

## GENERAL DESCRIPTION

The 84321I is a general purpose, dual output Crystal-to-3.3V Differential LVPECL High Frequency Synthesizer. The 84321I has a selectable TEST\_CLK or crystal inputs. The VCO operates at a frequency range of 620MHz to 780MHz. The VCO frequency is programmed in steps equal to the value of the input reference or crystal frequency. The VCO and output frequency can be programmed using the serial or parallel interfaces to the configuration logic. The low phase noise characteristics of the 84321I make it an ideal clock source for Fibre Channel 1, Fibre Channel 2, 10 Gigabit Fibre Channel, Gigabit Ethernet and 10 Gigabit Ethernet applications.

## FEATURES

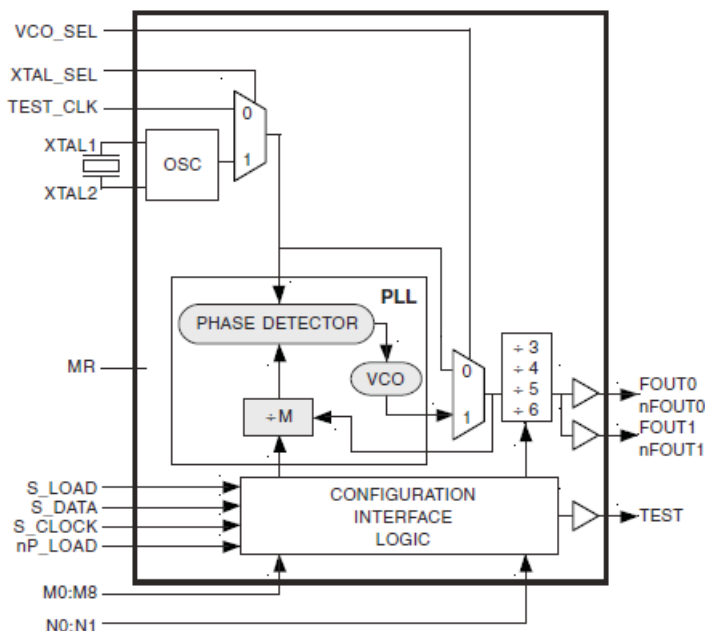
- Dual differential 3.3V LVPECL outputs
- Selectable crystal oscillator interface or LVCMOS/LVTTL TEST\_CLK
- Output frequency range: 103.3MHz to 260MHz
- Crystal input frequency range: 14MHz to 40MHz
- VCO range: 620MHz to 780MHz
- Parallel or serial interface for programming counter and output dividers
- RMS period jitter: 3ps (typical)
- RMS phase jitter at 155.52MHz, using a 38.88MHz crystal (12kHz to 20MHz): 2.5ps (typical)

Phase noise: 155.52MHz

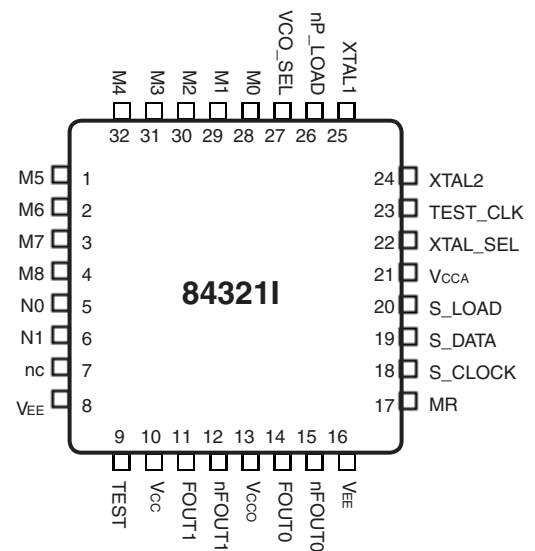
| Offset | Noise Power   |
|--------|---------------|
| 100Hz  | -84.1 dBc/Hz  |
| 1kHz   | -109.8 dBc/Hz |
| 10kHz  | -126.3 dBc/Hz |
| 100kHz | -128.7 dBc/Hz |

- 3.3V supply voltage
- -40°C to 85°C ambient operating temperature
- Available in lead-free (RoHS 6) package
- For functional replacement part use 8T49N241

## BLOCK DIAGRAM



## PIN ASSIGNMENT



**32-Lead LQFP**  
7mm x 7mm x 1.4mm package body  
**Y Package**  
Top View

## FUNCTIONAL DESCRIPTION

**NOTE:** The functional description that follows describes operation using a 25MHz crystal. Valid PLL loop divider values for different crystal or input frequencies are defined in the Input Frequency Characteristics, Table 5, NOTE 1.

The 84321I features a fully integrated PLL and therefore requires no external components for setting the loop bandwidth. A fundamental crystal is used as the input to the on-chip oscillator. The output of the oscillator is fed into the phase detector. A 25MHz crystal provides a 25MHz phase detector reference frequency. The VCO of the PLL operates over a range of 620MHz to 780MHz. The output of the M divider is also applied to the phase detector.

The phase detector and the M divider force the VCO output frequency to be M times the reference frequency by adjusting the VCO control voltage. Note that for some values of M (either too high or too low), the PLL will not achieve lock. The output of the VCO is scaled by a divider prior to being sent to each of the LVPECL output buffers. The divider provides a 50% output duty cycle.

The programmable features of the 84321I support two input modes to program the M divider and N output divider. The two input operational modes are parallel and serial. Figure 1 shows the timing diagram for each mode. In parallel mode, the nP\_LOAD input is initially LOW. The data on inputs M0 through M8 and N0 and N1 is passed directly to the M divider and N output divider. On the LOW-to-HIGH transition of the nP\_LOAD input, the data is latched and the M divider remains loaded until the next LOW transition on nP\_LOAD or until a serial event occurs. As a result, the M and N bits can be hardwired to set the M divider and N output divider to a specific default state that

will automatically occur during power-up. The TEST output is LOW when operating in the parallel input mode. The relationship between the VCO frequency, the crystal frequency and the M divider is defined as follows:

$$f_{VCO} = f_{xtal} \times M$$

The M value and the required values of M0 through M8 are shown in Table 3B, Programmable VCO Frequency Function Table. Valid M values for which the PLL will achieve lock for a 25MHz reference are defined as  $25 \leq M \leq 31$ . The frequency out is defined as follows:  $f_{OUT} = \frac{f_{VCO}}{N} = f_{xtal} \times \frac{M}{N}$

Serial operation occurs when nP\_LOAD is HIGH and S\_LOAD is LOW. The shift register is loaded by sampling the S\_DATA bits with the rising edge of S\_CLOCK. The contents of the shift register are loaded into the M divider and N output divider when S\_LOAD transitions from LOW-to-HIGH. The M divide and N output divide values are latched on the HIGH-to-LOW transition of S\_LOAD. If S\_LOAD is held HIGH, data at the S\_DATA input is passed directly to the M divider and N output divider on each rising edge of S\_CLOCK. The serial mode can be used to program the M and N bits and test bits T1 and T0. The internal registers T0 and T1 determine the state of the TEST output as follows:

| T1 | T0 | TEST Output                  |
|----|----|------------------------------|
| 0  | 0  | LOW                          |
| 0  | 1  | S_DATA, Shift Register Input |
| 1  | 0  | Output of M divider          |
| 1  | 1  | CMOS Fout                    |

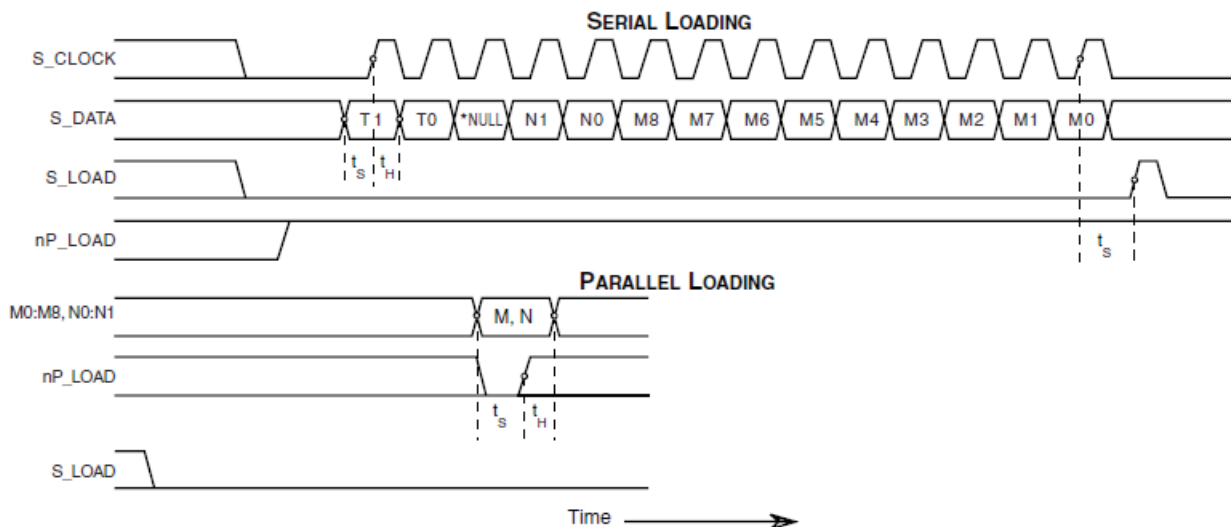


FIGURE 1. PARALLEL & SERIAL LOAD OPERATIONS

**\*NOTE:** The NULL timing slot must be observed.

**TABLE 1. PIN DESCRIPTIONS**

| Number                            | Name                                 | Type   |          | Description  |
|-----------------------------------|--------------------------------------|--------|----------|--|
| 1                                 | M5                                   | Input  | Pullup   | M divider inputs. Data latched on LOW-to-HIGH transition of nP_LOAD input. LVCMOS / LVTTTL interface levels.   |
| 2, 3, 4,<br>28, 29,<br>30, 31, 32 | M6, M7, M8,<br>M0, M1,<br>M2, M3, M4 | Input  | Pulldown |  |
| 5, 6                              | N0, N1                               | Input  | Pulldown |  |
| 7                                 | nc                                   | Unused |          |  |
| 8, 16                             | V <sub>EE</sub>                      | Power  |          | Negative supply pins.  |
| 9                                 | TEST                                 | Output |          | Test output which is ACTIVE in the serial mode of operation. Output driven LOW in parallel mode. LVCMOS/LVTTTL interface levels.   |
| 10                                | V <sub>CC</sub>                      | Power  |          | Core supply pin.   |
| 11, 12                            | FOUT1, nFOUT1                        | Output |          | Differential output for the synthesizer. LVPECL interface levels.  |
| 13                                | V <sub>CCO</sub>                     | Power  |          | Output supply pin.   |
| 14, 15                            | FOUT0, nFOUT0                        | Output |          | Differential output for the synthesizer. LVPECL interface levels.  |
| 17                                | MR                                   | Input  | Pulldown | Active High Master Reset. When logic HIGH, the internal dividers are reset causing the true outputs FOUTx to go low, and the inverted outputs nFOUTx to go high. When logic LOW, the internal dividers and the outputs are enabled. Assertion of MR does not affect loaded M, N, and T values. LVCMOS / LVTTTL interface levels. |
| 18                                | S_CLOCK                              | Input  | Pulldown | Clocks in serial data present at S_DATA input into the shift register on the rising edge of S_CLOCK. LVCMOS / LVTTTL interface levels.   |
| 19                                | S_DATA                               | Input  | Pulldown | Shift register serial input. Data sampled on the rising edge of S_CLOCK. LVCMOS/LVTTTL interface levels.   |
| 20                                | S_LOAD                               | Input  | Pulldown | Controls transition of data from shift register into the dividers. LVCMOS / LVTTTL interface levels.   |
| 21                                | V <sub>CCA</sub>                     | Power  |          | Analog supply pin.   |
| 22                                | XTAL_SEL                             | Input  | Pullup   | Selects between crystal or test inputs as the PLL reference source. Selects XTAL inputs when HIGH. Selects TEST_CLK when LOW. LVCMOS / LVTTTL interface levels.  |
| 23                                | TEST_CLK                             | Input  | Pulldown | Test clock input. LVCMOS / LVTTTL interface levels.  |
| 24, 25                            | XTAL2, XTAL1                         | Input  |          | Crystal oscillator interface. XTAL1 is the input. XTAL2 is the output.   |
| 26                                | nP_LOAD                              | Input  | Pulldown | Parallel load input. Determines when data present at M8:M0 is loaded into M divider, and when data present at N1:N0 sets the N output divider value. LVCMOS / LVTTTL interface levels.   |
| 27                                | VCO_SEL                              | Input  | Pullup   | Determines whether synthesizer is in PLL or bypass mode. LVCMOS / LVTTTL interface levels.   |

NOTE: *Pullup* and *Pulldown* refer 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    |
| R <sub>PULLDOWN</sub> | Input Pulldown Resistor |                 |         | 51      |         | kΩ    |

**TABLE 3A. PARALLEL AND SERIAL MODE FUNCTION TABLE**

| Inputs |         |      |      |        |         |        | Conditions  |
|--------|---------|------|------|--------|---------|--------|---|
| MR     | nP_LOAD | M    | N    | S_LOAD | S_CLOCK | S_DATA |   |
| H      | X       | X    | X    | X      | X       | X      | Reset. Forces outputs LOW.  |
| L      | L       | Data | Data | X      | X       | X      | Data on M and N inputs passed directly to the M divider and N output divider. TEST output forced LOW.             |
| L      | ↑       | Data | Data | L      | X       | X      | Data is latched into input registers and remains loaded until next LOW transition or until a serial event occurs. |
| L      | H       | X    | X    | L      | ↑       | Data   | Serial input mode. Shift register is loaded with data on S_DATA on each rising edge of S_CLOCK.                   |
| L      | H       | X    | X    | ↑      | L       | Data   | Contents of the shift register are passed to the M divider and N output divider.                                  |
| L      | H       | X    | X    | ↓      | L       | Data   | M divider and N output divider values are latched.  |
| L      | H       | X    | X    | L      | X       | X      | Parallel or serial input do not affect shift registers.   |
| L      | H       | X    | X    | H      | ↑       | Data   | S_DATA passed directly to M divider as it is clocked.   |

NOTE: L = LOW  
H = HIGH  
X = Don't care  
↑ = Rising edge transition  
↓ = Falling edge transition

**TABLE 3B. PROGRAMMABLE VCO FREQUENCY FUNCTION TABLE (NOTE 1)**

| VCO Frequency (MHz) | M Divide | 256 | 128 | 64 | 32 | 16 | 8  | 4  | 2  | 1  |
|---------------------|----------|-----|-----|----|----|----|----|----|----|----|
|                     |          | M8  | M7  | M6 | M5 | M4 | M3 | M2 | M1 | M0 |
| 625                 | 25       | 0   | 0   | 0  | 0  | 1  | 1  | 0  | 0  | 1  |
| 650                 | 26       | 0   | 0   | 0  | 0  | 1  | 1  | 0  | 1  | 0  |
| 675                 | 27       | 0   | 0   | 0  | 0  | 1  | 1  | 0  | 1  | 1  |
| •                   | •        | •   | •   | •  | •  | •  | •  | •  | •  | •  |
| 775                 | 31       | 0   | 0   | 0  | 0  | 1  | 1  | 1  | 1  | 1  |

NOTE 1: These M divide values and the resulting frequencies correspond to crystal or TEST\_CLK input frequency of 25MHz.

**TABLE 3C. PROGRAMMABLE OUTPUT DIVIDER FUNCTION TABLE**

| Inputs |    | N Divider Value | Output Frequency (MHz) |         |
|--------|----|-----------------|------------------------|---------|
| N1     | N0 |                 | Minimum                | Maximum |
| 0      | 0  | 3               | 206.7                  | 260     |
| 0      | 1  | 4               | 155                    | 195     |
| 1      | 0  | 5               | 124                    | 156     |
| 1      | 1  | 6               | 103.3                  | 130     |

**TABLE 3D. COMMONLY USED CONFIGURATION FUNCTION TABLE**

| Input         |                 |                 | Output Frequency (MHz) |
|---------------|-----------------|-----------------|------------------------|
| Crystal (MHz) | M Divider Value | N Divider Value |                        |
| 19.44         | 32              | 4               | 155.52                 |
| 19.53125      | 32              | 4               | 156.25                 |
| 25            | 25              | 4               | 156.25                 |
| 25            | 25              | 5               | 125                    |
| 25.50         | 25              | 3               | 212.50                 |
| 25.50         | 25              | 4               | 159.375                |
| 25.50         | 25              | 6               | 106.25                 |
| 38.88         | 16              | 4               | 155.52                 |

**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, $\theta_{JA}$ | 47.9°C/W (0 lfpm)        |
| 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 4A. POWER SUPPLY DC CHARACTERISTICS,  $V_{CC} = V_{CCA} = V_{CCO} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

| 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     |
| $V_{CCO}$ | Output Supply Voltage |                 | 3.135   | 3.3     | 3.465   | V     |
| $I_{EE}$  | Power Supply Current  |                 |         |         | 180     | mA    |
| $I_{CCA}$ | Analog Supply Current |                 |         |         | 30      | mA    |

**TABLE 4B. LVCMOS / LVTTTL DC CHARACTERISTICS,  $V_{CC} = V_{CCA} = V_{CCO} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

| Symbol   | Parameter           | Test Conditions   | Minimum                              | Typical | Maximum        | Units   |
|----------|---------------------|---|--------------------------------------|---------|----------------|---------|
| $V_{IH}$ | Input High Voltage  | VCO_SEL, XTAL_SEL, MR, S_LOAD, nP_LOAD, N0:N1, S_DATA, S_CLOCK, M0:M8 | 2                                    |         | $V_{CC} + 0.3$ | V       |
|          |                     | TEST_CLK  | 2                                    |         | $V_{CC} + 0.3$ | V       |
| $V_{IL}$ | Input Low Voltage   | VCO_SEL, XTAL_SEL, MR, S_LOAD, nP_LOAD, N0:N1, S_DATA, S_CLOCK, M0:M8 | -0.3                                 |         | 0.8            | V       |
|          |                     | TEST_CLK  | -0.3                                 |         | 1.3            | V       |
| $I_{IH}$ | Input High Current  | M0-M4, M6-M8, N0, N1, MR, S_CLOCK, TEST_CLK, S_DATA, S_LOAD, nP_LOAD  | $V_{CC} = V_{IN} = 3.465V$           |         | 150            | $\mu A$ |
|          |                     | M5, XTAL_SEL, VCO_SEL   | $V_{CC} = V_{IN} = 3.465V$           |         | 5              | $\mu A$ |
| $I_{IL}$ | Input Low Current   | M0-M4, M6-M8, N0, N1, MR, S_CLOCK, TEST_CLK, S_DATA, S_LOAD, nP_LOAD  | $V_{CC} = 3.465V$ ,<br>$V_{IN} = 0V$ | -5      |                | $\mu A$ |
|          |                     | M5, XTAL_SEL, VCO_SEL   | $V_{CC} = 3.465V$ ,<br>$V_{IN} = 0V$ | -150    |                | $\mu A$ |
| $V_{OH}$ | Output High Voltage | TEST; NOTE 1  | 2.6                                  |         |                | V       |
| $V_{OL}$ | Output Low Voltage  | TEST; NOTE 1  |                                      |         | 0.5            | V       |

NOTE 1: Outputs terminated with  $50\Omega$  to  $V_{CCO}/2$ .

**TABLE 4C. LVPECL DC CHARACTERISTICS,  $V_{CC} = V_{CCA} = V_{CCO} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

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

NOTE 1: Outputs terminated with  $50\ \Omega$  to  $V_{CCO} - 2V$ . See "Parameter Measurement Information" section, "3.3V Output Load Test Circuit".

**TABLE 5. INPUT FREQUENCY CHARACTERISTICS,  $V_{CC} = V_{CCA} = V_{CCO} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

| Symbol   | Parameter       | Test Conditions      | Minimum | Typical | Maximum | Units |
|----------|-----------------|----------------------|---------|---------|---------|-------|
| $f_{IN}$ | Input Frequency | TEST_CLK; NOTE 1     | 14      |         | 40      | MHz   |
|          |                 | XTAL1, XTAL2; NOTE 1 | 14      |         | 40      | MHz   |
|          |                 | S_CLOCK              |         |         | 50      | MHz   |

NOTE 1: For the input crystal and TEST\_CLK frequency range, the M value must be set for the VCO to operate within the 620MHz to 780MHz range. Using the minimum input frequency of 14MHz, valid values of M are  $45 \leq M \leq 55$ . Using the maximum frequency of 40MHz, valid values of M are  $16 \leq M \leq 19$ .

**TABLE 6. CRYSTAL CHARACTERISTICS**

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

**TABLE 7. AC CHARACTERISTICS,  $V_{CC} = V_{CCA} = V_{CCO} = 3.3V \pm 5\%$ ,  $T_A = -40^\circ\text{C}$  TO  $85^\circ\text{C}$** 

| Symbol         | Parameter                  | Test Conditions   | Minimum | Typical | Maximum | Units |
|----------------|----------------------------|-------------------|---------|---------|---------|-------|
| $F_{OUT}$      | Output Frequency           |                   | 103.3   |         | 260     | MHz   |
| $t_{jit(per)}$ | Period Jitter, RMS; NOTE 1 |                   |         | 3       | 5       | ps    |
| $t_{sk(o)}$    | Output Skew; NOTE 2, 3     |                   |         |         | 15      | ps    |
| $t_R / t_F$    | Output Rise/Fall Time      | 20% to 80%        | 200     |         | 700     | ps    |
| $t_S$          | Setup Time                 | M, N to nP_LOAD   | 5       |         |         | ns    |
|                |                            | S_DATA to S_CLOCK | 5       |         |         | ns    |
|                |                            | S_CLOCK to S_LOAD | 5       |         |         | ns    |
| $t_H$          | Hold Time                  | M, N to nP_LOAD   | 5       |         |         | ns    |
|                |                            | S_DATA to S_CLOCK | 5       |         |         | ns    |
|                |                            | S_CLOCK to S_LOAD | 5       |         |         | ns    |
| odc            | Output Duty Cycle          |                   | 45      |         | 55      | %     |
| $t_{LOCK}$     | PLL Lock Time              |                   |         |         | 1       | ms    |

See Parameter Measurement Information section.

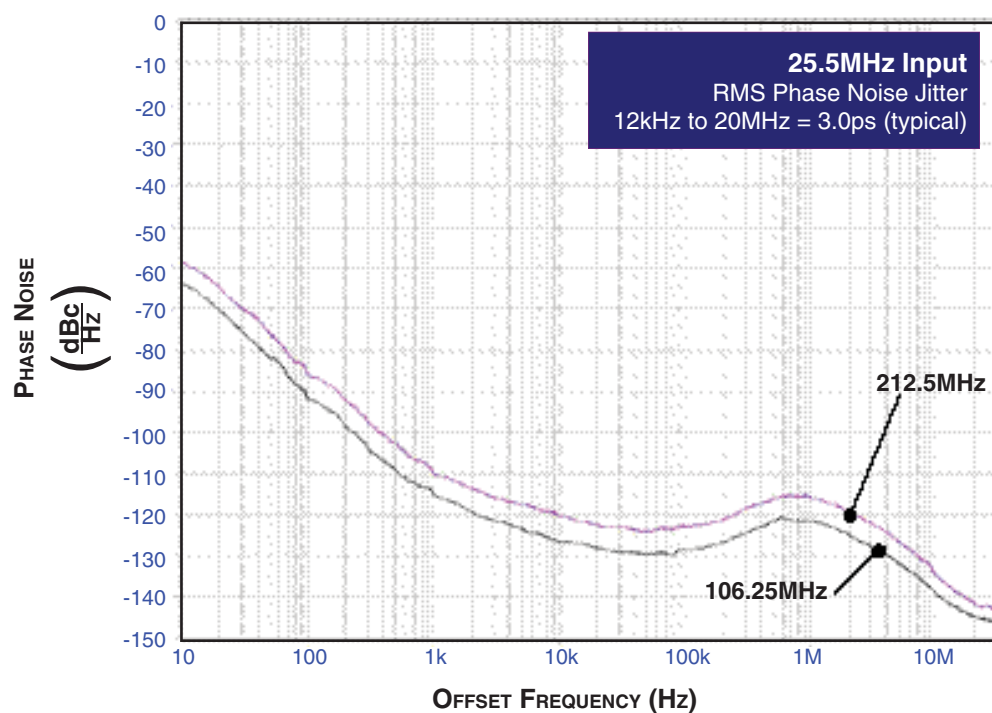
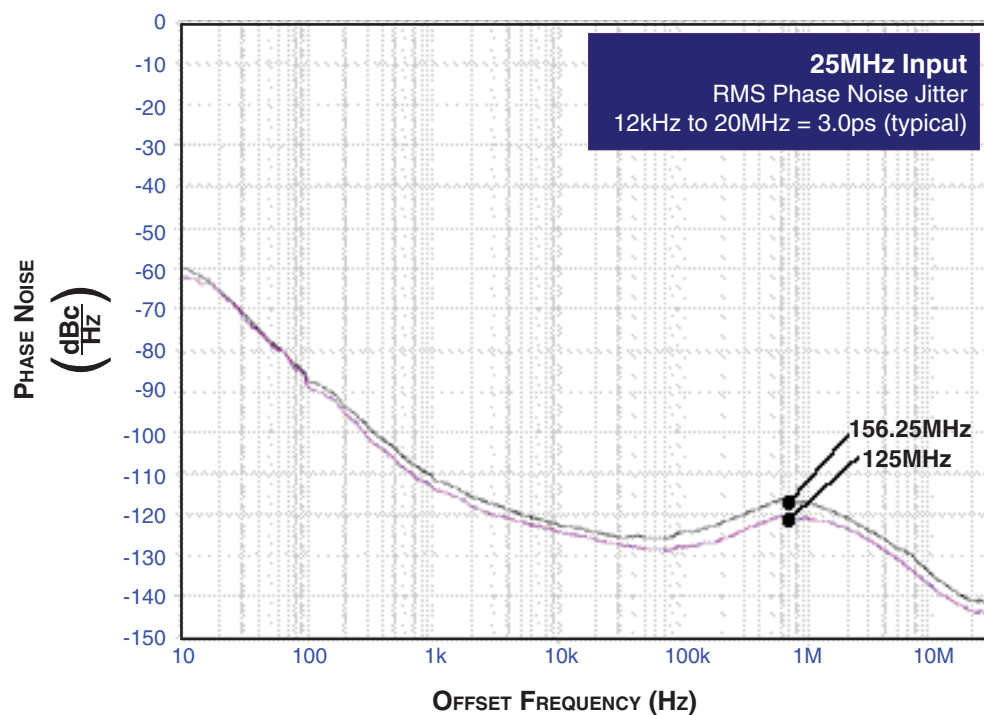
NOTE 1: Jitter performance using XTAL inputs.

NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions.

Measured at the output differential cross points.

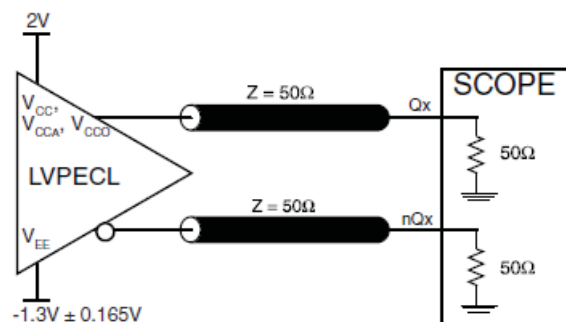
NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.

## TYPICAL PHASE NOISE

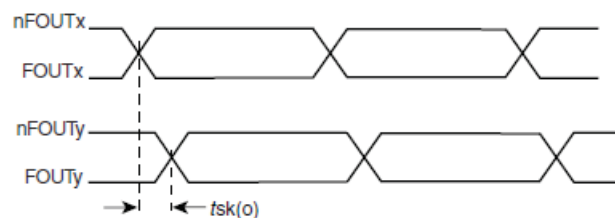




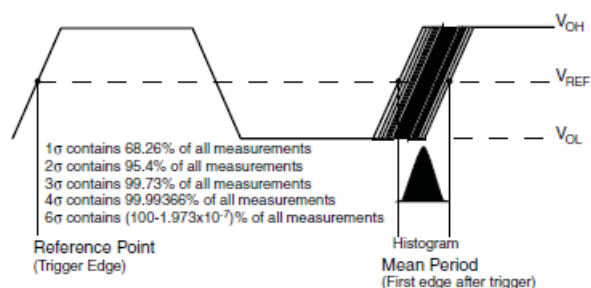
## PARAMETER MEASUREMENT INFORMATION



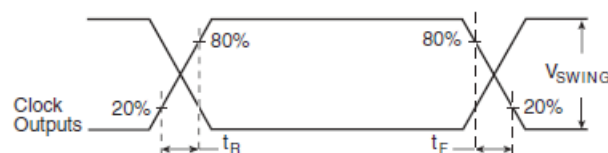
3.3V OUTPUT LOAD AC TEST CIRCUIT



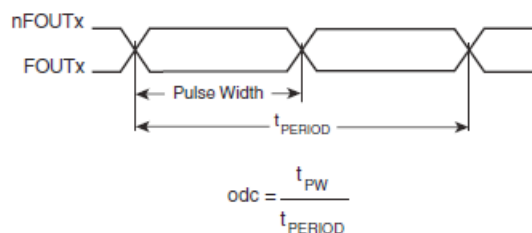
OUTPUT SKEW



PERIOD JITTER



OUTPUT RISE/FALL TIME



OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD



## APPLICATION INFORMATION

### TERMINATION FOR 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 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.

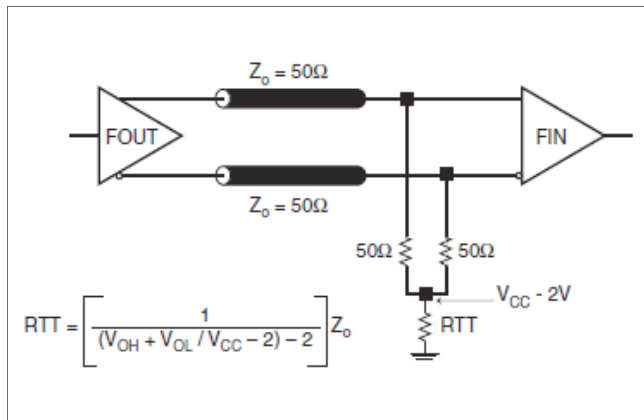


FIGURE 2A. LVPECL OUTPUT TERMINATION

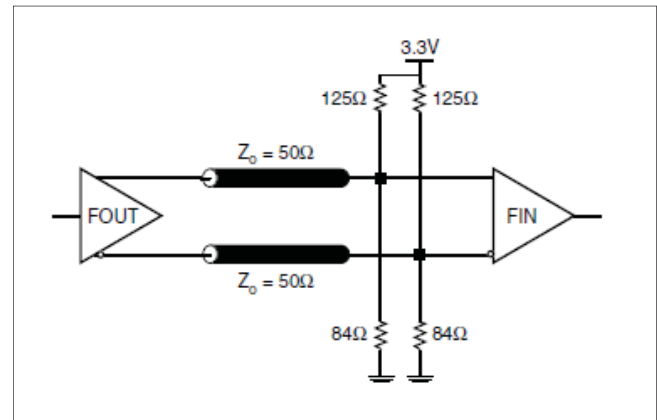


FIGURE 2B. LVPECL OUTPUT TERMINATION

### CRYSTAL INPUT INTERFACE

The 84321I has been characterized with 18pF parallel resonant crystals. The capacitor values shown in *Figure 3* below were determined using a 25MHz, 18pF parallel resonant crystal and were chosen to minimize the ppm error. These same capacitor

values will tune any 18pF parallel resonant crystal over the frequency range of 14MHz to 40MHz providing the other parameters specified in *Table 6*, Crystal Characteristics, are satisfied.

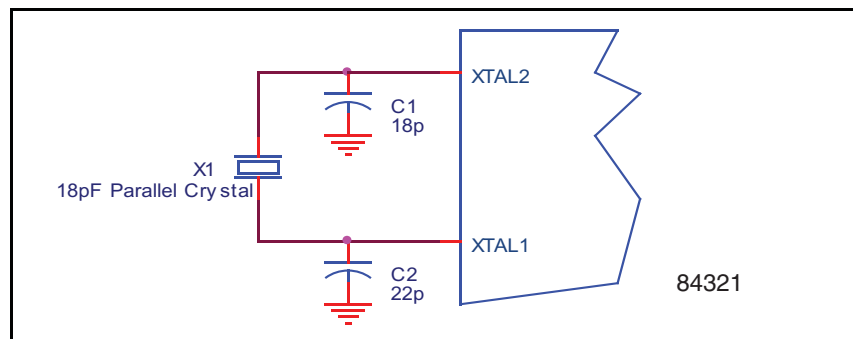


FIGURE 3. CRYSTAL INPUT INTERFACE

## POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The 84321I provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{CC}$ ,  $V_{CCA}$ , and  $V_{CCO}$  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 4 illustrates how a  $24\Omega$  resistor along with a  $10\mu\text{F}$  and a  $.01\mu\text{F}$  bypass capacitor should be connected to each  $V_{CCA}$  pin.

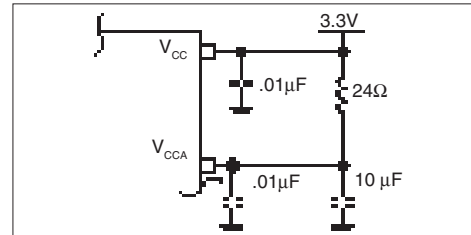


FIGURE 4. POWER SUPPLY FILTERING

## LAYOUT GUIDELINE

The schematic of the 84321I layout example used in this layout guideline is shown in Figure 5A. The 84321I recommended PCB board layout for this example is shown in Figure 5B. This layout example is used as a general guideline. The layout in the

actual system will depend on the selected component types, the density of the components, the density of the traces, and the stack up of the P.C. board.

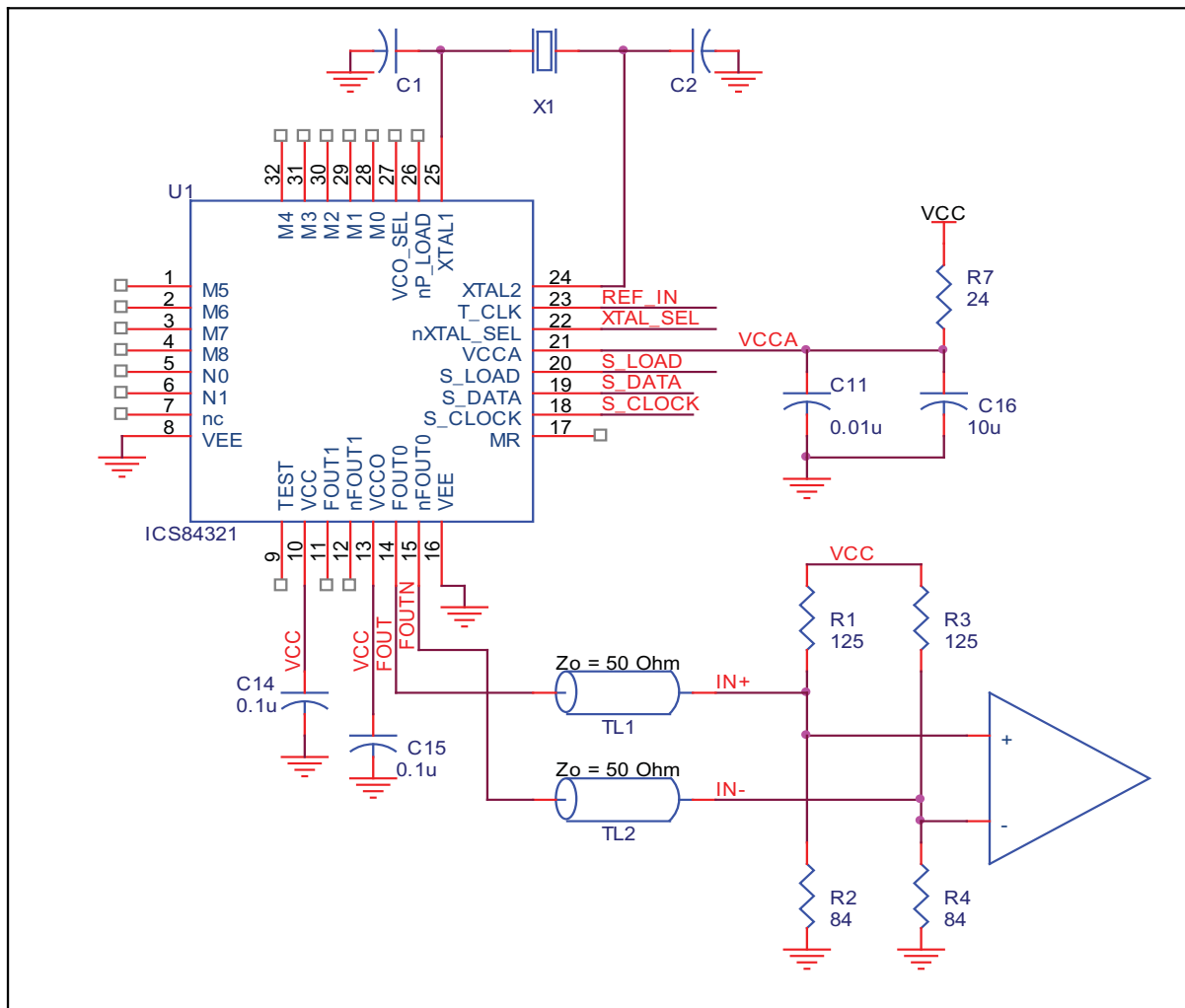


FIGURE 5A. SCHEMATIC OF RECOMMENDED LAYOUT

The following component footprints are used in this layout example:

All the resistors and capacitors are size 0603.

### POWER AND GROUNDING

Place the decoupling capacitors C14 and C15, as close as possible to the power pins. If space allows, placement of the decoupling capacitor on the component side is preferred. This can reduce unwanted inductance between the decoupling capacitor and the power pin caused by the via.

Maximize the power and ground pad sizes and number of vias capacitors. This can reduce the inductance between the power and ground planes and the component power and ground pins.

The RC filter consisting of R7, C11, and C16 should be placed as close to the  $V_{CCA}$  pin as possible.

### CLOCK TRACES AND TERMINATION

Poor signal integrity can degrade the system performance or cause system failure. In synchronous high-speed digital systems, the clock signal is less tolerant to poor signal integrity than other signals. Any ringing on the rising or falling edge or excessive ring back can cause system failure. The shape of the trace and the trace delay might be restricted by the available space on the board and the component location. While routing the traces, the clock signal traces should be routed first and should be locked prior to routing other signal traces.

- The differential 50Ω output traces should have the same length.
- Avoid sharp angles on the clock trace. Sharp angle turns cause the characteristic impedance to change on the transmission lines.
- Keep the clock traces on the same layer. Whenever possible, avoid placing vias on the clock traces. Placement of vias on the traces can affect the trace characteristic impedance and hence degrade signal integrity.
- To prevent cross talk, avoid routing other signal traces in parallel with the clock traces. If running parallel traces is unavoidable, allow a separation of at least three trace widths between the differential clock trace and the other signal trace.
- Make sure no other signal traces are routed between the clock trace pair.
- The matching termination resistors should be located as close to the receiver input pins as possible.

### CRYSTAL

The crystal X1 should be located as close as possible to the pins 25 (XTAL1) and 24 (XTAL2). The trace length between the X1 and U1 should be kept to a minimum to avoid unwanted parasitic inductance and capacitance. Other signal traces should not be routed near the crystal traces.

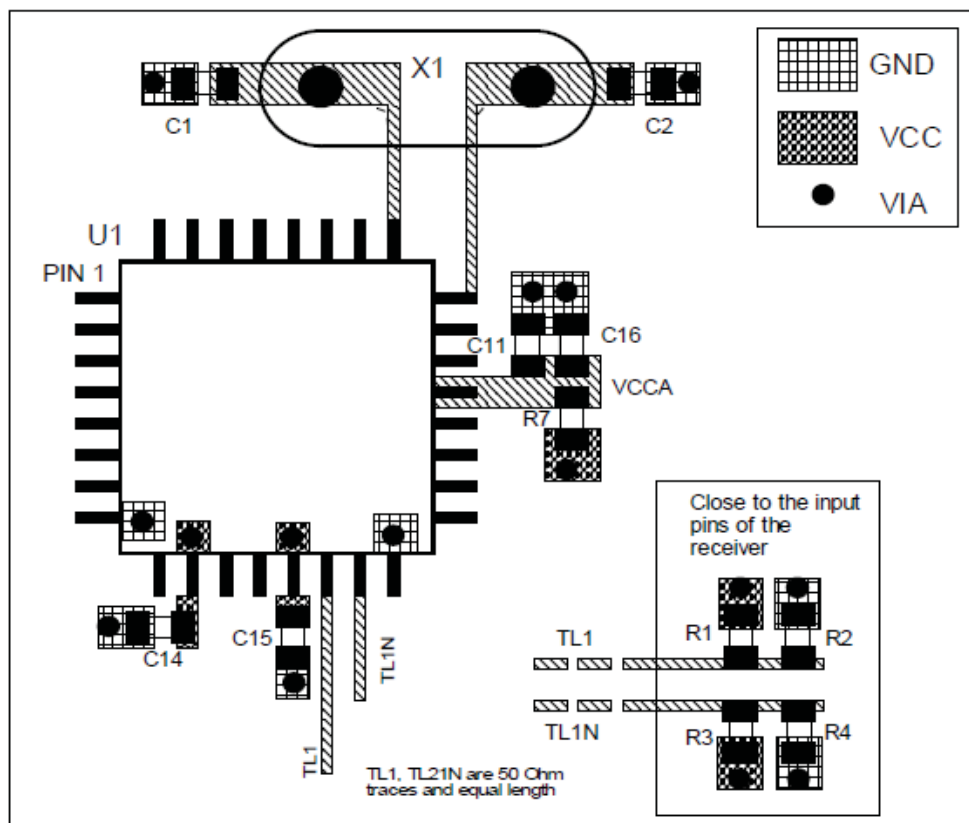


FIGURE 5B. PCB BOARD LAYOUT FOR 843211

# POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the 84321I. Equations and example calculations are also provided.

## 1. Power Dissipation.

The total power dissipation for the 84321I 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> =  $V_{CC\_MAX} * I_{EE\_MAX} = 3.465V * 180mA = 623.7mW$
- Power (outputs)<sub>MAX</sub> = **30mW/Loaded Output pair**  
If all outputs are loaded, the total power is  $2 * 30mW = 60mW$

**Total Power**<sub>MAX</sub> (3.465V, with all outputs switching) =  $623.7W + 60mW = 683.7mW$

## 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 the 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 200 linear feet per minute and a multi-layer board, the appropriate value is 42.1°C/W per Table 8 below.

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

$85^\circ C + 0.684W * 42.1^\circ C/W = 113.8^\circ C$ . 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).

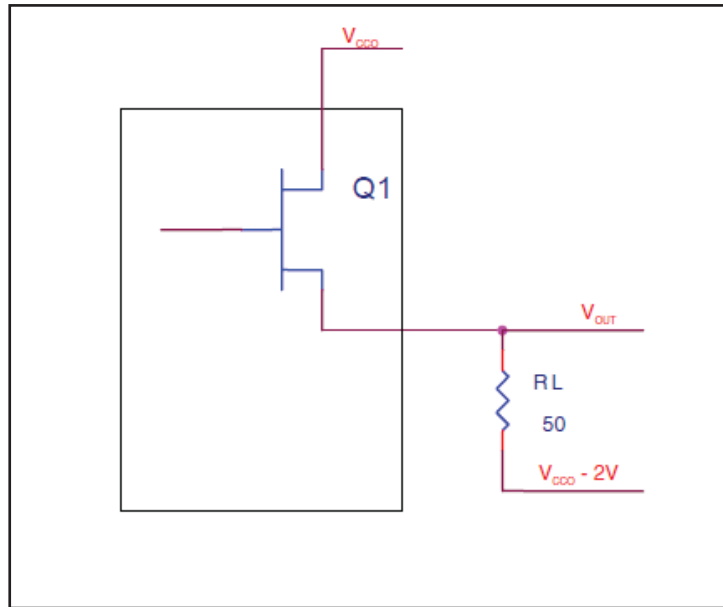
**TABLE 8. THERMAL RESISTANCE  $\theta_{JA}$  FOR 32-PIN LQFP, FORCED CONVECTION**

| $\theta_{JA}$ by Velocity (Linear Feet per Minute)  |          |          |          |
|---|----------|----------|----------|
|   | 0        | 200      | 500      |
| Single-Layer PCB, JEDEC Standard Test Boards  | 67.8°C/W | 55.9°C/W | 50.1°C/W |
| Multi-Layer PCB, JEDEC Standard Test Boards   | 47.9°C/W | 42.1°C/W | 39.4°C/W |
| <b>NOTE:</b> Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs. |          |          |          |

### 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  $V_{CCO} - 2V$ .

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

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

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

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

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

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

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

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

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

## RELIABILITY INFORMATION

TABLE 9.  $\theta_{JA}$  VS. AIR FLOW TABLE FOR 32 LEAD LQFP

| $\theta_{JA}$ by Velocity (Linear Feet per Minute)  |          |          |          |
|---|----------|----------|----------|
|   | 0        | 200      | 500      |
| Single-Layer PCB, JEDEC Standard Test Boards  | 67.8°C/W | 55.9°C/W | 50.1°C/W |
| Multi-Layer PCB, JEDEC Standard Test Boards   | 47.9°C/W | 42.1°C/W | 39.4°C/W |
| <b>NOTE:</b> Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs. |          |          |          |

### TRANSISTOR COUNT

The transistor count for 84321I is: 3744

PACKAGE OUTLINE - Y SUFFIX FOR 32 LEAD LQFP

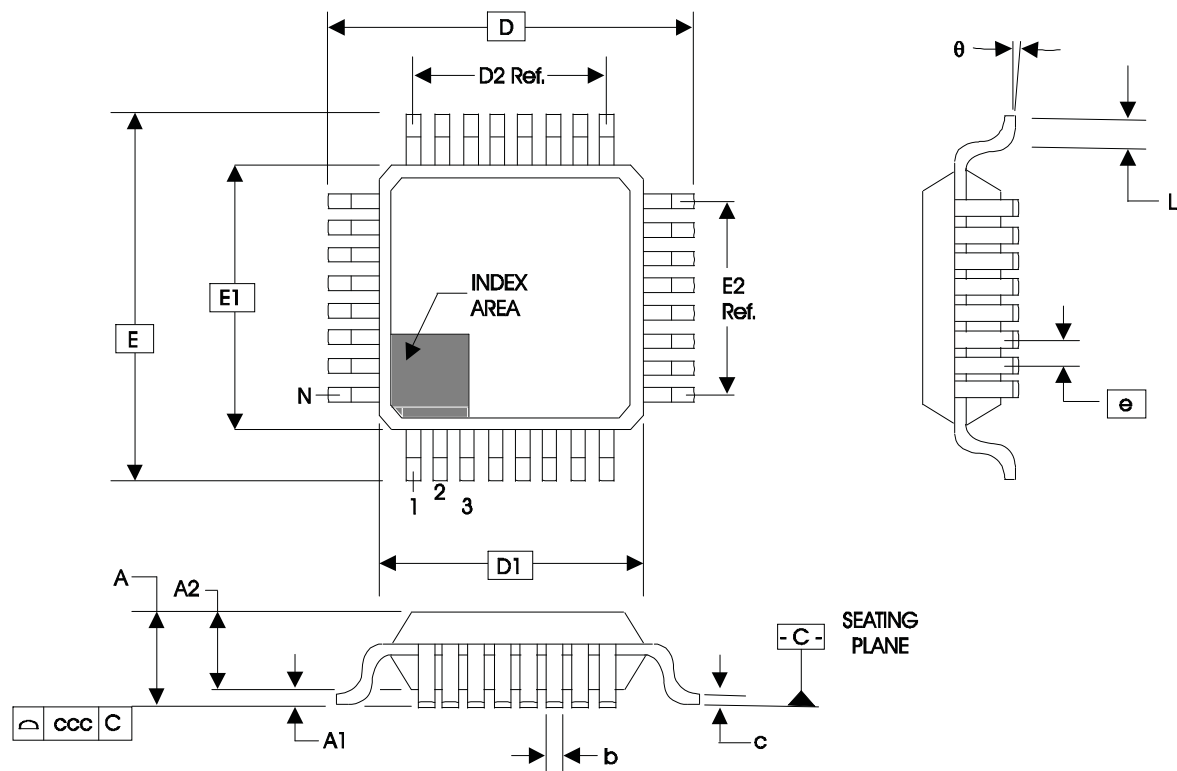


TABLE 10. PACKAGE DIMENSIONS

| JEDEC VARIATION<br>ALL DIMENSIONS IN MILLIMETERS |            |         |         |
|--|------------|---------|---------|
| SYMBOL   | BBA        |         |         |
|  | MINIMUM    | NOMINAL | MAXIMUM |
| N  | 32         |         |         |
| A  | --         | --      | 1.60    |
| A1   | 0.05       | --      | 0.15    |
| A2   | 1.35       | 1.40    | 1.45    |
| b  | 0.30       | 0.37    | 0.45    |
| c  | 0.09       | --      | 0.20    |
| D  | 9.00 BASIC |         |         |
| D1   | 7.00 BASIC |         |         |
| D2   | 5.60 Ref.  |         |         |
| E  | 9.00 BASIC |         |         |
| E1   | 7.00 BASIC |         |         |
| E2   | 5.60 Ref.  |         |         |
| e  | 0.80 BASIC |         |         |
| L  | 0.45       | 0.60    | 0.75    |
| $\theta$   | 0°         | --      | 7°      |
| ccc  | --         | --      | 0.10    |

Reference Document: JEDEC Publication 95, MS-026



**TABLE 11. ORDERING INFORMATION**

| Part/Order Number | Marking      | Package                 | Shipping Packaging | Temperature   |
|-------------------|--------------|-------------------------|--------------------|---------------|
| 84321AYILF        | ICS84321AYIL | Lead-Free, 32 Lead LQFP | Tray               | -40°C to 85°C |
| 84321AYILFT       | ICS84321AYIL | Lead-Free, 32 Lead LQFP | 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.

| REVISION HISTORY SHEET |       |         |  |         |
|------------------------|-------|---------|--|---------|
| Rev                    | Table | Page    | Description of Change  | Date    |
| B                      | 4C    | 1       | Features Section, added lead-free bullet.  | 4/10/07 |
|                        |       | 2       | Updated Figure 1, Parallel & Serial Load Operations Diagram.   |         |
|                        |       | 6       | LVPECL DC Characteristics Table -corrected $V_{OH}$ max. from $V_{CCO} - 1.0V$ to $V_{CCO} - 0.9V$ . |         |
|                        |       | 12 - 13 | Power Considerations - corrected power dissipation to reflect $V_{OH}$ max in Table 4C.              |         |
|                        | T11   | 16      | Ordering Information Table - added lead-free part number, marking and note.                          |         |
| B                      | T11   | 16      | Updated datasheet's header/footer with IDT from ICS.   | 8/7/10  |
|                        |       | 18      | Removed ICS prefix from Part/Order Number column.  |         |
|                        |       |         | Added Contact Page.  |         |
| B                      | T11   | 1       | Product Discontinuation Notice - Last time buy expires November 2, 2016.                             | 11/5/15 |
|                        |       | 16      | PDN# CQ-15-05.<br>Ordering Information - removed leaded devices.                                     |         |
|                        |       |         |  |         |



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