

## General Description

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

## Features

- One differential 3.3V LVPECL output
- Crystal oscillator interface designed for 22.4MHz – 28MHz, 18pF parallel resonant crystal
- Output frequency range: 112MHz – 140MHz
- VCO range: 560MHz – 700MHz
- Output duty cycle range: 49% – 51%
- RMS phase jitter at 125MHz, using a 25MHz crystal (1.875MHz – 20MHz): 0.650ps (typical)

### Offset Noise Power

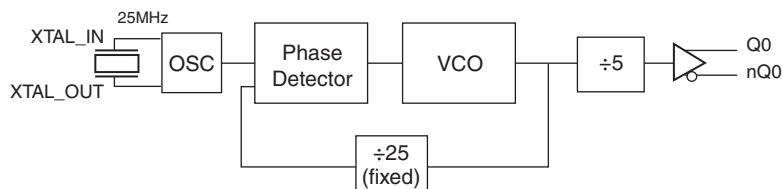
100Hz.....	-94.2 dBc/Hz
1kHz.....	-122.8 dBc/Hz
10kHz.....	-132.2 dBc/Hz
100kHz.....	-131.3 dBc/Hz

- Full 3.3V supply mode
- -40°C to 85°C ambient operating temperature
- Available in lead-free (RoHS 6) package

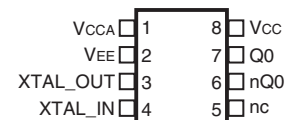
**Table 1. Frequency Table - Typical Applications**

Inputs	Output Frequency Range (MHz)
Crystal Frequency (MHz)	
25	125
26.6	133

## Block Diagram



## Pin Assignment



**ICS843021I**

**8 Lead TSSOP**

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

**G Package**

**Top View**

**Table 2. Pin Descriptions**

Number	Name	Type	Description
1	V <sub>CCA</sub>	Unused	Analog supply pin.
2	V <sub>EE</sub>	Power	Negative supply pin.
3, 4	XTAL_OUT XTAL_IN	Input	Crystal oscillator interface. XTAL_IN is the input, XTAL_OUT is the output.
5	nc	Unused	No connect.
6, 7	nQ0, Q0	Output	Differential output pair. LVPECL interface levels.
8	V <sub>CC</sub>	Power	Core supply pin.

**Table 3. Pin Characteristics**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
C <sub>IN</sub>	Input Capacitance			4		pF

## 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 <sub>CC</sub>	4.6V
Inputs, V <sub>I</sub>	-0.5V to V <sub>CC</sub> + 0.5V
Outputs, I <sub>O</sub> Continuos Current Surge Current	50mA 100mA
Package Thermal Impedance, $\theta_{JA}$	112.4°C/W (0 mps)
Storage Temperature, T <sub>STG</sub>	-65°C to 150°C

## DC Electrical Characteristics

**Table 4A. Power Supply DC Characteristics, V<sub>CC</sub> = 3.3V ± 10%, V<sub>EE</sub> = 0V, T<sub>A</sub> = -40°C to 85°C**

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V <sub>CC</sub>	Core Supply Voltage		2.97	3.3	3.63	V
V <sub>CCA</sub>	Analog Supply Voltage		2.97	3.3	3.63	V
I <sub>EE</sub>	Power Supply Current				85	mA

**Table 4B. LVPECL DC Characteristics,  $V_{CC} = 3.3V \pm 10\%$ ,  $V_{EE} = 0V$ ,  $T_A = -40^{\circ}C$  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 termination with  $50\Omega$  to  $V_{CC} - 2V$ .

**Table 5. Crystal Characteristics**

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation		Fundamental			
Frequency; NOTE 1		14		40	MHz
Equivalent Series Resistance (ESR)				50	$\Omega$
Shunt Capacitance				7	pF

NOTE 1: Input frequency is limited to a range of 22.4MHz – 28MHz due to VCO range.

## AC Electrical Characteristics

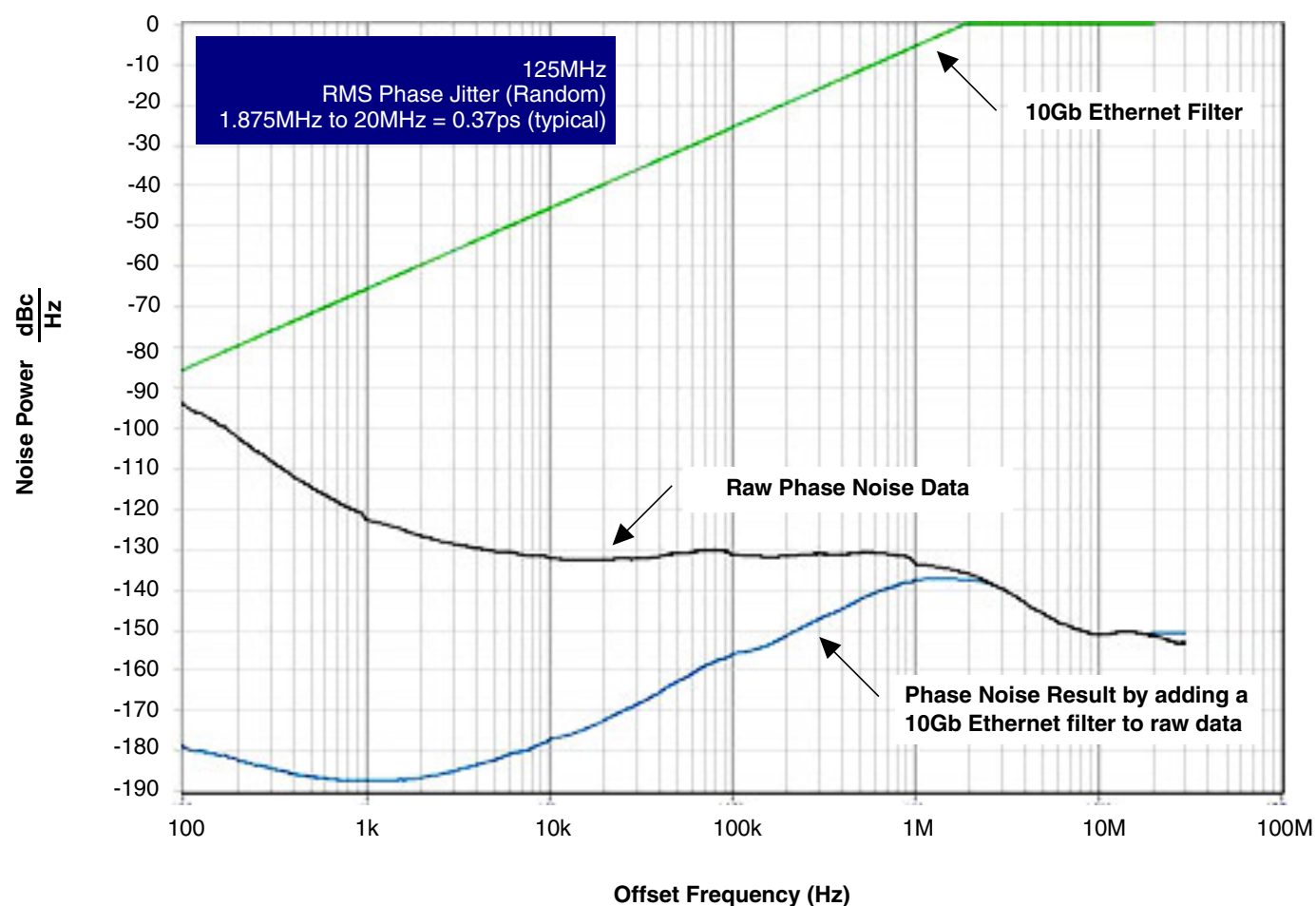
**Table 6. AC Characteristics,  $V_{CC} = 3.3V \pm 10\%$ ,  $V_{EE} = 0V$ ,  $T_A = 0^{\circ}C$  to  $70^{\circ}$** 

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
$f_{OUT}$	Output Frequency		112		140	MHz
$\bar{f}_{jit}(\emptyset)$	RMS Phase Jitter, Random; NOTE 1	125MHz, Integration Range: 1.875MHz – 20MHz		0.37	0.65	ps
$t_R / t_F$	Output Rise/Fall Time	20% to 80%	250		550	ps
odc	Output Duty Cycle		49		51	%

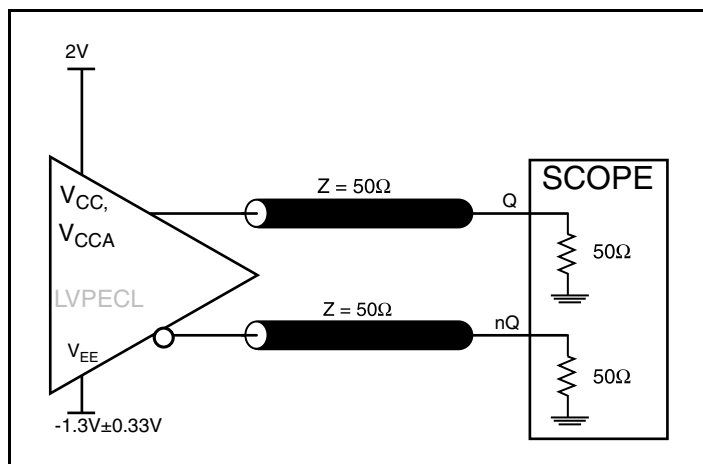
NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lfm. The device will meet specifications after thermal equilibrium has been reached under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

NOTE 1: Refer to Phase Noise Plot.

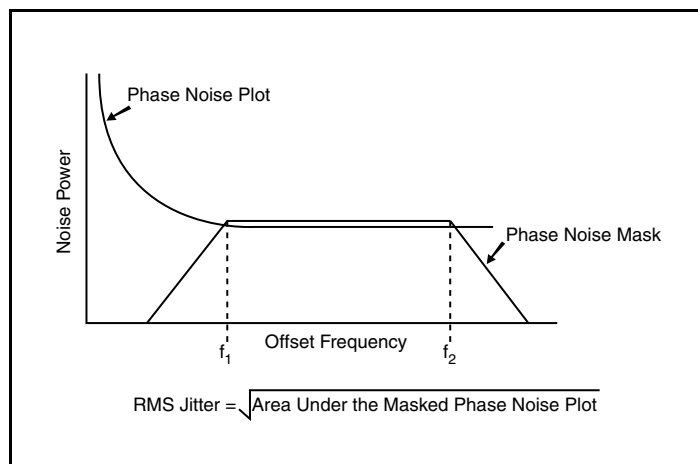
## Typical Phase Noise at 125MHz



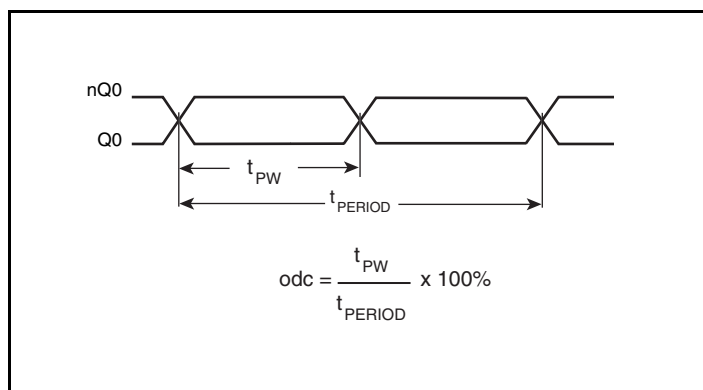
## Parameter Measurement Information



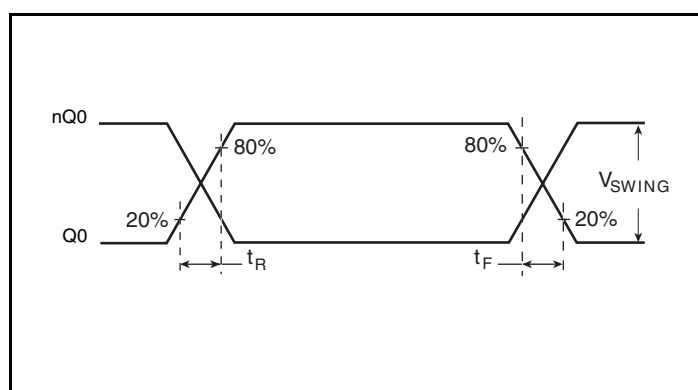
3.3V LVPECL Output Load AC Test Circuit



RMS Phase Jitter



Output Duty Cycle/Pulse Width/Period



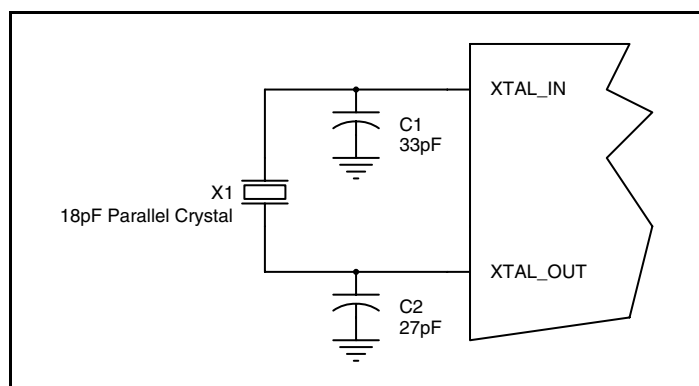
Output Rise/Fall Time

## Applications Information

### Crystal Input Interface

The ICS843021I 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**

## Overdriving the XTAL Interface

The XTAL\_IN input can be overdriven by an LVCMOS driver or by one side of a differential driver through an AC coupling capacitor. The XTAL\_OUT pin can be left floating. The amplitude of the input signal should be between 500mV and 1.8V and the slew rate should not be less than 0.2V/nS. For 3.3V LVCMOS inputs, the amplitude must be reduced from full swing to at least half the swing in order to prevent signal interference with the power rail and to reduce internal noise. *Figure 3A* shows an example of the interface diagram for a high speed 3.3V LVCMOS driver. This configuration requires that the sum of the output impedance of the driver ( $R_o$ ) and 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,  $R_1$  and  $R_2$  in parallel should equal the transmission line impedance. For most 50 $\Omega$  applications,  $R_1$  and  $R_2$  can be 100 $\Omega$ . This can also be accomplished by removing  $R_1$  and changing  $R_2$  to 50 $\Omega$ . The values of the resistors can be increased to reduce the loading for a slower and weaker LVCMOS driver. *Figure 3B* shows an example of the interface diagram for an LVPECL driver. This is a standard LVPECL termination with one side of the driver feeding the XTAL\_IN input. It is recommended that all components in the schematics be placed in the layout. Though some components might not be used, they can be utilized for debugging purposes. The datasheet specifications are characterized and guaranteed by using a quartz crystal as the input.

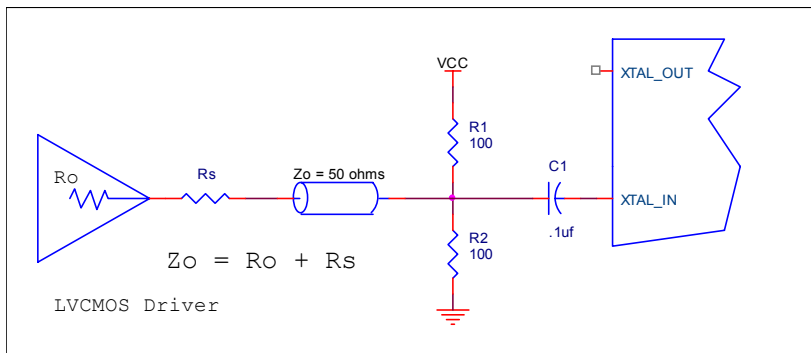


Figure 3A. General Diagram for LVCMOS Driver to XTAL Input Interface

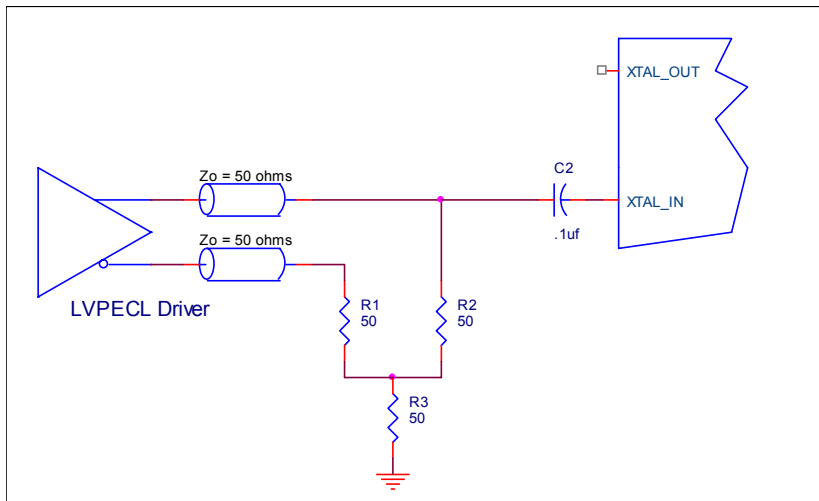


Figure 3B. General Diagram for LVPECL Driver to XTAL Input Interface

## Termination for 3.3V 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.

The differential outputs 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 3A and 3B* 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.

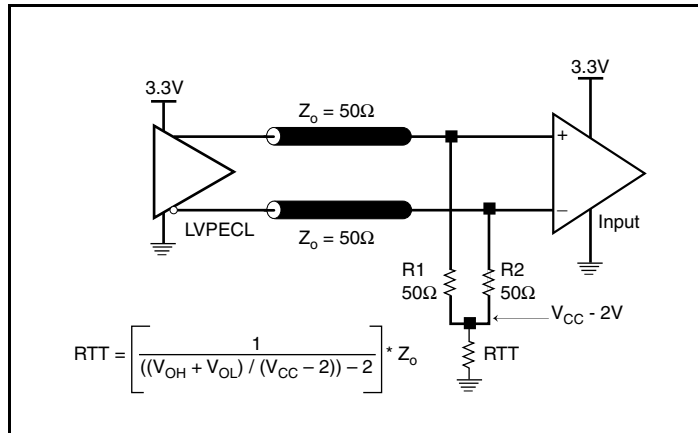


Figure 3A. 3.3V LVPECL Output Termination

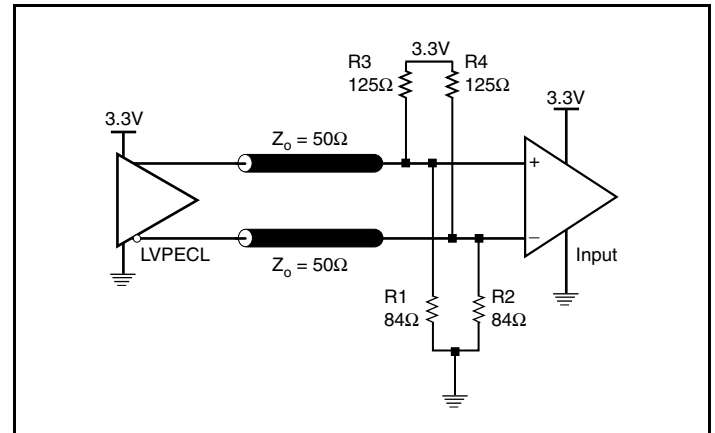


Figure 3B. 3.3V LVPECL Output Termination



## Schematic Example

Figure 4 shows an example of ICS843021I application schematic. In this example, the device is operated at  $V_{CC} = 3.3V$ . An 18pF parallel resonant 25MHz crystal is used. The load capacitance  $C1 = 33pF$  and  $C2 = 27pF$  are recommended for frequency accuracy. Depending on the parasitics of the printed circuit board layout, these values might require a slight adjustment to optimize the frequency accuracy. Crystals with other load capacitance specifications can be used. This will require adjusting  $C1$  and  $C2$ .

As with 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 ICS843021I provides separate power supplies to isolate noise from coupling into the internal PLL.

In order to achieve the best possible filtering, it is recommended that the placement of the filter components be on the device side of the PCB as close to the power pins as possible. If space is limited, the  $0.1\mu F$  capacitor in each power pin filter should be placed on the

device side of the PCB and the other components can be placed on the opposite side.

Power supply filter recommendations are a general guideline to be used for reducing external noise from coupling into the devices. The filter performance is designed for wide range of noise frequencies. This low-pass filter starts to attenuate noise at approximately 10kHz. If a specific frequency noise component is known, such as switching power supply frequencies, it is recommended that component values be adjusted and if required, additional filtering be added. Additionally, good general design practices for power plane voltage stability suggests adding bulk capacitances in the local area of all devices.

The schematic example focuses on functional connections and is not configuration specific. Refer to the pin description and functional tables in the datasheet to ensure the logic control inputs are properly set.

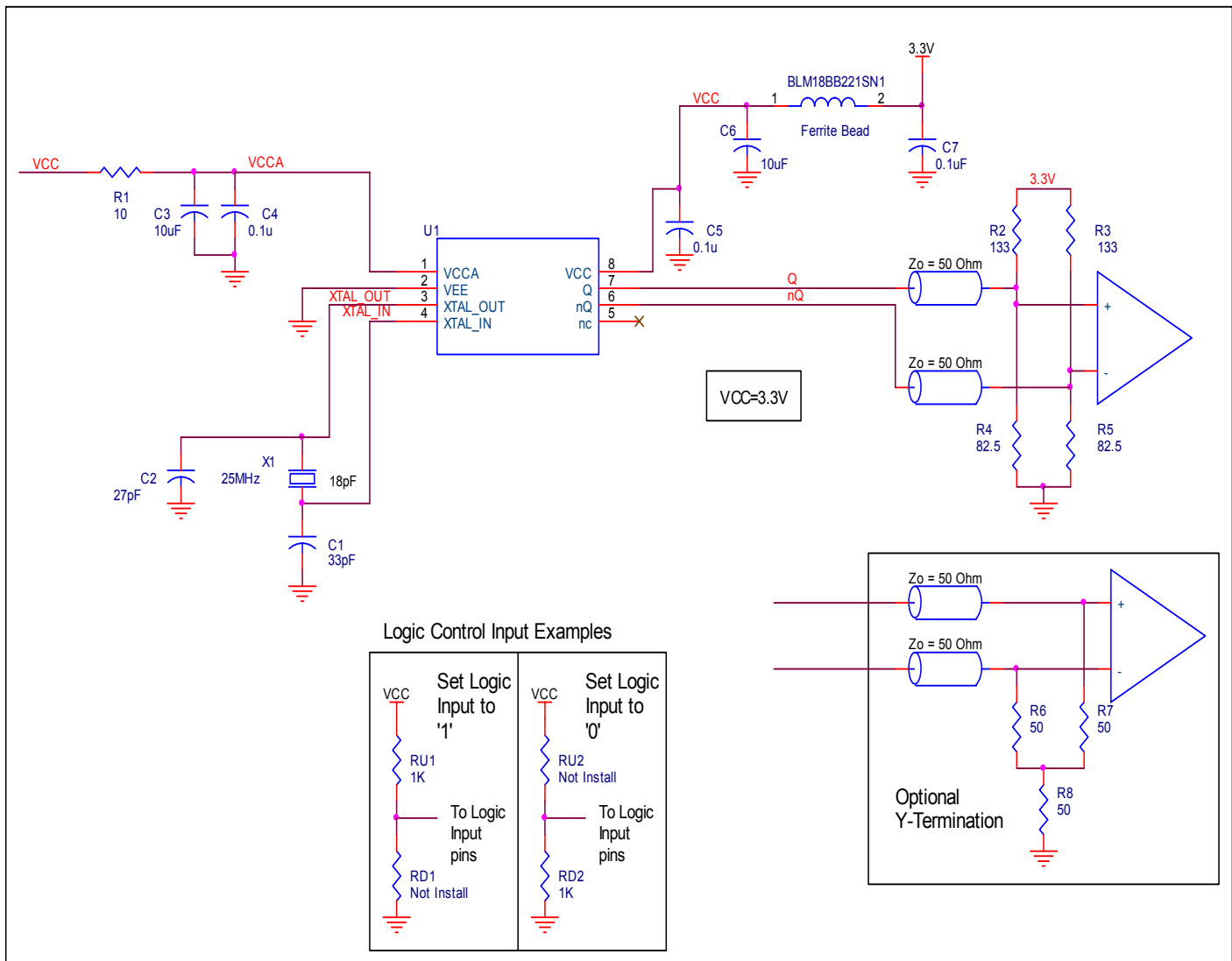


Figure 4. ICS843021I Schematic Example

## Power Considerations

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

### 1. Power Dissipation.

The total power dissipation for the ICS843021I is the sum of the core power plus the power dissipated in the load(s). The following is the power dissipation for  $V_{CC} = 3.3V + 10\% = 3.63V$ , 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> =  $V_{CC\_MAX} * I_{EE\_MAX} = 3.63V * 85mA = \mathbf{308.6mW}$
- Power (outputs)<sub>MAX</sub> = **30mW/Loaded Output pair**

**Total Power**<sub>MAX</sub> (3.63V, with all outputs switching) =  $308.6mW + 30mW = \mathbf{338.6mW}$

### 2. Junction Temperature.

Junction temperature,  $T_j$ , is the temperature at the junction of the bond wire and bond pad directly affects the reliability of the device. The maximum recommended junction temperature is 125°C. Limiting the internal transistor junction temperature,  $T_j$ , to 125°C ensures that the bond wire and bond pad temperature remains below 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 200 linear feet per minute and a multi-layer board, the appropriate value is 112.4°C/W per Table 7 below.

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

$$85^\circ C + 0.339W * 112.4^\circ C/W = 123.1^\circ C. \text{ This is below the limit of } 125^\circ C.$$

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 (multi-layer).

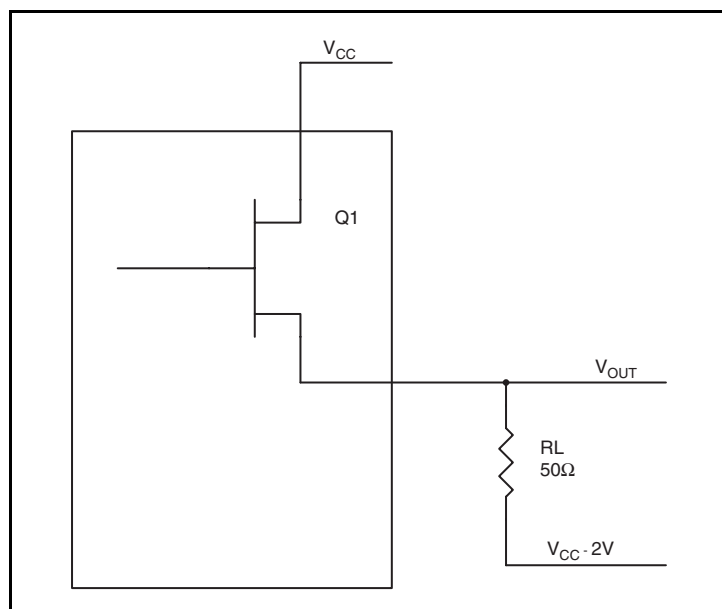
**Table 7. Thermal Resistance  $\theta_{JA}$  for 8 Lead TSSOP, Forced Convection**

$\theta_{JA}$ vs. Air Flow			
Meters per Second	0	1	2.5
Multi-Layer PCB, JEDEC Standard Test Boards	112.4°C/W	108.2°C/W	106.0°C/W

### 3. Calculations and Equations.

The purpose of this section is to calculate the power dissipation for the LVPECL output pair.

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.

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

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

$$\text{Total Power Dissipation per output pair} = Pd\_H + Pd\_L = \mathbf{30mW}$$

## Reliability Information

Table 8.  $\theta_{JA}$  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	112.4°C/W	108.2°C/W	106.0°C/W

## Transistor Count

The transistor count for ICS843021I is: 1928

## Package Outline and Package Dimensions

Package Outline - G Suffix for 8 Lead TSSOP

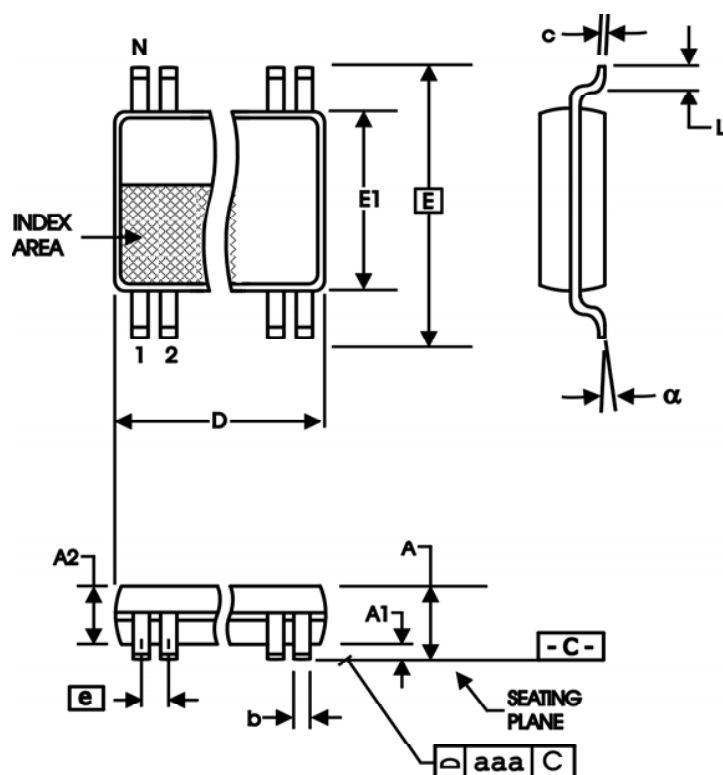


Table 9. Package Dimensions

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
$\alpha$	0°	8°
aaa		0.10

Reference Document: JEDEC Publication 95, MO-153

## Ordering Information

Table 10. Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
843021AGILF	21AIL	"Lead-Free" 8 Lead TSSOP	Tube	-40°C to 85°C
843021AGILFT	21AIL	"Lead-Free" 8 Lead 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.



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