



APPLICATION NOTE

AN1431: Si51x XO and VCXO Frequently Asked Questions

This document answers some of the most frequently asked questions for the Si510/11/12/13/14/15/16 oscillators. See Table 1 below for more details on the devices covered by this document. If you do not find the answers you are looking for, please contact [Skyworks Support and Resources](#).

Table 1. Covered Products

Type	Product	Number of Frequencies	Phase Jitter (fs RMS)	Frequency Range (MHz)
General Purpose Oscillator (XO)	Si510	Single	XO: 800, VCXO: 900	0.1 to 250
	Si511	Single		
	Si512	Dual		
	Si513	Dual		
Si514	Any (I ² C-enabled)			
General Purpose Voltage-Controlled Crystal Oscillator (VCXO)	Si515	Single		
	Si516	Dual		

Table 2. Frequently Asked Question Links

Question Category	Cross-Reference Link
Packaging	1.1. Is the Si51x oscillator, PCB land pattern, and package dimensions compatible with industry standards?
	1.2. What is the material composition of the pins?
	1.3. Is the plating process immersion gold, electroless gold, or electrolytic?
	1.4. What is the Moisture Sensitivity Level (MSL) of the ceramic packages?
	1.5. What is the MSL of the 2.5 x 3.2 mm package?
	1.6. Are the CLCC packages hermetically sealed?
	1.7. Are any flame retardants (halogen compounds) used in the package?
Quality and production	2.1. Where can I find RoHS, REACH, or other materials related to compliance information?
	2.2. Are the oscillator products available in tape and reel?
	2.3. What are the qualification test requirements for the Skyworks lead-free, RoHS-compliant, CLCC packages?

Table 2. Frequently Asked Question Links (Continued)

Question Category	Cross-Reference Link
Thermal and soldering	3.1. What is the maximum operating junction temperature of these devices?
	3.2. What are the Θ_{JA}, Θ_{JB}, and Θ_{JC} for these devices?
	3.3. What is the Coefficient of Thermal Expansion (CTE) in the plane of the PWB (x and y) for the 2.5 x 3.2 mm package?
	3.4. What is the typical temperature rise of one of these devices?
	3.5. Are the devices compatible with both leaded and “lead-free” assembly processes?
	3.6. What are the max reflow temperatures and profiles recommended for “lead-free” and “leaded” solder reflow processes?
	3.7. How many solder reflow cycles can the crystal oscillators support?
General part functionality	4.1. Is the FS pin on a Si510, Si511, Si512, Si513, or Si516 internally pulled up or pulled down?
	4.2. Is the frequency of a Si51x free running or is it internally controlled?
	4.3. What output clock skew data is available for the Si510/511?
	4.4. Can these oscillators output a sinusoid waveform instead of a square wave?
	4.5. Can VDD be set to a voltage other than the recommended driver voltage (e.g., when running a 3.3 V LVDS part at 2.5 V)?
	4.6. What output formats are supported by the Skyworks Si51x crystal oscillators for VDD = 1.8 V?
	4.7. Is it acceptable to route traces directly beneath Si51x crystal oscillators?
I ² C communication	5.1. What is the I2C address of my Si514?
	5.2. Is the I2C bus working correctly?
VCXO functionality (Si515/Si516 only)	6.1. What is Absolute Pull Range (APR)?
	6.2. Why is there no min APR listed for 2.5 V or 1.8 V for certain Kv values?

Table 3. Product Links

Link Type	Link
Si510 product web page	skyworksinc.com/en/Products/Timing/General-Purpose-Oscillators-XO/Si510
Si511 product web page	skyworksinc.com/en/Products/Timing/General-Purpose-Oscillators-XO/Si511
Si512 product web page	skyworksinc.com/en/Products/Timing/General-Purpose-Oscillators-XO/Si512
Si513 product web page	skyworksinc.com/en/Products/Timing/General-Purpose-Oscillators-XO/Si513
Si514 product web page	skyworksinc.com/en/Products/Timing/General-Purpose-Oscillators-XO/Si514
Si515 product web page	skyworksinc.com/en/Products/Timing/General-Purpose-Voltage-Controlled-Crystal-Oscillators-VCXO/Si515
Si516 product web page	skyworksinc.com/en/Products/Timing/General-Purpose-Voltage-Controlled-Crystal-Oscillators-VCXO/Si516
Part number lookup utility	tools.skyworksinc.com/TimingUtility/timing-part-number-search-results.aspx
Oscillator phase noise lookup utility	skyworksinc.com/tools/oscillator-phase-noise
Evaluation board/development kit	skyworksinc.com/en/Products/Timing/General-Purpose-Oscillators-XO/Si514#sectionEvaluation
Programmable oscillator calculator	skyworksinc.com/en/application-pages/Programmable-Oscillator-Software
Quality and reliability reports	skyworksinc.com/quality
Request technical support	Skyworks Support and Resources

Table 4. Relevant Application Notes

Link Type	Link
Application note	AN587: Output Termination Guide
	AN266: VCXO Tuning Slope (Kv), Stability, and Absolute Pull Range (APR)

1. Packaging

1.1. Is the Si51x oscillator, PCB land pattern, and package dimensions compatible with industry standards?

Yes, the package allows drop-in replacement of existing oscillators with the same packages. PCB land pattern and package dimension information can be found in device data sheets on the [Oscillators](#) product pages.

1.2. What is the material composition of the pins?

The pad composition on the 5 x 7 mm and 3.2 x 5 mm CLCC package are both NiAu (Nickel Gold):

- Ni (Nickel) thickness ranges between: 1.27 and 8.89 μm .
- Au (Gold) thickness is 0.3 μm (minimum) to 1.0 μm (maximum).

The pad composition on the 2.5 x 3.2 mm package is:

- Ni (Nickel) thickness ranges between 4 and 20 μm .
- Au (Gold) thickness ranges between 0.3 and 1.3 μm .

Refer to the [Skyworks Certificate of Conformance](#) web page for more information. Make sure to type the entire part number, including the dash suffix.

1.3. Is the plating process immersion gold, electroless gold, or electrolytic?

These oscillators use an electroless gold process.

1.4. What is the Moisture Sensitivity Level (MSL) of the ceramic packages?

Per the JEDEC specification (IPC/JEDEC J-STD-020C, July 2004), the devices are classified as MSL 1, which refers to the lowest moisture sensitive classification level.

Although the JEDEC specification applies to “non-hermetic” (e.g., plastic) packaging, Skyworks tests and assures the MSL of our oscillator products according to the JEDEC specifications noted above.

1.5. What is the MSL of the 2.5 x 3.2 mm package?

These packages are rated at MSL 2.

1.6. Are the CLCC packages hermetically sealed?

Yes, the CLCC cavity is hermetically sealed during the lid sealing process.

1.7. Are any flame retardants (halogen compounds) used in the package?

No, Skyworks oscillator packages are halogen- and phosphorous-free.

2. Quality and Production

2.1. Where can I find RoHS, REACH, or other materials related to compliance information?

Refer to the [Skyworks Certificate of Conformance](#) web page for full RoHS, REACH, and other material composition information. Make sure to type the entire part number, including the dash suffix.

2.2. Are the oscillator products available in tape and reel?

Yes, all oscillator products are available in tape and reel with an 8 mm pitch and 12 mm or 16 mm carrier tape width, as noted below for the different package types.

To specify tape and reel, include the “R” suffix on the part number when you place your oscillator order. Please refer to the [Look Up an Oscillator or Clock](#) web page for additional part number information. For example, the “R” at the end of the 510BBA125M000BAGR part number specifies the tape and reel option.

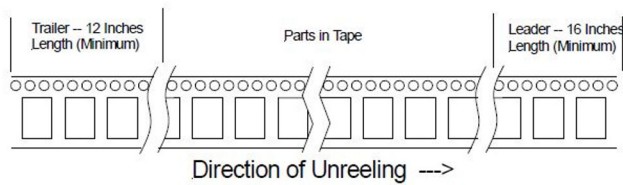
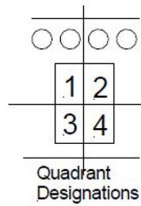
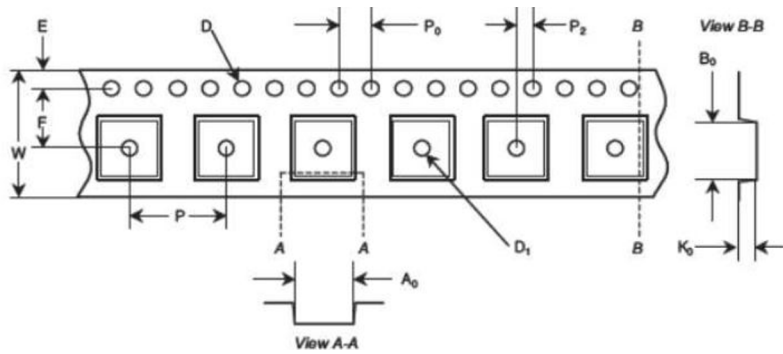
Tape and reel specifications and quantity information for all Skyworks products are available upon request from your local sales representative.

Note: *Part numbers that do not include an "R" suffix are shipped in coil tape which uses the same carrier tape dimensions with trailer and footer, but does not include a reel hub. Coil tape part numbers (without an "R" suffix) are typically only used for small quantity orders and tape and reel part numbers (with an "R" suffix) should be used for larger quantities.*

Tape and reel specifications are shown in Table 5, [Table 6](#), [Figure 1](#), and [Figure 2](#), and quantity information for all Skyworks products is available upon request from your local sales representative.

Table 5. Tape and Reel Specifications

Pkg	No. of Leads	Package Description	Carrier Tape							Reel Size Diameter (inch)	Reel Hub Diameter (inch)	Pin-1 Orientation (Quadrant)
			Width	Pitch	Pocket Size				Parts per Meter			
			W (mm)	P1 (mm)	A0 (mm)	B0 (mm)	K0 (mm)	K1 (mm)				
CLCC	4, 6, 8	CLCC 3.2 x 5	12	8	3.7	5.5	1.4	N/A	125	7	2.5	1
CLCC	4, 6, 8	CLCC 5 x 7	16	8	5.6	7.6	1.9	N/A	125	7	2.5	1
DFN	4, 6, 8	DFN 2.5 x 3.2	12	8	2.75	3.45	1.05	N/A	125	7	2.5	1



Tape Pitch	8 mm
Minimum Number of pockets for leader	51
Minimum Number of pockets for trailer	39

Figure 1. Standard Carrier Tape Dimensions

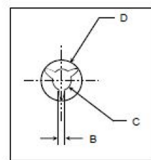
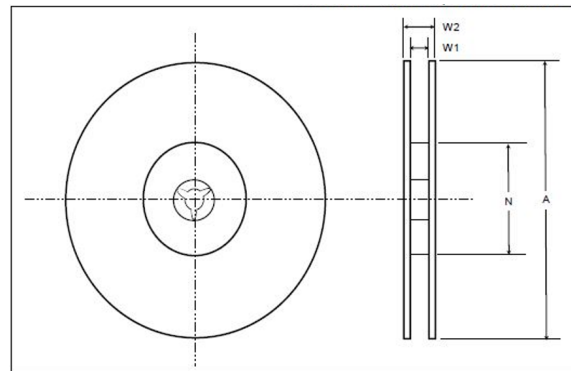


Figure 2. Reel Diagram (7 in.)

Table 6. Minimum Number of Pockets for Leader and Trailer (7-inch Reels)

		Symbol	Carrier Tape Width	
			12 mm	16 mm
Flange	Diameter (mm)	A	330.0	330.0
	Space between flange (mm)	W1	12.8	16.8
	Thickness (mm)	W2	18.2	22.2
Hub	Outer diameter (mm)	N	102.0	102.0
	Arbor hole diameter (mm)	C	13.0	13.0
	Key slit width (mm)	B	2.0	2.0
	Key slit width (mm)	D	20.2	20.2

2.3. What are the qualification test requirements for the Skyworks lead-free, RoHS-compliant, CLCC packages?

Because lead-free PCB assembly processes require higher reflow temperatures, the CLCC package assemblies have been qualified to be compatible with lead-free processes and temperatures. For representative package qualification tests, refer to Table 7. Final test results are included in the Si5xx Product Qualification Report.

Table 7. Qualification Test Requirements

Inspection Parameter	Method
Mechanical shock	MIL-STD-883, Method 2002
Mechanical vibration	MIL-STD-883, Method 2007
Solderability	MIL-STD-883, Method 2003
Gross and fine leak	MIL-STD-883, Method 1014
Physical dimensions	MIL-STD-883, Method 2016
Resistance to solder heat	MIL-STD-883, Method 2036
Wire pull and ball shear	MIL-STD-883, Method 2011
Die shear	MIL-STD-883, Method 2019
Internal moisture content	MIL-STD-883, Method 1018
External visual	MIL-STD-883, Method 2009
Internal visual	MIL-STD-883, Method 2014
HT storage	JEDEC JESD22 JA103
ELFR	JEDEC JESD22 JA108
Temperature cycle	JEDEC JESD22 JA104
HTOL	JEDEC JESD22 JA108

3. Thermal and Soldering

3.1. What is the maximum operating junction temperature of these devices?

The devices were designed to support a maximum operating junction temperature of 125 °C. This internal temperature should not be exceeded during device operation.

Operating ambient temperature range is –40 °C to +85 °C. Operation at temperatures outside of this range poses the risk of not meeting data sheet performance specifications.

The absolute maximum operating junction temperature above which damage may occur is $T_J = 150$ °C

3.2. What are the Θ_{JA} , Θ_{JB} , and Θ_{JC} for these devices?

Table 8. Thermal Resistance and Characteristics

Device	Package	Θ_{JA} (°C/W)	Θ_{JC} (°C/W)	Θ_{JB} (°C/W)	Test Conditions
Si51x	5 x 7 mm CLCC	110	61	61	JEDEC four layer 2S2P
	3 x 5 mm CLCC	110	61	61	JEDEC four layer 2S2P
	2.5 x 3.2 mm DFN	164	93	149	JEDEC four layer 2S2P

3.3. What is the Coefficient of Thermal Expansion (CTE) in the plane of the PWB (x and y) for the 2.5 x 3.2 mm package?

The 2.5 x 3.2 mm package is a laminate based package. The CTE of the laminate is approximately 5 ~ 15 ppm/°C in the x and y, and 10 ~ 30 ppm/°C in the Z direction.

3.4. What is the typical temperature rise of one of these devices?

In still air when directly soldered to a multilayer board, the temperature rise from self-heating, as measured on the device surface, is approximately 9 °C. If the device is mounted in a small spring latch socket, temperature rise may increase to between 20 °C and 30 °C.

3.5. Are the devices compatible with both leaded and “lead-free” assembly processes?

Yes, the device’s NiAu lead finish is compatible with both leaded (SnPb) and “lead-free” solder processes and pastes.

3.6. What are the max reflow temperatures and profiles recommended for “lead-free” and “lead-ed” solder reflow processes?

For lead-free processes, the Peak/Classification Temperature (Tp) is 260 °C. For lead-ed (SnPb) processes, the Tp is 240 °C.

Refer to the latest JEDEC specification (IPC/JEDEC J-STD-020C, July 2004). Excerpts below are included for reference only, to be used as starting values for developing a specific assembly profile. All temperatures refer to the top side of the package, measured on the package body surface.

Table 9. JEDEC J-STD-020 Specification Excerpt (Reference Only)

Profile Feature	SnPb Eutectic Assembly	Pb-Free Assembly
Average ramp-up rate (T _{smax} to T _p)	3 °C/second max	3 °C/second max
Preheat: <ul style="list-style-type: none"> • Temperature min (T_{smin}) • Temperature max (T_{smax}) • Time (T_{smin} to T_{smax}) 	100 °C 150 °C 60 to 120 seconds	150 °C 200 °C 60 to 180 seconds
Time maintained above: <ul style="list-style-type: none"> • Temperature (T_L) • Time (t_L) 	183 °C 60 to 150 seconds	217 °C 60 to 150 seconds
T _p	240 °C	260 °C
Time within 5 °C of T _p	20 seconds	20 to 40 seconds
Ramp-down rate	6 °C/second max	6 °C/second max
Time 25 °C to peak temperature	6 minutes max	8 minutes max

3.7. How many solder reflow cycles can the crystal oscillators support?

Skyworks Si51x devices are compliant with JEDEC J-STD-020. It is safe to reflow these devices up to three times at the peak reflow temperature.

4. General Part Functionality

4.1. Is the FS pin on a Si510, Si511, Si512, Si513, or Si516 internally pulled up or pulled down?

The FS pin is always set to have a ~45 kΩ pullup resistor. This setting is constant for all Si51x parts, regardless of different ordering option selections.

4.2. Is the frequency of a Si51x free running or is it internally controlled?

The frequency of the Si510, Si511, Si512, and Si513 is internally controlled by an AT-cut crystal and the frequency is therefore dependent on the crystal's temperature "S" curve.

Si514 devices follow the same S curve but allow modulation of the output frequency using digital I²C commands. Si515/16 devices follow the same S curve but can be also modulated by an analog V_C pin.

4.3. What output clock skew data is available for the Si510/511?

Si510/511 clock skew is not specified in the data sheet. A differential probe was used in characterization to measure signal integrity parameters for LVDS and LVPECL, so there is no skew data available for these formats. However, skew was measured for HCSL and dual differential CMOS.

Table 10. Output Clock Skew Data

HCSL	Dual Differential CMOS (No Load)	Dual Differential CMOS (15 pF)
<100 ps	<175 ps	<250 ps

4.4. Can these oscillators output a sinusoid waveform instead of a square wave?

No. Skyworks oscillators are only designed to produce square waves.

4.5. Can VDD be set to a voltage other than the recommended driver voltage (e.g., when running a 3.3 V LVDS part at 2.5 V)?

Skyworks oscillators are carefully characterized over process, voltage, and temperature so we can confidently ensure the minimum, typical, and maximum specifications listed in the data sheets. Although the oscillator may still function at voltages other than the specified driver voltage, important data sheet specs such as jitter can no longer be ensured if the device is operated outside its specified voltage.

4.6. What output formats are supported by the Skyworks Si51x crystal oscillators for VDD = 1.8 V?

The Si51x product family supports 1.8 V CMOS, 1.8 V HCSL, and a non-standard 1.8 V LVDS swing compatible output format. Our 1.8 V LVDS option has an output single-ended swing of nominally 350 mVPPSE with a non-standard CM voltage of 0.92 V.

4.7. Is it acceptable to route traces directly beneath Si51x crystal oscillators?

The Si51x devices all use CLCC or DFN packages. Therefore, the bottom of the package, excluding the pads, is insulated and traces can be routed directly beneath the device without shorting.

Even if there is room, this is not generally recommended since oscillator noise can couple to the traces.

It is much better to route traces on the other side of the PCB, or internally, where there is at least one intervening reference plane (i.e., a GND plane or well-bypassed VDD plane between the traces and the oscillator).

5. I²C Communication (Si514 Only)

5.1. What is the I²C address of my Si514?

Try using the Skyworks online [Look Up an Oscillator or Clock](#). Type in the full custom part number into the search bar and click **Search**. The resulting page shows all of the custom features associated with that part number.

5.2. Is the I²C bus working correctly?

Probing the device I²C pins with an oscilloscope can sometimes reveal signal integrity problems.

Si514 I²C communication is normally very robust, so if other devices on the I²C bus are communicating successfully, then the Si514 should also work.

6. VCXO Functionality (Si515/Si516 Only)

6.1. What is Absolute Pull Range (APR)?

Absolute Pull Range (APR) of a VCXO is the amount of pull range left over after subtracting the worst case total stability of the VCXO from the total pull range of the VCXO. APR is useful because it describes the minimum pull range available for tracking a PLL reference clock.

Skyworks is very conservative when calculating both total pull range and total stability for the min APR calculation. All of the specs used to calculate pull range and stability are set to their worst-case tolerances, producing the minimum possible pull range and the maximum possible frequency stability offset. This is how Skyworks can assure minimum APR performance across all parts produced.

If the minimum APR recommendations from the data sheet are properly followed, Skyworks can assure that the VCXO will never run out of voltage control range over the lifetime of the part.

Refer to [AN266: VCXO Tuning Slope \(Kv\), Stability, and Absolute Pull Range \(APR\)](#) for a more in-depth description.

6.2. Why is there no min APR listed for 2.5 V or 1.8 V for certain Kv values?

The calculation of APR relies on both the total pull range of the part and the total stability of the part. Total pull range is directly proportional to the control voltage range and the chosen tuning slope (Kv) value:

$$\pm TotalPullRange = 0.5 \times ControlVoltageRange \times Kv$$

As VDD decreases, the available control voltage range also decreases. Similarly, if the tuning slope (Kv) is decreased, the full range of tunable frequencies dramatically decreases.

When VDD and Kv get low enough, the total pull range can get close to the total stability of the part, causing the min APR to be low. In cases where min APR is less than ± 20 ppm, the VCXO could potentially have difficulty tracking a PLL reference clock as the part ages over time.

7. Revision History

Revision	Date	Description
B	February, 2026	Updated tape and reel information.
A	November, 2025	Initial Skyworks document release.

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