

## General Description

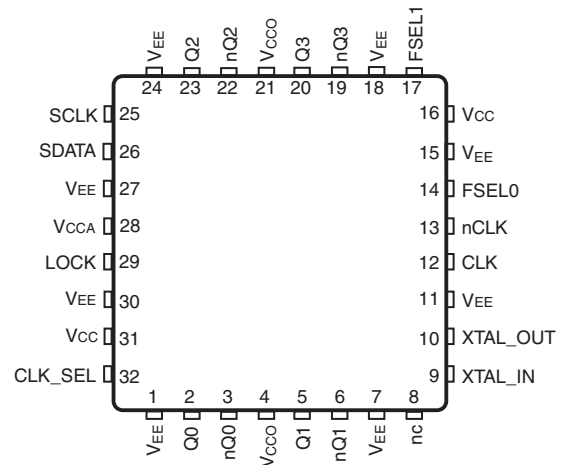
The IDT8T49N004I is a four output Clock Generator with selectable LVDS or LVPECL outputs. The IDT8T49N004I can generate any one of four frequencies from a single crystal or reference clock. The four frequencies are selected from the Frequency Selection Table (Table 3A) and are programmed via I<sup>2</sup>C interface. The four predefined frequencies are selected in the user application by two frequency selection pins. Note the desired programmed frequencies must be used with the corresponding crystal or clock frequency as indicated in Table 3A.

Excellent phase noise performance is maintained with IDT's Fourth Generation FemtoClock® NG PLL technology, which delivers sub-400fs RMS phase jitter.

## Features

- Fourth Generation FemtoClock NG PLL technology
- Four selectable LVPECL or LVDS outputs via I<sup>2</sup>C
- CLK, nCLK input pair can accept the following differential input levels: LVPECL, LVDS, HCSL
- FemtoClock NG VCO Range: 1.91GHz - 2.5GHz
- RMS phase jitter at 156.25MHz (12kHz - 20MHz): 228fs (typical)
- RMS phase jitter at 156.25MHz (10kHz - 1MHz): 175fs (typical)
- Full 2.5V or 3.3V power supply
- I<sup>2</sup>C programming interface
- PCI Express (2.5Gb/s), Gen 2 (5Gb/s), and Gen 3 (8Gb/s) jitter compliant
- -40°C to 85°C ambient operating temperature
- Lead-free (RoHS 6) packaging

## Pin Assignment



**IDT8T49N004I**

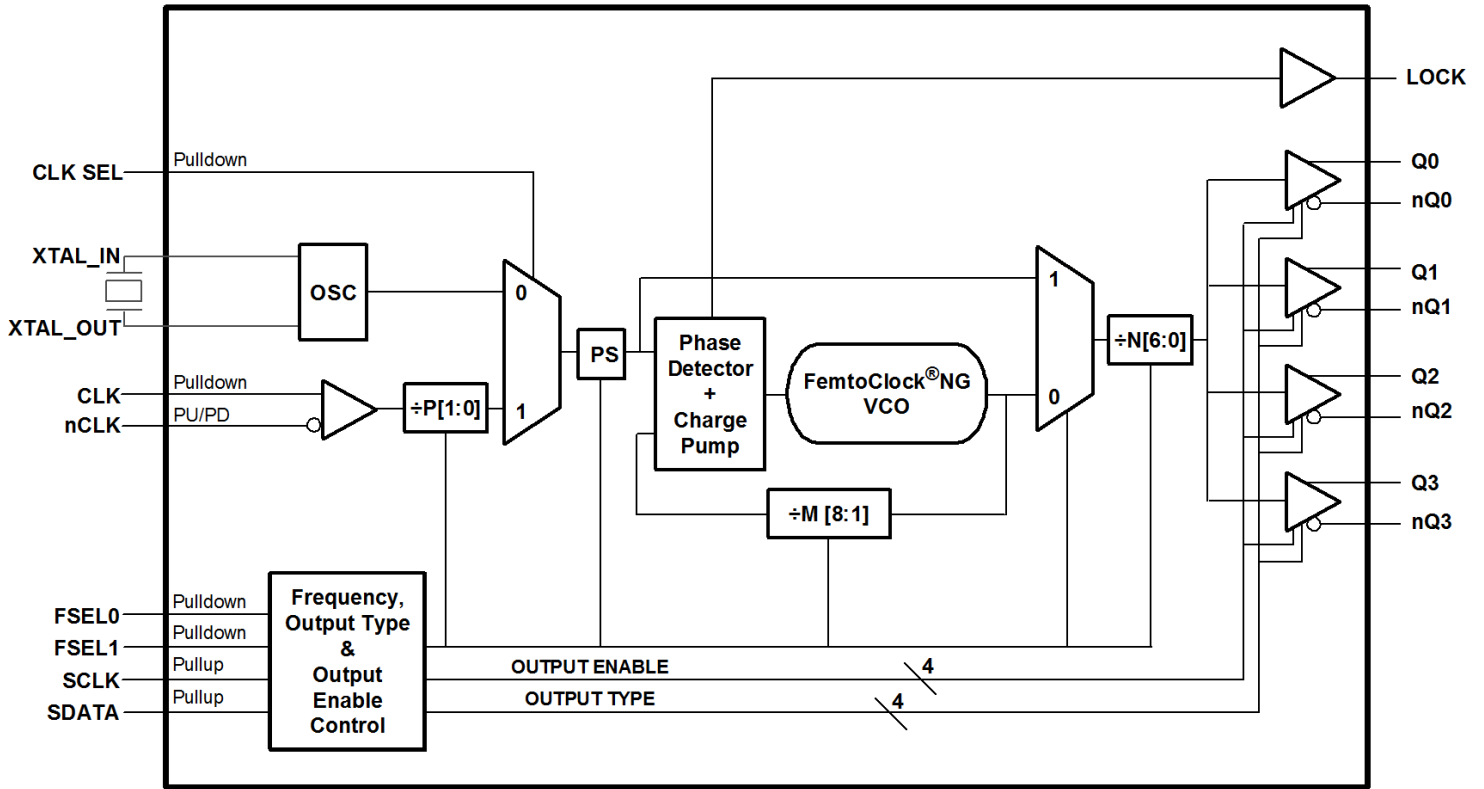
**32-Lead VFQFN**

**5mm x 5mm x 0.925mm package body**

**3.15mm x 3.15mm E-Pad**

**NL Package**

# Block Diagram



**Table 1. Pin Descriptions**

| Number                       | Name                | Type   |                     | Description  |
|------------------------------|---------------------|--------|---------------------|--|
| 1, 7, 11, 15, 18, 24, 27, 30 | V <sub>EE</sub>     | Power  |                     | Negative supply pins.  |
| 2, 3                         | Q0, nQ0             | Output |                     | Differential output pair. LVPECL or LVDS interface levels.   |
| 4, 21                        | V <sub>CCO</sub>    | Power  |                     | Output supply pins.  |
| 5, 6                         | Q1, nQ1             | Output |                     | Differential output pair. LVPECL or LVDS interface levels.   |
| 8                            | nc                  | Unused |                     | No connect.  |
| 9, 10                        | XTAL_IN<br>XTAL_OUT | Input  |                     | Crystal oscillator interface. XTAL_IN is the input, XTAL_OUT is the output. Crystal frequency is selected from Table 3A.   |
| 12                           | CLK                 | Input  | Pulldown            | Non-inverting differential clock input.  |
| 13                           | nCLK                | Input  | Pullup/<br>Pulldown | Inverting differential clock input. Internal resistor bias to V <sub>CCO</sub> /2.   |
| 14, 17                       | FSEL0,<br>FSEL1     | Input  | Pulldown            | Frequency and configuration. Selects between one of four factory programmable power-up default configurations. The four configurations can have different PLL states, output frequencies, output styles and output states. These default configurations can be overwritten after power-up via I <sup>2</sup> C. LVCMOS/LVTTL interface levels.<br>00 = Configuration 0 (default)<br>01 = Configuration 1<br>10 = Configuration 2<br>11 = Configuration 3 |
| 16, 31                       | V <sub>CC</sub>     | Power  |                     | Core supply pins.  |
| 19, 20                       | nQ3, Q3             | Output |                     | Differential output pair. LVPECL or LVDS interface levels.   |
| 22, 23                       | nQ2, Q2             | Output |                     | Differential output pair. LVPECL or LVDS interface levels.   |
| 25                           | SCLK                | Input  | Pullup              | I <sup>2</sup> C Clock Input. LVCMOS/LVTTL interface levels.   |
| 26                           | SDATA               | I/O    | Pullup              | I <sup>2</sup> C Data Input. Input: LVCMOS/LVTTL interface levels.<br>Output: Open Drain.  |
| 28                           | V <sub>CCA</sub>    | Power  |                     | Analog supply pin.   |
| 29                           | LOCK                | Output |                     | PLL Lock Indicator. LVCMOS/LVTTL interface levels.   |
| 32                           | CLK_SEL             | Input  | Pulldown            | Input source control pin. LVCMOS/LVTTL interface levels.<br>0 = XTAL (default)<br>1 = CLK, nCLK  |

NOTE: *Pullup* and *Pulldown* refer to internal input resistors. See Table 2, *Pin Characteristics*, for typical values.

**Table 2. Pin Characteristics**

| Symbol                | Parameter               | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------------------|-------------------------|-----------------|---------|---------|---------|-------|
| C <sub>IN</sub>       | Input Capacitance       |                 |         | 3.5     |         | pF    |
| R <sub>PULLDOWN</sub> | Input Pulldown Resistor |                 |         | 51      |         | kΩ    |
| R <sub>PULLUP</sub>   | Input Pullup Resistor   |                 |         | 51      |         | kΩ    |

## Frequency Configuration

Table 3A. Frequency Configuration Examples

| Output Frequencies (MHz) | Input Frequency or Crystal Frequency (MHz) | Input Clock Divider P | Input Clock Prescaler PS | Feedback Divider M | Output Divider N | VCO Frequency (MHz) |
|--------------------------|--|-----------------------|--------------------------|--------------------|------------------|---------------------|
| 30.72                    | 30.72                                      | 1                     | x2                       | 32                 | 64               | 1966.08             |
| 61.44                    | 30.72                                      | 1                     | x2                       | 32                 | 32               | 1966.08             |
| 62.5                     | 25   | 1                     | x2                       | 40                 | 32               | 2000                |
| 76.8                     | 30.72                                      | 1                     | x2                       | 40                 | 32               | 2457.6              |
| 78.125                   | 25   | 1                     | x2                       | 50                 | 32               | 2500                |
| 100                      | 25   | 1                     | x2                       | 40                 | 20               | 2000                |
| 106.25                   | 26.5625                                    | 1                     | x2                       | 40                 | 20               | 2125                |
| 122.8                    | 30.72                                      | 1                     | x2                       | 32                 | 16               | 1966.08             |
| 125                      | 25   | 1                     | x2                       | 40                 | 16               | 2000                |
| 133.33                   | 25   | 1                     | x2                       | 48                 | 18               | 2400                |
| 148.5                    | 27   | 1                     | x2                       | 44                 | 16               | 2376                |
| 150                      | 25   | 1                     | x2                       | 42                 | 14               | 2100                |
| 153.6                    | 30.72                                      | 1                     | x2                       | 40                 | 16               | 2457.6              |
| 155.52                   | 19.44                                      | 1                     | x2                       | 64                 | 16               | 2488.32             |
| 156.25                   | 25   | 1                     | x2                       | 50                 | 16               | 2500                |
|                          | 100  | 2                     | x1                       | 50                 | 16               | 2500                |
|                          | 125  | 5                     | x2                       | 50                 | 16               | 2500                |
| 159.375                  | 26.5625                                    | 1                     | x2                       | 36                 | 12               | 1912.5              |
| 160                      | 20   | 1                     | x2                       | 48                 | 12               | 1920                |
| 166.66                   | 25   | 1                     | x2                       | 40                 | 12               | 2000                |
| 184.32                   | 30.72                                      | 1                     | x2                       | 36                 | 12               | 2211.84             |
|                          | 61.44                                      | 1                     | x1                       | 36                 | 12               | 2211.84             |
| 187.5                    | 25   | 1                     | x1                       | 90                 | 12               | 2250                |
| 200                      | 25   | 1                     | x2                       | 40                 | 10               | 2000                |
| 212.5                    | 26.5625                                    | 1                     | x2                       | 40                 | 10               | 2125                |
| 250                      | 25   | 1                     | x2                       | 40                 | 8                | 2000                |
| 300                      | 25   | 1                     | x2                       | 48                 | 8                | 2400                |
| 311.04                   | 19.44                                      | 1                     | x2                       | 64                 | 8                | 2488.32             |
|                          | 77.76                                      | 1                     | x1                       | 32                 | 8                | 2488.32             |
|                          | 155.52                                     | 2                     | x1                       | 32                 | 8                | 2488.32             |
| 312.5                    | 25   | 1                     | x2                       | 50                 | 8                | 2500                |
|                          | 125  | 2                     | x1                       | 40                 | 8                | 2500                |
|                          | 156.25                                     | 5                     | x2                       | 40                 | 8                | 2500                |
| 318.75                   | 26.5625                                    | 1                     | x2                       | 36                 | 6                | 1912.5              |

Continued on next page.

| Output Frequencies (MHz) | Input Frequency or Crystal Frequency (MHz) | Input Clock Divider P | Input Clock Prescaler PS | Feedback Divider M | Output Divider N | VCO Frequency (MHz) |
|--------------------------|--|-----------------------|--------------------------|--------------------|------------------|---------------------|
| 322.265625               | 25.78125                                   | 2                     | x1                       | 150                | 6                | 1933.59375          |
| 375                      | 25   | 1                     | x1                       | 90                 | 6                | 2250                |
| 400                      | 25   | 1                     | x2                       | 40                 | 5                | 2000                |
| 425                      | 26.5625                                    | 1                     | x2                       | 40                 | 5                | 2125                |
| 491.52                   | 30.72                                      | 1                     | x2                       | 32                 | 4                | 1966.08             |
| 614.4                    | 30.72                                      | 1                     | x2                       | 40                 | 4                | 2457.6              |
|                          | 122.88                                     | 2                     | x1                       | 40                 | 4                | 2457.6              |
|                          | 153.6                                      | 5                     | x2                       | 40                 | 4                | 2457.6              |
| 622.08                   | 19.44                                      | 1                     | x2                       | 64                 | 4                | 2488.32             |
| 625                      | 25   | 1                     | x2                       | 50                 | 4                | 2500                |
| 1228.88                  | 30.72                                      | 1                     | x2                       | 40                 | 2                | 2457.6              |

NOTE: Each device supports 4 output frequencies (with related input or crystal value) as selected from this table Register Settings.

NOTE: XTAL operation:  $f_{OUT} = f_{REF} * PS * M / N$ ; CLK, nCLK input operation:  $f_{OUT} = (f_{REF} / P) * PS * M / N$ .

**Table 3B. I<sup>2</sup>C Register Map**

| Register | Binary Register Address | Register Bit |               |               |          |          |               |               |          |
|----------|-------------------------|--------------|---------------|---------------|----------|----------|---------------|---------------|----------|
|          |                         | D7           | D6            | D5            | D4       | D3       | D2            | D1            | D0       |
| 0        | 0000                    | M0[8]        | M0[7]         | M0[6]         | M0[5]    | M0[4]    | M0[3]         | M0[2]         | M0[1]    |
| 1        | 00001                   | M1[8]        | M1[7]         | M1[6]         | M1[5]    | M1[4]    | M1[3]         | M1[2]         | M1[1]    |
| 2        | 00010                   | M2[8]        | M2[7]         | M2[6]         | M2[5]    | M2[4]    | M2[3]         | M2[2]         | M2[1]    |
| 3        | 00011                   | M3[8]        | M3[7]         | M3[6]         | M3[5]    | M3[4]    | M3[3]         | M3[2]         | M3[1]    |
| 4        | 00100                   | unused       | N0[6]         | N0[5]         | N0[4]    | N0[3]    | N0[2]         | N0[1]         | N0[0]    |
| 5        | 00101                   | unused       | N1[6]         | N1[5]         | N1[4]    | N1[3]    | N1[2]         | N1[1]         | N1[0]    |
| 6        | 00110                   | unused       | N2[6]         | N2[5]         | N2[4]    | N2[3]    | N2[2]         | N2[1]         | N2[0]    |
| 7        | 00111                   | unused       | N3[6]         | N3[5]         | N3[4]    | N3[3]    | N3[2]         | N3[1]         | N3[0]    |
| 8        | 01000                   | unused       | BYPASS0       | PS0[1]        | PS0[0]   | P0[1]    | P0[0]         | CP0[1]        | CP0[0]   |
| 9        | 01001                   | unused       | BYPASS1       | PS1[1]        | PS1[0]   | P1[1]    | P1[0]         | CP1[1]        | CP1[0]   |
| 10       | 01010                   | unused       | BYPASS2       | PS2[1]        | PS2[0]   | P2[1]    | P2[0]         | CP2[1]        | CP2[0]   |
| 11       | 01011                   | unused       | BYPASS3       | PS3[1]        | PS3[0]   | P3[1]    | P3[0]         | CP3[1]        | CP3[0]   |
| 12       | 01100                   | reserved     | LVDS_SEL0[Q3] | LVDS_SEL0[Q2] | reserved | reserved | LVDS_SEL0[Q1] | LVDS_SEL0[Q0] | reserved |
| 13       | 01101                   | reserved     | LVDS_SEL1[Q3] | LVDS_SEL1[Q2] | reserved | reserved | LVDS_SEL1[Q1] | LVDS_SEL1[Q0] | reserved |
| 14       | 01110                   | reserved     | LVDS_SEL2[Q3] | LVDS_SEL2[Q2] | reserved | reserved | LVDS_SEL2[Q1] | LVDS_SEL2[Q0] | reserved |
| 15       | 01111                   | reserved     | LVDS_SEL3[Q3] | LVDS_SEL3[Q2] | reserved | reserved | LVDS_SEL3[Q1] | LVDS_SEL3[Q0] | reserved |
| 16       | 10000                   | reserved     | OE0[Q3]       | OE0[Q2]       | reserved | reserved | OE0[Q1]       | OE0[Q0]       | reserved |
| 17       | 10001                   | reserved     | OE1[Q3]       | OE1[Q2]       | reserved | reserved | OE1[Q1]       | OE1[Q0]       | reserved |
| 18       | 10010                   | reserved     | OE2[Q3]       | OE2[Q2]       | reserved | reserved | OE2[Q1]       | OE2[Q0]       | reserved |
| 19       | 10011                   | reserved     | OE3[Q3]       | OE3[Q2]       | reserved | reserved | OE3[Q1]       | OE3[Q0]       | reserved |
| 20       | 10100                   | reserved     | reserved      | reserved      | reserved | reserved | reserved      | unused        | unused   |
| 21       | 10101                   | unused       | unused        | unused        | unused   | unused   | unused        | unused        | unused   |
| 22       | 10110                   | unused       | unused        | unused        | unused   | unused   | unused        | unused        | unused   |
| 23       | 10111                   | unused       | unused        | unused        | unused   | unused   | unused        | unused        | unused   |

**Table 3C. I<sup>2</sup>C Function Descriptions**

| Bits   | Name   | Function  |
|--|--|---|
| Pn[1:0]  | Input Clock Divider Register n<br>(n = 0...3)      | Sets the PLL input clock divider. The divider value has the range of 1, 2, 4 and 5. See Table 3F. Pn[1:0] bits are programmed with values to support default configuration settings for FSEL[1:0].  |
| PSn(1:0)   | Input Prescaler Register n<br>(n = 0...3)          | Sets the PLL input clock prescaler value. Valid prescaler values are x0.5, x1 or x2. See Table 3F. Set prescaler to x2 for optimum phase noise performance. PSn[1:0] bits are programmed with values to support default configuration settings for FSEL[1:0].   |
| Mn[8:1]  | Integer Feedback Divider Register n<br>(n = 0...3) | Sets the integer feedback divider value. Based on the FemtoClock NG VCO range, the applicable feedback dividers settings are 16 thru 250. Please note the register value presents bits [8:1] of Mn, the LSB of Mn is not in the register. Mn[8:1] bits are programmed with values to support default configuration settings for FSEL[1:0].                                    |
| Nn[6:0]  | Output Divider Register n<br>(n = 0...3)           | Sets the output divider. The output divider value can range from 2, 3, 4, 5, 6 and 8, 10, 12 to 126 (step: 2). See Table 3G for the output divider coding. Nn[6:0] bits are programmed with values to support default configuration settings for FSEL[1:0].   |
| CPn[1:0]   | PLL Bandwidth Register n<br>(n = 0...3)            | Sets the FemtoClock NG PLL bandwidth by controlling the charge pump current. See Table 3H. CPn[1:0] bits are programmed with values to support default configuration settings for FSEL[1:0].  |
| BYPASSn  | PLL Bypass Register n<br>(n = 0...3)               | Bypasses PLL. Output of the prescaler is routed through the output divider N to the output fanout buffer. Programming a 1 to this bit bypasses the PLL. Programming a 0 to this bit routes the output of the prescaler through the PLL. BYPASSn bits are programmed with values to support default configuration settings for FSEL[1:0].                                      |
| OEn[Q0]<br>OEn[Q1]<br>OEn[Q2]<br>OEn[Q3]                         | Output Enable Register n<br>(n = 0...3)            | Sets the outputs to Active or High Impedance. Programming a 0 to this bit sets the outputs to High Impedance. Programming a 1, sets the outputs to active status. OEn[Q0], OEn[Q1], OEn[Q2], and OEn[Q3] bits are programmed with values to support default configuration settings for FSEL[1:0].   |
| LVDS_SELn[Q0]<br>LVDS_SELn[Q1]<br>LVDS_SELn[Q2]<br>LVDS_SELn[Q3] | Output Style Register n<br>(n = 0...3)             | Sets the differential output style to either LVDS or LVPECL interface levels. Programming a 1 to this bit sets the output styles to LVDS levels. Programming a 0 to this bit sets the output styles to LVPECL levels. LVDS_SELn[Q0], LVDS_SELn[Q1], LVDS_SELn[Q2], and LVDS_SELn[Q3] bits are programmed with values to support default configuration settings for FSEL[1:0]. |

**Table 3D. Feedback Divider Mn Coding**

| Register Bit           | Feedback Divider Mn |
|------------------------|---------------------|
| Mn[8:1]                |                     |
| Do Not Use             | 1 thru 15           |
| 00001000               | 16                  |
| 00001001               | 18                  |
| 00001010               | 20                  |
| 00001011               | 22                  |
| 00001100 thru 00011111 | 24 thru 62          |
| 00100000               | 64                  |
| 00100001               | 66                  |
| 00100010               | 68                  |
| 00100011               | 70                  |
| 00100100               | 72                  |
| ...                    | Mn                  |
| 00110010               | 100                 |
| 00110011               | 102                 |
| 00110100               | 104                 |
| 00110101               | 106                 |
| ...                    | Mn                  |
| 01111010               | 244                 |
| 01111011               | 246                 |
| 01111100               | 248                 |
| 01111101               | 250                 |

Note: Mn is always an even value. The Mn[0] bits are not implemented.

**Table 3E. Input Clock Divider Pn and Prescaler PSn Coding**

| CLK_SEL | Input | P[1:0] | PS[1:0] | Input Clock Divider P | Input Clock Prescaler PS | Input Frequency (MHz) |         |
|---------|-------|--------|---------|-----------------------|--------------------------|-----------------------|---------|
|         |       |        |         |                       |                          | Minimum               | Maximum |
| 0       | XTAL  | xx     | 00      | 1                     | x1                       | 10                    | 40      |
|         |       |        | 01      | 1                     | x0.5                     | 20                    | 40      |
|         |       |        | 1x      | 1                     | x2                       | 5                     | 40      |
| 1       | CLK   | 00     | 00      | 1                     | x1                       | 10                    | 120     |
|         |       |        | 01      | 1                     | x0.5                     | 20                    | 240     |
|         |       |        | 1x      | 1                     | x2                       | 5                     | 60      |
|         |       | 01     | 00      | 2                     | x1                       | 20                    | 240     |
|         |       |        | 01      | 2                     | x0.5                     | 40                    | 480     |
|         |       |        | 1x      | 2                     | x2                       | 10                    | 120     |
|         |       | 10     | 00      | 4                     | x1                       | 40                    | 480     |
|         |       |        | 01      | 4                     | x0.5                     | 80                    | 800     |
|         |       |        | 1x      | 4                     | x2                       | 20                    | 240     |
|         |       | 11     | 00      | 5                     | x1                       | 50                    | 600     |
|         |       |        | 01      | 5                     | x0.5                     | 100                   | 800     |
|         |       |        | 1x      | 5                     | x2                       | 25                    | 300     |

**Table 3F. Output Divider Nn Coding**

| Register Bit         |  | Output Divider<br>N | Output Frequency Range     |                            |
|----------------------|--|---------------------|----------------------------|----------------------------|
| N <sub>n</sub> [6:0] |  |                     | f <sub>OUT_MIN</sub> (MHz) | f <sub>OUT_MAX</sub> (MHz) |
| 000000X              |  | 2                   | Do Not Use                 |                            |
| 0000010              |  | 2                   | 955                        | 1250                       |
| 0000011              |  | 3                   | 636.67                     | 833.33                     |
| 0000100              |  | 4                   | 477.5                      | 625                        |
| 0000101              |  | 5                   | 382                        | 500                        |
| 000011X              |  | 6                   | 318.33                     | 416.67                     |
| 000100X              |  | 8                   | 238.75                     | 312.5                      |
| 000101X              |  | 10                  | 191                        | 250                        |
| 000110X              |  | 12                  | 159.1667                   | 208.33                     |
| 000111X              |  | 14                  | 136.4286                   | 178.57                     |
| 001000X              |  | 16                  | 119.375                    | 156.25                     |
| ...                  |  | N (even integer)    | (1910 ÷ N)                 | (2500 ÷ N)                 |
| 111101X              |  | 124                 | 15.40                      | 20.16                      |
| 111111X              |  | 126                 | 15.16                      | 19.84                      |

NOTE: X denotes “don’t care”.

**Table 3G. Charge Pump CP Settings**

| Register Bit |      | Feedback Divider (M) Value Range |         |
|--------------|------|----------------------------------|---------|
| CPn1         | CPn0 | Minimum                          | Maximum |
| 0            | 0    | 16                               | 48      |
| 0            | 1    | 48                               | 100     |
| 1            | 0    | 100                              | 250     |
| 1            | 1    | 192                              | 250     |

NOTE: FemtoClock NG PLL stability is only guaranteed over the feedback divider ranges listed in Table 3G.



## Power-up Default Configuration Description

The IDT8T49N004I supports a variety of options such as different output styles, number of programmed default frequencies, output enable and operating temperature range. The device options and default frequencies must be specified at the time of order and are programmed by IDT prior to shipment. The document, *Programmable FemtoClock® NG Product Ordering Guide* specifies the available order codes, including the device options and default frequency configurations. Example part number: 8T49N004A-007NLGI, specifies a quad frequency clock generator with default frequencies of 106.25MHz, 133.333MHz, 156.25MHz and 156.25MHz, with 4 LVDS

outputs that are enabled after power-up, specified over the industrial temperature range and housed in a lead-free (6/6 RoHS) VFQFN package.

Other order codes with respective programmed frequencies are available from IDT upon request. After power-up changes to the output frequencies are controlled by FSEL[1:0] or the I<sup>2</sup>C interface. Changes to the style (LVDS or LVPECL) and state (active or high impedance) of each individual output can also be controlled with the I<sup>2</sup>C interface after power up.

**Table 3H. Power-up Default Settings**

| FSEL1       | FSEL0       | Frequency   | PLL State (On or Bypass) | Output State (Active or High Impedance) | Output Style (LVDS or LVPECL) |
|-------------|-------------|-------------|--------------------------|---|-------------------------------|
| 0 (default) | 0 (default) | Frequency 0 | PLL State 0              | Output State 0                          | Output Style 0                |
| 0           | 1           | Frequency 1 | PLL State 1              | Output State 1                          | Output Style 1                |
| 1           | 0           | Frequency 2 | PLL State 2              | Output State 2                          | Output Style 2                |
| 1           | 1           | Frequency 3 | PLL State 3              | Output State 3                          | Output Style 3                |

## Serial Interface Configuration Description

The IDT8T49N004I has an I<sup>2</sup>C-compatible configuration interface to access any of the internal registers (Table 3B) for frequency and PLL parameter programming. The IDT8T49N004I acts as a slave device on the I<sup>2</sup>C bus and has the address 0b1101110. The interface accepts byte-oriented block write and block read operations. An address byte (P) specifies the register address (Table 3B) as the byte position of the first register to write or read. Data bytes (registers) are accessed in sequential order from the lowest to the highest byte (most significant bit first, see Table 3I, 3J).

Read and write block transfers can be stopped after any complete byte transfer. It is recommended to terminate the I<sup>2</sup>C read or write transfer after accessing byte #23 by sending a stop command.

For full electrical I<sup>2</sup>C compliance, it is recommended to use external pull-up resistors for SDATA and SCLK. The internal pull-up resistors have a size of 50kΩ typical.

**Table 3I. Block Write Operation**

| Bit           | 1     | 2:8           | 9     | 10  | 11:18          | 19  | 20:27         | 28  | 29-36           | 37  | ...           | ... | ...  |
|---------------|-------|---------------|-------|-----|----------------|-----|---------------|-----|-----------------|-----|---------------|-----|------|
| Description   | START | Slave Address | W (0) | ACK | Address Byte P | ACK | Data Byte (P) | ACK | Data Byte (P+1) | ACK | Data Byte ... | ACK | STOP |
| Length (bits) | 1     | 7             | 1     | 1   | 8              | 1   | 8             | 1   | 8               | 1   | 8             | 1   | 1    |

**Table 3J. Block Read Operation**

| Bit           | 1     | 2:8           | 9     | 10  | 11:18          | 19  | 20             | 21:27         | 28    | 29  | 30:37         | 38  | 39-46           | 47  | ...           | ... | ...  |
|---------------|-------|---------------|-------|-----|----------------|-----|----------------|---------------|-------|-----|---------------|-----|-----------------|-----|---------------|-----|------|
| Description   | START | Slave Address | W (0) | ACK | Address byte P | ACK | Repeated START | Slave Address | R (1) | ACK | Data Byte (P) | ACK | Data Byte (P+1) | ACK | Data Byte ... | ACK | STOP |
| Length (bits) | 1     | 7             | 1     | 1   | 8              | 1   | 1              | 7             | 1     | 1   | 8             | 1   | 8               | 1   | 8             | 1   | 1    |

## Absolute Maximum Ratings

NOTE: Stresses beyond those listed under *Absolute Maximum Ratings* may cause permanent damage to the device. These ratings are stress specifications only. Functional operation of product at these conditions or any conditions beyond those listed in the *DC Characteristics* or *AC Characteristics* is not implied. Exposure to absolute maximum rating conditions for extended periods may affect product reliability.

| Item   | Rating                               |
|--|--------------------------------------|
| Supply Voltage, $V_{CC}$                                       | 3.63V                                |
| Inputs, $V_I$<br>XTAL_IN<br>Other Input                        | 0V to 2V<br>-0.5V to $V_{CC} + 0.5V$ |
| Outputs, $I_O$ (LVPECL)<br>Continuous Current<br>Surge Current | 50mA<br>100mA                        |
| Outputs, $I_O$ (SDATA)   | 10mA                                 |
| Outputs, $I_O$ (LVDS)<br>Continuous Current<br>Surge Current   | 10mA<br>15mA                         |
| Package Thermal Impedance, $\theta_{JA}$                       | 33.1°C/W (0 mps)                     |
| Storage Temperature, $T_{STG}$                                 | -65°C to 150°C                       |

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics,  $V_{CC} = V_{CCO} = 3.3V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

| Symbol    | Parameter             | Test Conditions | Minimum         | Typical | Maximum  | Units |
|-----------|-----------------------|-----------------|-----------------|---------|----------|-------|
| $V_{CC}$  | Core Supply Voltage   |                 | 3.135           | 3.3     | 3.465    | V     |
| $V_{CCA}$ | Analog Supply Voltage |                 | $V_{CC} - 0.32$ | 3.3     | $V_{CC}$ | V     |
| $V_{CCO}$ | Output Supply Voltage |                 | 3.135           | 3.3     | 3.465    | V     |
| $I_{CCA}$ | Analog Supply Current |                 |                 |         | 32       | mA    |
| $I_{EE}$  | Power Supply Current  | LVPECL          |                 |         | 192      | mA    |
| $I_{CC}$  | Power Supply Current  | LVDS            |                 |         | 125      | mA    |
| $I_{CCO}$ | Output Supply Current | LVDS            |                 |         | 85       | mA    |

**Table 4B. Power Supply DC Characteristics,  $V_{CC} = V_{CCO} = 2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

| Symbol    | Parameter             | Test Conditions | Minimum         | Typical | Maximum  | Units |
|-----------|-----------------------|-----------------|-----------------|---------|----------|-------|
| $V_{CC}$  | Core Supply Voltage   |                 | 2.375           | 2.5     | 2.625    | V     |
| $V_{CCA}$ | Analog Supply Voltage |                 | $V_{CC} - 0.28$ | 2.5     | $V_{CC}$ | V     |
| $V_{CCO}$ | Output Supply Voltage |                 | 2.375           | 2.5     | 2.625    | V     |
| $I_{CCA}$ | Analog Supply Current |                 |                 |         | 28       | mA    |
| $I_{EE}$  | Power Supply Current  | LVPECL          |                 |         | 184      | mA    |
| $I_{CC}$  | Power Supply Current  | LVDS            |                 |         | 122      | mA    |
| $I_{CCO}$ | Output Supply Current | LVDS            |                 |         | 82       | mA    |

**Table 4C. LVCMOS/LVTTL DC Characteristics,  $V_{CC} = V_{CCO} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$** 

| Symbol   | Parameter                   |                                 | Test Conditions                               | Minimum | Typical | Maximum        | Units   |
|----------|-----------------------------|---------------------------------|---|---------|---------|----------------|---------|
| $V_{IH}$ | Input High Voltage          | SCLK, SDATA, CLK_SEL, FSEL[1:0] | $V_{CC} = 3.3V$                               | 2       |         | $V_{CC} + 0.3$ | V       |
|          |                             |                                 | $V_{CC} = 2.5V$                               | 1.7     |         | $V_{CC} + 0.3$ | V       |
| $V_{IL}$ | Input Low Voltage           | SCLK, SDATA, CLK_SEL            | $V_{CC} = 3.3V$                               | -0.3    |         | 0.8            | V       |
|          |                             | SCLK, SDATA, CLK_SEL            | $V_{CC} = 2.5V$                               | -0.3    |         | 0.7            | V       |
|          |                             | FSEL[1:0]                       | $V_{CC} = 3.3V$ or $2.5V$                     |         |         | 0.5            | V       |
| $I_{IH}$ | Input High Current          | SCLK, SDATA                     | $V_{CC} = V_{IN} = 3.465V$ or $2.625V$        |         |         | 5              | $\mu A$ |
|          |                             | CLK_SEL, FSEL[1:0]              | $V_{CC} = V_{IN} = 3.465V$ or $2.625V$        |         |         | 150            | $\mu A$ |
| $I_{IL}$ | Input Low Current           | SCLK, SDATA                     | $V_{CC} = 3.465V$ or $2.625V$ , $V_{IN} = 0V$ | -150    |         |                | $\mu A$ |
|          |                             | CLK_SEL, FSEL[1:0]              | $V_{CC} = 3.465V$ or $2.625V$ , $V_{IN} = 0V$ | -5      |         |                | $\mu A$ |
| $V_{OH}$ | Output High Voltage; NOTE 1 | LOCK                            | $V_{CCO} = 3.465V$                            | 2.6     |         |                | V       |
|          |                             | LOCK                            | $V_{CCO} = 2.625V$                            | 1.8     |         |                | V       |
| $V_{OL}$ | Output Low Voltage; NOTE 1  | LOCK                            | $V_{CCO} = 3.465V$ or $2.625V$                |         |         | 0.5            | V       |

NOTE 1: Outputs terminated with  $50\Omega$  to  $V_{CCO}/2$ . In the Parameter Measurement Information Section, see *Output Load Test Circuit Diagrams*.

**Table 4D. Differential DC Characteristics,  $V_{CC} = V_{CCO} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$** 

| Symbol    | Parameter                         |           | Test Conditions                               | Minimum  | Typical | Maximum         | Units   |
|-----------|-----------------------------------|-----------|---|----------|---------|-----------------|---------|
| $I_{IH}$  | Input High Current                | CLK, nCLK | $V_{CC} = V_{IN} = 3.465V$ or $2.625V$        |          |         | 150             | $\mu A$ |
| $I_{IL}$  | Input Low Current                 | nCLK      | $V_{CC} = 3.465V$ or $2.625V$ , $V_{IN} = 0V$ | -150     |         |                 | $\mu A$ |
|           |                                   | CLK       | $V_{CC} = 3.465V$ or $2.625V$ , $V_{IN} = 0V$ | -5       |         |                 | $\mu A$ |
| $V_{PP}$  | Peak-to-Peak Voltage              |           |   | 0.15     |         | 1.3             | V       |
| $V_{CMR}$ | Common Mode Input Voltage; NOTE 1 |           |   | $V_{EE}$ |         | $V_{CC} - 0.85$ | V       |

NOTE 1: Common mode input voltage is at the cross point.

**Table 4E. LVPECL DC Characteristics,  $V_{CC} = V_{CCO} = 3.3V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$** 

| Symbol      | Parameter                         | Test Conditions | Minimum         | Typical | Maximum          | Units |
|-------------|-----------------------------------|-----------------|-----------------|---------|------------------|-------|
| $V_{OH}$    | Output High Voltage; NOTE 1       |                 | $V_{CCO} - 1.1$ |         | $V_{CCO} - 0.75$ | V     |
| $V_{OL}$    | Output Low Voltage; NOTE 1        |                 | $V_{CCO} - 2.0$ |         | $V_{CCO} - 1.6$  | V     |
| $V_{SWING}$ | Peak-to-Peak Output Voltage Swing |                 | 0.6             |         | 1.0              | V     |

NOTE 1: Outputs termination with  $50\Omega$  to  $V_{CCO} - 2V$ .

**Table 4F. LVPECL DC Characteristics,  $V_{CC} = V_{CCO} = 2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$** 

| Symbol      | Parameter                         | Test Conditions | Minimum         | Typical | Maximum          | Units |
|-------------|-----------------------------------|-----------------|-----------------|---------|------------------|-------|
| $V_{OH}$    | Output High Voltage; NOTE 1       |                 | $V_{CCO} - 1.2$ |         | $V_{CCO} - 0.75$ | V     |
| $V_{OL}$    | Output Low Voltage; NOTE 1        |                 | $V_{CCO} - 2.0$ |         | $V_{CCO} - 1.5$  | V     |
| $V_{SWING}$ | Peak-to-Peak Output Voltage Swing |                 | 0.5             |         | 1.0              | V     |

NOTE 1: Outputs termination with  $50\Omega$  to  $V_{CCO} - 2V$ .

**Table 4G. LVDS DC Characteristics,  $V_{CC} = V_{CCO} = 3.3V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$** 

| Symbol          | Parameter                   | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------------|-----------------------------|-----------------|---------|---------|---------|-------|
| $V_{OD}$        | Differential Output Voltage |                 | 247     | 345     | 454     | mV    |
| $\Delta V_{OD}$ | $V_{OD}$ Magnitude Change   |                 |         |         | 50      | mV    |
| $V_{OS}$        | Offset Voltage              |                 | 1.15    | 1.25    | 1.375   | V     |
| $\Delta V_{OS}$ | $V_{OS}$ Magnitude Change   |                 |         |         | 50      | mV    |

**Table 4H. LVDS DC Characteristics,  $V_{CC} = V_{CCO} = 2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$** 

| Symbol          | Parameter                   | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------------|-----------------------------|-----------------|---------|---------|---------|-------|
| $V_{OD}$        | Differential Output Voltage |                 | 230     | 340     | 454     | mV    |
| $\Delta V_{OD}$ | $V_{OD}$ Magnitude Change   |                 |         |         | 50      | mV    |
| $V_{OS}$        | Offset Voltage              |                 | 1.15    | 1.25    | 1.375   | V     |
| $\Delta V_{OS}$ | $V_{OS}$ Magnitude Change   |                 |         |         | 50      | mV    |

**Table 5. Crystal Characteristics**

| Parameter                          | Test Conditions | Minimum     | Typical | Maximum | Units    |
|------------------------------------|-----------------|-------------|---------|---------|----------|
| Mode of Oscillation                |                 | Fundamental |         |         |          |
| Frequency                          |                 | 10          |         | 40      | MHz      |
| Load Capacitance ( $C_L$ )         |                 | 10          |         | 18      | pF       |
| Equivalent Series Resistance (ESR) |                 |             |         | 50      | $\Omega$ |

## AC Electrical Characteristics

**Table 6A. PCI Express Jitter Specifications,  $V_{CC} = V_{CCO} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$**

| Symbol                                | Parameter                                  | Test Conditions   | Minimum | Typical | Maximum | PCIe Industry Specification | Units |
|---------------------------------------|--|---|---------|---------|---------|-----------------------------|-------|
| $t_j$<br>(PCIe Gen 1)                 | Phase Jitter<br>Peak-to-Peak;<br>NOTE 1, 4 | $f = 100MHz$ , 25MHz Crystal Input<br>Evaluation Band: 0Hz - Nyquist<br>(clock frequency/2) |         | 8.3     | 13.2    | 86                          | ps    |
| $t_{REFCLK\_HF\_RMS}$<br>(PCIe Gen 2) | Phase Jitter RMS;<br>NOTE 2, 4             | $f = 100MHz$ , 25MHz Crystal Input<br>High Band: 1.5MHz - Nyquist<br>(clock frequency/2)    |         | 0.78    | 1.35    | 3.1                         | ps    |
| $t_{REFCLK\_LF\_RMS}$<br>(PCIe Gen 2) | Phase Jitter RMS;<br>NOTE 2, 4             | $f = 100MHz$ , 25MHz Crystal Input<br>Low Band: 10kHz - 1.5MHz                              |         | 0.05    | 0.10    | 3.0                         | ps    |
| $t_{REFCLK\_RMS}$<br>(PCIe Gen 3)     | Phase Jitter RMS;<br>NOTE 3, 4             | $f = 100MHz$ , 25MHz Crystal Input<br>Evaluation Band: 0Hz - Nyquist<br>(clock frequency/2) |         | 0.175   | 0.34    | 0.8                         | ps    |

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lpm. The device will meet specifications after thermal equilibrium has been reached under these conditions. For additional information, refer to the *PCI Express Application Note* section in the datasheet.

NOTE 1: Peak-to-Peak jitter after applying system transfer function for the Common Clock Architecture. Maximum limit for PCI Express Gen 1 is 86ps peak-to-peak for a sample size of  $10^6$  clock periods.

NOTE 2: RMS jitter after applying the two evaluation bands to the two transfer functions defined in the Common Clock Architecture and reporting the worst case results for each evaluation band. Maximum limit for PCI Express Generation 2 is 3.1ps RMS for  $t_{REFCLK\_HF\_RMS}$  (High Band) and 3.0ps RMS for  $t_{REFCLK\_LF\_RMS}$  (Low Band).

NOTE 3: RMS jitter after applying system transfer function for the common clock architecture. This specification is based on the *PCI Express Base Specification Revision 0.7, October 2009* and is subject to change pending the final release version of the specification.

NOTE 4: This parameter is guaranteed by characterization. Not tested in production.

**Table 6B. AC Characteristics,  $V_{CC} = V_{CCO} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$   $V_{EE} = 0V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}$** 

| Symbol                    | Parameter                           |                | Test Conditions   | Minimum | Typical | Maximum | Units |
|---------------------------|-------------------------------------|----------------|---|---------|---------|---------|-------|
| $f_{DIFF\_IN}$            | Differential Input Frequency        |                |   | 10      |         | 312.5   | MHz   |
| $f_{VCO}$                 | VCO Frequency                       |                |   | 1910    |         | 2500    | MHz   |
| $\sigma_{jit}(\emptyset)$ | RMS Phase Jitter, Random;<br>NOTE 1 |                | 25MHz Crystal, $f_{OUT} = 100MHz$ ,<br>Integration Range:<br>12kHz – 20MHz      |         | 258     | 332     | fs    |
|                           |                                     |                | 25MHz Crystal, $f_{OUT} = 125MHz$ ,<br>Integration Range: 12kHz –<br>20MHz      |         | 220     | 291     | fs    |
|                           |                                     |                | 25MHz Crystal, $f_{OUT} = 125MHz$ ,<br>Integration Range: 10kHz –<br>1MHz       |         | 164     | 232     | fs    |
|                           |                                     |                | 25MHz Crystal, $f_{OUT} =$<br>156.25MHz, Integration Range:<br>12kHz – 20MHz    |         | 228     | 306     | fs    |
|                           |                                     |                | 25MHz Crystal, $f_{OUT} =$<br>156.25MHz, Integration Range:<br>10kHz – 1MHz     |         | 175     | 234     | fs    |
|                           |                                     |                | 25MHz Crystal, $f_{OUT} = 250MHz$ ,<br>Integration Range: 12kHz –<br>20MHz      |         | 212     | 292     | fs    |
|                           |                                     |                | 30.72MHz Crystal, $f_{OUT} =$<br>491.52MHz, Integration Range:<br>12kHz – 20MHz |         | 213     | 299     | fs    |
|                           |                                     |                | 19.44MHz Crystal, $f_{OUT} =$<br>622.08MHz, Integration Range:<br>12kHz – 20MHz |         | 280     | 386     | fs    |
| $t_{sk(o)}$               | Output Skew;<br>NOTE 2, 3           | LVPECL Outputs | LVDS_SEL = 0  |         |         | 45      | ps    |
|                           |                                     | LVDS Outputs   | LVDS_SEL = 1  |         |         | 45      | ps    |
| $t_R / t_F$               | Output<br>Rise/Fall Time            | LVPECL Outputs | 20% - 80%, LVDS_SEL = 0   | 100     |         | 400     | ps    |
|                           |                                     | LVDS Outputs   | 20% - 80%, LVDS_SEL = 1   | 100     |         | 400     | ps    |
| odc                       | Output Duty Cycle                   |                | N > 3 Output Divider;<br>LVDS_SEL = 0 or 1                                      | 47      |         | 53      | %     |
|                           |                                     |                | N ≤ 3 Output Divider;<br>LVDS_SEL = 0 or 1                                      | 42      |         | 58      | %     |
| $t_{LOCK}$                | PLL Lock Time;<br>NOTE 3, 4         | LOCK Output    |   |         |         | 20      | ms    |
| $t_{TRANSITION}$          | Transition<br>Time;<br>NOTE 3, 4    | LOCK Output    |   |         |         | 20      | ms    |

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

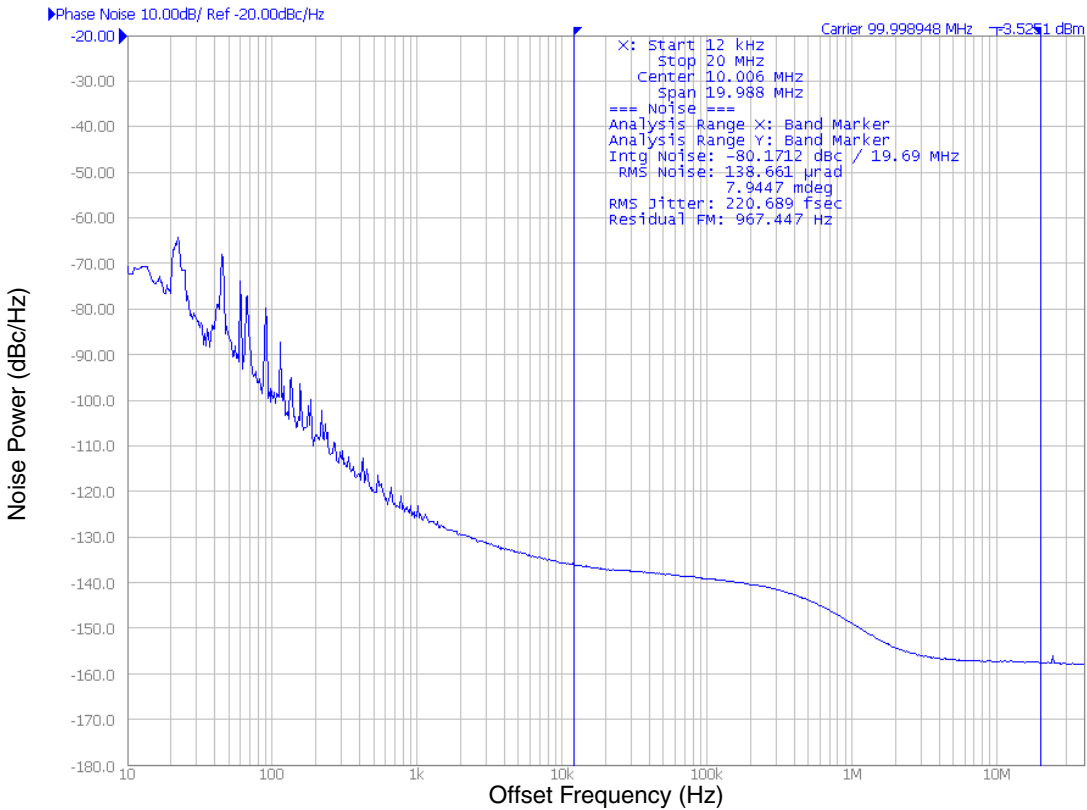
NOTE 1: Refer to Phase Noise Plots.

NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at the differential crosspoints.

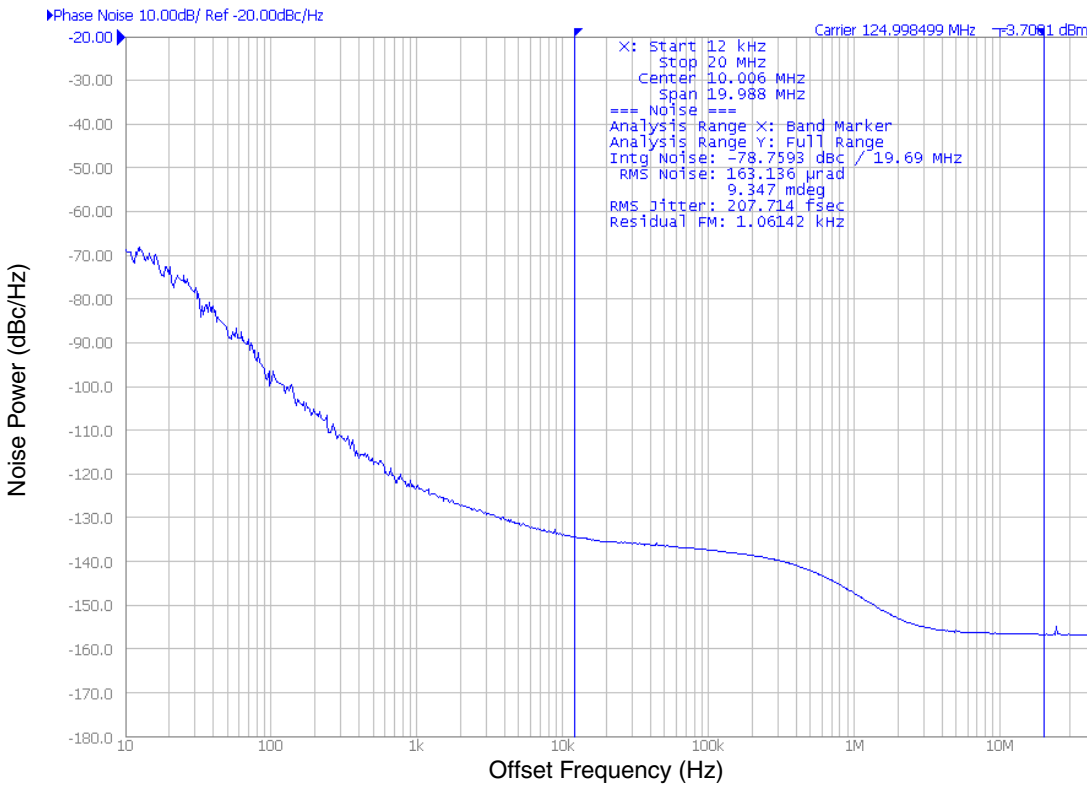
NOTE 3: These parameters are guaranteed by characterization. Not tested in production.

NOTE 4: Refer to  $t_{LOCK}$  and  $t_{TRANSITION}$  in Parameter Measurement Information.

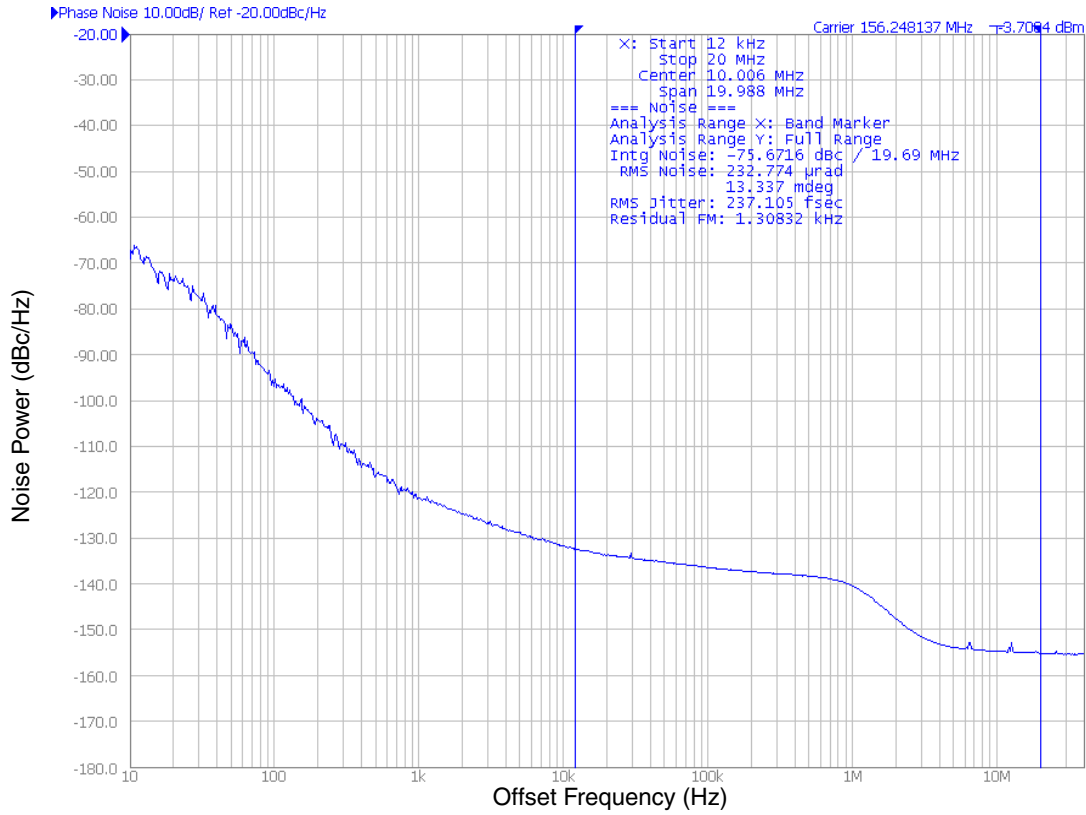
### Typical Phase Noise at 100MHz (3.3V)



### Typical Phase Noise at 125MHz (3.3V)

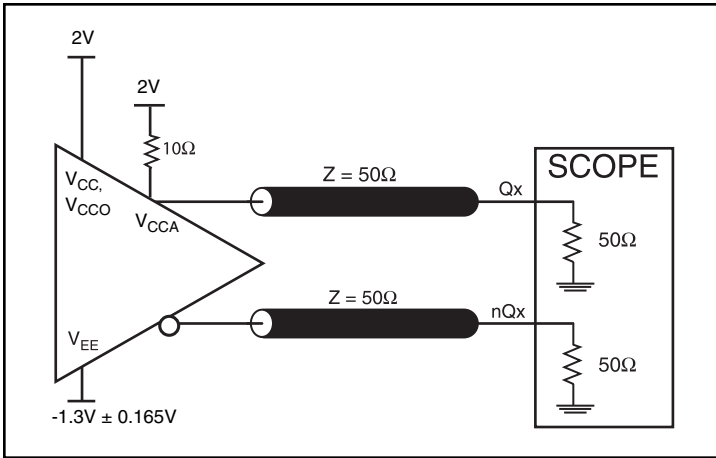


## Typical Phase Noise at 156.25MHz (3.3V)

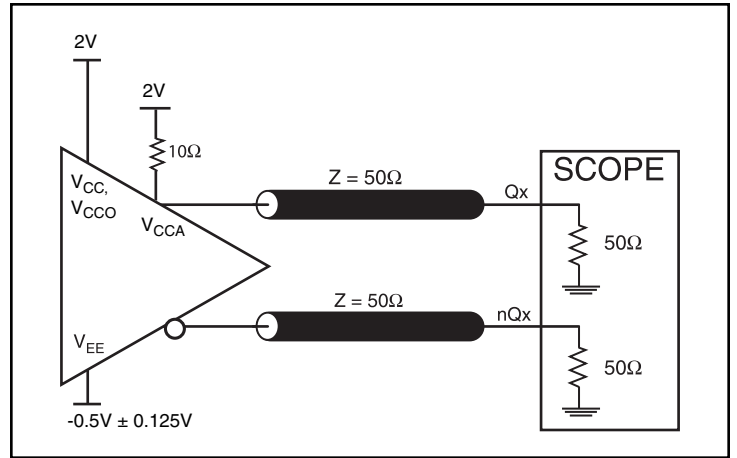




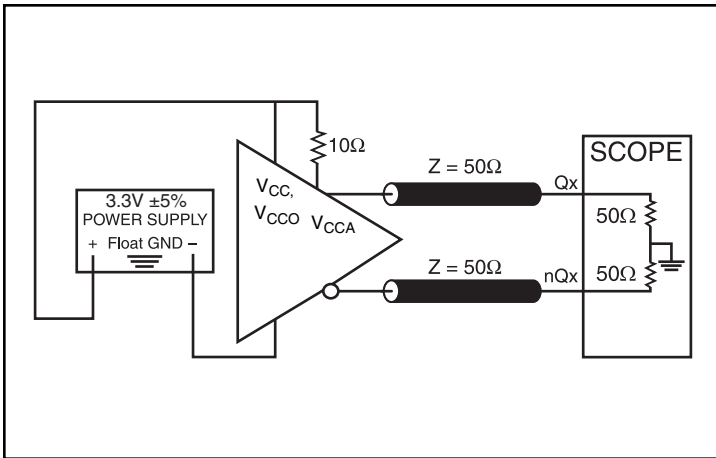
## Parameter Measurement Information



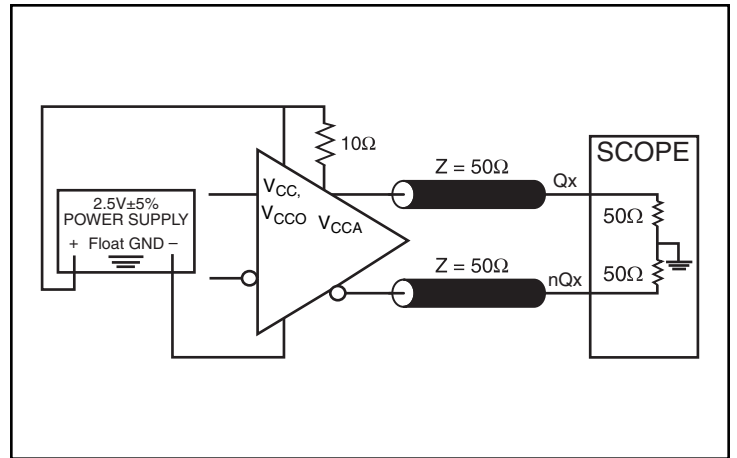
3.3V LVPECL Output Load AC Test Circuit



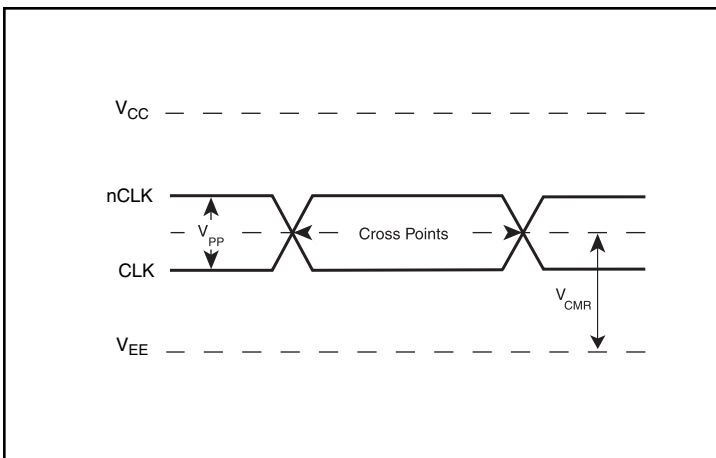
2.5V LVPECL Output Load AC Test Circuit



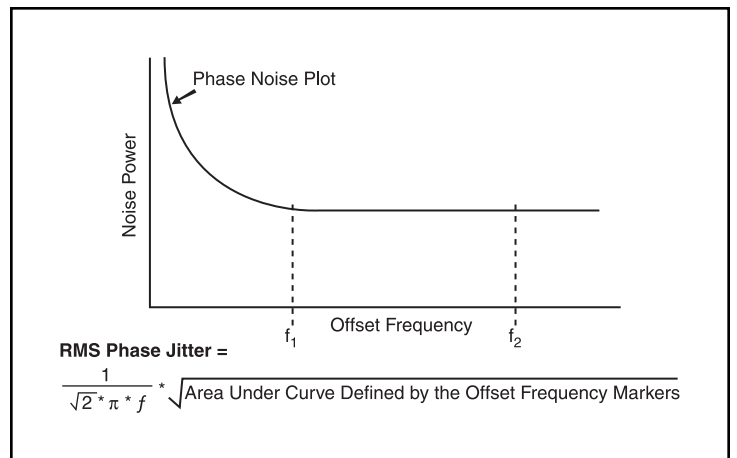
3.3V LVDS Output Load AC Test Circuit



2.5V LVDS Output Load AC Test Circuit

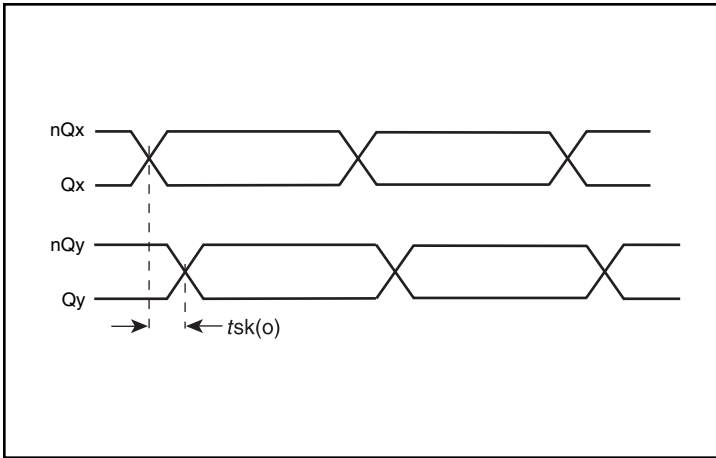


Differential Input Levels

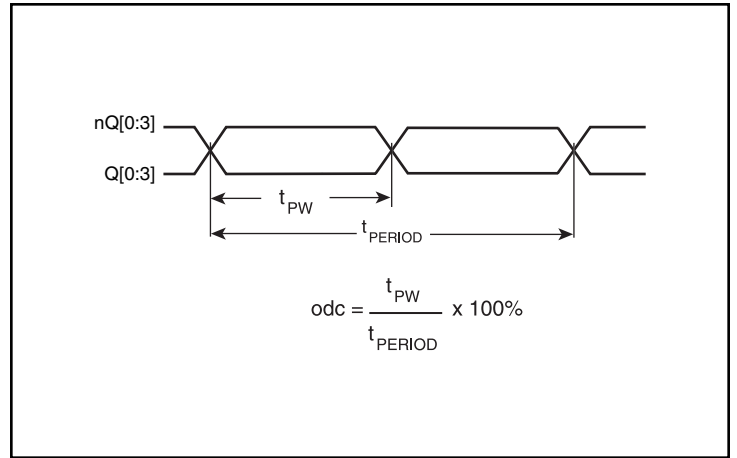


RMS Phase Jitter

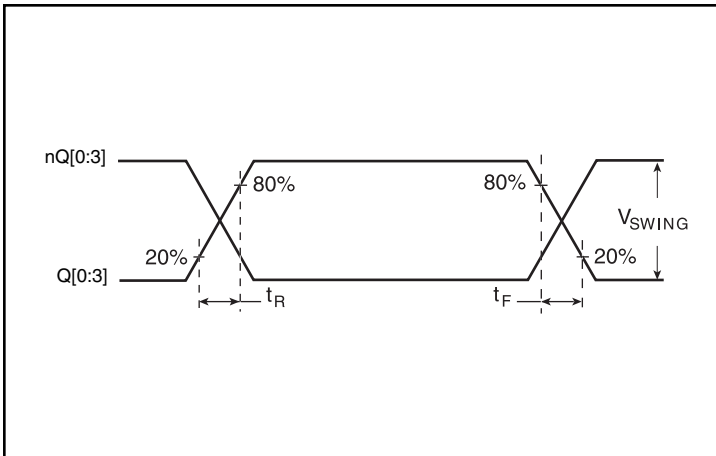
Parameter Measurement Information, continued



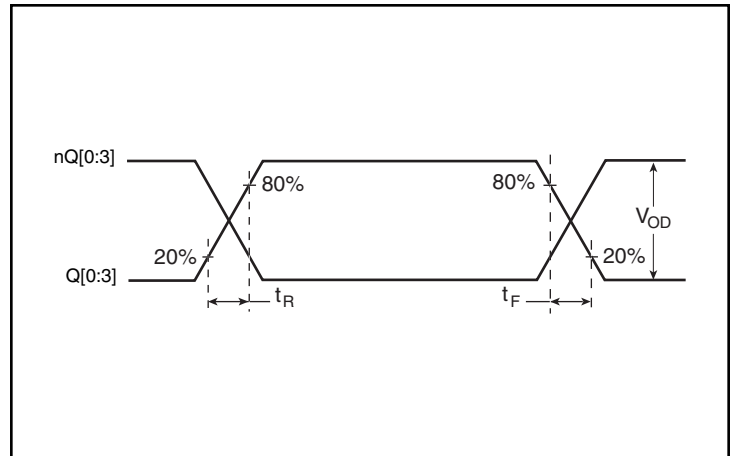
Output Skew



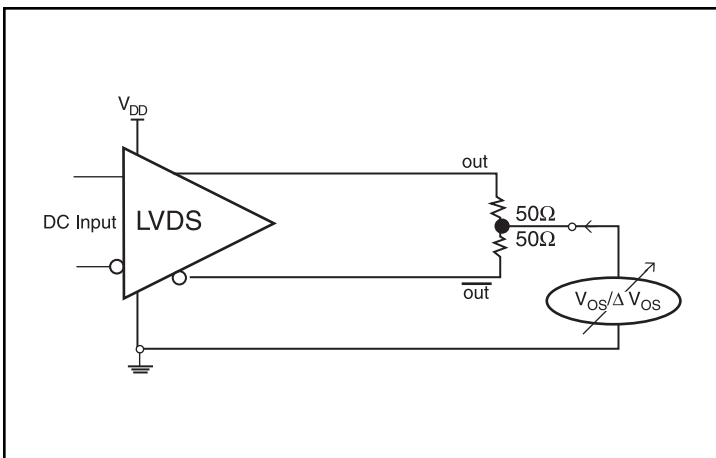
Output Duty Cycle/Pulse Width/Period



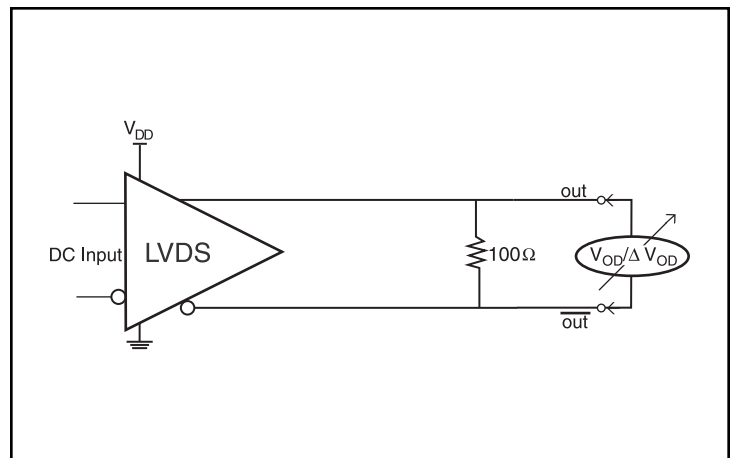
LVPECL Output Rise/Fall Time



LVDS Output Rise/Fall Time

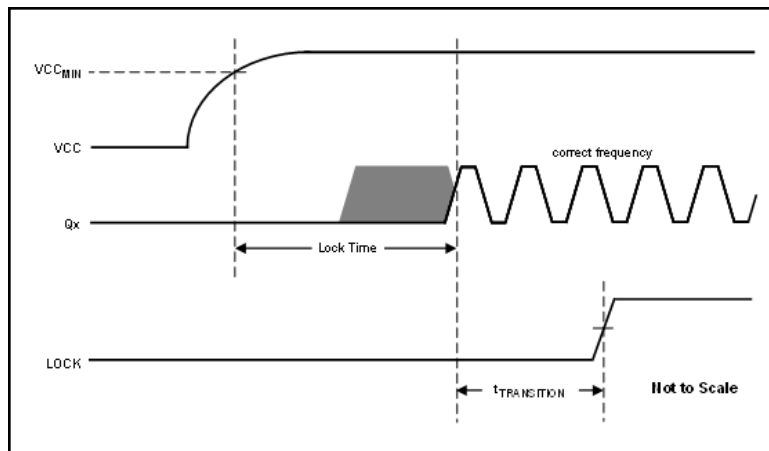


Offset Voltage Setup



Differential Output Voltage Setup

## Parameter Measurement Information, continued



LockTime & Transition Time

## Applications Information

### Recommendations for Unused Input and Output Pins

#### Inputs:

##### LVC MOS Control Pins

All control pins have internal pullups or pulldowns; additional resistance is not required but can be added for additional protection. A 1k $\Omega$  resistor can be used.

##### CLK/nCLK Inputs

For applications not requiring the use of the differential input, both CLK and nCLK can be left floating. Though not required, but for additional protection, a 1k $\Omega$  resistor can be tied from CLK to ground.

##### Crystal Inputs

For applications not requiring the use of the crystal oscillator input, both XTAL\_IN and XTAL\_OUT can be left floating. Though not required, but for additional protection, a 1k $\Omega$  resistor can be tied from XTAL\_IN to ground.

#### Outputs:

##### LVPECL Outputs

All unused LVPECL outputs can be left floating. We recommend that there is no trace attached. Both sides of the differential output pair should either be left floating or terminated.

##### LVDS Outputs

All unused LVDS output pairs can be either left floating or terminated with 100 $\Omega$  across. If they are left floating, there should be no trace attached.

## Wiring the Differential Input to Accept Single-Ended Levels

Figure 1 shows how a differential input can be wired to accept single ended levels. The reference voltage  $V_1 = V_{CC}/2$  is generated by the bias resistors R1 and R2. The bypass capacitor (C1) is used to help filter noise on the DC bias. This bias circuit should be located as close to the input pin as possible. The ratio of R1 and R2 might need to be adjusted to position the  $V_1$  in the center of the input voltage swing. For example, if the input clock swing is 2.5V and  $V_{CC} = 3.3V$ , R1 and R2 value should be adjusted to set  $V_1$  at 1.25V. The values below are for when both the single ended swing and  $V_{CC}$  are at the same voltage. This configuration requires that the sum of the output impedance of the driver ( $R_o$ ) and the series resistance ( $R_s$ ) equals the transmission line impedance. In addition, matched termination at the input will attenuate the signal in half. This can be done in one of two ways. First, R3 and R4 in parallel should equal the transmission

line impedance. For most  $50\Omega$  applications, R3 and R4 can be  $100\Omega$ . The values of the resistors can be increased to reduce the loading for slower and weaker LVCMOS driver. When using single-ended signaling, the noise rejection benefits of differential signaling are reduced. Even though the differential input can handle full rail LVCMOS signaling, it is recommended that the amplitude be reduced. The datasheet specifies a lower differential amplitude, however this only applies to differential signals. For single-ended applications, the swing can be larger, however  $V_{IL}$  cannot be less than  $-0.3V$  and  $V_{IH}$  cannot be more than  $V_{CC} + 0.3V$ . Though some of the recommended components might not be used, the pads should be placed in the layout. They can be utilized for debugging purposes. The datasheet specifications are characterized and guaranteed by using a differential signal.

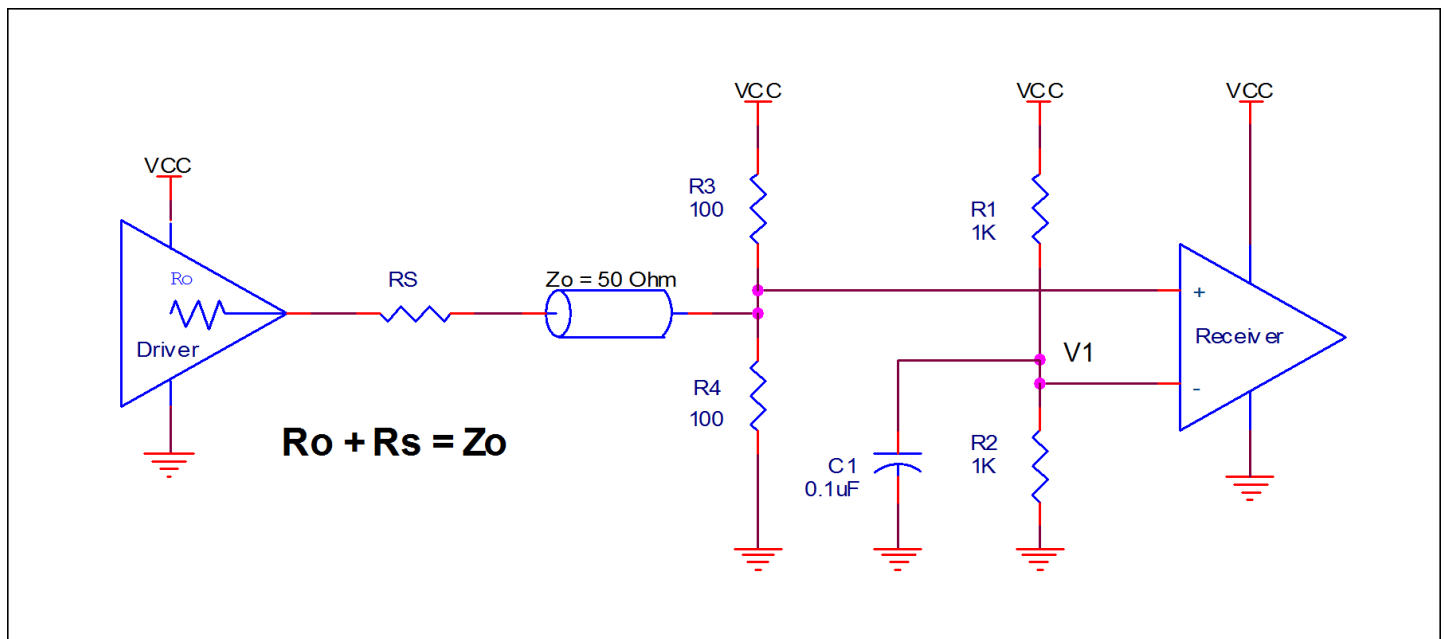


Figure 1. Recommended Schematic for Wiring a Differential Input to Accept Single-ended Levels

## Overdriving the XTAL Interface

The XTAL\_IN input can be overdriven by an LVCMOS driver or by one side of a differential driver through an AC coupling capacitor. The XTAL\_OUT pin can be left floating. The amplitude of the input signal should be between 500mV and 1.8V and the slew rate should not be less than 0.2V/nS. For 3.3V LVCMOS inputs, the amplitude must be reduced from full swing to at least half the swing in order to prevent signal interference with the power rail and to reduce internal noise. *Figure 2A* shows an example of the interface diagram for a high speed 3.3V LVCMOS driver. This configuration requires that the sum of the output impedance of the driver ( $R_o$ ) and the series resistance ( $R_s$ ) equals the transmission line impedance. In addition, matched termination at the crystal input will attenuate the signal in half. This

can be done in one of two ways. First,  $R_1$  and  $R_2$  in parallel should equal the transmission line impedance. For most 50Ω applications,  $R_1$  and  $R_2$  can be 100Ω. This can also be accomplished by removing  $R_1$  and changing  $R_2$  to 50Ω. The values of the resistors can be increased to reduce the loading for a slower and weaker LVCMOS driver. *Figure 2B* shows an example of the interface diagram for an LVPECL driver. This is a standard LVPECL termination with one side of the driver feeding the XTAL\_IN input. It is recommended that all components in the schematics be placed in the layout. Though some components might not be used, they can be utilized for debugging purposes. The datasheet specifications are characterized and guaranteed by using a quartz crystal as the input.

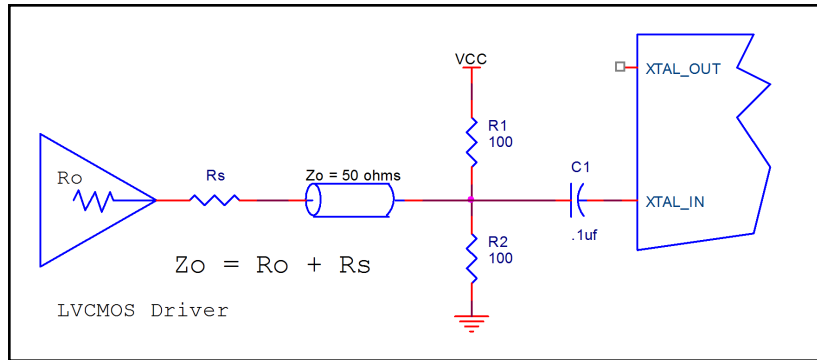


Figure 2A. General Diagram for LVCMOS Driver to XTAL Input Interface

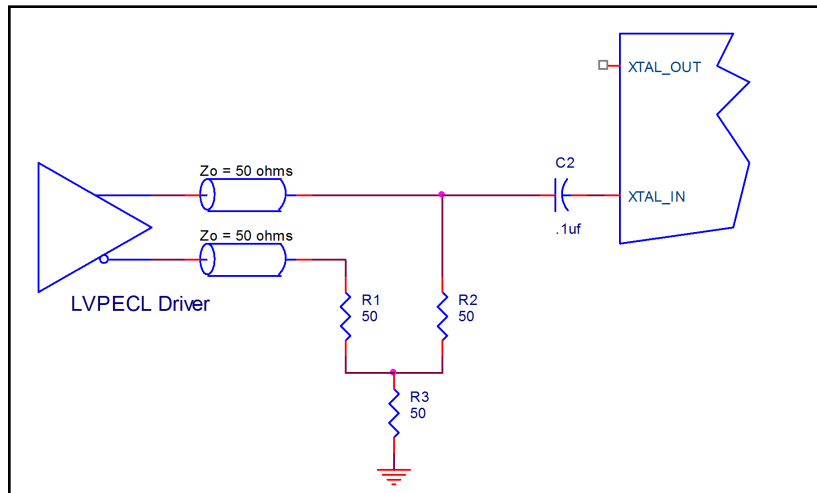
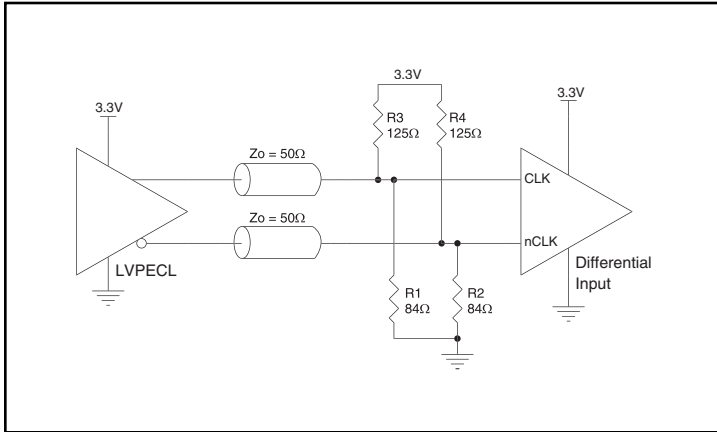


Figure 2B. General Diagram for LVPECL Driver to XTAL Input Interface

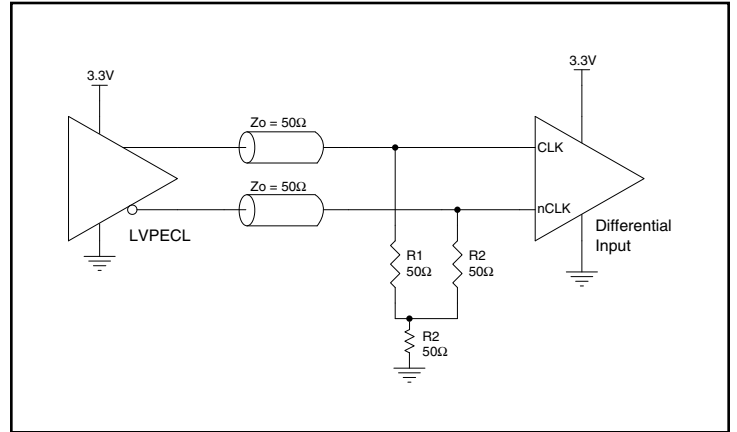
### 3.3V Differential Clock Input Interface

The CLK /nCLK accepts LVDS, LVPECL, HCSL and other differential signals. Both  $V_{SWING}$  and  $V_{OH}$  must meet the  $V_{PP}$  and  $V_{CMR}$  input requirements. *Figures 3A to 3D* show interface examples for the CLK/nCLK input driven by the most common driver types. The input

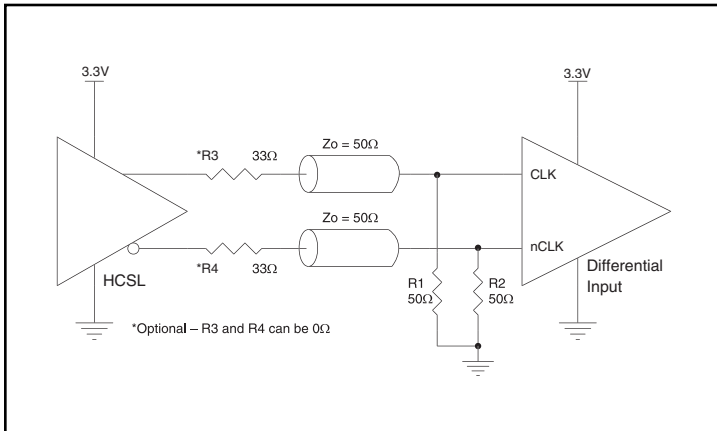
interfaces suggested here are examples only. If the driver is from another vendor, use their termination recommendation. Please consult with the vendor of the driver component to confirm the driver termination requirements.



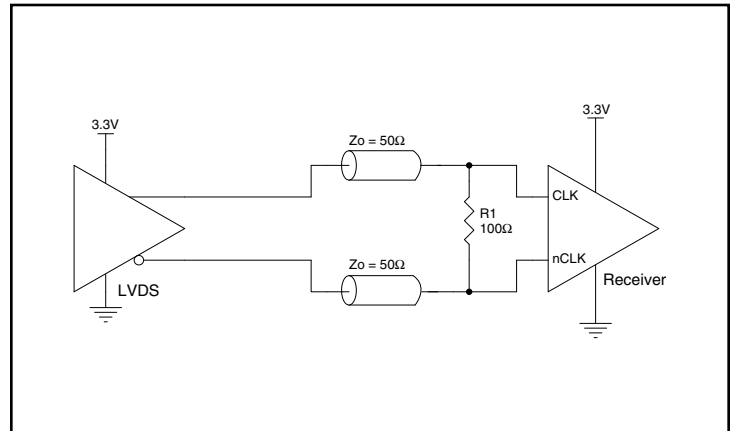
**Figure 3A. CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



**Figure 3B. CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



**Figure 3C. CLK/nCLK Input Driven by a 3.3V HCSL Driver**

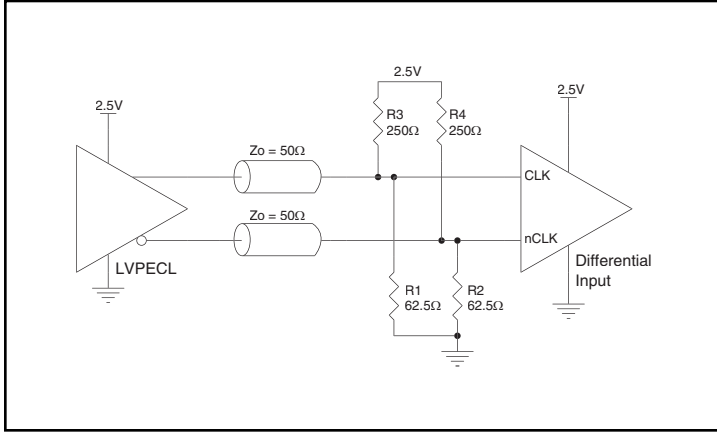


**Figure 3D. CLK/nCLK Input Driven by a 3.3V LVDS Driver**

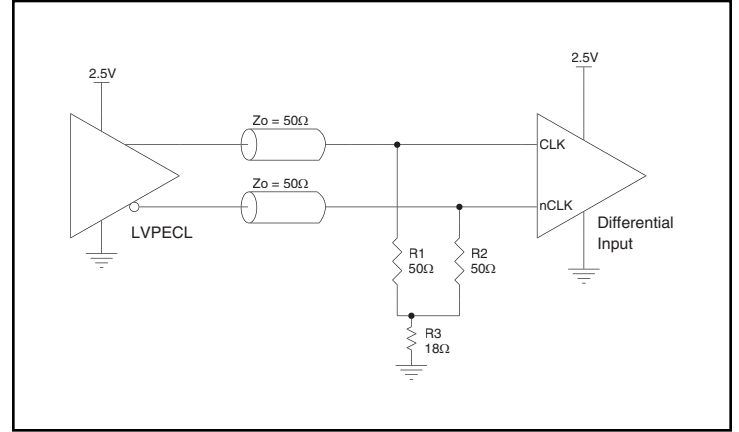
## 2.5V Differential Clock Input Interface

The CLK /nCLK accepts LVDS, LVPECL, HCSL and other differential signals. Both  $V_{SWING}$  and  $V_{OH}$  must meet the  $V_{PP}$  and  $V_{CMR}$  input requirements. *Figures 4A to 4D* show interface examples for the CLK/nCLK input driven by the most common driver types. The input

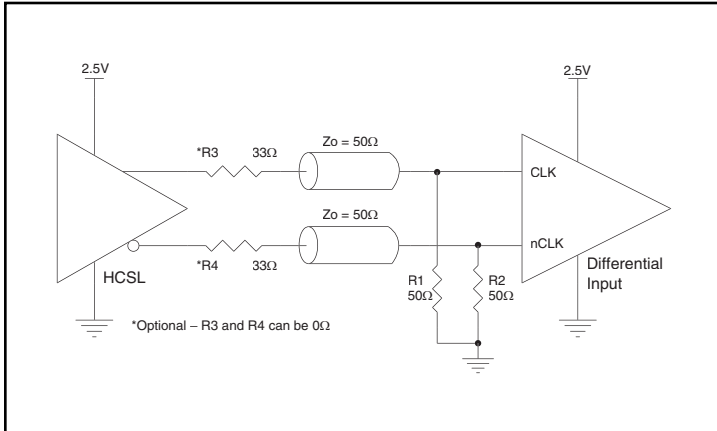
interfaces suggested here are examples only. If the driver is from another vendor, use their termination recommendation. Please consult with the vendor of the driver component to confirm the driver termination requirements.



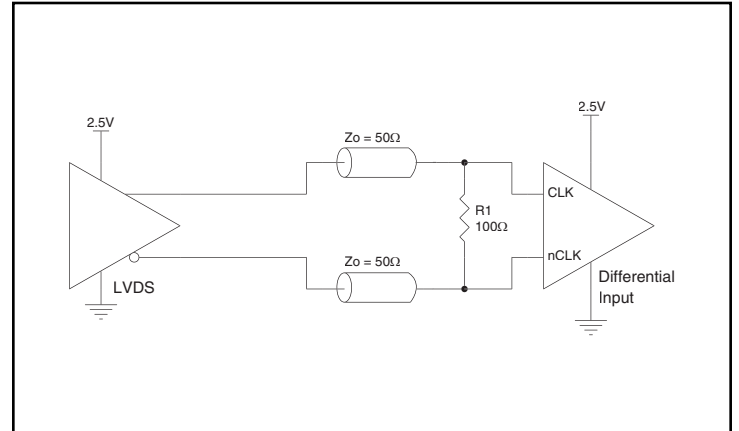
**Figure 4A.** CLK/nCLK Input Driven by a 2.5V LVPECL Driver



**Figure 4B.** CLK/nCLK Input Driven by a 2.5V LVPECL Driver



**Figure 4C.** CLK/nCLK Input Driven by a 2.5V HCSL Driver



**Figure 4D.** CLK/nCLK Input Driven by a 2.5V LVDS Driver

### LVDS Driver Termination

For a general LVDS interface, the recommended value for the termination impedance ( $Z_T$ ) is between  $90\Omega$  and  $132\Omega$ . The actual value should be selected to match the differential impedance ( $Z_0$ ) of your transmission line. A typical point-to-point LVDS design uses a  $100\Omega$  parallel resistor at the receiver and a  $100\Omega$  differential transmission-line environment. In order to avoid any transmission-line reflection issues, the components should be surface mounted and must be placed as close to the receiver as possible. IDT offers a full line of LVDS compliant devices with two types of output structures: current source and voltage source. The

standard termination schematic as shown in *Figure 5A* can be used with either type of output structure. *Figure 5B*, which can also be used with both output types, is an optional termination with center tap capacitance to help filter common mode noise. The capacitor value should be approximately  $50pF$ . If using a non-standard termination, it is recommended to contact IDT and confirm if the output structure is current source or voltage source type. In addition, since these outputs are LVDS compatible, the input receiver's amplitude and common-mode input range should be verified for compatibility with the output.

### Termination for 3.3V LVPECL Outputs

The clock layout topology shown below is a typical termination for LVPECL outputs. The two different layouts mentioned are recommended only as guidelines.

The differential outputs are low impedance follower outputs that generate ECL/LVPECL compatible outputs. Therefore, terminating resistors (DC current path to ground) or current sources must be used for functionality. These outputs are designed to drive  $50\Omega$

transmission lines. Matched impedance techniques should be used to maximize operating frequency and minimize signal distortion. *Figures 6A and 6B* show two different layouts which are recommended only as guidelines. Other suitable clock layouts may exist and it would be recommended that the board designers simulate to guarantee compatibility across all printed circuit and clock component process variations.

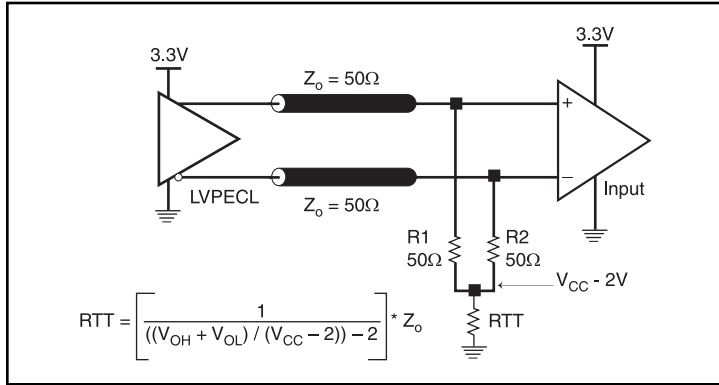


Figure 6A. 3.3V LVPECL Output Termination

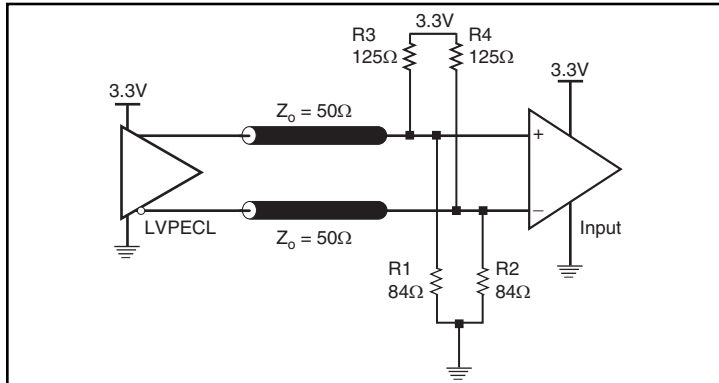


Figure 6B. 3.3V LVPECL Output Termination



## Termination for 2.5V LVPECL Outputs

Figure 7A and Figure 9B show examples of termination for 2.5V LVPECL driver. These terminations are equivalent to terminating 50Ω to  $V_{CC0} - 2V$ . For  $V_{CC0} = 2.5V$ , the  $V_{CC0} - 2V$  is very close to ground

level. The R3 in Figure 7B can be eliminated and the termination is shown in Figure 7C.

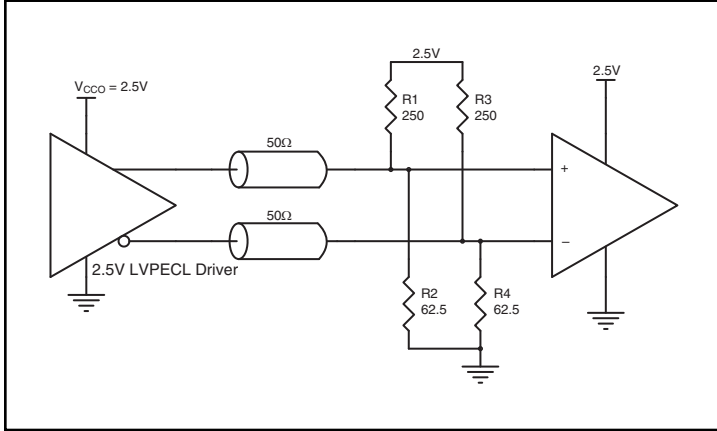


Figure 7A. 2.5V LVPECL Driver Termination Example

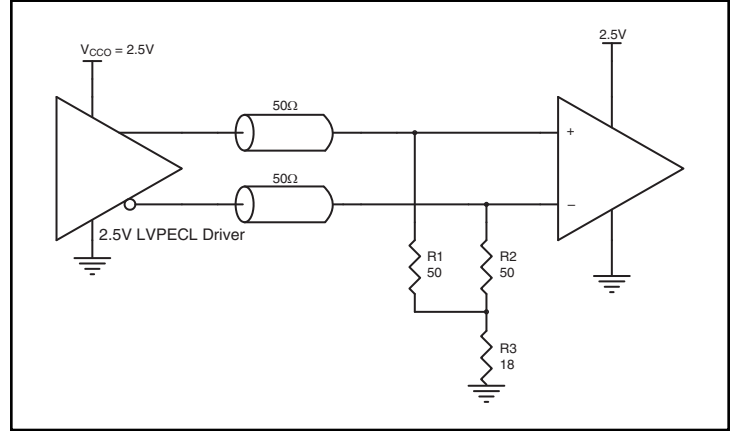


Figure 7B. 2.5V LVPECL Driver Termination Example

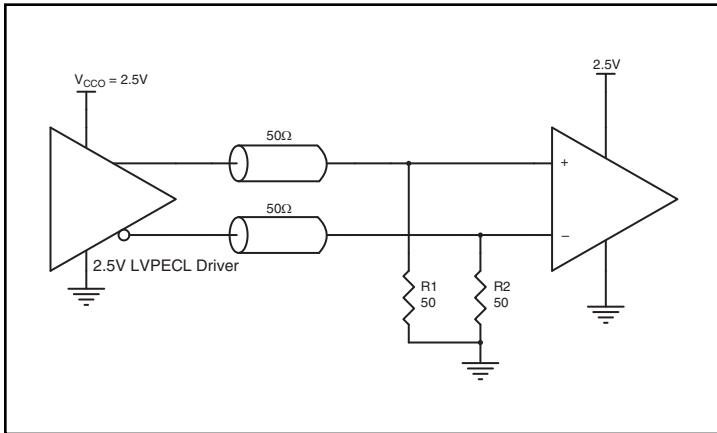


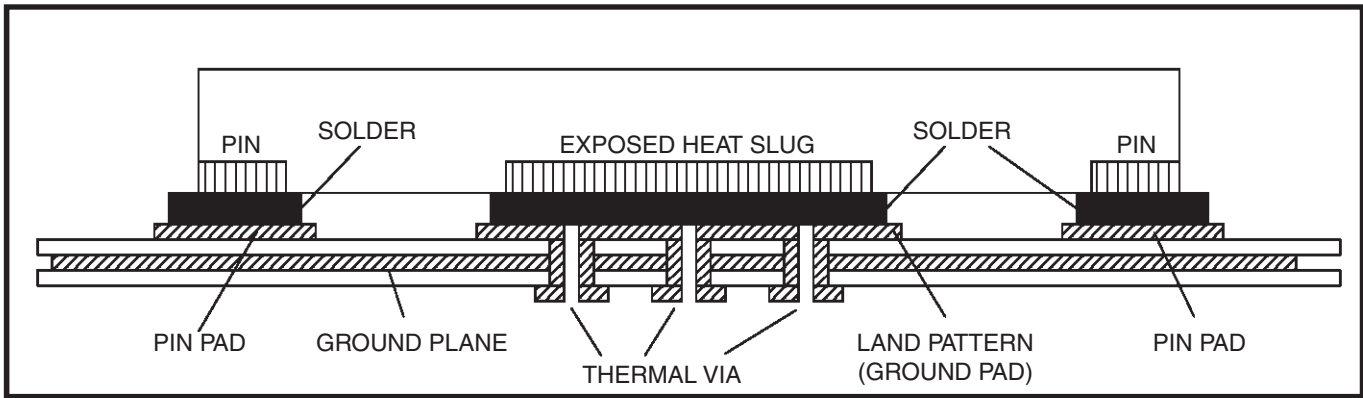
Figure 7C. 2.5V LVPECL Driver Termination Example

## VFQFN EPAD Thermal Release Path

In order to maximize both the removal of heat from the package and the electrical performance, a land pattern must be incorporated on the Printed Circuit Board (PCB) within the footprint of the package corresponding to the exposed metal pad or exposed heat slug on the package, as shown in *Figure 6*. The solderable area on the PCB, as defined by the solder mask, should be at least the same size/shape as the exposed pad/slug area on the package to maximize the thermal/electrical performance. Sufficient clearance should be designed on the PCB between the outer edges of the land pattern and the inner edges of pad pattern for the leads to avoid any shorts.

While the land pattern on the PCB provides a means of heat transfer and electrical grounding from the package to the board through a solder joint, thermal vias are necessary to effectively conduct from the surface of the PCB to the ground plane(s). The land pattern must be connected to ground through these vias. The vias act as “heat pipes”. The number of vias (i.e. “heat pipes”) are application specific

and dependent upon the package power dissipation as well as electrical conductivity requirements. Thus, thermal and electrical analysis and/or testing are recommended to determine the minimum number needed. Maximum thermal and electrical performance is achieved when an array of vias is incorporated in the land pattern. It is recommended to use as many vias connected to ground as possible. It is also recommended that the via diameter should be 12 to 13mils (0.30 to 0.33mm) with 1oz copper via barrel plating. This is desirable to avoid any solder wicking inside the via during the soldering process which may result in voids in solder between the exposed pad/slug and the thermal land. Precautions should be taken to eliminate any solder voids between the exposed heat slug and the land pattern. Note: These recommendations are to be used as a guideline only. For further information, please refer to the Application Note on the Surface Mount Assembly of Amkor’s Thermally/Electrically Enhance Leadframe Base Package, Amkor Technology.



**Figure 6. P.C. Assembly for Exposed Pad Thermal Release Path – Side View (drawing not to scale)**

## PCI Express Application Note

PCI Express jitter analysis methodology models the system response to reference clock jitter. The block diagram below shows the most frequently used *Common Clock Architecture* in which a copy of the reference clock is provided to both ends of the PCI Express Link.

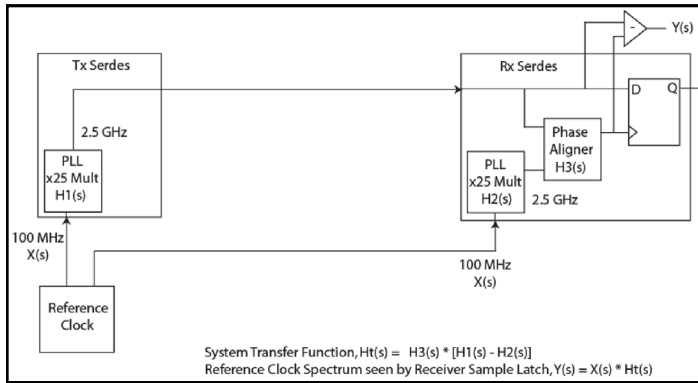
In the jitter analysis, the transmit (Tx) and receive (Rx) serdes PLLs are modeled as well as the phase interpolator in the receiver. These transfer functions are called H1, H2, and H3 respectively. The overall system transfer function at the receiver is:

$$H_t(s) = H_3(s) \times [H_1(s) - H_2(s)]$$

The jitter spectrum seen by the receiver is the result of applying this system transfer function to the clock spectrum X(s) and is:

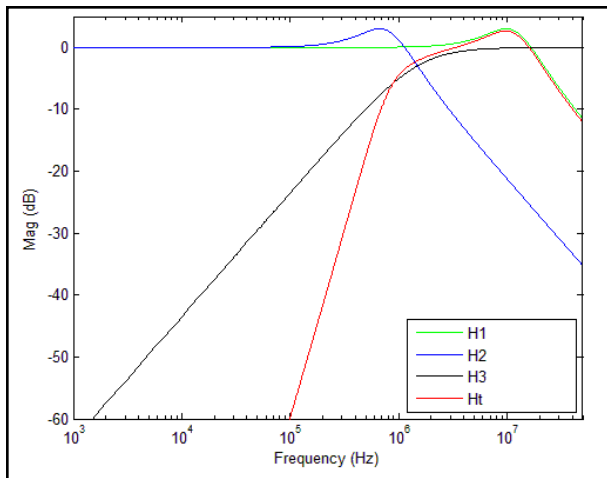
$$Y(s) = X(s) \times H_3(s) \times [H_1(s) - H_2(s)]$$

In order to generate time domain jitter numbers, an inverse Fourier Transform is performed on  $X(s) \times H_3(s) \times [H_1(s) - H_2(s)]$ .



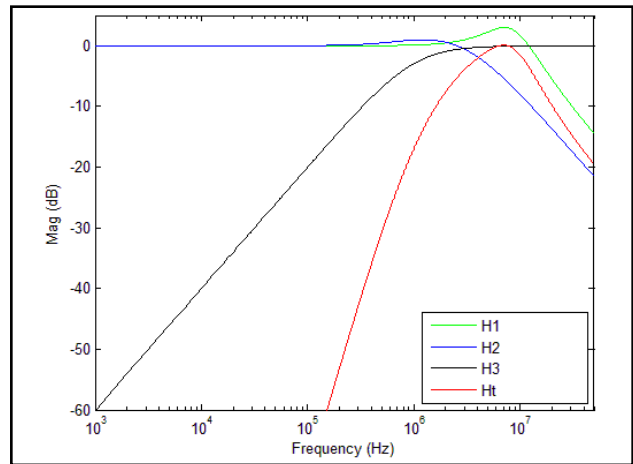
### PCI Express Common Clock Architecture

For **PCI Express Gen 1**, one transfer function is defined and the evaluation is performed over the entire spectrum: DC to Nyquist (e.g for a 100MHz reference clock: 0Hz – 50MHz) and the jitter result is reported in peak-peak.

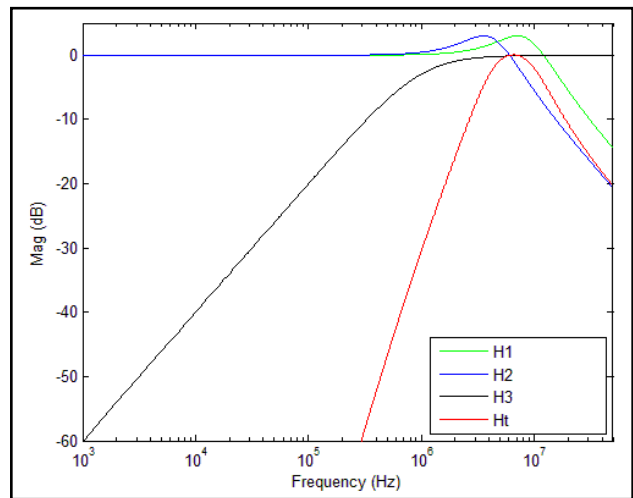


### PCI Express Gen 1 Magnitude of Transfer Function

For **PCI Express Gen 2**, two transfer functions are defined with 2 evaluation ranges and the final jitter number is reported in RMS. The two evaluation ranges for PCI Express Gen 2 are 10kHz – 1.5MHz (Low Band) and 1.5MHz – Nyquist (High Band). The plots show the individual transfer functions as well as the overall transfer function Ht.

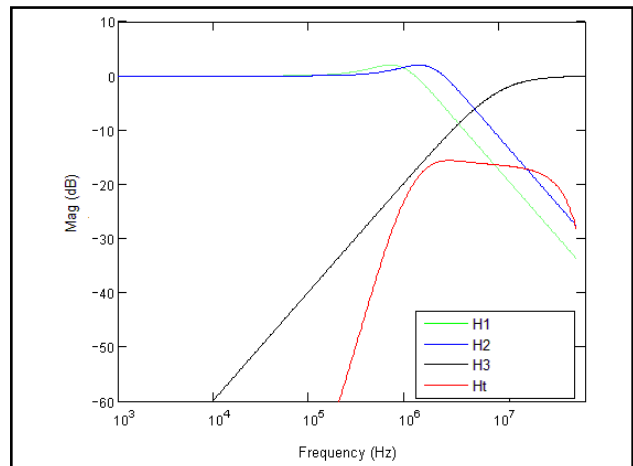


### PCI Express Gen 2A Magnitude of Transfer Function



### PCI Express Gen 2B Magnitude of Transfer Function

For **PCI Express Gen 3**, one transfer function is defined and the evaluation is performed over the entire spectrum. The transfer function parameters are different from Gen 1 and the jitter result is reported in RMS.



### PCI Express Gen 3 Magnitude of Transfer Function

For a more thorough overview of PCI Express jitter analysis methodology, please refer to IDT Application Note *PCI Express Reference Clock Requirements*.

## Schematic Layout

Figure 9 shows an example of IDT8T49N004I application schematic. The schematic focuses on functional connections and is not configuration specific. Refer to the pin description and functional tables in the datasheet to ensure that the logic control inputs are properly set.

In this example, the device is operated at  $V_{CC} = V_{CCO} = V_{CCA} = 3.3V$  rather than 2.5V. The CLK, nCLK inputs are provided by a 3.3V LVPECL driver and depicted with a Y-termination rather than the standard four resistor VCC-2V Thevinin termination for reasons of minimum termination power and layout simplicity. Three examples of PECL terminations are shown for the outputs to demonstrate some of the design options available with LVPECL.

As with any high speed analog circuitry, the power supply pins are vulnerable to noise. To achieve optimum jitter performance, power supply isolation is required. The IDT8T49N004I provides separate power supplies to isolate from coupling into the internal PLL.

In order to achieve the best possible filtering, it is recommended that the placement of the filter components be on the device side of the PCB as close to the power pins as possible. If space is limited, the 0.1uF capacitor in each power pin filter should be placed on the device side of the PCB and the other components can be placed on the opposite side.

Power supply filter recommendations are a general guideline to be used for reducing external noise from coupling into the devices. The  $V_{CC}$  and  $V_{CCO}$  filters start to attenuate noise at approximately 10kHz. If a specific frequency noise component is known, such as switching power supply frequencies, it is recommended that component values be adjusted and if required, additional filtering be added. Additionally, good general design practices for power plane voltage stability suggests adding bulk capacitances in the local area of all devices.

The schematic example focuses on functional connections and is not configuration specific. Refer to the pin description and functional tables in the datasheet to ensure the logic control inputs are properly set.

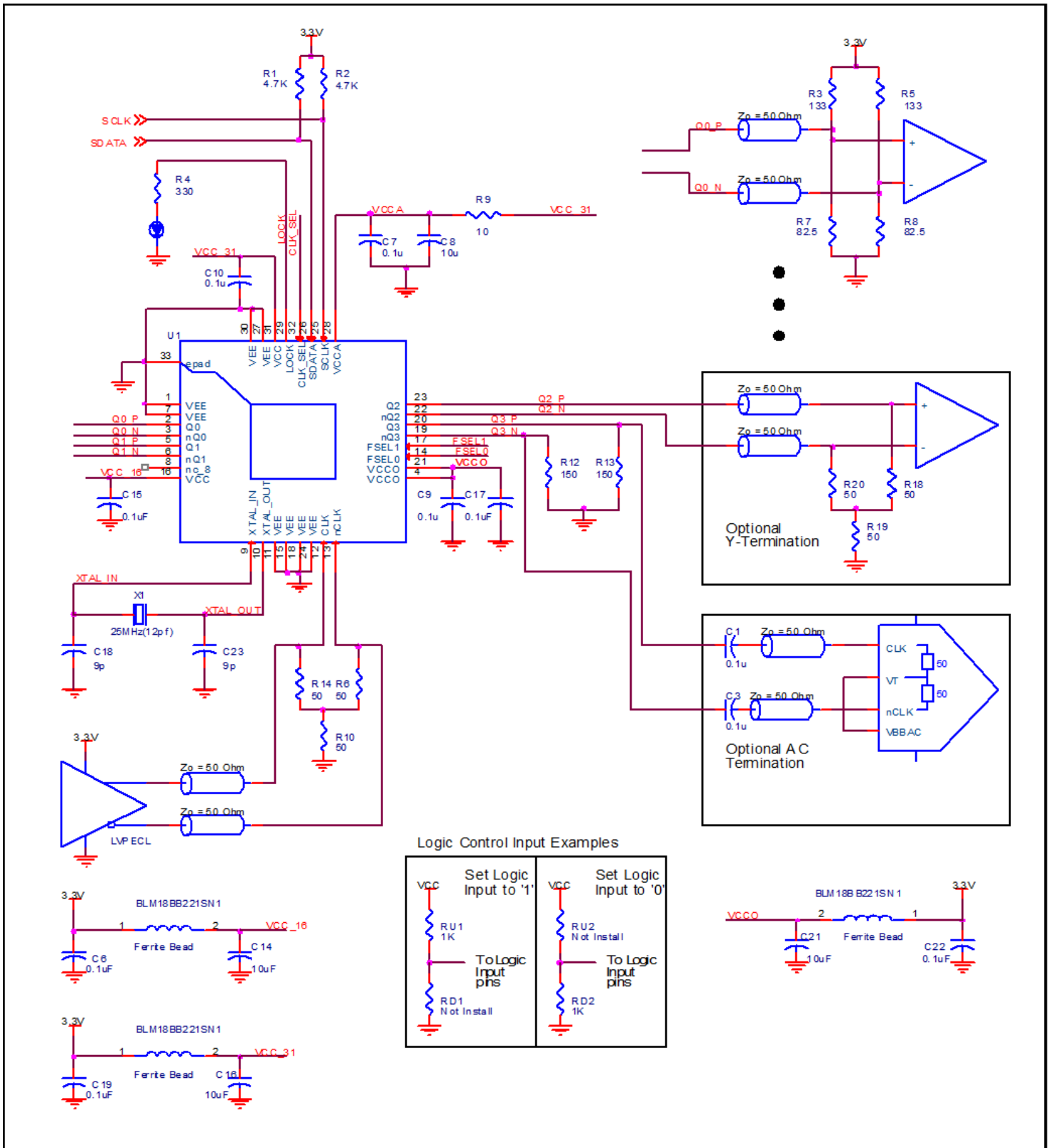


Figure 9. IDT8T49N004I Application Schematic

## LVPECL Power Considerations

This section provides information on power dissipation and junction temperature for the IDT8T49N004I. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the IDT8T49N004I is the sum of the core power plus the power dissipated in the load(s). The following is the power dissipation for  $V_{CC} = 3.465V$ , which gives worst case results.

NOTE: Please refer to Section 3 for details on calculating power dissipated in the load.

- Power (core)<sub>MAX</sub> =  $V_{CC\_MAX} * I_{EE\_MAX} = 3.465V * 192mA = 665.28mW$
- Power (outputs)<sub>MAX</sub> = **31.55mW/Loaded Output pair**  
If all outputs are loaded, the total power is  $4 * 31.55mW = 126.2mW$

**Total Power**<sub>MAX</sub> (3.465V, with all outputs switching) =  $665.28W + 126.2mW = 791.48W$

### 2. Junction Temperature.

Junction temperature,  $T_j$ , is the temperature at the junction of the bond wire and bond pad directly affects the reliability of the device. The maximum recommended junction temperature is 125°C. Limiting the internal transistor junction temperature,  $T_j$ , to 125°C ensures that the bond wire and bond pad temperature remains below 125°C.

The equation for  $T_j$  is as follows:  $T_j = \theta_{JA} * Pd\_total + T_A$

$T_j$  = Junction Temperature

$\theta_{JA}$  = Junction-to-Ambient Thermal Resistance

$Pd\_total$  = Total Device Power Dissipation (example calculation is in section 1 above)

$T_A$  = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance  $\theta_{JA}$  must be used. Assuming no air flow and a multi-layer board, the appropriate value is 33.1°C/W per Table 7 below.

Therefore,  $T_j$  for an ambient temperature of 85°C with all outputs switching is:

$$85^\circ C + 0.791W * 33.1^\circ C/W = 111.2^\circ C. \text{ This is below the limit of } 125^\circ C.$$

This calculation is only an example.  $T_j$  will obviously vary depending on the number of loaded outputs, supply voltage, air flow and the type of board (multi-layer).

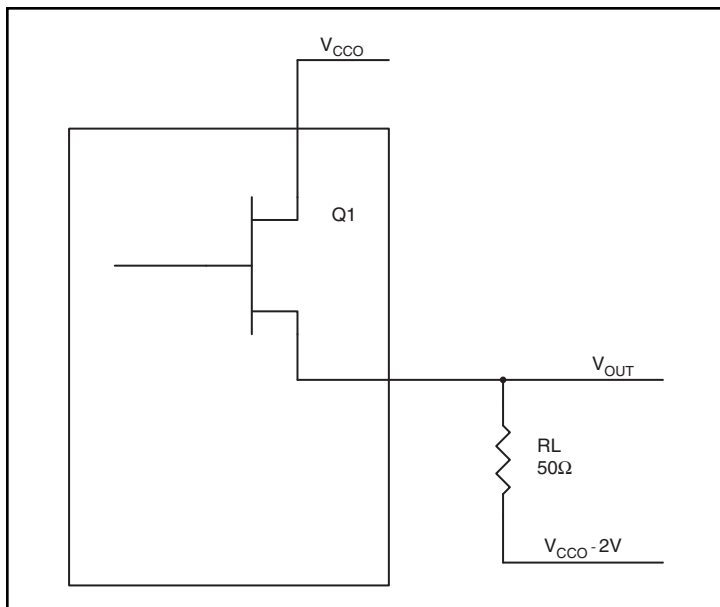
**Table 7. Thermal Resistance  $\theta_{JA}$  for 32-Lead VFQFN, Forced Convection**

| $\theta_{JA}$ by Velocity                   |          |          |          |
|---|----------|----------|----------|
| Meters per Second                           | 0        | 1        | 3        |
| Multi-Layer PCB, JEDEC Standard Test Boards | 33.1°C/W | 28.1°C/W | 25.4°C/W |

### 3. Calculations and Equations.

The purpose of this section is to calculate the power dissipation for the LVPECL output pair.

LVPECL output driver circuit and termination are shown in *Figure 12*.



**Figure 10. LVPECL Driver Circuit and Termination**

To calculate worst case power dissipation into the load, use the following equations which assume a 50Ω load, and a termination voltage of  $V_{CCO} - 2V$ .

- For logic high,  $V_{OUT} = V_{OH\_MAX} = V_{CCO\_MAX} - 0.75V$   
 $(V_{CCO\_MAX} - V_{OH\_MAX}) = 0.75V$
- For logic low,  $V_{OUT} = V_{OL\_MAX} = V_{CCO\_MAX} - 1.6V$   
 $(V_{CCO\_MAX} - V_{OL\_MAX}) = 1.6V$

$Pd\_H$  is power dissipation when the output drives high.

$Pd\_L$  is the power dissipation when the output drives low.

$$Pd\_H = [(V_{OH\_MAX} - (V_{CCO\_MAX} - 2V))/R_L] * (V_{CCO\_MAX} - V_{OH\_MAX}) = [(2V - (V_{CCO\_MAX} - V_{OH\_MAX}))/R_L] * (V_{CCO\_MAX} - V_{OH\_MAX}) = [(2V - 0.75V)/50\Omega] * 0.75V = \mathbf{18.75mW}$$

$$Pd\_L = [(V_{OL\_MAX} - (V_{CCO\_MAX} - 2V))/R_L] * (V_{CCO\_MAX} - V_{OL\_MAX}) = [(2V - (V_{CCO\_MAX} - V_{OL\_MAX}))/R_L] * (V_{CCO\_MAX} - V_{OL\_MAX}) = [(2V - 1.6V)/50\Omega] * 1.6V = \mathbf{12.80mW}$$

Total Power Dissipation per output pair =  $Pd\_H + Pd\_L = \mathbf{31.55mW}$

## LVDS Power Considerations

This section provides information on power dissipation and junction temperature for the IDT8T49N004I. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the IDT8T49N004I is the sum of the core power plus the analog power plus the power dissipated in the load(s). The following is the power dissipation for  $V_{CC} = 3.3V + 5\% = 3.465V$ , which gives worst case results.

- Power (core)<sub>MAX</sub> =  $V_{DD\_MAX} * (I_{DD\_MAX} + I_{DDA\_MAX}) = 3.465V * (125mA + 32mA) = 544mW$
- Power (outputs)<sub>MAX</sub> =  $V_{DDO\_MAX} * I_{DDO\_MAX} = 3.465V * 85mA = 294.525mW$

$$\text{Total Power}_{MAX} = 544mW + 294.525mW = 876.645mW$$

### 2. Junction Temperature.

Junction temperature,  $T_j$ , is the temperature at the junction of the bond wire and bond pad directly affects the reliability of the device. The maximum recommended junction temperature is 125°C. Limiting the internal transistor junction temperature,  $T_j$ , to 125°C ensures that the bond wire and bond pad temperature remains below 125°C.

The equation for  $T_j$  is as follows:  $T_j = \theta_{JA} * Pd\_total + T_A$

$T_j$  = Junction Temperature

$\theta_{JA}$  = Junction-to-Ambient Thermal Resistance

$Pd\_total$  = Total Device Power Dissipation (example calculation is in section 1 above)

$T_A$  = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance  $\theta_{JA}$  must be used. Assuming no air flow and a multi-layer board, the appropriate value is 33.1°C/W per Table 8 below.

Therefore,  $T_j$  for an ambient temperature of 85°C with all outputs switching is:

$$85^\circ\text{C} + 0.877W * 33.1^\circ\text{C}/W = 112.8^\circ\text{C}. \text{ This is below the limit of } 125^\circ\text{C}.$$

This calculation is only an example.  $T_j$  will obviously vary depending on the number of loaded outputs, supply voltage, air flow and the type of board (multi-layer).

**Table 8. Thermal Resistance  $\theta_{JA}$  for 32-Lead VFQFN, Forced Convection**

| Meters per Second                           | $\theta_{JA}$ by Velocity |          |          |
|---|---------------------------|----------|----------|
|   | 0                         | 1        | 3        |
| Multi-Layer PCB, JEDEC Standard Test Boards | 33.1°C/W                  | 28.1°C/W | 25.4°C/W |



## Reliability Information

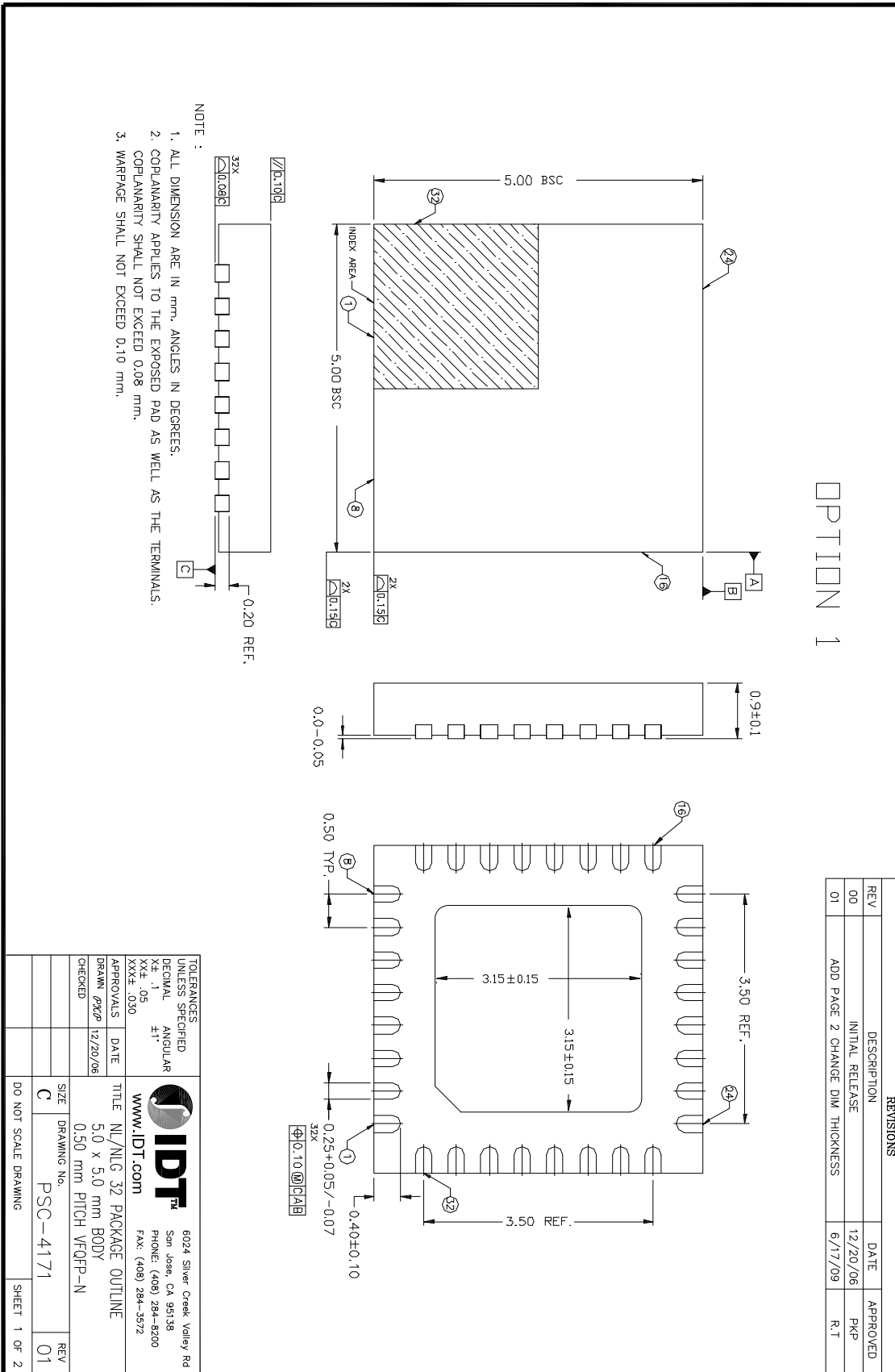
**Table 9.  $\theta_{JA}$  vs. Air Flow Table for a 32-Lead VFQFN**

| $\theta_{JA}$ vs. Air Flow                  |          |          |          |
|---|----------|----------|----------|
| Meters per Second                           | <b>0</b> | <b>1</b> | <b>3</b> |
| Multi-Layer PCB, JEDEC Standard Test Boards | 33.1°C/W | 28.1°C/W | 25.4°C/W |

## Transistor Count

The transistor count for IDT8T49N004I is: 26,856

### 32-Lead VFQFN Package Outline and Dimensions



## Ordering Information

Table 10. Ordering Information

| Part/Order Number  | Marking              | Package                   | Shipping Packaging | Temperature   |
|--------------------|----------------------|---------------------------|--------------------|---------------|
| 8T49N004A-dddNLGI  | IDT8T49N004A-dddNLGI | "Lead-Free" 32-Lead VFQFN | Tray               | -40°C to 85°C |
| 8T49N004A-dddNLGI8 | IDT8T49N004A-dddNLGI | "Lead-Free" 32-Lead VFQFN | Tape & Reel        | -40°C to 85°C |

NOTE: For the specific -ddd order codes, refer to the document *Programmable FemtoClock<sup>®</sup> NG Product Ordering Guide*.

## Revision History Sheet

| Rev | Table | Page         | Description of Change  | Date      |
|-----|-------|--------------|--|-----------|
| A   | T10   | 9, 35<br>35  | Changed name of the <i>IDT8T49N00xl Programmable FemtoClock® NG Product Ordering Information</i> document to <i>Programmable FemtoClock® Ordering Product Information</i><br>Deleted quantity from Tape & Reel, Deleted Lead Free note.  | 8/20/2013 |
| A   | T10   | 1<br>9<br>35 | Changed title to Programmable FemtoClock® NG LVPECL/LVDS Clock Generator with 4-Outputs.<br>Changed text from ' <i>Programmable FemtoClock® Ordering Product Information</i> ' to ' <i>Programmable FemtoClock® NG Product Ordering Guide</i> '.<br>Changed Note from ' <i>Programmable FemtoClock® Ordering Product Information</i> ' to ' <i>Programmable FemtoClock® NG Product Ordering Guide</i> '. | 9/26/13   |
| A   | T5    | 12           | changed the min load capacitance from 12pF to 10pF   | 10/22/13  |

