



Integrated
Circuit
Systems, Inc.

ICS84330

700MHz, Low JITTER, CRYSTAL-TO-3.3V
DIFFERENTIAL LVPECL FREQUENCY SYNTHESIZER

GENERAL DESCRIPTION

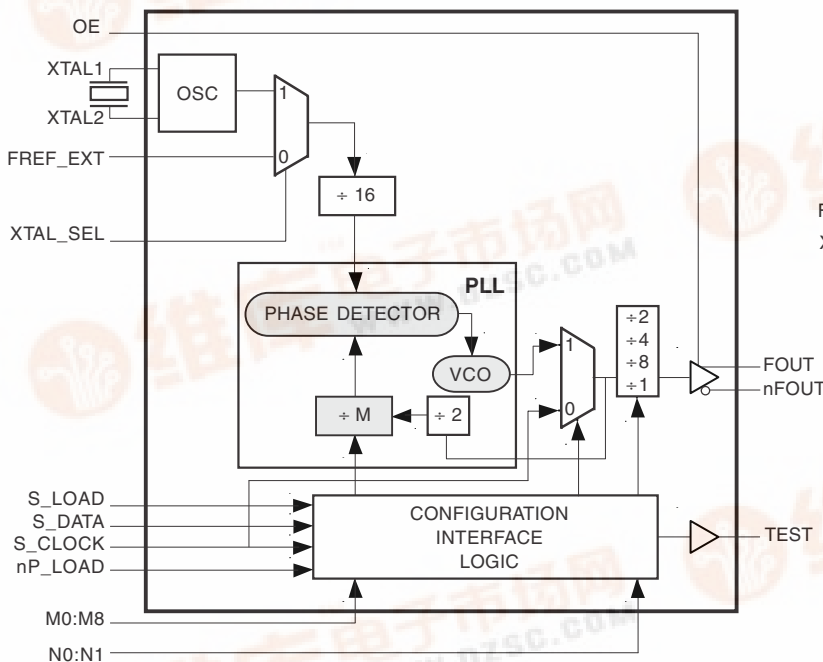


The ICS84330 is a general purpose, single output high frequency synthesizer and a member of the HiPerClockS™ family of High Performance Clock Solutions from ICS. The VCO operates at a frequency range of 250MHz to 700MHz. The VCO and output frequency can be programmed using the serial or parallel interfaces to the configuration logic. The output can be configured to divide the VCO frequency by 1, 2, 4, and 8. Output frequency steps from 250KHz to 2MHz can be achieved using a 16MHz crystal depending on the output divider setting.

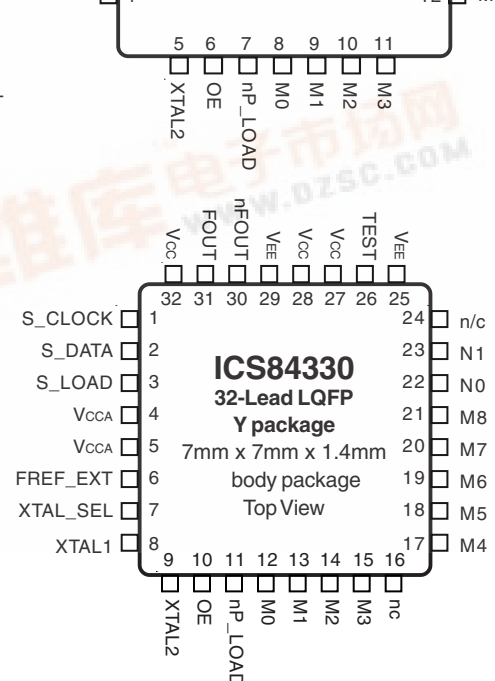
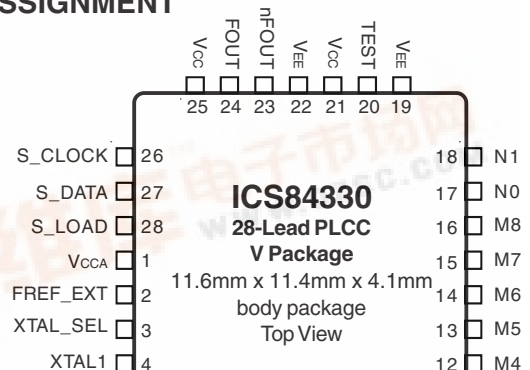
FEATURES

- Fully integrated PLL, no external loop filter requirements
- 1 differential 3.3V LVPECL output
- Crystal oscillator interface: 10MHz to 25MHz
- Output frequency range: 25MHz to 700MHz
- VCO range: 250MHz to 700MHz
- Parallel or serial interface for programming M and N dividers during power-up
- RMS Period jitter: 5ps (maximum)
- Cycle-to-cycle jitter: 40ps (maximum)
- 3.3V supply voltage
- 0°C to 70°C ambient operating temperature
- Pin compatible with the MC12430
- Lead-Free/Annealed package available
- Industrial temperature information available upon request

BLOCK DIAGRAM



PIN ASSIGNMENT





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FUNCTIONAL DESCRIPTION

NOTE: The functional description that follows describes operation using a 16MHz crystal. Valid PLL loop divider values for different crystal or input frequencies are defined in the Input Frequency Characteristics, Table 6, NOTE 1.

The ICS84330 features a fully integrated PLL and therefore requires no external components for setting the loop bandwidth. A quartz crystal is used as the input to the on-chip oscillator. The output of the oscillator is divided by 16 prior to the phase detector. With a 16MHz crystal this provides a 1MHz 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 2M 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 ICS84330 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 LOW. The data on inputs M0 through M8 and N0 through 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. The TEST output is Mode 000 (shift register out) when operating in the parallel input mode. The relationship between the VCO frequency, the crystal frequency and the M divider is defined as follows:

$$f_{VCO} = \frac{f_{xtal}}{16} \times 2M$$

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 are defined as $125 \leq M \leq 350$. The frequency out is defined as follows:

$$f_{out} = \frac{f_{VCO}}{N} = \frac{f_{xtal}}{16} \times \frac{2M}{N}$$

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 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 on each rising edge of S_CLOCK. The serial mode can be used to program the M and N bits and test bits T2:T0. The internal registers T2:T0 determine the state of the TEST output as follows:

| T2 | T1 | T0 | TEST Output | fOUT |
|----|----|----|--|---------------------|
| 0 | 0 | 0 | Shift Register Out | fOUT |
| 0 | 0 | 1 | High | fOUT |
| 0 | 1 | 0 | PLL Reference Xtal ÷ 16 | fOUT |
| 0 | 1 | 1 | (VCO ÷ M) / 2 (non 50% Duty Cycle M divider) | fOUT |
| 1 | 0 | 0 | fOUT | fOUT |
| | | | LVC MOS Output Frequency < 200MHz | fOUT |
| 1 | 0 | 1 | Low | fOUT |
| 1 | 1 | 0 | (S_CLOCK ÷ M) / 2 (non 50% Duty Cycle M divider) | S_CLOCK ÷ N divider |
| 1 | 1 | 1 | fOUT ÷ 4 | fOUT |

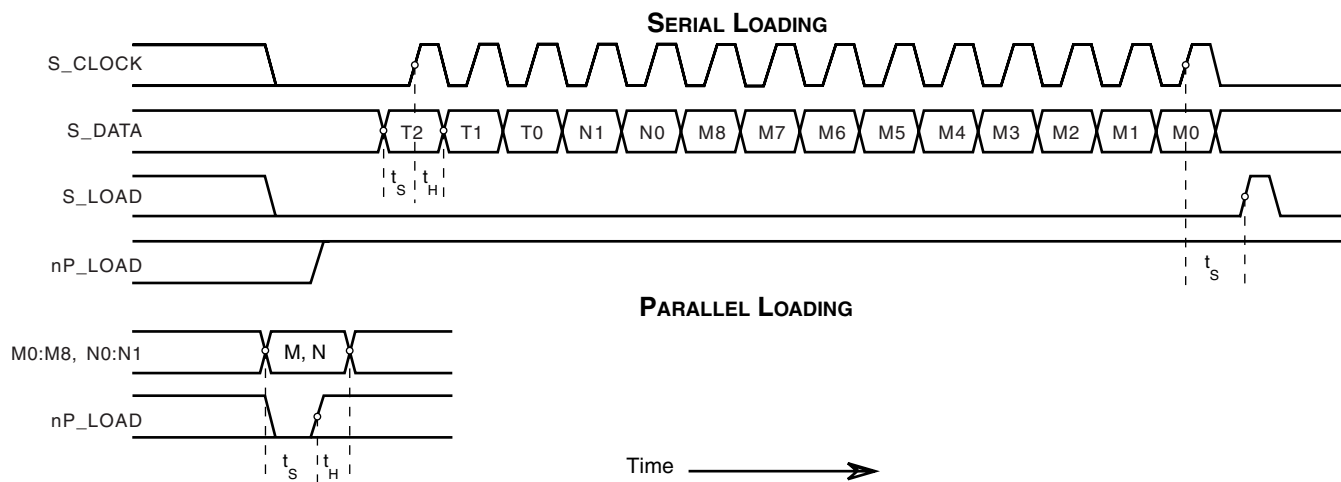


FIGURE 1. PARALLEL & SERIAL LOAD OPERATIONS



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TABLE 1. PIN DESCRIPTIONS

| Name | Type | | Description |
|--|--------|----------|--|
| V _{CCA} | Power | | Analog supply pin. |
| XTAL1, XTAL2 | | | Crystal oscillator interface. XTAL1 is an oscillator input. XTAL2 is an oscillator output. |
| XTAL_SEL | Input | Pullup | Selects between the crystal oscillator or FREF_EXT inputs as the PLL reference source. Selects XTAL inputs when HIGH. Selects FREF_EXT when LOW. LVCMOS / LVTTL interface levels. |
| OE | Input | Pullup | Output enable. LVCMOS / LVTTL interface levels. |
| nP_LOAD | Input | Pullup | 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 divide value. LVCMOS / LVTTL interface levels. |
| M0, M1, M2 M3, M4, M5 M6, M7, M8 | Input | Pullup | M divider inputs. Data latched on LOW-to-HIGH transition of nP_LOAD input. LVCMOS / LVTTL interface levels. |
| N0, N1 | Input | Pullup | Determines N output divider value as defined in Table 3C Function Table. LVCMOS / LVTTL interface levels. |
| V _{EE} | Power | | Negative supply pins. |
| TEST | Output | | Test output which is used in the serial mode of operation. LVCMOS / LVTTL interface levels. |
| V _{CC} | Power | | Core supply pins. |
| nFOUT, FOUT | Output | | Differential output for the synthesizer. 3.3V LVPECL interface levels. |
| nc | Unused | | Do not connect. |
| FREF_EXT | Input | Pulldown | PLL reference input. LVCMOS / LVTTL interface levels. |
| S_CLOCK | Input | Pulldown | Clocks the serial data present at S_DATA input into the shift register on the rising edge of S_CLOCK. LVCMOS / LVTTL interface levels. |
| S_DATA | Input | Pulldown | Shift register serial input. Data sampled on the rising edge of S_CLOCK. LVCMOS / LVTTL interface levels. |
| S_LOAD | Input | Pulldown | Controls transition of data from shift register into the M divider. LVCMOS / LVTTL 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 |



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TABLE 3A. PARALLEL AND SERIAL MODE FUNCTION TABLE

| Inputs | | | | | | Conditions |
|---------|------|------|--------|---------|--------|---|
| nP_LOAD | M | N | S_LOAD | S_CLOCK | S_DATA | |
| X | X | X | X | X | X | Reset. M and N bits are all set HIGH. |
| L | Data | Data | X | X | X | Data on M and N inputs passed directly to M divider and N output divider. TEST mode 000. |
| ↑ | Data | Data | X | X | X | Data is latched into input registers and remains loaded until next LOW transition or until a serial event occurs. |
| H | X | X | L | ↑ | Data | Serial input mode. Shift register is loaded with data on S_DATA on each rising edge of S_CLOCK. |
| H | X | X | ↑ | L | Data | Contents of the shift register are passed to the M divider and N output divider. |
| H | X | X | ↓ | L | Data | M divide and N output divide values are latched. |
| H | X | X | L | X | X | Parallel or serial input do not affect shift registers. |
| 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 | 125 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 |
| 252 | 126 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 254 | 127 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 256 | 128 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| • | • | • | • | • | • | • | • | • | • | • |
| • | • | • | • | • | • | • | • | • | • | • |
| 696 | 348 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 |
| 698 | 349 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 |
| 700 | 350 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 |

NOTE 1: These M divide values and the resulting frequencies correspond to a crystal frequency of 16MHz.

TABLE 3C. PROGRAMMABLE OUTPUT DIVIDER FUNCTION TABLE

| Inputs | | N Divider Value | Output Frequency (MHz) | |
|--------|----|-----------------|------------------------|---------|
| N1 | N0 | | Minimum | Maximum |
| 0 | 0 | 2 | 125 | 350 |
| 0 | 1 | 4 | 62.5 | 175 |
| 1 | 0 | 8 | 31.25 | 87.5 |
| 1 | 1 | 1 | 250 | 700 |



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ABSOLUTE MAXIMUM RATINGS

| | |
|--|--------------------------|
| Supply Voltage, V_{CC} | 4.6V |
| Inputs, V_I | -0.5V to $V_{CC} + 0.5V$ |
| Outputs, I_O | |
| Continuous Current | 50mA |
| Surge Current | 100mA |
| Package Thermal Impedance, θ_{JA} | |
| 32 Lead LQFP | 47.9°C/W (0 lfpm) |
| 28 Lead PLCC | 37.8°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. DC POWER SUPPLY CHARACTERISTICS, $V_{CC} = V_{CCA} = 3.3V \pm 5\%$, $T_A = 0^\circ C$ TO $70^\circ C$

| Symbol | Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|-----------|-----------------------|-----------------|---------|---------|---------|-------|
| V_{CC} | Core Supply Voltage | | 3.135 | 3.3 | 3.465 | V |
| V_{CCA} | Analog Supply Voltage | | 3.135 | 3.3 | 3.465 | V |
| I_{CC} | Power Supply Current | | | | 130 | mA |
| I_{CCA} | Analog Supply Current | | | | 15 | mA |

TABLE 4B. LVCMOS / LVTTTL DC CHARACTERISTICS, $V_{CC} = V_{CCA} = 3.3V \pm 5\%$, $T_A = 0^\circ C$ TO $70^\circ C$

| Symbol | Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|----------|-----------------------------|--|---------|---------|----------------|---------|
| V_{IH} | Input High Voltage | | 2 | | $V_{CC} + 0.3$ | V |
| V_{IL} | Input Low Voltage | | -0.3 | | 0.8 | V |
| I_{IH} | Input High Current | M0-M8, N0, N1, OE, nP_LOAD, XTAL_SEL $V_{CC} = V_{IN} = 3.465V$ | | | 5 | μA |
| | | S_LOAD, S_CLOCK FREF_EXT, S_DATA $V_{CC} = V_{IN} = 3.465V$ | | | 150 | μA |
| I_{IL} | Input Low Current | M0-M8, N0, N1, OE, nP_LOAD, XTAL_SEL $V_{CC} = 3.465V, V_{IN} = 0V$ | -150 | | | μA |
| | | S_LOAD, S_CLOCK FREF_EXT, S_DATA $V_{CC} = 3.465V, V_{IN} = 0V$ | -5 | | | μA |
| V_{OH} | Output High Voltage; NOTE 1 | | 2.6 | | | V |
| V_{OL} | Output Low Voltage; NOTE 1 | | | | 0.5 | V |

NOTE 1: Outputs terminated with 50Ω to $V_{CC}/2$.

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

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

NOTE 1: Outputs terminated with 50Ω to $V_{CC} - 2V$.



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TABLE 5. CRYSTAL CHARACTERISTICS

| Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|------------------------------------|-----------------|-------------|---------|---------|----------|
| Mode of Oscillation | | Fundamental | | | |
| Frequency | | 10 | | 25 | MHz |
| Equivalent Series Resistance (ESR) | | | | 70 | Ω |
| Shunt Capacitance | | | | 7 | pF |

TABLE 6. INPUT FREQUENCY CHARACTERISTICS, $V_{CC} = V_{CCA} = 3.3V \pm 5\%$, $T_A = 0^\circ\text{C}$ TO 70°C

| Symbol | Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|----------|-----------------|------------------|---------|---------|---------|-------|
| f_{IN} | Input Frequency | XTAL; NOTE 1 | 10 | | 25 | MHz |
| | | S_CLOCK | | | 50 | MHz |
| | | FREF_EXT; NOTE 2 | 10 | | | MHz |

NOTE 1: For the crystal frequency range the M value must be set to achieve the minimum or maximum VCO frequency range of 250MHz to 700MHz. Using the minimum frequency of 10MHz, valid values of M are $200 \leq M \leq 511$.

Using the maximum frequency of 25MHz, valid values of M are $80 \leq M \leq 224$.

NOTE 2: Maximum frequency on FREF_EXT is dependent on the internal M counter limitations. See Application Information Section for recommendations on optimizing the performance using the FREF_EXT input.

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

| Symbol | Parameter | Test Conditions | Minimum | Typical | Maximum | Units |
|----------------|----------------------------------|---|---------|---------|---------|-------|
| F_{OUT} | Output Frequency | | | | 700 | MHz |
| $t_{jit(per)}$ | Period Jitter, RMS; NOTE 1, 2 | | | | 5 | ps |
| $t_{jit(cc)}$ | Cycle-to-Cycle Jitter; NOTE 1, 2 | | | | 40 | ps |
| t_R / t_F | Output Rise/Fall Time | 20% to 80% | 200 | | 600 | ps |
| t_S | Setup Time | S_DATA to S_CLOCK | 20 | | | ns |
| | | S_CLOCK to S_LOAD | 20 | | | ns |
| | | M, N to nP_LOAD | 20 | | | ns |
| t_H | Hold Time | S_DATA to S_CLOCK | 20 | | | ns |
| | | M, N to nP_LOAD | 20 | | | ns |
| t_L | PLL Lock Time | | | | 10 | ms |
| odc | Output Duty Cycle | $N \neq 1$ | 45 | | 55 | % |
| | | $N = 1, f_{OUT} \leq 250\text{MHz}$ | 45 | | 55 | % |
| | | $N = 1, 250\text{MHz} < f_{OUT} \leq 500\text{MHz}$ | 40 | | 60 | % |

See Parameter Measurement Information section.

Characterized using a XTAL input.

NOTE 1: This parameter is defined in accordance with JEDEC Standard 65

NOTE 2: See Applications section.

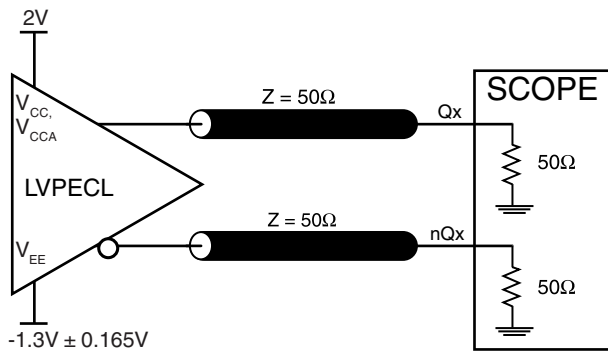


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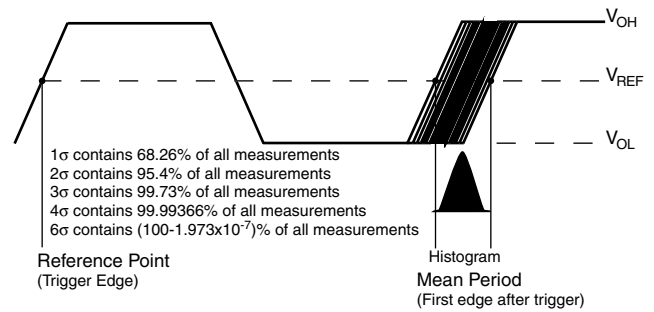
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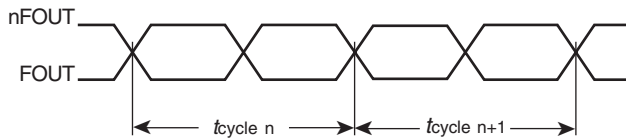
PARAMETER MEASUREMENT INFORMATION



3.3V OUTPUT LOAD AC TEST CIRCUIT



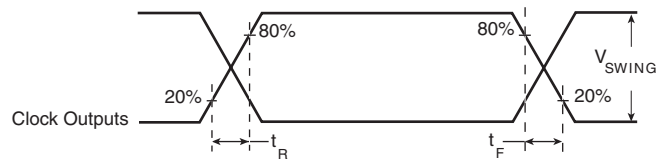
PERIOD JITTER



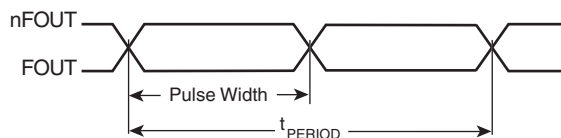
$$t_{jit(cc)} = t_{cycle\ n} - t_{cycle\ n+1}$$

1000 Cycles

CYCLE-TO-CYCLE JITTER



OUTPUT RISE/FALL TIME



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

OUTPUT DUTY CYCLE/PULSE WIDTH/PERIOD



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APPLICATION INFORMATION

POWER SUPPLY FILTERING TECHNIQUES

As in any high speed analog circuitry, the power supply pins are vulnerable to random noise. The ICS84330 provides separate power supplies to isolate any high switching noise from the outputs to the internal PLL. V_{CC} and V_{CCA} should be individually connected to the power supply plane through vias, and bypass capacitors should be used for each pin. To achieve optimum jitter performance, power supply isolation is required. *Figure 2* illustrates how a 10Ω resistor along with a $10\mu F$ and a $.01\mu F$ bypass capacitor should be connected to each V_{CCA} pin.

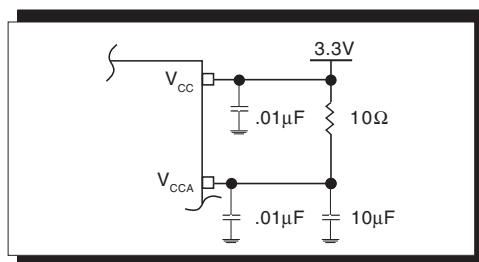


FIGURE 2. POWER SUPPLY FILTERING

TERMINATION FOR LVPECL OUTPUTS

The clock layout topology shown below is a typical termination for LVPECL outputs. The two different layouts mentioned are recommended only as guidelines.

FOUT and nFOUT are low impedance follower outputs that generate ECL/LVPECL compatible outputs. Therefore, terminating resistors (DC current path to ground) or current sources must be used for functionality. These outputs are designed to

drive 50Ω transmission lines. Matched impedance techniques should be used to maximize operating frequency and minimize signal distortion. *Figures 3A and 3B* 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.

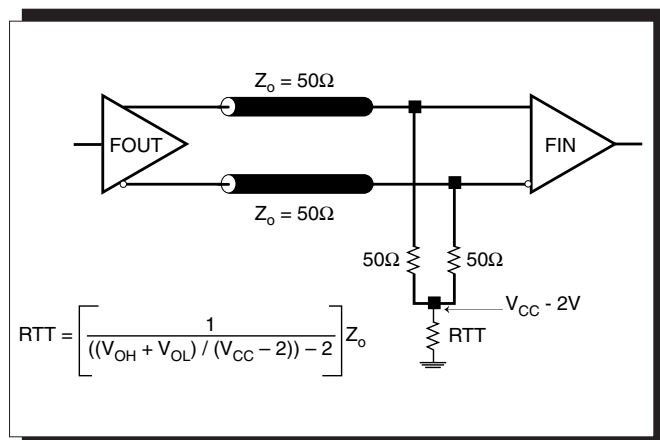


FIGURE 3A. LVPECL OUTPUT TERMINATION

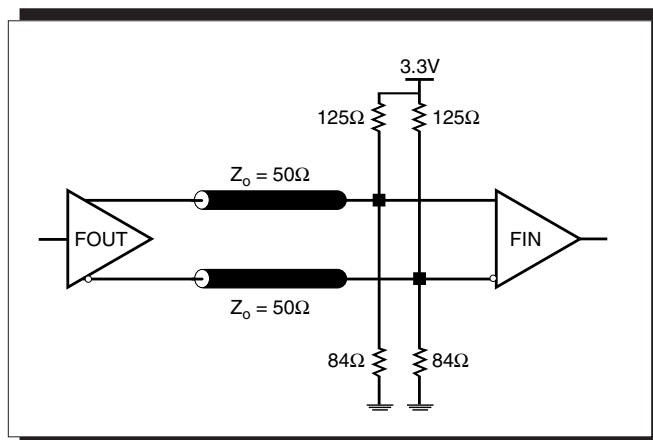


FIGURE 3B. LVPECL OUTPUT TERMINATION



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LVC MOS TO XTAL INTERFACE

The XTAL1 input can accept single ended LVC MOS signal through an AC couple capacitor. A general interface diagram is shown in *Figure 4*. The XTAL2 input can be left floating. The edge rate can be as slow as 10ns. If the incoming signal has sharp edge rate and the signal path is a long trace, proper termination for the driver and controlled characteristic imped-

ance trace may be required. The input can function with half swing amplitude. Reducing amplitude from full swing of 3.3V to half swing of about 1.65V can prevent signal interfere with power rail and may reduce noise. Please refer to the LVC MOS driver data sheet and application note for amplitude reduction and termination approach.

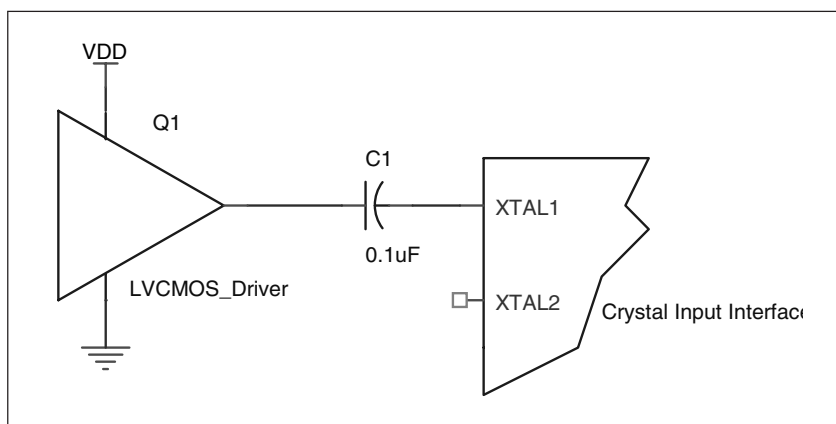


Figure 4. GENERAL DIAGRAM FOR LVC MOS DRIVER TO XTAL INPUT INTERFACE

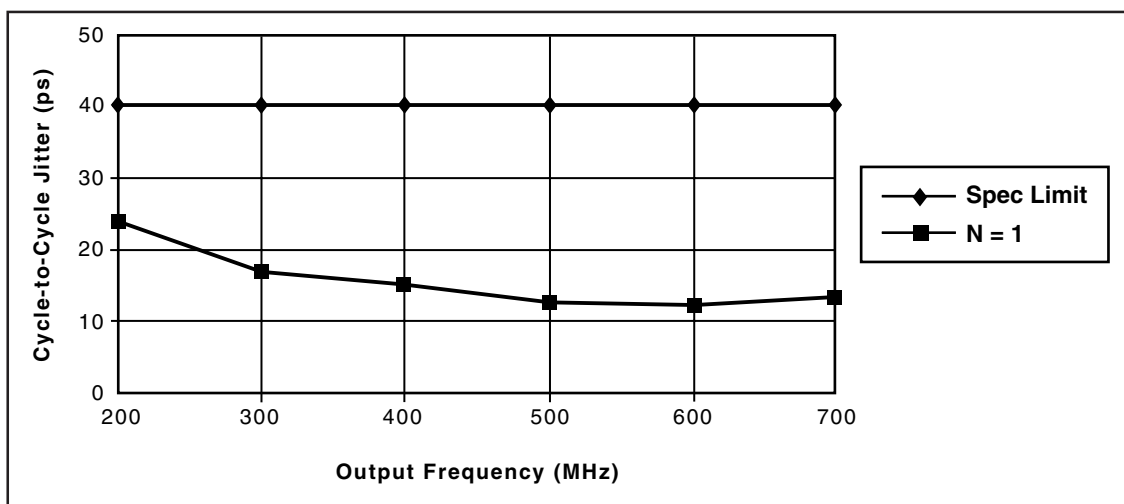


FIGURE 5. CYCLE-TO-CYCLE JITTER VS. f_{OUT} (using a 16MHz XTAL)

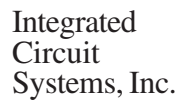


FIGURE 6A. SCHEMATIC OF RECOMMENDED LAYOUT



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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 C3 and C4, 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 50 Ω 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 4 (XTAL1) and 5 (XTAL2). The trace length between the X1 and U1 should be kept to a minimum to avoid unwanted parasitic inductance and capacitance. Other signal traces should not be routed near the crystal traces.

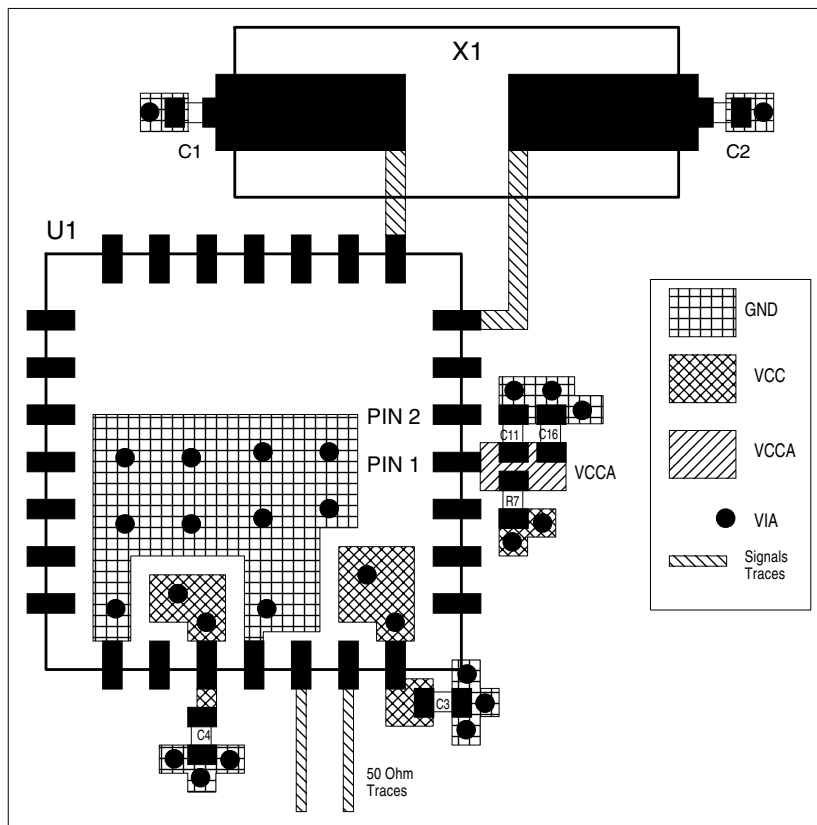


FIGURE 6B. PCB BOARD LAYOUT FOR ICS84330



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JITTER REDUCTION FOR FREF_EXT SINGLE END INPUT

If the FREF_EXT input is driven by a 3.3V LVCMOS driver, the jitter performance can be improved by reducing the amplitude swing and slowing down the edge rate. *Figure 7A* shows an amplitude reduction approach for a long trace. The swing will be approximately 0.85V for logic low and 2.5V for logic high

(instead of 0V to 3.3V). *Figure 7B* shows amplitude reduction approach for a short trace. The circuit shown in *Figure 7C* reduces amplitude swing and also slows down the edge rate by increasing the resistor value.

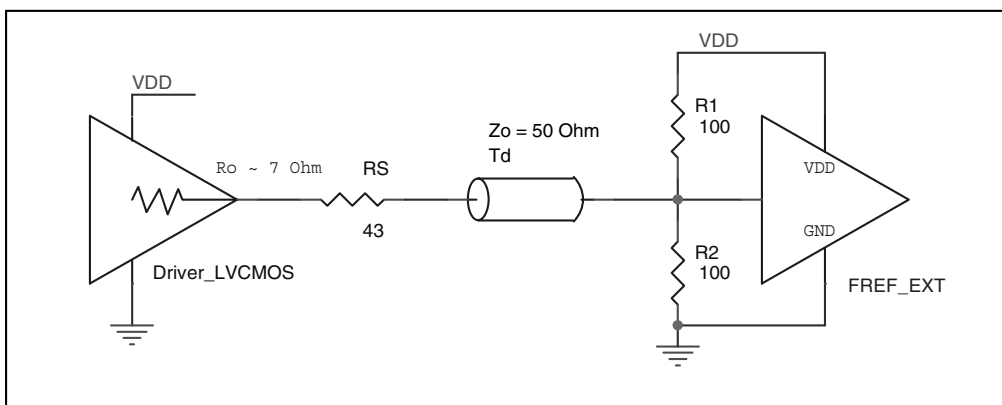


FIGURE 7A. AMPLITUDE REDUCTION FOR A LONG TRACE

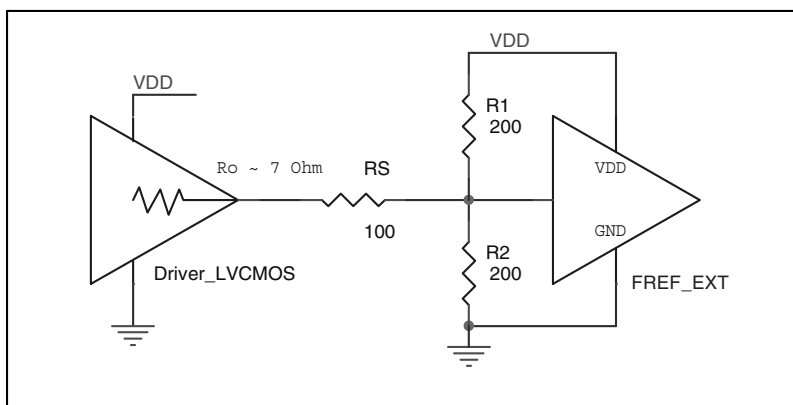


FIGURE 7B. AMPLITUDE REDUCTION FOR A SHORT TRACE

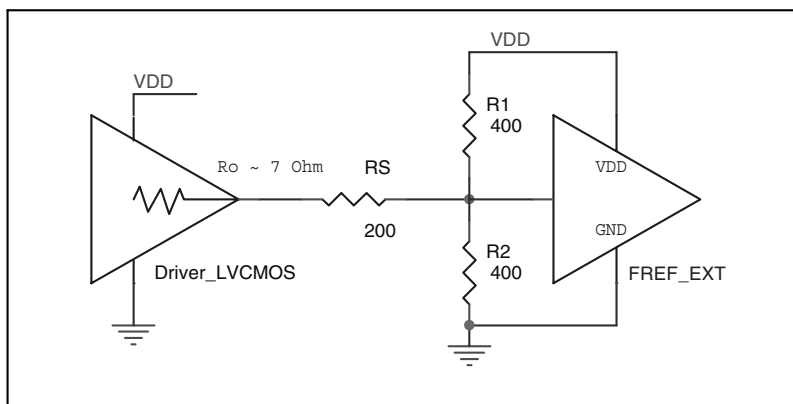


FIGURE 7C. EDGE RATE REDUCTION BY INCREASING THE RESISTOR VALUE



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POWER CONSIDERATIONS

This section provides information on power dissipation and junction temperature for the ICS84330. Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the ICS84330 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} = $V_{CC_MAX} * I_{EE_MAX} = 3.465V * 145mA = 502.4mW$
- Power (outputs)_{MAX} = **30.2mW/Loaded Output pair**
If all outputs are loaded, the total power is $1 * 30.2mW = 30.2mW$

$$\text{Total Power}_{MAX} (3.465V, \text{ with all outputs switching}) = 502.4 + 30.2mW = 532.6mW$$

2. Junction Temperature.

Junction temperature, T_j , is the temperature at the junction of the bond wire and bond pad and directly affects the reliability of the device. The maximum recommended junction temperature for HiPerClockS™ devices is 125°C.

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

T_j = Junction Temperature

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

Pd_total = Total Device Power Dissipation (example calculation is in section 1 above)

T_A = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance θ_{JA} must be used. Assuming a moderate air flow of 200 linear feet per minute and a multi-layer board, the appropriate value is 31.1°C/W per Table 9A below.

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

$$70^\circ C + 0.533W * 31.1^\circ C/W = 86.6^\circ C. \text{ This is well below the limit of } 125^\circ C.$$

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 9A. THERMAL RESISTANCE θ_{JA} FOR 28-PIN PLCC, FORCED CONVECTION

| θ_{JA} by Velocity (Linear Feet per Minute) | | | |
|---|----------|----------|----------|
| | 0 | 200 | 500 |
| Multi-Layer PCB, JEDEC Standard Test Boards | 37.8°C/W | 31.1°C/W | 28.3°C/W |
| NOTE: Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs. | | | |

TABLE 9B. 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. | | | |



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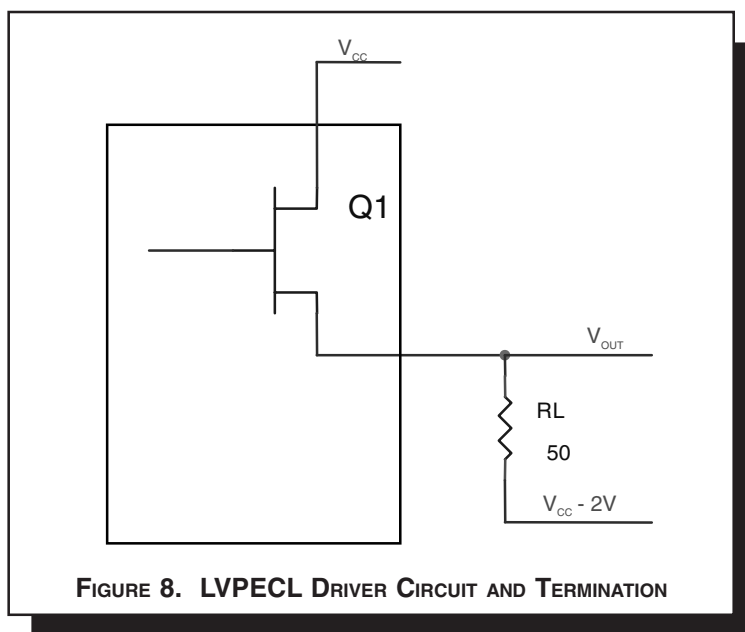
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3. Calculations and Equations.

The purpose of this section is to derive the power dissipated into the load.

LVPECL output driver circuit and termination are shown in the *Figure 8*.



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

- For logic high, $V_{OUT} = V_{OH_MAX} = V_{CC_MAX} - 1.0V$
 $(V_{CC_MAX} - V_{OH_MAX}) = 1.0V$
- For logic low, $V_{OUT} = V_{OL_MAX} = V_{CC_MAX} - 1.7V$
 $(V_{CC_MAX} - V_{OL_MAX}) = 1.7V$

Pd_H is power dissipation when the output drives high.

Pd_L is the power dissipation when the output drives low.

$$Pd_H = [(V_{OH_MAX} - (V_{CC_MAX} - 2V))/R_L] * (V_{CC_MAX} - V_{OH_MAX}) = [(2V - (V_{CC_MAX} - V_{OH_MAX}))/R_L] * (V_{CC_MAX} - V_{OH_MAX}) = [(2V - 1V)/50\Omega] * 1V = 20.0mW$$

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

$$\text{Total Power Dissipation per output pair} = Pd_H + Pd_L = 30.2mW$$



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RELIABILITY INFORMATION

TABLE 10A. θ_{JA} VS. AIR FLOW PLCC TABLE FOR 28 LEAD PLCC

| θ_{JA} by Velocity (Linear Feet per Minute) | | | |
|---|----------|----------|----------|
| | 0 | 200 | 500 |
| Multi-Layer PCB, JEDEC Standard Test Boards | 37.8°C/W | 31.1°C/W | 28.3°C/W |
| NOTE: Most modern PCB designs use multi-layered boards. The data in the second row pertains to most designs. | | | |

TABLE 10B. θ_{JA} VS. AIR FLOW LQFP 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. | | | |

TRANSISTOR COUNT

The transistor count for ICS84330 is: 4442



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PACKAGE OUTLINE - V SUFFIX FOR 28 LEAD PLCC

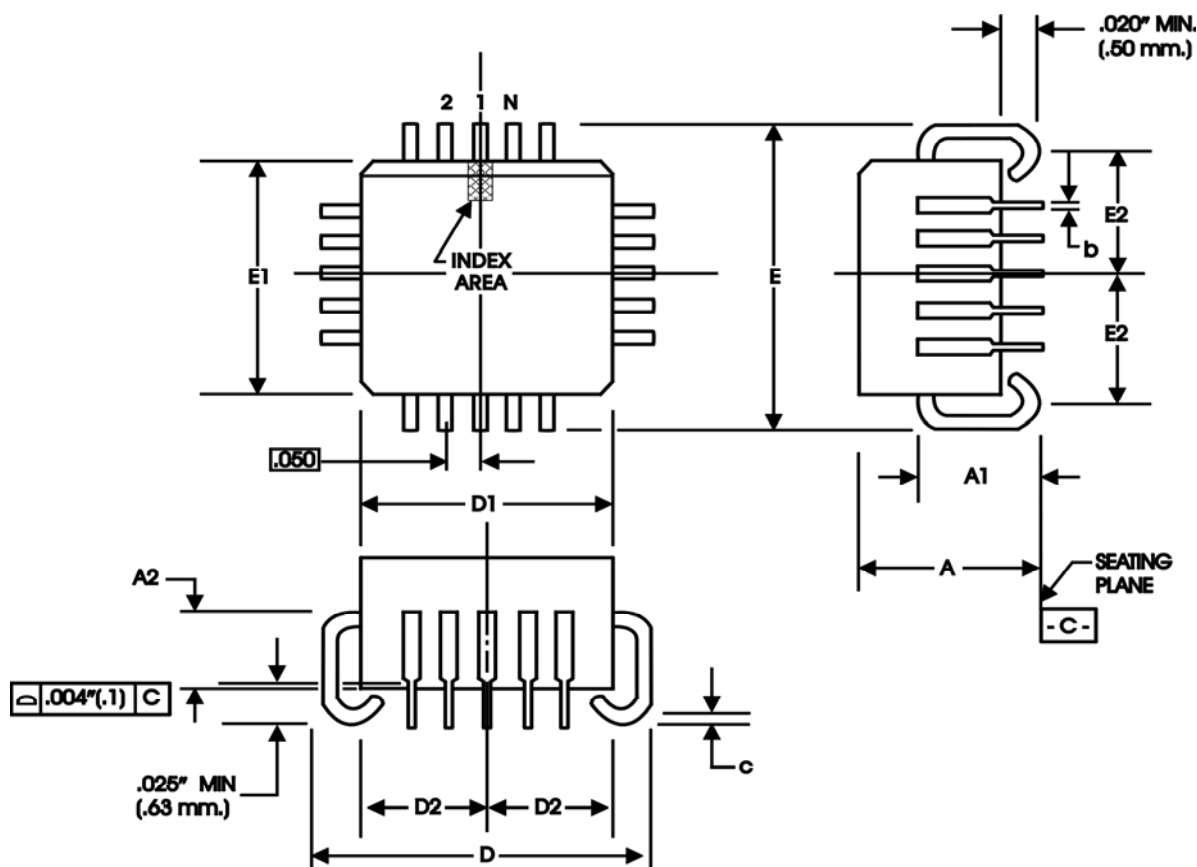


TABLE 11A. PACKAGE DIMENSIONS

| JEDEC VARIATION ALL DIMENSIONS IN MILLIMETERS | | |
|--|---------|---------|
| SYMBOL | MINIMUM | MAXIMUM |
| N | 28 | |
| A | 4.19 | 4.57 |
| A1 | 2.29 | 3.05 |
| A2 | 1.57 | 2.11 |
| b | 0.33 | 0.53 |
| c | 0.19 | 0.32 |
| D | 12.32 | 12.57 |
| D1 | 11.43 | 11.58 |
| D2 | 4.85 | 5.56 |
| E | 12.32 | 12.57 |
| E1 | 11.43 | 11.58 |
| E2 | 4.85 | 5.56 |

Reference Document: JEDEC Publication 95, MS-018



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PACKAGE OUTLINE - Y SUFFIX FOR 32 LEAD LQFP

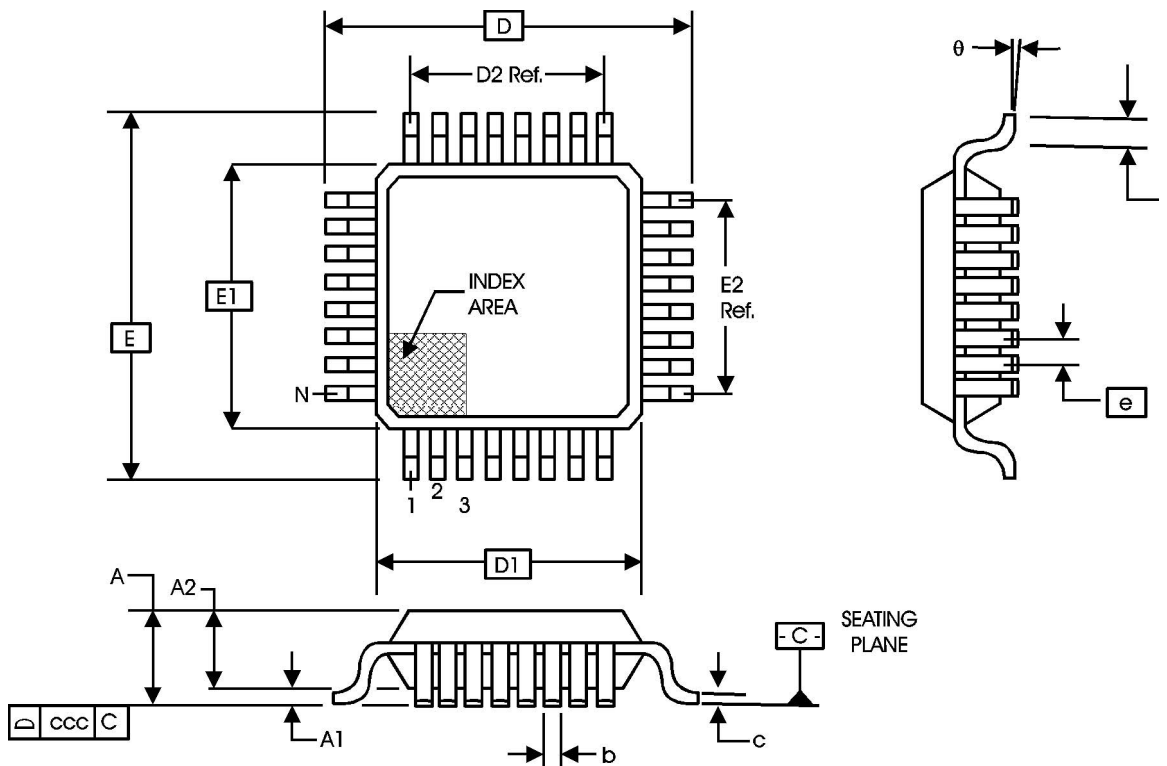


TABLE 11B. PACKAGE DIMENSIONS

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



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TABLE 12. ORDERING INFORMATION

| Part/Order Number | Marking | Package | Count | Temperature |
|-------------------|--------------|---|--------------|-------------|
| ICS84330BV | ICS84330BV | 28 Lead PLCC | 38 per Tube | 0°C to 70°C |
| ICS84330BVT | ICS84330BV | 28 Lead PLCC on Tape and Reel | 500 | 0°C to 70°C |
| ICS84330BY | ICS84330BY | 32 Lead LQFP | 250 per Tray | 0°C to 70°C |
| ICS84330BYT | ICS84330BY | 32 Lead LQFP on Tape and Reel | 1000 | 0°C to 70°C |
| ICS84330BYLN | ICS84330BYLN | 32 Lead "Lead Free/Annealed" LQFP | 250 per Tray | 0°C to 70°C |
| ICS84330BYLNT | ICS84330BYLN | 32 Lead "Lead Free/Annealed" LQFP on Tape and Reel | 1000 | 0°C to 70°C |

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| REVISION HISTORY SHEET | | | | |
|------------------------|-----------|------|--|---------|
| Rev | Table | Page | Description of Change | Date |
| A | T4A | 2 | Switched S_DATA and S_CLOCK labels in Figure 1, CLK_EN Timing Diagram. | 1/23/03 |
| | | 5 | DC Power Supply table - changed ICC Parameter to read Power.. from Core... | |
| | | 9 | Added "LVCMOS to XTAL Interface" section. | |
| | | 10 | Figure 7A Schematic Layout - revised, changed N[1:0]-01 to N[1:0]=00. Added C1 value (18p) and C2 value (22p). | |
| A | | 1 | Block Diagram, replaced N with values. | 3/24/03 |
| | | 8 | Deleted Crystal Input Interface section; external tune up capacitor not required. | |
| | | 10 | Revised Figure 6A, Schematic of Recommended Layout diagram. | |
| B | T2 T3B | 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 T6 Input Freq Charac. pg6). | 5/5/03 |
| | | 3 | Pin Characteristics Table - changed C _{IN} 4pF max. to 4pF typical. | |
| | | 4 | Prog. VCO Freq. Func. Table - replaced VCO Frequency 200MHz to 206MHz with 250MHz to 256MHz. Replaced M Divide 100 to 103 to 125 to 128. Adjusted Logic High and Logic Low data. | |
| | | 5 | Absolute Maximum Rating - changed Outputs V _O and rating to I _O with Continuous and Surge ratings. | |
| B | T12 | 18 | Ordering Information Table - added "Lead Free/Annealed" part number. Updated format throughout data sheet. | 7/26/04 |