



# FEMTOCLOCK® CRYSTAL-TO-LVDS CLOCK GENERATOR

ICS844251-14

## General Description

The ICS844251-14 is an Ethernet Clock Generator. The ICS844251-14 uses an 18pF parallel resonant crystal over the range of 23.2MHz – 30MHz. For Ethernet applications, a 25MHz crystal is used. The device has excellent <1ps phase jitter performance, over the 1.875MHz – 20MHz integration range. The ICS844251-14 is packaged in a small 8-pin TSSOP, making it ideal for use in systems with limited board space.

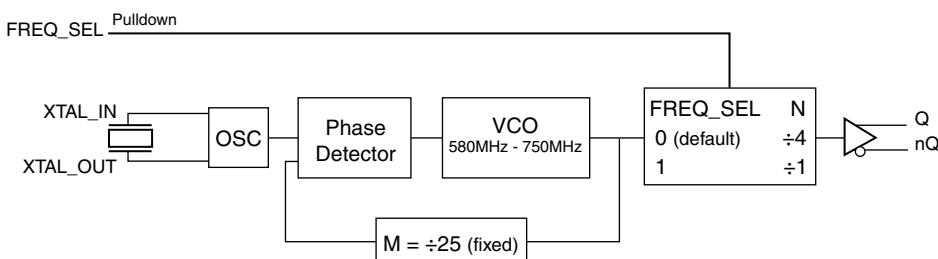
## Features

- One differential LVDS output pair
- Crystal oscillator interface designed for 18pF, parallel resonant crystal (23.2MHz – 30MHz)
- Output frequency ranges: 145MHz – 187.5MHz and 580MHz – 750MHz
- VCO range: 580MHz – 750MHz
- RMS phase jitter at 156.25MHz, using a 25MHz crystal (1.875MHz – 20MHz): 0.53ps (typical)
- Full 3.3V or 2.5V output supply modes
- 0°C to 70°C ambient operating temperature
- Available in lead-free (RoHS 6) package

Common Configuration Table

Inputs					Output Frequency Range (MHz)
Crystal Frequency (MHz)	FREQ_SEL	M	N	Multiplication Value M/N	
25	1	25	1	25	625
26.67	1	25	1	25	666.67
25 (default)	0	25	4	6.25	156.25

## Block Diagram



## Pin Assignment

VDDA	1	8	VDD
GND	2	7	Q
XTAL_OUT	3	6	nQ
XTAL_IN	4	5	FREQ_SEL

**ICS844251-14**

**8 Lead TSSOP**

**4.40mm x 3.0mm x 0.925mm  
package body**

**G Package**

**Top View**

**Table 1. Pin Descriptions**

Number	Name	Type		Description
1	V <sub>DDA</sub>	Output		Analog supply pin.
2	GND	Power		Power supply ground.
3, 4	XTAL_OUT XTAL_IN	Input		Crystal oscillator interface. XTAL_IN is the input, XTAL_OUT is the output.
5	FREQ_SEL	Input	Pulldown	Frequency select pin. LVCMOS/LVTTL interface levels.
6, 7	nQ, Q	Output		Differential output pair. LVDS interface levels.
8	V <sub>DD</sub>	Power		Core supply pin.

NOTE: *Pullup* refers 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

## 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, $I_O$ Continuous Current Surge Current	10mA 15mA
Package Thermal Impedance, $\theta_{JA}$	129.5°C/W (0 mps)
Storage Temperature, $T_{STG}$	-65°C to 150°C

## DC Electrical Characteristics

**Table 3A. Power Supply DC Characteristics,  $V_{DD} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

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		$V_{DD} - 0.10$	3.3	$V_{DD}$	V
$I_{DD}$	Power Supply Current				100	mA
$I_{DDA}$	Analog Supply Current				10	mA

**Table 3B. Power Supply DC Characteristics,  $V_{DD} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

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		$V_{DD} - 0.10$	2.5	$V_{DD}$	V
$I_{DD}$	Power Supply Current				95	mA
$I_{DDA}$	Analog Supply Current				10	mA

**Table 3C. LVCMOS/LVTTL DC Characteristics,  $V_{DD} = 3.3V \pm 5\%$  or  $2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{IH}$	Input High Voltage	$V_{DD} = 3.465V$	2		$V_{DD} + 0.3$	V
		$V_{DD} = 2.625V$	1.7		$V_{DD} + 0.3$	V
$V_{IL}$	Input Low Voltage	$V_{DD} = 3.465V$	-0.3		0.8	V
		$V_{DD} = 2.625V$	-0.3		0.7	V
$I_{IH}$	Input High Current	$V_{DD} = V_{IN} = 3.465V$ or $2.625V$			150	$\mu A$
$I_{IL}$	Input Low Current	$V_{DD} = 3.465V$ or $2.625V$ , $V_{IN} = 0V$	-5			$\mu A$

**Table 3D. LVDS DC Characteristics,  $V_{DD} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $70^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{OD}$	Differential Output Voltage		247		454	mV
$\Delta V_{OD}$	$V_{OD}$ Magnitude Change				50	mV
$V_{OS}$	Offset Voltage		1.275		1.525	V
$\Delta V_{OS}$	$V_{OS}$ Magnitude Change				50	mV

**Table 3E. LVDS DC Characteristics,  $V_{DD} = V_{DDA} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $70^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{OD}$	Differential Output Voltage		247		454	mV
$\Delta V_{OD}$	$V_{OD}$ Magnitude Change				50	mV
$V_{OS}$	Offset Voltage		1.0		1.4	V
$\Delta V_{OS}$	$V_{OS}$ Magnitude Change				50	mV

**Table 4. Crystal Characteristics**

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation		Fundamental			
Frequency		23.2		30	MHz
Equivalent Series Resistance (ESR)				50	$\Omega$
Shunt Capacitance				7	pF

NOTE: It is not recommended to overdrive the crystal input with an external clock.

## AC Electrical Characteristics

**Table 5A. AC Characteristics,  $V_{DD} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

Parameter	Symbol	Test Conditions	Minimum	Typical	Maximum	Units
$f_{OUT}$	Output Frequency	FREQ_SEL = 0	145		187.5	MHz
		FREQ_SEL = 1	580		750	MHz
$f_{jit}(\emptyset)$	RMS Phase Jitter, Random; NOTE 1	156.25MHz, Integration Range: 1.875MHz – 20MHz		0.53		ps
		625MHz, Integration Range: 1.875MHz – 20MHz		0.45		ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	70		550	ps
odc	Output Duty Cycle	FREQ_SEL = 0	48		52	%
		FREQ_SEL = 1	46		54	%

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

NOTE 1: Please refer to Phase Noise Plots.

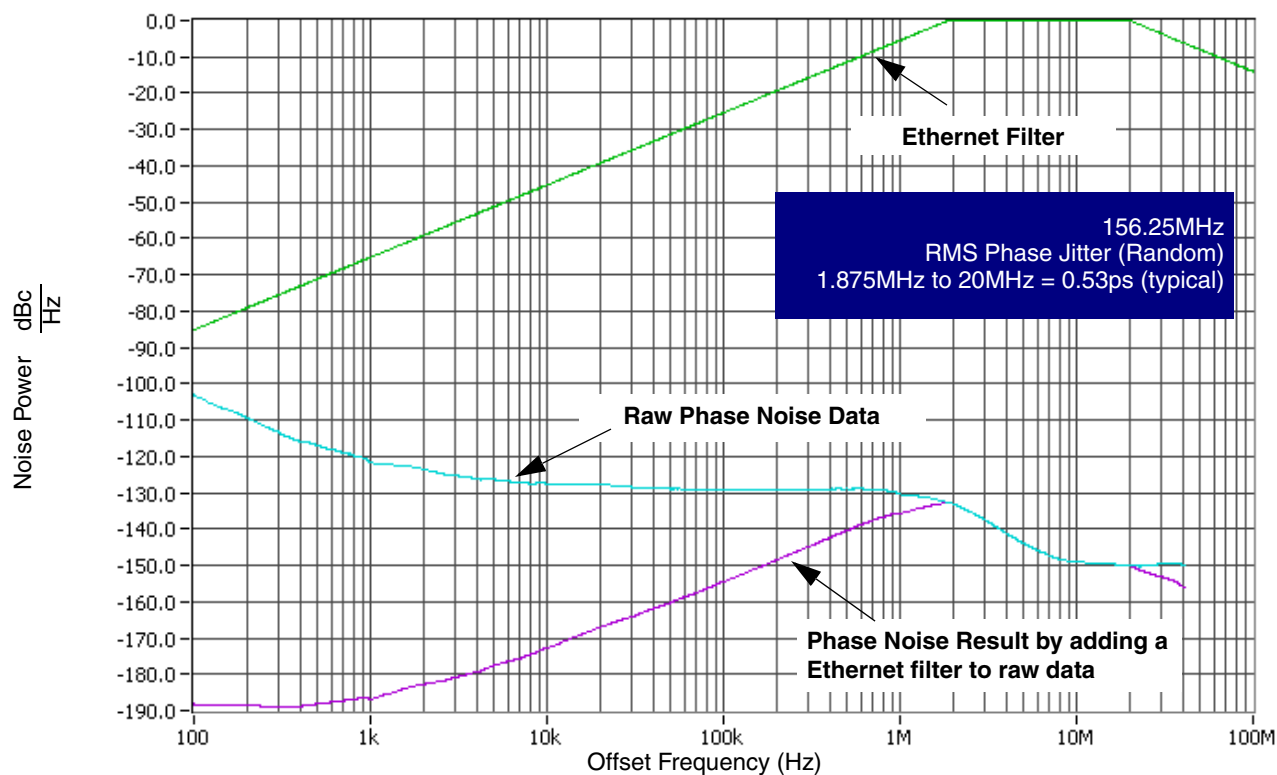
**Table 5B. AC Characteristics,  $V_{DD} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  to  $70^\circ C$**

Parameter	Symbol	Test Conditions	Minimum	Typical	Maximum	Units
$f_{OUT}$	Output Frequency	FREQ_SEL = 0	145		187.5	MHz
		FREQ_SEL = 1	580		750	MHz
$f_{jit}(\emptyset)$	RMS Phase Jitter, Random; NOTE 1	156.25MHz, Integration Range: 1.875MHz – 20MHz		0.54		ps
		625MHz, Integration Range: 1.875MHz – 20MHz		0.45		ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	70		550	ps
odc	Output Duty Cycle	FREQ_SEL = 0	48		52	%
		FREQ_SEL = 1	46		54	%

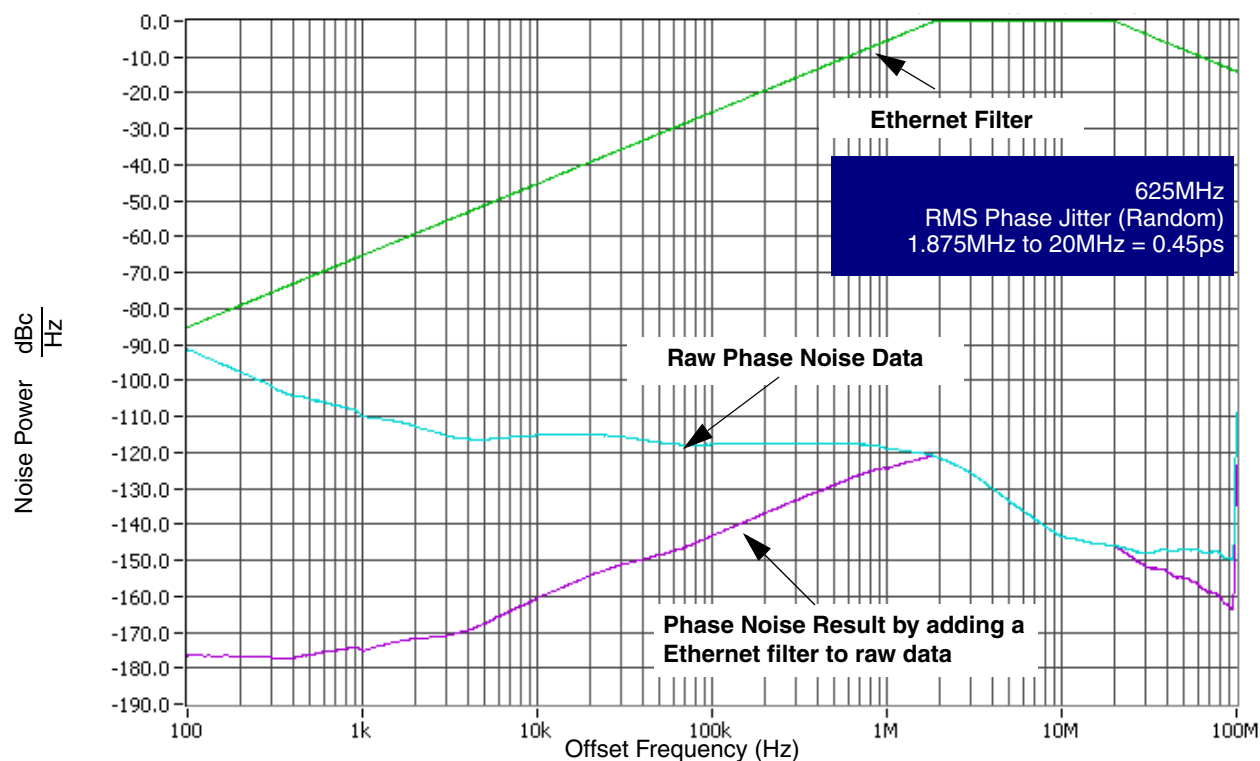
NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lfpm. The device will meet specifications after thermal equilibrium has been reached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

NOTE 1: Please refer to Phase Noise Plots.

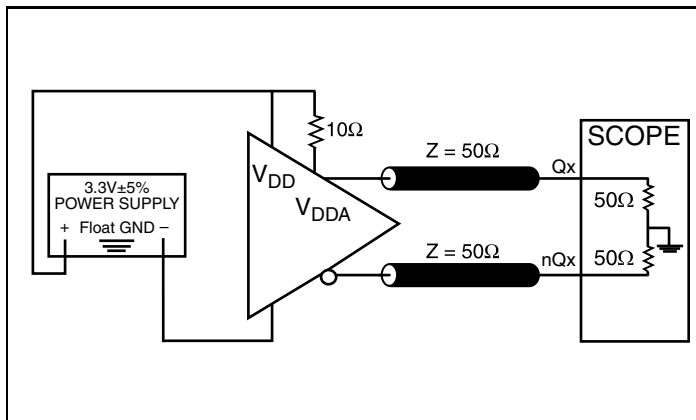
## Typical Phase Noise at 156.25MHz (3.3V)



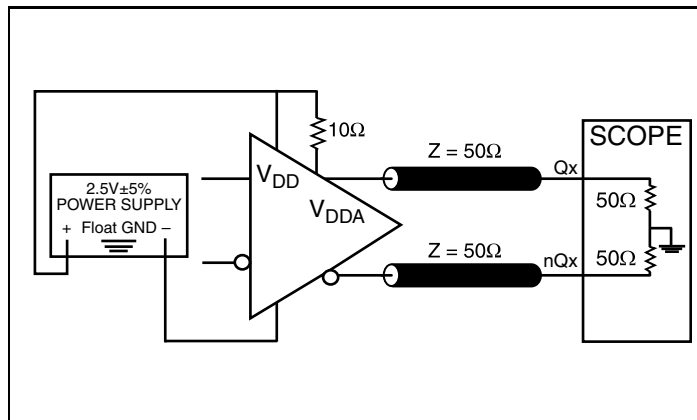
## Typical Phase Noise at 625MHz (3.3V)



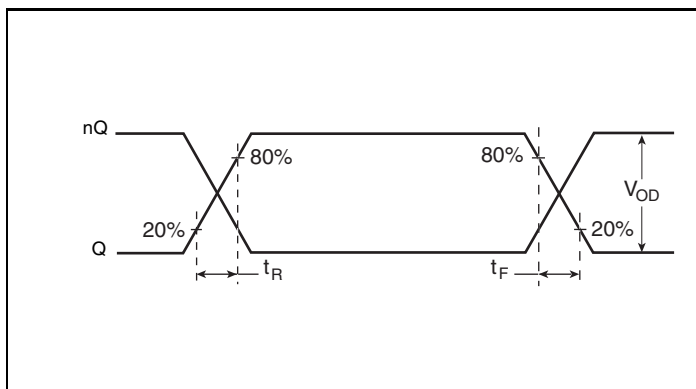
## Parameter Measurement Information



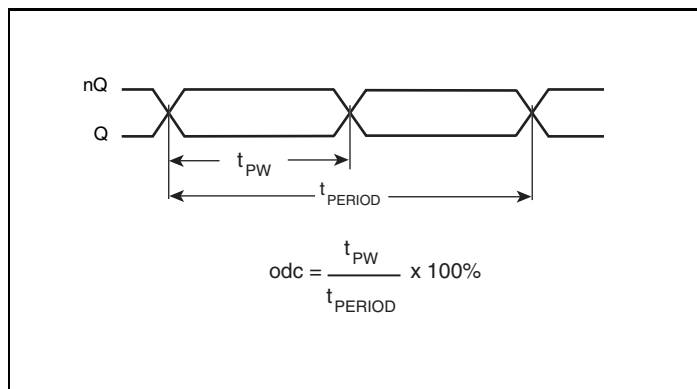
3.3V LVDS Output Load AC Test Circuit



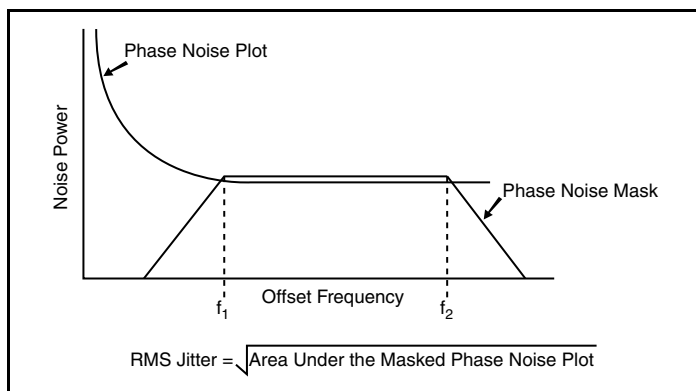
2.5V LVDS Output Load AC Test Circuit



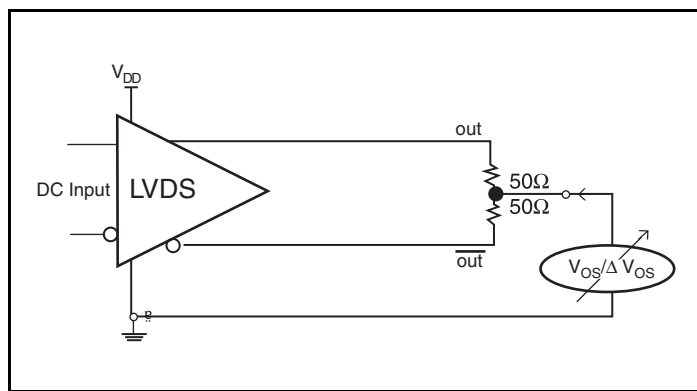
Output Rise/Fall Time



Output Duty Cycle/Pulse Width/Period

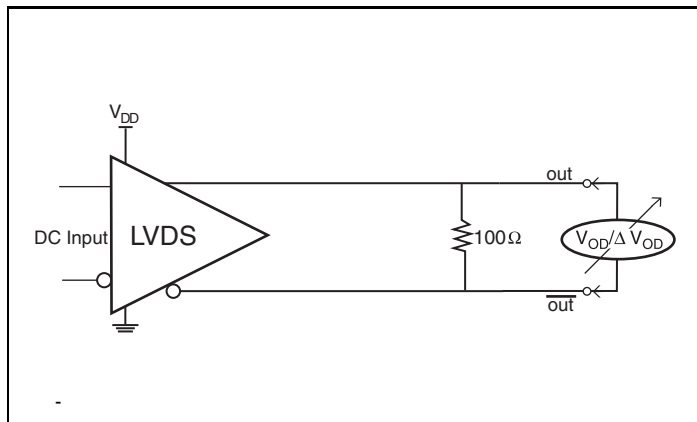


RMS Phase Jitter



OFFSET VOLTAGE SETUP

## Parameter Measurement Information, continued



DIFFERENTIAL OUTPUT VOLTAGE SETUP

## Application 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 ICS844251-14 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{DD}$  and  $V_{DDA}$  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  $V_{DD}$  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.

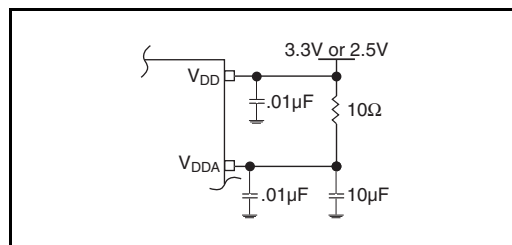


Figure 1. Power Supply Filtering

### Crystal Input Interface

The ICS844251-14 has been characterized with 18pF parallel resonant crystals. The capacitor values, C1 and C2, shown in *Figure 2* below were determined using a 25MHz, 18pF 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.

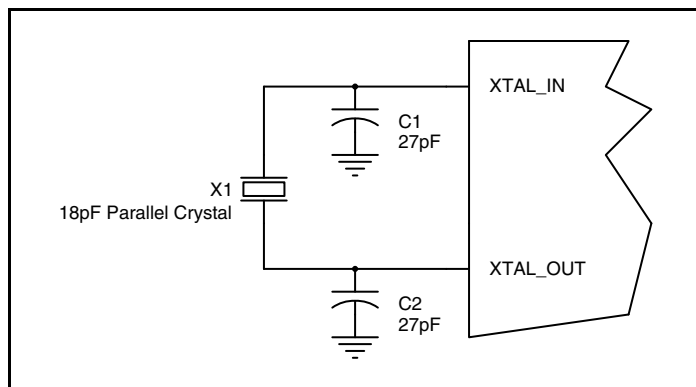


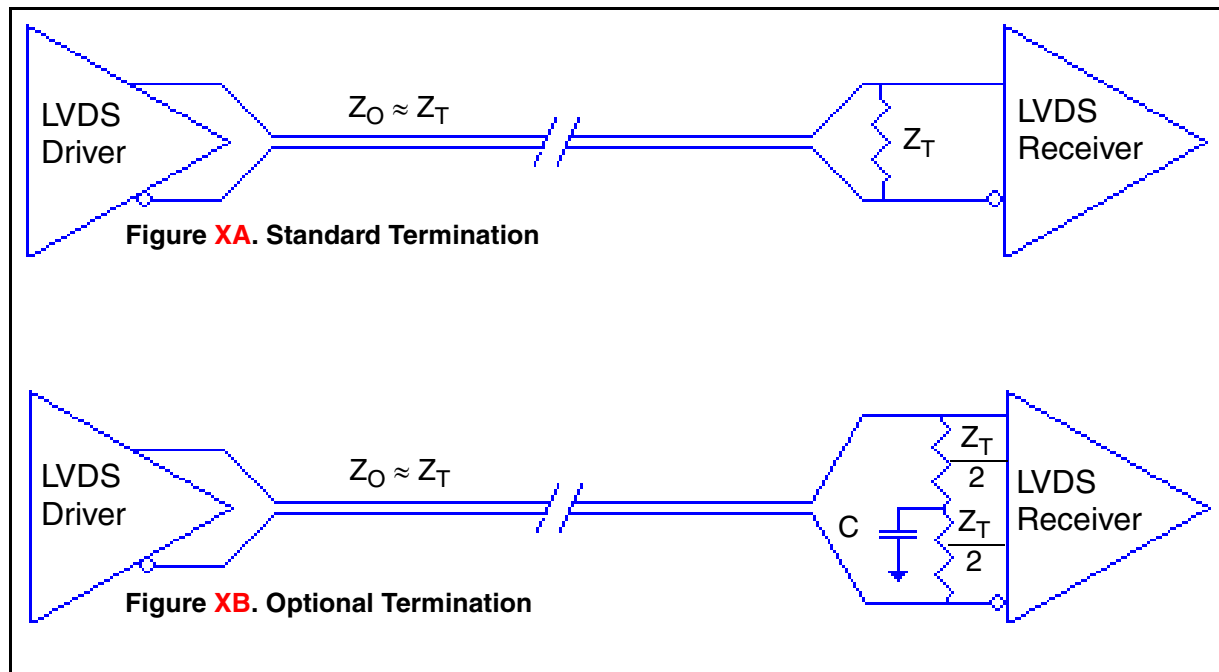
Figure 2. Crystal Input Interface



## LVDS Driver Termination

For a general LVDS interface, the recommended value for the termination impedance ( $Z_T$ ) is between  $90\Omega$  and  $132\Omega$ . The actual value should be selected to match the differential impedance ( $Z_0$ ) of your transmission line. A typical point-to-point LVDS design uses a  $100\Omega$  parallel resistor at the receiver and a  $100\Omega$  differential transmission-line environment. In order to avoid any transmission-line reflection issues, the components should be surface mounted and must be placed as close to the receiver as possible. IDT offers a full line of LVDS compliant devices with two types of output structures: current source and voltage source type. The standard

termination schematic as shown in *Figure XA* can be used with either type of output structure. *Figure XB*, which can also be used with both output types, is an optional termination with center tap capacitance to help filter common mode noise. The capacitor value should be approximately  $50\text{pF}$ . If using a non-standard termination, it is recommended to contact IDT and confirm if the output structure is current source or voltage source type. In addition, since these outputs are LVDS compatible, the input receiver's amplitude and common-mode input range should be verified for compatibility with the output.



LVDS Termination

## Schematic Example

Figure 5 shows an example of ICS844251-14 application schematic. In this example, the device is operated at  $V_{DD} = 3.3V$ . The decoupling capacitor should be located as close as possible to the power pin. The 18pF parallel resonant 25MHz crystal is used. The  $C1 = 27pF$  and  $C2 = 27pF$  are recommended for

frequency accuracy. For different board layouts, the  $C1$  and  $C2$  may be slightly adjusted for optimizing frequency accuracy. For the LVDS output drivers, place a  $100\Omega$  resistor as close to the receiver as possible.

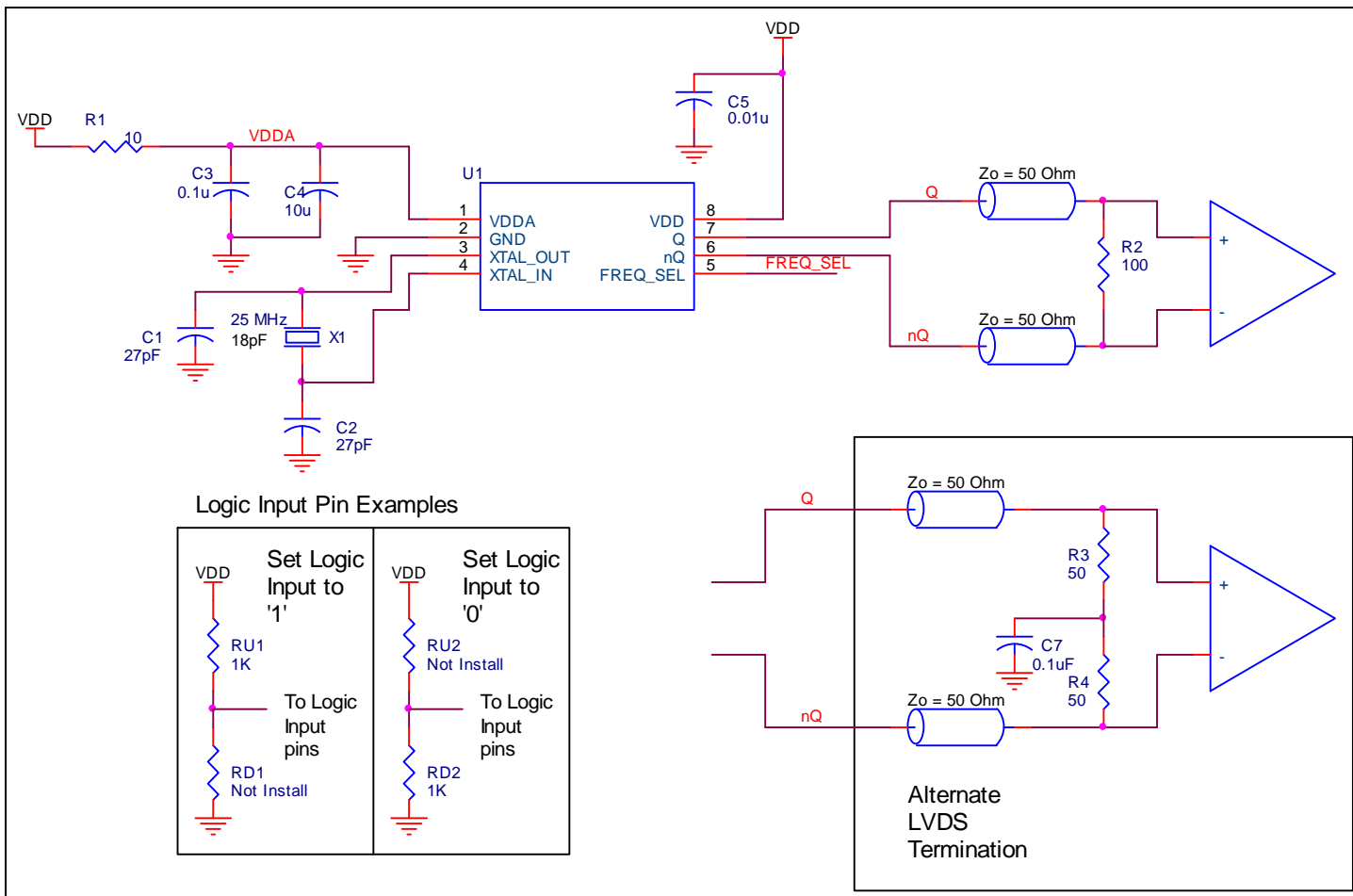


Figure 5. ICS844251-14 Schematic Example

## Power Considerations

This section provides information on power dissipation and junction temperature for the ICS844251-14. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS844251-14 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.

NOTE: Please refer to Section 3 for details on calculating power dissipated in the load.

- Power (core)<sub>MAX</sub> =  $V_{DD\_MAX} * (I_{DD\_MAX} + I_{DDA\_MAX}) = 3.465V * (100mA + 10mA) = \mathbf{381.15mW}$

### 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 is 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 129.5°C/W per Table 6 below.

Therefore,  $T_j$  for an ambient temperature of 70°C with all outputs switching is:

$$70^\circ\text{C} + 0.381\text{W} * 129.5^\circ\text{C/W} = 119.3^\circ\text{C}. \text{ This is below the limit of } 125^\circ\text{C}.$$

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 (single layer or multi-layer).

**Table 6. Thermal Resistance  $\theta_{JA}$  for 8 Lead TSSOP, Forced Convection**

Meters per Second	$\theta_{JA}$ by Velocity		
	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	129.5°C/W	125.5°C/W	123.5°C/W

## Reliability Information

Table 7.  $\theta_{JA}$  vs. Air Flow Table for a 8 Lead TSSOP

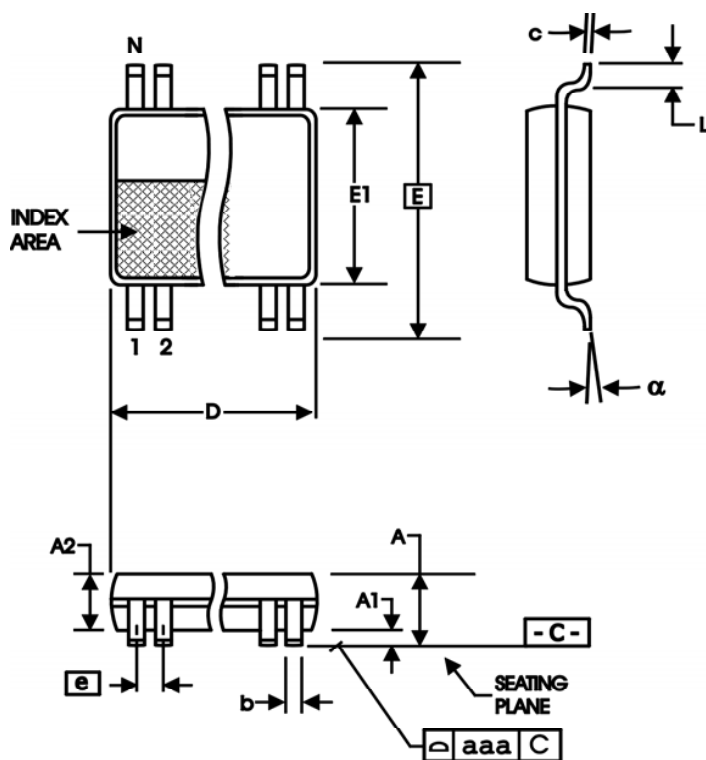
$\theta_{JA}$ vs. Air Flow			
Meters per Second	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	129.5°C/W	125.5°C/W	123.5°C/W

## Transistor Count

The transistor count for ICS844251-14 is: 2401

## Package Outline and Package Dimensions

Table 8. Package Dimensions



Package Outline - G Suffix for 8 Lead TSSOP

All Dimensions in Millimeters		
Symbol	Minimum	Maximum
N	8	
A		1.20
A1	0.5	0.15
A2	0.80	1.05
b	0.19	0.30
c	0.09	0.20
D	2.90	3.10
E	6.40 Basic	
E1	4.30	4.50
e	0.65 Basic	
L	0.45	0.75
α	0°	8°
aaa		0.10

Reference Document: JEDEC Publication 95, MO-153

## Ordering Information

Table 9. Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
844251BG-14	51B14	8 Lead TSSOP	Tube	0°C to 70°C
844251BG-14T	51B14	8 Lead TSSOP	Tape & Reel	0°C to 70°C
844251BG-14LF	1B14L	"Lead-Free" 8 Lead TSSOP	Tube	0°C to 70°C
844251BG-14LFT	1B14L	"Lead-Free" 8 Lead TSSOP	Tape & Reel	0°C to 70°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		11	Added schematic layout.	5/1/09
A	T4	1	Deleted HiPerClockS references throughout.	11/2/12
		4	Crystal Characteristics Table - added note.	
		8	Deleted application note, <i>LVC MOS to XTAL Interface</i> .	
		9	Updated Driver Termination Note.	
	T9	13	Deleted quantity from tape and reel. Deleted lead-free note.	

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