VCXO Jitter Attenuator & FemtoClock™ Multiplier

ICS813323

DATA SHEET

General Description

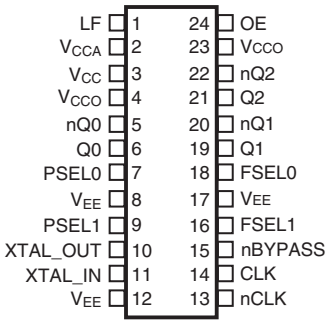
The ICS813323 is a PLL based synchronous multiplier that is optimized for SONET clock jitter attenuation and frequency translation. The device contains two internal frequency multiplication stages which are cascaded in series. The first stage is a VCXO PLL that is optimized to provide reference clock jitter attenuation. The second stage is a FemtoClock™ frequency multiplier that provides a low jitter, high frequency SONET output clock.

Pre-divider and output divider multiplication ratios are selected using device selection control pins. The multiplication ratios are optimized to support most common clock rates used in SONET applications. The VCXO requires the use of an external, inexpensive pullable crystal. The VCXO uses external passive loop filter components which allows configuration of the PLL loop bandwidth and damping characteristics.

Features

- Three differential LVPECL output pairs
- One differential input supports the following input types: LVPECL, LVDS, LVHSTL, SSTL, HCSL
- Accepts input frequencies from 19.44MHz to 622.08MHz, including: 77.76MHz and 155.52MHz input clocks
- Attenuates the phase jitter of the input clock by using a low-cost pullable fundamental mode VCXO crystal
- Outputs common SONET clock rates
- VCXO PLL bandwidth can be optimized for jitter attenuation and reference tracking using external loop filter connection
- Absolute pull range: ±50ppm
- FemtoClock frequency multiplier provides low jitter, high frequency output
- FemtoClock frequency: 622.08MHz
- RMS phase jitter @ 155.52MHz, using a 19.44MHz crystal (12kHz – 20MHz): 1.4ps (typical)
- Full 3.3V supply, or mixed 3.3V core/2.5V output supply
- 0°C to 70°C ambient operating temperature
- Available in lead-free (RoHS 6) package

Pin Assignment



ICS813323
24 Lead TSSOP
4.4mm x 7.8mm x 0.925mm package body
G Package
Top View

Block Diagram

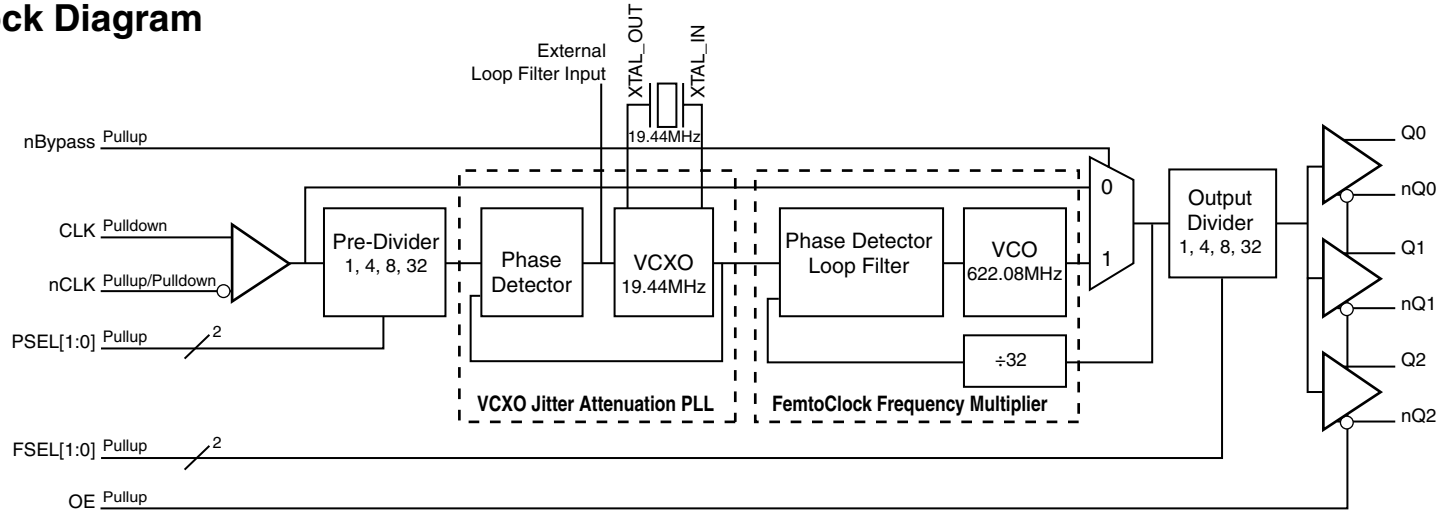


Table 1. Pin Descriptions

Number	Name	Type		Description
1	LF	Analog Input/Output		Loop filter connection node pin.
2	V_{CCA}	Power		Analog supply pin.
3	V_{CC}	Power		Core supply pin.
4, 23	V_{CCO}	Power		Output power supply pins.
5, 6 19, 20 21, 22	nQ0, Q0 Q1, nQ1 Q2, nQ2	Output		Differential clock outputs. LVPECL interface levels.
7, 9	PSEL0, PSEL1	Input	Pullup	Pre-divider select pins. LVCMOS/LVTTL interface levels. See Table 3A.
8, 12, 17	V_{EE}	Power		Negative supply pins.
10, 11	XTAL_OUT, XTAL_IN	Input		VCXO crystal oscillator interface. XTAL_IN is the input. XTAL_OUT is the output.
13	nCLK	Input	Pullup/ Pulldown	Inverting differential clock input. V_{CC}/2 bias voltage when left floating.
14	CLK	Input	Pulldown	Non-inverting differential clock input.
15	nBypass	Input	Pullup	PLL Bypass control pin. See Table 3D.
16, 18	FSEL1, FSEL0	Input	Pullup	Select pins. See Table 3B.
24	OE	Input	Pullup	Output enable. When logic LOW, the clock outputs are in High-Impedance. When logic HIGH, the clock outputs are enabled. LVCMOS/LVTTL interface levels. See Table 3C.

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. Pre-Divider Selection Function Table

Inputs		Pre-Divider Value
PSEL1	PSEL0	
0	0	÷1
0	1	÷4
1	0	÷8
1	1	÷32 (default)

Table 3B. FSEL Function Table

Inputs		Output Divider Value
FSEL1	FSEL0	
0	0	÷1
0	1	÷4
1	0	÷8
1	1	÷32 (default)

Table 3C. OE Function Table

Input	Clock Outputs	
OE	**Q[0:2]**	**nQ[0:2]**
0	LOW	HIGH
1	Enabled	Enabled

Table 3D. Bypass Function Table

nBypass Input	Operation
0	VCXO jitter attenuation PLL and FemtoClock multiplier bypassed. Input passed directly to N divider.
1 (default)	Normal operation mode.

Table 3E. Frequency Function Table

Input Frequency (MHz)	Input Divider	VCXO Crystal Frequency (MHz)	FemtoClock Feedback Divider	FemtoClock VCO Frequency (MHz)	Output Divider Value	Output Frequency (MHz)
19.44	÷1	19.44	32	622.08	÷1	622.08
19.44	÷1	19.44	32	622.08	÷4	155.52
19.44	÷1	19.44	32	622.08	÷8	77.76
19.44	÷1	19.44	32	622.08	÷32	19.44
77.76	÷4	19.44	32	622.08	÷1	622.08
77.76	÷4	19.44	32	622.08	÷4	155.52
77.76	÷4	19.44	32	622.08	÷8	77.76
77.76	÷4	19.44	32	622.08	÷32	19.44
155.52	÷8	19.44	32	622.08	÷1	622.08
155.52	÷8	19.44	32	622.08	÷4	155.52
155.52	÷8	19.44	32	622.08	÷8	77.76
155.52	÷8	19.44	32	622.08	÷32	19.44
622.08	÷32	19.44	32	622.08	÷1	622.08
622.08	÷32	19.44	32	622.08	÷4	155.52
622.08	÷32	19.44	32	622.08	÷8	77.76
622.08	÷32	19.44	32	622.08	÷32	19.44

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}	82.3°C/W (0 mps)
Storage Temperature, T_{STG}	-65°C to 150°C

DC Electrical Characteristics

Table 4A. LVPECL Power Supply DC Characteristics, $V_{CC} = V_{CCO} = 3.3V \pm 5\%$, $V_{EE} = 0V$, $T_A = 0°C$ 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} – 0.15	3.3	V_{CC}	V
V_{CCO}	Output Supply Voltage		3.135	3.3	3.465	V
I_{EE}	Power Supply Current				130	mA
I_{CCA}	Analog Supply Current				15	mA

Table 4B. LVPECL Power Supply DC Characteristics, $V_{CC} = 3.3V \pm 5\%$, $V_{CCO} = 2.5V \pm 5\%$, $V_{EE} = 0V$, $T_A = 0°C$ 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} – 0.15	3.3	V_{CC}	V
V_{CCO}	Output Supply Voltage		2.375	2.5	2.625	V
I_{EE}	Power Supply Current				130	mA
I_{CCA}	Analog Supply Current				15	mA

Table 4C. LVCMOS/LVTTL DC Characteristics, $V_{CC} = 3.3V \pm 5\%$, $T_A = 0°C$ 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	OE, PSEL[0:1], nBypass, FSEL[0:1]	$V_{CC} = V_{IN} = 3.465V$			5	µA
I_{IL}	Input Low Current	OE, PSEL[0:1], nBypass, FSEL[0:1]	$V_{CC} = 3.465$, $V_{IN} = 0V$	-150			µA

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

Symbol	Parameter		Test Conditions	Minimum	Typical	Maximum	Units
I_{IH}	Input High Current	CLK, nCLK	$V_{CC} = V_{IN}$ = 3.465V			150	µA
I_{IL}	Input Low Current	nCLK	V_{CC} = 3.465V, V_{IN} = 0V	-150			µA
		CLK	V_{CC} = 3.465V, V_{IN} = 0V	-5			µA
V_{PP}	Peak-to-Peak Input Voltage			0.15		1.3	V
V_{CMR}	Common Mode Input Voltage; NOTE 1			V_{EE} + 0.5		V_{CC} – 0.85	V

NOTE 1. Common mode voltage is defined as V_{IH}.

Table 4E. 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 Current; NOTE 1		V_{CCO} – 1.4		V_{CCO} – 0.9	µA
V_{OL}	Output Low Current; NOTE 1		V_{CCO} – 2.0		V_{CCO} – 1.7	µA
V_{SWING}	Peak-to-Peak Output Voltage Swing		0.6		1.0	V

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

Table 4F. 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 Current; NOTE 1		V_{CCO} – 1.4		V_{CCO} – 0.9	µA
V_{OL}	Output Low Current; NOTE 1		V_{CCO} – 2.0		V_{CCO} – 1.5	µA
V_{SWING}	Peak-to-Peak Output Voltage Swing		0.4		1.0	V

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

AC Electrical Characteristics

Table 5A. AC Characteristics, $V_{CC} = V_{CCO} = 3.3V \pm 5\%$, $V_{EE} = 0V$, $T_A = 0°C$ to $70°C$

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
f_{IN}	Input Frequency	PSEL = ÷1		19.44		MHz
		PSEL = ÷4		77.76		MHz
		PSEL = ÷8		155.52		MHz
		PSEL = ÷32		622.08		MHz
f_{OUT}	Output Frequency	FSEL = ÷1		622.08		MHz
		FSEL = ÷4		155.52		MHz
		FSEL = ÷8		77.76		MHz
		FSEL = ÷32		19.44		MHz
*t*jit(Ø)	RMS Phase Jitter, (Random), NOTE 1	155.52MHz f_{OUT}, 19.44MHz crystal, Integration Range: 12kHz – 20MHz		1.4	2	ps
*t*jit(per)	Period Jitter, RMS; NOTE 2			3.6	6.3	ps
*t*sk(o)	Output Skew; NOTE 3, 4				50	ps
t_R / t_F	Output Rise/Fall Time	20% to 80%	240		780	ps
odc	Output Duty Cycle		45		55	%
t_{LOCK}	VCXO & FemtoClock PLL Lock Time; NOTE 5	Reference Clock Input is ±50ppm from Nominal Frequency			70	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.
NOTE: Characterized with outputs at the same frequency using the loop filter components for the mid loop badwidth. Refer to *VCXO-PLL Loop Bandwidth Selection Table.*
NOTE 1: Refer to the Phase Noise Plot.
NOTE 2: Jitter performance using crystal inputs.
NOTE 3: This parameter is defined in accordance with JEDEC Standard 65.
NOTE 4: Defined as skew between outputs at the same supply voltage and with equal load conditions. Measured at the output differential cross points.
NOTE 5: Lock Time measured from power-up to stable output frequency.

Table 5B. AC 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
f_{IN}	Input Frequency	PSEL = ÷1		19.44		MHz
		PSEL = ÷4		77.76		MHz
		PSEL = ÷8		155.52		MHz
		PSEL = ÷32		622.08		MHz
f_{OUT}	Output Frequency	FSEL = ÷1		622.08		MHz
		FSEL = ÷4		155.52		MHz
		FSEL = ÷8		77.76		MHz
		FSEL = ÷32		19.44		MHz
*t*jit(Ø)	RMS Phase Jitter, (Random), NOTE 1	155.52MHz f_{OUT}, 19.44MHz crystal, Integration Range: 12kHz – 20MHz		1.4	2	ps
*t*jit(per)	Period Jitter, RMS; NOTE 2			3.3	5.5	ps
*t*sk(o)	Output Skew; NOTE 3, 4				50	ps
t_R / t_F	Output Rise/Fall Time	20% to 80%	240		780	ps
odc	Output Duty Cycle		45		55	%
t_{LOCK}	VCXO & FemtoClock PLL Lock Time; NOTE 5	Reference Clock Input is ±50ppm from Nominal Frequency			70	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.
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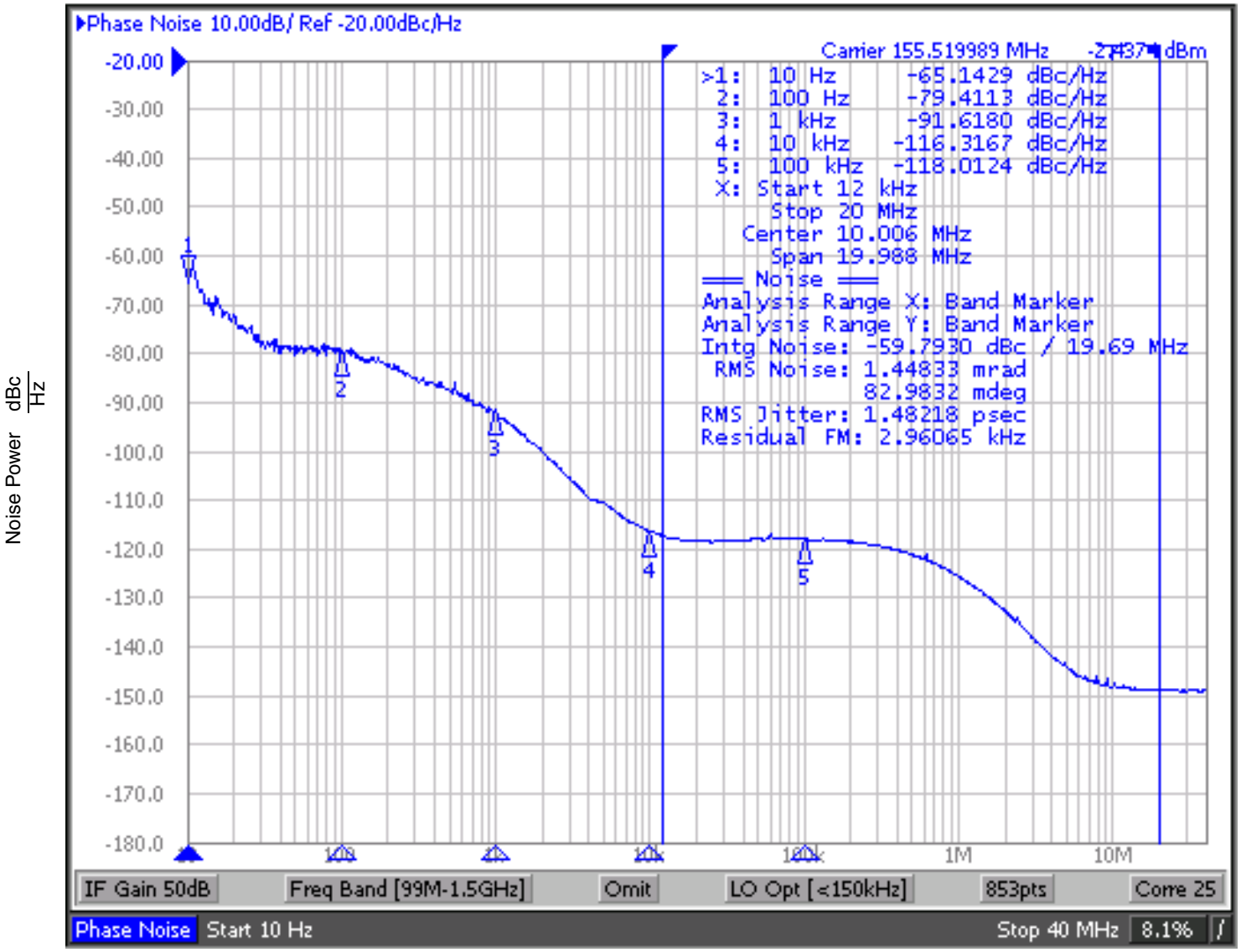
NOTE 5: Lock Time measured from power-up to stable output frequency.

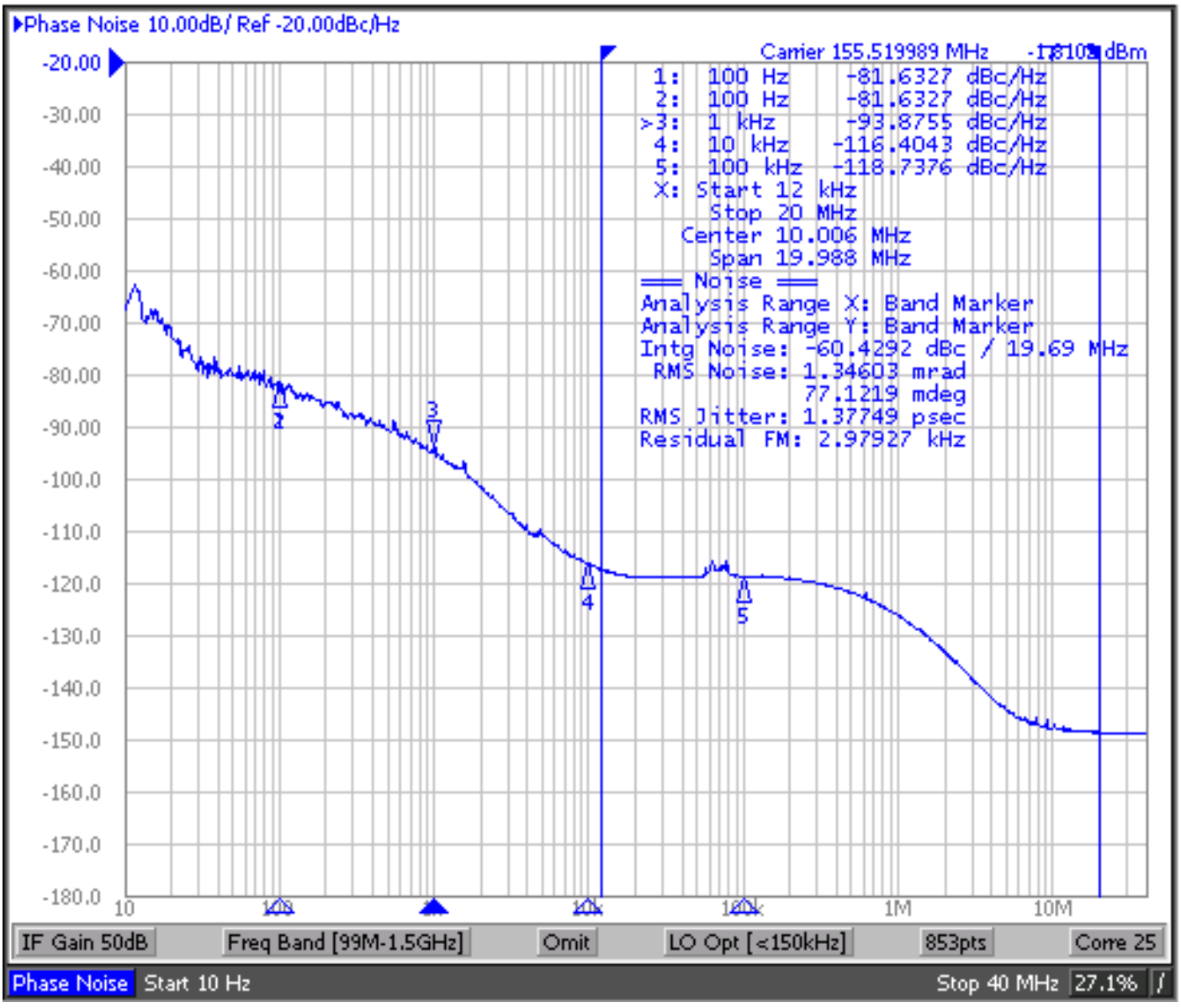
Typical Phase Noise at 155.52MHz @ 3.3V



Noise Power $\frac{dBc}{Hz}$

Offset Frequency (Hz)

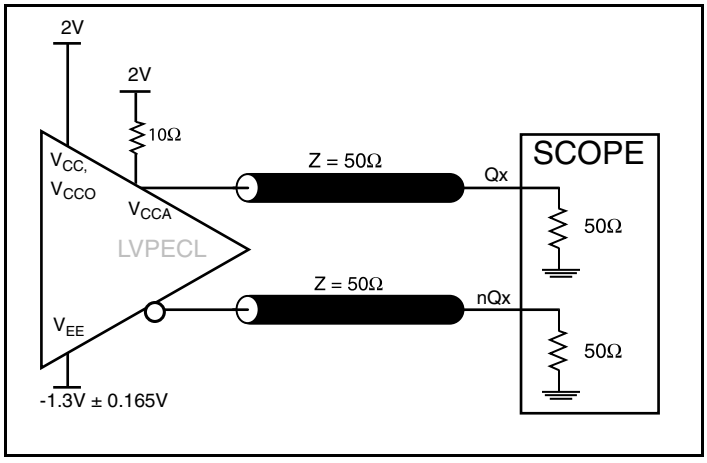
Typical Phase Noise at 155.52MHz @ 3.3V Core/2.5V Output



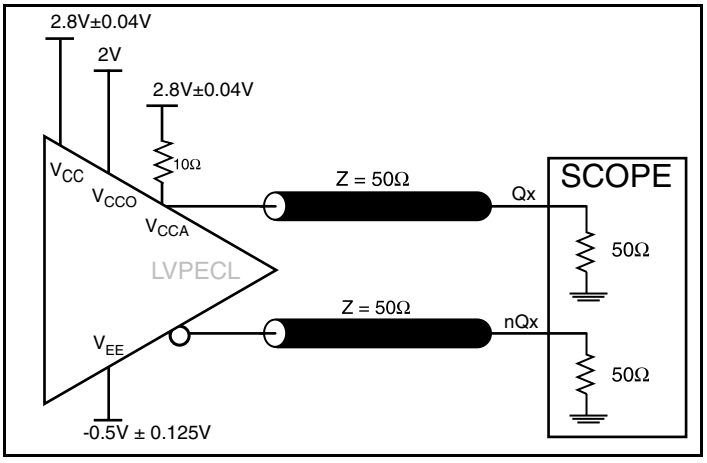
Noise Power $\frac{dBc}{Hz}$

Offset Frequency (Hz)

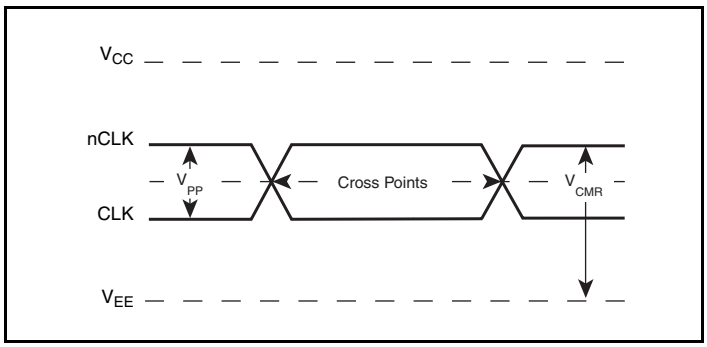
Parameter Measurement Information



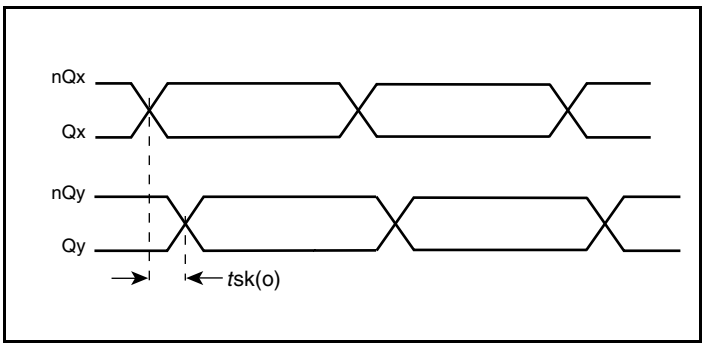
3.3V Core/3.3V LVPECL Output Load AC Test Circuit



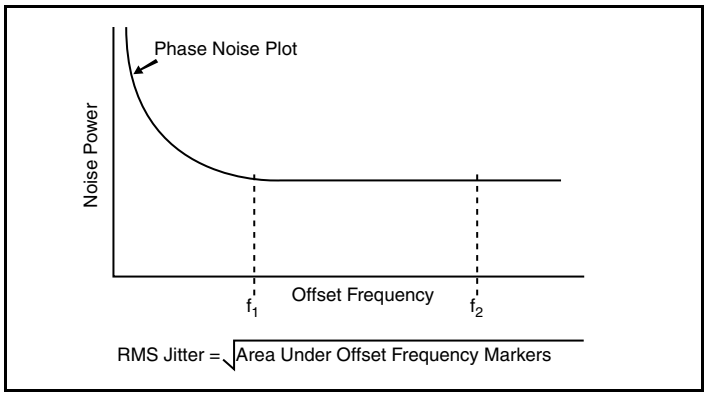
3.3V Core/2.5V LVPECL Output Load AC Test Circuit



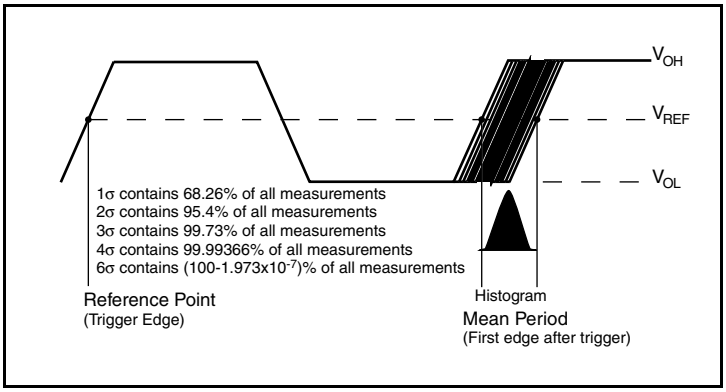
Differential Input Level



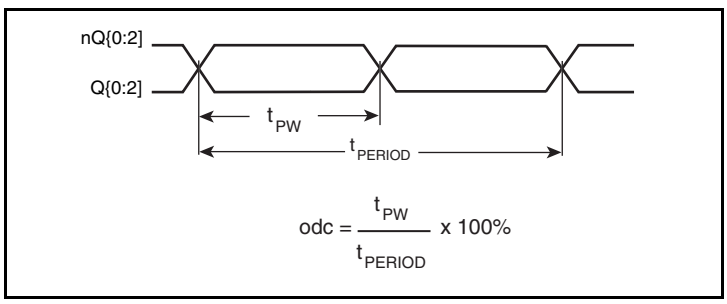
Output Skew



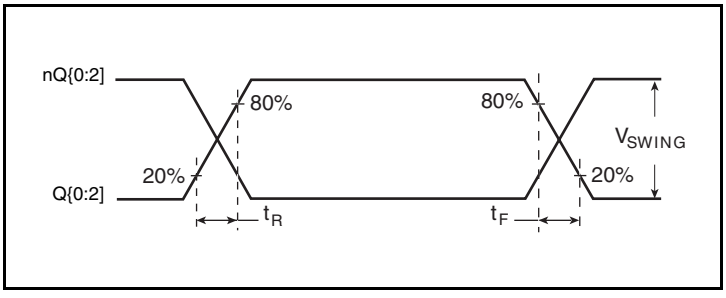
RMS Phase Jitter



Period Jitter

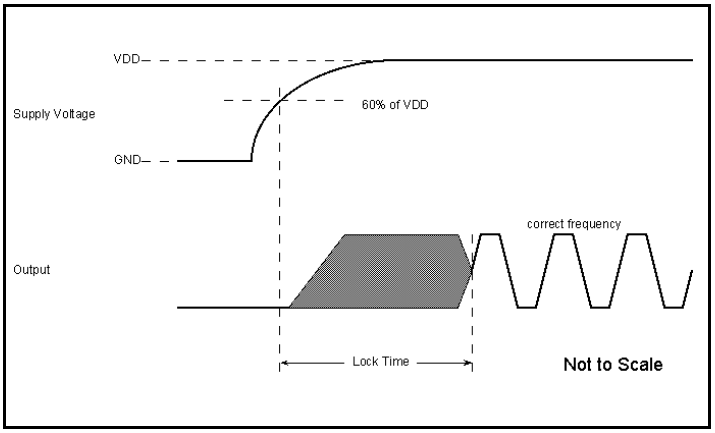


Output Duty Cycle/Pulse Width/Period



LVPECL Output Rise/Fall Time

Parameter Measurement Information, continued



VCXO & FemtoClock PLL Lock Time

Application Information

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 ICS813323 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 1* 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.

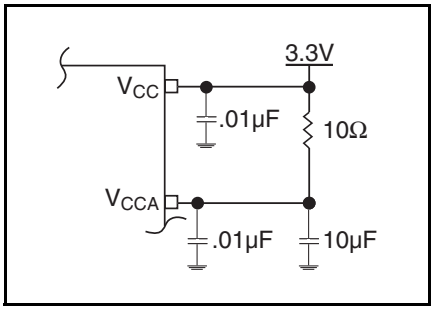


Figure 1. Power Supply Filtering

Wiring the Differential Input to Accept Single-Ended Levels

Figure 1 shows how a differential input can be wired to accept single ended levels. The reference voltage $V_{REF} = V_{CC}/2$ is generated by the bias resistors R1 and R2. The bypass capacitor (C1) is used to help filter noise on the DC bias. This bias circuit should be located as close to the input pin as possible. The ratio of R1 and R2 might need to be adjusted to position the V_{REF} in the center of the input voltage swing. For example, if the input clock swing is 2.5V and V_{CC} = 3.3V, R1 and R2 value should be adjusted to set V_{REF} at 1.25V. The values below are for when both the single ended swing and V_{CC} are at the same voltage. This configuration requires that the sum of the output impedance of the driver (Ro) and the series resistance (Rs) equals the transmission line impedance. In addition, matched termination at the input will attenuate the signal in half. This can be done in one of two ways. First, R3 and R4 in parallel should equal the transmission line impedance. For most 50Ω applications, R3 and R4 can be 100Ω. The values of the resistors can be increased to reduce the loading for slower and weaker LVCMOS driver. When using single-ended signaling, the noise rejection benefits of differential signaling are reduced. Even though the differential input can handle full rail LVCMOS signaling, it is recommended that the amplitude be reduced. The datasheet specifies a lower differential amplitude, however this only applies to differential signals. For single-ended applications, the swing can be larger, however V_{IL} cannot be less than -0.3V and V_{IH} cannot be more than V_{CC} + 0.3V. Though some of the recommended components might not be used, the pads should be placed in the layout. They can be utilized for debugging purposes. The datasheet specifications are characterized and guaranteed by using a differential signal.

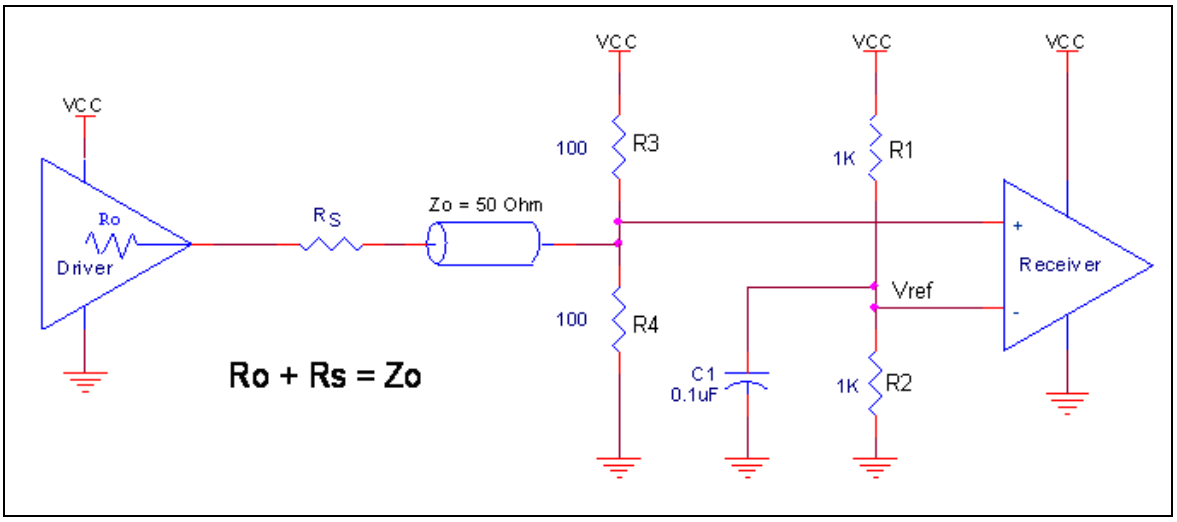


Figure 1. Recommended Schematic for Wiring a Differential Input to Accept Single-ended Levels

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.

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.

Differential Clock Input Interface

The CLK /nCLK accepts LVDS, LVPECL, LVHSTL, SSTL, HCSL and other differential signals. Both V_{SWING} and V_{OH} must meet the V_{PP} and V_{CMR} input requirements. *Figures 3A to 3F* show interface examples for the CLK/nCLK input driven by the most common driver types. The input interfaces suggested here are examples only.

Please consult with the vendor of the driver component to confirm the driver termination requirements. For example, in Figure 3A, the input termination applies for IDT open emitter LVHSTL drivers. If you are using an LVHSTL driver from another vendor, use their termination recommendation.

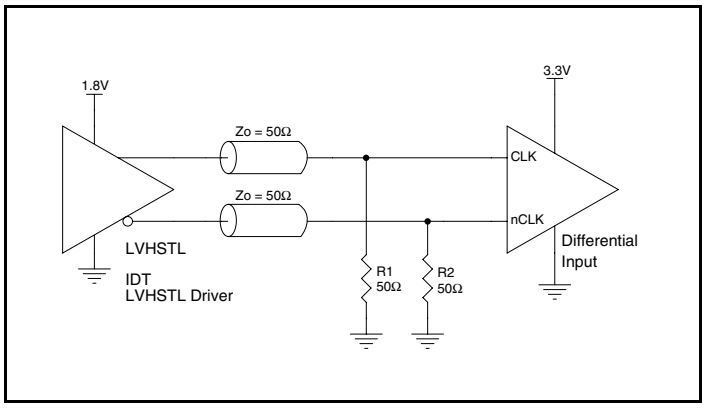


Figure 3A. CLK/nCLK Input Driven by an IDT Open Emitter LVHSTL Driver

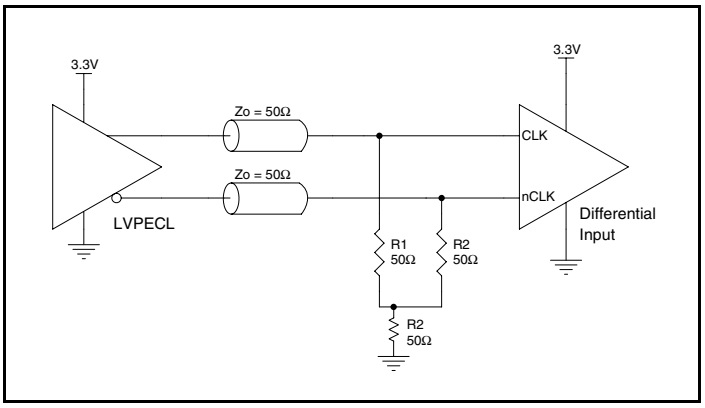


Figure 3B. CLK/nCLK Input Driven by a 3.3V LVPECL Driver

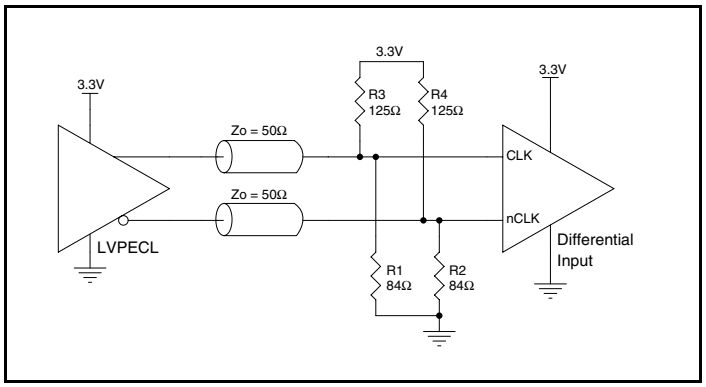


Figure 3C. CLK/nCLK Input Driven by a 3.3V LVPECL Driver

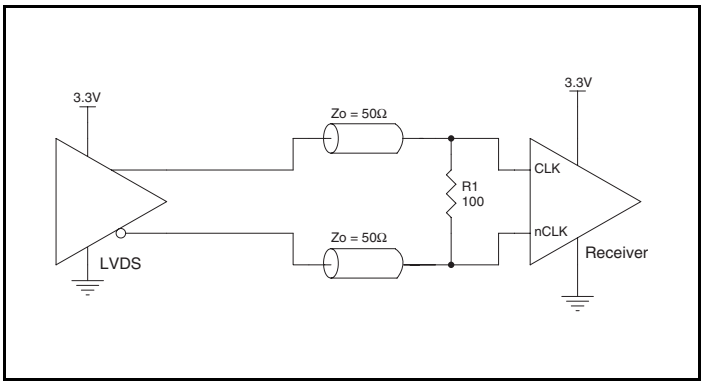


Figure 3D. CLK/nCLK Input Driven by a 3.3V LVDS Driver

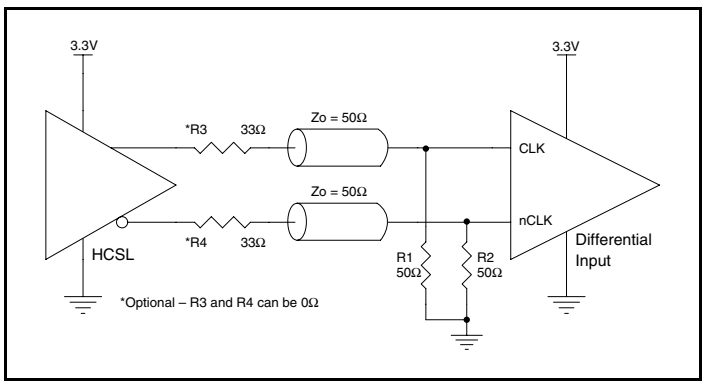


Figure 3E. CLK/nCLK Input Driven by a 3.3V HCSL Driver

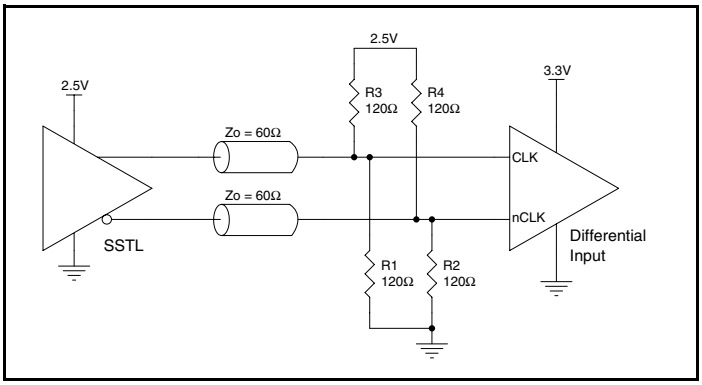


Figure 3F. CLK/nCLK Input Driven by a 2.5V SSTL Driver

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.

The differential outputs 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 4A and 4B* 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.

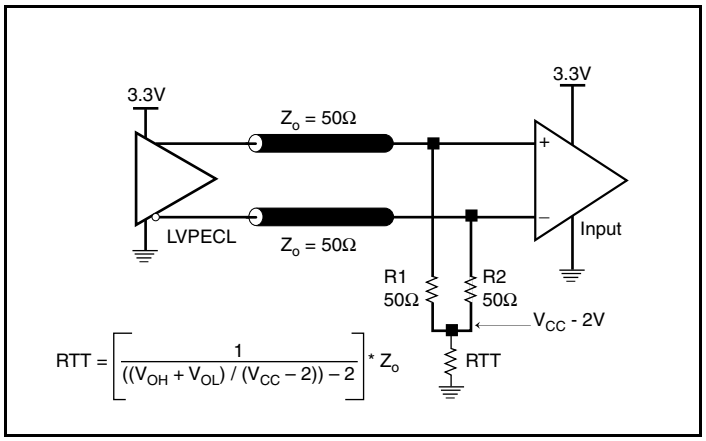


Figure 4A. 3.3V LVPECL Output Termination

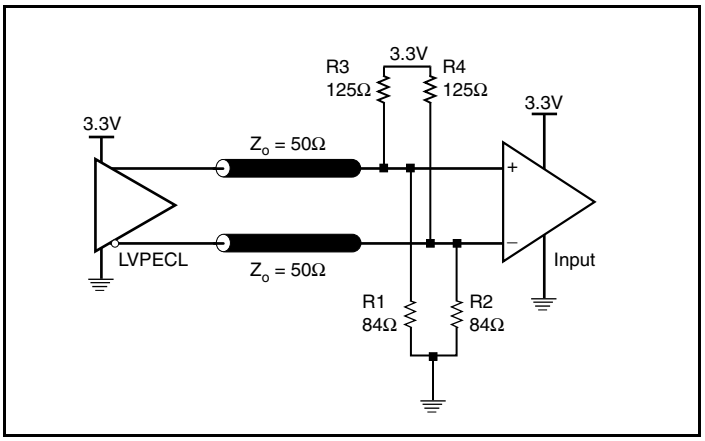


Figure 4B. 3.3V LVPECL Output Termination

Termination for 2.5V LVPECL Outputs

Figure 5A and *Figure 5B* 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 Figure5XB can be eliminated and the termination is shown in *Figure 5C.*

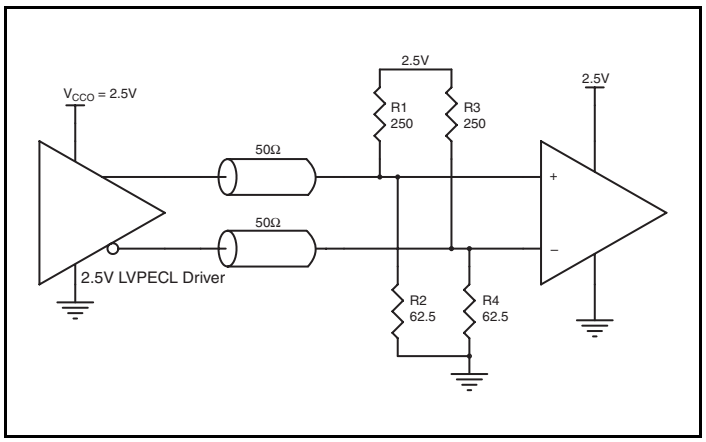


Figure 5A. 2.5V LVPECL Driver Termination Example

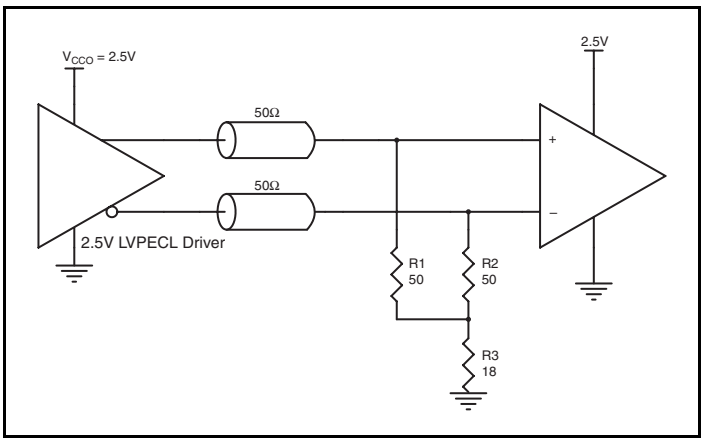


Figure 5B. 2.5V LVPECL Driver Termination Example

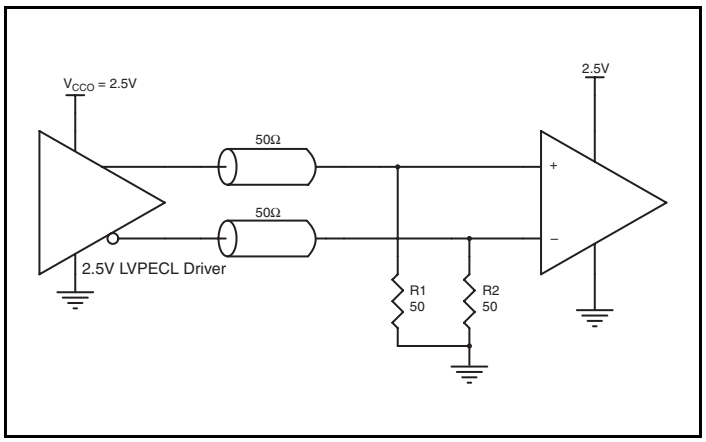


Figure 5C. 2.5V LVPECL Driver Termination Example

Schematic Example

Figure 6 shows an example of the ICS813323 application schematic. In this example, the device is operated at V_{CC} = V_{CCO} = 3.3V. The decoupling capacitors should be located as close as possible to the power pin. The input is driven by a 3.3V LVPECL driver. An optional 3-pole filter can also be used for additional spur reduction. It is recommended that the loop filter components be laid out for the 3-pole option. This will also allow the 2-pole filter to be used.

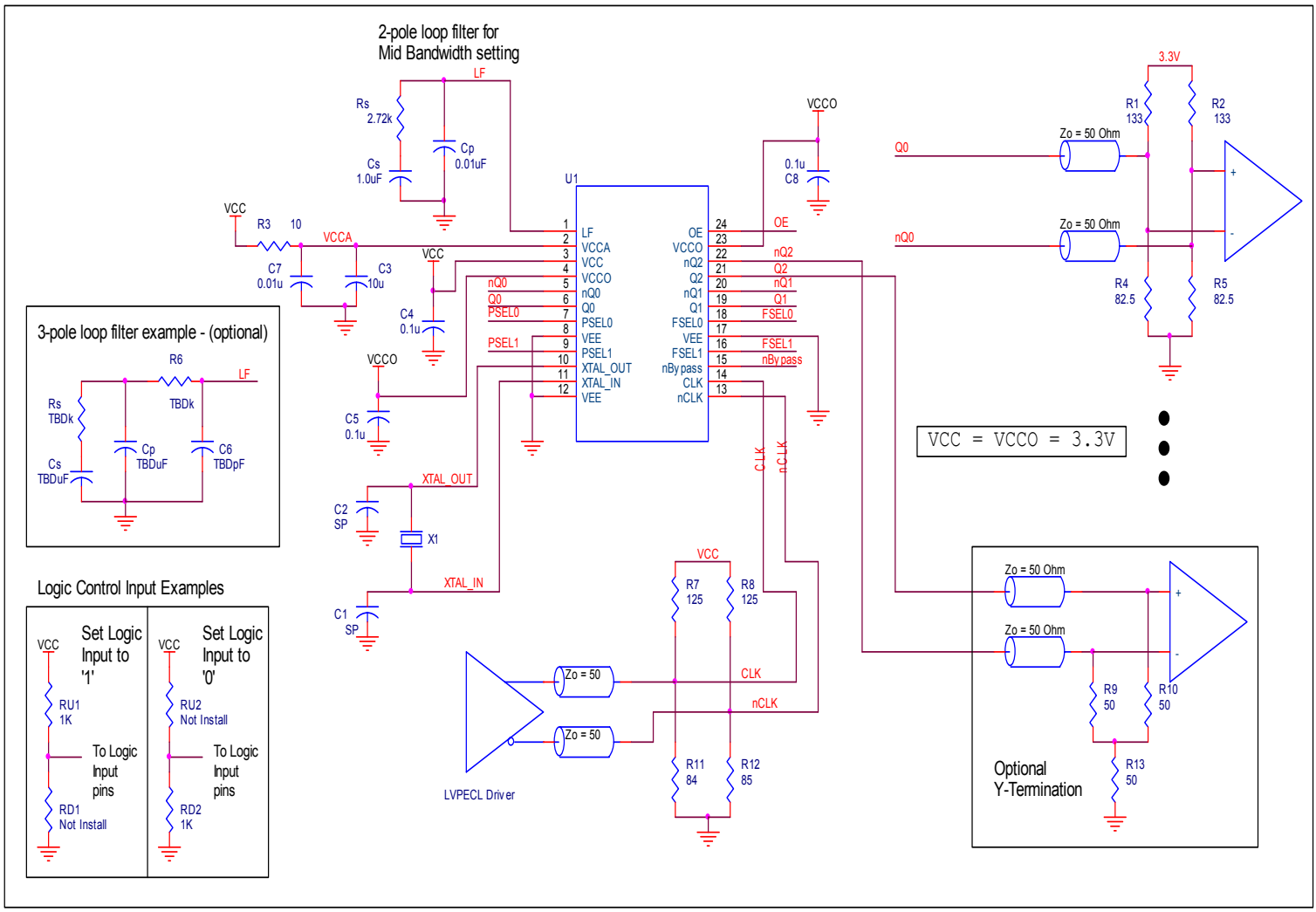


Figure 6. ICS813323 Schematic Layout

VCXO-PLL External Components

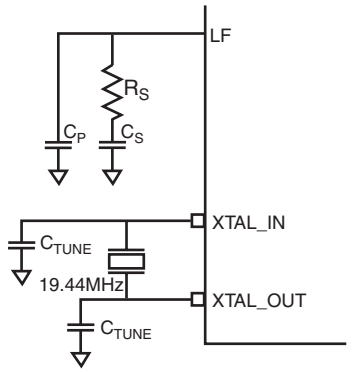
Choosing the correct external components and having a proper printed circuit board (PCB) layout is a key task for quality operation of the VCXO-PLL. In choosing a crystal, special precaution must be taken with the package and load capacitance (C_L). In addition, frequency, accuracy and temperature range must also be considered. Since the pulling range of a crystal also varies with the package, it is recommended that a metal-canned package like HC49 be used. Generally, a metal-canned package has a larger pulling range than a surface mounted device (SMD). For crystal selection information, refer to the *VCXO Crystal Selection Application Note.*

The crystal's load capacitance (C_L) characteristic determines it's resonating frequency and is closely related to the VCXO tuning range. The total external capacitance seen by the crystal when installed on a board is the sum of the stray board capacitance, IC package lead capacitance, internal varactor capacitance and any installed tuning capacitors (C_{TUNE}).

If the crystal (C_L) is greater than the total external capacitance, the VCXO will oscillate at a higher frequency than the crystal specification. If the crystal (C_L) is lower than the total external capacitance, the VCXO will oscillate at a lower frequency than the crystal specification. In either case, the absolute tuning range is reduced. The correct value of (C_L) is dependant on the characteristics of the VCXO. The recommended (C_L) in the Crystal Parameter Table balances the tuning range by centering the tuning curve.

The frequency of oscillation in the third overtone mode is not necessarily at exactly three times the fundamental frequency. The mechanical properties of the quartz element dictate the position of the overtones relative to the fundamental. The oscillator circuit may excite both the fundamental and overtone modes simultaneously. This will cause a nonlinearity in the tuning curve. This potential problem is why VCXO crystals are required to be tested for absence of any activity inside a ±200ppm window at three times the fundamental frequency. Refer to F_{L_3OVT} and $F_{L\_3OVT\_spurs}$ in the crystal Characteristics table.

The crystal and external loop filter components should be kept as close as possible to the device. Loop filter and crystal traces should be kept short and separated from each other. Other signal traces should be kept separate and not run underneath the device, loop filter or crystal components.



VCXO Characteristics Table

Symbol	Parameter	Typical	Units
k_{VCXO}	VCXO Gain	7625	Hz/V
C_{V_LOW}	Low Varactor Capacitance	10.7	pF
C_{V_HIGH}	High Varactor Capacitance	22	pF

VCXO-PLL Loop Bandwidth Selection Table

Bandwidth	Crystal Frequency	R_S (kΩ)	C_S (µF)	C_P (µF)
185.7Hz (Low)	19.44MHz	0.68	10	0.1
742.7Hz (Mid)	19.44MHz	2.7	1.0	0.01
1.857kHz (High)	19.44MHz	6.8	0.1	0.001

Crystal Characteristics

Symbol	Parameter	Test Conditions	Minimum	Typical	Maximum	Units
	Mode of Oscillation			Fundamental		
f_N	Frequency			19.44		MHz
f_T	Frequency Tolerance				±20	ppm
f_S	Frequency Stability				±20	ppm
	Operating Temperature Range		0		+70	^{0}C
C_L	Load Capacitance			10		pF
C_O	Shunt Capacitance			4		pF
C_O / C_1	Pullability Ratio			220	240	
F_{L_3OVT}	3rd Overtone F_L		200			pmm
$F_{L\_3OVT\_spurs}$	3rd Overtone F_L Spurs		200			pmm
ESR	Equivalent Series Resistance				20	Ω
	Drive Level				1	mW
	Aging @ 25 ^{0}C				±3 per year	ppm

Power Considerations

This section provides information on power dissipation and junction temperature for the ICS813323.
Equations and example calculations are also provided.

1. Power Dissipation.

The total power dissipation for the ICS813323 is the sum of the core power plus the power dissipated in the load(s).
The following is the power dissipation for V_{CCO} = 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_{CCO_MAX} * I_{EE_MAX} = 3.465V * 130mA = **450.45mW**
- Power (outputs)$_{MAX}$ = **30mW/Loaded Output pair**
  If all outputs are loaded, the total power is 3 * 30mW = **90mW**

Total Power$_{\_MAX}$ (3.3V, with all outputs switching) = 450.45mW + 90mW = **540.45mW**

2. Junction Temperature.

Junction temperature, Tj, is the temperature at the junction of the bond wire and bond pad directly affects the reliability of the device. The maximum recommended junction temperature is 125°C. Limiting the internal transistor junction temperature, Tj, to 125°C ensures that the bond wire and bond pad temperature remains below 125°C.

The equation for Tj is as follows: Tj = θ_{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 82.3°C/W per Table 6 below.

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

70°C + 0.540W * 82.3°C/W = 114.4°C. This is well 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 6. Thermal Resistance θ_{JA} for 24 Lead TSSOP, Forced Convection

θ_{JA} **by Velocity**			
Meters per Second	**0**	**1**	**2.5**
Multi-Layer PCB, JEDEC Standard Test Boards	82.3°C/W	78.0°C/W	75.95°C/W

3. Calculations and Equations.

The purpose of this section is to calculate the power dissipation for the LVPECL output pairs.

LVPECL output driver circuit and termination are shown in *Figure 6.*

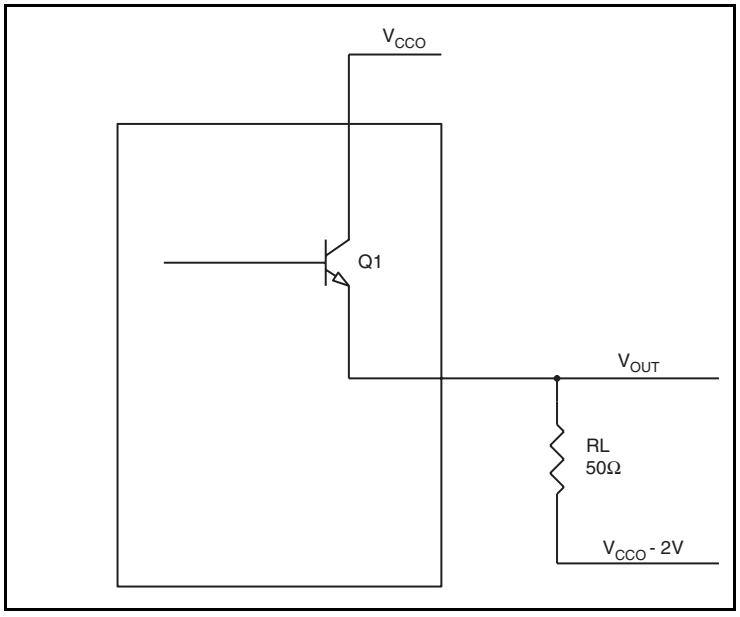


Figure 6. LVPECL Driver Circuit and Termination

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

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

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

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

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

Reliability Information

Table 7. θ_{JA} vs. Air Flow Table for a 24 Lead TSSOP

θ_{JA} vs. Air Flow			
Meters per Second	**0**	**1**	**2.5**
Multi-Layer PCB, JEDEC Standard Test Boards	82.3°C/W	78.0°C/W	75.95°C/W

Transistor Count

The transistor count for ICS813323 is: 2915

Package Outline and Package Dimensions

Package Outline - G Suffix for 24 Lead TSSOP

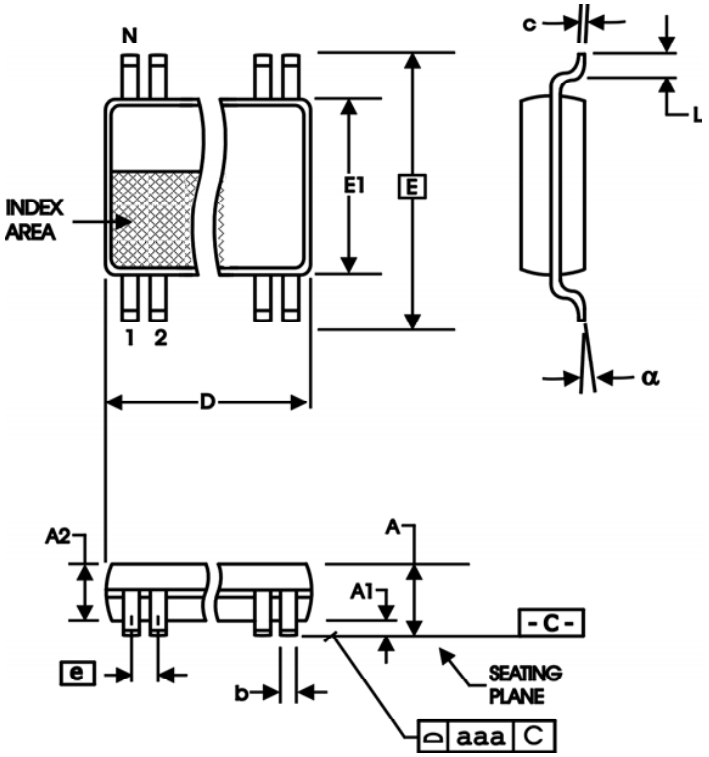


Table 8. Package Dimensions

All Dimensions in Millimeters		
Symbol	**Minimum**	**Maximum**
N	24	
A		1.20
A1	0.5	0.15
A2	0.80	1.05
b	0.19	0.30
c	0.09	0.20
D	7.70	7.90
E	6.40 Basic	
E1	4.30	4.50
e	0.65 Basic	
L	0.45	0.75
α	0°	8°
aaa		0.10

Reference Document: JEDEC Publication 95, MO-153

Ordering Information

Table 9. Ordering Information

Part/Order Number	Marking	Package	Shipping Packaging	Temperature
813323BGLF	ICS813323BGLF	“Lead-Free” 24 Lead TSSOP	Tube	0°C to 70°C
813323BGLFT	ICS813323BGLF	“Lead-Free” 24 Lead TSSOP	2500 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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