

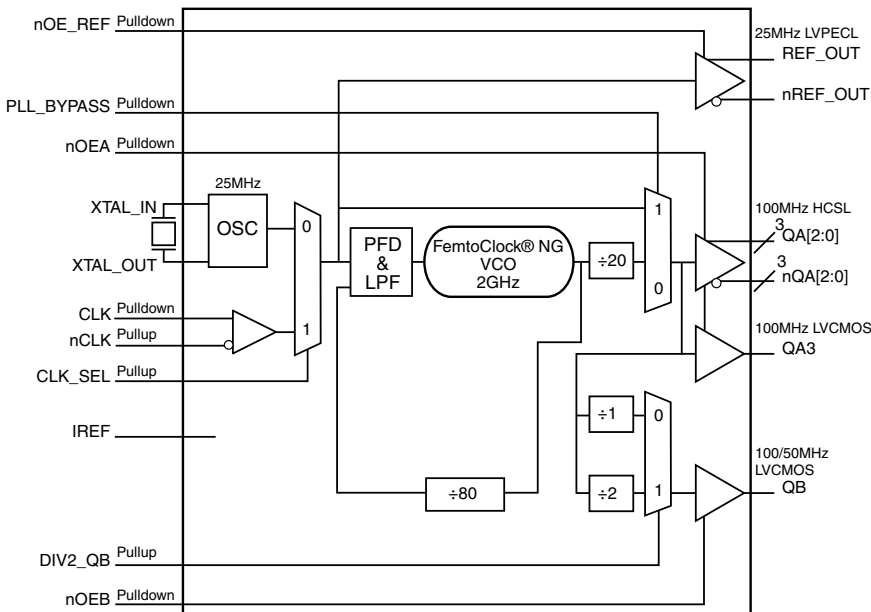
## General Description

The 841N4830 is a 3 HCSL, 1 LVPECL and 2 LVCMOS output Synthesizer optimized to generate PCI Express reference clock frequencies. The device uses IDT's fourth generation FemtoClock® NG technology for synthesis of high clock frequency at very low phase noise. It provides low power consumption with good power supply noise rejection. Using a 25MHz, 12pF parallel resonant crystal, the following frequencies can be generated: 100MHz, 50MHz and 25MHz. Maximum rms phase jitter of 0.36ps, easily meets PCI Express jitter requirements. The 841N4830 is packaged in a small 32-pin VFQFN package.

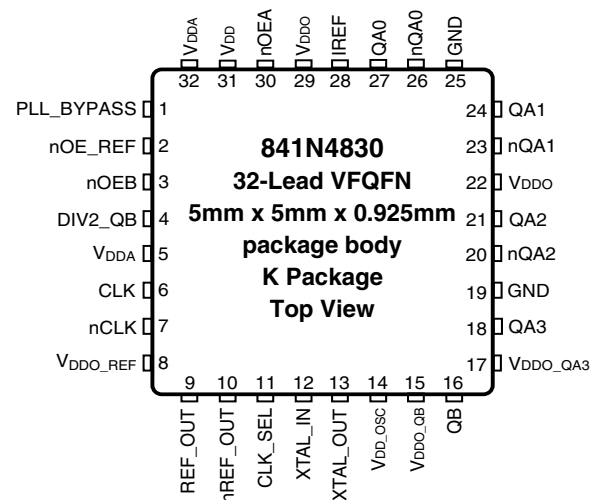
## Features

- Fourth generation FemtoClock® Next Generation (NG) technology
- Three differential HCSL outputs, one differential LVPECL and two single-ended LVCMOS/LVTTL outputs
- Crystal oscillator interface designed for a 25MHz, 12pF parallel resonant crystal
- CLK/nCLK input pair can accept the following differential input levels: LVPECL, LVDS, HCSL
- A 25MHz crystal generates output frequencies of: 100MHz, 50MHz and 25MHz
- VCO frequency: 2GHz
- RMS Phase Jitter @ 100MHz, (12kHz – 20MHz) using a 25MHz crystal: 0.36ps (maximum)
- Power supply noise rejection PSNR: -45dB (typical)
- PCI Express Gen 2 (5 Gb/s) jitter compliant
- Full 3.3V supply mode
- -40°C to 85°C ambient operating temperature
- Available in lead-free (RoHS 6) package

## Block Diagram



## Pin Assignment



## Pin Description and Pin Characteristic Tables

Table 1. Pin Descriptions

| Number   | Name                 | Type   |          | Description                                                                                                                                                                                          |
|----------|----------------------|--------|----------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 1        | PLL_BYPASS           | Input  | Pulldown | When HIGH, PLL is bypassed and outputs are driven by input crystal or clock. When LOW outputs are driven by PLL. LVCMOS/LVTTL interface levels. See Table 3D.                                        |
| 2        | nOE_REF              | Input  | Pulldown | Output enable signal for REF_OUT output. When LOW, outputs are enabled. LVCMOS/LVTTL interface levels. See Table 3C.                                                                                 |
| 3        | nOEB                 | Input  | Pulldown | Output enable signal for Bank B. When LOW, QB output is enabled. When HIGH, selects high impedance mode. LVCMOS/LVTTL interface levels. See Table 3B.                                                |
| 4        | DIV2_QB              | Input  | Pullup   | Select signal for the output divider for Bank B. LVCMOS/LVTTL clock output. See Table 3F.                                                                                                            |
| 5, 32    | V <sub>DDA</sub>     | Power  |          | Analog supply pins.                                                                                                                                                                                  |
| 6        | CLK                  | Input  | Pulldown | Non-inverting differential clock input.                                                                                                                                                              |
| 7        | nCLK                 | Input  | Pullup   | Inverting differential clock input.                                                                                                                                                                  |
| 8        | V <sub>DDO_REF</sub> | Power  |          | Output power supply pin for LVPECL reference outputs.                                                                                                                                                |
| 9, 10    | REF_OUT,<br>nREF_OUT | Output |          | 25MHz differential reference output pair. LVPECL interface levels.                                                                                                                                   |
| 11       | CLK_SEL              | Input  | Pullup   | Input select signal. When HIGH, selects CLK, nCLK inputs. When LOW, selects XTAL inputs. LVCMOS/LVTTL interface levels. See Table 3E.                                                                |
| 12<br>13 | XTAL_IN<br>XTAL_OUT  | Input  |          | Crystal oscillator interface XTAL_IN is the input, XTAL_OUT is the output.                                                                                                                           |
| 14       | V <sub>DD_OSC</sub>  | Power  |          | Core supply pin for crystal oscillator.                                                                                                                                                              |
| 15       | V <sub>DDO_QB</sub>  | Power  |          | Output power supply pin for Bank B LVCMOS output.                                                                                                                                                    |
| 16       | QB                   | Output |          | Single-ended output. LVCMOS/LVTTL interface levels.                                                                                                                                                  |
| 17       | V <sub>DDO_QA3</sub> | Power  |          | Output power supply pin for QA3 LVCMOS output.                                                                                                                                                       |
| 18       | QA3                  | Output |          | Single-ended output. LVCMOS/LVTTL interface levels.                                                                                                                                                  |
| 19, 25   | GND                  | Power  |          | Power supply ground.                                                                                                                                                                                 |
| 20, 21   | nQA2, QA2            | Output |          | 100MHz differential output pair. HCSL interface levels.                                                                                                                                              |
| 22, 29   | V <sub>DDO</sub>     | Power  |          | Output power supply pins for Bank A HCSL outputs.                                                                                                                                                    |
| 23, 24   | nQA1, QA1            | Output |          | 100MHz differential output pair. HCSL interface levels.                                                                                                                                              |
| 26, 27   | nQA0, QA0            | Output |          | 100MHz differential output pair. HCSL interface levels.                                                                                                                                              |
| 28       | IREF                 |        |          | 0.7V current reference resistor output. An external fixed precision resistor (475Ω) from this pin to ground provides a reference current used for differential current-mode QAx, nQAx clock outputs. |
| 30       | nOEA                 | Input  | Pulldown | Output Enable signal for Bank A. When LOW enables output. When HIGH selects high impedance mode. LVCMOS/LVTTL interface levels. See Table 3A.                                                        |
| 31       | V <sub>DD</sub>      | Power  |          | Core supply pin.                                                                                                                                                                                     |

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                          | CLK, nCLK                                                                                                                              |         | 2       |         | pF    |
|                       |                                            | Control Pins                                                                                                                           |         | 4       |         | pF    |
| R <sub>PULLUP</sub>   | Input Pullup Resistors                     |                                                                                                                                        |         | 100     |         | kΩ    |
| R <sub>PULLDOWN</sub> | Input Pulldown Resistors                   |                                                                                                                                        |         | 100     |         | kΩ    |
| C <sub>PD</sub>       | Power Dissipation Capacitance (per output) | V <sub>DD</sub> , V <sub>DD_OSC</sub> , V <sub>DDO</sub> , V <sub>DDO_REF</sub> ,<br>V <sub>DDO_QA3</sub> , V <sub>DDO_QB</sub> = 3.6V |         | 5       |         | pF    |
| R <sub>OUT</sub>      | Output Impedance                           | QA3, QB<br>V <sub>DDO_QA3</sub> , V <sub>DDO_QB</sub> = 3.6V                                                                           |         | 25      |         | Ω     |

## Function Tables

**Table 3A. nOEA Function Table**

| Input       | Outputs        |
|-------------|----------------|
| nOEA        | QA             |
| 0 (default) | Active         |
| 1           | High-Impedance |

**Table 3B. nOEB Function Table**

| Input       | Outputs        |
|-------------|----------------|
| nOEB        | QB             |
| 0 (default) | Active         |
| 1           | High-Impedance |

**Table 3C. nOE\_REF Function Table**

| Input       | Outputs        |
|-------------|----------------|
| nOE_REF     | REF_OUT        |
| 0 (default) | Active         |
| 1           | High-Impedance |

**Table 3D. PLL\_BYPASS Function Table**

| Input       | Outputs    |
|-------------|------------|
| PLL_BYPASS  | QA, QB     |
| 0 (default) | PLL        |
| 1           | Bypass PLL |

**Table 3E. CLK\_SEL Function Table**

| Input       | Selected Input |
|-------------|----------------|
| CLK_SEL     |                |
| 0           | XTAL           |
| 1 (default) | CLK, nCLK      |

**Table 3F. DIV2\_QB Function Table**

| Input       | Output Frequency |
|-------------|------------------|
| DIV2_QB     |                  |
| 0           | 100MHz           |
| 1 (default) | 50MHz            |

## 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, $V_{DD}$                                       | 3.63V                     |
| Inputs, $V_I$                                                  | -0.5V to $V_{DD} + 0.5V$  |
| Outputs, $V_O$ (LVCMOS, HCSL)                                  | -0.5V to $V_{DDO} + 0.5V$ |
| Outputs, $I_O$ (LVPECL)<br>Continuous Current<br>Surge Current | 50mA<br>100mA             |
| Package Thermal Impedance, $\theta_{JA}$                       | 37.7°C/W (0 mps)          |
| Storage Temperature, $T_{STG}$                                 | -65°C to 150°C            |

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics**,  $V_{DD} = V_{DD\_OSC} = 3.0V$  to  $3.6V$ ,  $V_{DDO} = V_{DDO\_QA3} = V_{DDO\_QB} = V_{DDO\_REF} = 2.7V$  to  $3.6V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$

| Symbol                      | Parameter             | Test Conditions      | Minimum         | Typical | Maximum  | Units |
|-----------------------------|-----------------------|----------------------|-----------------|---------|----------|-------|
| $V_{DD}$ ,<br>$V_{DD\_OSC}$ | Core Supply Voltage   |                      | 3.0             | 3.3     | 3.6      | V     |
| $V_{DDA}$                   | Analog Supply Voltage |                      | $V_{DD} - 0.32$ | 3.3     | $V_{DD}$ | V     |
| $V_{DDO}$ ,<br>$V_{DDOx}$   | Output Supply Voltage |                      | 2.7             | 3.3     | 3.6      | V     |
| $I_{EE}$                    | Power Supply Current  |                      |                 |         | 170      | mA    |
| $I_{DDA}$                   | Analog Supply Current | Included in $I_{EE}$ |                 |         | 32       | mA    |

$V_{DDOx}$  denotes  $V_{DDO\_REF}$ ,  $V_{DDO\_QA3}$  and  $V_{DDO\_QB}$ .

**Table 4B. LVCMOS/LVTTL DC Characteristics**,  $V_{DD} = 3.0V$  to  $3.6V$ ,  $V_{DDO\_QA3} = V_{DDO\_QB} = 2.7V$  to  $3.6V$ ,  $T_A = -40^\circ C$  to  $85^\circ C$

| Symbol   | Parameter          | Test Conditions                                                          | Minimum | Typical | Maximum        | Units   |
|----------|--------------------|--------------------------------------------------------------------------|---------|---------|----------------|---------|
| $V_{IH}$ | Input High Voltage |                                                                          | 2       |         | $V_{DD} + 0.3$ | V       |
| $V_{IL}$ | Input Low Voltage  |                                                                          | -0.3    |         | 0.8            | V       |
| $I_{IH}$ | Input High Current | CLK_SEL, DIV2_QB<br>$V_{DD} = V_{IN} = 3.6V$                             |         |         | 5              | $\mu A$ |
|          |                    | nOEA, nOEB,<br>nOE_REF,<br>PLL_BYPASS<br>$V_{DD} = V_{IN} = 3.6V$        |         |         | 150            | $\mu A$ |
| $I_{IL}$ | Input Low Current  | CLK_SEL, DIV2_QB<br>$V_{DD} = 3.6V$ , $V_{IN} = 0V$                      | -150    |         |                | $\mu A$ |
|          |                    | nOEA, nOEB,<br>nOE_REF,<br>PLL_BYPASS<br>$V_{DD} = 3.6V$ , $V_{IN} = 0V$ | -5      |         |                | $\mu A$ |

**Table 4C. Differential DC Characteristics,  $V_{DD} = 3.0V$  to  $3.6V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$** 

| Symbol    | Parameter                            | Test Conditions | Minimum                      | Typical | Maximum         | Units   |
|-----------|--------------------------------------|-----------------|------------------------------|---------|-----------------|---------|
| $I_{IH}$  | Input High Current                   | CLK             | $V_{DD} = V_{IN} = 3.6V$     |         | 150             | $\mu A$ |
|           |                                      | nCLK            | $V_{DD} = V_{IN} = 3.6V$     |         | 5               | $\mu A$ |
| $I_{IL}$  | Input Low Current                    | CLK             | $V_{DD} = 3.6V, V_{IN} = 0V$ | -5      |                 | $\mu A$ |
|           |                                      | nCLK            | $V_{DD} = 3.6V, V_{IN} = 0V$ | -150    |                 | $\mu A$ |
| $V_{PP}$  | Peak-to-Peak Voltage; NOTE 1         |                 | 0.15                         |         | 1.3             | V       |
| $V_{CMR}$ | Common Mode Input Voltage; NOTE 1, 2 |                 | GND + 0.5                    |         | $V_{DD} - 0.85$ | V       |

NOTE 1:  $V_{IL}$  should not be less than -0.3V.

NOTE 2: Common mode input voltage is defined as  $V_{IH}$ .

**Table 4D. LVPECL DC Characteristics,  $V_{DDO\_REF} = 2.7V$  to  $3.6V$ ,  $V_{EE} = 0V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$** 

| Symbol      | Parameter                         | Test Conditions | Minimum              | Typical | Maximum              | Units |
|-------------|-----------------------------------|-----------------|----------------------|---------|----------------------|-------|
| $V_{OH}$    | Output High Voltage; NOTE 1       |                 | $V_{DDO\_REF} - 1.4$ |         | $V_{DDO\_REF} - 0.9$ | V     |
| $V_{OL}$    | Output Low Voltage; NOTE 1        |                 | $V_{DDO\_REF} - 2.0$ |         | $V_{DDO\_REF} - 1.7$ | V     |
| $V_{SWING}$ | Peak-to-Peak Output Voltage Swing |                 | 0.6                  |         | 1.0                  | V     |

NOTE 1: Output termination with  $50\Omega$  to  $V_{DDO\_REF} - 2V$ .

**Table 5. Crystal Characteristics**

| Parameter                          | Test Conditions | Minimum     | Typical | Maximum | Units    |
|------------------------------------|-----------------|-------------|---------|---------|----------|
| Mode of Oscillation                |                 | Fundamental |         |         |          |
| Frequency                          |                 |             | 25      |         | MHz      |
| Equivalent Series Resistance (ESR) |                 |             |         | 50      | $\Omega$ |
| Shunt Capacitance                  |                 |             |         | 7       | pF       |

## AC Electrical Characteristics

**Table 6A. LVCMOS AC Characteristics**,  $V_{DD} = 3.0V$  to  $3.6V$ ,  $V_{DDO\_QA3} = V_{DDO\_QB} = 2.7V$  to  $3.6V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$

| Symbol               | Parameter                         |         | Test Conditions                          | Minimum | Typical | Maximum | Units |
|----------------------|-----------------------------------|---------|------------------------------------------|---------|---------|---------|-------|
| $f_{OUT}$            | Output Frequency                  | QB      | PLL mode                                 |         | 50      |         | MHz   |
|                      |                                   | QA3     | PLL mode                                 |         | 100     |         | MHz   |
|                      |                                   |         | PLL Bypass                               | 20      |         |         | MHz   |
| $f_{jit}(\emptyset)$ | RMS Phase Jitter (Random); NOTE 1 |         | 100MHz, Integration Range: 12kHz – 20MHz |         |         | 0.34    | ps    |
| $t_R / t_F$          | Output Rise/Fall Time             |         |                                          | 200     |         | 600     | ps    |
| odc                  | Output Duty Cycle                 |         |                                          | 47      |         | 53      | %     |
| $V_{OH}$             | Output High Voltage; NOTE 2       | QA3, QB |                                          | 2.2     |         |         | V     |
| $V_{OL}$             | Output Low Voltage; NOTE 2        | QA3, QB | $f \leq 100MHz$                          |         |         | 0.9     | V     |

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 lfm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

Using a 25MHz, 12pF quartz crystal.

NOTE 1: Refer to the Phase Noise plot.

NOTE 2: Outputs are terminated with  $50\Omega$  to  $V_{DDO\_X}/2$ . See Parameter Measurement Information, *Output Load Test Circuit diagram*.

**Table 6B. LVPECL AC Characteristics**,  $V_{DD} = 3.0V$  to  $3.6V$ ,  $V_{DDO\_REF} = 2.7V$  to  $3.6V$ ,  $V_{EE} = 0V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$

| Symbol      | Parameter             |                   | Test Conditions | Minimum | Typical | Maximum | Units |
|-------------|-----------------------|-------------------|-----------------|---------|---------|---------|-------|
| $f_{OUT}$   | Output Frequency      | REF_OUT, nREF_OUT |                 |         | 25      |         | MHz   |
| $t_R / t_F$ | Output Rise/Fall Time | REF_OUT, nREF_OUT | 20% to 80%      | 100     |         | 600     | ps    |
| odc         | Output Duty Cycle     | REF_OUT, nREF_OUT |                 | 49      |         | 51      | %     |

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 lfm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

**Table 6C. HCSL AC Characteristics,  $V_{DD} = 3.0V$  to  $3.6V$ ,  $V_{DDO} = 2.7V$  to  $3.6V$ ,  $T_A = -40^{\circ}C$  to  $85^{\circ}C$** 

| Symbol                | Parameter                                                   | Test Conditions                                                                   | Minimum | Typical | Maximum | Units |
|-----------------------|-------------------------------------------------------------|-----------------------------------------------------------------------------------|---------|---------|---------|-------|
| $f_{OUT}$             | Output Frequency                                            | PLL                                                                               |         | 100     |         | MHz   |
|                       |                                                             | PLL Bypass                                                                        | 20      |         |         | MHz   |
| $f_{REF}$             | Reference Frequency                                         |                                                                                   |         | 25      |         | MHz   |
| $t_{sk(b)}$           | Bank Skew; NOTE 1, 10                                       |                                                                                   |         |         | 50      | ps    |
| $f_{jit(\emptyset)}$  | Phase Jitter, RMS (Random); NOTE 11                         | 100MHz, Integration Range: 12kHz – 20MHz                                          |         |         | 0.36    | ps    |
| $t_{REFCLK\_HF\_RMS}$ | Phase Jitter RMS; NOTE 2                                    | 100MHz, 25MHz crystal input<br>High Band: 1.5MHz - Nyquist<br>(clock frequency/2) |         | 0.600   |         | ps    |
| $t_{REFCLK\_LF\_RMS}$ | Phase Jitter RMS; NOTE 2                                    | 100MHz, 25MHz crystal input<br>Low Band: 10kHz - 1.5MHz                           |         | 0.023   |         | ps    |
| $f_{jit(cc)}$         | Cycle-to-Cycle Jitter                                       | PLL Mode                                                                          |         |         | 30      | ps    |
| $t_L$                 | PLL Lock Time                                               |                                                                                   |         |         | 10      | ms    |
| $V_{RB}$              | Ring-back Voltage Margin; NOTE 4, 9                         |                                                                                   | -100    |         | 100     | mV    |
| $t_{STABLE}$          | Time before $V_{RB}$ is allowed; NOTE 4, 9                  |                                                                                   | 500     |         |         | ps    |
| $V_{HIGH}$            | Voltage High                                                |                                                                                   | 520     |         | 920     | mV    |
| $V_{LOW}$             | Voltage Low                                                 |                                                                                   | -150    |         | 150     | mV    |
| $V_{CROSS}$           | Absolute Crossing Voltage; NOTE 3, 6, 7                     |                                                                                   | 160     |         | 460     | mV    |
| $\Delta V_{CROSS}$    | Total Variation of $V_{CROSS}$ over all edges; NOTE 3, 6, 8 |                                                                                   |         |         | 140     | mV    |
|                       | Rising Edge Rate; NOTE 4, 5                                 |                                                                                   | 0.6     |         | 4.0     | V/ns  |
|                       | Falling Edge Rate; NOTE 4, 5                                |                                                                                   | 0.6     |         | 4.0     | V/ns  |
| PSNR                  | Power Supply Noise Reduction                                |                                                                                   |         | -45     |         | dB    |
| odc                   | Output Duty Cycle; NOTE 4                                   |                                                                                   | 49      |         | 51      | %     |

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 lfm. The device will meet specifications after thermal equilibrium has been reached under these conditions.

NOTE 1: Defined as skew within a bank of outputs at the same voltage and with equal load conditions.

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). See IDT Application Note *PCI Express Reference Clock Requirements* and also the PCI Express Application section of this datasheet which show each individual transfer function and the overall composite transfer function.

NOTE 3: Measurement taken from single ended waveform.

NOTE 4: Measurement taken from differential waveform.

NOTE 5: Measured from -150mV to +150mV on the differential waveform (derived from Q minus nQ). 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 6: Measured at the crosspoint where the instantaneous voltage value of the rising edge of Q equals the falling edge of nQ.

NOTE 7: Refers to the total variation from the lowest crosspoint to the highest, regardless of which edge is crossing. Refers to all crosspoints for this measurement.

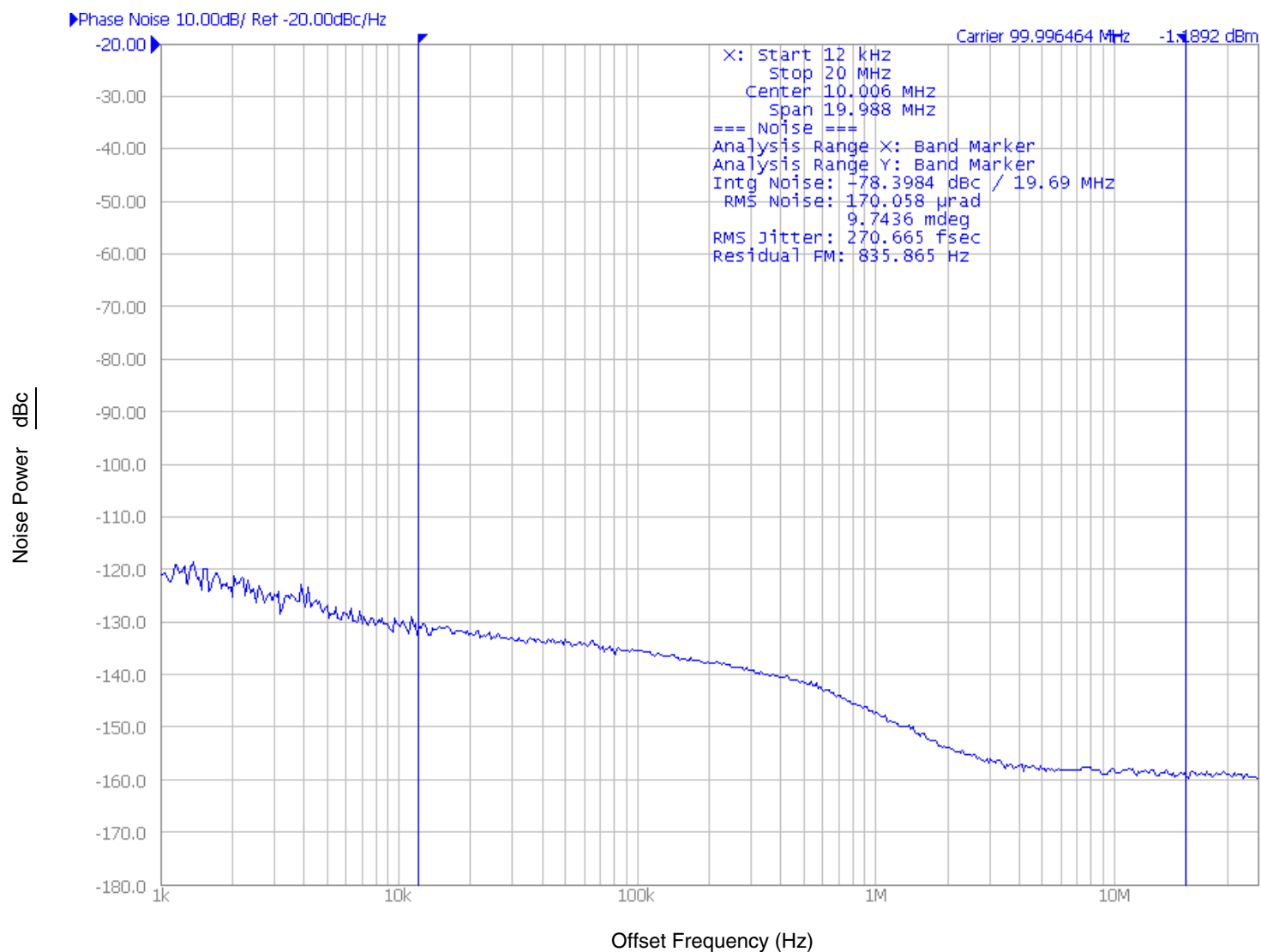
NOTE 8: Defined as the total variation of all crossing voltages of rising Q and falling nQ, This is the maximum allowed variance in  $V_{CROSS}$  for any particular system.

NOTE 9:  $T_{STABLE}$  is the time the differential clock must maintain a minimum  $\pm 150mV$  differential voltage after rising/falling edges before it is allowed to drop back into the  $V_{RB} \pm 100mV$  differential range.

NOTE 10: This parameter is defined in accordance with JEDEC Standard 65.

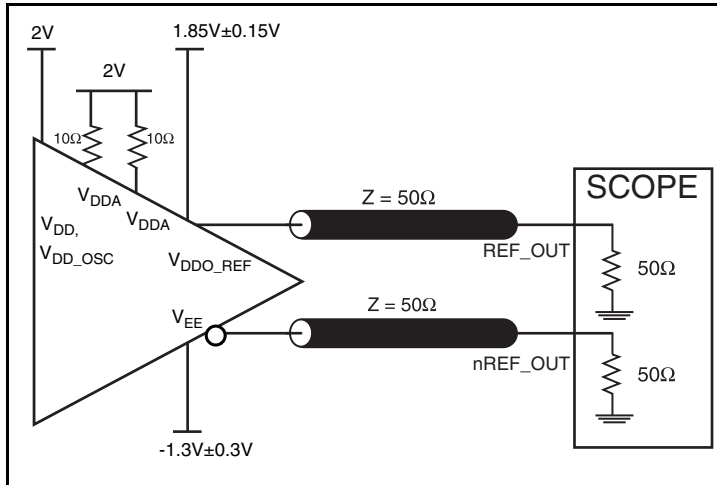
NOTE 11: See Phase Noise Plot.

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

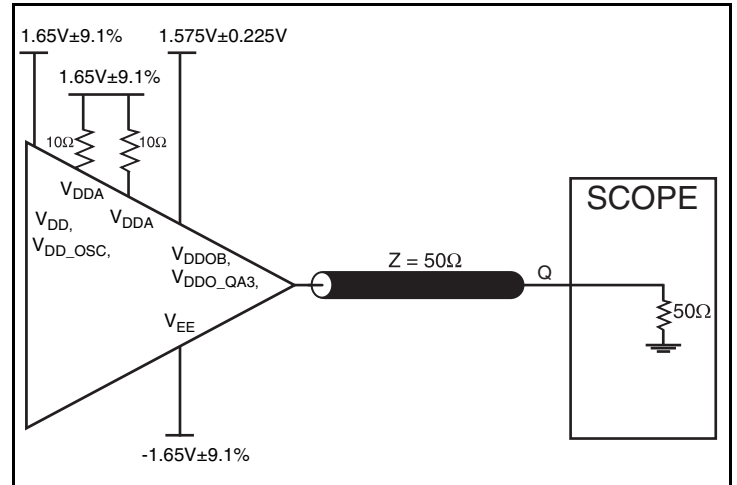




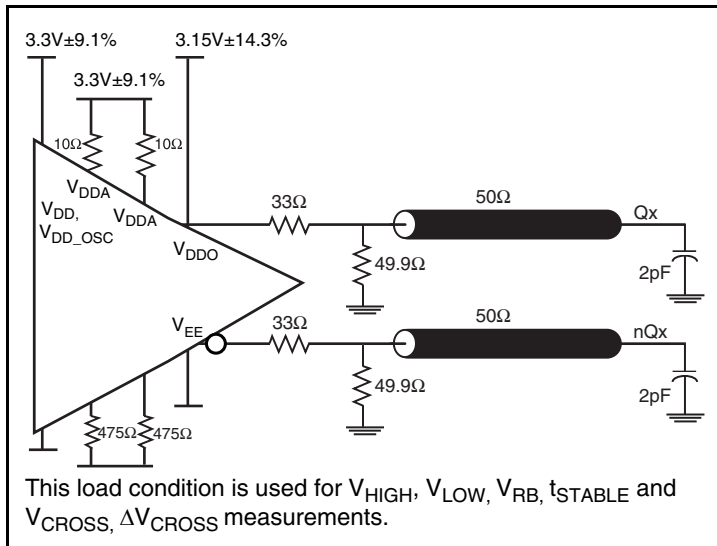
## Parameter Measurement Information



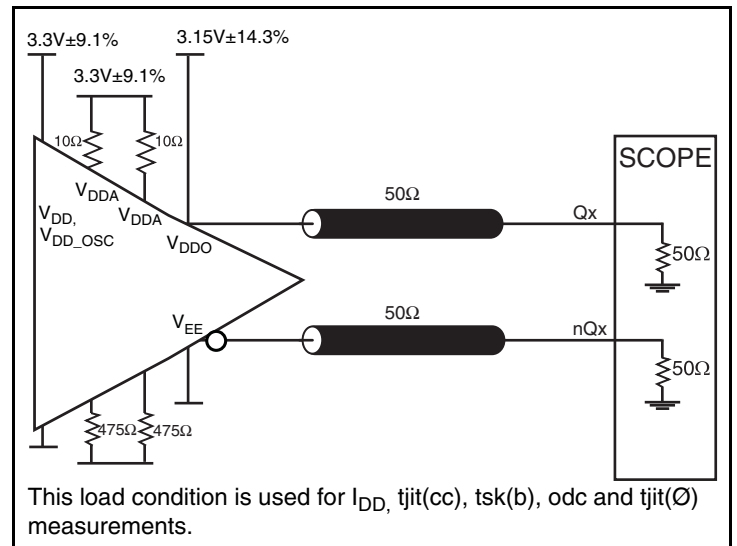
3.3V LVPECL Output Load Test Circuit



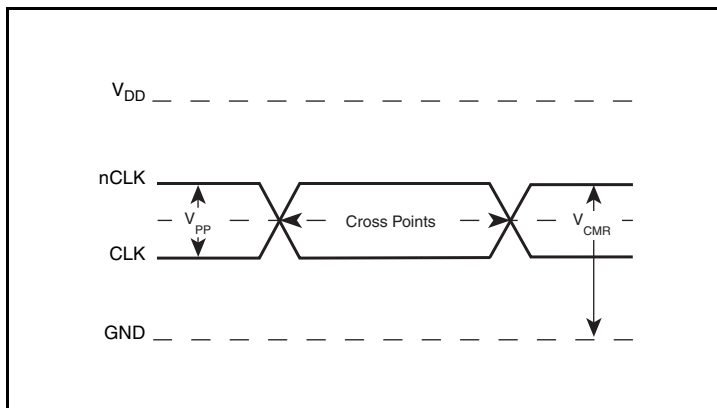
3.3V LVCMOS Output Load Test Circuit



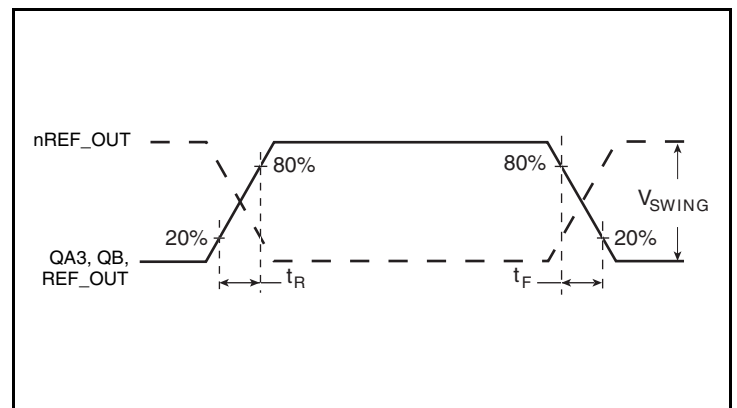
3.3V HCSL Output Load Test Circuit



3.3V HCSL Output Load Test Circuit

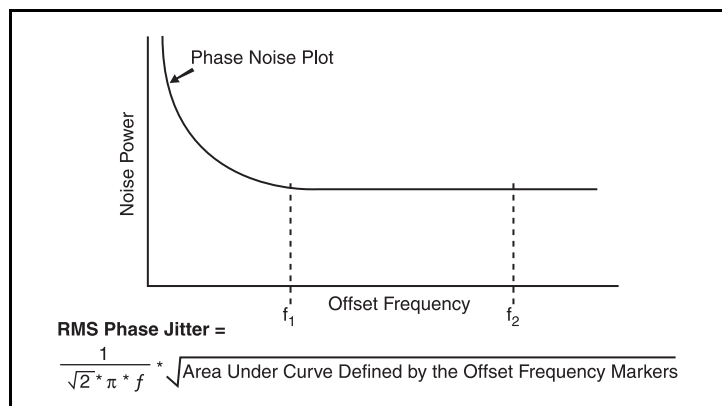


Differential Input Level

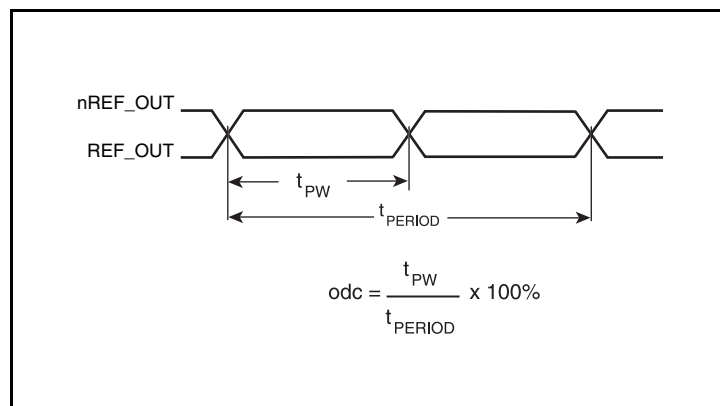


Output Rise/Fall Time (LVPECL, LVCMOS)

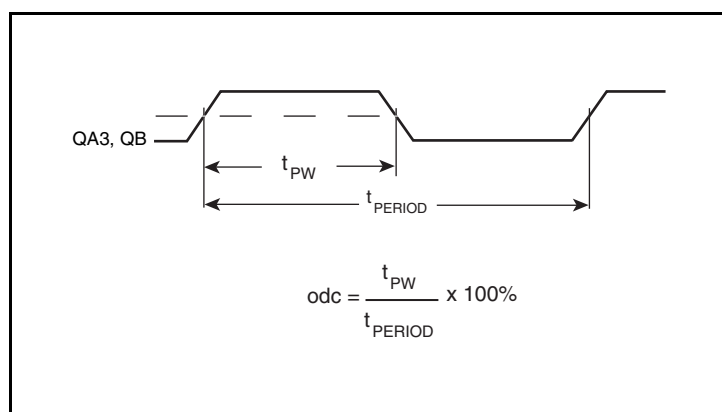
## Parameter Measurement Information, continued



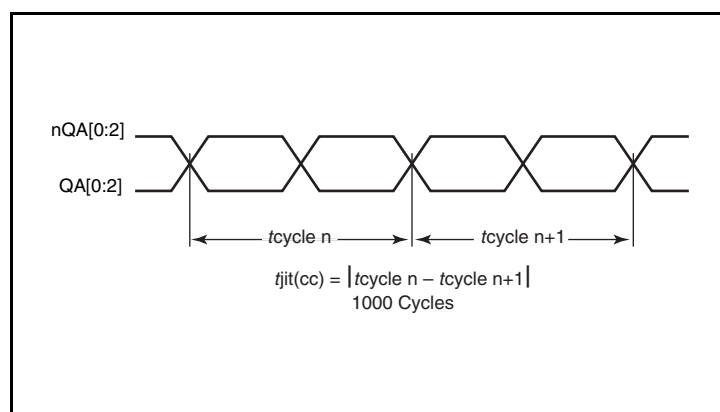
**RMS Phase Jitter**



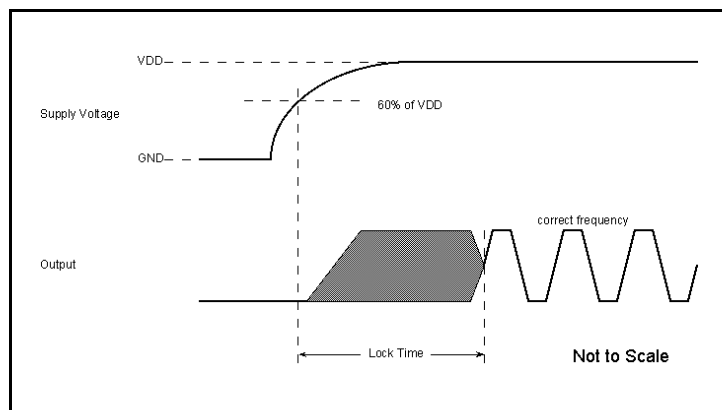
**LVPECL Output Duty Cycle/Pulse Width/Period**



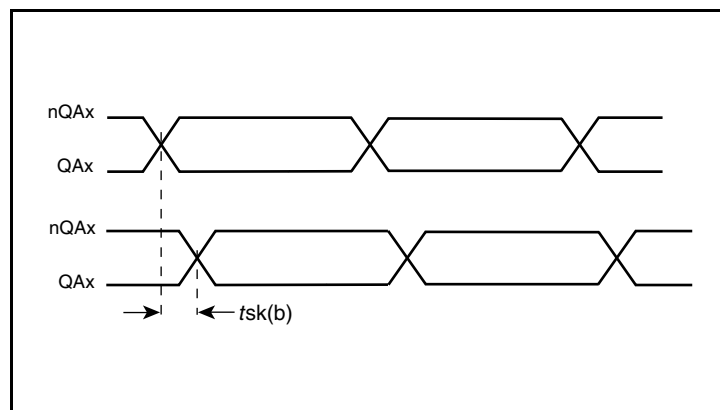
**LVCMOS Output Duty Cycle/Pulse Width/Period**



**Cycle-to-Cycle Jitter**

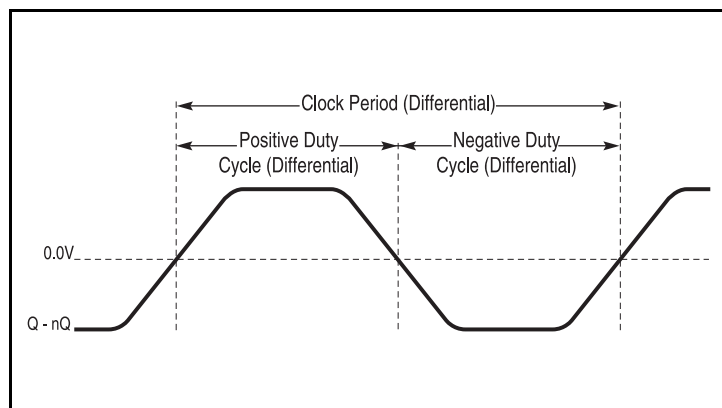


**PLL Lock Time**

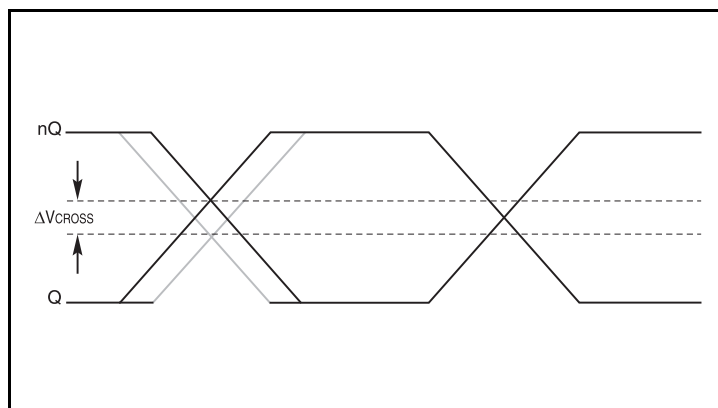


**Bank Skew**

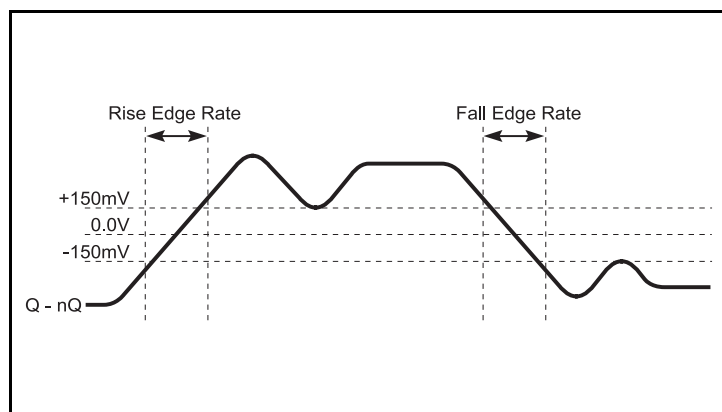
## Parameter Measurement Information, continued



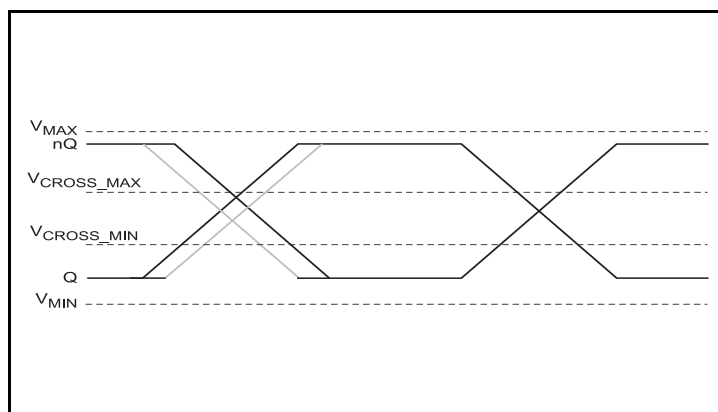
Differential Measurement Points for Duty Cycle/Period



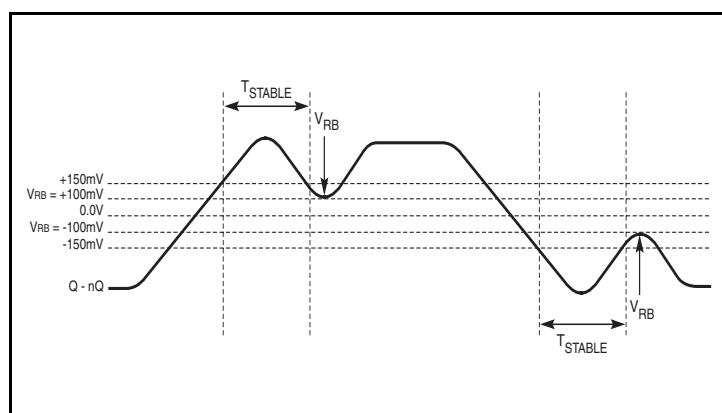
Single-ended Measurement Points for Delta Cross Point



Differential Measurement Points for Rise/Fall Edge Rate



Single-ended Measurement Points for Absolute Cross Point/Swing



Differential Measurement Points for Ringback

## Applications Information

### Power Supply Filtering Technique

As in 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 841N4830 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{DD}$ ,  $V_{DD\_OSC}$ ,  $V_{DDA}$ ,  $V_{DDO}$ , and  $V_{DDOx}$  should be individually connected to the power supply plane through vias, and  $0.01\mu F$  bypass capacitors should be used for each pin. Figure 1 illustrates this for a generic  $V_{DD}$  pin and also shows that  $V_{DDA}$  requires that an additional  $10\Omega$  resistor along with a  $10\mu F$  bypass capacitor be connected to the  $V_{DDA}$  pin.

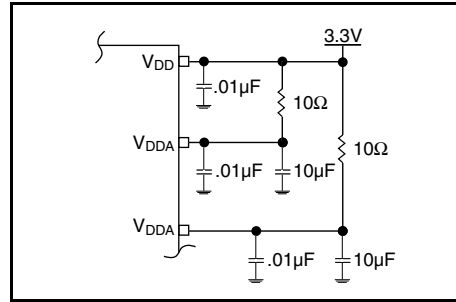


Figure 1. Power Supply Filtering

### 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 2A to 2D 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 open emitter LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.

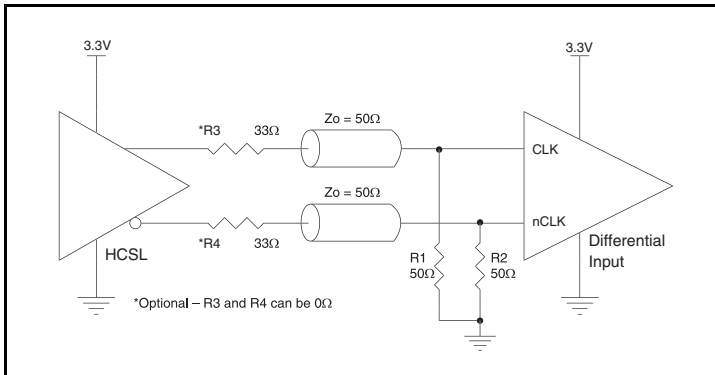


Figure 2A. CLK/nCLK Input Driven by a 3.3V HCSL Driver

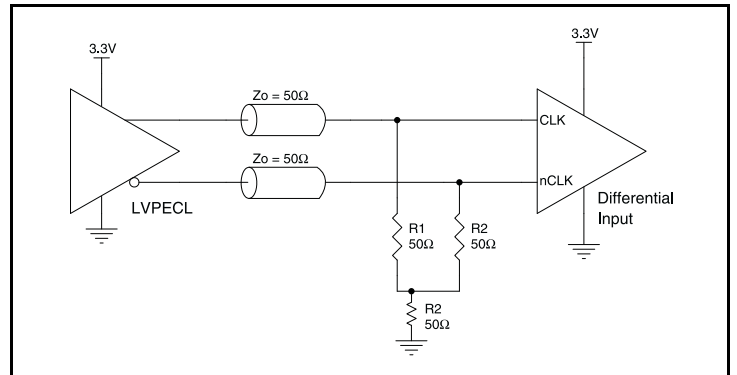


Figure 2B. CLK/nCLK Input Driven by a 3.3V LVPECL Driver

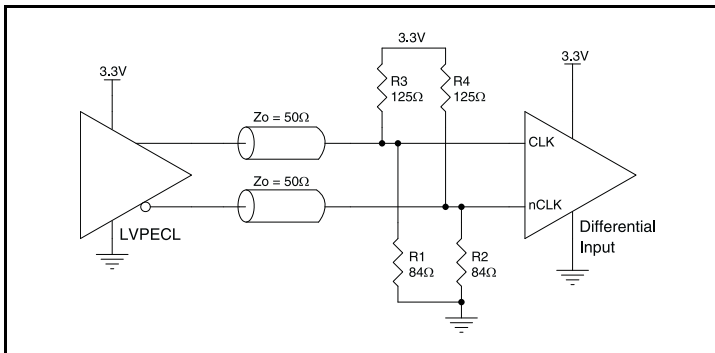


Figure 2C. CLK/nCLK Input Driven by a 3.3V LVPECL Driver

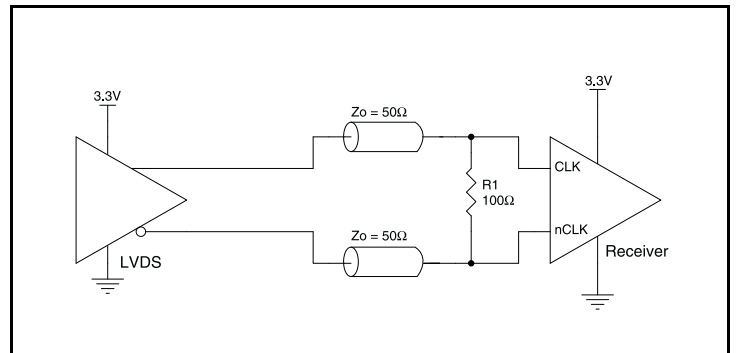


Figure 2D. CLK/nCLK Input Driven by a 3.3V LVDS Driver

## Crystal Input Interface

The 841N4830 has been characterized with 12pF parallel resonant crystals. The capacitor values, C1 and C2, shown in *Figure 3* below were determined using a 25MHz, 12pF parallel resonant crystal and were chosen to minimize the ppm error. The optimum C1 and C2 values can be slightly adjusted for different board layouts.

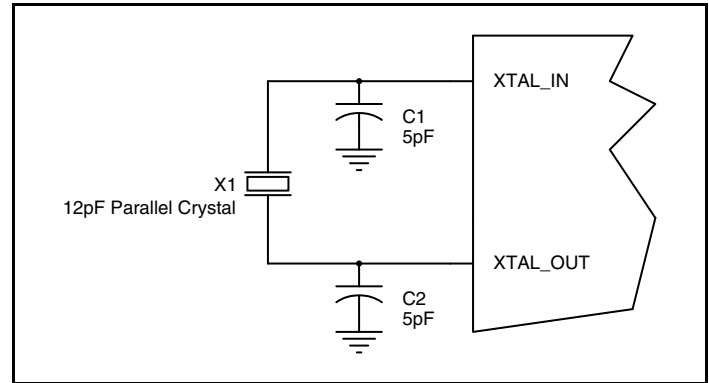


Figure 3. Crystal Input Interface

## Overdriving the XTAL Interface

The XTAL\_IN input can accept a single-ended LVCMOS signal through an AC coupling capacitor. A general interface diagram is shown in *Figure 4A*. The XTAL\_OUT pin can be left floating. The maximum amplitude of the input signal should not exceed 2V and the input edge rate can be as slow as 10ns. This configuration requires that the output impedance of the driver ( $R_o$ ) plus 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, 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 making R2 50Ω. By overdriving the crystal oscillator, the device will be functional, but note, the device performance is guaranteed by using a quartz crystal.

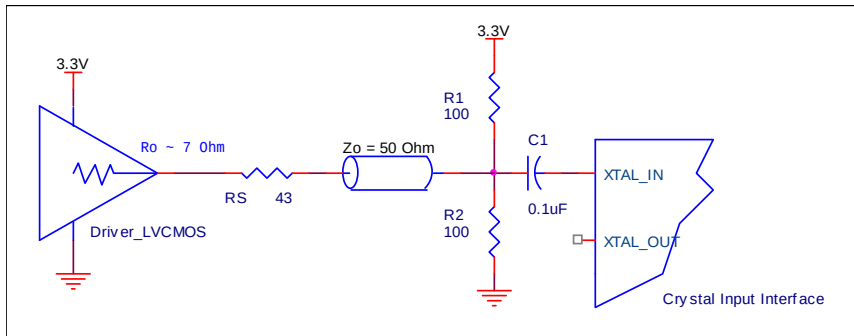


Figure 4A. General Diagram for LVCMOS Driver to XTAL Input Interface

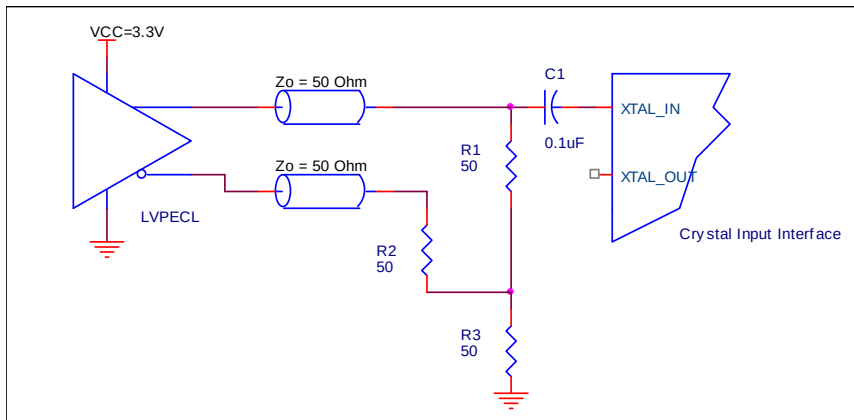
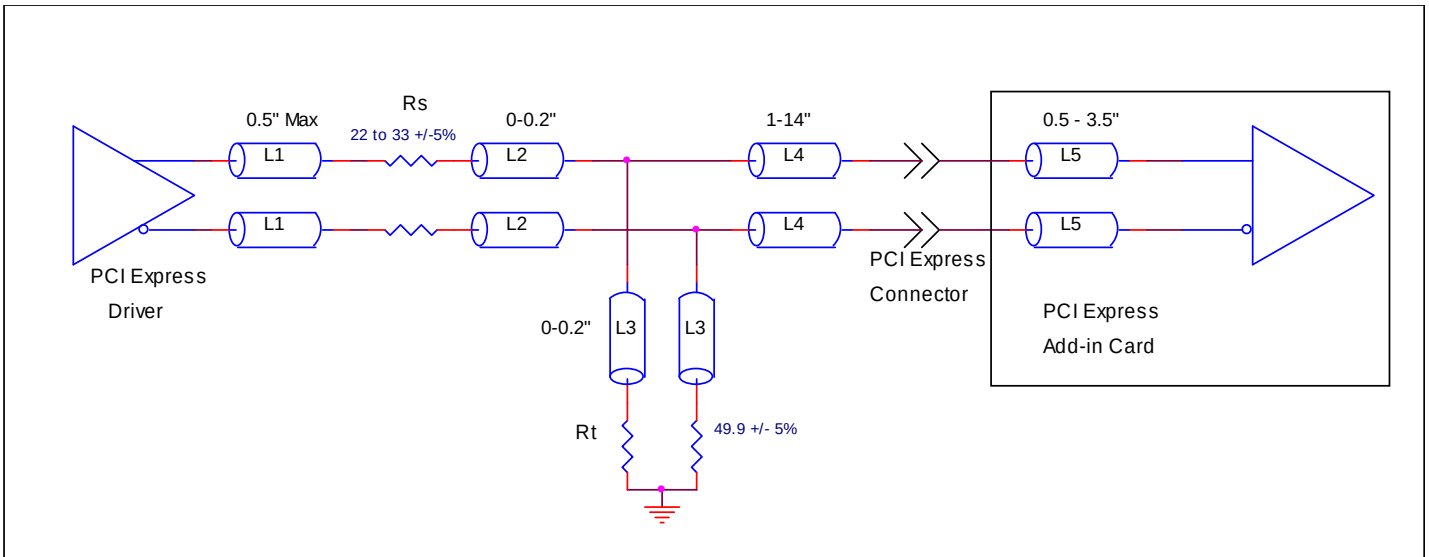


Figure 4B. General Diagram for LVPECL Driver to XTAL Input Interface

## Recommended Termination

Figure 5A 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

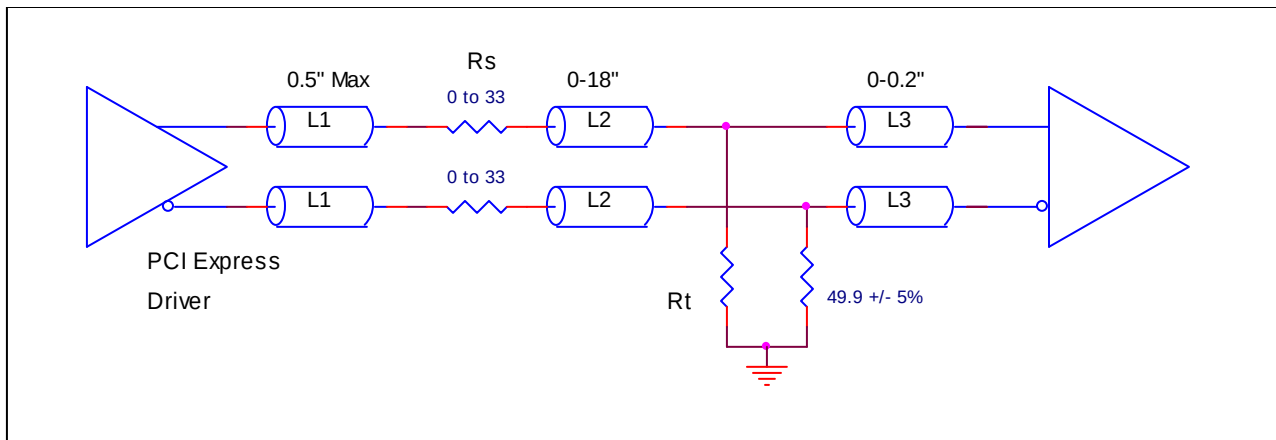
types. All traces should be  $50\Omega$  impedance single-ended or  $100\Omega$  differential.



**Figure 5A. Recommended Source Termination (where the driver and receiver will be on separate PCBs)**

Figure 5B 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 ( $R_s$ ) at the driver offers flexibility and can help dampen unwanted reflections. The optional resistor can range from  $0\Omega$  to  $33\Omega$ . All traces should be  $50\Omega$  impedance single-ended or  $100\Omega$  differential.



**Figure 5B. Recommended Termination (where a point-to-point connection can be used)**

## Recommendations for Unused Input Pins

### Inputs:

#### 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.

#### 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.

#### 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 1kΩ resistor can be used.

### Outputs:

#### LVPECL Output

The unused LVPECL output pair 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.

#### LVC MOS Outputs

All unused LVC MOS output 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.

## 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 50Ω 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.

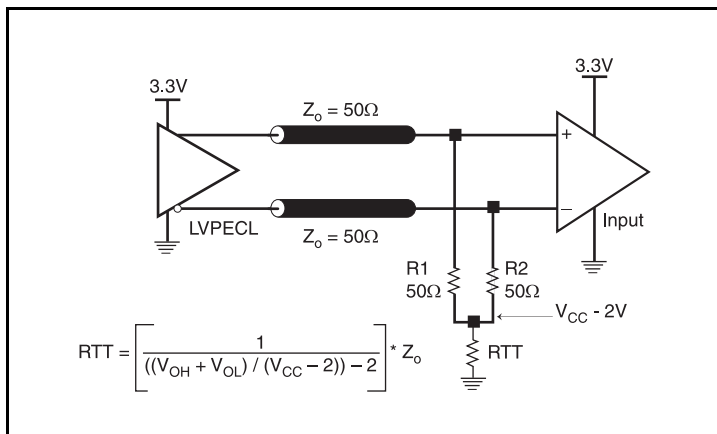


Figure 6A. 3.3V LVPECL Output Termination

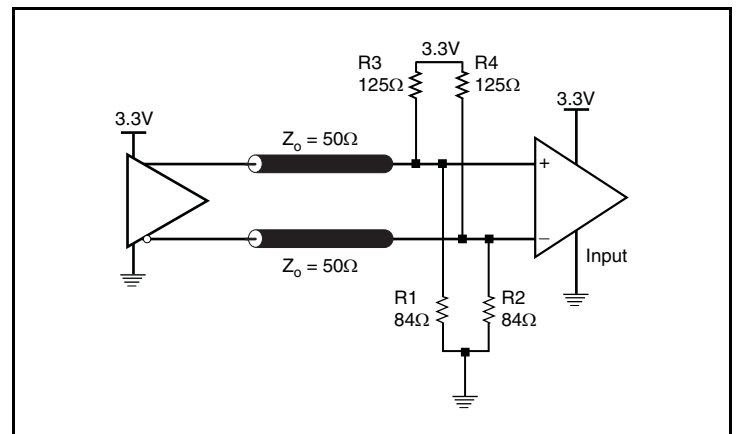


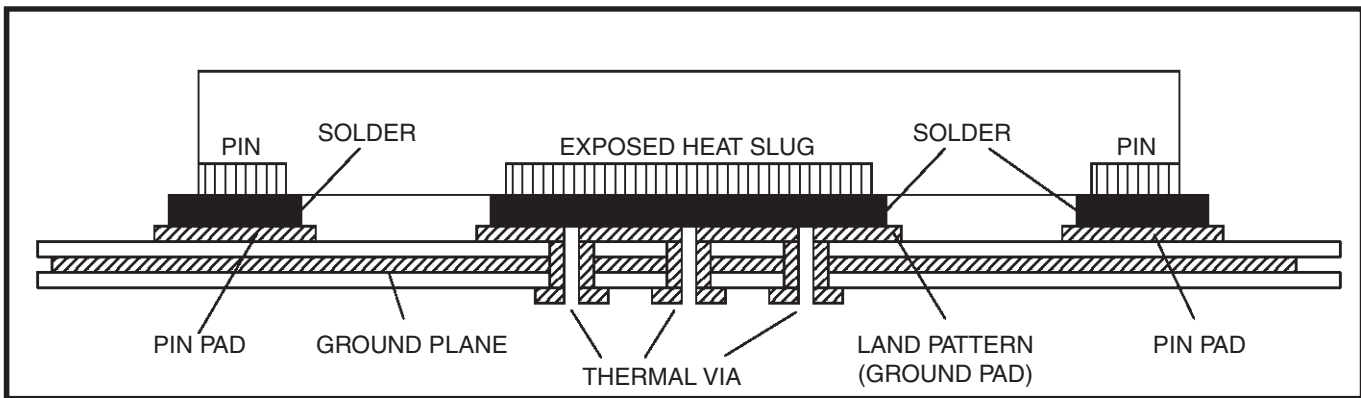
Figure 6B. 3.3V LVPECL Output Termination

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



## Schematic Example

Figure 8 shows an example of 841N4830 application schematic. 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.

In this example, the device is operated at  $V_{DD} = V_{DDO\_REF} = V_{DD\_OSC} = V_{DDO} = 3.3V$ . The 12pF parallel resonant 25MHz crystal is used. The C1 = 5pF and C2 = 5pF are recommended for frequency accuracy. For different board layouts, the C1 and C2 may be slightly adjusted for optimizing frequency accuracy. When designing the circuit board, return the capacitors to ground through a single point contact close to the package.

Two examples of HCSL terminations are shown in this schematic. The decoupling capacitors should be located as close as possible to the power pin.

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 841N4830 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 0.1uF 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 10 kHz. 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.

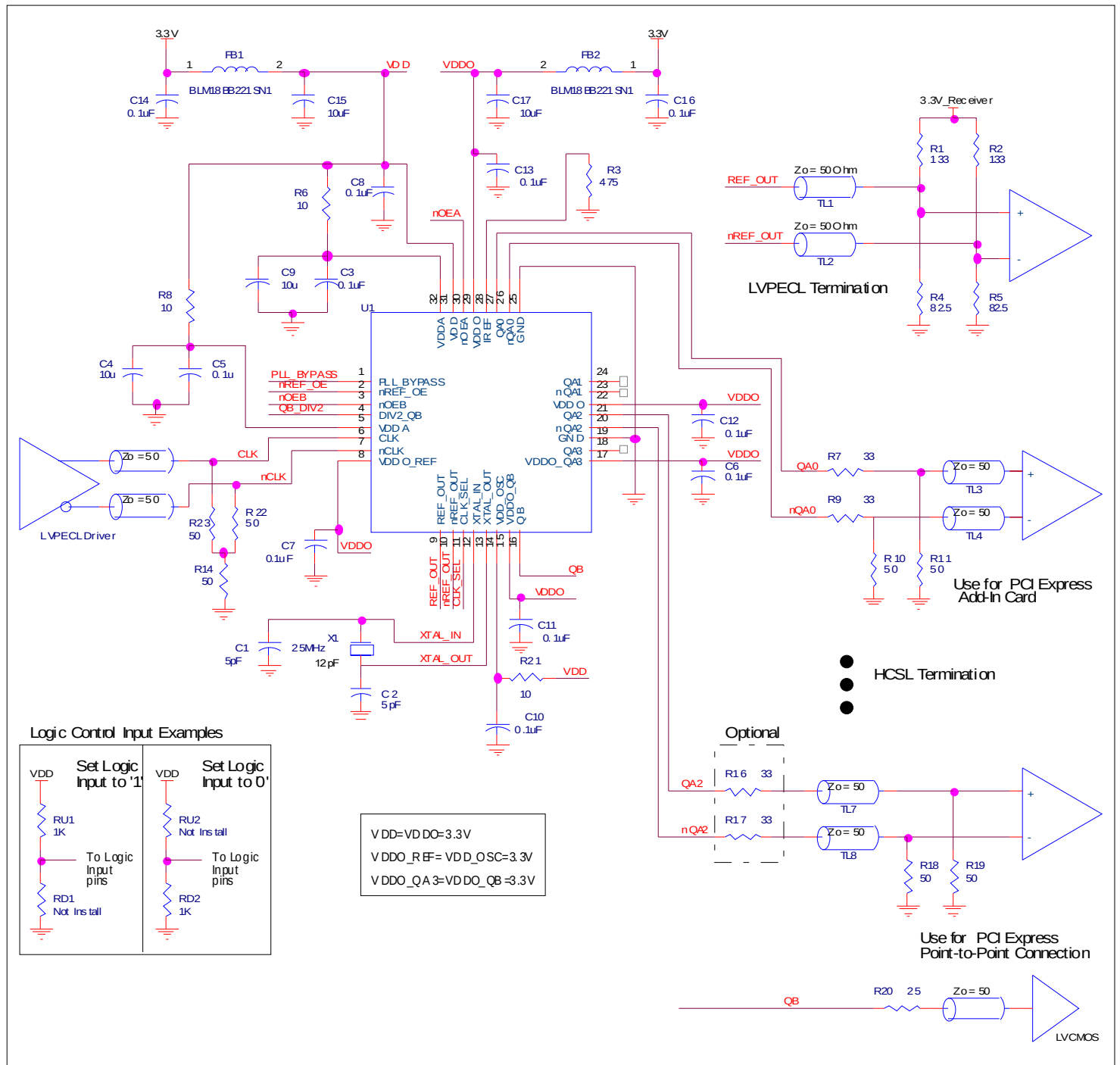


Figure 8. 841N4830 Application Schematic

## 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.

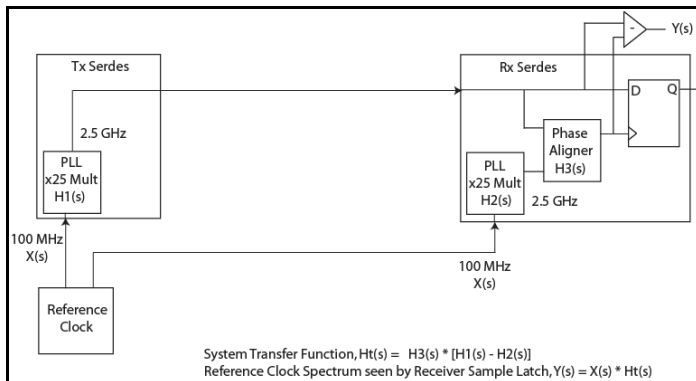
In the jitter analysis, the transmit (Tx) and receive (Rx) serdes PLLs are modeled as well as the phase interpolator in the receiver. These transfer functions are called H1, H2, and H3 respectively. The overall system transfer function at the receiver is:

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

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

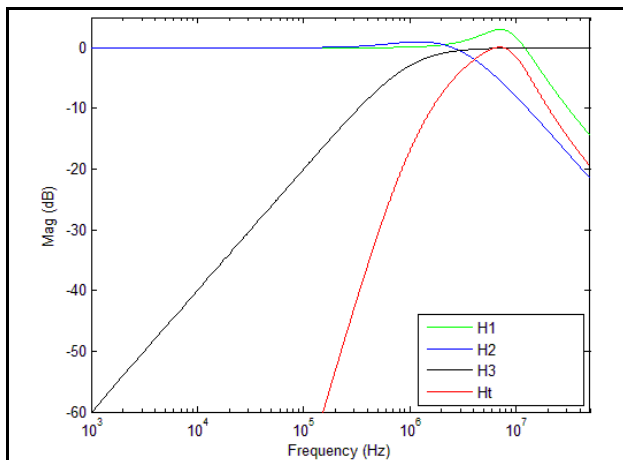
$$Y(s) = X(s) \times H_3(s) \times [H_1(s) - H_2(s)]$$

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

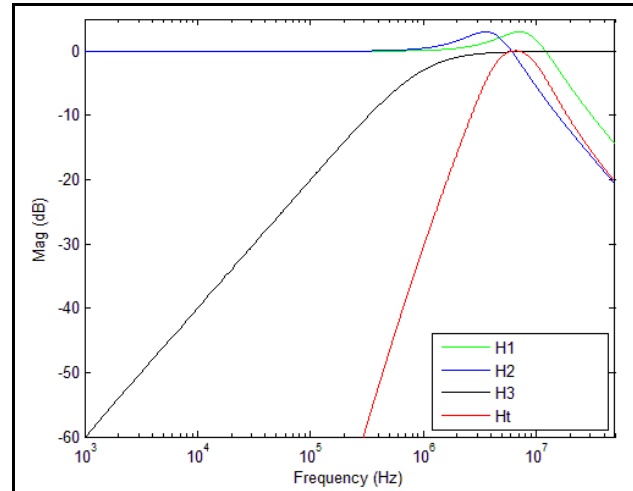


### PCI Express Common Clock Architecture

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

## Power Considerations

This section provides information on power dissipation and junction temperature for the 841N4830. Equations and example calculations are also provided.

### 1. Power Dissipation

The total power dissipation for the 841N4830 is the sum of the core power plus the power dissipated due to loading. The following is the power dissipation for  $V_{DD} = 3.3V + 0.3V = 3.6V$ , which gives worst case results.

NOTE: Please refer to Section 3A and 3B for details on calculating power dissipation due to loading.

#### Core

- Power(core) =  $V_{DD\_MAX} * I_{EE} = 3.6V * 170mA = \mathbf{612mW}$

#### LVPECL Output

LVPECL driver power dissipation is 30mW/Loaded output pair, total LVPECL output dissipation:

- Power(LVPECL) = 30mW

#### HSCL Output

HSCL driver power dissipation is 46.8mW/Loaded output pair, total HSCL output dissipation:

- Power(HSCL) =  $46.75mW * 3 = 140.25mW$

#### LVC MOS Output

- Output Impedance  $R_{OUT}$  Power Dissipation due to Loading  $50\Omega$  to  $V_{DD}/2$   
Output Current  $I_{OUT} = V_{DD\_MAX} / [2 * (50\Omega + R_{OUT})] = 3.6V / [2 * (50\Omega + 25\Omega)] = \mathbf{24mA}$
- Power Dissipation on the  $R_{OUT}$  per LVC MOS output  
Power ( $R_{OUT}$ ) =  $R_{OUT} * (I_{OUT})^2 = 25\Omega * (24mA)^2 = \mathbf{14.4mW}$  per output
- Total Power Dissipation on the  $R_{OUT}$   
**Total Power ( $R_{OUT}$ ) =  $14.4mW * 2 = \mathbf{28.8mW}$**

#### Dynamic Power Dissipation at 100MHz

$$\text{Power (100MHz)} = C_{PD} * \text{Frequency} * (V_{DD})^2 = 5pF * 100MHz * (3.6V)^2 = \mathbf{6.48mW \text{ per output}}$$

$$\mathbf{\text{Total Power (100MHz)} = 6.48mW * 2 = \mathbf{12.96mW}}$$

#### Total Power Dissipation

- Total Power**  
= Power (core) + Power(LVPECL) + Power(HSCL) + Total Power ( $R_{OUT}$ ) + Total Power (100MHz)  
=  $612mW + 30mW + 140.25mW + 28.8mW + 12.96mW$   
**= 824mW**

## 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 for devices 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 37.7°C/W per Table 7 below.

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

$85^\circ\text{C} + 0.824\text{W} * 37.7^\circ\text{C/W} = 116^\circ\text{C}$ . This is below the limit of 125°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).

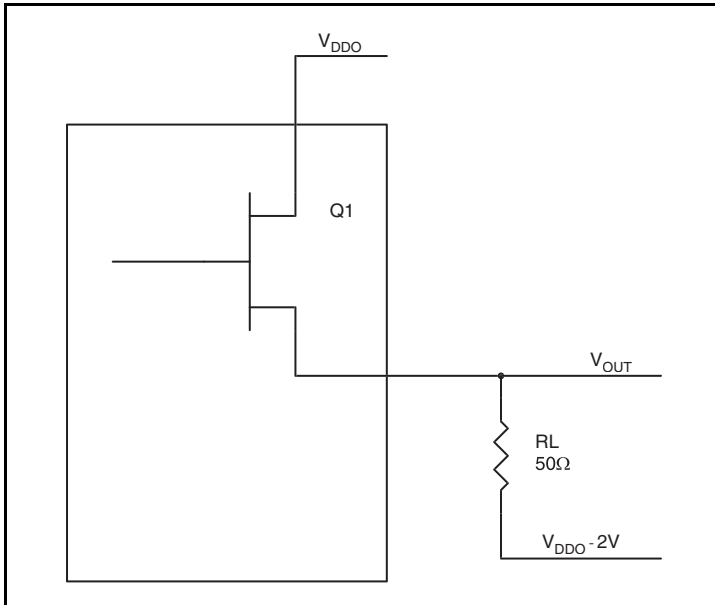
**Table 7. Thermal Resistance  $\theta_{JA}$  for 32 Lead VFQFN, Forced Convection**

| $\theta_{JA}$ by Velocity                   |          |          |          |
|---------------------------------------------|----------|----------|----------|
| Meters per Second                           | 0        | 1        | 2.5      |
| Multi-Layer PCB, JEDEC Standard Test Boards | 37.7°C/W | 32.9°C/W | 29.5°C/W |

### 3A. Calculations and Equations for LVPECL.

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

LVPECL output driver circuit and termination are shown in *Figure 9*.



**Figure 9. LVPECL Driver Circuit and Termination**

To calculate power dissipation per output due to loading, use the following equations which assume a 50Ω load, and a termination voltage of  $V_{DDO} - 2V$ .

- For logic high,  $V_{OUT} = V_{OH\_MAX} = V_{DDO\_MAX} - 0.9V$   
( $V_{CC\_MAX} - V_{OH\_MAX}$ ) = **0.9V**
- For logic low,  $V_{OUT} = V_{OL\_MAX} = V_{DDO\_MAX} - 1.7V$   
( $V_{CC\_MAX} - V_{OL\_MAX}$ ) = **1.7V**

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

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

$$Pd\_H = [(V_{OH\_MAX} - (V_{DDO\_MAX} - 2V))/R_L] * (V_{DDO\_MAX} - V_{OH\_MAX}) = [(2V - (V_{DDO\_MAX} - V_{OH\_MAX}))/R_L] * (V_{DDO\_MAX} - V_{OH\_MAX}) = [(2V - 0.9V)/50\Omega] * 0.9V = \mathbf{19.8mW}$$

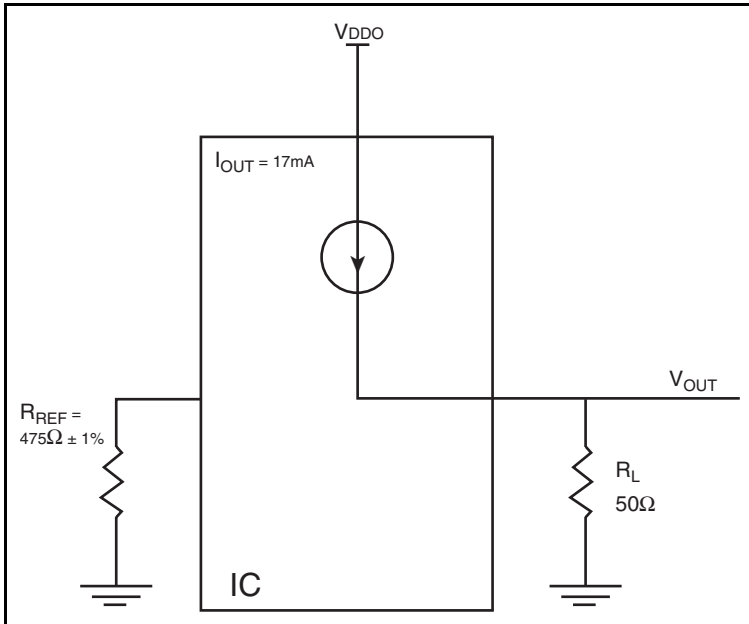
$$Pd\_L = [(V_{OL\_MAX} - (V_{DDO\_MAX} - 2V))/R_L] * (V_{DDO\_MAX} - V_{OL\_MAX}) = [(2V - (V_{DDO\_MAX} - V_{OL\_MAX}))/R_L] * (V_{DDO\_MAX} - V_{OL\_MAX}) = [(2V - 1.7V)/50\Omega] * 1.7V = \mathbf{10.2mW}$$

$$\text{Total Power Dissipation per output pair} = Pd\_H + Pd\_L = \mathbf{30mW}$$

### 3B. Calculations and Equations for HCSL.

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

HCSL output driver circuit and termination are shown in *Figure 10*.



**Figure 10. 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  $V_{DD\_MAX}$ .

$$\text{Power} = (V_{DD\_MAX} - V_{OUT}) * I_{OUT},$$

$$\text{since } V_{OUT} = I_{OUT} * R_L$$

$$= (V_{DD\_MAX} - I_{OUT} * R_L) * I_{OUT}$$

$$= (3.6V - 17mA * 50\Omega) * 17mA$$

Total Power Dissipation per output pair = **46.75mW**

## Reliability Information

**Table 8.  $\theta_{JA}$  vs. Air Flow Table for a 32 Lead VFQFN**

| $\theta_{JA}$ vs. Air Flow                  |          |          |          |
|---------------------------------------------|----------|----------|----------|
| Meters per Second                           | 0        | 1        | 2.5      |
| Multi-Layer PCB, JEDEC Standard Test Boards | 37.7°C/W | 32.9°C/W | 29.5°C/W |

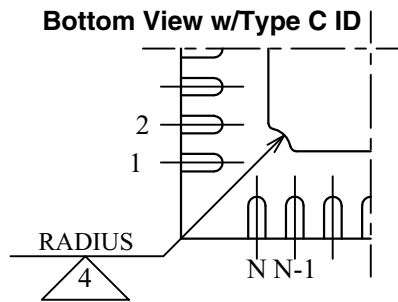
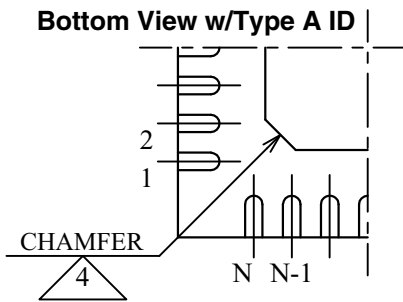
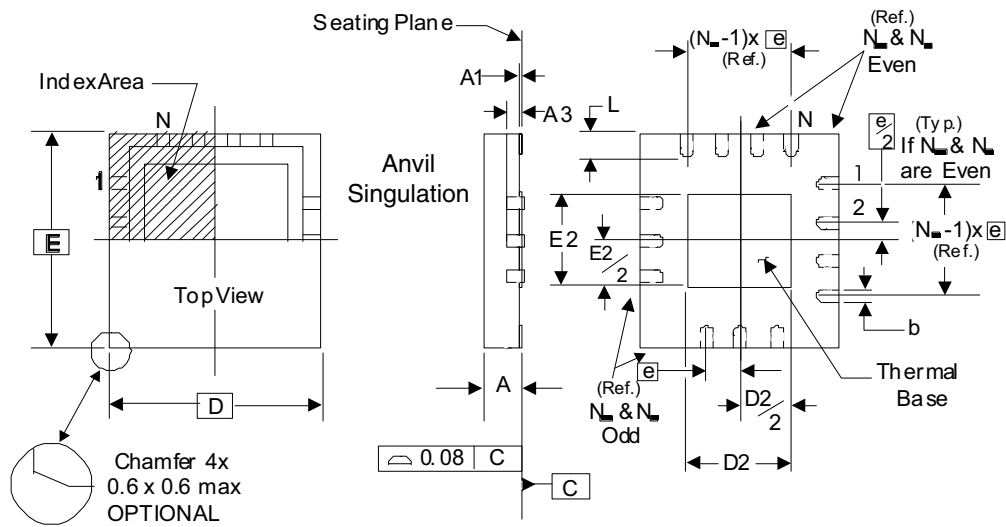
## Transistor Count

The transistor count for 841N4830 is: 23,123



# Package Outline and Package Dimensions

## Package Outline - K Suffix for 32 Lead VFQFN



There are 2 methods of indicating pin 1 corner at the back of the VFQFN package:

1. Type A: Chamfer on the paddle (near pin 1)
2. Type C: Mouse bite on the paddle (near pin 1)

**Table 9. Package Dimensions**

| JEDEC Variation: VHHD-2/-4<br>All Dimensions in Millimeters |            |         |         |
|-------------------------------------------------------------|------------|---------|---------|
| Symbol                                                      | Minimum    | Nominal | Maximum |
| N                                                           | 32         |         |         |
| A                                                           | 0.80       |         | 1.00    |
| A1                                                          | 0          |         | 0.05    |
| A3                                                          | 0.25 Ref.  |         |         |
| b                                                           | 0.18       | 0.25    | 0.30    |
| N <sub>D</sub> & N <sub>E</sub>                             |            |         | 8       |
| D & E                                                       | 5.00 Basic |         |         |
| D2 & E2                                                     | 3.0        |         | 3.3     |
| e                                                           | 0.50 Basic |         |         |
| L                                                           | 0.30       | 0.40    | 0.50    |

NOTE: The following package mechanical drawing is a generic drawing that applies to any pin count VFQFN package. This drawing is not intended to convey the actual pin count or pin layout of this device. The pin count and pin-out are shown on the front page. The package dimensions are in Table 9.

Reference Document: JEDEC Publication 95, MO-220

# Ordering Information

Table 10. Ordering Information

| Part/Order Number | Marking     | Package                   | Shipping Packaging                        | Temperature   |
|-------------------|-------------|---------------------------|-------------------------------------------|---------------|
| 841N4830BKILF     | ICSN4830BIL | “Lead-Free” 32 Lead VFQFN | Tray                                      | -40°C to 85°C |
| 841N4830BKILFT    | ICSN4830BIL | “Lead-Free” 32 Lead VFQFN | Tape & Reel, pin 1 orientation: EIA-481-C | -40°C to 85°C |
| 841N4830BKILF/W   | ICSN4830BIL | “Lead-Free” 32 Lead VFQFN | Tape & Reel, pin 1 orientation EIA-481-D  | -40°C to 85°C |

Table 11. Pin 1 Orientation in Tape and Reel Packaging

| Part Number Suffix | Pin 1 Orientation      | Illustration |
|--------------------|------------------------|--------------|
| T                  | Quadrant 1 (EIA-481-C) |              |
| /W                 | Quadrant 2 (EIA-481-D) |              |

## Revision History Sheet

| Rev | Table                 | Page                           | Description of Change                                                                                                                                                                                                                                                                               | Date      |
|-----|-----------------------|--------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------|
| A   |                       | 4                              | Supply Voltage, $V_{DD}$ . Rating changed from 4.5V min. to 3.63V per Errata NEN-11-03.                                                                                                                                                                                                             | 5/3/11    |
| B   | T6A<br>T6C            | 1                              | General Description: Maximum rms phase jitter changed to 0.34ps<br>Per PCN:<br>Features: changed to: RMS Phase Jitter @ 100MHz, (12kHz – 20MHz) using a 25MHz crystal: 0.34ps (maximum)                                                                                                             | 3/5/12    |
|     |                       | 6                              | Added 0.34 Maximum to $t_{jit}$ RMS Phase Jitter.                                                                                                                                                                                                                                                   |           |
|     |                       | 7                              | Added 0.34 Maximum to $t_{jit}$ , RMS Phase Jitter., Added 0.582 Typical to $t_{REFCLK\_HF\_RMS}$ RMS Phase Jitter. Added 0.023 Typical to $t_{REFCLK\_LF\_RMS}$ RMS Phase Jitter.                                                                                                                  |           |
|     |                       | 8                              | Added updated Phase Noise Plot.                                                                                                                                                                                                                                                                     |           |
|     |                       | 18                             | Added updated PCI Express Application Note                                                                                                                                                                                                                                                          |           |
|     |                       | 23<br>24                       | Changed Package Drawing<br>Changed Marking to ICSN4830BIL.                                                                                                                                                                                                                                          |           |
| C   | T4A                   | 4                              | Per PCN #N1206-01, changed $I_{EE}$ to 170mA Max.<br>Changed device reference to ICS841N4830BKI throughout the datasheet.                                                                                                                                                                           | 8/29/12   |
| D   | T4A<br><br>T6A<br>T6C |                                | Per PCN #N1206-01<br>Updated $V_{DD}$ min/max voltage from 3.135V min/3.465V max to 3.0V min / 3.6V max.<br>Updated $V_{DDO}$ min/max voltage from 3.135V min/3.465V max to 2.7V min / 3.6V max.                                                                                                    | 1/22/2013 |
|     |                       | 1                              | General Description and Features, updated RMS Phase Jitter spec to 0.36ps.                                                                                                                                                                                                                          |           |
|     |                       | 4 - 7<br>4                     | DC / AC Characteristic Tables - changed voltage supply table descriptions.<br>Power Supply DC Characteristics Table - changed Core supply voltage min / max specs;<br>changed $V_{DDO}$ supply voltage min / max specs;<br>corrected $V_{DDA}$ min spec from $V_{DD} - 0.16V$ to $V_{DD} - 0.32V$ . |           |
|     |                       | 6                              | LVC MOS AC Characteristic Table - changed odc min / max spec.                                                                                                                                                                                                                                       |           |
|     |                       | 7                              | HCSL AC Characteristic Table - changed Phase Jitter, RMS (Random) max spec.;<br>changed Phase Jitter (HF_RMS) typical spec.;<br>changed Cycle-to-Cycle max spec.                                                                                                                                    |           |
|     |                       | 9<br><br>18<br><br>19 - 20, 22 | Parameter Measurement Information - updated Test Circuit diagrams.<br><br>PCI Express Application Note - deleted Gen 1 information.<br><br>Power Considerations - changed $V_{DD} = 3.465V$ to $V_{DD} = 3.6V$ , updated equations.                                                                 |           |
| D   |                       | 17, 18                         | Updated schematic                                                                                                                                                                                                                                                                                   | 8/5/2013  |
| E   | T11<br>T10            | 26<br>26                       | Added P1 Orientation in Tape and Reel Table.<br>Ordering Information - Added W part number.                                                                                                                                                                                                         | 7/1/15    |
| F   |                       |                                | Updated datasheet header/footer.                                                                                                                                                                                                                                                                    | 5/23/16   |



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