FEMTOCLOCKS™ CRYSTAL-TO-3.3V, 2.5V LVPECL 400MHZ FREQUENCY SYNTHESIZER

ICS843801I-24

GENERAL DESCRIPTION

The ICS843801I-24 is a 400MHz Frequency Synthesizer and a member of the HiPerClocks™ family of high performance devices from IDT. The ICS843801I-24 uses an 18pF parallel resonant crystal over the range of 21.5625MHz - 25.3125MHz. The ICS843801I-24 has excellent <1ps phase jitter performance, over the 12kHz - 20MHz integration range. The ICS843801I-24 is packaged in a small 8-pin TSSOP, making it ideal for use in systems with limited board space.

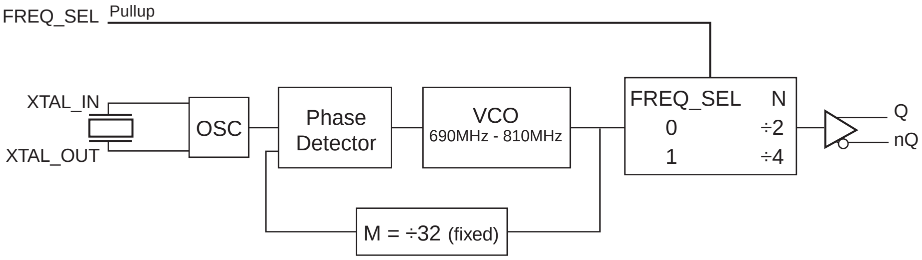
FEATURES

- One differential LVPECL output
- Crystal oscillator interface, 18pF parallel resonant crystal (21.5625MHz - 25.3125MHz)
- Output frequency range: 172.5MHz - 202.5MHz, and 345MHz - 405MHz
- VCO range: 690MHz - 810MHz
- RMS phase jitter @ 400MHz, using a 25MHz crystal (12kHz - 20MHz): 0.62ps (typical) @ 3.3V
- 3.3V or 2.5V operating supply
- -40°C to 85°C ambient operating temperature
- Available in both standard (RoHS5) and lead-free (RoHS 6) packages

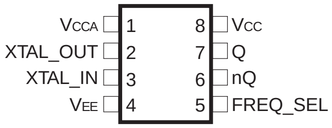
COMMON CONFIGURATION TABLE

Inputs					Output Frequency (MHz)
Crystal Frequency (MHz)	FREQ_SEL	M	N	Multiplication Value M/N	
25	0	32	2	16	400
25	1	32	4	8	200

BLOCK DIAGRAM



PIN ASSIGNMENT



ICS843801I-24

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 pre-production. The noted characteristics are based on initial product characterization and/or qualification. Integrated Device Technology, Incorporated (IDT) reserves the right to change any circuitry or specifications without notice.

TABLE 1. PIN DESCRIPTIONS

Number	Name	Type		Description
1	V_{CCA}	Power		Analog 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	FREQ_SEL	Input	Pullup	Frequency select pin. LVCMOS/LVTTL interface levels.
6, 7	nQ, Q	Output		Differential clock outputs. 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 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, $V_{CC} = V_{CCA} = 3.3V \pm 5\%$, TA = -40°C TO 85°C

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{CC}	Power Supply Voltage		3.135	3.3	3.465	V
V_{CCA}	Analog Supply Voltage		V_{CC} – 0.07	3.3	V_{CC}	V
I_{CC}	Power Supply Current			55		mA
I_{CCA}	Analog Supply Current			7		mA
I_{EE}	Power Supply Current			60		mA

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

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
V_{CC}	Power Supply Voltage		2.375	2.5	2.625	V
V_{CCA}	Analog Supply Voltage		V_{CC} – 0.07	2.5	V_{CC}	V
I_{CC}	Power Supply Current			50		mA
I_{CCA}	Analog Supply Current			7		mA
I_{EE}	Power Supply Current			60		mA

TABLE 3C. LVCMOS/LVTTL DC CHARACTERISTICS, $V_{CC} = V_{CCA} = 3.3V \pm 5\%$ OR $2.5V \pm 5\%$, 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	$V_{CC} = V_{IN}$ = 3.465V or 2.625V			5	µA
I_{IL}	Input Low Current	V_{CC} = 3.465V or 2.625V, V_{IN} = 0V	-150			µA

TABLE 3D. LVPECL DC CHARACTERISTICS, $V_{CC} = V_{CCA}$ = 3.3V±5% OR 2.5V±5%, T_A = -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		21.5625		25.3125	MHz
Equivalent Series Resistance (ESR)				50	Ω
Shunt Capacitance				7	pF
Drive Level				1	mW

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

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{OUT}	Output Frequency		172.5		202.5	MHz
			345		405	MHz
*t*jit(Ø)	RMS Phase Jitter (Random); NOTE 1	200MHz @ Integration Range: 12kHz - 20MHz		0.69		ps
		400MHz @ Integration Range: 12kHz - 20MHz		0.62		ps
t_R / t_F	Output Rise/Fall Time	20% to 80%		340		ps
odc	Output Duty Cycle			50		%

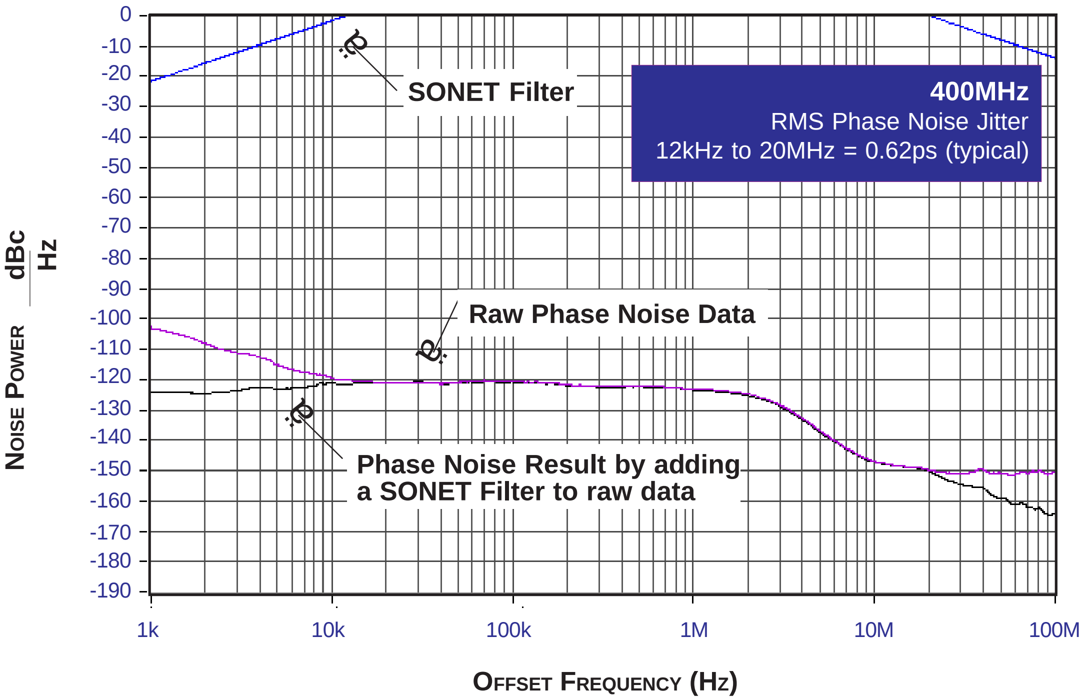
NOTE 1: Please refer to the Phase Noise Plots following this section.

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

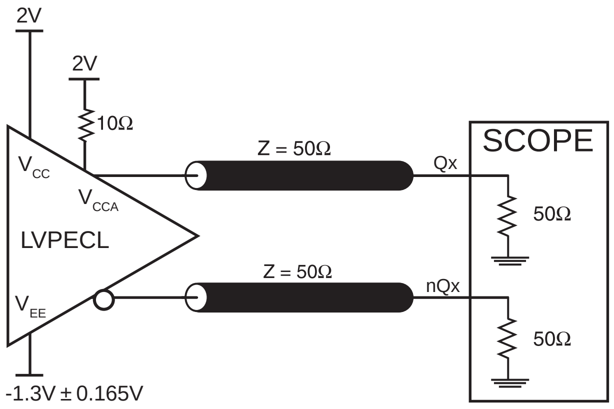
Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{OUT}	Output Frequency		172.5		202.5	MHz
			345		405	MHz
*t*jit(Ø)	RMS Phase Jitter (Random); NOTE 1	200MHz @ Integration Range: 12kHz - 20MHz		0.71		ps
		400MHz @ Integration Range: 12kHz - 20MHz		0.64		ps
t_R / t_F	Output Rise/Fall Time	20% to 80%		350		ps
odc	Output Duty Cycle			50		%

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

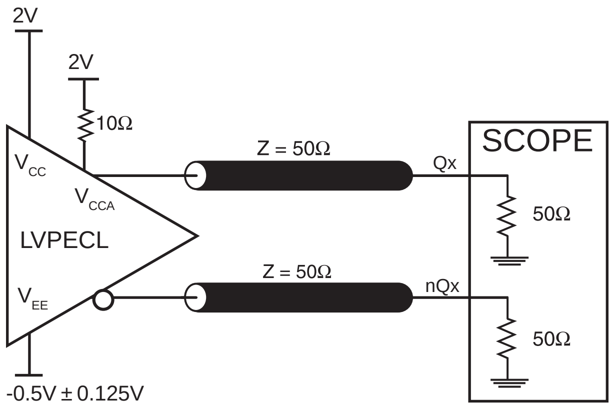
TYPICAL PHASE NOISE AT 400MHZ



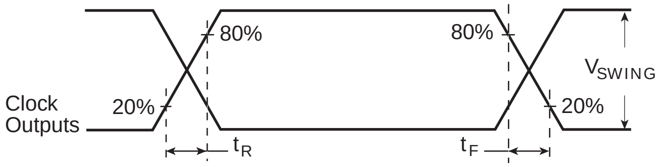
PARAMETER MEASUREMENT INFORMATION



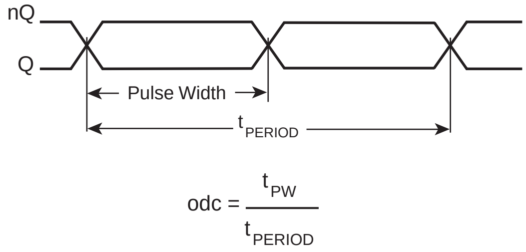
LVPECL 3.3V OUTPUT LOAD AC TEST CIRCUIT



LVPECL 2.5V OUTPUT LOAD AC TEST CIRCUIT

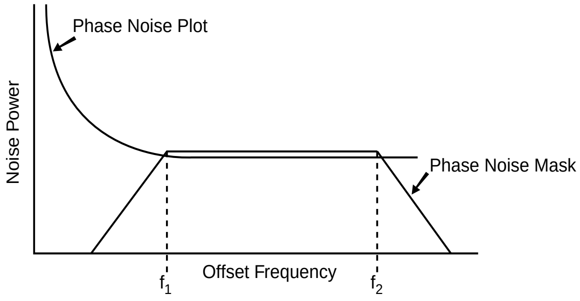


OUTPUT RISE/FALL TIME



$$odc = \frac{t_{PW}}{t_{PERIOD}}$$

OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD



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

RMS PHASE JITTER

APPLICATION INFORMATION

POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The ICS843801I-24 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 bypass capacitors should be used for each pin. To achieve optimum jitter performance, power supply isolation is required. *Figure 1* illustrates how a 10Ω resistor along with a 10µF and a .01µF bypass capacitor should be connected to each V_{CCA} pin.

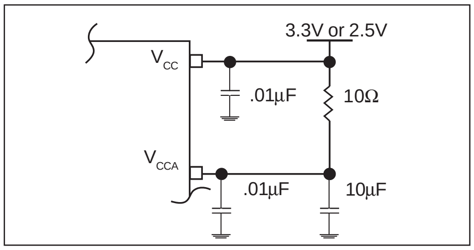


FIGURE 1. POWER SUPPLY FILTERING

CRYSTAL INPUT INTERFACE

The ICS843801I-24 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.

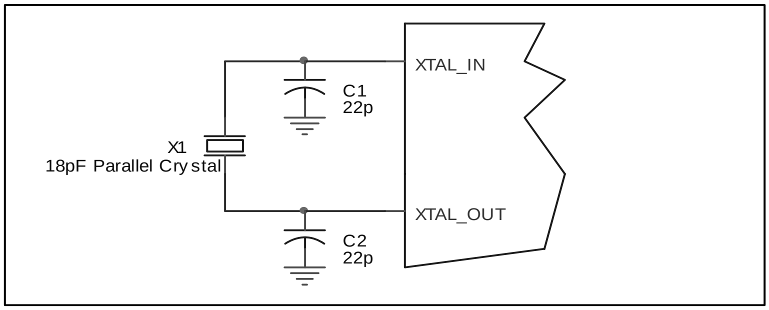


Figure 2. CRYSTAL INPUT INTERFACE

LVCMOS TO XTAL INTERFACE

The XTAL_IN input can accept a single-ended LVCMOS 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 LVCMOS 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 (Ro) plus the series resistance (Rs) 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 50Ω applications, R1 and R2 can be 100Ω. This can also be accomplished by removing R1 and making R2 50Ω.

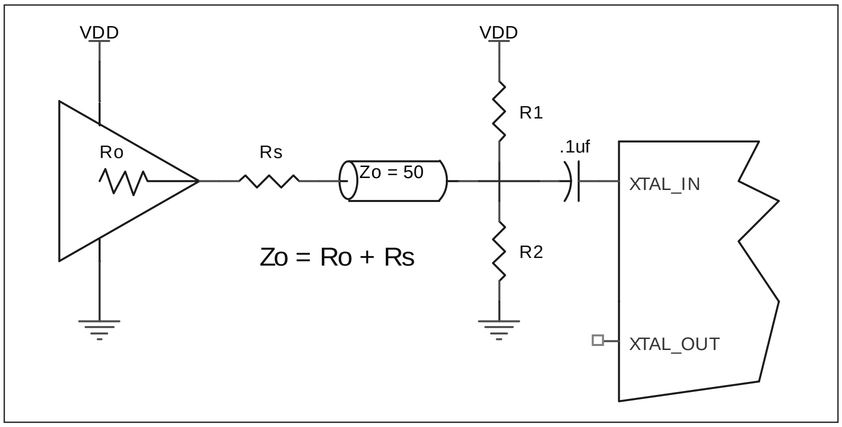


FIGURE 3. GENERAL DIAGRAM FOR LVCMOS DRIVER TO XTAL INPUT INTERFACE

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 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.

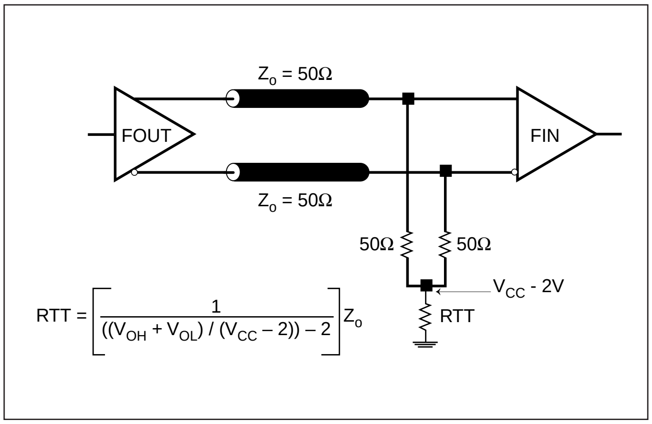


FIGURE 4A. LVPECL OUTPUT TERMINATION

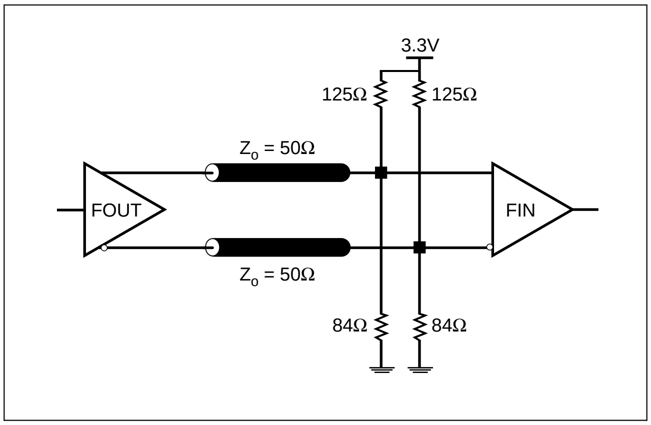


FIGURE 4B. LVPECL OUTPUT TERMINATION

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.*

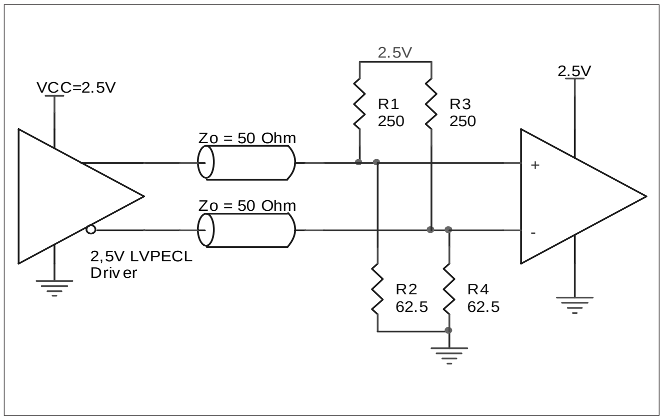


FIGURE 5A. 2.5V LVPECL DRIVER TERMINATION EXAMPLE

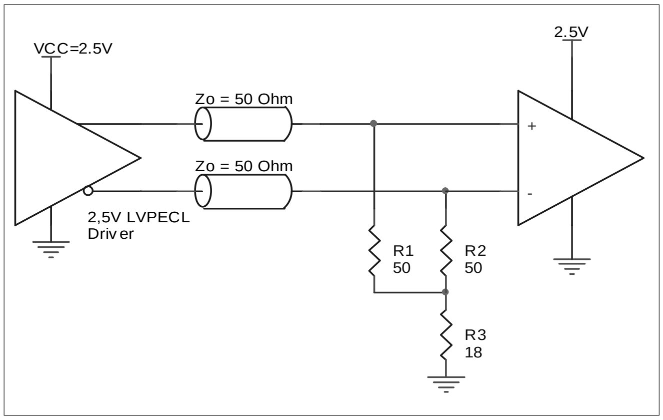


FIGURE 5B. 2.5V LVPECL DRIVER TERMINATION EXAMPLE

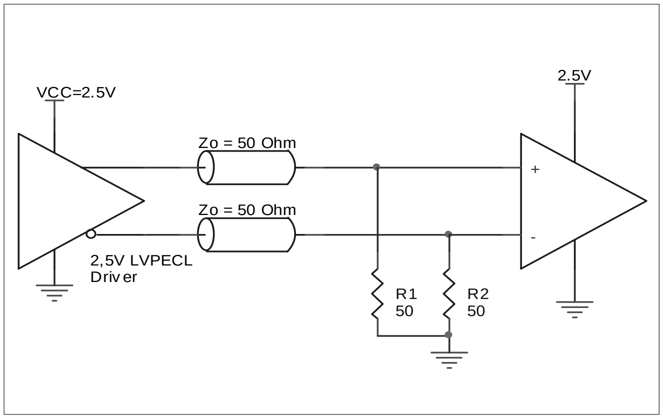


FIGURE 5C. 2.5V LVPECL TERMINATION EXAMPLE

POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS843801I-24.
Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the ICS843801I-24 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 $(core)_{MAX} = V_{CC\_MAX} * I_{EE\_TYP}$ = 3.465V * 60mA = **207.9mW**
- Power $(outputs)_{MAX}$ = **30mW/Loaded Output pair**

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

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: $Tj = \theta_{JA} * Pd\_total + T_A$

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 s witching is:
85°C + 0.238W * 90.5°C/W = 106.5°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 6.*

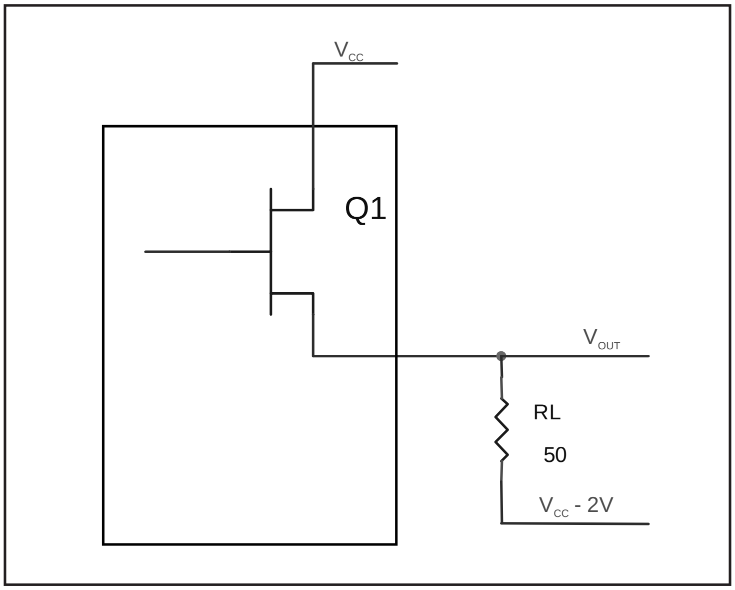


FIGURE 6. LVPECL DRIVER CIRCUIT AND TERMINATION

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, $V_{OUT} = V_{OH\_MAX} = \mathbf{V_{CC\_MAX} – 0.9V}$

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

- 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.

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

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 ICS843801I-24 is: 1649

PACKAGE OUTLINE - G SUFFIX FOR 8 LEAD TSSOP

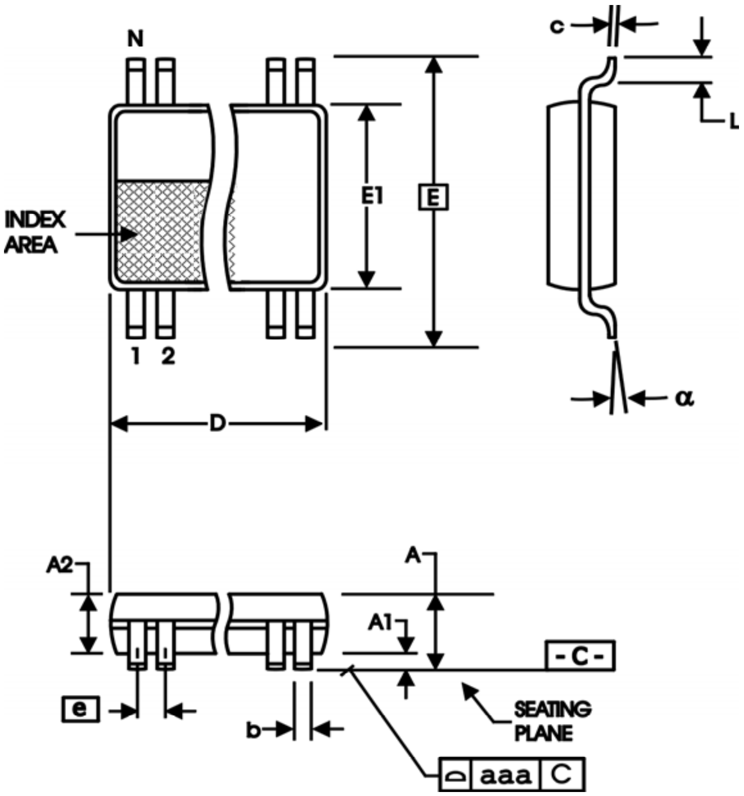


TABLE 8. PACKAGE DIMENSIONS

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
ICS843801AGI-24	3AI24	8 Lead TSSOP	tube	-40°C to 85°C
ICS843801AGI-24T	3AI24	8 Lead TSSOP	2500 tape & reel	-40°C to 85°C
ICS843801AGI-24LF	AI24L	8 Lead "Lead-Free" TSSOP	tube	-40°C to 85°C
ICS843801AGI-24LFT	AI24L	8 Lead "Lead-Free" TSSOP	2500 tape & reel	-40°C to 85°C

NOTE: Parts thar are ordered with an "LF" suffix to the part number are the Pb-Free configuraiton and are RoHS compliant.

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