700MHZ, CRYSTAL-TO-3.3V/2.5V LVPECL FREQUENCY SYNTHESIZER w/FANOUT BUFFER

ICS84314-02

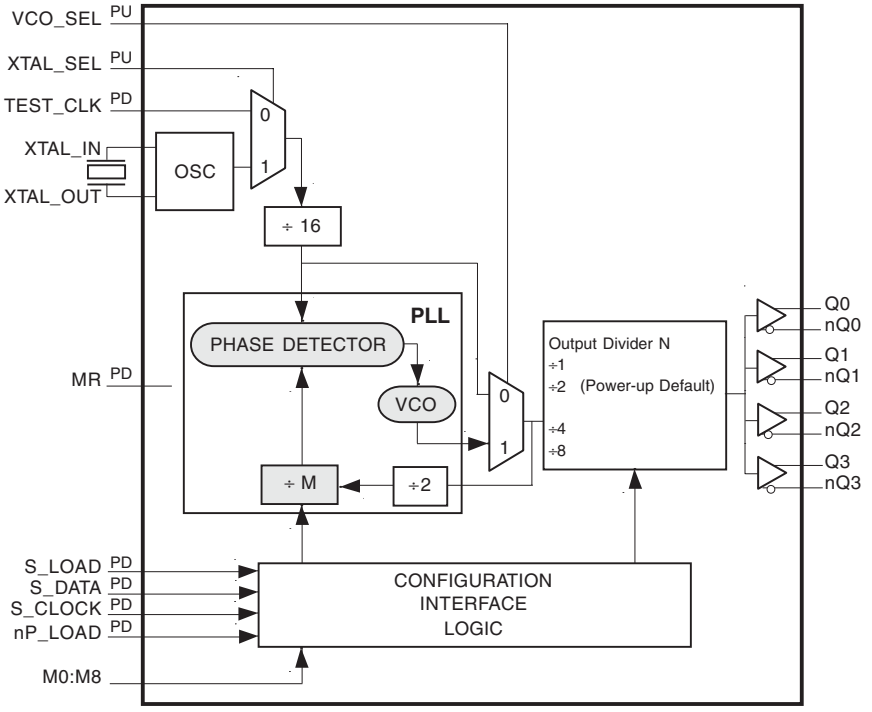
General Description

The ICS84314-02 is a general purpose quad output frequency synthesizer and a member of the HiPerClockS™ family of High Performance Clock Solutions from IDT. When the device uses parallel loading, the M bits are programmable and the output divider is hard-wired for divide by 2 thus providing a frequency range of 125MHz to 350MHz. In serial programming mode, the M bits are programmable and the output divider can be set for either divide by 1, 2, 4 or divide by 8, providing a frequency range of 31.25MHz to 700MHz. Additionally, the device supports spread spectrum clocking (SSC) for minimizing Electromagnetic Interference (EMI). The low cycle-cycle jitter and broad frequency range of the ICS84314-02 make it an ideal clock generator for a variety of demanding applications which require high performance.

Features

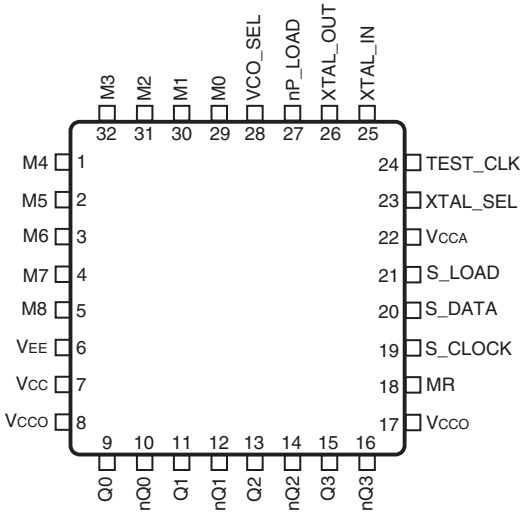
- Fully integrated PLL
- Four differential 3.3V or 2.5V LVPECL output pairs
- Selectable crystal oscillator interface or LVCMOS/LVTTL TEST_CLK input
- Output frequency range: 31.25MHz to 700MHz
- VCO range: 250MHz to 700MHz
- Parallel interface for programming M dividers
- Supports Spread Spectrum Clocking (SSC) Down spread: -0.6%
- Serial 3 wire interface
- Cycle-to-cycle jitter: 45ps (maximum)
- Output skew: 40ps (maximum)
- Output duty cycle: 47% – 53%
- Full 3.3V or mixed 3.3V core, 2.5V output operating supply
- 0°C to 70°C ambient operating temperature
- Industrial temperature information available upon request
- Available in both standard (RoHS 5) and lead-free (RoHS 6) packages

Block Diagram



NOTE: *Pullup (PU) and Pulldown (PD)* refer to internal input resistors. See Table 2, *Pin Characteristics,* for typical values.

Pin Assignment



ICS84314-02
32 Lead LQFP
Y Package
7mm x 7mm x 1.4mm package body
Top View

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 ICS84314-02 features a fully integrated PLL and therefore requires no external components for setting the loop bandwidth. A parallel-resonant, fundamental 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 ICS84314-02 support two input modes to program the M 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 is passed directly to the M 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 bits can be hardwired to set the M divider to a specific default state that will automatically occur during power-up. In parallel mode, the N output divider is set to 2. In serial mode, the N output divider can be set for either ÷1, ÷2, ÷4 or ÷8. The relationship between the VCO frequency, the crystal frequency and the M divider is defined as follows: $fVCO = \frac{fXTAL}{16} \times 2M$

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 for a 16MHz reference are defined as $125 \leq M \leq 350$. The frequency out is defined as follows: $fout = fVCO \times \frac{1}{N} = \frac{fXTAL}{16} \times 2M \times \frac{1}{N}$

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.

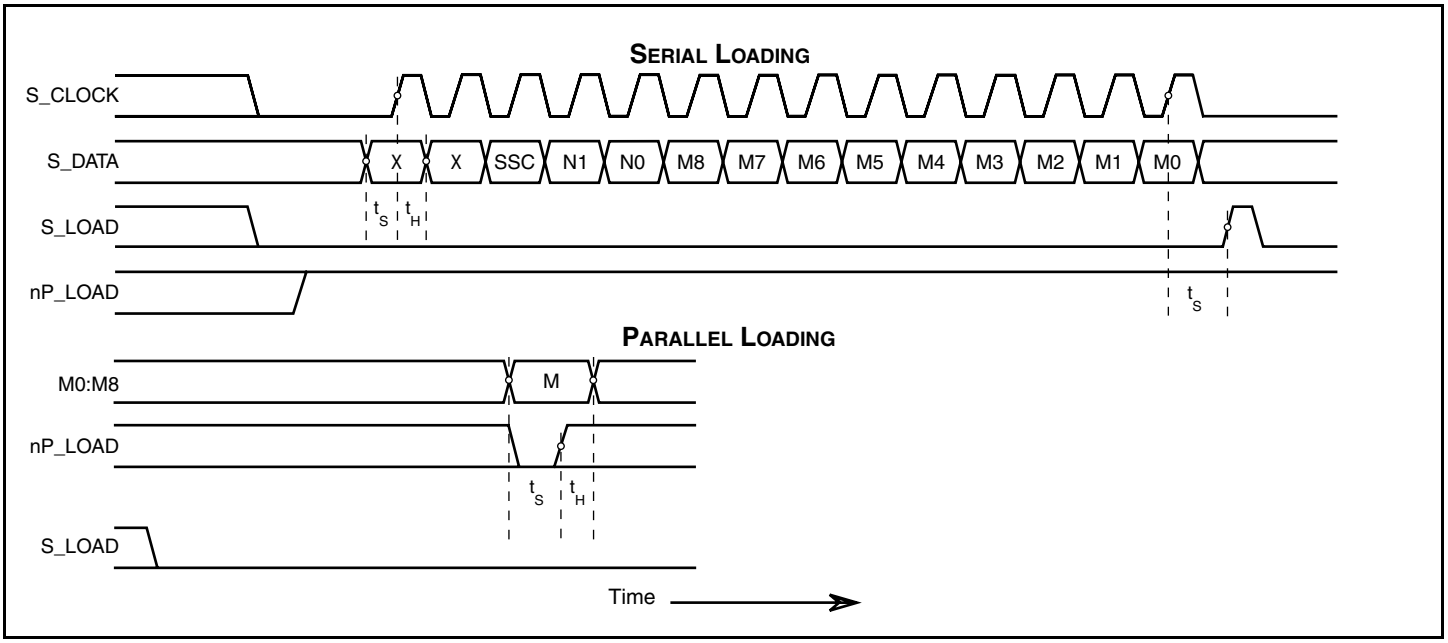


Figure 1. Parallel Load Operations

NOTE: X = Don't Care
N1 and N0 divider settings are only accessible through the serial configuration interface.

Table 1. Pin Descriptions

Number	Name	Type		Description
1, 2, 5, 29, 30, 31	M4, M5, M8 M0, M1, M2	Input	Pulldown	M divider inputs. Data latched on LOW-to-HIGH transition of nP_LOAD input. LVCMOS / LVTTL interface levels.
3, 4, 32	M6, M7, M3	Input	Pullup	
6	V_{EE}	Power		Negative supply pin.
7	V_{CC}	Power		Core supply pin.
8, 17	V_{CCO}	Power		Output supply pins.
9, 10	Q0, nQ0	Output		Differential clock outputs for the synthesizer. LVPECL interface levels.
11, 12	Q1, nQ1	Output		Differential clock outputs for the synthesizer. LVPECL interface levels.
13, 14	Q2, nQ2	Output		Differential clock outputs for the synthesizer. LVPECL interface levels.
15, 16	Q3, nQ3	Output		Differential clock outputs for the synthesizer. LVPECL interface levels.
18	MR	Input	Pulldown	Active High Master Reset. When logic HIGH, the internal dividers are reset causing the true outputs Qx to go low and the inverted outputs nQx to go high. When logic LOW, the internal dividers and the outputs are enabled. Assertion of MR does not affect loaded M values. LVCMOS / LVTTL interface levels.
19	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 / LVTTL interface levels.
20	S_DATA	Input	Pulldown	Shift register serial input. Data sampled on the rising edge of S_CLOCK. LVCMOS / LVTTL interface levels.
21	S_LOAD	Input	Pulldown	Controls transition of data from shift register into the dividers. LVCMOS / LVTTL interface levels.
22	V_{CCA}	Power		Analog supply pin.
23	XTAL_SEL	Input	Pullup	Selects between the crystal oscillator or test clock as the PLL reference source. Selects XTAL inputs when HIGH. Selects TEST_CLK when LOW. LVCMOS / LVTTL interface levels. See Table 3F.
24	TEST_CLK	Input	Pulldown	Single-ended test clock input. LVCMOS / LVTTL interface levels.
25, 26	XTAL_IN, XTAL_OUT	Input		Crystal oscillator interface. XTAL_IN is an oscillator input, XTAL_OUT is an oscillator output.
27	nP_LOAD	Input	Pulldown	Parallel load input. Determines when data present at M8:M0 is loaded into the M divider. LVCMOS / LVTTL interface levels.
28	VCO_SEL	Input	Pullup	Determines whether synthesizer is in PLL or bypass mode. LVCMOS / LVTTL interface levels. See Table 3G.

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

Function Tables

Table 3A. Parallel and Serial Mode Function Table

Inputs						Conditions
MR	nP_LOAD	M	S_LOAD	S_CLOCK	S_DATA	
H	X	X	X	X	X	Reset. Forces Qx outputs LOW, nQx outputs HIGH.
L	L	Data	X	X	X	Data on M inputs passed directly to the M divider.
L	↑	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	L	↑	Data	Serial input mode. Shift register is loaded with data on S_DATA on each rising edge of S_CLOCK.
L	H	X	↑	L	Data	Contents of the shift register are passed to the M divider and N output divider.
L	H	X	↓	L	Data	M divider and N output divider values are latched.
L	H	X	L	X	X	Parallel or serial input does not affect shift registers.
L	H	X	H	↑	Data	S_DATA passed directly to M divider as it is clocked.

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

Table 3B. Programmable VCO Frequency Function Table (NOTE 1)

VCO Frequency (MHz)	M Divide	256	128	64	32	16	8	4	2	1
		M8	M7	M6	M5	M4	M3	M2	M1	M0
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 crystal or TEST_CLK input frequency of 16MHz.

Table 3C. Programmable Output Divider Function Table (Serial Programming Mode Only)

Inputs			Outputs	
			Q[0:3], nQ[0:3]	
N1 Logic	N0 Logic	N Divide	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

Table 3D. N Output Divider Function Table (Serial Load)

N1 Logic Value	N0 Logic Value	N Output Divide
0	0	÷1
0	1	÷2 (Power-up Default)
1	0	÷4
1	1	÷8

Table 3E. SSC Function Table

SSC	SSC State
0	Off (Power-up Default)
1	Enabled

Table 3F. XTAL_SEL Function Table

XTAL_SEL	Operation
0	Selects TEST_CLK as reference frequency input.
1 (default)	Selects the crystal interface (XTAL_IN, XTAL_OUT) as reference frequency input.

Table 3G. VCO_SEL Function Table

VCO_SEL	Operation
0	Reference input signal bypasses the PLL. AC specifications do not apply in PLL bypass mode. The reference input signal is frequency-divided by the output divider
1 (default)	PLL mode (clock synthesis).

Absolute Maximum Ratings

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.

Item	Rating
Supply Voltage, V_{CC}	4.6V
Inputs, V_I	-0.5V to V_{CC}+ 0.5V
Outputs, I_O Continuous Current Surge Current	 50mA 100mA
Package Thermal Impedance, θ_{JA}	65.7°C/W (0 mps)
Storage Temperature, T_{STG}	-65°C to 150°C

DC Electrical Characteristics

Table 4A. Power Supply DC Characteristics, $V_{CC} = V_{CCO} = 3.3V±5\%$, $V_{EE} = 0V$, $T_A = 0°C$ 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} – 0.17	3.3	V_{CC}	V
V_{CCO}	Output Supply Voltage		3.135	3.3	3.465	V
I_{EE}	Power Supply Current				200	mA
I_{CCA}	Analog Supply Current				17	mA

Table 4B. Power Supply DC Characteristics, $V_{CC} = 3.3V±5\%$, $V_{CCO} = 2.5V±5\%$, $V_{EE} = 0V$, $T_A = 0°C$ 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} – 0.17	3.3	V_{CC}	V
V_{CCO}	Output Supply Voltage		2.375	2.5	2.625	V
I_{EE}	Power Supply Current				197	mA
I_{CCA}	Analog Supply Current				17	mA

Table 4C. LVCMOS/LVTTL DC Characteristics, T_A = 0°C to 70°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	TEST_CLOCK, nP_LOAD, S_DATA, S_CLOCK, S_LOAD, M[0:2], M4, M5, M8, MR	V_{CC} = V_{IN} = 3.465V			150	µA
		M3, M6, M7, XTAL_SEL, VCO_SEL	V_{CC} = V_{IN} = 3.465V			5	µA
I_{IL}	Input Low Current	TEST_CLOCK, nP_LOAD, S_DATA, S_CLOCK, S_LOAD, M[0:2], M4, M5, M8, MR	V_{CC} = 3.465V, V_{IN} = 0V	-5			µA
		M3, M6, M7, XTAL_SEL, VCO_SEL	V_{CC} = 3.465V, V_{IN} = 0V	-150			µA

NOTE 1: Characterized with 1ns input edge rate.

Table 4D. LVPECL DC Characteristics, V_{CC} = V_{CCO} = 3.3V±5%, V_{EE} = 0V, T_A = 0°C to 70°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.

Table 4E. LVPECL DC Characteristics, V_{CC} = 3.3V±5%, V_{CCO} = 2.5V±5%, V_{EE} = 0V, T_A = 0°C to 70°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} - 1.5	V
V_{SWING}	Peak-to-Peak Output Voltage Swing		0.4		1.0	V

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

Table 5. Input Characteristics, T_A = 0°C to 70°C

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
f_{IN}	Input Frequency	TEST_CLK; NOTE 1		10		40	MHz
		XTAL_IN, XTAL_OUT; NOTE 1		12		40	MHz
		S_CLOCK				50	MHz
t_R / t_F	Input Rise/Fall Time	TEST_CLK	20% - 80%			5	ns
		S_CLOCK, S_DATA, S_LOAD	20% - 80%		6		ns
		nP_LOAD	20% - 80%			50	ns

For the input crystal and reference 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 167 ≤ M ≤ 466. Using the maximum frequency of 40MHz, valid values of M are 50 ≤ M ≤ 140.

Table 6. Crystal Characteristics

Parameter	Test Conditions	Minimum	Typical	Maximum	Units
Mode of Oscillation		Fundamental			
Frequency		12		40	MHz
Equivalent Series Resistance (ESR)				50	Ω
Shunt Capacitance				7	pF

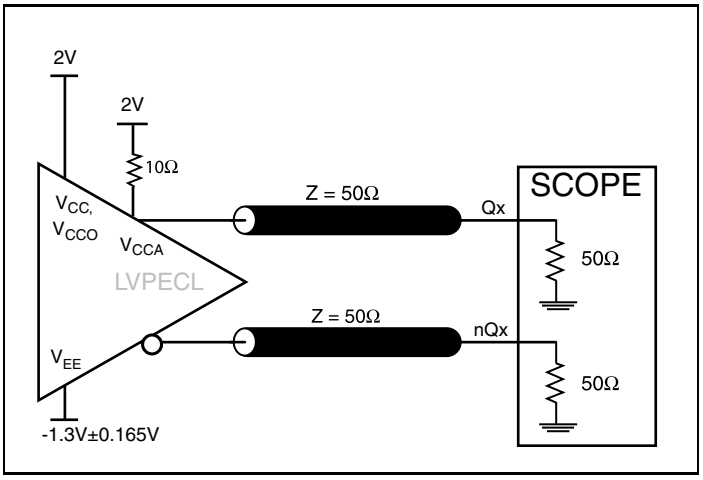
AC Electrical Characteristics

Table 7. AC Characteristics, V_{CC} = 3.3V±5%, V_{CCO} = 3.3V±5% or 2.5V±5%, V_{EE} = 0V, T_A = 0°C to 70°C

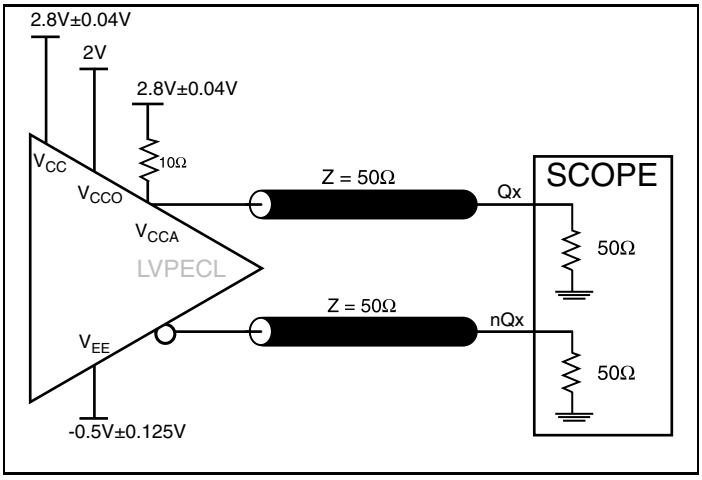
Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
f_{MAX}	Output Frequency Range			31.25		700	MHz
*t*jit(cc)	Cycle-to-Cycle Jitter; NOTE 1, 3		N ≠ ÷1			45	ps
			N = ÷1			60	ps
*t*jit(per)	Period Jitter, RMS; NOTE 1		N ≠ ÷1			6	ps
*t*sk(o)	Output Skew; NOTE 2, 3					40	ps
t_R / t_F	Output Rise/Fall Time		20% to 80%	200		700	ps
t_S	Setup Time	nP_LOAD to M		5			ns
		S_DATA to S_CLOCK		5			ns
		S_CLOCK to S_LOAD		5			ns
t_H	Hold Time	nP_LOAD to M		5			ns
		S_DATA to S_CLOCK		5			ns
		S_CLOCK to S_LOAD		5			ns
F_M	SSC Modulation Frequency; NOTE 4			30		33.33	kHz
F_{MF}	SSC Modulation Factor; NOTE 4				-0.6	-0.8	%
SSC_{RED}	Spectral Reduction; NOTE 4			7	10		dB
odc	Output Duty Cycle		N ≠ ÷1	47		53	%
t_{LOCK}	PLL Lock Time		from Power-up			20	ms
$t_{RE\text{-}LOCK}$	PLL Re-Lock Time; NOTE 5					1	ms

NOTE: Electrical parameters are guaranteed over the specified ambient operating temperature range, which is established when the device is mounted in a test socket with maintained transverse airflow greater than 500 lfpm. The device will meet specifications after thermal equilibrium has been reached under these conditions.
See Parameter Measurement Information section.
NOTE 1: Jitter performance using crystal inputs.
NOTE 2: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured from the output differential cross points.
NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.
NOTE 4: Spread Spectrum clocking enabled. XTAL = 20MHz, f_{OUT} = 100MHz, M = 160, N = 4.
NOTE 5: PLL Lock Time when changing M Divider through serial or parallel programming.

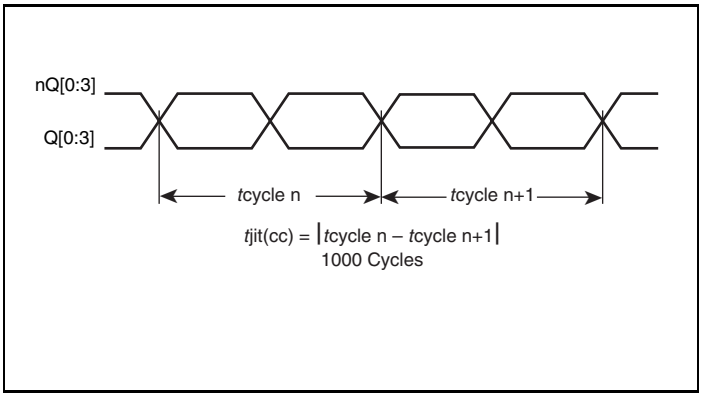
Parameter Measurement Information



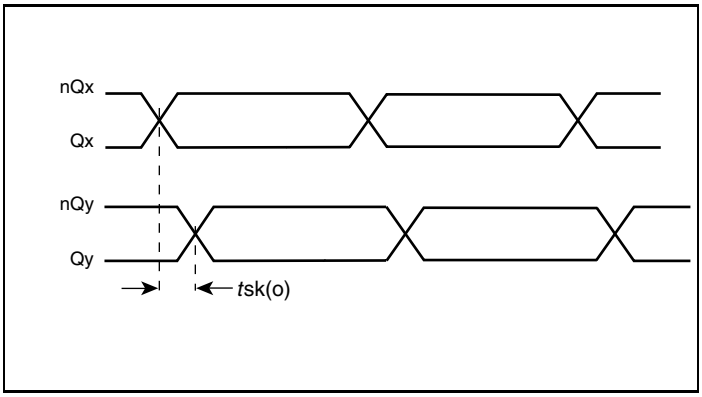
3.3 Core/3.3V LVPECL Output Load AC Test Circuit



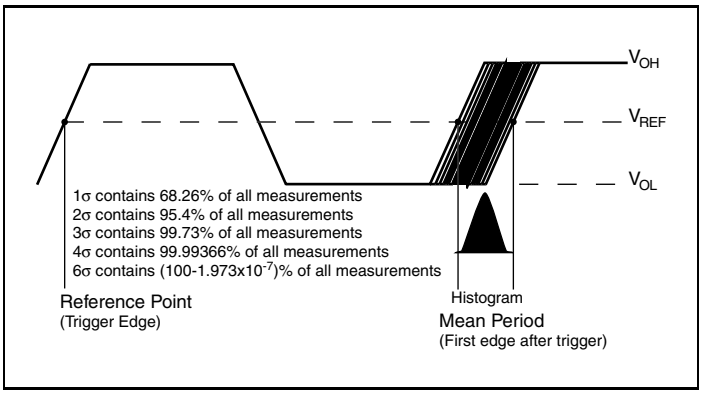
3.3 Core/2.5V LVPECL Output Load AC Test Circuit



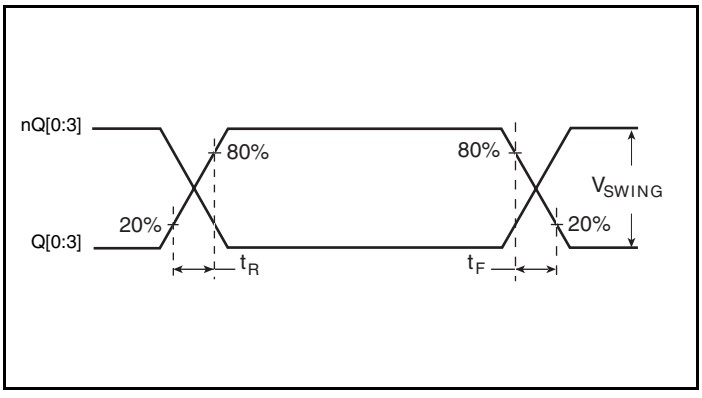
Cycle-to-Cycle Jitter



Output Skew

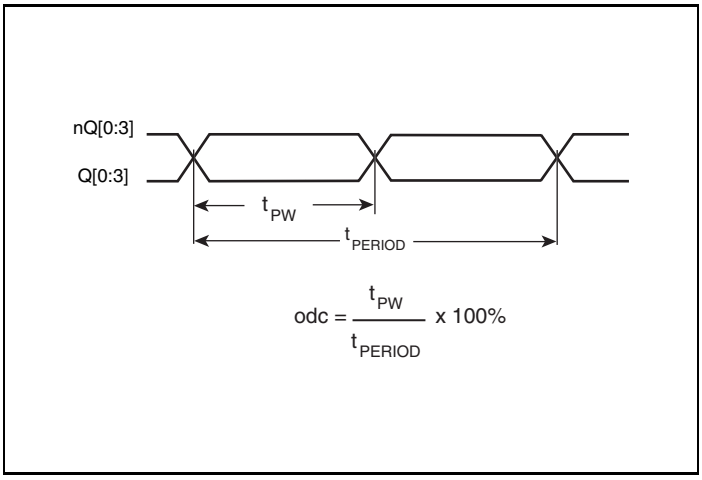


Period Jitter



Output Rise/Fall Time

Parameter Measurement Information, continued



Output Duty Cycle Pulse Width/Period

Application Information

Recommendations for Unused Input and Output Pins

Inputs:

LVCMOS Control Pins

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

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.

TEST_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 TEST_CLK to ground.

Outputs:

LVPECL Outputs

The unused LVPECL output pair 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.

Power Supply Filtering Technique

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 ICS84314-02 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 0.01µF 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 10µF bypass capacitor be connected to the V_{CCA} pin.

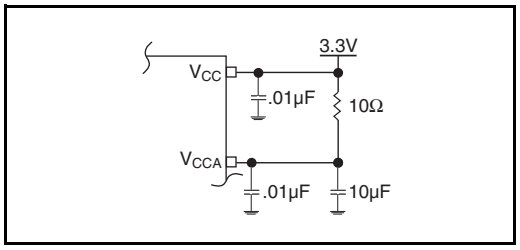


Figure 2. Power Supply Filtering

Crystal Input Interface

The ICS84314-02 has been characterized with 18pF parallel resonant crystals. The capacitor values, C1 and C2, shown in *Figure 3* below were determined using an 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.

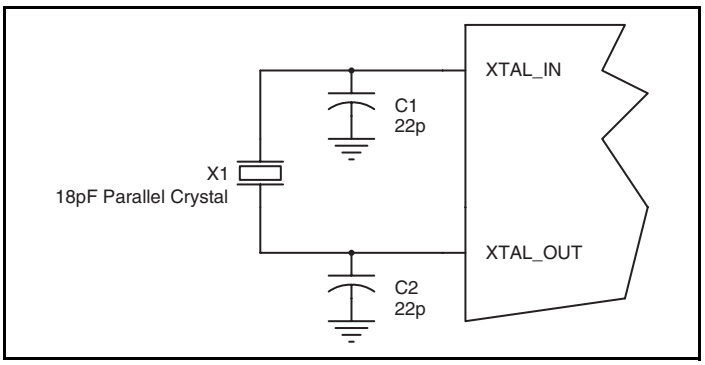


Figure 3. Crystal Input Interface

LVCMOS to XTAL Interface

The XTAL_IN input can accept a single-ended LVCMOS signal through an AC coupling capacitor. A general interface diagram is shown in *Figure 4.* The XTAL_OUT pin can be left floating. The input edge rate can be as slow as 10ns. For LVCMOS signals, it is recommended that the amplitude be reduced from full swing to half swing in order to prevent signal interference with the power rail and to reduce noise. This configuration requires that the output impedance of the driver (Ro) plus the series resistance (Rs) equals the transmission line impedance. In addition, matched termination at the crystal input will attenuate the signal in half. This can be done in one of two ways. First, R1 and R2 in parallel should equal the transmission line impedance. For most 50Ω applications, R1 and R2 can be 100Ω. This can also be accomplished by removing R1 and making R2 50Ω.

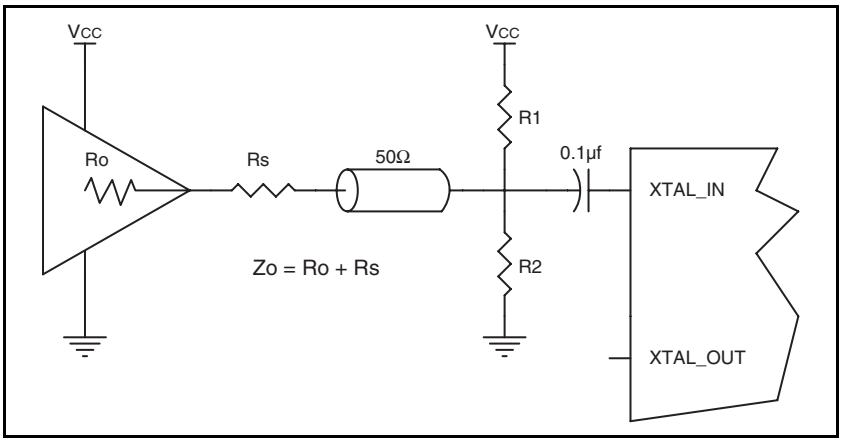


Figure 4. General Diagram for LVCMOS Driver to XTAL Input Interface

Spread Spectrum

Spread-spectrum clocking is a frequency modulation technique for EMI reduction. When spread-spectrum is enabled, a 30kHz triangle waveform is used with 0.6% down-spread (+0.0% / -0.6%) from the nominal 100MHz clock frequency. An example of a triangle frequency modulation profile is shown in *Figure 5A* below. The ramp profile can be expressed as:

The ICS84314-02 triangle modulation frequency deviation will not exceed 0.8% down-spread from the nominal clock frequency (+0.0% / -0.6%). An example of the amount of down spread relative to the nominal clock frequency can be seen in the frequency domain, as shown in *Figure 5B*. The ratio of this width to the fundamental frequency is typically 0.6%, and will not exceed 0.8%. The resulting spectral reduction will be greater than 7dB, as shown in Figure 5B. It is important to note the ICS84314-02 7dB minimum spectral reduction is the component-specific EMI reduction, and will not necessarily be the same as the system EMI reduction.

Fnom = Nominal Clock Frequency in Spread Off mode (100MHz with 20MHz IN)

Fm = Nominal Modulation Frequency (30kHz)

δ = Modulation Factor (0.6% down spread)

$$(1-\delta)Fnom + 2fm \times \delta \times Fnom \times t \text{ when } 0 < t < \frac{1}{2fm},$$

$$(1-\delta)Fnom - 2fm \times \delta \times Fnom \times t \text{ when } \frac{1}{2fm} < t < \frac{1}{fm}$$

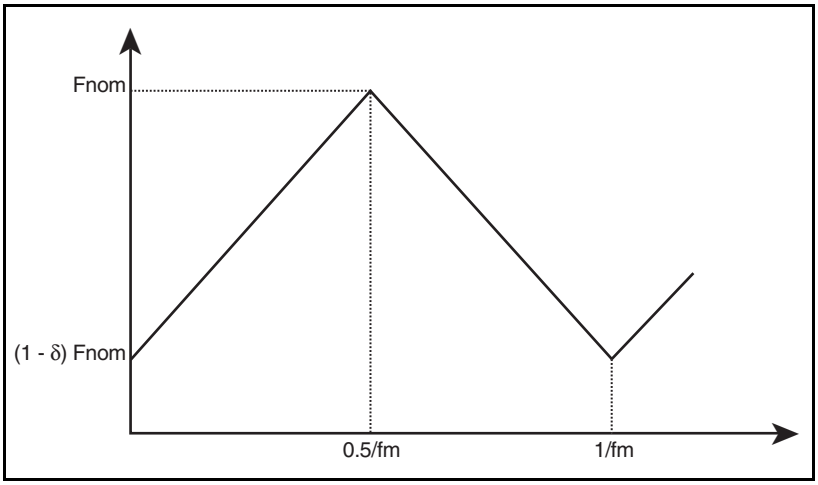


Figure 5A. Triangle Frequency Modulation

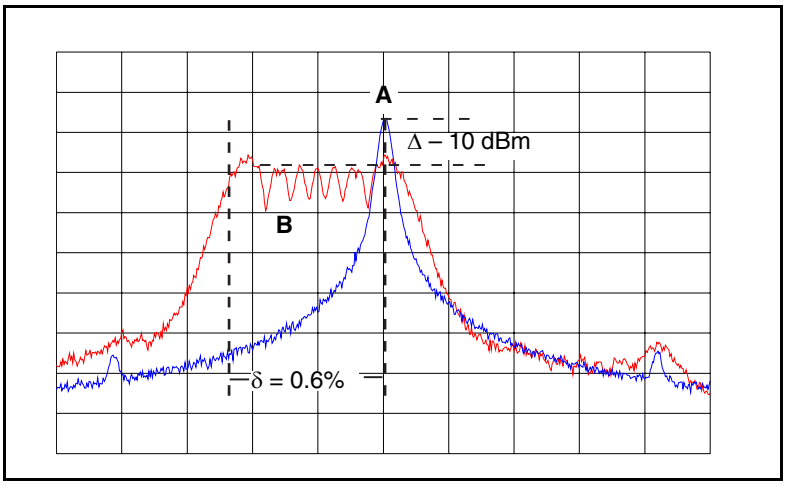


Figure 5B. 100MHz Clock Output In Frequency Domain
(A) Spread-Spectrum OFF
(B) Spread-Spectrum ON

Termination for 3.3V 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 6A and 6B* 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.

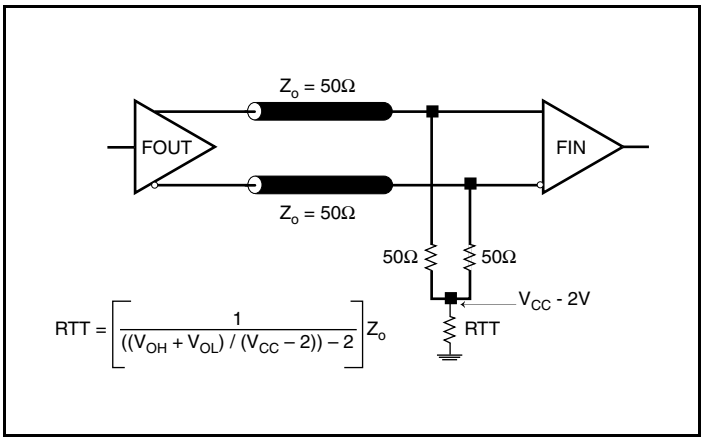


Figure 6A. 3.3V LVPECL Output Termination

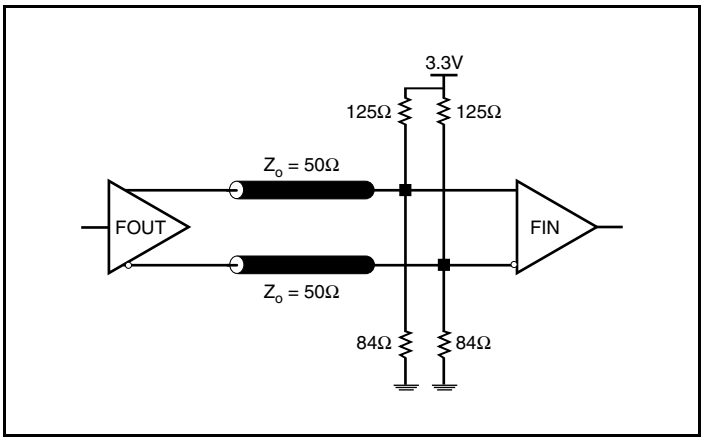


Figure 6B. 3.3V LVPECL Output Termination

Termination for 2.5V LVPECL Outputs

Figure 7A and *Figure 7B* show examples of termination for 2.5V LVPECL driver. These terminations are equivalent to terminating 50Ω to V_{CC} – 2V. For V_{CCO} = 2.5V, the V_{CCO} – 2V is very close to ground level. The R3 in Figure 7B can be eliminated and the termination is shown in *Figure 7C.*

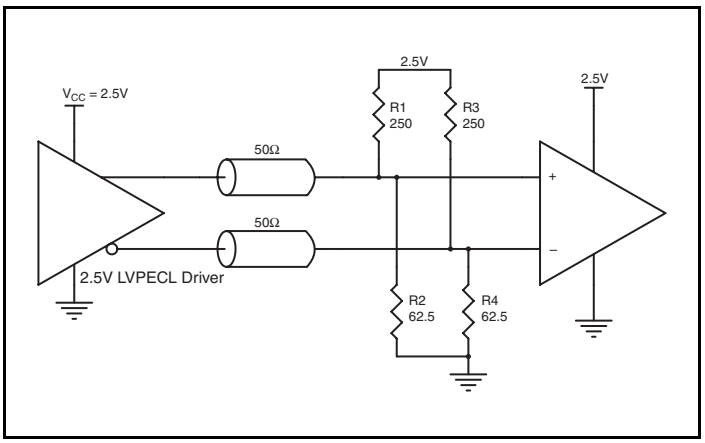


Figure 7A. 2.5V LVPECL Driver Termination Example

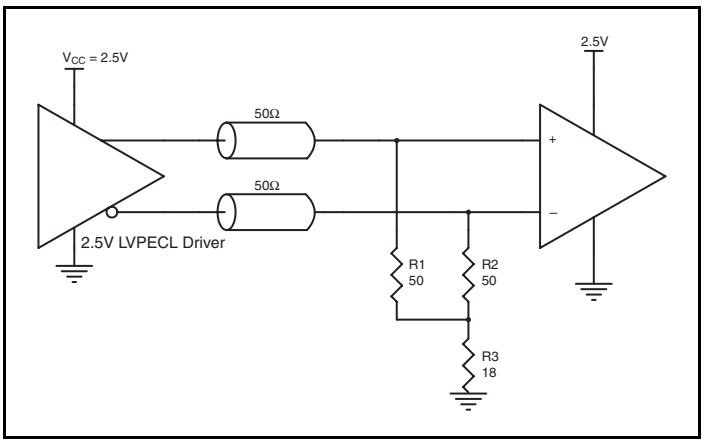


Figure 7B. 2.5V LVPECL Driver Termination Example

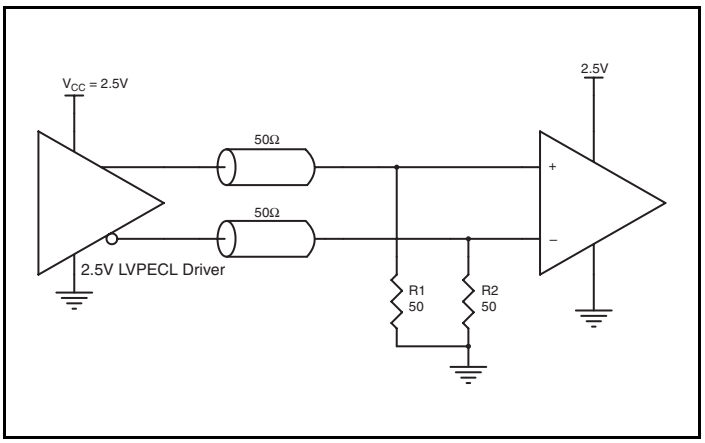


Figure 7C. 2.5V LVPECL Driver Termination Example

Layout Guideline

The schematic of the ICS84314-02 layout example used in this layout guideline is shown in *Figure 8A*. The ICS84314-02 recommended PCB board layout for this example is shown in *Figure 8B.* 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.

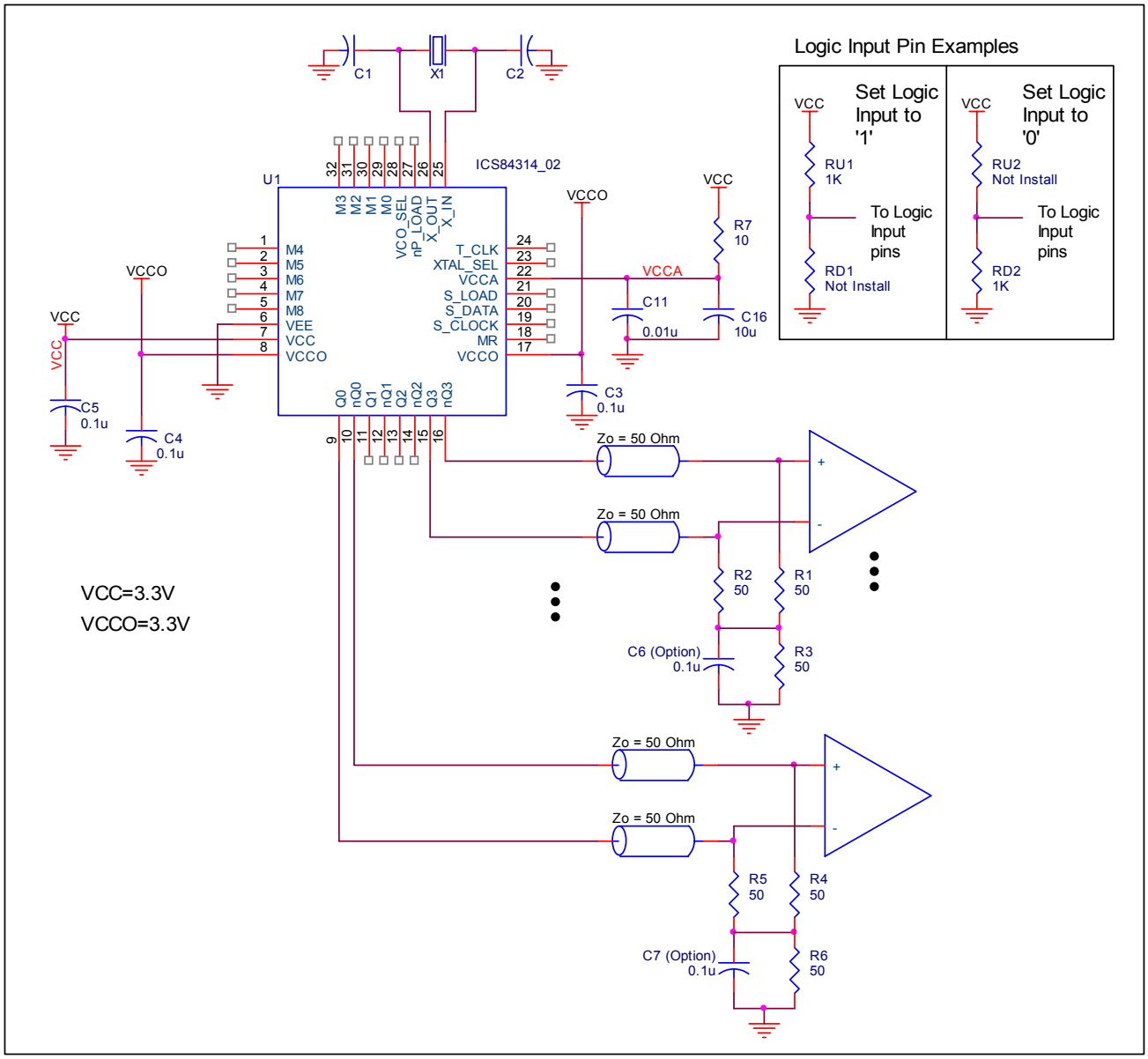


Figure 8A. ICS84314-02 Schematic of Recommended Layout

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, 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_{CCA} shares the same power supply with V_{CC}, insert the RC filter R7, C11, and C16 in between. Place this RC filter as close to the V_{CCA} 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 the 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 traces are routed between the clock trace pair.

The matching termination resistors R1, R2, R3 and R4 should be located as close to the receiver input pins as possible. Other termination schemes can also be used but are not shown in this example.

Crystal

The crystal X1 should be located as close as possible to the pins 25 (XTAL_IN) and 26 (XTAL_OUT). 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.

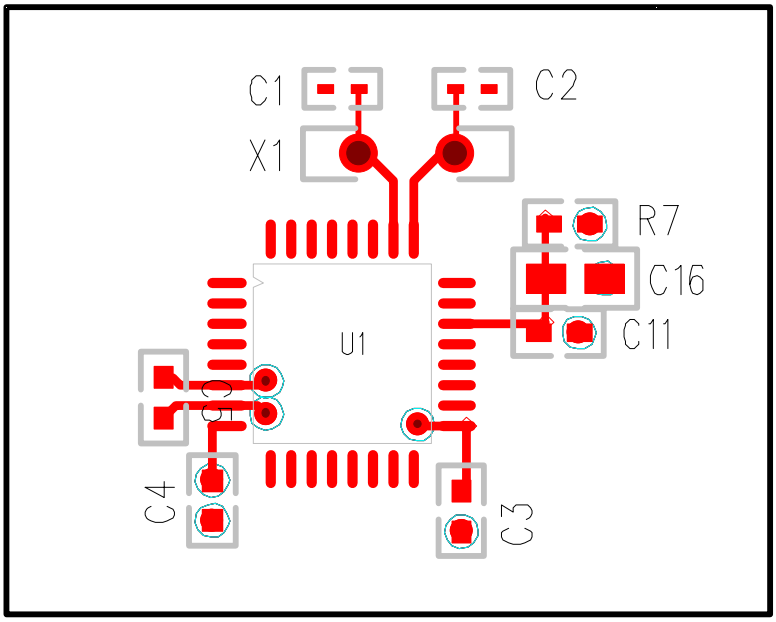


Figure 8B. PCB Board Layout for ICS84314-02

Power Considerations

This section provides information on power dissipation and junction temperature for the ICS84314-02.
Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the ICS84314-02 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 * 200mA = **693mW**
- Power $(outputs)_{MAX}$ = **30mW/Loaded Output Pair**
  If all outputs are loaded, the total power is 4 * 30mW = **120mW**

  Total Power$_{\_MAX}$ (3.465V, with all outputs switching) = 693mW + 120mW = **813mW**

2. Junction Temperature.

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

The equation for Tj is as follows: $Tj = \theta_{JA} * Pd\_total + T_A$

Tj = Junction Temperature

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

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

T_A = Ambient Temperature

In order to calculate junction temperature, the appropriate junction-to-ambient thermal resistance θ_{JA} must be used. Assuming no air flow and a multi-layer board, the appropriate value is 65.7°C/W per Table 8 below.

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

70°C + 0.813W * 65.7°C/W = 123.4°C. This is below the limit of 125°C.

This calculation is only an example. Tj will obviously vary depending on the number of loaded outputs, supply voltage, air flow and the type of board (multi-layer).

Table 8. Thermal Resistance θ_{JA} for 32 Lead LQFP, Forced Convection

θ_{JA} **by Velocity**			
Meters per Second	**0**	**1**	**2.5**
Multi-Layer PCB, JEDEC Standard Test Boards	65.7°C/W	55.9°C/W	52.4°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 9.*

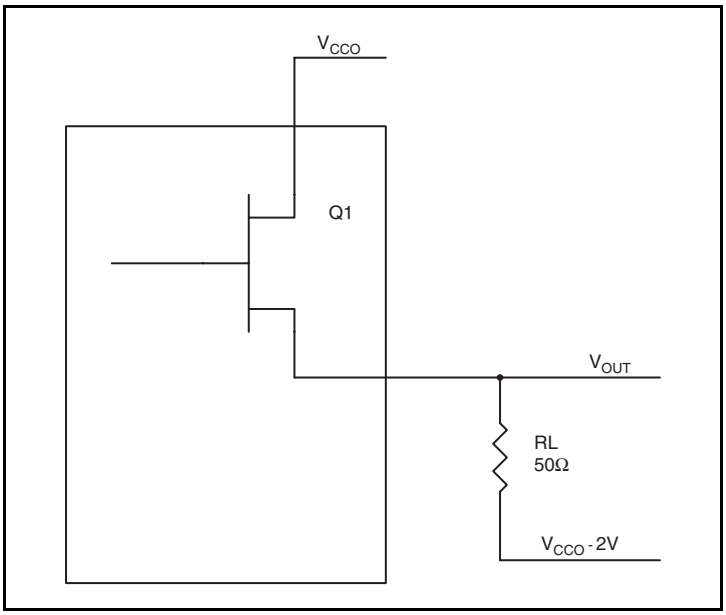


Figure 9. LVPECL Driver Circuit and Termination

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

- For logic high, $V_{OUT} = V_{OH\_MAX} =$ **V_{CCO_MAX} -0.9V**
  ($V_{CC\_MAX} - V_{OH\_MAX}$) = **0.9V**
- For logic low, $V_{OUT} = V_{OL\_MAX} =$ **V_{CCO_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.

$Pd\_H = [(V_{OH\_MAX} - (V_{CCO\_MAX} - 2V))/R_L] * (V_{CCO\_MAX} - V_{OH\_MAX}) = [(2V - (V_{CCO\_MAX} - V_{OH\_MAX}))/R_L] * (V_{CCO\_MAX} - V_{OH\_MAX}) =$
$[(2V - 0.9V)/50\Omega] * 0.9V =$ **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 9. θ_{JA} vs. Air Flow Table for a 32 Lead LQFP

θ_{JA} vs. Air Flow			
Meters per Second	**0**	**1**	**2.5**
Multi-Layer PCB, JEDEC Standard Test Boards	65.7°C/W	55.9°C/W	52.4°C/W

Transistor Count

The transistor count for ICS84314-02 is: 5051

Package Outline and Dimensions

Package Outline - Y Suffix for 32 Lead LQFP

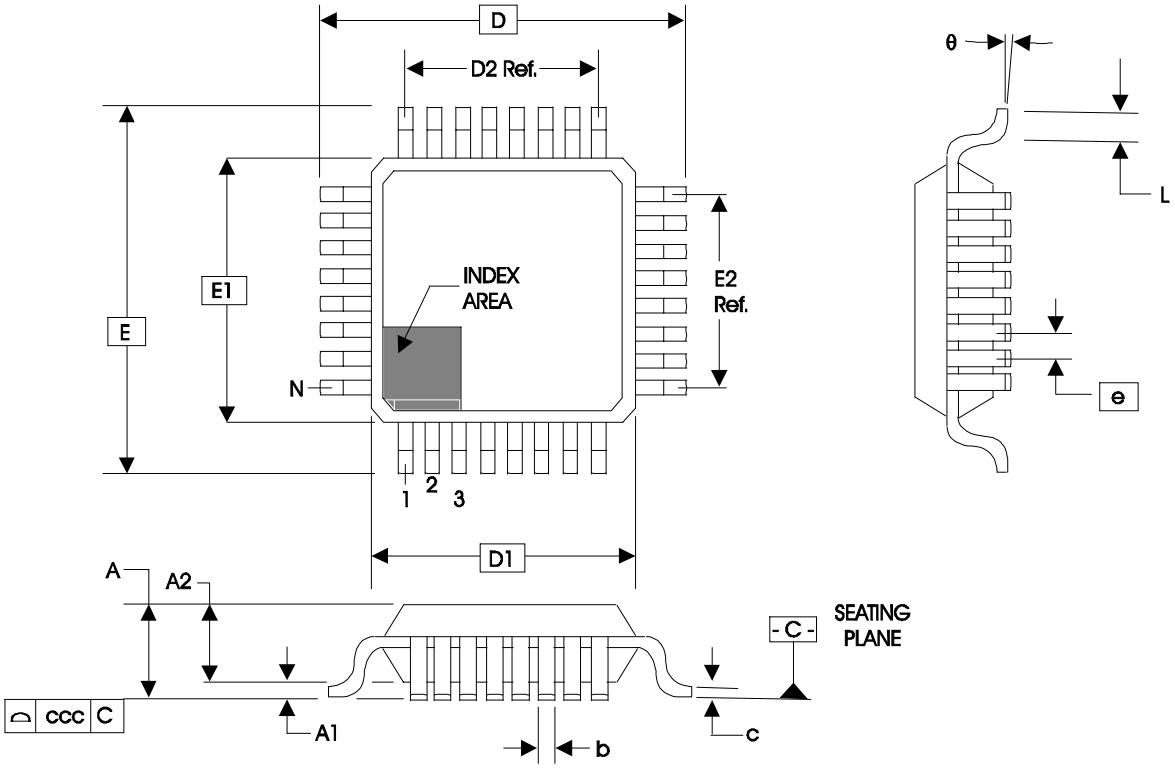


Table 10. Package Dimensions for 32 Lead LQFP

JEDEC Variation: BBA All Dimensions in Millimeters			
Symbol	**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 & E		9.00 Basic	
D1 & E1		7.00 Basic	
D2 & 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

Ordering Information

Table 11. Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
84314AY-02	ICS84314AY02	32 Lead LQFP	Tray	0°C to 70°C
84314AY-02T	ICS84314AY02	32 Lead LQFP	1000 Tape & Reel	0°C to 70°C
84314AY-02LF	ICS84314A02L	“Lead-Free” 32 Lead LQFP	Tray	0°C to 70°C
84314AY-02LFT	ICS84314A02L	“Lead-Free” 32 Lead LQFP	1000 Tape & Reel	0°C to 70°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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