



# FEMTOCLOCKS™ CRYSTAL-TO-3.3V LVPECL FREQUENCY SYNTHESIZER WITH/INTEGRATED FANOUT BUFFER

ICS843256

## GENERAL DESCRIPTION



The ICS843256 is a Crystal-to-3.3V LVPECL Clock Synthesizer/Fanout Buffer designed for Fibre Channel and Gigabit Ethernet applications and is a member of the HiperClockS™ family of High Performance Clock Solutions from IDT. The output frequency can be set using the frequency select pins and a 25MHz crystal for Ethernet frequencies, or a 19.44MHz crystal for SONET. The low phase noise characteristics of the ICS843256 make it an ideal clock for these demanding applications.

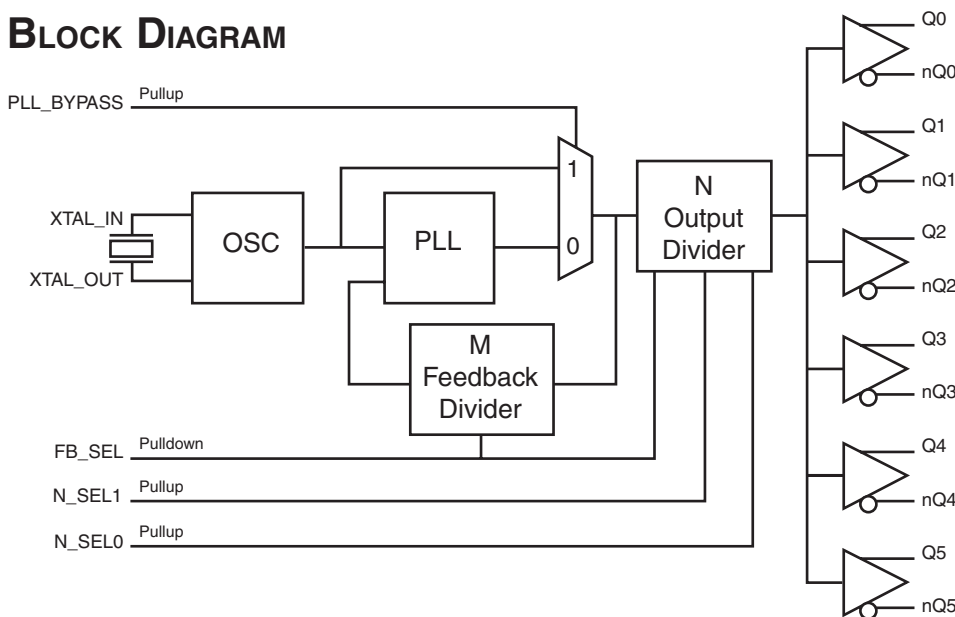
## FEATURES

- Six 3.3V differential LVPECL output pairs
- Output frequency range: 62.5MHz to 625MHz
- Crystal input frequency range: 15.625MHz to 25.5MHz
- RMS phase jitter at 156.25MHz, using a 25MHz crystal (1.875MHz to 20MHz): 0.41ps (typical) @ 3.3V
- Operating supply modes:  
Core/Output  
3.3V/3.3V  
3.3V/2.5V
- 0°C to 70°C ambient operating temperature
- Available in both standard (RoHS 5) and lead-free (RoHS 6) packages

SELECT FUNCTION TABLE

Inputs			Function		
FB_SEL	N_SEL1	N_SEL0	M Divide	N Divide	M/N
0	0	0	25	1	25
0	0	1	25	2	12.5
0	1	0	25	4	6.25
0	1	1	25	5	5
1	0	0	32	1	32
1	0	1	32	2	16
1	1	0	32	4	8
1	1	1	32	8	4

## BLOCK DIAGRAM



## PIN ASSIGNMENT

Vcco	1	24	Q3
Vcco	2	23	nQ3
nQ2	3	22	Q4
Q2	4	21	nQ4
nQ1	5	20	Q5
Q1	6	19	nQ5
nQ0	7	18	N_SEL1
Q0	8	17	VEE
PLL_BYPASS	9	16	VEE
VCCA	10	15	N_SEL0
Vcc	11	14	XTAL_OUT
FB_SEL	12	13	XTAL_IN

**24-Lead TSSOP, E-Pad**  
4.40mm x 7.8mm x 0.92mm  
body package  
**G Package**  
Top View

**TABLE 1. PIN DESCRIPTIONS**

Number	Name	Type		Description
1, 2	V <sub>CCO</sub>	Power		Output supply pins.
3, 4	nQ2, Q2	Output		Differential output pair. LVPECL interface levels.
5, 6	nQ1, Q1	Output		Differential output pair. LVPECL interface levels.
7, 8	nQ0, Q0	Output		Differential output pair. LVPECL interface levels.
9	PLL_BYPASS	Input	Pullup	Selects between the PLL and crystal inputs as the input to the dividers. When LOW, selects PLL. When HIGH, selects XTAL_IN, XTAL_OUT. LVCMOS / LVTTTL interface levels.
10	V <sub>CCA</sub>	Power		Analog supply pin.
11	V <sub>CC</sub>	Power		Core supply pin.
12	FB_SEL	Input	Pulldown	Feedback frequency select pin. LVCMOS/LVTTTL interface levels.
13, 14	XTAL_IN, XTAL_OUT	Input		Crystal oscillator interface. XTAL_IN is the input. XTAL_OUT is the output.
15, 18	N_SEL0 N_SEL1	Input	Pullup	Output frequency select pin. LVCMOS/LVTTTL interface levels.
16, 17	V <sub>EE</sub>			Negative supply pin.
19, 20	nQ5, Q5	Output		Differential output pair. LVPECL interface levels.
21, 22	nQ4, Q4	Output		Differential output pair. LVPECL interface levels.
23, 24	nQ3, Q3	Output		Differential output pair. LVPECL 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 <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. CRYSTAL FUNCTION TABLE**

Inputs				Function			
XTAL (MHz)	FB_SEL	N_SEL1	N_SEL0	M	VCO (MHz)	N	Output (MHz)
20	0	0	0	25	500	1	500
20	0	0	1	25	500	2	250
20	0	1	0	25	500	4	125
20	0	1	1	25	500	5	100
21.25	0	1	1	25	531.25	5	106.25
24	0	0	0	25	600	1	600
24	0	0	1	25	600	2	300
24	0	1	0	25	600	4	150
24	0	1	1	25	600	5	120
25	0	0	0	25	625	1	625
25	0	0	1	25	625	2	312.5
25	0	1	0	25	625	4	156.25
25	0	1	1	25	625	5	125
25.5	0	1	0	25	637.5	4	159.375
15.625	1	1	1	32	500	8	62.5
18.5625	1	1	1	32	594	8	74.25
18.75	1	0	0	32	600	1	600
18.75	1	0	1	32	600	2	300
18.75	1	1	0	32	600	4	150
18.75	1	1	1	32	600	8	75
19.44	1	0	0	32	622.08	1	622.08
19.44	1	0	1	32	622.08	2	311.04
19.44	1	1	0	32	622.08	4	155.52
19.44	1	1	1	32	622.08	8	77.76
19.53125	1	0	0	32	625	1	625
19.53125	1	0	1	32	625	2	312.5
19.53125	1	1	0	32	625	4	156.25
19.53125	1	1	1	32	625	8	78.125
20	1	1	1	32	640	8	80

## ABSOLUTE MAXIMUM RATINGS

Supply Voltage, $V_{CC}$	4.6V
Inputs, $V_I$	-0.5V to $V_{CC} + 0.5V$
Outputs, $I_O$	
Continuous Current	50mA
Surge Current	100mA
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,  $V_{CC} = V_{CCO} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{CC}$	Core Supply Voltage		3.135	3.3	3.465	V
$V_{CCA}$	Analog Supply Voltage		$V_{CC} - 0.12$	3.3	3.465	V
$V_{CCO}$	Output Supply Voltage		3.135	3.3	3.465	V
$I_{EE}$	Power Supply Current				190	mA
$I_{CCA}$	Analog Supply Current				12	mA

**TABLE 4B. POWER SUPPLY DC CHARACTERISTICS,  $V_{CC} = 3.3V \pm 5\%$ ,  $V_{CCO} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{CC}$	Core Supply Voltage		3.135	3.3	3.465	V
$V_{CCA}$	Analog Supply Voltage		$V_{CC} - 0.12$	3.3	3.465	V
$V_{CCO}$	Output Supply Voltage		2.375	2.5	2.625	V
$I_{EE}$	Power Supply Current				190	mA
$I_{CCA}$	Analog Supply Current				12	mA

**TABLE 4C. LVCMOS / LVTTTL DC CHARACTERISTICS,  $V_{CC} = 3.3V \pm 5\%$ ,  $V_{CCO} = 3.3V \pm 5\%$  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		2		$V_{CC} + 0.3$	V
$V_{IL}$	Input Low Voltage		-0.3		0.8	V
$I_{IH}$	Input High Current	FB_SEL	$V_{CC} = V_{IN} = 3.465V$		150	$\mu A$
		PLL_BYPASS, N_SEL0, N_SEL1	$V_{CC} = V_{IN} = 3.465V$		5	$\mu A$
$I_{IL}$	Input Low Current	FB_SEL	$V_{CC} = 3.465V, V_{IN} = 0V$	-5		$\mu A$
		PLL_BYPASS, N_SEL0, N_SEL1	$V_{CC} = 3.465V, V_{IN} = 0V$	-150		$\mu A$

**TABLE 4D. LVPECL DC CHARACTERISTICS,  $V_{CC} = 3.3V \pm 5\%$ ,  $V_{CCO} = 3.3V \pm 5\%$  OR  $2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$V_{OH}$	Output High Voltage; NOTE 1		$V_{CCO} - 1.4$		$V_{CCO} - 0.9$	V
$V_{OL}$	Output Low Voltage; NOTE 1		$V_{CCO} - 2.0$		$V_{CCO} - 1.7$	V
$V_{SWING}$	Peak-to-Peak Output Voltage Swing		0.6		1.0	V

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

**TABLE 5. CRYSTAL CHARACTERISTICS**

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation		Fundamental			
Frequency		15.625		25.5	MHz
Equivalent Series Resistance (ESR)				50	$\Omega$
Shunt Capacitance				7	pF
Drive Level				1	mW

NOTE: Characterized using an 18pF parallel resonant crystal.

**TABLE 6A. AC CHARACTERISTICS,  $V_{CC} = V_{CCO} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$F_{OUT}$	Output Frequency		62.5		625	MHz
$f_{jit}(\emptyset)$	RMS Phase Jitter (Random)	156.25MHz, Integration Range: 1.875MHz - 20MHz		0.41		ps
		156.25MHz, Integration Range: 12kHz - 20MHz		0.85		ps
$t_{sk(o)}$	Output Skew; NOTE 1, 2				40	ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	200		650	ps
odc	Output Duty Cycle	$F_{OUT} \leq 312.5MHz$	47		53	%
		$F_{OUT} > 312.5MHz$	45		55	%
$t_{LOCK}$	PLL Lock Time				20	ms

See Parameter Measurement Information section.

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

Measured at the output differential crossing points.

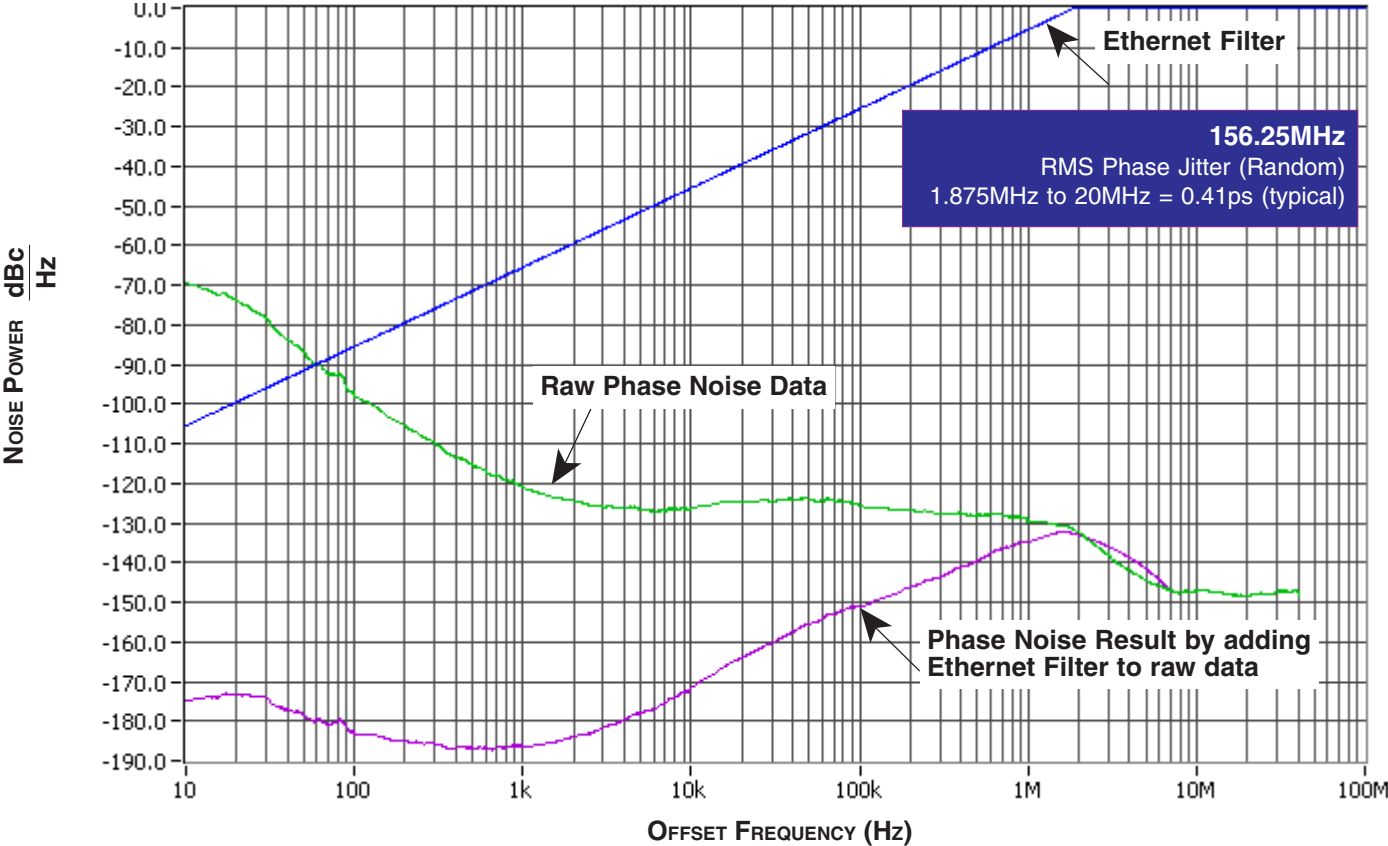
NOTE 2: This parameter is defined in accordance with JEDEC Standard 65.

**TABLE 6B. AC CHARACTERISTICS,  $V_{CC} = 3.3V \pm 5\%$ ,  $V_{CCO} = 2.5V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $70^\circ C$** 

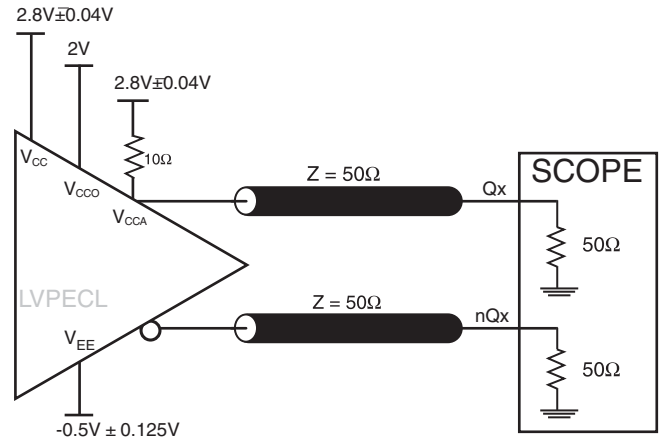
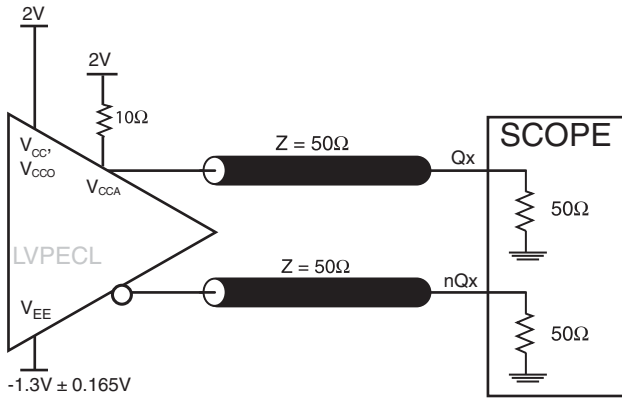
Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$F_{OUT}$	Output Frequency		62.5		625	MHz
$f_{jit}(\emptyset)$	RMS Phase Jitter (Random)	156.25MHz, Integration Range: 1.875MHz - 20MHz		0.41		ps
		156.25MHz, Integration Range: 12kHz - 20MHz		0.85		ps
$t_{sk(o)}$	Output Skew; NOTE 1, 2				45	ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	200		650	ps
odc	Output Duty Cycle		46		54	%
$t_{LOCK}$	PLL Lock Time				20	ms

For NOTES, please see Table 6A above.

### TYPICAL PHASE NOISE AT 156.25MHz @ 3.3V

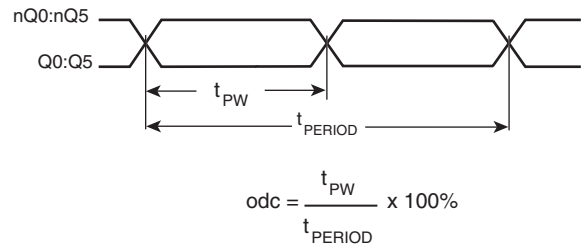
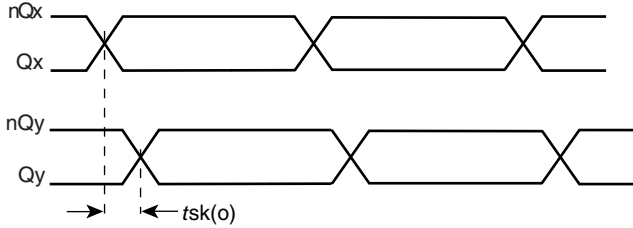


# PARAMETER MEASUREMENT INFORMATION



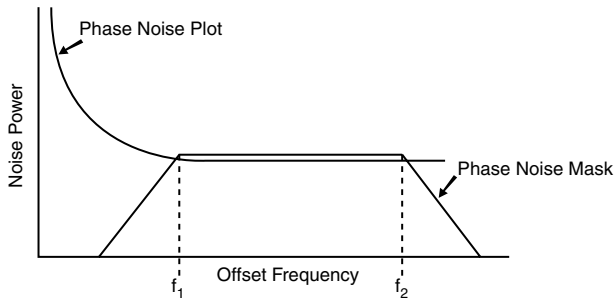
**3.3V CORE/3.3V OUTPUT LOAD AC TEST CIRCUIT**

**3.3V CORE/2.5V OUTPUT LOAD AC TEST CIRCUIT**

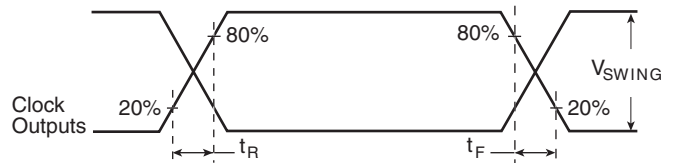


**OUTPUT SKEW**

**OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD**



$$\text{RMS Jitter} = \sqrt{\text{Area Under the Masked Phase Noise Plot}}$$



**RMS PHASE JITTER**

**OUTPUT RISE/FALL TIME**

# APPLICATION INFORMATION

## POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The ICS843256 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{CC}$ ,  $V_{CCA}$ , and  $V_{CCO}$  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  $10\Omega$  resistor along with a  $10\mu\text{F}$  and a  $.01\mu\text{F}$  bypass capacitor should be connected to each  $V_{CCA}$  pin.

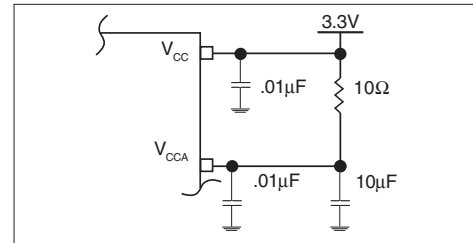


FIGURE 1. POWER SUPPLY FILTERING

## 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:

#### LVPECL OUTPUTS

All unused LVPECL outputs 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.

## CRYSTAL INPUT INTERFACE

The ICS843256 has been characterized with  $18\text{pF}$  parallel resonant crystals. The capacitor values shown in *Figure 2* below

were determined using an  $18\text{pF}$  parallel resonant crystal and were chosen to minimize the ppm error.

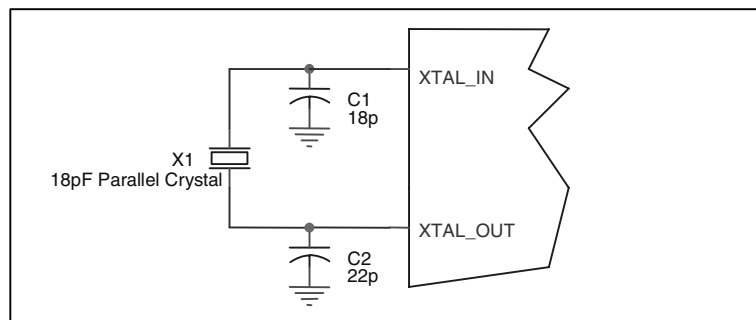


FIGURE 2. CRYSTAL INPUT INTERFACE

## 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,  $R1$  and  $R2$  in parallel should equal the transmission line impedance. For most  $50\Omega$  applications,  $R1$  and  $R2$  can be  $100\Omega$ . This can also be accomplished by removing  $R1$  and making  $R2$   $50\Omega$ .

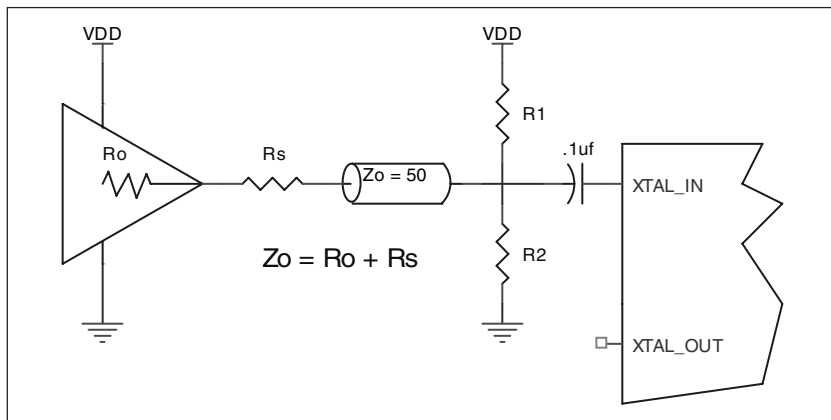


FIGURE 3. GENERAL DIAGRAM FOR LVC MOS DRIVER TO XTAL INPUT INTERFACE

## TERMINATION FOR 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.

FOUT and nFOUT are 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  $50\Omega$

transmission lines. Matched impedance techniques should be used to maximize operating frequency and minimize signal distortion. *Figures 4A and 4B* 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.

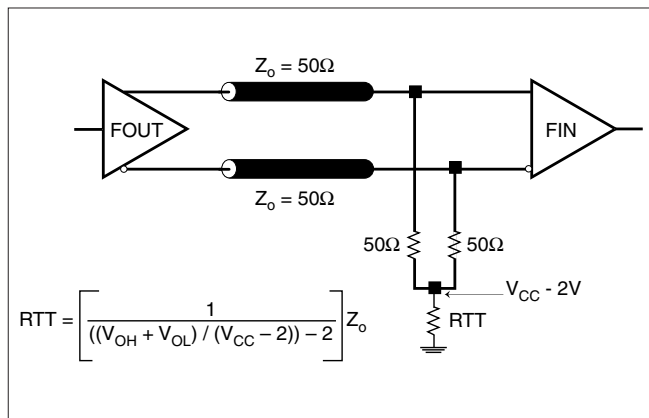


FIGURE 4A. LVPECL OUTPUT TERMINATION

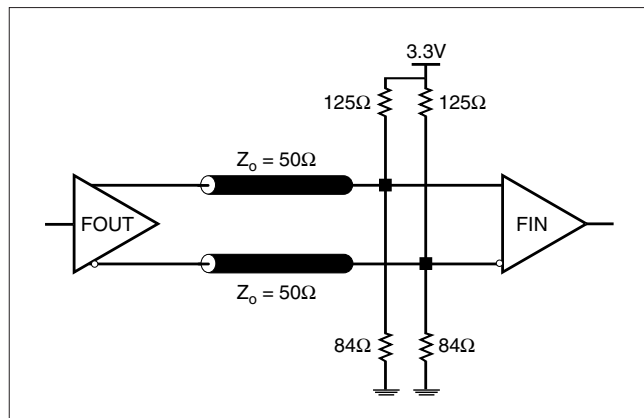


FIGURE 4B. LVPECL OUTPUT TERMINATION

## TERMINATION FOR 2.5V LVPECL OUTPUT

Figure 5A and Figure 5B show examples of termination for 2.5V LVPECL driver. These terminations are equivalent to terminating 50Ω to  $V_{cc} - 2V$ . For  $V_{cc} = 2.5V$ , the  $V_{cc} - 2V$  is very close to

ground level. The R3 in Figure 5B can be eliminated and the termination is shown in Figure 5C.

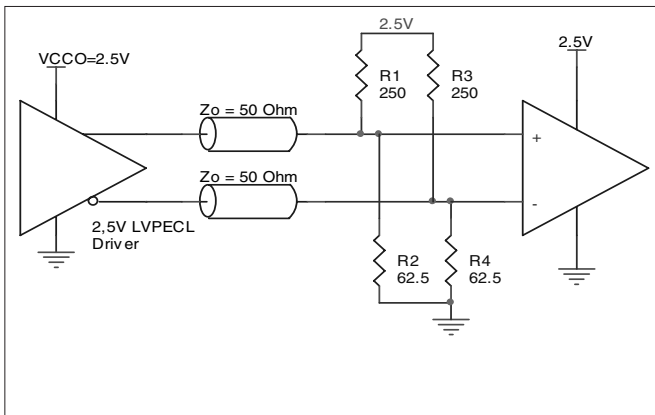


FIGURE 5A. 2.5V LVPECL DRIVER TERMINATION EXAMPLE

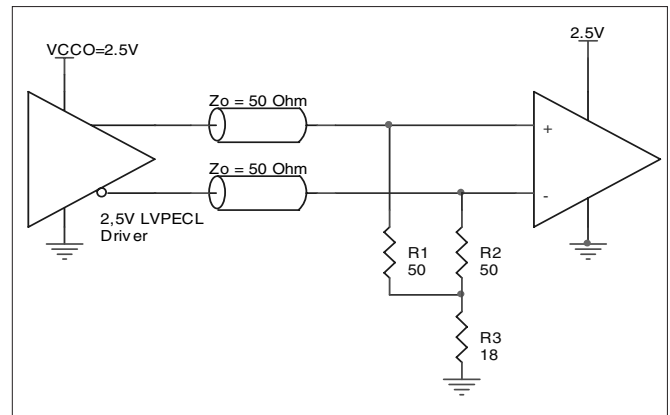


FIGURE 5B. 2.5V LVPECL DRIVER TERMINATION EXAMPLE

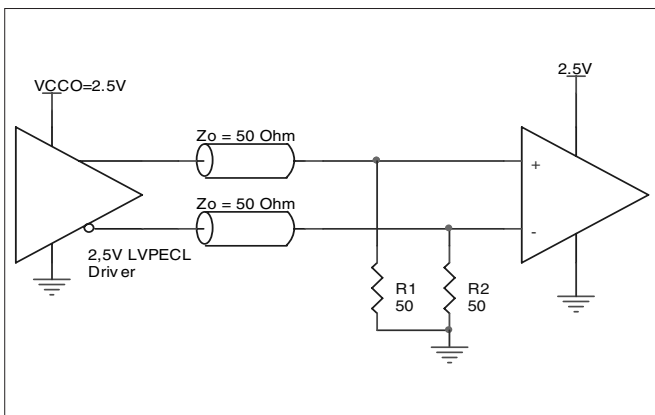


FIGURE 5C. 2.5V LVPECL TERMINATION EXAMPLE

# POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS843256. Equations and example calculations are also provided.

## 1. Power Dissipation.

The total power dissipation for the ICS843256 is the sum of the core power plus the power dissipated in the load(s). The following is the power dissipation for  $V_{CC} = 3.3V + 5\% = 3.465V$ , 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> =  $V_{CC,MAX} * I_{EE,MAX} = 3.465V * 190mA = 658.35mW$
- Power (outputs)<sub>MAX</sub> = **30mW/Loaded Output pair**  
If all outputs are loaded, the total power is  $6 * 30mW = 180mW$

**Total Power**<sub>MAX</sub> (3.465V, with all outputs switching) =  $658.35mW + 180mW = 838.35mW$

## 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 70°C with all outputs switching is:

$70°C + 0.838W * 37°C/W = 101°C$ . 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).

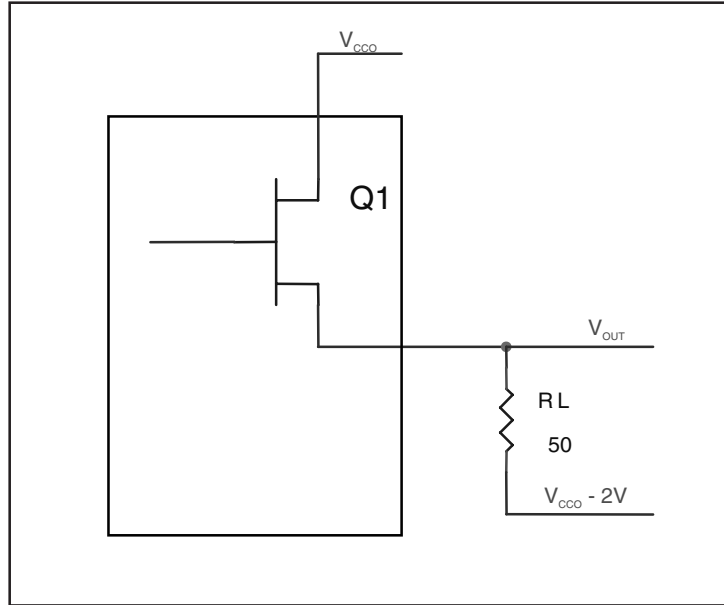
**TABLE 7B. THERMAL RESISTANCE  $\theta_{JA}$  FOR 24-PIN TSSOP, E-PAD FORCED CONVECTION**

$\theta_{JA}$ by Velocity (Meters per Second)			
	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	37°C/W	31°C/W	30°C/W

### 3. Calculations and Equations.

The purpose of this section is to derive the power dissipated into the load.

LVPECL output driver circuit and termination are shown in *Figure 6*.



**FIGURE 6. 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  $V_{CCO} - 2V$ .

- For logic high,  $V_{OUT} = V_{OH\_MAX} = V_{CCO\_MAX} - 0.9V$

$$(V_{CCO\_MAX} - V_{OH\_MAX}) = 0.9V$$

- For logic low,  $V_{OUT} = V_{OL\_MAX} = V_{CCO\_MAX} - 1.7V$

$$(V_{CCO\_MAX} - V_{OL\_MAX}) = 1.7V$$

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

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

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

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

Total Power Dissipation per output pair =  $Pd\_H + Pd\_L = 30mW$

# RELIABILITY INFORMATION

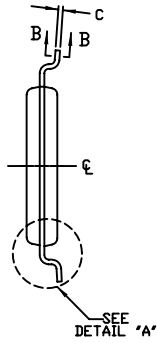
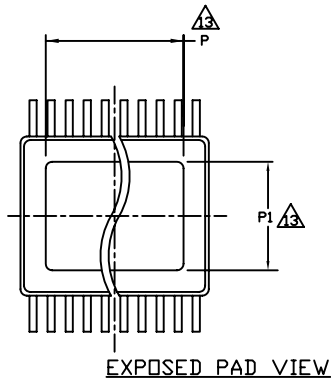
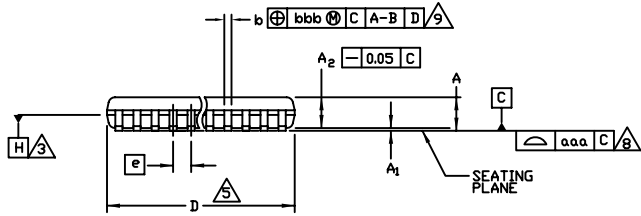
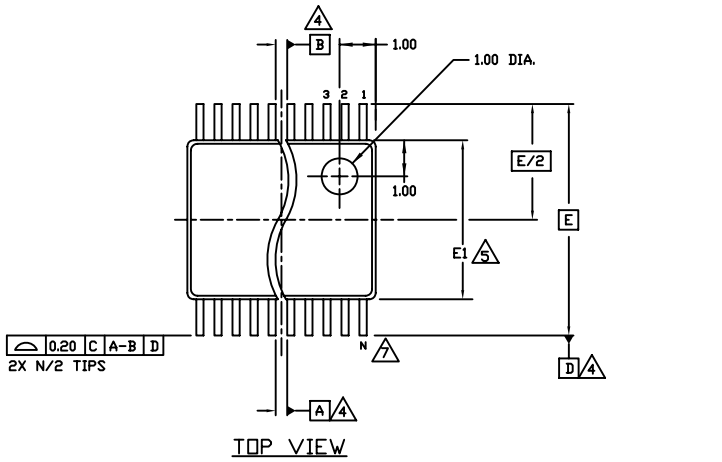
**TABLE 8.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 24 LEAD TSSOP, E-PAD**

$\theta_{JA}$ by Velocity (Meters per Second)			
	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	37°C/W	31°C/W	30°C/W

## TRANSISTOR COUNT

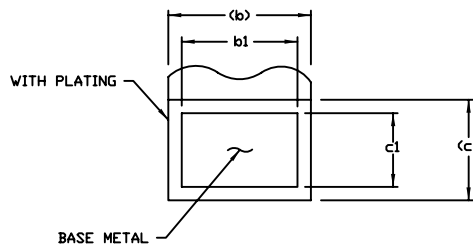
The transistor count for ICS843256 is: 3863

PACKAGE OUTLINE - G SUFFIX FOR 24 LEAD TSSOP, E-PAD

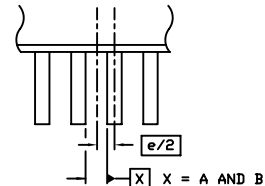


END VIEW

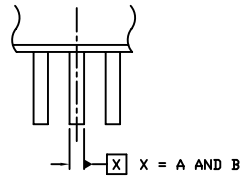
SIDE VIEW



SECTION "B-B"  
SCALE: 120/1  
(SEE NOTE 10)



EVEN LEAD SIDES  
TOPVIEW



ODD LEAD SIDES  
TOPVIEW

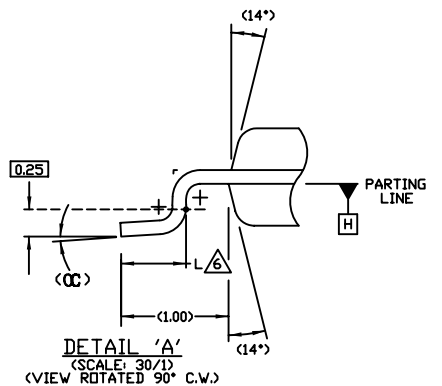


TABLE 9. PACKAGE DIMENSIONS

SYMBOL	Millimeters		
	Minimum	Nominal	Maximum
N	24		
A	--		1.10
A1	0.05		0.15
A2	0.85	0.90	0.95
b	0.19		0.30
b1	0.19	0.22	0.25
c	0.09		0.20
c1	0.09	0.127	0.16
D	7.70	7.80	7.90
E	6.40 BASIC		
E1	4.30	4.40	4.50
e	0.65 BASIC		
L	0.50	0.60	0.70
P			5.0
P1			3.2
$\alpha$	0°		8°
aaa	0.076		
bbb	0.10		

Reference Document: JEDEC Publication 95, MO-153

**TABLE 10. ORDERING INFORMATION**

<b>Part/Order Number</b>	<b>Marking</b>	<b>Package</b>	<b>Shipping Packaging</b>	<b>Temperature</b>
ICS843256BG	ICS843256BG	24 Lead TSSOP, E-Pad	tube	0°C to 70°C
ICS843256BGT	ICS843256BG	24 Lead TSSOP, E-Pad	2500 tape & reel	0°C to 70°C
ICS843256BGLF	ICS843256BGLF	24 Lead "Lead-Free" TSSOP, E-Pad	tube	0°C to 70°C
ICS843256BGLFT	ICS843256BGLF	24 Lead "Lead-Free" TSSOP, E-Pad	2500 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.

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