

# SiT9501

Ultra-low Jitter Differential XO for Standard Networking Frequencies



## Description

The **SiT9501** is a differential oscillator with an integrated MEMS resonator (such as ApexMEMS™), that is engineered for low-jitter applications requiring standard frequencies from 25 MHz to 644.53125 MHz.

In addition to standard differential signaling types, a unique FlexSwing™ output-driver performs like LVPECL and provides independent control of voltage swing and DC offset to simplify interfacing with chipsets having non-standard input voltage requirements and eliminate all external source-bias resistors. The device also integrates multiple on-chip regulators to filter power supply noise, eliminating the need for an external dedicated LDO.

The SiT9501 can be factory programmed for specific combinations of frequency, stability, output signaling, voltage, and output enable functionality. Programmability enables designers to optimize clock configurations while eliminating long lead times and customization costs associated with quartz devices where each combination is custom built.

The wide frequency range and programmability makes this device ideal for communications, enterprise, and industrial applications that require a variety of frequencies and operate in noisy environments.

Refer to [Manufacturing Notes](#) for proper reflow profile, tape and reel dimension, and other manufacturing related information.

## Features

- Standard frequencies from 25 MHz to 644.53125 MHz
- 45 fs RMS typical phase jitter for SerDes applications
- 9 fs/mV typical PSNR
- LVPECL, LVDS, HCSL, Low-power HCSL, and FlexSwing signaling options
- $\pm 20$ ,  $\pm 25$ ,  $\pm 30$ , and  $\pm 50$  ppm frequency stabilities
- Wide temperature range ( $-40^{\circ}\text{C}$  to  $105^{\circ}\text{C}$ )
- Factory programmable options for low lead time
- 1.8 V, 2.5 V, 3.3 V, and wide continuous power supply voltage range options
- 2 x 1.6, 2.5 x 2, 3.2 x 2.5 mm x mm package

## Applications

- 400G/800G network equipment
- Optical modules
- Coherent optics
- Network switches, routers
- Industrial networking equipment
- Test and measurement



## Block Diagram

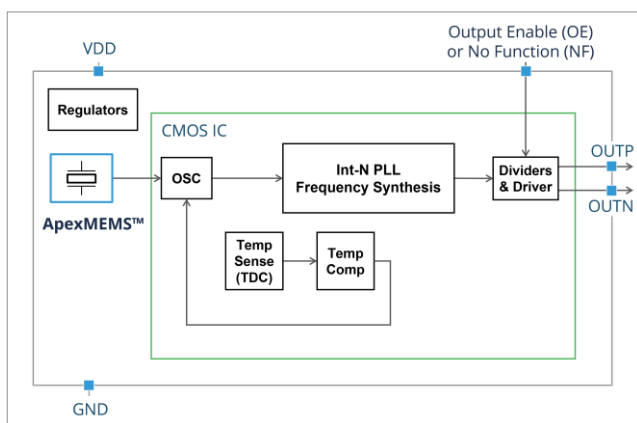


Figure 1. SiT9501 Block Diagram

## Package Pinout

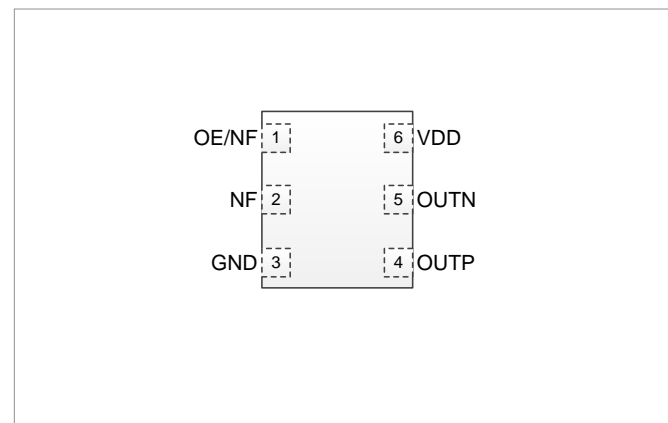


Figure 2. Pin Assignments (Top view)  
(Refer to [Table 16](#) for Pin Descriptions)

### SiT9501 Ultra-low Jitter Differential XO for Standard Networking Frequencies



SiT9501 features 45 fs RMS phase jitter for SerDes applications. Figure 3 shows the phase noise (green curve) observed by the system, after accounting for aliased phase noise when filtering (gray curve) the measured SiT9501 phase noise (blue curve). This “4-16A” phase jitter analysis methodology more accurately estimates reference clock

jitter than the legacy “12 kHz to 20 MHz” brick-wall filter methodology. It can be applied to all modern SerDes applications to optimize system performance. See “4-16A” Phase Jitter Methodology for SerDes Applications for more information.

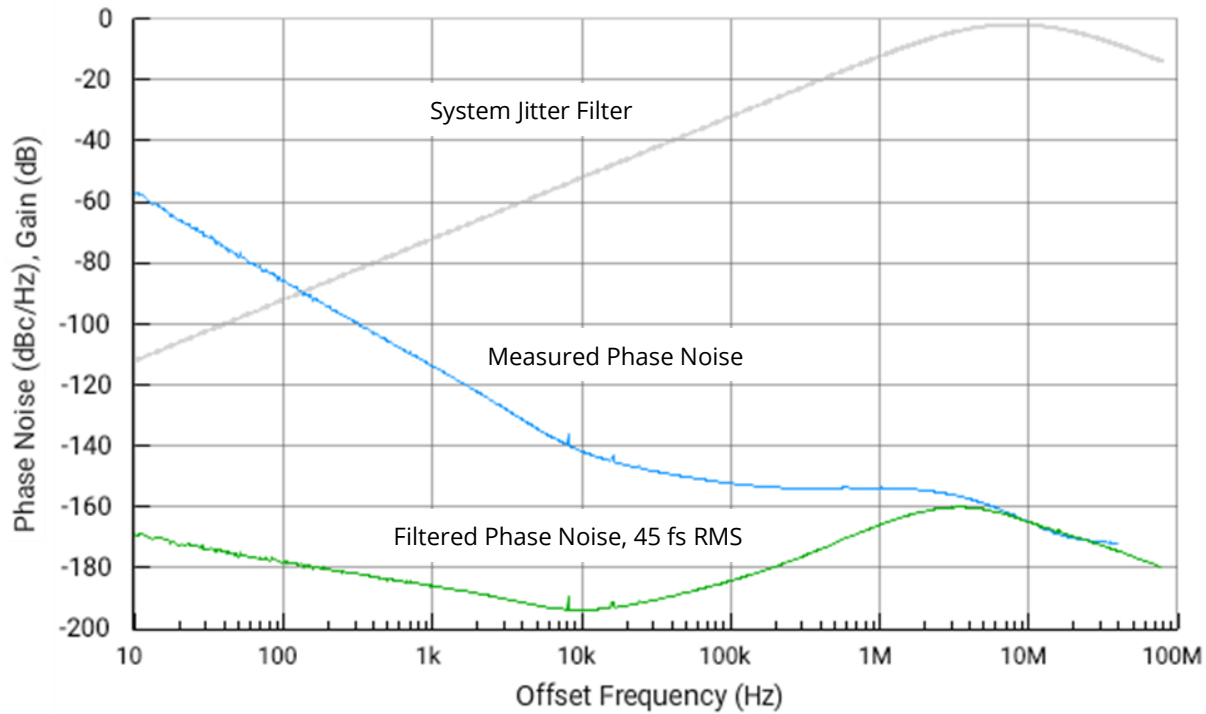


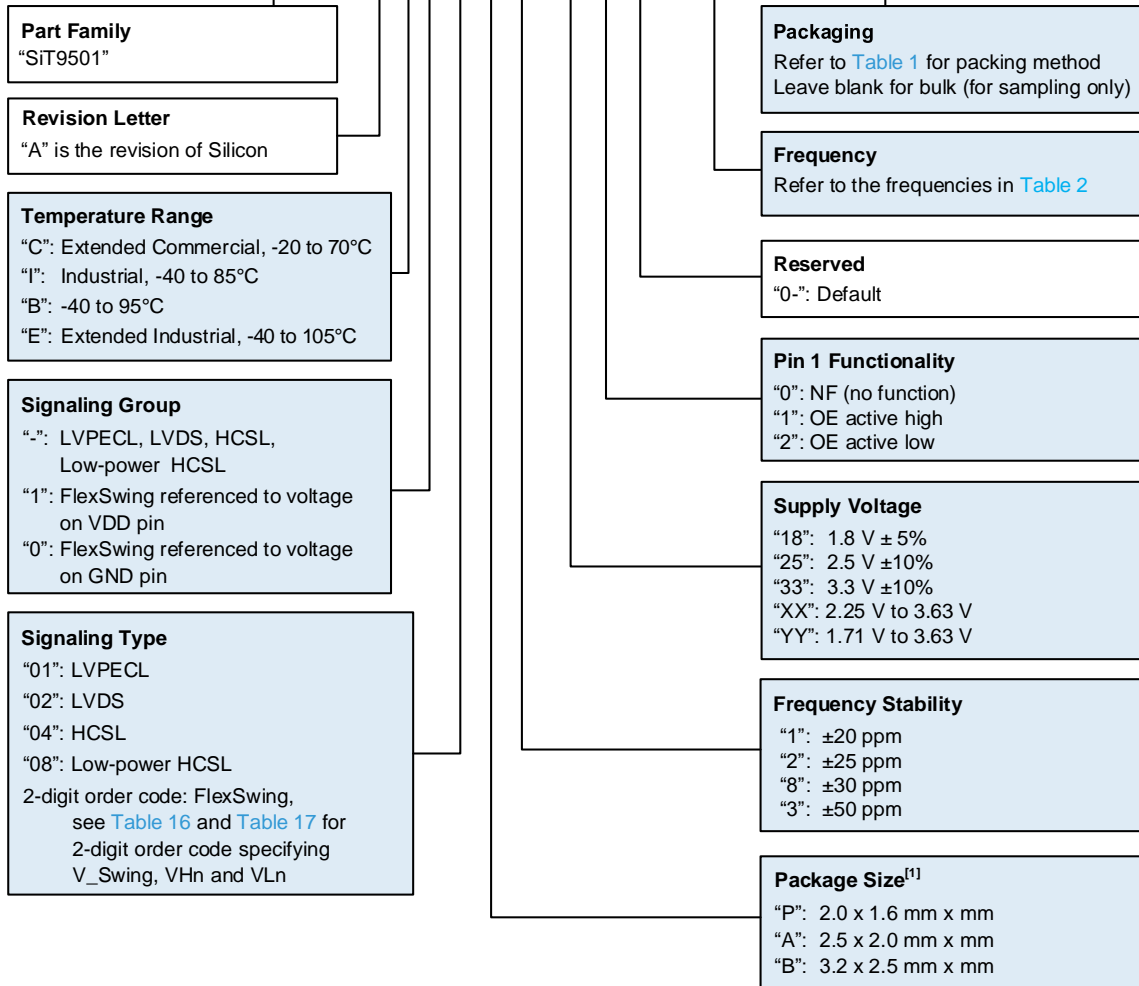
Figure 3. Phase noise before and after filtering for SiT9501 (156.25 MHz, LVPECL, 2.5V, 25°C). The filter is applied to analyze phase noise with aliasing included up to the 3<sup>rd</sup> harmonic and features first-order filter cutoff frequencies of 4 MHz (high pass) and 16 MHz (low pass).

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies



**Ordering Information**

**SiT9501AC-01P2-3310-156.250000D**



**Note:**

1. Contact SiTime for other package sizes.

**Table 1. Ordering Codes for Supported Tape & Reel Packing Method**

Device Size (mm x mm)	8 mm T&R (3ku)	8 mm T&R (1ku)	8 mm T&R (250u)
2.0 x 1.6	D	E	G
2.5 x 2.0	D	E	G
3.2 x 2.5	D	E	G

**Table 2. Supported Frequencies**

25.000000 MHz	39.062500 MHz	50.000000 MHz	53.125000 MHz	62.500000 MHz	78.125000 MHz	125.000000 MHz	156.250000 MHz
161.132813 MHz	250.000000 MHz	312.500000 MHz	322.265625 MHz	390.625000 MHz	625.000000 MHz	644.531250 MHz	

# SiT9501 Ultra-low Jitter Differential XO for Standard Networking Frequencies



## Table Of Contents

Description .....	1
Features .....	1
Applications .....	1
Block Diagram .....	1
Package Pinout .....	1
Ordering Information .....	3
Electrical Characteristics .....	5
Pin Description .....	15
"4-16A" Phase Jitter Methodology for SerDes Applications.....	16
FlexSwing Configurations.....	18
Test Circuit Diagrams.....	20
Test Setups for LVPECL Measurements .....	20
Test Setups for FlexSwing Measurements.....	21
Test Setups for LVDS Measurements.....	22
Test Setups for HCSL Measurements.....	23
Test Setups for Low-Power HCSL Measurements.....	24
Waveform Diagrams.....	25
Termination Diagrams .....	27
LVPECL and FlexSwing Termination .....	27
LVDS, Supply Voltage: 1.8 V $\pm$ 5%, 2.5 V $\pm$ 10%, 3.3 V $\pm$ 10%, 2.25 V to 3.63 V, 1.71 V to 3.63 V .....	28
HCSL, Supply Voltage: 1.8 V $\pm$ 5%, 2.5 V $\pm$ 10%, 3.3 V $\pm$ 10%, 2.25 V to 3.63 V, 1.71 V to 3.63 V .....	28
Low-power HCSL, Supply Voltage: 1.8 V $\pm$ 5%, 2.5 V $\pm$ 10%, 3.3 V $\pm$ 10%, 2.25 V to 3.63 V, 1.71 V to 3.63 V.....	28
Dimensions and Patterns — 2.0 x 1.6 mm x mm .....	29
Dimensions and Patterns — 2.5 x 2.0 mm x mm .....	30
Dimensions and Patterns — 3.2 x 2.5 mm x mm .....	31
Additional Information.....	32
Revision History .....	33

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies


## Electrical Characteristics

All Min and Max limits in the Electrical Characteristics tables are specified over operating temperature and rated operating voltage with standard output termination shown in the termination diagrams. Typical values are at 25°C and nominal supply voltage. See [Test Circuit Diagrams](#) for the test setups used with each signaling type.

**Table 3. Electrical Characteristics – Common to All Output Signaling Types**

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>Frequency Range</b>						
<b>Output Frequency Range</b>	f	Standard frequencies			MHz	Refer to frequencies listed in <a href="#">Ordering Information</a>
<b>Frequency Stability</b>						
<b>Frequency Stability</b>	F_stab	–	–	±20	ppm	Inclusive of initial tolerance, operating temperature, rated power supply voltage, load variation of 2 pF ± 10%, and 10 years aging at 85°C
		–	–	±25	ppm	
		–	–	±30	ppm	
		–	–	±50	ppm	
<b>10 Year Aging</b>	F_10y	–	±0.7	±2.3	ppm	Ambient temperature of 85°C
<b>Temperature Range</b>						
<b>Operating Temperature Range</b>	T_use	-20	–	+70	°C	Extended commercial, ambient temperature
		-40	–	+85	°C	Industrial, ambient temperature
		-40	–	+95	°C	Ambient temperature
		-40	–	+105	°C	Extended industrial, ambient temperature
<b>Supply Voltage</b>						
<b>Supply Voltage</b>	Vdd	1.71	–	3.63	V	Voltage-supply order code "YY"
		2.25	–	3.63	V	Voltage-supply order code "XX"
		1.71	1.80	1.89	V	Voltage-supply order code "18". <a href="#">Contact SiTime</a> for 1.5 V
		2.25	2.50	2.75	V	Voltage-supply order code "25"
		2.97	3.30	3.63	V	Voltage-supply order code "33"
<b>Input Characteristics</b>						
<b>Input Voltage High</b>	VIH	70%	–	–	Vdd	Logic High function for Pin 1
<b>Input Voltage Low</b>	VIL	–	–	30%	Vdd	Logic High function for Pin 1
<b>Input Pull-up/Pull-down Impedance</b>	Z_in	112.9	120	133.4	kΩ	Pin 1 for OE function
<b>Output Characteristics</b>						
<b>Duty Cycle</b>	DC	48	–	52	%	See <a href="#">Figure 19</a> for waveform
<b>Startup, OE and SE Timing</b>						
<b>Startup Time</b>	T_start	–	1.2	2	ms	Measured from the time Vdd reaches its rated minimum value
<b>Output Enable Time 1</b>	T_oe	–	–	100+3 clock cycles	ns	For all signaling types except Low-Power HCSL. Measured from the time OE pin toggles to enable logic level to the time clock pins reach 90% of final swing. See <a href="#">Figure 25</a> for waveform
<b>Output Enable Time 2</b>	T_oe	–	–	500+3 clock cycles	ns	For Low-Power HCSL signaling type. Measured from the time OE pin toggles to enable logic level to the time clock pins reach 90% of final swing. See <a href="#">Figure 25</a> for waveform
<b>Output Disable Time</b>	T_od	–	–	100+3 clock cycles	ns	Measured from the time OE pin toggles to disable logic level to the last clock edge. See <a href="#">Figure 26</a> for waveform
<b>Jitter and Phase Noise, measured at f = 156.25 MHz</b>						
<b>4-16A Phase Jitter<sup>[2]</sup></b>	T_416A	–	45	57 <sup>[4]</sup>	fs RMS	Measured with phase noise analyzer, extending (flat) phase noise to 3rd harmonic (i.e., 312.5 MHz offset), folding phase noise below the Nyquist frequency (i.e., 78.125 MHz offset), filtering and integrating from 10 kHz to Nyquist. Uses 4 MHz high pass and 16 MHz low pass filters, each with 20 dB/dec roll off. Includes spurs. See "4-16A" <a href="#">Phase Jitter Methodology for SerDes Applications</a> for additional details.
<b>0.012-20 Phase Jitter (legacy)</b>	T_phj	–	70	100	fs RMS	Measured with phase noise analyzer, integrating between 12 kHz and 20 MHz offset frequency. Recommended for SONET OC-48 applications. <a href="#">Contact SiTime</a> for 85 fs max option.
<b>Legacy Spurious Phase Noise</b>	T_spn	–	–	-112	dBc	12 kHz to 20 MHz offset frequency range
<b>RMS Period Jitter<sup>[3]</sup></b>	T_jitt_per	–	0.5	0.6	ps	Measured based on 10K cycles
<b>Peak Cycle-to-cycle Jitter<sup>[3]</sup></b>	T_jitt_cc	–	3.5	6.2	ps	Measured based on 1K cycles

**Note:**

2. Recommended for SerDes applications to improve the accuracy of clock jitter analysis, replacing the traditional 12 kHz to 20 MHz brick wall filter when application-specific filter characteristics are not explicitly specified.
3. Measured according to JESD65B using Keysight DSAX91604A Oscilloscope.
4. Max phase jitter for LVPECL.

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies


**Table 4. Electrical Characteristics – LVPECL** | Supply voltage (“order code”): 2.5 V  $\pm$ 10% (“25”), 3.3 V  $\pm$ 10% (“33”), 2.25 V to 3.63 V (“XX”). All typical specifications are measured at nominal supply voltage of 2.5 V and nominal frequency of 156.25 MHz unless otherwise stated. See [Figure 8](#) and [Figure 9](#) for test setups.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>Current Consumption, Frequency = 156.25 MHz</b>						
<b>Current Consumption, Output Enabled without Termination</b>	Idd_oe_nt	–	28.5	35.5	mA	Excluding load termination current
<b>Current Consumption, Output Enabled with Termination 1</b>	Idd_oe_wt1	–	39	49	mA	Including load termination current as shown in <a href="#">Figure 30</a> for Vdd=3.3 V $\pm$ 10%, Vdd=2.25 V to 3.63 V and R3=220 Ohms
		–	39	45	mA	Including load termination current as shown in <a href="#">Figure 30</a> for Vdd=2.5 V $\pm$ 10% and R3=220 Ohms
<b>Current Consumption, Output Enabled with Termination 2</b>	Idd_oe_wt2	–	55	61	mA	Including load termination current. See <a href="#">Figure 31</a> for termination
<b>Current Consumption Output Disabled with Termination 1</b>	Idd_od_wt1	–	46.5	58	mA	Including load termination current as shown in <a href="#">Figure 30</a> for Vdd=3.3 V $\pm$ 10%, Vdd=2.25 V to 3.63 V and R3=220 Ohms. Driver output is at logic-high voltage levels.
		–	46.5	53.5	mA	Including load termination current as shown in <a href="#">Figure 30</a> for Vdd=2.5 V $\pm$ 10% and R3=220 Ohms. Driver output is at logic-high voltage levels.
<b>Current Consumption, Output Disabled with Termination 2</b>	Idd_od_wt2	–	66	73	mA	Including load termination current. See <a href="#">Figure 31</a> for termination. Driver output is at logic-high voltage levels.
<b>Output Characteristics</b>						
<b>Output High Voltage</b>	VOH	Vdd-1.075	Vdd-0.95	Vdd-0.86	V	See <a href="#">Figure 18</a> for waveform
<b>Output Low Voltage</b>	VOL	Vdd-1.84	Vdd-1.7	Vdd-1.62	V	See <a href="#">Figure 18</a> for waveform
<b>Output Differential Voltage Swing</b>	V_Swing	1.4	1.5	1.65	V	See <a href="#">Figure 19</a> for waveform
<b>Rise/Fall Time</b>	Tr, Tf	–	170	200	ps	20% to 80%. See <a href="#">Figure 19</a> for waveform
<b>Differential Asymmetry, peak-peak</b>	V_da	–	45	–	mV	See <a href="#">Figure 21</a> for waveform
<b>Differential Skew, peak</b>	V_ds	–	$\pm$ 30	–	ps	See <a href="#">Figure 22</a> for waveform
<b>Overshoot Voltage, peak</b>	V_ov	–	12	–	%	Measured as percent of V_Swing. See <a href="#">Figure 23</a> for waveform
<b>Power Supply Noise Immunity</b>						
<b>Power Supply-Induced Jitter Sensitivity</b>	PSJS	–	9	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz
		–	2.0	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. Using RC power supply filter as shown in <a href="#">Figure 8</a>
<b>Power Supply-Induced Phase Noise</b>	PSPN	–	-79	–	dBc	50 mV peak-peak ripple on VDD
		–	-92	–	dBc	50 mV peak-peak ripple on VDD. Using RC power supply filter as shown in <a href="#">Figure 8</a>

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies


**Table 5. Electrical Characteristics – FlexSwing** | Supply voltage (“order code”) referred to VDD only: 2.5 V  $\pm$ 10% (“25”), 3.3 V  $\pm$ 10% (“33”), 2.25 V to 3.63 V (“XX”). All typical specifications are measured at nominal frequency of 156.25 MHz unless otherwise stated. See [Figure 10](#) and [Figure 11](#) for test setups.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>Current Consumption, Frequency = 156.25 MHz</b>						
<b>Current Consumption, Output Enabled without Termination</b>	Idd_oe_nt	–	29.5	38	mA	Excluding load termination current
<b>Current Consumption, Output Enabled with Termination</b>	Idd_oe_wt	–	37	47.5	mA	Including load termination current, for FlexSwing order code “ER”. See <a href="#">Figure 30</a> for Vdd=3.3 V $\pm$ 10%, Vdd=2.25 V to 3.63 V, and R3=220 Ohms
		–	37	43.5	mA	Including load termination current, for FlexSwing order code “ER”. See <a href="#">Figure 30</a> for Vdd=2.5 V $\pm$ 10%, and R3=220 Ohms
<b>Current Consumption Output Disabled with Termination</b>	Idd_od_wt	–	42.5	53	mA	Including load termination current, for FlexSwing order code “ER”. See <a href="#">Figure 30</a> for Vdd=3.3 V $\pm$ 10%, Vdd=2.25 V to 3.63 V, and R3=220 Ohms. Driver output is at logic-high voltage levels.
		–	42.5	49.5	mA	Including load termination current, for FlexSwing order code “ER”. See <a href="#">Figure 30</a> for Vdd=2.5 V $\pm$ 10%, and R3=220 Ohms. Driver output is at logic-high voltage levels.
<b>Output Characteristics</b>						
<b>Output High Voltage</b>	VOH	VHn -0.13	VHn	VHn +0.1	V	See <a href="#">Figure 18</a> for waveform; Refer to <a href="#">Table 17</a> or <a href="#">Table 18</a> order codes for nominal VOH (i.e. VHn) values
<b>Output Low Voltage</b>	VOL	VLn -0.13	VLn	VLn +0.12	V	See <a href="#">Figure 18</a> for waveform; Refer to <a href="#">Table 17</a> or <a href="#">Table 18</a> order codes for nominal VOL (i.e. VLn) values
<b>Output Differential Voltage Swing</b>	V_Swing	-15%	2*( VHn-VLn)	+15%	V	See <a href="#">Figure 19</a> for waveform
<b>Rise/Fall Time</b>	Tr, Tf	–	170	200	ps	20% to 80%. See <a href="#">Figure 19</a> for waveform
<b>Differential Asymmetry, peak-peak</b>	V_da	–	60	–	mV	See <a href="#">Figure 21</a> for waveform
<b>Differential Skew, peak</b>	V_ds	–	$\pm$ 40	–	ps	See <a href="#">Figure 22</a> for waveform
<b>Overshoot Voltage, peak</b>	V_ov	–	12	–	%	Measured as percent of V_Swing. See <a href="#">Figure 23</a> for waveform
<b>Power Supply Noise Immunity</b>						
<b>Power Supply-Induced Jitter Sensitivity</b>	PSJS	–	14	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. For FlexSwing order code “ER”
		–	2	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. For FlexSwing order code “ER”. Using RC power supply filter as shown in <a href="#">Figure 10</a>
<b>Power Supply-Induced Phase Noise</b>	PSPN	–	-75	–	dBc	50 mV peak-peak ripple on VDD. For FlexSwing order code “ER”
		–	-93	–	dBc	50 mV peak-peak ripple on VDD. For FlexSwing order code “ER”. Using RC power supply filter as shown in <a href="#">Figure 10</a>

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies


**Table 6. Electrical Characteristics – FlexSwing** | Supply voltage (“order code”) referred to GND, only: 1.8 V  $\pm$ 5% (“18”), 1.71 V to 3.63 V (“YY”). All typical specifications are measured at nominal frequency of 156.25 MHz unless otherwise stated. See [Figure 10](#) and [Figure 11](#) for test setups.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>Current Consumption, Frequency = 156.25 MHz</b>						
<b>Current Consumption, Output Enabled without Termination</b>	Idd_oe_nt	–	31	37.5	mA	Excluding load termination current
<b>Current Consumption, Output Enabled with Termination</b>	Idd_oe_wt	–	38.5	44	mA	Including load termination current, for FlexSwing order code “3E”. See <a href="#">Figure 30</a> for Vdd=1.8 V $\pm$ 5% and R3=220 Ohms
		–	38.5	45.5	mA	Including load termination current, for FlexSwing order code “3E”. See <a href="#">Figure 30</a> for Vdd=1.71 V to 3.63 V and R3=220 Ohms
<b>Current Consumption Output Disabled with Termination</b>	Idd_od_wt	–	44.5	50	mA	Including load termination current, for FlexSwing order code “3E”. See <a href="#">Figure 30</a> for Vdd=1.8 V $\pm$ 5% and R3=220 Ohms. Driver output is at logic-high voltage levels.
		–	44.5	51.5	mA	Including load termination current, for FlexSwing order code “3E”. See <a href="#">Figure 30</a> for Vdd=1.71 V to 3.63 V and R3=220 Ohms. Driver output is at logic-high voltage levels.
<b>Output Characteristics</b>						
<b>Output High Voltage</b>	VOH	VHn - 0.1	VHn	VHn + 0.12	V	See <a href="#">Figure 18</a> for waveform; Refer to <a href="#">Table 17</a> or <a href="#">Table 18</a> order codes for nominal VOH (i.e. VHn) values
<b>Output Low Voltage</b>	VOL	VLn - 0.1	VLn	VLn + 0.12	V	See <a href="#">Figure 18</a> for waveform; Refer to <a href="#">Table 17</a> or <a href="#">Table 18</a> order codes for nominal VOL (i.e. VLn) values
<b>Output Differential Voltage Swing</b>	V_Swing	-15%	2*( VHn-VLn)	+15%	V	See <a href="#">Figure 19</a> for waveform
<b>Rise/Fall Time</b>	Tr, Tf	–	170	210	ps	20% to 80%. See <a href="#">Figure 19</a> for waveform.
<b>Differential Asymmetry, peak-peak</b>	V_da	–	60	–	mV	See <a href="#">Figure 21</a> for waveform
<b>Differential Skew, peak</b>	V_ds	–	$\pm$ 40	–	ps	See <a href="#">Figure 22</a> for waveform
<b>Overshoot Voltage, peak</b>	V_ov	–	12	–	%	Measured as percent of V_Swing. See <a href="#">Figure 23</a> for waveform
<b>Power Supply Noise Immunity</b>						
<b>Power Supply-Induced Jitter Sensitivity</b>	PSJS	–	12	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. For FlexSwing order code “3E”
		–	2	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. For FlexSwing order code “3E”. Using RC power supply filter as shown in <a href="#">Figure 10</a>
<b>Power Supply-Induced Phase Noise</b>	PSPN	–	-76	–	dBc	50 mV peak-peak ripple on VDD. For FlexSwing order code “3E”
		–	-95	–	dBc	50 mV peak-peak ripple on VDD. For FlexSwing order code “3E”. Using RC power supply filter as shown in <a href="#">Figure 10</a>

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies


**Table 7. Electrical Characteristics – FlexSwing** | Supply voltage (“order code”) referred to GND, only: 2.5 V  $\pm$ 10% (“25”), 3.3 V  $\pm$ 10% (“33”), 2.25 V to 3.63 V (“XX”). All typical specifications are measured at nominal frequency of 156.25 MHz unless otherwise stated. See [Figure 10](#) and [Figure 11](#) for test setups.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>Current Consumption, Frequency = 156.25 MHz</b>						
<b>Current Consumption, Output Enabled without Termination</b>	Idd_oe_nt	–	30	36	mA	Excluding load termination current
<b>Current Consumption, Output Enabled with Termination</b>	Idd_oe_wt	–	37.5	44	mA	Including load termination current, for FlexSwing order code “VP”. See <a href="#">Figure 30</a> for Vdd=3.3 V $\pm$ 10%, Vdd=2.25 V to 3.63 V, and R3=220 Ohms
<b>Current Consumption Output Disabled with Termination</b>	Idd_od_wt	–	46	53	mA	Including load termination current, for FlexSwing order code “VP”. See <a href="#">Figure 30</a> for Vdd=3.3 V $\pm$ 10%, Vdd=2.25 V to 3.63 V, and R3=220 Ohms. Driver output is at logic-high voltage levels.
<b>Output Characteristics</b>						
<b>Output High Voltage</b>	VOH	VHn - 0.11	VHn	VHn + 0.1	V	See <a href="#">Figure 18</a> for waveform; Refer to <a href="#">Table 17</a> or <a href="#">Table 18</a> order codes for nominal VOH (i.e. VHn) values
<b>Output Low Voltage</b>	VOL	VLn - 0.1	VLn	VLn + 0.1	V	See <a href="#">Figure 18</a> for waveform; Refer to <a href="#">Table 17</a> or <a href="#">Table 18</a> order codes for nominal VOL (i.e. VLn) values
<b>Output Differential Voltage Swing</b>	V_Swing	-15%	2*(VHn-VLn)	+15%	V	See <a href="#">Figure 19</a> for waveform
<b>Rise/Fall Time</b>	Tr, Tf	–	170	200	ps	20% to 80%. See <a href="#">Figure 19</a> for waveform
<b>Differential Asymmetry, peak-peak</b>	V_da	–	60	–	mV	See <a href="#">Figure 21</a> for waveform
<b>Differential Skew, peak</b>	V_ds	–	$\pm$ 40	–	ps	See <a href="#">Figure 22</a> for waveform
<b>Overshoot Voltage, peak</b>	V_ov	–	12	–	%	Measured as percent of V_Swing. See <a href="#">Figure 23</a> for waveform
<b>Power Supply Noise Immunity</b>						
<b>Power Supply-Induced Jitter Sensitivity</b>	PSJS	–	14	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. For FlexSwing order code “VP”
		–	2	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. For FlexSwing order code “VP”. Using RC power supply filter as shown in <a href="#">Figure 10</a>
<b>Power Supply-Induced Phase Noise</b>	PSPN	–	-75	–	dBc	50 mV peak-peak ripple on VDD. For FlexSwing order code “VP”
		–	-93	–	dBc	50 mV peak-peak ripple on VDD. For FlexSwing order code “VP”. Using RC power supply filter as shown in <a href="#">Figure 10</a>

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies


**Table 8. Electrical Characteristics – LVDS** | Supply voltage (“order code”): 2.5 V  $\pm$ 10% (“25”), 3.3 V  $\pm$ 10% (“33”), 2.25 V to 3.63 V (“XX”). All typical specifications are measured at nominal supply of 2.5 V and nominal frequency of 156.25 MHz unless otherwise stated. See [Figure 12](#) and [Figure 13](#) for test setups.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>Current Consumption, Frequency = 156.25 MHz</b>						
<b>Current Consumption, Output Enabled without Termination</b>	Idd_oe_nt	–	25.5	32	mA	Excluding load termination current
<b>Current Consumption, Output Enabled with Termination</b>	Idd_oe_wt	–	29	35	mA	Including load termination current. See <a href="#">Figure 34</a> for termination
<b>Current Consumption Output Disabled with Termination</b>	Idd_od_wt	–	34.5	41	mA	Including load termination current. See <a href="#">Figure 34</a> for termination. Driver output is at logic-high voltage levels.
<b>Output Characteristics</b>						
<b>Differential Output Voltage</b>	VOD	250	360	450	mV	See <a href="#">Figure 20</a> for waveform
<b>Delta VOD</b>	$\Delta$ VOD	–	–	50	mV	See <a href="#">Figure 20</a> for waveform
<b>Offset Voltage</b>	VOS	1.125	1.25	1.375	V	See <a href="#">Figure 20</a> for waveform
<b>Delta VOS</b>	$\Delta$ VOS	–	–	50	mV	See <a href="#">Figure 20</a> for waveform
<b>Rise/Fall Time</b>	Tr, Tf	–	290	330	ps	Measured 20% to 80% using <a href="#">Figure 34</a> for termination. See <a href="#">Figure 19</a> for waveform
<b>Differential Asymmetry, peak-peak</b>	V_da	–	25	–	mV	See <a href="#">Figure 21</a> for waveform
<b>Differential Skew, peak</b>	V_ds	–	$\pm$ 40	–	ps	See <a href="#">Figure 22</a> for waveform
<b>Overshoot Voltage, peak</b>	V_ov	–	8	–	%	Measured as percent of VOD. See <a href="#">Figure 24</a> for waveform
<b>Power Supply Noise Immunity</b>						
<b>Power Supply-Induced Jitter Sensitivity</b>	PSJS	–	18	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz
	PSJS	–	3.5	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. Using RC power supply filter as shown in <a href="#">Figure 12</a>
<b>Power Supply-Induced Phase Noise</b>	PSPN	–	-73	–	dBc	50 mV peak-peak ripple on VDD
	PSPN	–	-88	–	dBc	50 mV peak-peak ripple on VDD. Using RC power supply filter as shown in <a href="#">Figure 12</a>

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies


**Table 9. Electrical Characteristics – LVDS** | Supply voltage (“order code”): 1.8 V  $\pm$ 5% (“18”), 1.71 V to 3.63 V (“YY”). All typical specifications are measured at nominal supply of 2.5V and nominal frequency of 156.25 MHz unless otherwise stated. See [Figure 12](#) and [Figure 13](#) for test setups.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>Current Consumption, Frequency = 156.25 MHz</b>						
<b>Current Consumption, Output Enabled without Termination</b>	Idd_oe_nt	–	25.5	32	mA	Excluding load termination current
<b>Current Consumption, Output Enabled with Termination</b>	Idd_oe_wt	–	29	35	mA	Including load termination current. See <a href="#">Figure 33</a> and <a href="#">Figure 34</a> for termination
<b>Current Consumption Output Disabled with Termination</b>	Idd_od_wt	–	34.5	41	mA	Including load termination current. See <a href="#">Figure 33</a> and <a href="#">Figure 34</a> for termination. Driver output is at logic-high voltage levels.
<b>Output Characteristics</b>						
<b>Differential Output Voltage</b>	VOD	250	330	450	mV	See <a href="#">Figure 20</a> for waveform
<b>Delta VOD</b>	$\Delta$ VOD	–	–	50	mV	See <a href="#">Figure 20</a> for waveform
<b>Offset Voltage</b>	VOS	1.125	1.25	1.375	V	See <a href="#">Figure 20</a> for waveform
<b>Delta VOS</b>	$\Delta$ VOS	–	–	50	mV	See <a href="#">Figure 20</a> for waveform
<b>Rise/Fall Time</b>	Tr, Tf	–	290	330	ps	Measured 20% to 80% using <a href="#">Figure 34</a> for termination. See <a href="#">Figure 19</a> for waveform
<b>Differential Asymmetry, peak-peak</b>	V_da	–	25	–	mV	See <a href="#">Figure 21</a> for waveform
<b>Differential Skew, peak</b>	V_ds	–	$\pm$ 40	–	ps	See <a href="#">Figure 22</a> for waveform
<b>Overshoot Voltage, peak</b>	V_ov	–	8	–	%	Measured as percent of VOD. See <a href="#">Figure 24</a> for waveform
<b>Power Supply Noise Immunity</b>						
<b>Power Supply-Induced Jitter Sensitivity</b>	PSJS	–	22.5	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz
		–	3.5	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. Using RC power supply filter as shown in <a href="#">Figure 12</a>
<b>Power Supply-Induced Phase Noise</b>	PSPN	–	-71	–	dBc	50 mV peak-peak ripple on VDD
		–	-88	–	dBc	50 mV peak-peak ripple on VDD. Using RC power supply filter as shown in <a href="#">Figure 12</a>

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies


**Table 10. Electrical Characteristics – HCSL** | Supply voltage (“order code”): 2.5 V  $\pm$ 10% (“25”), 3.3 V  $\pm$ 10% (“33”), 2.25 V to 3.63 V (“XX”), 1.8 V  $\pm$ 5% (“18”), 1.71 V to 3.63 V (“YY”). All typical specifications are measured at nominal supply of 2.5V and nominal frequency of 156.25 MHz unless otherwise stated. See [Figure 14](#) and [Figure 15](#) for test setups.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>Current Consumption, Frequency = 156.25 MHz</b>						
<b>Current Consumption, Output Enabled without Termination</b>	Idd_oe_nt	–	25	31	mA	Excluding load termination current
<b>Current Consumption, Output Enabled with Termination</b>	Idd_oe_wt	–	39.5	45	mA	Including load termination current. See <a href="#">Figure 35</a> for termination
<b>Current Consumption, Output Disabled with Termination</b>	Idd_od_wt	–	45	52	mA	Including load termination current. See <a href="#">Figure 35</a> for termination. Driver output is at logic-high voltage levels.
<b>Output Characteristics</b>						
<b>Output High Voltage</b>	VOH	0.60	0.7	0.95	V	See <a href="#">Figure 18</a> for waveform
<b>Output Low Voltage</b>	VOL	-0.1	0	0.1	V	See <a href="#">Figure 18</a> for waveform
<b>Output Differential Voltage Swing</b>	V_Swing	1.1	1.4	1.6	V	See <a href="#">Figure 19</a> for waveform
<b>Rise/Fall Time</b>	Tr, Tf	–	340	370	ps	Measured 20% to 80%. See <a href="#">Figure 19</a> for waveform
<b>Differential Asymmetry, peak-peak</b>	V_da	–	65	–	mV	See <a href="#">Figure 21</a> for waveform
<b>Differential Skew, peak</b>	V_ds	–	$\pm$ 70	–	ps	See <a href="#">Figure 22</a> for waveform
<b>Overshoot Voltage, peak</b>	V_ov	–	0	–	%	Measured as percent of V_Swing. See <a href="#">Figure 23</a> for waveform
<b>Power Supply Noise Immunity</b>						
<b>Power Supply-Induced Jitter Sensitivity</b>	PSJS	–	27	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz
		–	3.5	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. Using RC power supply filter as shown in <a href="#">Figure 14</a>
<b>Power Supply-Induced Phase Noise</b>	PSPN	–	-70	–	dBc	50 mV peak-peak ripple on VDD
		–	-88	–	dBc	50 mV peak-peak ripple on VDD. Using RC power supply filter as shown in <a href="#">Figure 14</a>

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies


**Table 11. Electrical Characteristics – Low-Power HCSL** | Supply voltage (“order code”): 2.5 V  $\pm$ 10% (“25”), 3.3 V  $\pm$ 10% (“33”), 2.25 V to 3.63 V (“XX”), 1.8 V  $\pm$ 5% (“18”), 1.71 V to 3.63 V (“YY”). All typical specifications are measured at nominal supply of 2.5V and nominal frequency of 156.25 MHz unless otherwise stated. See [Figure 16](#) and [Figure 17](#) for test setups.

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>Current Consumption, Frequency = 156.25 MHz</b>						
<b>Current Consumption, Output Enabled without Termination</b>	Idd_oe_nt	–	26	31.5	mA	Excluding load termination current
<b>Current Consumption, Output Enabled with Termination</b>	Idd_oe_wt	–	26.5	32	mA	Including load termination current. See <a href="#">Figure 36</a> for termination
<b>Current Consumption, Output Disabled with Termination</b>	Idd_od_wt	–	28.5	35	mA	Including load termination current. See <a href="#">Figure 36</a> for termination. Driver output is at logic-high voltage levels.
<b>Output Characteristics</b>						
<b>Output High Voltage</b>	VOH	0.8	0.92	1.15	V	See <a href="#">Figure 18</a> for waveform
<b>Output Low Voltage</b>	VOL	-0.1	0	0.1	V	See <a href="#">Figure 18</a> for waveform
<b>Output Differential Voltage Swing</b>	V_Swing	1.6	1.83	2.0	V	See <a href="#">Figure 19</a> for waveform
<b>Rise/Fall Time</b>	Tr, Tf	–	330	380	ps	Measured 20% to 80%. See <a href="#">Figure 19</a> for waveform
<b>Differential Asymmetry, peak-peak</b>	V_da	–	55	–	mV	See <a href="#">Figure 21</a> for waveform
<b>Differential Skew, peak</b>	V_ds	–	$\pm$ 30	–	ps	See <a href="#">Figure 22</a> for waveform
<b>Overshoot Voltage, peak</b>	V_ov	–	1	–	%	Measured as percent of V_Swing. See <a href="#">Figure 23</a> for waveform
<b>Power Supply Noise Immunity</b>						
<b>Power Supply-Induced Jitter Sensitivity</b>	PSJS	–	18	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz
		–	6.5	–	fs/mV	Power supply ripple from 10 kHz to 20 MHz. Using RC power supply filter as shown in <a href="#">Figure 16</a>
<b>Power Supply-Induced Phase Noise</b>	PSPN	–	-73	–	dBc	50 mV peak-peak ripple on VDD
		–	-82	–	dBc	50 mV peak-peak ripple on VDD. Using RC power supply filter as shown in <a href="#">Figure 16</a>

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies

**Table 12. Absolute Maximum Ratings**

Operation outside the absolute maximum ratings may cause permanent damage to the part. Performance of the IC is only guaranteed within the operational specifications, not at absolute maximum ratings.

Parameter	Test Conditions	Min.	Max.	Unit
Continuous Power Supply Voltage Range (Vdd)		-0.5	4.0	V
Input Voltage, Maximum	Any input pin	–	Vdd + 0.3	V
Input Voltage, Minimum	Any input pin	-0.3	–	V
Storage Temperature		-65	150	°C
Maximum Junction Temperature		–	135	°C

**Table 13. Thermal Considerations<sup>[5]</sup>**

Package	$\theta_{JA}$ (°C/W)	$\Psi_{JT}$ (°C/W)	$\theta_{JB}$ (°C/W)	$\theta_{JC,Top}$ (°C/W)
3225, 6-pin	111	5.1	34	86
2520, 6-pin	126	4.8	39	118
2016, 6-pin	149	3.9	40	163

**Notes:**

- $\theta_{JA}$ ,  $\Psi_{JT}$ ,  $\theta_{JB}$  and  $\theta_{JC}$  are provided according to JEDEC standards 51-2A, 51-7, 51-8, and 51-12.01 with a 25°C ambient and 250 mW power consumption (typical of 1 GHz  $f_{out}$ ). The conduction thermal resistances  $\theta_{JB}$  and  $\theta_{JC}$  are obtained with the assumption that all heat flows from the junction to a heat sink through either the solder pads ( $\theta_{JB}$ ) or the top of the package ( $\theta_{JC,Top}$ ). These may be used in a two-resistor compact model. The values of  $\theta_{JA}$  and  $\Psi_{JT}$  are strongly application dependent, and we report values based on the JEDEC thermal environment.  $\theta_{JA}$  is the thermal resistance to ambient on a JEDEC PCB - it is a highly conservative estimate, since the JEDEC board does not have vias to PCB planes in the vicinity of the package.  $\Psi_{JT}$  can be used to estimate the junction temperature from measurements of the temperature at the top of the package if the thermal environment is similar to the JEDEC environment.

**Table 14. Maximum Operating Junction Temperature<sup>[6]</sup>**

Max Operating Temperature (ambient)	Maximum Operating Junction Temperature
70°C	80°C
85°C	95°C
95°C	105°C
105°C	115°C

**Notes:**

- Datasheet specifications are not guaranteed if junction temperature exceeds the maximum operating junction temperature.

**Table 15. Environmental Compliance**

Parameter	Test Conditions	Value	Unit
Mechanical Shock Resistance	MIL-STD-883F, Method 2002	10,000	g
Mechanical Vibration Resistance	MIL-STD-883F, Method 2007	70	g
Soldering Temperature (follow standard Pb free soldering guidelines) <sup>[7]</sup>	MIL-STD-883F, Method 2003	260	°C
Moisture Sensitivity Level	MSL1 @ 260°C		
Electrostatic Discharge (HBM)	HBM, JESD22-A114	2,000	V
Charge-Device Model ESD Protection	JESD220C101	750	V
Latch-up Tolerance	JESD78 Compliant		

**Notes:**

- Please refer to [SiTime Manufacturing Notes](#).

## SiT9501 Ultra-low Jitter Differential XO for Standard Networking Frequencies



### Pin Description

Table 16. Pin Description

Pin	Map	Functionality	
1	OE/NF	Output Enable (OE)	H <sup>[8]</sup> : Specified frequency output L <sup>[9]</sup> : OUT: Logic HIGH,
		No Function (NF)	Open, 120 k $\Omega$ internal pull-down resistor to GND
2	NF	No Function	H or L or Open: No effect on output frequency or other device functions. <sup>[10]</sup>
3	GND	Power	Power Supply Ground
4	OUTP	Output	Oscillator output
5	OUTN	Output	Complementary oscillator output
6	VDD	Power	Power supply voltage <sup>[8]</sup>

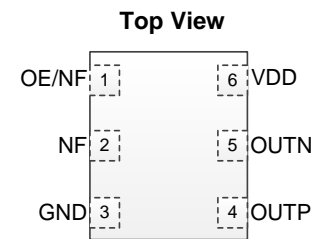


Figure 4. Pin Assignments

**Notes:**

8. OE pin includes a 120 k $\Omega$  internal pull-up resistor to VDD when active high, and a 120 k $\Omega$  internal pull-down resistor to GND when active low. In noisy environments, the OE pin is recommended to include an external 10 k $\Omega$  resistor (Use 10 k $\Omega$  pull-up if active high OE; use 10 k $\Omega$  pull-down if active low OE) when the pin is not externally driven.
9. Differential Logic high means OUTP=VOH, OUTN=VOL
10. Can be left open. SiTime recommends grounding it for better thermal performance.
11. A capacitor of value 0.1  $\mu$ F or higher between VDD and GND pins is required.

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies

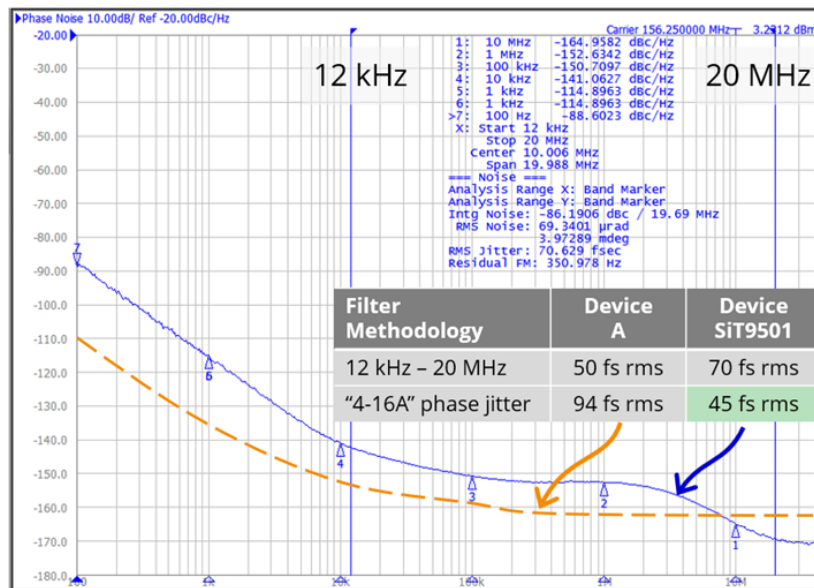


**“4-16A” Phase Jitter Methodology for SerDes Applications**

Proper evaluation of reference clock (refclk) jitter is critical to optimize system performance in high-speed serial links.

Figure 5 shows how the traditional 12 kHz to 20 MHz analysis of filtering refclk jitter can mislead designers to

select components that degrade rather than improve link performance. Using a more accurate filter analysis predicts a 50% reduction (45 vs 94 fs RMS) in jitter. Therefore, this datasheet replaces the legacy 12 kHz to 20 MHz filter analysis with a more accurate and established methodology adopted by several industry standards (e.g. PCI Express, CXL, UCIe) and implemented here as “4-16A” phase jitter. A brief overview follows.



**Figure 5. Two products analyzed with 2 different methodologies lead to opposite conclusions. The “4-16A” phase jitter methodology more accurately predicts in-system performance for modern SerDes applications.**

Established in 1991 for SONET OC-48 line rates, the traditional 12 kHz to 20 MHz jitter filter served as a golden reference to evaluate refclk jitter for over 30 years. The filter is used in nearly all clock and timing datasheets today. However, the results it provides no longer correlate with system performance and can create suboptimum link performance. Sources of filter error include incorrect corner frequencies, unrealistic brick-wall roll offs and a lack of accounting for aliased phase noise. Errors of tens of femtoseconds are significant today and will become more significant as data rates increase. For these reasons, we recommend customers adopt the more accurate “4-16A” phase jitter methodology for SerDes applications.

The conventional refclk jitter analysis uses a band-pass filter, as shown in Figure 6, to extract the refclk contribution to jitter observed at the receiver. Historically the refclk jitter filter was arbitrarily applied to phase noise up to an offset equal to the refclk Nyquist frequency. However, this ignores higher-offset phase noise that aliases when the refclk is sampled by a PLL’s digital phase detector. Studies have shown that extending the measured phase noise data flat to the third harmonic (or, twice the fundamental frequency in the offset-frequency axis) accurately estimates worst-case phase jitter<sup>[12]</sup>. Above the third harmonic, phase noise rolls off quickly and can be ignored.

**Note:**  
12. “How to evaluate reference-clock phase noise in high-speed serial links”, Signal Integrity Journal (May 3, 2019).

SiT9501 Ultra-low Jitter Differential XO for Standard Networking Frequencies

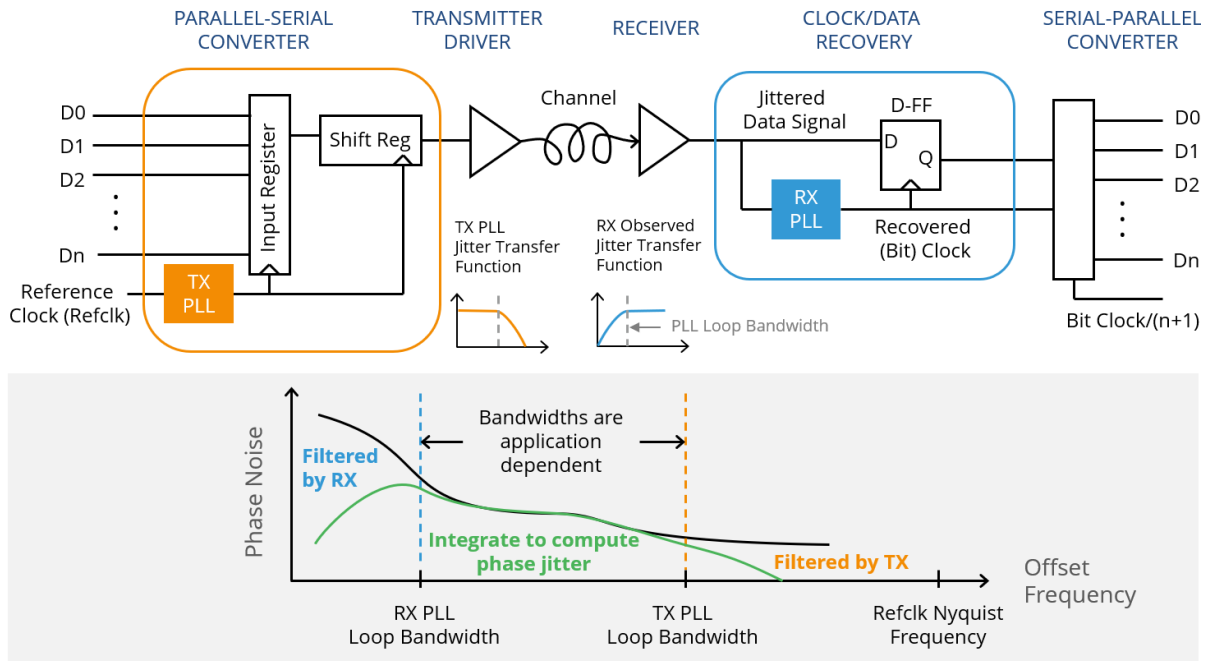


Figure 6. A generic serial link (top) uses a transmit PLL and receive CDR to low and high pass filter, respectively, refclk phase noise. This forms a band-pass system filter (bottom) for computing phase jitter.

The left Figure 7 chart illustrates this methodology of filtering aliased phase noise for a 156.25 MHz clock. Direct phase noise analyzer instruments (e.g., E5052B or FSWP) include an anti-aliasing filter. Thus, to account for aliasing, the phase noise is extended flat to the 3<sup>rd</sup> harmonic (468.75 MHz in the signal spectrum, or 312.5 MHz in offset frequency spectrum) and the jitter filter is folded across

Nyquist-zone boundaries (at 156.25/2, 156.25 and 156.25×3/2 MHz). Then the phase noise data is filtered and integrated to derive phase jitter. The right chart in Figure 7 illustrates a mathematically equivalent process that aliases the extended phase noise below an offset equal to the Nyquist frequency before filtering in the first Nyquist zone<sup>[12]</sup>.

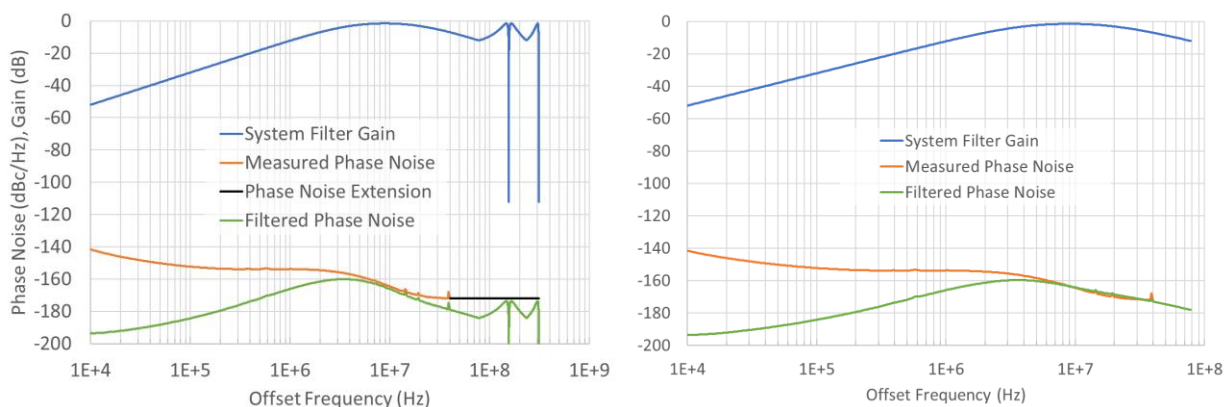


Figure 7. Illustration of two equivalent processes to filter aliased phase noise. The left chart extends (black) the measured phase noise (orange) to the 3<sup>rd</sup> harmonic, mirrors the filter (blue) across higher Nyquist zones before deriving the filtered phase noise (green). Alternatively, the right chart aliases the extended phase noise (not shown) below the Nyquist frequency before filtering (green). Integrating either green curve produces the same phase jitter.

A shorthand label for this methodology is “#-#A” phase jitter where the first and second numbers “#” are replaced with RX CDR and TX PLL bandwidths, respectively, and assuming 20 dB/dec roll offs (unless specified otherwise), and “A” indicates that aliasing is included. For example, “4-16A” phase jitter uses 4 MHz RX and 16 MHz TX bandwidths with aliasing. Here, 4 MHz represents the most common serial standard, Ethernet, which typically specifies a CDR bandwidth of 4 MHz for 10 Gbps and higher link

rates, and 16 MHz represents a worst-case estimate for TX PLL bandwidth (the PLL becomes unstable at higher bandwidths). This shorthand terminology makes it easy to describe variations. For example, “2-10A” phase jitter describes the same methodology but for 2 MHz RX CDR and 10 MHz TX PLL bandwidths. In practice, the exact bandwidths are application dependent, and “4-16A” is simply chosen here to represent the most common application (Ethernet).

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies



**FlexSwing Configurations**

A FlexSwing output-driver performs like LVPECL and additionally provides independent control of voltage swing and DC offset voltage levels. This simplifies interfacing with chipsets having non-standard input voltage requirements

and can eliminate all external source-bias resistors. FlexSwing supports power supply voltages from 1.71 V to 3.63 V, and the programmable VOH and VOL levels may be referenced to the voltage on either VDD or GND pins.

**Table 17. FlexSwing 2-digit Order Codes specifying VHn and VLn referenced to voltage on VDD pin**

Order Code V_Swing (V)		VLn																						
		A	B	C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	
		Vdd-2.31V	Vdd-2.26V	Vdd-2.21V	Vdd-2.16V	Vdd-2.11V	Vdd-2.06V	Vdd-2.01V	Vdd-1.96V	Vdd-1.91V	Vdd-1.86V	Vdd-1.82V	Vdd-1.77V	Vdd-1.72V	Vdd-1.67V	Vdd-1.62V	Vdd-1.57V	Vdd-1.52V	Vdd-1.47V	Vdd-1.42V	Vdd-1.37V	Vdd-1.32V	Vdd-1.28V	
VHn	A									AJ	AK	AL	AM	AN	AP	AQ	AR	AS	AT	AU	AV	AW	AX	
	B								1.94	1.94	BJ	BK	BL	BM	BN	BP	BQ	BR	BS	BT	BU	BV	BW	BX
	C							1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	
	D						1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	
	E				1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51		
	F				1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	
	G			1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	
	H		1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25	
	J	1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25		
	K	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25			
	L	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25				
	M	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25					
	N	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25						
	P	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25							
	Q	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25								
	R	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25									
	S	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25										
	T	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25											
	U	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25												
	V	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25													
	W	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25														

Supply Voltage	Available Colors
1.8V±5%	Not Supported
1.71V to 3.63V	Not Supported
2.5V±10%	Blue
3.3V±10%	Blue Red
2.25V to 3.63V	Blue
Note 13	Gray

**Note:**

- 13. Please [contact SiTime](#).
- 14. Table based on Y-Bias Termination with R3 = 220. See [Figure 30](#). Using different R3 value changes the VHn and VLn value.

The above table identifies supported combinations of nominal VOH (i.e. VHn) and nominal VOL (i.e. VLn) in colored boxes. The two-character code in each box corresponds to the VHn and VLn codes specified in the 2<sup>nd</sup> column and 2<sup>nd</sup> row in the table, respectively. The number in each box indicates the nominal differential swing (i.e. 2x VHn – VLn).

For example, order code “FS” selects VHn code “F” (i.e. Vdd-1.095 V) and VLn code “S” (i.e. Vdd-1.520 V) corresponding to a V\_Swing of 0.85 V peak-peak, which may be used for supply voltages of 2.5 V ±10%, 3.3 V ±10% or (2.25 V to 3.63 V). Alternatively, an order code of “GS” corresponds to a VHn code “G” (i.e. Vdd-1.14 V) and a VLn order code “S” (e.g. Vdd-1.520 V) corresponding to a V\_Swing of 0.760 V peak-peak, which may be used for a supply voltage of 3.3 V ±10%.

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies



**Table 18. FlexSwing 2-digit Order Codes specifying VHn and VLn referenced to voltage on GND pin**

Order Code V_Swing (V)		C	D	E	F	G	H	J	K	L	M	N	P	Q	R	S	T	U	V	W	X	Y										
		0.45V	0.49V	0.54V	0.59V	0.64V	0.69V	0.74V	0.79V	0.84V	0.89V	0.94V	0.99V	1.03V	1.08V	1.16V	1.23V	1.3V	1.38V	1.45V	1.53V	1.6V										
VHn	A																			AV	AW	AX	AY									
	B																			1.94	1.86	1.69	1.61									
		Supply Voltage		Available Colors																												
		1.8V±5%		Orange				Green																								
	C																			CU	CV	CW	CX	CY								
		1.71V to 3.63V		Green																												
	D																			DT	DU	DV	DW	DX	DY							
		2.5V±10%		Orange		Green		Blue		Purple																						
		3.3V±10%		Green				Blue		Red																						
	E																			ET	EU	EV	EW	EX	EY							
		2.25V to 3.63V		Green				Blue																								
		Note 15		Gray																												
	F																			FS	FT	FU	FV	FW	FX	FY						
																		1.94	1.77	1.69	1.52	1.44	1.27	1.18	1.10							
	G																			GS	GT	GU	GV	GW	GX	GY						
																		1.94	1.86	1.69	1.61	1.44	1.35	1.18	1.10							
	H																			HS	HT	HU	HV	HW	HX	HY						
																		1.94	1.86	1.77	1.69	1.61	1.52	1.35	1.27	1.10	1.01					
	J																			JS	JT	JU	JV	JW	JX	JY						
														1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.27	1.18	1.01	0.93								
	K																			KS	KT	KU	KV	KW	KX	KY						
												1.94	1.86	1.77	1.69	1.61	1.44	1.35	1.18	1.10	0.93	0.85										
	L																			LS	LT	LU	LV	LW	LX	LY						
												1.94	1.86	1.77	1.69	1.61	1.52	1.35	1.27	1.10	1.01	0.85	0.76									
M																			MR	MS	MT	MU	MV	MW	MX	MY						
											1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.27	1.18	1.01	0.93	0.76	0.68									
N																			NQ	NR	NS	NT	NU	NV	NX	NY						
											1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.18	1.10	0.93	0.85	0.68	0.59								
P																			PP	PQ	PR	PS	PT	PV	PW	PX	PY					
											1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.10	1.01	0.85	0.76	0.59	0.51							
Q																			QN	QP	QR	QS	QT	QU	QV	QW	QX	QY				
											1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.01	0.93	0.76	0.68	0.51	0.42						
R																			RM	RN	RP	RQ	RR	RS	RT	RV	RW	RY				
											1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	0.93	0.85	0.68	0.59	0.42	0.34					
S																			SL	SM	SN	SP	SQ	SR	SS	ST	SU	SV	SW	SY		
											1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.76	0.68	0.51	0.42	0.25				
T																			TK	TL	TM	TN	TP	TQ	TR	TS	TT	TU	TV	TY		
											1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.76	0.68	0.51	0.42	0.25				
U																			UJ	UK	UL	UM	UN	UP	UQ	UR	US	UT	UU	UY		
											1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.68	0.59	0.42	0.34				
V																			VH	VJ	VK	VL	VM	VN	VP	VQ	VR	VS	VT	VU	VY	
											1.94	1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.59	0.51	0.34	0.25			
W																			WG	WH	WJ	WK	WL	WM	WN	WP	WQ	WR	WS	WT	WY	
											1.86	1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.51	0.42	0.25				
X																			XF	XG	XH	XJ	XK	XL	XM	XN	XP	XQ	XR	XS	XZ	
											1.77	1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34				
Y																			YE	YF	YG	YH	YJ	YK	YL	YM	YN	YP	YQ	YR	YS	YZ
											1.69	1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.34	0.25					
Z																			ZD	ZE	ZF	ZG	ZH	ZJ	ZK	ZL	ZM	ZN	ZP	ZQ	ZR	ZY
											1.61	1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.25						
1																			1C	1D	1E	1F	1G	1H	1J	1K	1L	1M	1N	1P	1Q	1Y
											1.52	1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34							
2																			2C	2D	2E	2F	2G	2H	2J	2K	2L	2M	2N	2P	2Y	
											1.44	1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25							
3																			3C	3D	3E	3F	3G	3H	3J	3K	3L	3M	3N	3P	3Y	
											1.35	1.27	1.18	1.10	1.01	0.93	0.85	0.76	0.68	0.59	0.51	0.42	0.34	0.25								

Note:  
15. Please [contact SiTime](#).

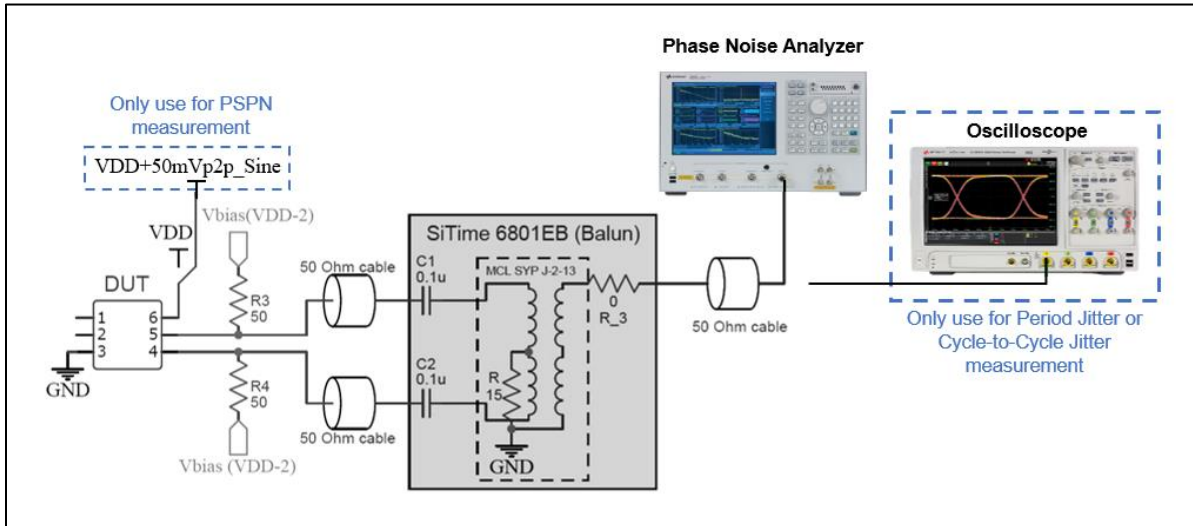
**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies



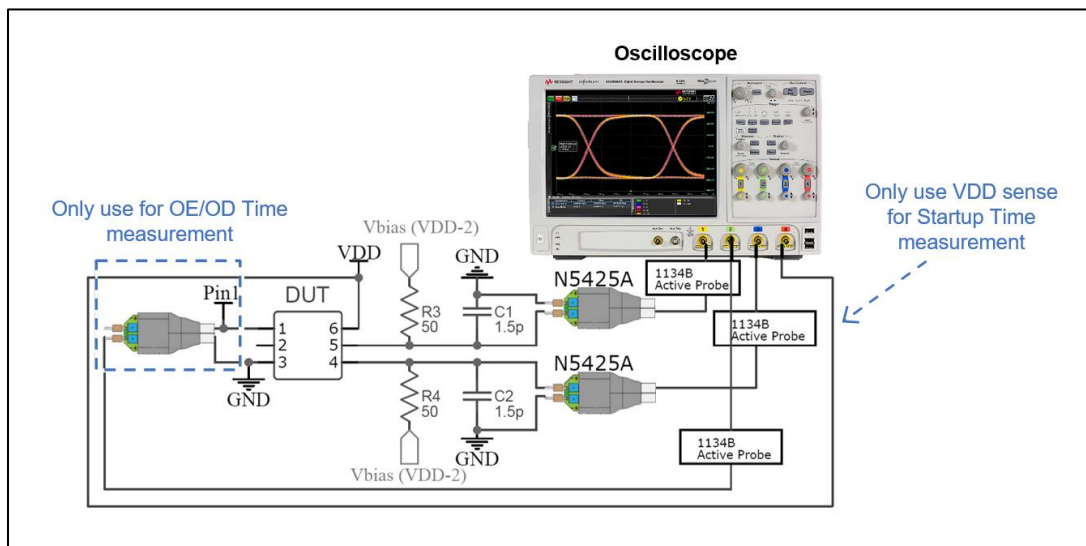
**Test Circuit Diagrams**

A 1.5 pF capacitive load is used at each differential output. Because of the additive input capacitance of the active probe used with the oscilloscope, the output characteristics for all signal types are measured with a total of 2 pF capacitive load.

**Test Setups for LVPECL Measurements**



**Figure 8. Test setup to measure LVPECL Phase Noise, Period Jitter, Cycle-to-Cycle Jitter, and Power Supply-Induced Phase Noise (PSPN) without filter added<sup>[16]</sup>**



**Figure 9. Test setup to measure LVPECL Waveform Characteristics, Current Consumption (with Termination 2)<sup>[17]</sup>, Output Enable/Disable Time, and Startup Time**

**Notes:**

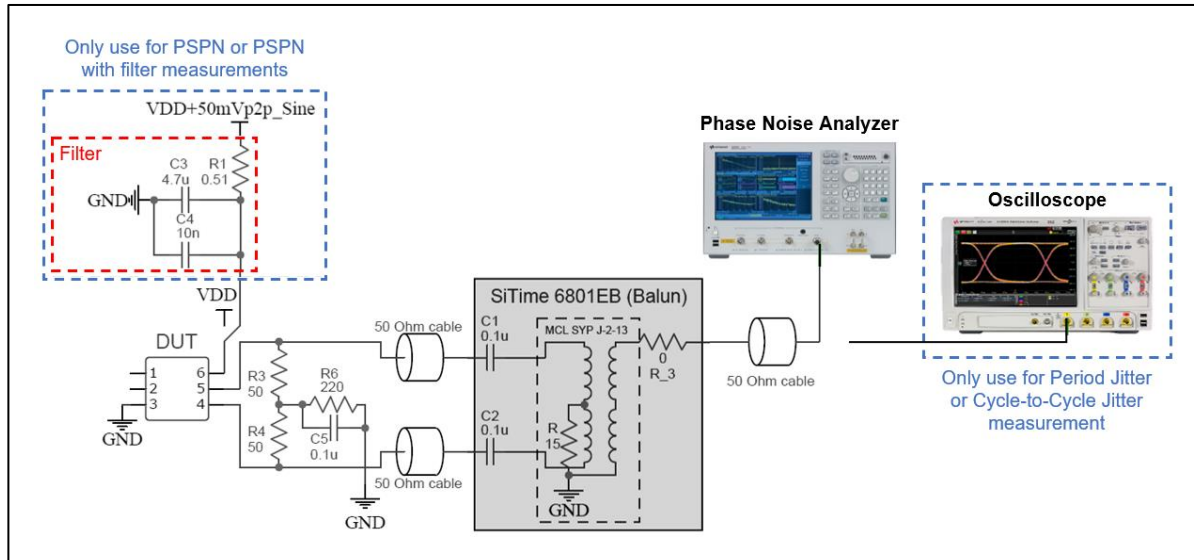
- 16. See Figure 10 for the test setup to measure LVPECL Power Supply-Induced Phase Noise (PSPN) with filter added.
- 17. See Figure 11 for the test setup to measure LVPECL Current Consumption with Termination 1 or without Termination.

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies

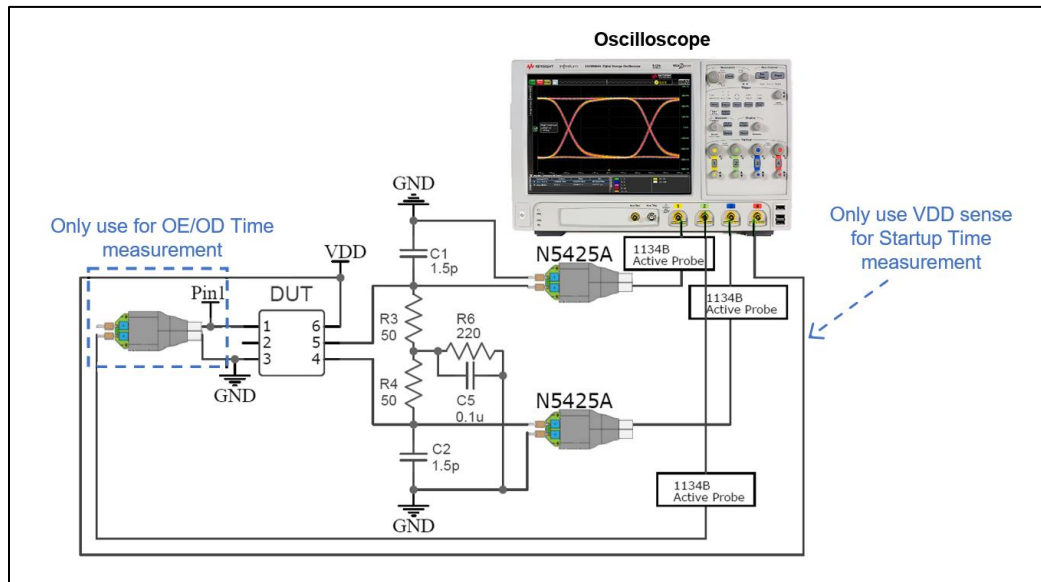


**Test Circuit Diagrams (continued)**

**Test Setups for FlexSwing Measurements<sup>[18]</sup>**



**Figure 10. Test setup to measure FlexSwing Phase Noise, Period Jitter, Cycle-to-Cycle Jitter, and Power Supply-Induced Phase Noise (PSPN) with and without filter added<sup>[19]</sup>**



**Figure 11. Test setup to measure FlexSwing Waveform Characteristics, Current Consumption<sup>[20]</sup>, Output Enable/Disable Time, and Startup Time**

**Note:**

- 18. The same test circuits are used for FlexSwing referenced to VDD and FlexSwing referenced to GND.
- 19. Test setup is also used to measure LVPECL Power Supply-Induced Phase Noise (PSPN) with filter added.
- 20. Test setup is also used to measure LVPECL Current Consumption with Termination 1 or without Termination.

SiT9501 Ultra-low Jitter Differential XO for Standard Networking Frequencies



Test Circuit Diagrams (continued)

Test Setups for LVDS Measurements

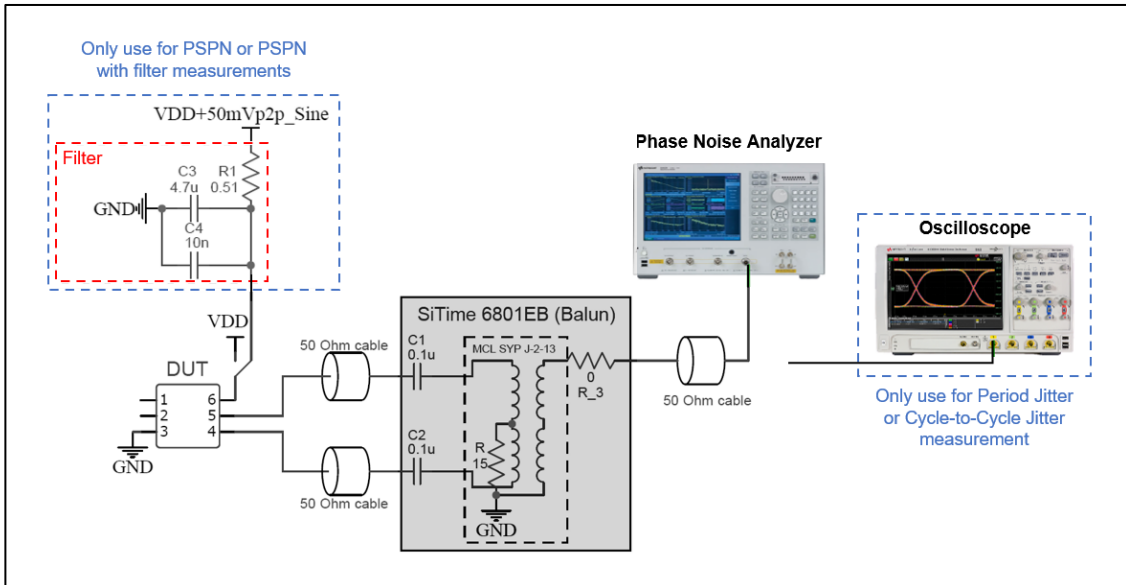


Figure 12. Test setup to measure LVDS Phase Noise, Period Jitter, Cycle-to-Cycle Jitter, and Power Supply-Induced Phase Noise (PSPN) with and without filter added

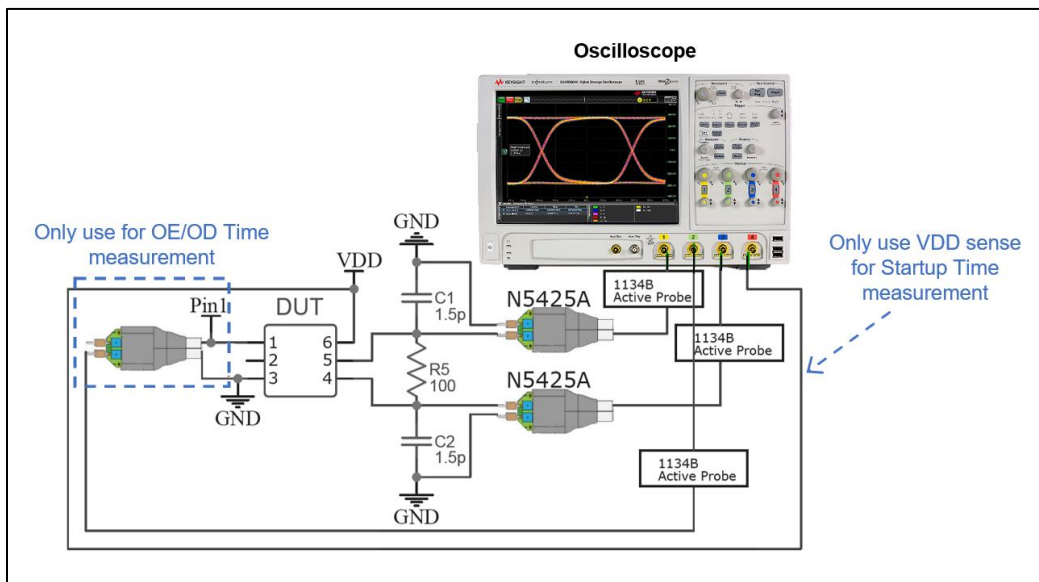


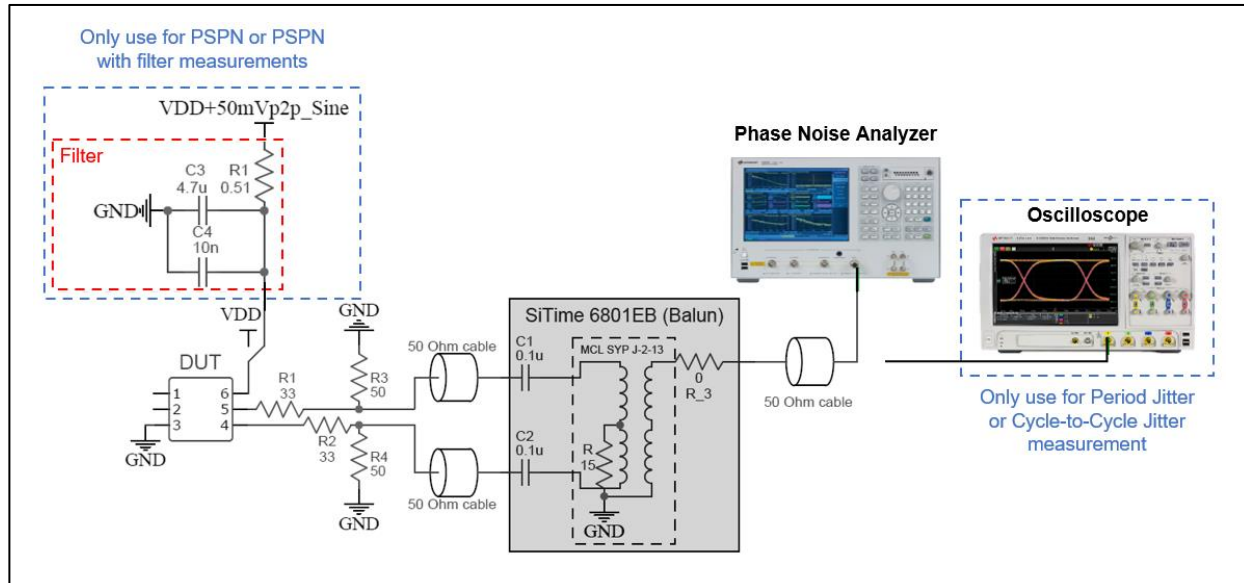
Figure 13. Test setup to measure LVDS Waveform Characteristics, Current Consumption, Output Enable/Disable Time, and Startup Time

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies

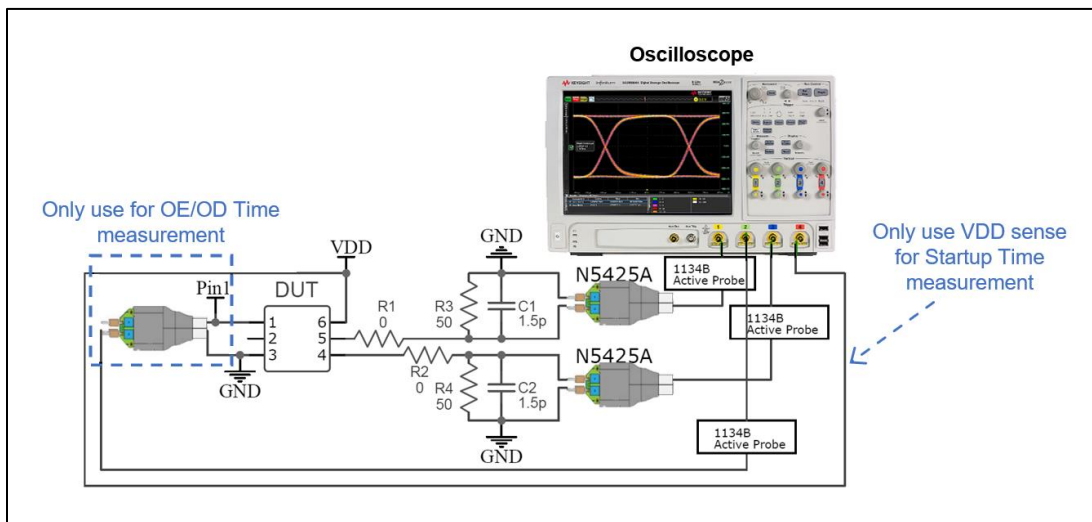


**Test Circuit Diagrams (continued)**

**Test Setups for HCSL Measurements**



**Figure 14. Test setup to measure HCSL Phase Noise, Period Jitter, Cycle-to-Cycle Jitter, and Power Supply-Induced Phase Noise (PSPN) with and without filter added**



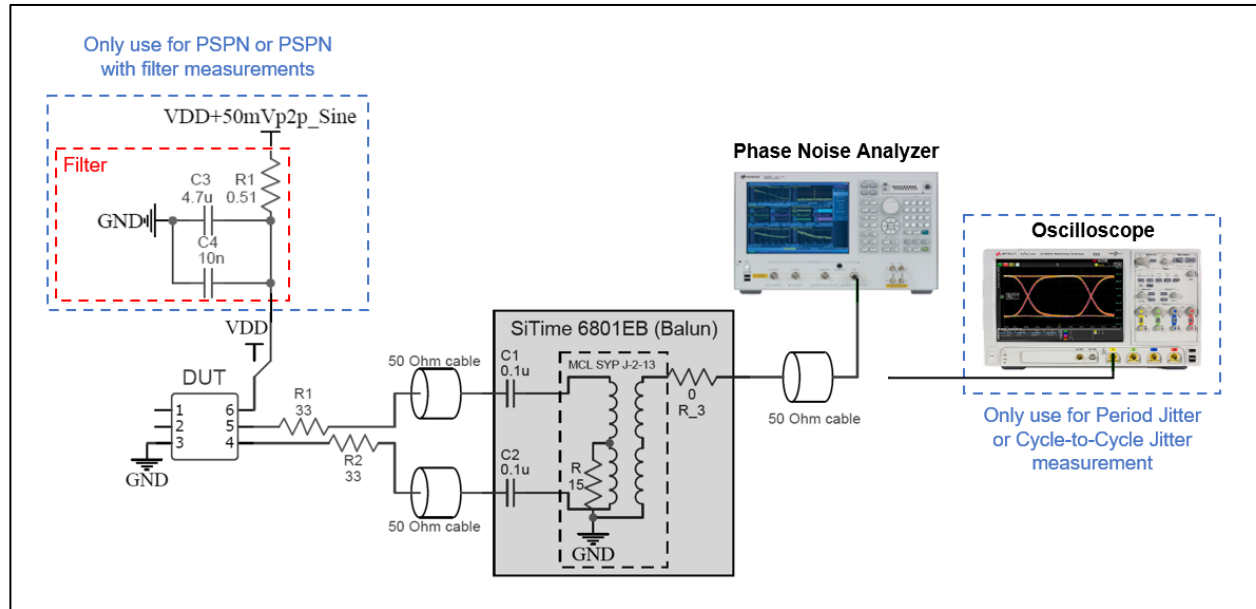
**Figure 15. Test setup to measure HCSL Waveform Characteristics, Current Consumption, Output Enable/Disable Time, and Startup Time**

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies

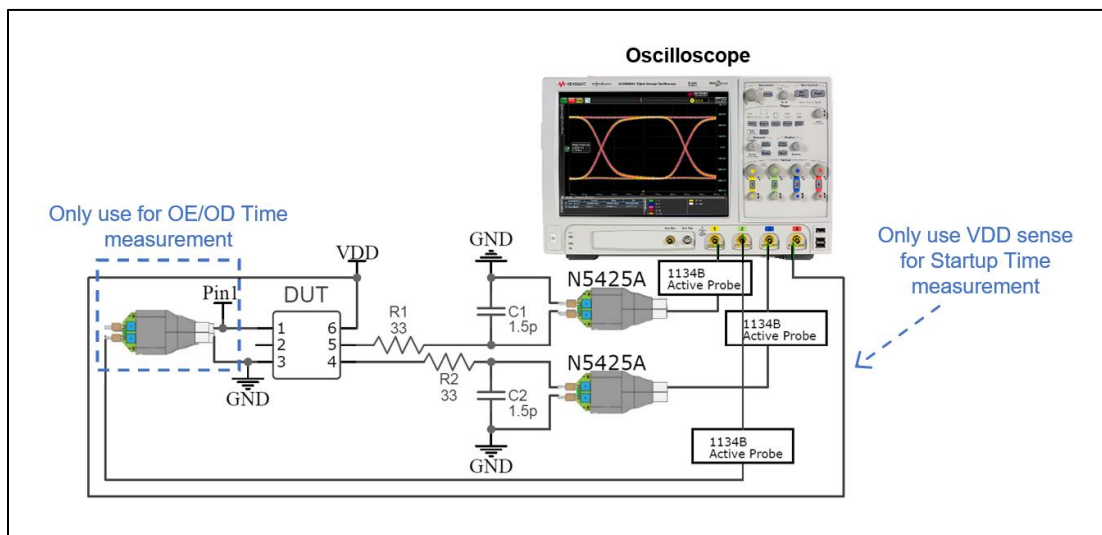


**Test Circuit Diagrams (continued)**

**Test Setups for Low-Power HCSL Measurements**



**Figure 16. Test setup to measure Low-Power HCSL Phase Noise, Period Jitter, Cycle-to-Cycle Jitter, and Power Supply-Induced Phase Noise (PSPN) with and without filter added**

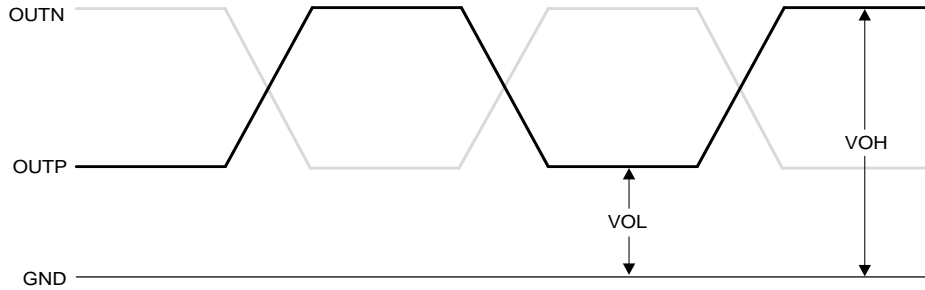


**Figure 17. Test setup to measure Low-Power HCSL Waveform Characteristics, Current Consumption, Output Enable/Disable Time, and Startup Time**

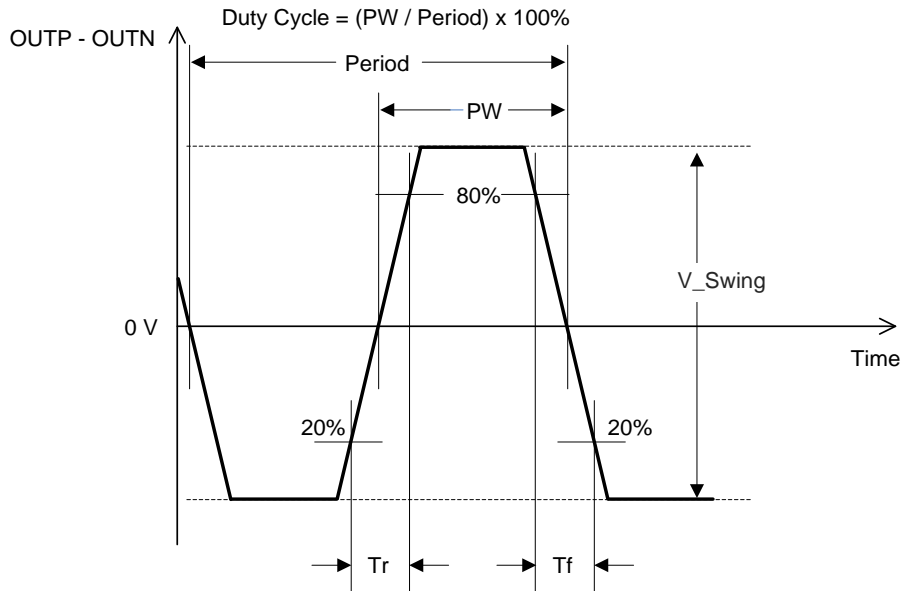
**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies



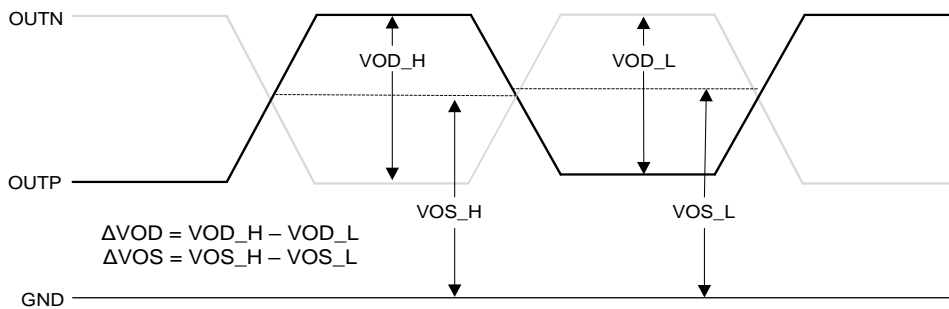
**Waveform Diagrams**



**Figure 18. LVPECL, HCSL, Low-Power HCSL, and FlexSwing Voltage Levels per Differential Pin**



**Figure 19. LVPECL, LVDS, HCSL, Low-Power HCSL, and FlexSwing Voltage Levels Across Differential Pair**

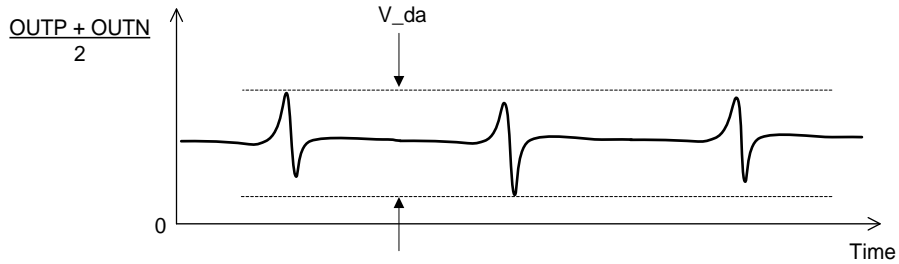


**Figure 20. LVDS Voltage Levels per Differential Pin**

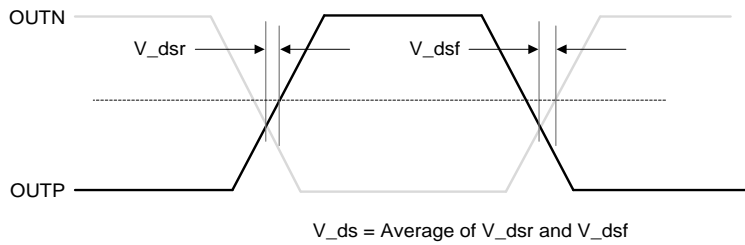
**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies



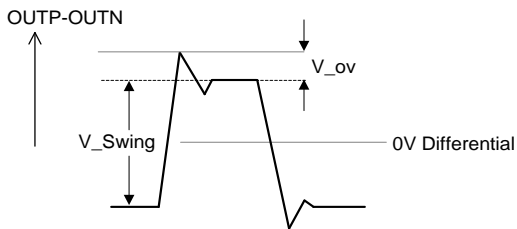
**Waveform Diagrams (continued)**



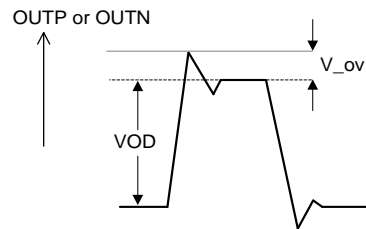
**Figure 21. Differential Asymmetry ( $V_{da}$ )**



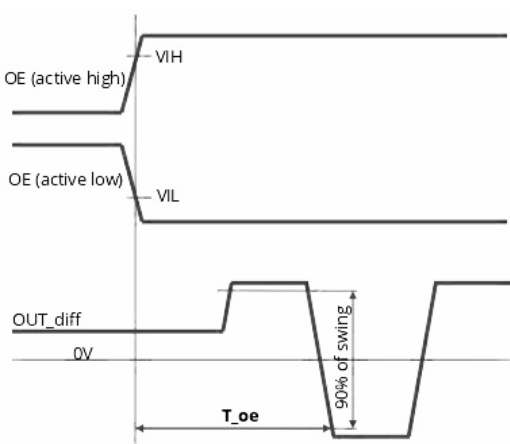
**Figure 22. Differential Skew ( $V_{ds}$ ) is measured as the Time between the Average Voltage Level and Crossing Voltage**



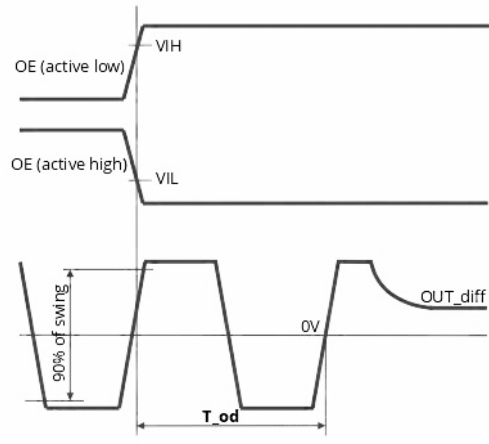
**Figure 23. Overshoot Voltage ( $V_{ov}$ ) for LVPECL, FlexSwing, HCSL, Low-power HCSL**



**Figure 24. Overshoot Voltage ( $V_{ov}$ ) for LVDS Output**



**Figure 25. OE Pin Enable Timing ( $T_{oe}$ )**



**Figure 26. OE Pin Disable Timing ( $T_{od}$ )**

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies



**Termination Diagrams**

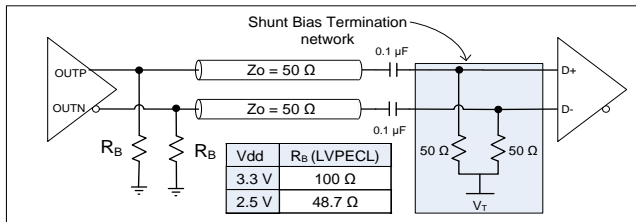
**LVPECL and FlexSwing Termination**

The SiT9501 FlexSwing output drivers support low power without sacrificing signal integrity via simple terminations as shown in Figure 28 and Figure 30, compared to traditional LVPECL drivers. The FlexSwing and LVPECL outputs are

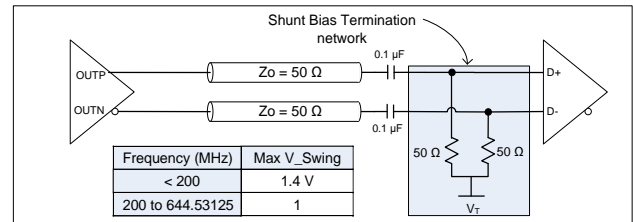
voltage-mode drivers. Use the table and figures below to select a termination circuit for the desired supply voltage. The table also provides LVPECL current consumption ( $I_{load}$ ) into the load termination.

**Table 19. Termination Options for LVPECL and FlexSwing Signaling**

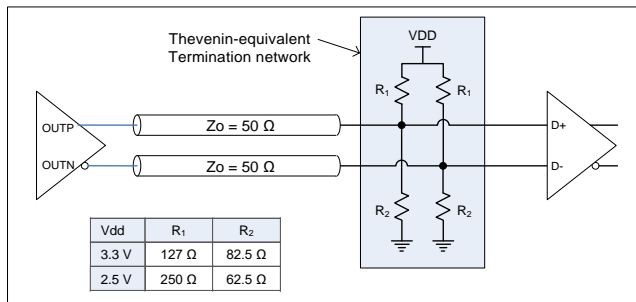
Signaling	Supply Voltage Order Codes	Termination Options					
		Figure 27	Figure 28	Figure 29	Figure 30	Figure 31	Figure 32
LVPECL referenced to Vdd	"25", "33", "XX"	OK to use $I_{load} = 40\text{ mA}$ with $100\ \Omega$ near-end bias resistor	<b>Do Not Use</b>	OK to use $I_{load} = 28\text{ mA}$	OK to use	OK to use $I_{load} = 28\text{ mA}$	<b>Do Not Use</b>
FlexSwing referenced to Vdd		OK to use <sup>21</sup>	OK to use (see Figure 28 for frequency ranges and voltage swings)	OK to use <sup>22</sup>	OK to use	OK to use	<b>Do Not Use</b>
FlexSwing referenced to Gnd	"25", "33", "XX", "YY"	OK to use <sup>21</sup>	OK to use (see Figure 28 for frequency ranges and voltage swings)	<b>Do Not Use</b>	OK to use	<b>Do Not Use</b>	<b>Do Not Use</b>
	"18"			<b>Do Not Use</b>	OK to use	<b>Do Not Use</b>	OK to use



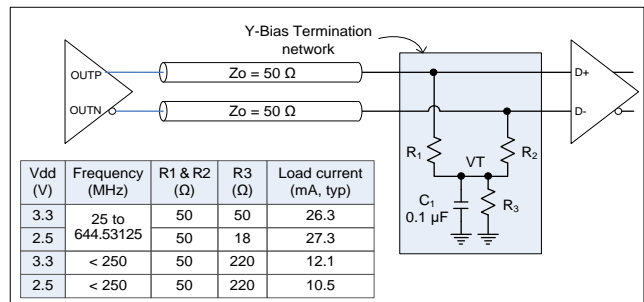
**Figure 27. Recommended LVPECL and FlexSwing<sup>[21]</sup> Termination when AC-coupled**



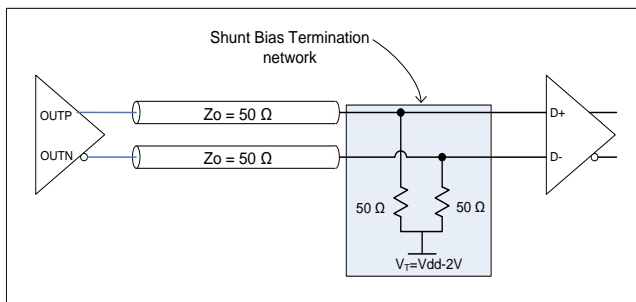
**Figure 28. Recommended FlexSwing Termination when AC-coupled**



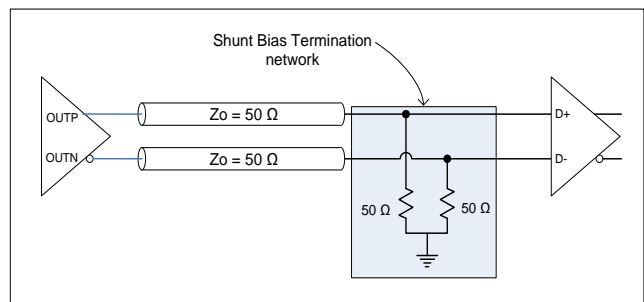
**Figure 29. LVPECL and FlexSwing DC-coupled Load Termination with Thevenin Equivalent Network<sup>[22]</sup>**



**Figure 30. LVPECL and FlexSwing with Y-Bias Termination**



**Figure 31. LVPECL and FlexSwing with DC-coupled Parallel Shunt Load Termination**



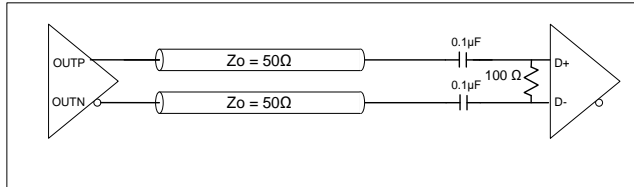
**Figure 32. FlexSwing Termination – Only for use with Supply Voltage Order Code "18"**

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies

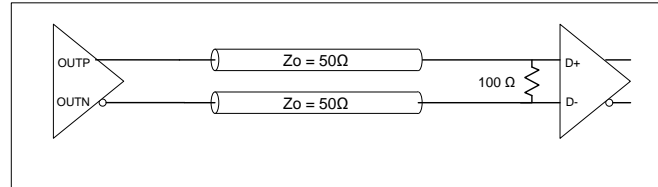


**Termination Diagrams (continued)**

**LVDS, Supply Voltage: 1.8 V ±5%, 2.5 V ±10%, 3.3 V ±10%, 2.25 V to 3.63 V, 1.71 V to 3.63 V**

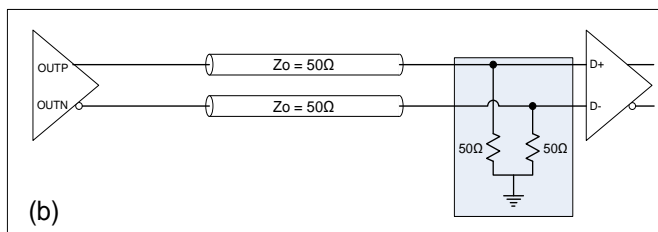
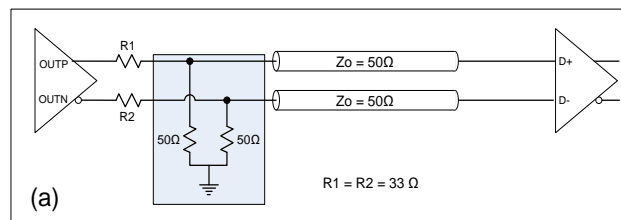


**Figure 33. LVDS AC Termination**



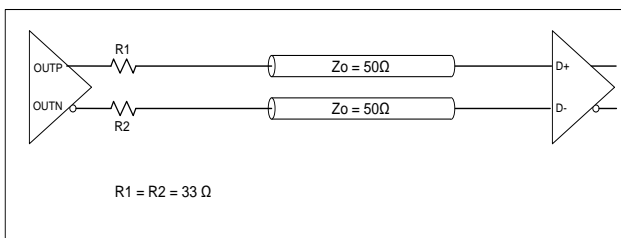
**Figure 34. LVDS DC Termination at the Load**

**HCSL, Supply Voltage: 1.8 V ±5%, 2.5 V ±10%, 3.3 V ±10%, 2.25 V to 3.63 V, 1.71 V to 3.63 V**



**Figure 35. (a) HCSL Source Termination and (b) HCSL Load Termination**

**Low-power HCSL, Supply Voltage: 1.8 V ±5%, 2.5 V ±10%, 3.3 V ±10%, 2.25 V to 3.63 V, 1.71 V to 3.63 V**



**Figure 36. Low-power HCSL Termination**

**Notes:**

- 21. Contact SiTime for optimum  $R_B$  values for FlexSwing options.
- 22. Contact SiTime for optimum  $R_1$  and  $R_2$  values for FlexSwing options.

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies



**Dimensions and Patterns — 2.0 x 1.6 mm x mm**

Package Size – Dimensions (Unit: mm)<sup>[23]</sup>

(TOP VIEW)                      (BOTTOM VIEW)

(SIDE VIEW)

	SYMBOL	MIN	NOM	MAX
TOTAL THICKNESS	A	0.700	0.750	0.800
STAND OFF	A1	0.000	0.035	0.050
BODY SIZE	X	D		
	Y	E		
LEAD WIDTH	b	0.225	0.275	0.325
LEAD LENGTH	L	0.300	0.400	0.500
LEAD PITCH	e	0.730 BSC		
PACKAGE TOLERANCE	aaa	0.100		
MOLD FLATNESS	bbb	0.100		
COPLANARITY	ccc	0.080		
NOTE				
1. ALL DIMENSION IN MM				

PKG INFO		DRAWING NO.	
6L PQFN 2.000x1.600x0.750 mm		POD-077-PQFN-006-C02016	
DATE	12/6/2021	REV	SHEET
		B02	01

Recommended Land Pattern (Unit: mm)<sup>[24]</sup>

Note : All units in mm.

PKG INFO		SPL DRAWING NO.	
6L QFN 2.000x1.600 mm		SPL-077-QFN-006-C02016	
DATE	2020/04/20	REV	SHEET
		B00	01

**Notes:**

- 23. Top Marking: Y denotes manufacturing origin and XXXX denotes manufacturing lot number. The value of "Y" will depend on the assembly location of the device.
- 24. A capacitor of value 0.1  $\mu$ F or higher between VDD and GND is required. An additional 10  $\mu$ F capacitor between VDD and GND is required for the best phase jitter performance.

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies



**Dimensions and Patterns — 2.5 x 2.0 mm x mm**

Package Size – Dimensions (Unit: mm)<sup>[23]</sup>

(TOP VIEW)                      (BOTTOM VIEW)

(SIDE VIEW)

	SYMBOL	MIN	NOM	MAX
TOTAL THICKNESS	A	0.800	0.850	0.900
STAND OFF	A1	0.000	0.035	0.050
BODY SIZE	X	D		
	Y	E		
LEAD WIDTH	b	0.330	0.380	0.430
LEAD LENGTH	L	0.550	0.650	0.750
LEAD PITCH	e	0.900 BSC		
PACKAGE TOLERANCE	aaa	0.100		
MOLD FLATNESS	bbb	0.100		
COPLANARITY	ccc	0.080		

NOTE

1. ALL DIMENSION IN MM

PKG INFO		DRAWING NO.	
6L PQFN 2.500x2.000x0.850 mm		POD-092-PQFN-006-C02520	
DATE	2/28/2024	REV	SHEET
		A01	01

Recommended Land Pattern (Unit: mm)<sup>[24]</sup>

Note : All units in mm.

PKG INFO		SPL DRAWING NO.	
6L PQFW 2.500x2.000 mm		SPL-078-PQFW-006-C02520	
DATE	2020/04/20	REV	SHEET
		A00	01

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies



**Dimensions and Patterns — 3.2 x 2.5 mm x mm**

Package Size – Dimensions (Unit: mm)<sup>[23]</sup>

	SYMBOL	MIN	NOM	MAX
TOTAL THICKNESS	A	0.800	0.850	0.900
STAND OFF	A1	0.000	0.035	0.050
BODY SIZE	X	D		
	Y	E		
LEAD WIDTH	b	0.550	0.600	0.650
	L	0.650	0.700	0.750
LEAD LENGTH	L1	0.800 REF		
LEAD PITCH	e	1.100 BSC		
PACKAGE TOLERANCE	aaa	0.100		
MOLD FLATNESS	bbb	0.100		
COPLANARITY	ccc	0.080		
DIMPLE WIDTH	T	0.150 REF		
DIMPLE LENGTH	P	0.150 REF		
DIMPLE DEPTH	A2	0.100 REF		
NOTE				
1. ALL DIMENSION IN MM				
PKG INFO		DRAWING NO.		
6L PQFD 3.200x2.500x0.850 mm		POD-076-PQFD-006-C03225		
DATE	10/11/2022	REV	SHEET	
		B01	01	

Recommended Land Pattern (Unit: mm)<sup>[24]</sup>

Note : All units in mm.

	PKG INFO	SPL DRAWING NO.	
	6L QFN 3.200x2.500 mm	SPL-076-QFN-006-C03225	
DATE	REV	SHEET	
2020/04/20	B00	01	

**SiT9501** Ultra-low Jitter Differential XO for Standard Networking Frequencies

**Additional Information**
**Table 20. Additional Information**

Document	Description	Download Link
<b>ECCN #: EAR99</b>	Five character designation used on the commerce Control List (CCL) to identify dual use items for export control purposes.	—
<b>HTS Classification Code: 8542.39.0000</b>	A Harmonized Tariff Schedule (HTS) code developed by the World Customs Organization to classify/define internationally traded goods.	—
<b>Manufacturing Notes</b>	Tape & Reel dimension, reflow profile and other manufacturing related info	<a href="https://www.sitime.com/support/resource-library/manufacturing-notes-sitime-products">https://www.sitime.com/support/resource-library/manufacturing-notes-sitime-products</a>
<b>Termination Techniques</b>	Termination design recommendations	<a href="http://www.sitime.com/support/application-notes">http://www.sitime.com/support/application-notes</a>
<b>Layout Techniques</b>	Layout recommendations	<a href="http://www.sitime.com/support/application-notes">http://www.sitime.com/support/application-notes</a>
<b>Evaluation Boards</b>	SiT6760EB	<a href="https://www.sitime.com/support/resource-library/user-manuals/sit6760eb-evaluation-board-user-manual">https://www.sitime.com/support/resource-library/user-manuals/sit6760eb-evaluation-board-user-manual</a>

## SiT9501 Ultra-low Jitter Differential XO for Standard Networking Frequencies



### Revision History

Table 21. Revision History

Revision	Release Date	Change Summary
0.5	27-Apr-2020	Advanced datasheet
0.51	18-May-2020	Formatting changes Fixed typos Added 2016 and 2520 packages
0.52	1-Jun-2020	Formatting changes Updated package drawings
0.53	2-Aug-2020	Modified Termination Diagrams section
0.54	23-Sep-2020	Modified LVPECL, FlexSwing, LVDS current consumption specifications Modified phase jitter specification Added FlexSwing order codes Added 250u T&R order code Changed rev table date format
0.55	23-Oct-2020	Trademarks update Modified termination for HCSL and low-power HCSL rise/fall time specs
0.56	15-Dec-2020	Updated current consumption
0.57	5-Jan-2021	Updated FlexSwing Electrical Characteristics tables and description Formatting updates
0.58	20-Jan-2022	General Updates
0.59	21-Mar-2022	General Updates
0.9	29-Jul-2022	Added Test Diagrams section Updated Electrical Characteristics tables and descriptions
0.91	1-Aug-2022	Preliminary datasheet
0.92	12-Aug-2022	Updated Test Diagrams and formatting
0.93	15-Aug-2022	Added additional jitter integration bandwidths Updated Disclaimer
0.94	11-Jan-2023	Updated Dimensions & Pattern diagrams
0.95	20-June-2023	Added 4-16A Phase Jitter specification and how to measure section
0.96	22-Aug-2023	Formatting changes to phase jitter specs
1.0	28-Feb-2024	Updated 2520 package Dimensions drawing Rev 1.0 Production Release

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