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Systems, Inc.

**PRELIMINARY**

**ICS843021I-01**  
FEMTOCLOCKS™ CRYSTAL-TO-3.3V, 2.5V  
125MHz LVPECL CLOCK GENERATOR

**GENERAL DESCRIPTION**



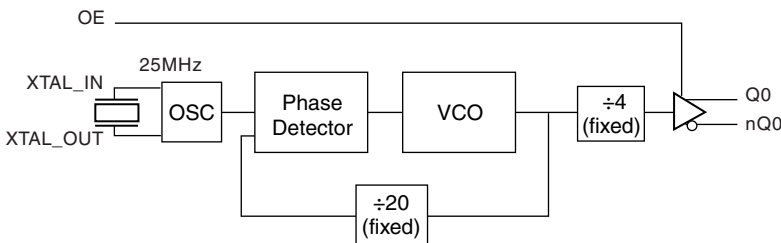
The ICS843021I-01 is a Gigabit Ethernet Clock Generator and a member of the HiPerClocks™ family of high performance devices from ICS. The ICS843021I-01 uses a 25MHz crystal to synthesize 125MHz. The ICS843021I-01 has excellent phase jitter performance, over the 1.875MHz – 20MHz integration range. The ICS843021I-01 is packaged in a small 8-pin TSSOP, making it ideal for use in systems with limited board space.

**FEATURES**

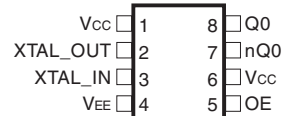
- 1 differential 3.3V LVPECL output
- Crystal oscillator interface designed for 25MHz, 18pF parallel resonant crystal
- Output frequency: 125MHz, using a 25MHz crystal
- VCO range: 490MHz - 640MHz
- RMS phase jitter @ 125MHz, using a 25MHz crystal (1.875MHz - 20MHz): 0.41ps (typical) (for 3.3V)
- Full 3.3V or 2.5V operating supply
- -40°C to 85°C ambient operating temperature



**BLOCK DIAGRAM**



**PIN ASSIGNMENT**



**ICS843021I-01**

**8-Lead TSSOP**

4.40mm x 3.0mm x 0.925mm package body

**G Package**

Top View

The Preliminary Information presented herein represents a product in prototyping or pre-production. The noted characteristics are based on initial product characterization. Integrated Circuit Systems, Incorporated (ICS) reserves the right to change any circuitry or specifications without notice.



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**TABLE 1. PIN DESCRIPTIONS**

Number	Name	Type		Description
1, 6	V <sub>CC</sub>	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 <sub>EE</sub>	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 are in a high impedance state. LVCMOS/LVTTL interface levels.
7, 8	nQ0, Q0	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 <sub>IN</sub>	Input Capacitance			4		pF
R <sub>PULLUP</sub>	Input Pullup Resistor			51		KΩ



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**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, $\theta_{JA}$	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,  $V_{CC} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

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		3.135	3.3	3.465	V
$I_{EE}$	Power Supply Current			60		mA

**TABLE 3B. POWER SUPPLY DC CHARACTERISTICS,  $V_{CC} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

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			57		mA

**TABLE 3C. LVCMOS/LVTTL DC CHARACTERISTICS,  $V_{CC} = 3.3V \pm 5\%$  OR  $2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

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

**TABLE 3D. LVPECL DC CHARACTERISTICS,  $V_{CC} = 3.3V \pm 5\%$  OR  $2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

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  $50\Omega$  to  $V_{CC} - 2V$ .



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**TABLE 4. CRYSTAL CHARACTERISTICS**

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation		Fundamental			
Frequency			25		MHz
Equivalent Series Resistance (ESR)				50	$\Omega$
Shunt Capacitance				7	pF

**TABLE 5A. AC CHARACTERISTICS,  $V_{CC} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{OUT}$	Output Frequency			125		MHz
$f_{jit}(\emptyset)$	RMS Phase Jitter (Random); NOTE 1	Intergration Range: 1.875MHz - 20MHz		0.41		ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%		400		ps
odc	Output Duty Cycle			50		%

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

**TABLE 5B. AC CHARACTERISTICS,  $V_{CC} = 2.5V \pm 5\%$ ,  $T_A = -40^\circ C$  TO  $85^\circ C$**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{OUT}$	Output Frequency			125		MHz
$f_{jit}(\emptyset)$	RMS Phase Jitter (Random); NOTE 1	Intergration Range: 1.875MHz - 20MHz		0.42		ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%		400		ps
odc	Output Duty Cycle			50		%

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

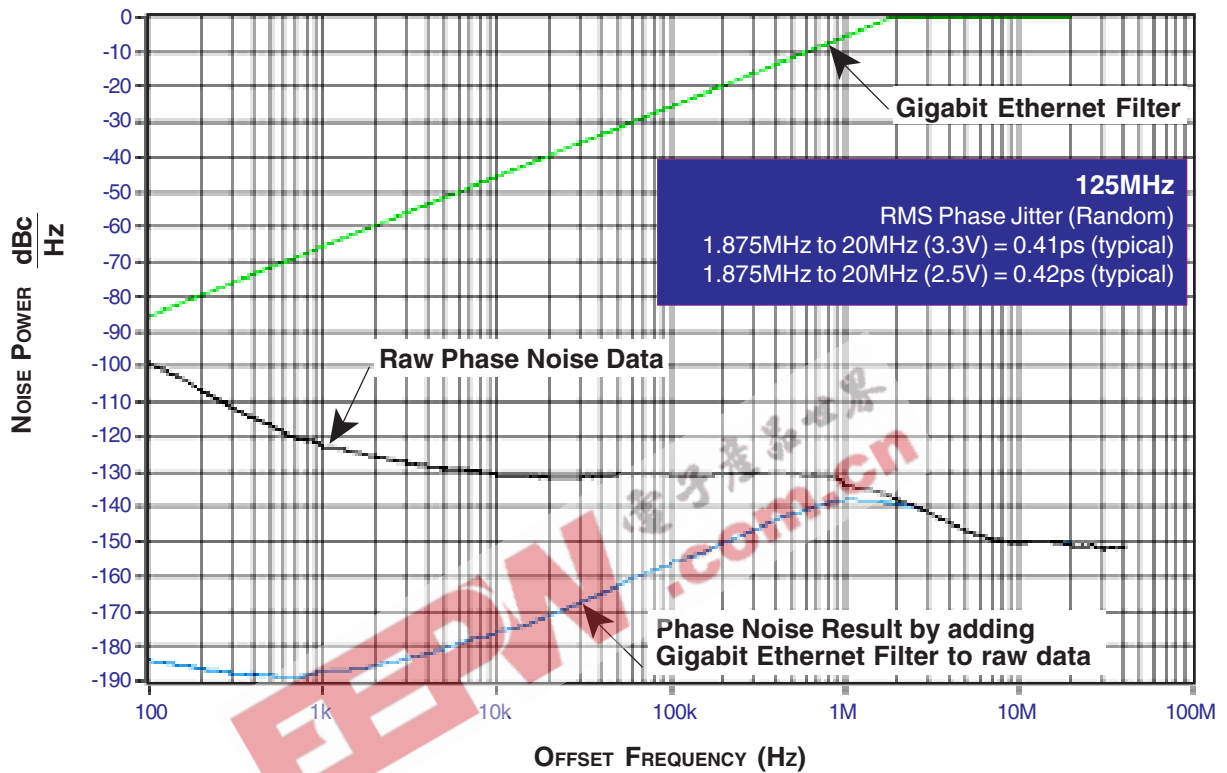


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**TYPICAL PHASE NOISE AT 125MHz (3.3V OR 2.5V)**



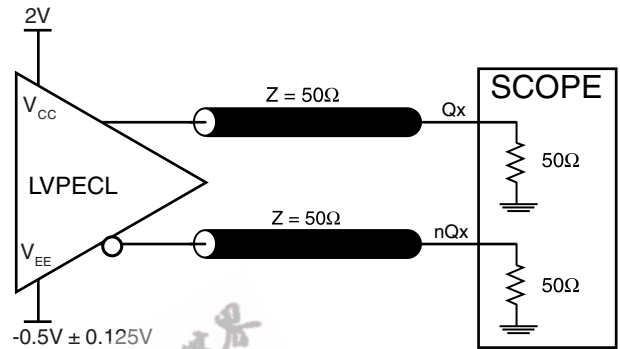
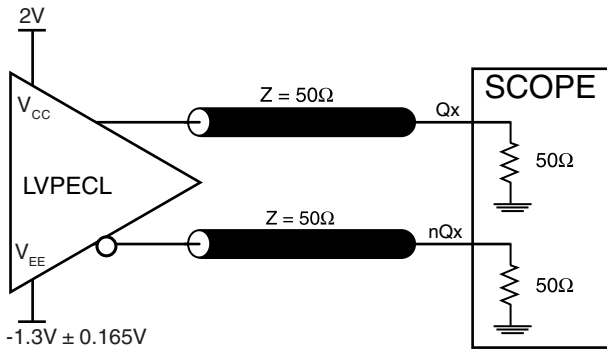


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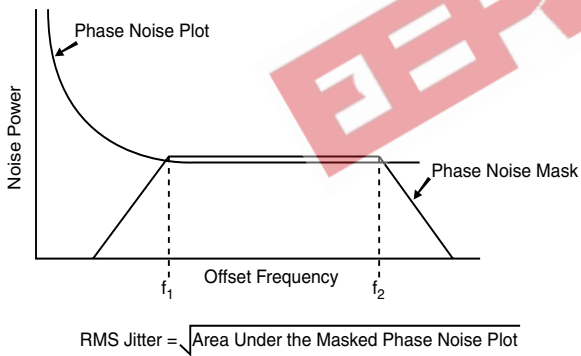
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**PARAMETER MEASUREMENT INFORMATION**



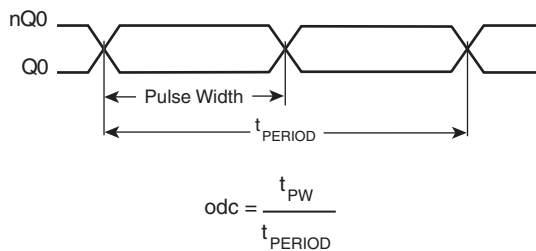
**3.3V OUTPUT LOAD AC TEST CIRCUIT**

**2.5V OUTPUT LOAD AC TEST CIRCUIT**



**RMS PHASE JITTER**

**OUTPUT RISE/FALL TIME**



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



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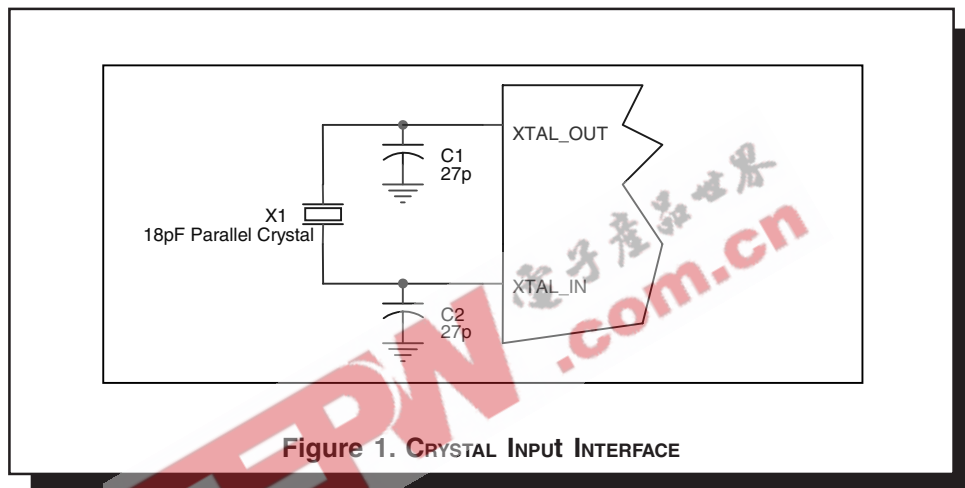
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## APPLICATION INFORMATION

### CRYSTAL INPUT INTERFACE

The ICS843021I-01 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.

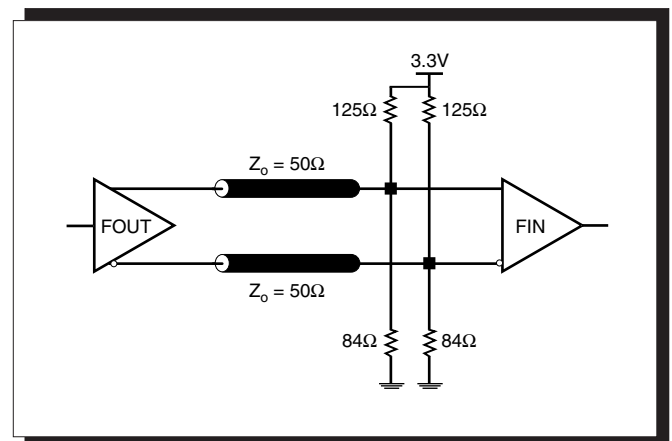
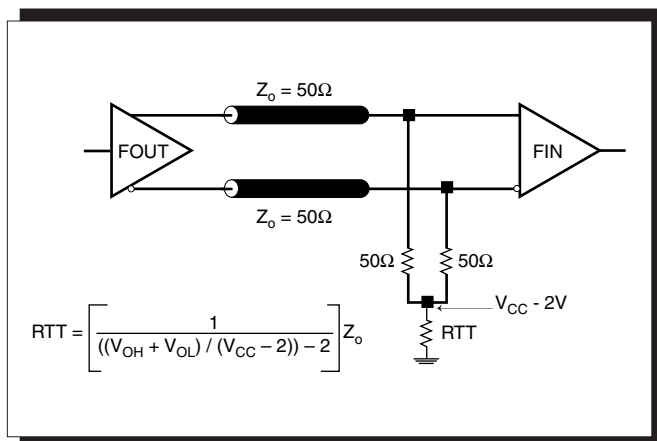


### TERMINATION FOR 3.3V LVPECL OUTPUT

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.





**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.

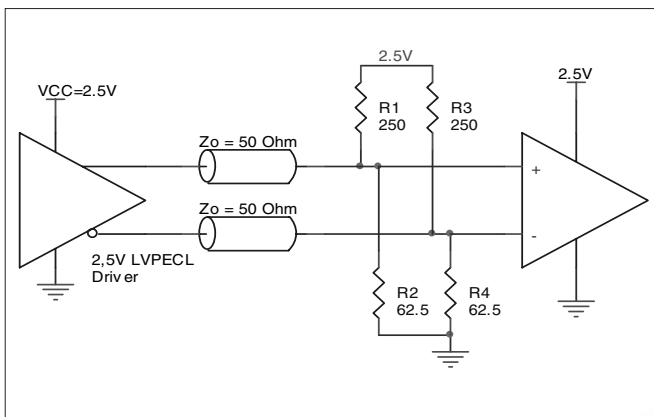


FIGURE 3A. 2.5V LVPECL DRIVER TERMINATION EXAMPLE

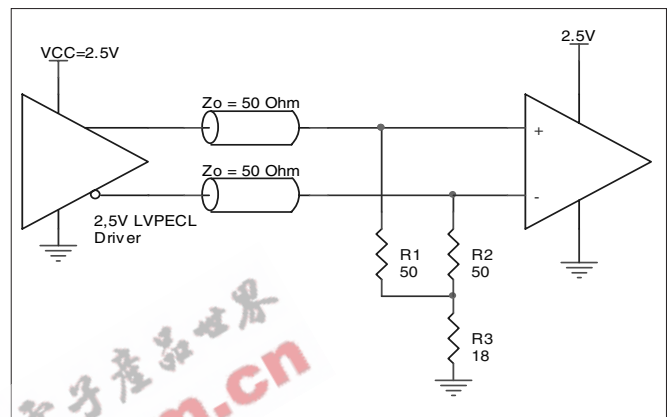


FIGURE 3B. 2.5V LVPECL DRIVER TERMINATION EXAMPLE

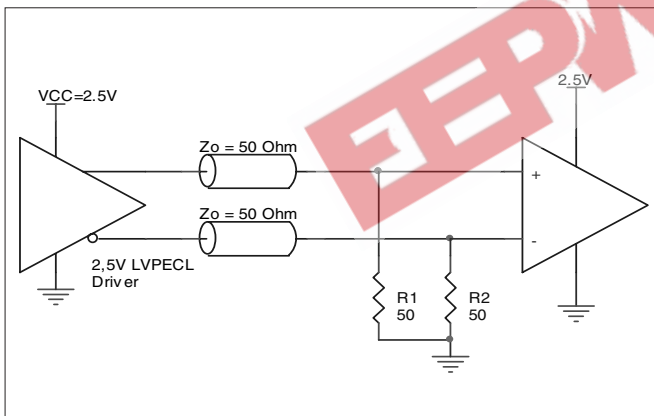


FIGURE 3C. 2.5V LVPECL TERMINATION EXAMPLE





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**APPLICATION SCHEMATIC**

Figure 4 shows an example of ICS843021I-01 application schematic. In this example, the device is operated at  $V_{CC} = 3.3V$ . The decoupling capacitor should be located as close as possible to the power pin. The input is driven by a 25MHz quartz crystal. For the LVPECL output drivers, only

two termination examples are shown in this schematic. Additional termination approaches are shown in the LVPECL Termination Application Note.

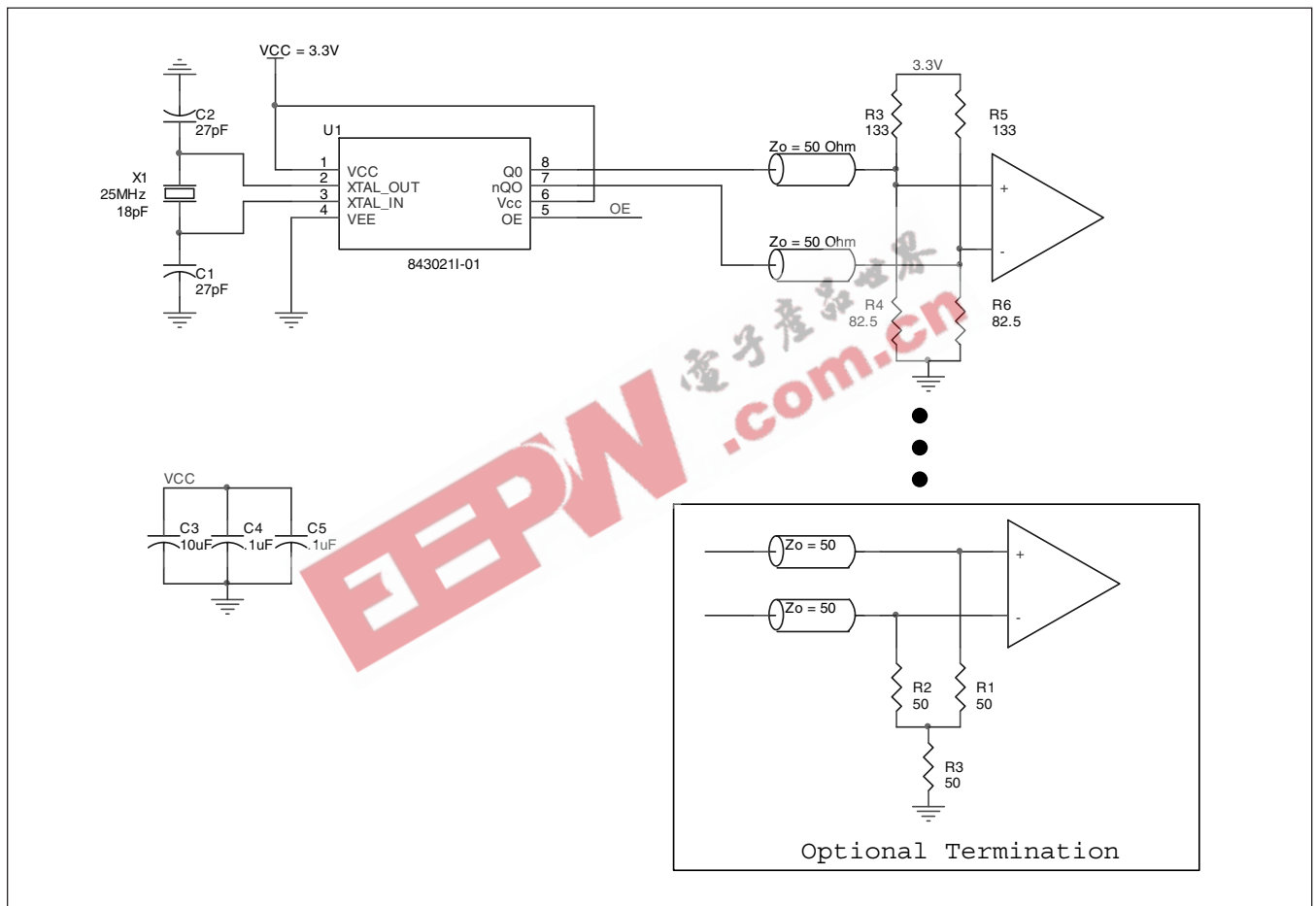


FIGURE 4. ICS843021I-01 SCHEMATIC EXAMPLE



## POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS843021I-01. Equations and example calculations are also provided.

### 1. Power Dissipation.

The total power dissipation for the ICS843021I-01 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> =  $V_{CC\_MAX} * I_{EE\_MAX} = 3.465V * 60mA = 207.9mW$
- Power (outputs)<sub>MAX</sub> = **30mW/Loaded Output pair**

$$\text{Total Power}_{\_MAX} (3.465V, \text{ with all outputs switching}) = 207.9mW + 30mW = \mathbf{237.9mW}$$

### 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

$\theta_{JA}$  = 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 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,  $T_j$  for an ambient temperature of 85°C with all outputs switching is:

$$85^\circ C + 0.238W * 90.5^\circ C/W = 106.5^\circ C. \text{ This is well below the limit of } 125^\circ C.$$

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-PIN TSSOP, FORCED CONVECTION**

$\theta_{JA}$ 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 5.

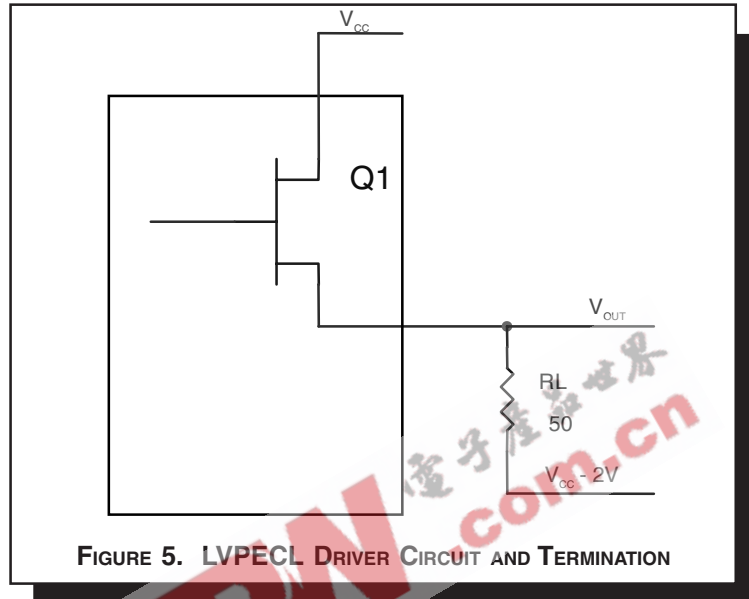


FIGURE 5. LVPECL DRIVER CIRCUIT AND TERMINATION

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,  $V_{OUT} = V_{OH\_MAX} = V_{CC\_MAX} - 0.9V$   
 $(V_{CC\_MAX} - V_{OH\_MAX}) = 0.9V$
- For logic low,  $V_{OUT} = V_{OL\_MAX} = V_{CC\_MAX} - 1.7V$   
 $(V_{CC\_MAX} - V_{OL\_MAX}) = 1.7V$

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

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

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

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



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## RELIABILITY INFORMATION

TABLE 7.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 8 LEAD TSSOP

$\theta_{JA}$ 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 ICS843021I-01 is: 1765

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PACKAGE OUTLINE - G SUFFIX FOR 8 LEAD TSSOP

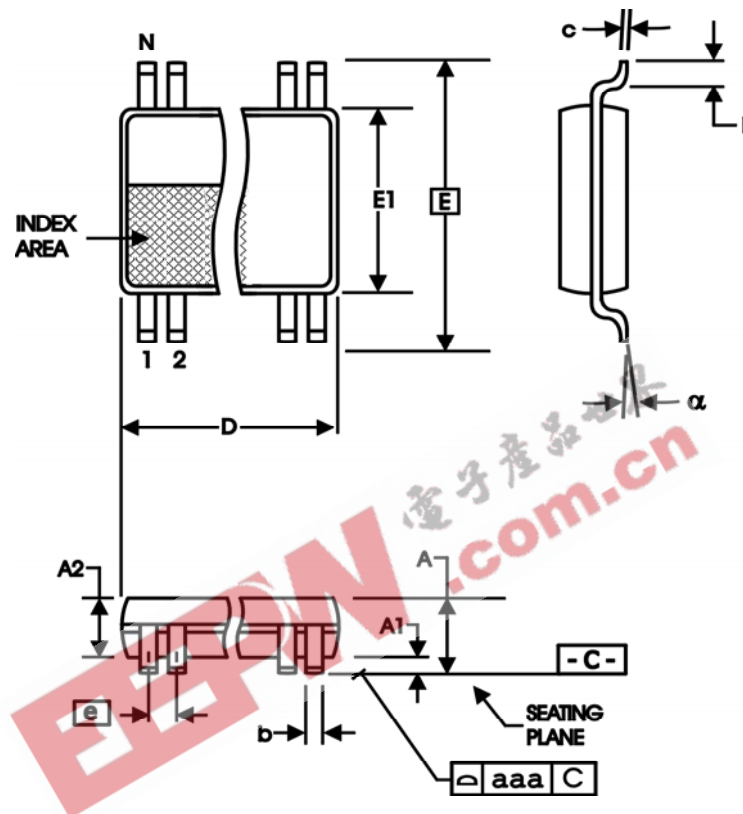


TABLE 8. PACKAGE DIMENSIONS

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
alpha	0°	8°
aaa	--	0.10

Reference Document: JEDEC Publication 95, MO-153



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**TABLE 9. ORDERING INFORMATION**

Part/Order Number	Marking	Package	Count	Temperature
ICS843021AGI-01	1AI01	8 lead TSSOP	100 per tube	-40°C to 85°C
ICS843021AGI-01T	1AI01	8 lead TSSOP on Tape and Reel	2500	-40°C to 85°C

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