

# 700MHZ, CRYSTAL OSCILLATOR-TO-DIFFERENTIAL LVDS FREQUENCY SYNTHESIZER

**ICS8442**

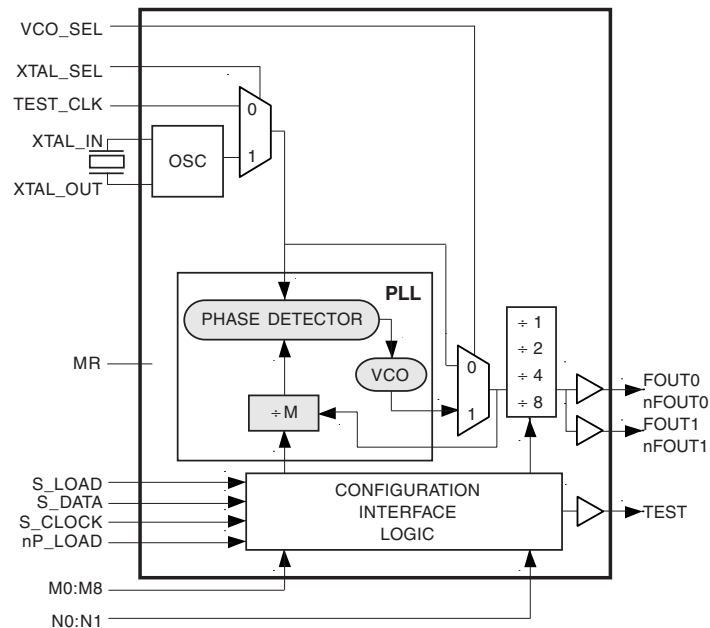
## GENERAL DESCRIPTION

The ICS8442 is a general purpose, dual output Crystal-to-Differential LVDS High Frequency Synthesizer and a member of the HiPerClockS™ family of High Performance Clock Solutions from ICS. The ICS8442 has a selectable TEST\_CLK or crystal input. The TEST\_CLK input accepts LVCMOS or LVTTTL input levels and translates them to LVDS levels. The VCO operates at a frequency range of 250MHz to 700MHz. 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 interface to the configuration logic. The low phase noise characteristics of the ICS8442 makes it an ideal clock source for Gigabit Ethernet and Sonet applications.

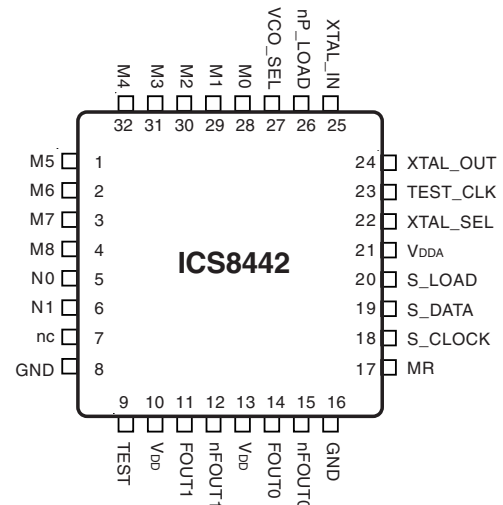
## FEATURES

- Dual differential LVDS outputs
- Selectable crystal oscillator interface or LVCMOS/LVTTTL TEST\_CLK
- Output frequency range: 31.25MHz to 700MHz
- Crystal input frequency range: 10MHz to 25MHz
- VCO range: 250MHz to 700MHz
- Parallel or serial interface for programming counter and output dividers
- RMS period jitter: 2.7ps (typical)
- Cycle-to-cycle jitter: 18ps (typical)
- 3.3V supply voltage
- 0°C to 85°C ambient operating temperature
- Lead-Free package fully RoHS compliant

## 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 ICS8442 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 250MHz to 700MHz. 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 LVDS output buffers. The divider provides a 50% output duty cycle.

The programmable features of the ICS8442 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 spe-

cific 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  $10 \leq M \leq 28$ . The frequency out is defined as follows:

$$F_{OUT} = \frac{f_{VCO}}{N} = \frac{f_{xtal} \times M}{N}$$

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                    |

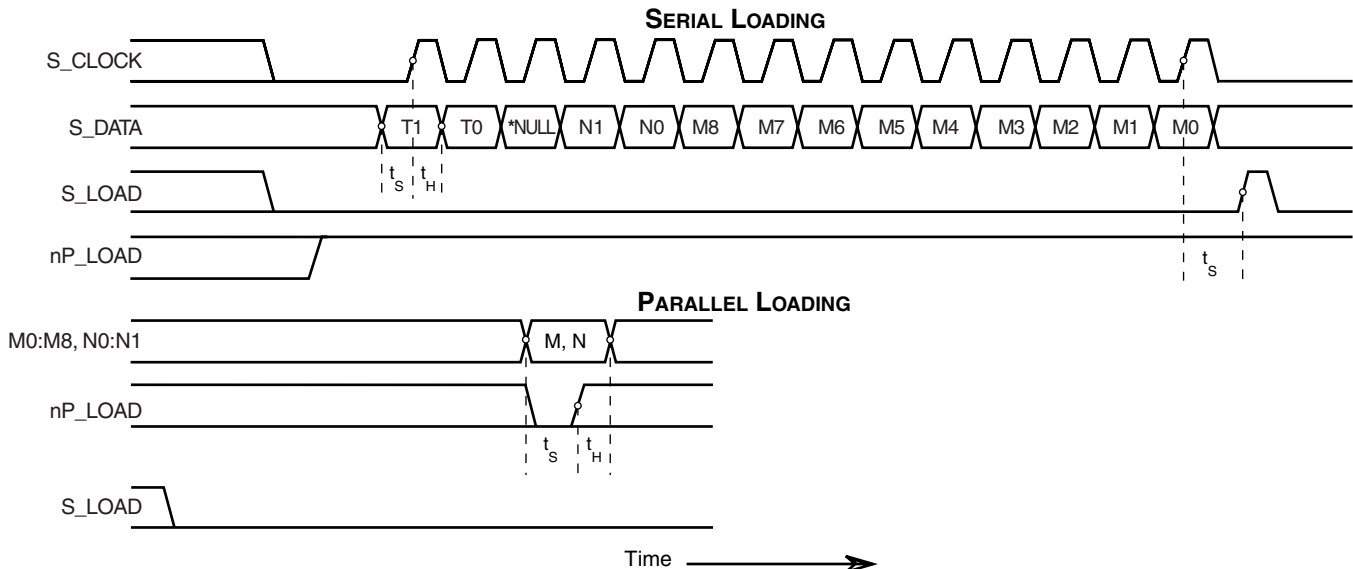


FIGURE 1. PARALLEL & SERIAL LOAD OPERATIONS

**\*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, 28, 29, 30, 31, 32 | M6, M7, M8, M0, M1, M2, M3, M4 | Input  | Pulldown |                                                                                                                                                                                                                                                                                                                                 |
| 5, 6                        | N0, N1                         | Input  | Pulldown |                                                                                                                                                                                                                                                                                                                                 |
| 7                           | nc                             | Unused |          | No connect.                                                                                                                                                                                                                                                                                                                     |
| 8, 16                       | GND                            | Power  |          | Power supply ground.                                                                                                                                                                                                                                                                                                            |
| 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, 13                      | V <sub>DD</sub>                | Power  |          | Core supply pins.                                                                                                                                                                                                                                                                                                               |
| 11, 12                      | FOUT1, nFOUT1                  | Output |          | Differential output for the synthesizer. LVDS interface levels.                                                                                                                                                                                                                                                                 |
| 14, 15                      | FOUT0, nFOUT0                  | Output |          | Differential output for the synthesizer. LVDS 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 effect 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>DDA</sub>               | Power  |          | Analog supply pin.                                                                                                                                                                                                                                                                                                              |
| 22                          | XTAL_SEL                       | Input  | Pullup   | Selects between crystal oscillator 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                      | XTAL_IN, XTAL_OUT              | Input  |          | Crystal oscillator interface. XTAL_IN is the input, XTAL_OUT 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. When HIGH, forces the outputs to a differential LOW state (FOUTx = LOW and nFOUTx = HIGH), but does not effect loaded M, N, and T values. |
| 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

| VCO Frequency (MHz) | M Divide | 256 | 128 | 64 | 32 | 16 | 8  | 4  | 2  | 1  |
|---------------------|----------|-----|-----|----|----|----|----|----|----|----|
|                     |          | M8  | M7  | M6 | M5 | M4 | M3 | M2 | M1 | M0 |
| 250                 | 10       | 0   | 0   | 0  | 0  | 0  | 1  | 0  | 1  | 0  |
| 275                 | 11       | 0   | 0   | 0  | 0  | 0  | 1  | 0  | 1  | 1  |
| •                   | •        | •   | •   | •  | •  | •  | •  | •  | •  | •  |
| •                   | •        | •   | •   | •  | •  | •  | •  | •  | •  | •  |
| 650                 | 26       | 0   | 0   | 0  | 0  | 1  | 1  | 0  | 1  | 0  |
| 675                 | 27       | 0   | 0   | 0  | 0  | 1  | 1  | 0  | 1  | 1  |
| 700                 | 28       | 0   | 0   | 0  | 0  | 1  | 1  | 1  | 0  | 0  |

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  | 1               | 250                    | 700     |
| 0      | 1  | 2               | 125                    | 350     |
| 1      | 0  | 4               | 62.5                   | 175     |
| 1      | 1  | 8               | 31.25                  | 87.5    |

**ABSOLUTE MAXIMUM RATINGS**

|                                          |                          |
|------------------------------------------|--------------------------|
| Supply Voltage, $V_{DD}$                 | 4.6V                     |
| Inputs, $V_I$                            | -0.5V to $V_{DD} + 0.5V$ |
| Outputs, $I_O$                           |                          |
| Continuous Current                       | 10mA                     |
| Surge Current                            | 15mA                     |
| 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,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$** 

| Symbol    | Parameter             | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------|-----------------------|-----------------|---------|---------|---------|-------|
| $V_{DD}$  | Core Supply Voltage   |                 | 3.135   | 3.3     | 3.465   | V     |
| $V_{DDA}$ | Analog Supply Voltage |                 | 3.135   | 3.3     | 3.465   | V     |
| $I_{DD}$  | Power Supply Current  |                 |         |         | 155     | mA    |
| $I_{DDA}$ | Analog Supply Current |                 |         |         | 20      | mA    |

**TABLE 4B. LVCMOS / LVTTTL DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$** 

| Symbol   | Parameter           | Test Conditions                                                               | Minimum                              | Typical | Maximum        | Units   |
|----------|---------------------|-------------------------------------------------------------------------------|--------------------------------------|---------|----------------|---------|
| $V_{IH}$ | Input High Voltage  | M0-M8, N0, N1, MR, nP_LOAD, S_CLOCK, S_DATA, S_LOAD, XTAL_SEL, VCO_SEL        | 2                                    |         | $V_{DD} + 0.3$ | V       |
|          |                     | TEST_CLK                                                                      | 2                                    |         | $V_{DD} + 0.3$ | V       |
| $V_{IL}$ | Input Low Voltage   | M0-M8, N0, N1, MR, nP_LOAD, S_CLOCK, S_DATA, S_LOAD, XTAL_SEL, VCO_SEL        | -0.3                                 |         | 0.8            | V       |
|          |                     | TEST_CLK                                                                      | -0.3                                 |         | 1.3            | V       |
| $I_{IH}$ | Input High Current  | M0-M4, M6-M8, N0, N1, MR, nP_LOAD, S_CLOCK, S_DATA, S_LOAD, XTAL_SEL, VCO_SEL | $V_{DD} = V_{IN} = 3.465V$           |         | 150            | $\mu A$ |
|          |                     | M5, XTAL_SEL, VCO_SEL                                                         | $V_{DD} = V_{IN} = 3.465V$           |         | 5              |         |
| $I_{IL}$ | Input Low Current   | M0-M4, M6-M8, N0, N1, MR, nP_LOAD, S_CLOCK, S_DATA, S_LOAD, XTAL_SEL, VCO_SEL | $V_{DD} = 3.465V$ ,<br>$V_{IN} = 0V$ | -5      |                | $\mu A$ |
|          |                     | M5, XTAL_SEL, VCO_SEL                                                         | $V_{DD} = 3.465V$ ,<br>$V_{IN} = 0V$ | -150    |                |         |
| $V_{OH}$ | 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  $V_{DD}/2$ . See Parameter Measurement Information section, "3.3V Output Load Test Circuit".

**TABLE 4C. LVDS DC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$** 

| Symbol          | Parameter                   | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------------|-----------------------------|-----------------|---------|---------|---------|-------|
| $V_{OD}$        | Differential Output Voltage |                 | 250     | 450     | 600     | mV    |
| $\Delta V_{OD}$ | $V_{OD}$ Magnitude Change   |                 |         |         | 50      | mV    |
| $V_{OS}$        | Offset Voltage              |                 | 1.125   | 1.4     | 1.6     | V     |
| $\Delta V_{OS}$ | $V_{OS}$ Magnitude Change   |                 |         |         | 50      | mV    |

**TABLE 5. INPUT FREQUENCY CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$** 

| Symbol   | Parameter       | Test Conditions           | Minimum | Typical | Maximum | Units |
|----------|-----------------|---------------------------|---------|---------|---------|-------|
| $f_{IN}$ | Input Frequency | TEST_CLK; NOTE 1          | 10      |         | 25      | MHz   |
|          |                 | XTAL_IN, XTAL_OUT; NOTE 1 | 10      |         | 25      | 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 250MHz to 700MHz range. Using the minimum input frequency of 10MHz valid values of M are  $25 \leq M \leq 70$ . Using the maximum frequency of 25MHz valid values of M are  $10 \leq M \leq 28$ .

**TABLE 6. CRYSTAL CHARACTERISTICS**

| Parameter                          | Test Conditions | Minimum     | Typical | Maximum | Units    |
|------------------------------------|-----------------|-------------|---------|---------|----------|
| Mode of Oscillation                |                 | Fundamental |         |         |          |
| Frequency                          |                 | 10          |         | 25      | MHz      |
| Equivalent Series Resistance (ESR) |                 |             |         | 50      | $\Omega$ |
| Shunt Capacitance                  |                 |             |         | 7       | pF       |
| Drive Level                        |                 |             |         | 1       | mW       |

**TABLE 7. AC CHARACTERISTICS,  $V_{DD} = V_{DDA} = 3.3V \pm 5\%$ ,  $T_A = 0^\circ C$  TO  $85^\circ C$** 

| Symbol         | Parameter                        | Test Conditions   | Minimum              | Typical | Maximum              | Units |
|----------------|----------------------------------|-------------------|----------------------|---------|----------------------|-------|
| $F_{OUT}$      | Output Frequency                 |                   | 31.25                |         | 700                  | MHz   |
| $f_{jit(cc)}$  | Cycle-to-Cycle Jitter; NOTE 1, 3 | N = 1, 2          |                      | 18      | 28                   | ps    |
|                |                                  | N = 4             |                      | 27      | 45                   | ps    |
| $f_{jit(per)}$ | Period Jitter, RMS; NOTE 1, 3    |                   |                      | 2.7     | 7                    | ps    |
| $t_{sk(o)}$    | Output Skew; NOTE 2, 3           |                   |                      |         | 15                   | ps    |
| $t_R / t_F$    | Output Rise/Fall Time            | 20% to 80%        | 150                  |         | 650                  | 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; NOTE 4        | N > 1             | 48                   |         | 52                   | %     |
| $t_{PW}$       | Output Pulse Width               | N = 1             | $t_{Period}/2 - 150$ |         | $t_{Period}/2 + 150$ | ps    |
| $t_{LOCK}$     | PLL Lock Time                    |                   |                      |         | 1                    | ms    |

See Parameter Measurement Information section.

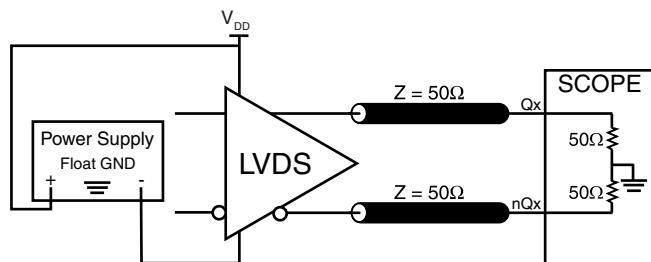
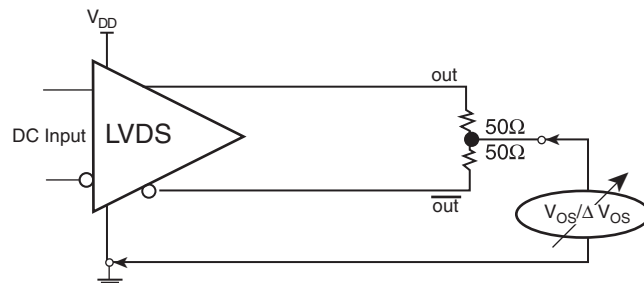
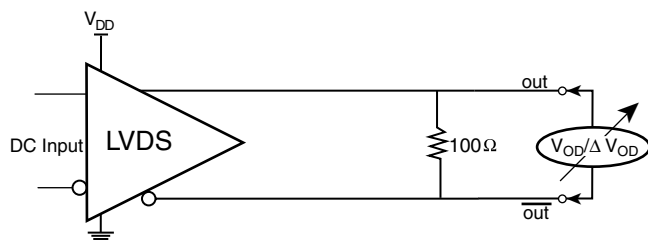
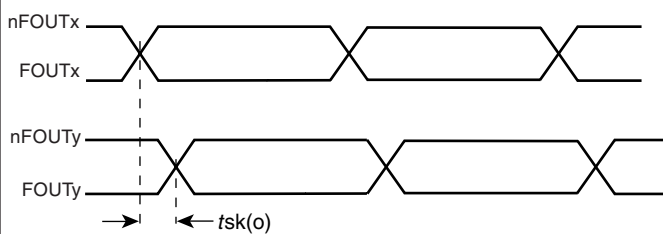
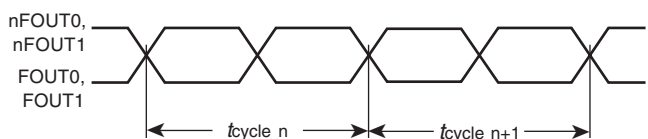
NOTE 1: Jitter performance using XTAL inputs.

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.

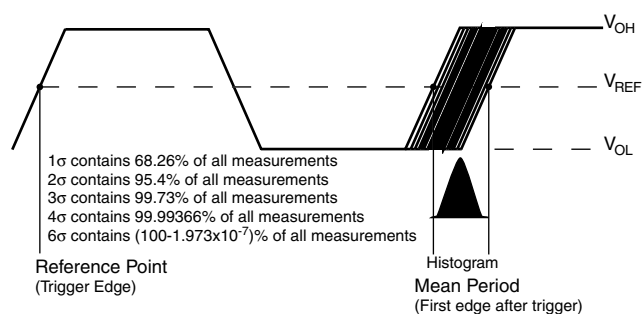
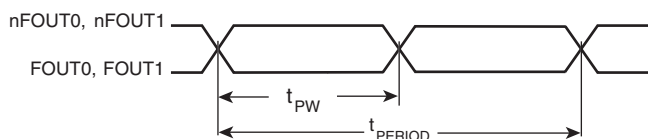
NOTE 4: In the Applications Section, please refer to the application note, "Differential Duty Cycle Improvement."

## PARAMETER MEASUREMENT INFORMATION

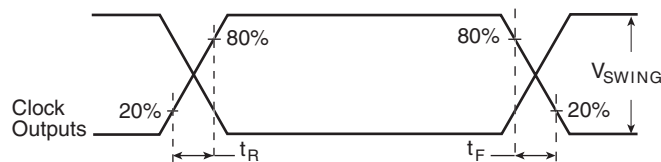

**3.3V OUTPUT LOAD TEST CIRCUIT**

**OFFSET VOLTAGE SETUP**

**DIFFERENTIAL OUTPUT VOLTAGE SETUP**

**OUTPUT SKEW**


$$t_{jit(cc)} = t_{cycle\ n} - t_{cycle\ n+1}$$

1000 Cycles

**Cycle-to-Cycle Jitter**

**Period Jitter**


$$odc = \frac{t_{PW}}{t_{PERIOD}} \times 100\%$$

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

**OUTPUT RISE/FALL TIME**

## APPLICATION INFORMATION

### STORAGE AREA NETWORKS

A variety of technologies are used for interconnection of the elements within a SAN. The tables below lists the common frequencies used as well as the settings for the ICS8442 to generate the appropriate frequency.

**Table 8. Common SANs Application Frequencies**

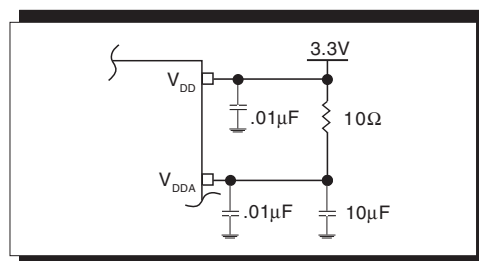
| Interconnect Technology | Clock Rate                       | Reference Frequency to SERDES (MHz) | Crystal Frequency (MHz) |
|-------------------------|----------------------------------|-------------------------------------|-------------------------|
| Gigabit Ethernet        | 1.25 GHz                         | 125, 250, 156.25                    | 25, 19.53125            |
| Fibre Channel           | FC1 1.0625 GHz<br>FC2 2.1250 GHz | 106.25, 53.125, 132.8125            | 16.6015625, 25          |
| Infiniband              | 2.5 GHz                          | 125, 250                            | 25                      |

**Table 9. Configuration Details for SANs Applications**

| Interconnect Technology | Crystal Frequency (MHz) | ICS8442 Output Frequency to SERDES (MHz) | ICS8442 M & N Settings |    |    |    |    |    |    |    |    |    |    |
|-------------------------|-------------------------|------------------------------------------|------------------------|----|----|----|----|----|----|----|----|----|----|
|                         |                         |                                          | M8                     | M7 | M6 | M5 | M4 | M3 | M2 | M1 | M0 | N1 | N0 |
| Gigabit Ethernet        | 25                      | 125                                      | 0                      | 0  | 0  | 0  | 1  | 0  | 1  | 0  | 0  | 1  | 0  |
|                         | 25                      | 250                                      | 0                      | 0  | 0  | 0  | 1  | 0  | 1  | 0  | 0  | 0  | 1  |
|                         | 25                      | 156.25                                   | 0                      | 0  | 0  | 0  | 1  | 1  | 0  | 0  | 1  | 1  | 0  |
|                         | 19.53125                | 156.25                                   | 0                      | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 1  | 0  |
| Fiber Channel 1         | 25                      | 53.125                                   | 0                      | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 1  | 1  | 1  |
|                         | 25                      | 106.25                                   | 0                      | 0  | 0  | 0  | 1  | 0  | 0  | 0  | 1  | 1  | 0  |
| Fiber Channel 2         | 16.6015625              | 132.8125                                 | 0                      | 0  | 0  | 1  | 0  | 0  | 0  | 0  | 0  | 1  | 0  |
| Infiniband              | 25                      | 125                                      | 0                      | 0  | 0  | 0  | 1  | 0  | 1  | 0  | 0  | 1  | 0  |
|                         | 25                      | 250                                      | 0                      | 0  | 0  | 0  | 1  | 0  | 1  | 0  | 0  | 0  | 1  |

### POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The ICS8442 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL.  $V_{DD}$  and  $V_{DDA}$  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, better power supply isolation is required. Figure 2 illustrates how a  $10\Omega$  along with a  $10\mu F$  and a  $.01\mu F$  bypass capacitor should be connected to each  $V_{DDA}$  pin.



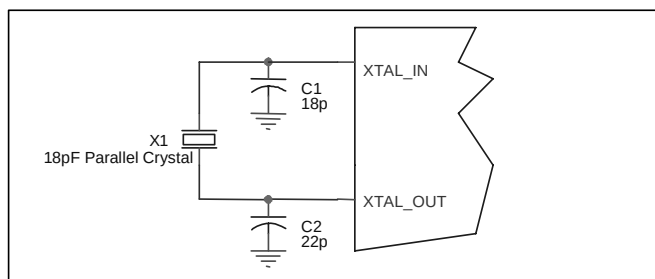
**FIGURE 2. POWER SUPPLY FILTERING**



## CRYSTAL INPUT INTERFACE

A crystal can be characterized for either series or parallel mode operation. The ICS8442 has a built-in crystal oscillator circuit. This interface can accept either a series or parallel crystal without additional components and generate frequencies with accuracy

suitable for most applications. Additional accuracy can be achieved by adding two small capacitors C1 and C2 as shown in *Figure 3*. Typical results using parallel 18pF crystals are shown in Table 10.

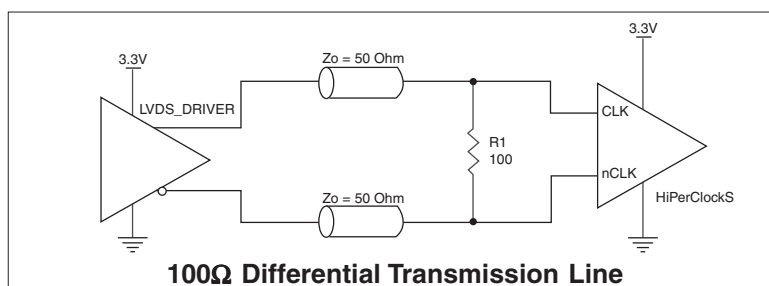


**Figure 3. CRYSTAL INPUT INTERFACE**

## LVDS DRIVER TERMINATION

A general LVDS interface is shown in *Figure 4*. In a 100Ω differential transmission line environment, LVDS drivers require a matched load termination of 100Ω across near the receiver in-

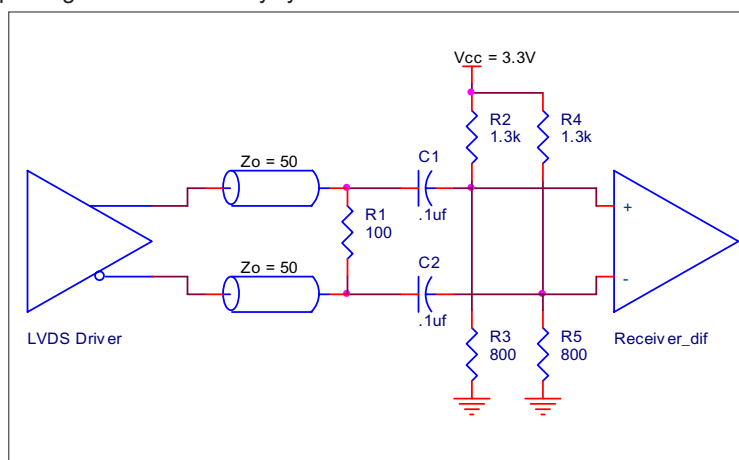
put. For a multiple LVDS outputs buffer, if only partial outputs are used, it is recommended to terminate the un-used outputs.



**FIGURE 4. TYPICAL LVDS DRIVER TERMINATION**

## DIFFERENTIAL DUTY CYCLE IMPROVEMENT

The schematic below is recommended for applications using the ÷1 output configuration for improving the differential duty cycle.



**FIGURE 5. DIFFERENTIAL DUTY CYCLE IMPROVEMENT**

## LAYOUT GUIDELINE

The schematic of the ICS8442 layout example used in this layout guideline is shown in *Figure 6A*. The ICS8442 recommended PCB board layout for this example is shown in *Figure 6B*. 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.

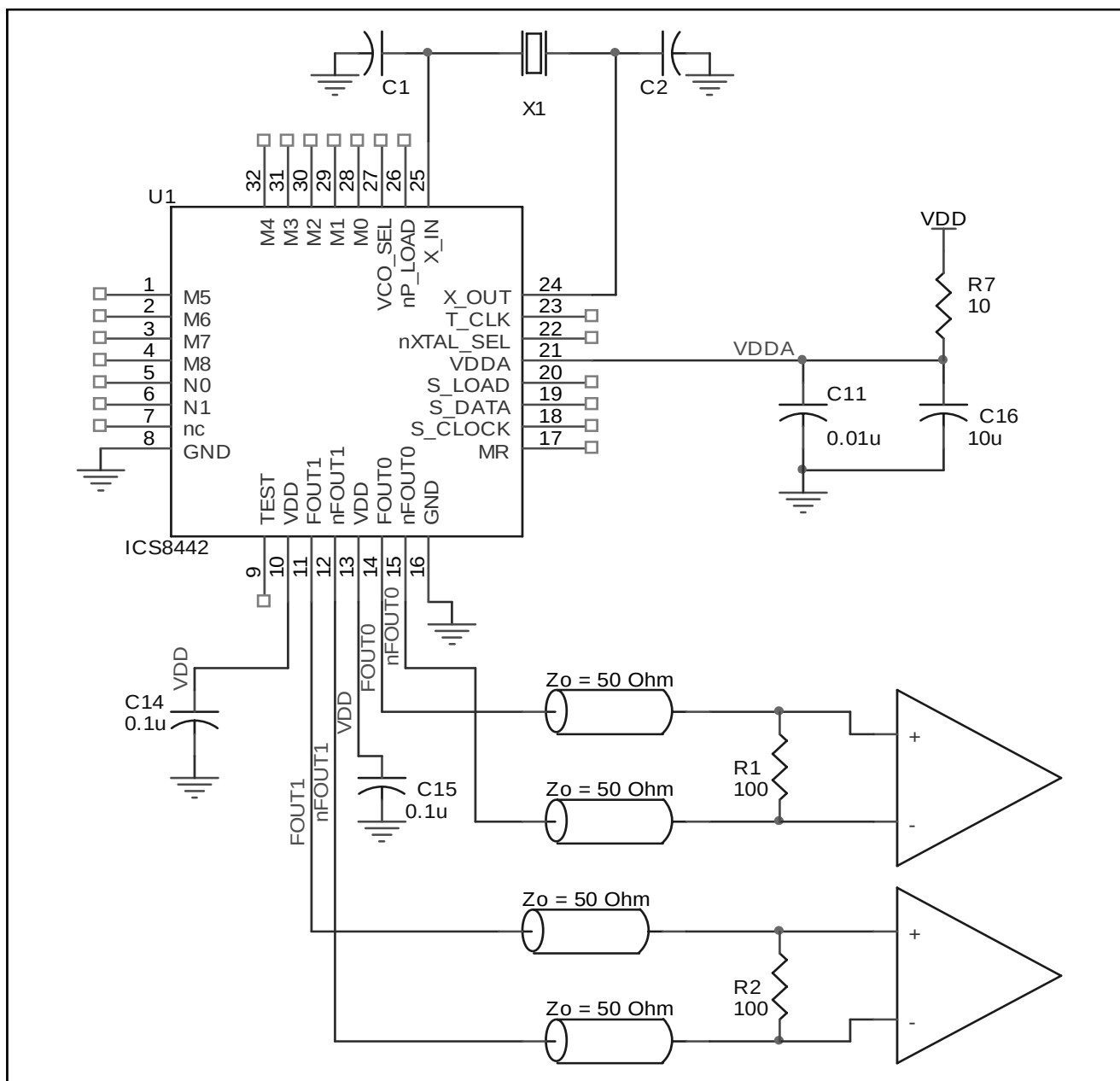


FIGURE 6A. RECOMMENDED SCHEMATIC LAYOUT

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, placing the decoupling capacitor at the component side is preferred. This can reduce unwanted inductance between the decoupling capacitor and the power pin generated by the via.

Maximize the pad size of the power (ground) at the decoupling capacitor. Maximize the number of vias between power (ground) and the pads. This can reduce the inductance between the power (ground) plane and the component power (ground) pins.

If  $V_{DDA}$  shares the same power supply with  $V_{DD}$ , insert the RC filter R7, C11, and C16 in between. Place this RC filter as close to the  $V_{DDA}$  as possible.

#### CLOCK TRACES AND TERMINATION

The component placements, locations and orientations should be arranged to achieve the best clock signal quality. Poor clock signal quality can degrade the system performance or cause system failure. In the synchronous high-speed digital system, the clock signal is less tolerable to poor signal quality than other signals. Any ringing on the rising or falling edge or excessive ring back can cause system failure. The trace shape 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 traces with 50Ω transmission lines TL1 and TL2 at FOUT and nFOUT should have equal delay and run adjacent to each other. Avoid sharp angles on the clock trace. Sharp angle turns cause the characteristic impedance to change on the transmission lines.
- Keep the clock trace on same layer. Whenever possible, avoid any vias on the clock traces. Any via on the trace can affect the trace characteristic impedance and hence degrade signal quality.
- To prevent cross talk, avoid routing other signal traces in parallel with the clock traces. If running parallel traces is unavoidable, allow more space between the clock trace and the other signal trace.
- Make sure no other signal trace is routed between the clock trace pair.

The matching termination resistors R1 and R2 should be located as close to the receiver input pins as possible. Other termination scheme can also be used but is not shown in this example.

#### CRYSTAL

The crystal X1 should be located as close as possible to the pins 24 (XTAL\_OUT) and 25 (XTAL\_IN). 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.

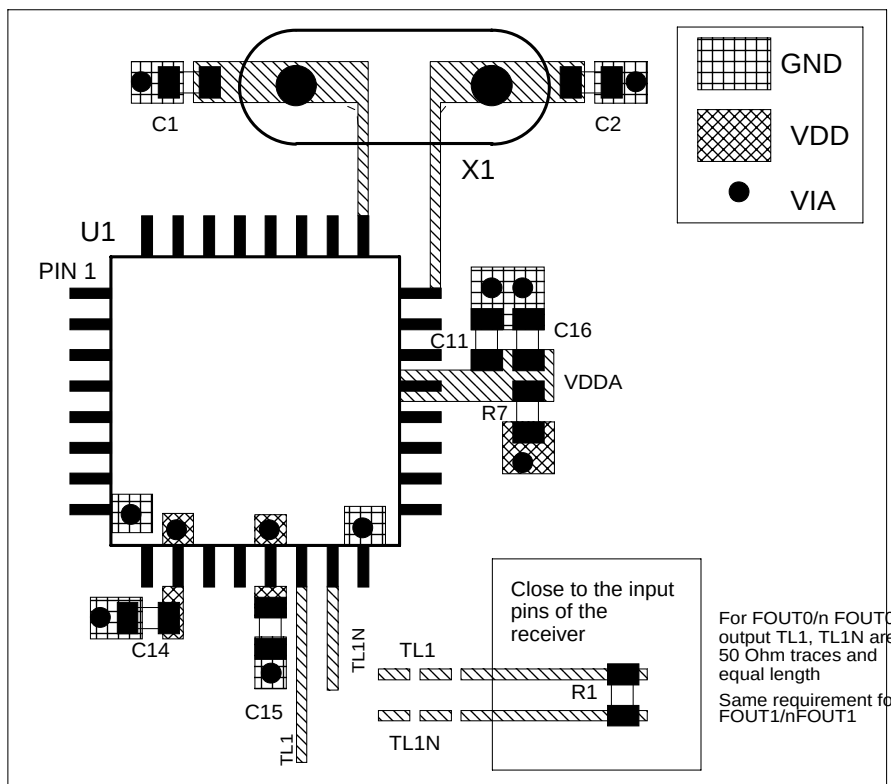


FIGURE 6B. PCB BOARD LAYOUT FOR ICS8442

## RELIABILITY INFORMATION

TABLE 10.  $\theta_{JA}$  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 |

**NOTE:** Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs.

### TRANSISTOR COUNT

The transistor count for ICS8442 is: 3662

## PACKAGE OUTLINE - Y SUFFIX FOR 32 LEAD LQFP

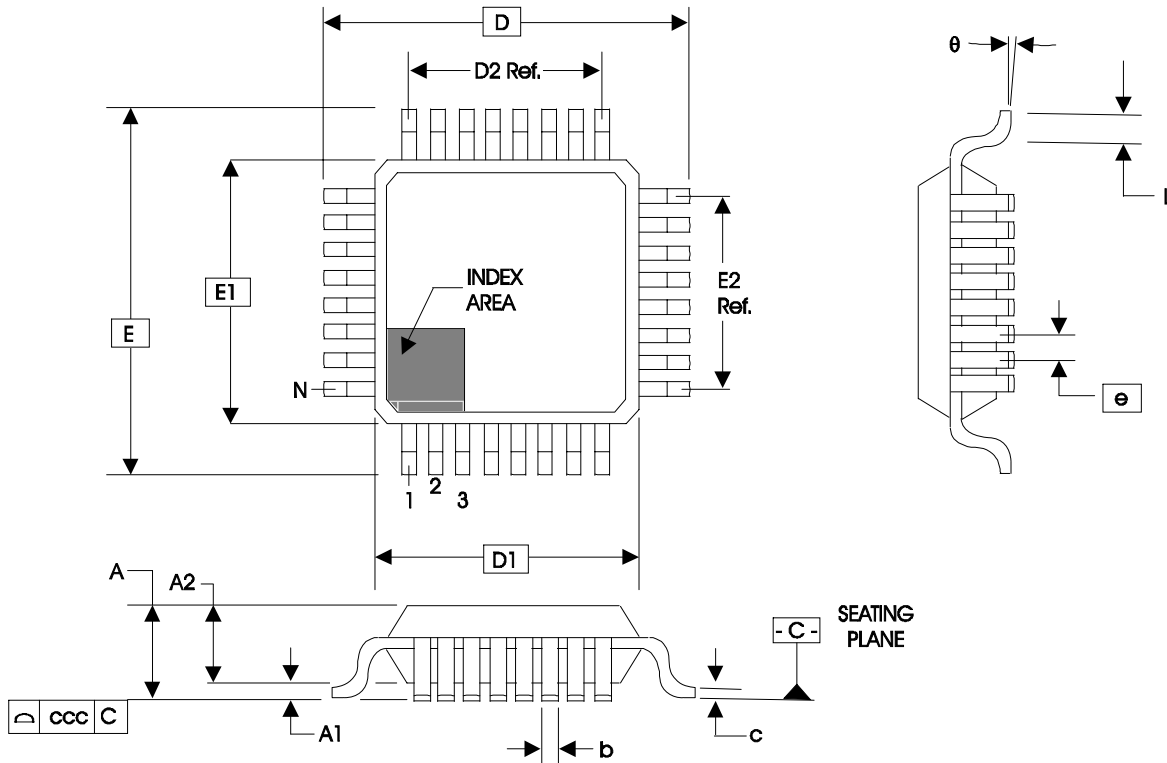


TABLE 11. PACKAGE DIMENSIONS

| 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    |
| θ                                                | 0°         | --      | 7°      |
| ccc                                              | --         | --      | 0.10    |

Reference Document: JEDEC Publication 95, MS-026

TABLE 12. ORDERING INFORMATION

| Part/Order Number | Marking     | Package                  | Shipping Packaging | Temperature |
|-------------------|-------------|--------------------------|--------------------|-------------|
| 8442AY            | ICS8442AY   | 32 Lead LQFP             | tray               | 0°C to 85°C |
| 8442AYT           | ICS8442AY   | 32 Lead LQFP             | 1000 tape & reel   | 0°C to 85°C |
| 8442AYLF          | ICS8442AYLF | 32 Lead "Lead-Free" LQFP | tray               | 0°C to 85°C |
| 8442AYLFT         | ICS8442AYLF | 32 Lead "Lead-Free" LQFP | 1000 tape & reel   | 0°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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| REVISION HISTORY SHEET |       |      |                                                                                                                                                                                                                                                                                                               |          |
|------------------------|-------|------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------|
| Rev                    | Table | Page | Description of Change                                                                                                                                                                                                                                                                                         | Date     |
| A                      |       | 2    | Corrected labels on the Parallel & Serial Load Operations diagram.                                                                                                                                                                                                                                            | 12/18/02 |
| B                      | T1    | 3    | Revised MR pin description.                                                                                                                                                                                                                                                                                   | 2/13/03  |
|                        | T4A   | 5    | Power Supply table - changed $I_{DD}$ to 155mA max. from 130mA max., changed $I_{DDA}$ to 20mA max. from 15mA max., and changed $I_{DDO}$ to 55mA max. from 45mA max.                                                                                                                                         |          |
| B                      |       | 9    | Added LVDS Driver Termination Section.                                                                                                                                                                                                                                                                        | 3/12/03  |
| C                      |       | 1    | General Description & Features - changed VCO min. from 200MHz to 250MHz and replaced throughout the datasheet in: (Functional Description pg2, T3C Program. Output Divider Func. Table pg4, and T5 Input Freq Charac. Table pg6).<br>- Features - changed min. Output Frequency Range from 25MHz to 31.25MHz. | 5/9/03   |
|                        | T1    | 3    | Pin Descriptions Table - revised XTAL1, XTAL2 pin description.                                                                                                                                                                                                                                                |          |
|                        | T2    | 3    | Pin Characteristics Table - changed $C_{IN}$ 4pF max. to 4pF typical.                                                                                                                                                                                                                                         |          |
|                        | T3B   | 4    | Prog. VCO Freq. Func. Table - deleted 200 and 225 rows, does not apply.                                                                                                                                                                                                                                       |          |
|                        |       | 5    | Power Supply DC Characteristics Table - deleted $V_{DDO}$ & $I_{DDO}$ rows, does not apply.                                                                                                                                                                                                                   |          |
|                        | T7    | 6    | AC Characteristics Table - change $F_{OUT}$ 25MHz min. to 31.25MHz min.                                                                                                                                                                                                                                       |          |
| C                      | T6    | 2    | Revised Parallel & Serial Load Operations diagram.                                                                                                                                                                                                                                                            | 8/12/03  |
|                        |       | 6    | Crystal Characteristics Table - changed ESR from 70Ω max. to 50Ω max.                                                                                                                                                                                                                                         |          |
|                        |       | 9    | Deleted Table 10, <i>Typical Results of Crystal Input Interface Frequency Fine Tuning</i>                                                                                                                                                                                                                     |          |
| C                      | T12   | 5    | Absolute Maximum Ratings - updated Outputs rating.                                                                                                                                                                                                                                                            | 7/8/04   |
|                        |       | 14   | Ordering Information table - added "Lead-Free" part number.                                                                                                                                                                                                                                                   |          |
| C                      | T7    | 6    | AC Characteristics Table - added Note 4.                                                                                                                                                                                                                                                                      | 12/15/04 |
|                        |       | 9    | Added Applications Note, "Differential Duty Cycle Improvement".                                                                                                                                                                                                                                               |          |
| D                      | T6    | 1    | Changed XTAL1/2 naming convention to XTAL_IN/_OUT throughout the datasheet.                                                                                                                                                                                                                                   | 5/10/05  |
|                        |       |      | Pin Assignment, corrected pin 24 to read XTAL_OUT from XTAL1 and pin 25 to XTAL_IN from XTAL2.                                                                                                                                                                                                                |          |
|                        |       | 2    | Updated Figure 1, Parallel & Serial Load Operations diagram.                                                                                                                                                                                                                                                  |          |
|                        |       | 6    | Crystal Characteristics Table - added Drive Level                                                                                                                                                                                                                                                             |          |
|                        |       | 6    | AC Characteristics Table - changed test conditions for Cycle-to-Cycle Jitter from $f \geq 350\text{MHz}$ to $N = 1, 2$ and $f < 350\text{MHz}$ to $N = 4$ .                                                                                                                                                   |          |
|                        |       | 9    | Corrected Crystal Input Interface diagram.                                                                                                                                                                                                                                                                    |          |
|                        |       | 10   | Updated Schematic Layout diagram.                                                                                                                                                                                                                                                                             |          |
|                        | T12   | 14   | Add Lead-Free note to Ordering Information Table.                                                                                                                                                                                                                                                             |          |

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