Integrated
Circuit
Systems, Inc.

ICS843023I

FEMTOCLOCKS™ CRYSTAL-TO-3.3V, 2.5V LVPECL CLOCK GENERATOR

GENERAL DESCRIPTION

The ICS843023I is a Gigabit Ethernet Clock Generator and a member of the HiPerClocks™ family of high performance devices from ICS. The ICS843023I uses a 25MHz crystal to synthesize 250MHz. The ICS843023I has excellent phase jitter performance, over the 1.875MHz – 20MHz integration range. The ICS843023I is packaged in a small 8-pin TSSOP, making it ideal for use in systems with limited board space.

FEATURES

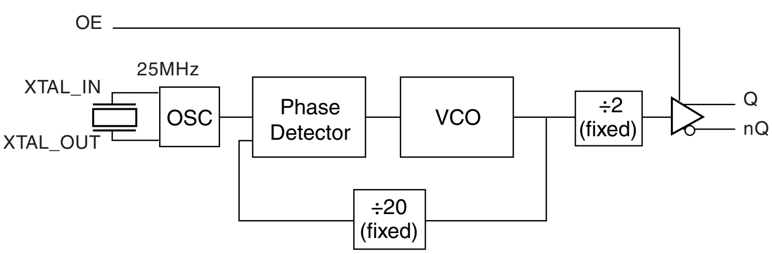
- 1 differential 3.3V LVPECL output
- Crystal oscillator interface designed for 25MHz, 18pF parallel resonant crystal
- Output frequency range: 245MHz - 320MHz
- VCO range: 490MHz - 640MHz
- RMS phase jitter @ 250MHz, using a 25MHz crystal (1.875MHz - 20MHz): 0.39ps (typical)

  Phase noise:

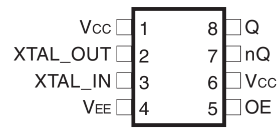
Offset	Noise Power
100Hz	-86.3 dBc/Hz
1kHz	-114.6 dBc/Hz
10kHz	-125.6 dBc/Hz
100kHz	-126 dBc/Hz

- 3.3V or 2.5V operating supply
- -40°C to 85°C ambient operating temperature
- Lead-Free package fully RoHS compliant

BLOCK DIAGRAM



PIN ASSIGNMENT



ICS843023I

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, 6	V_{CC}	Power		Core supply pin.
2, 3	XTAL_OUT, XTAL_IN	Input		Crystal oscillator interface. XTAL_IN is the input, XTAL_OUT is the output.
4	V_{EE}	Power		Negative supply pin.
5	OE	Input	Pullup	Active high output enable. When logic HIGH, the outputs are enabled and active. When logic LOW, the outputs are disabled and the device is in power down mode. LVCMOS/LVTTL interface levels.
7, 8	nQ, Q	Output		Differential clock outputs. LVPECL interface levels.

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_{IN}	Input Capacitance			4		pF
R_{PULLUP}	Input Pullup Resistor			51		kΩ

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, θ_{JA}	101.7°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 3A. POWER SUPPLY DC CHARACTERISTICS, V_{CC} = 3.3V±5%, TA = -40°C TO 85°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		3.135	3.3	3.465	V
I_{EE}	Power Supply Current				75	mA

TABLE 3B. POWER SUPPLY DC CHARACTERISTICS, V_{CC} = 2.5V±5%, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{CC}	Core Supply Voltage		2.375	2.5	2.625	V
V_{CCA}	Analog Supply Voltage		2.375	2.5	2.625	V
I_{EE}	Power Supply Current				70	mA

TABLE 3C. LVCMOS/LVTTL DC CHARACTERISTICS, V_{CC} = 3.3V±5% OR 2.5V±5%, TA = -40°C TO 85°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
V_{IH}	Input High Voltage		V_{CC} = 3.3V	2		V_{CC} + 0.3	V
			V_{CC} = 2.5V	1.7		V_{CC} + 0.3	V
V_{IL}	Input Low Voltage		V_{CC} = 3.3V	-0.3		0.8	V
			V_{CC} = 2.5V	-0.3		0.7	V
I_{IH}	Input High Current	OE	V_{CC} = V_{IN} = 3.465V or 2.625V			5	µA
I_{IL}	Input Low Current	OE	V_{CC} = 3.465V or 2.625V, V_{IN} = 0V	-150			µA

TABLE 3D. LVPECL DC CHARACTERISTICS, V_{CC} = 3.3V±5% OR 2.5V±5%, TA = -40°C TO 85°C

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

NOTE 1: Outputs terminated with 50Ω to V_{CC} - 2V.

TABLE 4. CRYSTAL CHARACTERISTICS

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation		Fundamental			
Frequency		24.5		32	MHz
Equivalent Series Resistance (ESR)				50	Ω
Shunt Capacitance				7	pF
Drive Level				1	mW

TABLE 5A. AC CHARACTERISTICS, V_{CC} = 3.3V±5%, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{OUT}	Output Frequency		245		320	MHz
*t*jit(Ø)	RMS Phase Jitter (Random); NOTE 1	250MHz, Integration Range: 1.875MHz - 20MHz		0.39		ps
t_R / t_F	Output Rise/Fall Time	20% to 80%	300		600	ps
odc	Output Duty Cycle		47		53	%

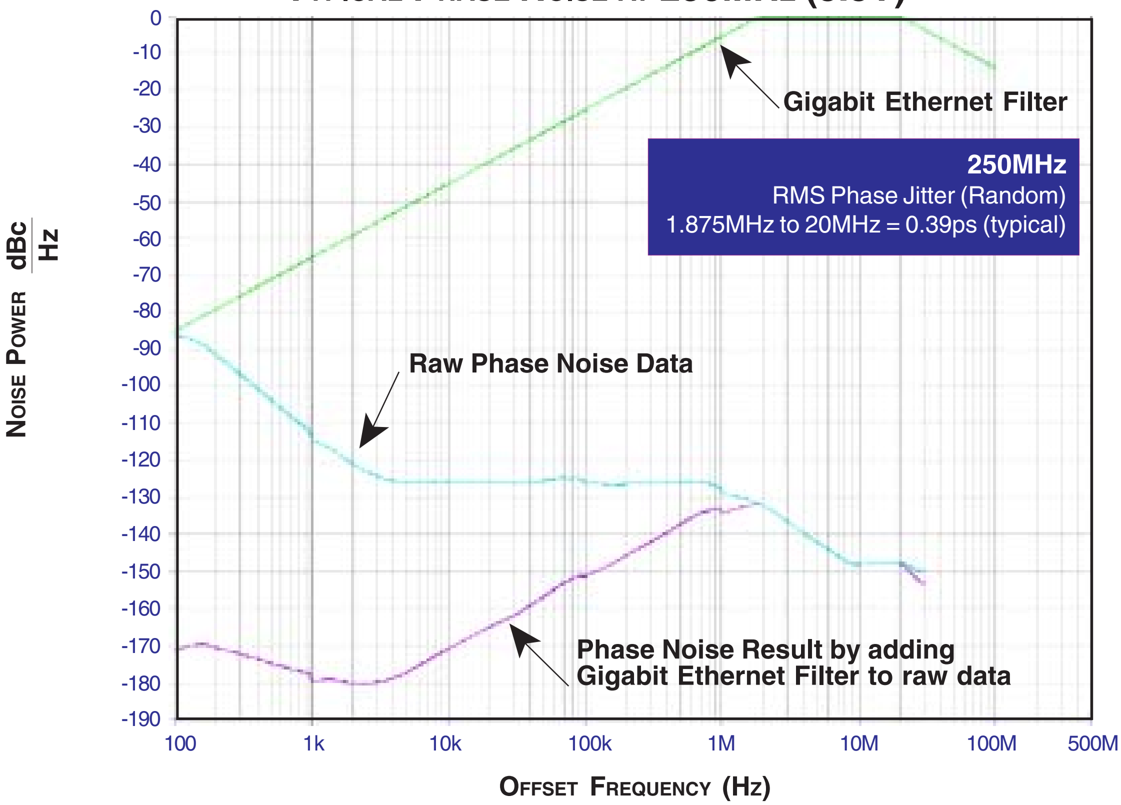
NOTE 1: Please refer to the Phase Noise Plot after this section.

TABLE 5B. AC CHARACTERISTICS, V_{CC} = 2.5V±5%, TA = -40°C TO 85°C

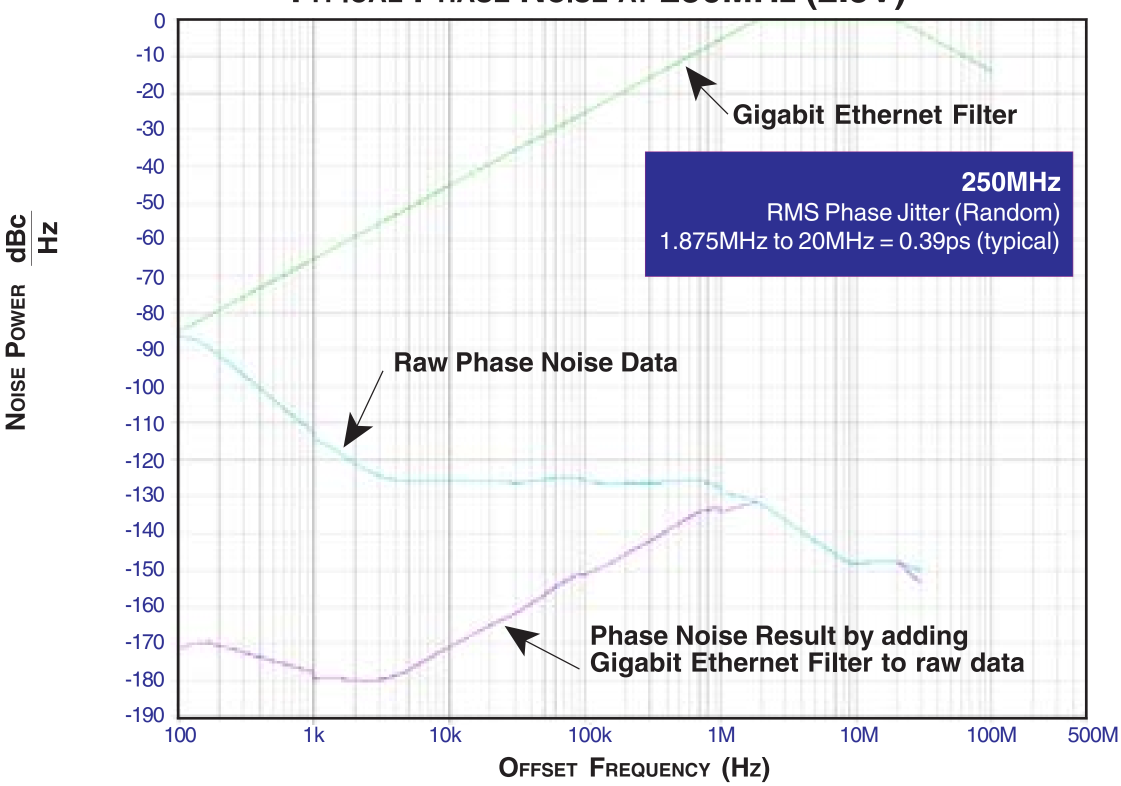
Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{OUT}	Output Frequency		245		320	MHz
*t*jit(Ø)	RMS Phase Jitter (Random); NOTE 1	250MHz, Integration Range: 1.875MHz - 20MHz		0.39		ps
t_R / t_F	Output Rise/Fall Time	20% to 80%	300		600	ps
odc	Output Duty Cycle		47		53	%

NOTE 1: Please refer to the Phase Noise Plot after this section.

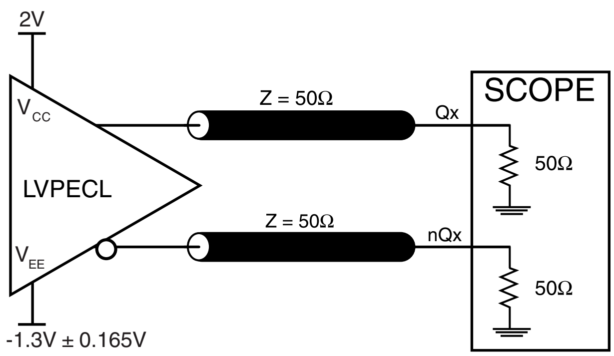
TYPICAL PHASE NOISE AT 250MHZ (3.3V)



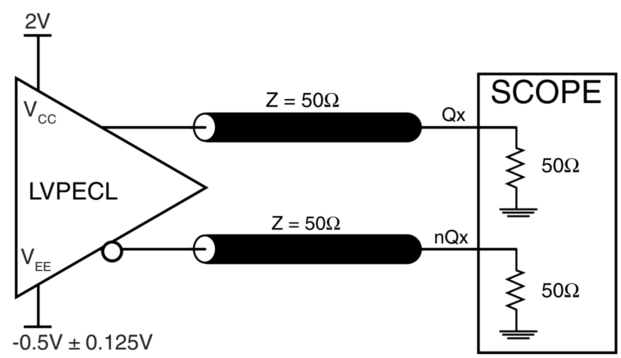
TYPICAL PHASE NOISE AT 250MHZ (2.5V)



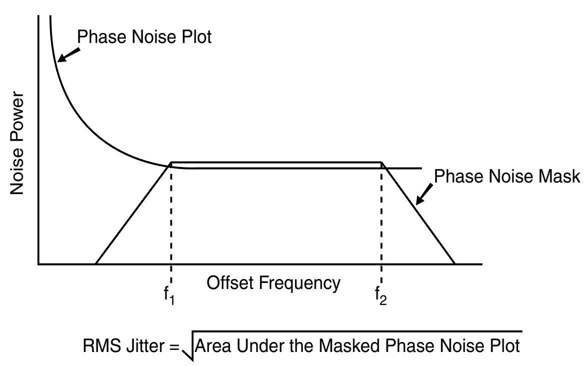
PARAMETER MEASUREMENT INFORMATION



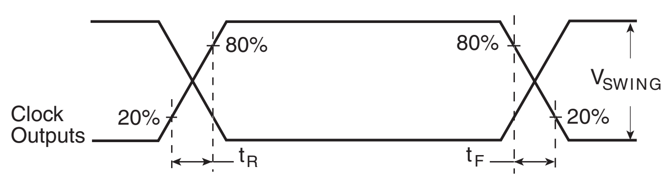
3.3V OUTPUT LOAD AC TEST CIRCUIT



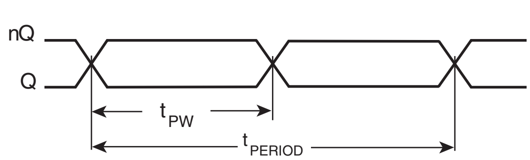
2.5V OUTPUT LOAD AC TEST CIRCUIT



RMS PHASE JITTER



OUTPUT RISE/FALL TIME



$$odc = \frac{t_{PW}}{t_{PERIOD}} \times 100\%$$

OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD

APPLICATION INFORMATION

CRYSTAL INPUT INTERFACE

The ICS843023I has been characterized with 18pF parallel resonant crystals. The capacitor values, C1 and C2, shown in *Figure 1* 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.

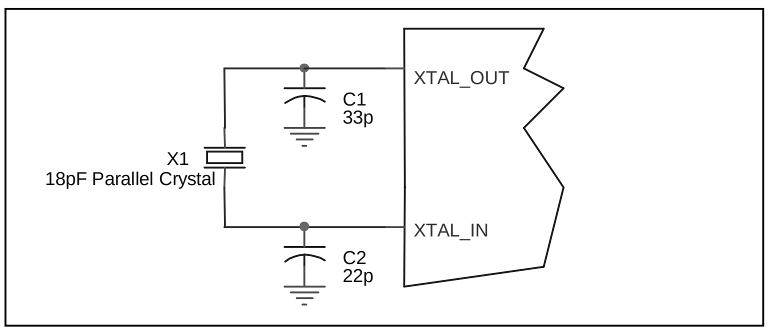


Figure 1. CRYSTAL INPUT INTERFACE

TERMINATION FOR 3.3V LVPECL OUTPUT

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 50Ω transmission lines. Matched impedance techniques should be used to maximize operating frequency and minimize signal distortion. *Figures 2A and 2B* 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.

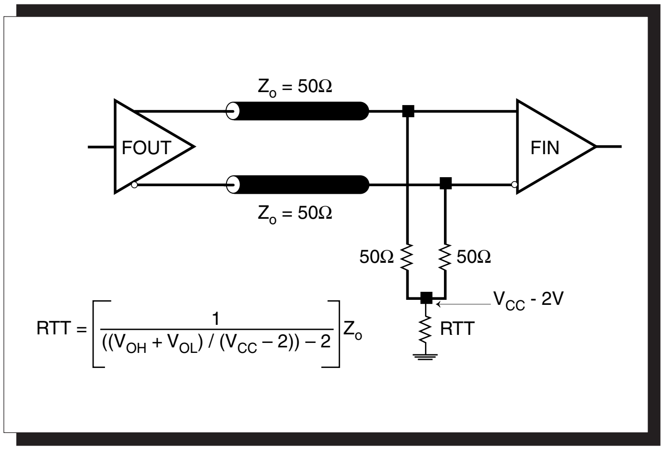


FIGURE 2A. LVPECL OUTPUT TERMINATION

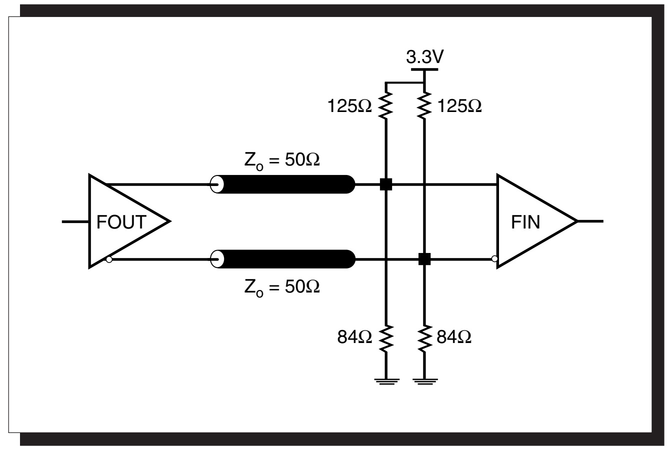


FIGURE 2B. LVPECL OUTPUT TERMINATION

TERMINATION FOR 2.5V LVPECL OUTPUT

Figure 3A and *Figure 3B* 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 3B can be eliminated and the termination is shown in *Figure 3C.*

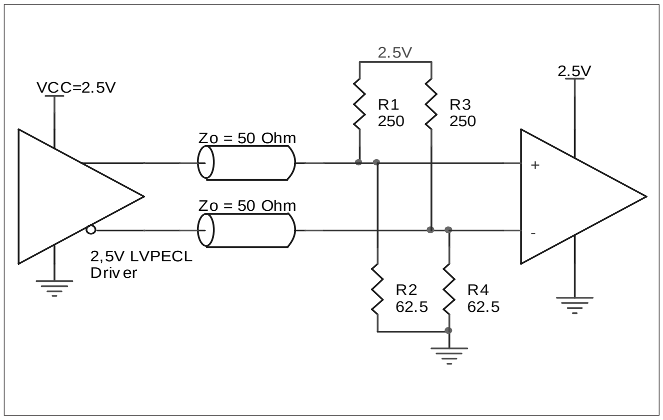


FIGURE 3A. 2.5V LVPECL DRIVER TERMINATION EXAMPLE

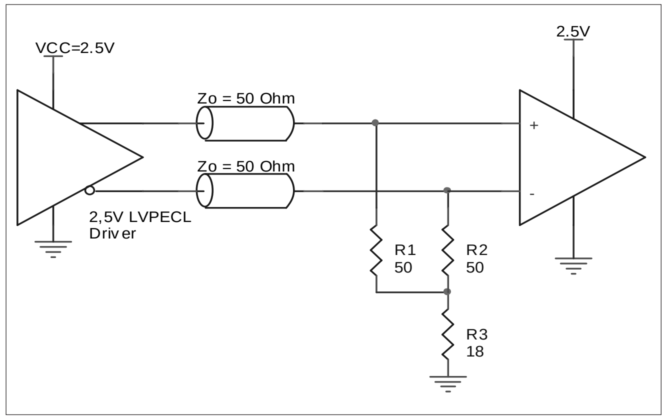


FIGURE 3B. 2.5V LVPECL DRIVER TERMINATION EXAMPLE

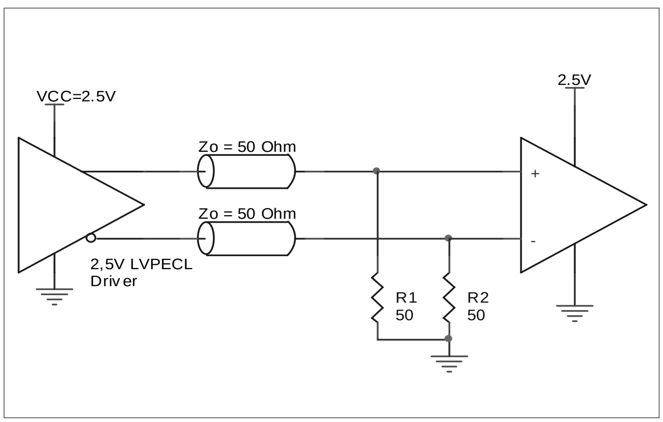


FIGURE 3C. 2.5V LVPECL TERMINATION EXAMPLE

POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS843023I.
Equations and example calculations are also provided.

1. Power Dissipation.
The total power dissipation for the ICS843023I 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)$_{MAX}$ = V_{CC_MAX} * I_{EE_MAX} = 3.465V * 75mA= **259.87mW**
- Power (outputs)$_{MAX}$ = **30mW/Loaded Output pair**

Total Power$_{\_MAX}$ (3.465V, with all outputs switching) = 259.87mW + 30mW = **289.87mW**

2. Junction Temperature.
Junction temperature, Tj, 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 Tj is as follows: Tj = θ_{JA} * Pd_total + T_A

Tj = 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 a moderate air flow of 1 meter per second and a multi-layer board, the appropriate value is 90.5°C/W per Table 6 below.

Therefore, Tj for an ambient temperature of 85°C with all outputs switching is:
85°C + 0.290W * 90.5°C/W = 111.2°C. This is well below the limit of 125°C.

This calculation is only an example. Tj 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 θ_{JA} FOR 8-PIN TSSOP, FORCED CONVECTION

θ_{JA} by Velocity (Meters per Second)			
	0	**1**	**2.5**
Multi-Layer PCB, JEDEC Standard Test Boards	101.7°C/W	90.5°C/W	89.8°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 4.*

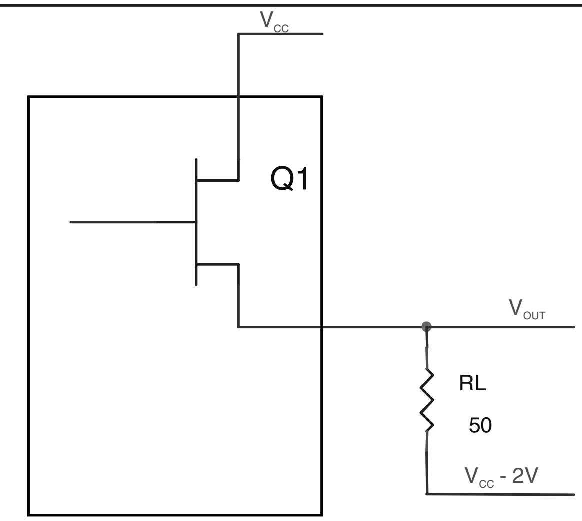


FIGURE 4. LVPECL DRIVER CIRCUIT AND TERMINATION

To calculate worst case power dissipation into the load, use the following equations which assume a 50Ω load, and a termination voltage of V_{CC} - 2V.

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

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

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

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

Pd_H is power dissipation when the output drives high.
Pd_L is the power dissipation when the output drives low.

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

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

Total Power Dissipation per output pair = Pd_H + Pd_L = **30mW**

RELIABILITY INFORMATION

TABLE 7. θ_{JA} VS. AIR FLOW TABLE FOR 8 LEAD TSSOP

θ_{JA} by Velocity (Meters per Second)			
	0	**1**	**2.5**
Multi-Layer PCB, JEDEC Standard Test Boards	101.7°C/W	90.5°C/W	89.8°C/W

TRANSISTOR COUNT

The transistor count for ICS843023I is: 2360

PACKAGE OUTLINE - G SUFFIX FOR 8 LEAD TSSOP

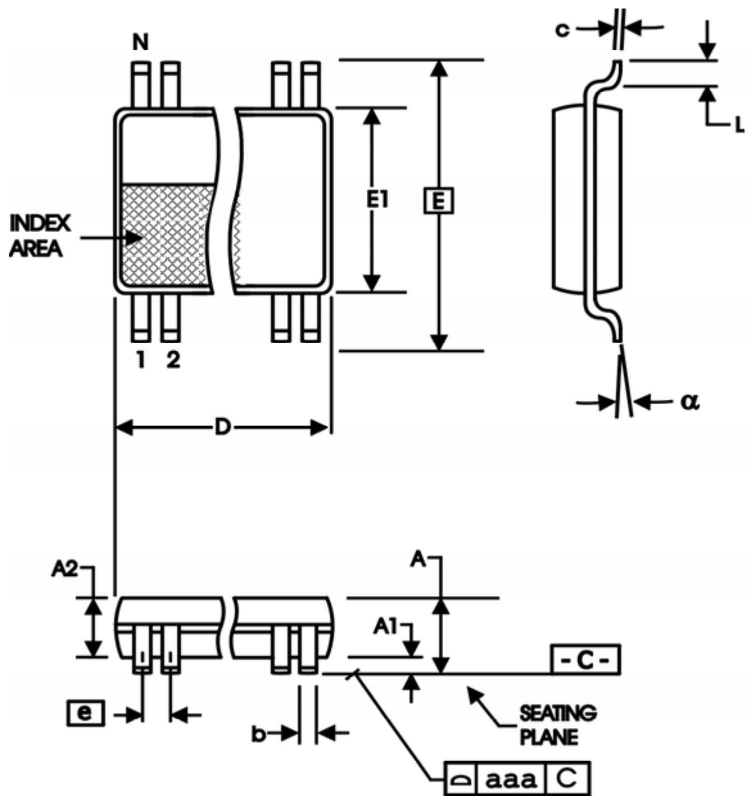


TABLE 8. PACKAGE DIMENSIONS

SYMBOL	Millimeters	
	Minimum	Maximum
N	8	
A	--	1.20
A1	0.05	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

TABLE 9. ORDERING INFORMATION

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
ICS843023AGI	023AI	8 Lead TSSOP	tube	-40°C to 85°C
ICS843023AGIT	023AI	8 Lead TSSOP	2500 tape & reel	-40°C to 85°C
ICS843023AGILF	TBD	8 Lead "Lead-Free" TSSOP	tube	-40°C to 85°C
ICS843023AGILFT	TBD	8 Lead "Lead-Free" TSSOP	2500 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.