40ns service time to any interrupts
- Powerful 20Mbit/s data logging debug capability
- 32-/64-bit saturation, single-cycle read-modify-write instructions, and 64-/32-bit and 32-/32-bit modulus division
- Enhanced tool suites with C and C++ support
- Unique real-time debugging capabilities
- 32-bit single-cycle fixed-point MAC
- Compatible with TMS320C24x™ DSP and TMS320C2xLP source code

Peripherals

- 16 to 128Kwords sectored Flash or factory programmed ROM (with code security)
- 12-bit A/D, as fast as 12.5MSPS throughput with 80ns (min) conversion time
- Flexible QEP, CAP, timers and PWM generation
- High-res mode resolution of 16-bits at 100kHz and over 12-bits at 1.5MHz ePWM frequency
- Up to two serial communication interfaces (SCI/UART)
- Up to four serial peripheral interfaces (SPI)
- Up to two enhanced CAN 2.0B modules
- McBSP or I^2C interface



TMS320C28x digital signal controller block diagram. The C28x™ controllers are 32-bit control-based DSPs with onboard reprogrammable Flash, factory programmed ROM, or cost effective RAM-only memory options and performance from 100 to 150MIPS.

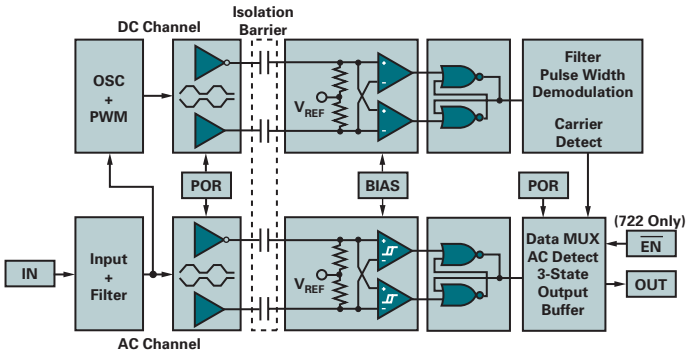
3.3V High-Speed Digital Isolators
ISO721, ISO722

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/ISO721 or **www.ti.com/sc/device/ISO722**

The ISO721 digital isolator is a logic input and output buffer separated by a silicon oxide (SiO_2) insulation barrier that provides galvanic isolation of up to 4000V. Used in conjunction with isolated power supplies, the IC prevents noise currents on a data bus or other circuits from entering the local ground and interfering with or damaging sensitive circuitry.

A binary input signal is conditioned, translated to a balanced signal, then differentiated by the capacitive isolation barrier. Across the isolation barrier, a differential comparator receives the logic transition information, then sets or resets a flip-flop and the output circuit accordingly. A periodic update pulse is sent across the barrier to ensure the proper DC level of the output. If this DC-refresh pulse is not received for more than 4µs, the input is assumed to be unpowered or not functional, and the fail-safe circuit drives the output to a logic high state.

Key Features
- 4000V isolation
- Fail-safe output
- Signaling rate up to 100Mbps
- UL 1577, IEC 60747-5-2 (VDE 0884, Rev. 2), IEC 61010-1 and CSA Approved
- 25kV/µs transient immunity



ISO721 functional block diagram.

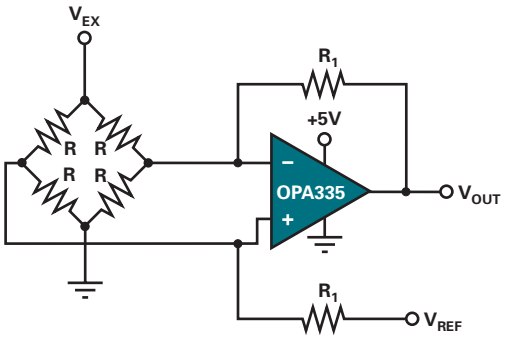
Zerø-Drift, Low-Offset, Single-Supply Op Amps
OPA334, OPA335

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/OPA334 or **www.ti.com/sc/device/OPA335**

The OPA334 and OPA335 CMOS op amps use auto-zeroing techniques to simultaneously provide very low offset voltage and near-zero drift over time and temperature. These high-precision amps offer high input impedance and rail-to-rail output swing.

Key Features
- Low offset voltage: 5µV (max)
- Zero drift: 0.05µV/°C (max)
- Quiescent current: 285µA
- Packaging: SOT23-5, SOT23-6, SO-8, MSOP-10 (dual)

Applications
- Transducer applications
- Electronic scales
- Temperature measurement



OPA335 –5V supply bridge amplifier.

ECG/Portable ECG and EEG

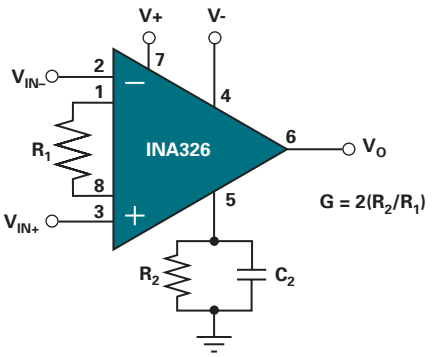
Precision, Rail-to-Rail I/O Instrumentation Amplifier
INA326

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/INA326

The INA326 is a precision instrumentation amplifier with rail-to-rail input and output and with true single-supply operation it offers very low DC errors and input common-mode ranges that extend beyond the positive and negative rails. Excellent long-term stability and very low 1/f noise assure low offset voltage and drift throughout the life of the product.

Key Features
- Low offset: 100µV (max)
- Low offset drift: 0.4µV/°C (max)
- Excellent long-term stability
- Very low 1/f noise
- Input common-mode range: 200mV below negative rail to 100mV above positive rail
- Wide output swing: within 10mV of rails
- Single supply: +2.7V to +5.5V
- Packaging: MSOP-8, MSOP-10

Applications
- Medical instrumentation
- Multi-channel data acquisition systems
- Low-level transducer amplifier for bridges, load cells, thermocouples
- Wide dynamic range sensor measurements



INA326 functional block diagram.

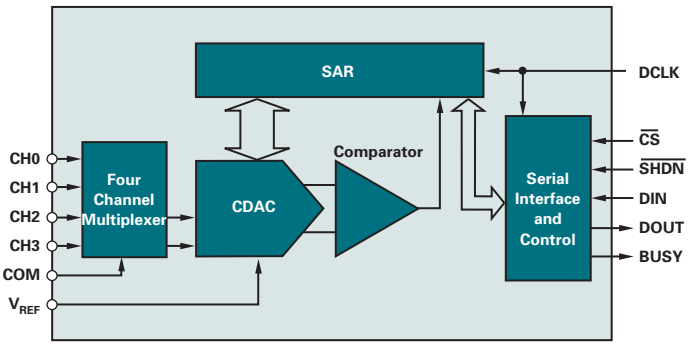
4-/8-Channel, 16-Bit, Serial Output ADC for Portable Applications
ADS8341, ADS8342, ADS8343, ADS8344, ADS8345

www.ti.com/sc/device/PARTnumber
(Replace **PARTnumber** with **ADS8341**, **ADS8342, ADS8343, ADS8344** or **ADS8345**)

The ADS8341 is a 4-channel, 16-bit ADC with synchronous serial interface. Typical power dissipation is 8mW at a 100kHz throughput rate and a +5V supply. The reference voltage can be varied between 500mV and V_{CC}, providing a corresponding input voltage range of 0V to V_{REF}. It is tested down to 2.7V operation. The serial interface also provides low-cost isolation for remote data acquisition.

Key Features
- Conversion rate: up to 100kHz
- 4-/8-channel single-ended or 2-channel differential input
- SINAD: 86dB
- Serial interface
- Single supply: 2.7V to 5V
- Packaging: SSOP-16

Applications
- Test and measurement
- Data acquisition
- Battery-powered devices



ADS8341 functional block diagram.

Component Recommendations for ECG/Portable ECG and EEG

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
INA118	Instrumentation Amp	110dB CMRR, 5nA (max) bias current, 50µV (max) offset	Bipolar supplies	
INA121	Instrumentation Amp	106dB CMRR, 4pA (max) bias current, 200µV (max) offset	Bipolar supplies	
INA126	Instrumentation Amp	175µA/ch supply, 3µV/°C (max) drift, 250µV (max) offset	Bipolar supplies	INA2126 (dual)
INA128	Instrumentation Amp	120dB CMRR, 5nA (max) bias current, 50µV (max) offset	Bipolar supplies	
OPA277	For Right Leg Drive	10µV offset, ±0.1µV/°C drift, 134dB open-loop gain		OPA2277 (dual) OPA4277 (quad)
INA321	Instrumentation Amp	94dB CMRR (G = 100), 500µV (max) offset, 7µV/°C (max) drift		
INA326	Instrumentation Amp	120dB CMRR (G=100), 100µV (max) offset, 0.4µV/°C (max) drift		
OPA130	FET-Input Amplifier	20pA (max) bias current, 90dB (min) CMRR, 1MHz BW		
OPA333	Precision Op Amp	1.8V V_S, 17µA/ch I_Q, 0.05µV/°C zero drift (max)	CMOS, zero-drift series, SC70, SOT23	OPA2333 (dual)
OPA335	Op Amp	5µV (max) offset, 0.05µV/°C (max) drift, 40µA supply, RRO	SOT23	OPA735, OPA333
OPA336	Op Amp	125µV (max) offset, 1.5µV/°C (max) drift, 32µA supply	SOT23	OPA379
Data Converters				
ADS1252	Delta-Sigma ADC	24-bit, 40kSPS, ±0.0015% (max) nonlinearity, 5V supply	Low power, fast conversion	ADS1251, ADS1253, ADS1254
ADS1255	Delta-Sigma ADC	24-bit, 30kSPS, ±0.0010% (max), input buffer, PGA 1:64, 5V supply	Complete measurement system	ADS1256
ADS1258	Delta-Sigma ADC	16-channel, 24-bit, 125k/23,7kSPS	Fastest multi-channel, delta-sigma ADC, measures all 16 inputs in <675µs	ADS1256, ADS1255, ADS8344
ADS1271	Delta-Sigma ADC	24-bit, 105kSPS data rate, 109dB SNR, –108dB THD	Designed for multichannel systems	**ADS1274, ADS1278**
ADS8325	µPower ADC	16-bit, 100kSPS, 2.7V to 5.5V supply	Low power, small size	ADS8320, ADS8341
ADS8342	Quad ADC	8-channel, 16-bit, 250kSPS, ±2.5V input range, parallel interface	Easy to use	
ADS8509	SAR ADC	16-bit, 250kSPS, 100dB SFDR, ±10V input range, SPI interface	Single supply, high voltage	ADS8505, ADS8507, ADS8508
DDC112	Charge-Digitizing ADC	Dual current input, 20-bit ADC, ±0.005% INL reading ±0.5ppm FSR	High precision, true integrating function	DDC114, DDC118, DDC232
References				
REF02	Precision V_{REF}	0.2% (max) initial accuracy, 10ppm/°C (max) drift, 1.4mA (max)	Excellent line/load regulation, low noise	
REF102	10V, Ultra Precision	0.05% (max) initial accuracy, 2.5ppm/°C (max) drift, 1.4mA (max)	Excellent stability and line/load regulation	
REF3112	Series Voltage	0.2% (max) initial accuracy, 15ppm/°C (max) drift, 100µA	Low power consumption for portable applications	REF3120, REF3125, REF3133
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q	Multiple output voltages, SOT23-6	
REF33xx	microPower Bandgap	0.1% (max) accuracy, 30ppm/°C (max) drift, 0.005mA (max) I_Q	Multiple output voltages, MSOP-8, SO-8	
REF50xx	Precision Reference	0.05% accuracy, 3ppm/°C (max) drift, 6μV_{PP} low noise	Multiple output voltages, SC71	
Processors				
TMS320C5000™	DSP	Power efficient, high performance		
TMS320F28x™	DSP	32-bit fixed point code, up to 150MIPs operation	Combination of DSP performance and MCU integration	
TMS320VC5506	DSP	200MHz, dual MAC, very low stand-by power of 0.12mW	Supported by eXpressDSP™ and many other software packages and tools	TMS320V5509A TMS320V5502

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

Component Recommendations for ECG/Portable ECG and EEG

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Processors (Continued)				
MSP430F20xx	Ultra Low Power 16-bit MCU	2 KB Flash, 128 B RAM, SPI+I^2C	8 ch. 12-bit ADC or 4 ch. 16-bit SD ADC, 4x4 mm package	
MSP430F22x4	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + I^2C + UART/LIN + IrDA	12 ch. 10-bit ADC, 2 op.amps	
MSP430F23x0	Ultra Low Power 16-bit MCU	32 KB Flash, 2 KB RAM, SPI + I^2C + UART/LIN + IrDA	Analog comparator, HW multiplier	
MSP430F15x	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comparator	
MSP430F16x	Ultra Low Power 16-bit MCU	60 KB Flash, 2 KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comp, HW multiplier	
MSP430F16xx	Ultra Low Power 16-bit MCU	55 KB Flash, 10 KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comp, HW multiplier	
MSP430F41x	Ultra Low Power 16-bit MCU	4 KB Flash, 256 B RAM, SVS, 96 segment LCD	Analog comparator	
MSP430F42x0	Ultra Low Power 16-bit MCU	32 KB Flash, 256 B RAM, 56 segment LCD	5 ch. 16-bit SD ADC, 12-bit DAC	
MSP430F42x	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + UART, SVS, 128 segment LCD	3 x 16-bit SD ADC	
MSP430F43x	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, analog comparator	
MSP430FG43x	Ultra Low Power 16-bit MCU	60 KB Flash, 2 KB RAM, SPI + UART, SVS, 128 segment LCD	12 ch. 12-bit ADC, 2 ch. 12-bit DAC, DMA, 3 op amps	
MSP430F44x	Ultra Low Power 16-bit MCU	60 KB Flash, 2 KB RAM, 2x SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, HW multiplier	
MSP430FG461x	Ultra Low Power 16-bit MCU	120 KB Flash, 8 KB RAM, SPI + I^2C + UART/LIN + IrDA, 160 LCD	12 ch.12-bit ADC, 2 ch.12-bit DAC, A-comp, 3 op amp, HW multiplier	
Power Management Products				
bq20z90	Battery Fuel Gauge	Instant accuracy better than 1% error over lifetime of the battery	Automatically adjusts for battery aging, battery self discharge and temperature inefficiencies	bq20z70, bq20z80
bq24703	Battery Charger	0V operation, ±0.4% charge voltage accuracy, integrated PWM	Dynamic power management, multichemistry	bq24702
bq24721C	Battery Charge Management	Multi-chemistry and multi-cell sync switch-mode charger	High efficiency, pack and system protection functions	
bq29330	Battery Safety	Battery pack full-protection analog front end	Provides individual cell voltages and battery voltage to battery management host	
DCH010505	Galvanic Isolated, DC/DC Converters	1W, 3kV isolation, minimal external components	Safety isolation, removal of ground loops	DCH010512, DCH010515 DCR021205
TPS3808	Voltage Supervisor	Low quiescent current, programmable-delay	Circuit initialization and timing supervision	TPS310x
TPS54350	DC/DC Converter	4.5 to 20V_{IN} 3A DC/DC with integrated switch FET, sync pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	TPS54550
TPS65130	Boost Converter	800mA switch, adjustable, dual output, positive and negative boost	Two supplies from one switcher	
TPS79901	Single Channel LDO	Very high rejection of power source noise	Low-noise power rails for sensitive analog components	TPS79501

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red.***

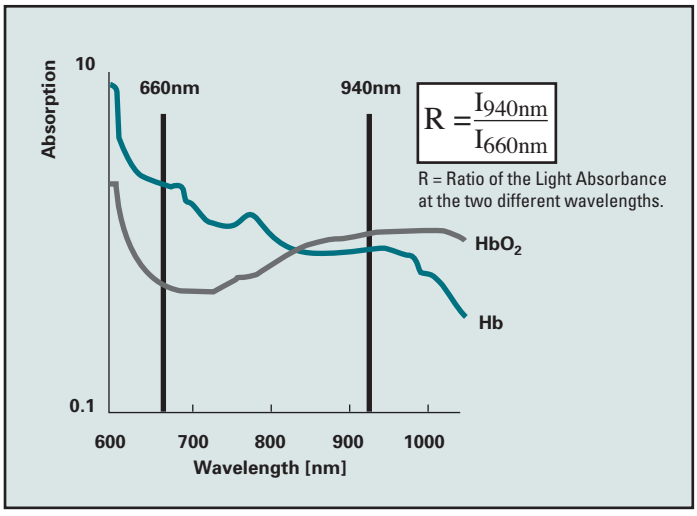
Pulse Oximetry

Overview

The pulse oximeter measures blood oxygenation by sensing the infrared and red light absorption properties of deoxygenated and oxygenated hemoglobin.

It is comprised of a sensing probe attached to a patient's earlobe, toe or finger that is connected to a data acquisition system for calculation and display of oxygen saturation level, heart rate and blood flow. Light sources, typically light-emitting diodes, shine visible red and infrared light. Deoxygenated hemoglobin allows more infrared light to pass through and absorbs more red light; highly oxygenated hemoglobin allows more red light to pass through and absorbs more infrared light. The oximeter senses and calculates an amount of light at those wavelengths proportional to the oxygen saturation (or desaturation) of the hemoglobin.

Because of the use of light in the absorbance measurement, the designer needs a true "light-to-voltage" conversion using current as the input signal. The classes of photodiode amplifiers suitable for pulse oximetry applications are the classical resistor-feedback transimpedance amplifier and the capacitor-feedback switched integrator. In either amplifier configuration, the resulting output voltage is read by an analog-to-digital converter and serialized for MSP430 microcontroller or TMS320™ DSP for processing.



With that, the oxygen saturation of the human blood:

$$SaO_2 = \frac{[O_2\text{–}Hb]}{[O_2\text{–}Hb] + [Hb]}$$

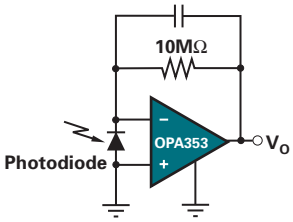
(Usually between 94% and 98%) can now be calculated based on the law of Lambert Beer.

$$I = I_O \bullet e^{-\varepsilon \cdot x}$$

That shows the resulting light (I) and its dependency of the light source (I_O), the coefficient of the extinction (ε, that results from pic) and the "amount" (χ) of each of the Hb types either oxygenated or deoxigenated.

The diagram shows the different absorption spectra of unloaded hemoglobin (Hb) and oxygen loaded hemoglobin (HbO_2).

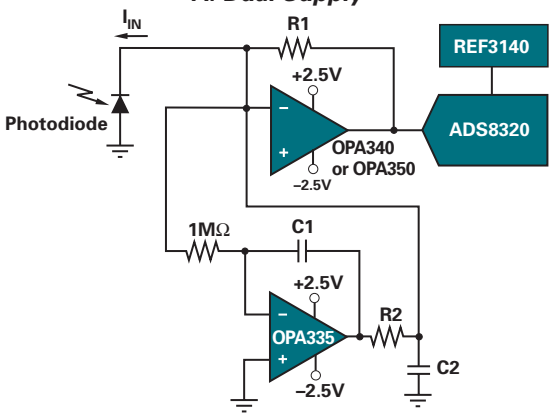
Signal Acquisition Challenges



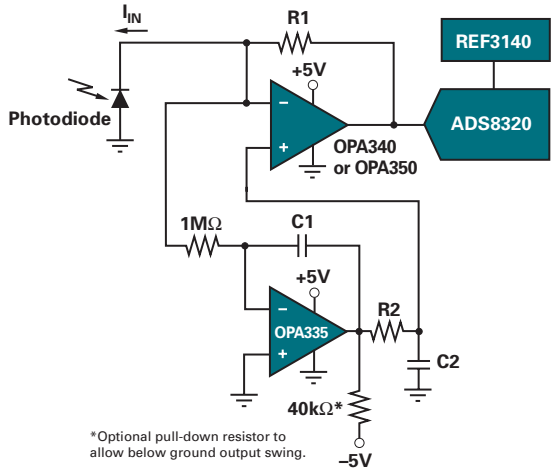
The resistor-feedback amplifier circuit shown at right is the most common bioelectric transimpedance circuit. With the amplifier used in the inverting configuration, the light shining on a photodiode produces a small current that flows to the amplifier summing junction and through the feedback resistor. Given the very large feedback resistor value, this circuit is extremely sensitive to changes in light intensity. For example, an input light signal of just 0.001μW can produce a full-swing output.

Depending on design requirements, it can be very useful to achieve output swing down to or below ground. The auto-zero transimpedance amplifier configurations shown on the next page will allow swing to ground in Figure A and very close to ground in Figure B. A pull-down resistor tied to –5V will allow swing slightly below ground to minimize errors as the output gets very close to zero volts.

A. Dual Supply



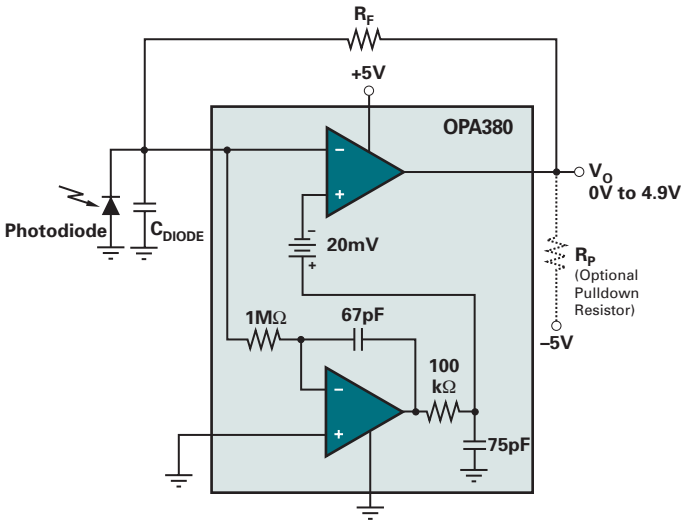
B. Single Supply



*Optional pull-down resistor to allow below ground output swing.

Pulse Oximetry

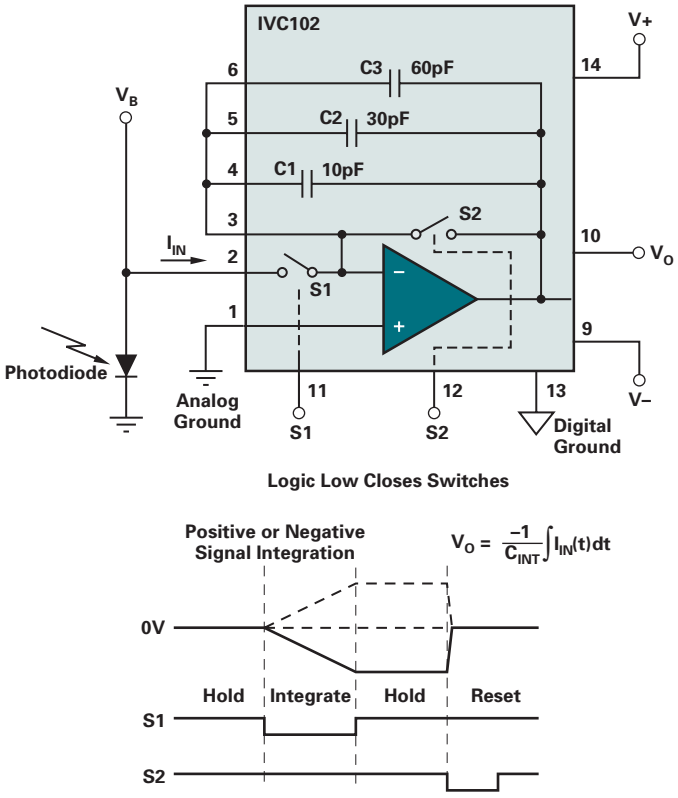
TI's OPA380 is a monolithic combination of the high-speed OPA355 and auto-zero OPA335 amps. It offers 90MHz gain bandwidth product and performs well as a 1MHz transimpedance amplifier with extremely high precision (25µV maximum offset and 0.1µV/°C maximum drift).



Depending on design requirements, the switched integrator can be a very effective solution. TI's IVC102 does not have the thermal noise of a feedback resistor and does not suffer from stability problems commonly found in transimpedance amps with a large feedback resistor. Using one photodiode with two IVC102s will eliminate dark current and ambient light errors, as errors common to both can be subtracted. Additionally, IVC102 allows for synchronized sampling at an integer multiple of AC line frequency, giving extremely high noise rejection. Transimpedance gain can easily be changed by extending or shortening integration time with switch S2.

Transimpedance Amplifier Requirements

- Low input bias current over temperature range of interest
- Low input capacitance relative to photodiode capacitance
- High gain bandwidth product
- Low voltage noise
- For maximum precision, low offset drift over temperature
- For single-supply systems:
  - Rail-to-rail input (including 0V) and output if operating the photodiode in photovoltaic (zero bias) mode
  - Rail-to-rail output only if operating the photodiode in photoconductive mode (biased)
  - Shutdown and/or low supply current if battery-powered system



Design Hints

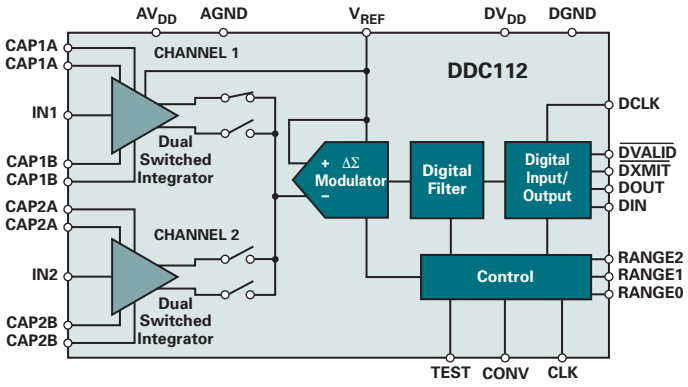
A small (< 1pF) capacitor in the feedback loop (C_F) will control gain-peaking caused by the diode capacitance. Noise (voltage-output fluctuation) is caused by resistor noise, amplifier and current noise, and environmental noise pickup (e.g., 50 or 60Hz line noise). To minimize noise in the circuit, the designer should choose a low-noise amplifier, select the largest practical feedback resistor, RF shield the amplifier inputs, include low-pass filtering and use good PCB layout technique.

If the photodiode shunt resistance is much larger than that of the feedback resistor, offset voltage is not significant. If offset voltage stability is paramount, an auto-zero solution including the OPA335 is best.

To achieve the highest levels of precision, system designers should choose the new OPA380. Designed to meet exacting transimpedance application requirements, the OPA380 provides an unbeatable combination of speed (85MHz GBW over 1MHz transimpedance bandwidth) and precision (25µV max offset, 0.1µV/°C drift, and low 1/f noise). A discrete alternative is to use OPA350 or OPA355, adding the OPA335 in the integrators-stabilized transimpedance configuration for circuits requiring low offset and drift. Note that the addition of the OPA335 integrator to a basic transimpedance amplifier will also reduce its very low frequency noise.

Mid-Range Solution Advantages:

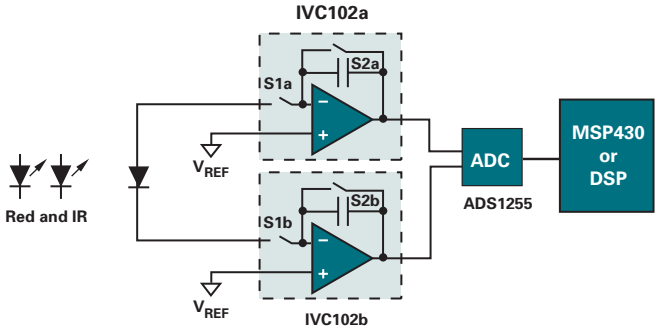
- Single-chip solution
- High resolution
- Low noise
- Wide input range by adjustable integration time
- No need for DC correction of the diode current



Mid-range solution block diagram.

High-End Solution Advantages:

- Very high resolution
- High noise immunity due to differential input
- High noise immunity due to synchronization on AC supply possible
- High noise immunity due to free access on integration and reset switches by SW
- No need for DC correction of the diode currents
- Huge input range can be covered (>24-bit) due to free programmable integration times



High-end solution block diagram.

Precision Switched Integrator Transimpedance Amplifier

IVC102

Get samples, datasheets, evaluation modules and app reports at:

www.ti.com/sc/device/IVC102

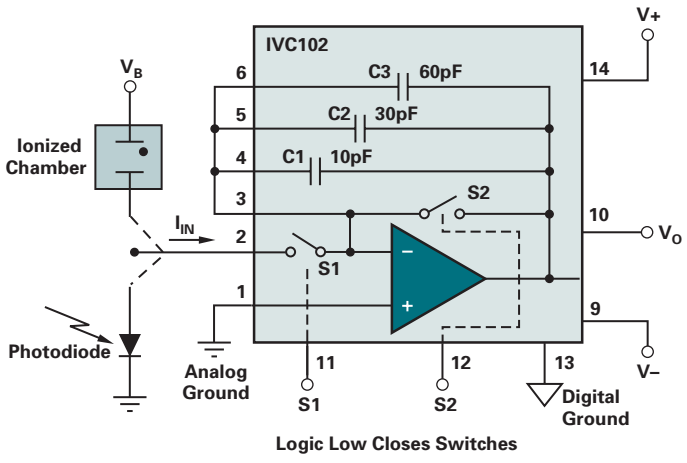
The IVC102 is a precision integrating amplifier with FET op amp, integrating capacitors and low-leakage FET switches. It integrates low-level input current for a user-determined period, storing the resulting voltage on the integrating capacitor. The IVC102 offers a precise, lower-noise alternative to conventional transimpedence op amp circuits requiring a very high-value feedback resistor, and can amplify low-level sensor currents from photodiodes and ionization chambers. The input signal current can be positive or negative.

Key Features

- On-chip integrating capacitors
- Gain programmed by timing
- Low input bias current: 750fA (max)
- Low nonlinearity: 0.005% (typ)
- Low switch charge injection
- Fast pulse integration

Applications

- Precision low current measurement
- Photodiode measurements
- Ionization chamber measurements
- Current/charge-output sensors
- Leakage current measurement



IVC102 functional block diagram.

Pulse Oximetry

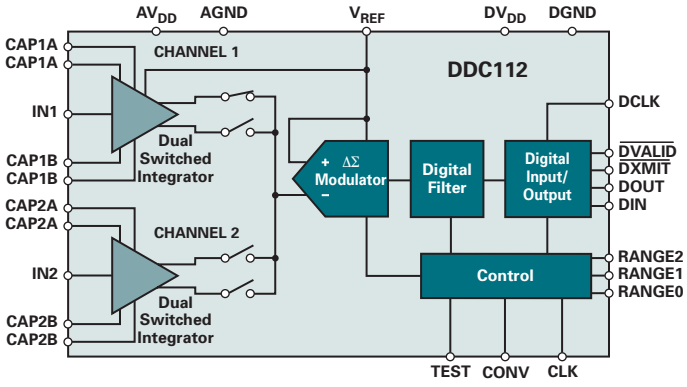
Dual, Current-Input, 20-Bit Charge Digitizing ADC
DDC112

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/DDC112

The DDC112 is a dual input, wide dynamic range, charge-digitizing ADC which allows low-level current output ICs to be connected directly to its inputs. Charge integration is continuous as each input uses two integrators; while one is being digitized, the other is integrating. In addition to the internal programmable full-scale ranges, external integrating capacitors allow an additional user-settable, full-scale range of up to 1000pC. A high-speed serial shift register, which holds the result of the last conversion, can be configured to allow multiple, cascaded DDC112s, minimizing interconnections.

Key Features
- Single-chip solution for measuring photodiodes
- High precision, true integrating function
- Low noise: 3.2ppm, rms
- Outstanding linearity: ±0.005% INL reading ±0.5ppm FSR
- Programmable full-scale: 50 to 1000pc
- Single supply: +5V supply
- Packaging: SO-28, TQFP-32

Applications
- Blood analysis
- Liquid/gas chromatography
- Direct photosensor digitization
- Infrared pyrometry



DDC112 functional block diagram.

1.1nV/√Hz Noise, Low-Power, Precision Op Amp
OPA211

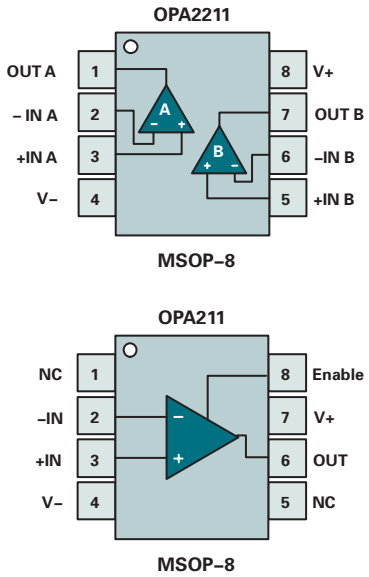
PREVIEW*

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/OPA211

The OPA211 series achieves very low 1.1nV/√Hz noise density with a supply current of only 3.6mA. It offers rail-to-rail output swing to maximize dynamic range. In precision data acquisition systems, the OPA211 provides <1µs settling time to 16-bit accuracy even for 10V output swings. By combining AC performance with only 100µV of offset and low drift over temperature, the OPA211 is able to drive fast, high-precision ADCs or buffer the outputs of high-resolution DACs.

Key Features
- Input voltage noise: 100nVPP, 0.1Hz - 10Hz
- Low offset voltage: 100µV (max)
- Low offset voltage drift: 0.2µV/°C (typ)
- Supply current: 3.6mA/ch
- Gain bandwidth product: 80MHz (G = 100)
- Slew rate: 27V/µs
- Supply range: ±2.25V to ±18V, +4.5V to +36V
- Output current: 30mA
- Unity gain stable
- Packaging: Tiny DFN-8, MSOP-8, SO-8

Applications
- Medical instruments
- Portable medical devices
- Ultrasound amplifiers
- Low-noise, low-power signal processing



Pin configurations.
**Product release scheduled for 3Q 2007.*

Component Recommendations for Pulse Oximeter Applications

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
IVC102	Transimpedance Amp	Precision switched integrator		
OPA211	Precision Op Amp	1.1nV/√Hz noise at 1kHz, 3.6mA/ch supply, 80MHz BW	Unity gain stable, RRO, shutdown	OPA227
OPA335	5V Op Amp	5µV offset, 0.05µV/°C drift, 350µA supply current		OPA735
OPA336	Op Amp	125µV offset, 1.5µV/°C drift, 32µA supply current		
OPA350	Op Amp	500µV V_{OS}, 38MHz, 2.5V to 5V supply		
OPA353	MicroAmplifier™ Series	High speed, single supply, rail-to-rail		
OPA363	Op Amp	1.8V, high CMR, RRIO, shutdown		OPA364
OPA380	Transimpedance Amp	90MHz GBW, over 1MHz transimpedance BW 25µV offset (max), 0.1µV/°C drift (max)		
OPA703	12V Op Amp	CMOS, rail-to-rail I/O		
OPA725	12V Op Amp	Very low noise, high speed, 12V CMOS		OPA727
Data Converters				
ADS8320	High Speed ADC	16-bit, 100kHz sample rate, 2.7V to 5V supply	microPower operation: 1.8mW at 100kHz and 2.7V	ADS8321, ADS8325DDC101
DDC112	Dual Current Input ADC	Wide dynamic range, charge digitizing, 20-bit ADC	Single-chip solution	
References				
REF31xy	Voltage Reference	0.2% voltage accuracy	Precise trigger voltage ADC	REF32xy, REF33xy
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q	Multiple output voltages, SOT23-6	
REF33xx	microPower Bandgap	0.1% (max) accuracy, 30ppm/°C (max) drift, 0.005mA (max) I_Q	Multiple output voltages, MSOP-8, SO-8	
REF50xx	Precision Reference	0.05% accuracy, 3ppm/°C (max) drift, 6µV_{PP} low noise	Multiple output voltages, SC71	
Processors				
TMS320C5000™	DSP	Power efficient, high performance		
TMS320F28x	DSP	32-bit fixed point code, up to 150MIPs operation	Combination of DSP performance and MCU integration	
Generation				
TMS320VC5506	DSP	200MHz, dual MAC, very low stand-by power of 0.12mW	Supported by eXpressDSP™ and many other software packages and tools	TMS320V5509A TMS320V5502
MSP430F20xx	Ultra Low Power 16-bit MCU	2 KB Flash, 128 B RAM, SPI+I^2C	8 ch. 12-bit ADC or 4 ch. 16-bit SD ADC, 4x4 mm package	
MSP430F22x4	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + I^2C + UART/LIN + IrDA	12 ch. 10-bit ADC, 2 op.amps	
MSP430F23x0	Ultra Low Power 16-bit MCU	32 KB Flash, 2 KB RAM, SPI + I^2C + UART/LIN + IrDA	Analog comparator, HW multiplier	
MSP430F15x	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comparator	
MSP430F16x	Ultra Low Power 16-bit MCU	60 KB Flash, 2 KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comp, HW multiplier	
MSP430F16xx	Ultra Low Power 16-bit MCU	55 KB Flash, 10 KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comp, HW multiplier	
MSP430F41x	Ultra Low Power 16-bit MCU	4 KB Flash, 256 B RAM, SVS, 96 segment LCD	Analog comparator	
MSP430F42x0	Ultra Low Power 16-bit MCU	32 KB Flash, 256 B RAM, 56 segment LCD	5 ch. 16-bit SD ADC, 12-bit DAC	
MSP430F42x	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + UART, SVS, 128 segment LCD	3 x 16-bit SD ADC	
MSP430F43x	Ultra Low Power 16-bit MCU	32 KB Flash, 1 KB RAM, SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, analog comparator	
MSP430FG43x	Ultra Low Power 16-bit MCU	60 KB Flash, 2 KB RAM, SPI + UART, SVS, 128 segment LCD	12 ch. 12-bit ADC, 2 ch. 12-bit DAC, DMA, 3 op amps	

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

Component Recommendations for Pulse Oximeter Applications

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Processors (Continued)				
MSP430F44x	Ultra Low Power 16-bit MCU	60 KB Flash, 2 KB RAM, 2x SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, HW multiplier	
MSP430FG461x	Ultra Low Power 16-bit MCU	120 KB Flash, 8 KB RAM, SPI + I^2C + UART/LIN + IrDA, 160 LCD	12 ch.12-bit ADC, 2 ch.12-bit DAC, A-comp, 3 op amp, HW multiplier	
Power Management Products				
bq2406x	Battery Charger	Linear 1-cell Li-Ion charger with thermal regulation, 6.5V OVP, temp sense	Good for space-limited designs with need for battery safety	bq2410x
TPS61081	LED Boost Converter	Input to output isolation	Protection from short between any pins and between any pin to ground	TPS61042
TPS71710	Low-Noise Single-Channel LDO	High bandwidth, very high rejection of power source noise	Low-noise power rails for sensitive analog components	TPS759xx, TPS739xx

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red.***

Portable Respiration Device

A portable respiration device supports a patient with the correct dose of oxygen. One pressure sensor in front of the valve measures the breathe-in air and another one after the valve measures the breath-out pressure. A microprocessor uses the data from the two pressure sensors and single flow sensor to calculate the output of the valve that is regulating the airflow. The medical staff can set the right air flow by a touch screen or key pad. A portable device, used in an ambulance for example, has sophisticated power management circuitry to support mains and battery operation.

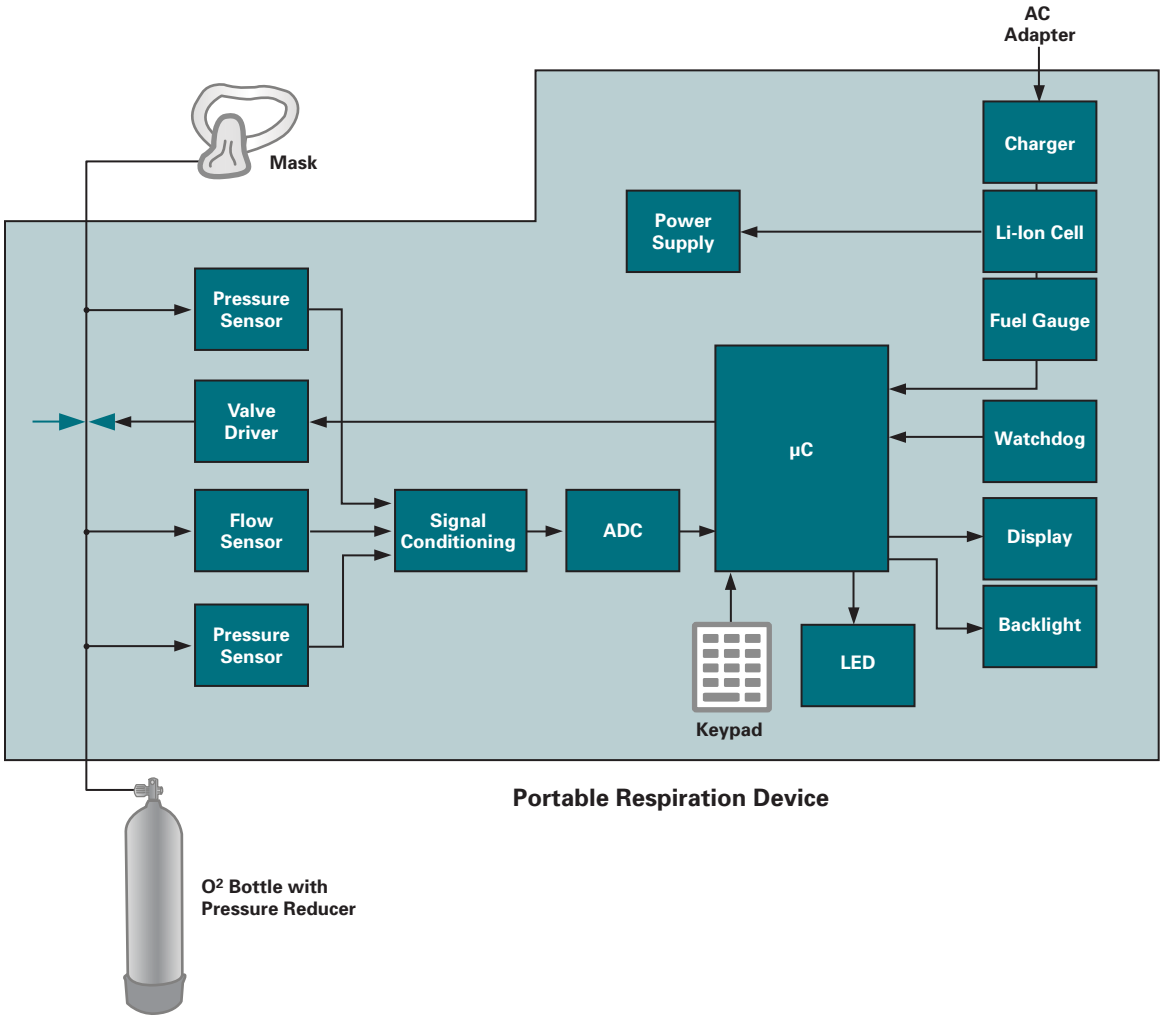
Future designs will likely be equipped with a wireless data transmission module.

Further Information

Pressure sensors play an important role for respiration equipment. See page 34 for a short tutorial on pressure sensing techniques and considerations.

Other TI Components to Consider

- DRV103 as valve driver
- Power amplifier family OPA54x, OPA56x as valve driver
- bq power management ICs for battery charging and fuel gauge
- LED drivers
- Low-power wireless for future designs
- RS-485 (SN65HVD3082), CAN (SN65HVD251) or other interface ICs for the communication between the sensor and controller board



Portable respiratory device block diagram.

Ventilation/Pressure Discussion

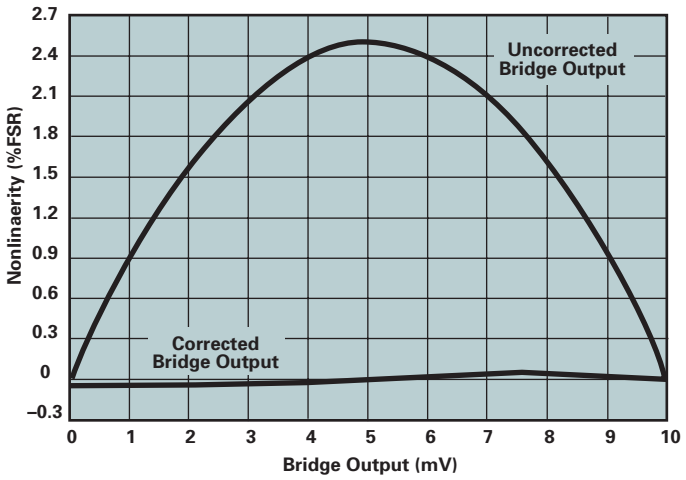
Pressure sensors convert a physical value–weight, tire pressure, level, force, and flow–into a differential signal in the mV/V range and are referred to as metal thick-film, ceramic or piezo-resistive. The majority of designers use the cost-effective piezo-sensors (25mbar – 25bar). However, these are very nonlinear, temperature dependent and have large offset and offset drift. Plus, they require attention to electronic calibration and compensation.

The block diagram (below) shows the functional block diagram of a pressure signal conditioning system.

Sensor Signal Conditioning — performs all necessary functions to calibrate, compensate for temperature variance, scale, and linearize the sensor signal.

Analog/Digital Processing — there are two ways to convert and linearize the sensor signal. The analog technique results in an analog solution and provides an analog output. This technique is inexpensive and fast, but limited to a maximum of 11- to 16-bit resolution. Digital is more precise, up to 24-bits, and provides a digital output at moderate speed.

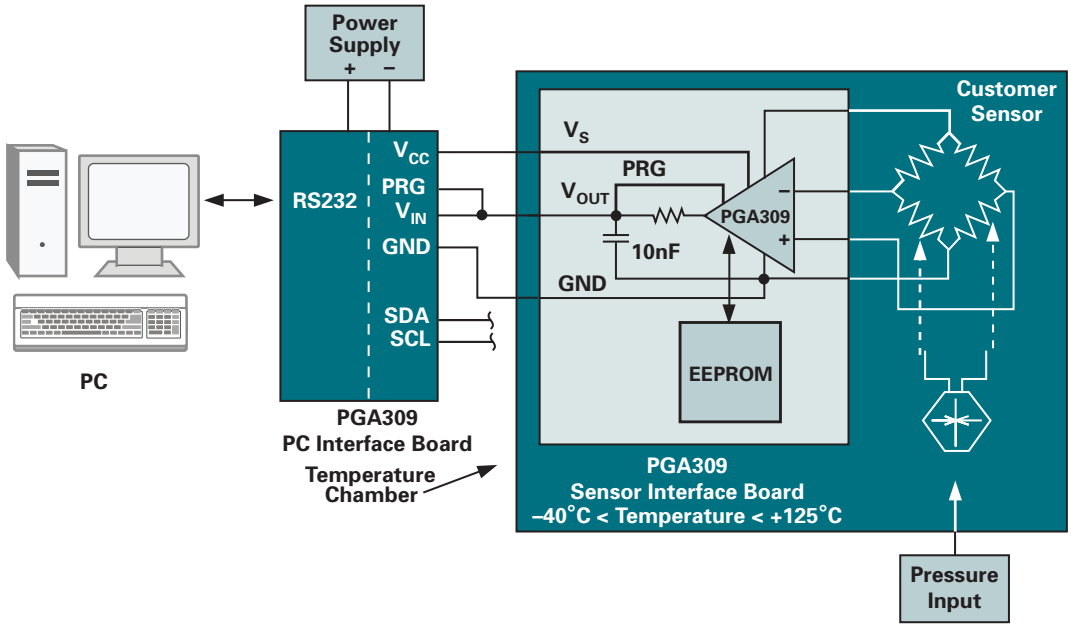
The bridge excitation linearization circuit is optimized for bridge pressure nonlinearities with a parabolic shape (at right). The linearization circuit is digitally programmable, but the pure analog signal conditioning side is handled by the same process as in TI's well-known 4-20mA transmitters, such as XTR105, XTR106 or XTR108. The heart of the PGA309 is a precision, low-drift programmable gain instrumentation amplifier using an auto-zero technique and includes a programmable fault monitor and over/underscale limiter. It also offers a digital temperature compensation circuit. Calibration is carried out either via a one-wire digital serial interface or through a two-wire industry-standard connection.



PGA309 bridge pressure nonlinearity correction.

Calibration parameters are stored in an external nonvolatile memory to eliminate manual trimming and achieve long-term stability. An evaluation module, PGA309EVM (see below) includes software and calibration sheet for easy evaluation of your sensor + PGA309 combination.

The highly integrated, CMOS PGA309, available in TSSOP-16, is tailored for bridge pressure sensors and adds to TI's portfolio of highly flexible, lowest noise amplifier and instrumentation amplifier solutions that also include the OPAx227, OPAx132, OPA335, OPA735, INA326, INA327, INA118 and INA122.



Block diagram of the PGA390EVM module.

Continuous Positive Airway Pressure Machines TMS320C2000™

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/c2000

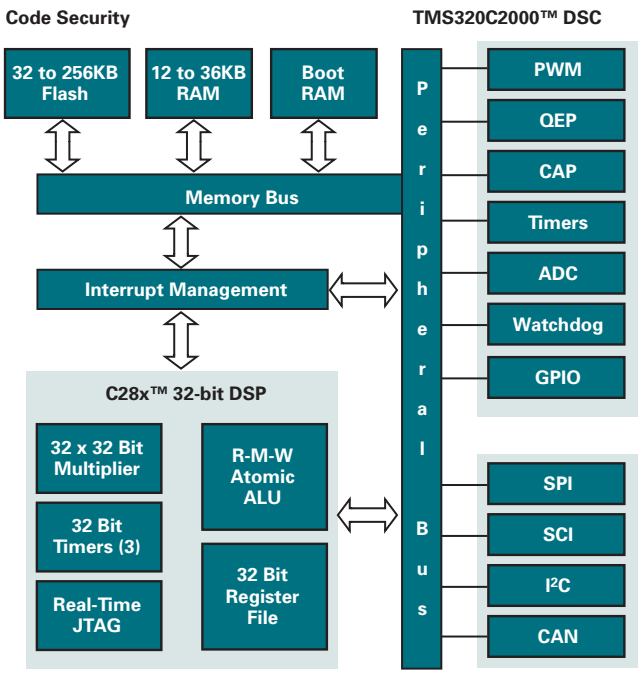
Continuous Positive Airway Pressure Machines (CPAP) are an effective means in preventing intubation, decreasing mortality in patients with acute respiratory failure, helping patients with sleep apnea and reducing chronic respiratory failure.

Designers of CPAP machines are concerned with the efficiency in running the motor that drives the continuous airflow of the patient, reducing as many components on the system board for a lower cost and easy development for a quicker time to market. CPAP systems designers value the TMS320C2000 Digital Signal Controller for its exceptional capabilities, including:

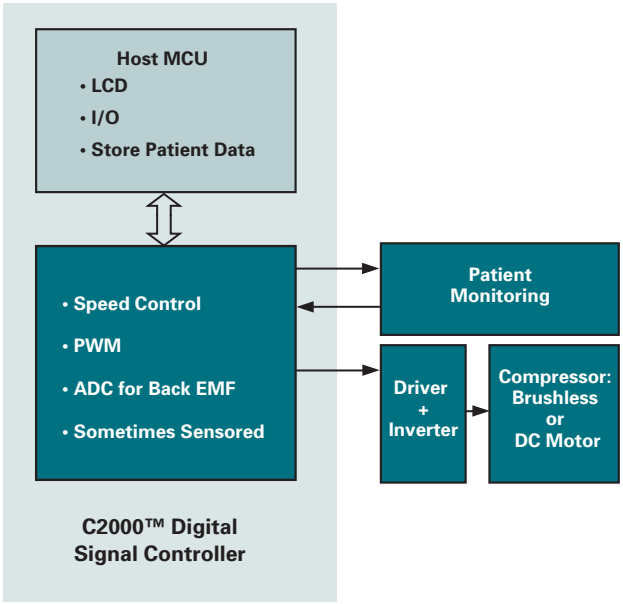
1. TMS320C2000 digital signal controllers are high-performance, low-cost ICs that control motor speed, position and torque in real time. If necessary these controllers can even provide the processing power for executing high-sophisticated position and speed estimation algorithms to control the motor using data from resolver, encoder and halleffect sensor.
2. These high-performance controllers not only provide accurate control of the motor but can also provide additional MIPS and peripheral integration to act as the host MCU. These ICs can perform up to 150MIPS and have a high level of peripheral integration with on-chip flash, a 12-bit, 16-channel ADC with up to 12.5MSPS performance and multiple GPIO pins so designers can use a single controller for a lower cost.
3. The C2000™ platform has an extensive motor control library (www.ti.com/c2000appsw) that can help a developer get the software framework necessary to control either a 1ph or 3ph BLDC motor. In addition, the C-compiler efficiency eliminates the need for most assembly coding.

Key Features

- Up to 150 DSP MIPS for reducing system cost
- On-chip programmable flash
- C-compiler efficiency eliminates the need for most assembly coding
- 10- or 12-bit ADCs with up to 16 channels and 12.5MSPS
- Independent or complementary PWM with deadband
- Independent duty-cycle or phase control
- 150ps high-resolution PWM
- Encoder interfaces and event capture inputs
- CAN 2.0B, SCI, SPI, and I²C port interfaces
- Long product life cycle assures supply continuity



TMS320C2000™ digital signal controller block diagram.



TMS320C2000™ digital signal controller in simplified patient monitoring system.

Ventilation/Pressure Discussion

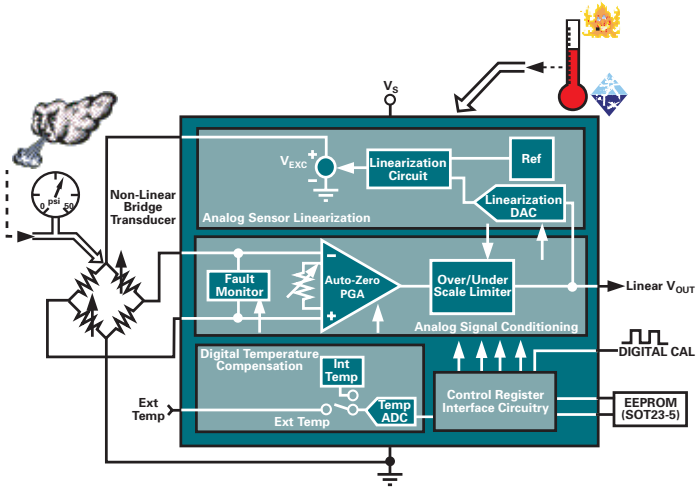
Complete Voltage-Output, Programmable Bridge Sensor Signal Conditioner
PGA309

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/PGA309

The PGA309 is a programmable analog signal conditioner designed for bridge sensors. The analog signal path amplifies the sensor signal and provides digital calibration for zero, span, zero drift, span drift, and sensor linearization errors with applied stress (pressure, strain, etc.). The calibration is done via a one-wire digital serial interface or through a two-wire industry-standard connection. The calibration parameters are stored in external nonvolatile memory (typically SOT23-5) to eliminate manual trimming and achieve long-term stability.

Key Features
- Ratiometric or absolute voltage output
- Digitally calibrated via single-wire or two-wire interface
- Eliminates potentiometer and trimming
- Low, time-stable total adjusted error
- +2.7V to +5.5V operation
- Packaging: Small TSSOP-16

Applications
- Bridge sensors
- Remote 4-20mA transmitters
- Strain, load, weight scales
- Automotive sensors



PGA309 functional block diagram.

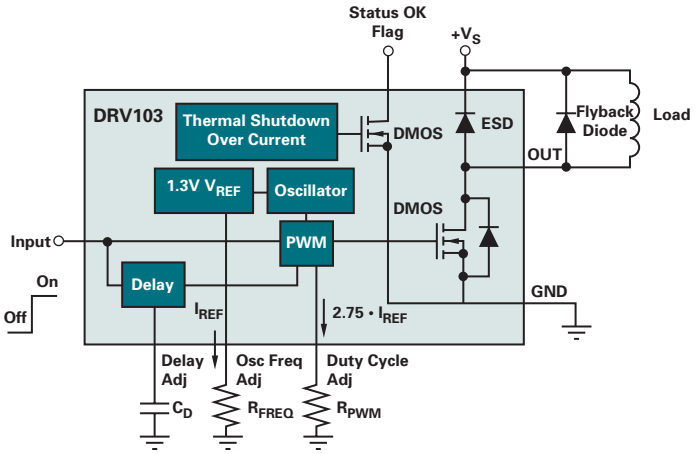
PWM Low-Side Driver for Valves, Solenoids and Coils
DRV103

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/DRV103

The DRV103 is a low-side DMOS power switch employing a pulse-width modulated (PWM) output. Its rugged design is optimized for driving electromechanical devices such as valves, solenoid, relays, actuators, motors and positioners. PWM operation conserves power and reduces heat rise, resulting in higher reliability and its adjustable PWM allows fine control of the power delivered to the load. DC-to-PWM output delay time and oscillator frequency are also externally adjustable.

Key Features
- High output drive: 1.5A and 3A versions
- Wide supply range: +8V to +32V
- Complete function:
  - Digitally controlled input
  - PWM output
  - Adjustable internal oscillator: 500Hz to 100kHz
  - Adjustable delay and duty cycle
- Fully protected:
  - Thermal and current limit shutdown with status OK indicator flag
- Packaging: SO-8, SO-8 PowerPAD™

Applications
- Electromechanical driver:
  - Solenoids, valves, positioners, actuators, relays, power contactor coils
- Hydraulic and pneumatic systems
- Medical and scientific analyzers
- Chemical processing
- Environment monitoring and HVAC



DRV103 functional block diagram.

High-Voltage, High-Current Operational Amplifier
OPA549

Get samples, datasheets, evaluation modules and app reports at:

www.ti.com/sc/device/OPA549

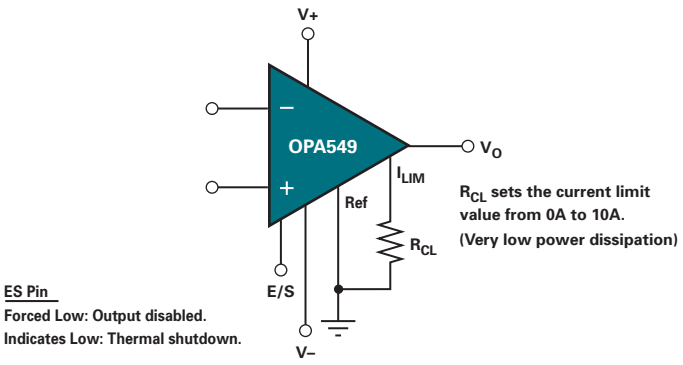
The OPA549 is a high-voltage, high current op amp designed for driving a wide variety of loads. It provides low-level signal accuracy and high output voltage and current. It is internally protected against over-temperature conditions and current overloads. In addition, the OPA549 provides an accurate, user-selected current limit. Unlike other designs which use a "power" resistor in series with the output current path, the OPA549 senses the load indirectly. This allows the current limit to be adjusted from 0A to 10A with a resistor/potentiometer, or controlled digitally with a voltage-out or current-out DAC.

Key Features

- High output current: 8A continuous, 10A peak
- Wide power supply range:
  - Single supply: +8V to +60V
  - Dual supply: ±4V to ±30V
- Wide output voltage swing
- High slew rate: 9V/µs
- Control reference pin
- Fully protected: thermal shutdown, adjustable current limit
- Output disable control
- Package: 11-pin power package

Applications

- Valve, actuator drivers
- Synchro, servo drivers
- Test equipment
- Transducer excitation
- Power supplies



OPA549 functional block diagram.

High-Side Measurement Current-Shunt Monitor with Dual Comparators
INA206, INA207, INA208

www.ti.com/sc/device/PARTnumber

(Replace **PARTnumber** with **INA206**, **INA207** or **INA208**)

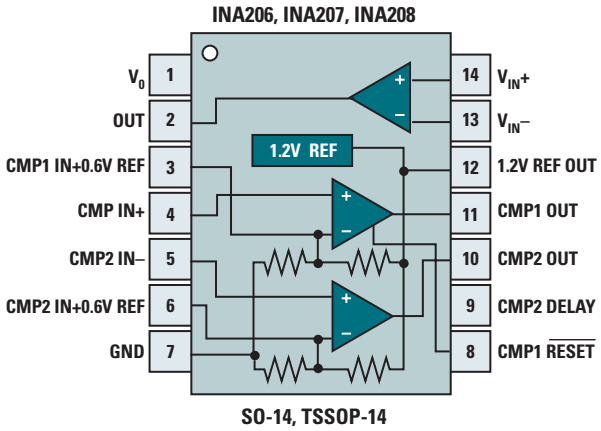
The INA206, INA207 and INA208 are a family of high-side, current-shunt monitors with voltage output, dual comparators and voltage reference. The INA206, INA207 and INA208 can sense drops across shunts at common-mode voltages from –16V to +80V. They are also available with three output voltage scales: 20V/V, 50V/V, and 100V/V with up to 500kHz bandwidth. The ICs incorporate two open-drain comparators with internal 0.6V references. Comparator 1 includes a latching capability, and Comparator 2 has a user-programmable delay on 14-pin versions. 14-pin versions also provide a 1.2V reference output.

Key Features

- Complete current sense solution
- Common-mode range: –16V to +80V
- High accuracy: 3.5% (max) over temp
- Bandwidth: 500kHz
- Quiescent current: 1.8mA
- Packaging: SO-14, TSSOP-14, MSOP-10

Applications

- Medical equipment
- Power management
- Battery chargers
- Notebook computers



INA206 functional block diagram.

Component Recommendations for Ventilation Applications

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
OPA549	Power Amplifier	8A continuous, 10A peak output current, 9µs slew rate	Wide supply range, thermal protection	OPA547, OPA548
OPA567	Power Amplifier	2A output, 150mV of rails with I/O = 2A output swing	Thermal protection, adj. current limit	OPA569
PGA309	Prog. Sensor Conditioner	Sensor error compensation: span, offset, temp drifts	Complete bridge sensor conditioner	
Data Converters				
ADS1258	Delta-Sigma ADC	16-channel, 24-bit, 125k/23.7kSPS	Fastest multi-channel, delta-sigma ADC, measures all 16 inputs in <675µs	ADS1251, ADS1253, ADS1212
ADS1271	Delta-Sigma ADC	24-bit, 105kSPS, serial interface, SPI w/FSYNC	Designed for multi-channel systems	**ADS1274**, **ADS1278**, ADS1284
ADS8325	µPower SAR ADC	16-bit, 100kSPS, 2.7V to 5.5V supply	Small size, low power	ADS8320, ADS8341, ADS8344
ADS8472	SAR ADC	16-bit, 1MSPS, ±0.4LSB (typ) INL	Zero latency, low power	
Processors				
TMS320F28x™	DSP	32-bit fixed point code, up to 150MIPs operation	Combination of DSP performance and MCU integration	
TMS320F2808	Digital Signal Controller	100MIPS, 8KB ROM, 36KB RAM, 128KB Flash, 12-bit ADC	I^2C, 4 SPI, 2 SCI, 2 CAN	
TMS320F2812	Digital Signal Controller	150MIPS, 8KB ROM, 36KB RAM, 256KB Flash, 12-bit ADC	McBSP, 1 SPI, 2 SCI, 1 CAN	
TMS320F28015	Digital Signal Controller	60MIPS, 8KB ROM, 12KB RAM, 32KB Flash, 12-bit ADC	I^2C, 1 SPI, 1 SCI	
MSP430F20xx	Ultra Low Power 16-bit MCU	2KB Flash, 128B RAM, SPI+I^2C	8 ch. 12-bit ADC or 4 ch. 16-bit SD ADC, 4x4 mm package	
MSP430F22x4	Ultra Low Power 16-bit MCU	32KB Flash, 1KB RAM, SPI + I^2C + UART/LIN + IrDA	12 ch. 10-bit ADC, 2 op.amps	
MSP430F23x0	Ultra Low Power 16-bit MCU	32KB Flash, 2KB RAM, SPI + I^2C + UART/LIN + IrDA	Analog comparator, HW multiplier	
MSP430F15x	Ultra Low Power 16-bit MCU	32KB Flash, 1KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comparator	
MSP430F16x	Ultra Low Power 16-bit MCU	60KB Flash, 2KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comp, HW multiplier	
MSP430F16xx	Ultra Low Power 16-bit MCU	55KB Flash, 10KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comp, HW multiplier	
MSP430F41x	Ultra Low Power 16-bit MCU	4KB Flash, 256B RAM, SVS, 96 segment LCD	Analog comparator	
MSP430F42x0	Ultra Low Power 16-bit MCU	32KB Flash, 256B RAM, 56 segment LCD	5 ch. 16-bit SD ADC, 12-bit DAC	
MSP430F42x	Ultra Low Power 16-bit MCU	32KB Flash, 1KB RAM, SPI + UART, SVS, 128 segment LCD	3 x 16-bit SD ADC	
MSP430F43x	Ultra Low Power 16-bit MCU	32KB Flash, 1KB RAM, SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, analog comparator	
MSP430FG43x	Ultra Low Power 16-bit MCU	60KB Flash, 2KB RAM, SPI + UART, SVS, 128 segment LCD	12 ch. 12-bit ADC, 2 ch. 12-bit DAC, DMA, 3 op amps	
MSP430F44x	Ultra Low Power 16-bit MCU	60KB Flash, 2KB RAM, 2x SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, HW multiplier	
MSP430FG461x	Ultra Low Power 16-bit MCU	120KB Flash, 8KB RAM, SPI + I^2C + UART/LIN + IrDA, 160 LCD	12 ch.12-bit ADC, 2 ch.12-bit DAC, A-comp, 3 op amp, HW multiplier	
Interface				
SN65HVD1050	CAN Transceiver	–27V to 40V bus-fault protection, meets or exceeds ISO11898-2	High EMI, low EME	HVD234 is 3.3V version
SN65HVD3082	RS-485 Transceiver	1/8 unit load — up to 256 nodes on a bus, 15kV ESD protection	Glitch-free power-up/down bus inputs and outputs	

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

Component Recommendations for Ventilation Applications

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Power Management Products				
bq2406x	Battery Charger	Linear 1-cell Li-Ion charger with thermal regulation, 6.5V OVP, temp sense	Good for space-limited designs with need for battery safety	bq2410x
bq27010	Battery Fuel Gauge	Li-Ion and Li-Pol battery gas gauge	Reports accurate time-to-empty of battery	bq27200
TPS2041B	USB Power Switches	USB compliant power source, short-circuit protection	Single-chip power-source solution for USB and memory cards	TPS2051B, TPS2061
TPS23750	Power-over-Ethernet	PoE interface and DC/DC controller in one IC	Transmit power and data to remote devices over ethernet cable	TPS2384
TPS61042	LED Boost Converter	Current source with overvoltage protection	Simple backlight boost for improved visibility of LCD	TPS61140
TPS63000	Buck Boost Converter	Automatic transition between step down and boost mode	Produce mid-range voltage out over entire range of battery	TPS621130
TPS62300	Step-Down Converter	500mA, 3MHz synchronous step-down converter	Very small inductor and high efficiency	TPS62040
TPS79901	Low-Noise-Single-Channel LDO	Very high rejection of power source noise	Low-noise power rails for sensitive analog components	TPS793xx, TPS795xx

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

Automatic External Defibrillator (AED)

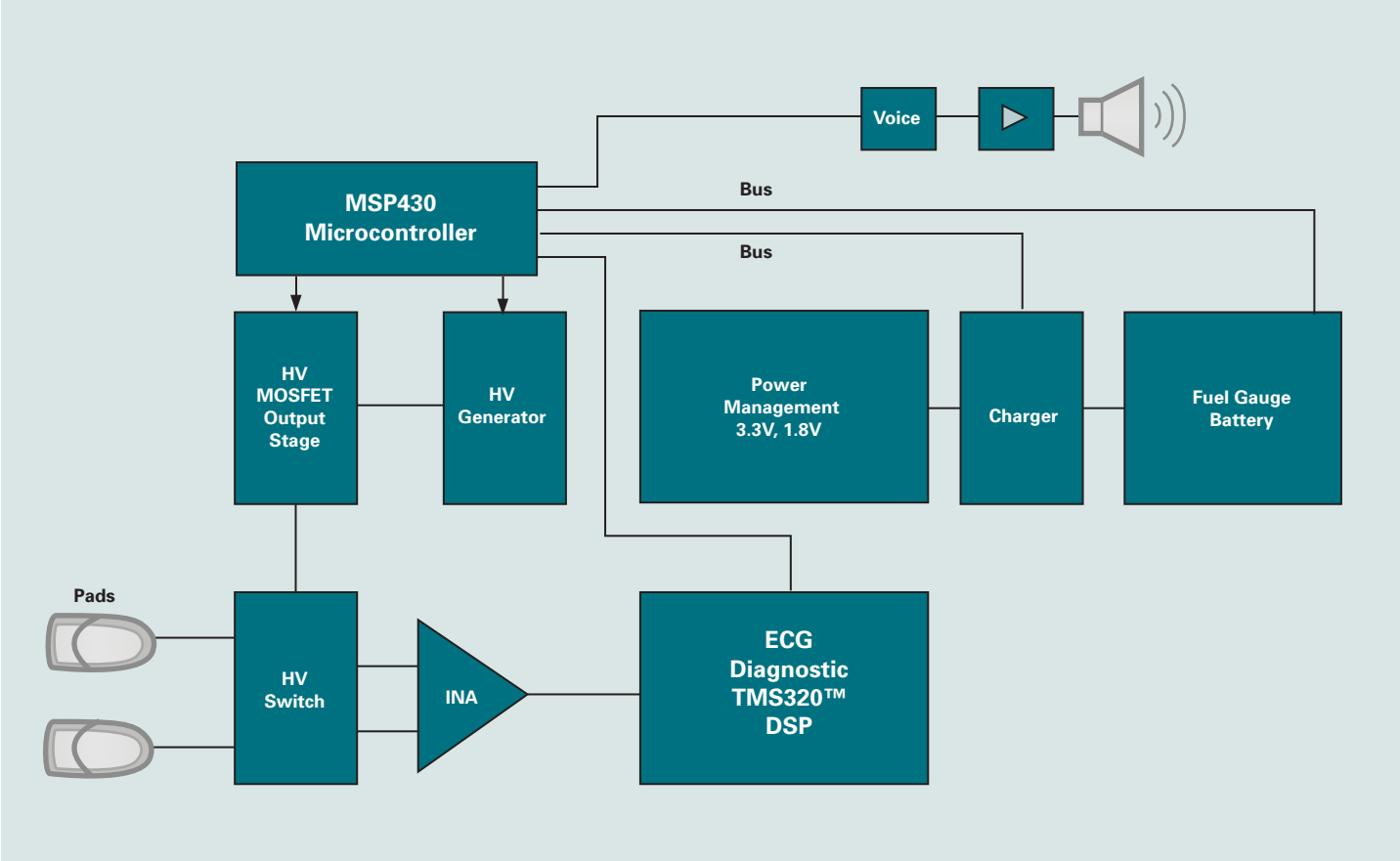
The automated external defibrillator (AED) is a highly sophisticated microprocessor-based device that monitors, assesses and automatically treats patients with life-threatening heart rhythms. It captures ECG signals from the therapy electrodes, runs an ECG-analysis algorithm to identify shockable rhythms, and then advises the operator about whether defibrillation is necessary. A basic defibrillator contains a high-voltage power supply, storage capacitor, optional inductor and patient electrodes (see block diagram). It develops an electrical charge in the capacitor to a certain voltage, creating the potential for current flow. The higher the voltage, the more current can potentially flow. The AED outputs audio instructions and visual prompts to guide the operator through the defibrillation procedure. In a typical defibrillation sequence, the AED provides voice prompts to instruct the user to attach the patient electrodes and starts acquiring ECG data. If the AED analyzes the patient's ECG and detects a shockable rhythm, the capacitor is charged according to energy stored in the capacitor, $W_c = \frac{1}{2}CV_c^2$; and capacitor voltage, $V_{c(t)} = V_{c(0)}e^{-t/RC}$, where R = R(lead) <<R(chest).

Then, following the instructions, the operator presses the shock button to deliver the high-voltage pulse; and current begins flowing through the body to depolarize most of the heart cells, which often re-establishes coordinated contractions and normal rhythm. The amount of flowing current is determined by the capacitor and body impedance. The accompanying graph shows the level of current and the length of time the current flows through the body.

Many jurisdictions and medical directors also require that the AED record the audio from the scene of a cardiac arrest for post-event analysis. All AEDs include a means to store and retrieve patient ECG patterns.

The front-end signals of the AED come from the ECG electrodes placed on the patient, which requires an instrumentation amplifier to amplify its very small amplitude (<10mV). The instrumentation amplifiers INA118/INA128/INA326 are designed to have:

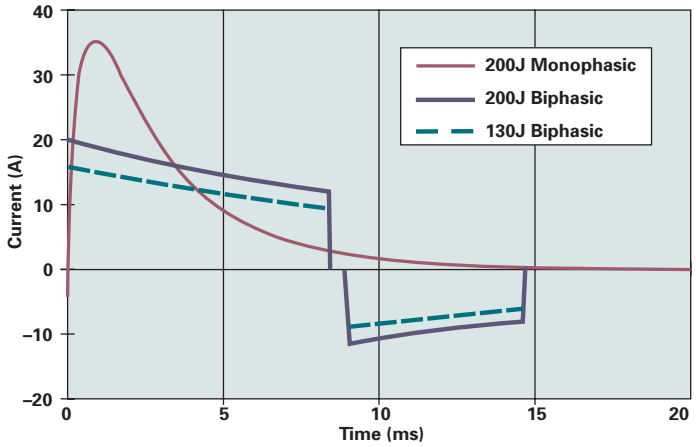
- Capability to sense low-amplitude signals from 0.1mV to 10mV,
- Very high input impedance (>5MΩ),
- Very low input leakage current (<1µA),
- Flat frequency response of 0.1Hz to 100Hz and
- High common-mode rejection ratio (CMRR) (>100dB).



System diagram.

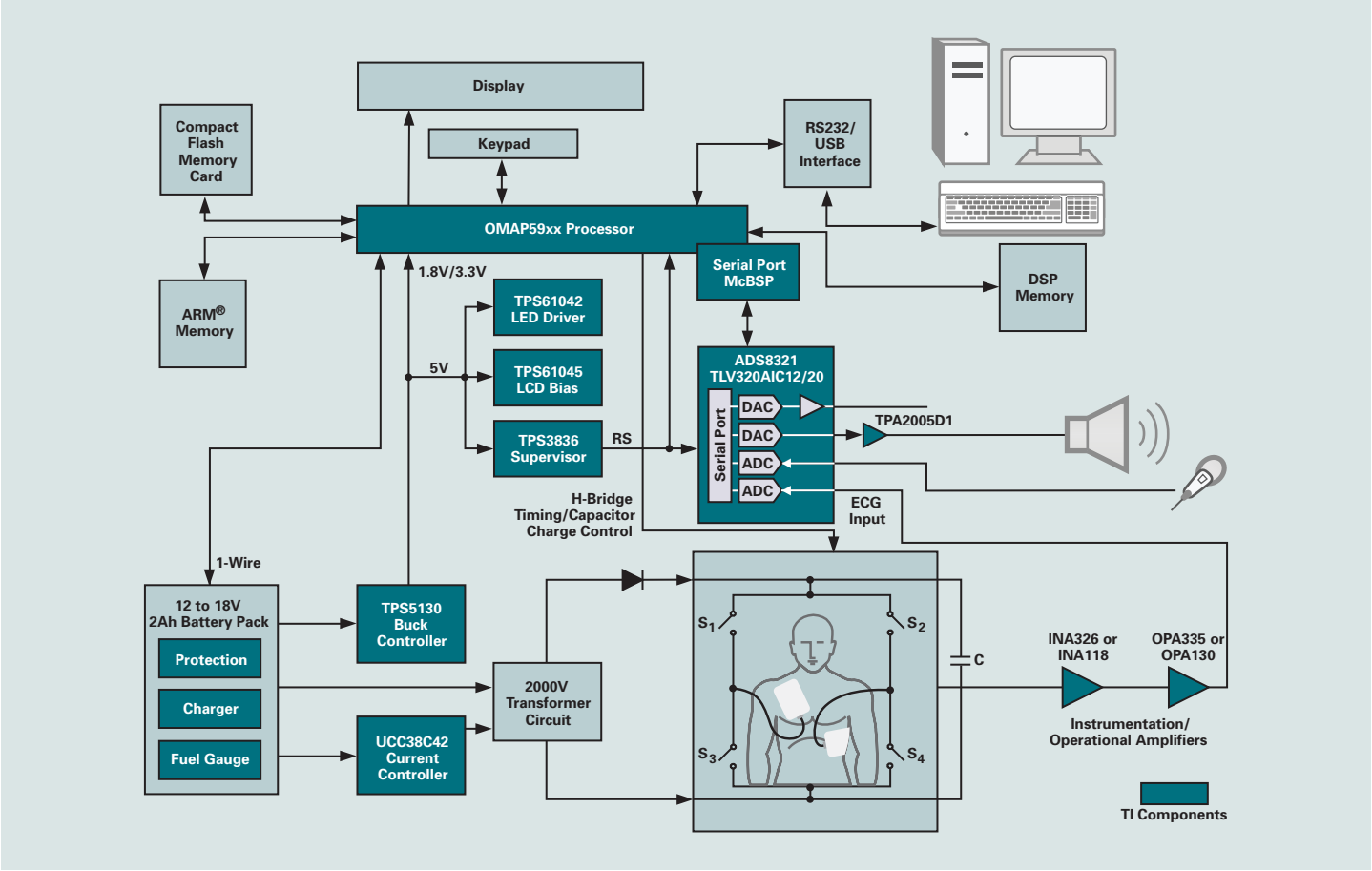
Automatic External Defibrillator (AED)

The other front-end signal of the AED is the microphone input for recording the audio from the scene of a cardiac arrest. Both ECG and microphone input are digitized and processed by a DSP. Most AED designs use a 16-bit processor and therefore work well with 16-bit ADCs to digitize ECG and voice input. The amplified ECG signal has a bandwidth of 0.1Hz to 100Hz and requires a minimum SNR of 50dB. The audio recording/playback signal typically has a bandwidth of 8kHz and requires a minimum SNR of 65dB. The microphone input also needs to be amplified with a maximum programmable gain of 40dB. The AED can have synthesized audio instruction with volume control output to either the headphone speaker or the 8Ω speaker. System designers will find that the TLV320AIC20 makes the AED front-end digitization very easy and simple because it integrates two ADCs, two DACs, a microphone amplifier, a headphone driver and an 8Ω driver with volume control; and it can be gluelessly interfaced to a DSP.



Typical AED drive current.

AEDs can deliver either monophasic or biphasic defibrillation waveforms to the heart. Monophasic delivers a current that travels in one direction throughout the shock. Newer biphasic technology allows the current to be reversed partway through the shock thus potentially lessening the risk of burns and myocardial damage.



AED block diagram.

Automatic External Defibrillator (AED)

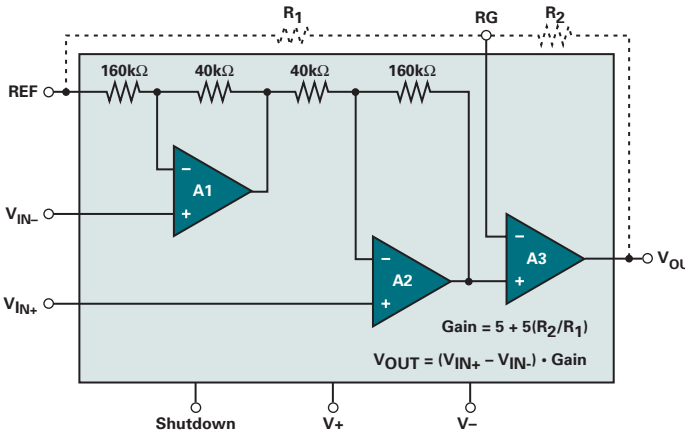
Single-Supply, microPower, RRO, CMOS Instrumentation Amplifier
INA321

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/INA321

The INA321 is a rail-to-rail output, CMOS instrumentation amp that provides amplification of differential signals with microPower current consumption of 40µA. It features <1µA current consumption in standby mode and returns to normal operation in microseconds making it a good choice for low-power battery or multiplexing applications. Configured internally for 5V/V gain, the INA321 offers exceptional flexibility with user-programmable external gain resistors. It reduces common-mode error over frequency and with CMRR remaining high up to 3kHz, line noise and line harmonics are rejected.

Key Features
- Low quiescent current: 40µA/ch
- High gain accuracy: 2ppm/°C, 0.02%, G = 5
- Low offset voltage: ±200µV
- High CMRR: 94dB
- Low bias current: 10pA
- Bandwidth: 500kHz, G = 5V/V
- Gain set with external resistors
- Packaging: MSOP-8 (single); TSSOP-14 (dual)

Applications
- Physiological amplifier: ECG, EEG, EMG
- Test equipment
- Differential line receivers with gain
- Industrial sensor amplifier: bridge, RTD, thermistor, position



INA321 functional block diagram.

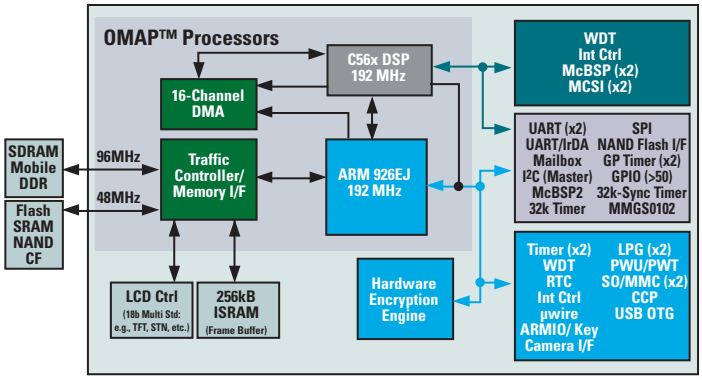
Embedded Applications Processor
OMAP5912

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/OMAP5912

The dual-core OMAP59xx processor integrates a TMS320C55x™ DSP core with an ARM9 core on a single chip for the optimal combination of application performance and low power consumption. This unique architecture offers an attractive solution to both DSP and ARM® developers, by providing the low-power, real-time signal processing capabilities of a DSP coupled with the command and control functionality of an ARM.

Key Features
- Extensive peripheral set supporting glueless interface to multiple radio technologies (GSM/GPRS, WLAN, BT, RF)
- Industry-leading C55x™ DSP core offering portable data terminalcentric algorithms via TI DSP Third Party Network
- Multibus architecture for PDT system-level optimization
- On-chip frame buffer supporting multiple display variations
- Hardware encryption engine enabling industry-standard security applications
- Robust man/machine interface ARM9 core for multiple operations

Applications
- Video and imaging processing
- Graphics and video acceleration
- Data processing
- Mobile communications



OMAP5912 peripheral block diagram.

Single- or Dual-Output, 3kV Isolation DC/DC Converter Family
DCH010505

Get samples and datasheets at: **www.ti.com/sc/device/DCH010505**

The DCH01 series are 1W, miniature DC/DC converters with 3kV isolation and are UL60950 certified.

These unregulated converters accept a 5V input and deliver single or dual outputs of 5V, 12V or 15V.

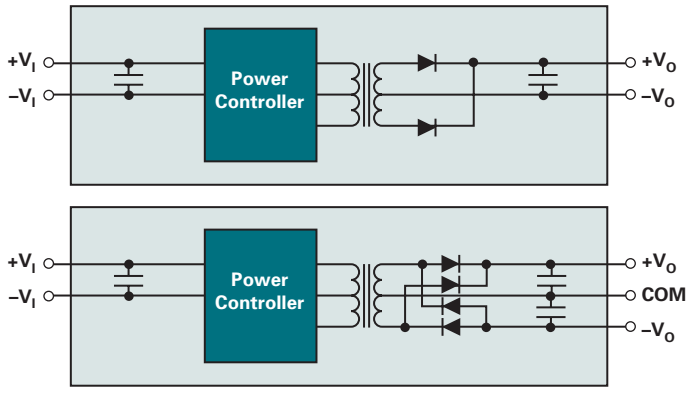
Offering high performance at low cost, DCH01 converters operate at up to 78% efficiency. The units have an industry standard SIP-7 footprint.

They are the only ICs in their product space with an open-frame package, contributing to excellent thermal performance and high reliability.

In signal chain applications such as PLC, Fieldbus and data acquisition, including those using TI's new ISO721 high-speed digital isolator, the DCH01 can be used for ground loop elimination. In addition to isolated applications, DCH01 converters can also be used for non-isolated applications that require the low-cost generation of a split-supply.

Key Features
- Output power: 1W
- Unregulated DC/DC converter
- 5V input (4.5V to 5.5V range)
- 5V, 12V, or 15V single and dual output models
- UL60950 recognized to 3kVdc isolation
- Efficiency: Up to 78%
- Packaging: Industry standard SIP-7 footprint

Applications
- Medical instrumentation
- Ground loop elimination
- Industrial control and instrumentation
- Test equipment
- Programmable logic controller



Single- and dual-output block diagrams.

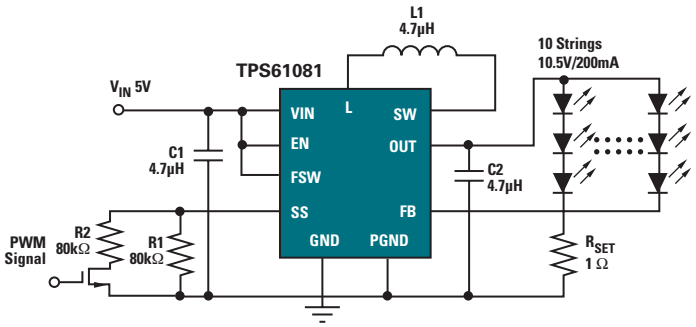
High-Voltage Boost Converter with 0.5A/1.3A Current Switch and Power Diode
TPS61080, TPS61081

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/TPS61080 or **www.ti.com/TPS61081**

The new TPS60180 and TPS60181 are 1.2MHz/600kHz fixed-frequency boost converters designed for portable devices. The highly integrated converters incorporate a power PWM switch, input/output isolation switch and power diode. Under short-circuit conditions (detected by measuring the input current) the isolation switch opens to disconnect the output from the input. This protects the converter, protects the input source from the output short, and guards against shorts between any single pin and ground (except for the V_{IN} pin). The converter also isolates the output from the input during shutdown to prevent any leakage current.

Key Features
- Input voltage range: 2.5V to 6V
- Output voltage: Up to 27V
- 0.5A integrated switch (TPS61080)
- 1.3A integrated switch (TPS61081)
- 12V/400mA and 24V/170mA from 5V input (typ)
- Integrated power diode
- 1.2MHz/600kHz selectable fixed switching frequency
- Input-to-output isolation
- Short-circuit protection
- Up to 87% efficiency

Applications
- 3.3V to 12V, 5V to 12V and 24V boost converter
- White LED backlight for media form factor display
- TFT-LCD bias supply



L1: TDK VLCF 5020 T-4R7N1R7-1
C1: Murata GRM 188 R60 J475 K; C2: Murata GRM 219 R61 C475 K

30 WLEDs driver with PWM dimming in MFF display.

Power Management for Diagnostics

1.6MHz, 3V to 6V Input, 3A DC/DC Synchronous Buck Converter
TPS54317

Get samples, datasheets, evaluation modules, app reports and software tools at: **www.ti.com/sc/device/TPS54317**

Key Features
- Input voltage range: 3V to 6V
- Two 3A (4.5A peak) integrated MOSFETs provide synchronous rectification
- Adjustable/synchronizable switching frequency to 1.6MHz
- Output voltage adjustable down to 0.9V
- Power good, enable, adjustable slow-start, current limit, thermal shutdown and 1% accuracy
- Supported by free SwitcherPro™ design software

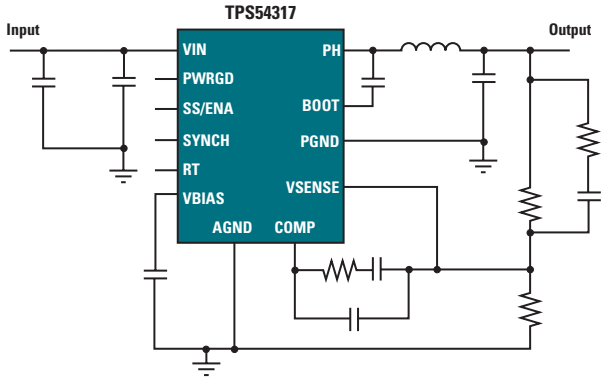
Applications*
- TI TMS320C64x™ DSPs
- Altera® Cyclone® II, Stratix® II, Stratix II GX, Stratix III
- Xilinx® Spartan®-3 family, Virtex®-5
- Core and IO power supplies

** TI's reference to other companies' products does not constitute TI's recommendation or approval of such products for use in any application.*

Other Low-Voltage SWIFT™ Components*

Part Number	V_{IN} Range (V)	I_{OUT} (A)	Frequency	Package
TPS54310	3 to 6	3	Up to 700kHz	20HTSSOP
TPS54610	3 to 6	6	Up to 700kHz	28HTSSOP
TPS54910	3 to 4	9	Up to 700kHz	28HTSSOP
TPS54010	3 to 4	14	Up to 700kHz	28HTSSOP

** Same feature set as TPS54317*



TPS54317 functional block diagram.

4.5V to 20V Input, 3A and 6A Converters
TPS54350, TPS54550

Get samples, datasheets, evaluation modules, app reports and software tools at: **www.ti.com/sc/device/TPS54350** or **www.ti.com/sc/device/TPS54550**

Key Features
- Input voltage range: 4.5V to 20V
- Synchronous buck for high efficiency
- Adjustable output voltage down to 0.9V
- Power good, enable, adjustable slow-start, current limit, thermal shutdown
- 180° out-of-phase switching
- TPS54350 and TPS54550 are footprint compatible
- Fixed 250kHz, 500kHz, or adjustable switching frequency

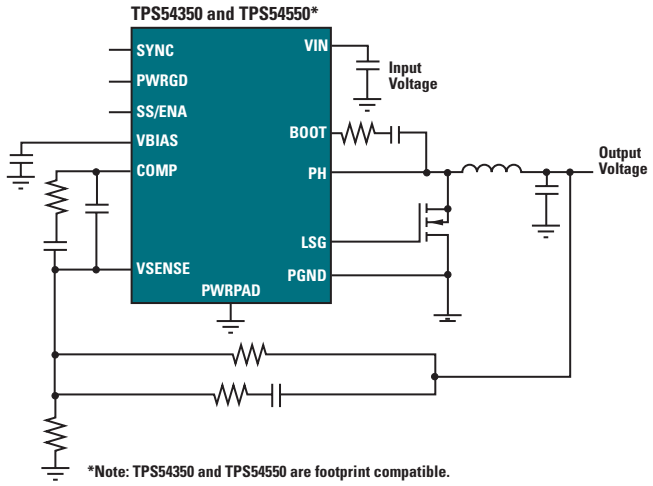
Applications*
- TI TMS320C64x™ DSPs
- Altera Cyclone II, Stratix II, Stratix II GX, Stratix III
- Xilinx Spartan-3 family, Virtex-5
- Core and IO power supplies

** TI's reference to other companies' products does not constitute TI's recommendation or approval of such products for use in any application.*

Mid-Voltage SWIFT™ Components

Part Number	V_{IN} Range (V)	I_{OUT} (A)	Compensation	Package
TPS54350	4.5 to 20	3	External	16HTSSOP
TPS5435x	4.5 to 20	3	Internal*	16HTSSOP
TPS54550	4.5 to 20	6	External	16HTSSOP

** Fixed output versions available (1.2, 1.5, 1.8, 2.5 and 3.3V)*



Functional block diagram.

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
INA118	Instrumentation Amp	110dB CMRR, 5nA (max) bias current, 50µV (max) offset	Bipolar supplies	
INA126	Instrumentation Amp	175µA/ch supply, 3µV/°C (max) drift, 250µV (max) offset	Bipolar supplies	INA2126 (dual)
OPA333	Precision Op Amp	1.8V V_S, 17µA/ch I_Q, 0.05µV/°C zero drift (max)	CMOS, zero-drift series, SC70, SOT23	OPA2333 (dual)
TPA2005D1	Class-D Audio Amp	1.4W output power, 75dB PSRR, 2.8mA/ch I_Q, 8Ω load (min)		
Data Converters				
ADS1100	ADC	16-bit, 128SPS (max), ±8LSB (max), serial I^2C interface	External reference, self-calibrating, delta-sigma	
ADS1250	ADC	20-bit, 25kSPS (max), PGA = 1 to 8, ±4	Data acquisition system, delta-sigma	ADS1251, ADS1252
ADS1252	Delta-Sigma ADC	24-bit, 40kSPS, 0.0015% (max) INL	2-wire synchronous serial interface	ADS1251, ADS1253, ADS1254, ADS7866
ADS7866	SAR ADC, Serial	1.2V, 12-bit, 200kSPS (max), 85dB SFDR		
ADS8325	µPower SAR ADC		Small size, low power	ADS8320, ADS8841, ADS8344
MSC1210	Data Acquisition System	Enhanced 8051 core with Flash memory and 24-bit ADC		
TLV320AIC20	Dual-Channel Codec	16-bit, 266kSPS, 81dB SNR for ADC, 78dB SNR for DAC	Fully compatible with TMS320C54x™ DSP power supplies	
TLV320AIC26	Audio Codec	24-bit, 53kSPS, 2.7V to 3.6V supply, L, R, I^2S, DSP interfaces	Low-power stereo DAC, mono ADC with speaker amp	
TSC2003	Touch Screen Controller	I^2C interface for standard, fast, high-speed modes	Direct battery measurement	ADS7845, TSC2000, **TSC2007**
TSC2046	Touch Screen Controller	Low voltage I/O, touch pressure measurement, 2.2V to 5.2V operation	QSPI™ and SP™ 3-wire interface	
References				
REF3112	Series Voltage	0.2% (max) initial accuracy, 15ppm/°C (max) drift, 100µA	Low power consumption for portable applications	REF3120, REF3125, REF3133
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q	Multiple output voltages, SOT23-6	
REF33xx	microPower Bandgap	0.1% (max) accuracy, 30ppm/°C (max) drift, 0.005mA (max) I_Q	Multiple output voltages, MSOP-8, SO-8	
REF50xx	Precision Reference	0.05% accuracy, 3ppm/°C (max) drift, 6μV_{PP} low noise	Multiple output voltages, SC71	
Processors				
MSP430F20xx	Ultra Low Power 16-bit MCU	2KB Flash, 128B RAM, SPI+I^2C	8 ch. 12-bit ADC or 4 ch. 16-bit SD ADC, 4x4 mm package	
MSP430F22x4	Ultra Low Power 16-bit MCU	32KB Flash, 1KB RAM, SPI + I^2C + UART/LIN + IrDA	12 ch. 10-bit ADC, 2 op.amps	
MSP430F23x0	Ultra Low Power 16-bit MCU	32KB Flash, 2KB RAM, SPI + I^2C + UART/LIN + IrDA	Analog comparator, HW multiplier	
MSP430F15x	Ultra Low Power 16-bit MCU	32KB Flash, 1KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comparator	
MSP430F16x	Ultra Low Power 16-bit MCU	60KB Flash, 2KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comp, HW multiplier	
MSP430F16xx	Ultra Low Power 16-bit MCU	55KB Flash, 10KB RAM, SPI + I^2C + UART, DMA, SVS	8 ch. 12-bit ADC, 2 ch.12-bit DAC, analog comp, HW multiplier	
MSP430F41x	Ultra Low Power 16-bit MCU	4KB Flash, 256B RAM, SVS, 96 segment LCD	Analog comparator	
MSP430F42x0	Ultra Low Power 16-bit MCU	32KB Flash, 256B RAM, 56 segment LCD	5 ch. 16-bit SD ADC, 12-bit DAC	
MSP430F42x	Ultra Low Power 16-bit MCU	32KB Flash, 1KB RAM, SPI + UART, SVS, 128 segment LCD	3 x 16-bit SD ADC	
MSP430F43x	Ultra Low Power 16-bit MCU	32KB Flash, 1KB RAM, SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, analog comparator	
MSP430FG43x	Ultra Low Power 16-bit MCU	60KB Flash, 2KB RAM, SPI + UART, SVS, 128 segment LCD	12 ch. 12-bit ADC, 2 ch. 12-bit DAC, DMA, 3 op amps	
MSP430F44x	Ultra Low Power 16-bit MCU	60KB Flash, 2KB RAM, 2x SPI + UART, SVS, 160 segment LCD	8 ch. 12-bit ADC, HW multiplier	

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red.***

Component Recommendations for AED Applications

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Processors (Continued)				
MSP430FG461x	Ultra Low Power 16-bit MCU	120 KB Flash, 8 KB RAM, SPI + I^2C + UART/LIN + IrDA, 160 LCD	12 ch.12-bit ADC, 2 ch.12-bit DAC, A-comp, 3 op amp, HW multiplier	
OMAP5910	OMAP™ Processor	Dual-core architecture with both DSP and RISC	DSP/BIOS™ software kernel foundation	OMAP5912
TMS320C5000™	DSP	Power efficient, high performance		
Power Management Products				
bq20z90	Battery Fuel Gauge	Instant accuracy better than 1% error over lifetime of the battery	Automatically adjusts for battery aging, battery self discharge and temperature inefficiencies	
bq24100	Battery Charge Management	Switch mode, 1100kHz switching frequency, >2A charge current	d/dt, min current primary charge termination method	
bq24721	Battery Charge Management	Multi-chemistry and multi-cell sync switch-mode charger	High efficiency, pack and system protection functions	
bq29330	Battery Safety	Battery pack full-protection analog front end	Provides individual cell voltages and battery voltage to battery management host	
DCP020515D	Isolated DC/DC Converter	2W, unregulated, up to 89% efficiency, 106W/in3 power density	EN55022 Class B EMC performance, UL1950 component	DCP02 series
TPS2041B	USB Power Switches	USB-compliant power source, short-circuit protection	Single-chip power source solution for USB and memory cards	TPS2051B, TPS2061
TPS2828	MOSFET Driver	2A output, 14ns rise and fall time, 24ns prop delay, inverting	Drives FETs for high-voltage transformer	TPS2829 non-inverting version
TPS3836	Voltage Supervisor	220nA supervisor with 10ms/200ms selectable delay time	Circuit initialization and timing supervision	TPS3809
TPS61042	White LED Driver	30V, 500mA switch boost converter, 1MHz switching frequency		TPS61140
UCC38C4x	PWM Controller	14.9/9V on/off UVLO thresholds, 1MHz frequency, 50% duty cycle		UCC3804, UCC3809
UCD7100	Digital Control Driver	Adjustable current limit, 3.3V, 10mA internal regulator	Applications requiring fast local peak current limit protection	

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red.***

In This Section

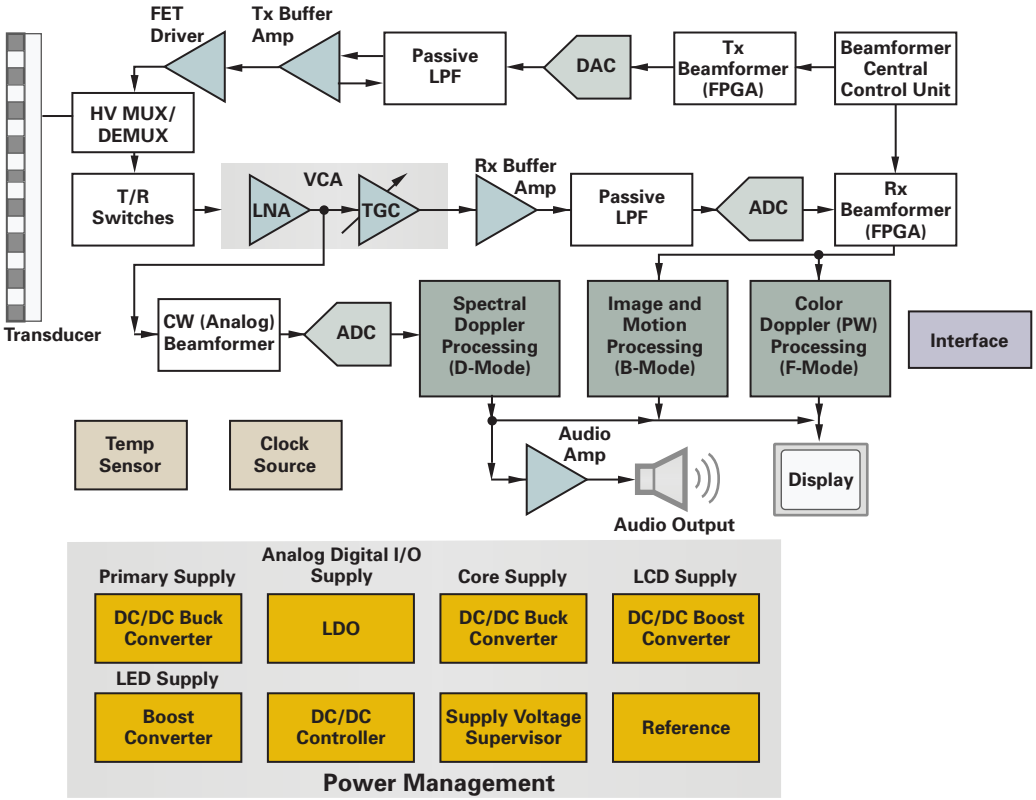
Ultrasound Systems

Ultrasound systems, both medical and industrial, use focal imaging techniques to achieve imaging performance far beyond what can be achieved through a single-channel approach. Using an array of receivers, a high-definition image can be built by time shifting, scaling and intelligently summing echo energy. The concept of time shifting and scaling receive signals from a transducer array provides the ability to "focus" on a single point in the scan region. By subsequently focusing at different points, an image is assembled.

When initiating a scan, a pulse is generated and transmitted from each of the 8 to 512 transducer elements. These pulses are timed and scaled to "illuminate" a specific region of the body. After transmitting, the transducer element immediately switches into receive mode. The pulse, now in the form of mechanical energy, propagates through the body as high-frequency sound waves, typically in the range of 1 to 15MHz. As it does, the signal weakens rapidly, falling off as the square of the distance traveled. As the signal travels, portions of the wave front energy are reflected. These reflections are the echoes that the receive electronics must detect. Signals reflected immediately will be very strong, as they are from reflections close to the surface, while reflections that occur long after the transmit pulse will be very weak, reflecting from deep in the body.

Because of limits on the amount of energy that can be put into the body, the industry must develop extremely sensitive receive electronics. At focal points close to the surface, the receive echoes are strong, requiring little if any amplification. This region is referred to as the near field. But at focal points deep in the body, the receive echoes will be extremely weak and must be amplified by a factor of 1000 or more. This region is referred to as the far field. These regions represent the two extremes in which the receive electronics must operate.

In the high-gain (far field) mode, the limit of performance is the sum of all noise sources in the receive chain. The two largest contributors of receive noise are the transducer/cable assembly and the receive low noise amplifier (LNA). In low gain (near field), the limit of



Ultrasound system block diagram.

performance is defined by the magnitude of the input signal. The ratio between these two signals defines the dynamic range of the system. Many receive chains integrate the LNA with a variable gain amplifier.

Low-pass filtering is typically used between the VCA and the ADC as an anti-aliasing filter and to limit the noise bandwidth. Depending on the specific system two- to five-pole filter, linear phase topologies can be found here. In selecting an op amp, the primary considerations include signal swing, minimum and maximum input frequencies, harmonic distortion and gain requirements. Analog-to-digital converters (ADCs) are typically 10- and 12-bit. SNR and power consumption are the most important issues, followed by channel integration.

Another trend in ADCs is the implementation of an LVDS interface between the ADC and the beamformer. By serializing the data coming out of the ADC, the number of interface lines can be reduced from 6144 to 1024 for a 512-channel system. This reduction translates to smaller and lower-cost PC boards, an essential part of portable imaging systems.

Among the functions the DSP can perform in the imaging system are the Doppler processing, 2D, 3D and even 4D imaging as well as a host of post processing algorithms to increase functionality and improve performance. The key requirements of the imaging system are high performance and high bandwidth. The TMS320C6455BZTZ DSP meets both these needs. The C6455 runs at 1GHz to handle the intensive processing needs of ultrasound and the SerialRapidIO peripheral provides 10Gb/s full duplex bandwidth.

There are many different levels of performance and functionality in ultrasound systems. Some solutions may have pieces that require a high dynamic range or that have functions that take far less cycles to do in floating point. Examples of these type of functions are spectral reduction and square root functions. The TMS320C6727 fits very well for these areas where floating point works best. When an ultrasound solution requires an operating system, the TMS320DM6446 may fill the need. In addition to having a powerful TMS32CC64x+™ core and video accelerators to handle the imaging needs, the DM6446 also has an ARM9™ core capable of handling the OS requirements.

The signal assembly is accomplished with a digital beamformer. This is typically a custom-designed ASIC, but this function has been implemented in different forms of programmable logic. Within the beamformer the digitized signal is scaled and time delayed to create the focusing effect in the receive chain. The properly adjusted signals are then summed together across all receive channels and passed to the imaging system. The imaging system can be developed as a separate ASIC, can be a programmable processor such as a DSP, or might be a full desktop computer.

Transmit elements require the control of 100V to 200V of signal swing. This is almost always accomplished with the use of high-voltage FETs. Control of the FETs can take one of two forms: on-off (push-pull) or class-AB linear control. The most popular is the push-pull approach, as it requires a much simpler and lower-cost interface to the FETs. The class-AB approach dramatically improves harmonic distortion but requires more complex drivers and consumes more power.

A wide variety of TI products have been chosen by system and equipment manufacturers for their ultrasound imaging applications, including op amps; single, dual and octal ADCs (all with fast-input overload recovery and excellent dynamic performance); digital signal processors; and the VCA8617, an integrated 8-channel, low-power ultrasound front-end IC. TI is also offering the ADS5270, an advanced 8-channel, 12-bit data converter with serialized LVDS interface, specifically for the ultrasound market.

TUS5000EVM Allows Rapid Prototyping for Ultrasound Applications

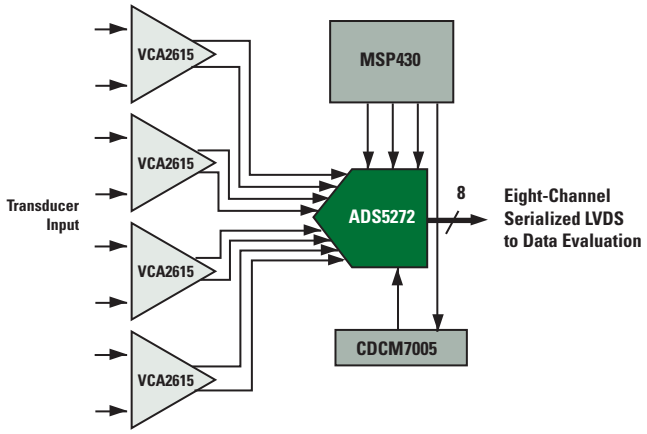
The TUS5000EVM was designed to interface four two-channel VCA2615 variable gain amplifiers with the 8-channel ADS5272 serialized LVDS-output ADC. A high-performance clock synchronizer and jitter cleaner, the CDCM7005, provides the 65MHz clock to the ADS5272 with a bypass option available. Designers can simply apply their real world input circuitry, such as an ultrasound probe, to the evaluation module to quickly evaluate the performance of TI's analog receive chain solution.

With a combined power per channel of 277mW, the VCA2615 and ADS5272 can be used for midrange and high-performance ultrasound applications.

A deserializer such as TI's ADSDESER-50EVM, is necessary in order to convert the serial LVDS outputs of the ADS5272 to parallel data for a complete evaluation.

Pricing and Availability

The TUS5000EVM is available today from TI. The price of $299 includes the evaluation module and User's Guide. The ADSDESER-50EVM is also available today from TI. The price of $399 includes the evaluation module, datasheet and User's Guide.



High-performance ultrasound signal chain.

Dual, Low-Noise Variable Gain Amplifiers
VCA2615, VCA2617

Get samples, datasheets and evaluation modules at:

www.ti.com/sc/device/VCA2615, www.ti.com/sc/device/VCA2617

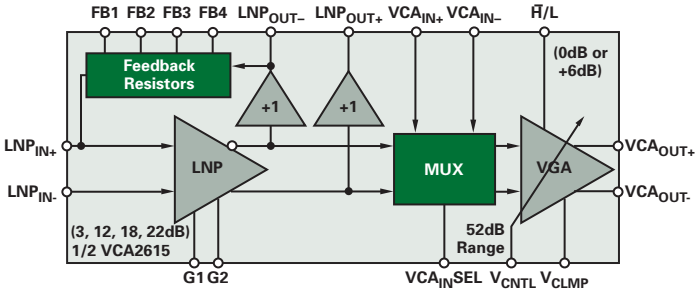
The VCA2615 dual-channel variable gain amplifier provides great performance in a small package for high-end, compact, and portable ultrasound applications. The integrated low noise pre-amplifier (LNA) provides extremely low noise while offering programmable gain and input resistance for maximum flexibility. The variable gain amplifier (VGA) provides up to 52dB gain range via an input control voltage. The VCA2617 is similar to the VCA2615 with the exclusion of the LNA circuitry. The VCA2617 is designed for use in systems where an LNA is external to the VGA.

Key Features

- Very low noise: 0.7nV/$\sqrt{\text{Hz}}$
- Programmable LNA gain
- Active termination
- Excellent overload recovery
- Adjustable output clipping level
- Independent VGA channel control (VCA2617)

Applications

- Medical ultrasound
- Industrial inspection



VCA2615 functional block diagram.

8-Channel Variable Gain Amplifiers
VCA8617, VCA8613

Get samples, datasheets, evaluation modules and app reports at:

www.ti.com/sc/device/VCA8617, www.ti.com/sc/device/VCA8613

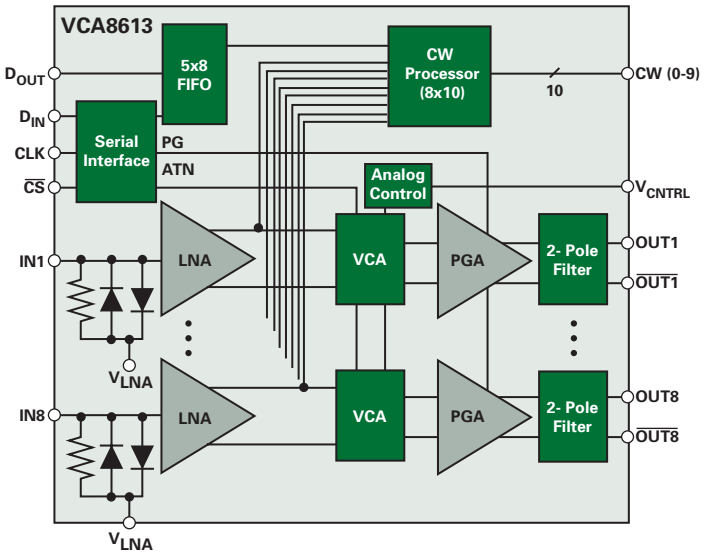
The VCA8617 is an 8-channel variable gain amplifier with excellent dynamic performance that enables its use in low-power, high-performance portable applications. Each channel consists of a 20dB gain low-noise pre-amp (LNA) and a variable gain amp (VGA). The differential outputs of the LNA can be switched through the 8x10 crosspoint switch, which is programmable though the serial interface port. The output of the LNA is fed directly into the VGA stage, which consists of a voltage-controlled amplifier (VCA) and a programmable gain amplifier (PGA). The output of the PGA feeds into an integrated low-pass filter.

Key Features

- Low input noise: 1nV/$\sqrt{\text{Hz}}$ at f_{IN} = 5MHz
- Integrated LNA
  - 20dB gain
  - 200mV$_{PP}$ input range
- Programmable VCA and PGA
- 15MHz low-pass filter
- Integrated CW switch matrix
- Low power operation: 100mW/channel
- Single supply: 3V
- Packaging: TQFP-64

Applications

- Medical imaging
- Portable ultrasound



VCA8613 functional block diagram.

Ultrasound/Portable Ultrasound

8-Channel, 10- and 12-Bit, 40 to 70MSPS ADCs with Serialized LVDS Interface

ADS5270, ADS5271, ADS5272, ADS5273, ADS5277, ADS5240, ADS5242

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/ADS527X, www.ti.com/sc/device/ADS5240, www.ti.com/sc/device/ADS5242

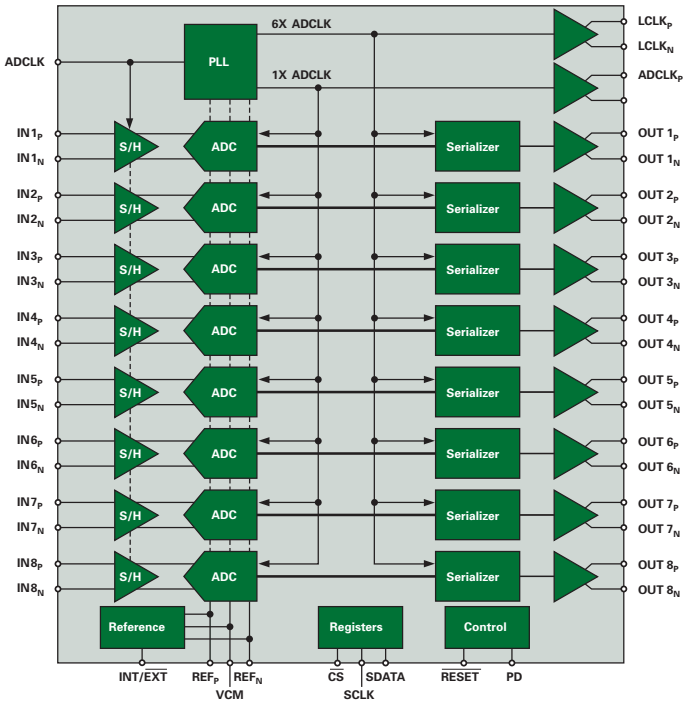
The ADS527x family provides eight high-performance ADCs in a small 80-lead TQFP package, making it possible to implement high channel counts in high-performance ultrasound systems. The low power dissipation per channel extends battery life and allows the ADS527x to be used in portable ultrasounds applications as well. Available in 12-bit, 40 to 70MSPS and 10-bit, 65MSPS versions, the ADS527x family has the flexibility to offer solutions across the entire spectrum of ultrasound systems. The ADS5240 and ADS5242 are 4-channel, 12-bit, 40MSPS and 65MSPS versions, respectively.

Key Features

- Eight 12- or 10-bit ADCs in one small 80-pin TQFP package
- Conversion rates: 40, 50, 65, and 70MSPS
- Power consumption: 123mW per channel at 65MSPS
- SNR: 70.5dB for 12-bits at 10MHz IF
- Individual channel power down

Applications

- Medical and other imaging
- Portable test equipment
- Wireless communications



ADS527x functional block diagram.

Dual, 10-Bit, 275MSPS DAC

DAC5652

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/DAC5652

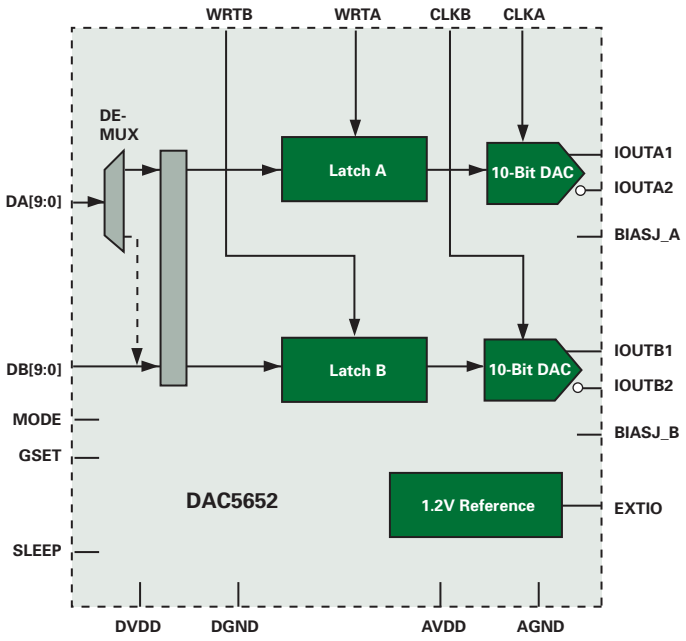
The DAC5652 is a dual, high-speed DAC with on-chip voltage reference. Each DAC has a high-impedance, differential current output suitable for single-ended or differential analog output configurations. External resistors allow scaling of the full-scale output current for each DAC separately or together, typically between 2mA and 20mA. An accurate on-chip voltage reference is temperature-compensated and delivers a stable 1.2V reference voltage. An external reference may be used. The DAC5652 has two parallel input ports with separate clocks and data latches. For flexibility, it also supports multiplexed data for each DAC on one port when operating in the interleaved mode.

Key Features

- Update rate: 275MSPS
- Single supply: 3V to 3.6V
- High SFDR: 80dBc at 5MHz
- High IMD_3: 78dBc at 15.1MHz and 16.1MHz
- Independent or single-resistor gain control
- Dual or interleaved data
- Low power: 290mW
- Packaging: TQFP-48

Applications

- Medical and test instrumentation
- Arbitrary waveform generators
- Direct digital synthesis



DAC5652 functional block diagram.

Ultra-Wideband, Current-Feedback Op Amp with Disable

OPA695

Get samples, datasheets, tool and app reports at: **www.ti.com/OPA695**

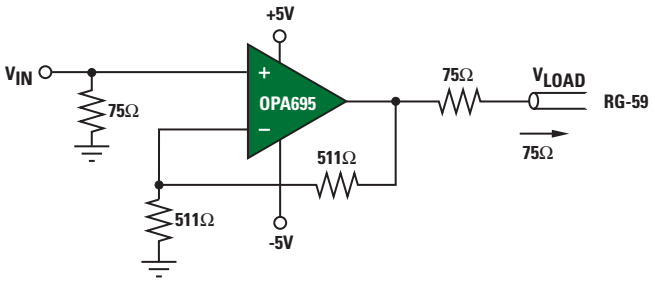
The OPA695 is a single channel, very broadband, current feedback operational amplifier. As a gain of +2V/V line driver, it offers 1.4GHz bandwidth with 2900V/µs slew rate. These give a 0.8ns rise time for a 2V output step — more than adequate for the highest speed video requirements. Single supply operation extends from +5V to +12V to span the most popular supplies used for fixed gain IF amplifiers. The OPA695's low 12.9mA supply current is precisely trimmed at +25°C. This trim, along with a low temperature drift, gives low system power over temperature.

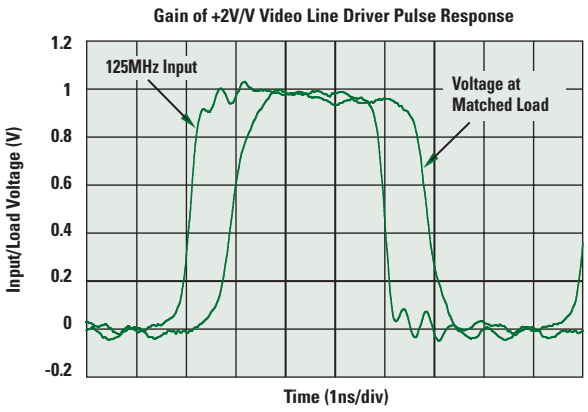
Key Features

- Gain = +2 bandwidth (1400MHz)
- Gain = +8 bandwidth (450MHz)
- Output voltage swing: ±4.2V
- Ultra-high slew rate: 4300V/µs
- Low power: 129mW
- Low disabled power: 0.5mW
- Packaging: SOT23-6, SO-8

Applications

- Very wideband ADC driver
- Low-cost precision IF amplifier
- Broadband video line driver





Video line driver.

TMS320DM644x Digital Media Processors Highest-Performance DSPs

TMS320DM644x

Get samples, datasheets, tool and app reports at:

www.ti.com/davinci

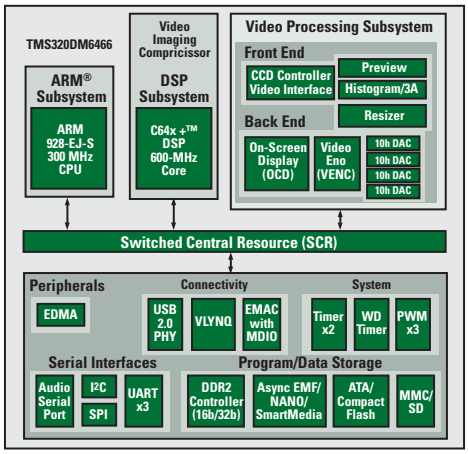
The TMS320DM644x digital media processors are highly integrated SoCs based on an ARM926 processor and the TMS320C64x+™ DSP core. It leverages TI's DaVinci™ technology to meet the networked media encode and decode application processing needs of next-generation embedded ICs. The DM6446 enables OEMs and ODMs to quickly bring to market devices featuring robust operating systems support, rich user interfaces, high processing performance, and long battery life through the maximum flexibility of a fully integrated mixed processor solution.

Key Features

- High-performance digital media SoC
  - 594MHz C64x+™ clock rate
  - 297MHz ARM926EJ-S™ clock rate
  - Eight 32-bit C64x+ instructions/cycle
  - 4752 C64x+ MIPS
  - Fully software compatible with C64x+/ARM9™
- Load-store architecture with non-aligned support
- 64 32-bit general-purpose registers
- Instruction packing reduces code size
- Embedded Trace Buffer™ (ETB11™) with 4KB memory for ARM9 debug
- Video processing subsystem
  - CCD and CMOS imager interface
  - Preview engine for real-time image processing
  - Glueless interface to common vide decoders

Applications

- Medical imaging
- Digital media
- Networked Media Encode/Decode



TMS320DM644x block diagram.

Ultrasound/Portable Ultrasound

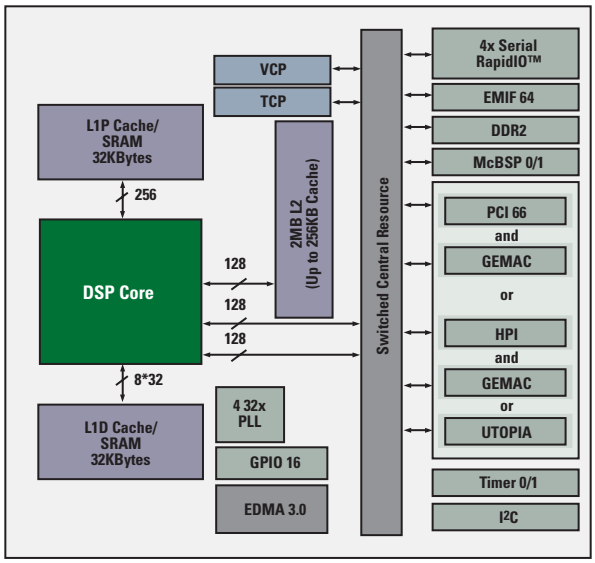
TMS320C645x DSP Generation, Fixed Point Highest-Performance DSPs
TMS320C6455

Get samples, datasheets, tool and app reports at:
www.ti.com/sc/device/TMS320C6455

The TMS320C64x+™ DSPs (including the TMS320C6455 IC) are the highest performance, fixed-point DSP generation in the TMS320C6000™ DSP platform. The C6455 IC is based on the third-generation, high-performance, advanced VelociTI™ very-long instruction-word (VLIW) architecture developed by TI, which allows these DSPs to be used for applications including video and telecom infrastructure, imaging/medical and wireless infrastructure (WI). The C64x+™ ICs are upward code-compatible from previous ICs that are part of the C6000™ DSP platform.

Key Features
- Based on the new TMS320C64x+ core 720MHz, 850MHz, 1GHz
- Memory:
  - 32KB L1D, 32KB L1P Cache/SRAM
  - 2MB L2, 256K Cache/SRAM, remainder SRAM only
- Acceleration
  - Viterbi decoder co-processor (VCP)
  - Turbo decoder co-processor (TCP)

Applications
- Serial RapidIO: 10Gb/s full duplex
- Other high-bandwidth peripherals: Gigabit Ethernet MAC, UTOPIA, PCI-66, HPI
- Two EMIFs: 32-bit DDR2, 64-bit EMIF



TMS320C6455/TMS320C6454 DSP block diagram.

TMS320C67x™ DSP Generation, Floating Point High-Performance DSPs
TMS320C6727

Get samples, datasheets, tool and app reports at: **www.ti.com/c6000**

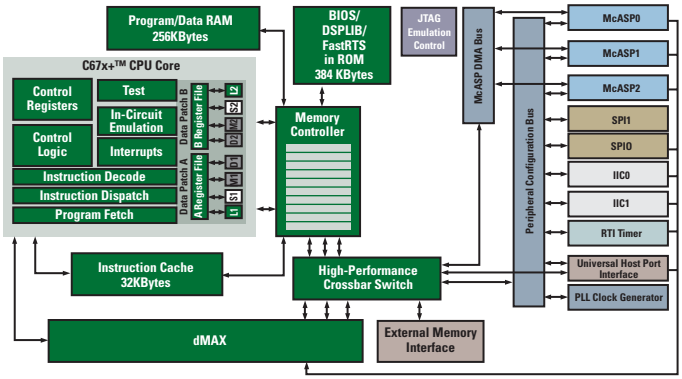
The TMS320C672x is the next generation of high-performance 32-/64-bit floating-point digital signal processors. The TMS320C672x includes the TMS320C6727, TMS320C6726, and TMS320C6722 ICs.

Enhanced C67x+™ CPU — The C67x+ CPU is an enhanced version of the C67x™ CPU used on the C671x DSPs. It is compatible with the C67x CPU but offers significant improvements in speed, code density, and floating-point performance per clock cycle. At 300MHz, the CPU is capable of a maximum performance of 2400MIPS/1800 MFLOPS by executing up to eight instructions (six of which are floating-point instructions) in parallel each cycle. The CPU natively supports 32-bit fixed-point, 32-bit single-precision floating-point, and 64-bit double-precision floating-point arithmetic.

Efficient Memory System — The memory controller maps the large on-chip 256K-byte RAM and 384K-byte ROM as unified program/data memory. Development is simplified since there is no fixed division between program and data memory size as on some other ICs. The memory controller supports single-cycle data accesses from the C67x+ CPU to the RAM and ROM.

Key Features
- 100% code-compatible DSPs
- Advanced VLIW architecture
- Up to eight 32-bit instructions executed each cycle
- Eight independent, multi-purpose functional units and up to sixty-four 32-bit registers
- Advanced DSP C compiler and assembly optimizer maximize efficiency and performance

Applications
- Medical and digital imaging
- 3D graphics



TMS320C6727 DSP block diagram.

Component Recommendations for Ultrasound/Portable Ultrasound

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
OPA695	High-Speed Op Amp	G = +2 BW 1400MHz, G = +8 BW 450MHz, 4300V/µs SR	Ultra-wideband, current feedback	
OPA832	Video Buffer Op Amp	G = +2 BW 80MHz, 3.9mA supply, 350V/µs SR	Low power, fixed gain	
OPA847	VFB Op Amp	3.9GHz GBW, 0.85nV/√Hz noise, 950V/µs SR	High DC accuracy, stable for gains ≥12V/V	
OPA861	Transconductance Amp	80MHz, open-loop, G = +5 BW, 900V/µs SR	95mA/V high transconductance, 5.4mA I_Q	
THS4131	High-Speed Op Amp	150MHz (–3dB) BW, 51V/µs SR, –100dB THD	Differential input/differential output	THS4120, THS4150
THS4304	High-Speed Op Amp	3GHz BW, 830V/µs SR, 2.4nV/√Hz noise, 7.5ns settling time (001%)	High bandwidth and fast settling time	
THS4509	High-Speed Op Amp	1900MHz BW, 6600V/µs SR, 2ns settling time (1%)	Low distortion, fully differential	THS4508, THS4511
VCA2615	Dual, Low-Noise LNA and VCA	Very low-noise: 0.7nV/√Hz	For high-end systems requiring high dynamic range and flexibility	VCA2611
VCA2617	Dual, Low-Power VCA	Differential I/O VCA, low power: 52mW/ch	Low-power, low-noise VCA to follow an off-chip LNA	VCA2614
VCA8613	8-Channel Ultrasound Front-End	Complete with LNA, VCA and LPF; lowest power: 75mW/ch, 3V supply	PGA output feeds directly into an integrated 2-pole, low-pass filter, allowing for direct ADC connection	
VCA8617	8-Channel Ultrasound Front-End	Complete with LNA, VCA and LPF; low noise of 1.0nV/√Hz	PGA output feeds directly into integrated low-pass filter	
Data Converters				
ADS1610	Delta-Sigma ADC	16-bit, 10MSPS, parallel interface	SYNC pin for simultaneous sampling	
ADS1605	Delta-Sigma ADC	16-bit, 5MSPS (10MSPS in 2x mode), 88dB SNR, –99dB THD	Selectable on-chip reference	
ADS5121	High-Speed ADC	8-channel, 10-bit, 40MSPS, 1.8V analog/digital supply	Low power, individual channel power down	ADS5122
ADS5232	High-Speed ADC	Dual 12-bit, 65MSPS, 3.3V analog/digital supply	Internal or external reference	
ADS5240	High-Speed ADC	4-channel, 12-bit, 65MSPS, 3.3V analog/digital supply	Serialzed LVDS outputs, integrated frame and bit patterns	ADS5242
ADS5272	High-Speed ADC	8-channel, 12-bit, 65MSPS, 3.3V analog/digital supply	Serialized LVDS outputs, integrated frame and bit patterns	ADS5271/72/73/77
ADS7809	AR ADC	16-bit, 100kHz sample rate, 86dN SINAD with 20kHz input, serial ouput	Output sync pulse for ease of use with standard DSP processors	
ADS8380	SAR ADC	18-bit, 600kHz sample rate, ±2LSB (typ), pseudo-differential input	Zero latency, serial interface with clock up to 40MHz	
DAC2900	High-Speed DAC	10-bit, 125MSPS dual DAC	Supports 3.3/5V	DAC2902, DAC2904
DAC5652	High-Speed DAC	10-bit, 275MSPS dual DAC	High sample rate with low power	DAC5662, DAC5672
DAC7615	V_{OUT} DAC	Quad, serial input, 12-bit, 20mW low power	Unipolar or bipolar operation, double-buffered inputs	DAC7714, DAC7554
DAC8560	V_{OUT} DAC	16-bit, 0.15nV-s glitch, ±10µs to 0.003% FSR settling time	Small package, low power	DAC8554, DAC8551, DAC8552
DAC8330	Precision DAC	16-bit, V_{OUT}, 1LSB INL	Very low power, serial interface	DAC8331, DAC8830
References				
REF31xy	Voltage Reference	0.2% voltage accuracy	Precise trigger voltage ADC	REF32xy, REF33xy
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q	Multiple output voltages, SOT23-6	
REF33xx	microPower Bandgap	0.1% (max) accuracy, 30ppm/°C (max) drift, 0.005mA (max) I_Q	Multiple output voltages, MSOP-8, SO-8	
REF50xx	Precision Reference	0.05% accuracy, 3ppm/°C (max) drift, 6µV_{PP} low noise	Multiple output voltages, SC71	
Processors				
TMS320C-6455BZTZ	DSP	1GHz, SRIO, 2MB RAM	High-performance, fixed-point 16-bit processor	TMS320C6454BZTZ
TMS320 DM6446BZWT	DSP	C64x+™, ARM9™, video accelerators	DaVinci™ digital media processor	TMS320DM6437, TMS320C6424
TMS320C6727	DSP	Up to 350MHz, 2100MFLOPS	Floating point DSP	TMS320C6713, TMS320C6726

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

Component Recommendations for Ultrasound/Portable Ultrasound

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Interface				
SN65LVDS387	16-Channel LVDS Driver	630Mbps	High density LVDS driver	SN65LVDS386
SN65MLVD047	4-Channel M-LVDS Driver	Higher differential swing	Industry standard	SN65LVDS348
Clocking				
CDC7005	Clock Synthesizer	Clock synchronizer with 5 LVPECL outputs	Jitter cleaning	CDCM7005
CDCM7005	Clock Synthesizer	Clock synchronizer with LVPECL and LVCMOS output	Jitter cleaning	CDC7005
CDCE706	Clock Generator	Programmable clock synthesizer	Universal ratio multiplier and divider	CDCE906
Power Management Products				
bq20z90	Battery Fuel Gauge	Instant accuracy better than 1% error over lifetime of the battery	Automatically adjusts for battery aging, battery self discharge and temperature inefficiencies	
bq24721	Battery Charge Management	Multi-chemistry and multi-cell sync switch-mode charger	High efficiency, pack and system protection functions	
bq29330	Battery Safety	Battery pack full-protection analog front end	Provides individual cell voltages and battery voltage to battery management host	
DCH010505	Galvanic Isolated, DC/DC Converters	1W, 3kV isolation, minimal external components	Safety isolation, removal of ground loops, reducing board space	DCH010512,DCH010515
DCP01B	DC/DC Converter	5V, 15V, 24V input bus, 1W, unregulated, dual isolated	1W P_{OUT} or I_{OUT}, ±5V, ±12V, ±15V V_O range	
DCP02	DC/DC Converter	5V, 15V, 24V input bus, 2W, unregulated, dual isolated	2W P_{OUT} or I_{OUT}, ±5V, ±12V, ±15V V_O range	
PTB48500A	DC/DC Converter	48V input bus, 30W, dual, isolated	30W P_{OUT} to I_{OUT}, 3.3V/1.2V V_O range	PTB48501A/B, PTB48502A/B
PTH08T220	Power Module	16A, 4.5V to 14V V_{IN}, adjustable V_{OUT}, with *TurboTrans™*	Complete power supply designed to meet ultra-fast transient requirements	PTH08T221
PTH04T240	Power Module	10A, 2.2V to 5.5V V_{IN}, adjustable V_{OUT}, with *TurboTrans*	Complete power supply designed to meet ultra-fast transient requirements	PTH04T241
TPS3307	Voltage Supervisor	Triple processor supervisor	Two fixed and one adjustable supervisor for system flexibility	TPS3808
TPS54317	DC/DC Converter	3.0 to 6.0 V_{IN} 3A DC/DC with integrated switch FET, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	
TPS54350	DC/DC Converter	4.5 to 20V_{IN} 3A DC/DC with integrated switch FET, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	TPS54550
TPS74401	Single-Channel LDO	3.0A ultra-low dropout linear regulator	Split bias and supply pin minimize heat generation	TPS74301
UCD9080	System Voltage Supervisor	GUI for programming eight power rails	Complete system power monitoring	UCD9111

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

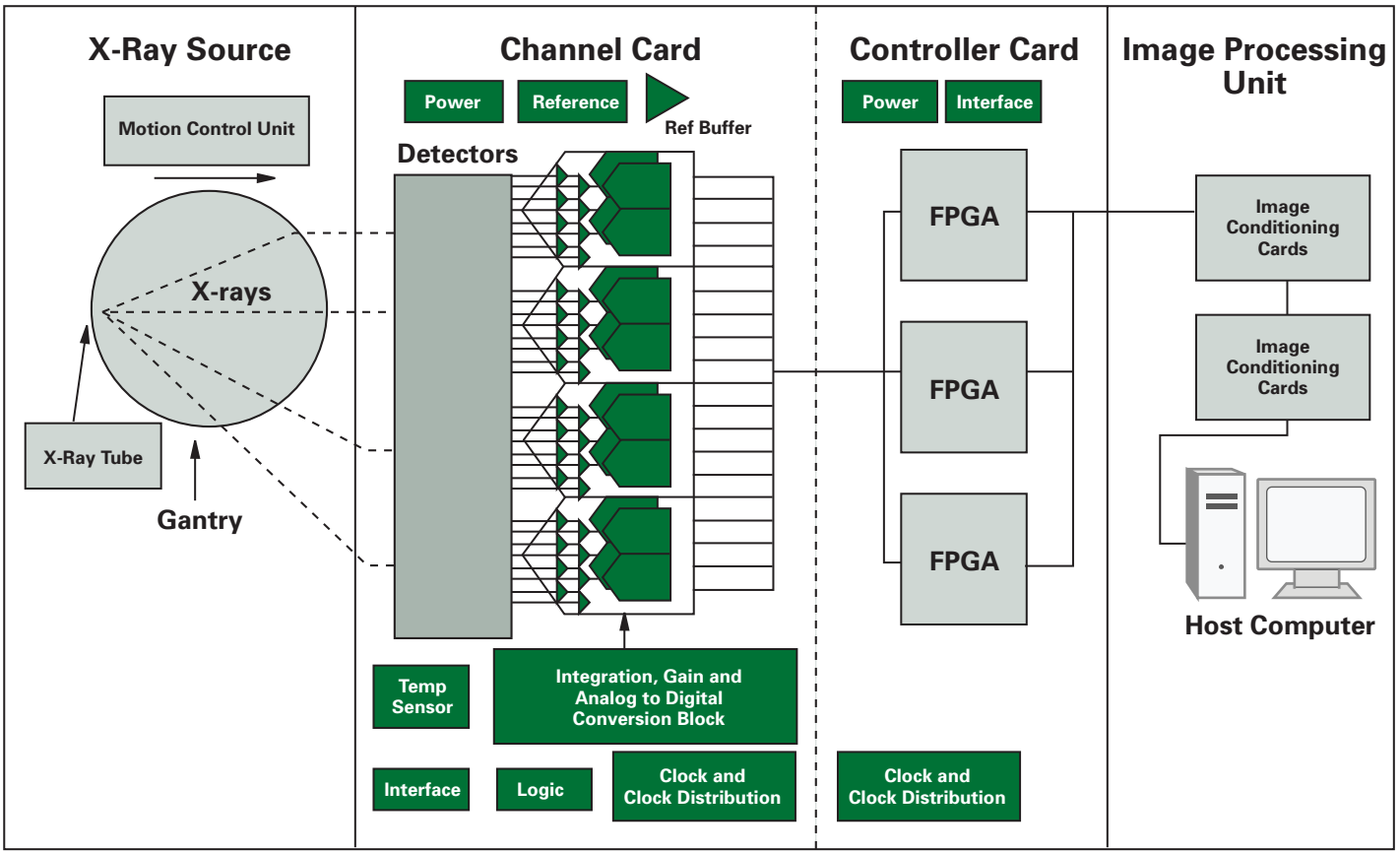
Computed Tomography

Computed Tomography (CT) is a medical imaging technique that produces three-dimensional images of internal human body parts from a large series of two-dimensional x-ray images taken around a single axis of rotation. When compared with a conventional x-ray radiograph, which is an image of many planes superimposed on each other, a CT image exhibits significantly improved contrast.

With the advent of diagnostic imaging systems like CT, where complex and intensive image processing is required, semiconductors play a very important role in developing imaging systems with increased density, flexibility and high performance. The block diagram below shows a typical CT scanner system. X-ray slice data is generated using an x-ray source that rotates around the object with x-ray detectors positioned on the opposite side of the circle from the x-ray source. Many data scans are progressively taken as the object is gradually passed through the gantry. Machines with faster computer systems and newer software strategies can process not only individual cross sections, but continuously changing cross sections as the gantry, with the object to be imaged, is slowly and smoothly slid through the x-ray circle. These are called helical or spiral CT machines. The detector system consists of a number of channel cards which has scintillator–photodiode solid state detectors. The x-rays interact with the scintillator and produce visible light which is in turn converted into a current by the photodiode. The depth information along the direction of the x-ray beam that is lost in radiography is recovered by viewing the slice from many different directions

The channel card has a front end system where charge on the detectors are integrated, gained by amplifiers and converted to digital values by ADCs. The digital data from all the channel cards are transferred by high-speed link to the controller card and onto the image conditioning cards. The image conditioning card is connected to the host computer where the CT images can be viewed. Here, the digital data are combined together by the mathematical procedure known as tomographic reconstruction. Power supplies, clocks and clock distribution circuits, reference and reference buffers, logic and interface products are some of the key blocks in the channel card subsystem. Control cards include FPGAs, power supplies, clocks and clock distribution circuitry and interface blocks.

TI offers several products that can meet the needs of designers of medical imaging systems by enabling the measurement of low-level currents produced by the photodiode arrays within a CT scanner.



CT scanner general system diagram.

CT Scanners

Dual, Current-Input, 20-Bit ADC
DDC232

Get samples, datasheets, app reports and evaluation modules at:
www.ti.com/sc/device/DDC232

TI offers several products that can meet the needs of designers of medical imaging systems by enabling the measurement of low-level currents produced by the photodiode arrays within a computed tomography (CT) scanner.

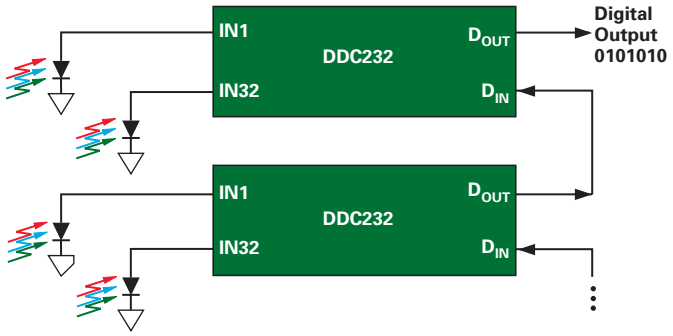
The DDC products are single-chip solutions for directly digitizing low-level currents from photodiode arrays in CT scanners. The dual-integrator front-end provides continuous charge collection. While one integrator is collecting the photodiode current, the other is being measured by the onboard 20-bit ADC. Integration time is user adjustable and the output data is retrieved over a serial interface that can be daisy chained to minimize digital interconnects in high-channel-count systems.

Key Features

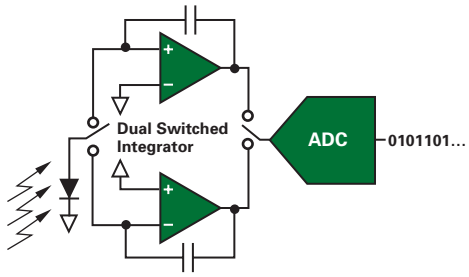
- Complete solution for measuring 32 photodiodes with 20-bit resolution
- Continuous charge collection
- Adjustable integration time: 160µs to over 1s
- Programmable full scale: 12.5pC up to 350pC
- Low noise: 5ppm, rms
- Integral nonlinearity: ±0.025% reading ±1ppm FSR
- Single supply with 7mW/channel power dissipation
- Serial digital interface with daisy chaining support
- Packaging: 8mm x 8mm BGA

Applications

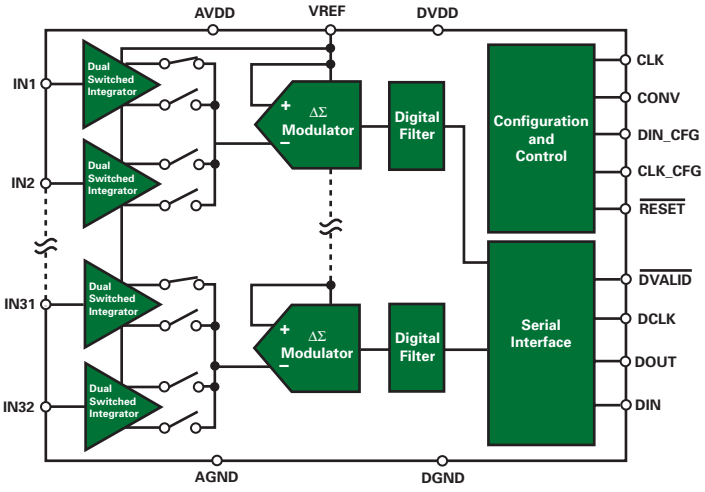
- CT scanners
- X-ray systems
- Photodiode sensor arrays



Photodiode measurement using the DDC232 ADC.

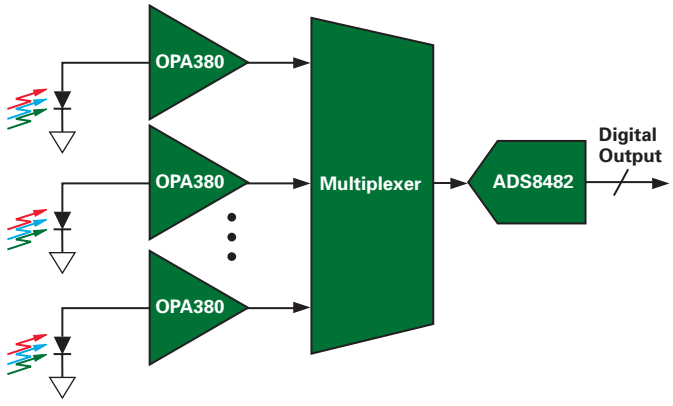


DDC architecture.



DDC232 functional diagram.

The OPA380 family of transimpedance amplifiers provides high-speed (90MHz gain bandwidth [GBW]) operation, with extremely high precision, excellent long-term stability, and very low 1/f noise, making it useful for high-speed CT scanner photodiode applications. The ADS8482 is an 18-bit 1MSPS ADC. The high-speed operation of the ADS8482 makes it well-suited for use with a multiplexer to measure multiple OPA380 channels.



CT scanner application using the OPA380 and the ADS8383.

Precision, High-Speed Transimpedance Amplifier
OPA380

Get datasheets and app reports at: **www.ti.com/sc/device/OPA380**

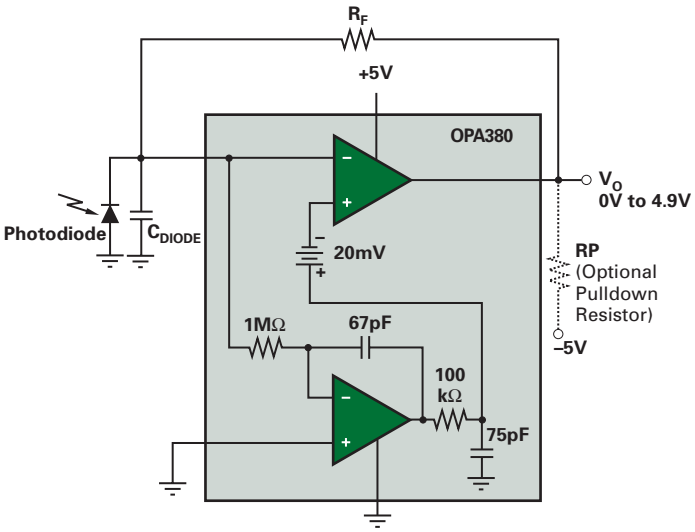
The OPA380 transimpedance amplifier family provides high speed, high precision and long-term stability. It exceeds the offset, drift and noise performance that conventional JFET op amps provide.

Key Features

- Over 1MHz TIA bandwidth
- Dynamic range: 5 decades
- Inherent long-term stability
- Output swing includes ground
- Very low 1/f noise
- Bias current: 50pA (max)
- Offset voltage: 2µV (max)
- Drift: 0.1µV°C
- Gain bandwidth: 90MHz
- Quiescent current: 6mA
- Supply range: 2.7V to 5.5V
- Single and dual versions
- Packaging: MSOP-8 and SO-8

Applications

- CT scanner front end
- Precision current-to-voltage measurements
- Optical amplifiers
- Photodiode monitoring



OPA380 functional block diagram.

18-Bit, 1MSPS, Differential Input, microPower ADC with Parallel Interface
ADS8482

Get samples, datasheets, app reports and evaluation modules at:
www.ti.com/sc/device/ADS8482

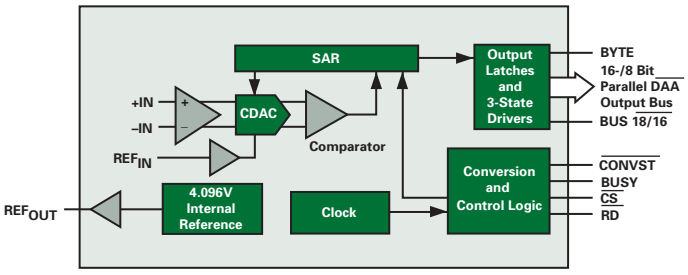
The ADS8482 is an 18-bit, 1MSPS ADC with an internal 4.096V reference and a pseudo-bipolar, fully differential input. It features a full 18-bit interface, a 16-bit hold option where data is read using two read cycles, or an 8-bit bus option using three read cycles. Other features include 99dB SNR, –121dB THD, 123dB SFDR, onboard reference with 6ppm/°C drift and onboard reference buffer.

Key Features

- Sample rate: 0 to 1MHz
- INL: ±1.2 LSB (typ); ±2.5 LSB (max)
- DNL: +0.75/–0.6 LSB (typ); +1.5/–1 LSB (max)
- 18-bit NMC ensured over temperature
- Offset error: ±0.05mV
- Offset error drift: ±0.05ppm/°C
- Zero latency
- Wide digital supply: 2.7V to 5.25V
- Low power: 225mW at 1MSPS
- Package: 48-lead QFN, 7mm x 7mm

Applications

- Medical instruments
- Transducer interface
- High-accuracy data acquisition systems



ADS8482 functional block diagram.

Component Recommendations for CT Scanner Applications

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifier				
OPA380	Transimpedance Amp	>1MHz BW, 50pA (max) bias current, excellent long-term stability	Precision, dynamic range 4 to 5 decades	OPA350, OPA335
Data Converters				
ADS8482	SAR ADC	18-bit, 1MSPS, parallel interface, int ref and ref buffer		ADS8481, ADS8413, ADS8472
DDC112	2 Channels	50 to 100pC full-scale	Up to 3kSPS data rate, 40mW/Ch	SOIC-28 or TQFP-32
DDC114	4 Channels	12.5 to 350pC full-scale	Up to 3.1kSPS data rate, 13.5mW/Ch	QFN-48
DDC118	8 Channels	12.5 to 350pC full-scale	Up to 3kSPS data rate, 40mW/Ch	QFN-48
DDC232	32 Channels	12.5 to 350pC full-scale	Up to 6kSPS data rate, 7mW/Ch	BGA-64
References				
REF31xy	Voltage Reference	0.2% voltage accuracy	Precise trigger voltage ADC	REF32xy, REF33xy
REF3140	Voltage Reference	15ppm/°C (max) drift, 5mV low dropout, 115µA (max) I_Q, 0.2% (max) accuracy	No load capacitor required	REF3130, REF3120
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q	Multiple output voltages, SOT23-6	
REF33xx	microPower Bandgap	0.1% (max) accuracy, 30ppm/°C (max) drift, 0.005mA (max) I_Q	Multiple output voltages, MSOP-8, SO-8	
REF50xx	Precision Reference	0.05% accuracy, 3ppm/°C (max) drift, 6µV_{PP} low noise	Multiple output voltages, SC71	
Processors				
TMS320F2808	Digital Signal Controller	100MIPS, 8KB ROM, 36KB RAM, 128KB Flash, 12-bit ADC	I^2C, 4 SPI, 2 SCI, 2 CAN	
TMS320F28015	Digital Signal Controller	60MIPS, 8KB ROM, 12KB RAM, 32KB Flash, 12-bit ADC	I^2C, 1 SPI, 1 SCI	
TMS320F2812	Digital Signal Controller	150MIPS, 8KB ROM, 36KB RAM, 256KB Flash, 12-bit ADC	McBSP, 1 SPI, 2 SCI, 1 CAN	
Interface				
XIO1100	x1 PCIe PHY	Interface FPGA to PCIe fabric between channels	PCIe 1.1 compliant, flexible MAC interface	
TLK1221	Gigabit Ethernet Serdes	Power 250mW	Smallest package	TLK2208B
SN65LVCP40	Dual 1:2 Mux/Buffer	Input EQ, output pre-emp	Improves signal range	SN65LVCP40
Analog Multiplexers				
TS3A5017	Dual SP4T 3.3V/2.5V Analog Multiplexer/ Demultiplexer	Low total harmonic distortion	Excellent signal integrity in both digital and analog applications	
TS3A5018	Quad SPDT 3.3V/2.5V Analog Switch	Low on state resistance and matching (R_{ON} = 10)	Minimizes signal loss and ensures less variance	
Power Management Products				
PTH04T240	Power Module	10A, 2.2V to 5.5V V_{IN}, adjustable V_{OUT}, with *TurboTrans™*	Complete power supply designed to meet ultra-fast transient requirements	PTH04T241
PTH08T220	Power Module	16A, 4.5V to 14V V_{IN}, adjustable V_{OUT}, with *TurboTrans*	Complete power supply designed to meet ultra-fast transient requirements	PTH08T221
TPS3307	Voltage Supervisor	Triple processor supervisor	Two fixed and one adjustable supervisor for system flexibility	TPS3808
TPS40020	2.25V to 5.5V DC/DC Controller	Synchronization pin, PG, enable	Eliminate beat noise/ceramic caps/FPGA/regulation from main power supply	
TPS40075	4.5V to 28V DC/DC Controller	Synchronization pin, PG, enable	Eliminate beat noise/ceramic caps/FPGA/regulation from main power supply	TPS40057
TPS54317	DC/DC Converter	3.0 to 6.0 V_{IN} 3A DC/DC with integrated switch FET, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	TPS54610/TPS54910
TPS54350	DC/DC Converter	4.5 to 20V_{IN} 3A DC/DC with integrated switch FET, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	TPS54550
TPS74401	Single Channel LDO	3.0A ultra-low dropout linear regulator	Split bias and supply pin minimize heat generation	TPS74301

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

MRI

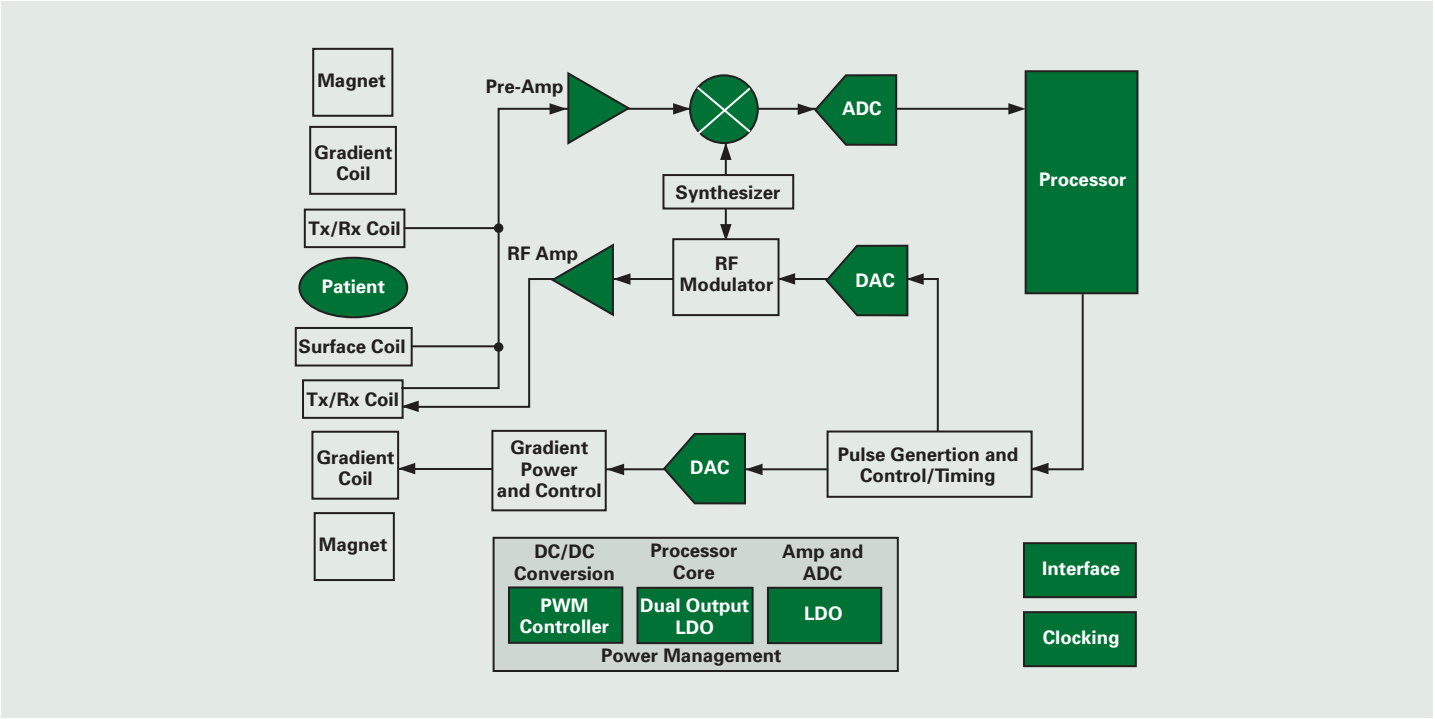
Magnetic Resonance Imaging (MRI) is a non-invasive diagnostic technology that produces physiologic images based on the use of magnetic and radio frequency (RF) fields. The MRI system uses powerful magnets to create a magnetic field which forces hydrogen atoms in the body into a particular alignment (resonance). Radio frequency energy is then distributed over the patient, which is disrupted by body tissue. The disruptions correspond to varying return signals which, when processed, create the image.

The accurate processing of these signals is key to obtaining high quality images. A key system consideration for the receive channel is high SNR. The return signals have narrow bandwidths with an IF location directly dependent on the main magnet's strength. Some systems use high-speed pipeline ADCs with wideband amplifiers to directly sample the IF, leaving large headroom for post-processing gain by a digital down converter or FPGA. Other systems mix the IF to baseband where lower-speed, higher-resolution SAR and delta-sigma ADCs can be used.

For controlling the magnetic and RF energy in the MRI, high-resolution, high-speed DACs are needed. High resolution is required to accurately define the area of the patient to be scanned. High-speed is necessary to match the high IFs being generated by the main magnet.

DSPs can be used to provide gradient processor control used for properly controlling the magnets in the MRI system. A DSP can also take care of preprocessing the signal before it reaches the image reconstruction engine.

A wide variety of TI products are available for MRI systems and equipment manufacturers, including op amps, DSPs, multi-channel high- and low-speed data converters, clocking distribution, interface, and power management.



Magnetic resonance imaging (MRI) system block diagram.

Magnetic Resonance Imaging (MRI)

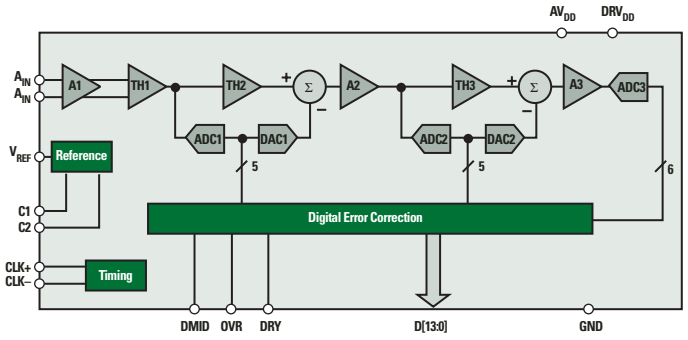
14-Bit, 105MSPS ADCs with Highest SFDR
ADS5424, ADS5423, ADS5433

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/PARTnumber
(Replace **PARTnumber** with **ADS5424**, **ADS5423** or **ADS5433**)

The ADS5423, ADS5424 and ADS5433 are 14-bit, 80MSPS and 105MSPS ADCs featuring the highest SFDR and enhanced SFDR performance for input frequencies up to 100MHz. At 80MSPS, SFDR is 96.5dBc (typ) and guaranteed to 91dBc over the industrial temp range with a –1dBFS 30MHz input signal. The ICs operate from 5V and 3.3V supplies, while providing 3.3V CMOS-compatible digital outputs. An internal reference generator is also provided to further simplify system design.

Key Features
- Sample rate: 14-bit, 80MSPS (ADS5423, ADS5433) 14-bit, 105MSPS (ADS5424)
- SNR: 74.4dBc at 80MSPS and 30MHz IF
- SFDR: 96.5dBc at 80MSPS and 30MHz IF
- Differential input range: 2.2Vpp
- CMOS-compatible outputs: 3.3V
- 2s-complement output format
- Total power dissipation: 1.85W
- Single supply: 5V
- Packaging: HTQFP-52

Applications
- Video and imaging
- Instrumentation
- Single- and multi-channel digital receivers



ADS5433 functional block diagram.

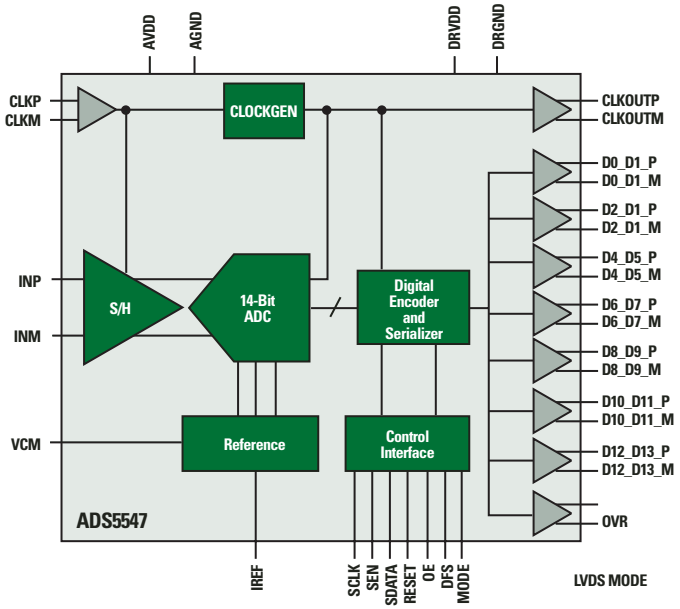
14-Bit, 210MSPS ADCs with LVDS/CMOS Outputs
ADS5545, ADS5546, ADS5547

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/ADS5546, **www.ti.com/sc/device/ADS5545** or
www.ti.com/sc/device/ADS5547

The ADS5547 is a high-performance, 14-bit, 210MSPS ADC that offers a fully differential LVDS DDR interface while parallel CMOS outputs can also be selected. With high analog bandwidth and low jitter input clock buffer, the IC supports both high SNR and high SFDR at high input frequencies. Programmable gain options can be used to improve SFDR performance at lower full-scale analog input ranges. A flexible output clock position programmability is available to ease capture and trade-off set up for hold times. The ADS5545 is a 14-bit, 170MSPS ADC and the ADS5546 is a 14-bit, 190MSPS ADC.

Key Features
- Total power dissipation: 1.23W
- SNR: 73.3dBFS at 70MHz IF
- SFDR: 85dBc at 70MHz IF, 0dB gain
- High analog bandwidth: up to 800MHz
- Double data rate (DDR) LVDS and parallel CMOS output options.
- Programmable gain up to 6dB for SNR/SFDR trade-off at high IF
- Analog and digital supply: 3.3V
- Internal and external reference support
- No external reference decoupling required
- Packaging: 48-QFN

Applications
- Medical imaging
- Test and measurement instrumentation
- High definition video
- Power amplifier linearization



ADS5547 functional block diagram.

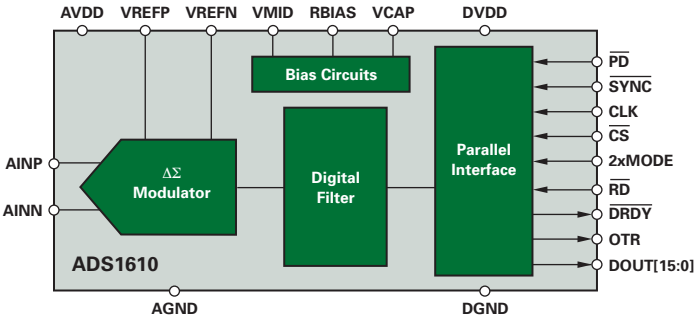
16-Bit, 10MSPS Delta-Sigma ADCs for Scientific Instrumentation
ADS1605, ADS1610

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/ADS1610 or **www.ti.com/sc/device/ADS1605**

The ADS1610 delta-sigma topology provides key system-level design advantages with respect to anti-aliasing filtering and clock jitter. Output data is supplied over a parallel interface and easily connects to TMS320™ DSPs. The power dissipation can be adjusted with an external resistor, allowing for reduction at lower operating speeds.

Key Features
- Output data rate: 10MSPS (ADS1610), 5MSPS (ADS1605)
- Signal bandwidth: 4.9MHz
- SNR: 86dBFS
- THD: –94dBS
- SFDR: 95dB
- On-chip digital filter simplifies anti-alias requirements
- Low group delay: 3µs
- Parallel interface
- Direct connection to TMS320 DSPs
- Packaging: TQFP-64

Applications
- Scientific instruments
- Test equipment
- Communications



ADS1610 functional block diagram.

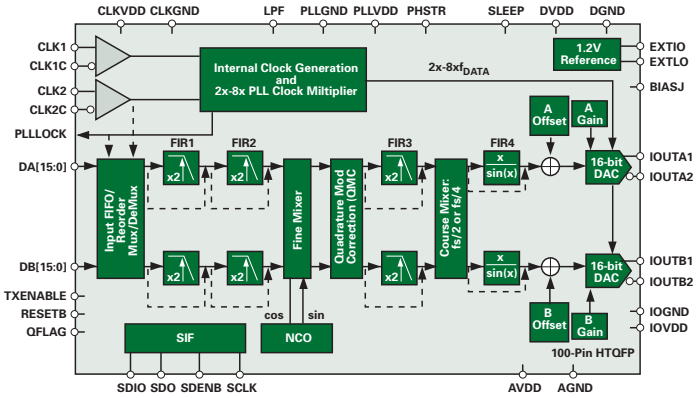
16-Bit, 500MSPS, 2x to 8x Interpolating, Dual-Channel DAC
DAC5687

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/DAC5687

The DAC5687 is a dual-channel, high-speed DAC with integrated 2x, 4x and 8x interpolation filters, a complex numerically controlled oscillator (NCO) and offers superior linearity, noise, crosstalk and PLL phase noise performance. The DAC5687 has six signal processing blocks: two interpolate-by-two digital filters, a fine frequency mixer, a quadrature modulation compensation block, a coarse frequency mixer with fs/2 or fs/4. The coarse and fine mixers can be combined to span a wider range of frequencies with fine resolution. Other features include several input options such as single-port interleaved data, even and odd multiplexing at half-rate and an input FIFO with either internal or external clock to ease the input timing ambiguity when the IC is clocked at the DAC output sample rate.

Key Features
- Selectable 2x - 8x interpolation
- On-chip PLL/VCO clock multiplier
- Full I_Q compensation including offset, gain and phase
- Complex mixer with 32-bit NCO
- I/O voltage: 1.8V or 3.2V
- On-chip reference: 1.2V
- Differential scalable output: 2mA to 20mA
- Flexible input options:
  - FIFO with latch on external or internal clock
  - Even/odd multiplexed input
  - Single port demultiplexed input

Applications
- Video and imaging
- Cable-modem termination systems
- Cellular base stations



DAC5687 functional block diagram.

Magnetic Resonance Imaging (MRI)

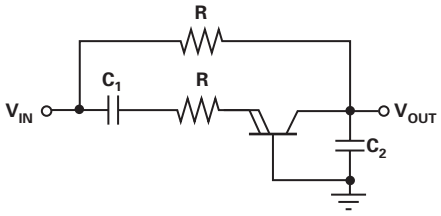
Wideband Operational Transconductance Amplifier
OPA861

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/OPA861

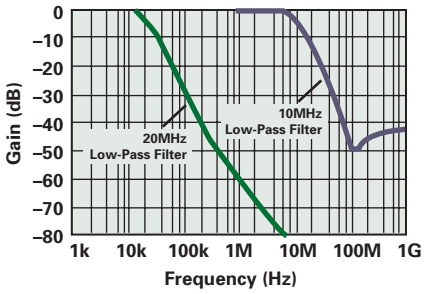
The OPA861 is a wideband, bipolar operational transconductance amplifier (OTA). The OTA or voltage-controlled current source can be viewed as an ideal transistor. Like a transistor, it has three terminals — a high-impedance input (base), a low-impedance input/output (emitter), and the current output (collector). The OPA861, however, is self-biased and bipolar. The output collector current is zero for a zero base-emitter voltage. AC inputs centered about zero produce an output current, which is bipolar and centered about zero. The transconductance of the OPA861 can be adjusted with an external resistor, allowing bandwidth, quiescent current and gain trade-offs to be optimized.

Key Features
- Wide bandwidth: 80MHz, open-loop, G = +5
- High slew rate: 900V/µs
- High transconductance: 95mA/V
- External I_Q-control
- Low quiescent current: 5.4mA

Applications
- Video equipment
- Communications
- High-speed data acquisition
- Wideband LED drivers
- Control-loop amplifiers
- Wideband active filters
- Line drivers



Low-pass Negative Impedance Converter (NIC) filter.



Frequency response of 20kHz and 10MHz low-pass NIC filters.

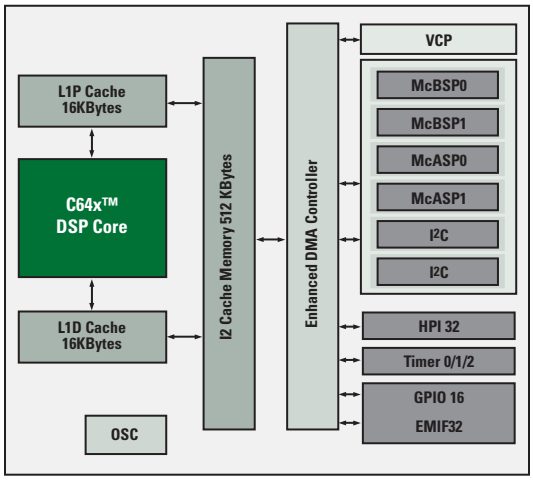
TMS320C64x™ DSP Generation, Fixed-Point High-Performance and Performance-Value DSPs
TMS320C6415

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/TMS320C6415

The TMS320C6415 digital signal processor (DSP) is a member of TI's TMS320C64x generation. The TMS320C64x generation offers a portfolio of high-performance DSPs integrated with peripherals tailored to a broad spectrum of applications. The TMS320C6415 is the industry's first 1GHz DSP on a 90nm process node and offers 100% upward object code compatibility within the C6000™ DSP family. It has an easy-to-use integrated development environment with an exceptional optimizing C compiler.

Key Features
- VelociTI.2™ architecture extensions with new instructions to accelerate performance in key applications
- Increased parallelism with quad 16-bit and octal 8-bit multiply accumulate performance
- Improved orthogonality with frequently used instructions available in more functional units
- Double the bandwidth resulting from more registers, wider load/store data paths and enlarged 2-level cache

Applications
- Imaging (medical, machine vision/inspection, defense/radar/sonar)



TMS320C6415 functional block diagram.

Component Recommendations for MRI Applications

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
OPA861	Transconductance Amp	80MHz, open-loop, G = +5 BW, 900V/µs SR	95mA/V high transconductance, 5.4mA I_Q	
THS4503	High-Speed Op Amp	370MHz BW, 3700V/µs SR, 5V, ±5V, 12V and 15V supply	Low distortion, fully differential	THS4504, THS4141
THS9000	Cascadeable Amp	50MHz to 400MHz, 50Ω input/output impedance	High dynamic range, single supply	
Data Converters				
ADS1610	Delta-Sigma ADC	16-bit, 10MSPS, parallel interface	SYNC pin for simultaneous sampling	ADS1605
ADS5423	High-Speed ADC	14-bit, 80MSPS, 74dBc at 80MSPS and 50MHz IF SNR	3.3V CMOS-compatible outputs, 2s-complement output format	ADS5424, ADS5433
ADS5500	High-Speed ADC	14-bit, 125MSPS, 71.2dBFS at 100MHz f_{IN} SNR	Serial programming interface	
ADS5545	High-Speed ADC	14-bit, 170MSPS, DDR LVDS/CMOS outputs	Programmable output clock position to ease data capture	ADS5546, ADS5547
ADS5547	High-Speed ADC	14-bit, 210MSPS, user-selectable DDR LVDS or CMOS parallel outputs	High performance	ADS5545, ADS5546
ADS6425	High Speed ADC	4 channel, 12-bit, 125MSPS, serial LVDS interface, 1.65W total power	High performance, multiple input option	
DAC5672	High-Speed DAC	14-bit, 275MSPS dual DAC	High sample rate with low power	DAC5662,DAC5652
DAC5687	High-Speed DAC	16-bit, 500MSPS interpolating with NCO	Digital integration and superior AC performance for flexible application and high quality transmission	DAC5686
DAC904	High-Speed DAC	14-bit, 165MSPS DAC	Low-power DAC	
DAC7725	V_{OUT} DAC	Quad, 12-bit, 250mW (max) power, 10µs to 0.012% settling time	Double-buffered data inputs	DAC7724, DAC902, DAC900
References				
REF31xy	Voltage Reference	0.2% voltage accuracy	Precise trigger voltage ADC	REF32xy, REF33xy
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q	Multiple output voltages, SOT23-6	
REF33xx	microPower Bandgap	0.1% (max) accuracy, 30ppm/°C (max) drift, 0.005mA (max) I_Q	Multiple output voltages, MSOP-8, SO-8	
REF50xx	Precision Reference	0.05% accuracy, 3ppm/°C (max) drift, 6µV_{PP} low noise	Multiple output voltages, SC71	
Processors				
TMS320C-6415TB	DSP	1GHz, C64x core	High-performance fixed-point DSP	TMS320C6414, TMS320C6455, TMS320C6454, TMS320C6701
TMS320F2808	Digital Signal Controller	100MIPS, 8KB ROM, 36KB RAM, 128KB Flash, 12-bit ADC	I^2C, 4 SPI, 2 SCI, 2 CAN	
TMS320F28015	Digital Signal Controller	60MIPS, 8KB ROM, 12KB RAM, 32KB Flash, 12-bit ADC	I^2C, 1 SPI, 1 SCI	
TMS320F2812	Digital Signal Controller	150MIPS, 8KB ROM, 36KB RAM, 256KB Flash, 12-bit ADC	McBSP, 1 SPI, 2 SCI, 1 CAN	
Interface				
SN65MLVD128	1:8 Fanout Buffer	200Mbps	Standardized M-LVDS	SN65MLVD2
TB5R1	4-Channel PECL Receiver	400Mbps	Replaces Agere parts	SN65LVP20
Clocking				
CDCE706	Clock Generator	Programmable clock synthesizer	Universal ratio multiplier and divider	CDCE906
CDCLVD110A	Clock Buffer	1:10 LVDS clock driver	Operating up to 900MHz with minimum skew	CDCLVP110, CDCP1803
CDCM7005	Clock Synthesizer	Clock synchronizer with LVPECL and LVCMOS output	Jitter cleaning	CDC7005
CDCP1803	Clock Buffer	Distributes one differential input to 3 LVPECL outputs	Accepts any differential signal input	CDCLVP110, CDCLVD110A
Digital Up/Down Converters				
GC5016	Digital Up/Down Converter	Quad, 160MSPS for 4 channels, 115dB SFDR	Many multiplex output options	
GC5018	Digital Down Converter	8-channel, real or complex DDC inputs, 115dB SFDR NCO	Final ACG	

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red.***

Component Recommendations for MRI Applications

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Power Management Products				
PTH04T240	Power Module	10A, 2.2V to 5.5V V_{IN}, adjustable V_{OUT}, with *TurboTrans™*	Complete power supply designed to meet ultra-fast transient requirements	PTH04T241
PTH08T220	Power Module	16A, 4.5-V to 14V V_{IN}, adjustable V_{OUT}, with *TurboTrans*	Complete power supply designed to meet ultra-fast transient requirements	PTH08T221
PTQA430033	Isolated DC/DC Module	100W, 1500VDC isolation, differential remote sense	High efficiency, industry-standard pin-compatible	PTQB425080
TPS3307	Voltage Supervisor	Triple processor supervisor	Two fixed and one adjustable supervisor for system flexibility	TPS3808
TPS40020	DC/DC Controller	2.25V to 5.5V_{IN}, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/regulation from main power supply	
TPS40075	DC/DC Controller	4.5V to 28V_{IN}, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/regulation from main power supply	TPS40057
TPS74401	Single-channel LDO	3.0A ultra-low dropout linear regulator	Split bias and supply pin minimize heat generation	TPS74301
TPS54317	DC/DC Converter	3.0V to 6.0V_{IN} 3A DC/DC with integrated switch FET, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	TPS54610/TPS54910
TPS54350	DC/DC Converter	4.5V to 20V_{IN} 3A DC/DC with integrated switch FET, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	TPS54550

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red.***

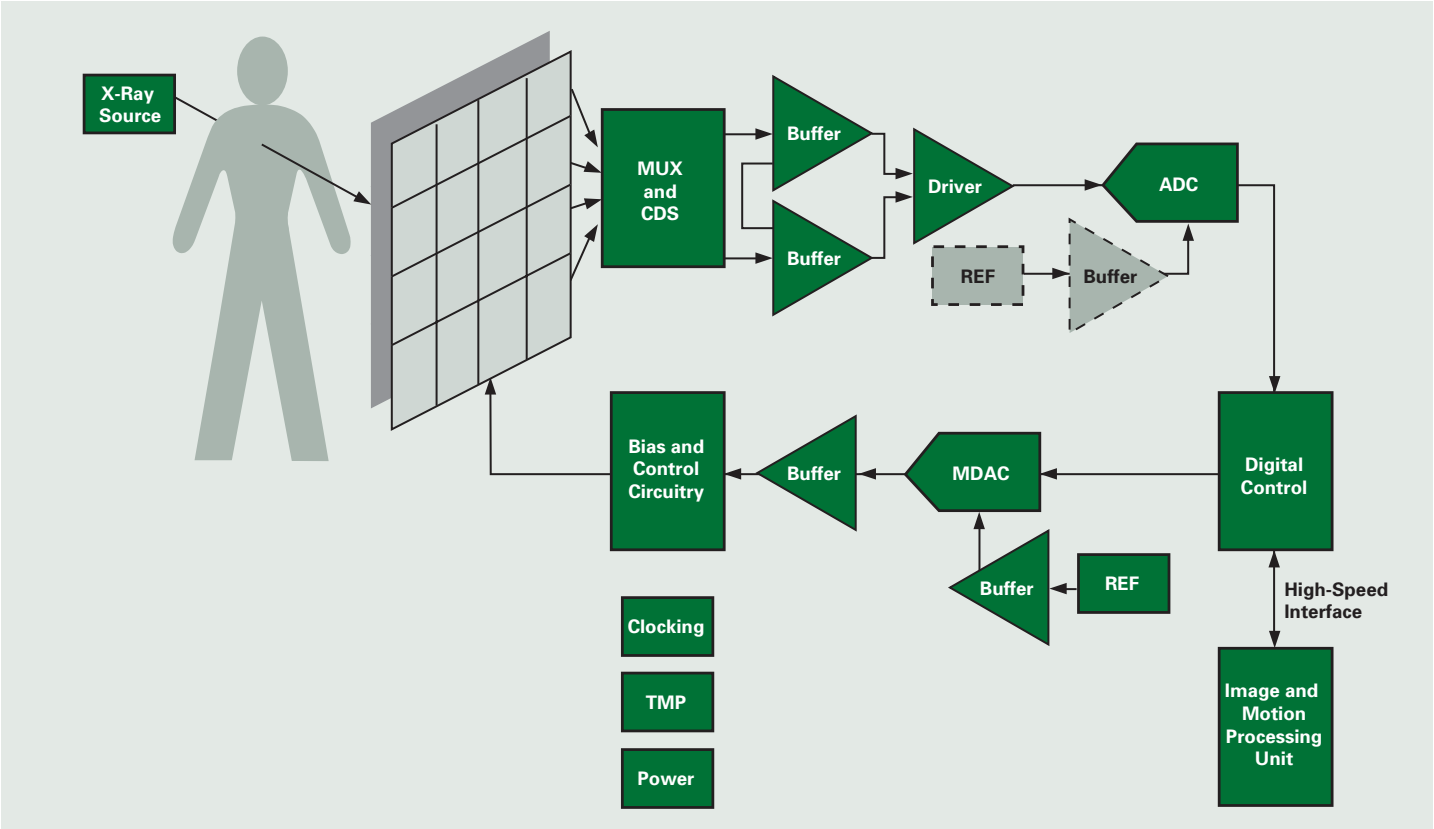
Digital X-Ray

Digital X-Ray Imaging is revolutionizing diagnostic radiology. In conventional x-ray systems, the signal degradation that occurs with each component consumes more than 60% of the original x-ray signal. At each stage of the system, the x-ray signal is degraded to some extent, even if the individual components are optimized for the application. As a result, typically less than 40% of the original image information is available for use in image production. In digital x-ray imaging, by adding a digital detector, the potential exists to capture over 80% of the original image information and equip the user with a wide range of post-processing tools to further improve the signal. Other key advantages of digital x-ray technology include processing image data to highlight regions of interest and suppress irrelevant information, combining image data with other pertinent patient information available from RIS/HIS systems, quickly transmitting the information anywhere over the networking connections and archiving all this information in minimal space.

There are two different approaches to digital x-ray technology, direct and indirect.

In direct conversion, flat-panel selenium detectors absorb x-rays directly and convert them into electrical charges at individual pixels. In indirect conversion, x-ray signals are converted first to light, which in turn are converted to electric charges. Both tiled CCD arrays and computed tomography use indirect conversion technology. Tiled CCD transitional technology employs multiple CCDs coupled to a scintillator plate via fiber optics. Computed tomography involves trapping electrons on photo stimulated plates and then exposing them to generate image data. In both approaches, charges proportional to x-ray intensity seen by the pixel is stored in the storage cap of a Thin Film Transistor (TFT). A number of such pixels form the Flat Detector Panel (FDP). The charges are read from the FDP by read-out electronics and turned into digital data.

The following block diagram shows the readout electronics required to convert the charge in the FDP to digital data. It has two chains: the acquisition chain and the biasing chain. In the acquisition chain, the front end consists of an analog front end, which is capable of multiplexing the charge on different storage caps of FDP (channels) and converting the charge into voltage. These voltages need to be correlated double sampled (CDS). The difference voltages of the signal level and reset level from the CDS block are converted to digital data by an analog-to-digital converter. The biasing chain generates bias voltages for the TFT array through intermediate bias and gate control circuitry. Digital control and data conditioning is made with an FPGA, which also manages high-speed serial communication with the external image processing unit through a high-speed interface (serialized, LVDS, optical). Temperature sensors, DACs, amplifiers and high input voltage capable switching regulators are other key



Digital x-ray block diagram.

Digital X-Ray

blocks in the system. They must have an enable pin and synchronizable frequency to avoid crosstalk with other blocks in the acquisition chain.

The number of pixels of the FDP will influence the number of ADC channels vs ADC speed. Static or dynamic acquisition also determines the ADC speed. While static acquisition means a single image in less than 1s, dynamic means an image is refreshed at 30Hz, for more specific cardiovascular, fluoroscopic or related applications which require much faster data conversion with the same number of channels. An ADC in the range of 2MSPS and more, with excellent DC performance, will be suitable.

The main metric for image quality is "Detection Quantum Efficiency" (DQE), a combination of contrast and SNR, expressed in percentage. Higher the contrast and lower the noise, higher is the DQE. Contrast is the number of shades of gray, determined by the output resolution of the ADC. Generally, 14-bits or 16-bits will be suitable for the application. SNR indicates not only SNR from the ADC, but system SNR where x-ray dose, pixel size and all electronic components are contributing. SNR can be increased by increasing x-ray dose, increasing photodiode spacing and decreasing noise from the electronics.

Increasing the x-ray dose is not suitable for patients or operators. Increasing photodiode spacing may also not be suitable, because this decreases spatial resolution. Decreasing the noise from electronics in the system is the main challenge. The total noise in the system is root-Square-Sum of all noise contributions over the signal chain, assuming all are uncorrelated. This means that all parts have to be ultra-low noise or heavily filtered when applicable. These include ADCs, op amps and references. Stability over temperature is yet another important challenge. Internal temperature increase due to power dissipation may offset gray levels and distort the image especially during dynamic acquisitions. Hence, temperature stability of ADCs, op amps and references should be high.

Key Products

Acquisition chain

TI's fastest 16-bits SAR ADCs, with differential inputs:

- ADS8422: 4MSPS (serialized parallel output)
- ADS8413: 2MSPS (LVDS output)
- ADS8412: 2MSPS (parallel output)

Serialized LVDS saves FPGA I/Os and EMI, but on the other hand adds power dissipation to the ADC.

High-speed low-noise op amps:

- THS4130/THS4131 (with or without shutdown)
- THS4031/THS4032, single or dual

Biasing chain

12-bit and 16-bit multiplying DACs:

- DAC8811: 16-bit, single
- DAC8812: 16-bit, dual
- DAC8814: 16-bit, quad
- DAC7811: 12-bit, single

Low-noise precision amplifiers:

- OPAx211
- OPAx227
- OPAx277

Low-noise precision references:

- REF50xx
- REF02

16-Bit, 4MSPS, Fully Differential Input ADC with Parallel Interface and Reference

ADS8422

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/ADS8422

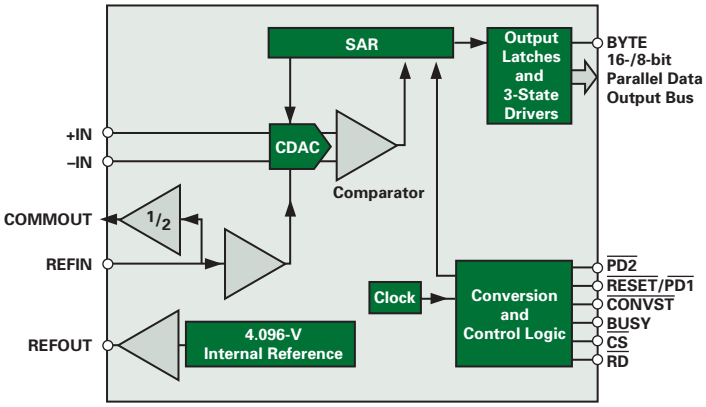
The ADS8422 is a 16-bit, 4MSPS ADC with internal 4.096V reference and a fully differential, pseudo-bipolar input. It includes a full 16-bit interface and an 8-bit option where data is read using two 8-bit read cycles if necessary. It is characterized over the industrial –40°C to +85°C temperature range.

Key Features

- Fully differential input with pseudo-bipolar input range: –4V to +4V
- 16-bit NMC at 4MSPS
- INL: 1LSB (typ)
- SNR: 92dB
- THD: –102dB (typ) with 100kHz input
- Internal 4.096V reference and reference buffer
- High-speed parallel interface
- Low power: 155mW at 4MHz (typ)
- Flexible power-down scheme
- $REF_{IN}/2$ available for setting analog input common-mode voltage

Applications

- Medical instruments
- Instrumentation
- Spectrum analysis
- High-speed, high-resolution, zero-latency data acquisition systems



ADS8422 functional block diagram.

High-Speed, Low-Noise, Fully Differential I/O Amplifiers

THS4130, THS4131

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/THS4130, www.ti.comsc/device/THS4131

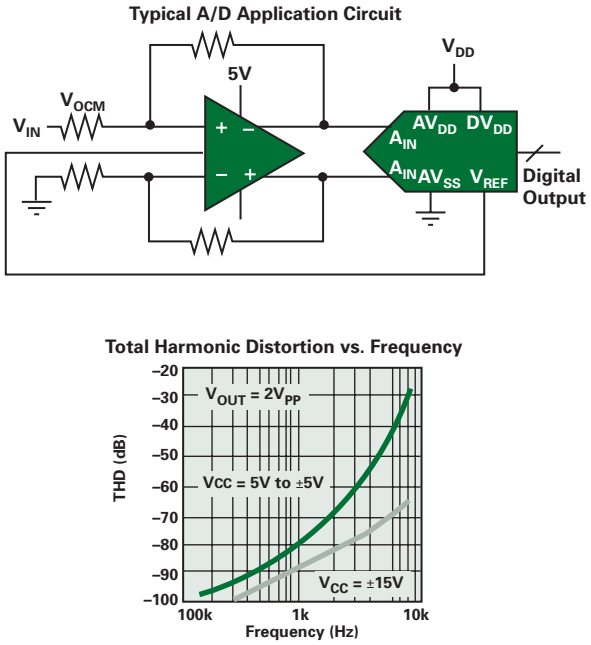
The THS4130 and THS4131 are fully differential input/differential output amplifiers with a true fully differential signal path from input to output. This design provides excellent common-mode noise rejection and improved total harmonic distortion.

Key Features

- Bandwidth: 150MHz (–3dB, V_{CC} = ±15V)
- Slew rate: 51V/µs
- THD_3 at 250kHz: –100dB
- Low noise: 1.3nV/$\sqrt{Hz}$ input referred noise
- Differential input/differential output:
  - Balanced outputs reject common-mode noise
  - Reduced second harmonic distortion due to differential output
- Wide power supply range:
  - Single supply: V_{CC} = 5V
  - Dual supply: ±15V
- Packaging: SOIC-8, MSOP-8, MSOP-8 PowerPAD™

Applications

- Single-ended to differential conversion
- Differential ADC driver
- Differential antialiasing
- Output level shifter
- Differential transmitter and receiver



THS4130 application circuit.

Digital X-Ray

Low-Noise, Very Low-Drift, High-Precision Voltage References
REF50xx

PREVIEW*

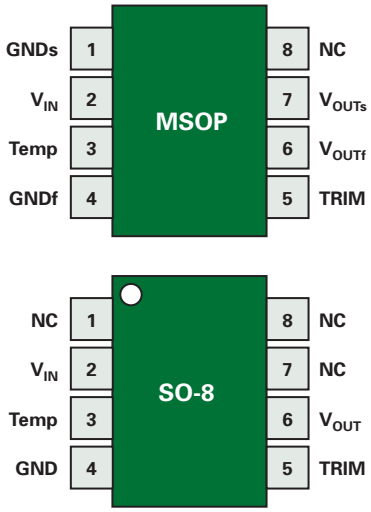
Get preliminary datasheets at: **www.ti.com/sc/device/REF5020**

The REF50xx is a family of low-noise, low-drift, high-precision voltage references. Designed for use in high-precision data acquisition systems, REF50xx has both sinking and sourcing capability and is very robust to any line and load changes. The REF50xx has excellent temperature drift (3ppm/°C) and high accuracy both achieved by using a proprietary design technique and post-package precision correction.

Key Features
- High accuracy: 0.05%
- Very low temperature drift: 3ppm/°C
- High output current: ±10mA
- Temperature range: –40°C to +125°C
- Packaging: MSOP-8, SO-8

Applications
- Medical instrumentation
- 16-bit data acquisition systems
- Industrial process control
- ATE equipment

Model	Voltage Out
REF5020	2.048
REF5025	2.5
REF5030	3.0
REF5040	4.096
REF5045	4.5
REF5050	5
REF5100	10



Package diagrams.

**Product release scheduled for 3Q 2007.*

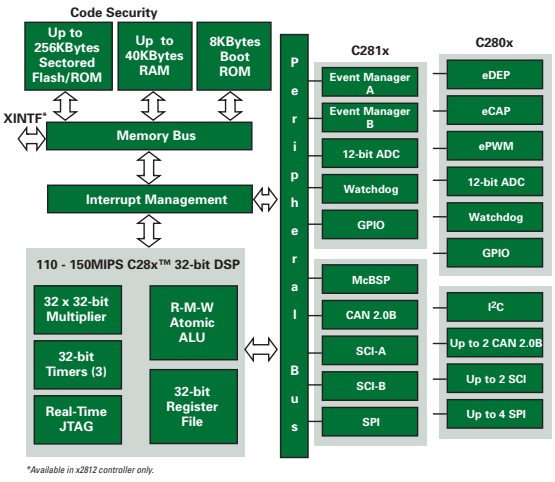
TMS320C28x™ Controller Generation, Fixed-Point MCU Control. DSP Performance
TMS320F2810

Get samples, datasheets, tools and app reports at:
www.ti.com/sc/device/TMS320F2810

The TMS320F2810, TMS320F2811, TMS320F2812, TMS320C2810, TMS320C2811, and TMS320C2812 ICs, members of the TMS320C28x DSP generation, are highly integrated, high-performance solutions for demanding control applications.

Key Features
- Ultra-fast 20 to 40ns service time to any interrupts
- Powerful 20Mbit/s data logging debug capability
- 32-/64-bit saturation, single-cycle read-modify-write instructions, and 64-/32-bit and 32-/32-bit modulus division
- Enhanced tool suites with C and C++ support
- Unique real-time debugging capabilities
- 32-bit single-cycle fixed-point MAC
- Compatible with TMS320C24x™ DSP and TMS320C2xLP source code

Peripherals
- 16 to 128Kwords sectored Flash or factory programmed ROM (with code security)
- 12-bit A/D, as fast as 12.5MSPS throughput with 80ns (min) conversion time
- Flexible QEP, CAP, timers and PWM generation
- High-res mode resolution of 16-bits at 100kHz and over 12-bits at 1.5MHz ePWM frequency
- Up to two serial communication interfaces (SCI/UART)
- Up to four serial peripheral interfaces (SPI)
- Up to two enhanced CAN 2.0B modules
- McBSP or I^2C interface



TMS320C28x™ Digital Signal Controller Block Diagram. The C28x™ controllers are 32-bit control-based DSPs with onboard reprogrammable Flash, factory programmed ROM, or cost-effective RAM-only memory options and performance from 100 to 150MIPS.

Component Recommendations for Digital X-Ray Applications

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
THS413x	High-Speed Op Amp	150MHz (–3dB) BW, 51V/µs SR, -100dB THD at 250kHz	Differential input/differential output	THS4120, THS4150
THS403x	High-Speed Op Amp	100MHz, 1.6nV/$\sqrt{Hz}$ noise, 100V/µs SR, 90mA output	Low distortion	THS4051, THS4081
OPAx211	Precision Op Amp	1.1nV/$\sqrt{Hz}$ at 1kHz noise, 3.6mA/ch supply, 80MHz BW	Unity gain stable, RRO, shutdown	OPA227
OPAx227	Precision Op Amp	10µV offset, ±0.1µV/°C drift, 134dB open-loop-gain 140dB CMRR		OPA228
OPAx277	Precision Op Amp	10µV offset, ±0.1µV/°C drift, 134dB open-loop gain		OPA4277 (quad)
Data Converters				
ADS8413	SAR ADC	16-bit, 2MSPS, serial LVDS		ADS8412
ADS8422	SAR ADC	16-bit, 4MSPS, int. ref and ref buffer		
DAC8814	DAC	16-bit, quad, multiply DAC		DAC8811, DAC8812, DAC7811
Processors				
TMS320F2810	DSP	150MIPS, Controller Area Network (CAN) peripheral	CAN for board level communication, combination of DSP performance and MCU integration	
TMS320DM-6446BZWT	DSP	C64x+, ARM9, video accelerators	Image processing, display	TMS320DM6441, TMS320DM6437
Interface				
SN65LV1023A	10:1 LVDS Serdes	Embedded clock	Smallest package	SN65LV1224B
SN65LVDS31	4-Channel LVDS Driver	400Mbps	Industry standard	SN65LVDS32
TLK6201EA	PC Board Equalizer	Up to 6.25Gbps operation, low power, high input dynamic range	CML data outputs	
Temperature Sensor				
TMP175	Digital Temp Sensor	27 addresses, ±1.5°C (max) accuracy, 50µA I_Q, 9- to 12-bit resolution	Two-wire interface, serial output	TMP75
TMP275	Digital Temp Sensor	8 addresses, ±0.5°C (max) accuracy, 50µA I_Q, 9- to 12-bit resolution	Two-wire interface, serial output	
Power Management Products				
DCH010505	Galvanic Isolated, DC/DC Converters	1W, 3kV isolation, minimal external components	Safety isolation, removal of ground loops, reducing board space	DCH010512, DCH010515
PTH04T240	Power Module	10A, 2.2V to 5.5V V_{IN}, adjustable V_{OUT}, with *TurboTrans™*	Complete Power supply designed to meet ultra-fast transient requirements	PTH04T241
PTH08T220	Power Module	16A, 4.5V to 14V V_{IN}, adjustable V_{OUT}, with *TurboTrans*	Complete power supply designed to meet ultra-fast transient requirements	PTH08T221
TPS3307	Voltage Supervisor	Triple processor supervisor	Two fixed and one adjustable supervisor for system flexibility	TPS3808
TPS40020	DC/DC Controller	2.25V to 5.5 V_{IN}, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/regulation from main power supply	
TPS40075	DC/DC Controller	4.5V to 28 V_{IN}, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/regulation	TPS40057
TPS54317	DC/DC Converter	3.0V to 6.0 V_{IN} 3A DC/DC with integrated switch FET, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	TPS54610/TPS54910
TPS54350	DC/DC Converter	4.5V to 20V_{IN} 3A DC/DC with integrated switch FET, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	TPS54550
TPS74401	Single-Channel LDO	3.0A ultra-low dropout linear regulator	Split bias and supply pin minimize heat generation	TPS74301

*Preview products are listed in **bold blue**.*

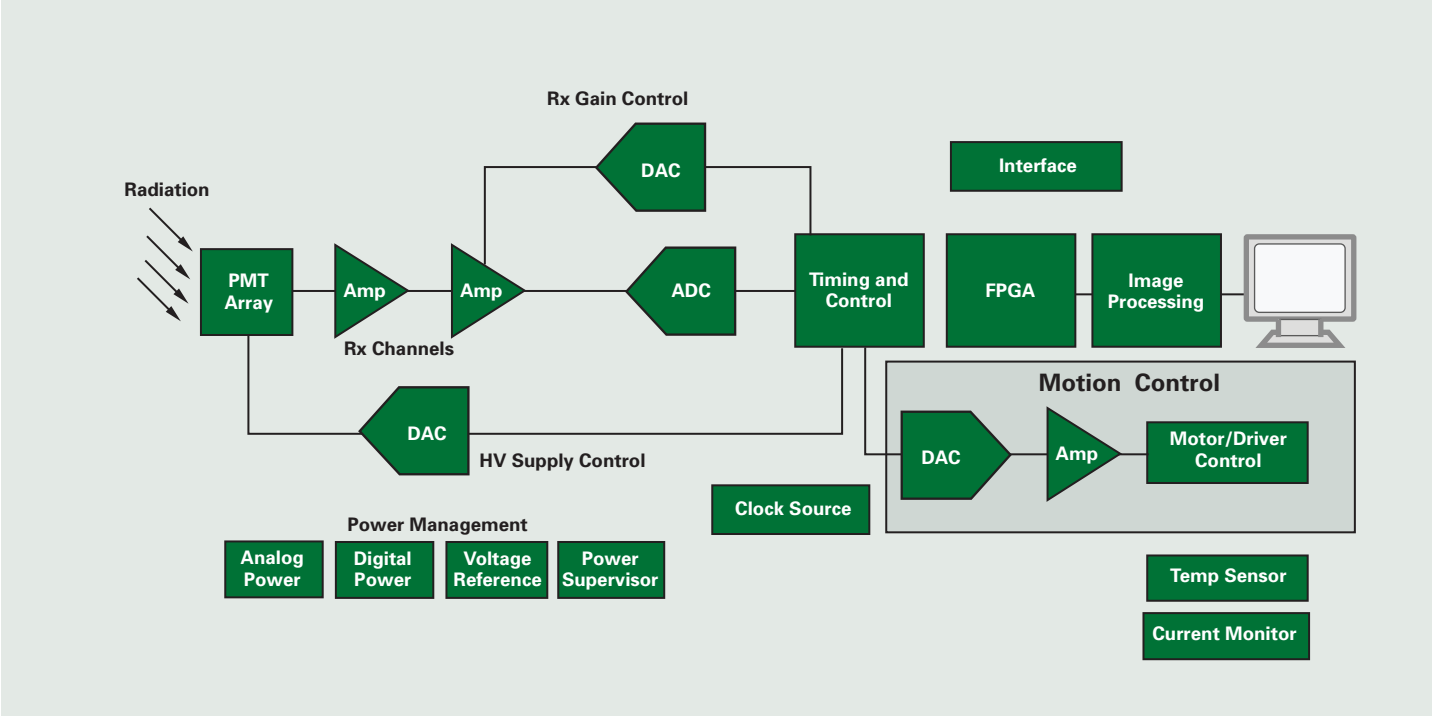
*New products are listed in **bold red.***

PET Scanners

PET Scanners

Positron Emission Tomography (PET) is a non-invasive diagnostic technology that produces physiologic images based on radiation emissions from the body. These emissions are generated by radioactive chemical elements taken by the patient, which are designed to target specific organs or tissues. The radioactive emissions are converted to light via a scintillation crystal detector and are amplified and converted to an output current by a photomultiplier tube (PMT). The PMT's current output is then converted to a voltage which is amplified and filtered before being converted to a digital signal by an ADC. In addition to the detector signal processing of the receive channels, there are also a number of control functions. DSPs, microcontrollers and digital-to-analog converters are used in this application for functions such as varying the gain of the input amplifiers, controlling the PMT high-voltage power supply, and motion control for the detector ring assembly and patient entry/exit.

A wide variety of TI products are available for PET imaging systems and equipment manufacturers, including op amps, multi-channel data converters, temperature sensors, clocking distribution, interface, DSPs and power management.



PET scanner system block diagram.

8-Channel, 10- and 12-Bit, 40 to 70MSPS ADCs with Serialized LVDS Interface

ADS5270, ADS5271, ADS5272, ADS5273, ADS5277, ADS5240, ADS5242

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/PARTnumber
(Replace **PARTnumber** with **ADS5270**, **ADS5271**, **ADS5272**, **ADS5273**, **ADS5277**, **ADS5240** or **ADS5242**)

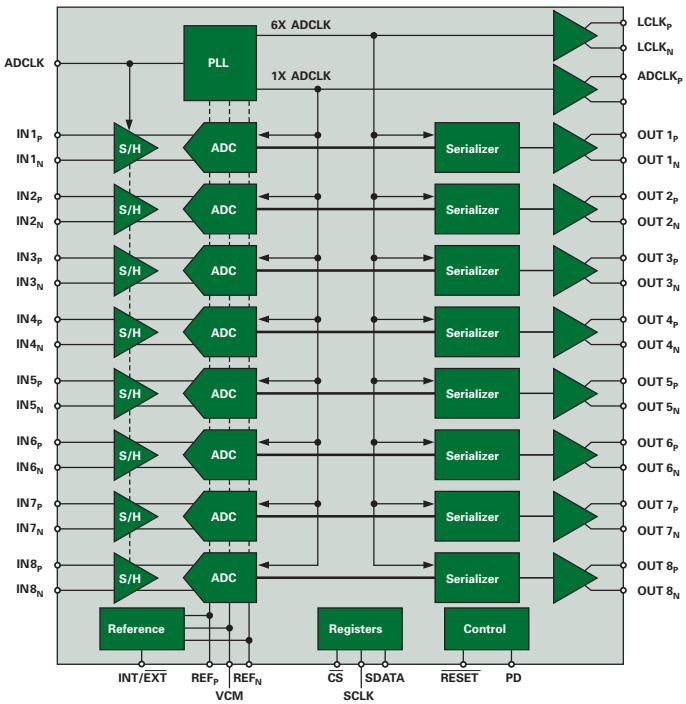
The ADS527x family provides eight high-performance ADCs in a small 80-lead TQFP package, making it possible to implement high channel counts in high-performance ultrasound systems. The low power dissipation per channel extends battery life and allows the ADS527x to be used in portable ultrasounds applications as well. Available in 12-bit, 40 to 70MSPS and 10-bit, 65MSPS versions, the ADS527x family has the flexibility to offer solutions across the entire spectrum of ultrasound system applications. The ADS5240 and ADS5242 are 4-channel, 12-bit, 40MSP and 65MSPS versions, respectively.

Key Features

- Eight 12- or 10-bit ADCs in one small 80-pin TQFP package
- Conversion rates: 40, 50, 65, and 70MSPS
- Power consumption: 123mW per channel at 65MSPS
- SNR: 70.5dB for 12-bits at 10MHz IF
- Individual channel power down

Applications

- Medical and other imaging
- Portable test equipment
- Wireless communications



ADS527x functional block diagram.

High-Speed Deserializer Aids Evaluation of TI's HS ADCs with Serialized LVDS Outputs

ADSDeSer-50EVM

To order complete evaluation module go to:
http://focus.ti.com/docs/toolsw/folders/print/adsdeser-50evm.html

The ADSDeSer-50EVM is designed to interface to TI's serialized low-voltage differential signal (LVDS) output data converters with an operating frequency of up to 70MHz and up to eight simultaneous data channels. The ADSDeSer-50EVM provides an easy way to examine the serialized data output from the serialized LVDS data converters by deserializing the data and converting to a standard parallel data port. As there is no clock embedded, a synchronous clock output is provided separately, along with the eight channels of data. This EVM can be used to evaluation the following ICs: ADS5270, ADS5271, ADS5272, ADS5273, ADS5240 and ADS5242.

EVM Features

- Accommodates 10- and 12-bit ADCs with up to 50MSPS sampling rate
- LVDS Deserializer for up to 600Mbps
- Up to eight channels simultaneously
- Synchronous clock signal

Also Supplied

- BOM
- Datasheet
- Populated EVM board
- Schematic
- User's Guide

An additional application note from Xilinx®, "Connecting Xilinx FPGAs to Texas Instruments ADS527x Series ADCs" (XAPP774 (v1.2)), is available on the Xilinx website and describes how to connect a high-speed ADS527x IC with serialized LVDS output to a Virtex™-II or Virtex-II Pro FPGA. Lower speed ADC527x components can be connected to Spartan™-3 FPGAs.

To highlight the performance of both the ADC and the FPGA, the reference design described in the application note uses the ADS5273, which is the highest speed sampling ADC. The ADS5273 interfaces to an XC2V250-6FG256 IC (to fit the Texas Instruments demo board) and to an XC2VP20-6FF896 IC (to fit Xilinx demo boards).

To download this application note, go to:
http://direct.xilinx.com/bvdocs/appnotes/XAPP774.pdf

For more information or to order TI's deserializer EVM solution, go to:
http://focus.ti.com/docs/toolsw/folders/print/adsdeser-50evm.html

TI's reference to other companies' products does not constitute TI's recommendation or approval of such products for use in any application. See 'Important Notice.'

Component Recommendations for PET Scanner Applications

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
OPA657	High-Speed Op Amp	FET-Input, 1.6GHz GBW, 4.8nV/√Hz noise, 70mA output	High dynamic range, fast overdrive recovery	
OPA860	Transconductance Amp	80MHz, open-loop, G = +5 BW, 900V/µs SR	95mA/V high transconductance, buffer	
OPA2690	VFB Op Amp	Dual, 220MHz, G = 2 BW, 1800V/µs SR, 190mA output	+5V supply, disable	OPA2691
THS4130	High-Speed Op Amp	150MHz BW (–3dB), 51V/µs slew rate, –100dB THD at 250kHz	High-speed, fully differential I/O	
THS7530	High-Speed VGA	1.1nV/√Hz noise, 300MHz BW, 11.6dB to 46.5dB continuously variable gain	High-speed, fully differential	
VCA810	Voltage-Controlled Amp	±40dB high gain adjust range, 2.4nV/√Hz noise, ±60mA output current	Differential in/single-ended out	
Data Converters				
ADS5240	High-Speed ADC	4-channel, 12-bit, 40MSPS, serial LVDS interface	Integrated frame and bit pattern, 4 current modes for LVDS	ADS5242, ADS5525
ADS5272	High-Speed ADC	8-channel, 12-bit, 65MSPS, 3.3V analog/digital supply	Serialized LVDS outputs, integrated frame and bit patterns	
ADS5444	High-Speed ADC	13-bit, 250MSPS, 2W power dissipation, 5V supply	LVDS-compatible outputs	ADS5424, ADS5440
ADS5525	High-Speed ADC	12-bit, 170MSPS, DDR/LVDS CMOS outputs	Programmable gain up to 6dB for SNR/SFDR trade-off at high IF	ADS5527, ADS5545
ADS5527	High-Speed ADC	12-bit, 210MSPS, DDR/LVDS CMOS outputs	Internal/external reference support	ADS5545, ADS5440
DAC5652	High-Speed DAC	10-bit, 275MSPS dual DAC	High sample rate with low power	DAC5662, DAC5672
DAC2900	High-Speed DAC	10-bit, 125MSPS dual DAC	Supports 3.3/5V	DAC2902, DAC2904
DAC7554	V_{OUT} DAC	Quad, 12-bit, 2.7V to 5.5V supply, 5µs settling time	Ultra-low glitch, ultra-low crosstalk	DAC7614, DAC7615
DAC7731	V_{OUT} DAC	16-bit, 150mW (max) low power, 5µs settling time, +10V int. reference	Unipolar or bipolar operation	DAC8811
References				
REF31xy	Voltage Reference	0.2% voltage accuracy	Precise trigger voltage ADC	REF32xy, REF33xy
REF3140	Voltage Reference	15ppm/°C (max) drift, 5mV low dropout, 115µA (max) I_Q, 0.2% (max) accuracy	No load capacitor required	REF3130, REF3120
REF32xx	Low Drift, Bandgap	0.2% (max) accuracy, 7ppm/°C (max) drift, 0.1mA (max) I_Q	Multiple output voltages, SOT23-6	
REF33xx	microPower Bandgap	0.1% (max) accuracy, 30ppm/°C (max) drift, 0.005mA (max) I_Q	Multiple output voltages, MSOP-8, SO-8	
REF50xx	Precision Reference	0.05% accuracy, 3ppm/°C (max) drift, 6µV_{PP} low noise	Multiple output voltages, SC71	
Interface				
SN65LVCP40	Dual 1:2 Mux/Buffer	Input EQ, output pre-emp	Improves signal range	SN65LVCP404
TLK1221	Gigabit Ethernet Serdes	Power 250mW	Smallest package	TLK2208B
Clocking				
CDCLVP110	Clock Driver	Low voltage, 1:10 LVPECL/HSTL	Selectable inputs, minimum skew	
CDCLVD110	Clock Buffer	1:10 LVDS clock driver	Operating up to 900MHz with minimum skew	CDCP1803, CDCLVD110A
CDCM7005	Clock Synthesizer	Clock synchronizer with 5 LVPECL outputs	Jitter cleaning	CDC7005
Power Management Products				
PTH04T240	Power Module	10A, 2.2V to 5.5V V_{IN}, adjustable V_{OUT}, with *TurboTrans™*	Complete power supply designed to meet ultra-fast transient requirements	PTH04T241
PTH08T220	Power Module	16A, 4.5V to 14V V_{IN}, adjustable V_{OUT}, with *TurboTrans*	Complete power supply designed to meet ultra-fast transient requirements	PTH08T221
PTQA430033	Isolated DC/DC Module	100W, 1500VDC isolation, differential remote sense	High efficiency, industry-standard pin-compatible	PTQB425080
TPS3307	Voltage Supervisor	Triple processor supervisor	Two fixed and one adjustable supervisor for system flexibility	TPS3808
TPS40020	DC/DC Controller	2.25 to 5.5 V_{IN}, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/regulation from main power supply	

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

Component Recommendations for PET Scanner Applications

Component Recommendations (Continued)

Component	Description	Key Features	Benefits	Other TI Solutions
Power Management Products (Continued)				
TPS40075	DC/DC Controller	4.5 to 28 V_{IN}, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/regulation from main power supply	TPS40057
TPS74401	Single-Channel LDO	3.0A ultra-low dropout linear regulator	Split bias and supply pin minimize heat generation	TPS74301
TPS54317	DC/DC Converter	3.0 to 6.0 V_{IN} 3A DC/DC with integrated switch FET, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	TPS54610/TPS54910
TPS54350	DC/DC Converter	4.5 to 20V_{IN} 3A DC/DC with integrated switch FET, synchronization pin, enable	Eliminate beat noise/ceramic caps/FPGA/integration	TPS54550
UCD9080	System Voltage Supervisor	GUI Programmable 8-channel sequencer	Complete system power monitoring	UCD9111

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

Power Management for Medical Imaging

8-Channel Power-Supply Sequencer and Monitor
UCD9080

Get samples, datasheets, evaluation modules, app reports and software tools at: **www.ti.com/sc/device/UCD9080**

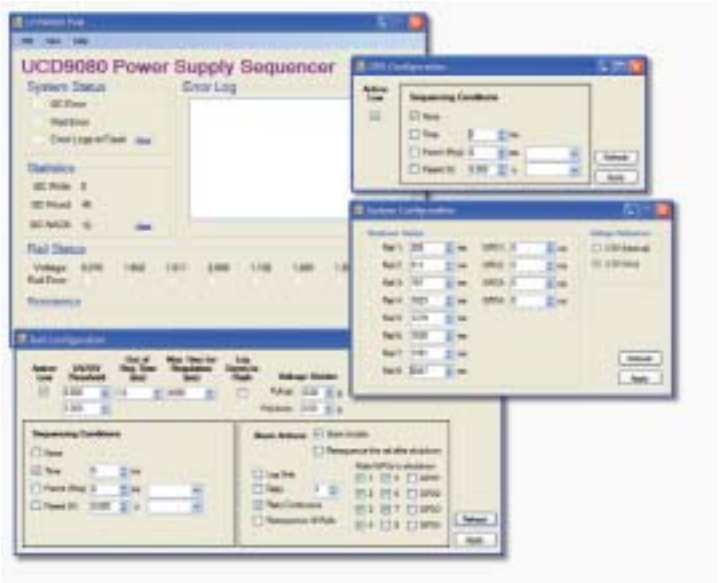
Key Features

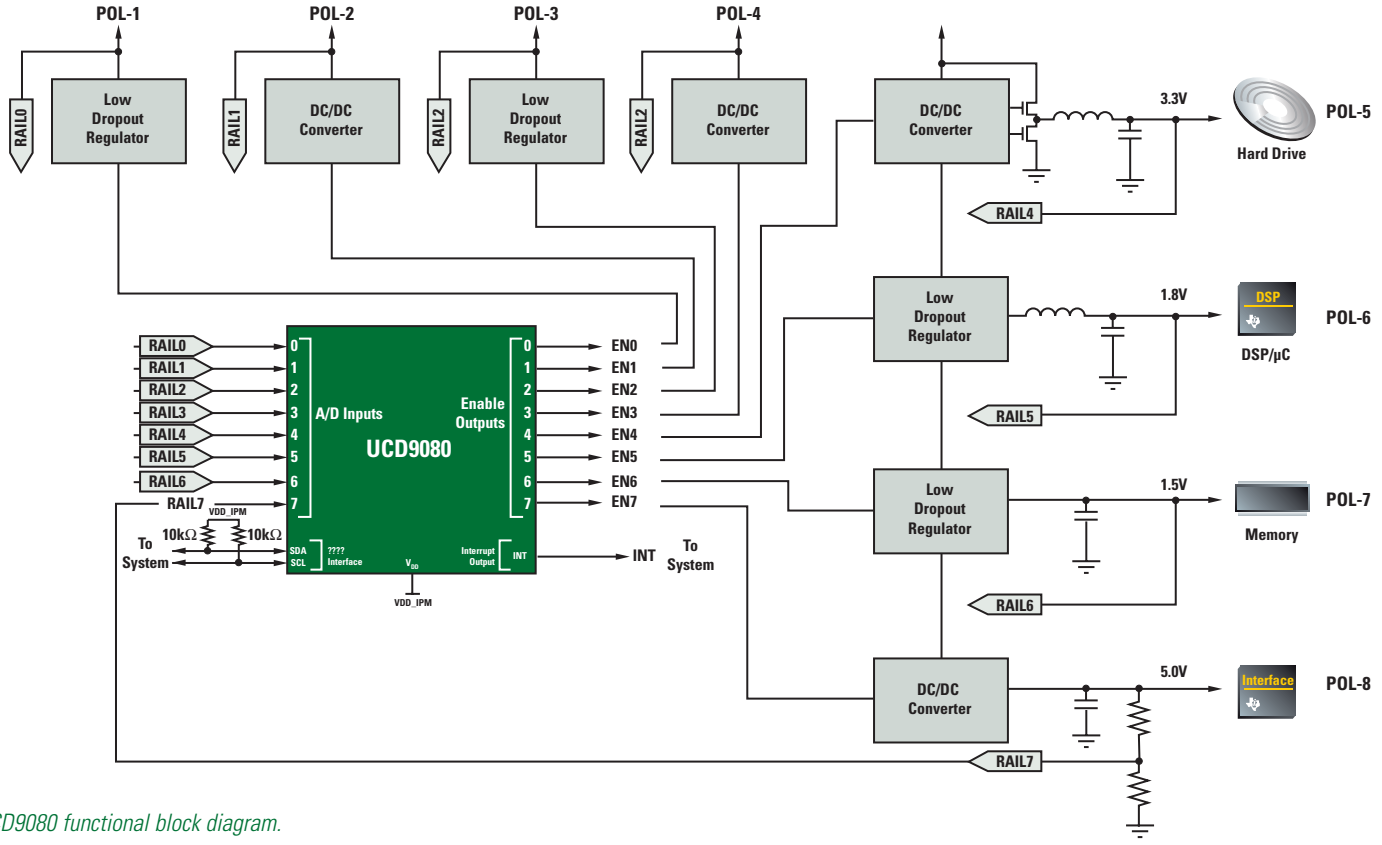
- Sequencing and monitoring of up to 8 voltage rails
- All rails monitored and updated every 50µs 3.5mV resolution
- Sequencing of up to three digital outputs for power-on-reset and other functions
- Under- and over-voltage threshold per rail
- I^2C interface for configuration and monitoring
- Microsoft® Windows® GUI for configuration and monitoring
- Flexible rail shutdown
- Supply voltage: 3.3V
- Low power consumption: 300µA, 3.0V

Applications

- Telecommunications switches servers
- Networking equipment
- Test equipment
- Any system requiring sequencing of multiple voltage rails

Component	Description
UCD9111	Single Phase POL Digital Power Controller
UCD9112	Dual Phase POL Digital Power Controller
UCD9501	32-Bit Digital Signal Controller for Power Management
UCD7100	Digital Control Single, Low-Side ±4A MOSFET Driver with Current Sense
UCD7201	Digital Control Dual, Low Side ±4A MOSFET Driver with Single Common Current Sense
UCD7230	Digital Power Compatible Synchronous Buck Driver





UCD9080 functional block diagram.

2nd Generation PTH Point-of-Load Modules
PTH08T2xx

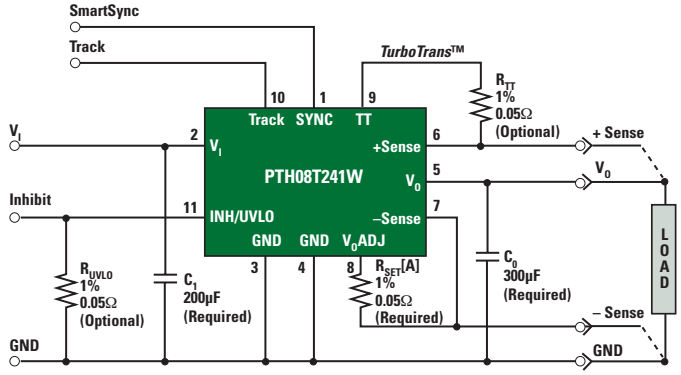
Get samples, datasheets, evaluation modules, app reports and software tools at: **www.ti.com/T2**

Key Features
- *TurboTrans*™ technology
- 1.5% output regulation
- SmartSync synchronization
- Auto-Track™ sequencing

Benefits
T2s reduce development costs and save PCB space:
- Sequencing easily solved with Auto-Track technology
- Smart Sync synchronization for input cap reduction/easier filtering
- *TurboTrans* technology for high transient load applications
- Stable with ultra-low ESR caps
- 1.5% tolerance meets specs of FPGA core

Typical Component Specifications

Model	V_{IN} (V)	V_{OUT} (V)	I_{OUT} (A)
PTH04T260W	2.2 to 5.5	0.7 to 3.6	3
PTH08T260/261W	4.5 to 14	0.7 to 5.5	3
PTH04T230W	2.2 to 5.5	0.7 to 3.6	6
PTH08T230/231W	4.5 to 14	0.7 to 5.5	6
PTH04T240/241W	2.2 to 5.5	0.7 to 3.6	10
PTH08T240/241W	4.5 to 14	0.7 to 5.5	10
PTH04T220W	2.2 to 5.5	0.7 to 3.6	16
PTH08T220/221W	4.5 to 14	0.7 to 5.5	16
PTH05T210W	2.2 to 5.5	0.7 to 3.6	30
PTH08T210W	4.5 to 14	0.7 to 3.6	30
PTH08T250W	4.5 to 14	0.7 to 3.6	50
PTV08T250W	8 to 14	0.8 to 3.6	50



PTH08T2xx functional block diagram.

100W, Isolated DC/DC Module
PTQA430033

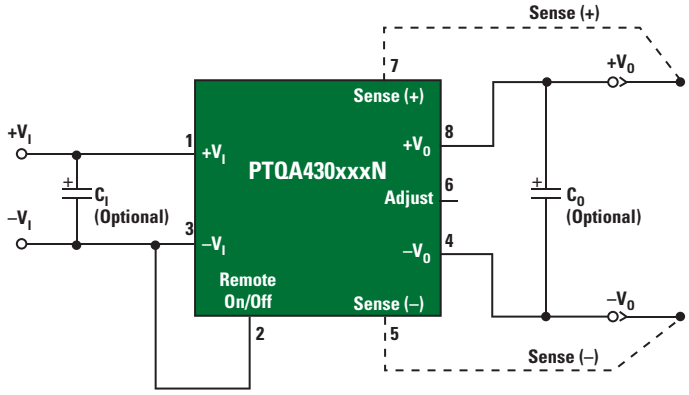
Get samples, datasheets, evaluation modules, app reports and software tools at: **www.ti.com/sc/device/PTQA430033**

Key Features
- 48V input (36V to 75V range)
- Standard quarter-brick footprint
- High efficiency (92% at 3.3V full load)
- 1500VDC I/O isolation
- On/off control
- Overcurrent protection
- Differential remote sense
- Undervoltage lockout
- Output overvoltage protection
- Overtemperature shutdown

Benefits
- Pin-compatible with industry-standard products
- Small size, high current applications

Typical Component Specifications

Model	Input (V)	Output Current (A)	Output (V)
PTQA	4	30	025
	4 = 48	30 = 30	025 = 2.5
		20 = 20	033 = 3.3
			050 - 5.0



PTQA430033 functional block diagram.

Medical Instrumentation

In This Section

Medical Instrumentation

Medical instruments are available today for a wide variety of different applications. Typical applications include instruments for medical laboratories, analytical instruments for in-vitro diagnostics, surgical instruments and dental equipment.

As all of these applications are very specific in design and system requirements, it is difficult to provide general information pertaining to these applications. However, medical instruments have one thing in common: the need for high-precision circuits to support the precise acquisition of pressure, light and temperature values. This includes the acquisition of small capacitances and currents.

TI's portfolio provides many integrated circuit solutions for these applications. The precision linear portfolio meets the need for typical ICs by offering low bias, precision and high-speed amplifiers with J-FET inputs, zero-drift operational amplifiers for precision-over-life-time applications and low-noise amplifiers for sensitive measurement circuits. The data acquisition portfolio complements these component by offering high-resolution, low-noise analog-to-digital and digital-to-analog data acquisition systems. The ultra-low-power MSP430 microcontroller family, or a member of one of the three DSP families, TMS320F28x™, TMS320DM64x™ and TMS320C64x™, can easily manage signal processing tasks. TI's wide portfolio of interface ICs, both wired and wireless, can facilitate many data transmission tasks.

Featured Products

- Low-bias, precision J-FET amplifier: OPA827
- Low-bias, high-speed amplifier: THS4631
- Auto-zero, low-drift amplifier: OPA735
- Auto-zero, low-drift, high-speed amplifier: OPA380
- Precision, low-noise bipolar amplifier: OPA211
- Sensor signal conditioner PGA309
- 16-channel, fast cycling 24-bit, low-noise A/D converter: ADS1258
- Single-channel, 24-bit ADC with DC accuracy and AC performance: ADS1271
- 16-bit, ±10V input, single-supply family of SAR A/D converters: ADS8507, ADS8509, ADS8513
- 16-bit, 4MSPS parallel output SAR A/D converter: ADS8422
- 16-bit, 2MSPS A/D converter with LVDS interface: ADS8410
- High-accuracy 16-bit D/A converter: DAC8820
- 12-bit, 4-channel D/A converter with SPI interface: DAC7554

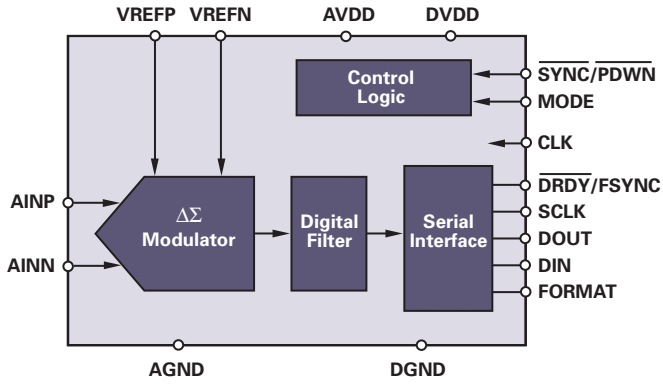
24-Bit, ADC with Excellent AC and DC Performance
ADS1271

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/ADS1271

The ADS1271 is a 24-bit, delta-sigma ADC with up to 105kSPS data rate. It offers the unique combination of excellent DC accuracy and outstanding AC performance. The high-order, chopper-stabilized modulator achieves very low drift with low in-band noise. The onboard decimation filter suppresses modulator and signal out-of-band noise. The ADS1271 provides a usable signal bandwidth up to 90% of the Nyquist rate with only 0.005dB of ripple.

Key Features
- AC performance: 109dB SNR (52kSPS); 105dB THD
- DC accuracy: 1.8mV/°C offset drift; 2ppm/°C gain drift
- High resolution: 109dB SNR
- Easy synchronization for multi-channel data acquisition
- Daisy-chain support to simplify data retrieval when using multiple ICs

Applications
- Outstanding resolution when measuring from DC to 50kHz signals



ADS1271 functional block diagram.

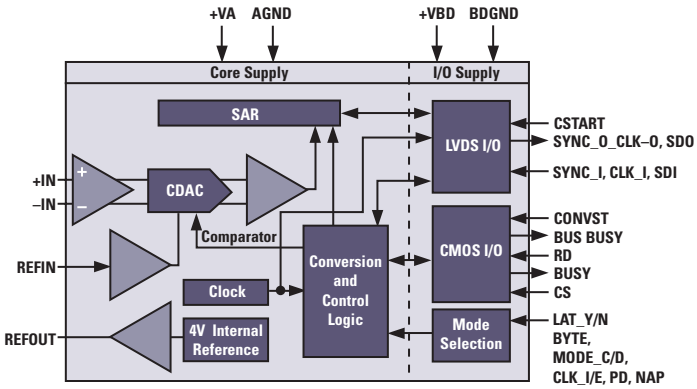
16-Bit, 2MSPS ADC with LVDS Serial Interface
ADS8410

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/ADS8410

The ADS8410 is a 16-bit, 2MSPS ADC with 4V internal reference. It includes a 200Mbps, LVDS serial interface design to support daisy chaining or cascading of multiple ICs. A selectable 16-/8-bit data frame mode enables the use of a single-shift register chip for converting the data to parallel format. The ADS8410 unipolar single-ended input range supports a differential input swing of 0V to $+V_{REF}$.

Key Features
- SNR: 87.6db at 10kHz I/P
- THD: –98dB at 10kHz I/P
- INL: ±1LSB (typ); ±2.5LSB (max)
- DNL: +0.8/–0.5LSB (typ); +1.5/–1LSB (max)
- Unipolar differential input range: 0V to 4V
- 200Mbps LVDS serial interface
- 16-/8-bit data frame
- Zero latency at full speed
- Power dissipation: 290mW at 2MSPS
- Packaging: QFN-48

Applications
- Medical instrumentation
- High-speed data acquisition systems
- High-speed close-loop systems
- Communications



ADS8410 functional block diagram.

Medical Instrumentation

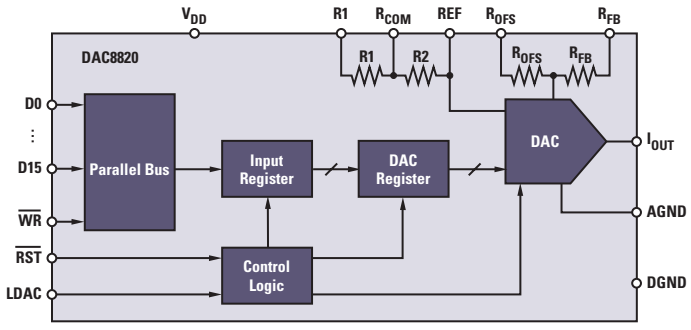
16-Bit, Parallel Input, Multiplying DAC
DAC8820

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/DAC8820

The DAC8820 is a multiplying DAC designed to operate from a single 2.7V to 5.5V supply. The applied external reference input voltage determines the full-scale output current. An internal feedback resistor provides temperature tracking for the full-scale output when combined with an external, current-to-voltage precision amplifier. A parallel interface offers high-speed communications.

Key Features
- INL: ±0.5LSB
- DNL: ±1LSB
- 16-bit monotonic
- Low noise: 10nV/$\sqrt{\text{Hz}}$
- Low power: I_{DD} = 2µA
- Analog power supply: +2.7V to +5.5V
- Settling time: 0.5µs
- 4-quadrant multiplying reference
- Reference bandwidth: 8MHz
- Packaging: SSOP-28

Applications
- Instrumentation
- Automatic test equipment
- Digitally controlled calibration
- Industrial control



DAC8820 functional block diagram.

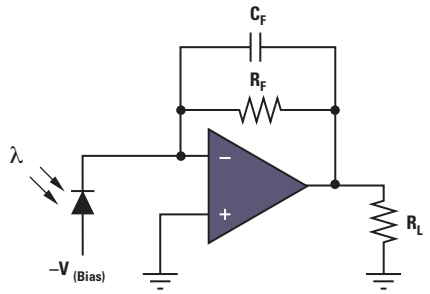
High-Voltage, Wideband, FET-Input Operational Amplifier
THS4631

Get samples, datasheets, evaluation modules and app reports at:
www.ti.com/sc/device/THS4631

The THS4631 is a high-speed, FET-input op amp designed for applications requiring wideband operation, high-input impedance and high power supply voltages. By providing a 210MHz gain bandwidth product, ±15V supply operation and 100pA input bias current, the THS4631 is capable of simultaneous wideband transimpedance gain and large output signal swing. The fast 1000V/µs slew rate allows for fast settling times and good harmonic distortion at high frequencies.

Key Features
- High bandwidth:
  - 325MHz in unity gain
  - 210MHz gain bandwidth product
- High slew rate:
  - 900V/µs (G = 2)
  - 1000V/µs (G = 5)
- Low distortion: –76dB, SFDR at 5MHz
- Input bias current: 100pA (max)
- Input voltage noise: 7nV/$\sqrt{\text{Hz}}$
- Input impedance: 109 || 3.9pF
- Wide supply range: ±5V to ±15V
- Packaging: SOIC-8, MSOP-8 PowerPAD™

Applications
- Wideband photodiode amplifier
- High-speed transimpedance gain stage
- Test and measurement systems
- Current-DAC output buffer
- Active filtering
- High-speed signal integrator
- High-impedance buffer



Photodiode circuit.

Component Recommendations for Medical Instrumentation

Component Recommendations

Component	Description	Key Features	Benefits	Other TI Solutions
Amplifiers				
OPA211	Precision Op Amp	1.1nV/√Hz at 1kHz low noise, 0.2µV/°C offset drift, 80MHz (G = 100) BW	<1µs settling time to 16-bit accuracy	
OPA277	Precision Op Amp	10µV offset voltage, ±0.1µV/°C low drift, 134dB open-loop gain, 140dB CMRR	Available in S, D, Q	OPA177, OPA627
OPA380	Transimpedance Amp	90MHz GBW, over 1MHz transimpedance BW, 25µV offset (max), 0.1µV/°C drift (max)		
OPA735	CMOS Op Amp	0.05µV/°C zero drift (max), 750µA I_Q (max), 5µV offset voltage	Zero-Drift Series, dual version available	OPA734
OPA827	JFET-Input Op Amp	1µV/°C drift, 4.5mA/ch I_Q, 250µV offset voltage, 18MHz BW	Outstanding DC precision with excellent AC performance	
PGA309	Prog. Sensor Conditioner	Sensor error compensation: span, offset, temp drifts	Complete bridge sensor conditioner	
THS4520	High-Speed Op Amp	450MHz (G = 2V/V), 570V/µs SR, 2nV/√Hz noise (f>10MHz)	Single-to-differential conversion	
THS4131	High-Speed Op Amp	150MHz (–3dB) BW, 51V/µs SR, –100dB HD3 at 250kHz	Low noise, fully differential I/O	
THS4631	High-Speed Op Amp	210MHz GBW, 900V/µs(G=2) SR, –76dB SFDR at 5MHz	±5 and ±15V supply operation, 95mA output current	
Data Converters				
ADS1258	Delta-Sigma ADC	16-channel, 24-bit, 125k/23.7kSPS	Fastest multi-channel delta-sigma ADC, measures all 16 inputs in <675µs	**ADS1274**, **ADS1278**, ADS1605, ADS1602, ADS1601
ADS1271	Delta-Sigma ADC	24-bit, 105kSPS, serial interface, SPI w/FSYNC	Designed for multi-channel systems	
ADS1610	Delta-Sigma ADC	16-bit, 10MSPS, parallel interface	SYNC pin for simultaneous sampling	ADS1605
ADS8410	SAR ADC	16-bit, 2MHz, 87.5dB at 10kHz I/P SNR, int. ref.	200Mbps LVDS serial interface	
ADS8413	SAR ADC	16-bit, 2MSPS, LVDS interface int ref and buffer		
ADS8422	SAR ADC	16-bit, 4MSPS, 1LSB INL (typ), parallel interface	Zero latency	
DAC8560	V_{OUT} DAC	16-bit, 0.15nV-s glitch, ±10µs to 0.003%FSR settling time	Small package, low power	
DAC8814	Quad, Multiplying DAC	16-bit, 1LSB (max) diff nonlinearity, 0.5µs settling time		
DAC8820	DAC	16-bit, parallel input multiplying, ±1.5LSB DNL, ±1LSB INL	2.7V to 5.5V supply, low noise, low power	DAC8814, DAC8822
Power Management Products				
TPS3307	Voltage Supervisor	Triple processor supervisor	Two fixed and one adjustable supervisor for system flexibility	TPS3808
TPS74401	Single-Channel LDO	3.0A ultra-low dropout linear regulator	Split bias and supply pin minimize heat generation	TPS74301
TPS61081	LED Boost Converter	Input to output isolation	Protection from short between any pins and between any pin to ground	TPS61042
TPS79901	Single-Channel LDO	Very high rejection of power source noise	Low noise power rails for sensitive analog components	TPS79501

*Preview products are listed in **bold blue**.*

*New products are listed in **bold red**.*

Enhanced Product

Texas Instruments Enhanced Product Family

TI features a line of Enhanced Product (EP) ICs with additional value-added qualifications and processing. EP ICs are TI catalog products encompassing ICs from multiple families including DSPs, analog and mixed-signal, digital logic, ASIC, microcontrollers and programmable logic.

These products will complement the broad portfolio of military grade ceramic ICs currently produced by TI. These EP products are cost-effective catalog ICs that are available in plastic packages. EP ICs offer several advantages over standard commercial off-the-shelf products:

- Stand-alone datasheets
- A controlled baseline — one assembly/test site and one wafer fabrication site
- Enhanced product change notification (PCN) via electronic distribution
  - Die revisions
  - Assembly process changes
  - Material changes such as mold compound and lead finish
  - Electrical performance
  - Manufacturing location
- Extended temperature up to and including –55°C to +125°C
- Qualification pedigree to assure reliable operation over specified temperature range
- Assurance from TI that the IC will perform to datasheet electrical specifications in environments that require extended temperatures

TI's new products will offer an alternative to up screening for customers who believe that a plastic packaged part is suitable for their particular application. Although the EP products receive additional testing and process verification over and above their commercial counterparts, they may still not be suitable for all environments. For those applications that require a ceramic/hermetic packaged integrated circuit, TI has an expansive product line to meet those needs. More information on EP products is available at **www.ti.com/ep**.

TI Analog eLab™ Design Center

The Analog eLab™ Design Center Web site, **www.ti.com/analogelab**, offers designers a single site that allows access to the latest analog product information, design tools and technical information to help simplify and accelerate the design process.

A new feature of the Analog eLab is the SwitcherPro™ power supply design tool – TI's Pro Series of tools – and a new release of TINA-TI™ 7.0 simulation environment, which now includes SMPS (switch-mode power supply) simulation with acceleration.

The SwitcherPro tool enables designers to quickly and easily create both internally and externally compensated DC/DC power supply designs and analyze circuit performance. The SwitcherPro tool also has an effortless interface that permits users to work with multiple designs simultaneously.

The TINA-TI 7.0 simulation environment includes a comprehensive schematic editor and SPICE simulator for analog front-end circuit analysis with PSpice® syntax compatibility. The tool allows for optimized convergence algorithms for faster power management simulations and also provides behavioral elements support.*

**Disclaimer: This simulation tool should not be relied upon for designs involving medical applications. Systems designers are responsible for choosing the appropriate simulation tools for the specific application.*

The online Analog eLab Design Center supports the engineer through all steps of the analog design process, from concept to completion. A few examples of available resource areas in the Analog eLab Design Center include

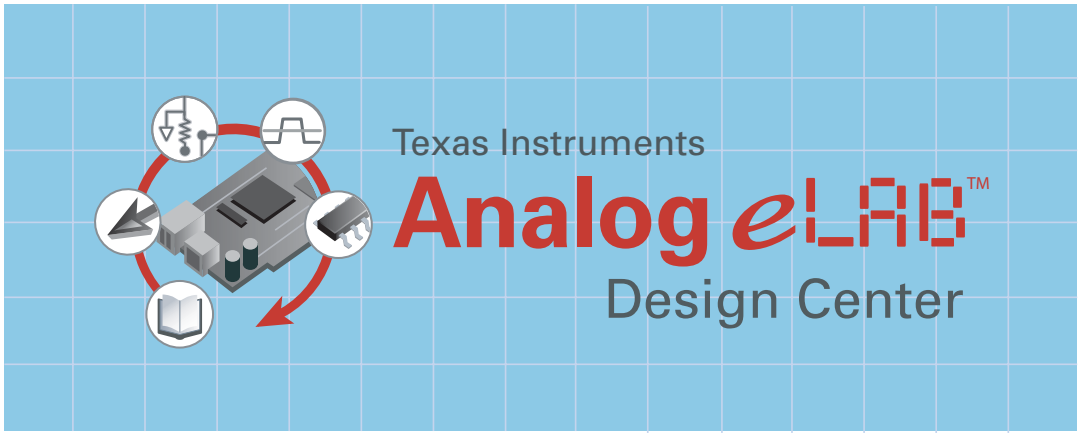
Learn – Through training such as Analog eLab Webcasts, designers can leverage a multitude of training material and TI's analog experts to aid in solving real-world design issues with practical, usable information.

Select – Several simple quick search tools assist designers in navigating through TI's robust analog portfolio to find specific product choices for their circuit needs.

Design – The TI Pro Series of design tools includes the newly-released SwitcherPro power supply design aide, as well as FilterPro™, OpAmpPro™ and MDACBufferPro™ tools. Engineers also have access to a large library of qualified reference designs to assist in developing the right solution.

Simulate – The Analog eLab Design Center offers designers the free SPICE-based TINA-TI simulation tool to analyze their circuit design. The TINA-TI program is powerful and easy-to-use for designing, simulating and analyzing analog circuits.

Sample – Engineers can request samples for fast, free delivery of TI products and buy products and evaluation modules in small quantities.



www.ti.com/analogelab

TI Design Tools

Below you'll find a sampling of the design tools TI offers to simplify your design process. To access any of the following application reports, type the URL **www-s.ti.com/sc/techlit/*litnumber*** and replace *litnumber* with the number in the Lit Number column.
For a complete list of analog application reports, visit: **analog.ti.com/appnotes**
For a complete list of DSP application reports, visit: **www.dspvillage.ti.com/tools**

Title	Lit Number
Amplifiers	
Single-Supply Operation of Isolation Amplifiers	SBOA004
Very Low Cost Analog Isolation with Power	SBOA013
Boost Instrument Amp CMR with Common-Mode Driven Supplies	SBOA014
DC Motor Speed Controller: Control a DC Motor without Tachometer Feedback	SBOA043
PWM Power Driver Modulation Schemes	SLOA092
Thermo-Electric Cooler Control Using a TMS320F2812 DSP and a DRV592 Power Amplifier	SPRA873
Isolation Amps Hike Accuracy and Reliability	SBOA064
Make a –10V to +10V Adjustable Precision Voltage Source	SBOA052
±200V Difference Amplifier with Common-Mode Voltage Monitor	SBOA005
AC Coupling Instrumentation and Difference Amplifiers	SBOA003
Extending the Common-Mode Range of Difference Amplifiers	SBOA008
Level Shifting Signals with Differential Amplifiers	SBOA038
Photodiode Monitoring with Op Amps	SBOA035
Single-Supply Operation of Isolation Amplifiers	SBOA004
Precision IA Swings Rail-to-Rail on Single 5V Supply	SBOA033
Pressure Transducer to ADC Application	SLOA056
Buffer Op Amp to ADC Circuit Collection	SLOA098
Amplifiers and Bits: An Introduction to Selecting Amplifiers for Data Converters	SLOA035B
Diode-Connected FET Protects Op Amps	SBOA058
Signal Conditioning Piezoelectric Sensors	SLOA033A
Diode-Based Temperature Measurement	SBOA019
Single-Supply, Low-Power Measurements of Bridge Networks	SBOA018
Thermistor Temperature Transducer to ADC Application	SLOA052
Signal Conditioning Wheatstone Resistive Bridge Sensors	SLOA034
Low-Power Signal Conditioning for a Pressure Sensor	SLAA034
Interfacing the MSP430 and TMP100 Temperature Sensor	SLAA151
Data Converters	
Interfacing the ADS8361 to the TMS320F2812 DSP	SLAA167
Interfacing the TLC2552 and TLV2542 to the MSP430F149	SLAA168
MSC1210 In-Application Flash Programming	SBAA087
Pressure Transducer to ADC Application	SLOA056
Measuring Temperature with the ADS1216, ADS1217, or ADS1218	SBAA073
SPI-Based Data Acquisition/Monitor Using the TLC2551 Serial ADC	SLAA108A
Implementing a Direct Thermocouple Interface with MSP430x4xx and ADS1240	SLAA125A
Using the ADS7846 Touch Screen Controller with the Intel SA-1110 StrongArm Processor	SBAA070
Complete Temp Data Acquisition System from a Single +5V Supply	SBAA050
Interfacing the ADS1210 with an 8xC51 Microcontroller	SBAA010
Programming Tricks for Higher Conversion Speeds Utilizing Delta Sigma Converters	SBAA005
Retrieving Data from the DDC112	SBAA026
Selecting an ADC	SBAA004
Synchronization of External Analog Multiplexers with the	SBAA013
The DDC112's Test Mode	SBAA025
Understanding the DDC112's Continuous and Non-Continuous Modes	SBAA024
Thermistor Temperature Transducer to ADC Application	SLOA052
Low-Power Signal Conditioning for a Pressure Sensor	SLAA034
Signal Acquisition and Conditioning with Low Supply Voltages	SLAA018
An Optical Amplifier Pump Laser Reference Design Based on the AMC7820	SBAA072

Title	Lit Number
Processors	
Microcontrollers	
Programming a Flash-Based MSP430 Using the JTAG Interface	SLAA149
Mixing C and Assembler with the MSP430	SLAA140
Implementing an Ultra-Low Power Keypad Interface with the MSP430	SLAA139
Heart Rate Monitor and EKG Monitor Using the MSP430FG439	SLAA280
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