

### General Description



The ICS8430S071 is a PLL-based clock generator specifically designed for Cavium Networks SoC processors. This high performance device is optimized to generate the processor core reference clock, the DDR reference clocks, the PCI/PCI-X bus clocks, and the clocks for both the Gigabit Ethernet MAC and PHY. The clock generator offers ultra low-jitter, low-skew clock outputs, and edge rates that easily meet the input requirements for the CN3005/CN3010/CN3020 processors. The output frequencies are generated from a 25MHz external input source or an external 25MHz parallel resonant crystal. The extended temperature range of the ICS8430S071 supports telecommunication, networking, and storage requirements.

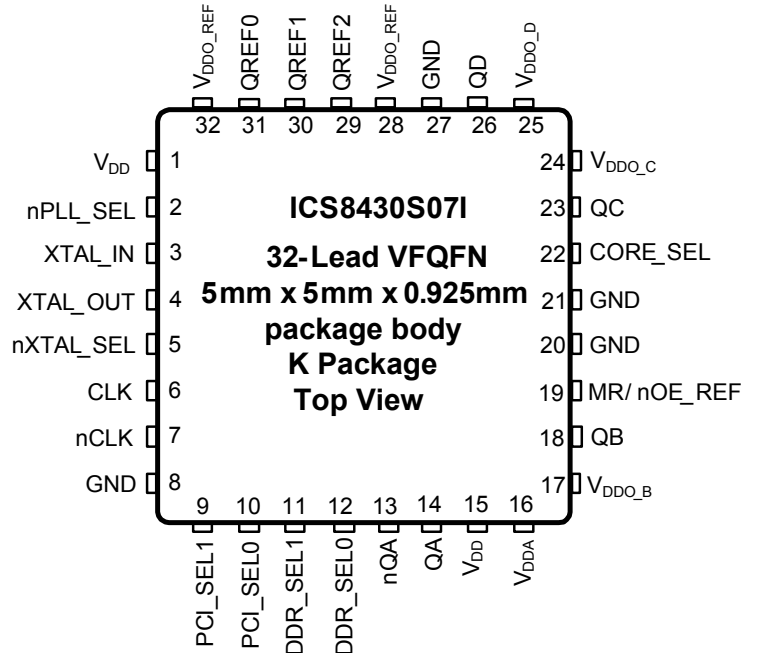
### Applications

- Systems using CN30XX MIPS64 Broadband Processors
- Networking, control and storage equipment, including routers, switches, application-aware gateways, triple-play gateways, WLAN and 3G/4G access and aggregation devices, storage arrays, storage networking equipment, servers, and intelligent NICs
- 802.11 a/b/g/n wireless for home data and multi-media distribution
- QoS for high quality Voice, Video, and Data Service
- Next-generation PON, VDSL2, and Cable Networks
- High-performance NAS
- Audio/Video Storage and Distribution
- Consumer Space Media Server

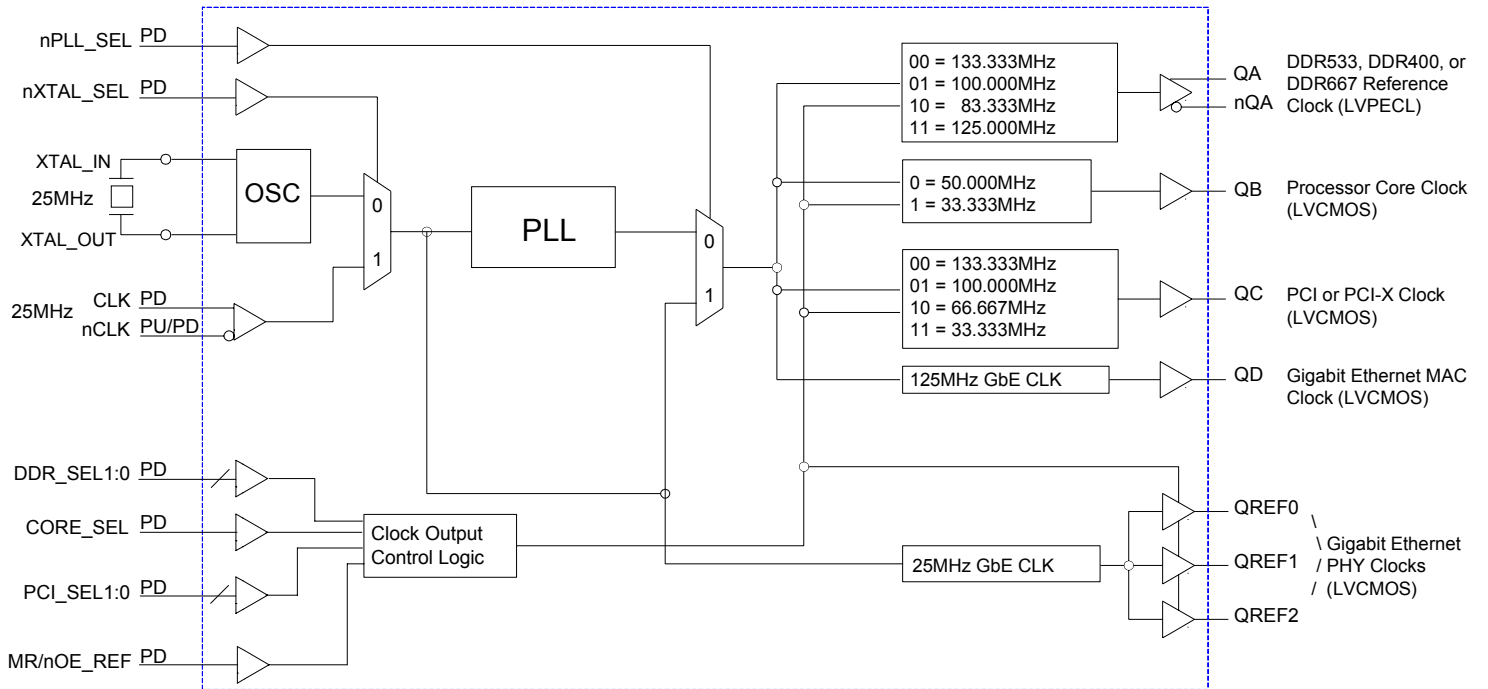
### Features

- One selectable differential LVPECL output pair for DDR 533/400/667
- Six LVCMOS/ LVTTTL outputs, 15Ω typical output impedance
  - One selectable core clock for the processor
  - One selectable clock for the PCI/ PCI-X bus
  - One 125MHz clock reference for GbE MAC
  - Three 25MHz clock references for GbE PHY
- Selectable external crystal or differential (single-ended) input source
- Crystal oscillator interface designed for 25MHz, parallel resonant crystal
- Differential input pair (CLK, nCLK) accepts LVPECL, LVDS, LVHSTL, SSTL, HCSL input levels
- Internal resistor bias on nCLK pin allows the user to drive CLK input with external single-ended (LVCMOS/ LVTTTL) input levels
- RMS phase jitter @ 125MHz, using a 25MHz crystal (1.875MHz - 20MHz): 0.78ps (typical), QD output
- Output supply:
  - LVPECL** – 3.3V Core
  - LVCMOS** – Core/Output
  - 3.3V/3.3V
  - 3.3V/2.5V
- -40°C to 85°C ambient operating temperature
- Available in lead-free (RoHS 6) package

### Pin Assignment



### Block Diagram



**Table 1. Pin Descriptions**

Number	Name	Type		Description
1, 15	V <sub>DD</sub>	Power		Core supply pins.
2	nPLL_SEL	Input	Pulldown	PLL bypass. When LOW, selects PLL (PLL Enable). When HIGH, bypasses the PLL. LVCMOS/LVTTL interface levels.
3, 4	XTAL_IN, XTAL_OUT	Input		Parallel resonant crystal interface. XTAL_OUT is the output, XTAL_IN is the input.
5	nXTAL_SEL	Input	Pulldown	Selects XTAL inputs when LOW. Selects differential clock (CLK, nCLK) input when HIGH. LVCMOS/LVTTL interface levels.
6	CLK	Input	Pulldown	Non-inverting differential clock input.
7	nCLK	Input	Pullup/ Pulldown	Inverting differential clock input. Internal resistor bias to V <sub>DD</sub> /2.
8, 20, 21, 27	GND	Power		Power supply ground.
9, 10	PCI_SEL1, PCI_SELO	Input	Pulldown	Selects the PCI/PCI-X reference clock output frequency. See Table 3C. LVCMOS/LVTTL interface levels.
11, 12	DDR_SEL1, DDR_SELO	Input	Pulldown	Selects the DDR reference clock output frequency. See Table 3B. LVCMOS/LVTTL interface levels.
13, 14	nQA, QA	Output		Differential output pair. LVPECL interface levels.
16	V <sub>DDA</sub>	Power		Analog supply pin.
17	V <sub>DDO_B</sub>	Power		Bank B output supply pin. 3.3 V or 2.5V supply.
18, 23, 26, 29, 30, 31	QB, QC, QD, QREF2, QREF1, QREF0	Output		Single-ended outputs. LVCMOS/LVTTL interface levels.
19	MR/nOE_REF	Input	Pulldown	Active HIGH Master Reset. Active LOW output enable. When logic HIGH, the internal dividers are reset and the QREF[2:0] outputs are in high impedance (HI-Z). When logic LOW, the internal dividers and the outputs are enabled. LVCMOS/ LVTTL interface levels.
22	CORE_SEL	Input	Pulldown	Selects the processor core clock output frequency. The output frequency is 50MHz when LOW, and 33.333MHz when HIGH. See Table 3A. LVCMOS/LVTTL interface levels.
24	V <sub>DDO_C</sub>	Power		Bank C output supply pin. 3.3 V or 2.5V supply.
25	V <sub>DDO_D</sub>	Power		Bank D output supply pin. 3.3 V or 2.5V supply.
28, 32	V <sub>DDO_REF</sub>	Power		REF bank output supply pins. 3.3 V or 2.5V supply.

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			2		pF
$C_{PD}$	Power Dissipation Capacitance (per output)	$V_{DD}, V_{DDO\_X} = 3.465V$		4		pF
		$V_{DD} = 3.465V, V_{DDO\_X} = 2.625V$		4		pF
$R_{PULLUP}$	Input Pullup Resistor			51		k $\Omega$
$R_{PULLDOWN}$	Input Pulldown Resistor			51		k $\Omega$
$R_{OUT}$	Output Impedance	QB, QC, QD, QREF[0:2] $V_{DDO\_X} = 3.465V$		15		$\Omega$
		QB, QC, QD, QREF[0:2] $V_{DDO\_X} = 2.625V$		20		$\Omega$

NOTE:  $V_{DDO\_X}$  denotes  $V_{DDO\_B}$ ,  $V_{DDO\_C}$ ,  $V_{DDO\_D}$  and  $V_{DDO\_REF}$ .

## Function Tables

**Table 3A. QB Output Control Input Function Table**

Input	Output Frequency
<b>CORE_SEL</b>	<b>QB</b>
0 (default)	50MHz
1	33.333MHz

**Table 3B. QA Output Control Input Function Table**

Inputs		Output Frequency
DDR_SEL1	DDR_SEL0	QA, nQA
0 (default)	0 (default)	133.333MHz
0	1	100.000MHz
1	0	83.333MHz
1	1	125.000MHz

**Table 3C. QC Output Control Input Function Table**

Inputs		Output Frequency
PCI_SEL1	PCI_SEL0	QC
0 (default)	0 (default)	133.333MHz
0	1	100.000MHz
1	0	66.6667MHz
1	1	33.333MHz

## 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, $V_{DD}$	4.6V
Inputs, $V_I$	-0.5V to $V_{DD} + 0.5V$
Outputs, $V_O$ (LVCMOS)	-0.5V to $V_{DD} + 0.5V$
Outputs, $I_O$ (LVPECL) Continuous Current Surge Current	50mA 100mA
Package Thermal Impedance, $\theta_{JA}$	39.5°C/W (0 mps)
Storage Temperature, $T_{STG}$	-65°C to 150°C

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics,  $V_{DD} = V_{DDO\_X} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$**

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		$V_{DD} - 0.20$	3.3	$V_{DD}$	V
$V_{DDO\_X}$	Output Supply Voltage		3.135	3.3	3.465	V
$I_{DD}$	Power Supply Current				170	mA
$I_{DDA}$	Analog Supply Current				20	mA
$I_{DDO\_X}$	Output Supply Current				25	mA

NOTE:  $V_{DDO\_X}$  denotes  $V_{DDO\_B}$ ,  $V_{DDO\_C}$ ,  $V_{DDO\_D}$  and  $V_{DDO\_REF}$ .

NOTE:  $I_{DDO\_X} = I_{DDO\_B}$ ,  $I_{DDO\_C}$ ,  $I_{DDO\_D}$  and  $I_{DDO\_REF}$ .

**Table 4B. Power Supply DC Characteristics,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO\_X} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$**

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		$V_{DD} - 0.20$	3.3	$V_{DD}$	V
$V_{DDO\_X}$	Output Supply Voltage		2.375	2.5	2.625	V
$I_{DD}$	Power Supply Current				160	mA
$I_{DDA}$	Analog Supply Current				20	mA
$I_{DDO\_X}$	Output Supply Current				20	mA

NOTE:  $V_{DDO\_X}$  denotes  $V_{DDO\_B}$ ,  $V_{DDO\_C}$ ,  $V_{DDO\_D}$  and  $V_{DDO\_REF}$ .

NOTE:  $I_{DDO\_X} = I_{DDO\_B}$ ,  $I_{DDO\_C}$ ,  $I_{DDO\_D}$  and  $I_{DDO\_REF}$ .

**Table 4B. LVCMOS/LVTTL DC Characteristics,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO\_X} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$** 

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	nPLL_SEL, CORE_SEL, nXTAL_SEL, PCI_SEL[0:1], DDR_SEL[0:1], MR/nOE_REF	$V_{DD} = V_{IN} = 3.465V$			150	$\mu\text{A}$
$I_{IL}$	Input Low Current	nPLL_SEL, CORE_SEL, nXTAL_SEL, PCI_SEL[0:1], DDR_SEL[0:1], MR/nOE_REF	$V_{DD} = 3.465V, V_{IN} = 0V$	-10			$\mu\text{A}$
$V_{OH}$	Output High Voltage; NOTE 1		$V_{DDO\_X} = 3.465V$	2.6			V
			$V_{DDO\_X} = 2.625V$	1.8			V
$V_{OL}$	Output Low Voltage: NOTE 1		$V_{DDO\_X} = 3.465V$ or $2.625V$			0.6	V

NOTE 1: Outputs terminated with  $50\Omega$  to  $V_{DDO\_X}/2$ . See Parameter Measurement Information, *Output Load Test Circuit diagram*.

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

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
$I_{IH}$	Input High Current	CLK/nCLK	$V_{DD} = V_{IN} = 3.465V$			150	$\mu\text{A}$
$I_{IL}$	Input Low Current	CLK	$V_{DD} = 3.465V, V_{IN} = 0V$	-10			$\mu\text{A}$
		nCLK	$V_{DD} = 3.465V, V_{IN} = 0V$	-150			$\mu\text{A}$
$V_{PP}$	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 4D. LVPECL DC Characteristics,  $V_{DD} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{OH}$	Output High Voltage; NOTE 1		$V_{DD} - 1.4$		$V_{DD} - 0.8$	V
$V_{OL}$	Output Low Voltage; NOTE 1		$V_{DD} - 2.0$		$V_{DD} - 1.7$	V
$V_{SWING}$	Peak-to-Peak Output Voltage Swing		0.55		1.0	V

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

**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
Drive Level				300	$\mu$ W

NOTE: Characterized using an 18pF parallel resonant crystal.

## AC Electrical Characteristics

**Table 6. AC Characteristics,  $V_{DD} = 3.3V \pm 5\%$ ,  $V_{DDO\_X} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units	
$f_{MAX}$	Output Frequency	QA/nQA	DDR_SEL[1:0] = 00		133.333		MHz
		QA/nQA	DDR_SEL[1:0] = 01		100		MHz
		QA/nQA	DDR_SEL[1:0] = 10		83.333		MHz
		QA/nQA	DDR_SEL[1:0] = 11		125		MHz
		QB	CORE_SEL = 0		50		MHz
		QB	CORE_SEL = 1		33.333		MHz
		QC	PCI_SEL[1:0] = 00		133.333		MHz
		QC	PCI_SEL[1:0] = 01		100		MHz
		QC	PCI_SEL[1:0] = 10		66.667		MHz
		QC	PCI_SEL[1:0] = 11		33.333		MHz
		QD			125		MHz
	QREF[0:2]			25		MHz	
$t_{sk}(b)$	Bank Skew; NOTE 2, 4	QREF[0:2]			35	ps	
$t_{sk}(pp)$	Part-to-Part Skew; NOTE 3, 4	QREF[0:2]			400	ps	
$t_{jit}(cc)$	Cycle-to-Cycle Jitter; NOTE 4, 5	QB, QC,			270	ps	
		QA/nQA	measured at crosspoint		95	ps	
		QD			200	ps	
$t_{jit}(per)$	Period Jitter (pk-pk); NOTE 4	QA/nQA	measured at crosspoint	-90	90	ps	
$t_{jit}(hper)$	Half-period Jitter (pk-pk)	QA/nQA	measured at crosspoint	-90	90	ps	
$t_{jit}(\emptyset)$	RMS Phase Jitter, (Random); NOTE 1	QREF[0:2]	25MHz (10kHz to 5MHz)		0.73	ps	
		QD	125MHz (1.875MHz to 20MHz)		0.78	ps	
$t_R / t_F$	Output Rise/Fall Time	QB	20% to 80%	100	450	ps	
		QA/nQA		100	300	ps	
		QC, QREF[0:2]		100	450	ps	
		QD		100	450	ps	
odc	Output Duty Cycle	QA/nQA		49	51	%	
		QB, QC, QD, QREF[0:2]		45	55	%	

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

NOTE: All parameters measured at  $f_{MAX}$  unless noted otherwise.

NOTE 1: Refer to the phase noise plot.

NOTE 2: Defined as skew within a bank of outputs at the same supply voltage and with equal load conditions.

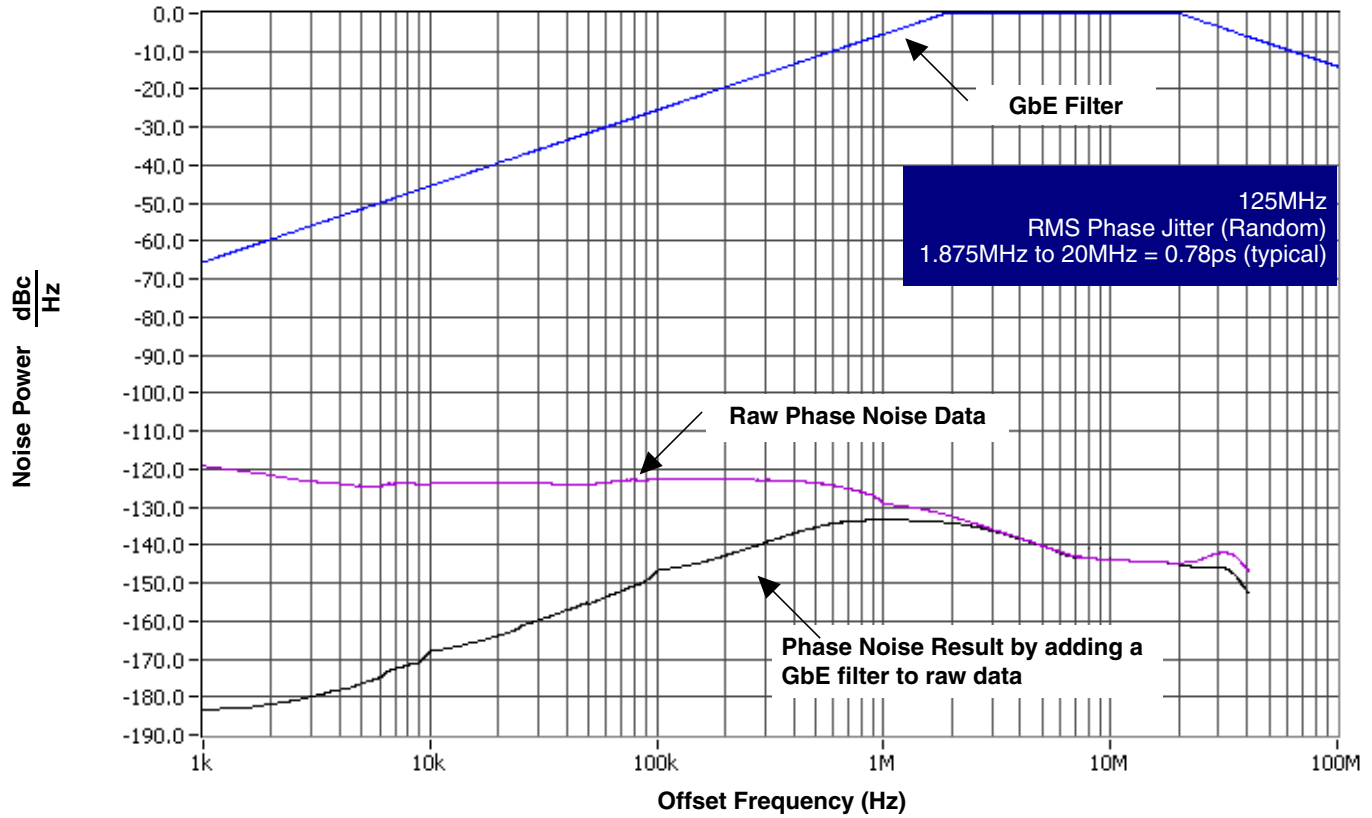
NOTE 3: Defined as skew between outputs on different devices operating at the same supply voltage and with equal load conditions. Using the same type of inputs on each device, the outputs are measured at  $V_{DDO}/2$ .

NOTE 4: This parameter is defined in accordance with JEDEC Standard 65.

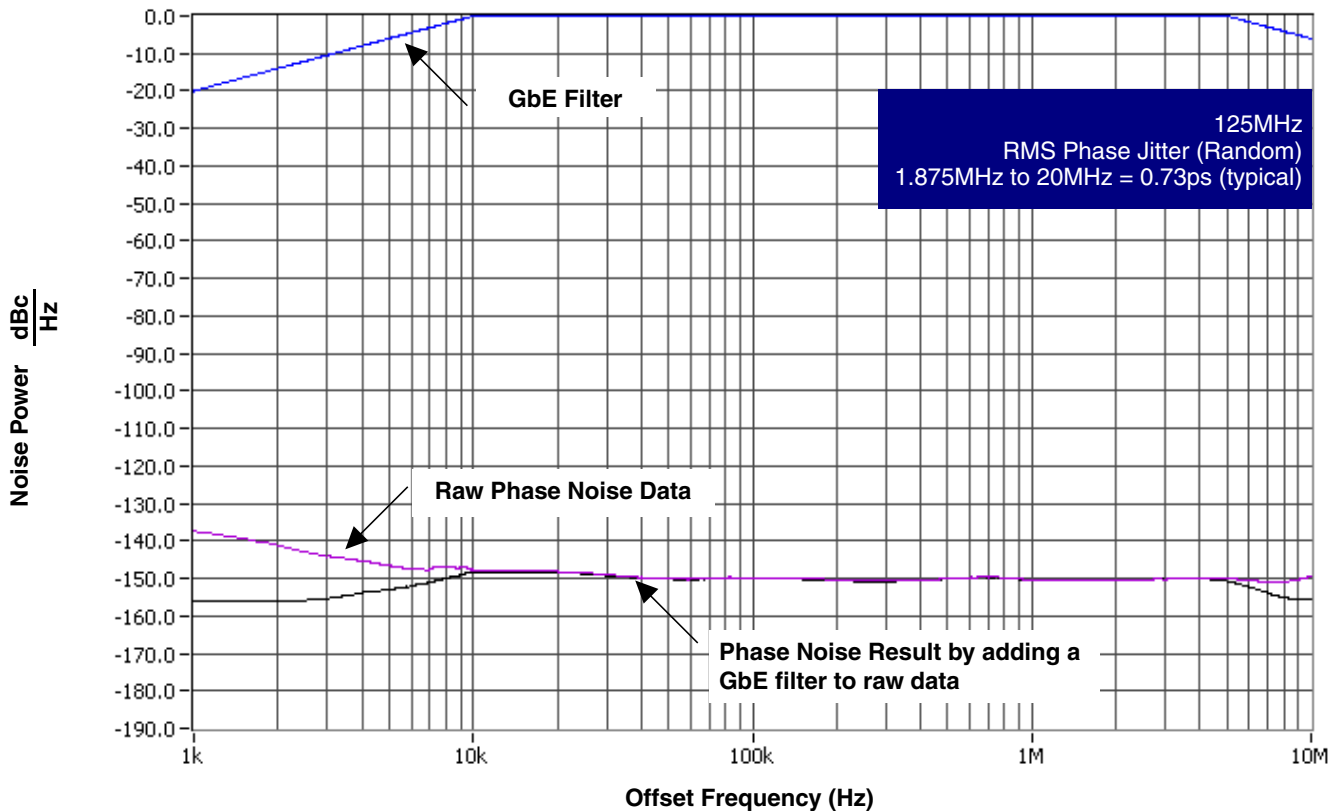
NOTE 5: All outputs running at corresponding  $f_{MAX}$ .



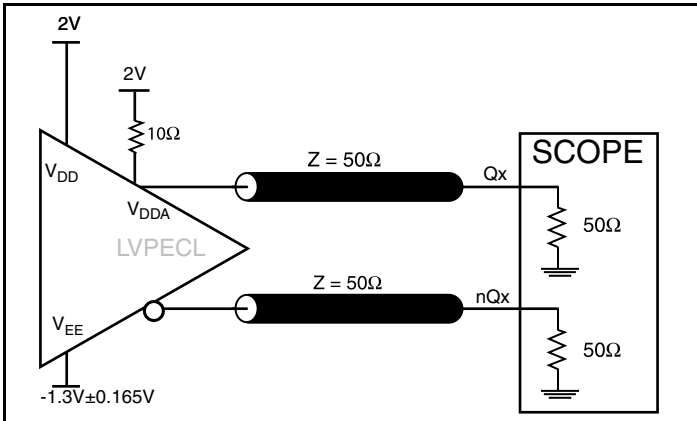
### Typical Phase Noise at 125MHz (QD output @ 3.3V)



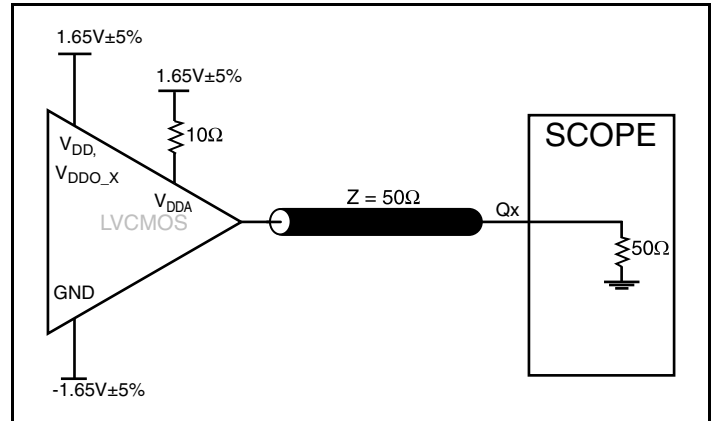
### Typical Phase Noise at 25MHz (QREF output @ 3.3V)



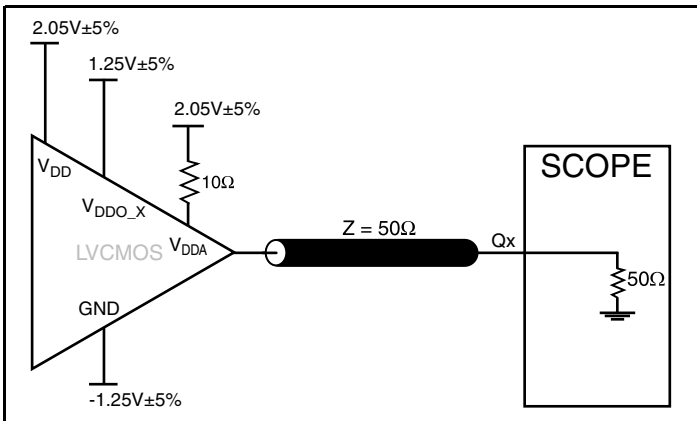
### Parameter Measurement Information



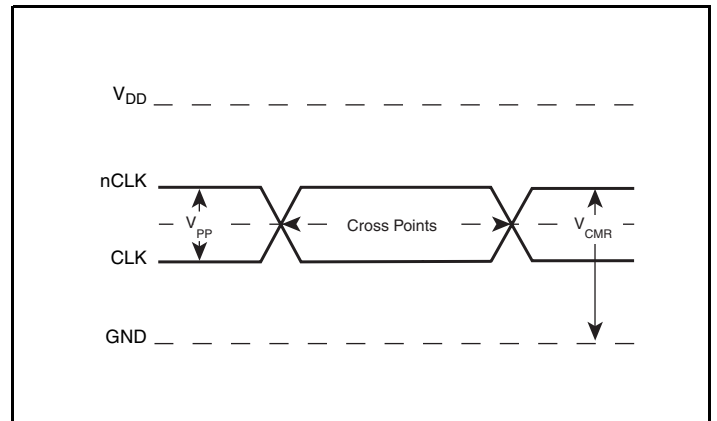
3.3V Core/3.3V LVPECL Output Load AC Test Circuit



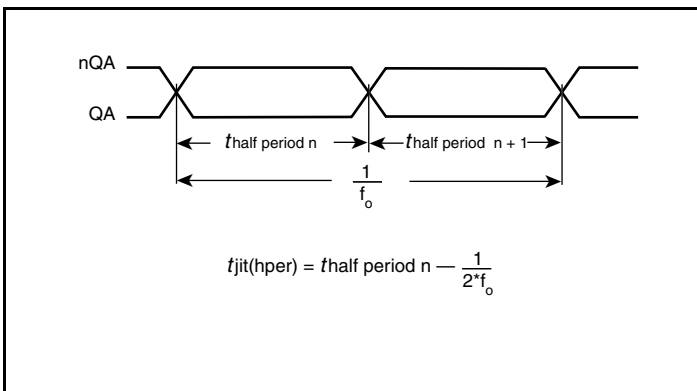
3.3V Core/3.3V LVCMOS Output Load AC Test Circuit



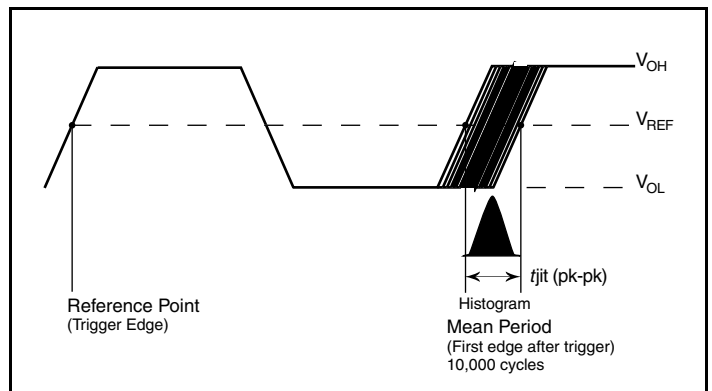
3.3V Core/2.5V LVCMOS Output Load AC Test Circuit



Differential Input Level

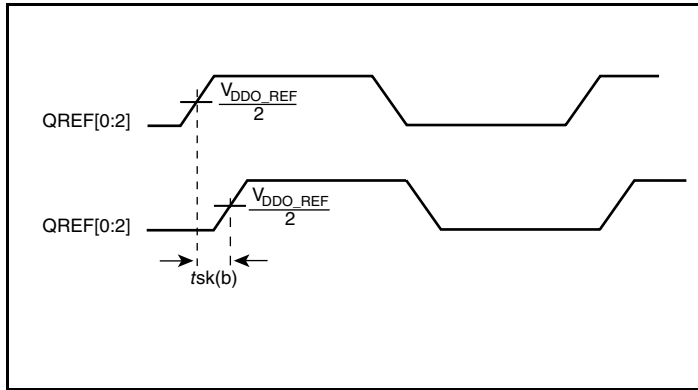


Half Period Jitter

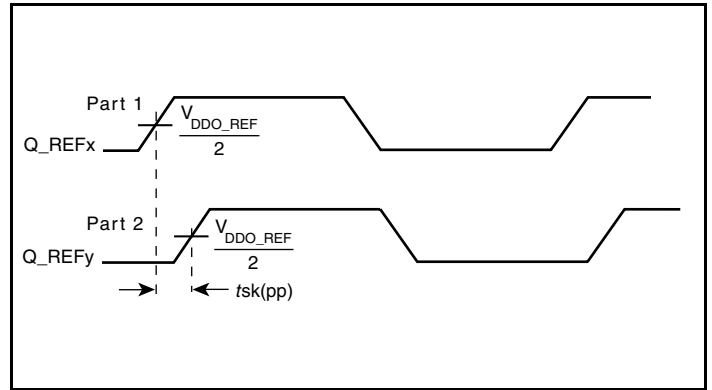


Period Jitter

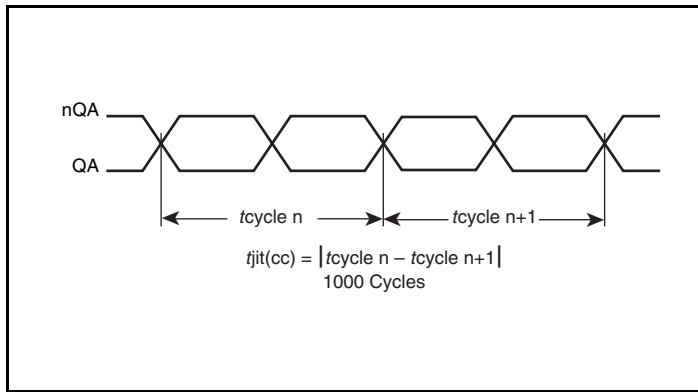
### Parameter Measurement Information, continued



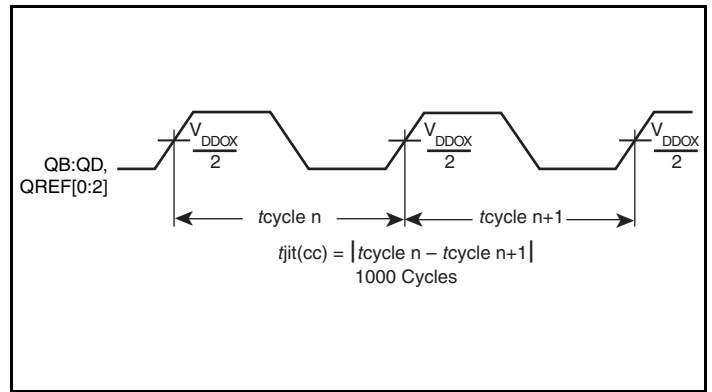
**LVCMOS Bank Skew**



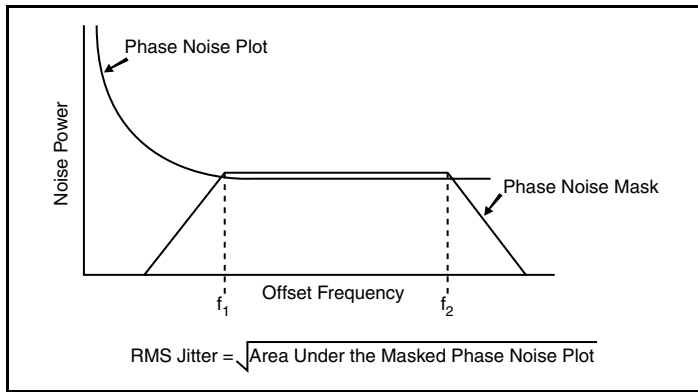
**LVCMOS Part-to-Part Skew**



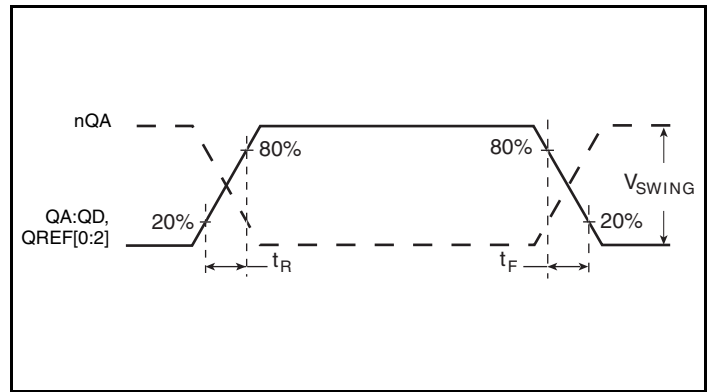
**LVPECL Cycle-to-Cycle Jitter**



**LVCMOS Cycle-to-Cycle Jitter**

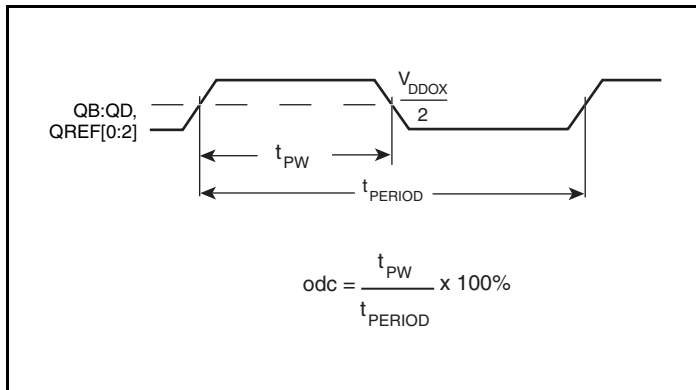


**RMS Phase Jitter**

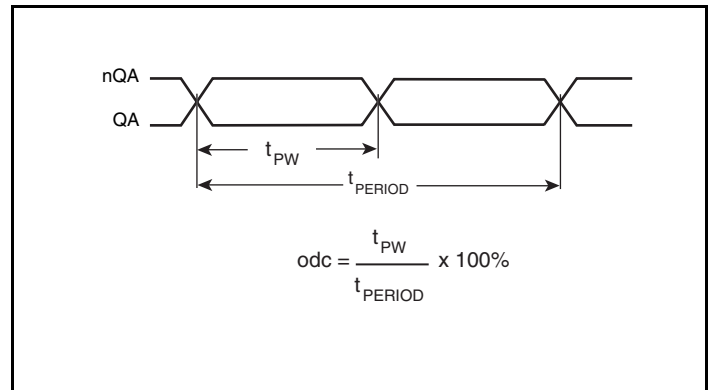


**Output Rise/Fall Time**

## Parameter Measurement Information, continued



LVCOS Output Duty Cycle/Pulse Width/Period



LVPECL Output Duty Cycle/Pulse Width/Period

## Application Information

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

Figure 1 shows how the differential input can be wired to accept single-ended levels. The reference voltage  $V_{REF} = V_{DD}/2$  is generated by the bias resistors R1, R2 and C1. This bias circuit should be located as close as possible to the input pin. The ratio of R1 and R2 might need to be adjusted to position the  $V_{REF}$  in the center of the input voltage swing. For example, if the input clock swing is only 2.5V and  $V_{DD} = 3.3V$ ,  $V_{REF}$  should be 1.25V and  $R2/R1 = 0.609$ .

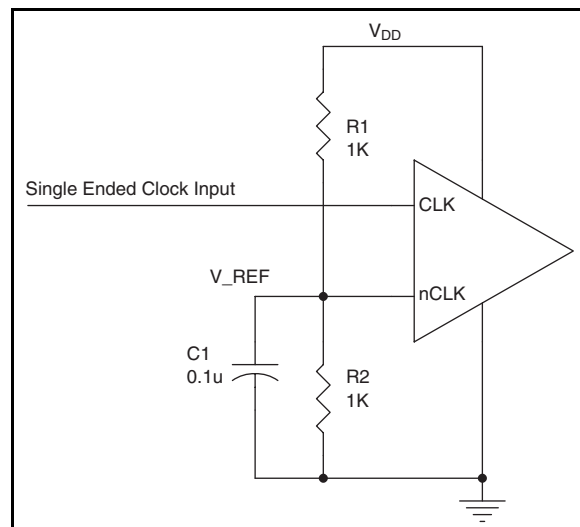
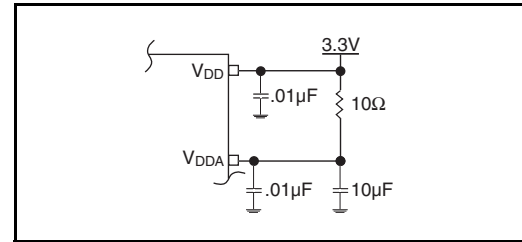


Figure 1. Single-Ended Signal Driving Differential Input

## 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 ICS8430S071 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{DD}$ ,  $V_{DDA}$  and  $V_{DDO\_X}$  should be individually connected to the power supply plane through vias, and  $0.01\mu\text{F}$  bypass capacitors should be used for each pin. *Figure 2* illustrates this for a generic  $V_{DD}$  pin and also shows that  $V_{DDA}$  requires that an additional  $10\Omega$  resistor along with a  $10\mu\text{F}$  bypass capacitor be connected to the  $V_{DDA}$  pin.



**Figure 2. Power Supply Filtering**

## Recommendations for Unused Input and Output 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  $1\text{k}\Omega$  resistor can be tied from CLK to ground.

#### Crystal Inputs

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

#### LVC MOS Control Pins

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

### Outputs:

#### LVPECL Outputs

The unused LVPECL output 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.

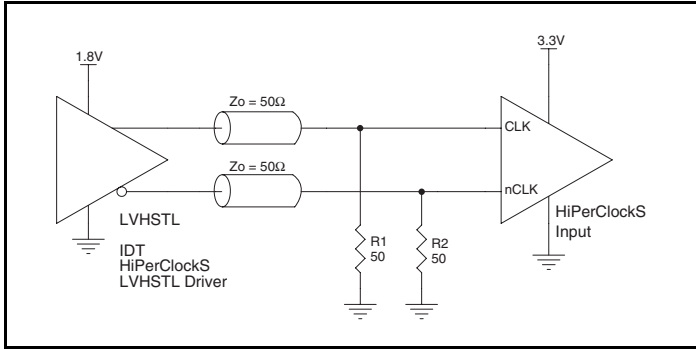
#### LVC MOS Outputs

All unused LVC MOS output can be left floating. There should be no trace attached.

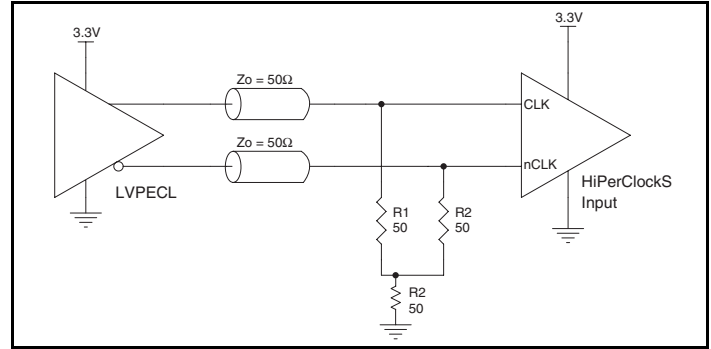
### Differential Clock Input Interface

The CLK /nCLK accepts LVDS, LVPECL, LVHSTL, SSTL, HCSL and other differential signals. Both  $V_{SWING}$  and  $V_{OH}$  must meet the  $V_{PP}$  and  $V_{CMR}$  input requirements. *Figures 3A to 3F* show interface examples for the HiPerClockS 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

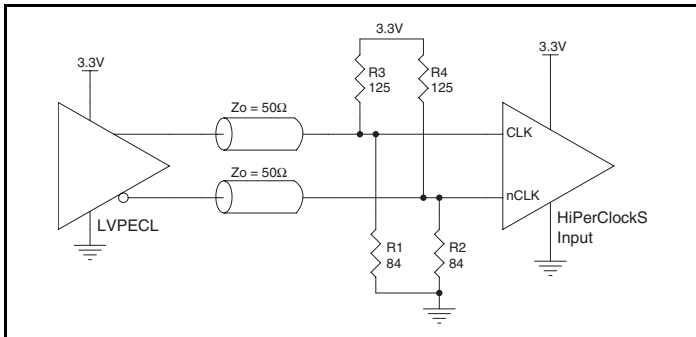
component to confirm the driver termination requirements. For example, in Figure 3A, the input termination applies for IDT HiPerClockS open emitter LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.



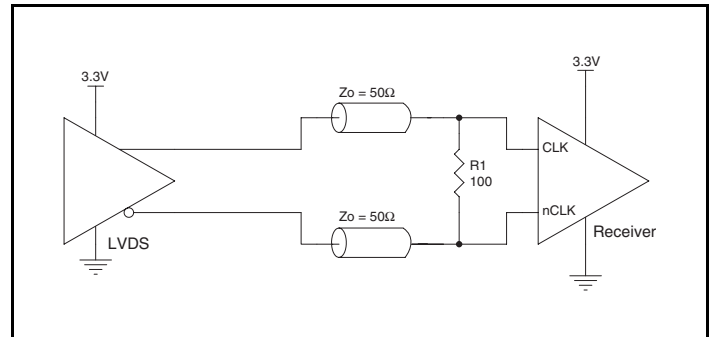
**Figure 3A. HiPerClockS CLK/nCLK Input Driven by an IDT Open Emitter HiPerClockS LVHSTL Driver**



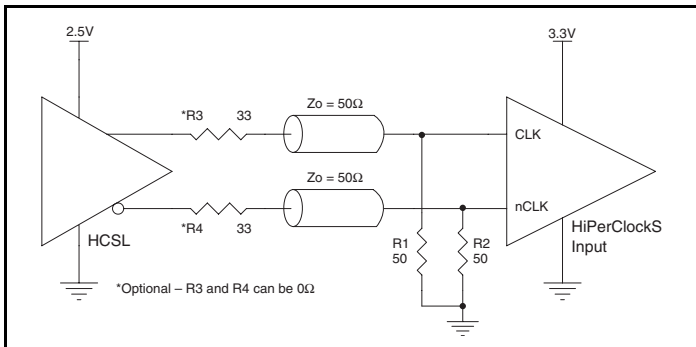
**Figure 3B. HiPerClockS CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



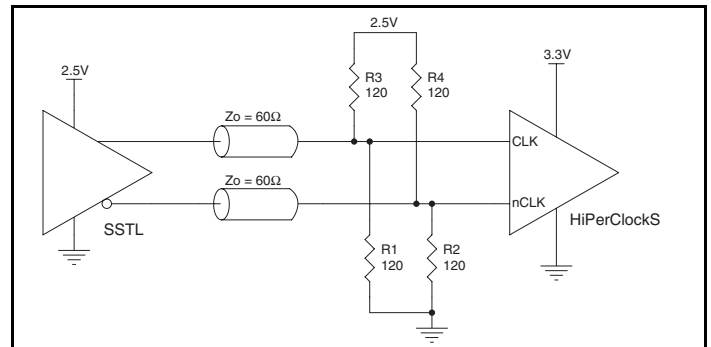
**Figure 3C. HiPerClockS CLK/nCLK Input Driven by a 3.3V LVPECL Driver**



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



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



**Figure 3F. HiPerClockS CLK/nCLK Input Driven by a 2.5V SSTL Driver**

## Crystal Input Interface

The ICS8430S071 has been characterized with 18pF parallel resonant crystals. The capacitors C1 and C2 are not required, but can be populated for optimal ppm accuracy. The C1 and C2 values

can be slightly adjusted to minimize ppm error for different board layouts.

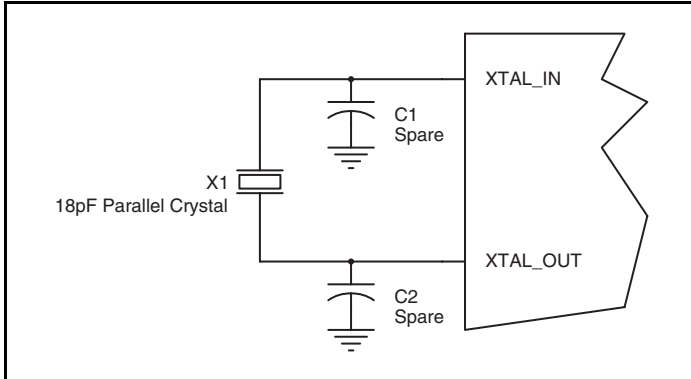


Figure 4. Crystal Input Interface

## LVC MOS to XTAL Interface

The XTAL\_IN input can accept a single-ended LVC MOS signal through an AC coupling capacitor. A general interface diagram is shown in *Figure 5*. The XTAL\_OUT pin can be left floating. The input edge rate can be as slow as 10ns. For LVC MOS signals, it is recommended that the amplitude be reduced from full swing to half swing in order to prevent signal interference with the power rail and to reduce noise. 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.

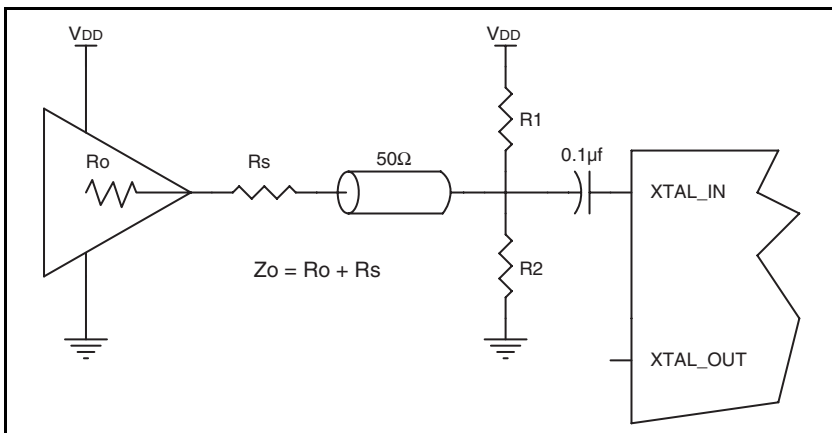


Figure 5. General Diagram for LVC MOS Driver to XTAL Input Interface

## 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 output pair is 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.

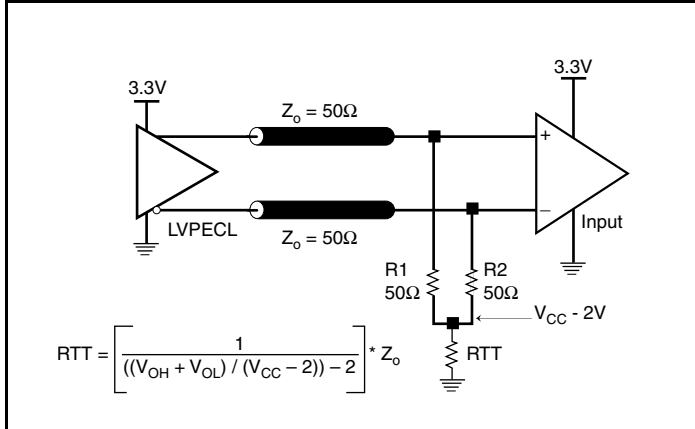


Figure 6A. 3.3V LVPECL Output Termination

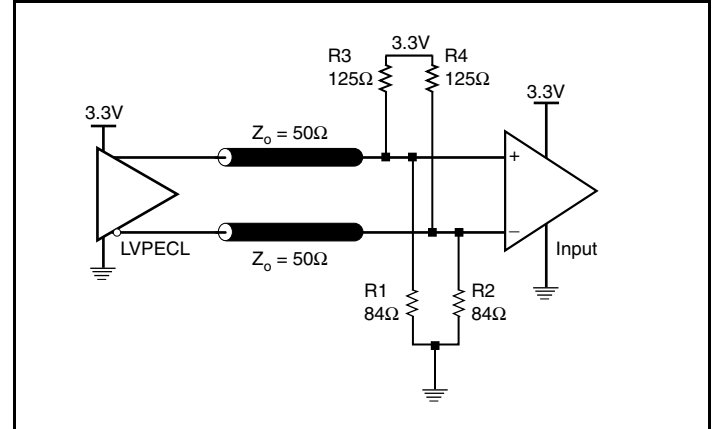


Figure 6B. 3.3V LVPECL Output Termination

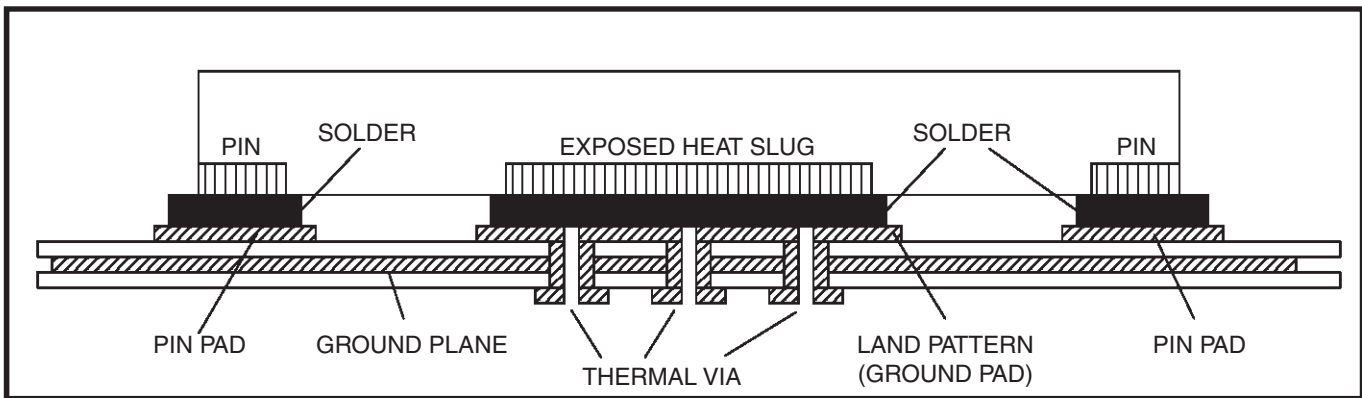


## VFQFN EPAD Thermal Release Path

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)**

## Application Schematic

Figure 8 shows a schematic example of using an ICS8430S071. The crystal inputs are parallel resonant crystal with load capacitor  $CL=18pF$ . The frequency fine tuning capacitors C1 and C2 are optional. The tuning capacitor value can be slightly adjusted to optimize the frequency accuracy. This schematic example shows hardwired logic control input handling. The logic inputs can also be driven by 3.3V LVCMOS drivers. It is recommended to have one bypass capacitor per power pin. In general, the bypass capacitor

values are ranged from 0.01 $\mu F$  to 0.1 $\mu F$ . Each bypass capacitor should be located as close as possible to the power pin. The low pass filter R6, C3 and C4 for clean analog supply should also be located as close to the  $V_{DDA}$  pin as possible. Only two examples of LVPECL termination and one example of LVCMOS termination are shown in this schematic. Additional examples of LVPECL terminations and LVCMOS terminations can be found in the LVPECL Termination and LVCMOS Termination Application Notes.

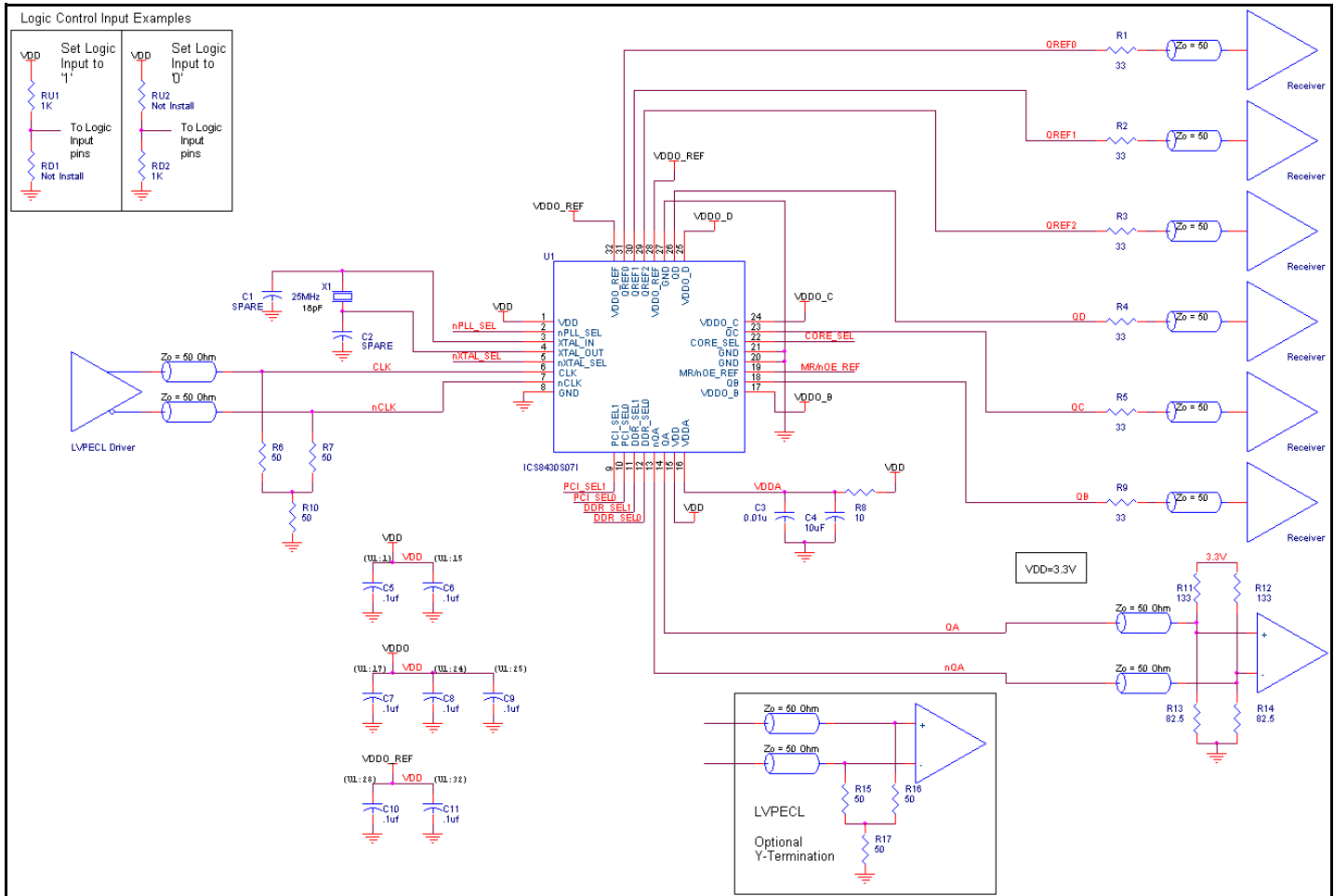


Figure 8. ICS8430S071 Schematic Example

## Power Considerations

This section provides information on power dissipation and junction temperature for the ICS8430S071. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS8430S071 is the sum of the core power plus the analog power plus the power dissipated in the load(s). The following is the power dissipation for  $V_{DD} = 3.3V + 5\% = 3.465V$ , which gives worst case results.

#### Core and LVPECL Output Power Dissipation

- Power (core)<sub>MAX</sub> =  $V_{DD\_MAX} * (I_{EE\_MAX} + I_{DDA} + I_{DDO}) = 3.465V * (170mA + 20mA + 25mA) = 744.98mW$
- Power (output)<sub>MAX</sub> = **30mW/Loaded Output Pair**

#### LVC MOS Output Power Dissipation

- Output Impedance  $R_{OUT}$  Power Dissipation due to Loading  $50\Omega$  to  $V_{DDO}/2$   
Output Current  $I_{OUT} = V_{DDO\_MAX} / [2 * (50\Omega + R_{OUT})] = 3.465V / [2 * (50\Omega + 15\Omega)] = 26.7mA$
- Power Dissipation on the  $R_{OUT}$  per LVC MOS output  
Power ( $R_{OUT}$ ) =  $R_{OUT} * (I_{OUT})^2 = 15\Omega * (26.7mA)^2 = 10.7mW$  per output
- Total Power Dissipation on the  $R_{OUT}$   
**Total Power ( $R_{OUT}$ ) =  $10.7mW * 6 = 64.2mW$**
- Dynamic Power Dissipation at 25MHz  
Power (25MHz) =  $C_{PD} * Frequency * (V_{DDO})^2 = 4pF * 25MHz * (3.465V)^2 = 1.5mW$  per output  
**Total Power (25MHz) =  $1.5mW * 3 = 4.5mW$**
- Dynamic Power Dissipation at 133MHz  
Power (133MHz) =  $C_{PD} * Frequency * (V_{DDO})^2 = 4pF * 133MHz * (3.465V)^2 = 8mW$  per output  
**Total Power (133MHz) =  $8mW * 3 = 24mW$**

#### Total Power Dissipation

- **Total Power**  
= Power (core) + Power (LVPECL output) + Total Power ( $R_{OUT}$ ) + Total Power (25MHz) + Total Power (125MHz)  
=  $745mW + 30mW + 64.2mW + 4.5mW + 24mW$   
= **867.7mW**

## 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 HiPerClockS 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 39.5°C/W per Table 7 below.

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

$$85^\circ\text{C} + 0.868\text{W} * 39.5^\circ\text{C/W} = 119.2^\circ\text{C}. \text{ This is below the limit of } 125^\circ\text{C}.$$

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

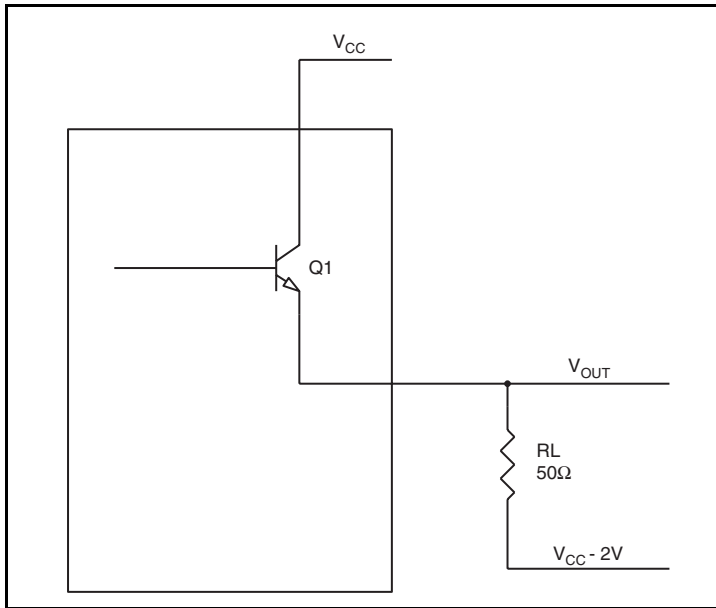
**Table 7. Thermal Resistance  $\theta_{JA}$  for 32 Lead VFQFN, Forced Convection**

$\theta_{JA}$ Vs. Air Flow			
Meters per Second	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	39.5°C/W	34.5°C/W	31.0°C/W

### 3. Calculations and Equations.

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

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



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

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

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

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

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

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

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

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

## Reliability Information

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

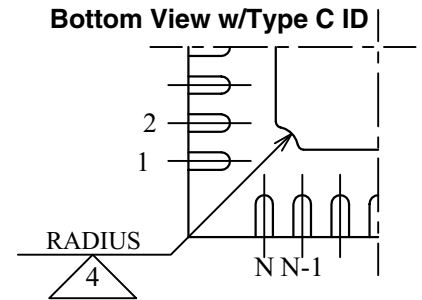
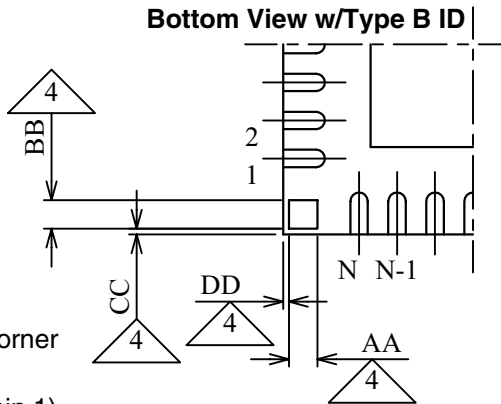
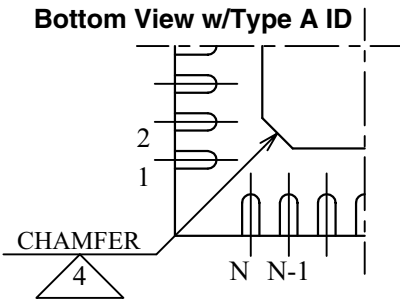
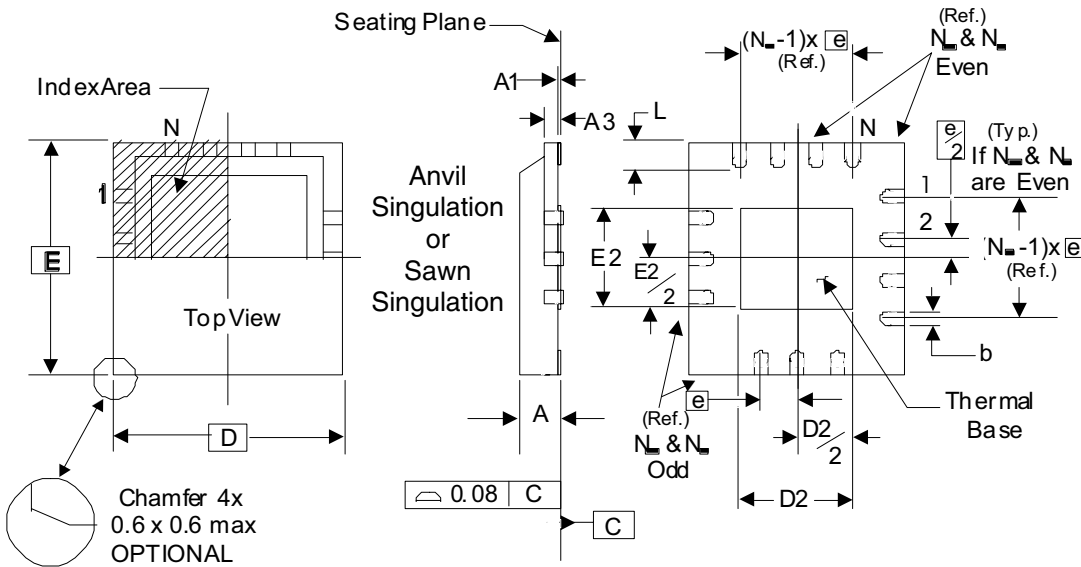
$\theta_{JA}$ vs. Air Flow			
Meters per Second	<b>0</b>	<b>1</b>	<b>2.5</b>
Multi-Layer PCB, JEDEC Standard Test Boards	39.5°C/W	34.5°C/W	31.0°C/W

## Transistor Count

The transistor count for ICS8430S071 is: 10,871

# Package Outline and Package Dimensions

## Package Outline - K Suffix for 32 Lead VFQFN



There are 3 methods of indicating pin 1 corner at the back of the VFQFN package are:

1. Type A: Chamfer on the paddle (near pin 1)
2. Type B: Dummy pad between pin 1 and N.
3. Type C: Mouse bite on the paddle (near pin 1)

**Table 9. Package Dimensions**

JEDEC Variation: VHHD-2/-4 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

Reference Document: JEDEC Publication 95, MO-220

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 pinout are shown on the front page. The package dimensions are in Table 9.

## Ordering Information

**Table 10. Ordering Information**

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
8430S07AKILF	ICS30S07AIL	"Lead-Free" 32 Lead VFQFN	Tray	-40°C to 85°C
8430S07AKILFT	ICS30S07AIL	"Lead-Free" 32 Lead VFQFN	2500 Tape & Reel	-40°C to 85°C

NOTE: Parts that are ordered with an "LF" suffix to the part number are the Pb-Free configuration and are RoHS compliant.

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## Revision History Sheet

Rev	Table	Page	Description of Change	Date
A		23	Package Outline & Dimensions - added pin 1 indicator in package drawing.	9/3/09



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