

LMX2581EVM

User's Guide



Literature Number: SNAU136C
November 2012—Revised November 2013

LMX2581EVM User's Guide

The Texas Instruments LMX2581EVM evaluation module (EVM) helps designers evaluate the operation and performance of the LMX2581 Wideband Frequency Synthesizer. The EVM contains one Frequency Synthesizer.

Converter: U1

IC: LMX2581

Package: LQA32A

Topic	Page
1 Setup	3
2 Using the EVM Software	5
3 Board Construction	9
4 PCB Layers	15
5 Measured Performance Data	20
6 Bill of Materials	39

1 Setup

1.1 Input and Output Connector Description

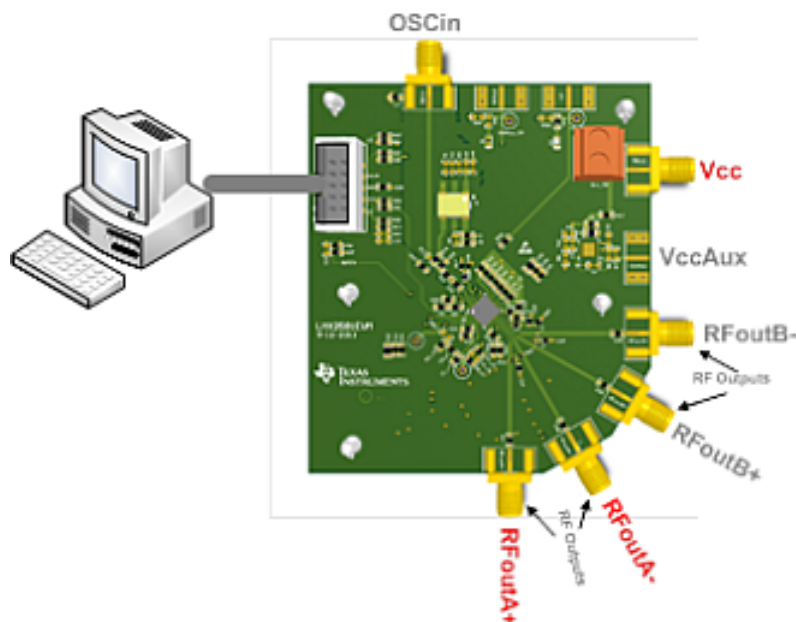


Figure 1. Evaluation Board Setup

Table 1. Inputs and Outputs

Output Name(s)	Input/Output	Required?	Function
RFoutA+/RFoutA- RFoutB+/RFoutB	Output	Required	These are two differential outputs. Connect any of the four outputs to a spectrum analyzer or phase noise analyzer. It is recommended to put a 50 ohm terminator for the unused side of the differential output. Failure to do so will degrade performance, especially output power and harmonics. The Agilent E5052A was used for these instructions.
V CC	Input	Required	Connect to a 3.3 V Power Supply. Ensure the current limit is set above 300 mA.
V CC Aux	Input	Optional	This gives the option to supply power to an external VCO.
Programming Interface	Input	Required	Connect the board to a PC using the provided cable.
OSCin	Input	Optional	The on-board 100 MHz XO has been enabled. To disable the XO and utilize the OSCin port move R13 to R12 and disconnect R4 (removing power from the XO).

1.2 Installing the EVM Software

Go to <http://www.ti.com/tool/codeloader> and download and run the most current software.

1.3 Loop Filter Values and Configuration Information

Table 2. Loop Filter values and Configuration

Category	Parameter	Value
Configuration	OSCI _n Frequency (MHz)	100 MHz
	Phase Detector Frequency (MHz)	20 MHz
	VCO Frequency	1850 to 3760 MHz
	Charge Pump Gain	2400 μ A
VCO Gain	VCO Core 1	15 to 25 MHz/V
	VCO Core 2	18 to 32 MHz/V
	VCO Core 3	23 to 40 MHz/V
	VCO Core 4	26 to 46 MHz/V
Loop Filter Components	C1_LF	1.8 nF
	C2_LF	56 nF
	C3_LF	Open
	C4_LF	3.3 nF
	R2_LF	390 Ω
	R3_LF	270 Ω
	R4_LF	0
Loop Filter Characteristics	Loop Bandwidth	28.7 kHz
	Phase Margin	49.7°

Note that C4_LF is placed and C3_LF is left off because C4_LF is closer to the Vtune input. It is recommended that the capacitor next to the VCO be at least 3.3 nF for optimal VCO phase noise. If this constraint is violated, then there can be some degradation in the VCO phase noise in the 200kHz to 1 MHz region, depending on how much smaller than 3.3 nF this capacitor is.

1.4 Burning in the Crystal Oscillator

To get the best stability and phase noise from this XO, it is recommended to let the board run for several in order burn in the crystal oscillator.

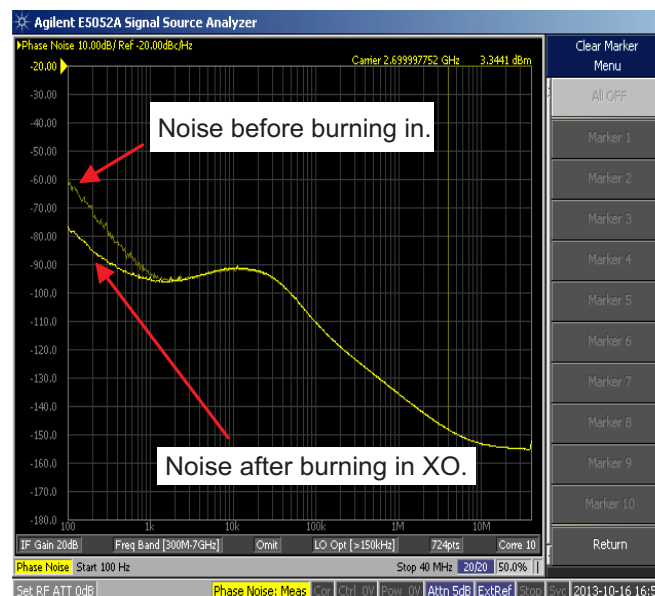


Figure 2. Impact of Burning in the XO

2 Using the EVM Software

2.1 Main Setup and Default Mode

NOTE: To restore the device to its default settings at any time, load the default mode from the “Modes” menu.

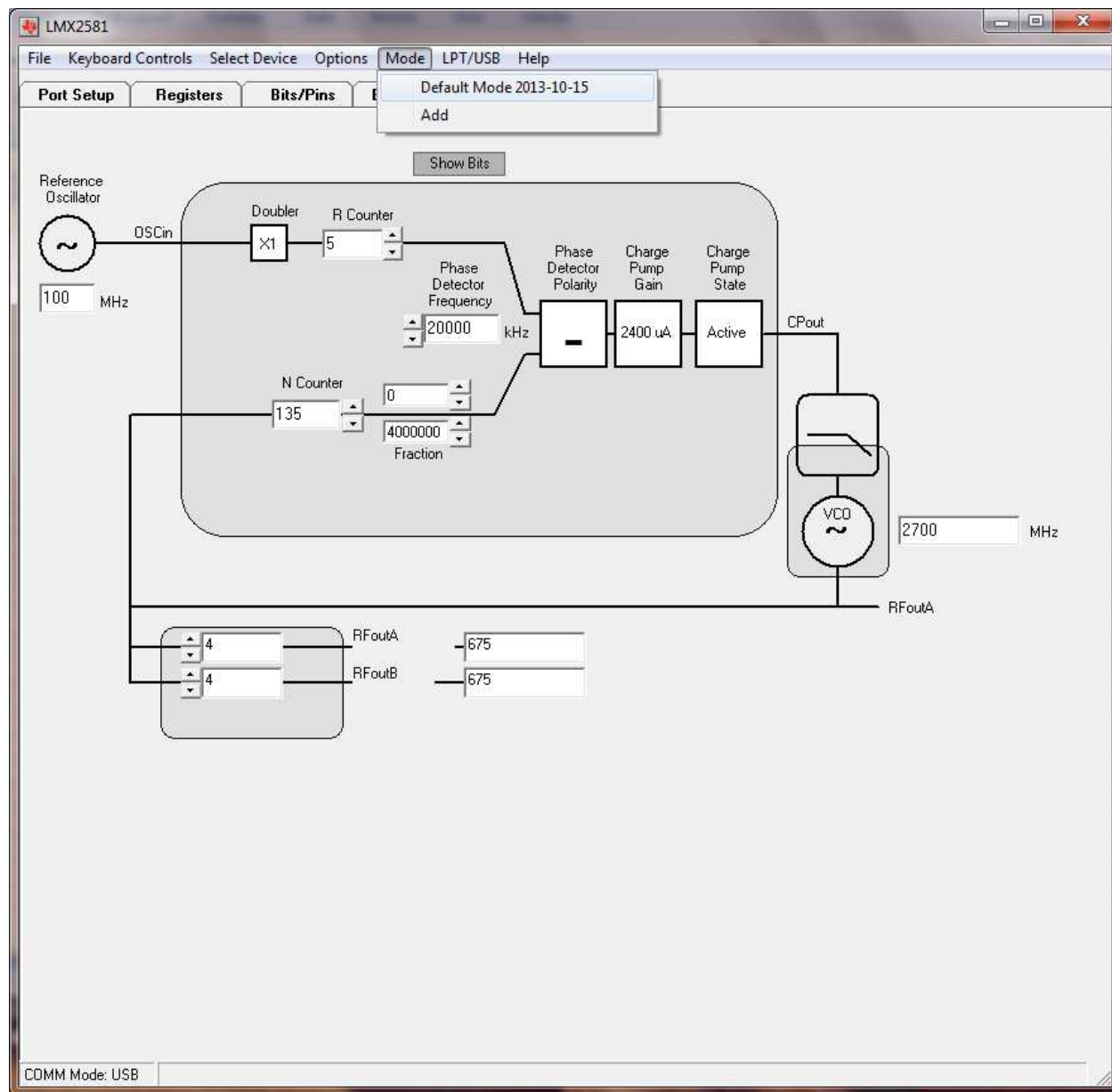


Figure 3. Loading Default Mode for the Main Configuration Screen

2.2 Loading the Device

To load the settings for the first time, you can either load this from the main menu as shown above or press <CTRL>+L. When the frequency or programmable bit settings are changed, CodeLoader will change the register associated with that programmable bit or change, but not all the registers.

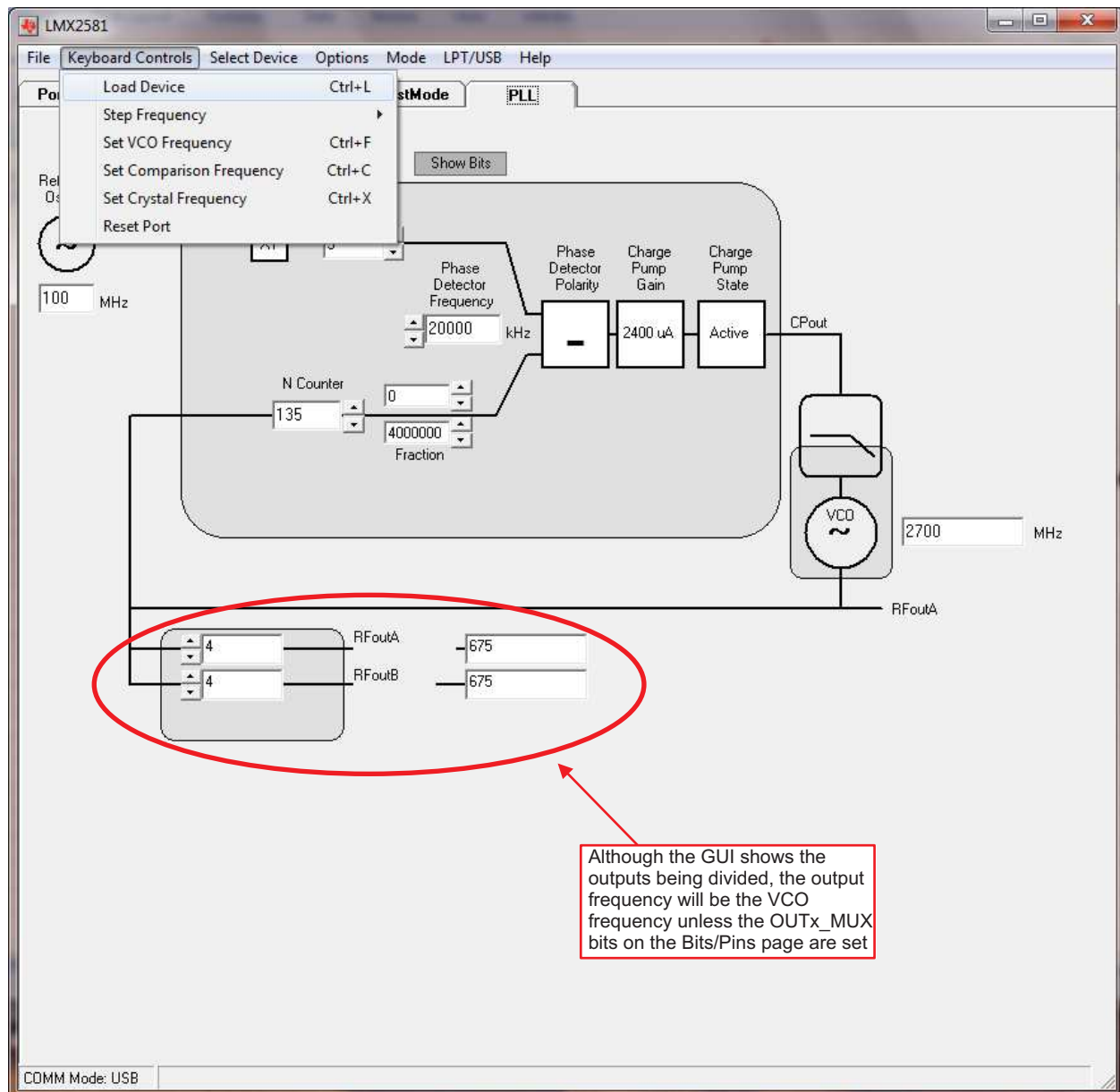


Figure 4. Loading the device

2.3 Port Setup

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. CodeLoader does NOT auto detect the correct settings for this. Also note that the BUFEN pin does not work with the USB2ANY board because pin location 5 is reserved for other purposes. Be aware that the board has been revised and the port setup has changed.

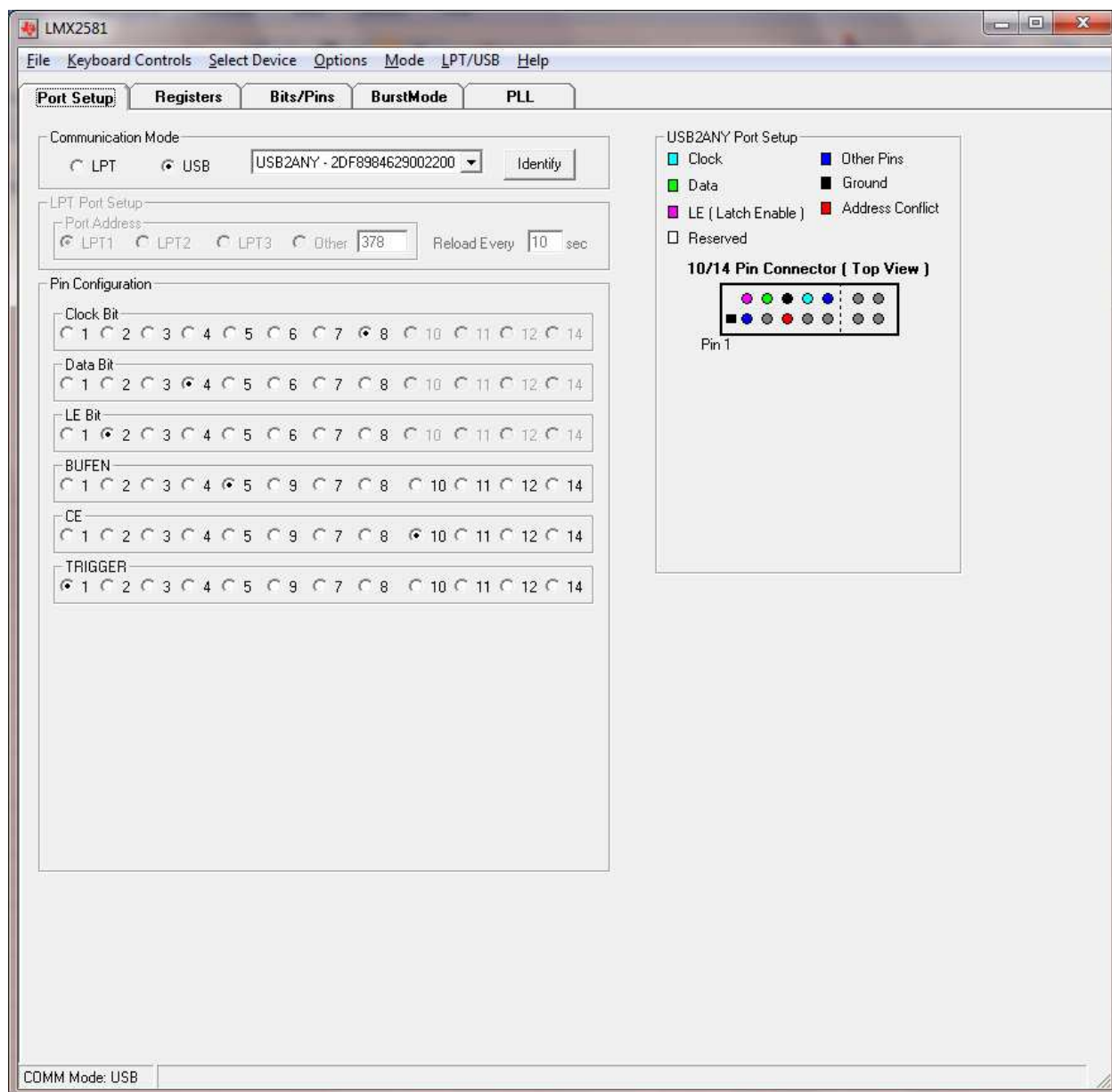


Figure 5.

2.4 Bits/Pins Settings

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.

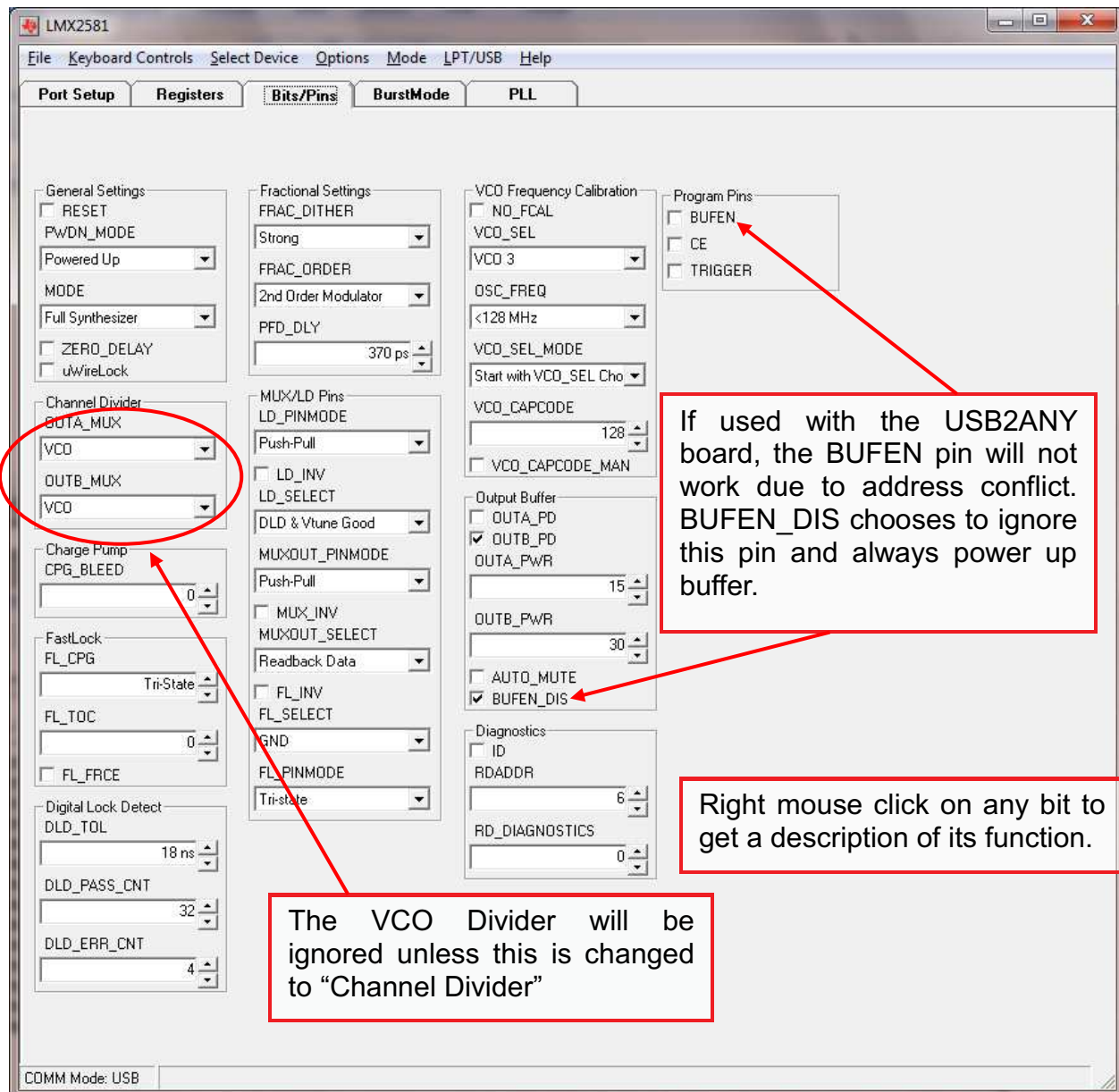


Figure 6. Bits/Pins Settings

3 Board Construction

3.1 Board Layer Stack Up

The board is made on FR4 for the Prepreg and Core Layers. The top layer is 1 oz copper.

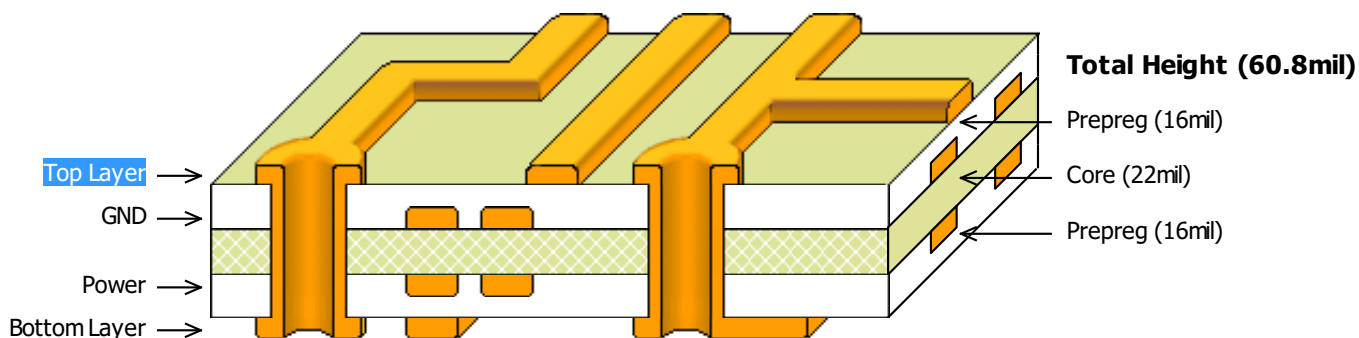


Figure 7. Board Layer Stack Up

FR4 material was chosen because of convenience, availability, and cost. If one was to use Rogers 4003 on the top Prepreg layer, the output power improves about 1 dB. Otherwise, the performance is very similar.

3.3 Comments and Recommendations for Evaluation Board Schematic

OSCin Input

The OSCin input has components of a series 47 Ω , shunt 18 Ω , and series 33 Ω , followed by a DC blocker capacitor. This divides down the CMOS output level of the XO and also makes the impedance as seen from the OSCin pin looking out to be about 50 Ω .

The OSCin input can also be driven by the OSCin SMA. To do this, remove R6 and R14; change R13, R15, and L3 to 0 Ω ; and make R15 51 Ω . Note that if L3 is not changed and left as a ferrite bead, this can create degraded performance when used with an external signal generator.

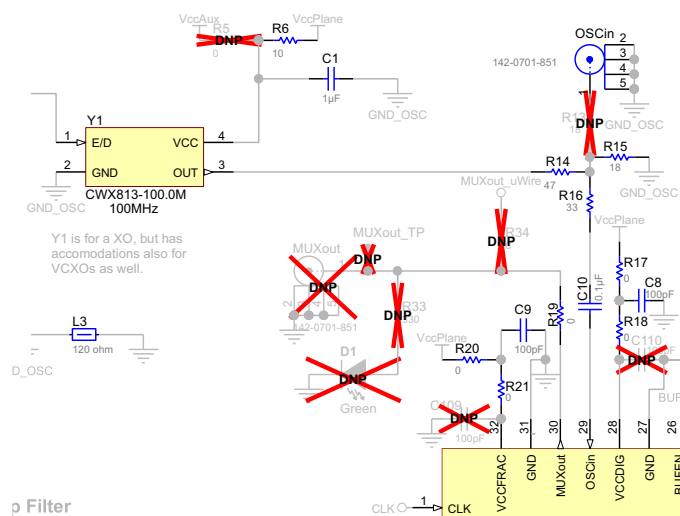


Figure 9. OSCin Input Diagram

Complementary OSCin Input Recommendation

When the OSCin trace is differential, the approach shown in Figure 10 can also be used to convert it for the single-ended input of the LMX2581. This circuit makes impedance seen from the LMX2581 OSCin pin looking out to be 50 Ω as well as the termination for the differential trace to be 100 Ω . Note that only one side of the 100 Ω differential trace can be grounded or it will change the desired 100 Ω termination for the differential trace.

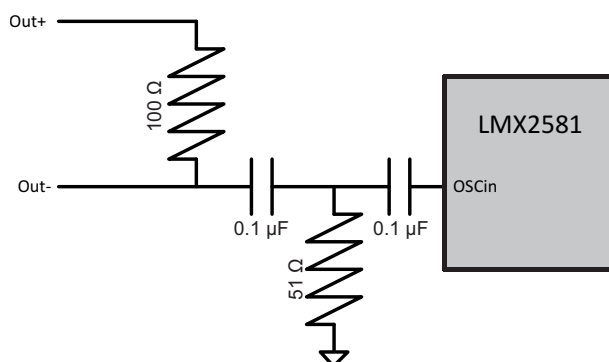


Figure 10. Complementary OSCin Input Recommendation Diagram

Copyright © 2012–2013, Texas Instruments Incorporated

Power Supply Bypassing

The bypassing of the power supply pins does not have a large impact on fractional spurs, although placing the ferrite bead L4 on the VccBUF pin improves the spurs at the phase detector frequency offset. This board accommodates the possibility to change this bypassing to either filter noise coming to the pin, or by preventing noise going out from the pin to the ground plane, as in the case of the VccBUF pin.

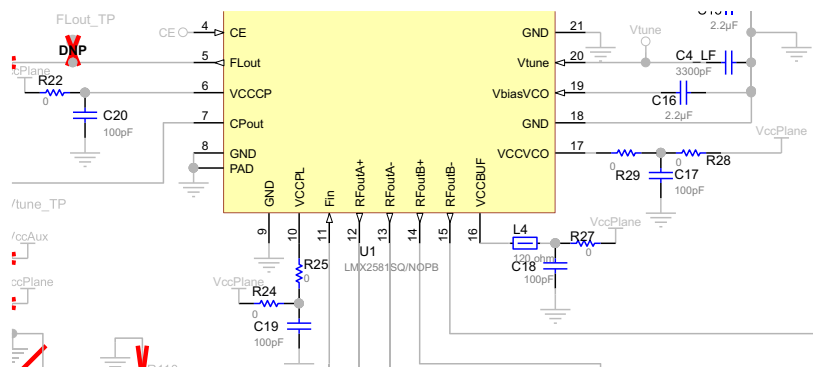


Figure 13. Power Supply Bypassing Diagram

Pins 18,19,22,23, and 24

For the best performance, it is best to have a solid ground connection between the grounds of these pins. Larger value, higher quality capacitors are good for pins 23 and 24

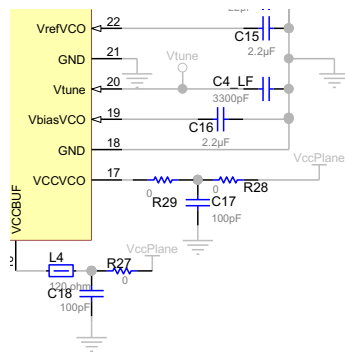


Figure 14. Pins 18,19,22,23, and 24 Diagram

The outputs can have either an inductor or resistor pull-up. The board has both values. The placement of this pull-up component close to the chip is critical for output power. For this board, the routing of both outputs compromised the output power a little because it forced this component a little farther away and also it was done on FR4. If a single output was routed on a dielectric like Rogers4003, the output power could have been slightly higher.

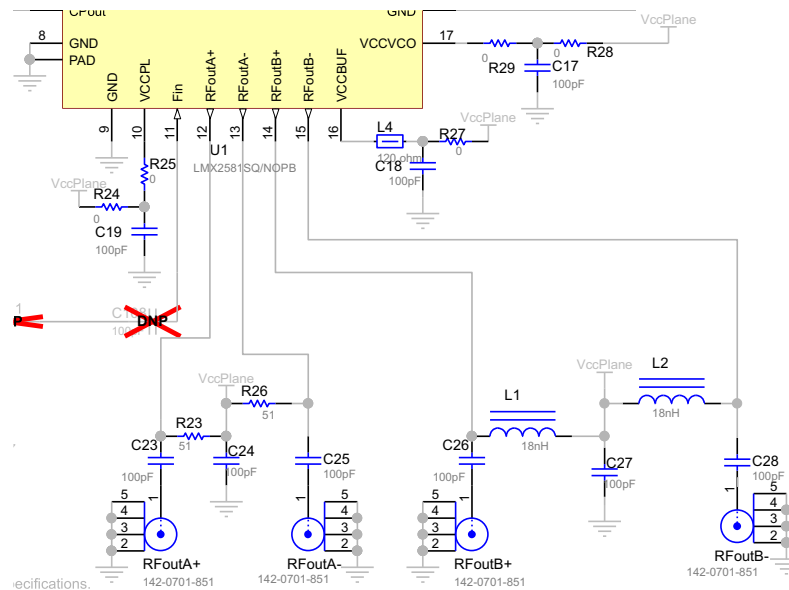


Figure 15. Outputs Diagram

4 PCB Layers

Figure 16 shows the assembly diagram that indicates where the components are placed.

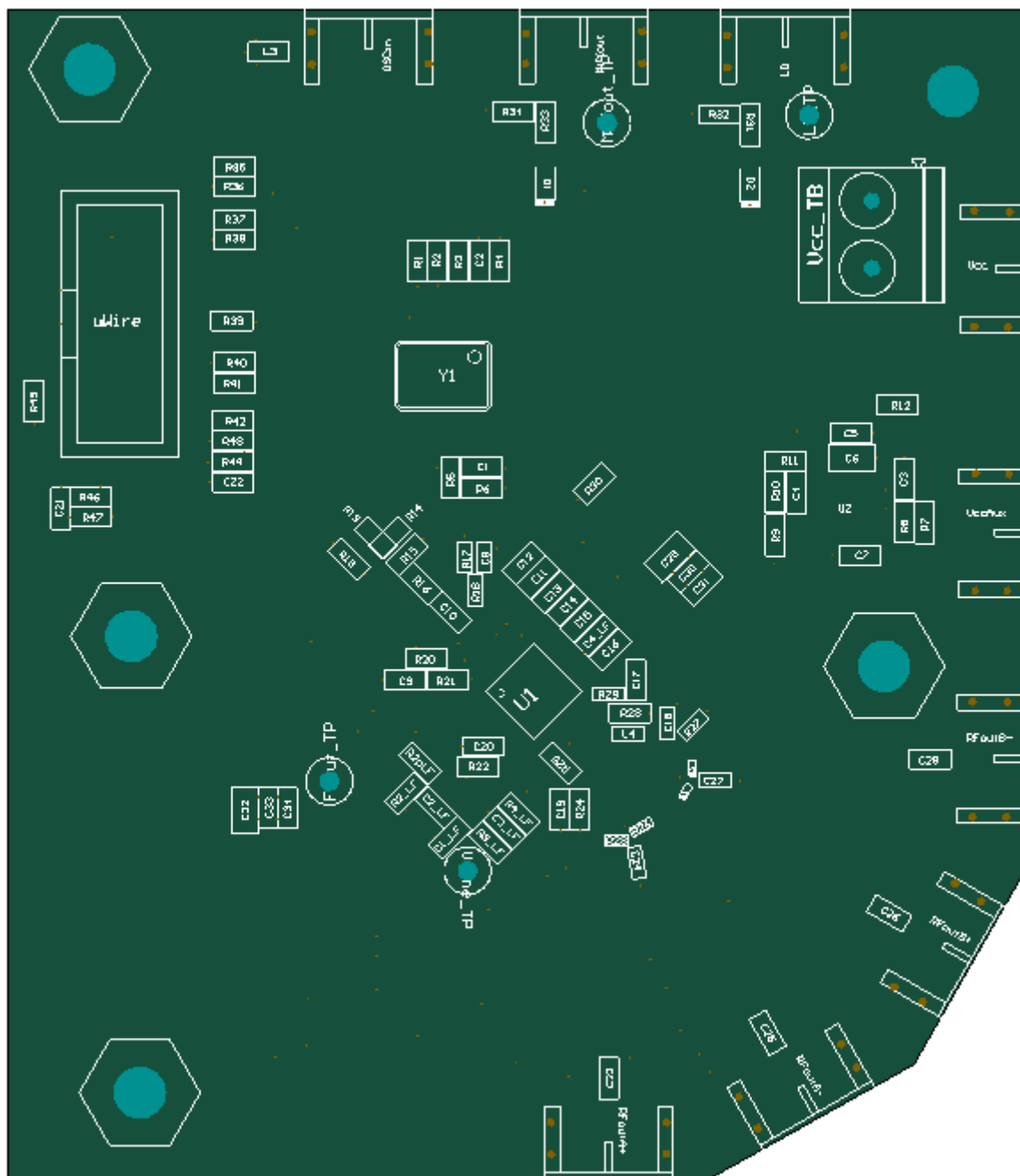


Figure 16. Top Assembly Layer

In the Top Layer, [Figure 17](#), note the solid polygon on the northeast side of the chip, which gives solid grounding to the VregVCO, VbiasVCO, as well as the closed capacitor on the loop filter. This is recommended for optimal performance. On the output traces, the placement of the pull-up component also needs to be as close to the device as possible for optimal output power. For this layout, about 1 dB of power was sacrificed in order to route both outputs, thereby forcing this pull-up component farther away.

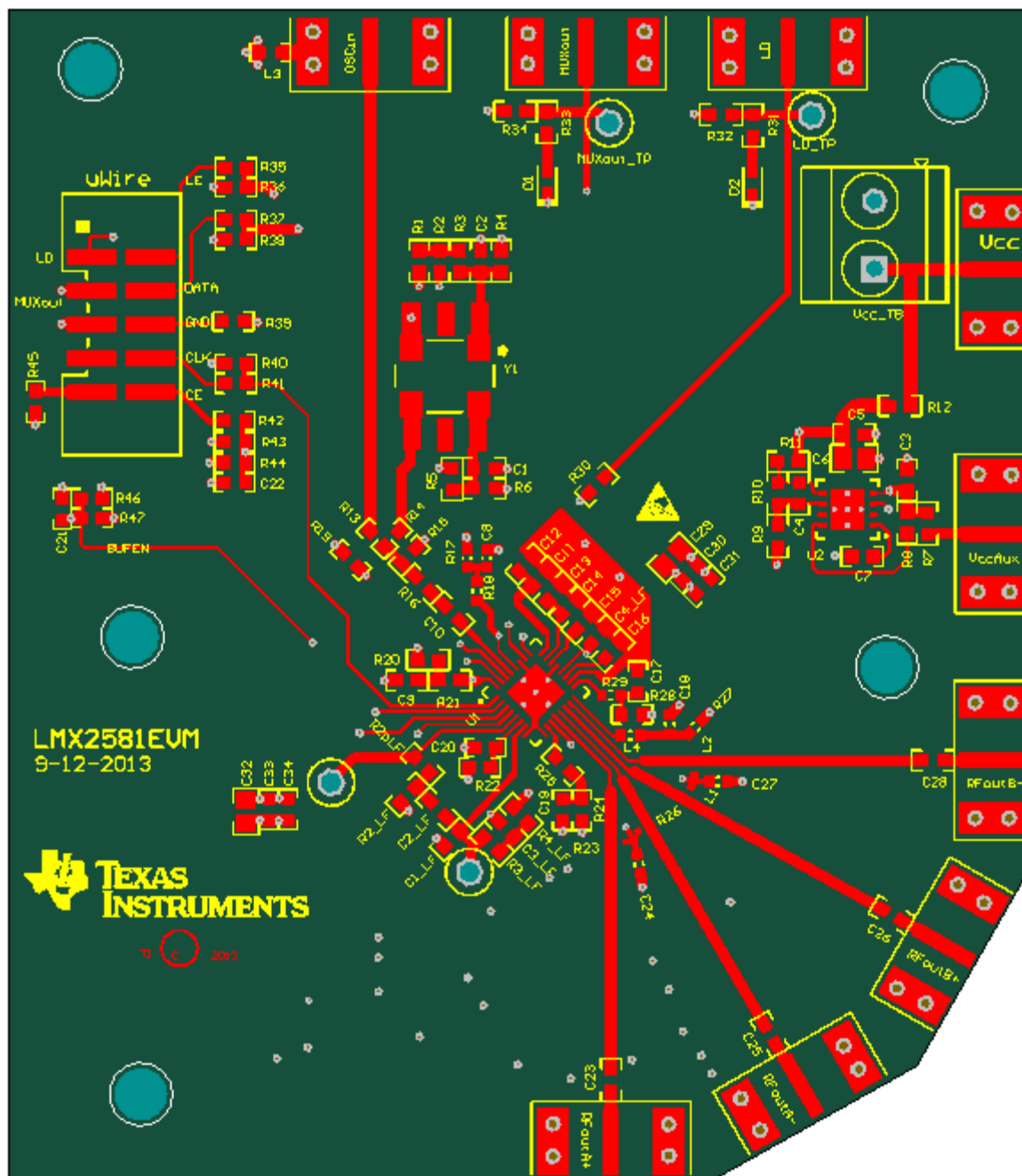


Figure 17. Top Layer

On the Ground Layer, [Figure 18](#), notice there is a main region and a second region that is cut out below the OSCin source. There is a connection through component L3 on the top layer. This reduces coupling from the OSCin signal to the outputs that can potentially spurs at +/- Foscin offset.

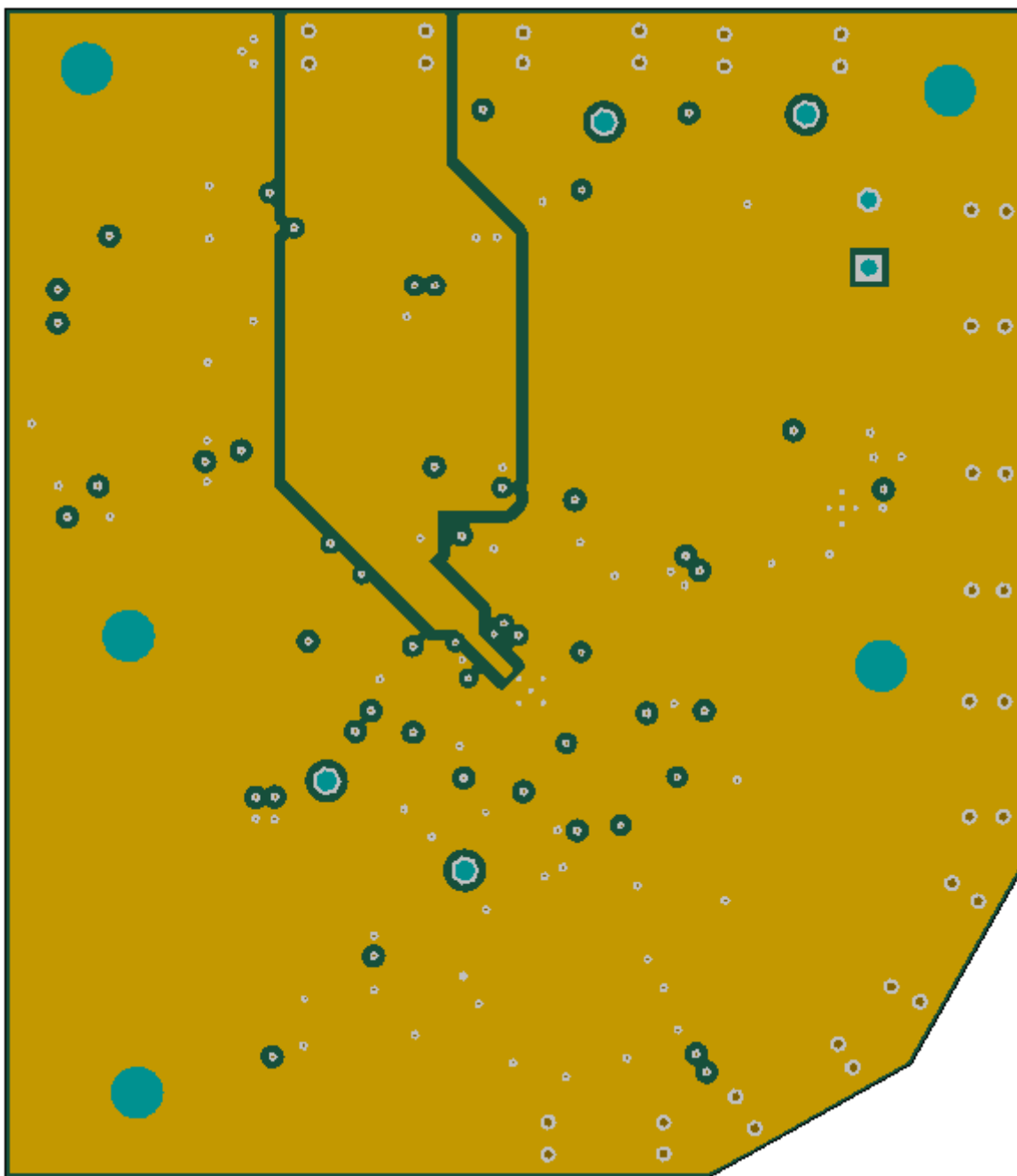


Figure 18. Ground Layer

The power layer, [Figure 19](#), is used to route the power signals. There is a cutout below the OSCin signal to reduce any coupling the OSCin frequency from nearby vias to the power plane.

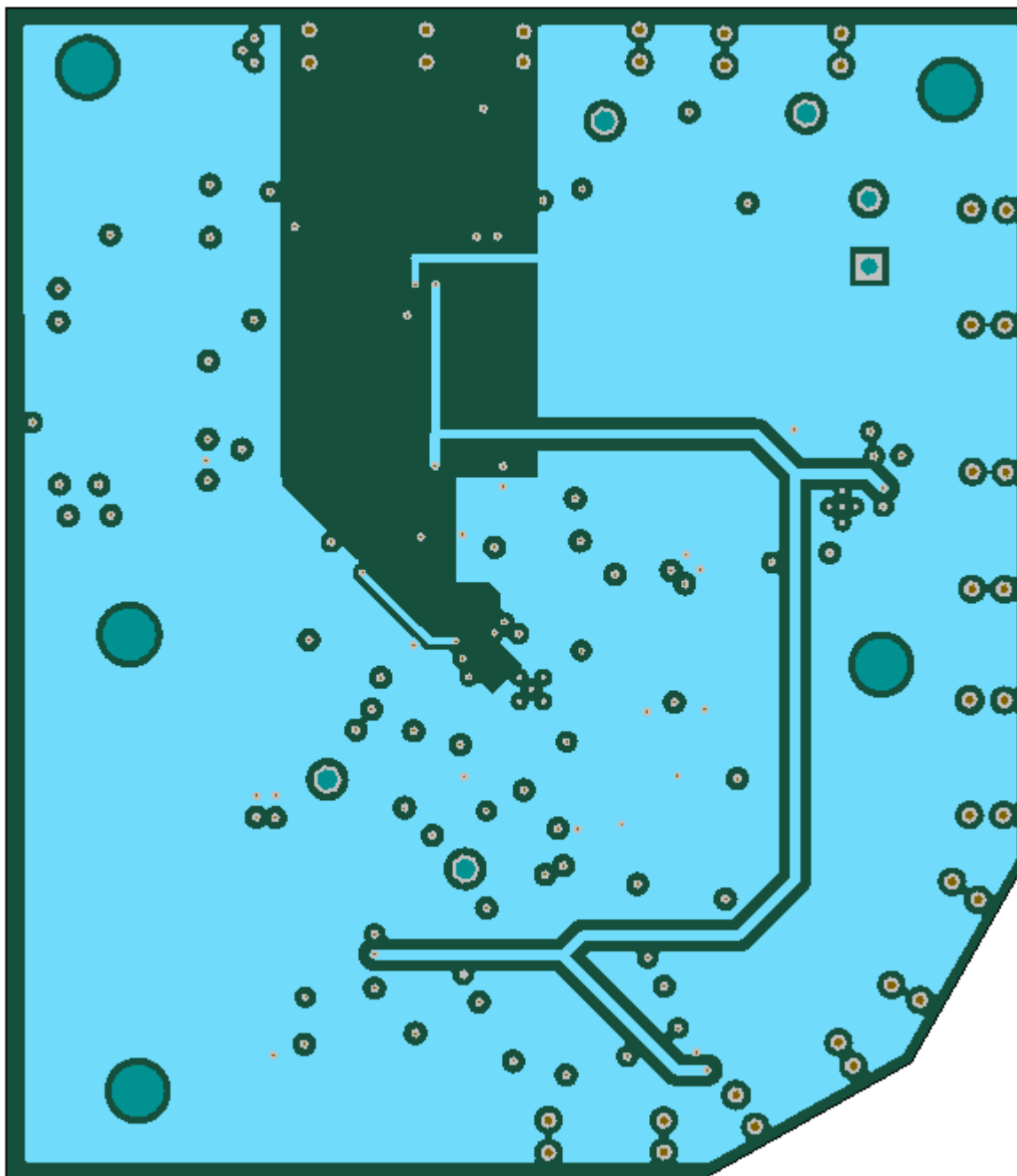


Figure 19. Power Layer

Copyright © 2012–2013, Texas Instruments Incorporated

5 Measured Performance Data

5.1 Phase Noise in Default Mode

Figure 21 shows the phase noise in default mode. This was taken with a clean input (Wenzel 100 MHz Oscillator), which shows that the device can achieve -99 dBc/Hz for a 2.7 GHz carrier at 1 KHz offset.

The 10 kHz number could be improved for a wider bandwidth. See section Section 5.7 for some examples with a wider bandwidth filter.

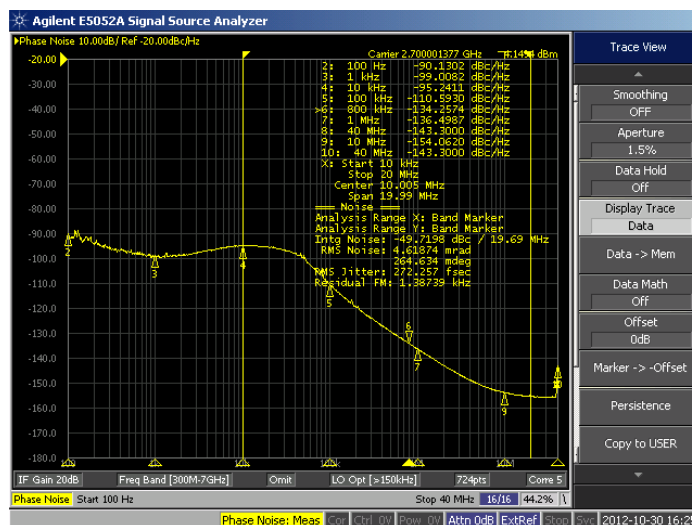


Figure 21. Phase Noise (Default Mode)
Plot 1 of 3

Figure 22 shows the phase noise in default mode. The difference for this one is that it uses the on-board XO. Comparing to the plot above, we see that the XO, not the LMX2581, is the dominant source of phase noise at 100 Hz and 1 kHz.

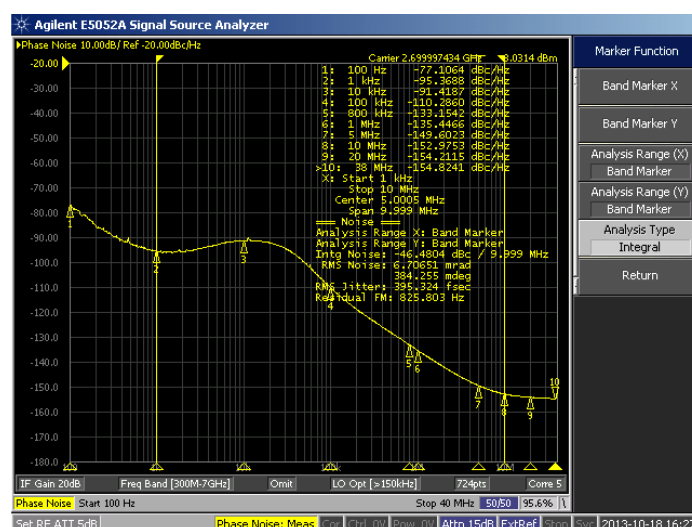


Figure 22. Phase Noise (Default Mode)
Plot 2 of 3

Figure 23 shows a 2700 MHz output signal with various divides. For offsets of 1 MHz and below the phase noise follows a $20 \cdot \log(\text{divide})$ relationship. However, past 10 MHz, the phase noise does not follow this and the larger divide values are showing the noise floor of the divider to be about -155 dBc/Hz.

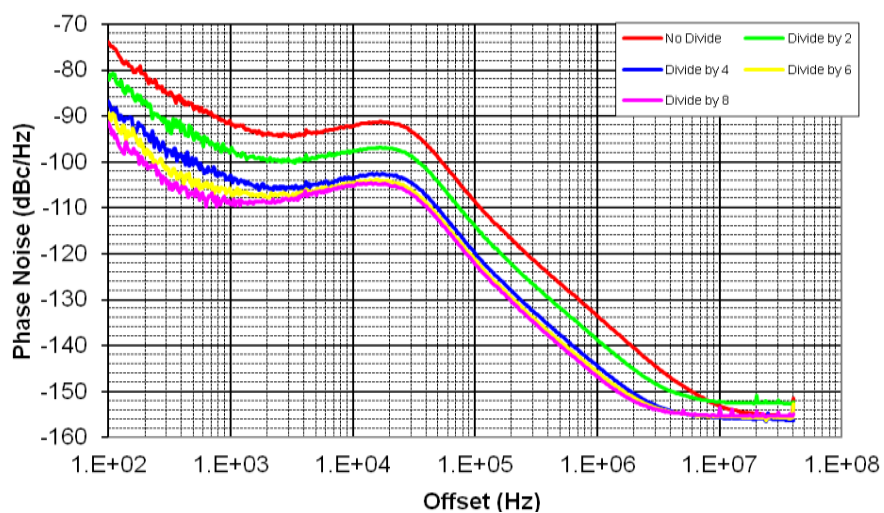


Figure 23. Phase Noise (Default Mode)
Plot 3 of 3

5.2 VCO Phase Noise

5.2.1 Fvco = 1900 MHz

Figure 24 and Figure 25 show the phase noise of just the VCO.

These are single-ended measurements and the unused side of the differential output was terminated with a 50 Ω terminator. For these measurements, the programmable output power settings were OUTA_PWR=15 and OUTB_PWR=30.

To get the most accurate measurement, the PLL was tuned 3 MHz away from any harmonic of the 100 MHz OSCin frequency and the charge pump was set to tri-state. Even though the charge pump was tri-stated, a narrow bandwidth filter was used to minimize any frequency drifting.

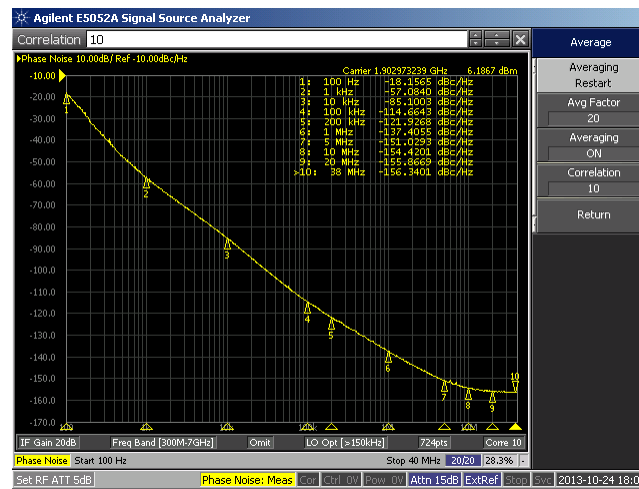


Figure 24. VCO Phase Noise
Fvco = 1900 MHz
RFOutA+

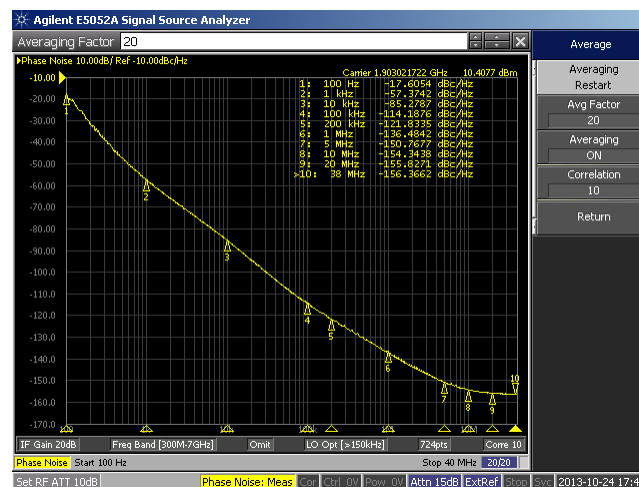


Figure 25. VCO Phase Noise
Fvco = 1900 MHz
RFOutB+

5.2.2 Fvco = 2200 MHz

Figure 26 and Figure 27 show the phase noise of just the VCO.

These are single-ended measurements and the unused side of the differential output was terminated with a 50 Ω terminator. For these measurements, the programmable output power settings were OUTA_PWR=15 and OUTB_PWR=30.

To get the most accurate easurement, the PLL was tuned 3 MHz away from any harmonic of the 100 MHz OSCin frequency and the charge pump was set to tri-state. Even though the charge pump was tri-stated, a narrow bandwidth filter was used to minimize any frequency drifting.

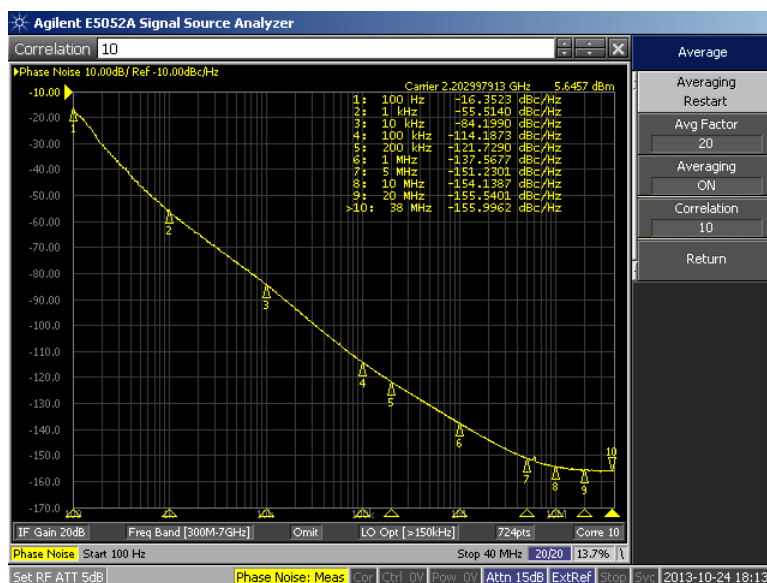


Figure 26. VCO Phase Noise
Fvco = 2200 MHz
RFOutA+

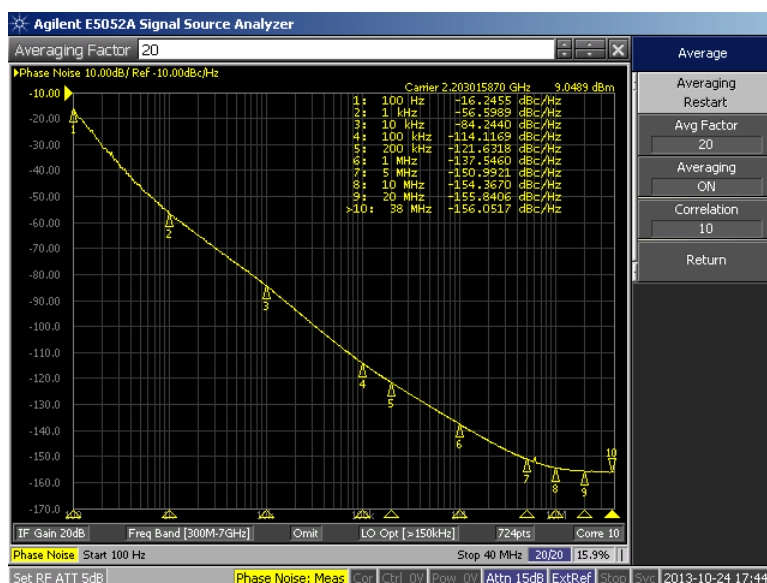


Figure 27. VCO Phase Noise
Fvco = 2200 MHz
RFOutB+

5.2.3 Fvco = 2700 MHz

Figure 28 and Figure 29 plots show the phase noise of just the VCO.

These are single-ended measurements and the unused side of the differential output was terminated with a 50 Ω terminator. For these measurements, the programmable output power settings were OUTA_PWR=15 and OUTB_PWR=30.

To get the most accurate easurement, the PLL was tuned 3 MHz away from any harmonic of the 100 MHz OSCin frequency and the charge pump was set to tri-state. Even though the charge pump was tri-stated, a narrow bandwidth filter was used to minimize any frequency drifting.

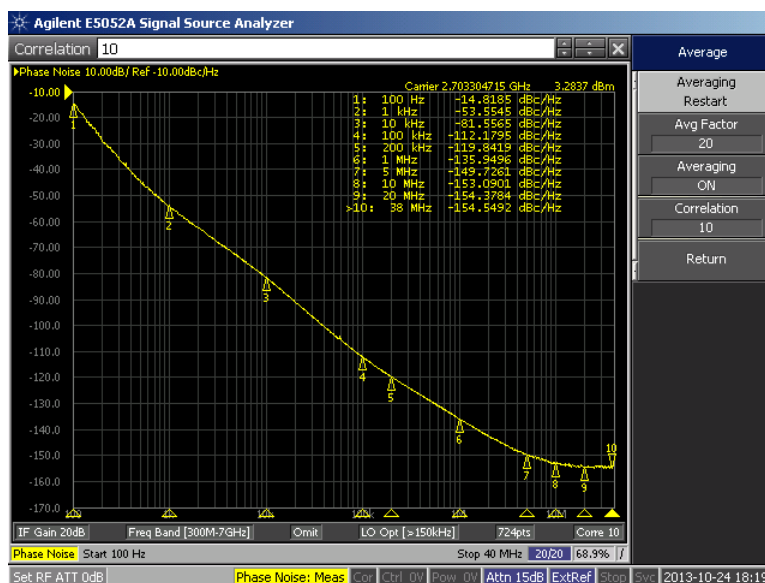


Figure 28. VCO Phase Noise
Fvco = 2700 MHz
RFOutA+

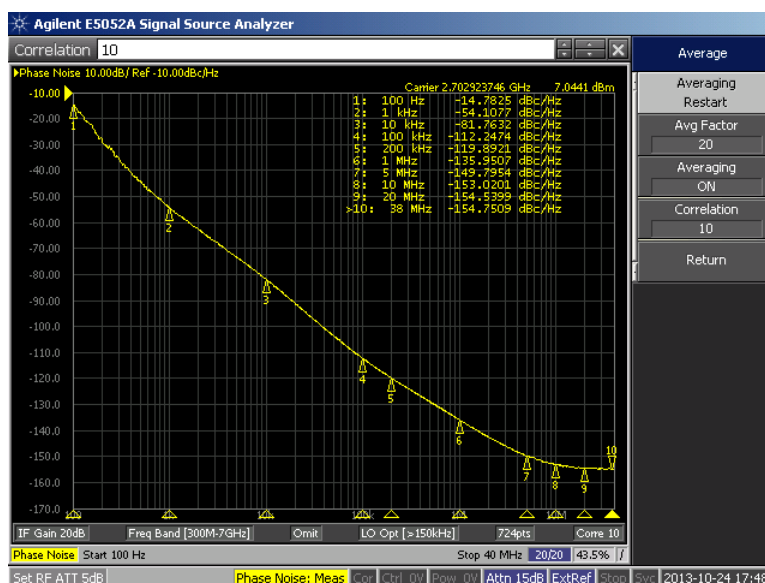


Figure 29. VCO Phase Noise
Fvco = 2700 MHz
RFOutB+

5.2.4 Fvco = 3300 MHz

Figure 30 and Figure 31 plots show the phase noise of just the VCO.

These are single-ended measurements and the unused side of the differential output was terminated with a 50 Ω terminator. For these measurements, the programmable output power settings were OUTA_PWR=15 and OUTB_PWR=30.

To get the most accurate measurement, the PLL was tuned 3 MHz away from any harmonic of the 100 MHz OSCin frequency. Unlike the plots at the other frequencies, the charge pump was NOT tri-stated and the PLL is locked. The marker at 100 Hz was removed because this is not pure VCO noise and is impacted by the loop filter.

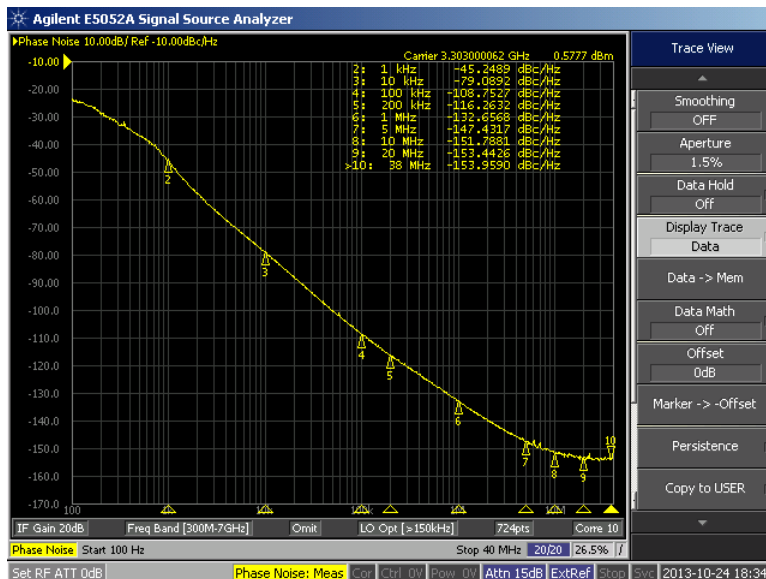


Figure 30. VCO Phase Noise
Fvco = 3300 MHz
RFOutA+

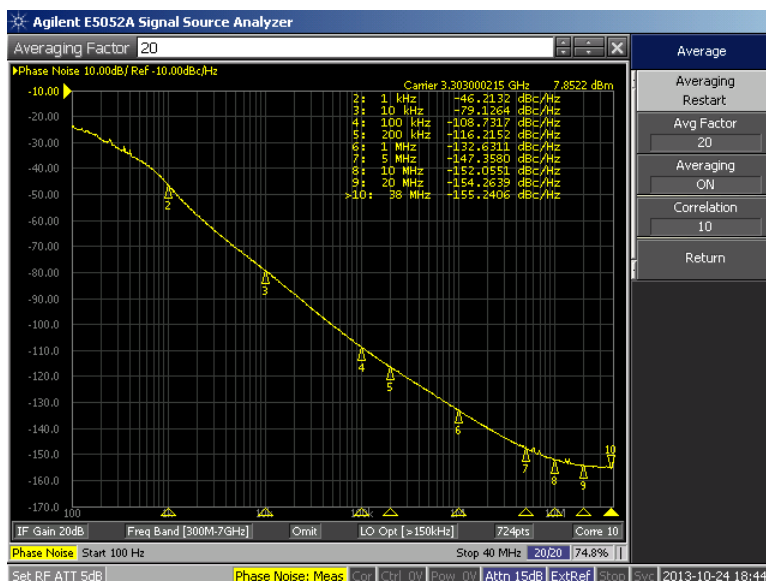


Figure 31. VCO Phase Noise
Fvco = 3300 MHz
RFOutB+

5.3 Fractional Spurs

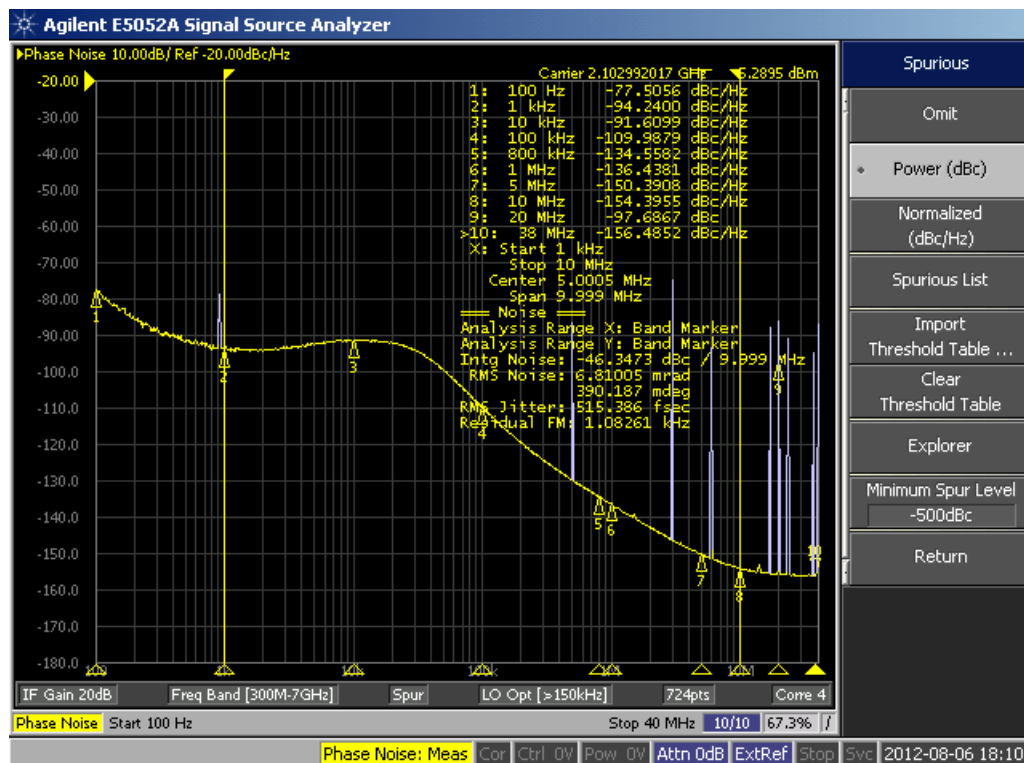


Figure 32. Fvco = 2103 MHz
(No Divide)

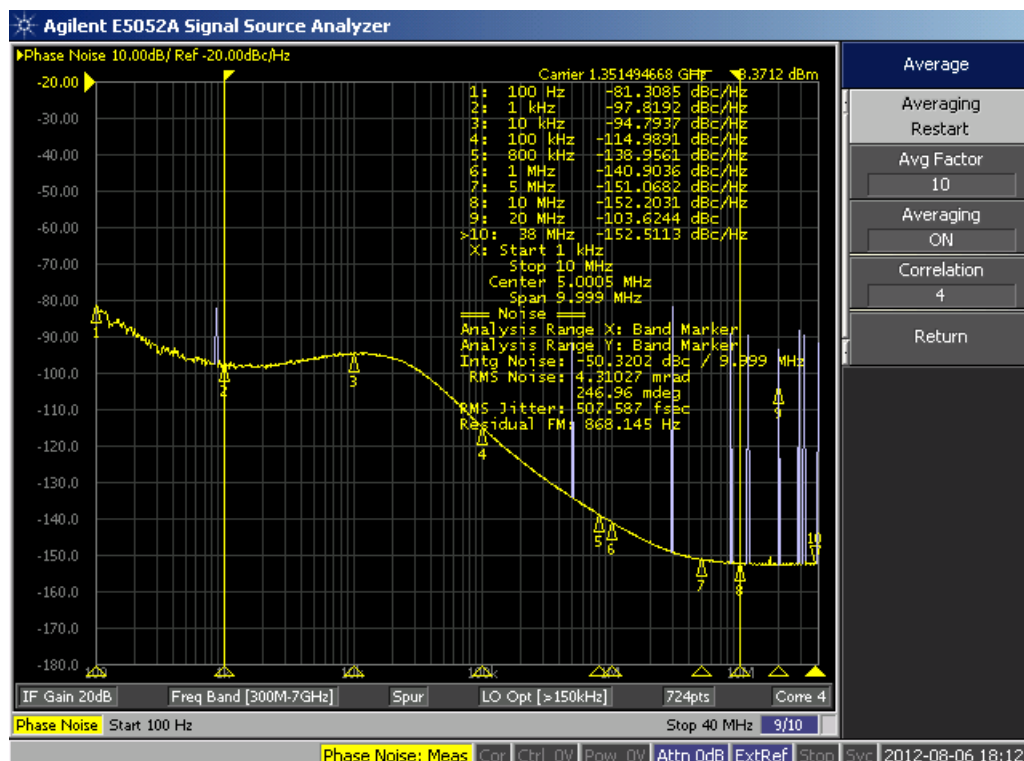


Figure 33. Fvco = 2103 MHz/2 = 1051.5 MHz
(Divide by 2)

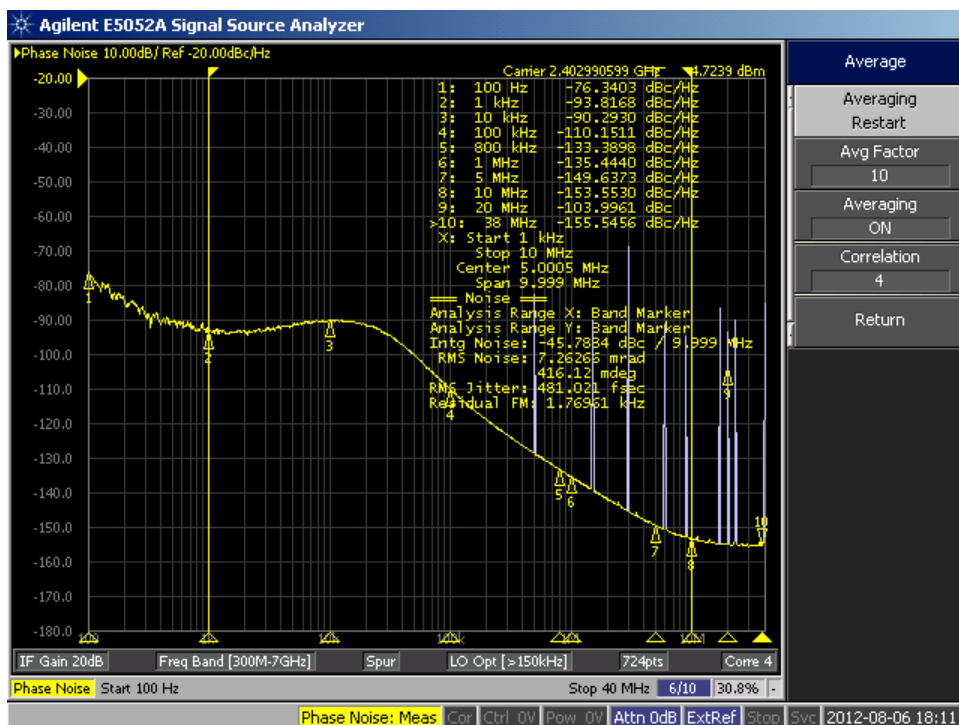


Figure 34. Fvco = 2403 MHz
(No Divide)

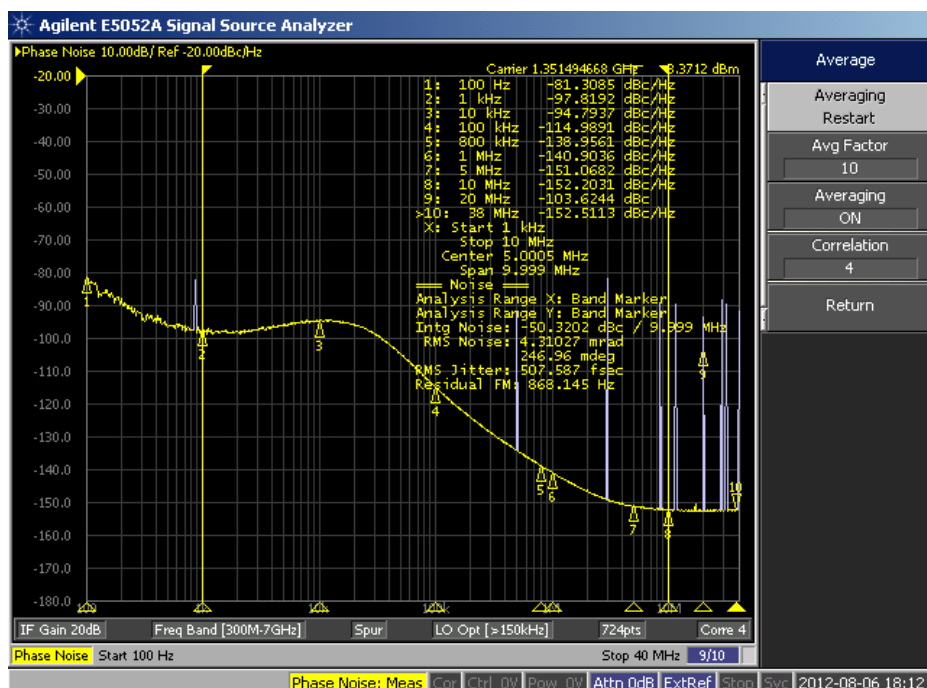


Figure 35. Frequency = 2403/2 = 1201.5 MHz
(Divide by 2)



Figure 36. Fvco = 2703 MHz
(No Divide)

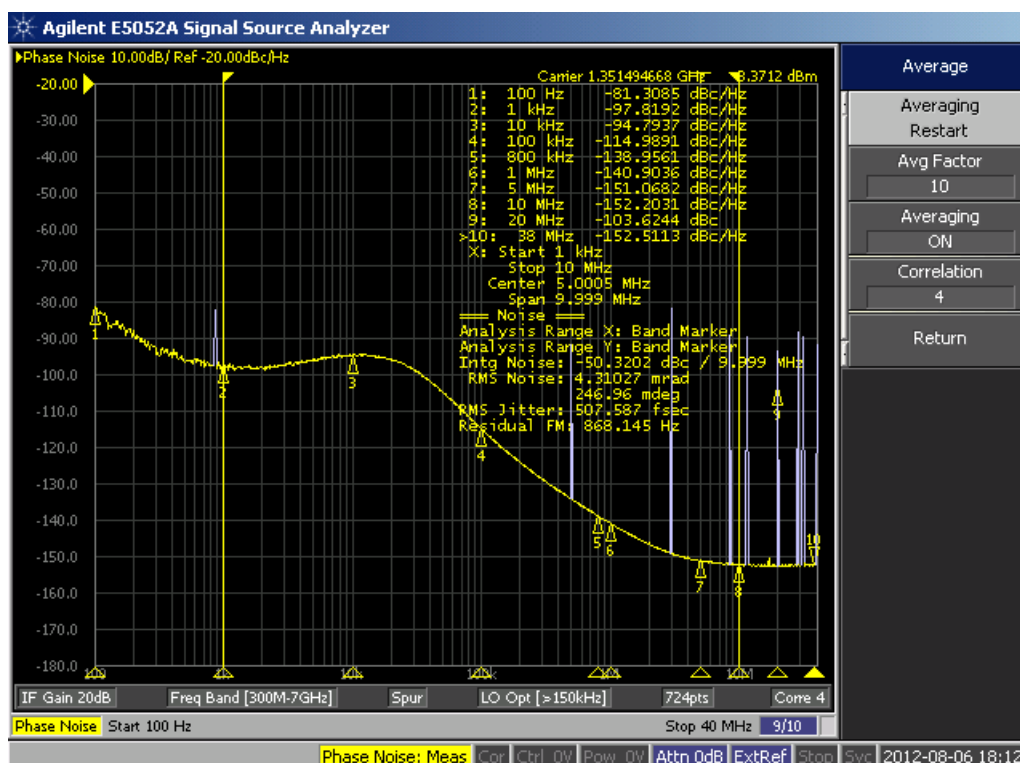


Figure 37. Frequency = 2703/2 = 1451.5 MHz
(Divide by 2)



Figure 38. Fvco = 3403 MHz
(No Divide)

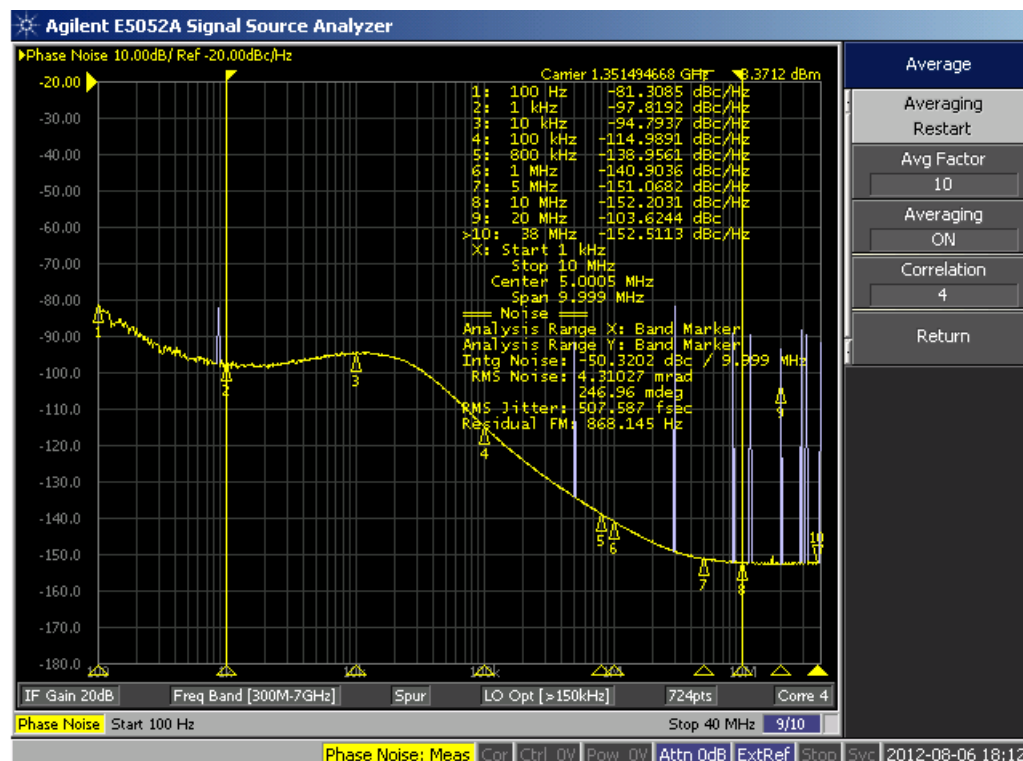


Figure 39. Frequency = 3403/2 = 1051.5 MHz
(Divide by 2)

5.4 Lock Time (VCO Digital Calibration Time)

Figure 40 shows the VCO tuning from 1850 to 3800 MHz. The VCO divider has been set to 2 because the measurement equipment (HP53310A) could not handle the higher frequency. This is starting at Core 1 and we can see all the different cores switching in. This is the VCO calibration time and is independent of the loop filter. This can be dramatically improved by guiding the VCO to the correct frequency.

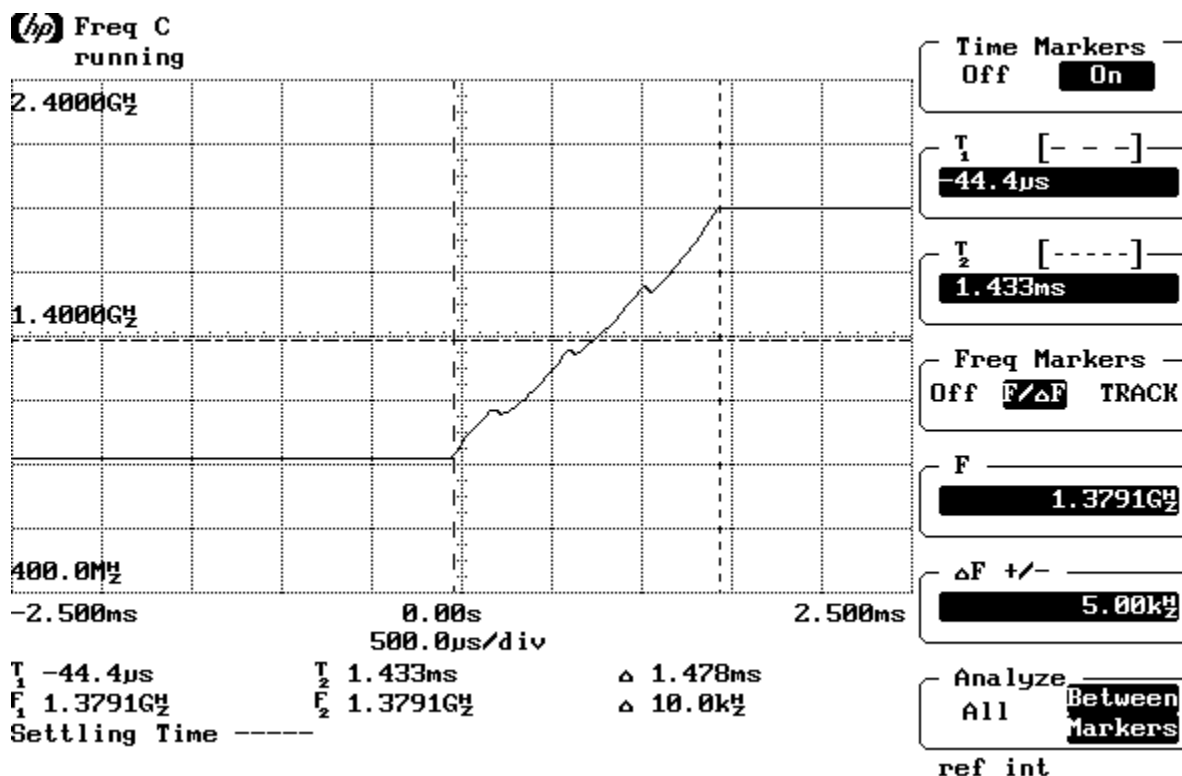


Figure 40.

Figure 41 shows that this lock time can be improved by telling the VCO where to start. For this, the VCO was selected to start at VCO core 4 with a capcode of 47. Although a different value could be used to improve the lock time more, a value of 47 represents might be a reasonable starting point that would account for process and temperature variations. Note that even if the wrong core is chosen, such as choosing the lower end of a higher frequency core vs. a higher end of a lower frequency core, this algorithm still dramatically improves lock time. This lock time can be decreased much further ($<10\ \mu\text{s}$) if the OSCin and phase detector frequencies are raised.

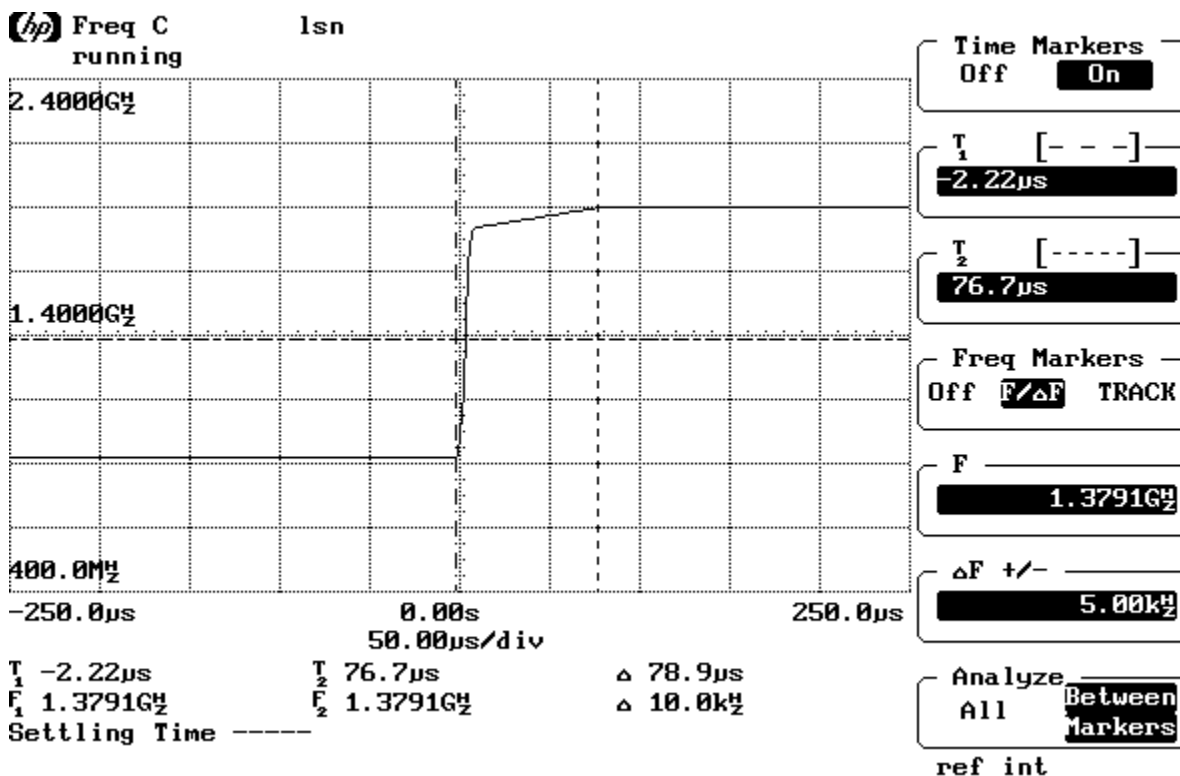


Figure 41.

5.5 Lock Time (Analog PLL Lock Time)

Figure 42 shows a glitch that may occur after the VCO calibration is finished. Because the LMX2581 has 4 cores with 256 different frequency bands, the PLL is fairly close on frequency the time that the VCO calibration is finished. This plot shows that this calibration is getting within about 200 kHz of the final frequency, so this is all the analog PLL has to settle out.

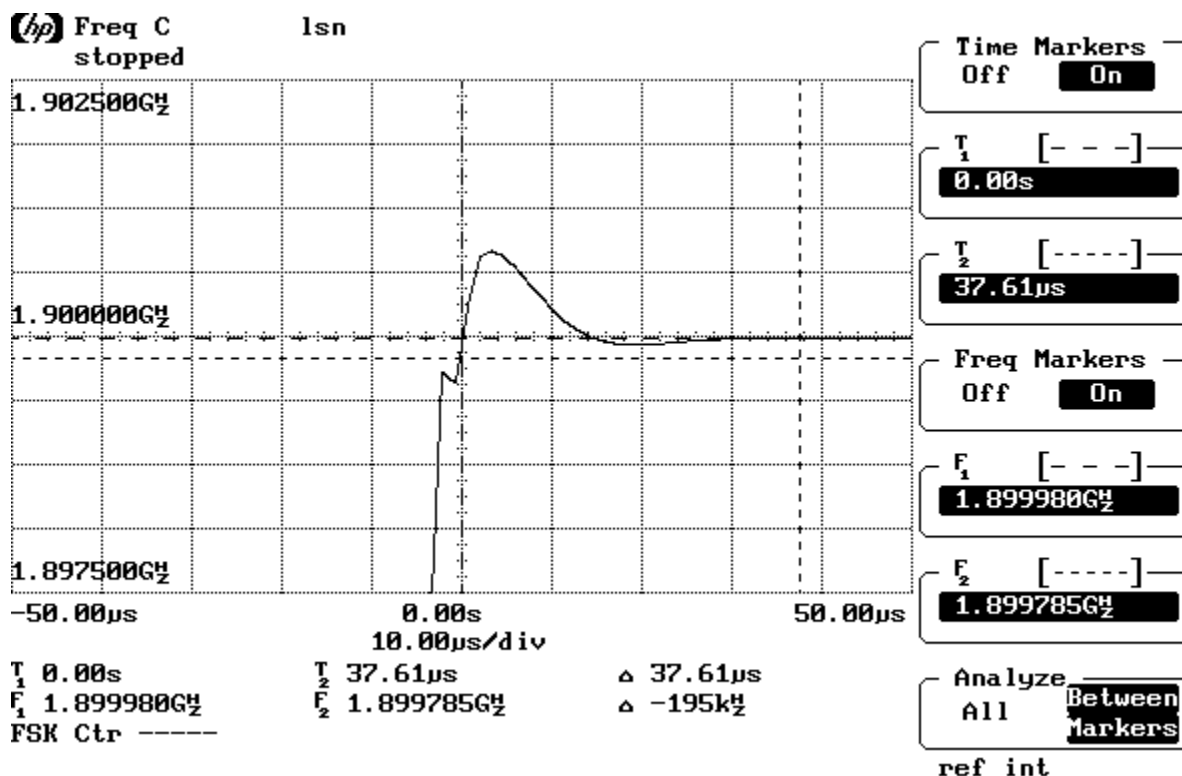


Figure 42.

Figure 43 shows the PLL settling to the final frequency.

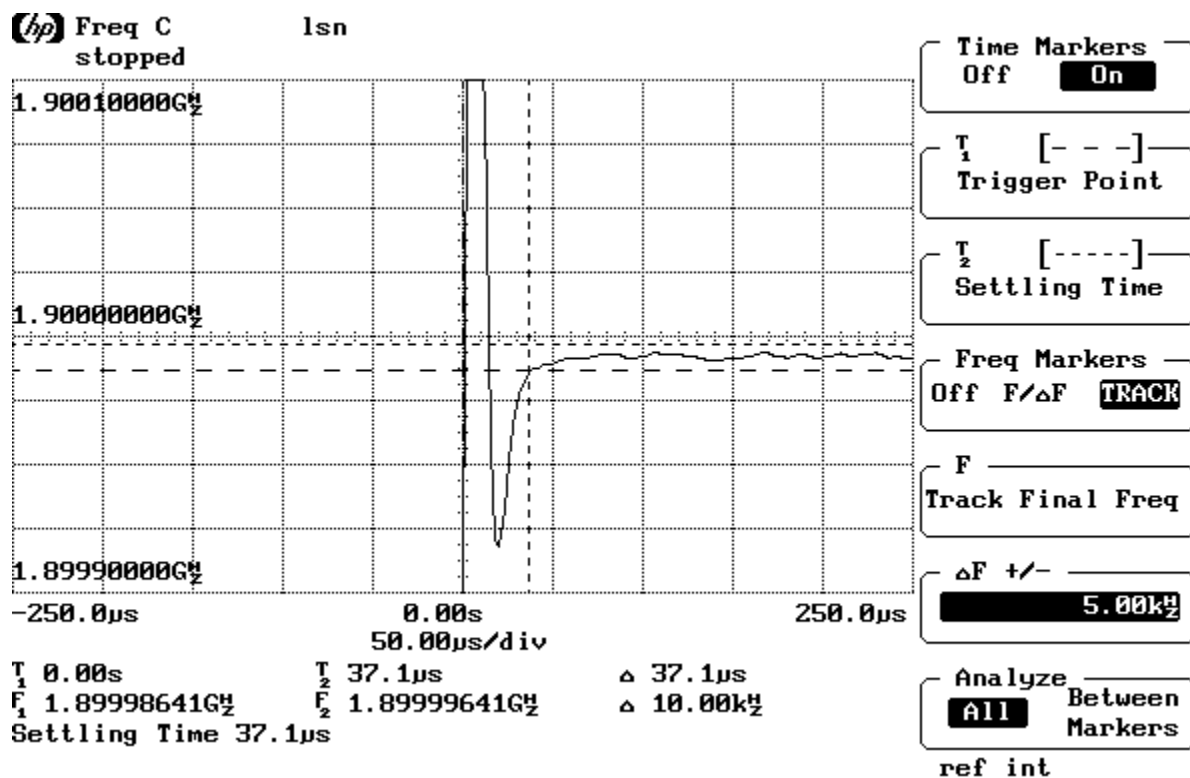


Figure 43.

5.6 Output Power

5.6.1 Impact of the Frequency and Board On Output Power for OUTx_PWR = 15

Figure 44 shows the impact of frequency on the output power for a setting of 15. The power from OUTA and OUTB are different because OUTA uses a 51 ohm pull-up and OUTB uses an 18 nH inductor. In general, the inductor gives higher output power for the same settings at higher frequencies, although the output impedance is not matched. The output impedance is equal to the impedance of the pull-up component. In general, the inductor gives more output power for the same setting, except at lower frequencies.

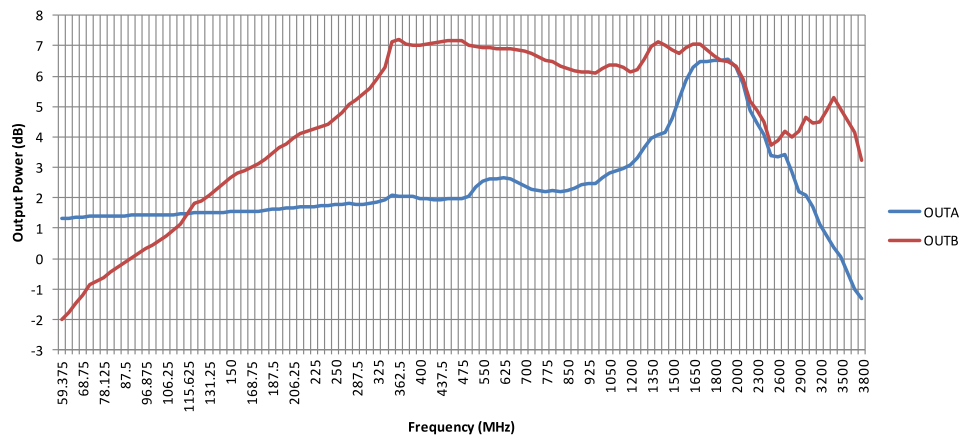


Figure 44.

Figure 45 shows the output power for two different versions of the evaluation board with identical layout for the output buffers, but different materials, for a setting of for OUTx_PWR=15. There is only a small difference in the output power between Rogers4003 and FR4.

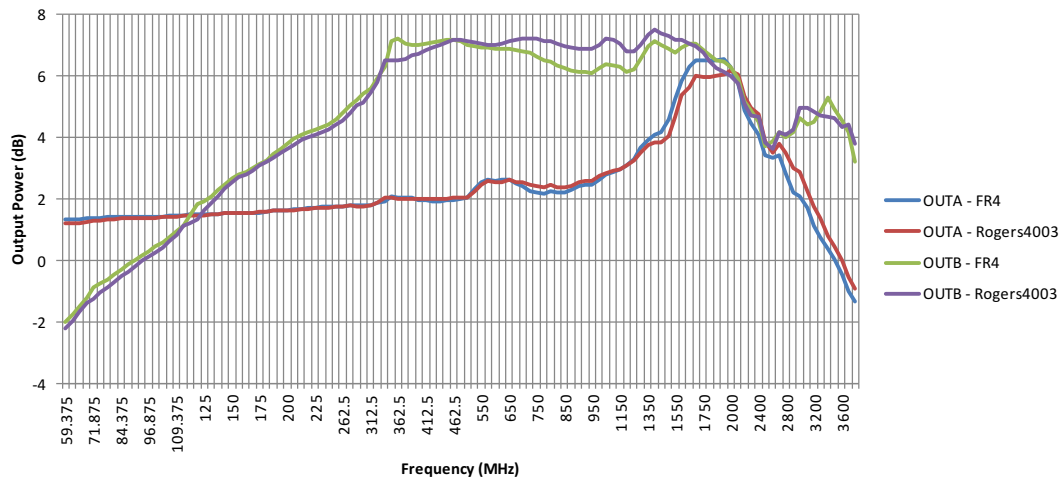


Figure 45.

Figure 46 is from a different board that had a single output routed with a very short trace and was on ROGERS4003 dielectric for a setting of OUTx_PWR = 15. Because only a single output was routed, the layout was more optimized and the result is a higher output power with a flatter frequency response. The legend shows different values of the pull-up component that were used.

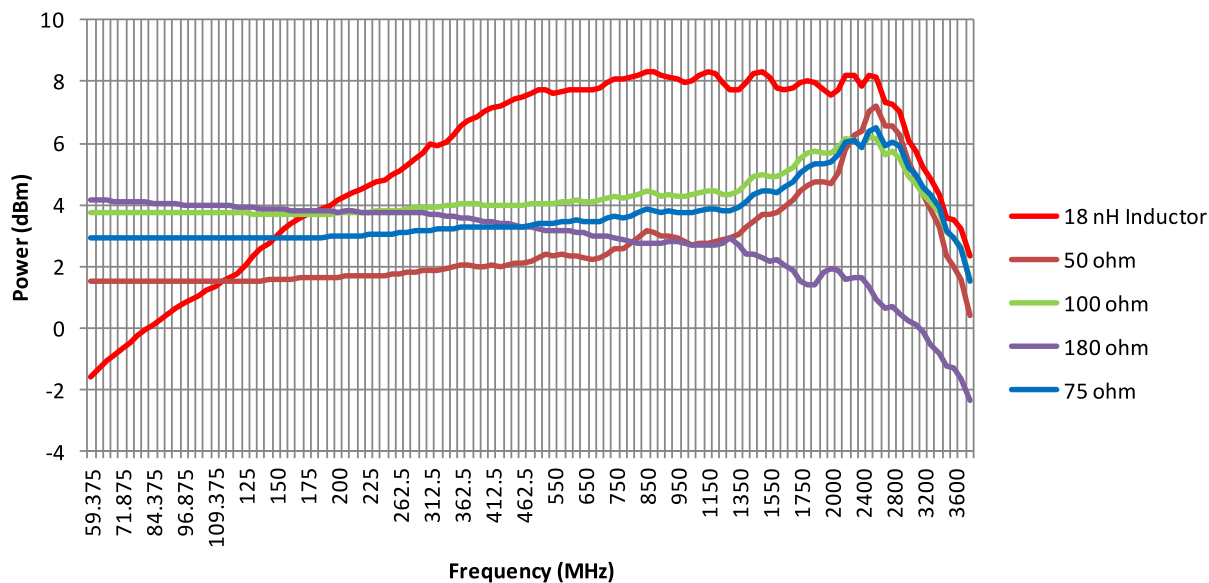


Figure 46.

5.6.2 Impact of OUTx_PWR on Output Power and Noise Floor at 2.7 GHz

Figure 47 shows the impact of OUTx_PWR on the x axis and the output power. For the inductor pull-up on OUTB, higher settings give more power.

For the 51 Ω resistor pull-up (OUTA), it is not recommended to go above a setting of 30 Ω because it gives less output power, degrades the noise floor, and draws more current.

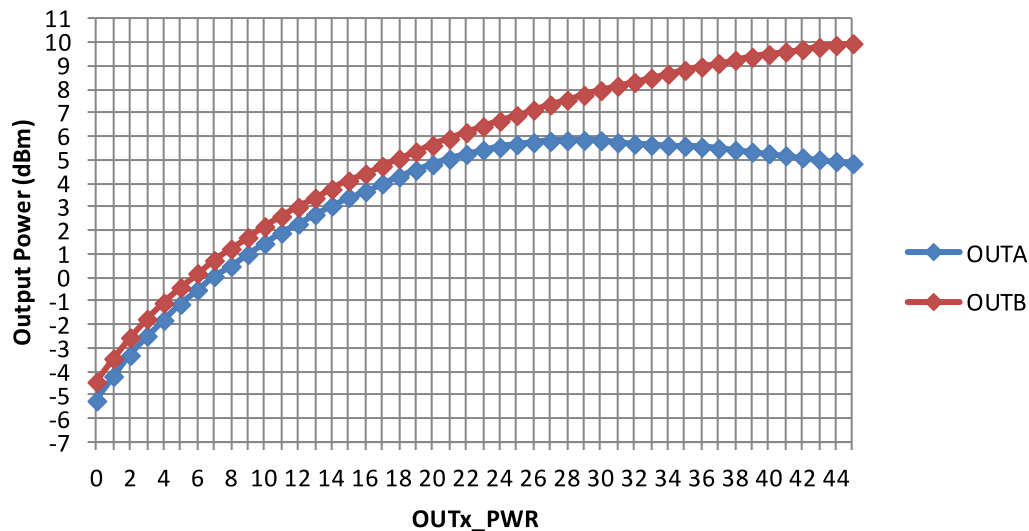


Figure 47.

Figure 48 shows the noise floor as a function of OUTx_PWR. This suggests that a setting of 15 is optimal for noise floor for the 51 ohm resistor pull-up (OUTA). For the inductor pull-up (OUTB), a setting closer to 30 is more optimal.

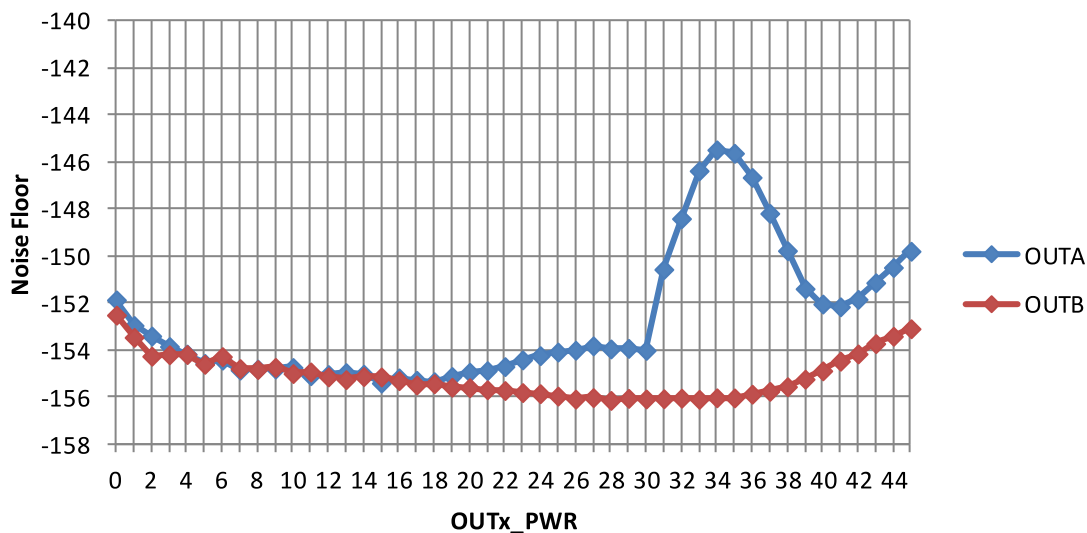


Figure 48.

5.7 LMX2581 and LMK04816 Measurements on a Different Board

5.7.1 Output Power and Phase Noise on Another Board

Figure 49 shows the output of the LMX2581 driven by the LMK04816 with a board routed with a single output. This used an inductor pull-up and was set to the maximum output power.

For the user that wants raw power, this is the part. When optimized for maximum output power, the SINGLE-ENDED output power is +14.4 dBm!

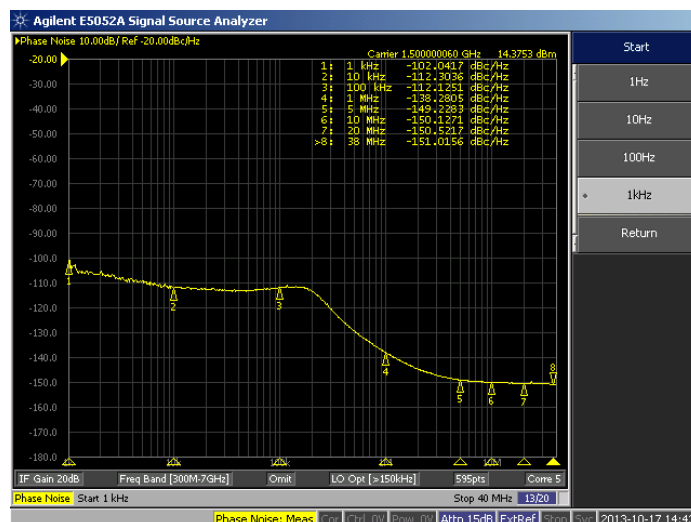


Figure 49.

Figure 50 is the same board output at 2.2 GHz output.

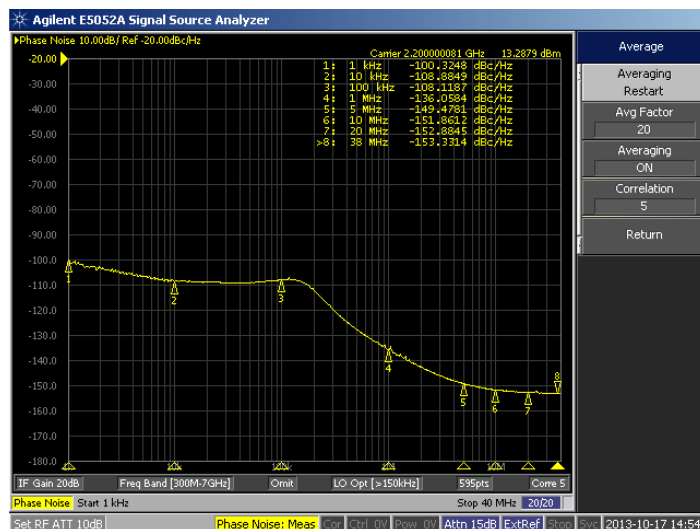


Figure 50.

Figure 51 is this same LMK04816 + LMX2581 board output at 2.7 GHz. This uses a 100 MHz phase detector and a wider loop bandwidth. Comparing to the plot in Section 5.1. Section 5.1, there is a significant improvement in close-in phase noise due mainly to the wider loop bandwidth

The noise floor is a little worse because it is slightly worse at the highest output power setting that was 45 in this case.

This is more typical of a loop bandwidth that one would use for a clocking application or something with wider channel spacing.

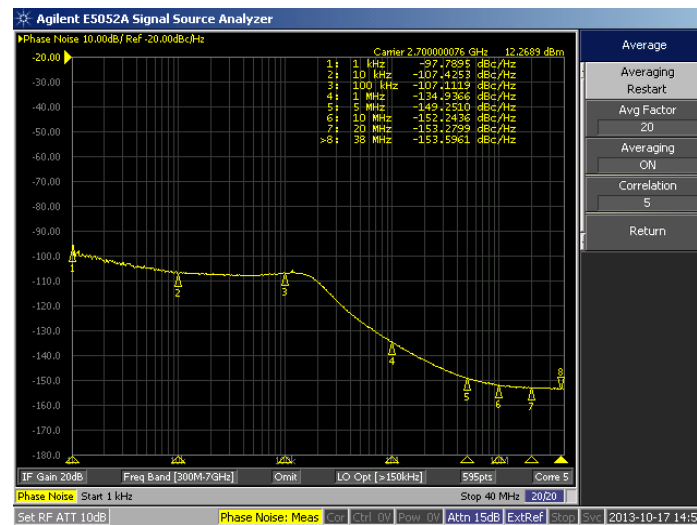


Figure 51.

6 Bill of Materials

Table 3. LMX2581 Bill of Materials

Schematic Rev A, Assembly Variant 001 Generated 9/13/2013					
Designator	Description	RoHS	Manufacturer	Part Number	Qty
!PCB	Printed Circuit Board	Y	Any	SV601009	1
C1, C5	CAP, CERM, 1uF, 16V, +/-10%, X7R, 0603	Y	TDK	C1608X7R1C105K	2
C1_LF	CAP, CERM, 1800pF, 100V, +/-5%, X7R, 0603	Y	AVX	06031C182JAT2A	1
C2_LF	CAP, CERM, 0.056uF, 16V, +/-10%, X7R, 0603	Y	MuRata	GRM188R71H563KA93D	1
C4_LF	CAP, CERM, 3300pF, 100V, +/-10%, X7R, 0603	Y	AVX	06031C332KAT2A	1
C6, C29, C32	CAP, CERM, 10uF, 10V, +/-10%, X5R, 0805	Y	Kemet	C0805C106K8PACTU	3
C8, C9, C17, C18, C19, C20, C23, C24, C25, C26, C27, C28, C31, C34	CAP, CERM, 100pF, 50V, +/-5%, C0G/NP0, 0603	Y	Kemet	C0603C101J5GACTU	14
C10, C30, C33	CAP, CERM, 0.1uF, 16V, +/-5%, X7R, 0603	Y	AVX	0603YC104JAT2A	3
C11, C13	CAP, CERM, 10uF, 10V, +/-10%, C0G/NP0, 0603	Y	TDK	C1608X5R1A106M	2
C12, C14	CAP, CERM, 22uF, 10V, +/-20%, X5R, 0603	Y	Samsung	CL10A226MP8NUNE	2
C15, C16	CAP, CERM, 2.2uF, 10V, +/-10%, X5R, 0603	Y	Kemet	C0603C225K8PACTU	2
D2	LED, Green, SMD	Y	Lite-On	LTST-C190GKT	1
L1, L2	Inductor, Multilayer, Air Core, 18nH, 0.3A, 0.36 Ω , SMD	Y	MuRata	LQG15HS18NJ02D	2
L3, L4	3A Ferrite Bead, 120 Ω @ 100MHz, SMD	Y	MuRata	BLM18SG121TN1D	2
OSCin, RFoutA+, RFoutA-, RFoutB+, RFoutB-, Vcc	Connector, SMT, End launch SMA 50 ohm	Y	Emerson	142-0701-851	6
R2_LF	RES, 390 Ω , 5%, 0.1W, 0603	Y	Vishay-Dale	CRCW0603390RJNEA	1
R3_LF	RES, 270 Ω , 5%, 0.1W, 0603	Y	Vishay-Dale	CRCW0603270RJNEA	1
R4_LF, R12, R17, R18, R19, R20, R21, R22, R24, R25, R27, R28, R29, R30, R39	RES, 0 Ω , 5%, 0.1W, 0603	Y	Vishay-Dale	CRCW06030000Z0EA	15
R6	RES, 10 Ω , 5%, 0.1W, 0603	Y	Vishay-Dale	CRCW060310R0JNEA	1
R14	RES, 47 Ω , 5%, 0.1W, 0603	Y	Vishay-Dale	CRCW060347R0JNEA	1
R15	RES, 18 Ω , 5%, 0.1W, 0603	Y	Vishay-Dale	CRCW060318R0JNEA	1
R16	RES, 33 Ω , 5%, 0.1W, 0603	Y	Vishay-Dale	CRCW060333R0JNEA	1
R23, R26	RES, 51 Ω , 5%, 0.063W, 0402	Y	Vishay-Dale	CRCW040251R0JNED	2

Table 3. LMX2581 Bill of Materials (continued)

Schematic Rev A, Assembly Variant 001 Generated 9/13/2013					
R31	RES, 330 Ω , 5%, 0.1W, 0603	Y	Yageo America	RC0603JR-07330RL	1
R35, R37, R41, R42, R46	RES, 10k Ω , 5%, 0.1W, 0603	Y	Vishay-Dale	CRCW060310K0JNEA	5
R36, R38, R40, R43, R47	RES, 12k Ω , 5%, 0.1W, 0603	Y	Vishay-Dale	CRCW060312K0JNEA	5
S1, S2, S3, S4, S5	HEX STANDOFF SPACER, 9.53 mm	Y	Richco Plastics	TCBS-6-01	5
U1	LMX2581 Wideband Frequency Synthesizer	Y	Texas Instruments	LMX2581SQ/NOPB	1
uWire	Header (shrouded), 100mil, 5x2, Gold-plated, SMD	Y	FCI	52601-S10-8LF	1
Vcc_TB	Terminal Block, 10.76x17x11 mm, 2POS, 26-12AWG, TH	Y	Weidmuller	1592820000	1
Y1	OSC 100.0000MHZ 3.3 V +-25PPM SMD	Y	Connor-Winfield	CWX813-100.0M	1

Revision History

This Revision History highlights the technical changes made to the **SNAU136A** document to make it the **SNAU136B** revision.

SNAU136 Revisions

SEE	ADDITIONS/MODIFICATIONS/DELETIONS
SNAU136C	General Comments: The evaluation board was updated to accommodate the USB2ANY header and was also conducted on FR4 instead of Rogers4003. Modifications to components and their placement, such as moving C4_LF next to the Vtune pin and pulling back the ground and power planes from the vias to minimize spurs were also implemented.
Section 2.3	Updated to show USB2ANY programming interface
Section 5.2	Updated VCO phase noise plots
Section 5.6	Added plots on output power
Section 5.7	Added plots for wider bandwidth
Section 3.2	Schematic Information Added
Section 4	Layout Information Added
Table 3	Bill of Material and Assembly Information Added
Section 3.3	Added comments about use with external signal.

NOTE: Page numbers for previous revisions may differ from page numbers in the current version.

EVALUATION BOARD/KIT/MODULE (EVM) ADDITIONAL TERMS

Texas Instruments (TI) provides the enclosed Evaluation Board/Kit/Module (EVM) under the following conditions:

The user assumes all responsibility and liability for proper and safe handling of the goods. Further, the user indemnifies TI from all claims arising from the handling or use of the goods.

Should this evaluation board/kit not meet the specifications indicated in the User's Guide, the board/kit may be returned within 30 days from the date of delivery for a full refund. THE FOREGOING LIMITED WARRANTY IS THE EXCLUSIVE WARRANTY MADE BY SELLER TO BUYER AND IS IN LIEU OF ALL OTHER WARRANTIES, EXPRESSED, IMPLIED, OR STATUTORY, INCLUDING ANY WARRANTY OF MERCHANTABILITY OR FITNESS FOR ANY PARTICULAR PURPOSE. EXCEPT TO THE EXTENT OF THE INDEMNITY SET FORTH ABOVE, NEITHER PARTY SHALL BE LIABLE TO THE OTHER FOR ANY INDIRECT, SPECIAL, INCIDENTAL, OR CONSEQUENTIAL DAMAGES.

Please read the User's Guide and, specifically, the Warnings and Restrictions notice in the User's Guide prior to handling the product. This notice contains important safety information about temperatures and voltages. For additional information on TI's environmental and/or safety programs, please visit www.ti.com/esh or contact TI.

No license is granted under any patent right or other intellectual property right of TI covering or relating to any machine, process, or combination in which such TI products or services might be or are used. TI currently deals with a variety of customers for products, and therefore our arrangement with the user is not exclusive. TI assumes no liability for applications assistance, customer product design, software performance, or infringement of patents or services described herein.

REGULATORY COMPLIANCE INFORMATION

As noted in the EVM User's Guide and/or EVM itself, this EVM and/or accompanying hardware may or may not be subject to the Federal Communications Commission (FCC) and Industry Canada (IC) rules.

For EVMs **not** subject to the above rules, this evaluation board/kit/module is intended for use for ENGINEERING DEVELOPMENT, DEMONSTRATION OR EVALUATION PURPOSES ONLY and is not considered by TI to be a finished end product fit for general consumer use. It generates, uses, and can radiate radio frequency energy and has not been tested for compliance with the limits of computing devices pursuant to part 15 of FCC or ICES-003 rules, which are designed to provide reasonable protection against radio frequency interference. Operation of the equipment may cause interference with radio communications, in which case the user at his own expense will be required to take whatever measures may be required to correct this interference.

General Statement for EVMs including a radio

User Power/Frequency Use Obligations: This radio is intended for development/professional use only in legally allocated frequency and power limits. Any use of radio frequencies and/or power availability of this EVM and its development application(s) must comply with local laws governing radio spectrum allocation and power limits for this evaluation module. It is the user's sole responsibility to only operate this radio in legally acceptable frequency space and within legally mandated power limitations. Any exceptions to this are strictly prohibited and unauthorized by Texas Instruments unless user has obtained appropriate experimental/development licenses from local regulatory authorities, which is responsibility of user including its acceptable authorization.

For EVMs annotated as FCC – FEDERAL COMMUNICATIONS COMMISSION Part 15 Compliant

Caution

This device complies with part 15 of the FCC Rules. Operation is subject to the following two conditions: (1) This device may not cause harmful interference, and (2) this device must accept any interference received, including interference that may cause undesired operation.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

FCC Interference Statement for Class A EVM devices

This equipment has been tested and found to comply with the limits for a Class A digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference when the equipment is operated in a commercial environment. This equipment generates, uses, and can radiate radio frequency energy and, if not installed and used in accordance with the instruction manual, may cause harmful interference to radio communications. Operation of this equipment in a residential area is likely to cause harmful interference in which case the user will be required to correct the interference at his own expense.

FCC Interference Statement for Class B EVM devices

This equipment has been tested and found to comply with the limits for a Class B digital device, pursuant to part 15 of the FCC Rules. These limits are designed to provide reasonable protection against harmful interference in a residential installation. This equipment generates, uses and can radiate radio frequency energy and, if not installed and used in accordance with the instructions, may cause harmful interference to radio communications. However, there is no guarantee that interference will not occur in a particular installation. If this equipment does cause harmful interference to radio or television reception, which can be determined by turning the equipment off and on, the user is encouraged to try to correct the interference by one or more of the following measures:

- Reorient or relocate the receiving antenna.
- Increase the separation between the equipment and receiver.
- Connect the equipment into an outlet on a circuit different from that to which the receiver is connected.
- Consult the dealer or an experienced radio/TV technician for help.

For EVMs annotated as IC – INDUSTRY CANADA Compliant

This Class A or B digital apparatus complies with Canadian ICES-003.

Changes or modifications not expressly approved by the party responsible for compliance could void the user's authority to operate the equipment.

Concerning EVMs including radio transmitters

This device complies with Industry Canada licence-exempt RSS standard(s). Operation is subject to the following two conditions: (1) this device may not cause interference, and (2) this device must accept any interference, including interference that may cause undesired operation of the device.

Concerning EVMs including detachable antennas

Under Industry Canada regulations, this radio transmitter may only operate using an antenna of a type and maximum (or lesser) gain approved for the transmitter by Industry Canada. To reduce potential radio interference to other users, the antenna type and its gain should be so chosen that the equivalent isotropically radiated power (e.i.r.p.) is not more than that necessary for successful communication.

This radio transmitter has been approved by Industry Canada to operate with the antenna types listed in the user guide with the maximum permissible gain and required antenna impedance for each antenna type indicated. Antenna types not included in this list, having a gain greater than the maximum gain indicated for that type, are strictly prohibited for use with this device.

Cet appareil numérique de la classe A ou B est conforme à la norme NMB-003 du Canada.

Les changements ou les modifications pas expressément approuvés par la partie responsable de la conformité ont pu vider l'autorité de l'utilisateur pour actionner l'équipement.

Concernant les EVMs avec appareils radio

Le présent appareil est conforme aux CNR d'Industrie Canada applicables aux appareils radio exempts de licence. L'exploitation est autorisée aux deux conditions suivantes : (1) l'appareil ne doit pas produire de brouillage, et (2) l'utilisateur de l'appareil doit accepter tout brouillage radioélectrique subi, même si le brouillage est susceptible d'en compromettre le fonctionnement.

Concernant les EVMs avec antennes détachables

Conformément à la réglementation d'Industrie Canada, le présent émetteur radio peut fonctionner avec une antenne d'un type et d'un gain maximal (ou inférieur) approuvé pour l'émetteur par Industrie Canada. Dans le but de réduire les risques de brouillage radioélectrique à l'intention des autres utilisateurs, il faut choisir le type d'antenne et son gain de sorte que la puissance isotrope rayonnée équivalente (p.i.r.e.) ne dépasse pas l'intensité nécessaire à l'établissement d'une communication satisfaisante.

Le présent émetteur radio a été approuvé par Industrie Canada pour fonctionner avec les types d'antenne énumérés dans le manuel d'usage et ayant un gain admissible maximal et l'impédance requise pour chaque type d'antenne. Les types d'antenne non inclus dans cette liste, ou dont le gain est supérieur au gain maximal indiqué, sont strictement interdits pour l'exploitation de l'émetteur.

【Important Notice for Users of EVMs for RF Products in Japan】

This development kit is NOT certified as Confirming to Technical Regulations of Radio Law of Japan

If you use this product in Japan, you are required by Radio Law of Japan to follow the instructions below with respect to this product:

1. Use this product in a shielded room or any other test facility as defined in the notification #173 issued by Ministry of Internal Affairs and Communications on March 28, 2006, based on Sub-section 1.1 of Article 6 of the Ministry's Rule for Enforcement of Radio Law of Japan,
2. Use this product only after you obtained the license of Test Radio Station as provided in Radio Law of Japan with respect to this product, or
3. Use of this product only after you obtained the Technical Regulations Conformity Certification as provided in Radio Law of Japan with respect to this product. Also, please do not transfer this product, unless you give the same notice above to the transferee. Please note that if you could not follow the instructions above, you will be subject to penalties of Radio Law of Japan.

Texas Instruments Japan Limited
(address) 24-1, Nishi-Shinjuku 6 chome, Shinjuku-ku, Tokyo, Japan

<http://www.tij.co.jp>

【無線電波を送信する製品の開発キットをお使いになる際の注意事項】

本開発キットは技術基準適合証明を受けておりません。

本製品のご使用に際しては、電波法遵守のため、以下のいずれかの措置を取っていただく必要がありますのでご注意ください。

1. 電波法施行規則第6条第1項第1号に基づく平成18年3月28日総務省告示第173号で定められた電波暗室等の試験設備でご使用いただく。
2. 実験局の免許を取得後ご使用いただく。
3. 技術基準適合証明を取得後ご使用いただく。

なお、本製品は、上記の「ご使用にあたっての注意」を譲渡先、移転先に通知しない限り、譲渡、移転できないものとします。

上記を遵守頂けない場合は、電波法の罰則が適用される可能性があることをご留意ください。

日本テキサス・インスツルメンツ株式会社
東京都新宿区西新宿 6 丁目 2 4 番 1 号
西新宿三井ビル

<http://www.tij.co.jp>

EVALUATION BOARD/KIT/MODULE (EVM) WARNINGS, RESTRICTIONS AND DISCLAIMERS

For Feasibility Evaluation Only, in Laboratory/Development Environments. Unless otherwise indicated, this EVM is not a finished electrical equipment and not intended for consumer use. It is intended solely for use for preliminary feasibility evaluation in laboratory/development environments by technically qualified electronics experts who are familiar with the dangers and application risks associated with handling electrical mechanical components, systems and subsystems. It should not be used as all or part of a finished end product.

Your Sole Responsibility and Risk. You acknowledge, represent and agree that:

1. You have unique knowledge concerning Federal, State and local regulatory requirements (including but not limited to Food and Drug Administration regulations, if applicable) which relate to your products and which relate to your use (and/or that of your employees, affiliates, contractors or designees) of the EVM for evaluation, testing and other purposes.
2. You have full and exclusive responsibility to assure the safety and compliance of your products with all such laws and other applicable regulatory requirements, and also to assure the safety of any activities to be conducted by you and/or your employees, affiliates, contractors or designees, using the EVM. Further, you are responsible to assure that any interfaces (electronic and/or mechanical) between the EVM and any human body are designed with suitable isolation and means to safely limit accessible leakage currents to minimize the risk of electrical shock hazard.
3. Since the EVM is not a completed product, it may not meet all applicable regulatory and safety compliance standards (such as UL, CSA, VDE, CE, RoHS and WEEE) which may normally be associated with similar items. You assume full responsibility to determine and/or assure compliance with any such standards and related certifications as may be applicable. You will employ reasonable safeguards to ensure that your use of the EVM will not result in any property damage, injury or death, even if the EVM should fail to perform as described or expected.
4. You will take care of proper disposal and recycling of the EVM's electronic components and packing materials.

Certain Instructions. It is important to operate this EVM within TI's recommended specifications and environmental considerations per the user guidelines. Exceeding the specified EVM ratings (including but not limited to input and output voltage, current, power, and environmental ranges) may cause property damage, personal injury or death. If there are questions concerning these ratings please contact a TI field representative prior to connecting interface electronics including input power and intended loads. Any loads applied outside of the specified output range may result in unintended and/or inaccurate operation and/or possible permanent damage to the EVM and/or interface electronics. Please consult the EVM User's Guide prior to connecting any load to the EVM output. If there is uncertainty as to the load specification, please contact a TI field representative. During normal operation, some circuit components may have case temperatures greater than 60°C as long as the input and output are maintained at a normal ambient operating temperature. These components include but are not limited to linear regulators, switching transistors, pass transistors, and current sense resistors which can be identified using the EVM schematic located in the EVM User's Guide. When placing measurement probes near these devices during normal operation, please be aware that these devices may be very warm to the touch. As with all electronic evaluation tools, only qualified personnel knowledgeable in electronic measurement and diagnostics normally found in development environments should use these EVMs.

Agreement to Defend, Indemnify and Hold Harmless. You agree to defend, indemnify and hold TI, its licensors and their representatives harmless from and against any and all claims, damages, losses, expenses, costs and liabilities (collectively, "Claims") arising out of or in connection with any use of the EVM that is not in accordance with the terms of the agreement. This obligation shall apply whether Claims arise under law of tort or contract or any other legal theory, and even if the EVM fails to perform as described or expected.

Safety-Critical or Life-Critical Applications. If you intend to evaluate the components for possible use in safety critical applications (such as life support) where a failure of the TI product would reasonably be expected to cause severe personal injury or death, such as devices which are classified as FDA Class III or similar classification, then you must specifically notify TI of such intent and enter into a separate Assurance and Indemnity Agreement.

IMPORTANT NOTICE

Texas Instruments Incorporated and its subsidiaries (TI) reserve the right to make corrections, enhancements, improvements and other changes to its semiconductor products and services per JESD46, latest issue, and to discontinue any product or service per JESD48, latest issue. Buyers should obtain the latest relevant information before placing orders and should verify that such information is current and complete. All semiconductor products (also referred to herein as "components") are sold subject to TI's terms and conditions of sale supplied at the time of order acknowledgment.

TI warrants performance of its components to the specifications applicable at the time of sale, in accordance with the warranty in TI's terms and conditions of sale of semiconductor products. Testing and other quality control techniques are used to the extent TI deems necessary to support this warranty. Except where mandated by applicable law, testing of all parameters of each component is not necessarily performed.

TI assumes no liability for applications assistance or the design of Buyers' products. Buyers are responsible for their products and applications using TI components. To minimize the risks associated with Buyers' products and applications, Buyers should provide adequate design and operating safeguards.

TI does not warrant or represent that any license, either express or implied, is granted under any patent right, copyright, mask work right, or other intellectual property right relating to any combination, machine, or process in which TI components or services are used. Information published by TI regarding third-party products or services does not constitute a license to use such products or services or a warranty or endorsement thereof. Use of such information may require a license from a third party under the patents or other intellectual property of the third party, or a license from TI under the patents or other intellectual property of TI.

Reproduction of significant portions of TI information in TI data books or data sheets is permissible only if reproduction is without alteration and is accompanied by all associated warranties, conditions, limitations, and notices. TI is not responsible or liable for such altered documentation. Information of third parties may be subject to additional restrictions.

Resale of TI components or services with statements different from or beyond the parameters stated by TI for that component or service voids all express and any implied warranties for the associated TI component or service and is an unfair and deceptive business practice. TI is not responsible or liable for any such statements.

Buyer acknowledges and agrees that it is solely responsible for compliance with all legal, regulatory and safety-related requirements concerning its products, and any use of TI components in its applications, notwithstanding any applications-related information or support that may be provided by TI. Buyer represents and agrees that it has all the necessary expertise to create and implement safeguards which anticipate dangerous consequences of failures, monitor failures and their consequences, lessen the likelihood of failures that might cause harm and take appropriate remedial actions. Buyer will fully indemnify TI and its representatives against any damages arising out of the use of any TI components in safety-critical applications.

In some cases, TI components may be promoted specifically to facilitate safety-related applications. With such components, TI's goal is to help enable customers to design and create their own end-product solutions that meet applicable functional safety standards and requirements. Nonetheless, such components are subject to these terms.

No TI components are authorized for use in FDA Class III (or similar life-critical medical equipment) unless authorized officers of the parties have executed a special agreement specifically governing such use.

Only those TI components which TI has specifically designated as military grade or "enhanced plastic" are designed and intended for use in military/aerospace applications or environments. Buyer acknowledges and agrees that any military or aerospace use of TI components which have **not** been so designated is solely at the Buyer's risk, and that Buyer is solely responsible for compliance with all legal and regulatory requirements in connection with such use.

TI has specifically designated certain components as meeting ISO/TS16949 requirements, mainly for automotive use. In any case of use of non-designated products, TI will not be responsible for any failure to meet ISO/TS16949.

Products

Audio	www.ti.com/audio
Amplifiers	amplifier.ti.com
Data Converters	dataconverter.ti.com
DLP® Products	www.dlp.com
DSP	dsp.ti.com
Clocks and Timers	www.ti.com/clocks
Interface	interface.ti.com
Logic	logic.ti.com
Power Mgmt	power.ti.com
Microcontrollers	microcontroller.ti.com
RFID	www.ti-rfid.com
OMAP Applications Processors	www.ti.com/omap
Wireless Connectivity	www.ti.com/wirelessconnectivity

Applications

Automotive and Transportation	www.ti.com/automotive
Communications and Telecom	www.ti.com/communications
Computers and Peripherals	www.ti.com/computers
Consumer Electronics	www.ti.com/consumer-apps
Energy and Lighting	www.ti.com/energy
Industrial	www.ti.com/industrial
Medical	www.ti.com/medical
Security	www.ti.com/security
Space, Avionics and Defense	www.ti.com/space-avionics-defense
Video and Imaging	www.ti.com/video

TI E2E Community

e2e.ti.com