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# 4-PLL Spread-Spectrum Clock Generator

## Features

- Input frequencies
  - Crystal input: 8 MHz to 48 MHz
  - Reference clock: 8 MHz to 250 MHz LVCMOS
  - Reference clock: 8 MHz to 700 MHz differential
- Output frequencies
  - 25 MHz to 700 MHz LVDS, LVPECL, HCSL, CML
  - 3 MHz to 250 MHz LVCMOS
  - 1 kHz to 8 MHz for one LVCMOS output
- RMS phase jitter: 1-ps max at 12-kHz to 20-MHz offset
- PCIe 1.0/2.0/3.0 compliant
- SATA 2.0, USB 2.0/3.0, 1/10-GbE compliant
- Maximum 12 outputs split in two banks with six outputs each.
  - Up to eight differential output pairs (HCSL, LVPECL, CML, or LVDS)
  - Up to 12 LVCMOS outputs

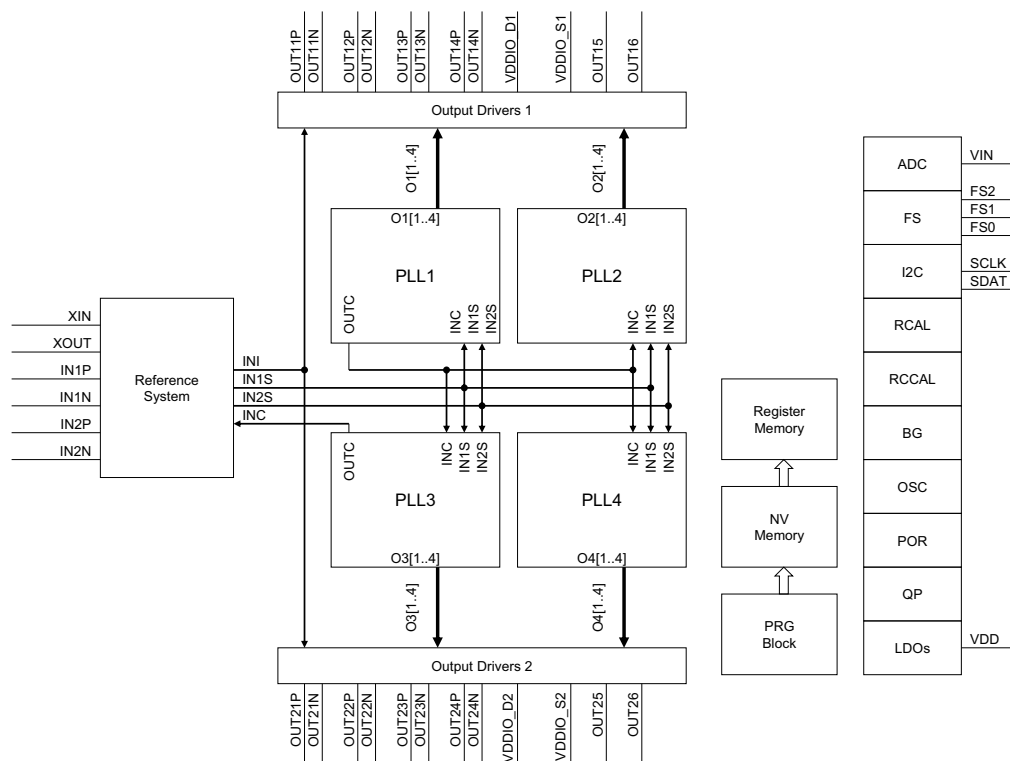
- Up to 100-ps skew for differential outputs within a bank
- Four fractional N-type phase-locked loops (PLLs) with
  - VCXO ( $\pm 120$  ppm with steps of 0.23 ppm)
  - Spread-spectrum capability (Logic SS and Lexmark profile 0.1% to 5% in 0.1% steps, down or center spread)
- Supply voltage: 1.8 V, 2.5 V, and 3.3 V
- Zero-delay buffer (ZDB) and non-zero delay buffer (NZDB) configurations
- I<sup>2</sup>C configurable with onboard programming
- Industrial-grade device, offered in 48-pin QFN (7 × 7 × 1.0 mm) package

## Functional Description

The CY27410 device configuration can be created using [ClockWizard 2.1](#). For programming support, contact Cypress technical support or send an email to [clocks@cypress.com](mailto:clocks@cypress.com).

For a complete list of related documentation, click [here](#).

## Logic Block Diagram



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## Functional Overview

The CY27410 is a standard-performance programmable clock generator with four independent fractional PLLs, which generates any frequency with a zero-ppm synthesis error. Each PLL is followed by a set of four independent dividers to generate four different frequencies from a single PLL. All four dividers are synchronized to generate phase-aligned clock outputs with minimal skew. The PLLs also support the spread-spectrum feature to reduce EMI. PLL 1 has VCXO functionality to achieve ppm granularity of output frequency.

The CY27410 accepts a crystal clock or a single-ended/differential reference clock. The device supports up to 12 outputs, divided into two banks with six outputs each. Four outputs of PLL 1 and PLL 2 are multiplexed to output Bank 1, and four clock outputs of PLL 3 and PLL 4 are multiplexed to output Bank 2. The 12 outputs of the two banks are configurable as eight differential outputs, 12 single-ended outputs, or a combination of differential and single-ended outputs.

The CY27410 has an on-chip volatile and nonvolatile memory, composed of eight registers, which store the device configuration settings. These registers can be accessed and programmed onboard through the I<sup>2</sup>C interface. You can also configure the device on-the-fly to completely reprogram the device on the application board. Besides the I<sup>2</sup>C interface, external signals can be applied to multifunction pins for different functions such as the following:

- Dynamically change the output frequency
- Output enable/disable
- Power down
- Spread ON/OFF

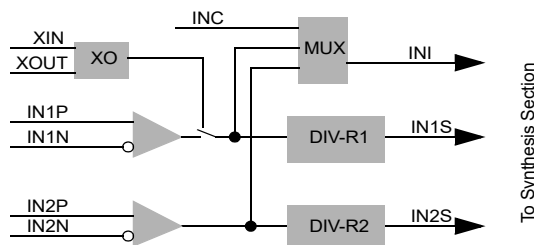
One low-frequency clock output, in kilohertz, is provided to meet the need of widely used reference frequencies, such as 32.768 kHz. The jitter specs of the CY27410 make it an ideal choice for the following communication protocols: PCIe 1.0/2.0/3.0, USB 2.0/3.0, SATA 1.0/2.0, and 1/10GbE.

## Input System

The input system supports the following (see Figure 1):

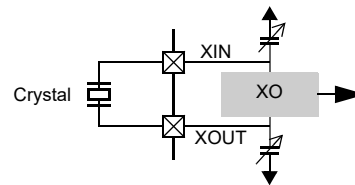
- XIN/XOUT supports crystal input.
- IN1 supports differential and single-ended clock inputs.
- IN2 supports differential and single-ended clock inputs.

**Figure 1. Oscillator/Clock Input Block Diagram**



If a crystal is used, XIN and XOUT are connected to a crystal oscillator to generate the required internal frequency, as shown in Figure 2. The supported differential tuning capacitor range is 8 pF to 12 pF.

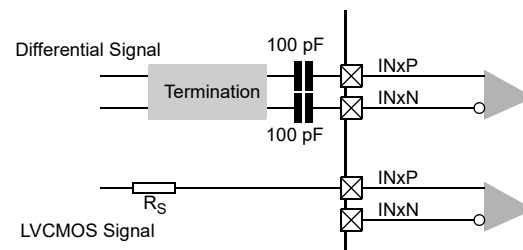
**Figure 2. Connecting a Crystal**



IN1 and IN2 are designed to accept either a single-ended or differential reference input. IN2 can be used to accept the feedback signal to implement the ZDB functionality of the device.

The differential inputs are capable of interfacing with multiple standards, such as LVPECL, LVDS, CML, and HCSL. The differential signals must be of AC-coupling, as shown in Figure 3.

**Figure 3. Interfacing Differential and Single-Ended Signals**



## VCXO Input Block

The VIN input is used for the VCXO functionality of the device. In this functionality, the output can change with respect to an input voltage required for audio-visual applications. The output frequency can vary up to  $\pm 120$  ppm. This input voltage directly controls the PLL 1 fractional divider to provide the VCXO functionality.

## Frequency Select Input

The CY27410 supports frequency-select features with which the customer can change output frequencies on-the-fly. The device has eight configuration register sets, which can be preprogrammed or written through I<sup>2</sup>C. Changing the signal level of the FS pins (high and low) selects the appropriate configuration registers and changes the output frequency accordingly.

## I<sup>2</sup>C Block (SCLK, SDAT)

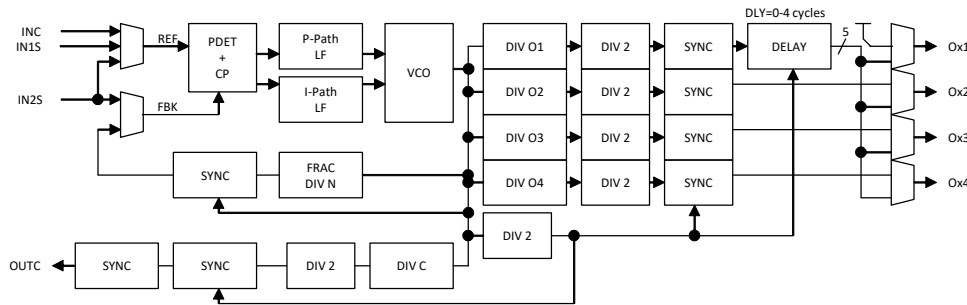
The CY27410 supports I<sup>2</sup>C programming of internal registers, which can be used to configure the device. The CY27410 also supports user-profile programming to flash memory and allows partial updates. Read, Write, or Read/Write protection is also available. The device is compliant with the I<sup>2</sup>C-bus Specification, version 2.1 or later. The critical I<sup>2</sup>C specifications are as follows:

- 400 kb/s (Fast mode)
- 7-bit addressing support
- Selectable device address (programmable), default = 69 hex (7 bits)

## Synthesis Section

The CY27410 contains four PLLs, which are the core synthesis blocks of the chip. Each PLL has a fractional N capability, which supports output frequency generation based on an input reference frequency to an accuracy of 100 ppb. The output of the PLL is fed into four dividers and then moves to synchronizers to generate glitch-free clock transition features, variable delay generation circuits to support the programmable delay feature, and so on. The output dividers and multiplexers are also included as part of this subsystem. All the four PLLs have the same architecture, as shown in Figure 4.

**Figure 4. PLL Architecture**

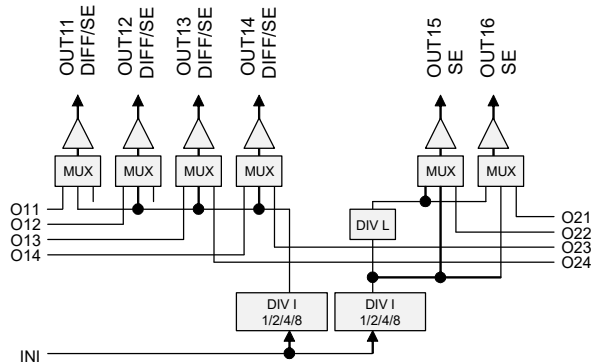


## Output Section

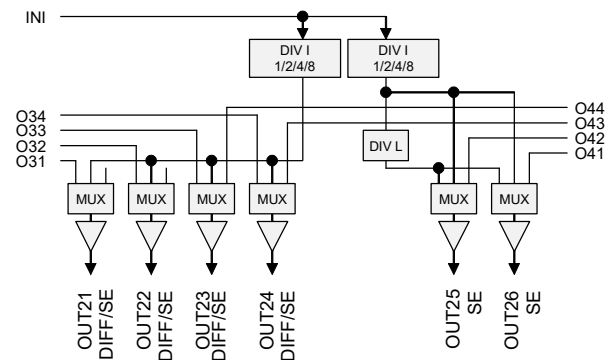
The CY27410 has two banks of outputs, which are located at the top and bottom of the device. Each bank consists of six outputs with OUT11–OUT14 and OUT21–OUT24 supporting both differential and single-ended outputs and OUT15–OUT16 and OUT25–OUT26 supporting only single-ended outputs.

Each output is fed from a PLL through a divider and then to a MUX, which helps in selecting the source for the output, as shown in Figure 5 and Figure 6.

**Figure 5. Bank1 Outputs**



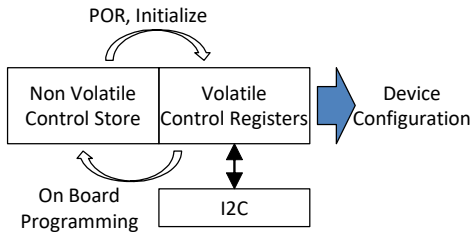
**Figure 6. Bank2 Outputs**



## Onboard Programming

One can write the device memory on the customer board, enabling the use of a blank device that is not preprogrammed. This enables use of the same device across multiple projects and lets you program the device based on individual projects. Conceptual onboard programming is shown in [Figure 7](#).

**Figure 7. Onboard Programming**



## Functional Features and Application Considerations

The CY27410 is a 4-PLL spread-spectrum clock generator targeted at consumer, industrial, and low-end networking applications. The key specifications of the part are differential inputs (2) and outputs (12), supporting frequencies up to 700 MHz. The device has a low RMS phase jitter of 1-ps max and value-added features, such as VCXO, Frequency Select, and PLL Bypass modes. This part is designed to support key standards, such as PCIe 1.0/2.0/3.0, USB 2.0/3.0, and 10GbE.

The product supports LVDS, LVPECL, CML, HCSL, and LVCMOS logic levels.

### Clock Generator

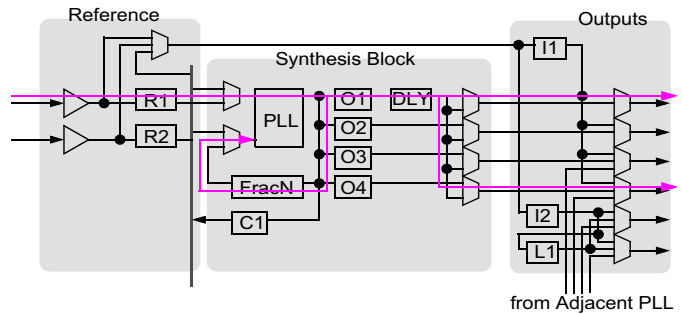
The main feature of the CY27410 is frequency generation from an external reference (IN1) or a crystal. There are four variables to determine the final output frequency. They are input REF, the DIV-R (R1), FracN (DIV-N) dividers, and the post dividers (DIV-O). The basic formula for determining the final output frequency is:

- Clock Generator mode
  - $f_{OUT} = ((REF \times DIV-N) / DIV-R) / DIV-O$

- PLL Bypass mode
  - $f_{OUT} = REF / DIV-I$  or  $REF / DIV-I / DIV-L$

The basic PLL block diagram is shown in [Figure 8](#). Each of the outputs from the PLL is fed to the output MUX through a Delay circuit that provides a certain delay to the individual clock, if needed.

**Figure 8. PLL Block Diagram, Clock Generation**



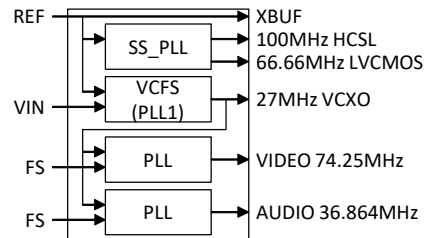
### PCIe (HCSL) Clock Generation

For PCIe applications, the CY27410 provides eight differential outputs that have the same spread on it at any particular point of time.

### VCXO and Related Frequencies

The CY27410 provides VCXO functionality and a cascading PLL option to generate critical frequencies with a fixed reference. Digital televisions have a requirement for the audio and video clocks to follow a 27-MHz VCXO signal so that they are synchronized. The architecture of the chip must ensure that this is met by cascading, as shown in [Figure 9](#).

**Figure 9. Cascading PLLs**



Apart from having the audio and video clocks following the 27-MHz VCXO input, they also need complex divider ratios to generate the output frequencies. Commonly used divider ratios for audio and video signals are listed in [Table 1](#).

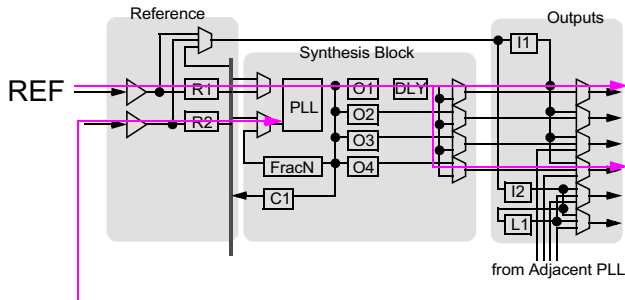
**Table 1. Audio and Video Frequencies**

Output Frequency	Ratios
74.17582418	91:250
33.8688	625:784
22.5792	1875:1568
16.9344	1250:784
11.2896	1875:784
5.6448	1875:392
36.864	375:512

### Zero-Delay Buffer Functionality

The CY27410 acts as a zero-delay buffer (ZDB) for one output from a single PLL block. To implement this feature, take one of the outputs and send it back as a feedback reference to the PLL. By providing a divider in the feedback loop, the device can also act as a frequency-multiplying ZDB (see Figure 10). This functionality is supported only when the PLL is in the integer N mode.

**Figure 10. ZDB Configuration**

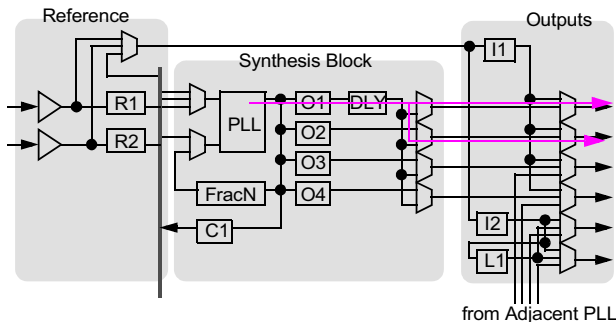


The CY27410 provides the frequency-multiplying ZDB by modulating the R1 and R2 values in the integer ratio. If both the values are identical, the CY27410 acts as a simple ZDB.

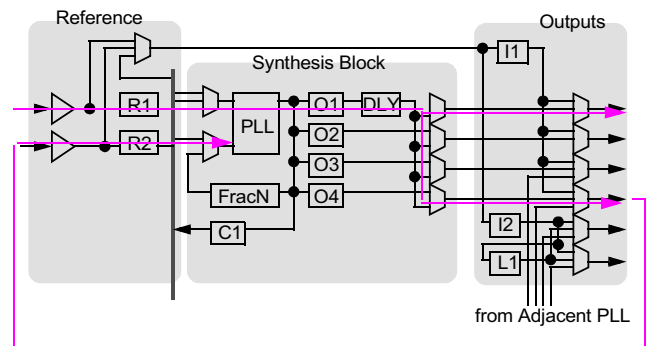
### Early/Late Output Phase

The CY27410 supports a delay circuit in the divider to provide 0 to  $4 \times VCO/2$  cycles. Therefore, an output has a certain lag phase or lead phase to other outputs when this feature is used. This functionality is also available in the ZDB mode and provides “early” phase or “delayed” phase to the Reference input. Refer to Figure 11 and Figure 12.

**Figure 11. Early/Delayed Phase Output**



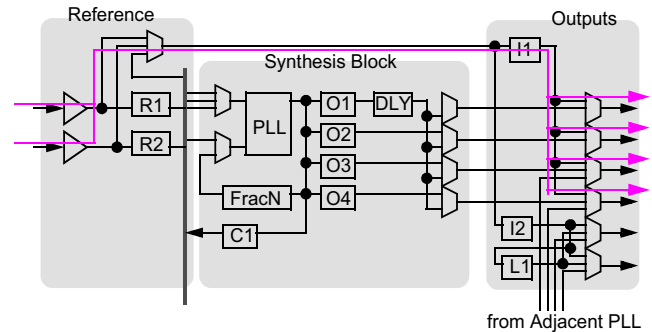
**Figure 12. Early/Late Phase in ZDB Configuration**



### Non-Zero Delay Buffer

The CY27410 supports the PLL-bypass mode, which bypasses the entire synthesis block to act as a configurable non-zero delay buffer (NZDB) with level translation and selectable inputs, as shown in Figure 13.

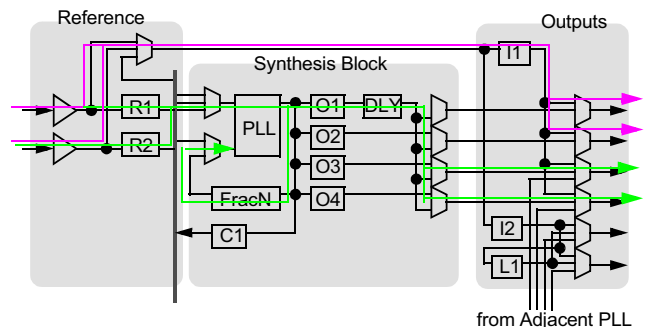
**Figure 13. NZDB Configuration**



### Combination Clock Generator and Buffer

The CY27410 provides a combination of a clock generator and a buffer in one device. This is achieved by configuring the input and output selectors for the desired split configuration. An example of such an application is shown in Figure 14.

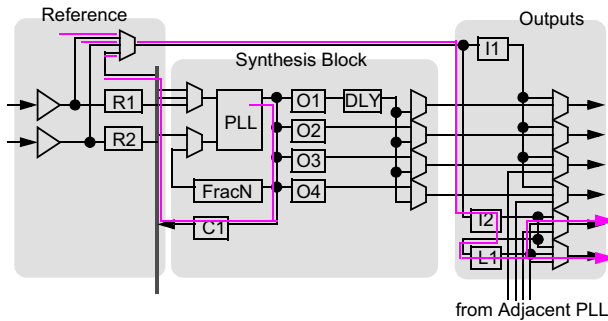
**Figure 14. Clock Generator and NZDB**



### Low-Frequency Output

The CY27410 integrates low-frequency generator counters for LVCMOS outputs that may be used for watchdog-time and/or kHz-order clocks for application, as shown in Figure 15.

**Figure 15. Low-frequency Output Option**



### Spread Spectrum

To help reduce electromagnetic interference (EMI), the CY27410 supports spread-spectrum modulation. The output clock frequencies can be modulated to spread energy across a broader range of frequencies and lower system EMI. The CY27410 implements two types of spread profiles for modulation: linear and nonlinear.

The spread spectrum can be applied to any output clock, any frequency, and any spread amount ranging from 0.1% to 5% in 0.1% steps. The center or down spread can be programmable.

The spread modulation rate is limited from 30 kHz to 60 kHz.

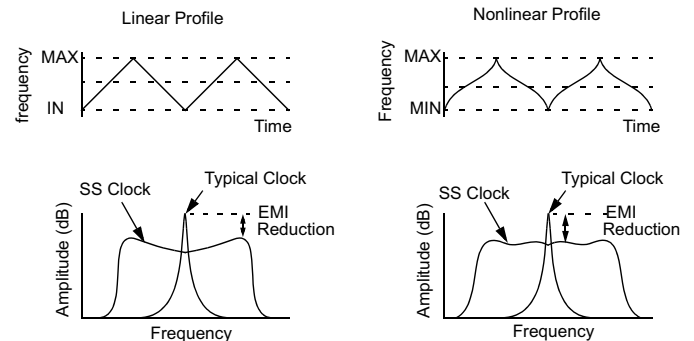
The spread spectrum is generated digitally in the FracN modulation, which means all the parameters are independent of process, voltage, and temperature variations. All the frequencies generated by the same PLL have the same amount of modulation.

As shown in Figure 16, a harmonic of a modulated clock has a much lower amplitude than that of an unmodulated signal. The reduction in amplitude is dependent on the harmonic number and the frequency deviation or spread. The equation for the reduction in the nonlinear profile is:

$$\text{dB} = 6.5 + 9 * \log_{10}(P) + 9 * \log_{10}(F)$$

where P is the percentage of deviation and F is the frequency in megahertz where the reduction is measured.

**Figure 16. Spread-Spectrum Profile**



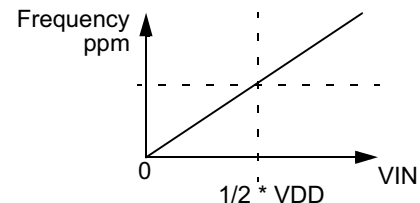
### VCXO (VCFS) Functionality

The CY27410 supports VCXO functionality without pulling the crystal frequency. This function is implemented by modulating the FracN counter according to the VIN level, as shown in Figure 17. Therefore, this is called voltage-controlled frequency shift (VCFS).

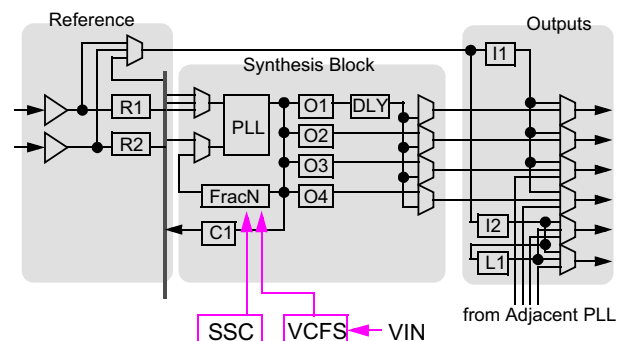
The VCFS function is implemented by modulating the FracN divider, which means all the parameters are independent of the process, voltage, and temperature variations.

It is not possible to combine the VCFS operation with spread spectrum (see Figure 18).

**Figure 17. VCFS Profile**



**Figure 18. VCFS and Spread Spectrum**





### Crystal Oscillator

The CY27410 supports various low-cost crystals as a reference oscillator at IN1 (XIN/XOUT) to generate multiple frequencies in a single chip. The CY27410 supports a crystal with a nominal load capacitance specification from 8 pF to 12 pF. As shown in [Figure 2 on page 3](#), the CY27410 integrates all the components, such as a feedback resistor and tuning capacitor, to oscillate the clock with a particular crystal for the following specifications.

To enable proper operation, the crystal specification is divided into three ranges:

- Low range ( $F_{NOM}$ ) = 8 to 12 MHz
- Midrange = 12 to 20 MHz
- High range = 20 to 48 MHz

The corresponding crystal parameters are listed in [Table 2](#).

**Table 2. Crystal Specifications**

Range	Min Frequency (MHz)	Max Frequency (MHz)	Max R1 (ohms)	Max DL ( $\mu$ W)
Low	8	12	150	100
Mid	12	20	70	100
High	20	48	50	100
<b><math>C_L</math> (pF) for all Ranges</b>		<b>Associated Max <math>C_0</math> (pF)</b>		
8		2		
9		2		
10		2		
12		3		

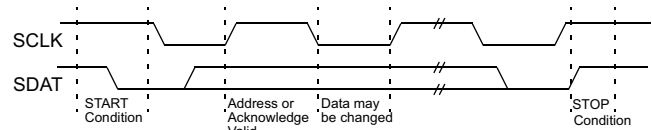
### Serial Programming Interface Protocol

The CY27410 uses the SDAT and SCLK pins for a 2-wire serial interface that operates up to 400 Kb/s in Read and Write modes. It complies with the I<sup>2</sup>C bus standard. The basic Write protocol is:

Start Bit; 7-bit Device Address; R/W Bit; Slave Clock Acknowledge (ACK); 8-bit Memory Address (MA); ACK; 8-bit Data; ACK; 8-bit Data in MA+1 if desired; ACK; 8-bit Data in MA+2; ACK; and more until STOP Bit.

The basic serial format is shown in [Figure 19](#).

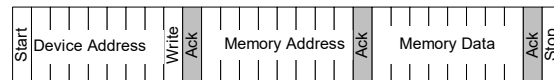
**Figure 19. Data Transfer Sequence on the Serial Bus**



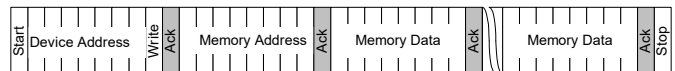
A valid write operation must have a full 8-bit register address after the device address word from the master, which is followed by an acknowledge bit from the slave (SDAT = 0/LOW). The next eight bits must contain the data word intended for storage. After the data word is received, the slave responds with another acknowledge bit (SDAT = 0/LOW), and the master must end the write sequence with a STOP condition (see [Figure 20](#)).

**Figure 20. Data Frame Architecture (Write)**

#### Random Write



#### Sequential Write



Read operations are initiated the same way as write operations, except that the R/W bit of the slave address is set to '1' (HIGH).

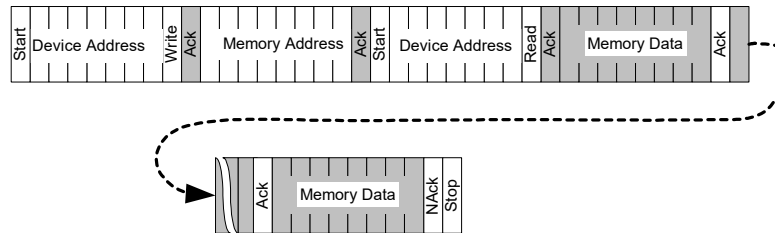
There are two basic read operations: random read and sequential read. [Figure 21](#) illustrates these operations.

**Figure 21. Data Frame Architecture (Read)**

#### Random Read



#### Sequential Read



Through random read operations, the master may access any memory location. To perform this type of read operation, first set the word address. Send the address to the CY27410 as part of a write operation. After the word address is sent, the master generates a START condition following the acknowledge. This terminates the write operation before any data is stored in the address, but not before the internal address pointer is set. Next, the master reissues the control byte with the R/W byte set to '1'.

Then, the CY27410 issues an acknowledge and transmits the 8-bit word. The master device does not acknowledge the transfer, but does generate a STOP condition, which causes the CY27410 to stop transmission.

Sequential read operations follow the same process as random reads, except that the master issues an acknowledge instead of a STOP condition after transmission of the first 8-bit data word. This action results in an incrementing of the internal address pointer, and subsequently output of the next 8-bit data word. By continuing to issue acknowledges instead of STOP conditions, the master may serially read the entire contents of the slave device memory.

## Pinouts

The CY27410 devices are available in the 48-pin QFN package.

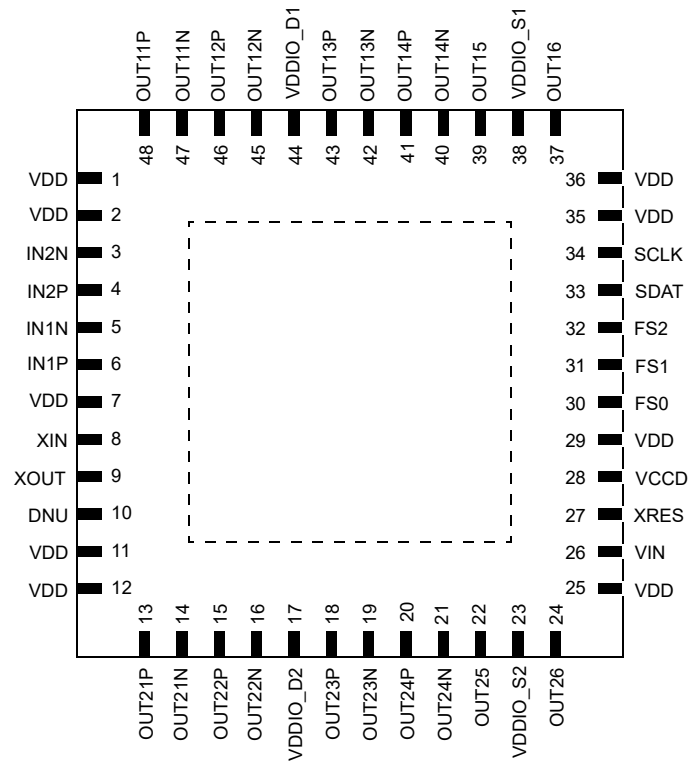
**Table 3. CY27410 Pin Definitions**

Name	I/O	Type	# of Pins	Pin #	Function
XIN	I	Crystal	1	8	XIN for crystal
XOUT	O	Crystal	1	9	XOUT for crystal
IN1P	I	LVC MOS/ Differential	1	6	True input for IN1 differential pair. IN1 for LVC MOS input. Need external series capacitor for differential input.
IN1N	I	Differential	1	5	Complement input for IN1 differential pair. None for LVC MOS input. Need external series capacitor for differential input.
IN2P	I	LVC MOS / Differential	1	4	Feedback input for ZDB mode. True input for IN2 differential pair. IN2 for LVC MOS input Need external series CAPS for differential input.
IN2N	I	Differential	1	3	Feedback input for ZDB mode. Complement input for IN2 differential pair. None for LVC MOS input. Need external series CAPS for differential input.
OUT15	O	LVC MOS	1	39	LVC MOS clock output 15
OUT16	O	LVC MOS	1	37	LVC MOS clock output 16
OUT11P	O	LVC MOS / Differential	1	48	Output 11 true output (differential) or Output 11 LVC MOS
OUT11N	O	Differential	1	47	Output 11 complement output (differential) connect to OUT11P for LVC MOS
OUT12P	O	LVC MOS / Differential	1	46	Output 12 true output (differential) or LVC MOS clock output 12
OUT12N	O	Differential	1	45	Output 12 complement output (differential) connect to OUT12P for LVC MOS
OUT13P	O	LVC MOS / Differential	1	43	Output 13 complement output (differential) or Output 13 LVC MOS
OUT13N	O	Differential	1	42	Output 13 complement output (differential) connect to OUT13P for LVC MOS
OUT14P	O	LVC MOS / Differential	1	41	Output 14 true output (differential) or Output 14 LVC MOS output
OUT14N	O	Differential	1	40	Output 14 complement output (differential) connect to OUT14P for LVC MOS
OUT21P	O	LVC MOS / Differential	1	13	Output 21 true output (differential) or Output 21 LVC MOS output
OUT21N	O	Differential	1	14	Output 21 complement output (differential) connect to OUT21P for LVC MOS
OUT22P	O	LVC MOS / Differential	1	15	Output 22 true output (differential) or Output 22 LVC MOS output
OUT22N	O	Differential	1	16	Output 22 complement output (differential) connect to OUT22P for LVC MOS
OUT23P	O	LVC MOS / Differential	1	18	Output 23 true output (differential) or Output 23 LVC MOS output
OUT23N	O	Differential	1	19	Output 23 complement output (differential) connect to OUT23P for LVC MOS
OUT24P	O	LVC MOS / Differential	1	20	Output 24 true output (differential) or Output 24 LVC MOS output

**Table 3. CY27410 Pin Definitions** *(continued)*

Name	I/O	Type	# of Pins	Pin #	Function
OUT24N	O	Differential	1	21	Output 24 complement output (differential) connect to OUT24P for LVCMOS
OUT25	O	LVCMOS	1	22	LVCMOS clock output 25
OUT26	O	LVCMOS	1	24	LVCMOS clock output 26
DNU			1	10	Pin for test purpose
SDAT	I/O	LVCMOS / Open Drain	1	33	I <sup>2</sup> C serial data pin
SCLK	I	LVCMOS	1	34	I <sup>2</sup> C clock pin
FS0	I	LVCMOS	1	30	Frequency Select pin
FS1	I	LVCMOS	1	31	Frequency Select pin
FS2	I	LVCMOS	1	32	Frequency Select pin
VIN	I	Analog	1	26	Voltage input for ADC
VDDIO_D1	PWR	PWR	1	44	Output power supply for Bank 1 differential outputs
VDDIO_S1	PWR	PWR	1	38	Output power supply for Bank 1 LVCMOS outputs
VDDIO_D2	PWR	PWR	1	17	Output power supply for Bank 2 Differential outputs
VDDIO_S2	PWR	PWR	1	23	Output power supply for Bank 2 LVCMOS outputs
VDD	PWR	PWR	9	1, 2, 7, 11, 12, 25, 29, 35, 36	Core power supply
XRES	I	LVCMOS	1	27	Active low RESET SIGNAL
GND	GND	GND	E-PAD		Supply ground
VCCD	Analog	Analog	1	28	For 1.8-V operation, connect to VDD. For 2.5-V or 3.3-V operation, do not connect to VDD; connect a 100-nF capacitor between this pin and GND.

**Figure 22. 48-Pin QFN Pinout**



## Electrical Specifications

Exceeding maximum ratings may shorten the useful life of the device.

### Absolute Maximum Ratings

**Table 4. Absolute Maximum Ratings**

Symbol	Description	Conditions	Min	Typ	Max	Units
$V_{DD}$	Core supply voltage		-0.5	—	4.6	V
$V_{DDIOX}$	Output bank supply voltage		-0.5	—	4.6	V
$V_{IN}$	Input voltage	Relative to $V_{SS}$	-0.5	—	$V_{DD} + 0.4$	V
$V_{IN2C}$	I2C Bus input voltage	SCLK, SDAT pins	-0.5	—	6	V
$T_S$	Storage temperature	Non functional	-55	—	+150	°C
$ESD_{HBM}$	ESD (human body model)	JEDEC JS-001-2012	2000	—	—	V
$ESD_{CDM}$	ESD (charged device model)	JEDEC JESD22-C101E	500	—	—	V
$ESD_{MM}$	ESD (machine model)	JEDEC JESD22-A115B	200	—	—	V
LU	Latchup	JEDEC JESD78D	—	—	140	mA
UL-94	Flammability rating	V-0 at 1/8 in	—	—	10	ppm
MSL	Moisture sensitivity level		—	3	—	

### Operating Temperature

**Table 5. Operating Temperature**

Symbol	Description	Conditions	Min	Typ	Max	Units
$T_A$	Ambient temperature		-40	—	+85	°C
$T_J$	Junction temperature		-40	—	+100	°C

### Operating Power Supply

**Table 6. Operating Power Supply**

Symbol	Description	Conditions	Min	Typ	Max	Units
$V_{DD}$	Core supply voltage	1.8-V range: $\pm 5\%$	1.71	1.80	1.89	V
		2.5-V range: $\pm 10\%$	2.25	2.50	2.75	V
		3.3-V range: 5%	3.13	3.3	3.46	V
$V_{DDIO}$	Output supply voltage	1.8-V range: $\pm 5\%$	1.71	1.80	1.89	V
		2.5-V range: $\pm 10\%$	2.25	2.50	2.75	V
		3.3-V range: 5%	3.13	3.30	3.46	V
$I_{DDO}$	Power supply current per pair	LVPECL, output pair terminated 50 $\Omega$ to $V_{TT}$ ( $V_{DD} - 2$ V)	—	—	38.0	mA
		LVPECL, output pair terminated 50 $\Omega$ to $V_{TT}$ ( $V_{DD} - 1.7$ V)	—	—	27.0	mA
$I_{DDO}$	Power supply current per pair	LVDS, output pair terminated 100 $\Omega$	—	—	13.25	mA
$I_{DDO}$	Power supply current per pair	HCSL, output pair terminated 33 $\Omega$ to 49.9 $\Omega$ to GND	—	—	26.5	mA
$I_{DDO}$	Power supply current per pair	CML, output pair terminated 50 $\Omega$ to $V_{DD}$	—	—	18.0	mA
$I_{DDO}$	Power supply current per pair	CMOS, 10-pF load, 33 MHz	—	—	6.0	mA
$I_{DDPLL1}$	Current consumption per PLL	Includes DIVC	—	—	26.5	mA
$I_{DDXO}$	XO/Input block current consumption	XO or IN1 input buffer on, IN2 input buffer off	—	—	3.5	mA

**Table 6. Operating Power Supply (continued)**

Symbol	Description	Conditions	Min	Typ	Max	Units
$I_{DDPM}$	Power management block current consumption		–	–	2.5	mA
$t_{PLLLOCK}$	PLL lock time	Time from PLL enabled to PLL stable (PLL reaches at $\pm 1$ -ppm accuracy)	–	–	250	$\mu$ s
$t_{LOCK}$	Device power-up time	Time from minimum specified $V_{DD}$ to Output Stable in XO-based clock gen mode. In the case of external clock input, $t_{LOCK}$ will reduce by the crystal oscillator startup time ( $t_{OSCSTART}$ ). This specification is valid when the reference is available and stable at startup. For supply ramps slower than the $t_{PU\_SR}$ spec where customers use XRES during power up. Power-up time will be calculated from the release of XRES to output stable.	–	–	10.0	ms
$t_{OSCSTART}$	Crystal oscillator startup time	Time from crystal oscillator power-up to crystal oscillator stable. Crystal $F_{NOM} = 25$ MHz, $C1 > 1$ fF	–	–	4	ms
$t_{PU\_SR}$	Power supply slew rate during power up	Power-supply ramp rate for $V_{DD}$ to reach minimum specified voltage (power ramp must be monotonic). For supply ramps slower than 1 V/ms, use XRES to externally keep the part in RESET during power-up and release XRES after $V_{DD}$ reaches the minimum specification.	1	–	67	V/ms

## DC Chip-Level Specifications

**Table 7. DC Electrical Specifications Input**

Symbol	Description	Conditions	Min	Typ	Max	Units
$V_{IH33}$	Input high voltage	LVC MOS and logic inputs, $V_{DD} = 3.3$ V	2.0	–	–	V
$V_{IH25}$	Input high voltage	LVC MOS and logic inputs, $V_{DD} = 2.5$ V	1.7	–	–	V
$V_{IH18}$	Input high voltage	LVC MOS and logic inputs, $V_{DD} = 1.8$ V	1.1	–	–	V
$V_{IL33}$	Input low voltage	LVC MOS and logic inputs, $V_{DD} = 3.3$ V	–	–	0.8	V
$V_{IL25}$	Input low voltage	LVC MOS and logic inputs, $V_{DD} = 2.5$ V	–	–	0.7	V
$V_{IL18}$	Input low voltage	LVC MOS and logic inputs, $V_{DD} = 1.8$ V	–	–	0.5	V
$V_{DIFF}$	Differential input	LVDS, CML, PECL, HCSL. Differential amplitude, pk.	0.30	–	1.45	V
$DC_{DIFF}$	Duty cycle, differential clock input	Measured at crossing point	40	50	60	%
$DC_{LVC MOS}$	Duty cycle, LVC MOS clock input	Measured at $1/2 V_{DD}$	40	50	60	%
$I_{IH}$	Input high current	Input = $V_{DD}$	–	–	150	$\mu$ A
$I_{IL}$	Input low current	Input = GND	–150	–	–	$\mu$ A
$C_{IN}$	Input capacitance, IN1, IN2	Measured at 10 MHz, differential	–	–	3.0	pF
$V_{PPSINE}$	AC input swing pk	Clipped sine wave, AC coupled through a 1000-pF capacitor.	0.8	1.0	1.2	V
$R_P$	Input pull-down resistance	LVC MOS clock input	75	115	170	k $\Omega$

## DC Output Specifications

**Table 8. DC Specifications for LVCMOS Output**

Symbol	Description	Conditions	Min	Typ	Max	Units
$V_{OH}$	Output high voltage	4-mA load	$V_{DDIO} - 0.3$	—	—	V
$V_{OL}$	Output low voltage	4-mA load	—	—	0.3	V

**Table 9. DC Specifications for LVDS Output ( $V_{DDIO} = 2.5\text{-V}$  or  $3.3\text{-V}$  range)**

Symbol	Description	Conditions	Min	Typ	Max	Units
$V_{PP}$	LVDS output AC single-ended pk-pk,	8 MHz to 325 MHz	250	—	510	mV
$V_{PP}$	LVDS output AC single-ended pk-pk	325 MHz to 700 MHz	200	—	510	mV
$\Delta V_{PP}$	Change in $V_{PP}$ between complementary output states		—	—	50	mV
$V_{OCM}$	Output common-mode voltage	Met only at 2.5 V and 3.3 V. Need AC coupling for 1.8-V operation	1.125	1.200	1.375	V
$\Delta V_{OCM}$	Change in $V_{OCM}$ between complementary output states		—	—	50	mV
$I_{OZ}$	Output leakage current	Output off, $V_{OUT} = 0.75\text{ V}$ to $1.75\text{ V}$	–20	—	20	$\mu\text{A}$

**Table 10. DC Specifications for LVPECL Output ( $V_{DDIO} = 2.5\text{-V}$  or  $3.3\text{-V}$  range)**

Symbol	Description	Conditions	Min	Typ	Max	Units
$V_{OH}$	Output high voltage	$R\text{-term} = 50\ \Omega$ to $V_{TT}$ ( $V_{DDIO} - 2.0\text{ V}$ )	$V_{DDIO} - 1.165$	—	$V_{DDIO} - 0.800$	V
$V_{OL}$	Output low voltage	$R\text{-term} = 50\ \Omega$ to $V_{TT}$ ( $V_{DDIO} - 2.0\text{ V}$ )	$V_{DDIO} - 2.0$	—	$V_{DDIO} - 1.620$	V
$V_{PP}$	LVPECL output AC single ended pk-pk,	$f_{OUT} = 8\text{ MHz}$ to $150\text{ MHz}$	450	—	—	mV
		$f_{OUT} = 150\text{ MHz}$ to $700\text{ MHz}$	320	—	—	mV

**Table 11. DC Specifications for CML Output ( $V_{DDIO} = 2.5\text{-V}$  or  $3.3\text{-V}$  range)**

Symbol	Description	Conditions	Min	Typ	Max	Units
$V_{OH}$	Output high voltage	$R\text{-term} = 50\ \Omega$ to $V_{DDIO}$	$V_{DDIO} - 0.1$	—	—	V
$V_{OL}$	Output low voltage	$R\text{-term} = 50\ \Omega$ to $V_{DDIO}$	$V_{DDIO} - 0.7$	—	$V_{DDIO} - 0.3$	V
$V_{PP}$	CML output AC single-ended pk-pk	$f_{OUT} = 8\text{ MHz}$ to $150\text{ MHz}$	250	—	700	mV
$V_{PP}$	CML output AC single-ended pk-pk	$150 < f_{OUT} < 700\text{ MHz}$	200	—	600	mV



**Table 12. DC Specifications for HCSL Output ( $V_{DDIO} = 2.5\text{-V}$  or  $3.3\text{-V}$  range)**

Symbol	Description	Conditions	Min	Typ	Max	Units
$V_{OCM}$	Output common mode voltage	Common mode	350	—	400	mV
$V_{OHDIFF}$	Differential output high voltage	Measurement taken from differential waveform	150	—	—	mV
$V_{OLDIFF}$	Differential output low voltage	Measurement taken from differential waveform	—	—	–150	mV
$V_{CROSS}$	Absolute crossing point voltage	Measurement taken from single-ended waveform	250	—	550	mV
$V_{CROSSDELTA}$	Variation of $V_{CROSS}$ over all rising clock edges	Measurement taken from single-ended waveform	—	—	140	mV

**Table 13. Input Frequency Range**

Symbol	Description	Conditions	Min	Typ	Max	Units
$F_{CRYSTAL}$	Crystal frequency	Fundamental AT CUT crystal	8	—	48	MHz
$F_{REFERENCE}$	Reference frequency	Internal reference to PLL	8	—	40	MHz
$F_{INCMOS}$	LVC MOS input frequency	Buffer mode, all PLLs OFF	8	—	250	MHz
$F_{INCMOS}$	LVC MOS input frequency	Buffer mode, one or more PLL active	8	—	125	MHz
$F_{INCMOS}$	LVC MOS input frequency	CLKGEN mode	8	—	250	MHz
$F_{INCMOS}$	LVC MOS input frequency	ZDB mode, PLL in integer N configuration	8	—	250	MHz
$F_{INDIFF}$	Differential clock input frequency	Buffer mode, all PLLs OFF	8	—	700	MHz
$F_{INDIFF}$	Differential clock input frequency	Buffer mode, one or more PLL active	8	—	125	MHz
$F_{INDIFF}$	Differential clock input frequency	CLKGEN mode	8	—	300	MHz
$F_{INDIFF}$	Differential clock input frequency	ZDB mode, PLL in integer N configuration	8	—	300	MHz
$F_{INCAS}$	Cascading clock frequency	Internal cascading frequency in the Buffer mode	8	—	125	MHz

## AC Input Clock Specifications

**Table 14. AC Input Clock Electrical Specification**

Symbol	Description	Conditions	Min	Typ	Max	Units
$t_{CMOSDC}$	LVC MOS clock input duty cycle	Measured at $1/2 V_{DD}$ 20%–80%, Functional	40	50	60	%
$t_{DIFFDC}$	Differential clock input duty cycle	Measured at $V_{OCM}$ 20%–80%, Functional	40	50	60	%
$t_{RFCMOS}$	LVC MOS clock input rise/fall time	Measured between 20%–80% of $V_{DD}$	—	—	4	ns

## AC Output Specifications

**Table 15. AC Electrical Specifications LVC MOS Output. Load:  $15\text{ pF} < 100\text{MHz}$ ,  $7.5\text{ pF} < 200\text{ MHz}$ ,  $5\text{ pF} > 200\text{ MHz}$** 

Symbol	Description	Conditions	Min	Typ	Max	Units
<b>Common AC Electrical Specifications</b>						
$t_{RFCMOS}$	Rise/fall time	$f_{OUT} < 100\text{MHz}$ , 20%–80%	—	—	2.0	ns
$t_{RFCMOS}$	Rise/fall time	$f_{OUT} < 200\text{MHz}$ , 20%–80%	—	—	1.5	ns
$t_{RFCMOS}$	Rise/fall time	$f_{OUT} < 250\text{MHz}$ , 20%–80%	—	—	1.3	ns
$t_{SKEW}$	Output to output skew	Equally loaded, measured at $1/2 V_{IOX}$ , in a bank, derived from the same PLL,	—	—	150	ps

**Table 15. AC Electrical Specifications LVCMOS Output. Load: 15 pF < 100MHz, 7.5 pF < 200 MHz, 5 pF > 200 MHz (continued)**

Symbol	Description	Conditions	Min	Typ	Max	Units
<b>Buffer Mode</b>						
$f_{OUT}$	Output frequency	All PLLs off	8	—	250	MHz
$f_{OUT}$	Output frequency	With one or more PLL running	8	—	125	MHz
$t_{DC}$	Output duty cycle	Measured at 1/2 $V_{IOX}$ . Input DC = 50%	40	50	60	%
$t_{JIT\_ADD}$	Additive RMS phase jitter	$f_{OUT}$ = 156.25 MHz, 12 kHz-20 MHz offset, DIVI=1. Input slew rate 1.8 V/ns, 20%–80% $V_{DD}$	—	0.7	1.0	ps
$t_{DELAY}$	Propagation delay	Input to output delay	—	—	7.0	ns
<b>ZDB Mode (IN1 = REF, Differential or LVCMOS feedback to IN2)</b>						
$f_{OUT}$	Output frequency		8	—	250	MHz
$t_{DC}$	Output duty cycle	Measured at 1/2 $V_{IOX}$ , $f_{OUT}$ > 200 MHz, $V_{DDIO}$ = 2.5 V or 3.3 V. $f_{OUT}$ > 100MHz, $V_{DDIO}$ = 1.8 V	40	50	60	%
$t_{DC}$	Output duty cycle	Measured at 1/2 $V_{IOX}$ , $f_{OUT}$ ≤ 200 MHz $V_{DDIO}$ = 2.5 V or 3.3 V. $f_{OUT}$ ≤ 100 MHz, $V_{DDIO}$ = 1.8 V	45	50	55	%
$t_{OCCJ}$	Cycle-to-cycle jitter	pk, measured at 1/2 $V_{IOX}$ over 10-k cycle, $f_{OUT}$ = 100 MHz. Input slew rate 1.8 V/ns, 20%–80% $V_{DD}$ . Configuration dependent	—	—	50	ps
$t_{PJ}$	Period jitter	pk-pk, measured at 1/2 $V_{IOX}$ over 10-k cycle, $f_{OUT}$ = 100 MHz. Input slew rate 1.8 V/ns, 20%–80% $V_{DD}$ . Configuration dependent	—	—	100	ps
$t_{PDELAY}$	Propagation delay	Measured at 1/2 $V_{IOX}$ ±250 ps excludes any delay added onboard (from output to inputs). Delay onboard ( $t_{DELAY\_BOARD}$ ) must not exceed 2-ns max. Total delay in the ZDB mode is $t_{DELAY\_BOARD} + t_{PDELAY}$	–350	—	350	ps
<b>CLKGEN Mode</b>						
$f_{OUT}$	Output frequency		3	—	250	MHz
$f_{OUTL}$	Low frequency output	1 kHz is supported when the max input frequency to DIVL is 48 MHz	0.001	—	50	MHz
$t_{DC}$	Output duty cycle	Measured at 1/2 $V_{IOX}$ , $f_{OUT}$ > 200 MHz, $V_{DDIO}$ = 2.5 V or 3.3 V. $f_{OUT}$ > 100 MHz, $V_{DDIO}$ = 1.8 V	40	50	60	%
$t_{DC}$	Output duty cycle	Measured at 1/2 $V_{IOX}$ , $f_{OUT}$ ≤ 200 MHz $V_{DDIO}$ = 2.5 V or 3.3 V. $f_{OUT}$ ≤ 100 MHz, $V_{DDIO}$ = 1.8 V	45	—	55	%
$t_{CCJ}$	Cycle-to-cycle jitter	pk, measured at 1/2 $V_{IOX}$ over 10-k cycle, $f_{OUT}$ =100 MHz. Configuration dependent	—	—	50	ps
$t_{PJ}$	Period jitter	pk-pk, measured at 1/2 $V_{IOX}$ over 10-k cycle, $f_{OUT}$ = 100 MHz. Input reference 25-MHz crystal. Configuration dependent	—	—	100	ps

**Table 15. AC Electrical Specifications LVCMOS Output. Load: 15 pF < 100MHz, 7.5 pF < 200 MHz, 5 pF > 200 MHz (continued)**

Symbol	Description	Conditions	Min	Typ	Max	Units
<b>SSC Mode</b>						
$f_{OUT}$	Output frequency		3	–	250	MHz
$t_{DC}$	Output duty cycle	Measured at 1/2 $V_{IOX}$ , $f_{OUT} > 200$ MHz, $V_{DDIO} = 2.5$ V or 3.3 V. $f_{OUT} > 100$ MHz, $V_{DDIO} = 1.8$ V	40	50	60	%
$t_{DC}$	Output duty cycle	Measured at 1/2 $V_{IOX}$ , $f_{OUT} \leq 200$ MHz $V_{DDIO} = 2.5$ V or 3.3 V. $f_{OUT} \leq 100$ MHz, $V_{DDIO} = 1.8$ V	45	50	55	%
$t_{CCJ}$	Cycle-to-cycle jitter	pk, measured at 1/2 $V_{IOX}$ over 10-k cycle, $f_{OUT} = 100$ MHz, with a spread of 0.5%. Input reference 25-MHz crystal. Configuration dependent	–	–	100	ps

**Table 16. AC Electrical Specifications, Differential Output (LVPECL, CML, LVDS) <sup>[1]</sup>**

Symbol	Description	Conditions	Min	Typ	Max	Units
<b>COMMON AC Electrical Specifications</b>						
$t_{RF}$	PECL output rise/fall time	20%–80% of AC levels, measured at 622.08 MHz	–	–	450	ps
$t_{RF}$	CML output rise/fall time	20%–80% of AC levels, measured at 622.08 MHz	–	–	450	ps
$t_{RF}$	LVDS output rise/fall time	20%–80% of AC levels, measured at 622.08 MHz	–	–	450	ps
$t_{SK1}$	Output skew	Four differential output pairs in a bank, derived from the same PLL, with same standard and load conditions	–	–	100	ps
<b>BUFFER Mode</b>						
$t_{ODC}$	Output duty cycle	Differential input signal at 50% duty cycle, differential signal, 622.08 MHz	45	50	55	%
$t_{ODC}$	Output duty cycle	LVCMOS input signal at 50% duty cycle, differential signal, 250 MHz	40	50	60	%
$t_{PD}$	Propagation delay	Measured at differential signal, 156.25 MHz	–	–	4	ns
$t_{JIT\_ADD}$	Additive RMS phase jitter	$f_{OUT} = 156.25$ MHz, 12-k to 20-MHz offset, DIV1 = 1. Input slew rate 4 V/ns differential 400-mV amplitude.	–	–	400	fs
<b>ZDB Mode (REF=IN1, 1 pair of output is feedback to IN2)</b>						
$t_{ODC}$	Output duty cycle	Measured at differential signal, 100 MHz	45	50	55	%
$t_{CCJ}$	Cycle-to-cycle jitter	pk, measured differential signal over 10-k cycle, $f_{OUT} = 156.25$ MHz. Input slew rate 4 V/ns differential 400-mV amplitude. (all differential outputs on)	–	–	50	ps
$t_{PJ}$	Period jitter	pk-pk, measured differential signal over 10-k cycle, $f_{OUT} = 156.25$ MHz. Input slew rate 4 V/ns differential 400-mV amplitude. (all differential outputs on)	–	–	50	ps

**Note**

1. AC parameters for differential outputs are guaranteed for only differential outputs. LVCMOS is Off.

**Table 16. AC Electrical Specifications, Differential Output (LVPECL, CML, LVDS) <sup>[1]</sup> (continued)**

Symbol	Description	Conditions	Min	Typ	Max	Units
$t_{PD}$	Propagation delay	Measured differential signal, $f_{OUT} = 156.25$ MHz, $\pm 250$ ps is excluding any delay added onboard (from output to inputs). Delay onboard ( $t_{DELAY\_BOARD}$ ) must not exceed 2-ns max. Total delay in the ZDB mode is $t_{DELAY\_BOARD} + t_{PDELAY}$	-300	—	300	ps
$t_{J_{RMS}}$	RMS phase jitter	$f_{IN} = f_{OUT} = 156.25$ MHz, 12-k to 20-MHz offset. Input slew rate 4 V/ns differential 400-mV amplitude	—	0.7	1.0	ps
PNg10k	Phase noise, offset = 10 kHz	$f_{IN} = f_{OUT} = 156.25$ MHz. Input slew rate 4 V/ns differential 400-mV amplitude.	—	—	-110	dBc/Hz
PNg100k	Phase noise, offset = 100 kHz	$f_{IN} = f_{OUT} = 156.25$ MHz. Input slew rate 4 V/ns differential 400-mV amplitude.	—	—	-119	dBc/Hz
PNg1M	Phase noise, offset = 1 MHz	$f_{IN} = f_{OUT} = 156.25$ MHz. Input slew rate 4 V/ns differential 400-mV amplitude.	—	—	-131	dBc/Hz
PNg10M	Phase noise, offset = 10 MHz	$f_{IN} = f_{OUT} = 156.25$ MHz. Input slew rate 4 V/ns differential 400-mV amplitude.	—	—	-147	dBc/Hz
PN-SPUR	Spur	At frequency offsets equal to and greater than the update rate of the PLL. Input slew rate 4 V/ns differential 400-mV amplitude.	—	—	-65	dBc/Hz
<b>CLKGEN Mode</b>						
$t_{ODC}$	Output duty cycle	Measured at differential signal, 622.08 MHz	45	50	55	%
$t_{CCJ}$	Cycle-to-cycle jitter	pk, measured at differential signal, 156.25 MHz, over 10-k cycles. Input frequency (24 MHz to 40 MHz) crystal. (all differential outputs on)	—	—	50	ps
$t_{PJ}$	Period jitter	pk-pk, measured at differential signal 156.25 MHz, over 10-k cycles. Input frequency (24 MHz to 40 MHz) crystal. (all differential outputs on)	—	—	50	ps
$t_{J_{RMS}}$	RMS phase jitter	$f_{OUT} = 156.25$ MHz, 12-k to 20-MHz offset	—	0.7	1.0	ps
PNg10k	Phase noise, offset = 10 kHz	$f_{OUT} = 156.25$ MHz. Input reference 25-MHz crystal	—	—	-110	dBc/Hz
PNg100k	Phase noise, offset = 100 kHz	$f_{OUT} = 156.25$ MHz. Input reference 25-MHz crystal	—	—	-119	dBc/Hz
PNg1M	Phase noise, offset = 1 MHz	$f_{OUT} = 156.25$ MHz. Input reference 25-MHz crystal	—	—	-131	dBc/Hz
PNg10M	Phase noise, offset = 10 MHz	$f_{OUT} = 156.25$ MHz. Input reference 25-MHz crystal	—	—	-147	dBc/Hz
PN-SPUR	Spur	At frequency offsets equal to and greater than the update rate of the PLL	—	—	-65	dBc/Hz

**Table 16. AC Electrical Specifications, Differential Output (LVPECL, CML, LVDS) <sup>[1]</sup> (continued)**

Symbol	Description	Conditions	Min	Typ	Max	Units
<b>SSC Mode</b>						
$t_{CCJ}$	Cycle-to-cycle jitter	pk, measured at differential signal, 156.25 MHz, over 10-k cycles. Input frequency (24 MHz to 40 MHz) crystal, with a spread of 0.5% (all differential outputs on).	–	–	70	ps

**Table 17. AC Electrical Specification HSCL Output <sup>[2, 3]</sup>**

Symbol	Description	Conditions	Min	Typ	Max	Units
<b>Common AC Electrical Specifications</b>						
$f_{OC}$	Output frequency	HCSL	96	–	400	MHz
$E_R$	Rising edge rate	Measurement taken from differential waveform, –150 mV to +150 mV	0.6	–	4	V/ns
$E_F$	Falling edge rate	Measurement taken from differential waveform, –150 mV to +150 mV	0.6	–	4	V/ns
$T_{STABLE}$	Time before $V_{RB}$ is allowed	Measurement taken from differential waveform, –150 mV to +150 mV	500	–	–	ps
$T_{PERIOD\_AVG}$	Average clock period accuracy, 100 MHz	Measurement taken from differential waveform, Spread Spectrum On, 0.5% down spread	–300	–	2800	ppm
$T_{PERIOD\_ABS}$	Absolute period, 100 MHz	Measurement taken from differential waveform, Spread Spectrum On, 0.5% down spread	9.874	–	10.203	ns
$R-F_{MATCHING}$	Rise-fall matching	Measurement taken from single-ended waveform. Rising edge rate to falling edge rate matching 100 MHz	–20	–	+20	%
<b>BUFFER Mode</b>						
$T_{DC}$	Duty cycle	Measurement taken from differential waveform	45	50	55	%
$t_{RMS\_ADD}$	Additive phase noise	Input slew rate 4 V/ns differential 400-mV amplitude.	–	–	0.4	ps (RMS)
<b>ZDB Mode (REF = IN1, 1 output pair fed back to IN2)</b>						
$T_{DC}$	Duty cycle	Measurement taken from differential waveform	45	50	55	%
$T_{CCJITTER}$	Cycle-to-cycle jitter	pk, measured at differential signal 100 MHz, over 10-k cycles. Input slew rate 4 V/ns differential 400-mV amplitude (all differential outputs on).	–	–	50	ps
$J_{RMS}$	Random jitter PCIe 3.0 Common clocked	PCIe Gen3 filters. Input slew rate 4 V/ns differential 400-mV amplitude.	–	0.7	1.0	ps (RMS)
$t_{PD}$	Propagation delay	Early/Late option is OFF	–300	–	300	ps

**Notes**

- AC parameters for differential outputs are guaranteed for only differential outputs. LVCMOS is Off.
- All output clocks 100MHz HCSL format. Jitter is from PCIe jitter filter combination that produces the highest jitter.

**Table 17. AC Electrical Specification HSCL Output** <sup>[2, 3]</sup> (continued)

Symbol	Description	Conditions	Min	Typ	Max	Units
<b>CLKGEN Mode</b>						
T <sub>DC</sub>	Duty cycle	Measurement taken from differential waveform	45	50	55	%
T <sub>CCJITTER</sub>	Cycle-to-cycle jitter	pk, measured at differential signal, 100 MHz, over 10-k cycles. Input frequency (24 MHz–40 MHz) crystal (all differential outputs on).	–	–	50	ps
J <sub>RMS</sub>	Random jitter PCIe 3.0 Common clocked	REF = 25-MHz crystal, f <sub>OUT</sub> = 100 MHz, PCIe Gen3 filters	–	0.7	1.0	ps

**Table 18. AC I<sup>2</sup>C Specifications**

Symbol	Description	Conditions	Min	Typ	Max	Units
f <sub>SCK</sub>	SCK clock frequency		0	–	400	kHz
t <sub>HD:STA</sub>	Hold time START condition		0.6	–	–	μs
t <sub>LOW</sub>	Low period of the SCK clock		1.3	–	–	μs
t <sub>HIGH</sub>	High period of the SCK clock		0.6	–	–	μs
t <sub>SU:STA</sub>	Setup time for a repeated START condition		0.6	–	–	μs
t <sub>HD:DAT</sub>	Data hold time		0	–	–	μs
t <sub>SU:DAT</sub>	Data setup time		100	–	–	ns
t <sub>R</sub>	Rise time		–	–	300	ns
t <sub>F</sub>	Fall time		–	–	300	ns
t <sub>SU:STO</sub>	Setup time for STOP condition		0.6	–	–	μs
t <sub>BUF</sub>	Bus-free time between STOP and START conditions		1.3	–	–	μs

**Table 19. Spread-Spectrum Specifications**

Symbol	Description	Conditions	Min	Typ	Max	Units
F <sub>MOD</sub>	Modulation rate		30	–	60	kHz
SSper	Spread spectrum amount	Total %	0.1	–	5.0	%
SSStep	Spread spectrum% step		–	0.1	–	%

**Table 20. Output Selection Specifications**

Symbol	Description	Conditions	Min	Typ	Max	Units
$t_{FS}$	Frequency switching time	Frequency switching time for OUT13,14, 23, 24. Both PLLs are active (change MUX selection Bit).	–	–	500	$\mu s$
$t_{FS}$	Frequency switching time	Frequency switching time for all outputs, DIVO value change	–	–	500	$\mu s$
$t_{FS}$	Frequency switching time	Frequency switching time for all outputs. PLL value change.	–	–	1000	$\mu s$
$t_{FS}$	Output turn-on time	Output turn-on time from FS. PLL is active, change OE or MUX.	–	–	500	$\mu s$
$t_{FS}$	Output turn-on time	Output turn-on time from FS. Resume PLL from Power Down.	–	–	1000	$\mu s$
$t_{OFF}$	Output turn-off time	Output turn-off time from FS. PLL is active, change OE or MUX.	–	–	500	$\mu s$

**Table 21. NV Memory Specification**

Symbol	Description	Conditions	Min	Typ	Max	Units
DRET	NV memory data retention		10	–	–	Years
PROG <sub>CYCLE</sub>	Programming cycle	Programming cycle for NV memory	100K	–	–	Cycle

**Table 22. Miscellaneous Specifications**

Symbol	Description	Conditions	Min	Typ	Max	Units
$t_{XRES}$	XRES Low time		10	–	–	$\mu s$
$T_{PROG}$	Flash programming temperature		5	–	55	°C
$C_{INADC}$	Input capacitance VIN pin		–	–	10	pF

**Table 23. Thermal Resistance**

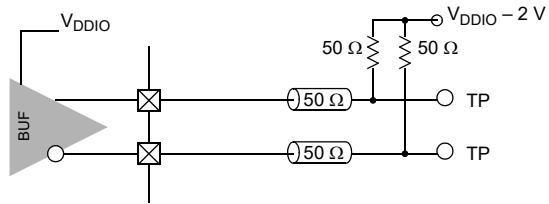
Parameter <sup>[4]</sup>	Description	Test Conditions	48-pin QFN	Unit
$\theta_{JA}$	Thermal resistance (junction to ambient)	Test conditions follow standard test methods and procedures for measuring thermal impedance, in accordance with EIA/JESD51.	15.64	°C/W
$\theta_{JC}$	Thermal resistance (junction to case)		2.21	°C/W

**Note**

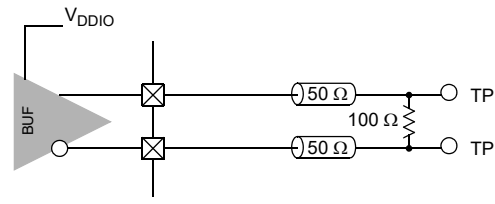
4. These parameters are guaranteed by design and are not tested.

## Test and Measurement Circuits

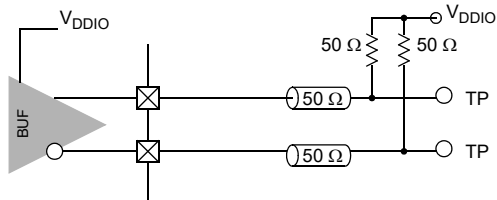
**Figure 23. LVPECL Output Load and Test Circuit**



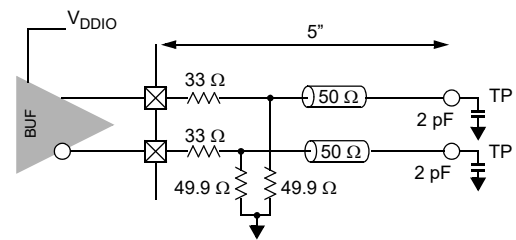
**Figure 24. LVDS Output Load and Test Circuit**



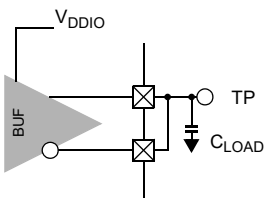
**Figure 25. CML Output Load and Test Circuit**



**Figure 26. HCSL Output Load and Test Circuit**



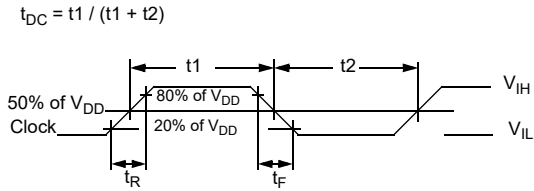
**Figure 27. LVCMOS Output Load and Test Circuit**



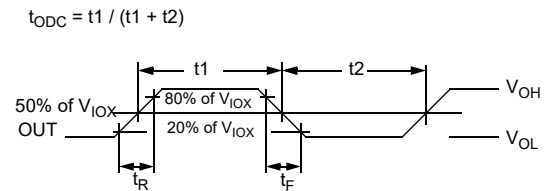


## Voltage and Timing Definitions

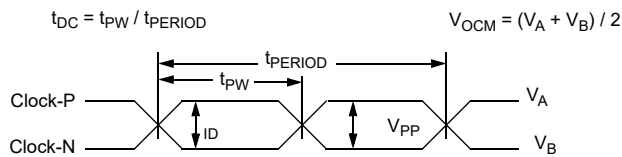
**Figure 28. LVCMOS Input Definitions**



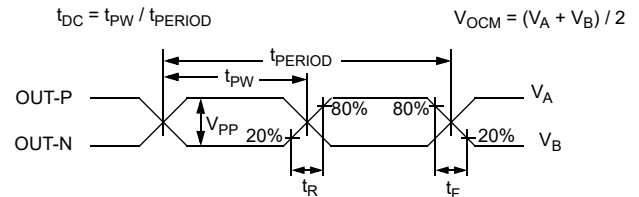
**Figure 29. LVCMOS Output Definitions**



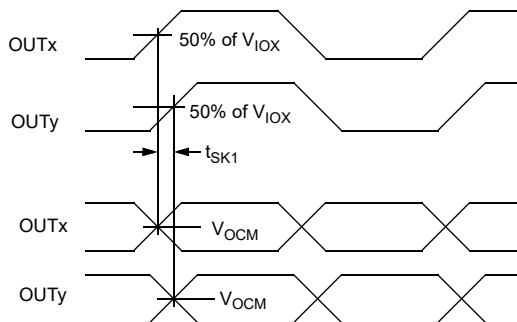
**Figure 30. Differential Input Definitions**



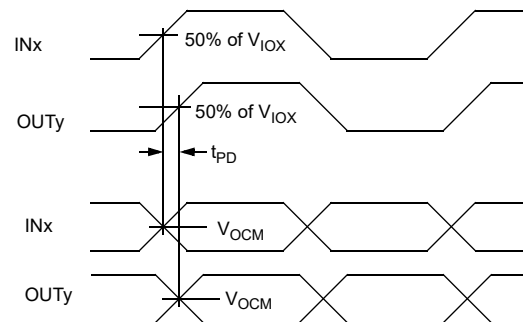
**Figure 31. Differential Output Definitions**



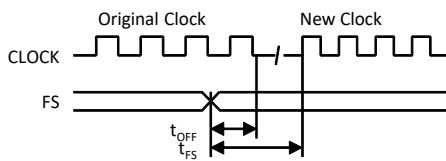
**Figure 32. Skew Definition**



**Figure 33. Propagation Delay Definition**

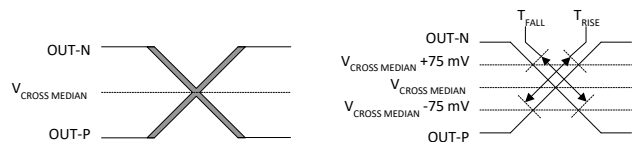


**Figure 34. Output Enable/Disable/Frequency Select Timing**



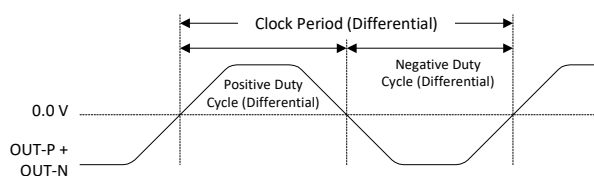
**Figure 35. HCSL Single-ended Measurement Point-2**

Rise and Fall Time Matching

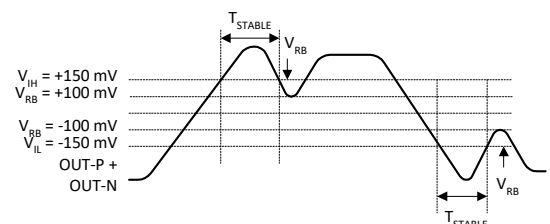


**Figure 36. HCSL Differential Measurement Point**

Duty Cycle and Period

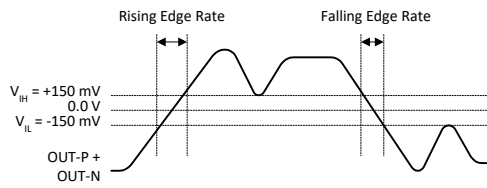


**Figure 37. HCSL Differential Measurement for Ringback**

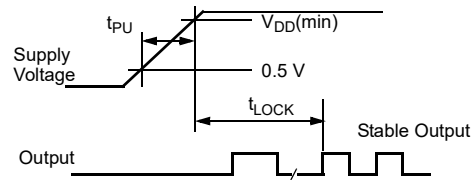


**Figure 38. HCSL Rise and Fall Time**

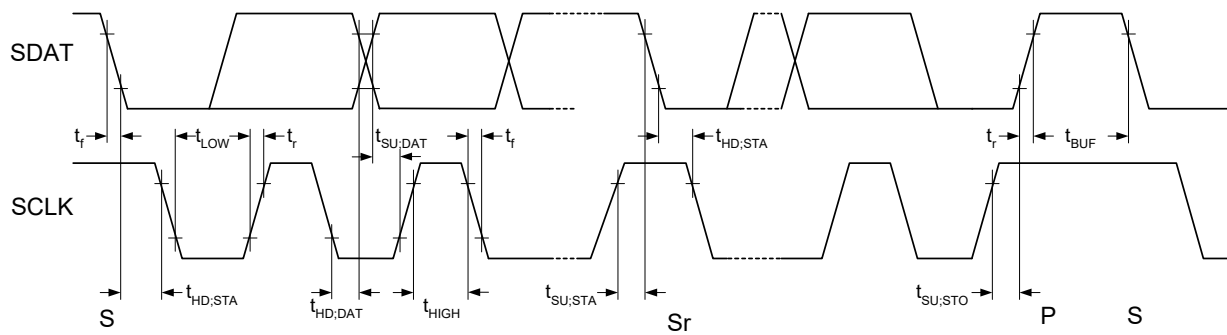
Rise and Fall Time



**Figure 39. Power Ramp and PLL Lock Time**



**Figure 40. Definition for Timing for Fast/Standard Mode on the I<sup>2</sup>C Bus**

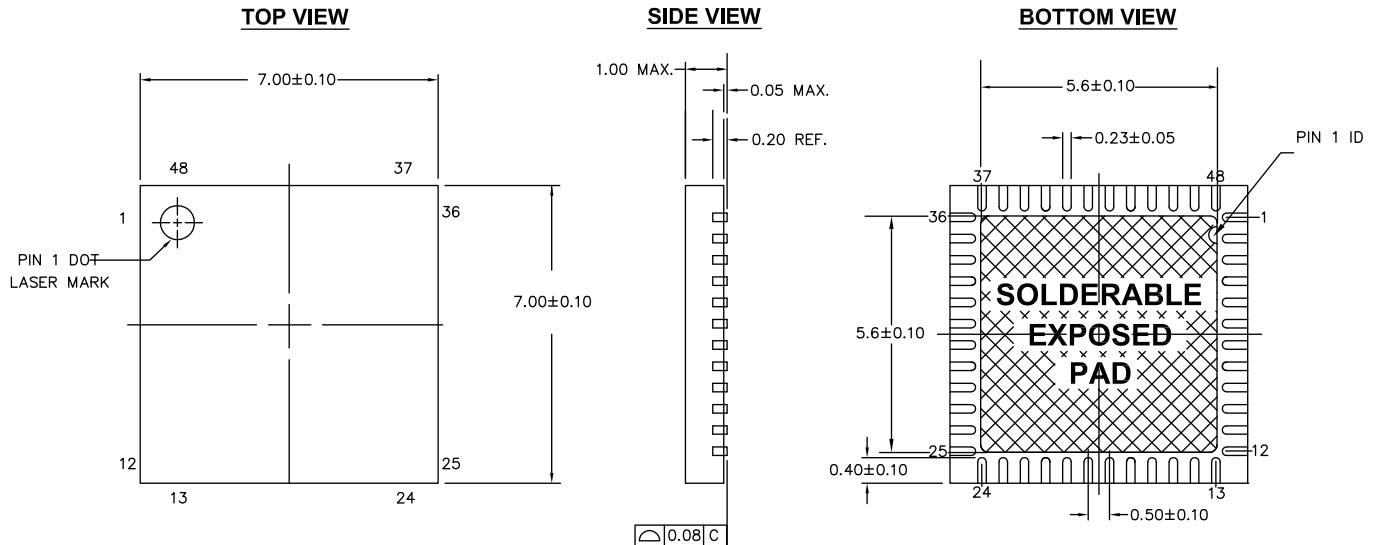


## Packaging Information


This section illustrates the packaging specifications for the CY27410 device.

**Important Note** The EPAD must be connected to ground to reduce the thermal resistance and for signaling ground.

**Figure 41. 48-Pin QFN (7 × 7 × 1.00 mm) LT48D 5.6 × 5.6 E-Pad (Sawn) Package Outline**



### NOTES:

1.  HATCH AREA IS SOLDERABLE EXPOSED METAL.
2. REFERENCE JEDEC#: MO-220
3. PACKAGE WEIGHT: REFER TO PMDD SPEC.
4. ALL DIMENSIONS ARE IN MM [MIN/MAX]
5. PACKAGE CODE

PART #	DESCRIPTION
LT48D	LEAD FREE

001-45616 \*F

For information on the preferred dimensions for mounting QFN packages, refer to the Cypress [application note AN72845 - Design Guidelines for Cypress Quad Flat No Extended Lead \(QFN\) Packaged Devices](#).

## Solder Reflow Specifications

Table 24 shows the solder reflow temperature limits that must not be exceeded.

**Table 24. Solder Reflow Specifications**

Package	Maximum Peak Temperature (T <sub>C</sub> )	Maximum Time above T <sub>C</sub> - 5 °C
48-pin QFN	260 °C	30 seconds

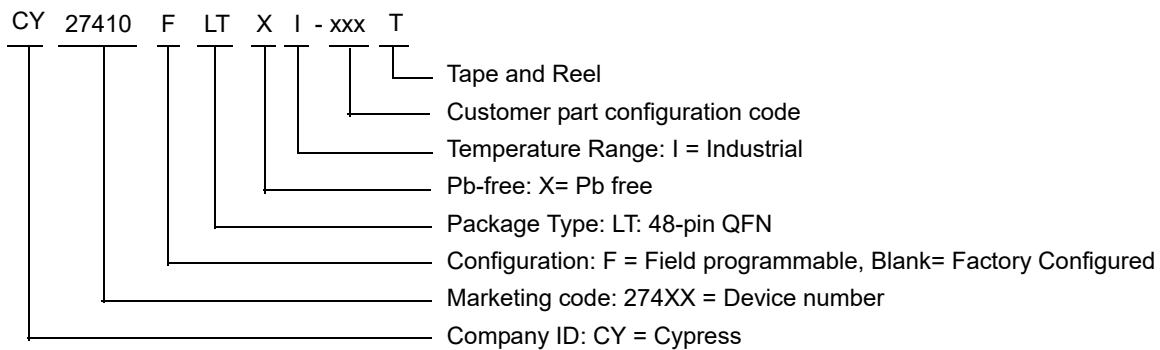
## Ordering Information

The following table lists the CY27410 device's key package features and ordering codes.

**Table 25. Ordering Information**

Part Number	Configuration	Package	Production Flow
CY27410FLTXI	Field programmable	48-pin QFN	Industrial, –40 °C to +85 °C
CY27410FLTXIT	Field programmable	48-pin QFN – Tape and Reel	Industrial, –40 °C to +85 °C
CY27410LTXI-xxx	Factory configured	48-pin QFN	Industrial, –40 °C to +85 °C
CY27410LTXI-xxxT	Factory configured	48-pin QFN – Tape and Reel	Industrial, –40 °C to +85 °C

## Ordering Code Definitions



## Acronyms

**Table 26. Acronyms Used in this Document**

Acronym	Description
AC	alternating current
ADC	analog-to-digital converter
API	application programming interface
CML	current-mode logic
CMOS	complementary metal oxide semiconductor
DC	direct current
ESD	electrostatic discharge
FS	frequency select
GUI	graphical user interface
HCSL	high-speed current steering logic
I <sup>2</sup> C	inter-integrated circuit
I/O	input/output
ISSP	in-system serial programming
JEDEC	Joint Electron Devices Engineering Council
LDO	low dropout (regulator)
LSB	least-significant bit
LVC MOS	low voltage complementary metal oxide semiconductor
LVDS	low-voltage differential signals
LVPECL	low-voltage positive emitter-coupled logic
MSB	most-significant byte
NV	non-volatile
NZDB	non-zero delay buffer
OE	output enable
PCIe	PCI express
POR	power-on reset
PSoC®	Programmable System-on-Chip
QFN	quad flat no-lead
RMS	root mean square
SCLK	serial I <sup>2</sup> C clock
SDAT	serial I <sup>2</sup> C data
TSSOP	thin shrunk small outline package
USB	universal serial bus
XTAL	crystal
ZDB	zero delay buffer

## Document Conventions

### Units of Measure

**Table 27. Units of Measure**

Symbol	Unit of Measure
°C	degree Celsius
dBc	decibels relative to the carrier
fF	femtofarad
fs	femtosecond
g	gram
GHz	gigahertz
Hz	hertz
KHz	kilohertz
Ksps	kilo samples per second
kΩ	kilohm
MHz	megahertz
MΩ	megaohm
μA	microampere
μF	microfarad
μH	microhenry
μs	microsecond
μW	microwatt
mA	milliampere
ms	millisecond
mV	millivolt
nA	nanoampere
nF	nanofarad
ns	nanosecond
nV	nanovolt
Ω	ohm
pA	picoampere
pF	picofarad
pp	peak-to-peak
ppm	parts per million
ppb	parts per billion
ps	picosecond
sps	samples per second
σ	sigma: one standard deviation
V	volt
W	watt

## Document History Page

Document Title: CY27410, 4-PLL Spread-Spectrum Clock Generator Document Number: 001-89074				
Rev.	ECN	Orig. of Change	Submission Date	Description of Change
*G	4866820	BPIN	07/31/2015	Changed status from Preliminary to Final. Post to external web.
*H	4889775	XHT	08/19/2015	Updated <a href="#">Features</a> : Replaced "75-ps skew" with "100-ps skew".
*I	4930976	XHT	09/23/2015	Updated <a href="#">Functional Overview</a> : Updated <a href="#">Input System</a> : Updated description.
*J	5090700	XHT	01/18/2016	Updated <a href="#">Ordering Information</a> : Updated part numbers. Updated <a href="#">Ordering Code Definitions</a> . Completing Sunset Review.
*K	5351208	XHT	07/14/2016	Updated Cy Logo and Copyright.
*L	5682054	PSR	04/03/2017	Added <a href="#">Functional Description</a> . Updated <a href="#">Packaging Information</a> : spec 001-45616 – Changed revision from *E to *F. Updated to new template.
*M	6486386	XHT	02/15/2019	Updated to new template. Completing Sunset Review.

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