

700MHZ, CYRSTAL-TO-3.3V DIFFERENTIAL LVPECL FREQUENCY SYNTHESIZER

ICS8432-51

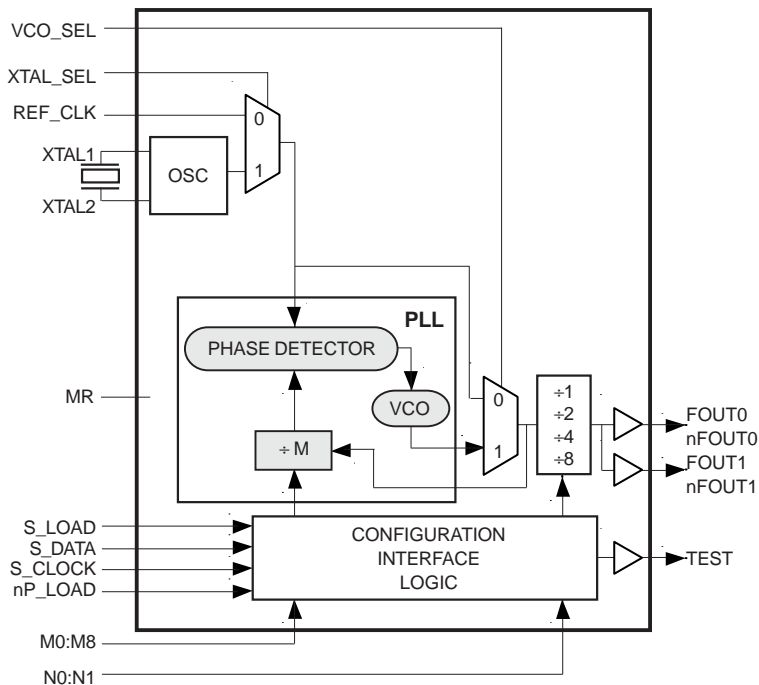
GENERAL DESCRIPTION

The ICS8432-51 is a general purpose, dual output Crystal-to-3.3V Differential LVPECL High Frequency Synthesizer. The ICS8432-51 has a selectable REF_CLK or crystal input. 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 ICS8432-51 make it an ideal clock source for Gigabit Ethernet, Fibre Channel 1 and 2, and Infiniband applications.

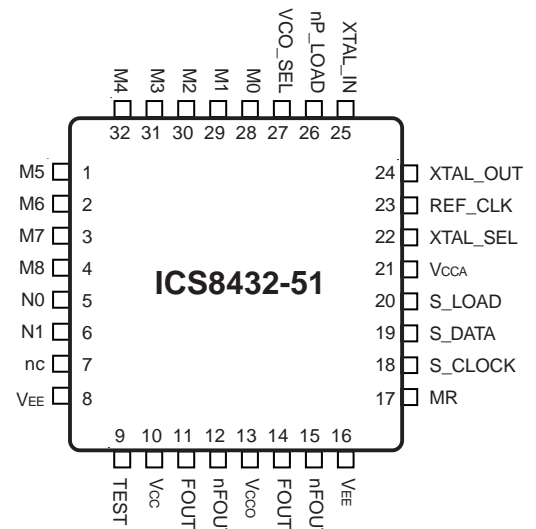
FEATURES

- Dual differential 3.3V LVPECL outputs
- Selectable crystal oscillator interface or LVCMOS/LVTTL REF_CLK
- Output frequency range: 31.25MHz to 700MHz
- Crystal input frequency range: 12MHz to 25MHz
- VCO range: 250MHz to 700MHz
- Parallel or serial interface for programming counter and output dividers
- RMS period jitter: 3.5ps (maximum)
- Cycle-to-cycle jitter: 25ps (maximum)
- 3.3V supply voltage
- 0°C to 70°C ambient operating temperature
- Available in both standard (RoHS 5) and lead-free (RoHS 6) packages
- Replaces the ICS8432-01

BLOCK DIAGRAM



PIN ASSIGNMENT



32-Lead LQFP

7mm x 7mm x 1.4mm package body
Y Package
 Top View

32-Lead VFQFN

5mm x 5mm x 0.925mm package body
K 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 ICS8432-51 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 LVPECL output buffers. The divider provides a 50% output duty cycle.

The programmable features of the ICS8432-51 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 $10 \leq M \leq 28$. 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 |

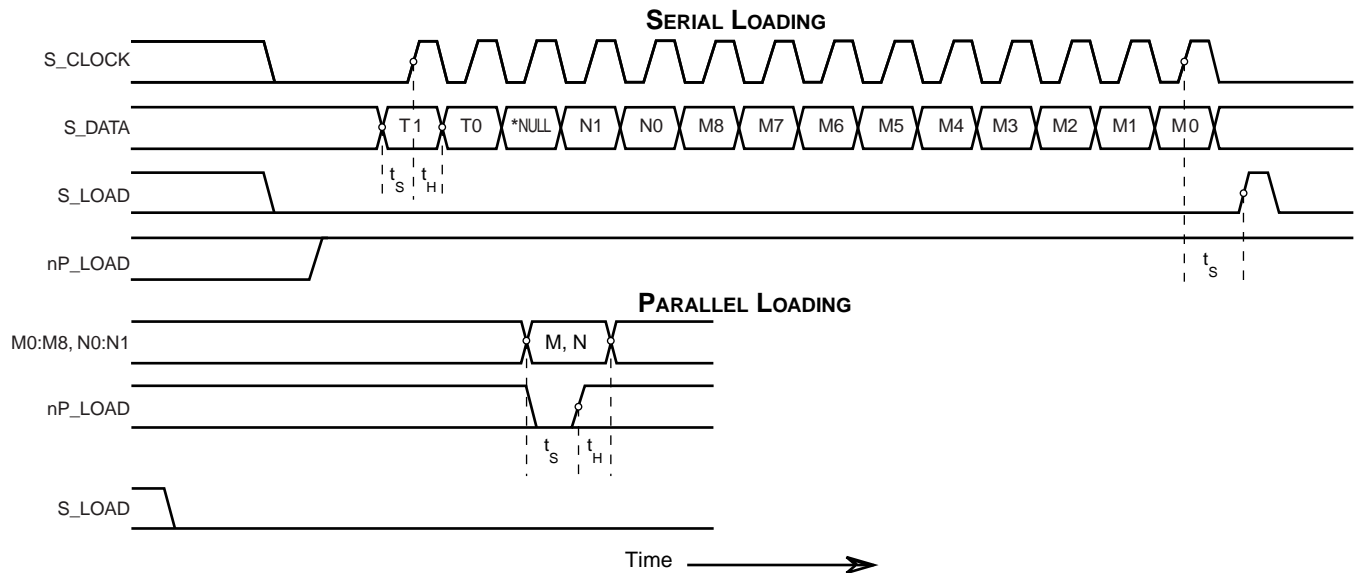


FIGURE 1. PARALLEL & SERIAL LOAD OPERATIONS

*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, 28, 29, 30, 31, 32 | M6, M7, M8, M0, M1, M2, M3, M4 | Input | Pulldown | |
| 5, 6 | N0, N1 | Input | Pulldown | Determines output divider value as defined in Table 3C, Function Table. LVCMOS / LVTTTL interface levels. |
| 7 | nc | Unused | | No connect. |
| 8, 16 | V _{EE} | 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 _{CC} | Power | | Core supply pin. |
| 11, 12 | FOUT1, nFOUT1 | Output | | Differential output for the synthesizer. 3.3V LVPECL interface levels. |
| 13 | V _{CCO} | Power | | Output supply pin. |
| 14, 15 | FOUT0, nFOUT0 | Output | | Differential output for the synthesizer. 3.3V 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 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 _{CCA} | 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 | REF_CLK | Input | Pulldown | Referenc clock input. LVCMOS / LVTTTL interface levels. |
| 24, 25 | XTAL_OUT, XTAL_IN | 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 _{IN} | Input Capacitance | | | 4 | | pF |
| R _{PULLUP} | Input Pullup Resistor | | | 51 | | kΩ |
| R _{PULLDOWN} | 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

| 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_{CC} | 4.6V |
| Inputs, V_I | -0.5V to $V_{CC} + 0.5$ V |
| Outputs, I_O | |
| Continuous Current | 50mA |
| Surge Current | 100mA |
| Package Thermal Impedance, θ_{JA} | |
| 32 Lead LQFP | 47.9°C/W (0 lfpm) |
| 32 Lead VFQFN | 41.07°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, $V_{CC} = V_{CCO} = 3.3V \pm 5\%$, $T_A = 0^\circ\text{C}$ TO 70°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 | | $V_{CC} - 0.15$ | 3.3 | 3.465 | V |
| V_{CCO} | Output Supply Voltage | | 3.135 | 3.3 | 3.465 | V |
| I_{EE} | Power Supply Current | | | | 135 | mA |
| I_{CCA} | Analog Supply Current | | | | 15 | mA |

TABLE 4B. LVCMOS / LVTTTL DC CHARACTERISTICS, $V_{CC} = V_{CCO} = 3.3V \pm 5\%$, $T_A = 0^\circ\text{C}$ TO 70°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 |
| | | REF_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 |
| | | REF_CLK | -0.3 | | 1.3 | V |
| I_{IH} | Input High Current | M0-M4, M6-M8, N0, N1, MR, S_CLOCK, REF_CLK, S_DATA, S_LOAD, nP_LOAD | $V_{CC} = V_{IN} = 3.465V$ | | 150 | μA |
| | | M5, XTAL_SEL, VCO_SEL | $V_{CC} = V_{IN} = 3.465V$ | | 5 | μA |
| I_{IL} | Input Low Current | M0-M4, M6-M8, N0, N1, MR, S_CLOCK, REF_CLK, S_DATA, S_LOAD, nP_LOAD | $V_{CC} = 3.465V,$ $V_{IN} = 0V$ | -5 | | μA |
| | | M5, XTAL_SEL, VCO_SEL | $V_{CC} = 3.465V,$ $V_{IN} = 0V$ | -150 | | μA |
| 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 50Ω to $V_{CCO}/2$.

TABLE 4C. LVPECL DC CHARACTERISTICS, $V_{CC} = V_{CCO} = 3.3V \pm 5\%$, $T_A = 0^\circ C$ TO $70^\circ C$

| 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 50Ω to $V_{CCO} - 2V$. See "Parameter Measurement Information" section, figure "3.3V Output Load Test Circuit".

TABLE 5. INPUT FREQUENCY CHARACTERISTICS, $V_{CC} = V_{CCO} = 3.3V \pm 5\%$, $T_A = 0^\circ C$ TO $70^\circ C$

| Symbol | Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|----------|-----------------|---------------------------|---------|---------|---------|-------|
| f_{IN} | Input Frequency | REF_CLK; NOTE 1 | 12 | | 25 | MHz |
| | | XTAL_IN, XTAL_OUT; NOTE 1 | 12 | | 25 | MHz |
| | | S_CLOCK | | | 50 | MHz |

NOTE 1: For the input crystal and REF_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 12MHz, valid values of M are $21 \leq M \leq 58$. 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 | | 12 | | 25 | MHz |
| Equivalent Series Resistance (ESR) | | | | 70 | Ω |
| Shunt Capacitance | | | | 7 | pF |
| Drive Level | | | | 1 | mW |

TABLE 7. AC CHARACTERISTICS, $V_{CC} = V_{CCO} = 3.3V \pm 5\%$, $T_A = 0^\circ C$ TO $70^\circ C$

| 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 | $f_{VCO} > 350MHz$ | | | 25 | ps |
| $f_{jit(per)}$ | 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 | $N > 1$ | 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.

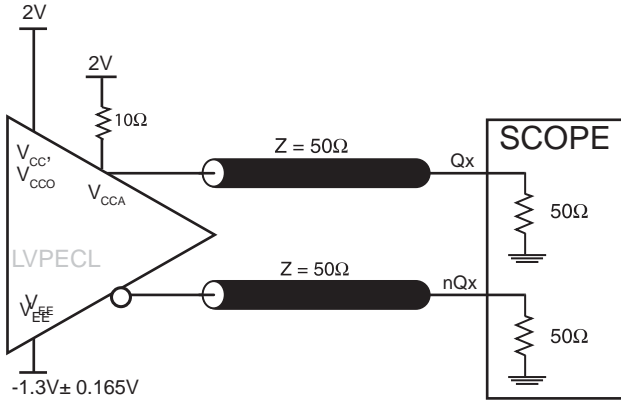
NOTE 1: Jitter performance using XTAL inputs.

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

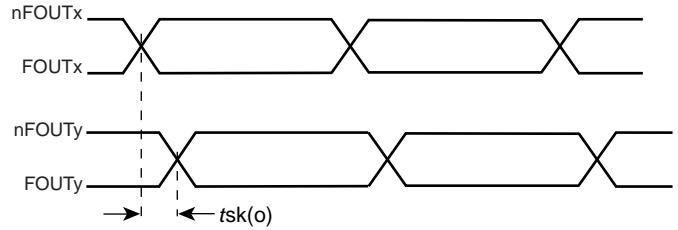
Measured at the output differential cross points.

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

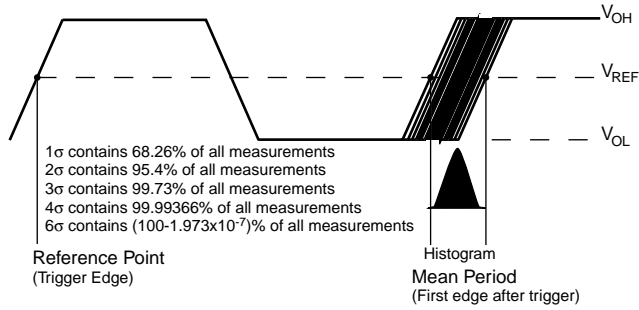
PARAMETER MEASUREMENT INFORMATION



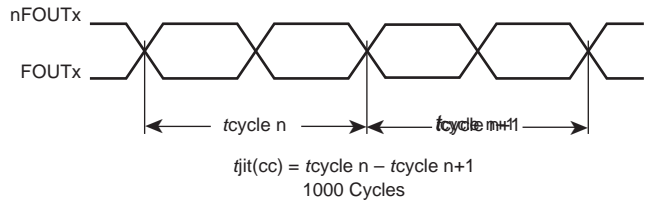
3.3V OUTPUT LOAD AC TEST CIRCUIT



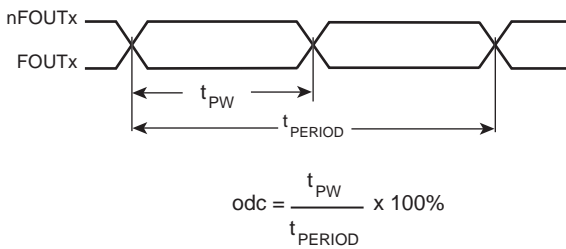
OUTPUT SKEW



PERIOD JITTER



CYCLE-TO-CYCLE JITTER



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 ICS8432-51 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 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) | ICS8432-51 Output Frequency to SERDES (MHz) | ICS8432-51 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. To achieve optimum jitter performance, power supply isolation is required. The ICS8432-51 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 $0.01\mu\text{F}$ bypass capacitors should be used for each pin.

Figure 2 illustrates this for a generic V_{CC} pin and also shows that V_{CCA} requires that an additional 10Ω resistor along with a $10\mu\text{F}$ bypass capacitor be connected to the V_{CCA} pin.

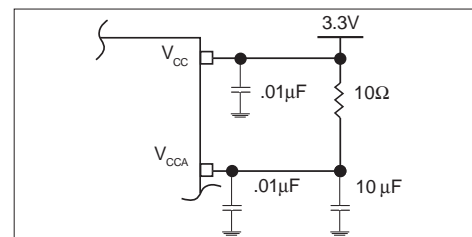


FIGURE 2. POWER SUPPLY FILTERING

CRYSTAL INPUT INTERFACE

The ICS8432-51 has been characterized with 18pF parallel resonant crystals. The capacitor values, C1 and C2, shown in *Figure 3* 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.

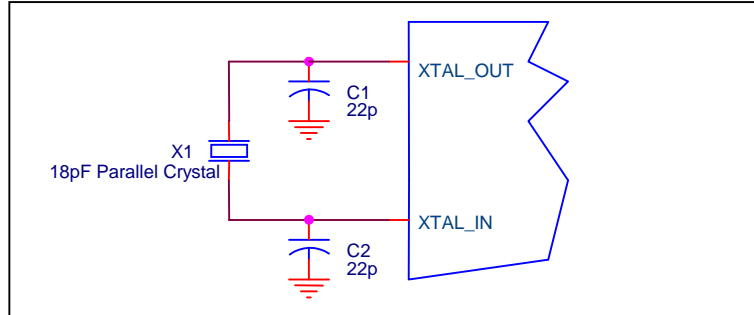


FIGURE 3. CRYSTAL INPUT INTERFACE

LVC MOS TO XTAL INTERFACE

The XTAL_IN input can accept a single-ended LVC MOS signal through an AC coupling capacitor. A general interface diagram is shown in *Figure 4*. The XTAL_OUT pin can be left floating. The input edge rate can be as slow as 10ns. For LVC MOS inputs, it is recommended that the amplitude be reduced from full swing to half swing in order to prevent signal interference with the power rail and to reduce noise. This configuration requires that the output

impedance of the driver (R_o) plus the series resistance (R_s) equals the transmission line impedance. In addition, matched termination at the crystal input will attenuate the signal in half. This can be done in one of two ways. First, R_1 and R_2 in parallel should equal the transmission line impedance. For most 50 Ω applications, R_1 and R_2 can be 100 Ω . This can also be accomplished by removing R_1 and making R_2 50 Ω .

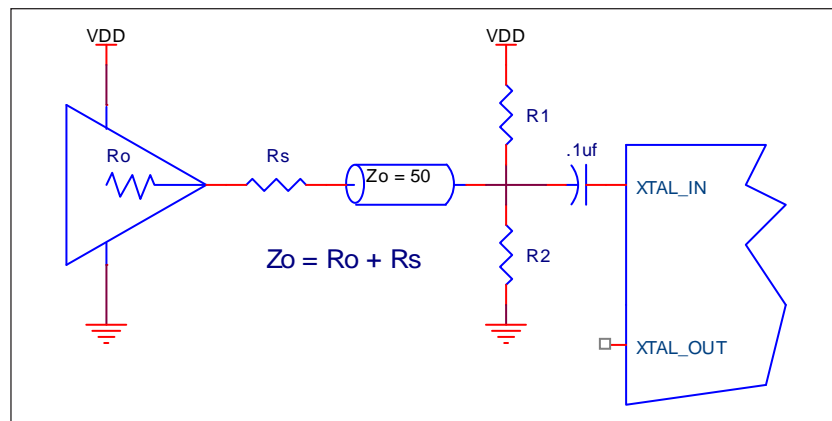


FIGURE 4. GENERAL DIAGRAM FOR LVC MOS DRIVER TO XTAL INPUT INTERFACE

RECOMMENDATIONS FOR UNUSED INPUT AND OUTPUT PINS

INPUTS:

CRYSTAL INPUTS

For applications not requiring the use of the crystal oscillator input, both XTAL_IN and XTAL_OUT can be left floating. Though not required, but for additional protection, a 1kΩ resistor can be tied from XTAL_IN to ground.

REF_CLK INPUT

For applications not requiring the use of the test clock, it can be left floating. Though not required, but for additional protection, a 1kΩ resistor can be tied from the REF_CLK to ground.

LVC MOS CONTROL PINS

All control pins have internal pull-ups or pull-downs; additional resistance is not required but can be added for additional protection. A 1kΩ resistor can be used.

OUTPUTS:

LVPECL OUTPUTS

All unused LVPECL outputs can be left floating. We recommend that there is no trace attached. Both sides of the differential output pair should either be left floating or terminated.

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.

FOUTx and nFOUTx 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 5A and 5B* 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.

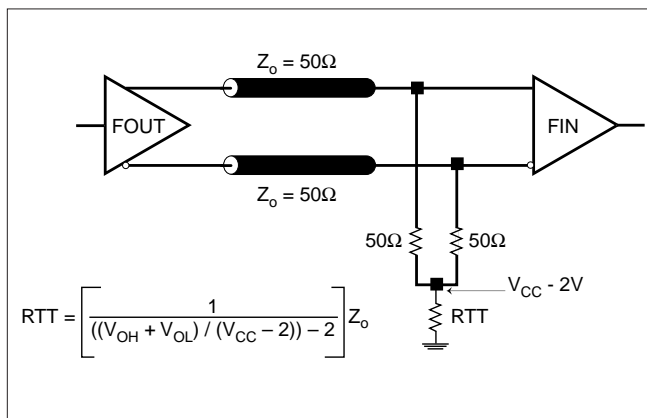


FIGURE 5A. LVPECL OUTPUT TERMINATION

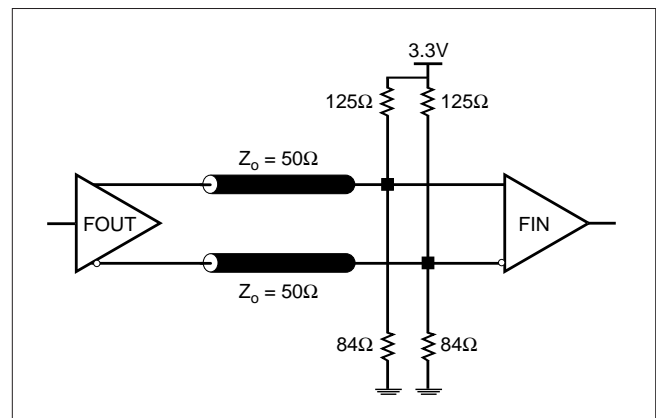


FIGURE 5B. LVPECL OUTPUT TERMINATION

VFQFN EPAD THERMAL RELEASE PATH

In order to maximize both the removal of heat from the package and the electrical performance, a land pattern must be incorporated on the Printed Circuit Board (PCB) within the footprint of the package corresponding to the exposed metal pad or exposed heat slug on the package, as shown in *Figure 6*. The solderable area on the PCB, as defined by the solder mask, should be at least the same size/shape as the exposed pad/slug area on the package to maximize the thermal/electrical performance. Sufficient clearance should be designed on the PCB between the outer edges of the land pattern and the inner edges of pad pattern for the leads to avoid any shorts.

While the land pattern on the PCB provides a means of heat transfer and electrical grounding from the package to the board through a solder joint, thermal vias are necessary to effectively conduct from the surface of the PCB to the ground plane(s). The land pattern must be connected to ground through these vias. The vias act as “heat pipes”. The number of vias (i.e. “heat pipes”)

are application specific and dependent upon the package power dissipation as well as electrical conductivity requirements. Thus, thermal and electrical analysis and/or testing are recommended to determine the minimum number needed. Maximum thermal and electrical performance is achieved when an array of vias is incorporated in the land pattern. It is recommended to use as many vias connected to ground as possible. It is also recommended that the via diameter should be 12 to 13mils (0.30 to 0.33mm) with 1oz copper via barrel plating. This is desirable to avoid any solder wicking inside the via during the soldering process which may result in voids in solder between the exposed pad/slug and the thermal land. Precautions should be taken to eliminate any solder voids between the exposed heat slug and the land pattern. Note: These recommendations are to be used as a guideline only. For further information, refer to the Application Note on the *Surface Mount Assembly* of Amkor's Thermally/Electrically Enhance Leadframe Base Package, Amkor Technology.

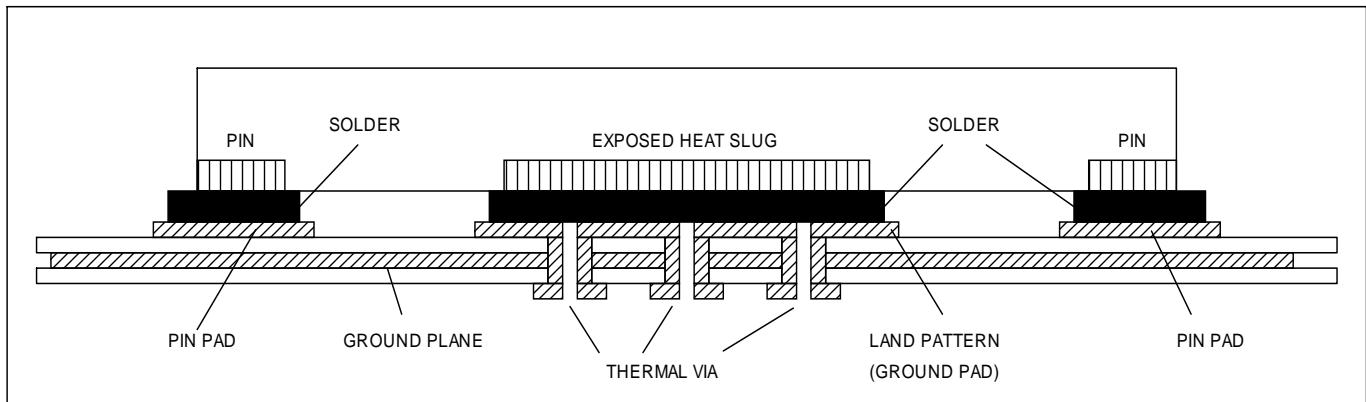


FIGURE 6. P.C. ASSEMBLY FOR EXPOSED PAD THERMAL RELEASE PATH –SIDE VIEW (DRAWING NOT TO SCALE)

LAYOUT GUIDELINE

The schematic of the ICS8432-51 layout example used in this layout guideline is shown in Figure 7A. The ICS8432-51 recommended PCB board layout for this example is shown in Figure 7B. 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.

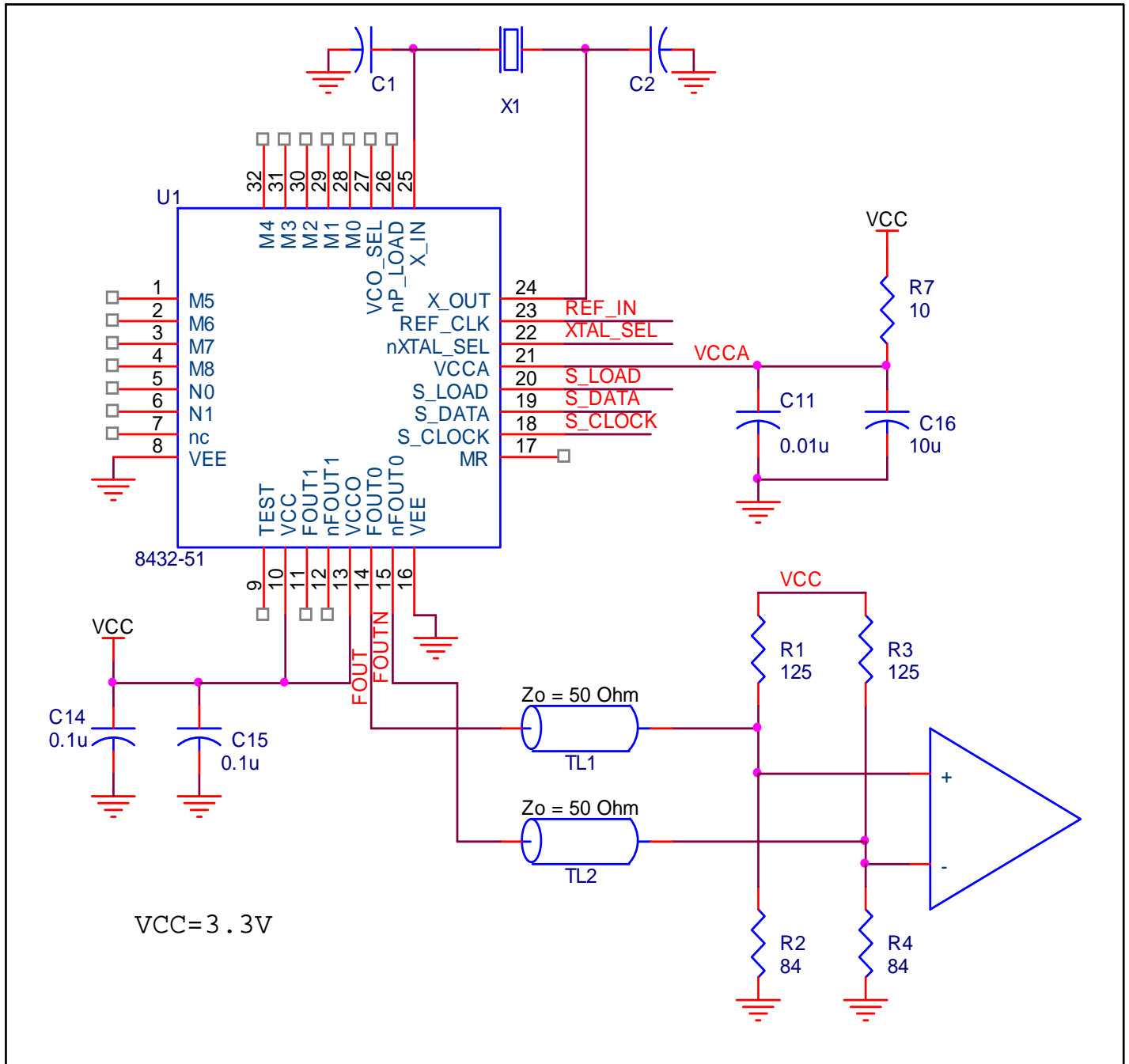


FIGURE 7A. SCHEMATIC OF RECOMMENDED LAYOUT

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 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.

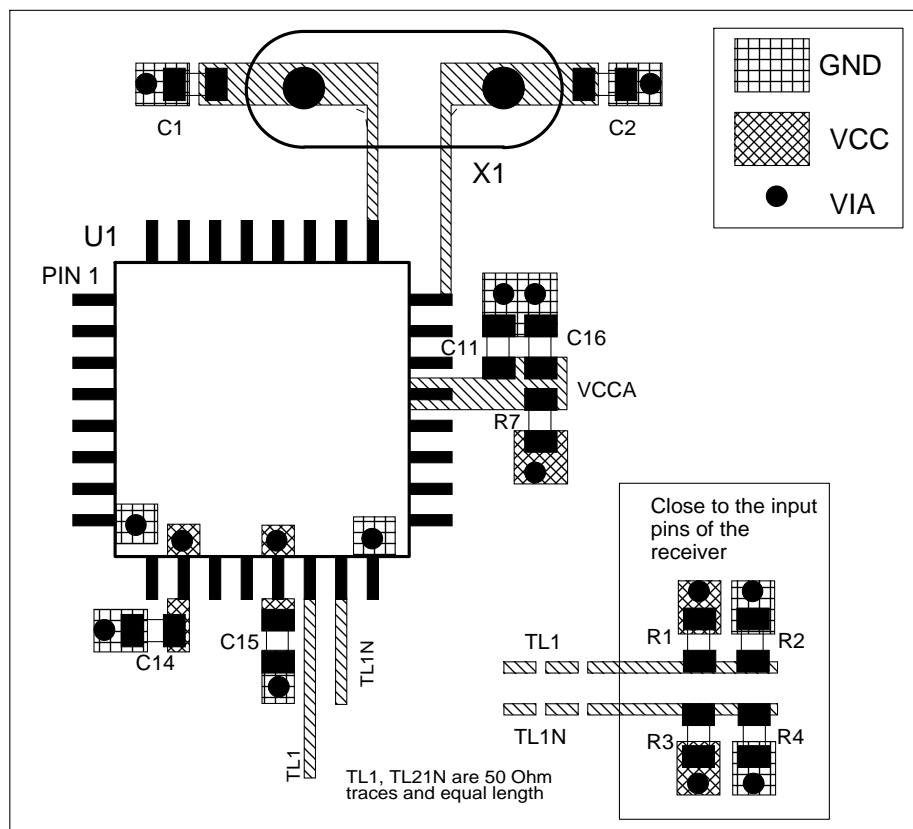


FIGURE 7B. PCB BOARD LAYOUT FOR ICS8432-51

POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS8432-51. Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the ICS8432-51 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} = $V_{CC,MAX} * I_{EE,MAX} = 3.465V * 135mA = 467.8mW$
- Power (outputs)_{MAX} = **30mW/Loaded Output pair**
If all outputs are loaded, the total power is $2 * 30mW = 60mW$

$$\text{Total Power}_{MAX} (3.465V, \text{ with all outputs switching}) = 467.8mW + 60mW = 527.8mW$$

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 devices is 125°C.

The equation for T_j is as follows: $T_j = \theta_{JA} * Pd_{total} + T_A$

T_j = Junction Temperature

θ_{JA} = Junction-to-Ambient Thermal Resistance

Pd_{total} = Total Device Power Dissipation (example calculation is in section 1 above)

T_A = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance θ_{JA} must be used. Assuming a moderate air flow of 200 linear feet per minute and a multi-layer board, the appropriate value is 42.1°C/W per Table 10A below.

Therefore, T_j for an ambient temperature of 70°C with all outputs switching is:
 $70^\circ C + 0.528W * 42.1^\circ C/W = 92.2^\circ C$. 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 10A. THERMAL RESISTANCE θ_{JA} FOR 32-PIN LQFP, FORCED CONVECTION

| | θ_{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.

TABLE 10B. THERMAL RESISTANCE θ_{JA} FOR 32-PIN VFQFN, FORCED CONVECTION

| | θ_{JA} by Velocity (Linear Feet per Minute) |
|---|--|
| | 0 |
| Multi-Layer PCB, JEDEC Standard Test Boards | 34.8°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 8*.

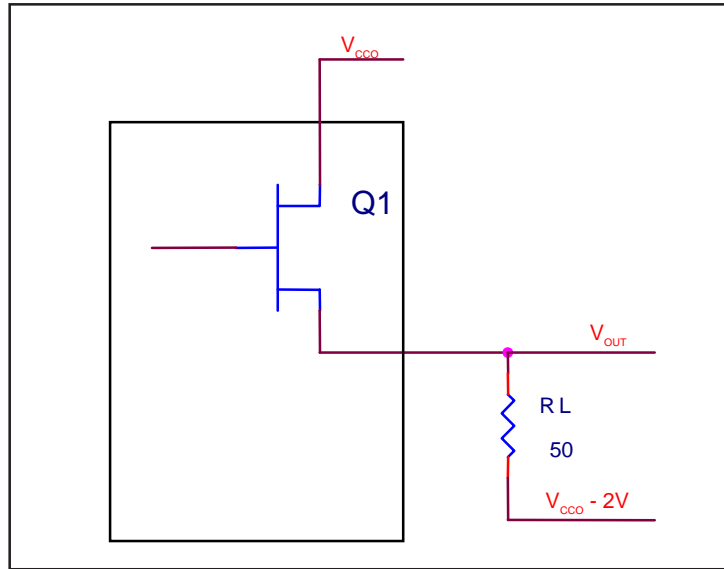


FIGURE 7. LVPECL DRIVER CIRCUIT AND TERMINATION

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.

$$Pd_H = [(V_{OH_MAX} - (V_{CCO_MAX} - 2V))/R_L] * (V_{CCO_MAX} - V_{OH_MAX}) = [(2V - (V_{CCO_MAX} - V_{OH_MAX}))/R_L] * (V_{CCO_MAX} - V_{OH_MAX}) = [(2V - 0.9V)/50\Omega] * 0.9V = 19.8mW$$

$$Pd_L = [(V_{OL_MAX} - (V_{CCO_MAX} - 2V))/R_L] * (V_{CCO_MAX} - V_{OL_MAX}) = [(2V - (V_{CCO_MAX} - V_{OL_MAX}))/R_L] * (V_{CCO_MAX} - V_{OL_MAX}) = [(2V - 1.7V)/50\Omega] * 1.7V = 10.2mW$$

Total Power Dissipation per output pair = $Pd_H + Pd_L = 30mW$

RELIABILITY INFORMATION

TABLE 11A. θ_{JA} VS. AIR FLOW TABLE FOR 32 LEAD LQFP

| θ_{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.

TABLE 11B. θ_{JA} VS. AIR FLOW TABLE FOR 32 LEAD VFQFN PACKAGE

| θ_{JA} by Velocity (Linear Feet per Minute) | |
|--|----------|
| | 0 |
| Multi-Layer PCB, JEDEC Standard Test Boards | 34.8°C/W |

TRANSISTOR COUNT

The transistor count for ICS8432-51 is: 3743

PACKAGE OUTLINE - Y SUFFIX FOR 32 LEAD LQFP

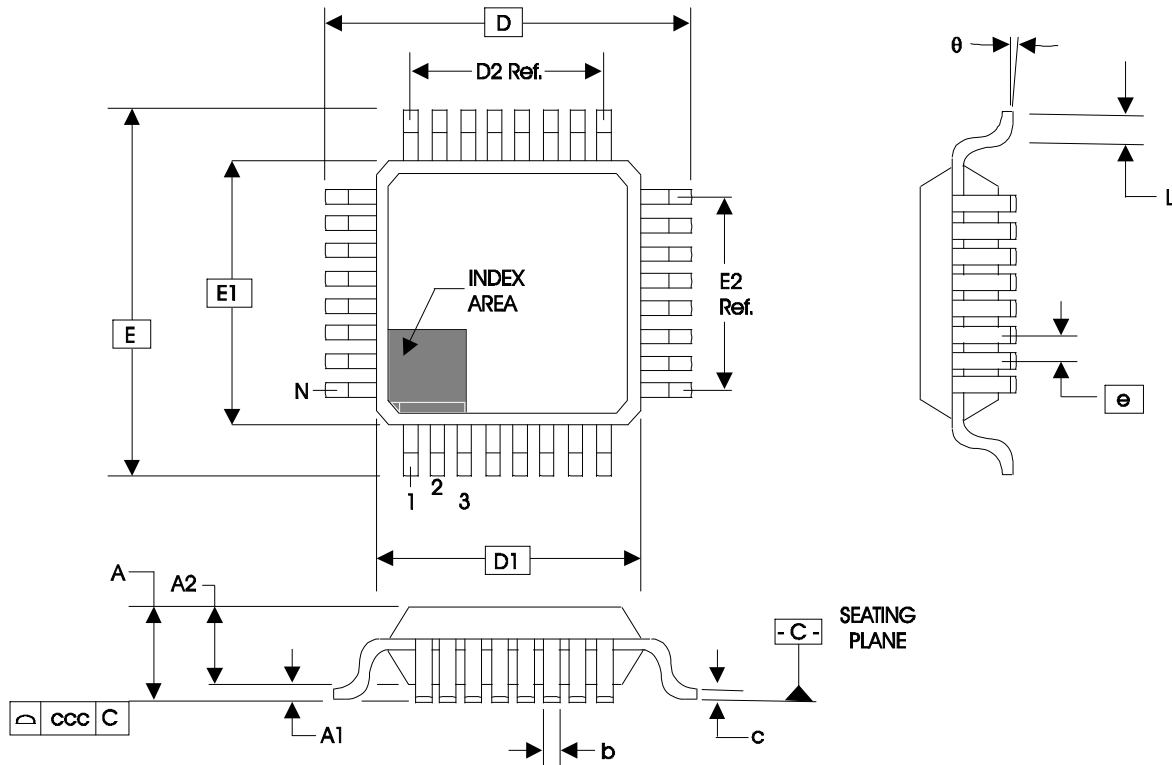
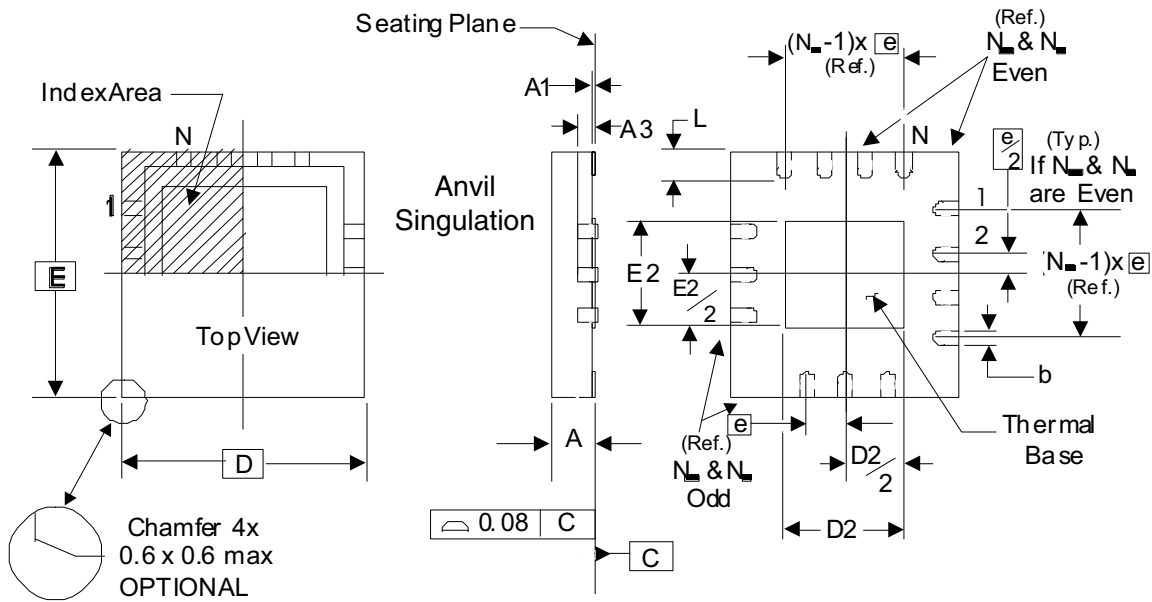


TABLE 12A. PACKAGE DIMENSIONS

| JEDEC VARIATION 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 |
| ● | 0° | -- | 7° |
| ccc | -- | -- | 0.10 |

Reference Document: JEDEC Publication 95, MS-026

PACKAGE OUTLINE - K SUFFIX 32 LEAD VFQFN



NOTE: The following package mechanical drawing is a generic drawing that applies to any pin count VFQFN package. This drawing is not intended to convey the actual pin count or pin layout of

this device. The pin count and pinout are shown on the front page. The package dimensions are in Table 8 below.

TABLE 12B. PACKAGE DIMENSIONS

| JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS | | |
|--|----------------|---------|
| SYMBOL | Minimum | Maximum |
| N | 32 | |
| A | 0.80 | 1.0 |
| A1 | 0 | 0.05 |
| A3 | 0.25 Reference | |
| b | 0.18 | 0.30 |
| e | 0.50 BASIC | |
| N_o | 8 | |
| N_e | 8 | |
| D | 5.0 | |
| D2 | 3.0 | 3.30 |
| E | 5.0 | |
| E2 | 3.0 | 3.30 |
| L | 0.30 | 0.50 |

Reference Document: JEDEC Publication 95, MO-220

TABLE 13. ORDERING INFORMATION

| Part/Order Number | Marking | Package | Shipping Packaging | Temperature |
|-------------------|--------------|---------------------------|--------------------|--------------|
| 8432CY-51LF | ICS8432CY51L | 32 lead "Lead Free" LQFP | Tube | 0°C to +70°C |
| 8432CY-51LFT | ICS8432CY51L | 32 lead "Lead Free" LQFP | Tape and Reel | 0°C to +70°C |
| 8432CK-51LF | ICS8432C51L | 32 lead "Lead Free" VFQFN | Tube | 0°C to +70°C |
| 8432CK-51LFT | ICS8432C51L | 32 lead "Lead Free" VFQFN | Tape and Reel | 0°C to +70°C |

NOTE: "LF" suffix to the part number are the PB-free configuration, RoHS compliant

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). - 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. | |
| | T4A | 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 | T1 | 1 | Pin Assignment - corrected XTAL pins. Pin 24 is labeled XTAL2 and pin 25 is labeled XTAL1. | 5/28/03 |
| | | 2 | Revised Parallel & Serial Load Operations diagram. | |
| | | 3 | Pin Descriptions Table - corrected XTAL pins to correspond with the pin number. Changed XTAL1 to read input and XTAL2 to read output. | |
| | | 10 | Updated Figure 5A schematic to correspond the XTAL pins with the Pin Assignment. | |
| | | 11 | Crystal section, corrected pin 24 to read XTAL2 and pin 25 to read XTAL1. | |
| C | T13 | 1 | Features Section - added Lead-Free bullet. | 4/8/05 |
| | | 16 | Ordering Information - added Lead-Free part number. | |
| D | T4A T6 | 1 | Added 32 Lead VFQFN Package for Pin Assignment. | 4/13/06 |
| | | 5 | Power Supply DC Characteristics Table - changed V_{CCA} min. from 3.135V to $V_{CC} - 0.15V$. | |
| | | 6 | Crystal Characteristics Table - added Drive Level. | |
| | | 9 | Added <i>LVC MOS to XTAL Interface</i> . | |
| | | 10 | Added <i>Recommendations for Unused Input and Output Pins</i> . Added VFQFN package throughout the datasheet. | |
| E | T4C | 1 | Changed naming convention of TEST_CLK to REF_CLK, (pin 24) XTAL2 to XTAL_OUT, and (pin 25) XTAL1 to XTAL_IN. Changed throughout the datasheet. | 4/10/07 |
| | | 6 | LVPECL DC Characteristics Table - corrected V_{OH} max. from $V_{CCO} - 1.0V$ to $V_{CCO} - 0.9V$. | |
| | 13 - 14 | Power Considerations - corrected power dissipation to reflect V_{OH} max in Table 4C. | | |
| | T13 | 18 | Ordering Information Table - corrected ICS8432BK-51 marking to ICS8432BK51. Added VFQFN marking. | |
| F | | 1 | Pin Assignment - corrected typo on pin 25 from XTAL_OUT to XTAL_IN. | 5/13/08 |
| | | 11 | Added <i>VFQFN EPAD Thermal Release Path section</i> . | |
| F | T12B T13 | 1 | General Description - deleted the HiperClocks logo. | 11/13/12 |
| | | 18 | VFQFN Package Dimensions - corrected D2/E2 dimensions | |
| | | 19 | Ordering Information Table - per PCN# N1209-02 updated die revision ordering and marking from "B" to "C". Updated footer part number from revision "B" to "C". | |

ICS8432-51

700MHZ, CRYSTAL-TO-3.3V DIFFERENTIAL LVPECL FREQUENCY SYNTHESIZER

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