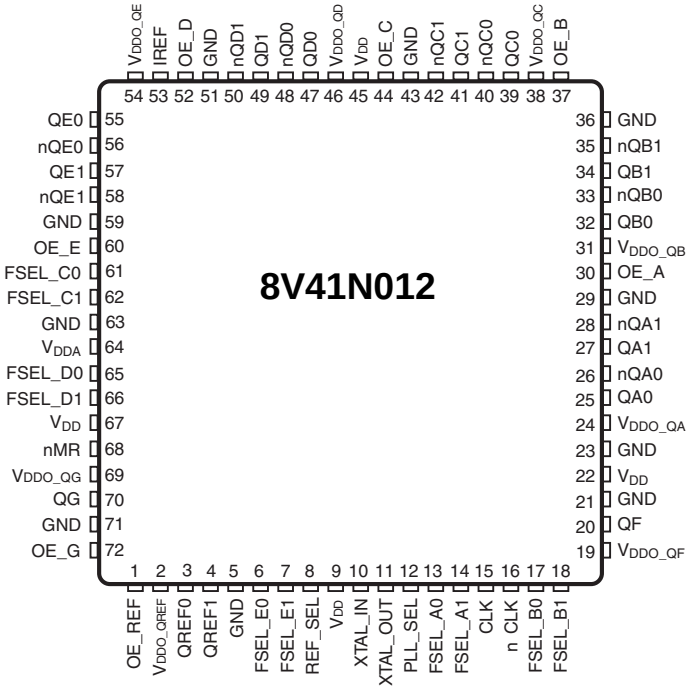
## General Description

The 8V41N012 is a PLL-based clock generator specifically designed for Cavium Networks Octeon II processors. This high performance device is optimized to generate the processor core reference clock, the PCI-Express, sRIO, XAUI, SerDes reference clocks and the clocks for both the Gigabit Ethernet MAC and PHY. The output frequencies are generated from a 25MHz external input source or an external 25MHz parallel resonant crystal. The industrial temperature range of the 8V41N012 supports telecommunication, networking, and storage requirements.

## Features

- Ten selectable 100MHz, 125MHz, 156.25MHz and 312.5MHz clocks for PCI Express, sRIO and GbE, HCSL interface levels
- One single-ended QG LVCMOS/LVTTL clock output at 125MHz
- One single-ended QF LVCMOS/LVTTL clock output at 50MHz
- Two single-ended QREFx LVCMOS/LVTTL outputs at 25MHz
- Selectable external crystal or differential (single-ended) input source
- Crystal oscillator interface designed for 25MHz, parallel resonant crystal
- Differential CLK, nCLK input pair that can accept: LVPECL, LVDS, LVHSTL, HCSL input levels
- Internal resistor bias on nCLK pin allows the user to drive CLK input with external single-ended (LVCMOS/ LVTTL) input levels
- Supply Modes, (125MHz QG output and 25MHz QREFx outputs):
  Core / Output
  3.3V / 3.3V
  3.3V / 2.5V
- Supply Modes, (HCSL outputs, and 50MHz QF output):
  Core / Output
  3.3V / 3.3V
- -40°C to 85°C ambient operating temperature
- Lead-free (RoHS 6) packaging

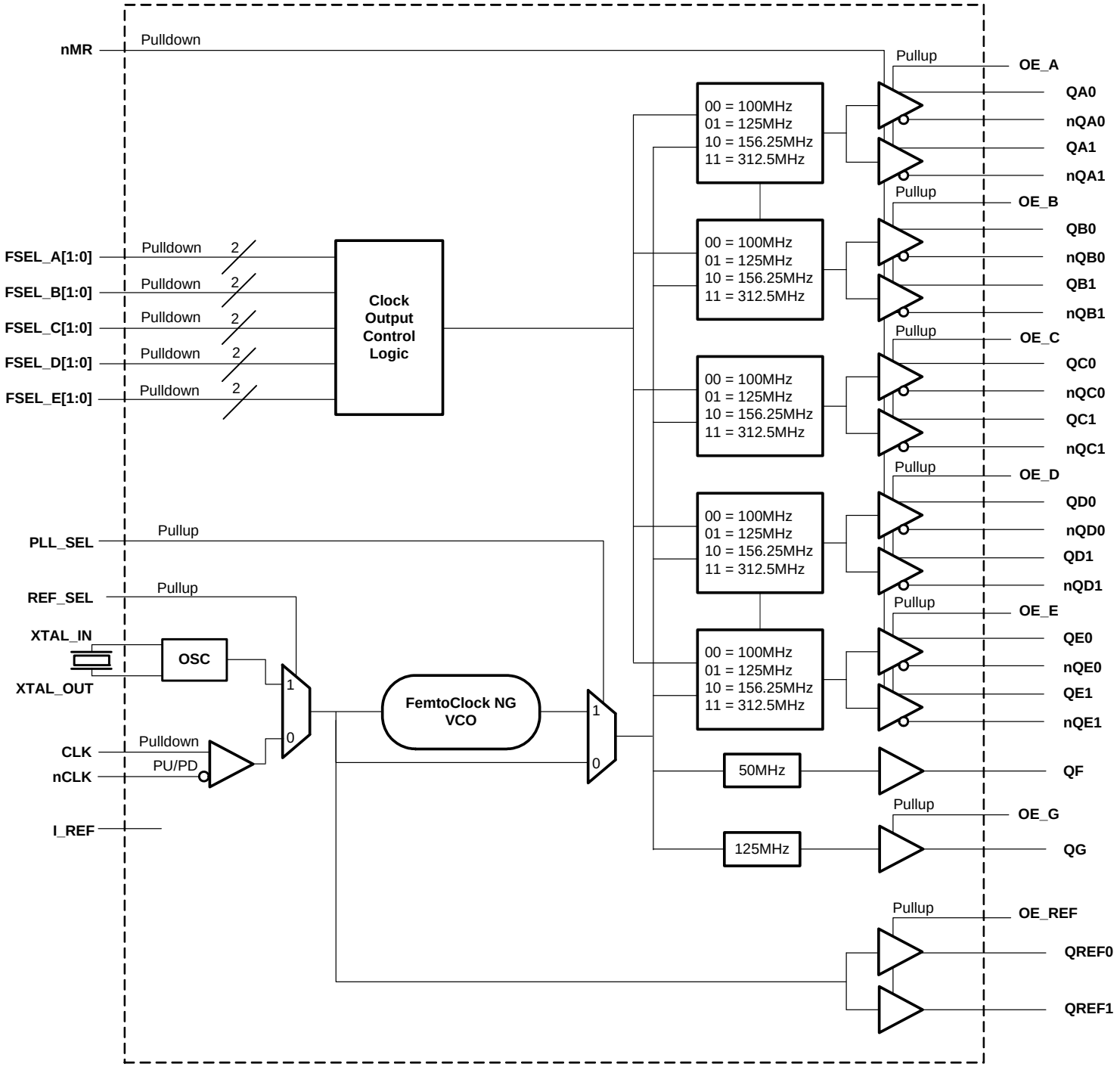
## Pin Assignment




72-Lead, 10mm x 10mm VFQFN

NOTE: Exposed pad must always be connected to GND.
NOTE: Pin 1 is located at bottom left corner as shown.

## Block Diagram



# Pin Descriptions and Characteristics

**Table 1. Pin Descriptions**

| Number | Name | Type | | Description |
|---|---|---|---|---|
| 1 | OE_REF | Input | Pullup | Active HIGH output enable for QREF0 and QREF1 outputs. LVCMOS/LVTTL interface levels.<br>0 = QREF0, QREF1 outputs disabled/high impedance<br>1 = QREF0, QREF1 outputs enabled (default) |
| 2 | $V_{DDO_QREF}$ | Power | | QREF0, QREF1 output supply pin (LVCMOS/LVTTL). 3.3V or 2.5V supply. |
| 3, 4 | QREF0, QREF1 | Output | | Single-ended REF outputs. 3.3V or 2.5V LVCMOS/LVTTL interface levels. |
| 5, 21, 23, 29, 36, 43, 51, 59, 63, 71 | GND | Power | | Power supply ground. |
| 6, 7 | FSEL_E0 FSEL_E1 | Input | Pulldown | Selects the QEx, nQEx output frequency. LVCMOS/LVTTL interface levels.<br>00 = 100MHz (default)<br>01 = 125MHz<br>10 = 156.25MHz<br>11 = 312.5MHz |
| 8 | REF_SEL | Input | Pullup | Input source control pin. LVCMOS/LVTTL interface levels.<br>0 = CLK, nCLK<br>1 = XTAL (default) |
| 9, 22, 45, 67 | $V_{DD}$ | Power | | Core supply pins. |
| 10, 11 | XTAL_IN XTAL_OUT | Input | | Parallel resonant crystal interface. XTAL_OUT is the output, XTAL_IN is the input. |
| 12 | PLL_SEL | Input | Pullup | PLL bypass control pin. LVCMOS/LVTTL interface levels.<br>0 = Bypass mode<br>1 = PLL mode (default) |
| 13, 14 | FSEL_A0 FSEL_A1 | Input | Pulldown | Selects the QAx, nQAx output frequency. LVCMOS/LVTTL interface levels.<br>00 = 100MHz (default)<br>01 = 125MHz<br>10 = 156.25MHz<br>11 = 312.5MHz |
| 15 | CLK | Input | Pulldown | Non-inverting differential clock input. |
| 16 | nCLK | Input | Pullup/ Pulldown | Inverting differential clock input. Internal resistor bias to $V_{DD}/2$. |
| 17, 18 | FSEL_B0 FSEL_B1 | Input | Pulldown | Selects the QBx, nQBx output frequency. LVCMOS/LVTTL interface levels.<br>00 = 100MHz (default)<br>01 = 125MHz<br>10 = 156.25MHz<br>11 = 312.5MHz |
| 19 | $V_{DDO_QF}$ | Power | | QF output supply pin (LVCMOS/LVTTL). 3.3V supply. |
| 20 | QF | Output | | Single-ended output. 3.3V LVCMOS/LVTTL interface levels. |
| 24 | $V_{DDO_QA}$ | Power | | Bank A (HCSL) output supply pin. 3.3 V supply. |
| 25, 26 | QA0, nQA0 | Output | | Bank A differential output pair. HCSL interface levels. |
| 27, 28 | QA1, nQA1 | Output | | Bank A differential output pair. HCSL interface levels. |
| 30 | OE_A | Input | Pullup | Active HIGH output enable for Bank A outputs. LVCMOS/LVTTL interface levels.<br>0 = Bank A outputs disabled/high impedance<br>1 = Bank A outputs enabled (default) |
| 31 | $V_{DDO_QB}$ | Power | | Bank B (HCSL) output supply pin. 3.3V supply. |

*Continued on next page*

**Table 1. Pin Descriptions, Continued**

| Number | Name | Type | | Description |
|---|---|---|---|---|
| 32, 33 | QB0, nQB0 | Output | | Bank B differential output pair. HCSL interface levels. |
| 34, 35 | QB1, nQB1 | Output | | Bank B differential output pair. HCSL interface levels. |
| 37 | OE_B | Input | Pullup | Active HIGH output enable for Bank B outputs. LVCMOS/LVTTL interface levels.<br>0 = Bank B outputs disabled/high impedance<br>1 = Bank B outputs enabled (default) |
| 38 | $V_{DDO_QC}$ | Power | | Bank C (HCSL) output supply pin. 3.3V supply. |
| 39, 40 | QC0, nQC0 | Output | | Bank C differential output pair. HCSL interface levels. |
| 41, 42 | QC1, nQC1 | Output | | Bank C differential output pair. HCSL interface levels. |
| 44 | OE_C | Input | Pullup | Active HIGH output enable for Bank C outputs. LVCMOS/LVTTL interface levels.<br>0 = Bank C outputs disabled/high impedance<br>1 = Bank C outputs enabled (default) |
| 46 | $V_{DDO_QD}$ | Power | | Bank D (HCSL) output supply pin. 3.3V supply. |
| 47, 48 | QD0, nQD0 | Output | | Bank D differential output pair. HCSL interface levels. |
| 49, 50 | QD1, nQD1 | Output | | Bank D differential output pair. HCSL interface levels. |
| 52 | OE_D | Input | Pullup | Active HIGH output enable for Bank D outputs. LVCMOS/LVTTL interface levels.<br>0 = Bank D outputs disabled/high impedance<br>1 = Bank D outputs active (default) |
| 53 | $I_{REF}$ | Input | | External fixed precision resistor (475Ω) from this pin to ground provides a reference current used for differential current-mode. |
| 54 | $V_{DDO_QE}$ | Power | | Bank E (HCSL) output supply pin. 3.3V supply. |
| 55, 56 | QE0, nQE0 | Output | | Bank E differential output pair. HCSL interface levels. |
| 57, 58 | QE1, nQE1 | Output | | Bank E differential output pair. HCSL interface levels. |
| 60 | OE_E | Input | Pullup | Active HIGH output enable for Bank E outputs. LVCMOS/LVTTL interface levels.<br>0 = Bank E outputs disabled/high impedance<br>1 = Bank E outputs enabled (default) |
| 61,<br>62 | FSEL_C0<br>FSEL_C1 | Input | Pulldown | Selects the QCx, nQCx output frequency. LVCMOS/LVTTL interface levels.<br>00 = 100MHz (default)<br>01 = 125MHz<br>10 = 156.25MHz<br>11 = 312.5MHz |
| 64 | $V_{DDA}$ | Power | | Analog supply pin. |
| 65,<br>66 | FSEL_D0<br>FSEL_D1 | Input | Pulldown | Selects the QDx, nQDx output frequency. LVCMOS/LVTTL interface levels.<br>00 = 100MHz (default)<br>01 = 125MHz<br>10 = 156.25MHz<br>11 = 312.5MHz |
| 68 | nMR | Input | Pulldown | Active LOW Master Reset. LVCMOS/LVTTL interface levels.<br>0 = Reset. The internal dividers are reset causing the true outputs Qx to go low and the inverted outputs nQx to go high. (default)<br>1 = Active. The internal dividers and the outputs are active. |
| 69 | $V_{DDO_QG}$ | Power | | QG output supply pins (LVCMOS/LVTTL). 3.3V or 2.5V supply. |
| 70 | QG | Output | | Bank G single-ended output. 3.3V or 2.5V LVCMOS/LVTTL interface levels. |
| 72 | OE_G | Input | Pullup | Active HIGH output enable for Bank G output. LVCMOS/LVTTL interface levels.<br>0 = Bank G outputs disabled/high impedance<br>1 = Bank G outputs enabled (default) |
| | EPAD | | | Connect to GND. |

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 |
|---|---|---|---|---|---|---|---|
| $C_{IN}$ | Input Capacitance | CLK, nCLK | | | 2.5 | | pF |
| | | Control Pins | | | 6 | | pF |
| $R_{PULLUP}$ | Input Pullup Resistor | | | | 50 | | kΩ |
| $R_{PULLDOWN}$ | Input Pulldown Resistor | | | | 50 | | kΩ |
| $R_{OUT}$ | Output Impedance | QF, QG, QREF[1:0] | $V_{DDO_QF} = V_{DDO_QG} = V_{DDO_QREF} = 3.465V$ | | 15 | | Ω |
| | | QG, QREF[1:0] | $V_{DDO_QREF}, V_{DDO_QG} = 2.625V$ | | 19 | | Ω |

## Function Tables

**Table 3A. FSEL_X Control Input Function Table**

| Input | Output Frequency |
|---|---|
| **FSEL_X[1:0]** | **Q[Ax:Ex], nQ[Ax:Ex]** |
| 00 (default) | 100MHz |
| 01 | 125MHz |
| 10 | 156.25MHz |
| 11 | 312.50MHz |

NOTE: FSEL_X denotes FSEL_A, _B, _C, _D, _E.
NOTE: Any two outputs operated at the same frequency will be synchronous.

**Table 3B. PLL_SEL Control Input Function Table**

| Input | |
|---|---|
| **PLL_SEL** | **Operation** |
| 0 | PLL Bypass |
| 1 (default) | PLL Mode |

**Table 3C. REF_SEL Control Input Function Table**

| Input | |
|---|---|
| **REF_SEL** | **Clock Source** |
| 0 | CLK, nCLK |
| 1 (default) | XTAL_IN, XTAL_OUT |

**Table 3D. OE_[A:E] Control Input Function Table**

| Input | Outputs |
|---|---|
| **OE_[A:E]** | **Q[Ax:Ex], nQ[Ax:Ex]** |
| 0 | High-Impedance |
| 1 (default) | Enabled |

**Table 3E. OE_G Control Input Function Table**

| Input | Outputs |
|---|---|
| **OE_G** | **QG** |
| 0 | High-Impedance |
| 1 (default) | Enabled |

**Table 3F. OE_REF Control Input Function Table**

| Input | Output |
|---|---|
| **OE_REF** | **QREF[1:0]** |
| 0 | High-Impedance |
| 1 (default) | Enabled |

## 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, $V_{DD}$ | 3.6V |
| Inputs, $V_I$<br>XTAL_IN<br>Other Inputs | <br>0V to 2V<br>-0.5V to $V_{DD}$ + 0.5V |
| Outputs, $V_O$ | -0.5V to $V_{DDO_QX}$ + 0.5V |
| Package Thermal Impedance, $\theta_{JA}$ | 26.6°C/W (0 mps) |
| Storage Temperature, $T_{STG}$ | -65°C to 150°C |

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics,**
$V_{DD}$ = 3.3V ± 5%, $V_{DDO_Q[A:E]}$ = $V_{DDO_Q[F:G]}$ = $V_{DDO_QREF}$ = 3.3V ± 5%, $T_A$ = -40°C to 85°C

| Symbol | Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|---|
| $V_{DD}$ | Core Supply Voltage | | 3.135 | 3.3 | 3.465 | V |
| $V_{DDA}$ | Analog Supply Voltage | | $V_{DD}$ – 0.225 | 3.3 | $V_{DD}$ | V |
| $V_{DDO_QX}$ | Output Supply Voltage | | 3.135 | 3.3 | 3.465 | V |
| $I_{DD}$ | Power Supply Current | | | 193 | 235 | mA |
| $I_{DDA}$ | Analog Supply Current | | | 36 | 45 | mA |
| $I_{DDO_QX}$ | Output Supply Current | No Load | | 24 | 30 | mA |

NOTE: $V_{DDO_QX}$ denotes $V_{DDO_Q[A:E]}$, $V_{DDO_Q[F:G]}$, $V_{DDO_QREF}$.
NOTE: $I_{DDO_QX}$ denotes $I_{DDO_Q[A:E]}$ + $I_{DDO_Q[F:G]}$ + $I_{DDO_QREF}$.

**Table 4B. Power Supply DC Characteristics,** $V_{DD}$ = 3.3V ± 5%, $V_{DDO_QG}$ = $V_{DDO_QREF}$ = 2.5V ± 5%, $T_A$ = -40°C to 85°C

| Symbol | Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|---|
| $V_{DD}$ | Core Supply Voltage | | 3.135 | 3.3 | 3.465 | V |
| $V_{DDA}$ | Analog Supply Voltage | | $V_{DD}$ – 0.225 | 3.3 | $V_{DD}$ | V |
| $V_{DDO_QG}$/ $V_{DDO_QREF}$ | Output Supply Voltage | | 2.375 | 2.5 | 2.625 | V |
| $I_{DD}$ | Power Supply Current | | | 193 | 235 | mA |
| $I_{DDA}$ | Analog Supply Current | | | 36 | 45 | mA |
| $I_{DDO_QG}$ + $I_{DDO_QREF}$ | Output Supply Current | No Load | | 8 | 15 | mA |

**Table 4C. LVCMOS/LVTTL DC Characteristics,**
$V_{DD} = V_{DDO_Q[A:E]} = V_{DDO_QF} = 3.3V \pm 5\%$; $V_{DDO_QG} = V_{DDO_QREF} = 3.3V \pm 5\%$ or $2.5V \pm 5\%$, $T_A$ = -40°C to 85°C

| Symbol | Parameter | | Test Conditions | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|---|---|
| $V_{IH}$ | Input High Voltage | | | 2.2 | | $V_{DD}$ + 0.3 | V |
| $V_{IL}$ | Input Low Voltage | | | -0.3 | | 0.8 | V |
| $I_{IH}$ | Input High Current | nMR, FSEL_A[1:0], FSEL_B[1:0], FSEL_C[1:0], FSEL_D[1:0], FSEL_E[1:0] | $V_{DD} = V_{IN} = 3.465V$ | | | 150 | µA |
| | | REF_SEL, PLL_SEL, OE_REF, OE_A, OE_B, OE_C, OE_D, OE_E, OE_G | $V_{DD} = V_{IN} = 3.465V$ | | | 10 | uA |
| $I_{IL}$ | Input Low Current | nMR, FSEL_A[1:0], FSEL_B[1:0], FSEL_C[1:0], FSEL_D[1:0], FSEL_E[1:0] | $V_{DD} = 3.465V$, $V_{IN} = 0V$ | -10 | | | µA |
| | | REF_SEL, PLL_SEL, OE_REF, OE_A, OE_B, OE_C, OE_D, OE_E, OE_G | $V_{DD} = 3.465V$, $V_{IN} = 0V$ | -150 | | | uA |
| $V_{OH}$ | Output High Voltage | | $V_{DDO_QF} = V_{DDO_QG}$, $V_{DDO_QREF} = 3.465V$ | 2.6 | | | V |
| | | | $V_{DDO_QG}$, $V_{DDO_QREF} = 2.625V$ | 1.8 | | | V |
| $V_{OL}$ | Output Low Voltage | | $V_{DDO_QF} = V_{DDO_QG}$, $V_{DDO_QREF} = 3.465V$ or $V_{DDO_QG}$, $V_{DDO_QREF} = 2.625V$ | | | 0.6 | V |

**Table 4D. Differential DC Characteristics,** $V_{DD} = 3.3V \pm 5\%$, $T_A$ = -40°C to 85°C

| Symbol | Parameter | | Test Conditions | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|---|---|
| $I_{IH}$ | Input High Current | CLK, nCLK | $V_{DD} = V_{IN} = 3.465V$ | | | 150 | µA |
| $I_{IL}$ | Input Low Current | CLK | $V_{DD} = 3.465V$, $V_{IN} = 0V$ | -5 | | | µA |
| | | nCLK | $V_{DD} = 3.465V$, $V_{IN} = 0V$ | -150 | | | µA |
| $V_{PP}$ | Peak-to-Peak Input Voltage; NOTE 1 | | | 0.15 | | 1.3 | V |
| $V_{CMR}$ | Common Mode Input Voltage; NOTE 1, 2 | | | 0.5 | | $V_{DD}$ – 0.85 | V |

NOTE 1: $V_{IL}$ should not be less than -0.3V.
NOTE 2: Common mode voltage is defined as $V_{IH}$.

**Table 5. Crystal Characteristics**

| Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|
| Mode of Oscillation | | | Fundamental | | |
| Frequency | | | 25 | | MHz |
| Equivalent Series Resistance (ESR) | | | | 50 | Ω |
| Load Capacitance (CL) | | | 12 | | pF |
| Shunt Capacitance | | | | 7 | pF |

**Table 6. Input Frequency Characteristics,**
$V_{DD} = V_{DDO_Q[A:E]} = V_{DDO_QF} = 3.3V \pm 5\%$; $V_{DDO_QG} = V_{DDO_QREF} = 3.3V \pm 5\%$ or $2.5V \pm 5\%$, $T_A$ = -40°C to 85°C

| Symbol | Parameter | | Test Conditions | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|---|---|
| $F_{IN}$ | Input Frequency | CLK, nCLK | | | 25 | | MHz |
| | | XTAL_IN, XTAL_OUT | | | 25 | | MHz |

## AC Electrical Characteristics

**Table 7A. PCI Express Jitter Specifications,** $V_{DD} = V_{DDO_Q[A:E]} = 3.3V \pm 5\%$, $T_A$ = -40°C to 85°C

| Symbol | Parameter | Test Conditions | Minimum | Typical | Maximum | PCIe Industry Specification | Units |
|---|---|---|---|---|---|---|---|
| $t_j$ (PCIe Gen 1) | Phase Jitter Peak-to-Peak; NOTE 1, 4 | $f$ = 100MHz, 25MHz Crystal Input Evaluation Band: 0Hz - Nyquist (clock frequency/2) | | 6.97 | 11.18 | 86 | ps |
| $t_{REFCLK_HF_RMS}$ (PCIe Gen 2) | Phase Jitter RMS; NOTE 2, 4 | $f$ = 100MHz, 25MHz Crystal Input High Band: 1.5MHz - Nyquist (clock frequency/2) | | 0.70 | 1.84 | 3.10 | ps |
| $t_{REFCLK_LF_RMS}$ (PCIe Gen 2) | Phase Jitter RMS; NOTE 2, 4 | $f$ = 100MHz, 25MHz Crystal Input Low Band: 10kHz - 1.5MHz | | 0.03 | 0.07 | 3.0 | ps |
| $t_{REFCLK_RMS}$ (PCIe Gen 3) | Phase Jitter RMS; NOTE 3, 4 | $f$ = 100MHz, 25MHz Crystal Input Evaluation Band: 0Hz - Nyquist (clock frequency/2) | | 0.16 | 0.49 | 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 lfpm. 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 7B. HCSL AC Characteristics,**

$V_{DD} = V_{DDO_Q[A:E]} = V_{DDO_QF} = 3.3V \pm 5\%$; $V_{DDO_QG} = V_{DDO_QREF} = 3.3V \pm 5\%$ or $2.5V \pm 5\%$, $T_A$ = -40°C to 85°C

| Symbol | Parameter | | Test Conditions | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|---|---|
| $f_{OUT}$ | Output Frequency | Q[A:E], nQ[A:E] | FSEL_x[1:0] = 00 | | 100 | | MHz |
| | | | FSEL_x[1:0] = 01 | | 125 | | MHz |
| | | | FSEL_x[1:0] = 10 | | 156.25 | | MHz |
| | | | FSEL_x[1:0] = 11 | | 312.5 | | MHz |
| $V_{RB}$ | Ring-Back Voltage Margin; NOTE 1, 2 | Q[A:E], nQ[A:E] | | -100 | | 100 | mV |
| $t_{STABLE}$ | Time before $V_{RB}$ is allowed; NOTE 1, 2 | Q[A:E], nQ[A:E] | | 500 | | | ps |
| $V_{MAX}$ | Absolute Max Output Voltage; NOTE 3, 4 | Q[A:E], nQ[A:E] | | | | 1150 | mV |
| $V_{MIN}$ | Absolute Min Output Voltage; NOTE 3, 5 | Q[A:E], nQ[A:E] | | -300 | | | mV |
| $V_{CROSS}$ | Absolute Crossing Voltage; NOTE 3, 6, 7 | Q[A:E], nQ[A:E] | | 175 | | 550 | mV |
| $\Delta V_{CROSS}$ | Total Variation of $V_{CROSS}$ over All Edges; NOTE 3, 6, 8 | Q[A:E], nQ[A:E] | | | | 140 | mV |
| $t_{SLEW+}$ | Rising Edge Rate; NOTE 1, 9 | Q[A:E], nQ[A:E] | | 0.6 | | 4.0 | V/ns |
| $t_{SLEW-}$ | Falling Edge Rate; NOTE 1, 9 | Q[A:E], nQ[A:E] | | 0.6 | | 4.0 | V/ns |
| odc | Output Duty Cycle | Q[A:E], nQ[A:E] | | 48 | 50 | 52 | % |
| tjit(Ø) | RMS Phase Jitter, (Random); NOTE 10 | Q[A:E], nQ[A:E] | 100MHz, Integration Range: (12kHz to 20MHz) | | 0.32 | 0.45 | ps |
| | | | 125MHz, Integration Range: (12kHz to 20MHz) | | 0.31 | 0.45 | ps |
| | | | 156.25MHz, Integration Range: (12kHz to 20MHz) | | 0.30 | 0.45 | ps |
| | | | 312.5MHz, Integration Range: (12kHz to 20MHz) | | 0.29 | 0.45 | ps |
| tjit($R_J$) | Random Jitter, RMS; NOTE 11 | | Q[A:E], nQ[A:E] = 125MHz, 25MHz XTAL, PLL Mode | | 2 | 5 | ps |
| tjit($D_J$) | Deterministic Jitter, Pk-to-Pk; NOTE 11 | | | | 1 | 3 | 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 lfpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.
NOTE: All parameters measured at $f_{OUT}$ and in PLL mode unless noted otherwise.
NOTE: Refer to applications section for information on peak-to-peak jitter calculations.
NOTE 1: Measurement taken from differential waveform.
NOTE 2: $t_{STABLE}$ is the time the differential clock must maintain a minimum ±150mV differential voltage after rising/falling edges before it is allowed to drop back into the $V_{RB}$ ±100mV range. See Parameter Measurement Information Section.
NOTE 3: Measurement taken from single-ended waveform.
NOTE 4: Defined as the maximum instantaneous voltage including overshoot. See Parameter Measurement Information Section.
NOTE 5: Defined as the minimum instantaneous voltage including undershoot. See Parameter Measurement Information Section.
NOTE 6: Measured at the crossing point where the instantaneous voltage value of the rising edge of Q[Ax:Ex] equals the falling edge of nQ[Ax:Ex].
NOTE 7: Refers to the total variation from the lowest crossing point to the highest, regardless of which edge is crossing. Refers to all crossing points for this measurement.
*Notes continued on next page.*

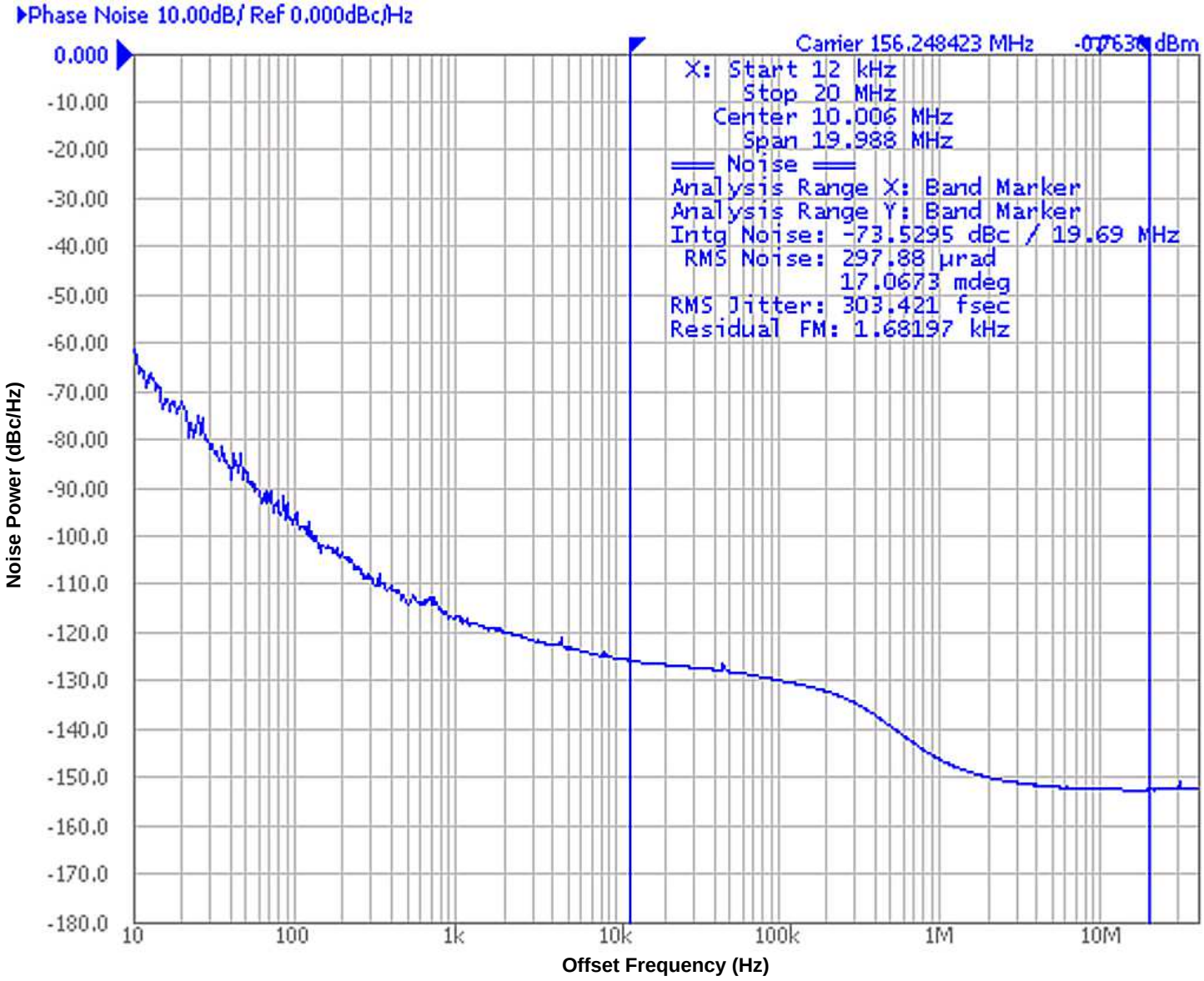
NOTE 8: Defined as the total variation of all crossing voltages of rising Q[Ax:Ex] and falling nQ[Ax:Ex]. This is the maximum allowed variance in Vcross for any particular system.
NOTE 9: Measured from -150mV to +150mV on the differential waveform (derived from Q[Ax:Ex] minus nQ[Ax:Ex]). The signal must be monotonic through the measurement region for rise and fall time. The 300mV measurement window is centered on the differential zero crossing.
NOTE 10: Measurements taken with 25MHz XTAL as input source and spur off.
NOTE 11: Measurements taken with Wavecrest SIA-3000 Analyzer.

**Table 7C. LVCMOS AC Characteristics,**
$V_{DD} = V_{DDO_Q[A:E]} = V_{DDO_QF} = 3.3V \pm 5\%$; $V_{DDO_QG} = V_{DDO_QREF} = 3.3V \pm 5\%$ or $2.5V \pm 5\%$, $T_A$ = -40°C to 85°C

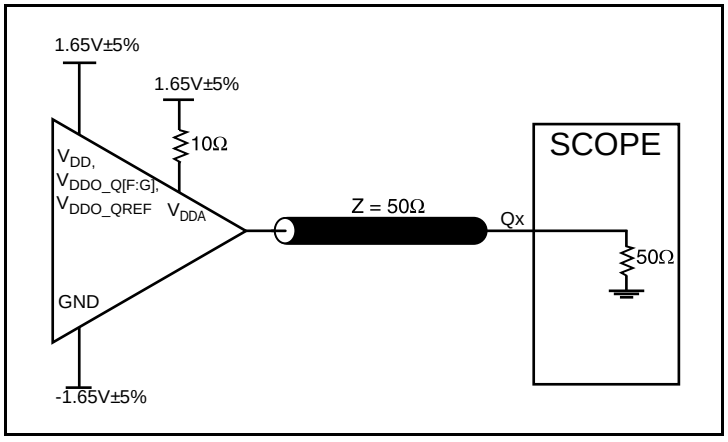
| Symbol | Parameter | | Test Conditions | Minimum | Typical | Maximum | Units |
|---|---|---|---|---|---|---|---|
| $f_{OUT}$ | Output Frequency | QF | | | 50 | | MHz |
| | | QG | | | 125 | | MHz |
| | | QREF[1:0] | | | 25 | | MHz |
| tr/tf | Output Rise/Fall Time | QF, QG, QREF[1:0] | 20% to 80% | 180 | | 700 | ps |
| odc | Output Duty Cycle | QF, QG, QREF[1:0] | | 47 | 50 | 53 | % |
| tjit(Ø) | RMS Phase Jitter, (Random); NOTE 1 | QF | 50MHz, Integration Range: (12kHz to 20MHz) | | 0.35 | 0.45 | ps |
| | | QG | 125MHz, Integration Range: (12kHz to 20MHz) | | 0.30 | 0.40 | ps |
| | | QREF[1:0] | 25MHz, Integration Range: (12kHz to 5MHz) | | 0.32 | 0.40 | ps |
| tjit($R_J$) | Random Jitter, RMS; NOTE 2 | QF, QG, QREF[1:0] | Q[A:E], nQ[A:E] = 125MHz, 25MHz XTAL, PLL Mode | | 2 | 5 | ps |
| tjit($D_J$) | Deterministic Jitter, Pk-to-Pk; NOTE 2 | QF | Q[A:E], nQ[A:E] = 125MHz, 25MHz XTAL, PLL Mode | | 3 | 25 | ps |
| | | QG | | | 1 | 5 | ps |
| | | QREF[1:0] | | | 1 | 3 | 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 lfpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.
NOTE: All parameters measured at $f_{OUT}$ and in PLL mode unless noted otherwise.
NOTE: Refer to applications section for information on peak-to-peak jitter calculations.
NOTE 1: Measurements taken with 25MHz XTAL as input source and spur off.
NOTE 2: Measurements taken with Wavecrest SIA-3000 Analyzer. QG characterized with QREF[1:0] disabled.

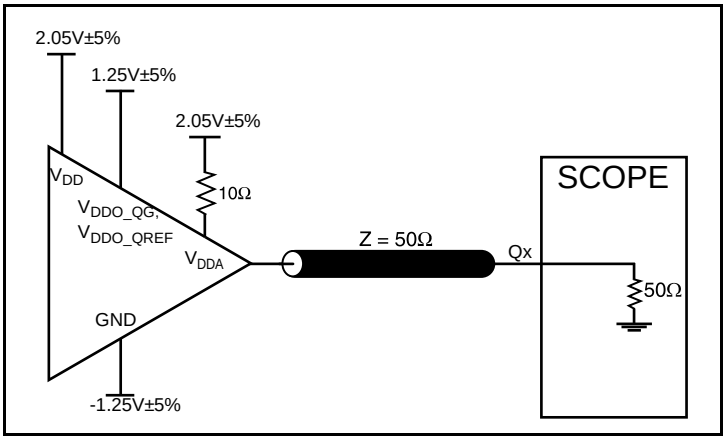
## Typical Phase Noise at 156.25MHz



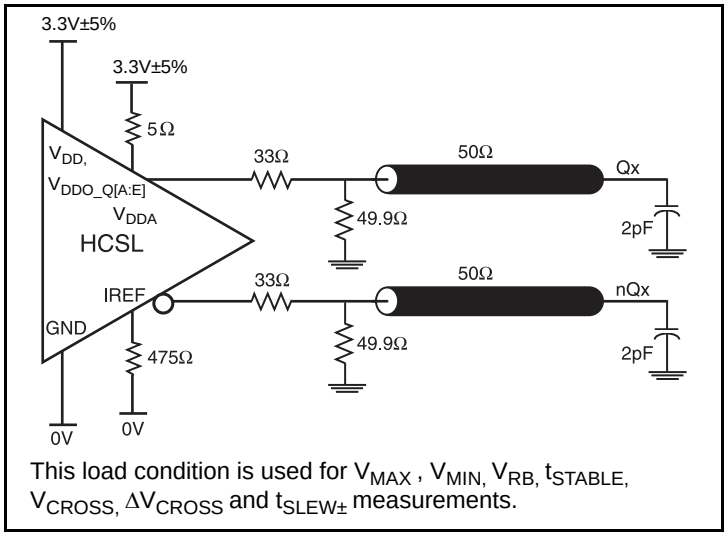
## Parameter Measurement Information



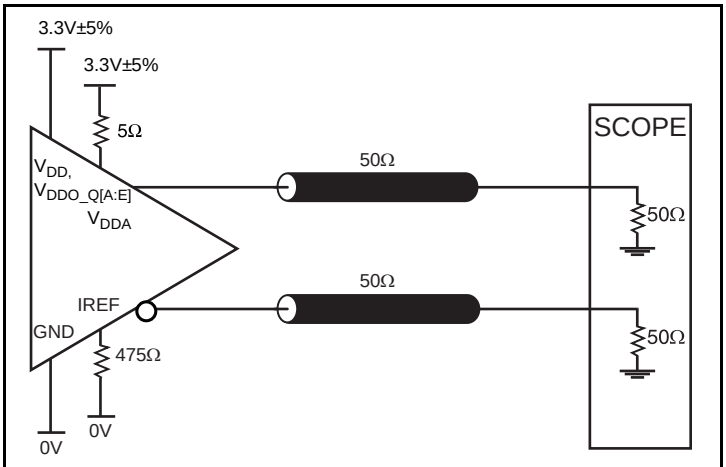

**3.3V Core/3.3V LVCMOS Output Load Test Circuit**



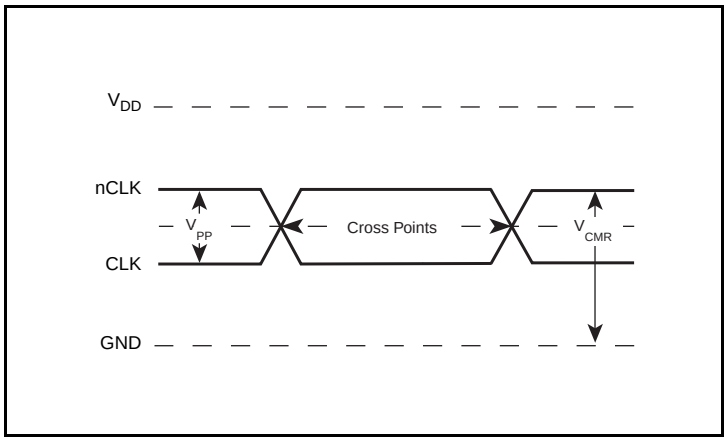

**3.3V Core/2.5V LVCMOS Output Load Test Circuit**



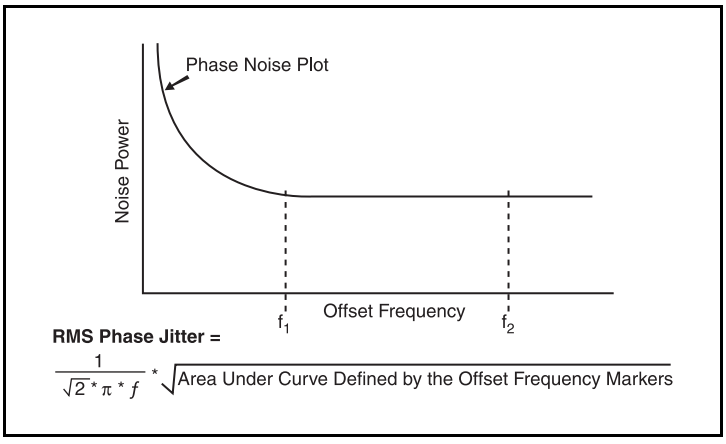

**3.3V Core/3.3V HCSL Output Load Test Circuit 1**




**3.3V Core/3.3V HCSL Output Load Test Circuit 2**

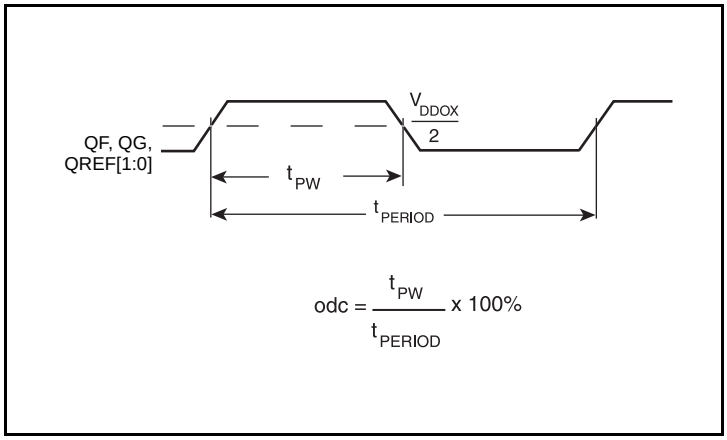



**Differential Input Level**

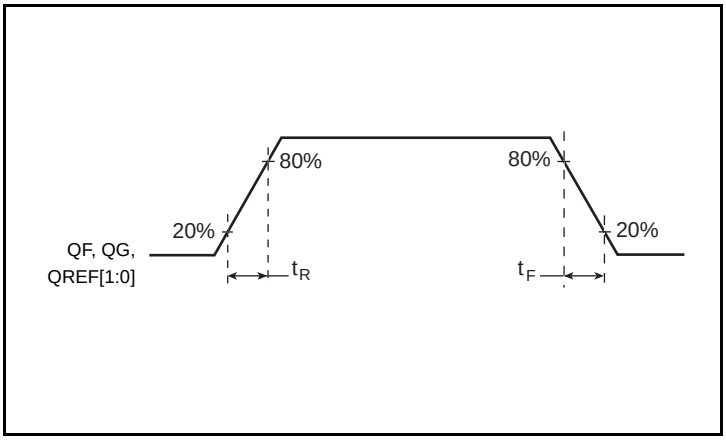



**RMS Phase Jitter**

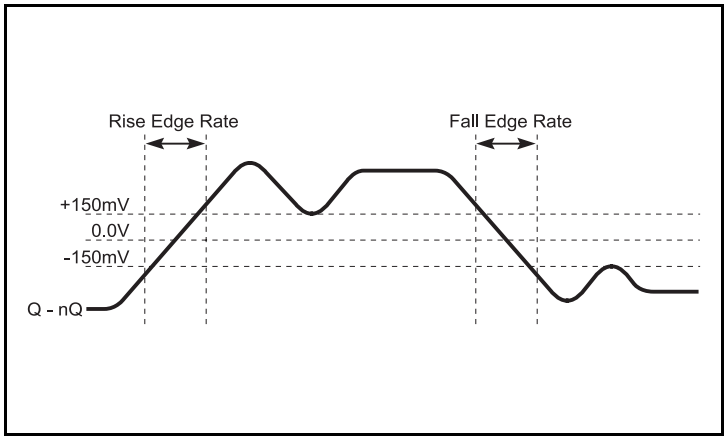
## Parameter Measurement Information, continued



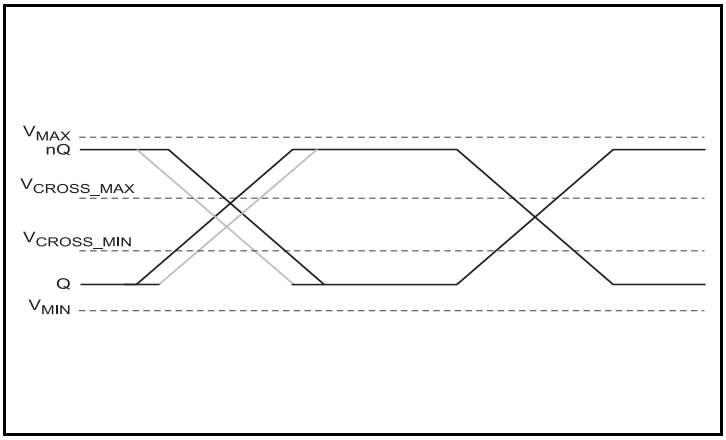

**LVCMOS Output Duty Cycle/Pulse Width**



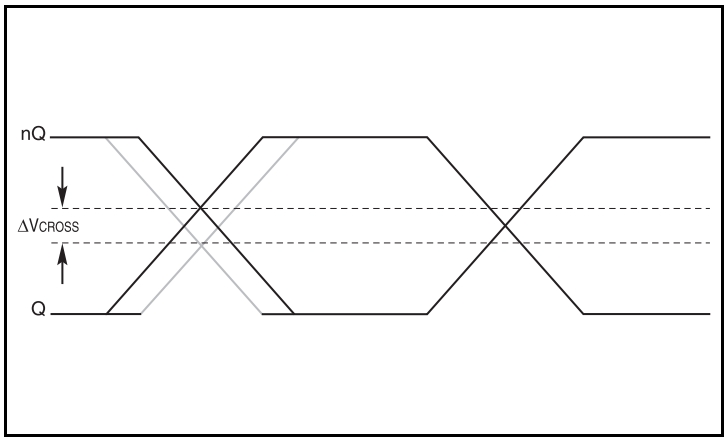

**LVCMOS Output Rise/Fall Time**



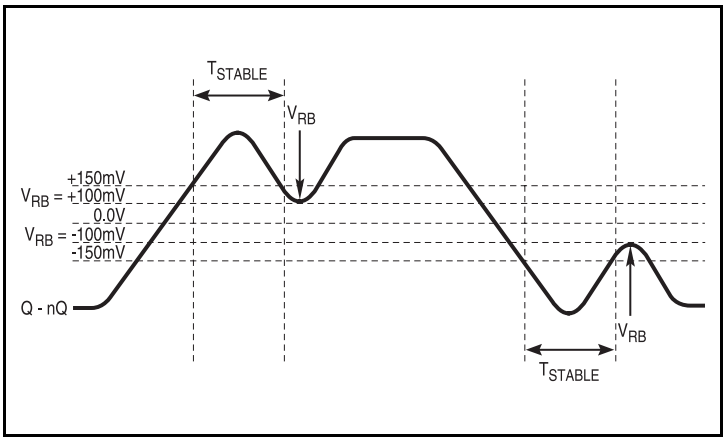

**Differential Measurement Points for Rise/Fall Time Edge Rate**




**Single-ended Measurement Points for Absolute Cross Point/Swing**

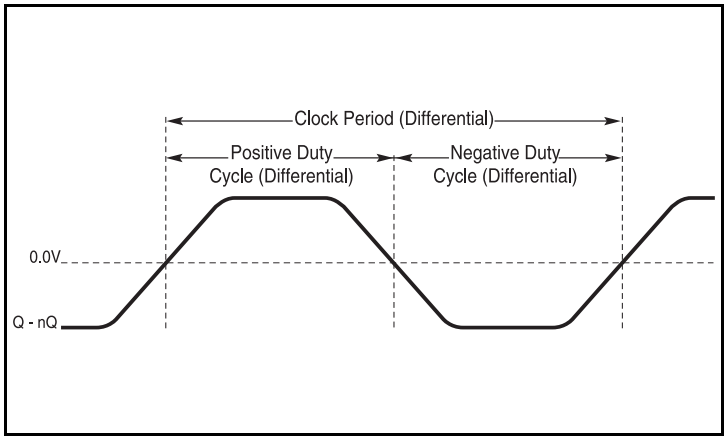



**Single-ended Measurement Points for Delta Cross Point**




**Differential Measurement Points for Ringback**

## Parameter Measurement Information, continued




**Differential Measurement Points for Duty Cycle/Period**

# Applications Information

## Peak-to-Peak Jitter Calculations

A standard deviation of a statistical population or data set is the square root of its variance. A standard deviation is used to calculate the probability of an anomaly or to predict a failure. Many times, the term "root mean square" (RMS) is used synonymously for standard deviation. This is accurate when referring to the square root of the mean squared deviation of a signal from a given baseline and when the data set contains a Gaussian distribution with no deterministic components. A low standard deviation indicates that the data set is close to the mean with little variation. A large standard deviation indicates that the data set is spread out and has a large variation from the mean.

A standard deviation is required when calculating peak-to-peak jitter. Since true peak-to-peak jitter is random and unbounded, it is important to always associate a bit error ratio (BER) when specifying a peak-to-peak jitter limit. Without it, the specification does not have a boundary and will continue get larger with sample size. Given that a BER is application specific, many frequency timing devices specify jitter as an RMS. This allows the peak-to-peak jitter to be calculated for the specific application and BER requirement. Because a standard deviation is the variation from the *mean* of the data set, it is important to always calculate the peak-to-peak jitter using the typical RMS value.

*Table 8* shows the BER with its appropriate RMS Multiplier. There are two columns for the RMS multiplier, one should be used if your signal is data and the other should be used if the signal is a repetitive clock signal. The difference between the two is the data transition density (DTD). The DTD is the number of rising or falling transitions divided by the total number of bits. For a clock signal, they are equal, hence the DTD is 1. For Data, on average, most common encoding standards have a 0.5 DTD.

**Table 8. BER Table**

| BER | RMS Multiplier Data, “DTD = 0.5” | RMS Multiplier Clock, “DTD = 1” |
|---|---|---|
| $10^{-3}$ | 6.180 | 6.582 |
| $10^{-4}$ | 7.438 | 7.782 |
| $10^{-5}$ | 8.530 | 8.834 |
| $10^{-6}$ | 9.507 | 9.784 |
| $10^{-7}$ | 10.399 | 10.654 |
| $10^{-8}$ | 11.224 | 11.462 |
| $10^{-9}$ | 11.996 | 12.218 |
| $10^{-10}$ | 12.723 | 12.934 |
| $10^{-11}$ | 13.412 | 13.614 |
| $10^{-12}$ | 14.069 | 14.260 |
| $10^{-13}$ | 14.698 | 14.882 |
| $10^{-14}$ | 15.301 | 15.478 |
| $10^{-15}$ | 15.883 | 16.028 |

Once the BER is chosen, there are two circumstances to consider. Is the data set purely Gaussian or does it contains any deterministic component? If it is Gaussian, then the peak to peak jitter can be calculated by simply multiplying the RMS multiplier with the typical RMS specification. For example, if a $10^{-12}$ BER is required for a clock signal, multiply 14.260 times the typical jitter specification.

**Jitter (peak-to-peak) = RMS Multiplier * RMS (typical)**

If the datasheet contains deterministic components, then the random jitter ($R_J$) and deterministic jitter ($D_J$) must be separated and analyzed separately. $R_J$, also known as Gaussian jitter, is not bounded and the peak-to-peak will continue to get larger as the sample size increases. Alternatively, peak-to-peak value of $D_J$ is bounded and can easily be observed and predicted. Therefore, the peak to peak jitter for the random component must be added to the deterministic component. This is called total jitter ($T_J$).

**Total Jitter (peak-to-peak) = [RMS Multiplier * Random Jitter ($R_J$)] + Deterministic Jitter ($D_J$)**

The *total jitter equation* is not specific to one type of jitter classification. It can be used to calculate BER on various types of RMS jitter. It is important that the user understands their jitter requirement to ensure they are calculating the correct BER for their jitter requirement.

NOTE: Use $R_J$ and $D_J$ values from AC Characteristics Tables 7B and 7C to calculate $T_J$.

## 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 $V_1 = V_{DD}/2$ 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 is driven from a single-ended 2.5V LVCMOS driver and the DC offset (or swing center) of this signal is 1.25V, the R1 and R2 values should be adjusted to set the V1 at 1.25V. The values below are for when both the single ended swing and $V_{DD}$ are at the same voltage. This configuration requires that the sum of the output impedance of the driver (Ro) and the series resistance (Rs) 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 50Ω applications, R3 and R4 can be 100Ω. 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 while maintaining an edge rate faster than 1V/ns. 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 $V_{DD}$ + 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.

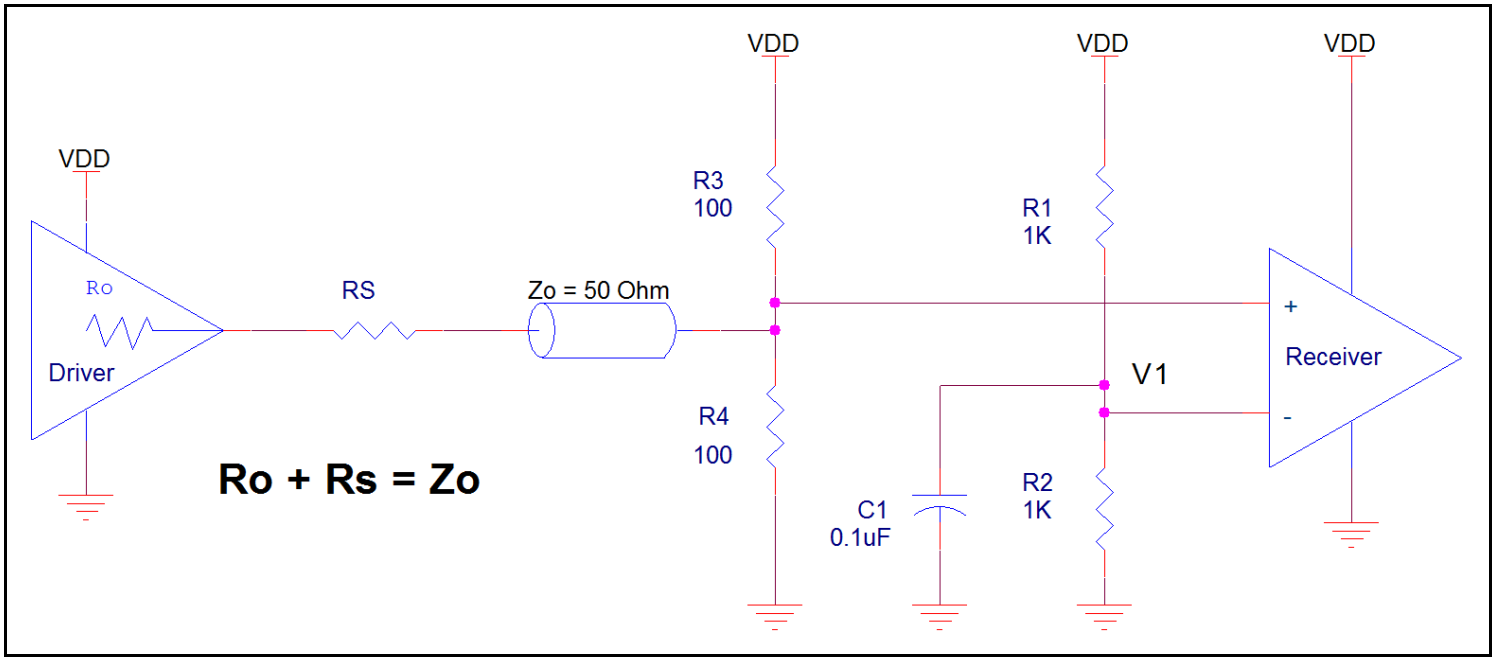



**Figure 1. Recommended Schematic for Wiring a Differential Input to Accept Single-ended Levels**

## Differential Clock Input Interface

The CLK /nCLK accepts LVDS, LVPECL, LVHSTL, HCSL and other differential signals. Both $V_{SWING}$ and $V_{OH}$ must meet the $V_{PP}$ and $V_{CMR}$ input requirements. *Figures 2A to 2E* show interface examples for the CLK/nCLK input driven by the most common driver types. The input interfaces suggested here are examples only. Please consult with the vendor of the driver component to confirm the driver termination requirements. For example, in Figure 2A, the input termination applies for IDT open emitter LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.

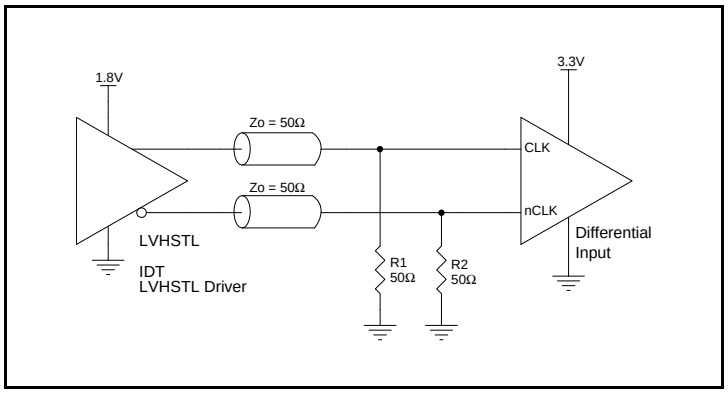



**Figure 2A. CLK/nCLK Input Driven by an IDT Open Emitter LVHSTL Driver**

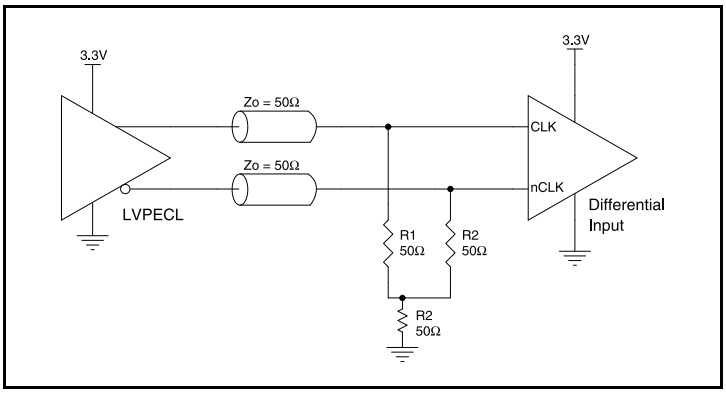



**Figure 2B. CLK/nCLK Input Driven by a 3.3V LVPECL Driver**

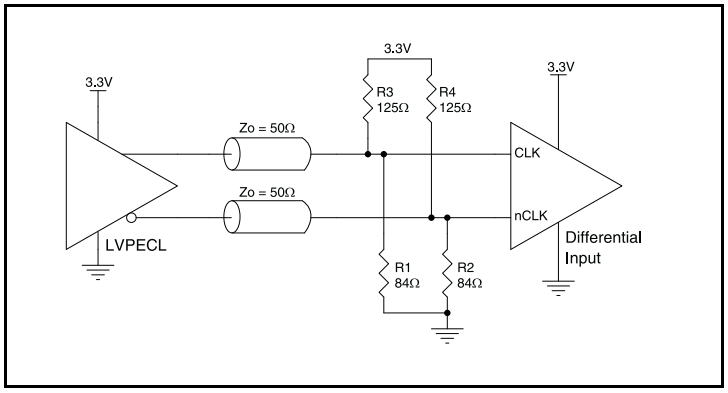



**Figure 2C. CLK/nCLK Input Driven by a 3.3V LVPECL Driver**

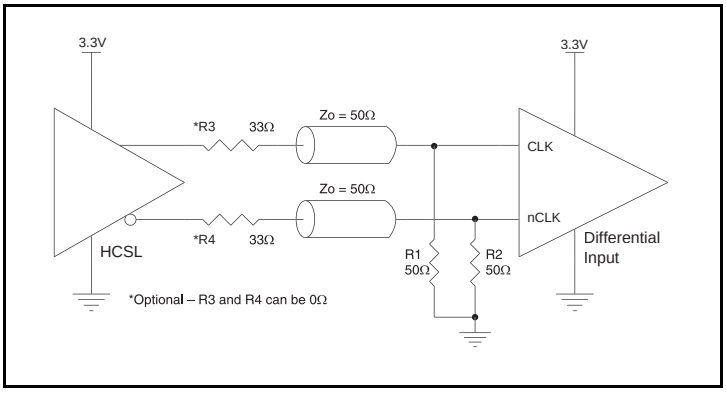



**Figure 2D. CLK/nCLK Input Driven by a 3.3V HCSL Driver**

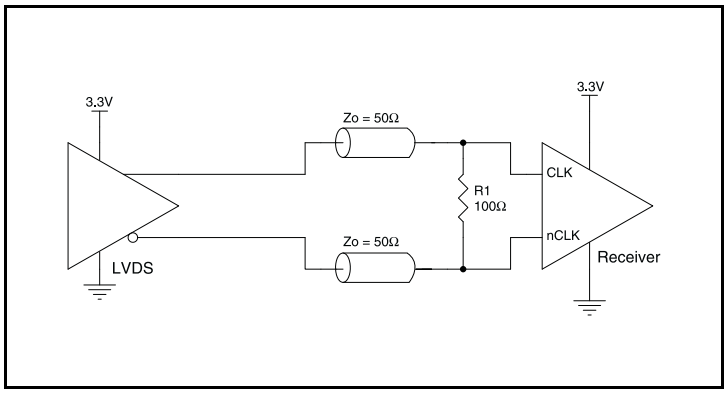



**Figure 2E. CLK/nCLK Input Driven by a 3.3V LVDS Driver**

## 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 3A* 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 (Ro) and the series resistance (Rs) 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, R1 and R2 in parallel should equal the transmission line impedance. For most 50Ω applications, R1 and R2 can be 100Ω. This can also be accomplished by removing R1 and changing R2 to 50Ω. The values of the resistors can be increased to reduce the loading for a slower and weaker LVCMOS driver. *Figure 3B* 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.

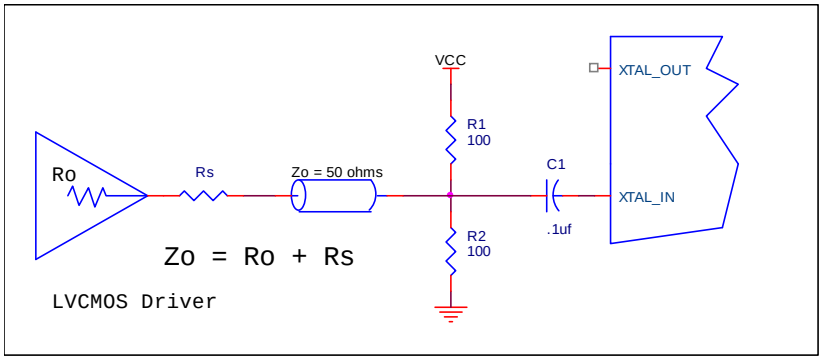



**Figure 3A. General Diagram for LVCMOS Driver to XTAL Input Interface**

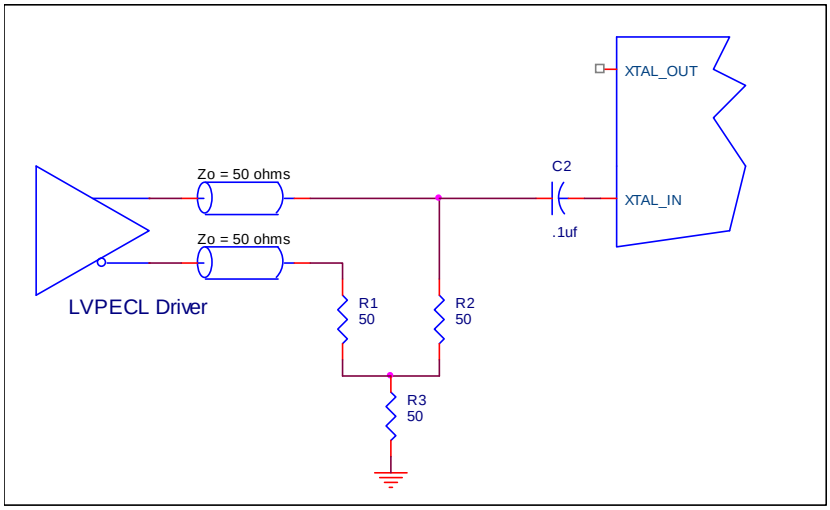



**Figure 3B. General Diagram for LVPECL Driver to XTAL Input Interface**

## Recommended Termination

*Figure 4A* is the recommended source termination for applications where the driver and receiver will be on a separate PCBs. This termination is the standard for PCI Express™ and HCSL output types. All traces should be 50Ω impedance single-ended or 100Ω differential.

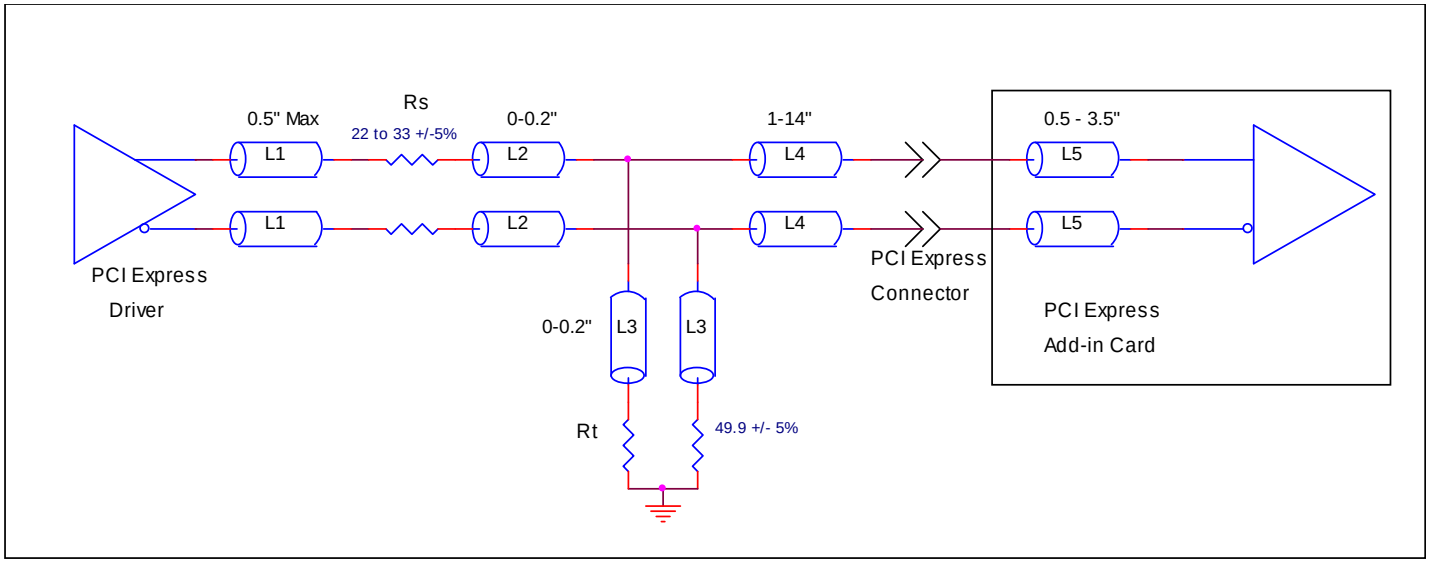



**Figure 4A. Recommended Source Termination (where the driver and receiver will be on separate PCBs)**

*Figure 4B* is the recommended termination for applications where a point-to-point connection can be used. A point-to-point connection contains both the driver and the receiver on the same PCB. With a matched termination at the receiver, transmission-line reflections will be minimized. In addition, a series resistor (Rs) at the driver offers flexibility and can help dampen unwanted reflections. The optional resistor can range from 0Ω to 33Ω. All traces should be 50Ω impedance single-ended or 100Ω differential.

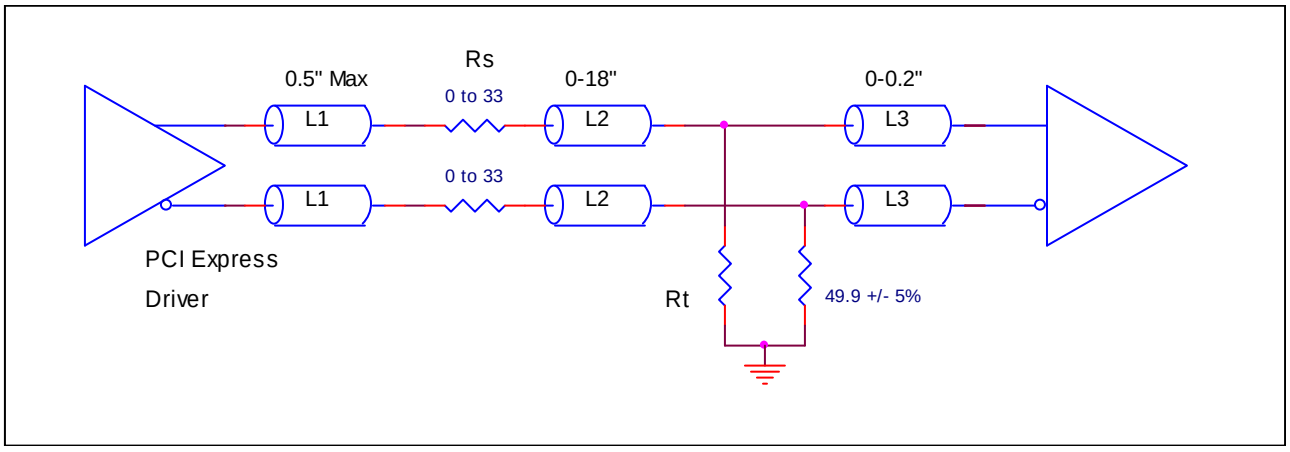



**Figure 4B. Recommended Termination (where a point-to-point connection can be used)**

## 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 5.* 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.

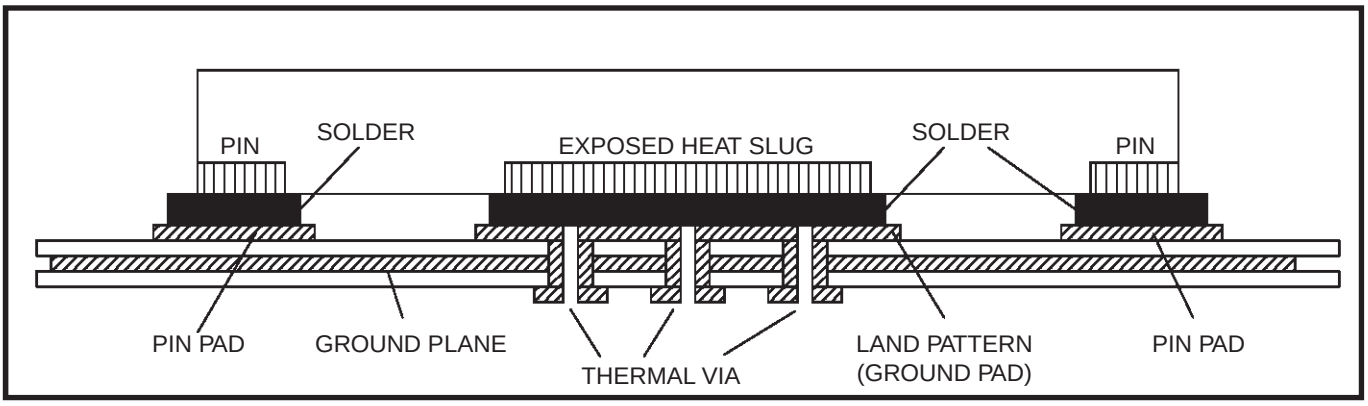



**Figure 5. P.C. Assembly for Exposed Pad Thermal Release Path – Side View (drawing not to scale)**

## Recommendations for Unused Input and Output Pins

### Inputs:

#### LVCMOS Control Pins

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

#### 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 1kΩ resistor can be tied from XTAL_IN to ground.

#### 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 1kΩ resistor can be tied from CLK to ground.

### Outputs:

#### LVCMOS Outputs

All unused LVCMOS outputs can be left floating. There should be no trace attached.

#### Differential Outputs

All unused differential 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.

## 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.

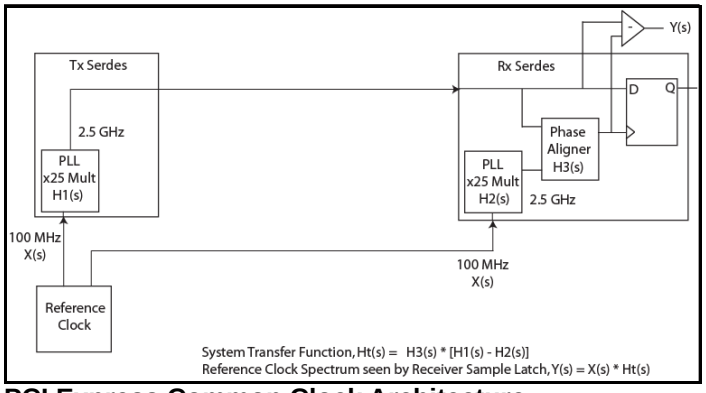
In the jitter analysis, the transmit (Tx) and receive (Rx) serdes PLLs are modeled as well as the phase interpolator in the receiver. These transfer functions are called H1, H2, and H3 respectively. The overall system transfer function at the receiver is:

$$Ht(s) = H3(s) \times [H1(s) - H2(s)]$$

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

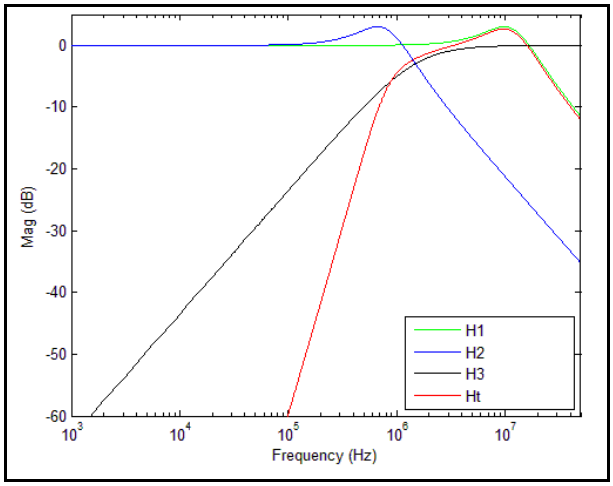
$$Y(s) = X(s) \times H3(s) \times [H1(s) - H2(s)]$$

In order to generate time domain jitter numbers, an inverse Fourier Transform is performed on X(s)*H3(s) * [H1(s) - H2(s)].



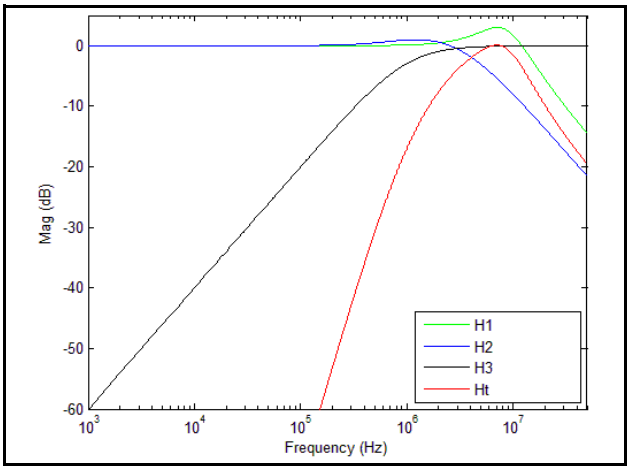

**PCI Express Common Clock Architecture**

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.

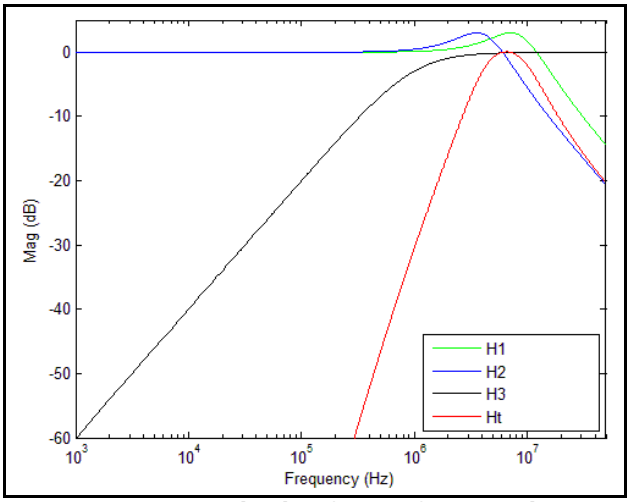



**PCIe Gen 1 Magnitude of Transfer Function**

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.

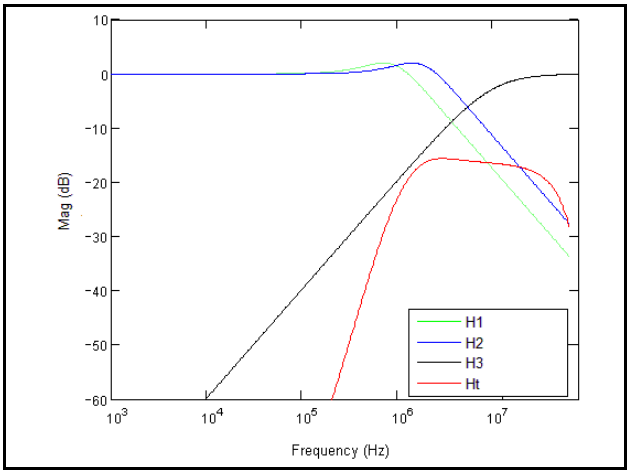



**PCIe Gen 2A Magnitude of Transfer Function**




**PCIe 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.




**PCIe 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 Example

Figure 6 (next page) shows an example of 8V41N012 application schematic. In this example, the device is operated at $V_{DD}$ = $V_{DDA}$ = $V_{DDO_Qx}$ = 3.3V. 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 that the logic control inputs are properly set.

A 12pF parallel resonant 25MHz crystal is used. For this device, the crystal load capacitors are required for proper operation. The load capacitance, C1 = C2 = 2pF, are recommended for frequency accuracy. Depending on the variation of the parasitic stray capacity of the printed circuit board traces between the crystal and the Xtal_In and Xtal_Out pins, the values of C1 and C2 might require a slight adjustment to optimize the frequency accuracy. Crystals with other load capacitance specifications can be used, but this will require adjusting C1 and C2. When designing the circuit board, return the capacitors to ground though a single point contact close to the package. Two Fox crystal options are shown in the schematic for design flexibility.

The ePAD provides a low thermal impedance connection between the internal device and the PCB. It also provides an electrical connection to the die and must be connected to ground.

As with any high speed analog circuitry, the power supply pins are vulnerable to random noise. To achieve optimum jitter performance, power supply isolation is required. The 8V41N012 provides separate power supplies to isolate any high switching noise 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 0.1µF capacitor in each power pin filter should be placed on the device side. The other components can be on the opposite side of the PCB.

Power supply filter recommendations are a general guideline to be used for reducing external noise from coupling into the devices. The filter performance is designed for a wide range of noise frequencies. This low-pass filter starts to attenuate noise at approximately 10kHz. If a specific frequency noise component is known, such as switching power supplies 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 capacitance in the local area of all devices.

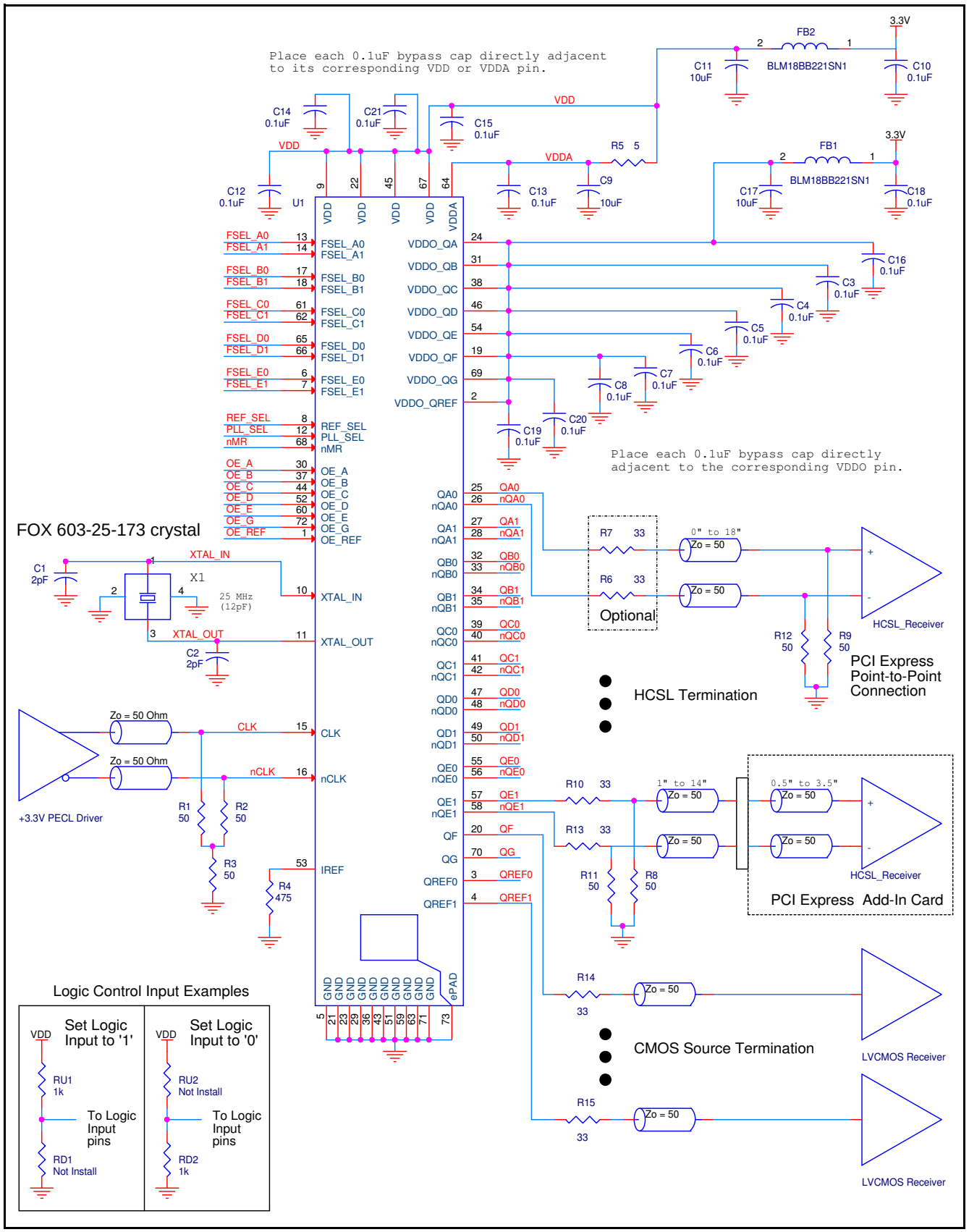



**Figure 6. 8V41N012 Schematic Example**

# Power Considerations

This section provides information on power dissipation and junction temperature for the 8V41N012. Equations and example calculations are also provided.

**1. Power Dissipation.**

The total power dissipation for the 8V41N012 is the sum of the core power plus the analog power plus the power dissipated due to loading. The following is the power dissipation for $V_{DD}$ = 3.3V + 5% = 3.465V, which gives worst case results.

NOTE: Please refer to Section 3 for details on calculating power dissipated due to loading.

- Power (core)$_{MAX}$ = $V_{DD_MAX}$ * ($I_{DD}$ + $I_{DDA}$)= 3.465V * (235mA + 45mA) = **970.2mW**
- Power (HCSL)$_{MAX}$ = (3.465V – 17mA * 50) 17mA = **44.5mW** per output
- Total Power (HCSL)$_{MAX}$ = 44.5mW * 10 = **445mW**

**LVCMOS Driver Power Dissipation**

- Output Impedance $R_{OUT}$ Power Dissipation due to Loading 50Ω to $V_{DDO_Qx}$ / 2
  Output Current $I_{OUT}$ = $V_{DD_MAX}$ / [2 * (50Ω + $R_{OUT}$)] = 3.465V / [2 * (50Ω + 15Ω)] = **26.65mA**
- Power Dissipation on the $R_{OUT}$ per LVCMOS output
  Power (LVCMOS) = $R_{OUT}$ * ($I_{OUT}$)$^2$ = 15Ω * (26.65mA)$^2$ = **10.65mW per output**
- Total Power Dissipation on the $R_{OUT}$
  Total Power ($R_{OUT}$) = 10.65mW * 4 = **42.6mW**

- Total Power Dissipation
- **Total Power**
  = Power (core) + Total Power (HCSL) + Total Power ($R_{OUT}$)
  = 970.2mW + 445mW + 42.6mW
  **= 1457.8mW**

**2. Junction Temperature.**

Junction temperature, Tj, 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, Tj, to 125°C ensures that the bond wire and bond pad temperature remains below 125°C.

The equation for Tj is as follows: Tj = $\theta_{JA}$ * Pd_total + $T_A$

Tj = 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 26.6°C/W per Table 9 below.

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

85°C + 1.458W * 26.6°C/W = 123.8°C. This is below the limit of 125°C.

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

**Table 9. Thermal Resistance $\theta_{JA}$ for 72 Lead VFQFN, Forced Convection**

| $\theta_{JA}$ vs. Air Flow | | | |
|---|---|---|---|
| Meters per Second | **0** | **1** | **2** |
| Multi-Layer PCB, JEDEC Standard Test Boards | 26.6°C/W | 20°C/W | 17.9°C/W |

**3. Calculations and Equations.**

The purpose of this section is to calculate power dissipation on the IC per HCSL output pair.

HCSL output driver circuit and termination are shown in *Figure 7.*

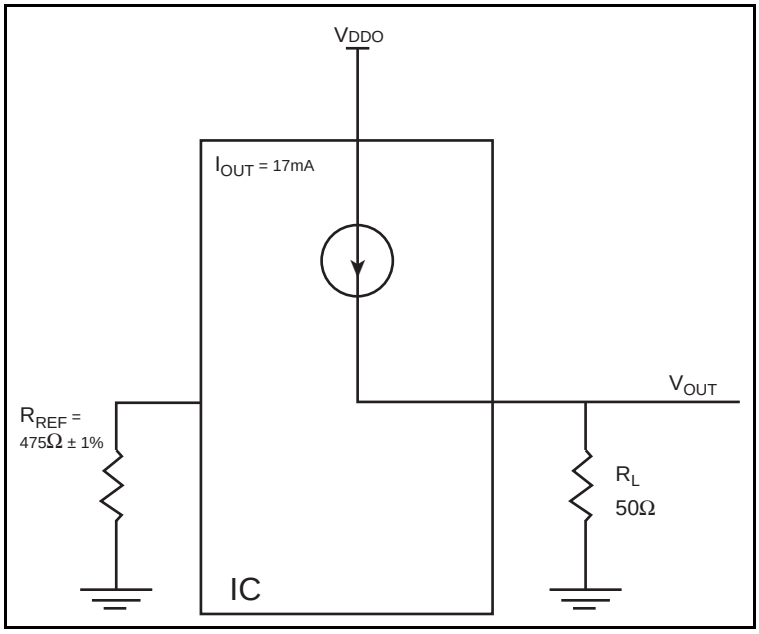



**Figure 7. HCSL Driver Circuit and Termination**

HCSL is a current steering output which sources a maximum of 17mA of current per output. To calculate worst case on-chip power dissipation, use the following equations which assume a 50Ω load to ground.

The highest power dissipation occurs when $V_{DD_MAX}$.

Power = $(V_{DD_MAX} – V_{OUT}) * I_{OUT}$
since $V_{OUT} = I_{OUT} * R_L$

Power = $(V_{DD_MAX} – I_{OUT} * R_L) * I_{OUT}$

= (3.465V – 17mA * 50Ω) * 17mA

Total Power Dissipation per output pair = **44.5mW**

# Reliability Information

**Table 10. $\theta_{JA}$ vs. Air Flow Table for a 72 Lead VFQFN**

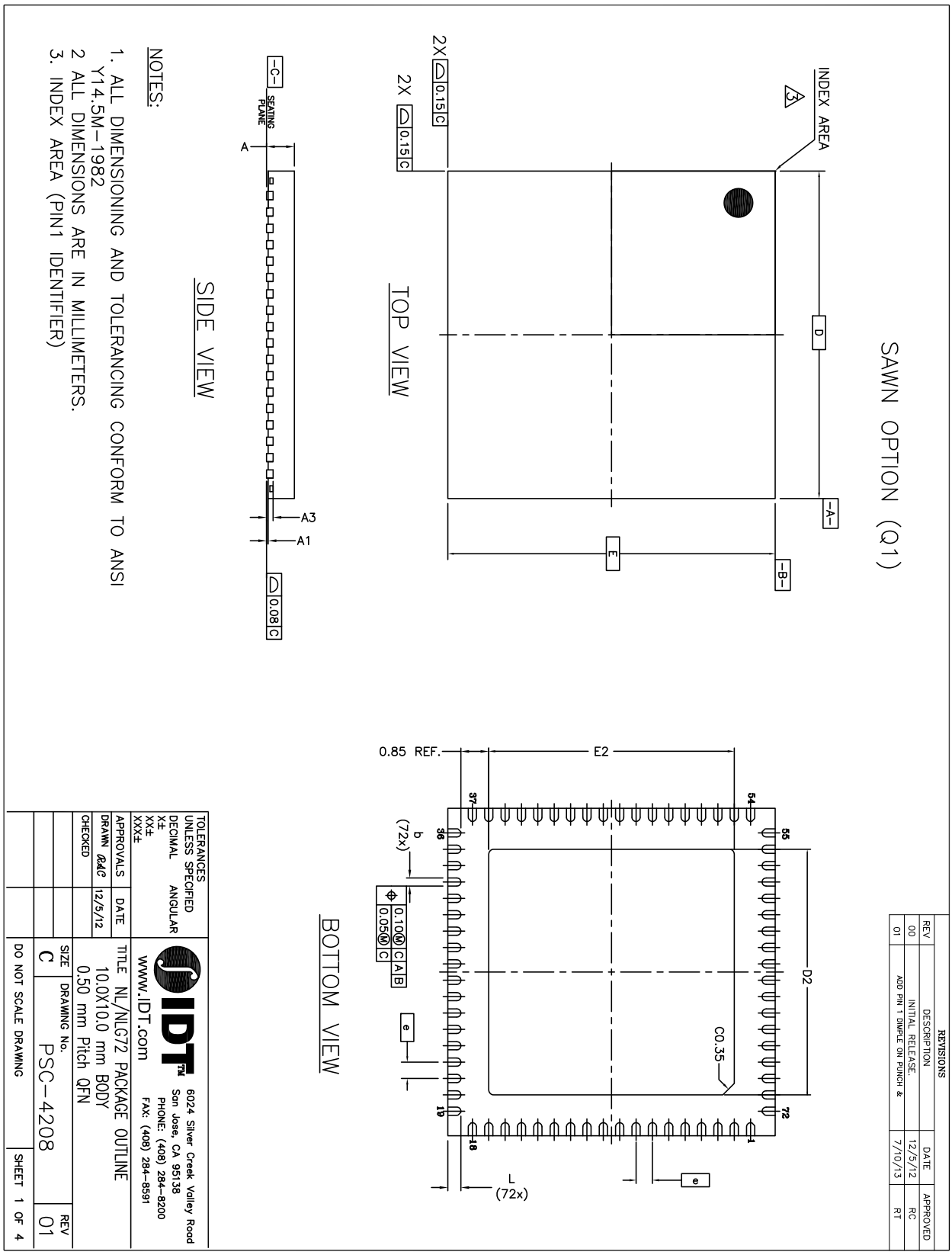
| $\theta_{JA}$ vs. Air Flow | | | |
|---|---|---|---|
| Meters per Second | **0** | **1** | **2** |
| Multi-Layer PCB, JEDEC Standard Test Boards | 26.6°C/W | 20°C/W | 17.9°C/W |

## Transistor Count

The transistor count for 8V41N012 is: 175,936

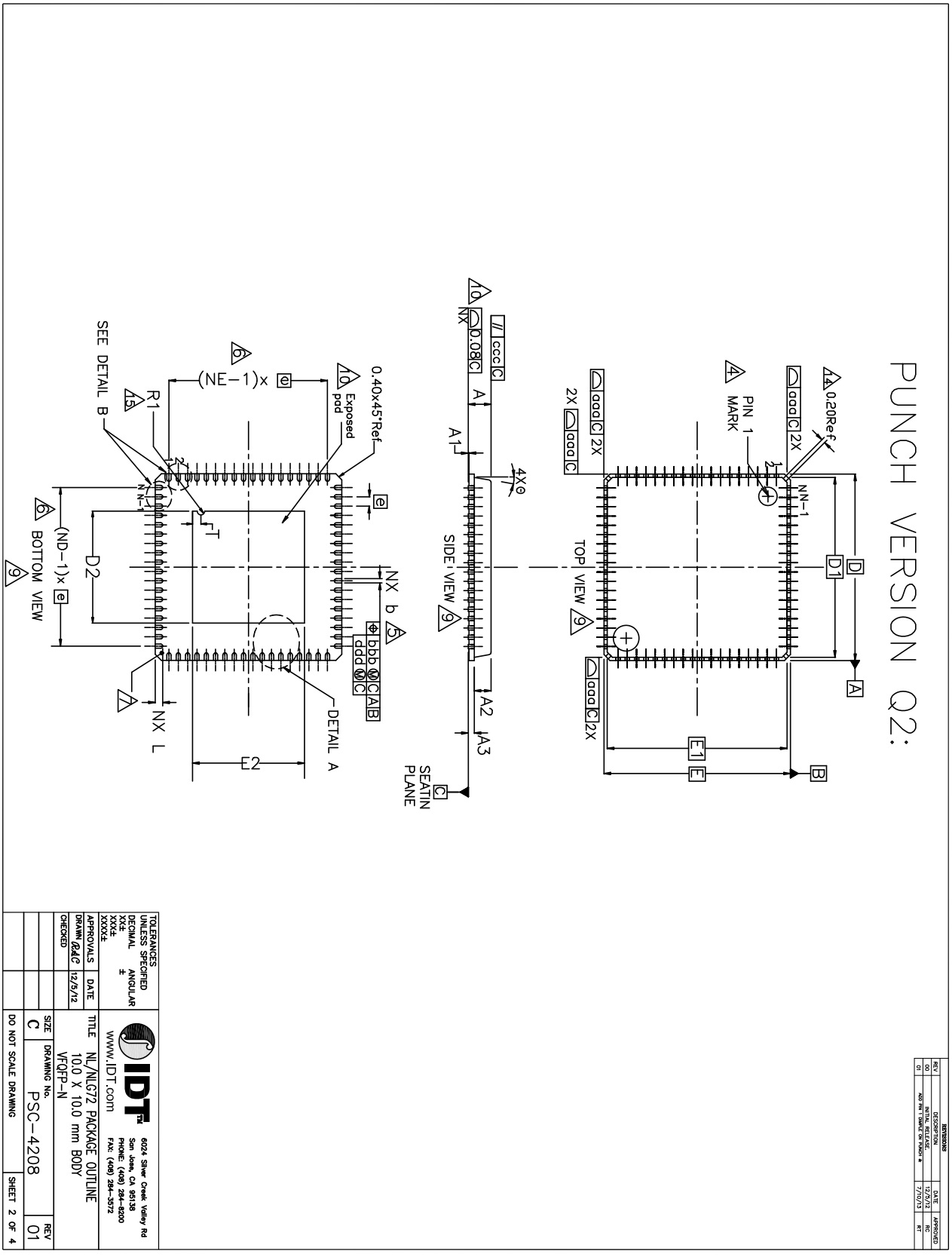
# Package Outline and Package Dimensions

## Package Outline - 72 Lead VFQFN



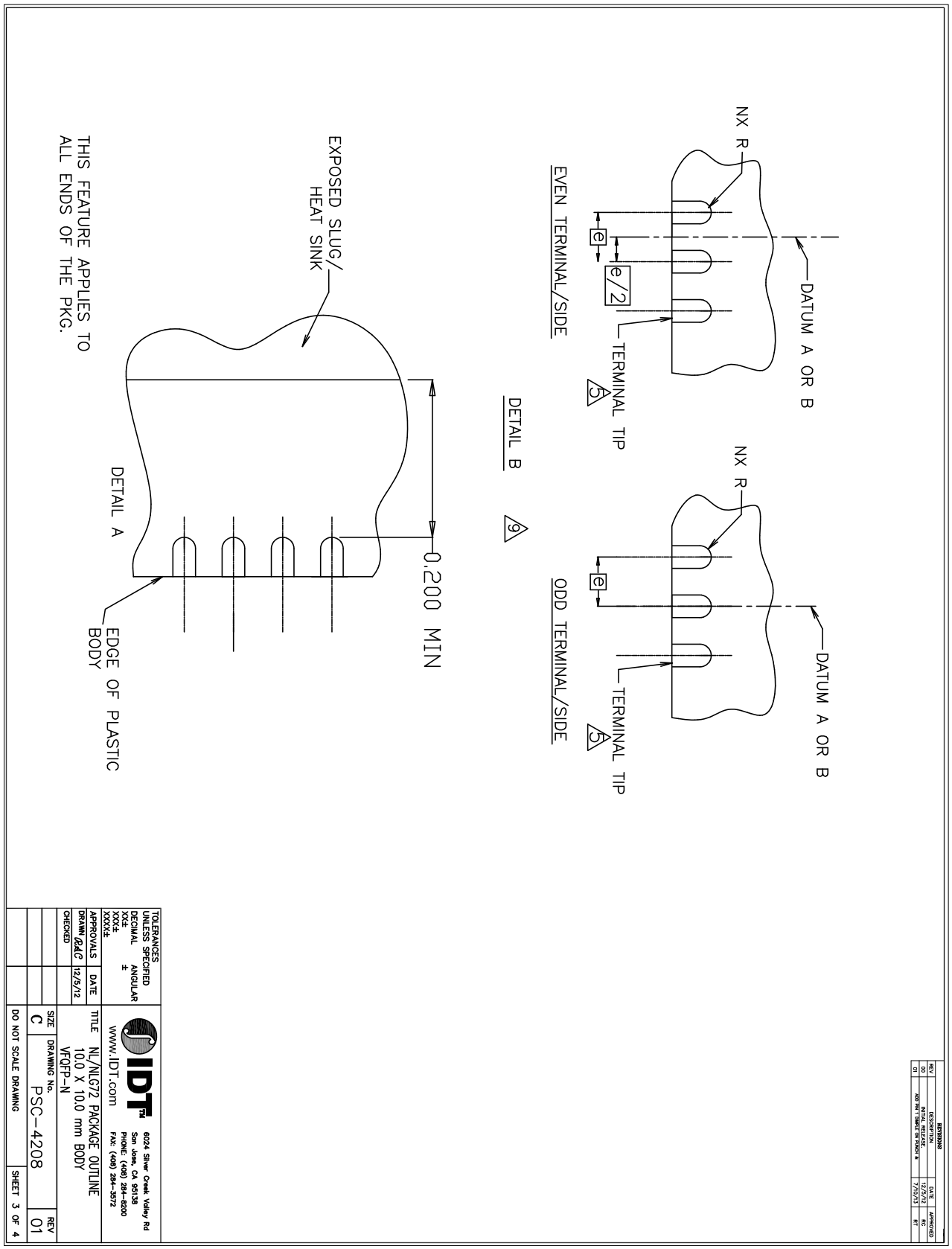
# Package Outline and Package Dimensions

## Package Outline - 72 Lead VFQFN



# Package Outline and Package Dimensions

## Package Outline - 72 Lead VFQFN



# Package Outline and Package Dimensions

## Package Outline - 72 Lead VFQFN

| REVISIONS | | | |
|---|---|---|---|
| REV | DESCRIPTION | DATE | APPROVED |
| 00 | INITIAL RELEASE. | 12/5/12 | RC |
| 01 | ADD PIN 1 DIMPLE ON PUNCH & | 7/10/13 | RT |

### SAW VERSION:

| SYMBOL | DIMENSION | | | NOTE |
|---|---|---|---|---|
| | MIN. | NOM. | MAX. | |
| D2 | SEE EPAD OPTION | | | |
| E2 | SEE EPAD OPTION | | | |
| k | 0.20 | – | – | |
| N | | 72 | | 6 |
| Nd | | 18 | | 6 |
| Ne | | 18 | | 6 |

### EPAD OPTION:

| SYMBOL | P1 | | | P2 | | | P3 | | |
|---|---|---|---|---|---|---|---|---|---|
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| E2 | 7.40 | 7.50 | 7.60 | 5.90 | 6.00 | 6.10 | 5.80 | 5.90 | 6.00 |
| D2 | 7.40 | 7.50 | 7.60 | 5.90 | 6.00 | 6.10 | 5.80 | 5.90 | 6.00 |

### LEAD OPTION

| SYMBOL | Z1 | | | Z2 | | |
|---|---|---|---|---|---|---|
| | MIN. | NOM. | MAX. | MIN. | NOM. | MAX. |
| L | 0.45 | 0.50 | 0.55 | 0.30 | 0.40 | 050 |

| TOLERANCE OF FORM & POSITION | | |
|---|---|---|
| pitch / SYMBOL | 0.40mm | 0.50mm |
| aaa | 0.10 | 0.15 |
| bbb | 0.07 | 0.10 |
| ccc | 0.10 | 0.10 |
| ddd | 0.05 | 0.05 |
| NOTES | 1,2 | |

| COMMON DIMENSIONS | | | |
|---|---|---|---|
| DIM / SYMBOL | MIN | NOM | MAX |
| A | 0.80 | 0.90 | 1.00 |
| A1 | 0 | 0.02 | 0.05 |
| A3 REF | – | 0.20 ref | – |
| Θ | 0 | – | 14 |
| T ref. | – | 0.45 | – |
| R1 | – | 0.20 | – |
| R ref. b min/2 | | | |
| NOTES | | 1,2 | |
| b | 0.18 | 0.25 | 0.30 |
| e | 0.50 BSC | | |
| D | 10.00 BSC | | |
| E | 10.00 BSC | | |

NOTES:

1. DIMENSIONING & TOLERANCING CONFORM TO ASME Y14.5M–1994.
2. ALL DIMENSIONS ARE IN MILLIMETERS. ANGLES ARE IN DEGREES.
3. N IS THE TOTAL NUMBER OF TERMINALS.
   Nd IS THE NUMBER OF TERMINALS IN X–DIRECTION &
   Ne IS THE NUMBER OF TERMINALS IN Y–DIRECTION.
4. THE TERMINAL #1 IDENTIFIER AND TERMINAL NUMBERING CONVENTION SHALL CONFORM TO JEDEC PUB. 95 SEC. 4.3 SPP–002. DETAILS OF TERMINAL #1 IDENTIFIER ARE OPTIONAL, BUT MUST BE LOCATED WITHIN THE ZONE INDICATED. THE TERMINAL #1 IDENTIFIER MAY BE EITHER A MOLD OR MARKED FEATURE.
5. DIMENSION b APPLIES TO METALLIZED TERMINAL AND IS MEASURED BETWEEN 0.25mm AND 0.30mm FROM TERMINAL TIP.
6. ND AND NE REFER TO THE NUMBER OF TERMINALS ON EACH D AND E SIDE RESPECTIVELY.
7. DEPOPULATION IS POSSIBLE IN A SYMMETRICAL FASHION.

### PUNCH VERSION

| SYMBOL | DIMENSION | | | NOTE |
|---|---|---|---|---|
| | MIN. | NOM. | MAX. | |
| D2 | SEE EPAD OPTION | | | |
| E2 | SEE EPAD OPTION | | | |
| D1 | 9.75 BSC | | | |
| E1 | 9.75 BSC | | | |
| N | | 72 | | 3 |
| Nd | | 18 | | 6 |
| Ne | | 18 | | 6 |
| A2 | 0 | 0.65 | 1.00 | |

| TOLERANCES UNLESS SPECIFIED | |
|---|---|
| DECIMAL | ANGULAR |
| XX± | ± |
| XXX± | |
| XXXX± | |

IDT™ www.IDT.com
6024 Silver Creek Valley Rd
San Jose, CA 95138
PHONE: (408) 284–8200
FAX: (408) 284–3572

| APPROVALS | DATE |
|---|---|
| DRAWN RAC | 12/5/12 |
| CHECKED | |

TITLE: NL/NLG72 PACKAGE OUTLINE 10.0 X 10.0 mm BODY VFQFP–N

| SIZE | DRAWING No. | REV |
|---|---|---|
| C | PSC–4208 | 01 |

DO NOT SCALE DRAWING — SHEET 4 OF 4



©2016 Integrated Device Technology, Inc.

# Ordering Information

**Table 11. Ordering Information**

| Part/Order Number | Marking | Package | Shipping Packaging | Temperature |
|---|---|---|---|---|
| 8V41N012NLGI | 8V41N012NLGI | 72 Lead VFQFN, Lead-Free | Tray | -40°C to 85°C |
| 8V41N012NLGI8 | 8V41N012NLGI | 72 Lead VFQFN, Lead-Free | Tape & Reel | -40°C to 85°C |

# Revision History Sheet

| Rev | Table | Page | Description of Change | Date |
|---|---|---|---|---|
| B | | 23 | Updated schematic with IDT crystal recommendation.<br>Deleted prefix/suffix from part number throughout the datasheet.<br>Updated header/footer. | 7/22/15 |
| C | | 23 | Schematic - replaced IDT crystal recommendation with FOX crystal.<br>Updated header/footer. | 11/2/16 |

**Corporate Headquarters**
6024 Silver Creek Valley Road
San Jose, CA 95138 USA
www.IDT.com

**Sales**
1-800-345-7015 or 408-284-8200
Fax: 408-284-2775
www.IDT.com/go/sales

**Tech Support**
www.IDT.com/go/support

DISCLAIMER Integrated Device Technology, Inc. (IDT) reserves the right to modify the products and/or specifications described herein at any time, without notice, at IDT's sole discretion. Performance specifications and operating parameters of the described products are determined in an independent state and are not guaranteed to perform the same way when installed in customer products. The information contained herein is provided without representation or warranty of any kind, whether express or implied, including, but not limited to, the suitability of IDT's products for any particular purpose, an implied warranty of merchantability, or non-infringement of the intellectual property rights of others. This document is presented only as a guide and does not convey any license under intellectual property rights of IDT or any third parties.

IDT's products are not intended for use in applications involving extreme environmental conditions or in life support systems or similar devices where the failure or malfunction of an IDT product can be reasonably expected to significantly affect the health or safety of users. Anyone using an IDT product in such a manner does so at their own risk, absent an express, written agreement by IDT.

Integrated Device Technology, IDT and the IDT logo are trademarks or registered trademarks of IDT and its subsidiaries in the United States and other countries. Other trademarks used herein are the property of IDT or their respective third party owners. For datasheet type definitions and a glossary of common terms, visit www.idt.com/go/glossary. Integrated Device Technology, Inc. All rights reserved.