



FEMTOCLOCKS™ CRYSTAL-TO-LVDS FREQUENCY SYNTHESIZER

ICS844008I-15

GENERAL DESCRIPTION



The ICS844008I-15 is an 8 output LVDS Synthesizer optimized to generate PCI Express™ reference clock frequencies and is a member of the HiPerClocks™ family of high performance clock solutions from IDT. Using a 25MHz parallel resonant crystal, the following frequencies can be generated based on F_SEL pin: 100MHz or 125MHz. The ICS844008I-15 uses IDT's 3rd generation low phase noise VCO technology and can achieve <1ps typical rms phase jitter, easily meeting PCI Express jitter requirements. The ICS844008I-15 is packaged in a 32-pin LQFP package.

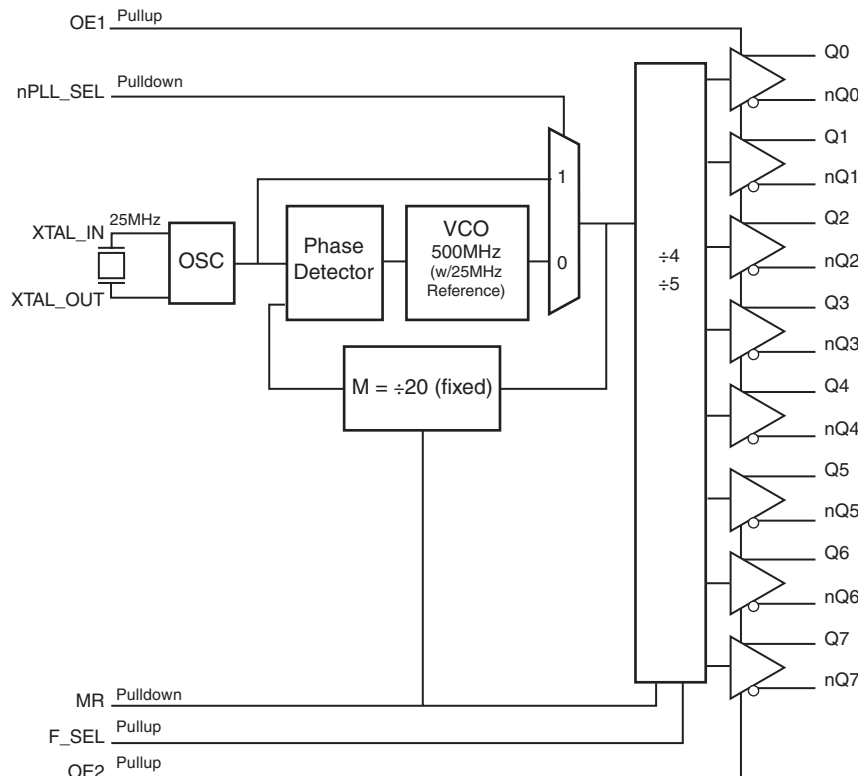
FEATURES

- Eight LVDS outputs
- Crystal oscillator interface
- Supports the following output frequencies: 100MHz or 125MHz
- VCO: 500MHz
- RMS phase jitter @ 125MHz, using a 25MHz crystal (1.875MHz - 20MHz): 0.42ps (typical)
- Full 3.3V supply modes
- -40°C to 85°C ambient operating temperature
- Available in both standard (RoHS 5) and lead-free (RoHS 6) packages

FREQUENCY SELECT FUNCTION TABLE

Input					Output Frequency (MHz)
Input Frequency (MHz)	F_SEL	M Divider Value	N Divider Value	M/N Divider Value	
25MHz	0	20	4	5	125
25MHz	1	20	5	4	100 (default)

BLOCK DIAGRAM



PIN ASSIGNMENT

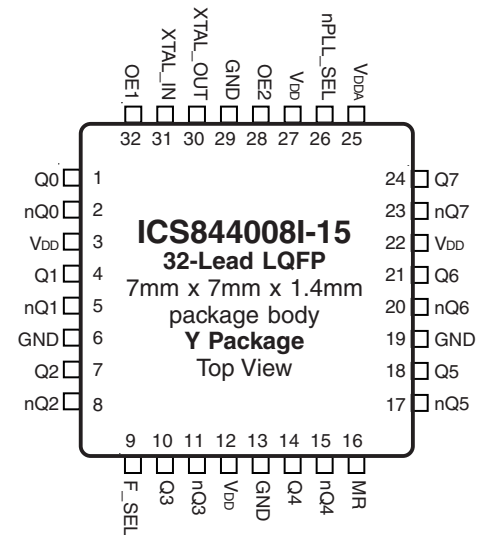


TABLE 1. PIN DESCRIPTIONS

Number	Name	Type		Description
1, 2	Q0, nQ0	Output		Differential output pair. LVDS interface levels.
3, 12, 22, 27	V _{DD}	Power		Core supply pin.
4, 5	Q1, nQ1	Output		Differential output pair. LVDS interface levels.
6, 13, 19, 29	GND	Power		Power supply ground.
7, 8	Q2, nQ2	Output		Differential output pair. LVDS interface levels.
9	F_SEL	Input	Pullup	Frequency select pin LVCMOS/LVTTL interface levels.
10, 11	Q3, nQ3	Output		Differential output pair. LVDS interface levels.
14, 15	Q4, nQ4	Output		Differential output pair. LVDS interface levels.
16	MR	Input	Pulldown	Active HIGH Master Reset. When logic HIGH, the internal dividers are reset causing the true outputs Qx to go low and the inverted outputs nQx to go high. When logic LOW, the internal dividers and the outputs are enabled. LVCMOS/LVTTL interface levels.
17, 18	nQ5, Q5	Output		Differential output pair. LVDS interface levels.
20, 21	nQ6, Q6	Output		Differential output pair. LVDS interface levels.
23, 24	nQ7, Q7	Output		Differential output pair. LVDS interface levels.
25	V _{DDA}	Power		Analog supply pin.
26	nPLL_SEL	Input	Pulldown	Selects between the PLL and XTAL as input to the dividers. When LOW, selects PLL (PLL Enable). When HIGH, selects the XTAL (PLL Bypass). LVCMOS/LVTTL interface levels.
28	OE2	Input	Pullup	Output enable for Q5/nQ5:Q7/nQ7 outputs. LVCMOS/LVTTL interface levels.
30, 31	XTAL_OUT, XTAL_IN	Input		Parallel resonant crystal interface. XTAL_OUT is the output, XTAL_IN is the input.
32	OE1	Input	Pullup	Output enable for Q0/nQ0:Q4/nQ4 outputs. LVCMOS/LVTTL interface levels.

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		kΩ
R _{PULLUP}	Input Pullup Resistor			51		kΩ

TABLE 3A. OE1 FUNCTION TABLE

Input	Outputs
OE1	Q0:Q4, nQ0:nQ4
0	Places outputs in Hi-Z state
1	Normal operation

TABLE 3B. OE2 FUNCTION TABLE

Input	Outputs
OE2	Q5:Q7, nQ5:nQ7
0	Places outputs in Hi-Z state
1	Normal operation

ABSOLUTE MAXIMUM RATINGS

Supply Voltage, V_{DD}	4.6V
Inputs, V_I	-0.5V to $V_{DD} + 0.5V$
Outputs, I_O	
Continuous Current	10mA
Surge Current	15mA
Package Thermal Impedance, θ_{JA}	65.7°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, $V_{DD} = V_{DDA} = 3.3V \pm 5\%$, $T_A = -40^\circ C$ TO $85^\circ C$

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		$V_{DD} - 0.15$	3.3	V_{DD}	V
I_{DD}	Power Supply Current				150	mA
I_{DDA}	Analog Supply Current				15	mA

TABLE 4B. LVCMOS / LVTTTL DC CHARACTERISTICS, $V_{DD} = V_{DDA} = 3.3V \pm 5\%$, $T_A = -40^\circ C$ TO $85^\circ C$

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{IH}	Input High Voltage	$V_{DD} = 3.3V$	2		$V_{DD} + 0.3$	V
V_{IL}	Input Low Voltage	$V_{DD} = 3.3V$	-0.3		0.8	V
I_{IH}	Input High Current	MR, nPLL_SEL	$V_{DD} = V_{IN} = 3.465$		150	μA
		OE1, OE2, F_SEL	$V_{DD} = V_{IN} = 3.465$		5	μA
I_{IL}	Input Low Current	MR, nPLL_SEL	$V_{DD} = 3.465V, V_{IN} = 0V$	-5		μA
		OE1, OE2, F_SEL	$V_{DD} = 3.465V, V_{IN} = 0V$	-150		μA

TABLE 4C. LVDS DC CHARACTERISTICS, $V_{DD} = V_{DDA} = 3.3V \pm 5\%$, $T_A = -40^\circ C$ TO $85^\circ C$

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{OD}	Differential Output Voltage		260	360	460	mV
ΔV_{OD}	V_{OD} Magnitude Change				50	mV
V_{OS}	Offset Voltage		1.2	1.3	1.5	V
ΔV_{OS}	V_{OS} Magnitude Change				50	mV
I_{OZ}	High Impedance Leakage Current		-10	± 1	10	μA
I_{OFF}	Power Off Leakage		-20	± 1	20	μA
I_{OSD}	Differential Output Short Circuit Current			-3.5	-5	mA
I_{OS}	Output Short Circuit Current			-3.5	-5	mA

TABLE 5. CRYSTAL CHARACTERISTICS

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation		Fundamental			
Frequency			25		MHz
Parts per Million (ppm); NOTE 1				100	ppm
Equivalent Series Resistance (ESR)				40	Ω
Shunt Capacitance				5	pF
Drive Level				100	μ W

NOTE: Characterized using an 18pF parallel resonant crystal.

NOTE 1: When used with recommended 50ppm crystal and external trim caps adjusted for user PC board.

TABLE 6. AC CHARACTERISTICS, $V_{DD} = V_{DDA} = 3.3V \pm 5\%$, $T_A = -40^\circ\text{C}$ TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{OUT}	Output Frequency	FSEL = 0		125		MHz
		FSEL = 1		100		MHz
$t_{sk(o)}$	Output Skew; NOTE 1, 2				110	ps
$t_{sk(b)}$	Bank Skew; NOTE 2, 3	Q0/nQ0:Q4/nQ4			50	ps
		Q5/nQ5:Q7/nQ7			50	ps
$f_{jit(cc)}$	Cycle-to-Cycle Jitter				25	ps
$f_{jit}(\emptyset)$	RMS Phase Jitter (Random); NOTE 4	125MHz, (1.875MHz - 20MHz)		0.42		ps
		100MHz, (1.875MHz - 20MHz)		0.46		ps
t_R / t_F	Output Rise/Fall Time	20% to 80%	100		600	ps
odc	Output Duty Cycle		45		55	%

Minimum and Maximum values are design target specs.

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

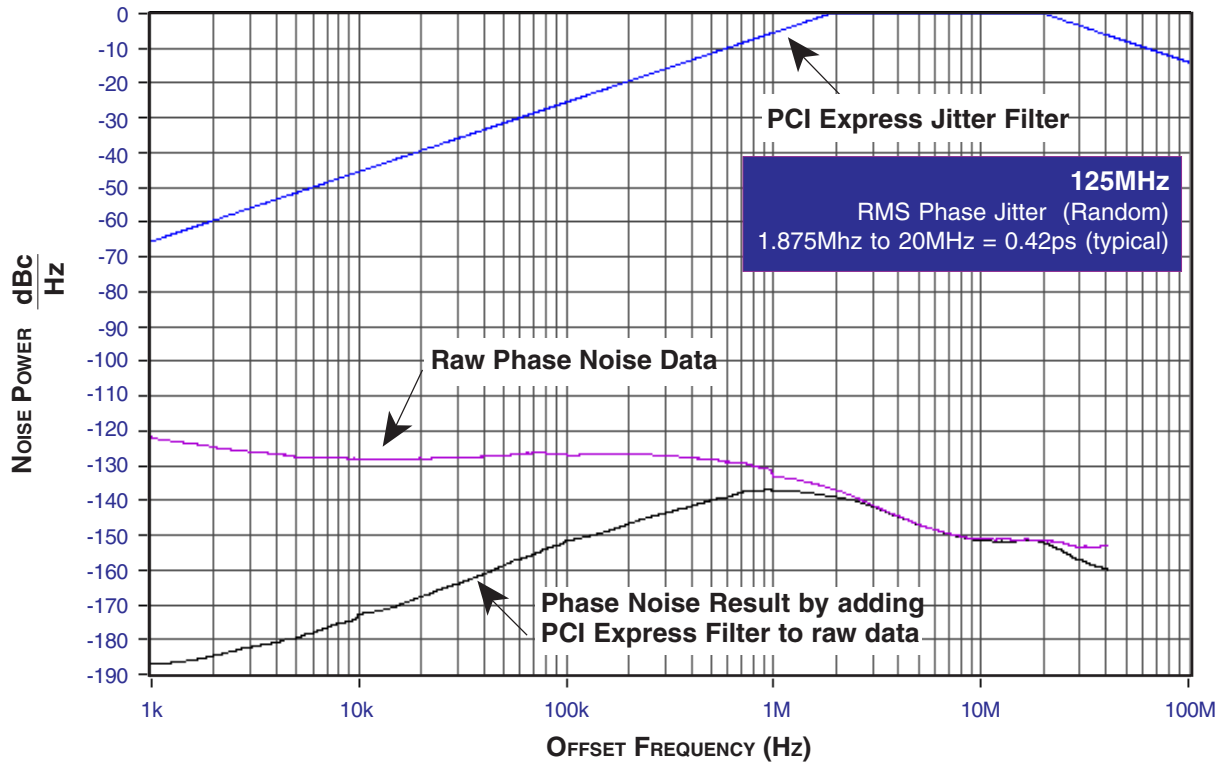
Measured at $V_{DD}/2$.

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

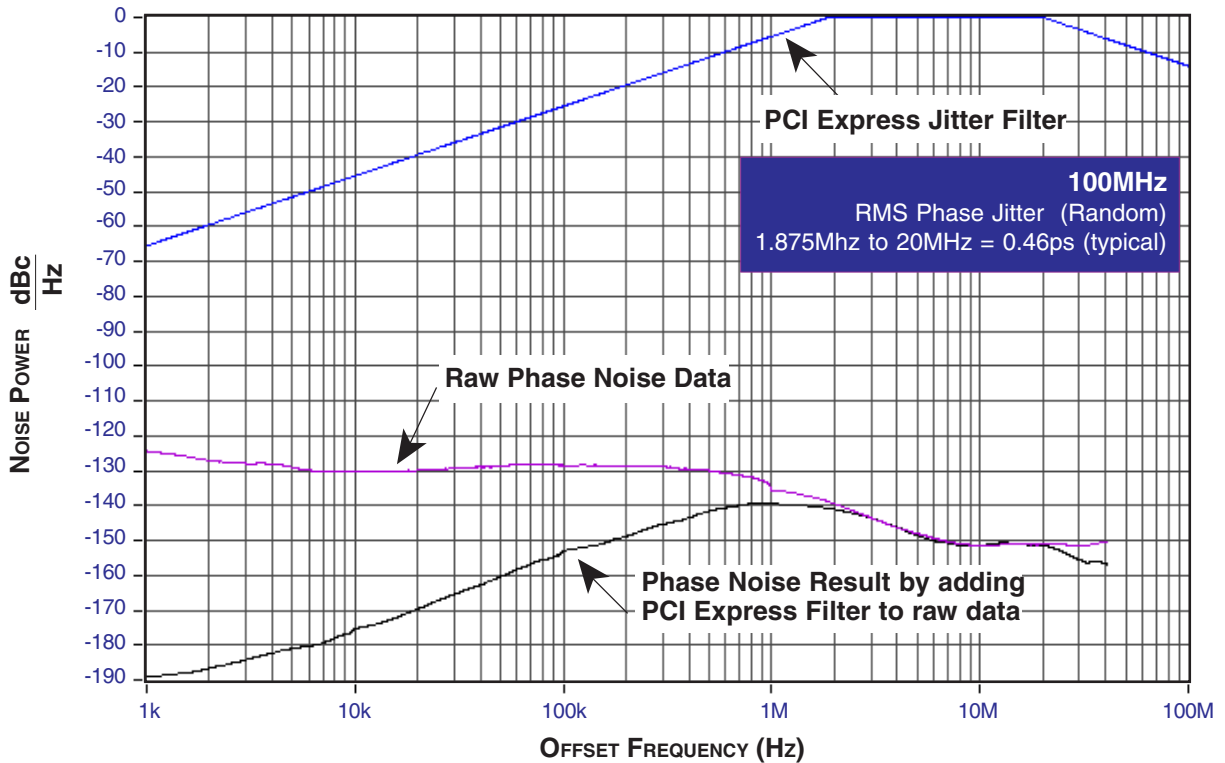
NOTE 3: Defined as skew within a bank of outputs at the same voltages and with equal load conditions.

NOTE 4: Please refer to the Phase Noise Plot.

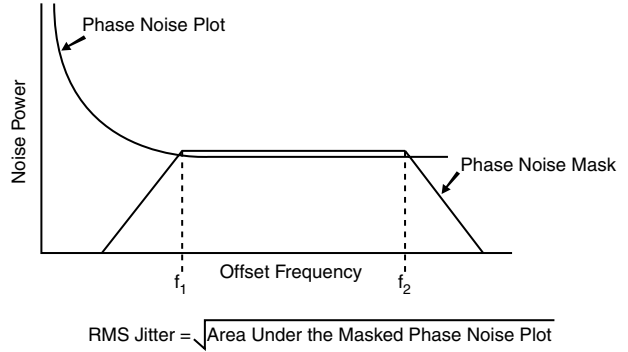
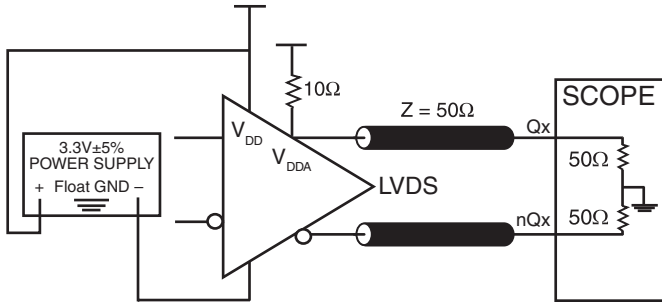
TYPICAL PHASE NOISE AT 125MHz



TYPICAL PHASE NOISE AT 100MHz

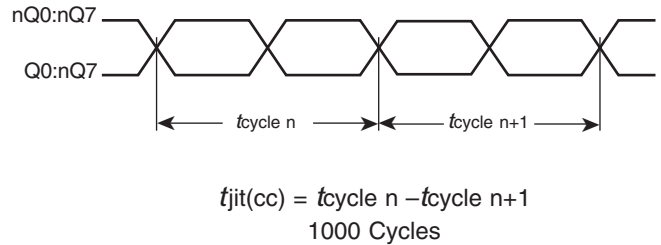
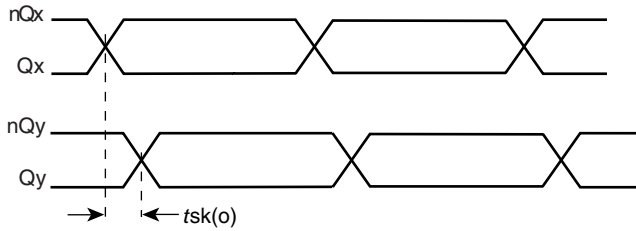


PARAMETER MEASUREMENT INFORMATION



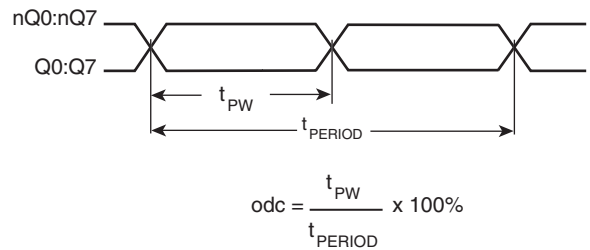
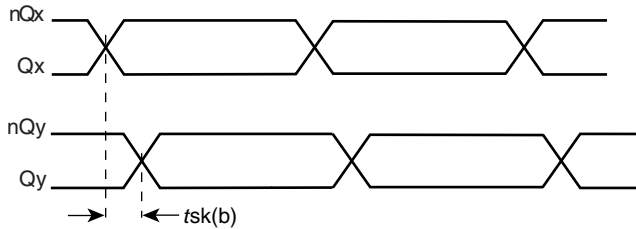
3.3V CORE/3.3V OUTPUT LOAD AC TEST CIRCUIT

RMS PHASE JITTER



OUTPUT SKEW

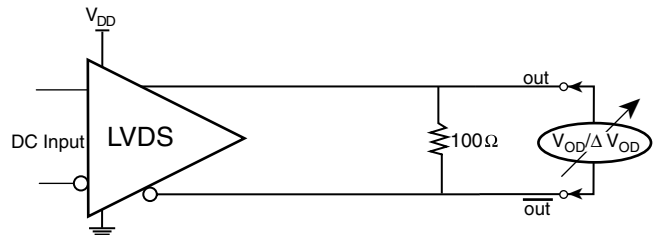
CYCLE-TO-CYCLE JITTER



Where x = 0, 1, 2, 3 or 4, and
Where y = 5, 6 or 7

BANK SKEW

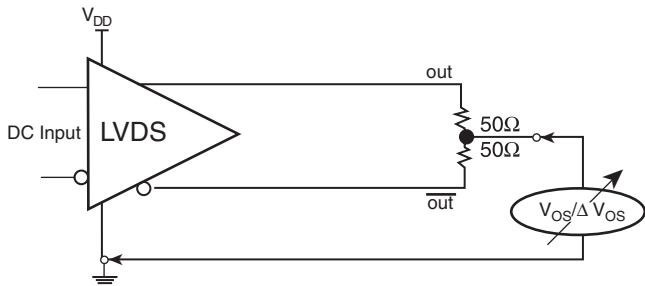
OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD



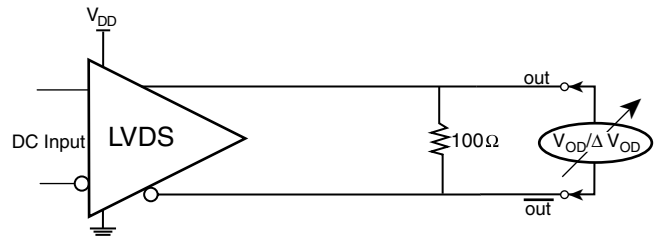
OUTPUT RISE/FALL TIME

DIFFERENTIAL OUTPUT VOLTAGE SETUP

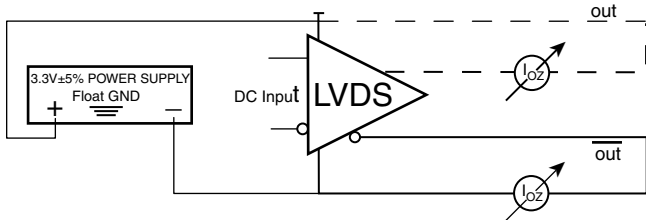
PARAMETER MEASUREMENT INFORMATION, CONTINUED



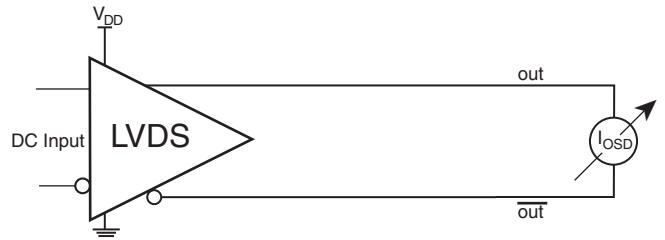
OFFSET VOLTAGE SETUP



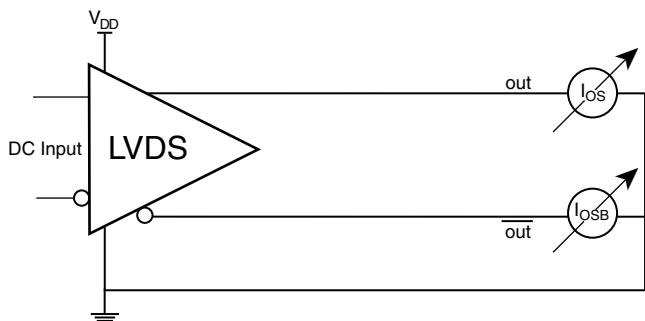
DIFFERENTIAL OUTPUT VOLTAGE SETUP



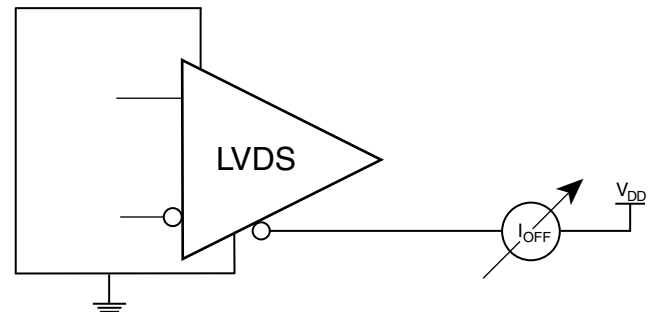
HIGH IMPEDANCE LEAKAGE CURRENT SETUP



DIFFERENTIAL OUTPUT SHORT CIRCUIT SETUP



OUTPUT SHORT CIRCUIT CURRENT SETUP



POWER OFF LEAKAGE SETUP

APPLICATION INFORMATION

POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The ICS844008I-15 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 bypass capacitors should be used for each pin. To achieve optimum jitter performance, power supply isolation is required. *Figure 1* illustrates how a 10Ω resistor along with a $10\mu\text{F}$ and a $0.01\mu\text{F}$ bypass capacitor should be connected to each V_{DDA} .

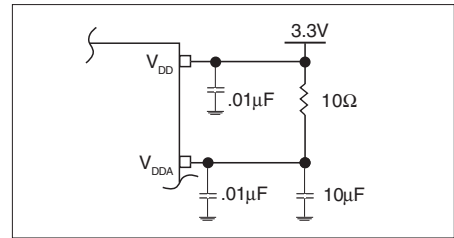


FIGURE 1. POWER SUPPLY FILTERING

CRYSTAL INPUT INTERFACE

The ICS844008I-15 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.

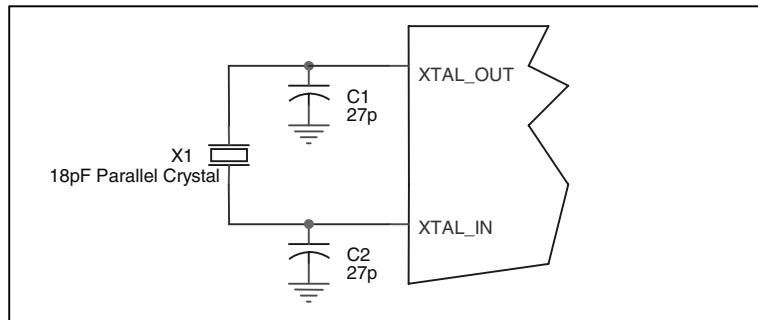


FIGURE 2. CRYSTAL INPUT INTERFACE

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

All unused LVDS outputs should be terminated with 100Ω resistor between the differential pair.

3.3V LVDS DRIVER TERMINATION

A general LVDS interface is shown in *Figure 3*. In a 100Ω differential transmission line environment, LVDS drivers require a matched load termination of 100Ω across near the receiver

input. For a multiple LVDS outputs buffer, if only partial outputs are used, it is recommended to terminate the unused outputs.

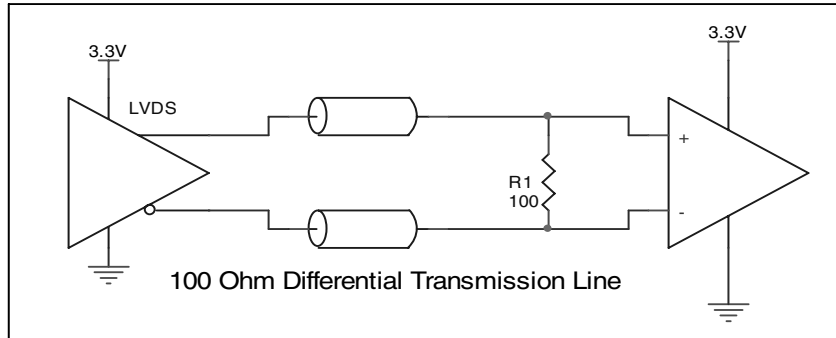


FIGURE 3. TYPICAL LVDS DRIVER TERMINATION

SCHEMATIC EXAMPLE

Figure 4 shows an example of 844008I-15 application schematic. In this example, the device is operated at $V_{DD}=3.3V$. 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.

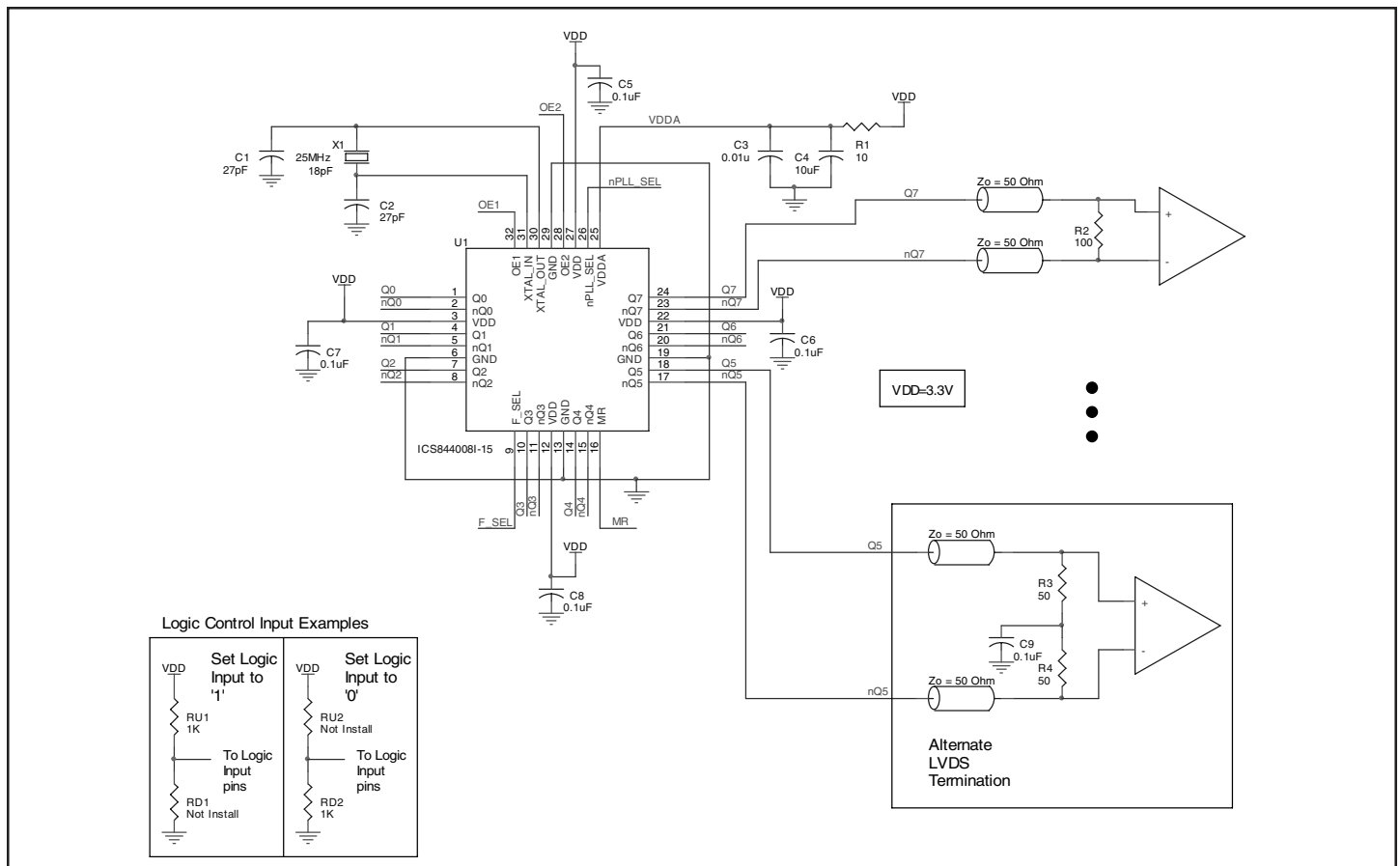


FIGURE 4. ICS844008I-15 SCHEMATIC EXAMPLE

POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS844008I-15. Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the ICS844008I-15 is the sum of the core 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.

- Power (core)_{MAX} = $V_{DD_MAX} * (I_{DD_MAX} + I_{DDA_MAX}) = 3.465V * (150mA + 15mA) = 571.73mW$

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: $T_j = \theta_{JA} * Pd_total + T_A$

T_j = Junction Temperature

θ_{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 θ_{JA} must be used. Assuming no air flow and a multi-layer board, the appropriate value is 65.7°C/W per Table 7 below.

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

$$85^\circ\text{C} + 0.572\text{W} * 65.7^\circ\text{C}/\text{W} = 122.5^\circ\text{C}. \text{ This is below the limit of } 125^\circ\text{C}.$$

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 7. THERMAL RESISTANCE θ_{JA} FOR 32-LEAD LQFP, FORCED CONVECTION

	θ_{JA} by Velocity (Meters per Second)		
	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	65.7°C/W	55.9°C/W	52.4°C/W

RELIABILITY INFORMATION

TABLE 8. θ_{JA} VS. AIR FLOW TABLE FOR 32 LEAD LQFP

θ_{JA} by Velocity (Meters per Second)			
	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	65.7°C/W	55.9°C/W	52.4°C/W

TRANSISTOR COUNT

The transistor count for ICS844008I-15 is: 2609

PACKAGE OUTLINE - Y SUFFIX FOR 32 LEAD LQFP

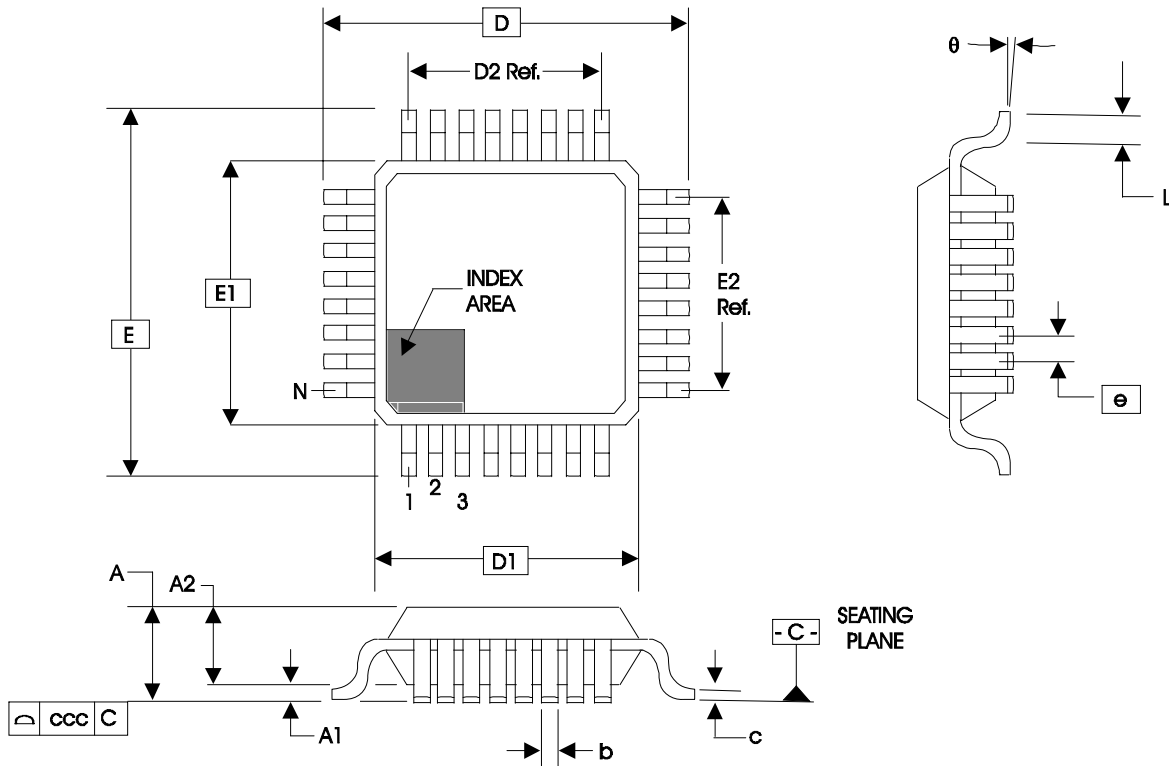


TABLE 9. PACKAGE DIMENSIONS

JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS			
SYMBOL	BBA		
	MINIMUM	NOMINAL	MAXIMUM
N	32		
A	--	--	1.60
A1	0.05	--	0.15
A2	1.35	1.40	1.45
b	0.30	0.37	0.45
c	0.09	--	0.20
D	9.00 BASIC		
D1	7.00 BASIC		
D2	5.60 Ref.		
E	9.00 BASIC		
E1	7.00 BASIC		
E2	5.60 Ref.		
e	0.80 BASIC		
L	0.45	0.60	0.75
θ	0°	--	7°
ccc	--	--	0.10

Reference Document: JEDEC Publication 95, MS-026

TABLE 10. ORDERING INFORMATION

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
ICS844008BYI-15LF	ICS4008BI15L	32 Lead "Lead-Free" LQFP	tube	-40°C to 85°C
ICS844008BYI-15LFT	ICS4008BI15L	32 Lead "Lead-Free" LQFP	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.

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