

# SiT3921

## Digitally Controlled Differential Oscillator (DCXO)



### Features

- Factory programmable between 1 MHz and 220 MHz accurate to 6 decimal places
- Digital controlled pull range
- Widest pull range options:  $\pm 25$ ,  $\pm 50$ ,  $\pm 100$ ,  $\pm 200$ ,  $\pm 400$ ,  $\pm 800$ ,  $\pm 1600$  ppm
- Superior pull range linearity of  $\leq 1\%$ , 10 times better than quartz
- $< 1$  ps RMS phase jitter (random) over 12 kHz to 20 MHz bandwidth
- Industrial and extended commercial temperature ranges
- Industry-standard packages: 3.2 mm x 2.5 mm, 5.0 mm x 3.2 mm and 7.0 mm x 5.0 mm
- For frequencies higher than 220 MHz, refer to SiT3922 datasheet

### Applications

- Ideal for SONET, Video, Instrumentation, Satellite applications
- Telecom, networking, broadband



### Electrical Characteristics

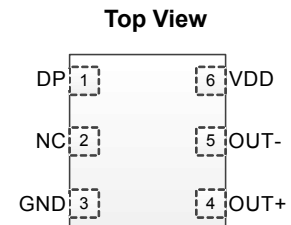
Parameters	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>LVPECL and LVDS, Common DC and AC Characteristics</b>						
Output Frequency Range	f	1	–	220	MHz	
Frequency Stability	F_stab	-10	–	+10	ppm	Inclusive of initial tolerance, operating temperature, rated power, supply voltage and load change
		-25	–	+25	ppm	
		-50	–	+50	ppm	
Operating Temperature Range	T_use	-40	–	+85	°C	Industrial
		-20	–	+70	°C	Extended Commercial
Start-up Time	T_start	–	–	10	ms	
Duty Cycle	DC	45	–	55	%	Contact SiTime for tighter duty cycle
Pull Range	PR	$\pm 25, \pm 50, \pm 100, \pm 200, \pm 400, \pm 800, \pm 1600$			ppm	See the last page for Absolute Pull Range, APR table
Linearity	Lin	–	0.2	1	%	
Frequency Change Polarity	–	Positive Slope			–	
First Year Aging	F_aging	-1.5	–	+1.5	ppm	25°C
10-year Aging		-5	–	+5	ppm	85°C
Input Low Voltage	VIL	–	–	0.2xVdd	V	
Input Middle Voltage	VIM	0.4xVdd	–	0.6xVdd	V	
Input High Voltage	VIH	0.8xVdd	–	–	V	
Input High or Low Pulse Width	T_logic	500	–	–	ns	
Input Middle Pulse Width	T_middle	500	–	–	ns	
Input to Output Isolation					TBD	
Input Impedance	Zin	TBD	–	–	k $\Omega$	Pin 1
Input Capacitance	Cin	–	–	TBD	pF	Pin 1
<b>LVPECL, DC and AC Characteristics</b>						
Supply Voltage	Vdd	2.97	3.3	3.63	V	
		2.25	2.5	2.75	V	
Current Consumption	Idd	–	61	69	mA	Excluding Load Termination Current, Vdd = 3.3V or 2.5V
Maximum Output Current	I-driver	–	–	30	mA	Maximum average current drawn from OUT+ or OUT-
Output High Voltage	VOH	Vdd-1.1	–	Vdd-0.7	V	See Figure 9
Output Low Voltage	VOL	Vdd-1.9	–	Vdd-1.5	V	See Figure 9
Output Differential Voltage Swing	V_Swing	1.2	1.6	2.0	V	See Figure 9
Rise/Fall Time	Tr, Tf	–	300	500	ps	20% to 80%
RMS Period Jitter	T_jitt	–	1.2	1.7	ps	f = 100 MHz, Vdd = 3.3V or 2.5V
		–	1.2	1.7	ps	f = 156.25 MHz, Vdd = 3.3V or 2.5V
		–	1.2	1.7	ps	f = 212.5 MHz, Vdd = 3.3V or 2.5V
RMS Phase Jitter (random)	T_phj	–	0.5	0.75	ps	f = 156.25 MHz, Integration bandwidth = 12 kHz to 20 MHz, all Vdds

### Electrical Characteristics

Parameter	Symbol	Min.	Typ.	Max.	Unit	Condition
<b>LVDS, DC, and AC Characteristics</b>						
Supply Voltage	Vdd	2.97	3.3	3.63	V	
		2.25	2.5	2.75	V	
Current Consumption	Idd	–	47	55	mA	Excluding Load Termination Current, Vdd = 3.3V or 2.5V
Differential Output Voltage	VOD	200	350	500	mV	See Figure 12
VOD Magnitude Change	ΔVOD	–	–	50	mV	See Figure 12
Offset Voltage	VOS	1.125	1.2	1.375	V	See Figure 12
VOS Magnitude Change	ΔVOS	–	–	50	mV	See Figure 12
Rise/Fall Time	Tr, Tf	360	495	600	ps	20% to 80%
RMS Period Jitter	T <sub>jitt</sub>	–	1.2	1.7	ps	f = 100 MHz, Vdd = 3.3V or 2.5V
		–	1.2	1.7	ps	f = 156.25 MHz, Vdd = 3.3V or 2.5V
		–	1.2	1.7	ps	f = 212.5 MHz, Vdd = 3.3V or 2.5V
RMS Phase Jitter (random)	T <sub>phj</sub>	–	0.5	0.75	ps	f = 156.25 MHz, Integration bandwidth = 12 kHz to 20 MHz, all Vdds

### Pin Description

Pin	Map	Functionality	
1	DP	Input	Digital programming pin
2	NC	Input	No Connect
3	GND	Power	VDD power supply ground
4	OUT+	Output	Oscillator output
5	OUT-	Output	Complementary oscillator output
6	VDD	Power	Power supply voltage



### Absolute Maximum

Attempted operation outside the absolute maximum ratings may cause permanent damage to the part. Actual performance of the IC is only guaranteed within the operational specifications, not at absolute maximum ratings.

Parameter	Min.	Max.	Unit
Storage Temperature	-65	150	°C
VDD	-0.5	4	V
Electrostatic Discharge	–	2000	V
Soldering Temperature (follow standard Pb free soldering guidelines)	–	260	°C
Program Retention over -40 to 125°C, Process, VDD (0 to 3.65V)	1,000+	–	years

### Thermal Consideration

Package	θJA, 4 Layer Board (°C/W)	θJC, Bottom (°C/W)
7050, 6-pin	142	27
5032, 6-pin	97	20
3225, 6-pin	109	20

### Environmental Compliance

Parameter	Condition/Test Method
Mechanical Shock	MIL-STD-883F, Method 2002
Mechanical Vibration	MIL-STD-883F, Method 2007
Temperature Cycle	JESD22, Method A104
Solderability	MIL-STD-883F, Method 2003
Moisture Sensitivity Level	MSL1 @ 260°C

### Default Startup Condition

The SiT3921 starts up at its factory programmed frequency and settings. The control register values are initialized all zeros, effectively setting the frequency to the middle of the control range.

### Frequency Control Protocol Description

The device includes two DCXO registers; writing to these registers controls the output frequency. Data for each register is written to the device using a data frame.

### Data Frame Format

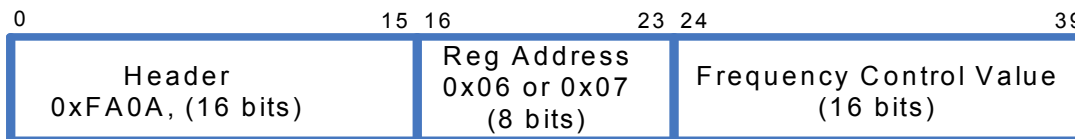
Each frame consists of 40 bits. A frame has 3 parts:

- The header, 16 bit
- Register address, 8 bit
- The data word (represented as 2's complement numbers), 16 bit.

Bits are sent MSB first.

Frames are sent LS word first in mode 2.

The header allows the devices to recognize that the master is initiating communication. The header includes the device address, which is factory programmable. The valid header is 0xFAIA, where "I" can be a hex digits from 0 to F. If not specified at the order time, it will be defaulted to zero. In this document in all examples and text, the device address is considered to be zero (default).



### Frequency Control Mode 1

In this resolution mode, only one frame per frequency update is required, and the output frequency is updated at the end of each frame. The length of the frequency control data is 16 bits, and is written to the device as shown below:



Figure 1. Frequency Control Mode 1

### Frequency Control Mode 2

In this mode, two frames per frequency update are required, and frequency is only updated at the end of the second frame. The frequency control value in this mode is 23 bits. This value is written to the device in two frames as follows:

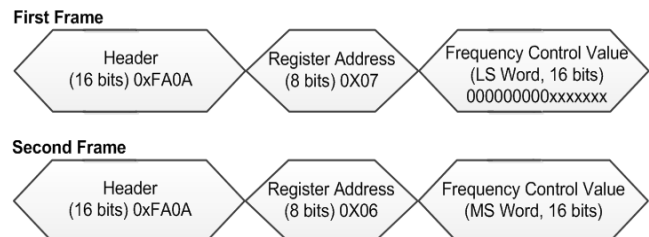


Figure 2. Frequency Control Mode 2

### Resolution and Update Rate for Mode 1

Pull Range (ppm)	Step Resolution (ppb)	Max Update Rate (Updates Per Second)
±25	1	25 K
±50	1.5	25 K
±100	3	25 K
±200	6	25 K
±400	12	25 K
±800	25	25 K
±1600	49	25 K

### Resolution and Update Rate for Mode 2

Pull Range (ppm)	Step Resolution (ppb)	Max Update Rate (Updates Per Second)
±25	1	12.5 K
±50	1	12.5 K
±100	1	12.5 K
±200	1	12.5 K
±400	1	12.5 K
±800	1	12.5 K
±1600	1	12.5 K

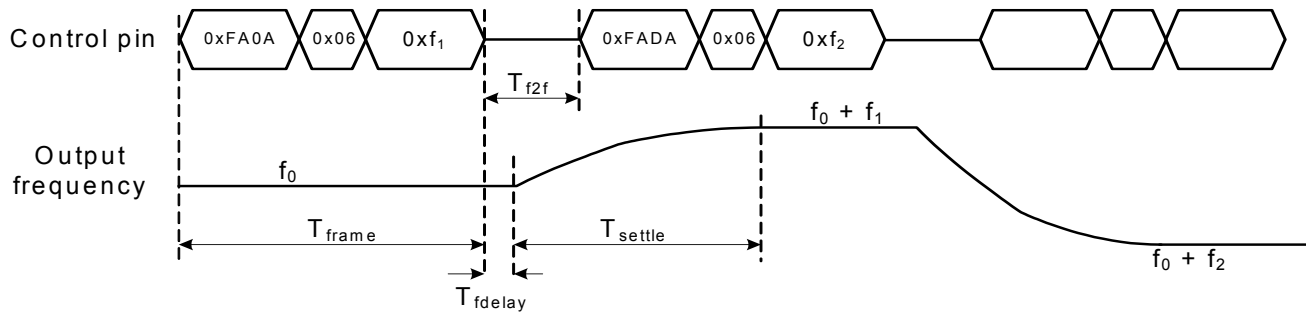


Figure 3. Mode 1 Frame Timing

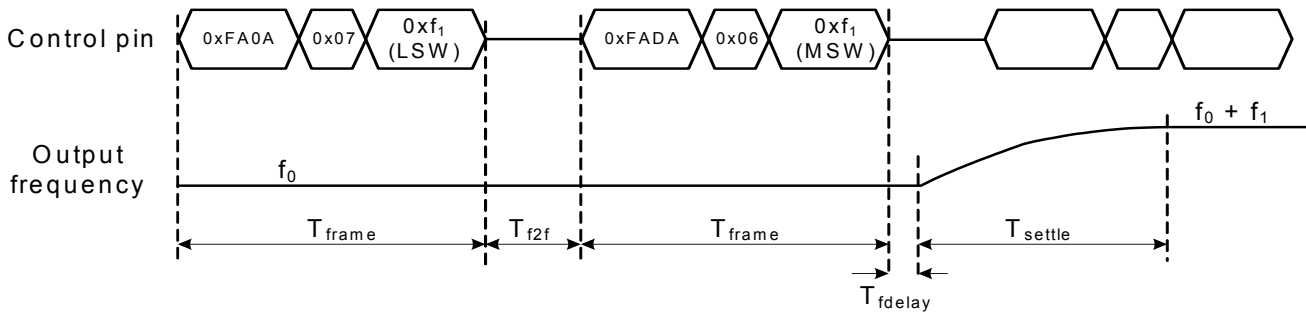


Figure 4. Mode 2 Frame Timing

### Frame Timing Parameters

Parameter	Symbol	Min.	Max.	Unit
Frame Length	$T_{frame}$	40	—	$\mu\text{S}$
Frame to Frame Delay	$T_{f2f}$	2	—	$\mu\text{S}$
Frequency Settling Time	$T_{settle}$	—	30	$\mu\text{S}$
Frame to Frequency Delay	$T_{fdelay}$	—	8	$\mu\text{S}$

### Calculating Pull Range PPM offset

The frequency control value must be encoded as a 2's complement number (16-bit in mode 1 and 23-bit in mode 2), representing the full scale range of the device. For example, for a  $\pm 1600\text{ppm}$  device in mode 2, the 23-bit number represents the full  $\pm 1600\text{ppm}$  range.

The upper 16 bits of the value are written to address 0x06. If the high-resolution register (address 0x07) is used, the other 7 bits are written to the lowest seven bits of address 0x07.

Here are the steps to calculate the frequency control value:

1. Find the scale factor (calculated for half of the pull range) from the tables below where PR is the Pull Range:

#### K (scale)Factor

Mode	K = Scale Factor
1	$(2^{15}-1) / (\text{PR} * 1.00135625)$
2	$(2^{22}-1) / (\text{PR} * 1.00135625)$

2. Enter the desired\_PPM in equation below:

Frequency control (decimal value) = round (desired\_PPM \* K).

3. For any frequency shifts (positive or negative PPM), convert the frequency control value to a 2's complement binary number.

Two examples follow:

### Example 1

This example shows how to shift the frequency by +245.6 ppm in a device with ±1600 pull range using Mode 2 (23-bit):

Decimal value:  $\text{round}(245.6 * K) = 642954$   
 23-bit value = 0x09CF8A

LS Word value = 0x000A (to be written to address 0x07)  
 MS Word value = 0x139F (to be written to address 0x06)  
 Write LS Word: 0xFA0A 07 000A (Frequency will not update)  
 Write MS Word: 0xFA0A 06 139F (Frequency updates after write)

### Example 2

This example shows how to shift the frequency by -831.2 ppm in a device with ±1600 pull range using Mode 2 (23-bit):

Decimal value:  $\text{round}(\text{abs}(831.2 * K)) = 2175989$   
 23-bit abs binary value: 01000010011001111110101  
 23-bit 2's comp binary value: 1011110110011000 0001011

LS Word value = 0x 000B  
 MS Word value = 0x BD98  
 Write LS Word: 0xFA0A 07 000B (Frequency will not update)  
 Write MS Word: 0xFA0A 06 BD98 (Frequency updates after write)

## Physical Interface

The SiTime DCMO uses a serial input interface to adjust the frequency control value. The interface uses a one-wire tri-level return-to-middle signaling format. Figure 5 below shows the signal waveform of the interface.

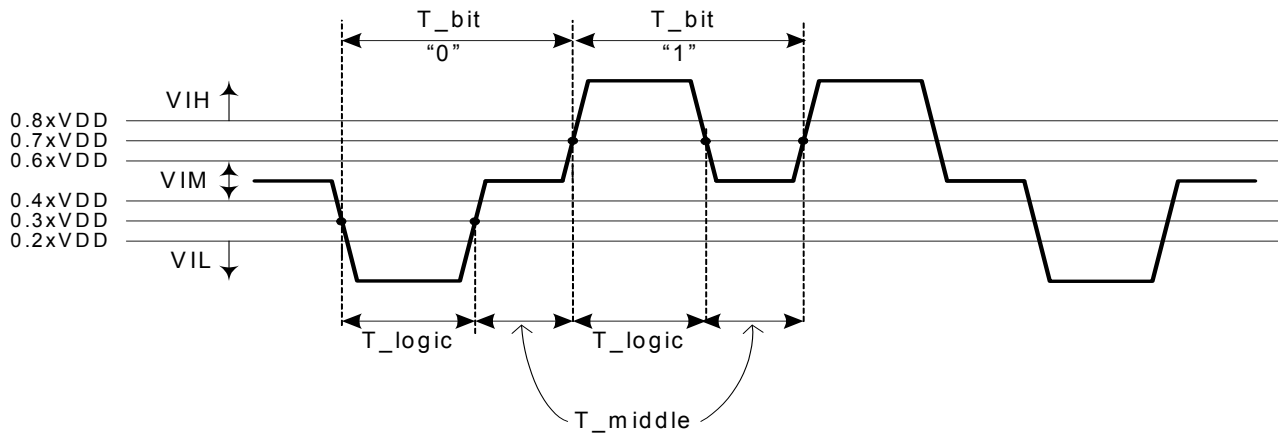


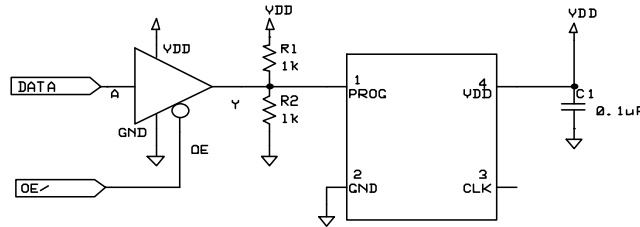
Figure 5. Serial 1-Wire Tri-Level Signaling

A logical bit “1” is defined by a high-logic followed by mid-logic. A logical bit “0” is defined by a low-logic followed by mid-logic. The voltage ranges and time durations corresponding to low-logic, high-, and mid-logic are illustrated in Figure 5 and specified in electrical specification table.

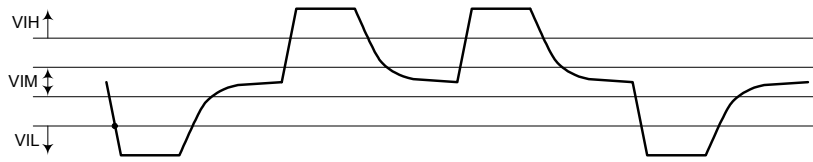
The overall baud rate is computed as below:

$$\text{baud\_rate} = \frac{1}{T\_bit}$$

Figure 6 shows a simple circuit to generate tri-level circuit with a general purpose IO (GPIO) with tri-state capability. Most FPGAs and micro controllers/processors include such GPIOs. If the GPIO does not support tri-state output, two IO s may be used in combination with external tri-state buffer to generate the tri-level signal; an example of such buffer is the SN74LVC1G126. The waveform at the output of the tri-state buffer is shown in Figure 7. When the GPIO drives Low or High voltage, the rise/fall times are typically fast (sub-5ns range). When the output is set to Hi-Z, the output settles at middle voltage with a RC response. The time constant is determined based on the total capacitance on frequency control pin and the parallel resistance of the pull-up and pull-down resistors. The time constant in most practical situations will be less than 50ns; this necessitate choosing longer T<sub>middle</sub> to allow the RC waveform to settle within 5% or so.

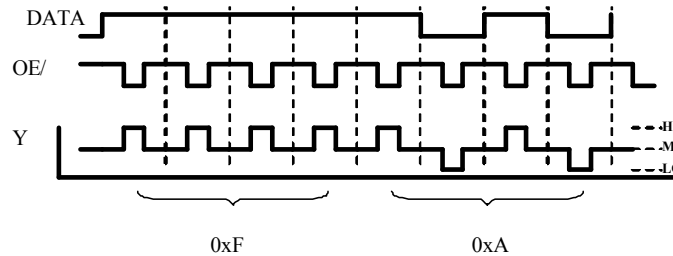


**Figure 6. Circuit Diagram for Generating Tri-Level Signal with Tri-State Buffer**



**Figure 7. Tri-State Signal Generated with Tri-State Buffer**

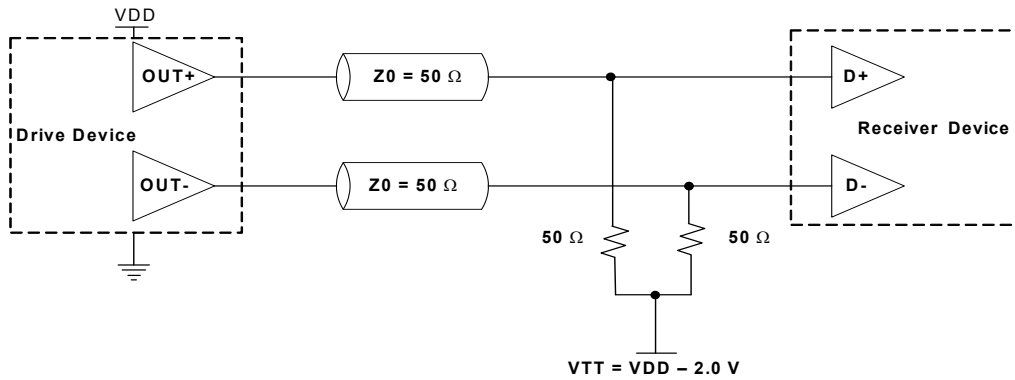
When using a tri-state buffer as shown above, care must be taken if the DATA and OE lines transition at the same time that there are no glitches. A glitch might occur, for example, if the OE line enables the output slightly before the data line has finished its logical transition. One way around this, albeit at the cost of some data overhead, is to use an extra OE cycle on every bit, as shown in Figure 8. Note that the diagram assumes an SN74LVC125, which has a low-true OE/ line (output is enabled when OE/ is low). For a high-true OE part, such as the SN74LVC126, the polarity of that signal would be reversed.



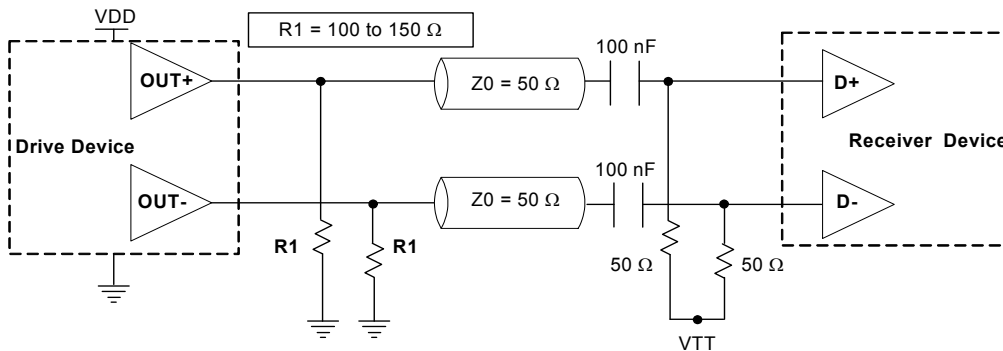
**Figure 8. Signal Polarity**

**Termination Diagrams**

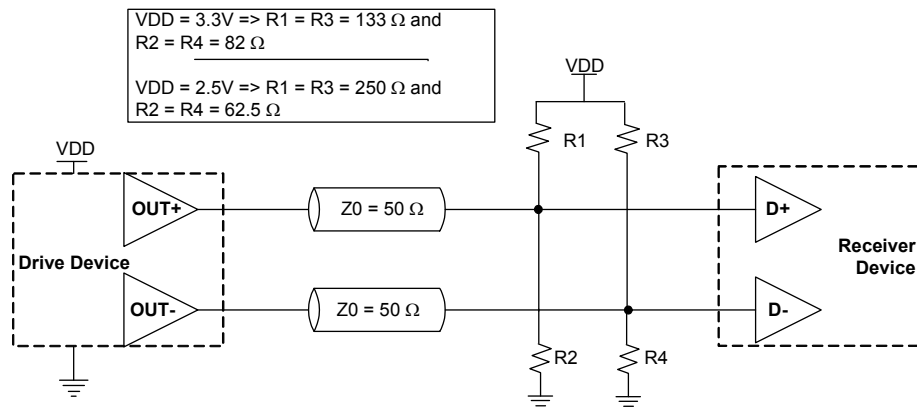
LVPECL:



**Figure 9. LVPECL Typical Termination**



**Figure 10. LVPECL AC Coupled Termination**



**Figure 11. LVPECL with Thevenin Typical Termination**

LVDS:

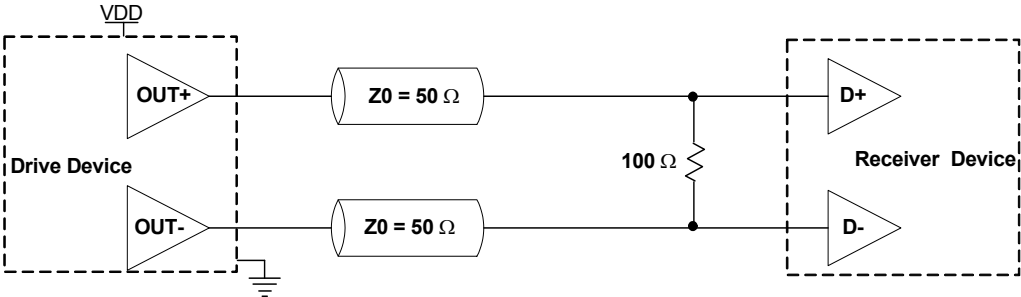
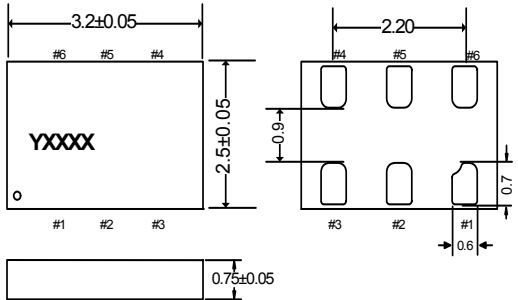
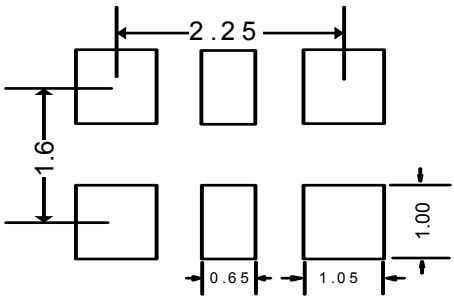
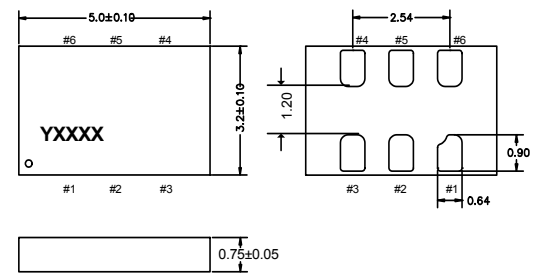
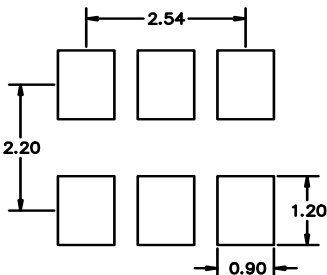
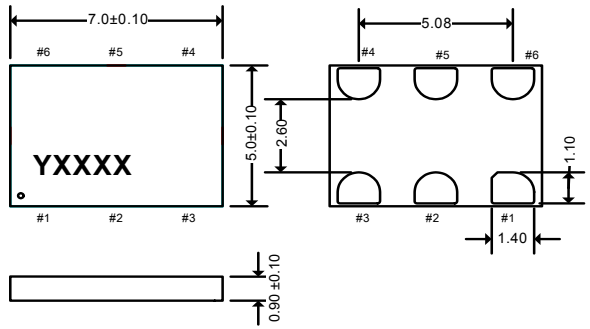
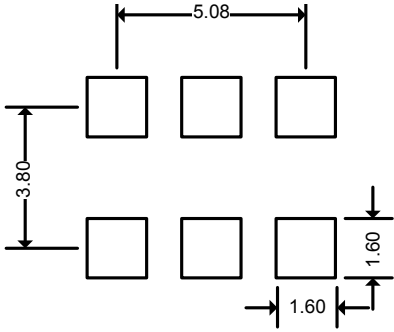


Figure 12. LVDS Single Termination (Load Terminated)



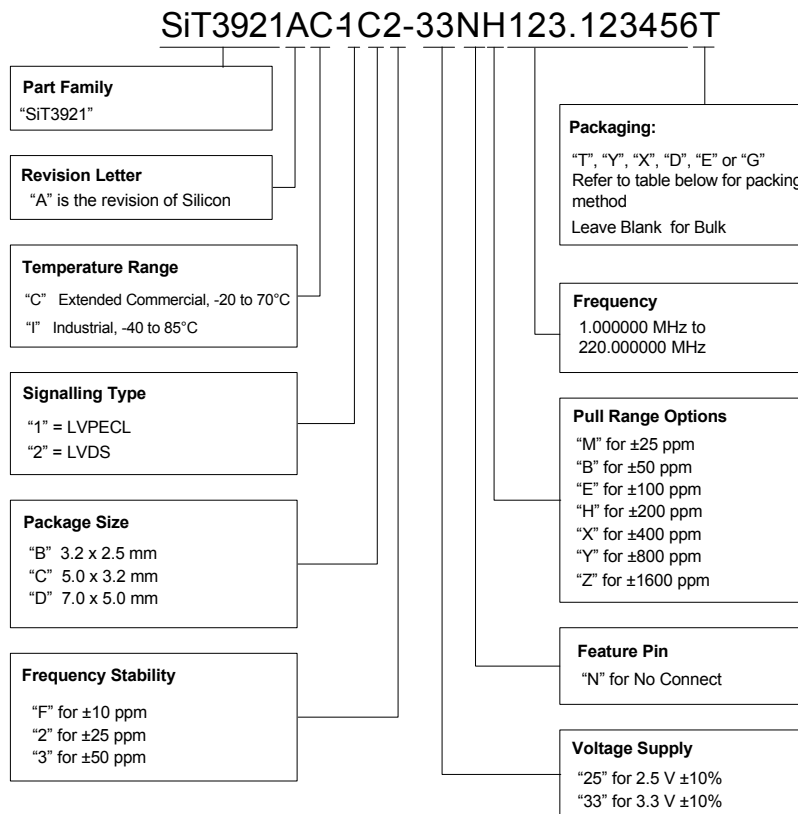
### Dimensions and Patterns

Package Size – Dimensions (Unit: mm) <sup>[1]</sup>	Recommended Land Pattern (Unit: mm) <sup>[2]</sup>
<p><b>3.2 x 2.5 x 0.75 mm</b></p>  <p>Top view dimensions: 3.2±0.05 mm (width), 2.5±0.05 mm (height). Pin locations: #6, #5, #4 (top); #1, #2, #3 (bottom). Marking: YXXXX, o. Bottom view dimensions: 2.20 mm (width), 0.9 mm (height), 0.7 mm (pin height), 0.6 mm (pin offset). Land pattern dimensions: 2.25 mm (width), 1.6 mm (height), 0.65 mm (pin width), 1.05 mm (pin spacing), 1.00 mm (pin height).</p>	 <p>Land pattern dimensions: 2.25 mm (width), 1.6 mm (height), 0.65 mm (pin width), 1.05 mm (pin spacing), 1.00 mm (pin height).</p>
<p><b>5.0 x 3.2 x 0.75 mm</b></p>  <p>Top view dimensions: 5.0±0.10 mm (width), 3.2±0.10 mm (height). Pin locations: #6, #5, #4 (top); #1, #2, #3 (bottom). Marking: YXXXX, o. Bottom view dimensions: 2.54 mm (width), 1.20 mm (height), 0.90 mm (pin height), 0.64 mm (pin offset). Land pattern dimensions: 2.54 mm (width), 2.20 mm (height), 0.90 mm (pin width).</p>	 <p>Land pattern dimensions: 2.54 mm (width), 2.20 mm (height), 0.90 mm (pin width).</p>
<p><b>7.0 x 5.0 x 0.90 mm</b></p>  <p>Top view dimensions: 7.0±0.10 mm (width), 5.0±0.10 mm (height). Pin locations: #6, #5, #4 (top); #1, #2, #3 (bottom). Marking: YXXXX, o. Bottom view dimensions: 5.08 mm (width), 2.60 mm (height), 1.10 mm (pin height), 1.40 mm (pin offset). Land pattern dimensions: 5.08 mm (width), 3.80 mm (height), 1.60 mm (pin width).</p>	 <p>Land pattern dimensions: 5.08 mm (width), 3.80 mm (height), 1.60 mm (pin width).</p>

**Notes:**

1. 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.
2. A capacitor of value 0.1 μF between Vdd and GND is recommended.

### Ordering Information



### APR Definition

Absolute pull range (APR) = Nominal pull range (PR) - frequency stability (F\_stab) - Aging (F\_aging)

### APR Table

Nominal Pull Range	Frequency Stability		
	± 10	± 25	±50
	APR (ppm)		
± 25	± 10	—	—
± 50	± 35	± 20	—
± 100	± 85	± 70	± 45
± 200	± 185	± 170	± 145
± 400	± 385	± 370	± 345
± 800	± 785	± 770	± 745
± 1600	± 1585	± 1570	± 1545

### Ordering Codes for Supported Tape & Reel Packing Method

Device Size	8 mm T&R (3ku)	8 mm T&R (1ku)	8 mm T&R (250u)	12 mm T&R (3ku)	12 mm T&R (1ku)	12 mm T&R (250u)	16 mm T&R (3ku)	16 mm T&R (1ku)	16 mm T&R (250u)
7.0 x 5.0 mm	—	—	—	—	—	—	T	Y	X
5.0 x 3.2 mm	—	—	—	T	Y	X	—	—	—
3.2 x 2.5 mm	D	E	G	T	Y	X	—	—	—

### Revision History

Version	Release Date	Change Summary
0.3	3/27/12	Original
1.0	6/6/14	Included 3225 package
1.1	12/2/14	Modified Thermal Consideration values, removed OE options

# SiT3921

## Digitally Controlled Differential Oscillator (DCXO)



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