SNAU136, LMX2581EVM User's Guide

Contents

1. Introduction

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 (See Table 1).

Table 1: Device and Package Configurations

CONVERTER	IC	PACKAGE
U1	LMX2581	LQA32A

2. Setup

Input/Output Connector Description

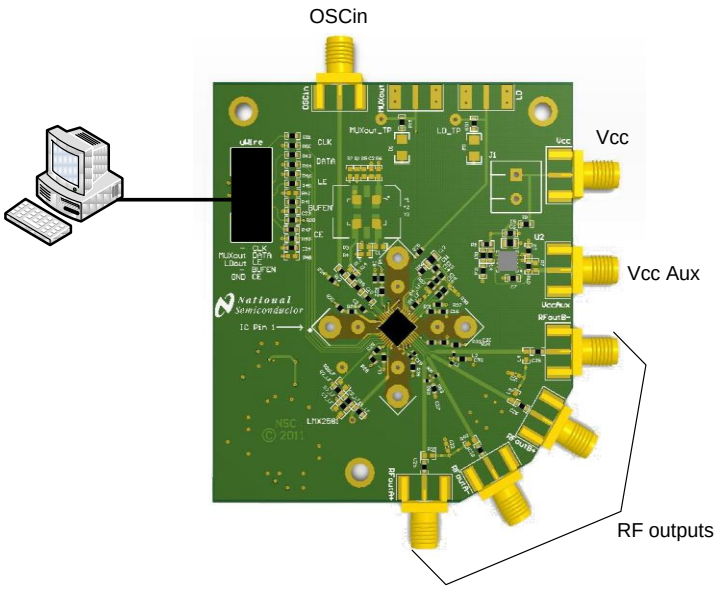


Figure 1 - Evaluation Board Setup

RFoutA+/A-/B+/B- Output
These are two differential outputs. Connect any of the four outputs to a spectrum analyzer or phase noise analyzer. The Agilent E5052A was used for these instructions.

These are differential outputs. If using single-ended, be sure to terminate the unused side with a 50 ohm load or resistor.

Vcc – Input
Connect to a 3.3 V Power Supply. Ensure the current limit is set above 300 mA.

VccAux – Unused Input
This gives the option to supply power to an external VCO.

LPT Connector - Input
Connect the board to a PC using the provided LPT cable. This can also be used with the external USB interface board.

OSCin – Unused Input
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).

If you are using the 100 MHz XO, it needs to be burnt in before the first time it is used to ensure the best phase noise and stability. See section on this.

Loop Filter Values

Parameter	LMX2581 100 MHz OSCin
VCO Frequency (MHz)	1850 - 3760
VCO Gain (MHz/V), VCO Core 1	15–25
VCO Gain (MHz/V), VCO Core 2	18 - 32
VCO Gain (MHz/V), VCO Core 3	23 - 40
VCO Gain (MHz/V), VCO Core 4	26 - 46
Loop Bandwidth (kHz)	28.7
Phase Margin (deg)	49.7
C1_LF (nF)	1.8
C2_LF (nF)	56
C3_LF (nF)	3.3
C4_LF (nF)	Open
R2 (kΩ)	0.390
R3_LF (kΩ)	0.270
R4_LF (kΩ)	0
Charge Pump Gain	2400 uA
Phase Detector Frequency (MHz)	20
OSCin Frequency (MHz)	100

1. Table 2 - Loop Filter Values

The datasheet advises that the capacitor next to the VCO input (C3_LF in this case) should be at least 3.3 nF. The LMX2581 will certainly work for lower values, but this can cause phase noise degradation at farther offsets if this capacitor is too small.

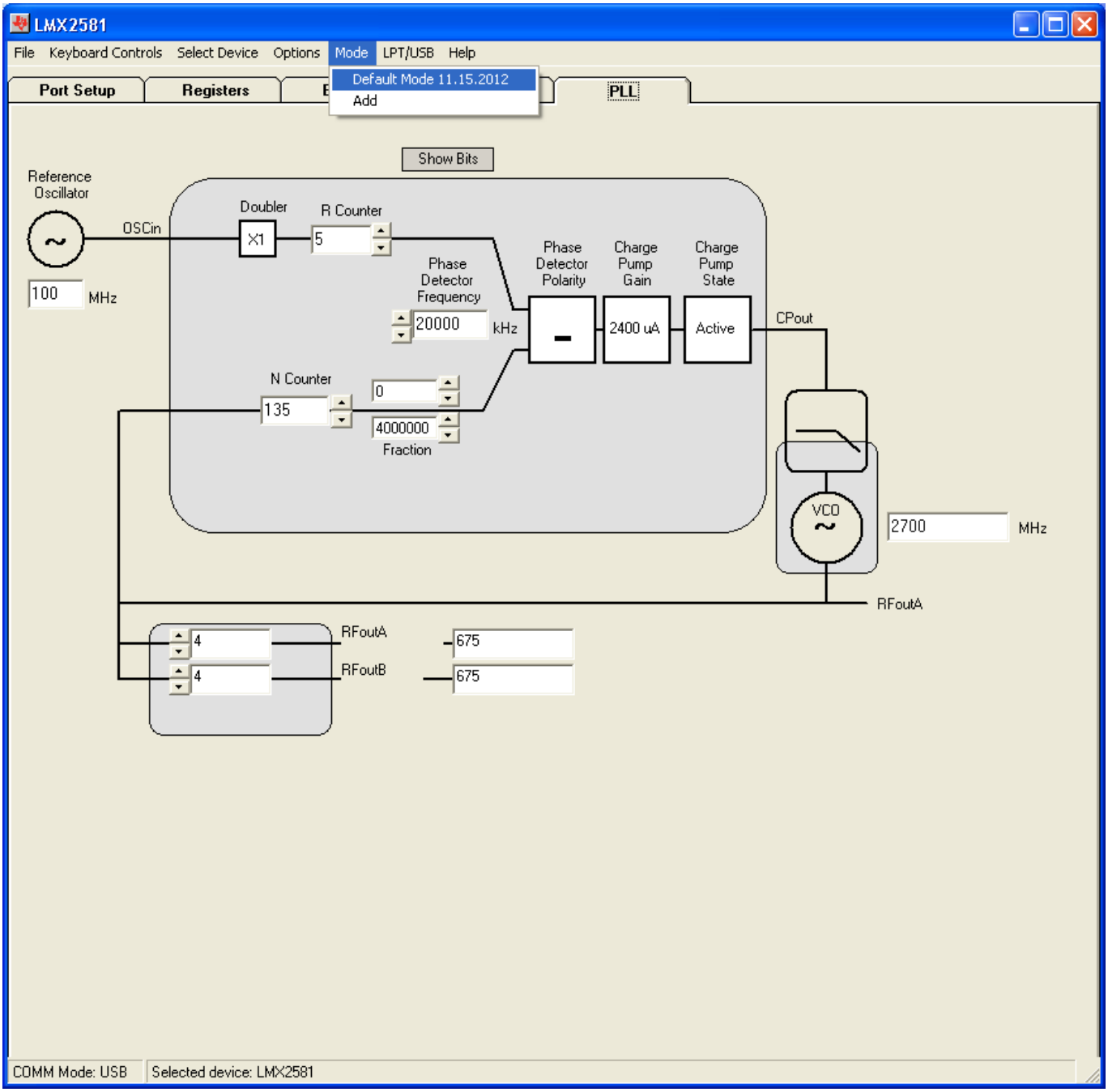
Installing the EVM Software

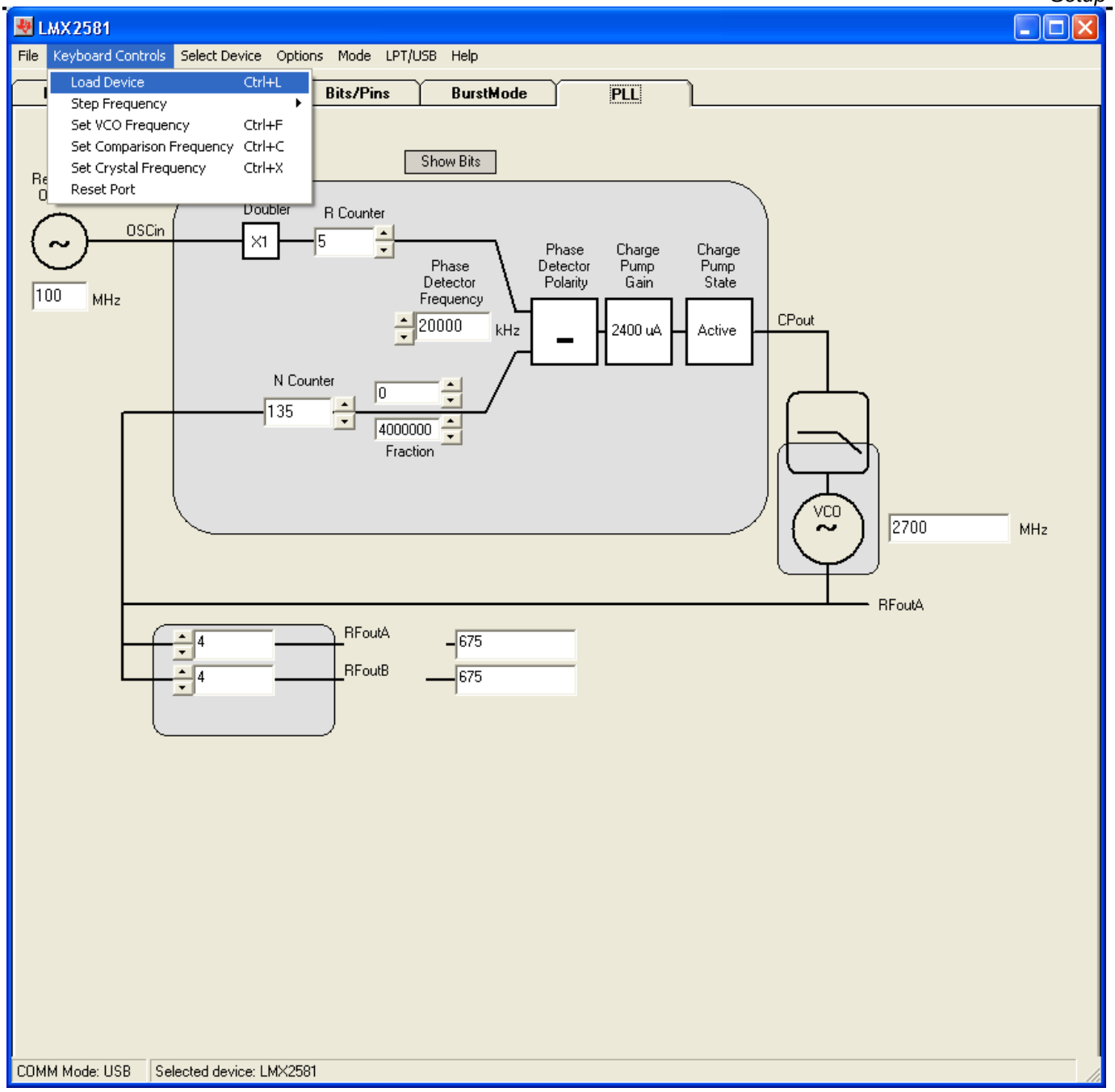
Go to http://www.ti.com/tool/codeloader
Click on the download button to download the software.
Run the executable file.

Burning in the Crystal Oscillator

The LMX2581 comes with a crystal oscillator on the board. This crystal oscillator was chosen because it has good phase noise, standard package, and most importantly it is readily available. However, it is not necessarily the most accurate and does require to be burnt in. This is not done before the boards are shipped. To burn in the crystal, all one has to do is hook up the evaluation board and leave power applied. This improves crystal stability and also phase noise at low offsets below 1 kHz.

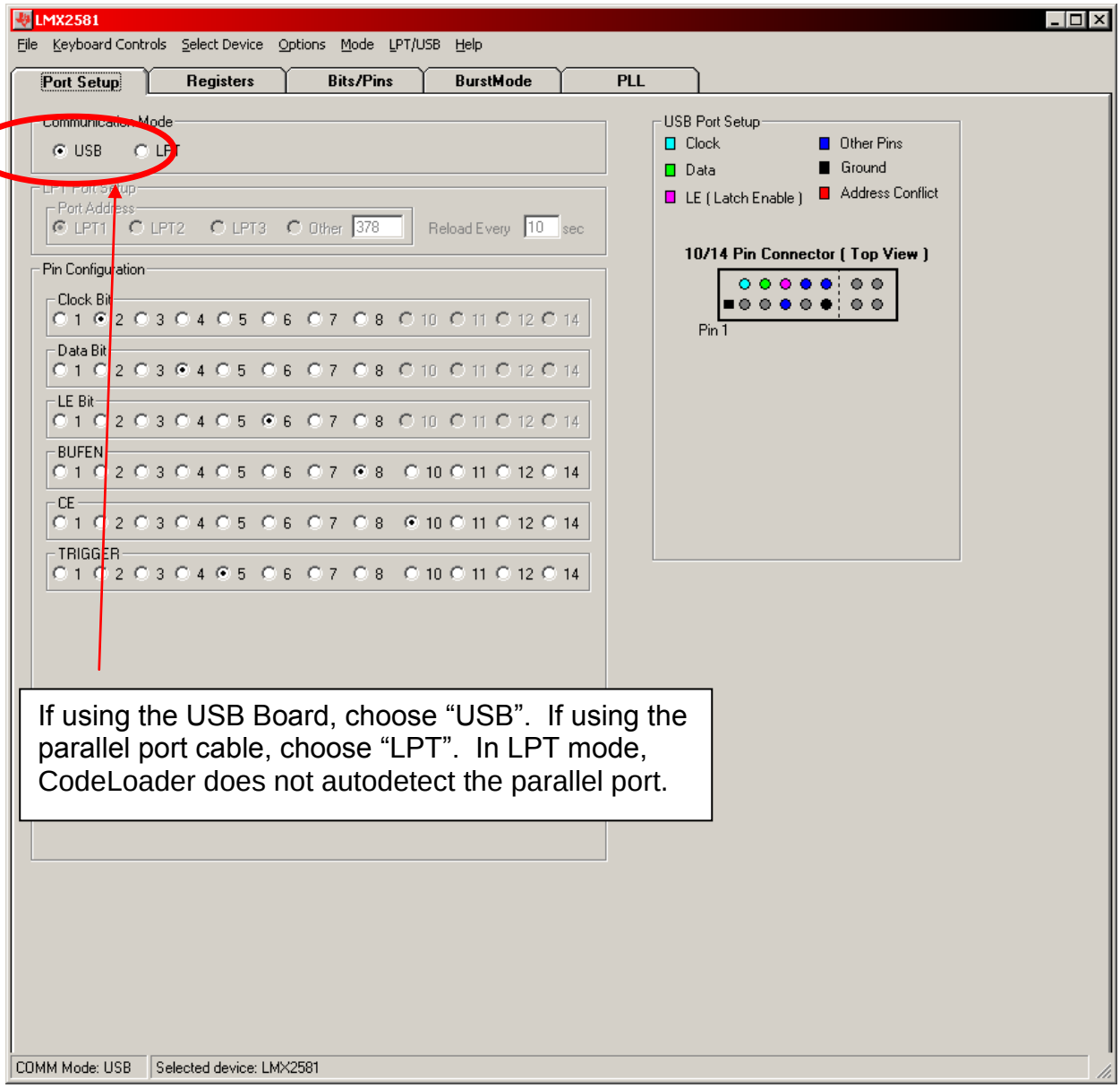
Using the EVM Software





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.

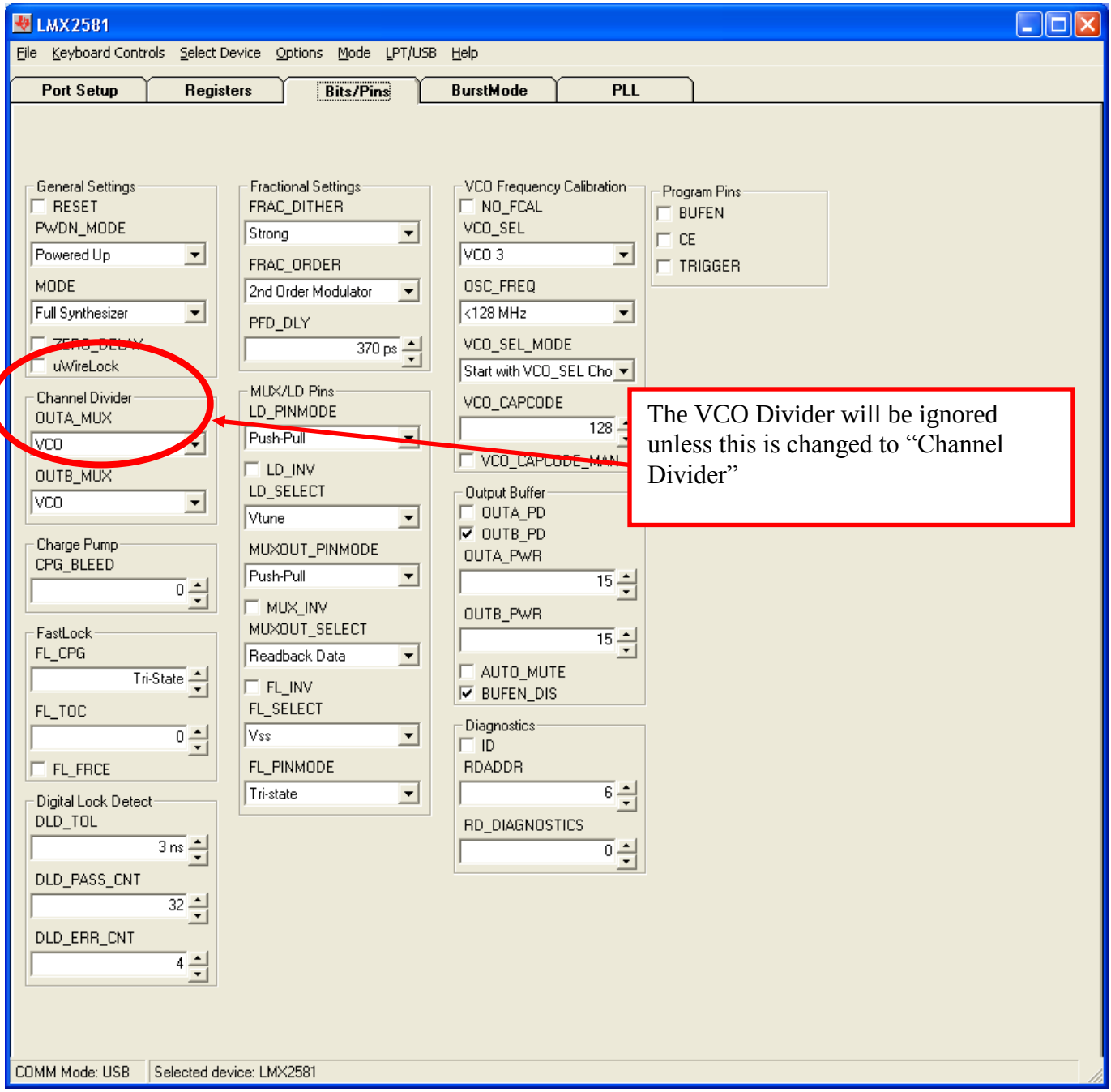
Note that pushing <Cntrl+L> will also load the CodeLoader.



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

However, if using a LPT cable, then this should be indicated in the port setup.

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.



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3. Board Layer Stackup

Layers of the 4 layer evaluation board shall include:
Blue is dielectrics

- Top layer for high priority high frequency signals (GTL)
  - 1 oz CU
- RO4003 Dielectric, 16 mils
- Ground plane (GP1)
- FR4, 18 mils thick.
- Power plane – VccCLK (GP2)
- FR4, 22 mils
- Bottom layer copper clad for thermal relief (GBL)

Top to bottom layer order:

LMX2581.GTL	(1)	Top Layer
LMX2581.GP1	(2)	GND Plane
LMX2581.G1	(3)	Power
LMX2581.GBL	(4)	Bottom Layer

4. Schematic

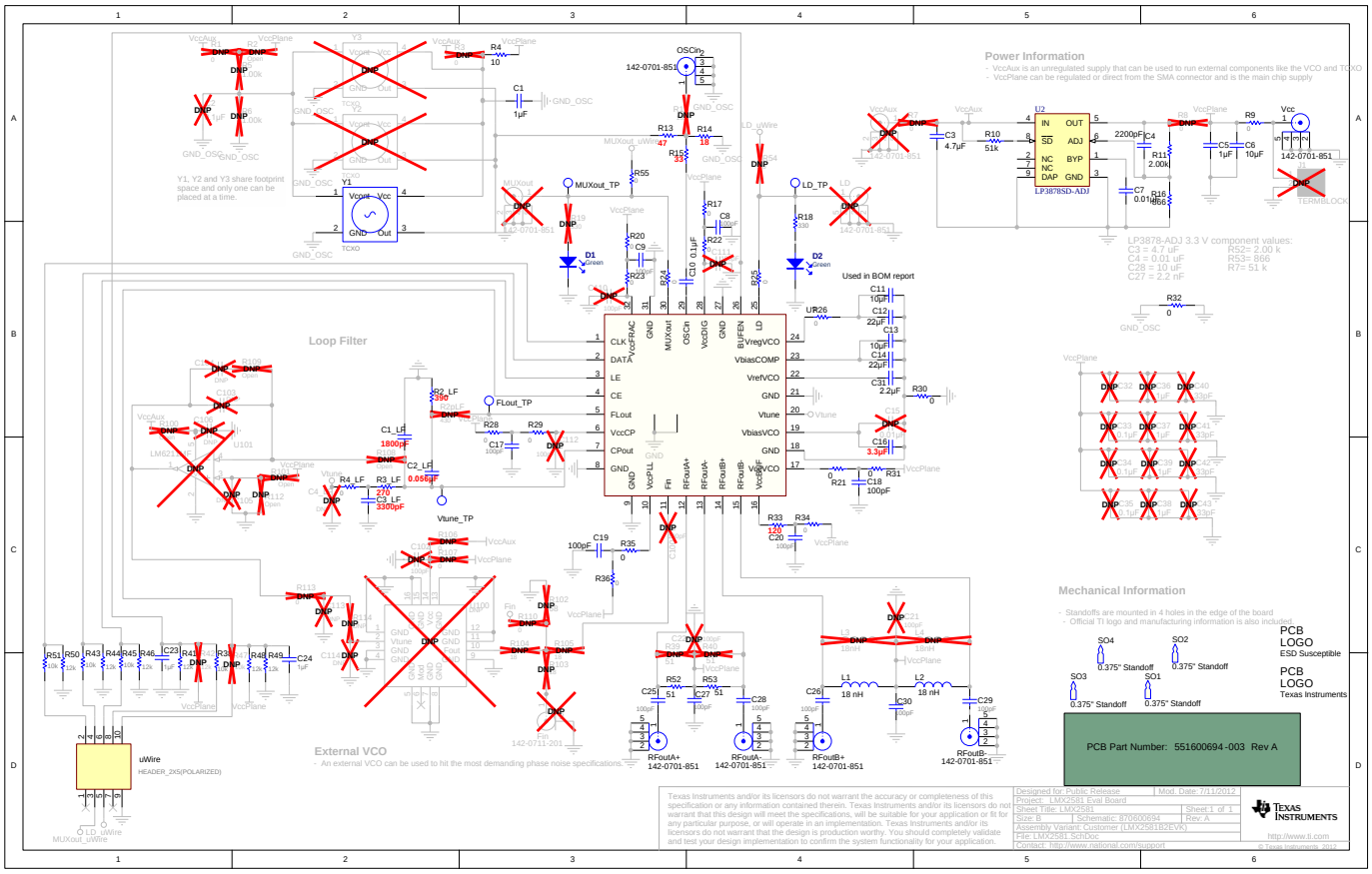


Figure 2: LMX2581EVM Schematic

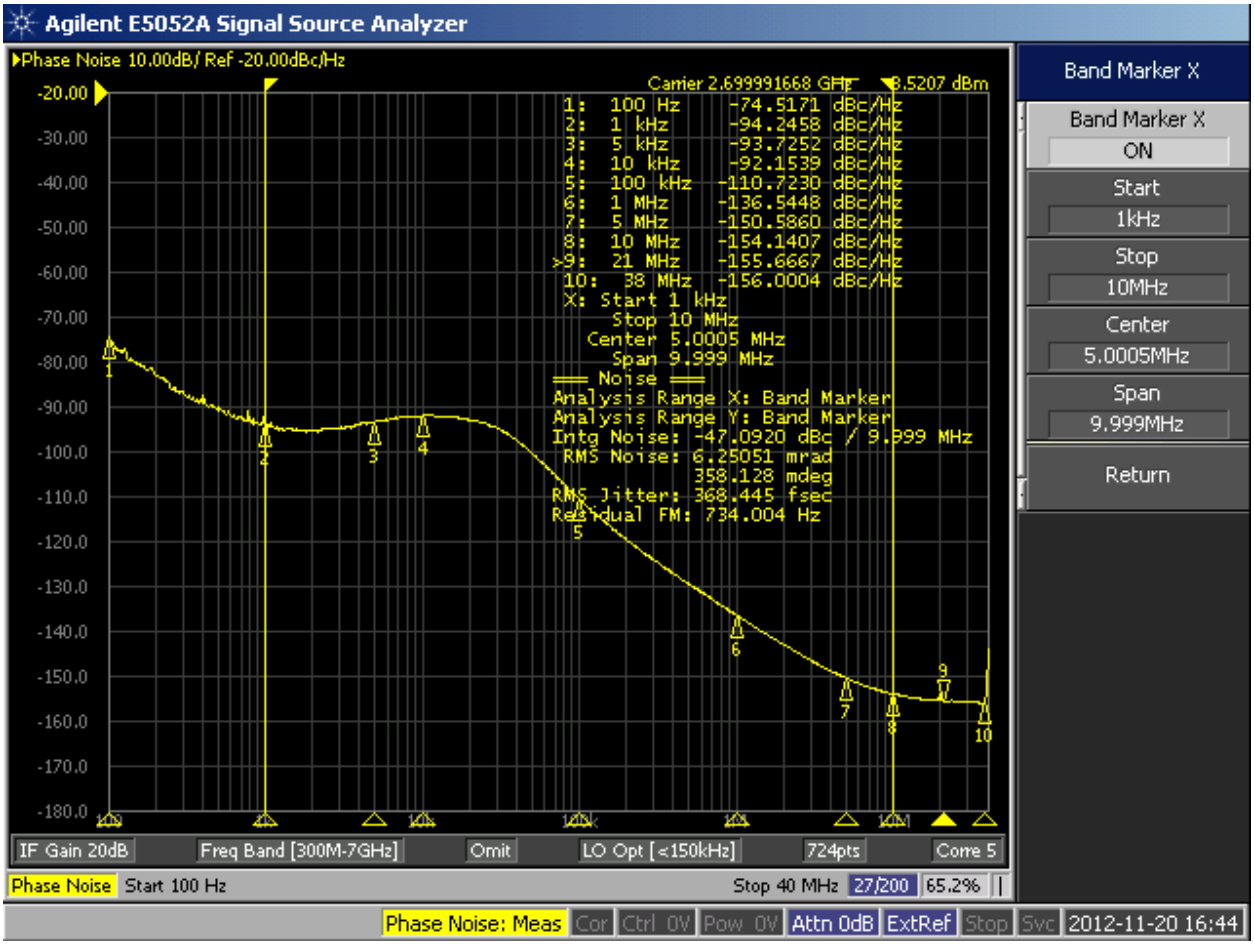
5. Bill of Materials

Item	Designator	Description	Manufacturer	PartNumber	Quantity
1	AA1	Printed Circuit Board	TBD	Used in BOM Report	1
2	C1, C5, C23, C24, C31	CAP, CERM, 1uF, 16V, +/-10%, X7R, 0603	TDK	C1608X7R1C105K	5
3	C1_LF	CAP, CERM, 1800pF, 100V, +/-5%, X7R, 0603	AVX	06031C182JAT2A	1
4	C2_LF	CAP, CERM, 0.056uF, 16V, +/-10%, X7R, 0603	MuRata	GRM188R71C563KA01D	1
5	C3	CAP, CERM, 4.7uF, 10V, +/-10%, X5R, 0603	Kemet	C0603C475K8PACTU	1
6	C3_LF	CAP, CERM, 3300pF, 100V, +/-5%, X7R, 0603	AVX	06031C332JAT2A	1
7	C4	CAP, CERM, 2200pF, 100V, +/-5%, X7R, 0603	AVX	06031C222JAT2A	1
8	C6	CAP, CERM, 10uF, 10V, +/-10%, X5R, 0805	Kemet	C0805C106K8PACTU	1
9	C7	CAP, CERM, 0.01uF, 25V, +/-5%, C0G/NP0, 0603	TDK	C1608C0G1E103J	1
10	C8, C9, C17, C18, C20, C25, C26, C27, C28, C29, C30	CAP, CERM, 100pF, 50V, +/-5%, C0G/NP0, 0603	Kemet	C0603C101J5GACTU	11
11	C10	CAP, CERM, 0.1uF, 16V, +/-5%, X7R, 0603	AVX	0603YC104JAT2A	1
12	C11, C13	CAP, CERM, 10uF, 10V, +/-10%, C0G/NP0, 0603	TDK	C1608X5R1A106M	2
13	C12	CAP, CERM, 22uF, 10V, +/-20%, X5R, 0805	Taiyo Yuden	LMK212BJ226MG-T	1
14	C14	Capacitor	MuRata	GRM188R60G226MEA0L	1
15	C16	CAP, CERM, 3.3uF, 6.3V, +/-10%, X5R, 0603	Kemet	C0603C335K9PACTU	1
16	C19	CAP, CERM, 100pF, 25V, +/-5%, C0G/NP0, 0402	MuRata	GRM1555C1E101JA01D	1
17	D1, D2	LED 2.8X3.2MM 565NM GRN CLR SMD	Lumex Opto/Components Inc.	SML-LX2832GC	2
18	FLout_TP, LD_TP, MUXout_TP, Vtune_TP	Testpoint			4
19	L1, L2	Inductor	Murata	LQG15HS18NJ02D	2
20	OSCin, RFoutA+, RFoutA-, RFoutB+, RFoutB-, Vcc	Connector, SMT, End launch SMA 50 ohm	Emerson Network Power Connectivity	142-0701-851	6
21	R2_LF	RES, 390 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW0603390RJNEA	1
22	R3_LF	RES, 270 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW0603270RJNEA	1
23	R4	RES, 10 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060310R0JNEA	1
24	R4_LF, R9, R17, R20, R21, R22, R23, R24, R25, R26, R28, R29, R31, R32, R33, R34, R36, R55	RES, 0 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW06030000Z0EA	18
25	R10	RES, 51k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060351K0JNEA	1
26	R11	RES, 2.00k ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW06032K00FKEA	1
27	R13	RES, 47 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060347R0JNEA	1
28	R14	RES, 68 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060318R0JNEA	1
29	R15	RES, 33 ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060333R0JNEA	1
30	R16	RES, 866 ohm, 1%, 0.1W, 0603	Vishay-Dale	CRCW0603866RFKEA	1
31	R18	RES, 330 ohm, 5%, 0.1W, 0603	Yageo America	RC0603JR-07330RL	1
32	R35	RES, 0 ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW04020000Z0ED	1
33	R38, R43, R45, R51	RES, 10k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060310K0JNEA	4
34	R41, R44, R46, R48, R49, R50	RES, 12k ohm, 5%, 0.1W, 0603	Vishay-Dale	CRCW060312K0JNEA	6
35	R52, R53	RES, 51 ohm, 5%, 0.063W, 0402	Vishay-Dale	CRCW040251R0JNED	2
36	SO1, SO2, SO3, SO4	0.375" Standoff	Voltrex	SPCS-6	4
37	U1		National Semiconductor	LMX2581	1
38	U2	Micropower 800mA Low Noise 'Ceramic Stable' Adjustable Voltage Regulator for 1V to 5V Applications	National Semiconductor	LP3878SD-ADJ	1
39	uWire	Connector	FCI	52601-G10-8LF	1
40	Y1	Oscillator	Connor Winfield	CWX813-100.00M	1

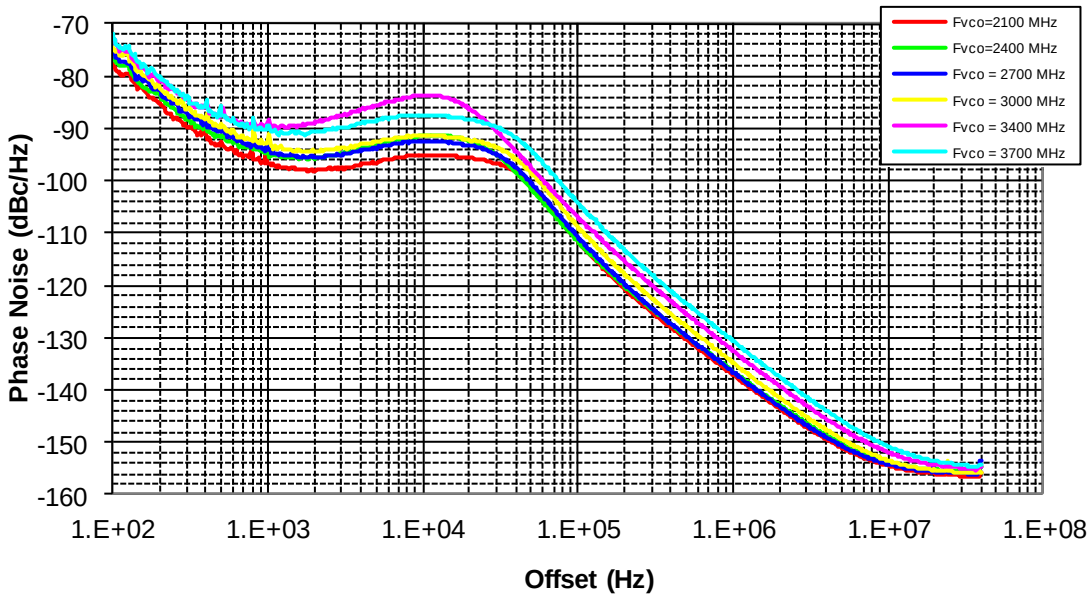
Table 3: LMX2581EVM Bill of Materials

6. Measured Performance Data

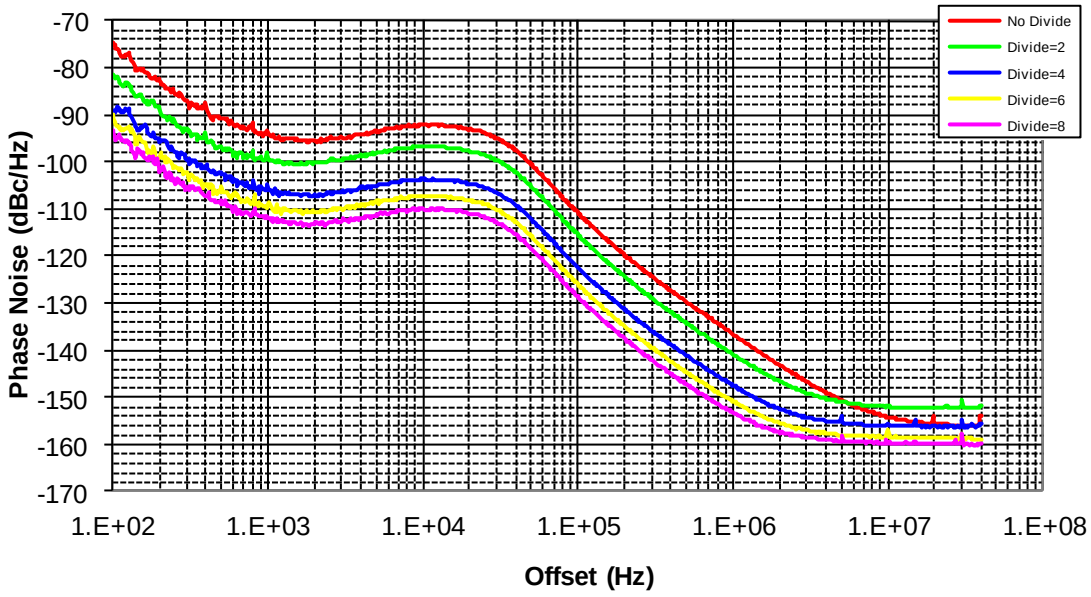
Phase Noise



Phase Noise vs. VCO Frequency



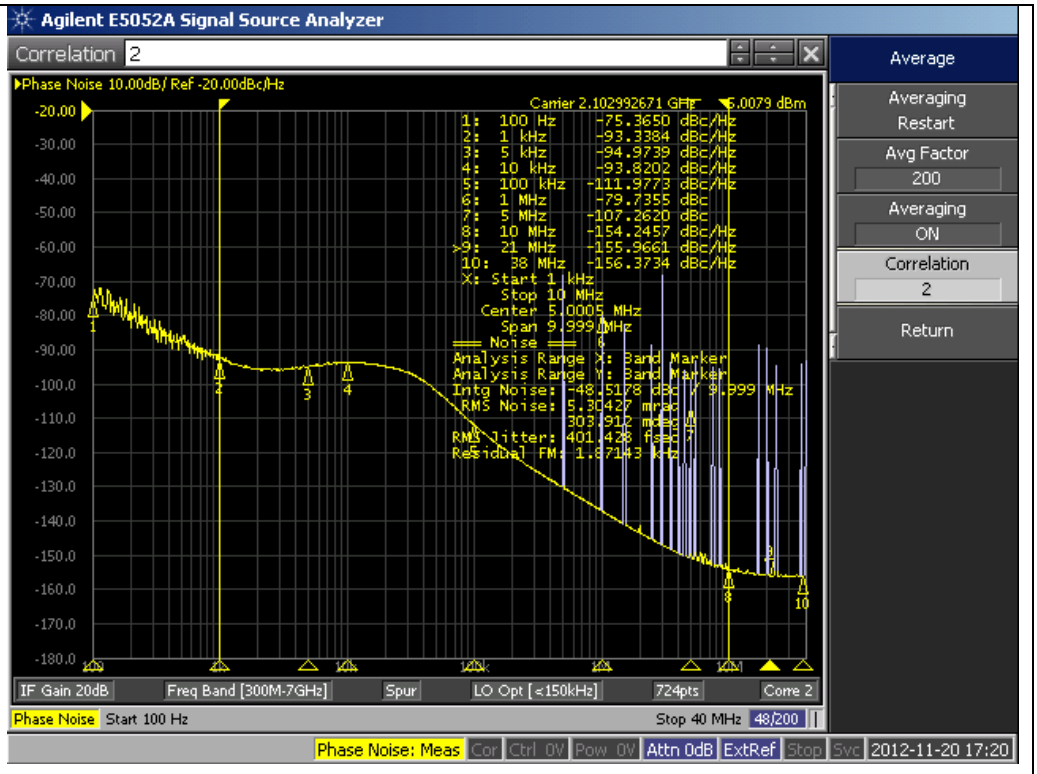
Impact of Divide for Fvco = 2700 MHz



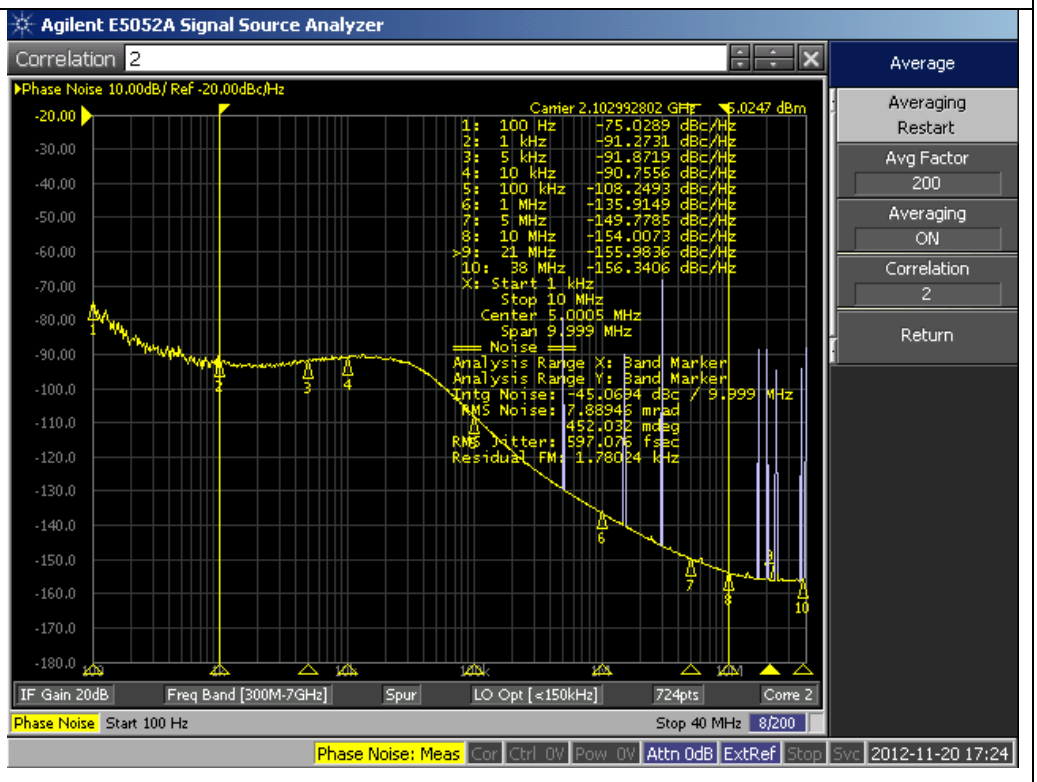
Fractional Spurs

Fvco = 2103 MHz

2nd Order Modulator
PFD_DLY = 370 ps

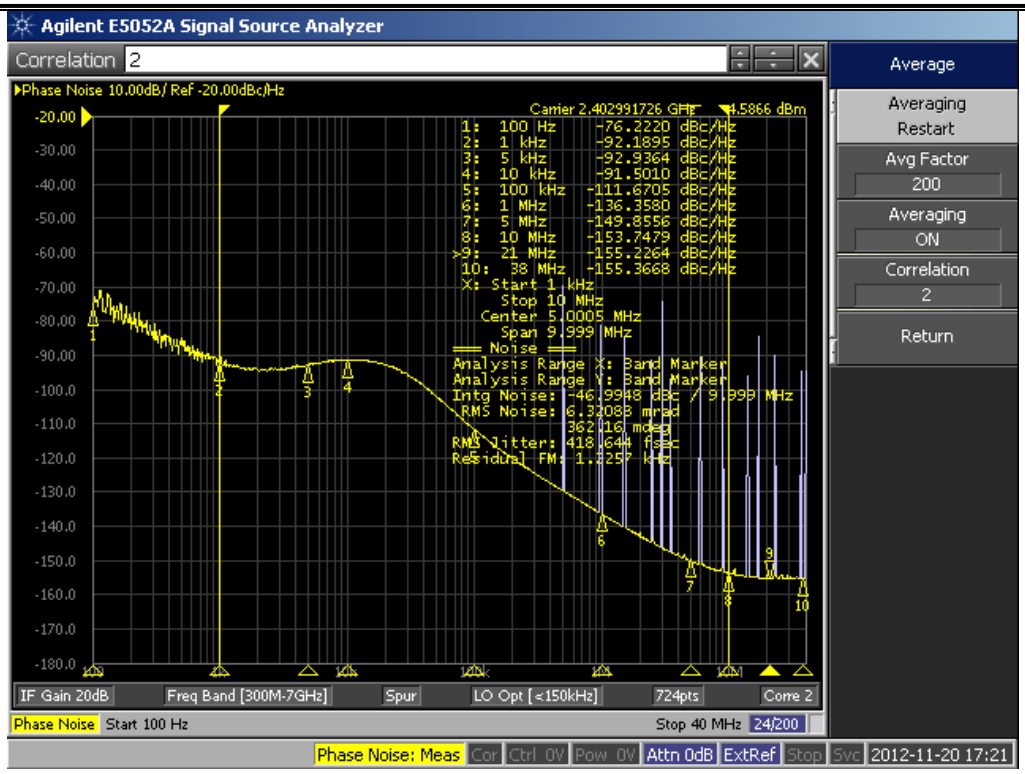


3rd Order Modulator
PFD_DLY = 1460 ps

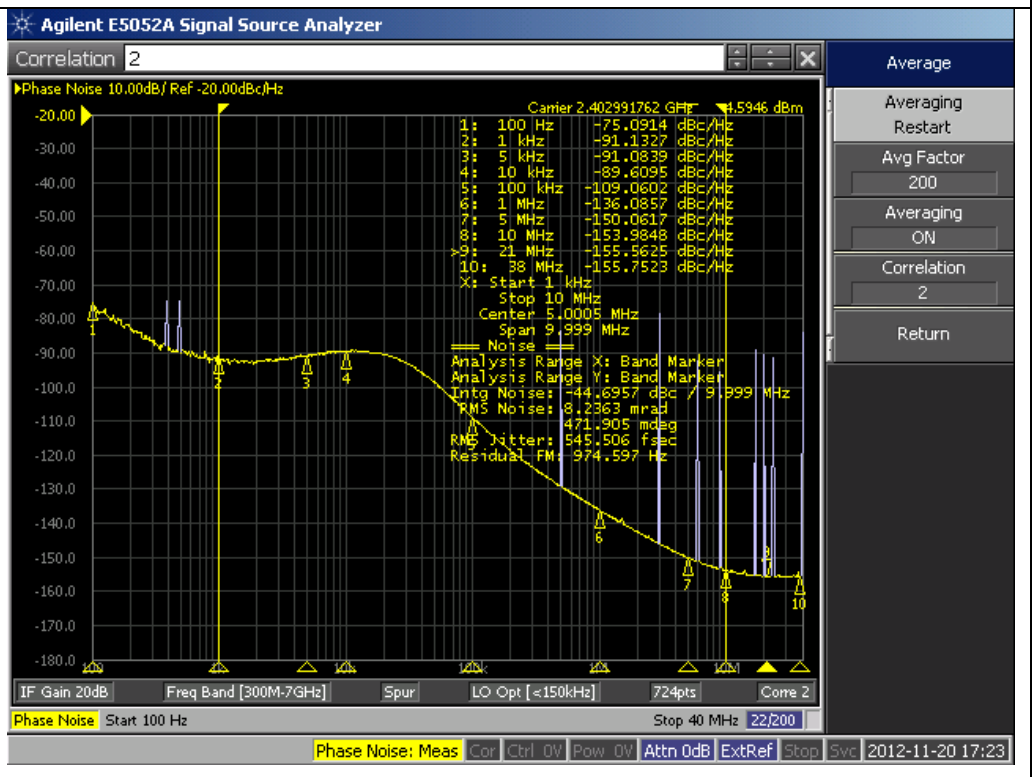


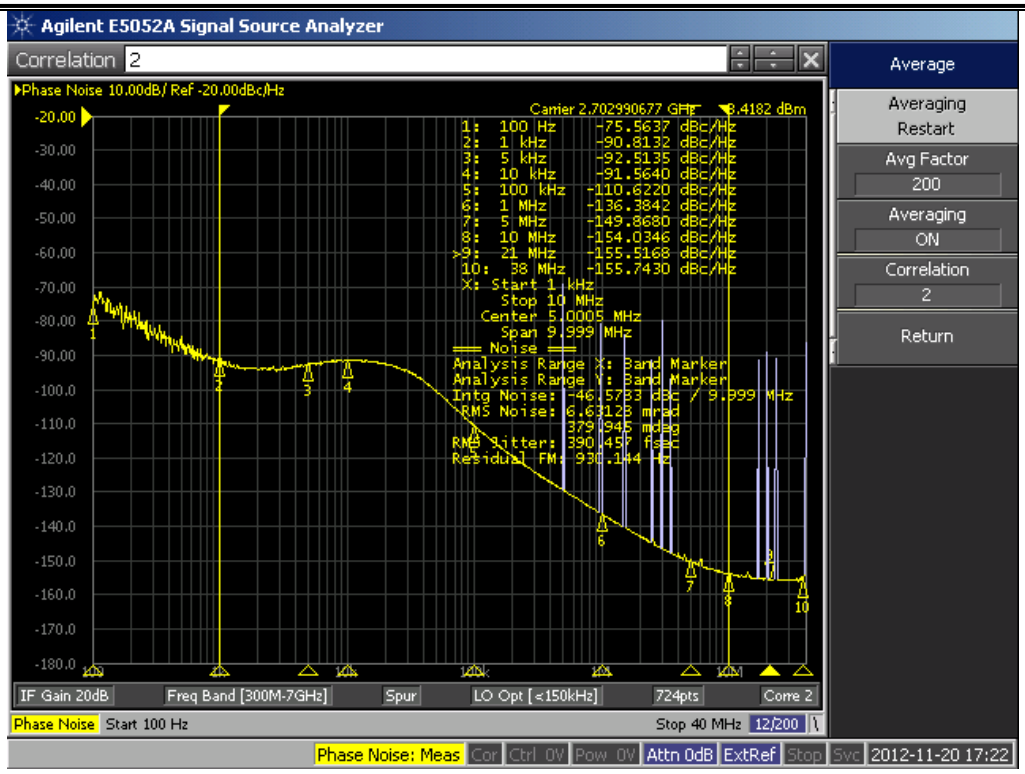
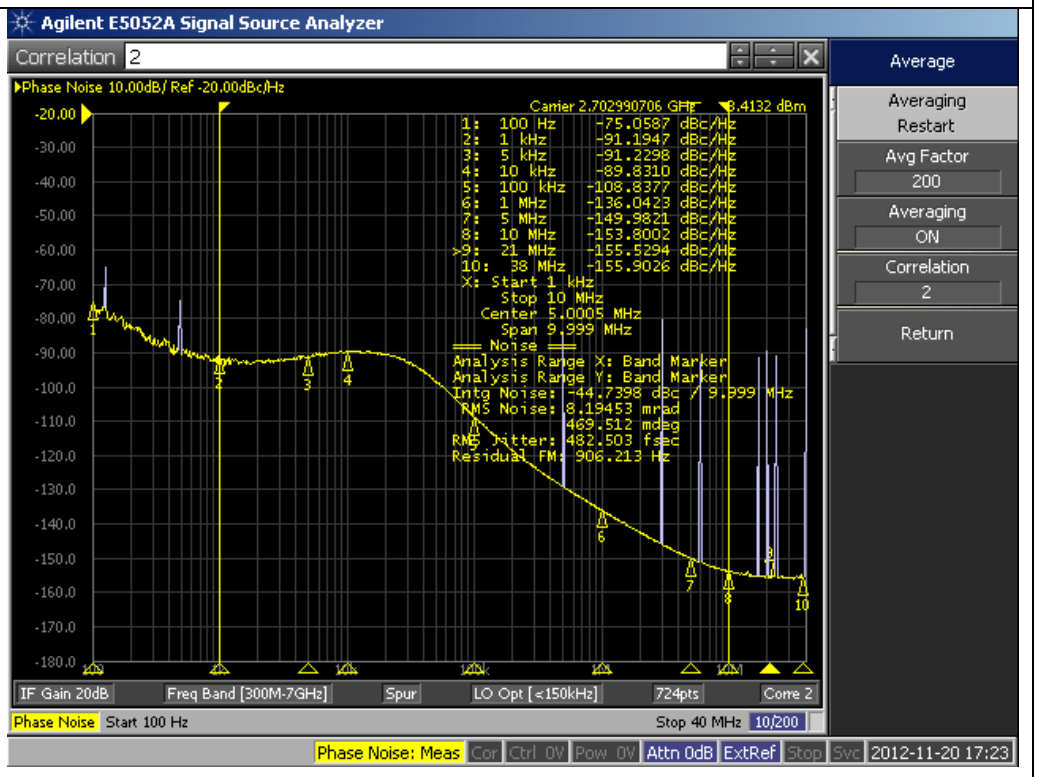
Fvco = 2403 MHz

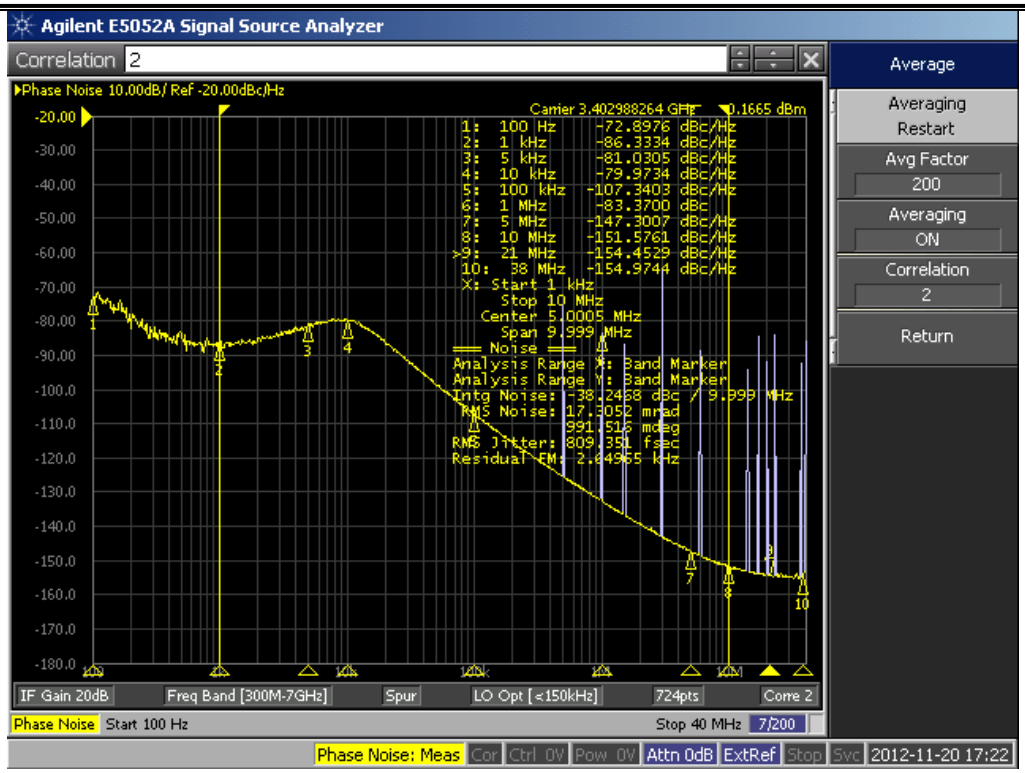
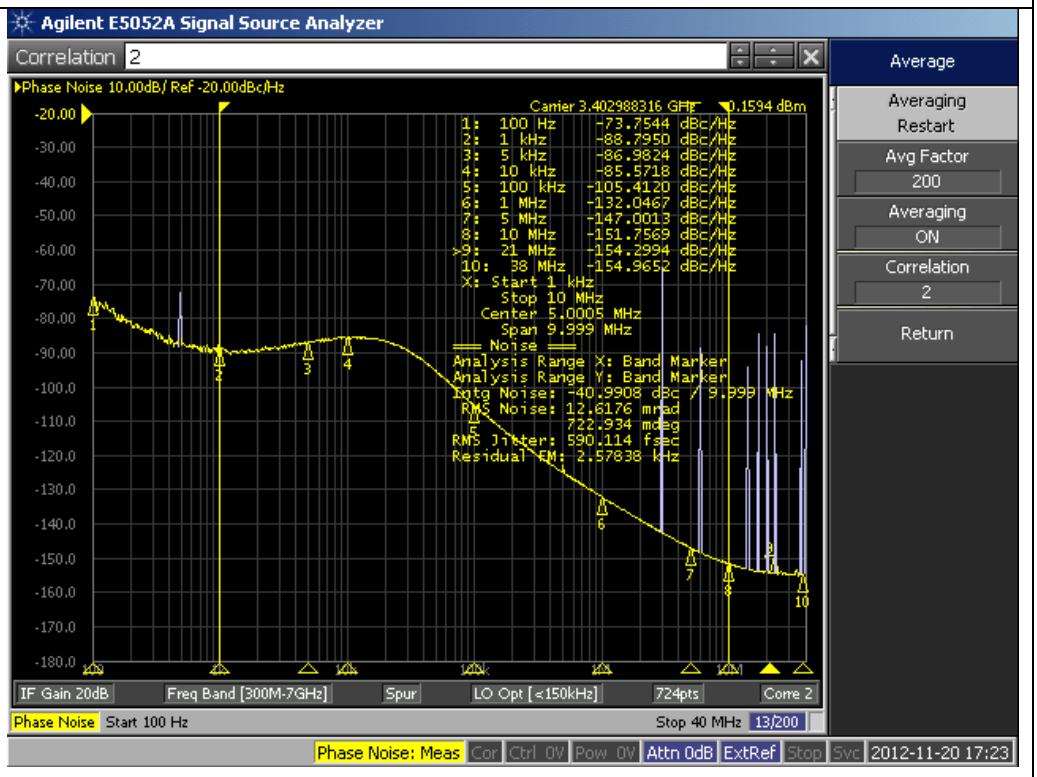
2nd Order Modulator
PFD_DLY = 370 ps



3rd Order Modulator
PFD_DLY = 1460 ps



Fvco = 2703 MHz	2nd Order Modulator PFD_DLY = 370 ps	
	3rd Order Modulator PFD_DLY = 1460 ps	

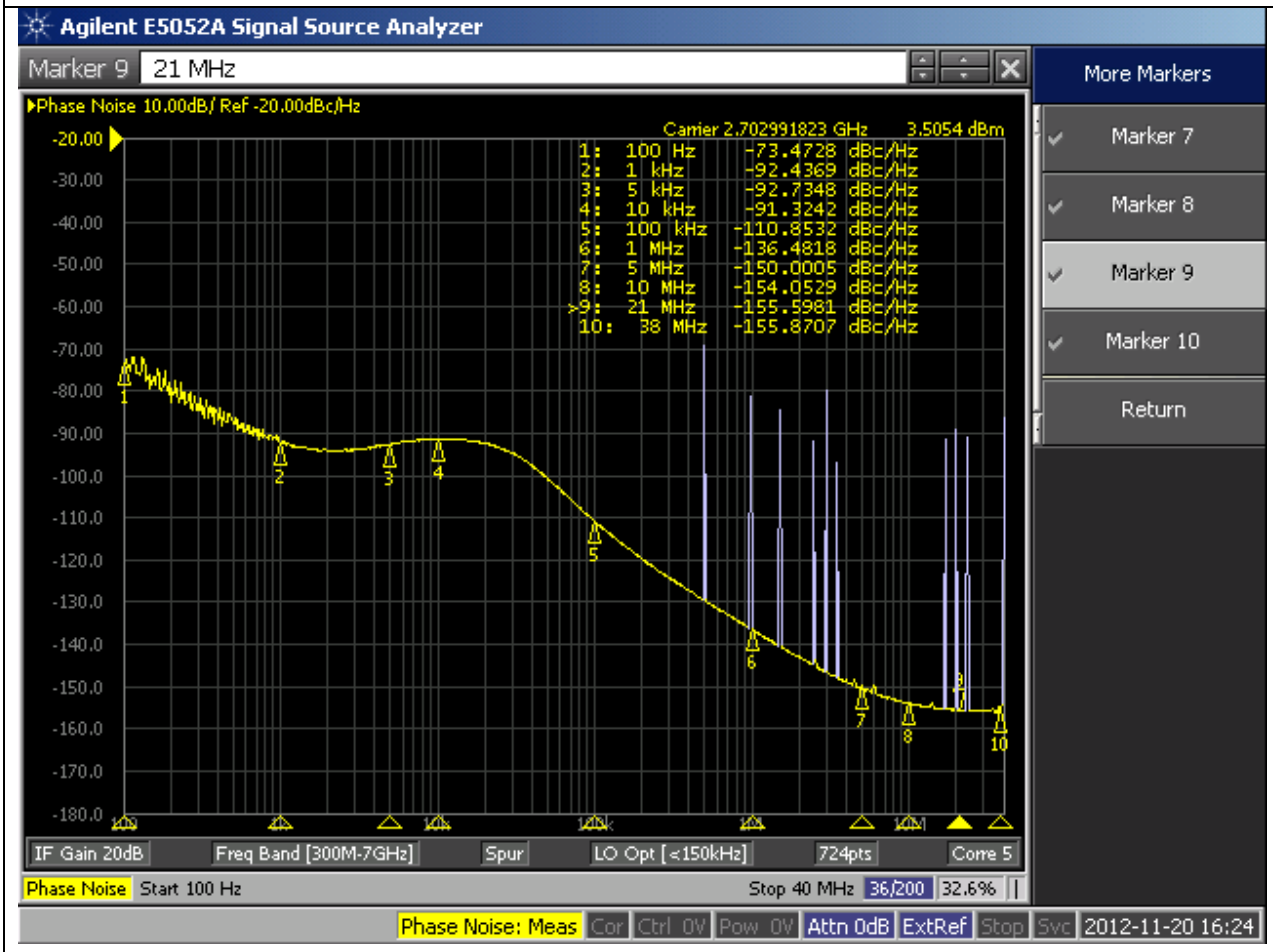
Fvco = 3403 MHz	2nd Order Modulator PFD_DLY = 370 ps	
	3rd Order Modulator PFD_DLY = 1460 ps	

Fractional Spurs (Impact of Various Settings)

For these measurements, they were all taken at 2703 MHz with the same board, but various things were varied to show the impact.

Default Setting

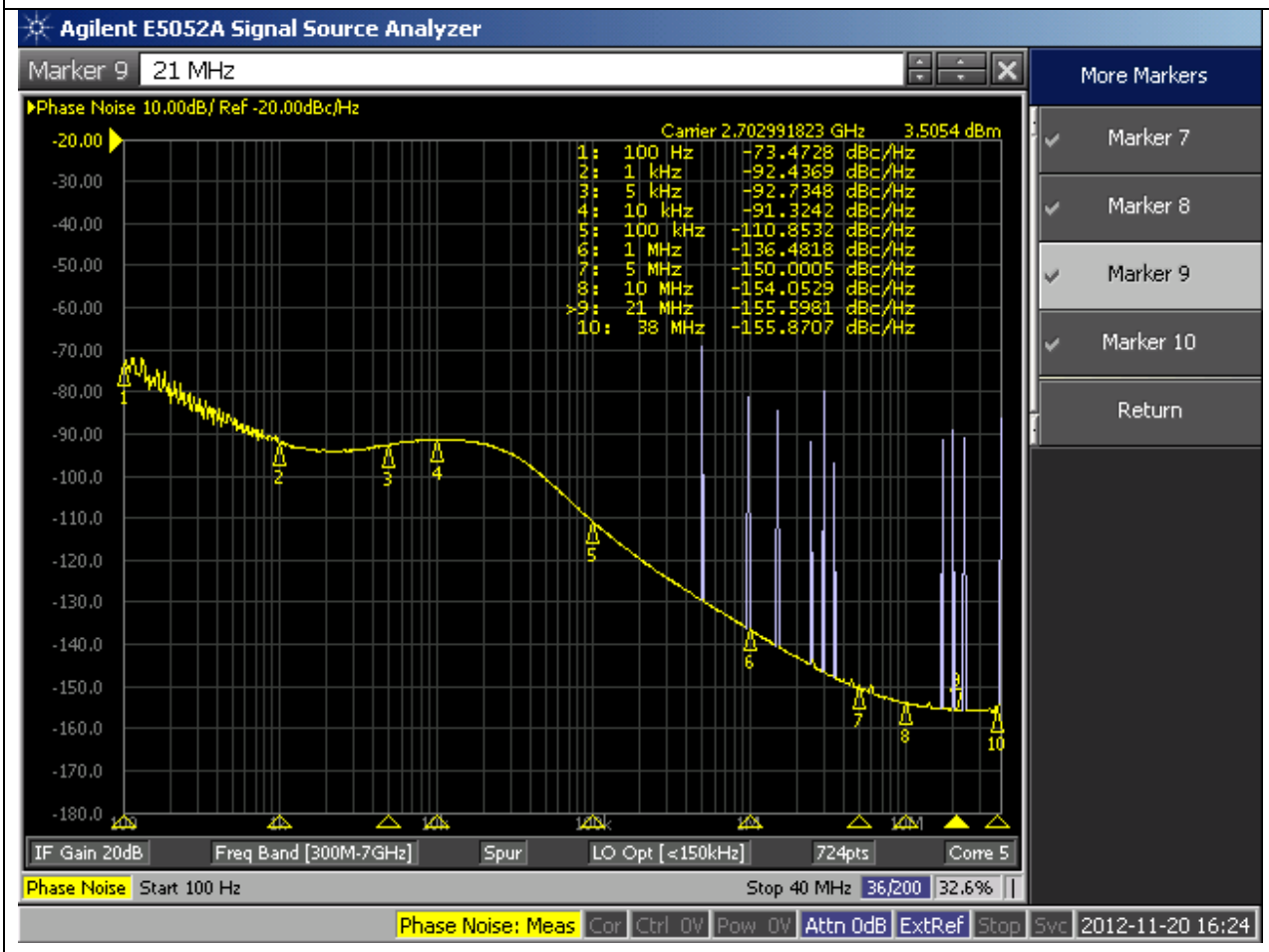
2nd Order modulator, Fpd =20 MHz, Kpd=24x, PFD_DLY = 370 ps, Strong Dithering



This is the default setting which the following spur plots will be compared to. Compare this to the phase noise plot for integer mode to see that the fractional circiutry can be set up to add no phase noise, just spurs. The user has programmability to sacrifice phase noise for spurs. For the 2nd order modulator, the added phase noise is typically fairly low.

Impact of Disabling Dithering

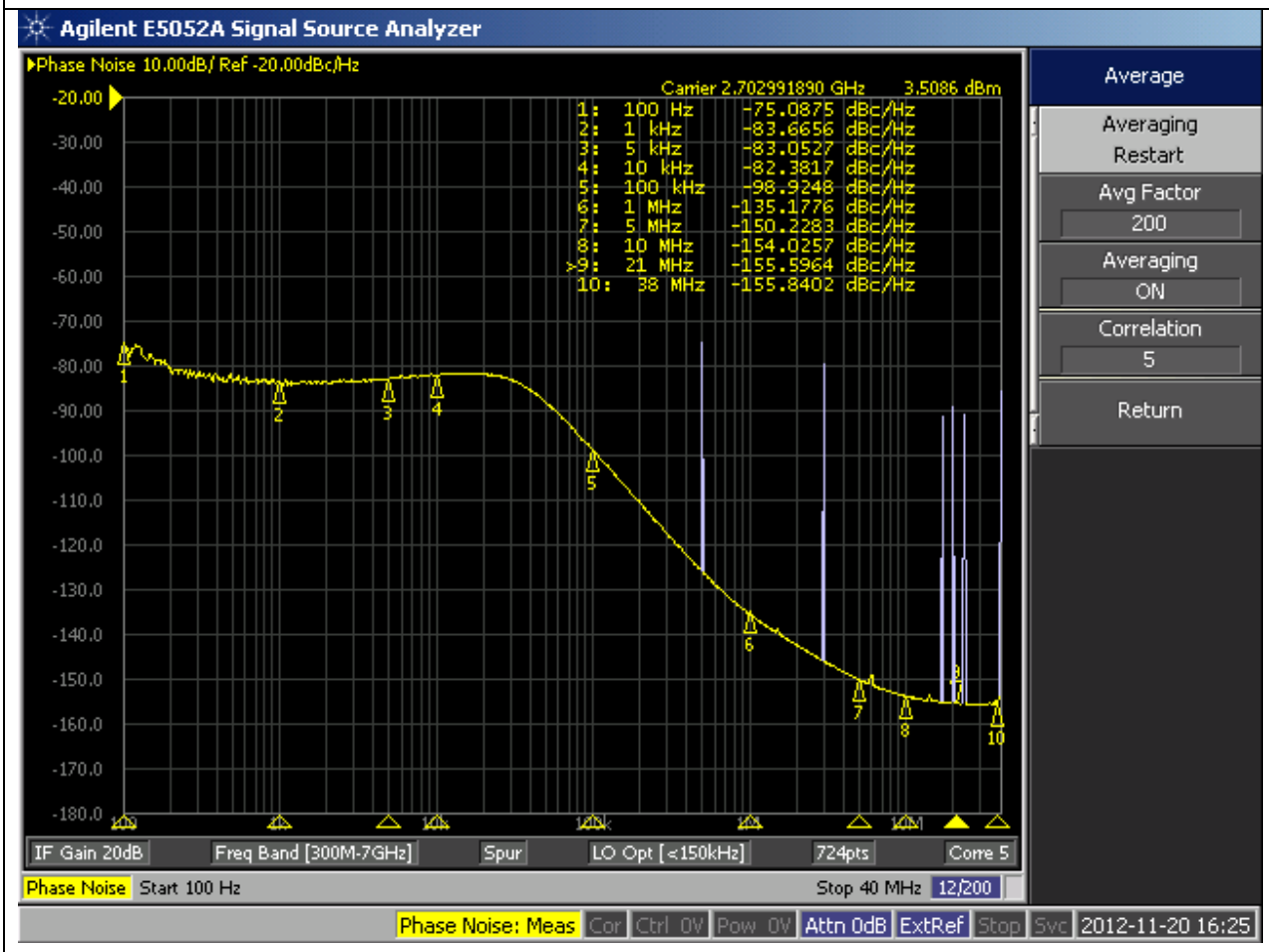
2nd Order modulator, Fpd =20 MHz, Kpd=24x, PFD_DLY = 370 ps, **Dithering Disabled**



For the 2nd order modulator, disabling dithering did not have much of an impact on the noise or fractional spurs. However, we will see later that it has a much more noticable impact for the 3rd order modulator.

Impact of Using a 3rd Order Modulator

3rd Order modulator, Fpd =20 MHz, Kpd=24x, PFD_DLY = 370 ps, Strong Dithering

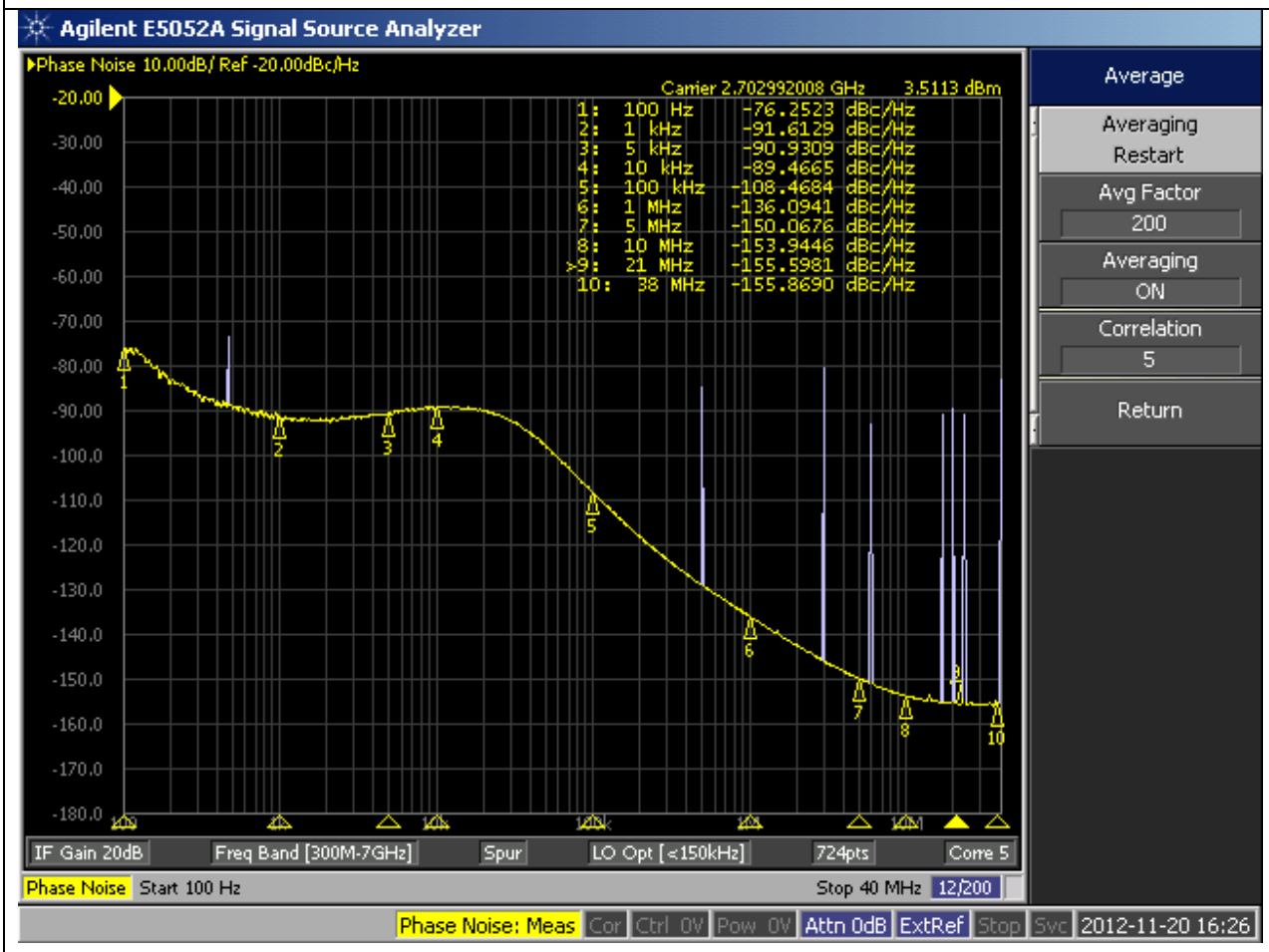


When the 3rd order modulator is used with strong dithering, there is a clear increase in the close-in phase noise, but many spurs go away. However, the integer boundary spur at 3 MHz is unaffected.

Note that there are 4 levels of dithering and other ways to mitigate this fractional noise without sacrificing spurs. If dithering was to be disabled, there would be no fractional spurs.

Impact of Increasing PFD_DLY for a 3rd Order Modulator with Strong Dithering

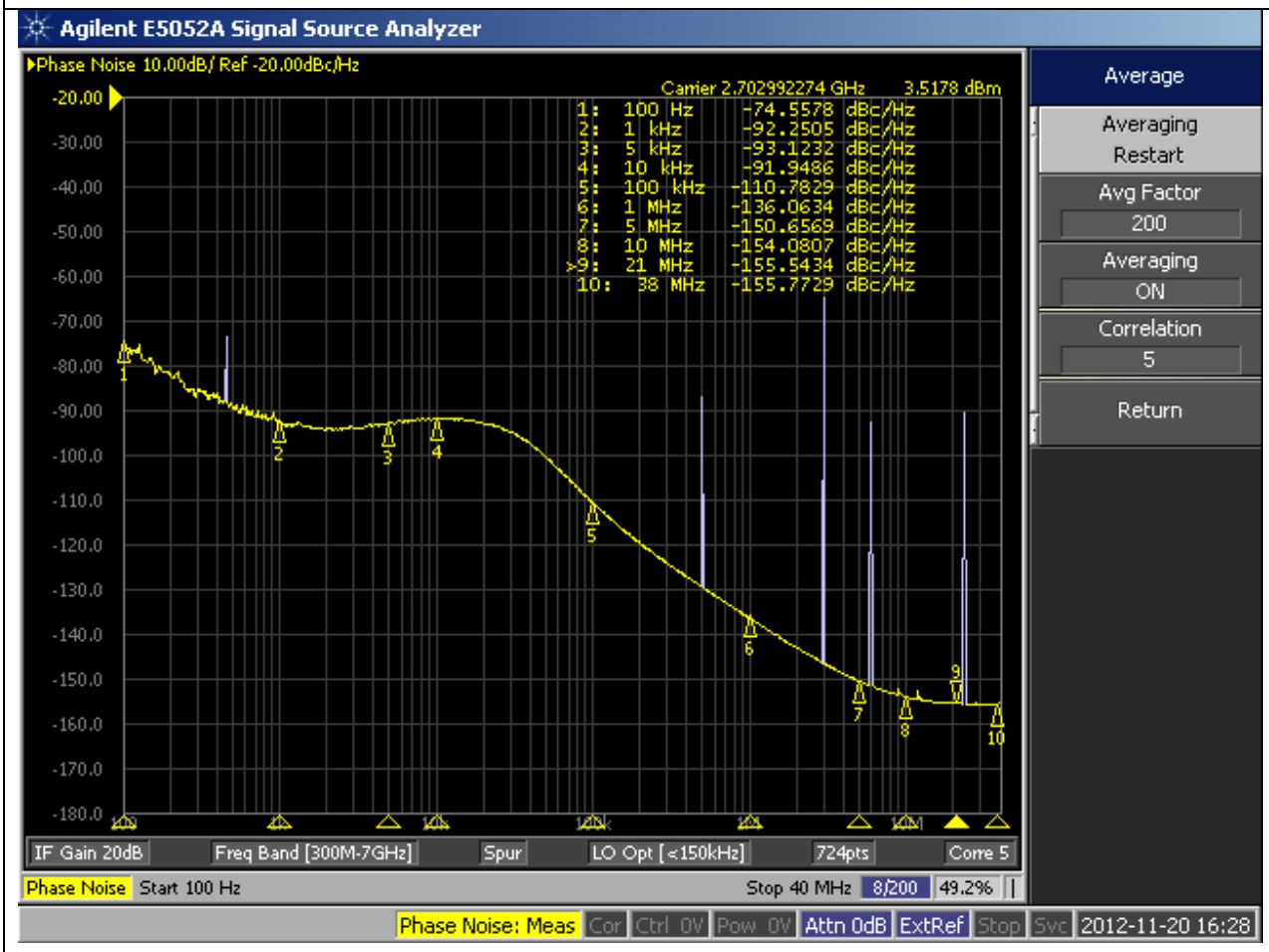
3rd Order modulator, Fpd =20 MHz, Kpd=24x, **PFD_DLY = 1460 ps**, Strong Dithering



Increasing the PFD_DLY setting is effective in significantly reducing the fractional noise without sacrificing spurs. For the 2nd order modulator, this is typically good to keep at lower settings, but for the 3rd order modulator, it is very effective.

Impact of Increasing the Phase Detector Frequency

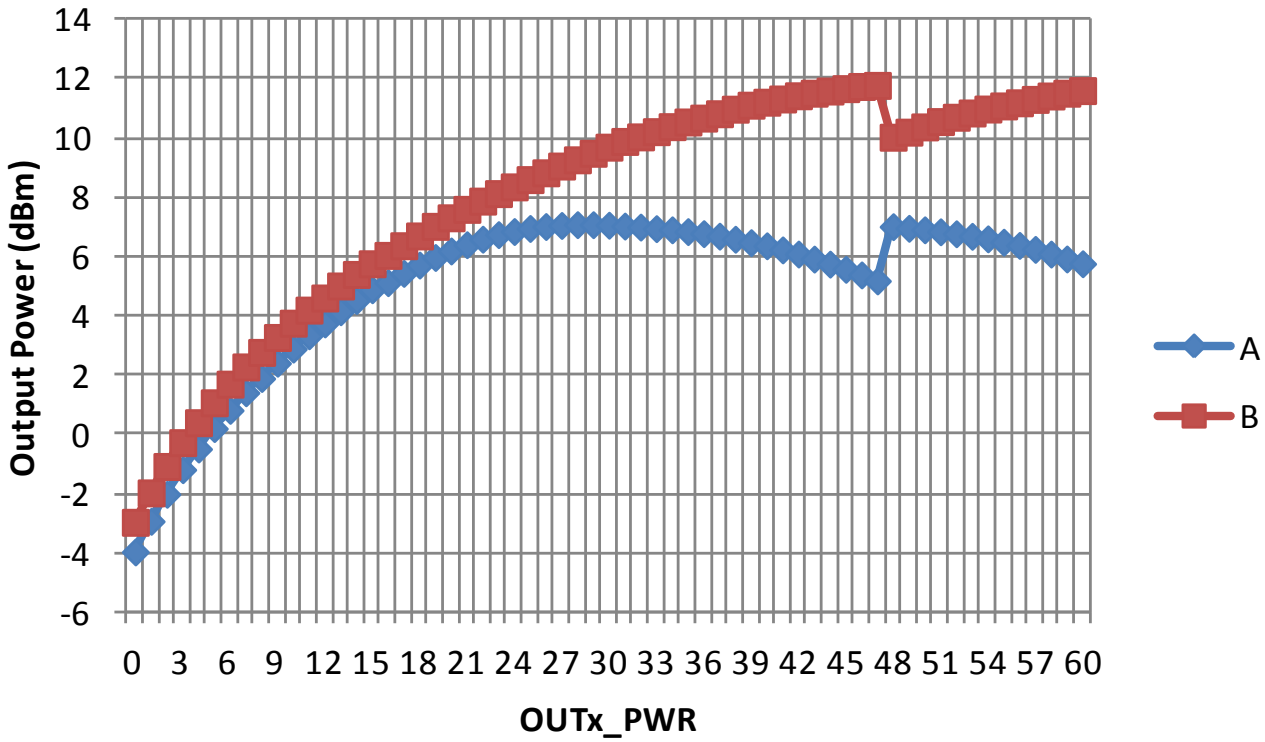
2nd Order modulator, **Fpd =100 MHz**, **Kpd=5x**, PFD_DLY = 1460 ps, Strong Dithering



For this measurement, the phase detector was increased by a factor of 5 and the charge pump gain was lowered by a factor very close to 5. This keeps the loop bandwidth constant and allows a measurement with the same device and loop filter parameters to compare only the impact of changing the phase detector frequemcy. Comparing to the very first (default) measurement, we see that many spurs are gone, but the integer boundary spur at 3 MHz offset has increased by about 15 dB.

In general, a higher phase detector frequency does tend to lead to better phase noise and spurs except for the integer boundary spur, which is worse for higher phase detector frequencies.

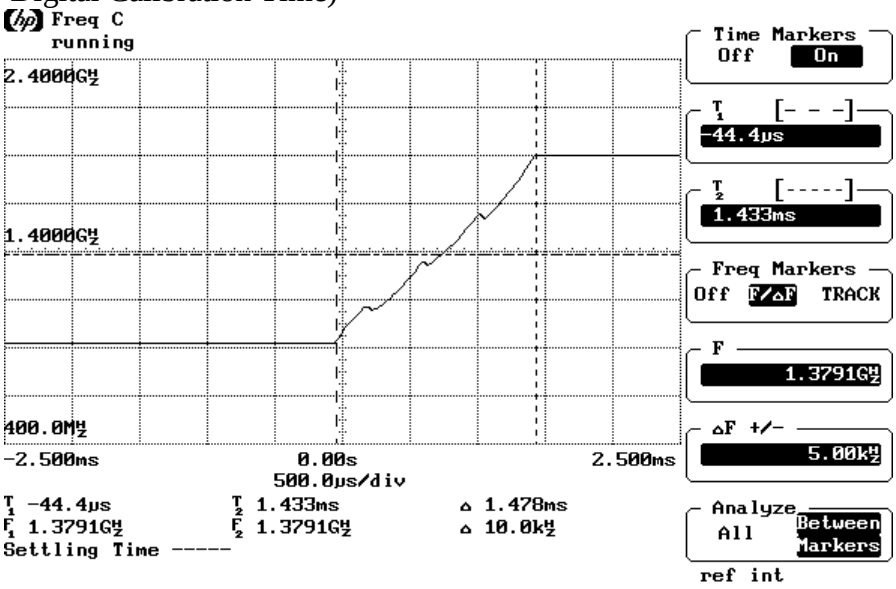
Output Power



The above data was taken by taking the single-ended output power for RFoutA+ and RFoutB+ varying the OUTx_PWR programming field. RFoutA- and RFoutB- were terminated with a 50 ohm load. Notice that OUTA and OUTB have different performance. THIS IS NOT BECAUSE THE OUTPUTS ARE DIFFERENT IN THE CHIP. The reason for this difference is that RFoutA outputs have a resistive (50 ohm) pull-up and the RFoutB output has an inductive pull-up.

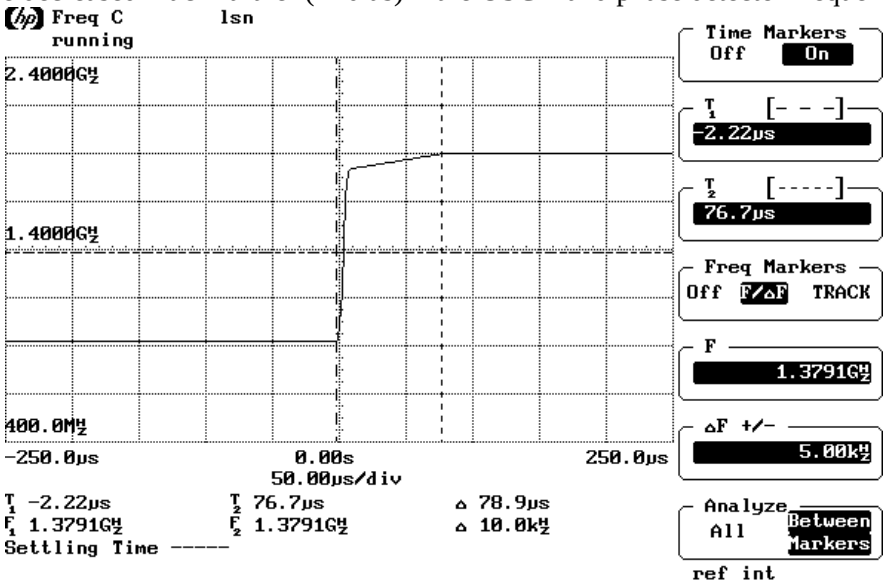
The inductor pull-up offers higher output power and the current consumption is lower, so it is an excellent choice, but the matching is not very good because the output impedance is equal to the pull-up component and board traces. For the inductive pull-up, consider using a large inductor so that it looks like high impedance at the frequency of operation

Lock Time (VCO Digital Calibration Time)

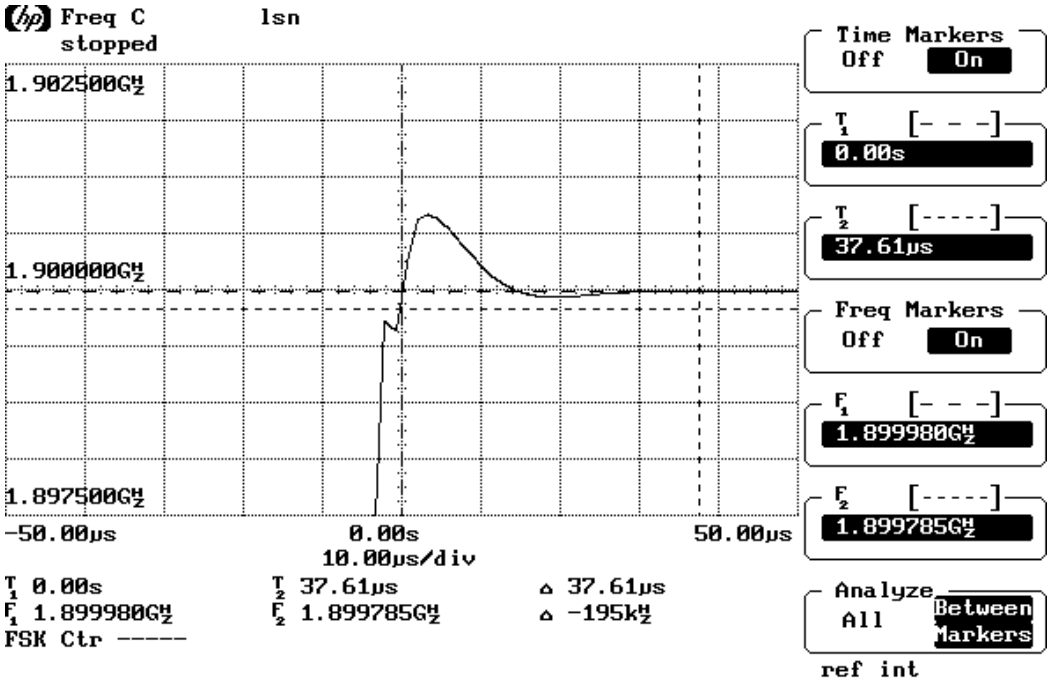


The above plot shows the VCO tuning from 1850 to 3800 MHz. The VCO divider has been set to 2 because the measurement equipment (HP53310A) could not handle the higher frequency. This is starting at Core 1 and we can see all the different cores switchining in. This is the VCO calibration time and is independent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

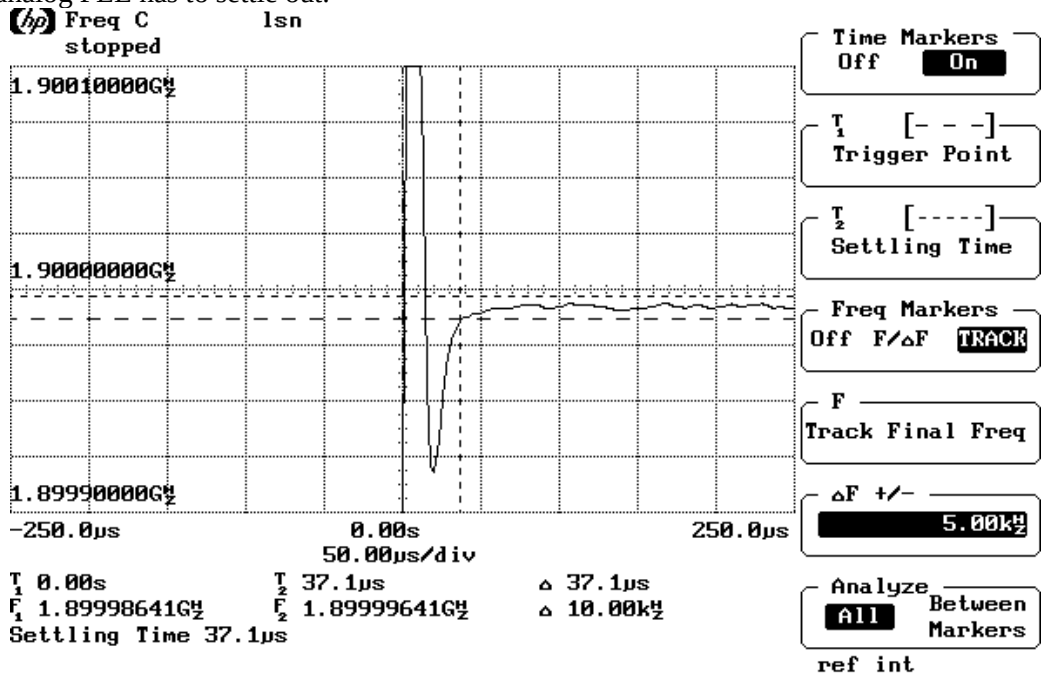
The plot below that this lock time can be improved by telling the VCO where to start. For this, the VCO was selected to start at VCO core 4 with a capcode of 47. Although a different value could be used to improve the lock time more, a value of 47 represents might be a reasonable starting point that 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 us) if the OSCin and phase detector frequencies are raised.



Lock Time (Analog PLL Lock Time)



The glitch in the plot above is showing what happens after the VCO calibration is done. 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 is showing that this calibration is getting within about 200 kHz of the final frequency, so this is all that he analog PLL has to settle out.



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.

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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 this Product 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.

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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. 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.

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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.

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