

## GENERAL DESCRIPTION

The 844008I-46 is a 10Gb Ethernet Clock Generator and a member of the HiPerClocks™ family of high performance devices from IDT. The 844008I-46 can synthesize 156.25MHz or 100MHz with a 25MHz crystal. It has a total of 8 LVDS outputs. The 844008I-46 has excellent phase jitter performance and is packaged in a 32 Lead VFQFN package, making it ideal for use in systems with limited board space.

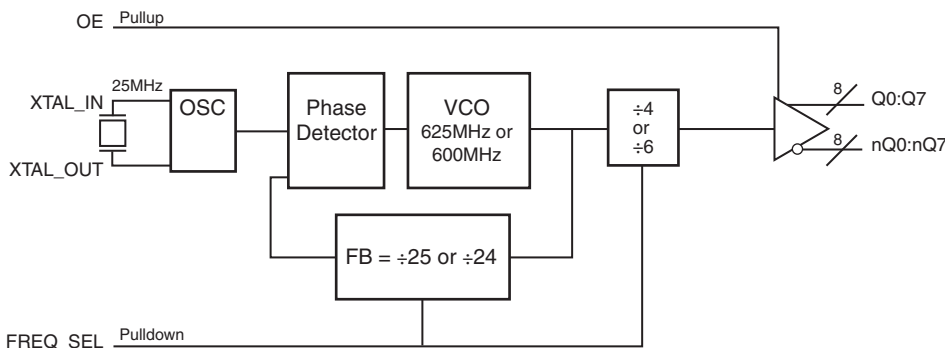
## FEATURES

- Eight differential LVDS outputs
- Crystal oscillator interface designed for 18pF parallel resonant crystals
- Supports the following output frequencies: 156.25MHz or 100MHz
- VCO frequency: 625MHz or 600MHz
- RMS phase jitter @ 156.25MHz, using a 25MHz crystal (1.875MHz - 20MHz): 0.45ps (typical)
- Full 2.5V supply mode
- -40°C to 85°C ambient operating temperature
- Available in lead-free (RoHS 6) packages
- For functional replacement part use 8T49N285

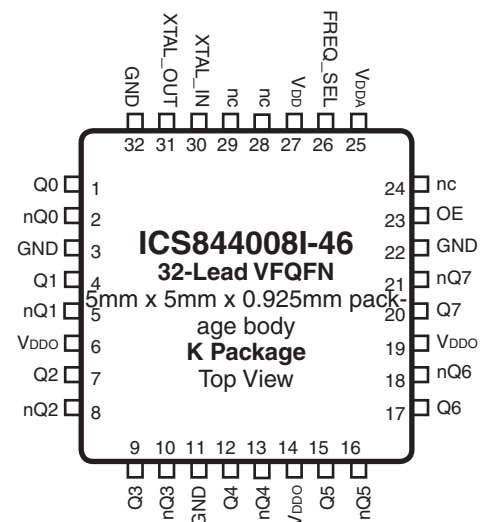
FREQUENCY SELECT FUNCTION TABLE

Input		FB Divider	Output Divider	VCO (MHz)	Output Frequency (MHz)
XTAL Frequency (MHz)	FREQ_SEL				
25	0	÷25	÷4	625	156.25 (default)
25	1	÷24	÷6	600	100

## BLOCK DIAGRAM



## PIN ASSIGNMENT



**TABLE 1. PIN DESCRIPTIONS**

Number	Name	Type		Description
1, 2	Q0, nQ0	Output		Differential output pair. LVDS interface levels.
3, 11, 22, 32	GND	Power		Power supply ground.
4, 5	Q1, nQ1	Output		Differential output pair. LVDS interface levels.
6, 14, 19	V <sub>DDO</sub>	Power		Output supply pins.
7, 8	Q2, nQ2	Output		Differential output pair. LVDS interface levels.
9, 10	Q3, nQ3	Output		Differential output pair. LVDS interface levels.
12, 13	Q4, nQ4	Output		Differential output pair. LVDS interface levels.
15, 16	Q5, nQ5	Output		Differential output pair. LVDS interface levels.
17, 18	Q6, nQ6	Output		Differential output pair. LVDS interface levels.
20, 21	Q7, nQ7	Output		Differential output pair. LVDS interface levels.
23	OE	Input	Pullup	Output enable pin. When LOW, outputs are disabled. When HIGH, outputs are enabled. LVCMOS/LVTTL interface levels. See Table 3.
24, 28, 29	nc	Unused		No connect.
25	V <sub>DDA</sub>	Power		Analog supply pin.
26	FREQ_SEL	Input	Pulldown	Frequency select pin. LVCMOS/LVTTL interface levels.
27	V <sub>DD</sub>	Power		Core supply pin.
30, 31	XTAL_IN, XTAL_OUT	Input		Parallel resonant crystal interface. XTAL_OUT is the output, XTAL_IN is the input.

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			4		pF
R <sub>PULLDOWN</sub>	Input Pulldown Resistor			51		kΩ
R <sub>PULLUP</sub>	Input Pullup Resistor			51		kΩ

**TABLE 3. OE FUNCTION TABLE**

Inputs OE	Outputs Q[0:7]/nQ[0:7]
1	Enabled (default)
0	Hi-Z

**ABSOLUTE MAXIMUM RATINGS**

Supply Voltage, $V_{DD}$	4.6V
Inputs, $V_I$	-0.5V to $V_{DD} + 0.5V$
Outputs, $I_O$ (LVDS)	
Continuous Current	10mA
Surge Current	15mA
Package Thermal Impedance, $\theta_{JA}$	37°C/W (0 mps)
Storage Temperature, $T_{STG}$	-65°C to 150°C

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.

**TABLE 4A. POWER SUPPLY DC CHARACTERISTICS,  $V_{DD} = V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{DD}$	Core Supply Voltage		2.375	2.5	2.625	V
$V_{DDA}$	Analog Supply Voltage		$V_{DD} - 0.25$	2.5	$V_{DD}$	V
$V_{DDO}$	Output Supply Voltage		2.375	2.5	2.625	V
$I_{DD}$	Power Supply Current				60	mA
$I_{DDA}$	Analog Supply Current				25	mA
$I_{DDO}$	Output Supply Current				140	mA

**TABLE 4B. LVCMOS / LVTTTL DC CHARACTERISTICS,  $V_{DD} = V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  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	OE	$V_{DD} = V_{IN} = 2.625$		5	$\mu\text{A}$
		FREQ_SEL	$V_{DD} = V_{IN} = 2.625$		150	$\mu\text{A}$
$I_{IL}$	Input Low Current	OE	$V_{DD} = 2.625V, V_{IN} = 0V$	-150		$\mu\text{A}$
		FREQ_SEL	$V_{DD} = 2.625V, V_{IN} = 0V$	-5		$\mu\text{A}$

**TABLE 4C. LVDS DC CHARACTERISTICS,  $V_{DD} = V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{OD}$	Differential Output Voltage		247	340	454	mV
$\Delta V_{OD}$	$V_{OD}$ Magnitude Change				50	mV
$V_{OS}$	Offset Voltage		1.10	1.25	1.375	V
$\Delta V_{OS}$	$V_{OS}$ Magnitude Change				50	mV

**TABLE 5. CRYSTAL CHARACTERISTICS**

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation		Fundamental			
Frequency			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.

**TABLE 6. AC CHARACTERISTICS,  $V_{DD} = V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{OUT}$	Output Frequency	FREQ_SEL = 0		156.25		MHz
		FREQ_SEL = 1		100		MHz
tsk(o)	Output Skew; NOTE 1, 2				75	ps
tjit(cc)	Cycle-to-Cycle Jitter				20	ps
tjit( $\emptyset$ )	RMS Phase Jitter (Random); NOTE 3	156.25MHz (1.875MHz - 20MHz)		0.45		ps
		100MHz (1.875MHz - 20MHz)		0.52		ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	300		700	ps
odc	Output Duty Cycle		48		52	%

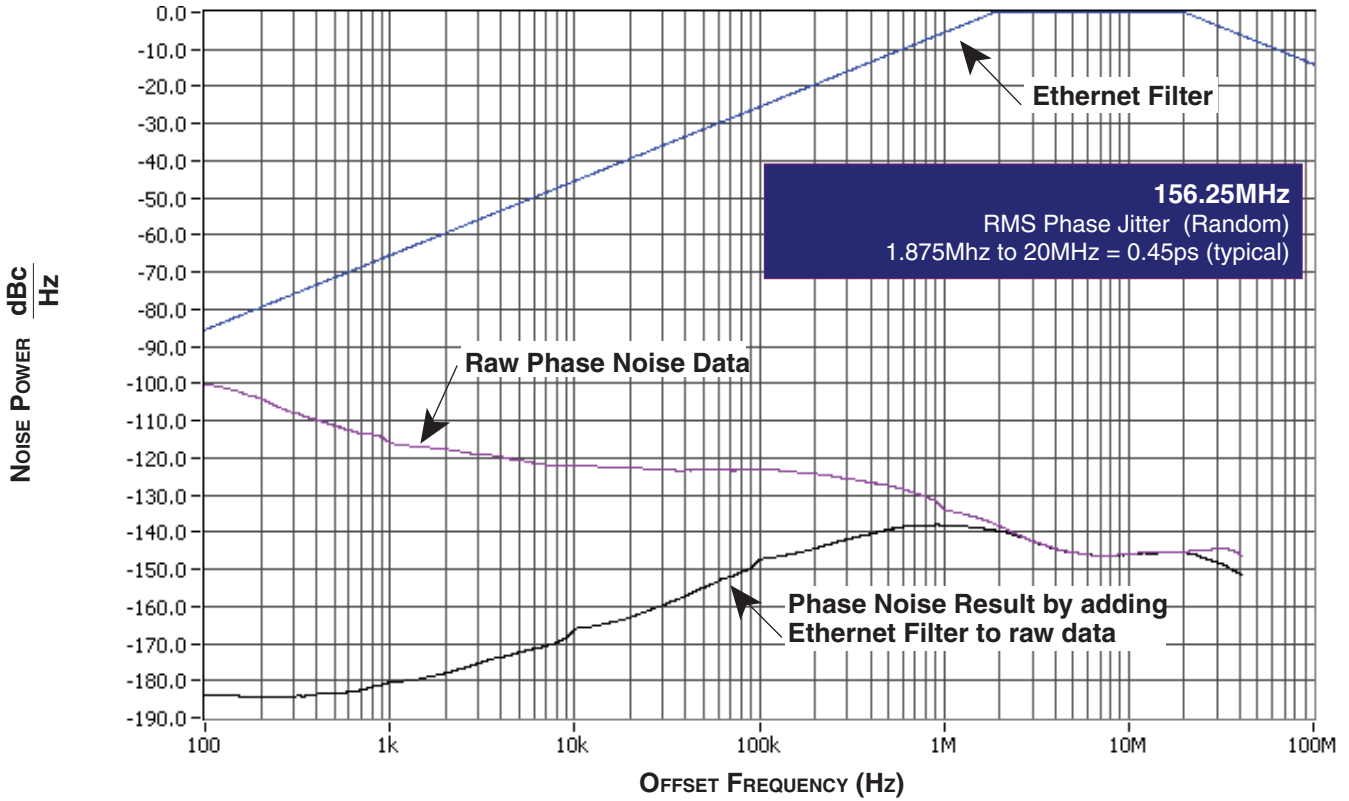
NOTE 1: Defined as skew between outputs at the same supply voltages and with equal load conditions.

Measured at the differential cross points.

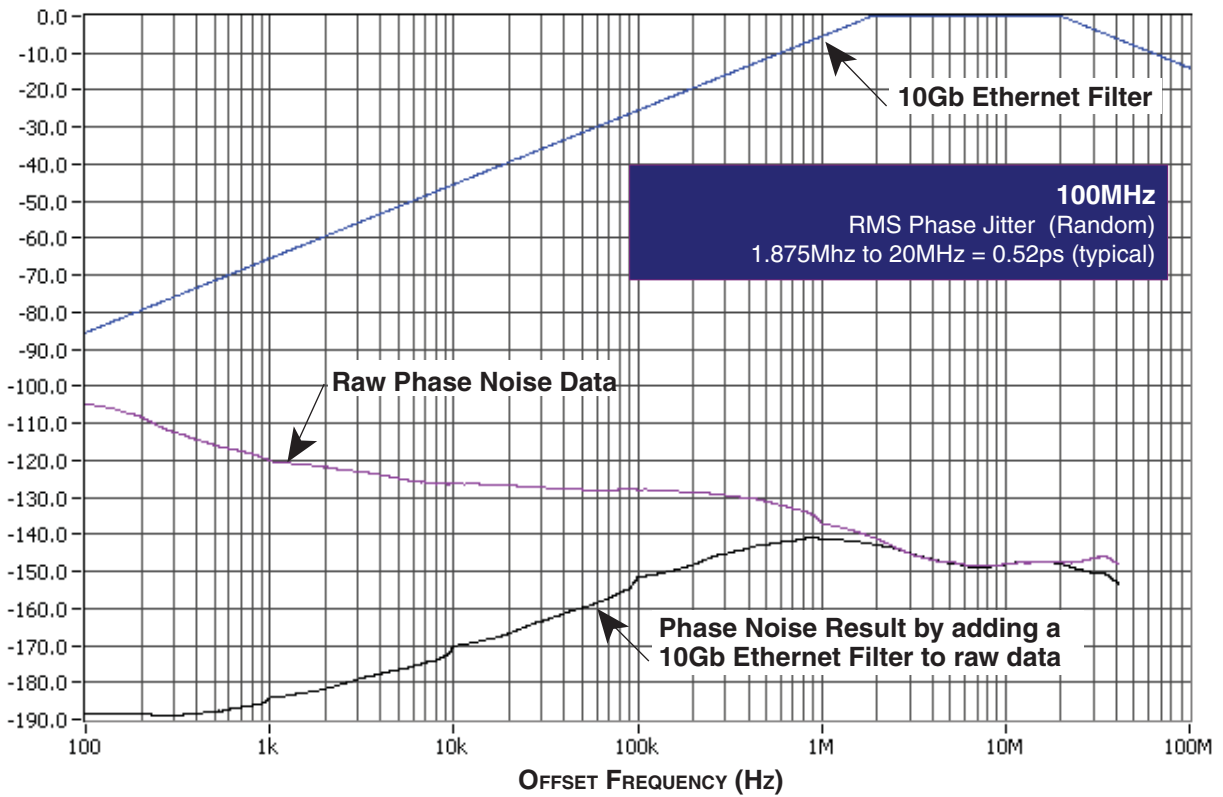
NOTE 2: This parameter is defined in accordance with JEDEC Standard 65.

NOTE 3: Please refer to the Phase Noise Plot.

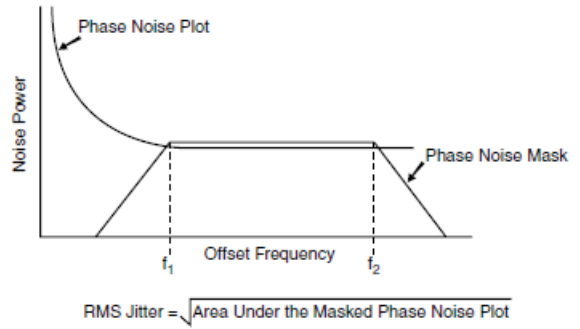
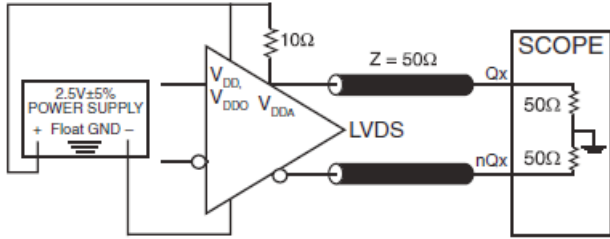
### TYPICAL PHASE NOISE AT 156.25MHz



### TYPICAL PHASE NOISE AT 100MHz

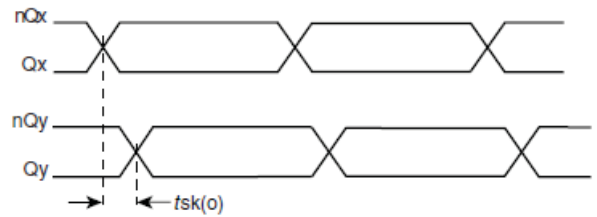
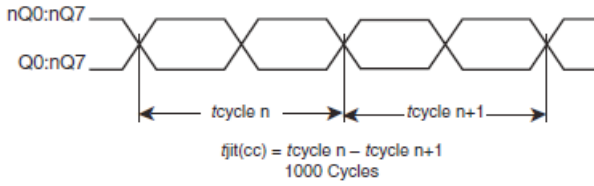


# PARAMETER MEASUREMENT INFORMATION



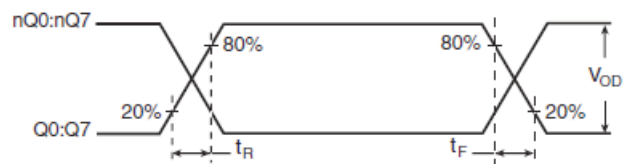
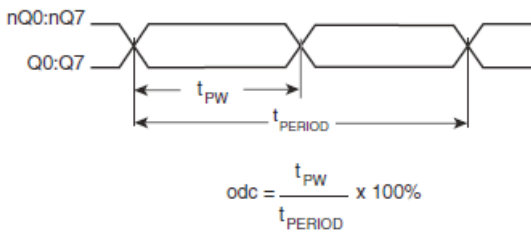
2.5V LVDS OUTPUT LOAD AC TEST CIRCUIT

RMS PHASE JITTER



CYCLE-TO-CYCLE JITTER

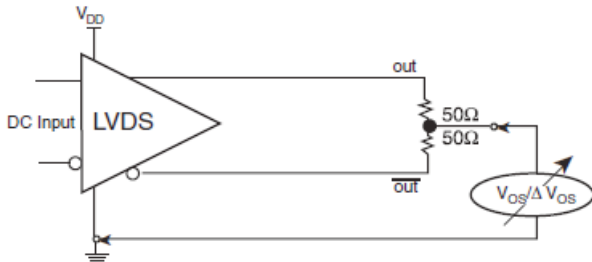
OUTPUT SKEW



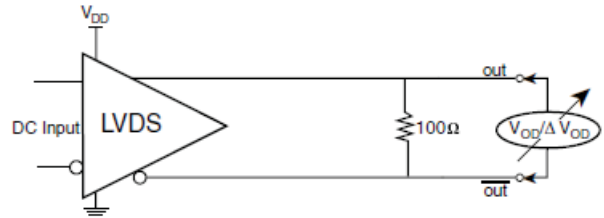
OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD

OUTPUT RISE/FALL TIME

## PARAMETER MEASUREMENT INFORMATION, CONTINUED



OFFSET VOLTAGE SETUP



DIFFERENTIAL OUTPUT VOLTAGE SETUP

## APPLICATION INFORMATION

### POWER SUPPLY FILTERING TECHNIQUES

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 8440081-46 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{DD}$ ,  $V_{DDA}$ , and  $V_{DDO}$  should be individually connected to the power supply plane through vias, and 0.01μF bypass capacitors should be used for each pin. Figure 1 illustrates this for a generic  $V_{CC}$  pin and also shows that  $V_{DDA}$  requires that an additional 10Ω resistor along with a 10μF bypass capacitor be connected to the  $V_{DDA}$  pin.

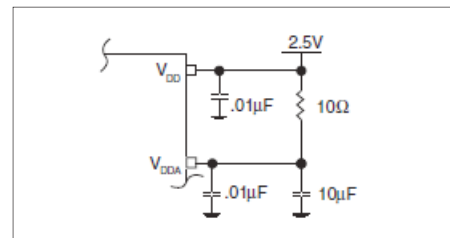


FIGURE 1. POWER SUPPLY FILTERING

**RECOMMENDATIONS FOR UNUSED INPUT AND OUTPUT PINS**

**INPUTS:**

**LVC MOS CONTROL PINS**

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

**OUTPUTS:**

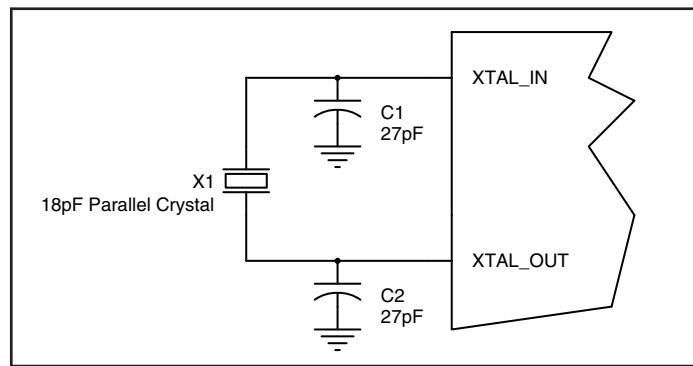
**LVDS OUTPUTS**

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

**CRYSTAL INPUT INTERFACE**

The 8440081-46 has been characterized with an 18pF parallel resonant crystals. The capacitor values shown in

Figure 2 below were determined using a 25MHz parallel resonant crystal and were chosen to minimize the ppm error.

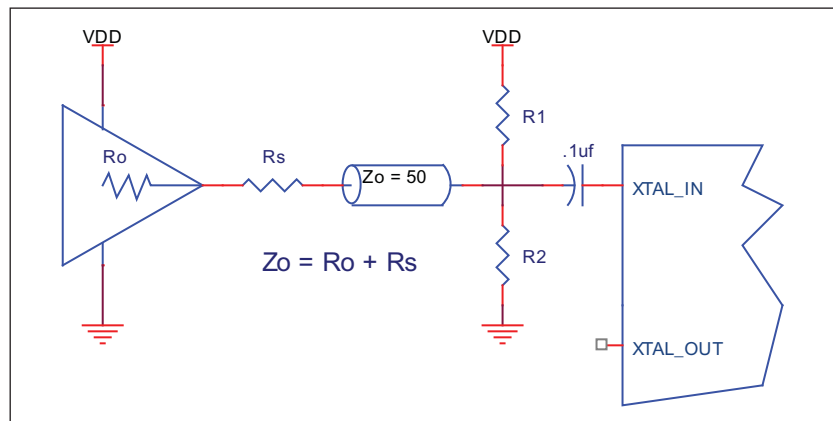


**FIGURE 2. CRYSTAL INPUT INTERFACE**

**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 3. The XTAL\_OUT pin can be left floating. The input edge rate can be as slow as 10ns. For LVC MOS inputs, 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,  $R_1$  and  $R_2$  in parallel should equal the transmission line impedance. For most 50Ω applications,  $R_1$  and  $R_2$  can be 100Ω. This can also be accomplished by removing  $R_1$  and making  $R_2$  50Ω.



**FIGURE 3. GENERAL DIAGRAM FOR LVC MOS DRIVER TO XTAL INPUT INTERFACE**



### 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 4*. 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, refer to the Application Note on the *Surface Mount Assembly* of Amkor’s Thermally/Electrically Enhance Leadframe Base Package, Amkor Technology.

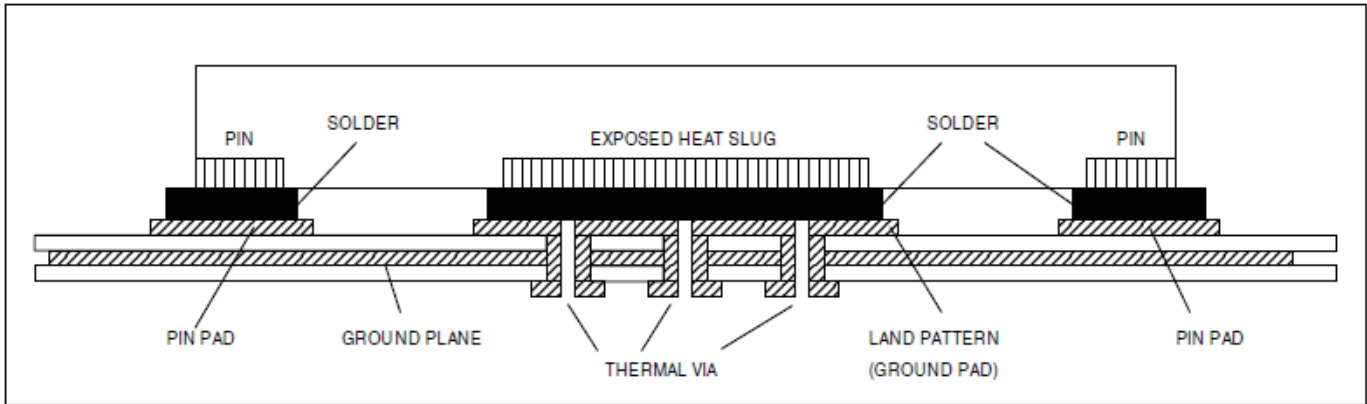


FIGURE 4. P.C.ASSEMBLY FOR EXPOSED PAD THERMAL RELEASE PATH –SIDE VIEW (DRAWING NOT TO SCALE)

### 2.5V LVDS DRIVER TERMINATION

*Figure 5* shows a typical termination for LVDS driver in characteristic impedance of 100Ω differential (50Ω single) transmission line environment.

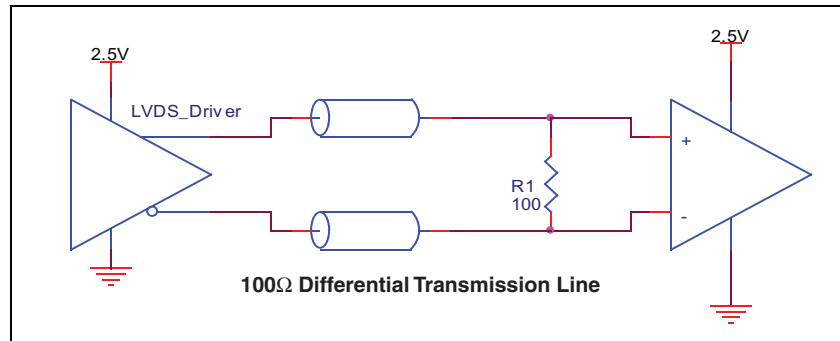
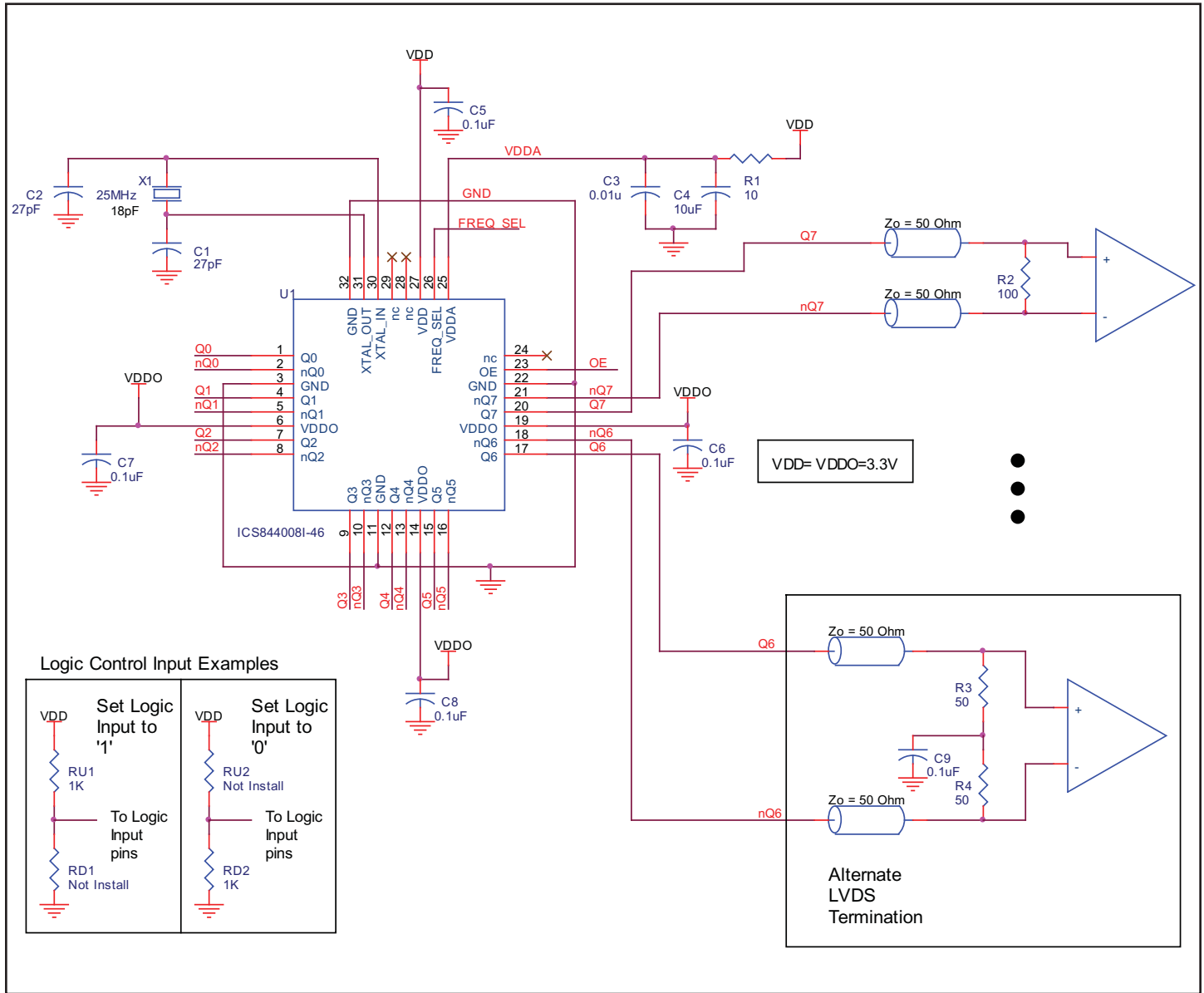


FIGURE 5. TYPICAL LVDS DRIVER TERMINATION

**SCHEMATIC LAYOUT**

Figure 6 shows an example of 844008I-46 application schematic. In this example, the device is operated at  $V_{DD} = V_{DDO} = 3.3V$ . The 18pF parallel resonant 25MHz crystal is used. The  $C1 = 27pF$  and  $C2 = 27pF$  are recommended

for frequency accuracy. For different board layout, the  $C1$  and  $C2$  may be slightly adjusted for optimizing frequency accuracy. Two examples of LVDS for receiver without built-in termination are shown in this schematic.



**FIGURE 6. 844008I-46 SCHEMATIC LAYOUT**

## POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the 844008I-46. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the 844008I-46 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  $V_{DD} = 2.5V + 5\% = 2.625V$ , which gives worst case results.

- Power (core)<sub>MAX</sub> =  $V_{DD\_MAX} * (I_{DD\_MAX} + I_{DDA\_MAX} + I_{DDO\_MAX}) = 2.625V * (60mA + 25mA + 140mA) = 590.625mW$

### 2. Junction Temperature.

Junction temperature, T<sub>j</sub>, is the temperature at the junction of the bond wire and bond pad and directly affects the reliability of the device. The maximum recommended junction temperature for HiPerClockS™ devices is 125°C.

The equation for T<sub>j</sub> is as follows:  $T_j = \theta_{JA} * Pd\_total + T_A$

T<sub>j</sub> = Junction Temperature

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

Pd<sub>total</sub> = Total Device Power Dissipation (example calculation is in section 1 above)

T<sub>A</sub> = 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°C/W per Table 7 below.

Therefore, T<sub>j</sub> for an ambient temperature of 85°C with all outputs switching is:  
 $85°C + 0.591W * 37°C/W = 106.8°C$ . This is well below the limit of 125°C.

This calculation is only an example. T<sub>j</sub> will obviously vary depending on the number of loaded outputs, supply voltage, air flow, and the type of board (single layer or multi-layer).

**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	37.0°C/W	32.4°C/W	29.0°C/W

## RELIABILITY INFORMATION

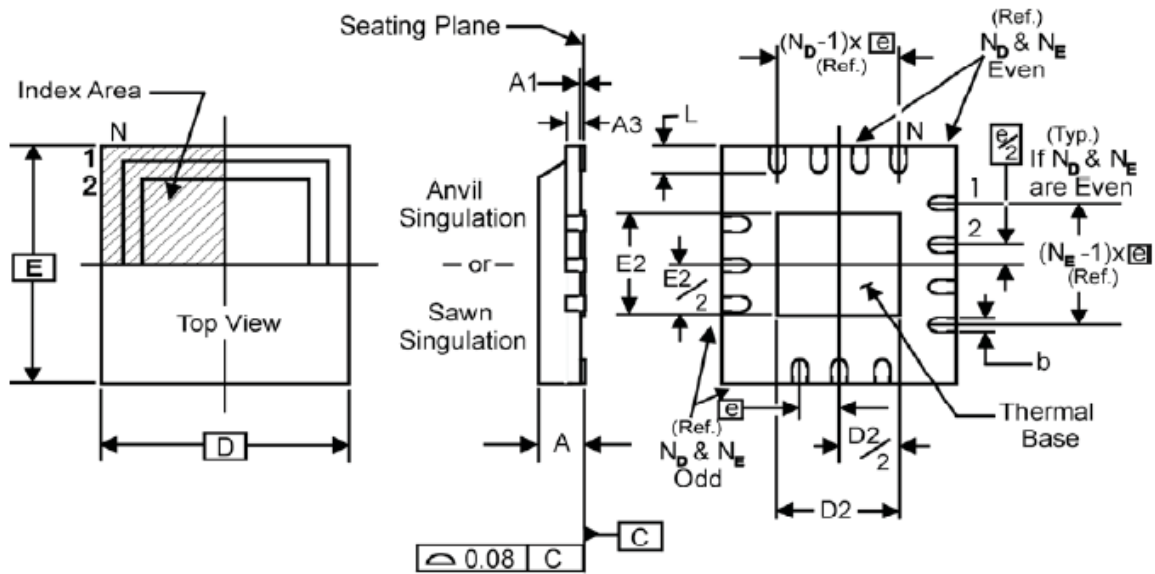
TABLE 8.  $\theta_{JA}$  vs. AIR FLOW TABLE FOR 32 LEAD VFQFN

$\theta_{JA}$ vs. Air Flow (Meters per Second)			
	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	37.0°C/W	32.4°C/W	29.0°C/W

### TRANSISTOR COUNT

The transistor count for 844008I-46 is: 2993

PACKAGE OUTLINE - K SUFFIX FOR 32 LEAD VFQFN



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 below.

TABLE 9. PACKAGE DIMENSIONS

JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS (VHHD -2/ -4)		
SYMBOL	Minimum	Maximum
N	32	
A	0.80	1.0
A1	0	0.05
A3	0.25 Reference	
b	0.18	0.30
e	0.50 BASIC	
N <sub>D</sub>	8	
N <sub>E</sub>	8	
D, E	5.0 BASIC	
D2, E2	3.0	3.3
L	0.30	0.50

Reference Document: JEDEC Publication 95, MO-220

**TABLE 10. ORDERING INFORMATION**

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
844008AKI-46LF	ICS008AI46L	32 Lead "Lead-Free" VFQFN	Tray	-40°C to 85°C
844008AKI-46LFT	ICS008AI46L	32 Lead "Lead-Free" VFQFN	1000 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.

**REVISION HISTORY SHEET**

<b>Rev</b>	<b>Table</b>	<b>Page</b>	<b>Description of Change</b>	<b>Date</b>
A		1	Product Discontinuation Notice - Last time buy expires November 2, 2016. PDN# CQ-15-05	11/6/15





## IMPORTANT NOTICE AND DISCLAIMER

RENESAS ELECTRONICS CORPORATION AND ITS SUBSIDIARIES (“RENESAS”) PROVIDES TECHNICAL SPECIFICATIONS AND RELIABILITY DATA (INCLUDING DATASHEETS), DESIGN RESOURCES (INCLUDING REFERENCE DESIGNS), APPLICATION OR OTHER DESIGN ADVICE, WEB TOOLS, SAFETY INFORMATION, AND OTHER RESOURCES “AS IS” AND WITH ALL FAULTS, AND DISCLAIMS ALL WARRANTIES, EXPRESS OR IMPLIED, INCLUDING, WITHOUT LIMITATION, ANY IMPLIED WARRANTIES OF MERCHANTABILITY, FITNESS FOR A PARTICULAR PURPOSE, OR NON-INFRINGEMENT OF THIRD PARTY INTELLECTUAL PROPERTY RIGHTS.

These resources are intended for developers skilled in the art designing with Renesas products. You are solely responsible for (1) selecting the appropriate products for your application, (2) designing, validating, and testing your application, and (3) ensuring your application meets applicable standards, and any other safety, security, or other requirements. These resources are subject to change without notice. Renesas grants you permission to use these resources only for development of an application that uses Renesas products. Other reproduction or use of these resources is strictly prohibited. No license is granted to any other Renesas intellectual property or to any third party intellectual property. Renesas disclaims responsibility for, and you will fully indemnify Renesas and its representatives against, any claims, damages, costs, losses, or liabilities arising out of your use of these resources. Renesas' products are provided only subject to Renesas' Terms and Conditions of Sale or other applicable terms agreed to in writing. No use of any Renesas resources expands or otherwise alters any applicable warranties or warranty disclaimers for these products.

(Rev.1.0 Mar 2020)

### Corporate Headquarters

TOYOSU FORESIA, 3-2-24 Toyosu,  
Koto-ku, Tokyo 135-0061, Japan  
[www.renesas.com](http://www.renesas.com)

### Contact Information

For further information on a product, technology, the most up-to-date version of a document, or your nearest sales office, please visit:  
[www.renesas.com/contact/](http://www.renesas.com/contact/)

### Trademarks

Renesas and the Renesas logo are trademarks of Renesas Electronics Corporation. All trademarks and registered trademarks are the property of their respective owners.