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FEMTOCLOCKS™ CRYSTAL-TO-3.3V LVPECL CLOCK GENERATOR

ICS843021

General Description



The ICS843021 is a Gigabit Ethernet Clock Generator and a member of the HiPerClocks™ family of high performance devices from IDT. The ICS843021 uses a 25MHz crystal to synthesize 125MHz. The ICS843021 has excellent phase jitter performance, over the 1.875MHz – 20MHz integration range. The ICS843021 is packaged in a small 8-pin TSSOP, making it ideal for use in systems with limited board space.

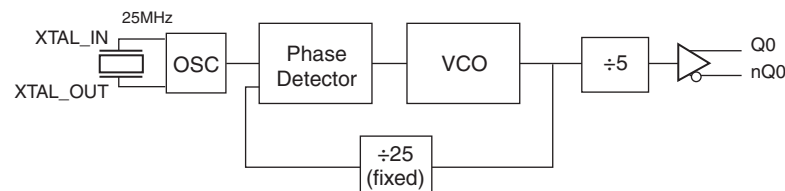
Features

- 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 @ 125MHz, using a 25MHz crystal (1.875MHz – 20MHz): 0.65ps (maximum)
- | 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
 - 0°C to 70°C ambient operating temperature
 - Industrial temperature information available upon request
 - Available in both standard (RoHS 5) and lead-free (RoHS 6) packages

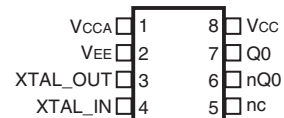
Table 1. Frequency Table - Typical Applications

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

Block Diagram



Pin Assignment



ICS843021

8 Lead TSSOP

4.40mm x 3.0mm x 0.925mm package body

G Package

Top View

Table 2. Pin Descriptions

Number	Name	Type	Description
1	V _{CCA}	Unused	Analog supply pin.
2	V _{EE}	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 _{CC}	Power	Core supply pin.

NOTE: *Pullup* refers to internal input resistors. See Table 2, *Pin Characteristics*, for typical values.

Table 3. Pin Characteristics

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
C _{IN}	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_{CC}	4.6V
Inputs, V_I	-0.5V to $V_{CC} + 0.5V$
Outputs, I_O Continuos Current Surge Current	50mA 100mA
Package Thermal Impedance, θ_{JA}	101.7°C/W (0 mps)
Storage Temperature, T_{STG}	-65°C to 150°C

DC Electrical Characteristics

Table 4A. Power Supply DC Characteristics, $V_{CC} = 3.3V \pm 10\%$, $T_A = 0^\circ C$ to $70^\circ C$

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{CC}	Positive Supply Voltage		2.97	3.3	3.63	V
V_{CCA}	Analog Supply Voltage		2.97	3.3	3.63	V
I_{EE}	Power Supply Current				85	mA

Table 4B. LVPECL DC Characteristics, $V_{CC} = 3.3V \pm 10\%$, $T_A = 0^\circ C$ to $70^\circ C$

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

NOTE 1: Outputs termination with 50Ω 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	Ω
Shunt Capacitance				7	pF

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

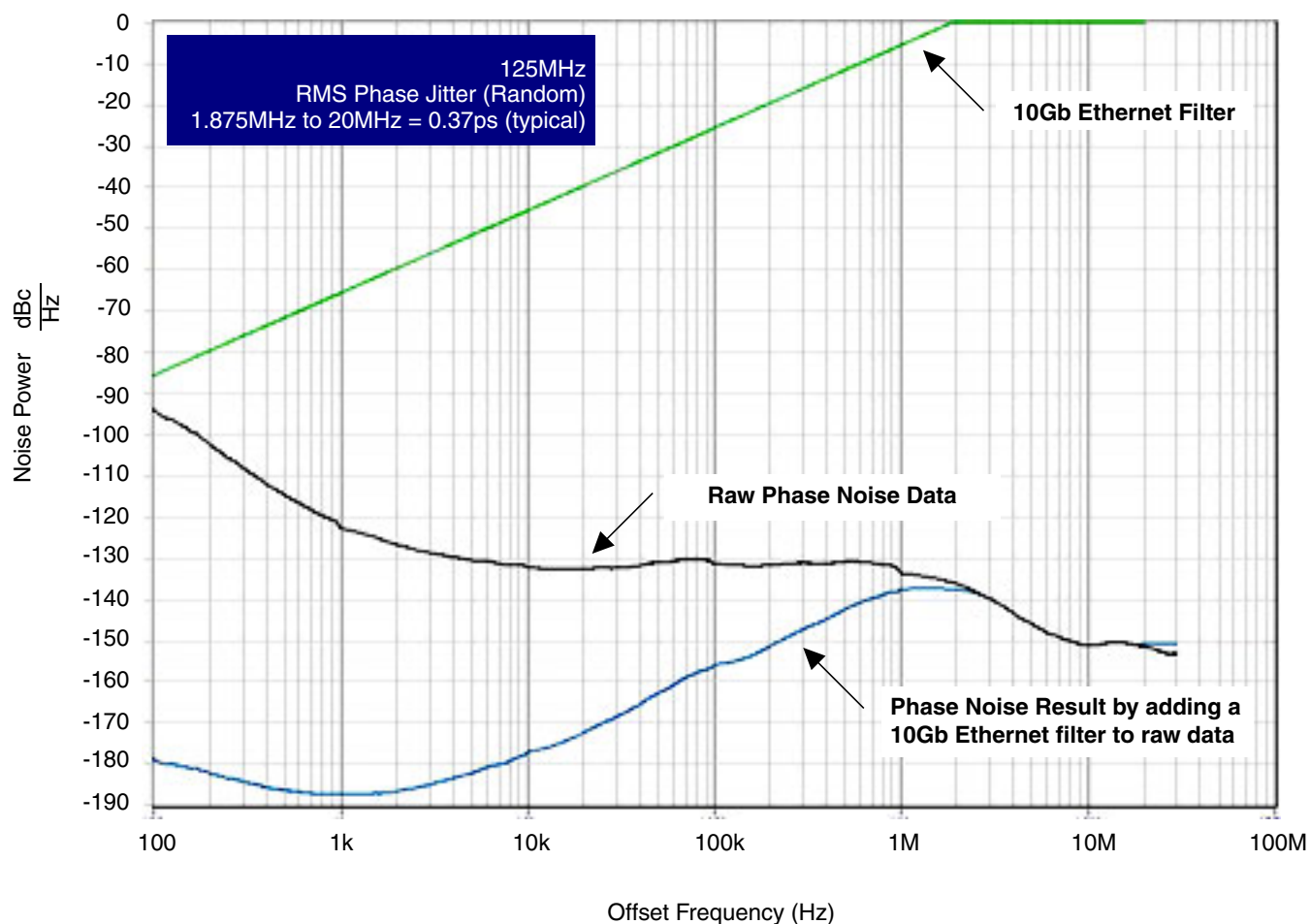
AC Electrical Characteristics

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

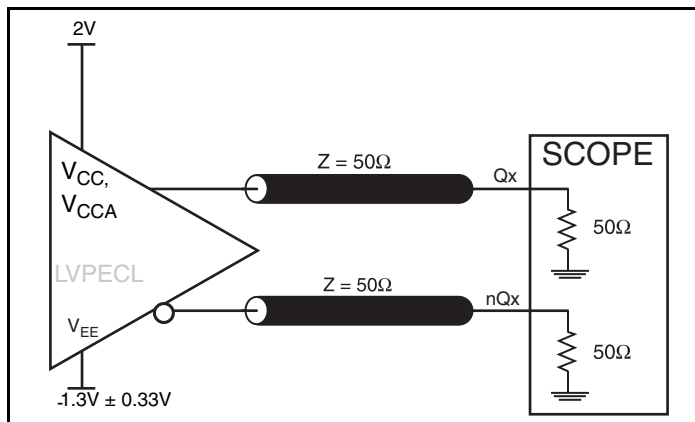
Parameter	Symbol	Test Conditions	Minimum	Typical	Maximum	Units
f_{OUT}	Output Frequency		112		140	MHz
$f_{jit}(\phi)$	RMS Phase Jitter, Random; NOTE 1	125MHz, (Integration Range: 1.875MHz – 20MHz)		0.37	0.65	ps
t_R / t_F	Output Rise/Fall Time	20% to 80%	250		550	ps
odc	Output Duty Cycle		49		51	%

NOTE 1: Please refer to Phase Noise Plot.

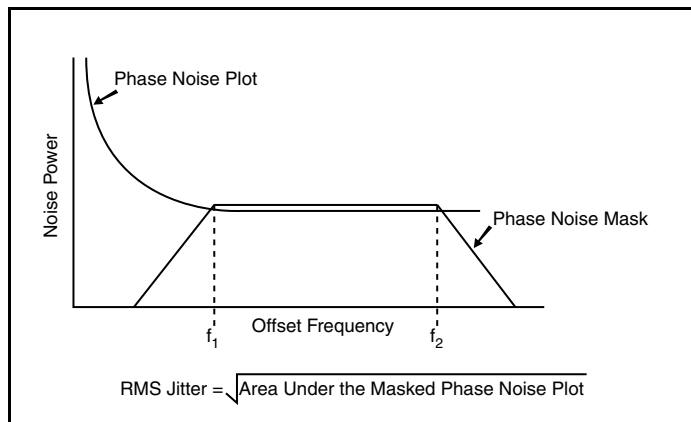
Typical Phase Noise at 125MHz



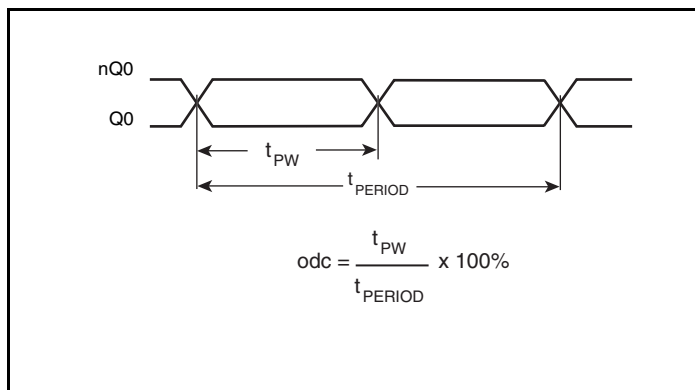
Parameter Measurement Information



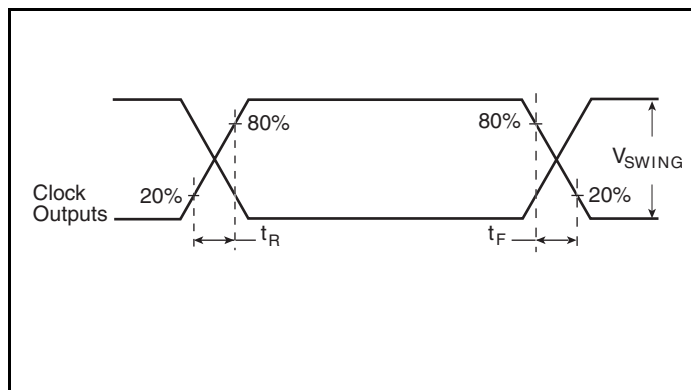
3.3V LVPECL Output Load AC Test Circuit



RMS Phase Jitter



Output Duty Cycle/Pulse Width/Period



Output Rise/Fall Time

Application Information

Power Supply Filtering Technique

As in 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 ICS843021 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL. V_{CC} and V_{CCA} should be individually connected to the power supply plane through vias, and $0.01\mu\text{F}$ bypass capacitors should be used for each pin. *Figure 1* illustrates this for a generic V_{CC} pin and also shows that V_{CCA} requires that an additional 10Ω resistor along with a $10\mu\text{F}$ bypass capacitor be connected to the V_{CCA} pin.

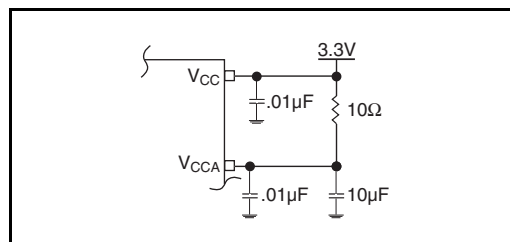


Figure 1. Power Supply Filtering

Crystal Input Interface

The ICS843021 has been characterized with 18pF parallel resonant crystals. The capacitor values, $C1$ and $C2$, shown in *Figure 2* 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.

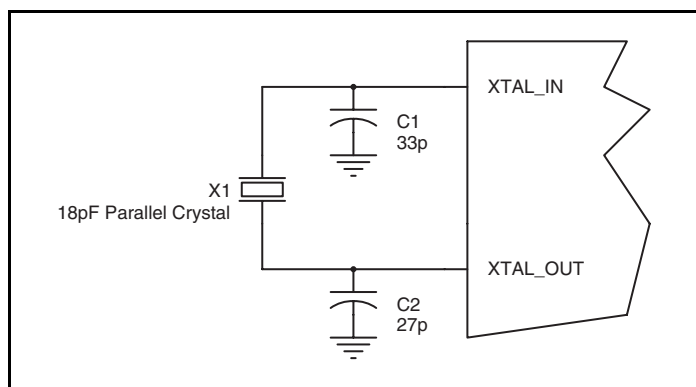


Figure 2. Crystal Input Interface

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, R_1 and R_2 in parallel should equal the transmission line impedance. For most 50Ω applications, R_1 and R_2 can be 100Ω. This can also be accomplished by removing R_1 and making R_2 50Ω.

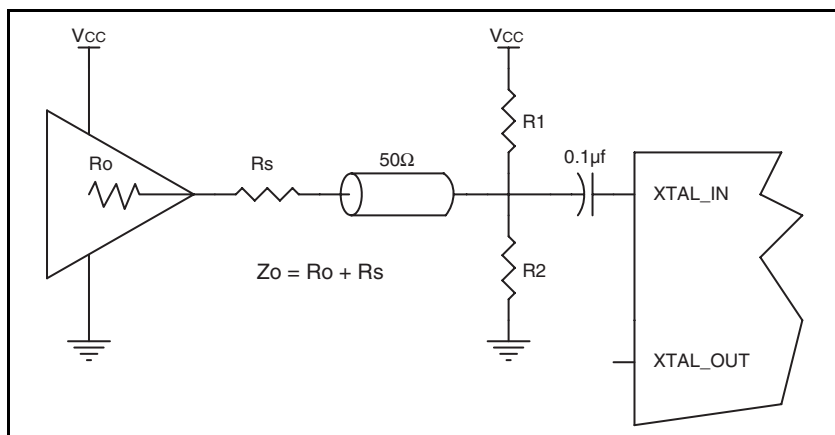


Figure 3. General Diagram for LVC MOS Driver to XTAL Input Interface

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.

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 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.

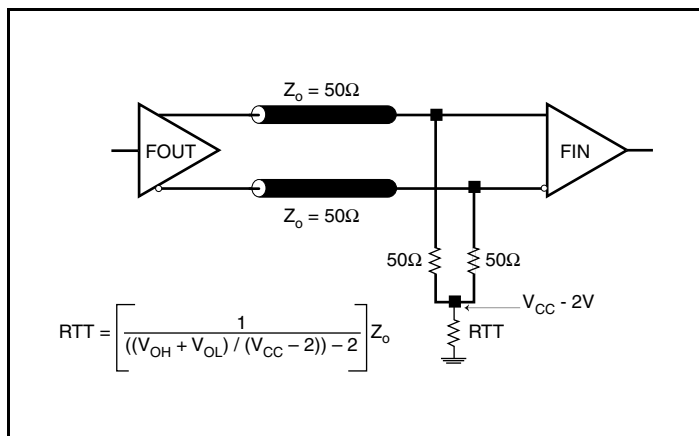


Figure 4A. 3.3V LVPECL Output Termination

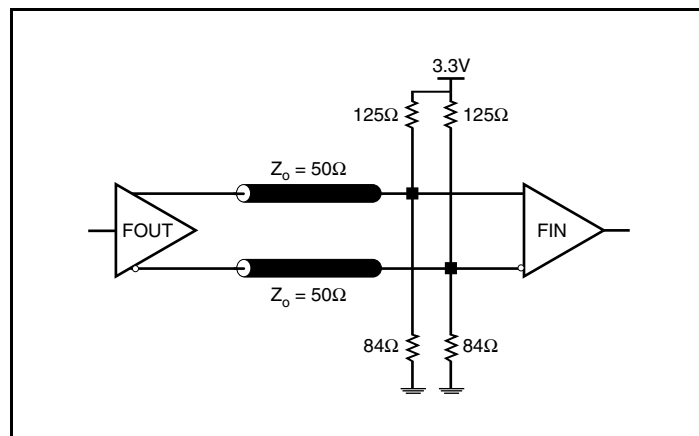


Figure 4B. 3.3V LVPECL Output Termination

Power Considerations

This section provides information on power dissipation and junction temperature for the ICS843021. Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the ICS843021 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)_{MAX} = $V_{CC_MAX} * I_{EE_MAX} = 3.63V * 85mA = 308.6mW$
- Power (outputs)_{MAX} = **30mW/Loaded Output pair**

Total Power_{MAX} (3.3V, with all outputs switching) = $308.6mW + 30mW = 338.6mW$

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 a moderate air flow of 200 linear feet per minute and a multi-layer board, the appropriate value is 90.5°C/W per Table 8 below.

Therefore, T_j for an ambient temperature of 70°C with all outputs switching is:

$70^\circ C + 0.339W * 90.5^\circ C/W = 100.7^\circ C$. This is well below the limit of 125°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 8. Thermal Resistance θ_{JA} for 8 Lead 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 6*.

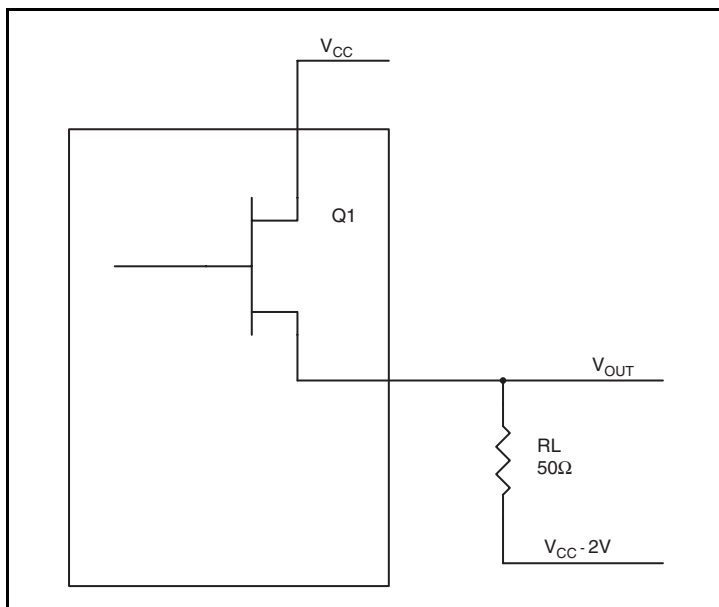


Figure 6. LVPECL Driver Circuit and Termination

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

- For logic high, $V_{OUT} = V_{OH_MAX} = V_{CC_MAX} - 0.9V$
 $(V_{CC_MAX} - V_{OH_MAX}) = 0.9V$
- For logic low, $V_{OUT} = V_{OL_MAX} = V_{CO_MAX} - 1.7V$
 $(V_{CC_MAX} - V_{OL_MAX}) = 1.7V$

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 9. θ_{JA} vs. Air Flow Table for a 8 Lead TSSOP

θ_{JA} vs. Air Flow			
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 ICS843021 is: 1928

Package Outline and Package Dimension

Package Outline - G Suffix for 8 Lead TSSOP

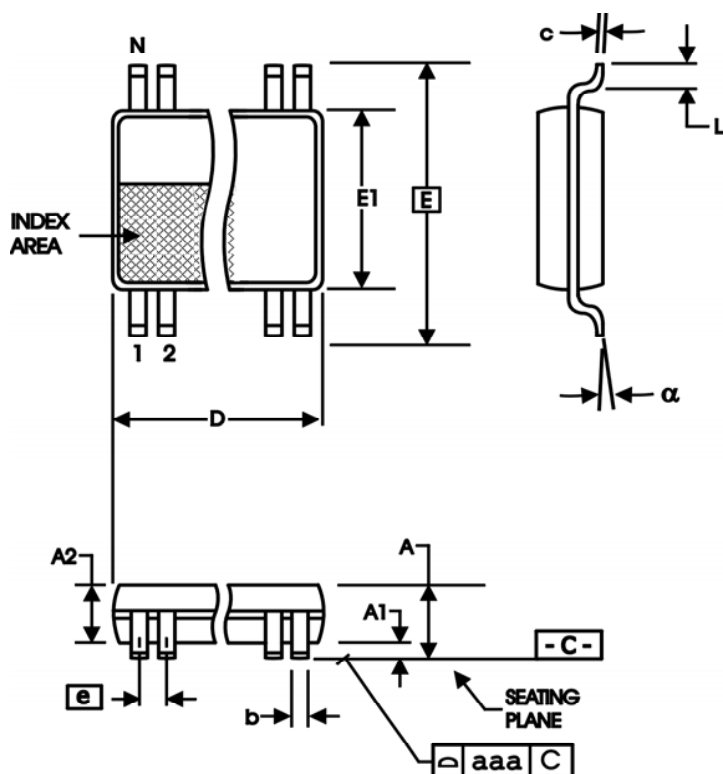


Table 10. Package Dimensions

All Dimensions in Millimeters		
Symbol	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

Ordering Information

Table 11. Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
ICS843021AG	3021A	8 Lead TSSOP	Tube	0°C to 70°C
ICS843021AGT	3021A	8 Lead TSSOP	2500 Tape & Reel	0°C to 70°C
ICS843021AGLF	021AL	“Lead-Free” 8 Lead TSSOP	Tube	0°C to 70°C
ICS843021AGLFT	021AL	“Lead-Free” 8 Lead TSSOP	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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Revision History Sheet

Rev	Table	Page	Description of Change	Date
B	T5 T6	1	Added Function Table.	10/6/04
		3	Features section - updated Crystal, Output Frequency & VCO range bullets.	
		4	Crystal Characteristics Table - changed Frequency from 25MHz typical to 14MHz min. and 40MHz max. Added Note 1. AC Characteristics Table - changed Output Frequency from 125MHz typical to 112MHz min. and 140MHz max.	
B	T11	12	Ordering Information Table - corrected count from 154 per tube to 100	10/15/04
C	T4A	3	Power Supply Table - increased V_{CC} to $3.3V \pm 10\%$ from 5% and is reflected throughout the datasheet.	11/3/04
C	T8 T9 T11	3	Absolute Maximum Ratings - corrected Package Thermal Impedance air flow.	11/30/04
		9	Thermal Resistance Table - corrected air flow.	
		11	Corrected air flow in table.	
		12	Ordering Information Table - corrected marking.	
C	T11	1	Features Section - added Lead-Free bullet.	3/31/05
		12	Ordering Information Table - added Lead-Free part number.	
D	T6	1	Features section - changed RMS phase jitter spec.	11/21/07
		4	AC Characteristics Table - added maximum RMS Phase Jitter spec of 0.65ps.	
		7	Added <i>LVC MOS to XTAL Interface</i> section.	
		7	Added <i>Termination for 3.3V LVPECL Output</i> section. Updated datasheet to new format.	

ICS843021

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