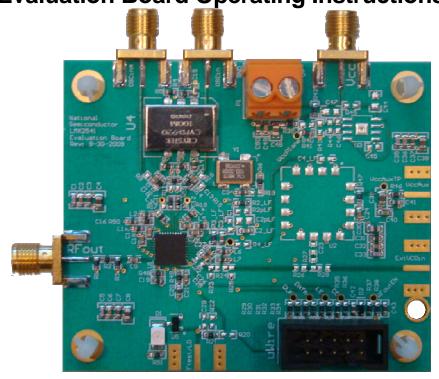


LMX2541 Family

Ultra Low Noise Frequency Synthesizer with Integrated VCO Evaluation Board Operating Instructions

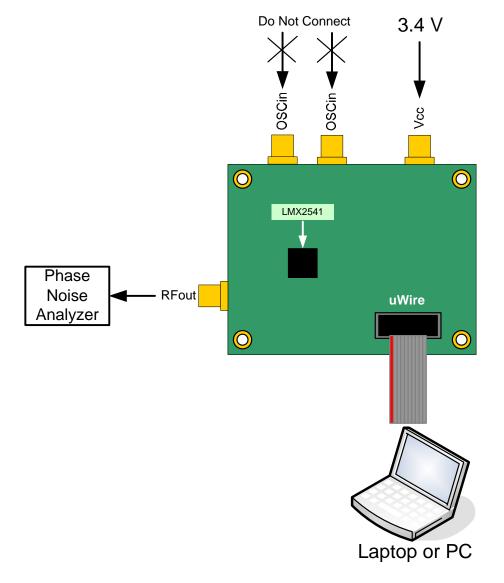


National Semiconductor Corporation High Speed Signal Path Division Precision Timing Devices 12-4-2009

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QUICK SETUP



Connect to a spectrum analyzer or phase noise analyzer. The Agilent E5052A was used for these instructions.

<u>Vcc</u>

Connect to a 3.4 volt low noise power supply

<u>uWire</u> Connect to a computer with CodeLoader software

ExtVCOin

This is not used in the default setup, but is included to support the use of an external VCO. In Full Chip Mode, this device has an on-chip VCO.

Ftest/LD

The LED is to ensure that the part is locked. This output can be very useful for diagnostic purposes

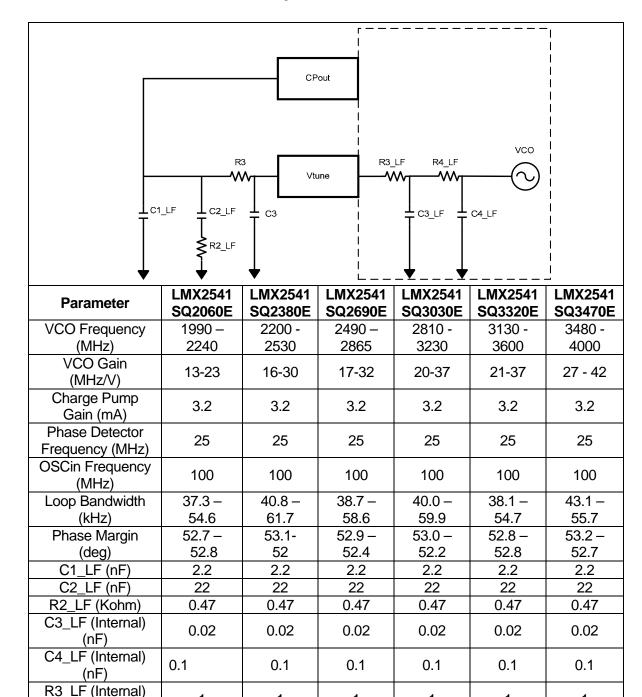
OSCin/OSCin*

This is not used in the default setup, but is included to support the use of an external OSCin signal. The board includes a 100 MHz TCXO, which has two varieties. The OSCin signal is absolutely critical for the phase noise and spur performance of the LMX2541.

Manufacturer	Model	Frequency	Comments	
Connor Winfield	CWX-813	100 MHz	Good phase noiseLow CostDrifts a lot.	
Crystek	CVPD920	100 MHz	Good Phase NoiseDrifts much lessHigh Cost	
National Semiconductor	LMK01000 LMK02000 LMK03000 LMK04000	Any	 Eliminate drift issues Potentially the best phase noise Best for fractional spurs 	

Be very aware of the TCXO drift and the contribution that it can have to phase noise. Termination of the TCXO has a large impact on fractional spurs as well. The best results can be achieved by driving this board with an LMK01000 LVPECL output. Doing so results in about a 4 dB spur improvement.

Loop Filter Values



1

0.2

1

0.2

1

0.2

1

0.2

1

0.2

1

0.2

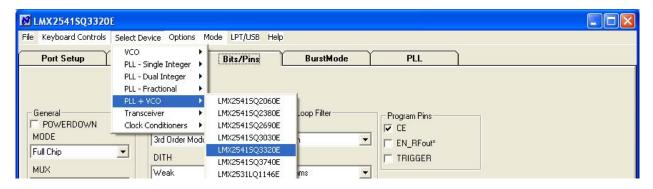
(Kohm) R4_LF (Internal)

(Kohm)

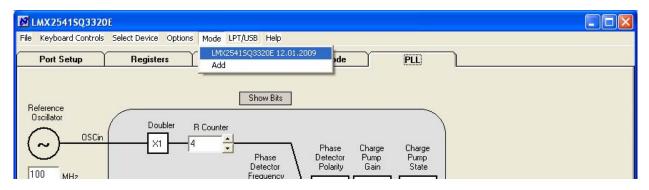
^{*} Note that the VCO gain does change a fair amount. Although not demonstrated in these instructions, the charge pump gain could be adjusted to account for this variation.

CodeLoader Setup

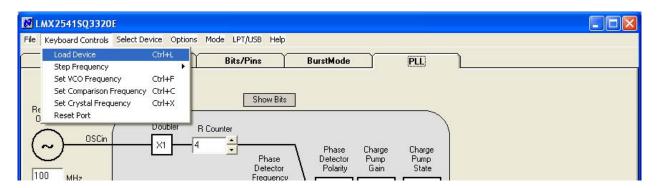
Select the part. In this case, it is the LMX2541SQ3320E.



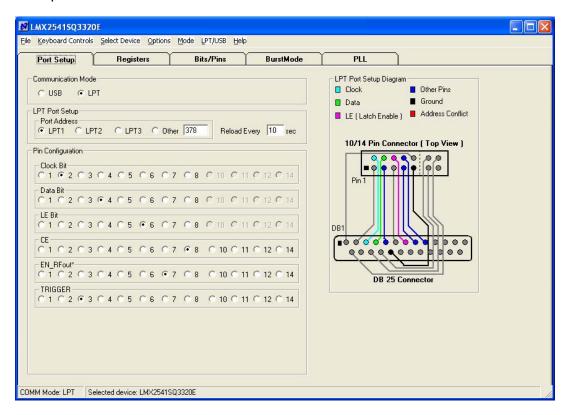
Choose the correct startup mode. This is determined by the part option.



Load the part. You can load it from the menu or also press Cntrl + L.



On the Port Setup tab, the user may select the type of communication port (USB or Parallel) that will be used to program the device on the evaluation board. If parallel port is selected, the user should ensure that the correct port address is entered.

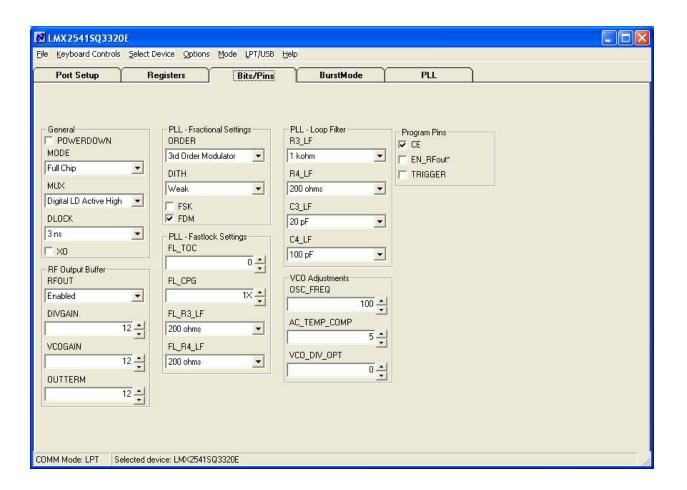


The Pin Configuration field is hardware dependent and normally <u>SHOULD NOT</u> be changed by the user.

The evaluation board is typically shipped with a parallel port cable that is used to interconnect the board to a PC LPT port, enabling the board to be programmed.

Separately available is a USB2UWIRE-IFACE board which simplifies evaluation by enabling the user to establish a USB connection from the Codeloader 4 software to the evaluation board. http://www.national.com/store/view_item/index.html?nsid=USB2UWIRE-IFACE

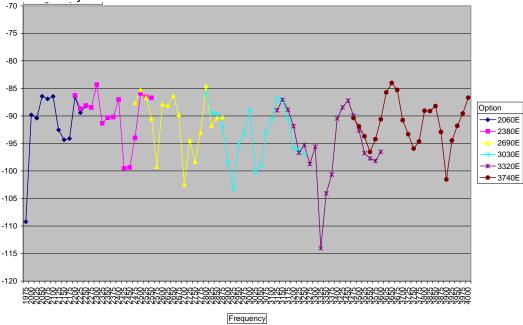
To view the function of any bit on the CodeLoader configuration tabs, place the cursor over the desired bit register label and click the right mouse button on it for a description. This Bits/Pins configuration is common to all options of the LMX2541 evaluation board.



Spurs

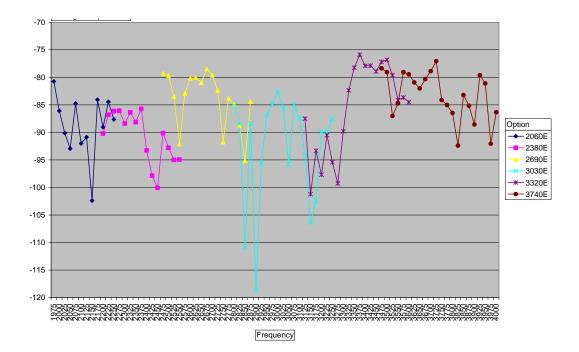
Oscillator Spurs

Oscillator spurs occur at the oscillator frequency (100 MHz) offset from the carrier. They can be largely impacted by the board layout. These were taken in 25 MHz increments.



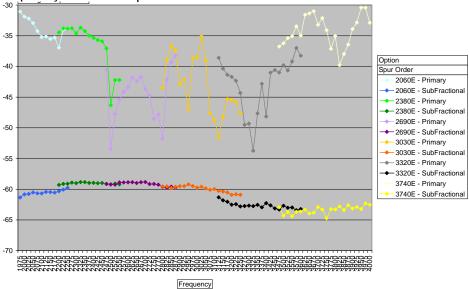
Reference (Phase Detector) Spurs

Reference spurs occur at a multiple of the phase detector frequency (25 MHz) from the carrier

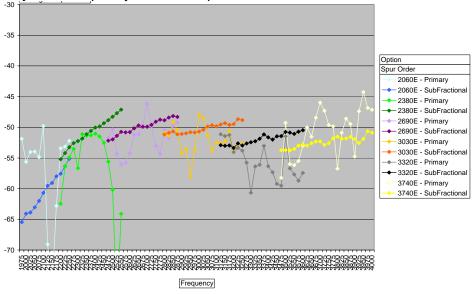


Fractional Spurs

In-band spurs occur inside the loop bandwidth. These spurs were measured with a WORST CASE fraction of 1/5000. The primary fractional spurs are at 5 kHz and the sub-fractional spurs are at 2.5 kHz. The actual frequency is the frequency in the chart plus 5 kHz.



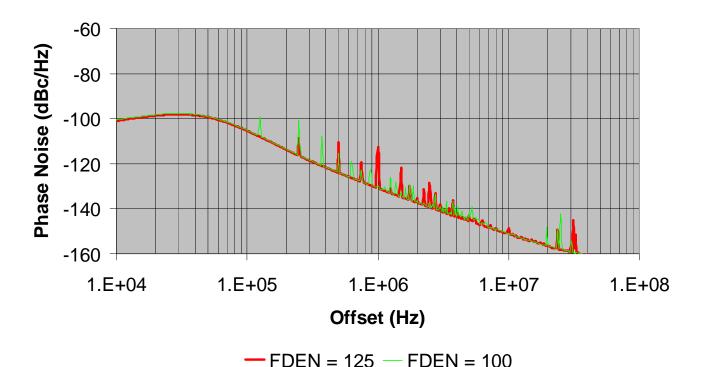
Out-band spurs occur inside the loop bandwidth. These spurs were measured with a WORST CASE fraction of 1/100. The primary fractional spurs are at 250 kHz and the sub-fractional spurs are at 125 kHz. The actual frequency is the frequency in the chart plus 250 kHz.

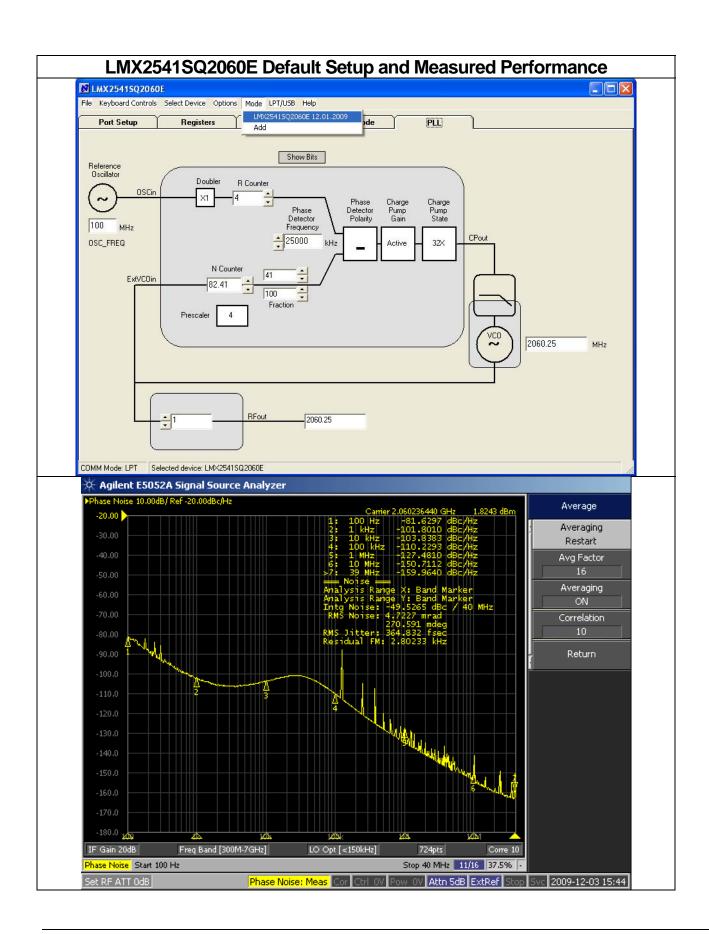


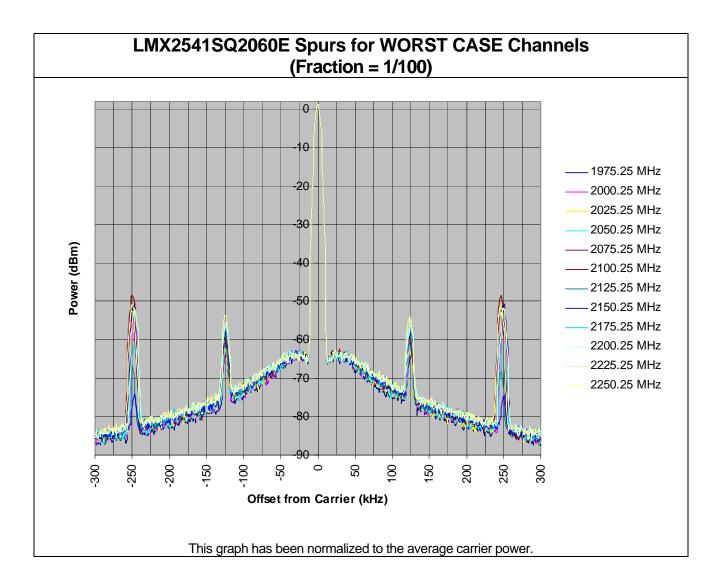
Minimizing Fractional Spurs

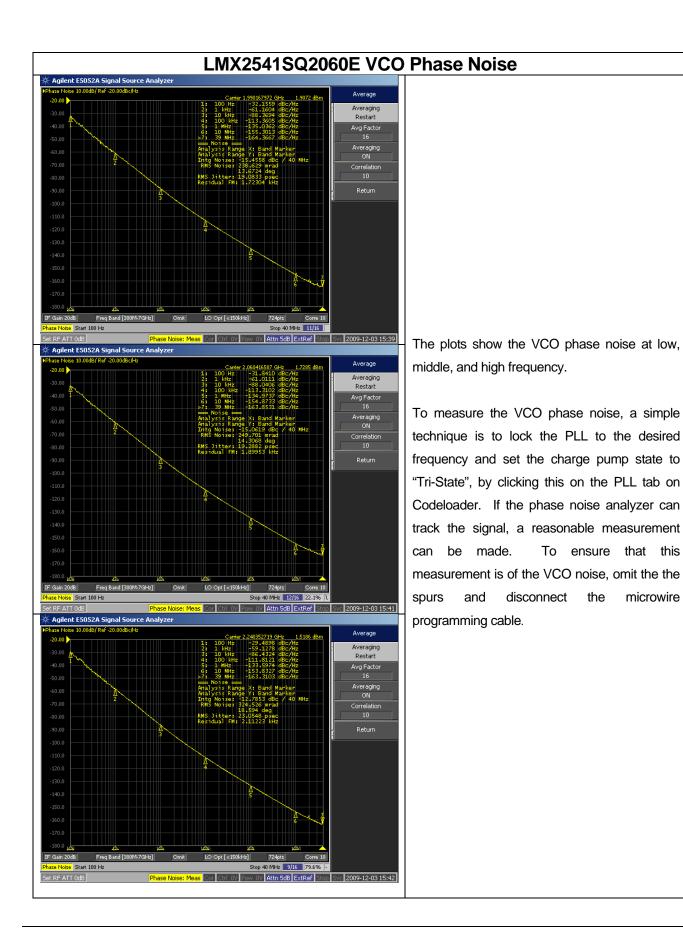
- Both fractional and sub-fractional spurs are highly sensitive to the OSCin signal. Higher slew rates are desired. Also, the termination makes a big difference. For this evaluation board, a series 120 ohm resistor had a large impact.
- The best results have been achieved when driving the part differentially with an LVPECL output of the LMK01000/2000/3000/400 series of clock conditioner devices from National Semiconductor.
- The spurs on this evaluation board are relatively high because the loop bandwidth is very wide. This
 wide loop bandwidth takes advantage of the close-in phase noise, but it does expose the fractional
 spurs more. The fractional spurs can be reduced by orders of magnitude by reducing the loop
 bandwidth. This requires a re-design of the loop filter.
- To eliminate the SubFractional spurs entirely, choose a fractional denominator with no factors of 2 or 3. For this 100 MHz TCXO and 250 kHz channel spacing, a phase detector frequency of 6.25 MHz and a fractional denominator of 25 would work. However, the higher N value does degrade the phase noise. An ideal scenario would be to use a TCXO frequency of something like 125 MHz. Then the sub-fractional spurs are eliminated if the phase detector is chosen to be 30.25 MHz and the fractional denominator is chosen to be 125.

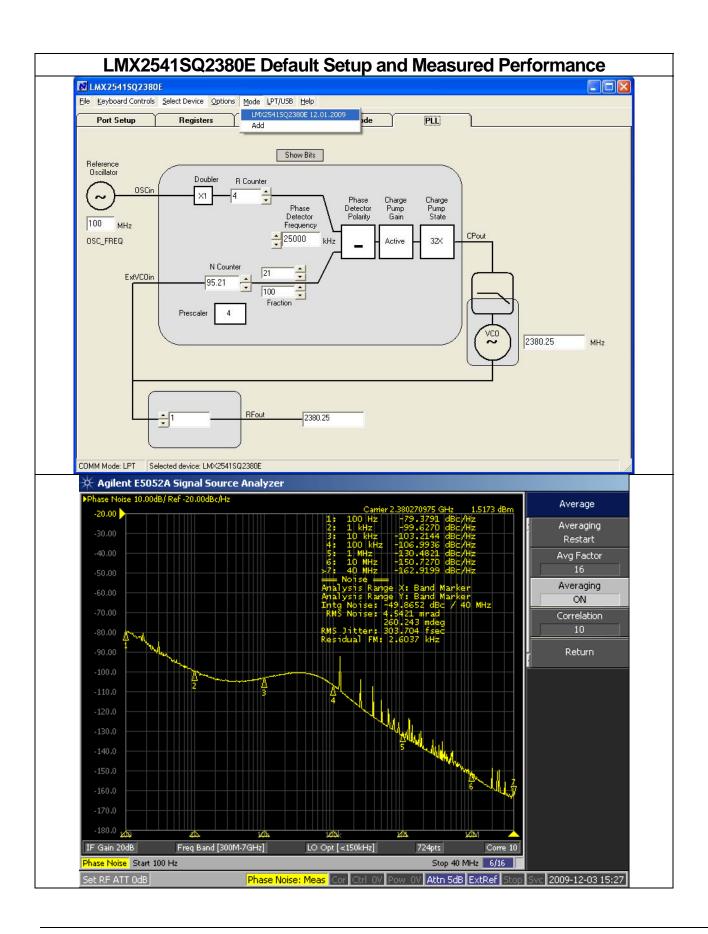
In the plot below, one was taken with the default 100 MHz TCXO and another was taken with a 125 MHz signal. The phase detector frequency was changed to 31.25 MHz, but the charge pump gain was reduced to 26X to compensate for this. This is the same part, board, and frequency (3030.25 MHz). Although the fraction is different, notice that the fractional denominator of 125 has no sub fractional spurs at 125 kHz, 375 kHz, and so on. An LMK01000 evaluation board driven by a 1250 MHz signal was used to produce this 125 MHz signal.

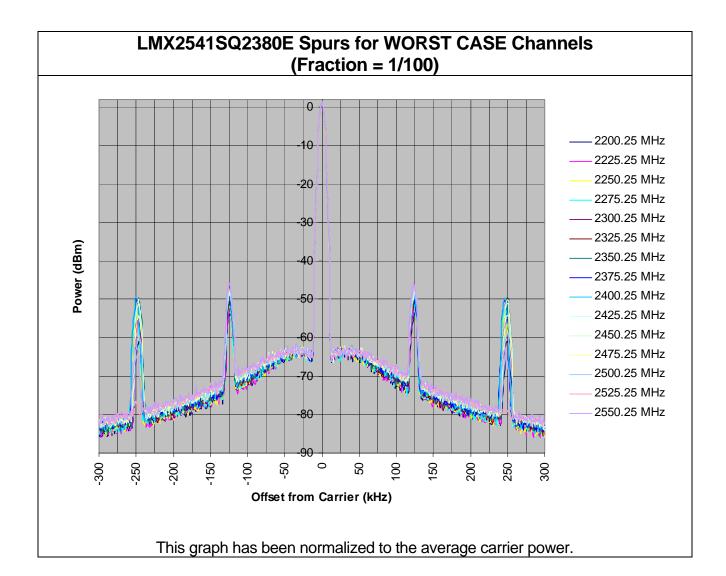


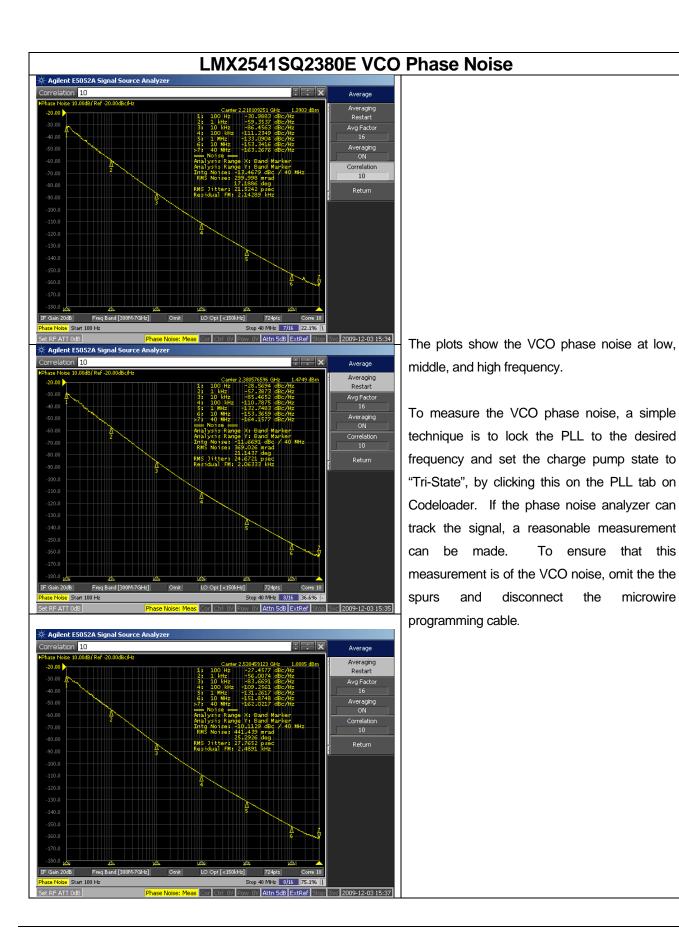






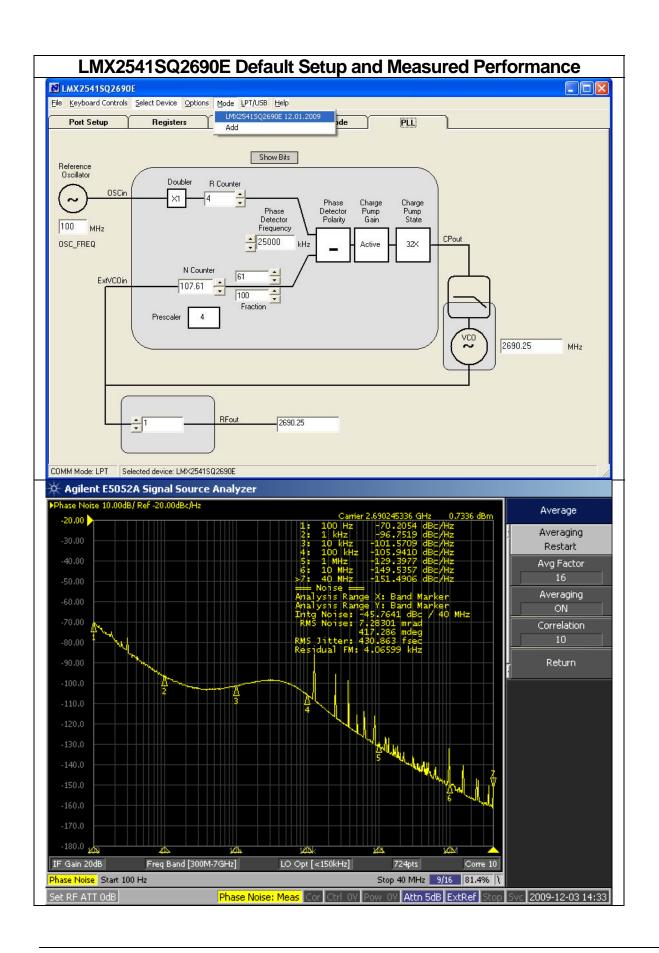


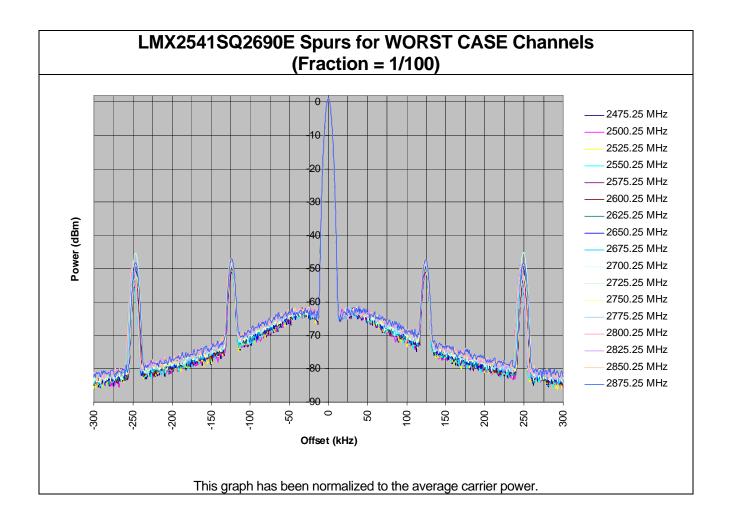


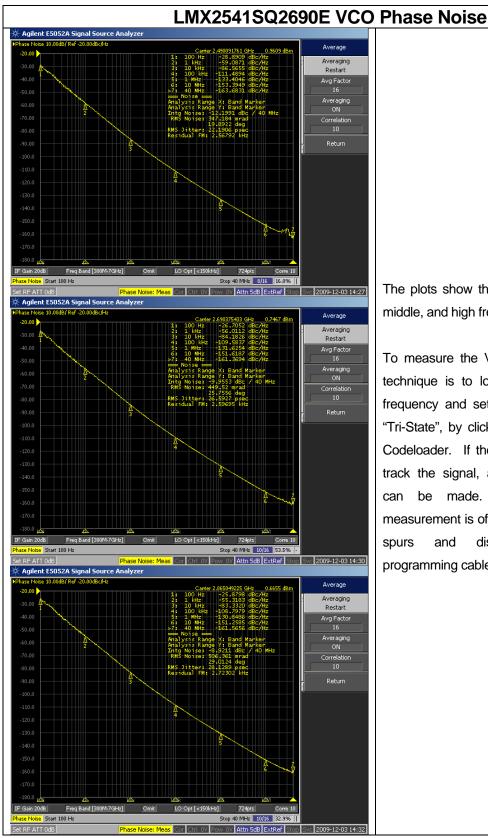


the

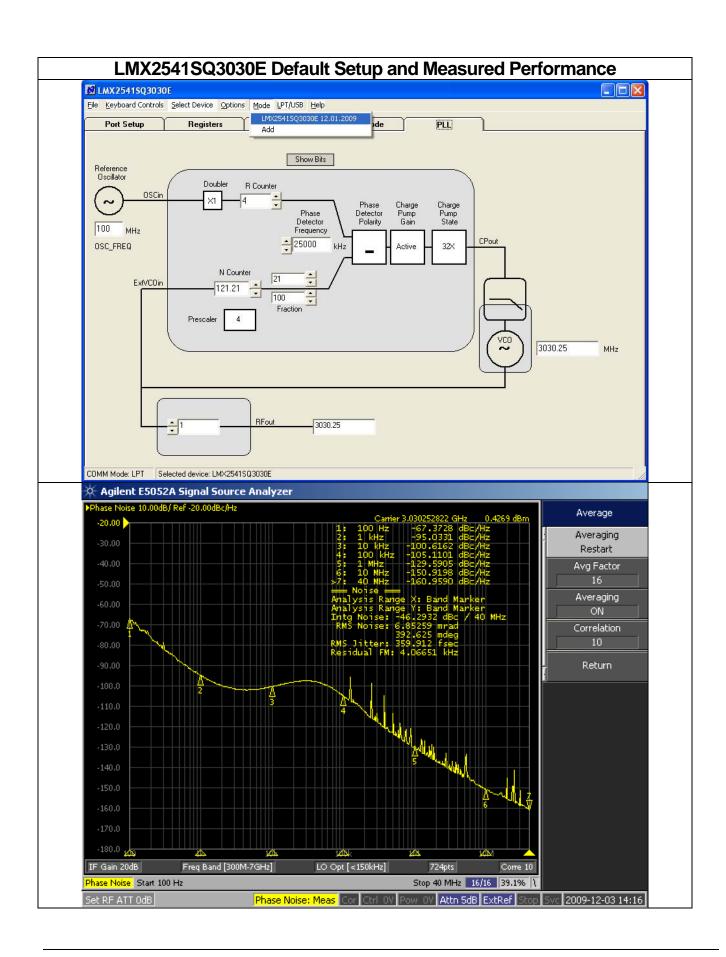
microwire

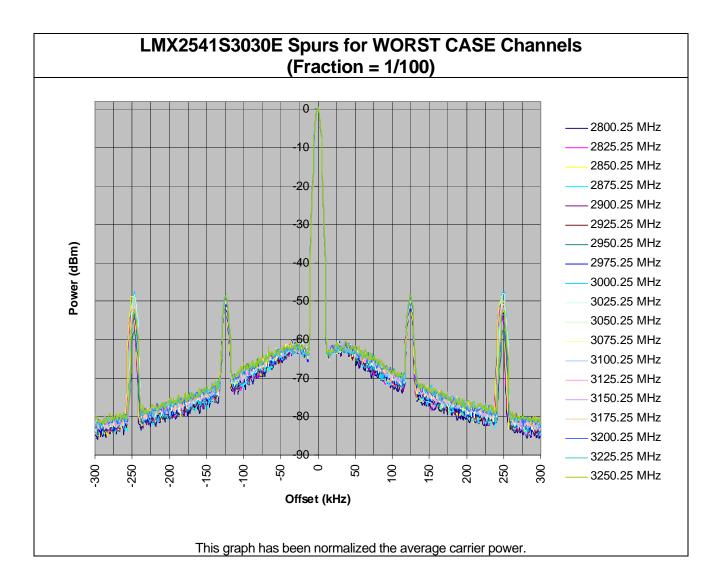






The plots show the VCO phase noise at low, middle, and high frequency.

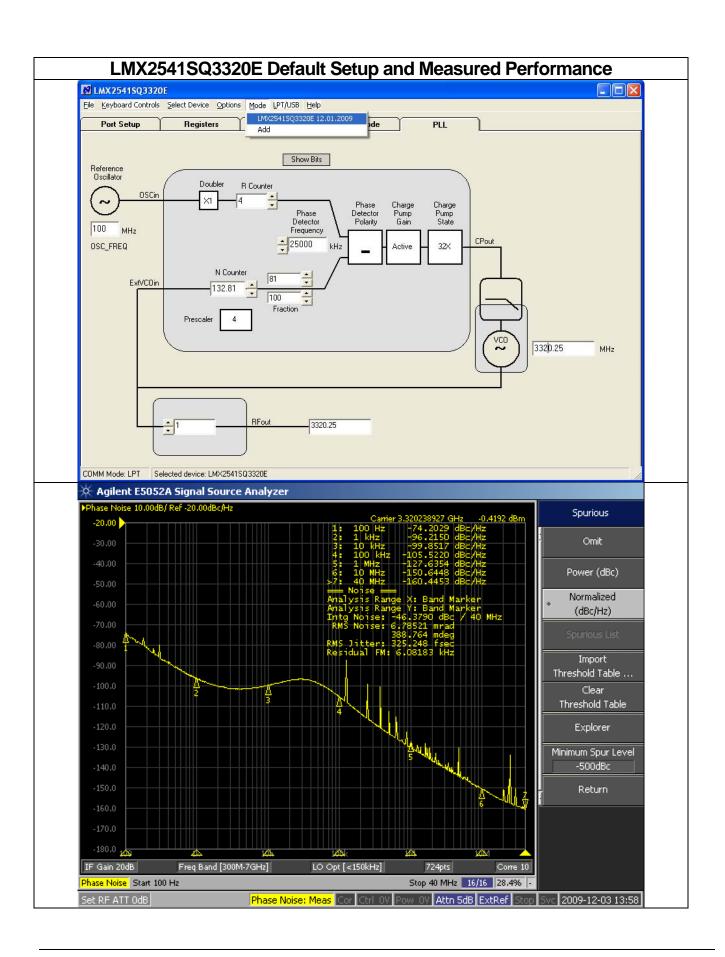


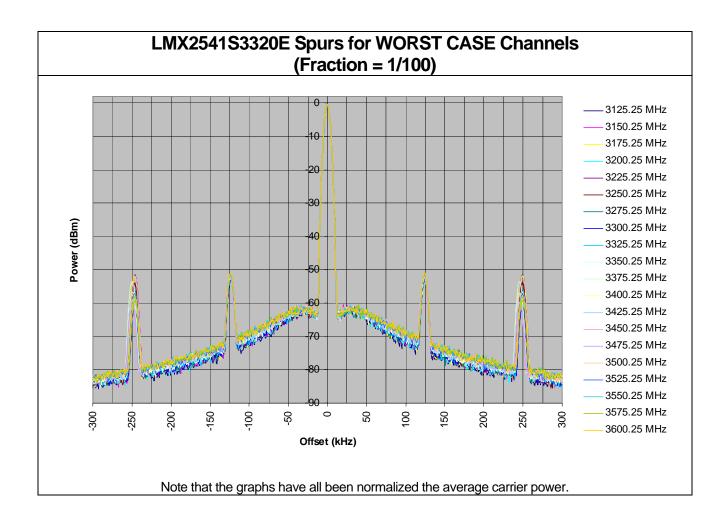


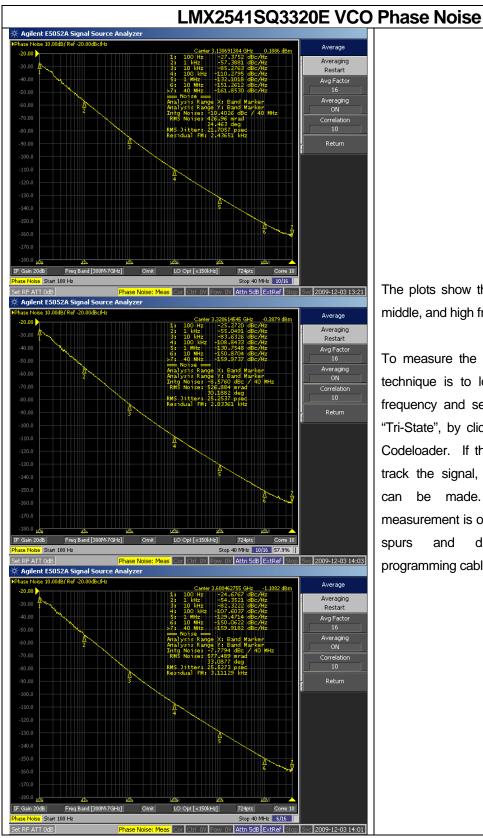
LMX2541SQ3030E VCO Phase Noise



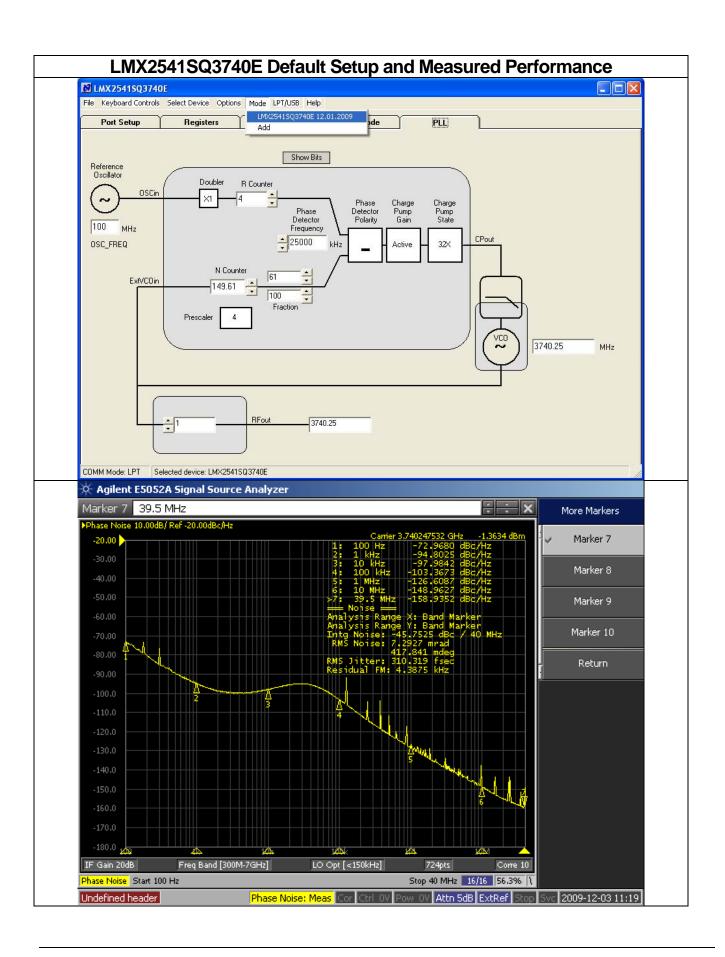
The plots show the VCO phase noise at low, middle, and high frequency.

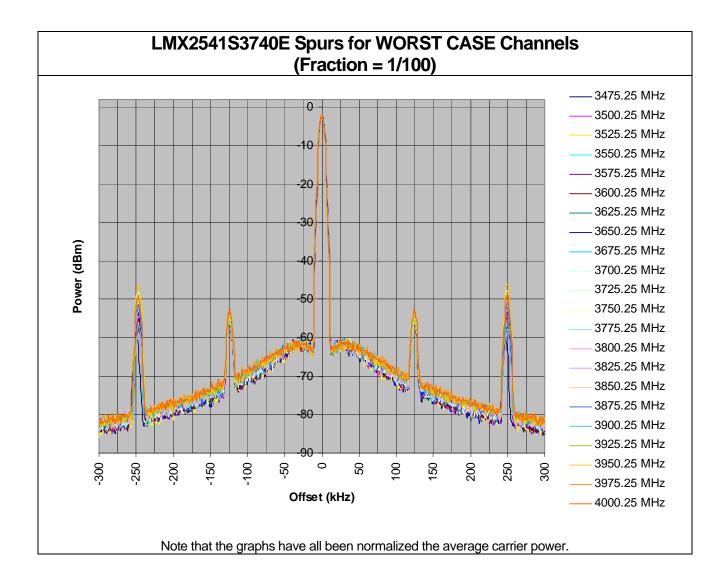






The plots show the VCO phase noise at low, middle, and high frequency.





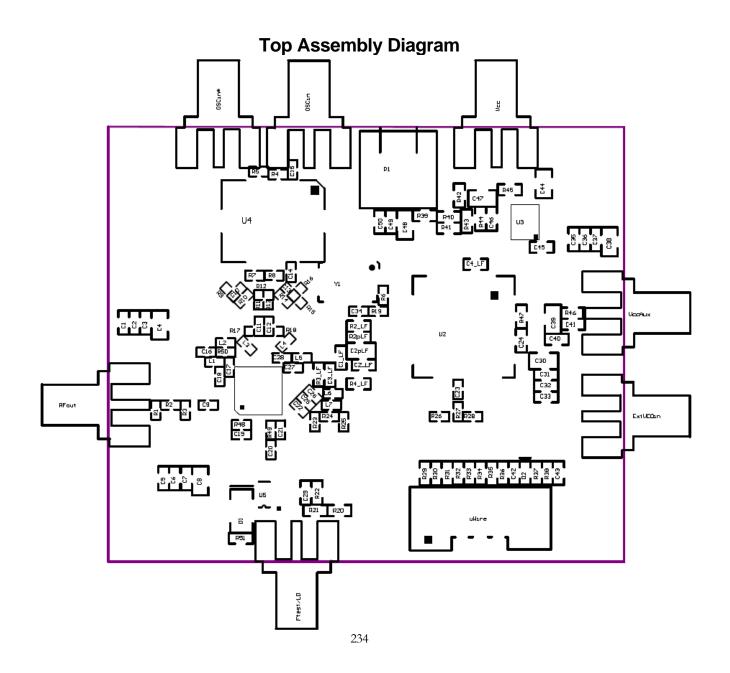
LMX2541SQ3740E VCO Phase Noise



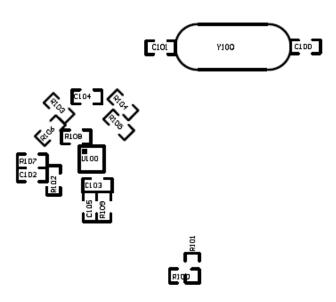
The plots show the VCO phase noise at low, middle, and high frequency.

Bill of Materials

Revision	9/30/2009			
Part	Manufacturer	Part Number	Qty	Identifier
		Сар	acitors	
100 pF	Kemet	C0603C101J5GAC	4	C1, C5, C33, C35
2.2 nF	Kemet	C0603C222J5GAC	1	C3_LF
22 nF	Kemet	C0603C223K5RAC	1	C2_LF
0.1 uF	Kemet	C0603C104K5RAC	19	C2, C6, C9, C10, C11, C12, C13, C17, C18, C21, C24, C25 C26, C27, C28, C32, C36, C40, C49
1 uF	Kemet	C0603C105K8VAC	10	C3, C7, C16, C19, C31, C37, C41, C42, C43, C50
4.7 uF	Kemet	C0603C475K9PAC	4	C14, C15, C20, C34
10 uF	Kemet	C0805C106K9PAC	6	C4, C8, C30, C38, C39, C48
		Res	sistors	
0 ohm	Vishay/Dale	CRCW06030000Z0EA	7	R3_LF, R12, R21, R39, R41, R42, R46
4.7 ohm	Vishay/Dale	CRCW06034R7JNEA	2	R49, R50
10 ohm	Vishay/Dale	CRCW060310R0JNEA	3	R6, R47, R48
18 ohm	Vishay/Dale	CRCW060318R0JNEA	1	R2
51 ohm	Vishay/Dale	CRCW060351R0JNEA	2	R10, R14
120 ohm	Vishay/Dale	CRCW0603120RJNEA	3	R7, R8, R51
180 ohm	Vishay/Dale	CRCW0603180RJNEA	1	R36
330 ohm	Vishay/Dale	CRCW0603330RJNEA	2	R1, R3
470 ohm	Vishay/Dale	CRCW0603470RJNEA	1	R2_LF
2.2 k	Vishay/Dale	CRCW06032K20JNEA	1	R35
15 k	Vishay/Dale	CRCW060315K0JNEA	3	R30, R32, R34
27 k	Vishay/Dale	CRCW060327K0JNEA	5	R29, R31, R33, R37, R38
100 k	Vishay/Dale	CRCW0603100KJNEA	2	R4, R5
· ·		C	ther	
Ferrite	Digikey	490-1015-1-ND	7	L1, L2, L3, L4, L5, L6, L7
3.3 V zener	Comchip	CZRU52C3V3	1	D2
HEADER_2X5 (POLARIZED)	FCI Electronics	52601-S10-8	1	uWire
Green LED	Lumex	SML-LX2832GC-TR	1	D1
POWER_SMALL	Weidmuller	1594540000.0	1	P1
SMA	Johnson Components	142-0701-851	4	OSCin, OSCin*, RFout, Vcc
TCXO - 100 MHz	Connor-Winfield	CWX813 - 100 MHz	1	Y1
NFET	Fairchild	BSS138	1	U5
VCXO - 100 MHz	CRYSTEK	CVPD-920 – 100 MHz	1	U4
LMX2541	National Semiconductor	LMX2541SQxxxx	1	U1
Standoffs	SPC Technology	SPCS-6	4	Place in Holes at the corners of the board.
		C)pen	
Open	-	Open Capacitor	14	C1_LF, C2pLF, C4_LF, C22, C23, C29, C44, C45, C46, C4
Open		Open Capacitor	6	C100, C101, C102, C103, C104, C105
Open	-	Open Resistor	22	R2pLF,R4_LF, R9, R11, R13, R15, R16, R17, R18, R19, R20, R22, R23, R24, R25, R26, R27, R28, R40, R43, R44, R45
Open	-	Open Resistor	9	R100, R101, R102, R103, R104, R105, R106, R107, R108 R109
Open	-	Open Crystal	1	Y100
Open	-	Open IC	3	U2, U3, U100
Open	-	Open SMA	3	ExtVCOin, Ftest/LD, VccAux

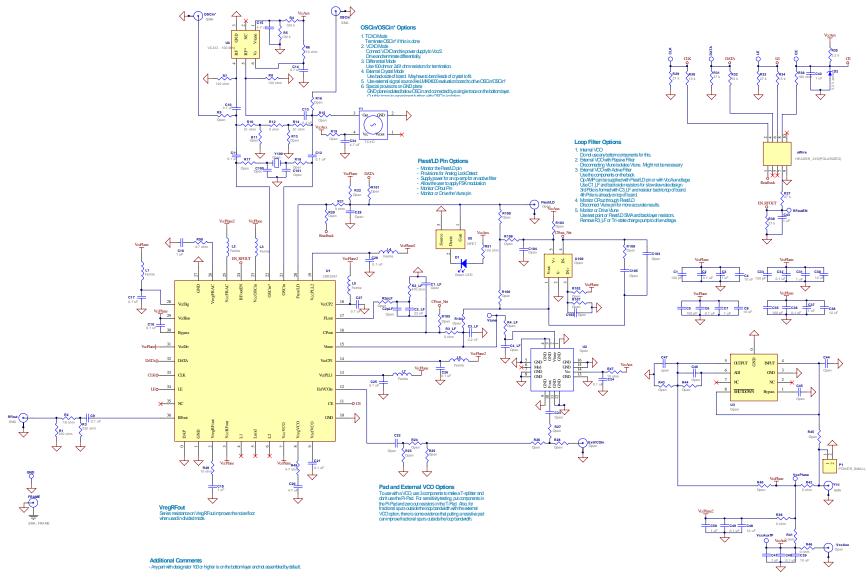


Bottom Assembly Diagram



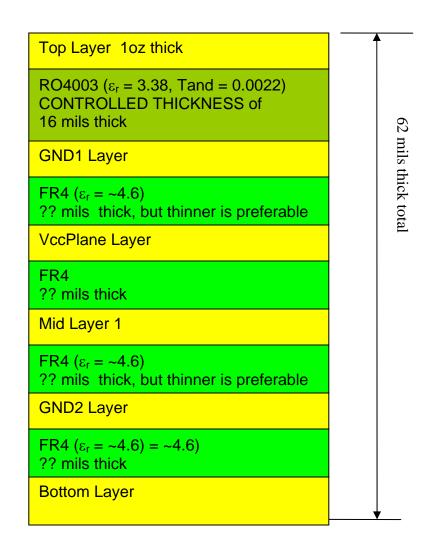
No Components are assembled on the bottom layer in the default setup.

Schematic

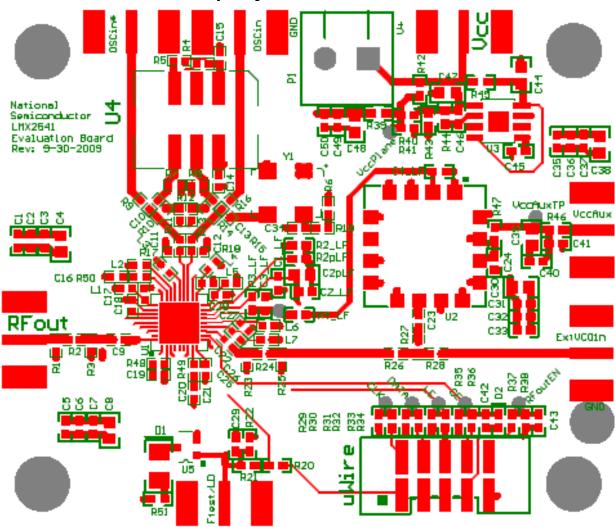


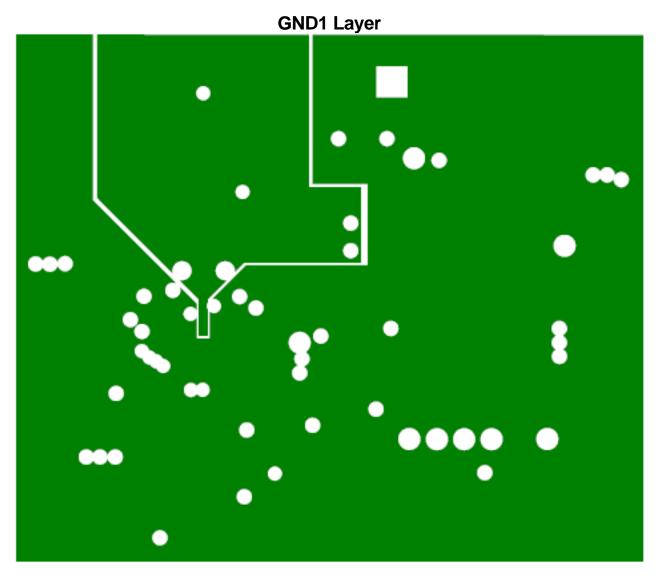
Board Layer Stackup

Board Material	Rogers RO4003
Number of Layers	6
Board Thickness	0.062"
Copper Weight	1 oz Finished
Finish	Immersion Gold
Solder Mask Color	Green/Gloss
Tosting	100% Electrical
Testing	Testing

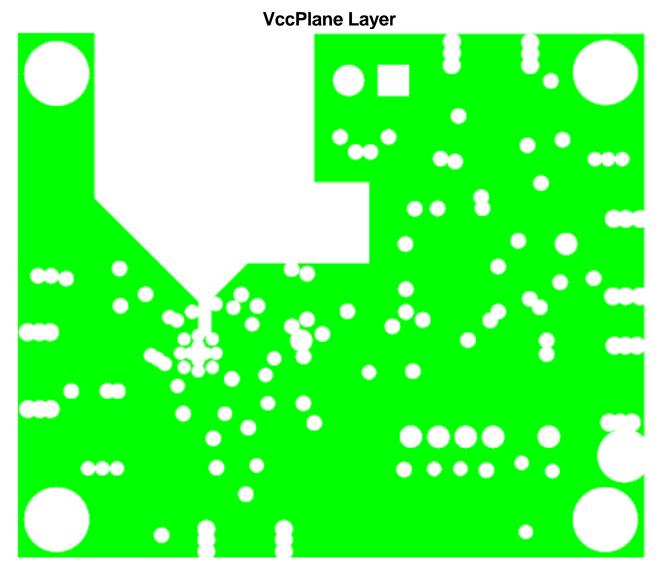


Top Layer and Silkscreen



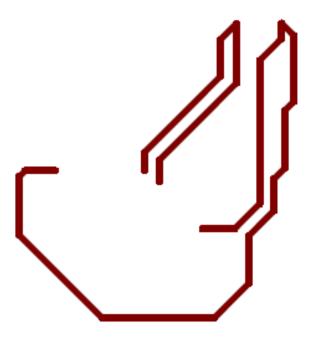


Beneath the TCXO, the ground plane is separated. It is believed that this may improve spurs, especially at offset frequencies equal to the TCXO frequency. These planes are connected on the bottom layer by a small trace.

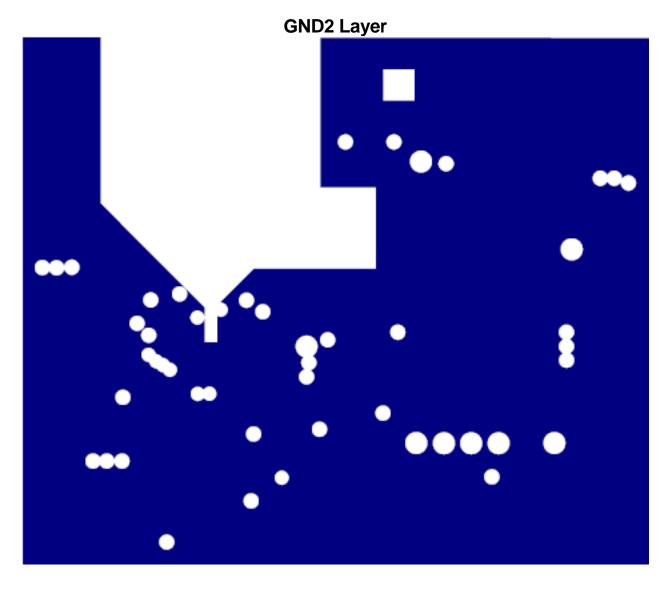


Beneath the TCXO, the power plane is removed to minimize the chance of any noise getting onto this plane.

MidLayer 1

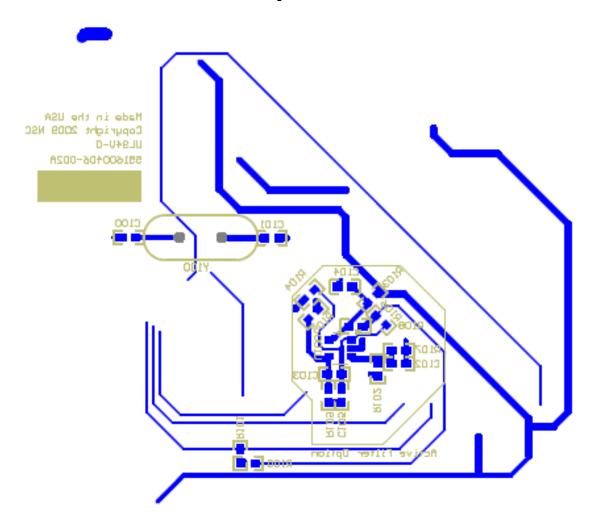


Certain pins like VccFRAC and the TCXO supply pins could potentially be sources of noise. These traces were put on this separate layer to try to isolate them more from the



Beneath the TCXO, the ground plane is separated. It is believed that this may improve spurs, especially at offset frequencies equal to the TCXO frequency. These planes are connected on the bottom layer by a small trace.

Bottom Layer and Silkscreen



This layer has the small trace that connects the grounded pieces in the GND1 layer. It has options for an active filter and crystal as well.