

**GENERAL DESCRIPTION**

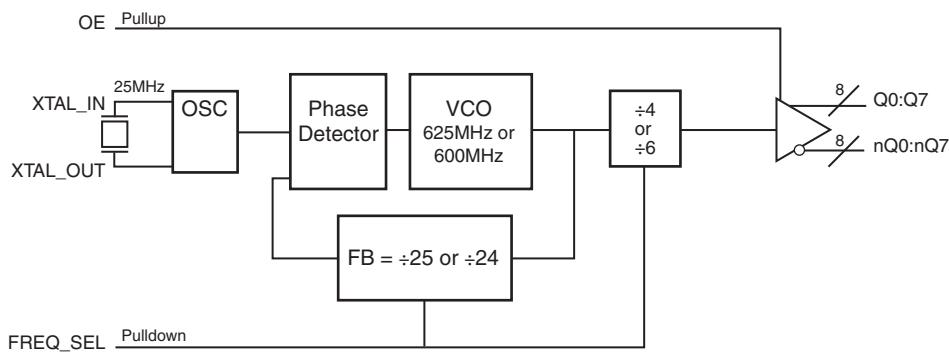
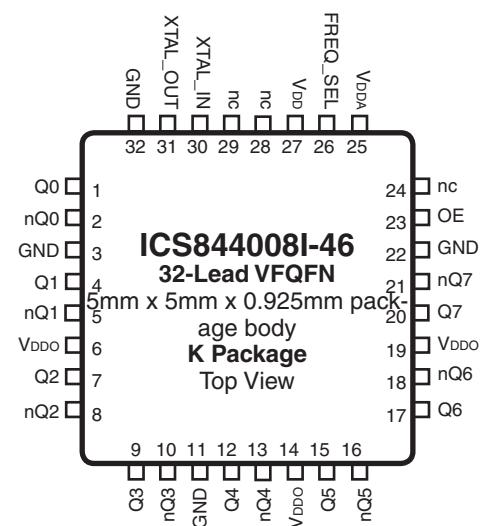
The 844008I-46 is a 10Gb Ethernet Clock Generator and a member of the HiPerClocks™ family of high performance devices from IDT. The 844008I-46 can synthesize 156.25MHz or 100MHz with a 25MHz crystal. It has a total of 8 LVDS outputs. The 844008I-46 has excellent phase jitter performance and is packaged 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	$V_{DDO}$	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	$V_{DDA}$	Power		Analog supply pin.
26	FREQ_SEL	Input	Pulldown	Frequency select pin. LVCMOS/LVTTL interface levels.
27	$V_{DD}$	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
$C_{IN}$	Input Capacitance			4		pF
$R_{PULLDOWN}$	Input Pulldown Resistor			51		k $\Omega$
$R_{PULLUP}$	Input Pullup Resistor			51		k $\Omega$

**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,  $V_{DD} = V_{DDO} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$ 

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

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

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	Ω
Shunt Capacitance				7	pF
Drive Level				300	μW

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  $85^\circ\text{C}$ 

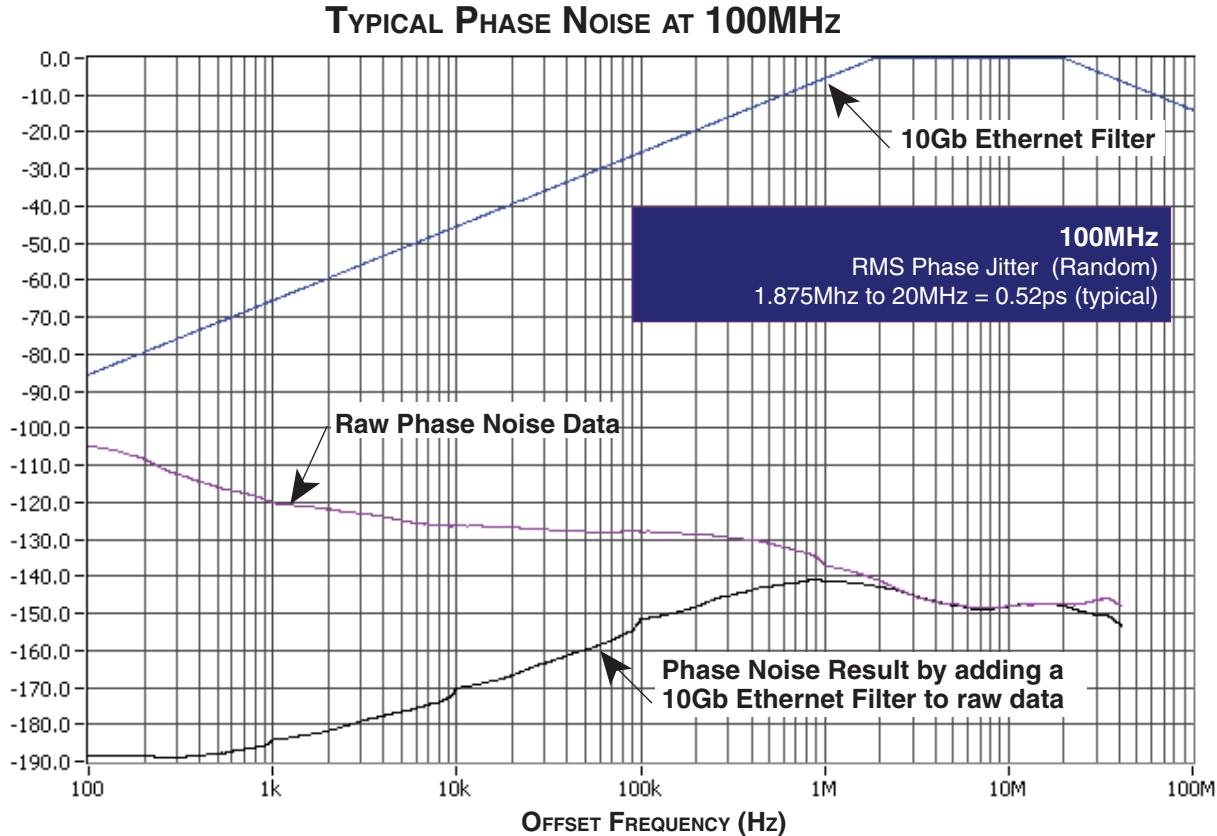
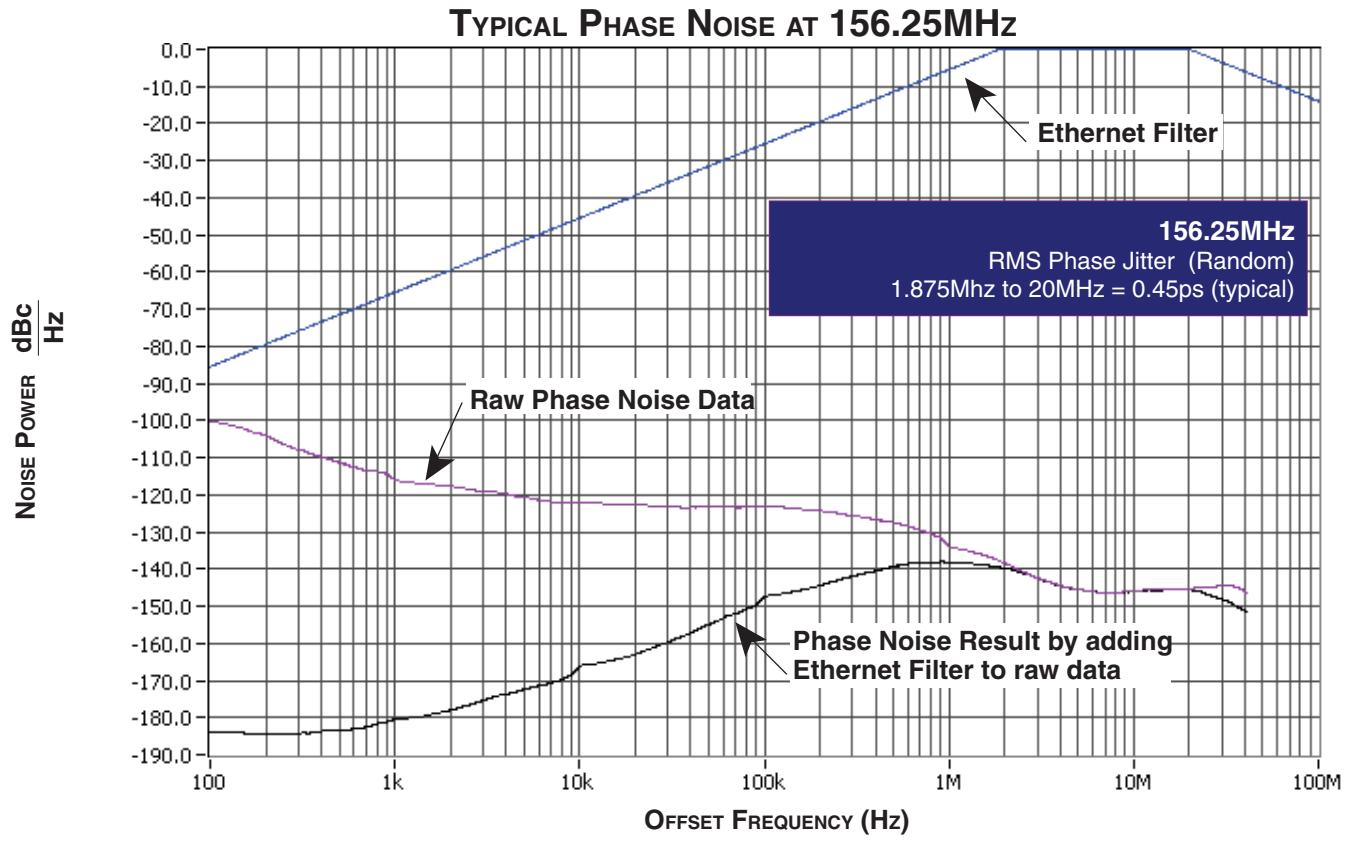
Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{out}$	Output Frequency	FREQ_SEL = 0		156.25		MHz
		FREQ_SEL = 1		100		MHz
$tsk(o)$	Output Skew; NOTE 1, 2				75	ps
$t_{jit(cc)}$	Cycle-to-Cycle Jitter				20	ps
$t_{jit(\emptyset)}$	RMS Phase Jitter (Random); NOTE 3	156.25MHz (1.875MHz - 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.

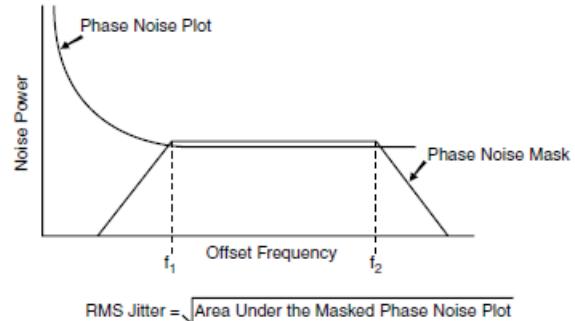
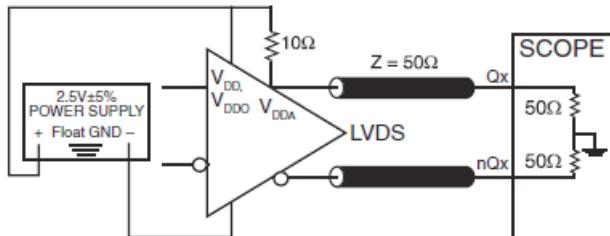
Measured at the differential cross points.

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

NOTE 3: Please refer to the Phase Noise Plot.

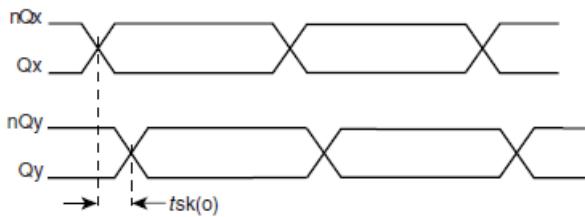
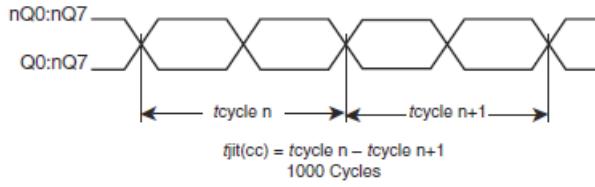


# PARAMETER MEASUREMENT INFORMATION



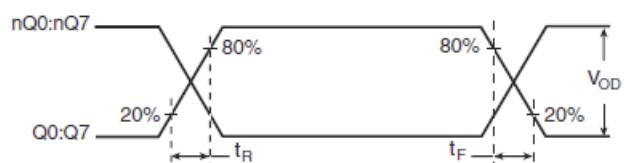
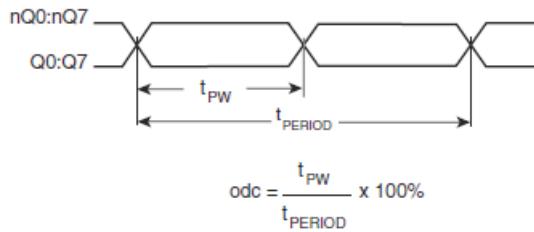
2.5V LVDS OUTPUT LOAD AC TEST CIRCUIT

RMS PHASE JITTER



CYCLE-TO-CYCLE JITTER

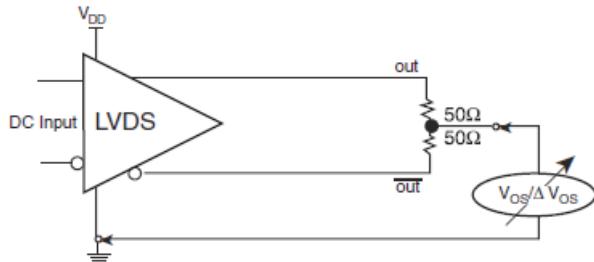
OUTPUT SKEW



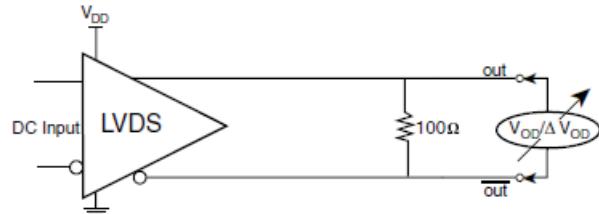
OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD

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 844008I-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  $0.01\mu F$  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  $10\Omega$  resistor along with a  $10\mu F$  bypass capacitor be connected to the  $V_{DDA}$  pin.

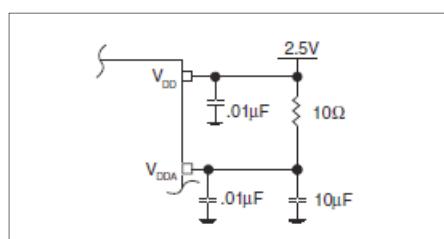


FIGURE 1. POWER SUPPLY FILTERING

## 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  $1\text{k}\Omega$  resistor can be used.

### OUTPUTS:

#### LVDS OUTPUTS

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

## CRYSTAL INPUT INTERFACE

The 844008I-46 has been characterized with an  $18\text{pF}$  parallel resonant crystals. The capacitor values shown in

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

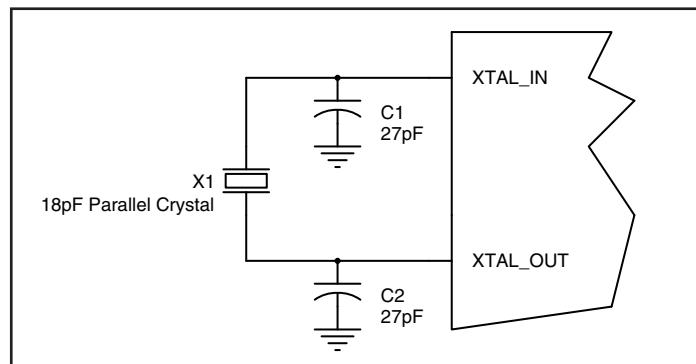


FIGURE 2. CRYSTAL INPUT INTERFACE

## 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  $10\text{ns}$ . 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 ( $\text{Ro}$ ) plus the series resistance ( $\text{Rs}$ ) equals the transmission line impedance. In addition, matched termination at the crystal input will attenuate the signal in half. This can be done in one of two ways. First,  $\text{R1}$  and  $\text{R2}$  in parallel should equal the transmission line impedance. For most  $50\Omega$  applications,  $\text{R1}$  and  $\text{R2}$  can be  $100\Omega$ . This can also be accomplished by removing  $\text{R1}$  and making  $\text{R2}$   $50\Omega$ .

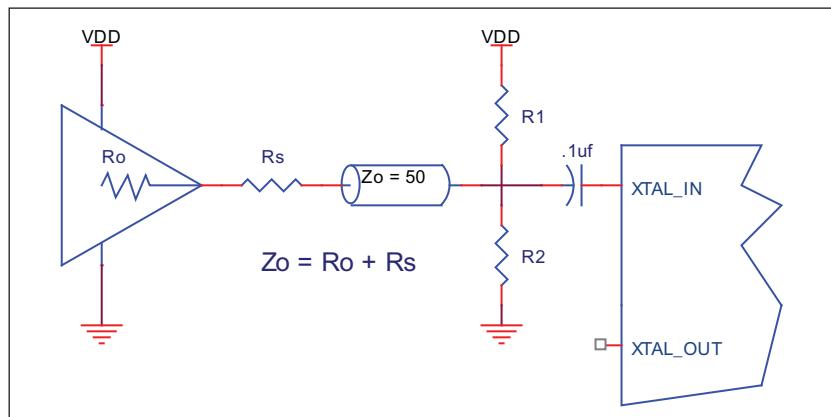


FIGURE 3. GENERAL DIAGRAM FOR LVC MOS DRIVER TO XTAL INPUT INTERFACE

## 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 Leadfame Base Package, Amkor Technology.

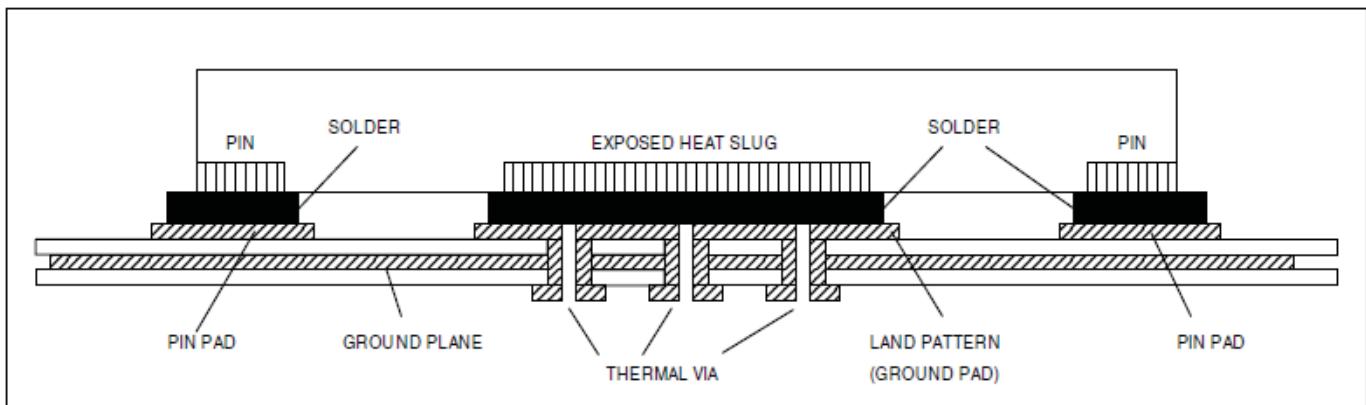


FIGURE 4. P.C. ASSEMBLY FOR EXPOSED PAD THERMAL RELEASE PATH – SIDE VIEW (DRAWING NOT TO SCALE)

## 2.5V LVDS DRIVER TERMINATION

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

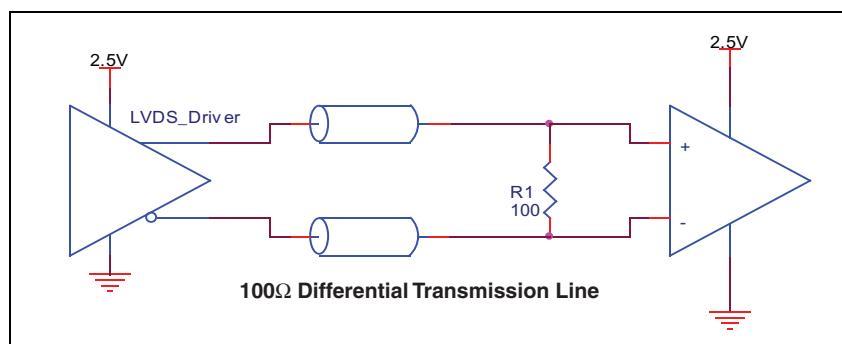


FIGURE 5. TYPICAL LVDS DRIVER TERMINATION

## 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.

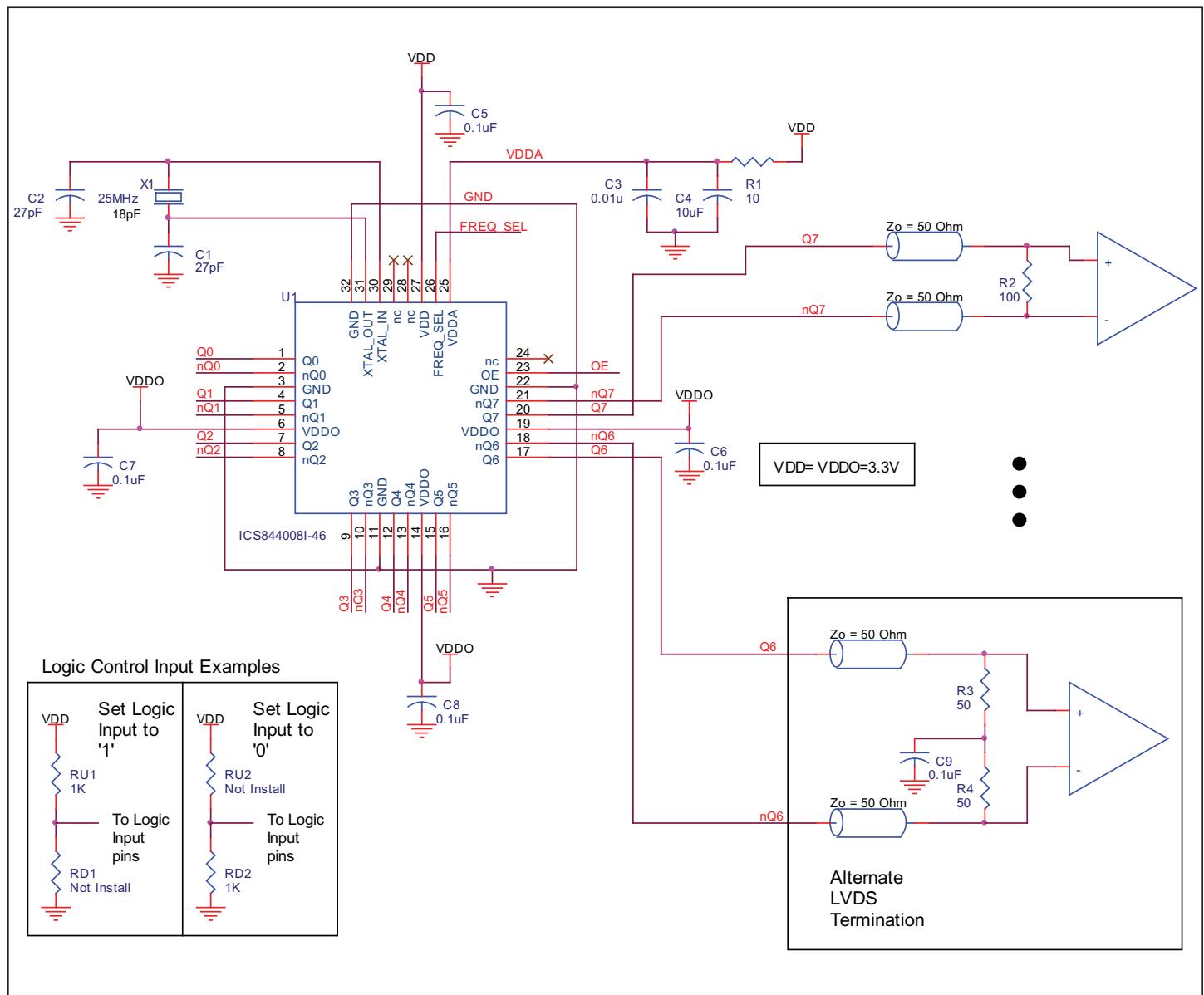


FIGURE 6. 844008I-46 SCHEMATIC LAYOUT

## 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,  $T_j$ , 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  $T_j$  is as follows:  $T_j = \theta_{JA} * P_{d\_total} + T_A$

$T_j$  = Junction Temperature

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

$P_{d\_total}$  = 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°C/W per Table 7 below.

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

$$85^\circ\text{C} + 0.591\text{W} * 37^\circ\text{C/W} = 106.8^\circ\text{C}$$

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 (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)			
Multi-Layer PCB, JEDEC Standard Test Boards	0 37.0°C/W	1 32.4°C/W	2.5 29.0°C/W

## RELIABILITY INFORMATION

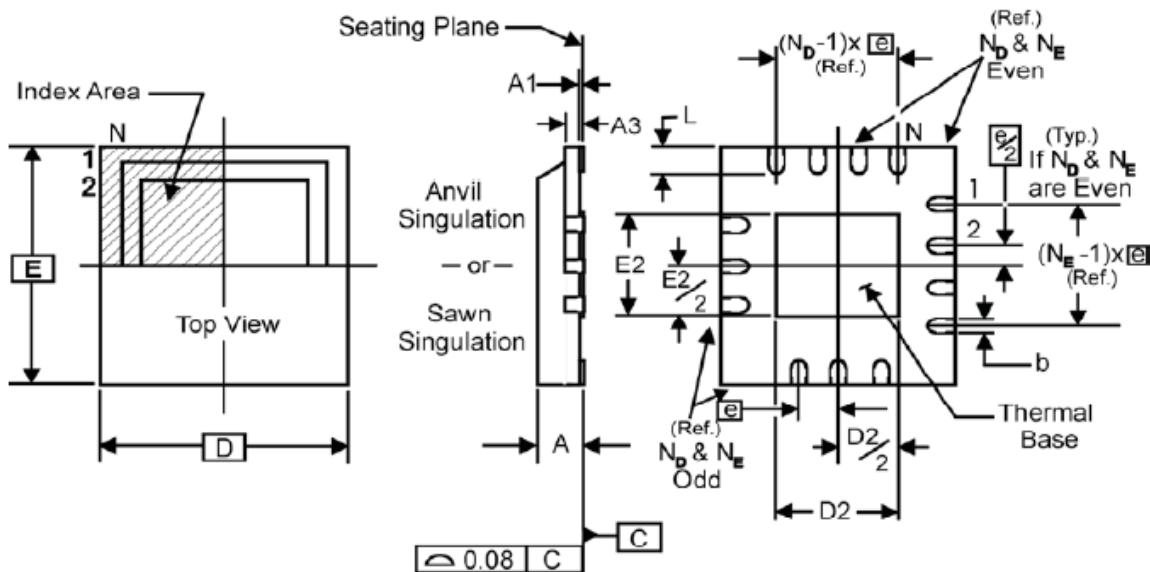
TABLE 8.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 32 LEAD VFQFN

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

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



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

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