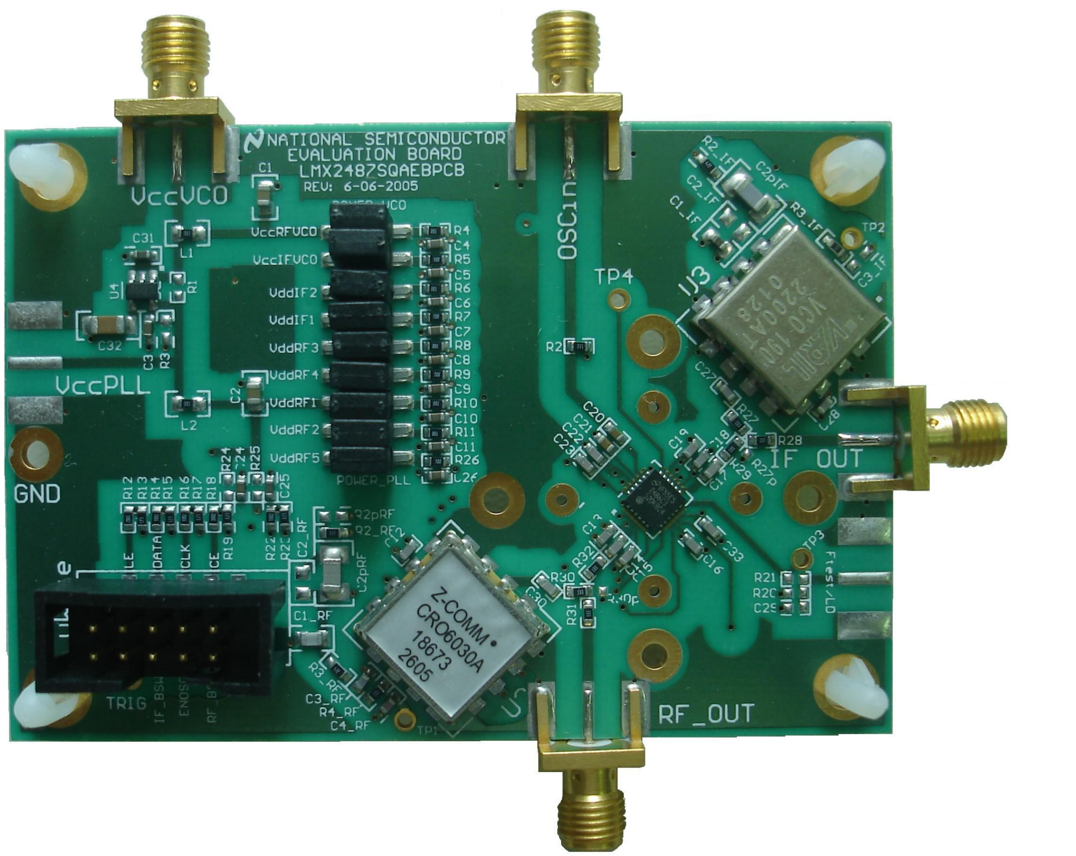
LMX2487 Evaluation Board Instructions



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LMX2487SQFPEBI Rev 5.26.2007

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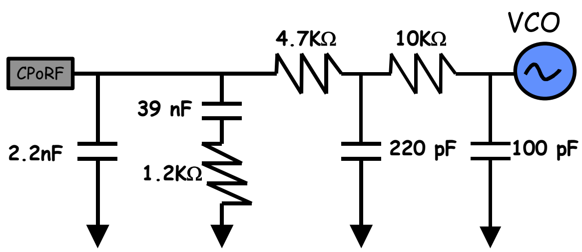
General Description

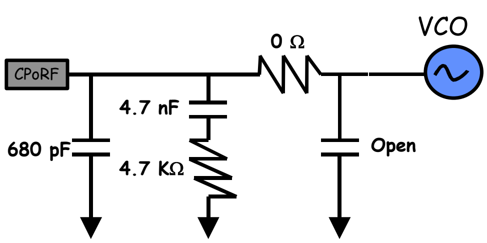
The LMX2487 Evaluation Board simplifies evaluation of the LMX2487 4.5 GHz/3.0 GHz ***PLLatinum™ dual frequency synthesizer***. The board enables all performance measurements with no additional support circuitry. The evaluation board consists of a LMX2487 device, a RF VCO module and IF VCO & RF/IF loop filters built by discrete components. The SMA flange mount connectors are provided for external reference input, RF and IF VCO outputs, and the power and grounding connection. A cable assembly is bundled with the evaluation board for connecting to a PC through the parallel printer port. By means of ***MICROWIRE™*** serial port emulation, the *CodeLoader* software included can be run on a PC to facilitate the LMX2487 internal register programming for the evaluation and measurement.

RF Loop Filter			
Phase Margin	48.6 deg	Pole Ratio T3 /T1	39.7 %
Loop Bandwidth	9.3 KHz	Pole Ratio T4/T3	39.2 %
Lock Time	6000 – 6040 MHz to 1 KHz tolerance in 404 uS w/o CSR	Roll-Off @ 200 KHz	-50.8 dB



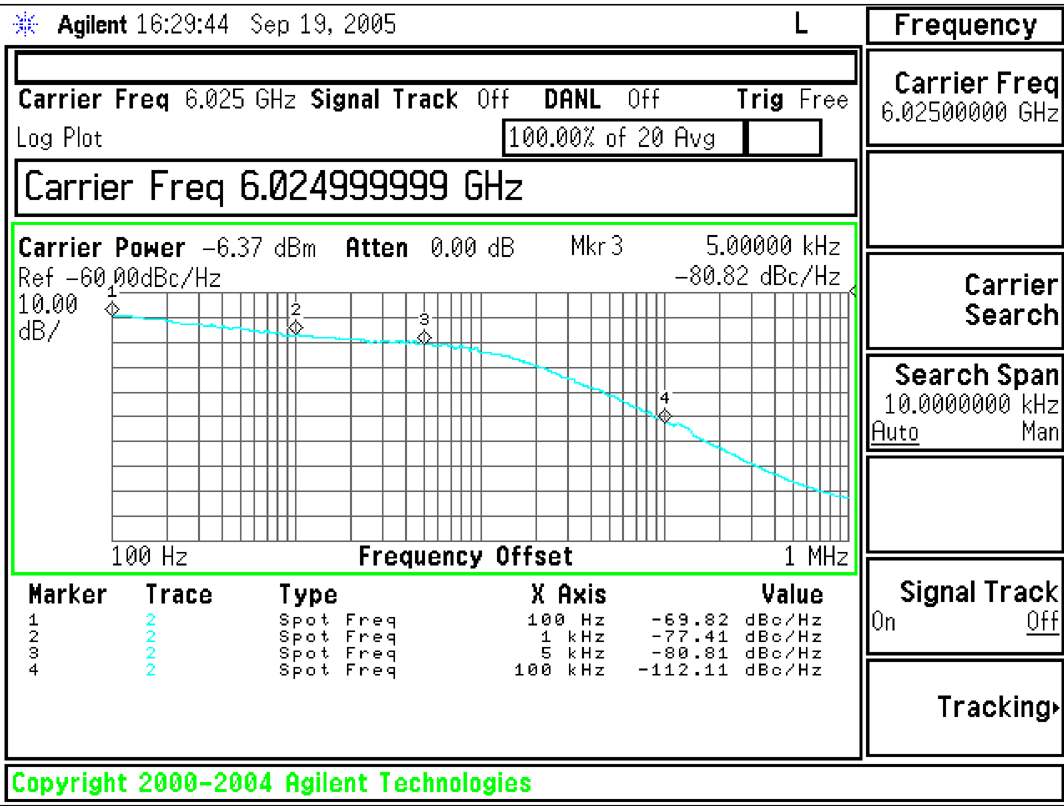
Settings for Operation	
Kϕ	8X (760 uA)
Comparison Frequency	20 MHz
Output Frequency	6000-6030
PLL Supply	2.5 Volts
VCO Supply	5 Volts
Other Information	
VCO Used	ZCOMM CRO6030A
VCO Gain	20 MHz/Volt
VCO Input Capacitance	50 pF

IF Loop Filter			
Phase Margin	48.1 deg	Theoretical Discrete Lock Time	2.1 – 2.2 GHz to 1 KHz tolerance in 160 uS
Loop Bandwidth	16.8 KHz	Spur Gain @ 50 KHz	50.5 dB

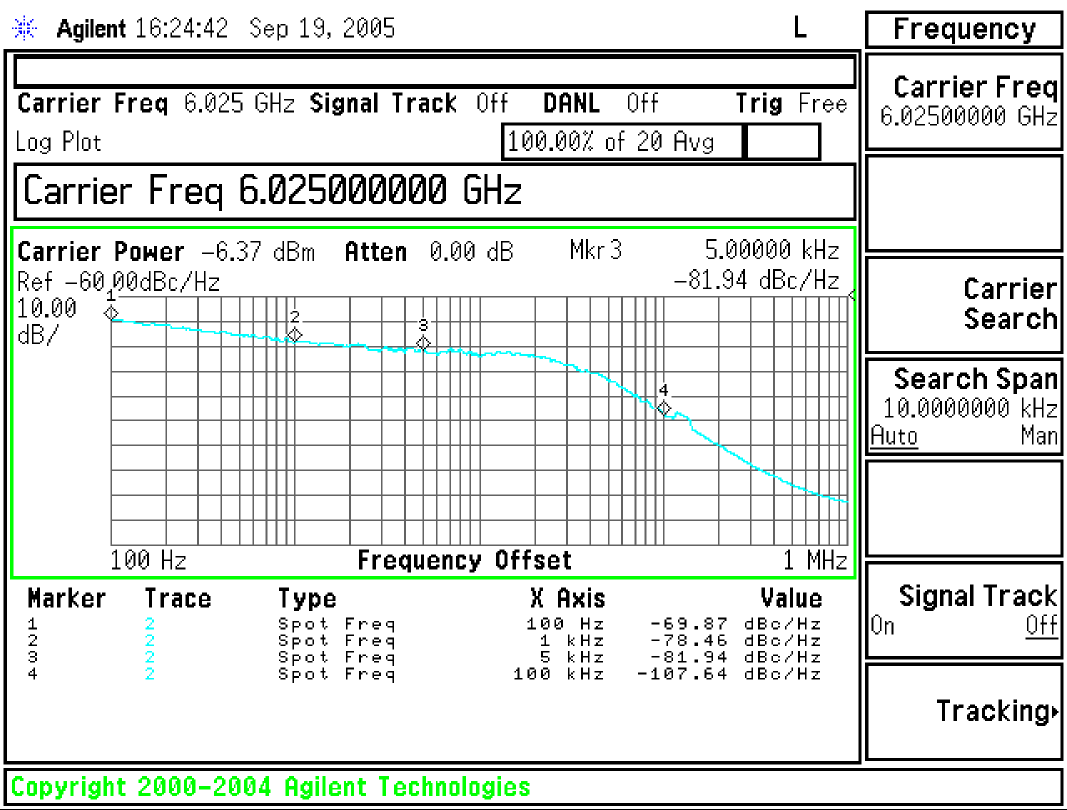


Settings for Operation	
Kϕ	3.5 mA
Comparison Frequency	200 kHz
Output Frequency	2100 - 2200 MHz
PLL Supply	3.3 Volts from regulator
VCO Supply	5.5 volts
Other Information	
VCO Used	VARIL 190-2200T
VCO Gain	80 MHz/Volt
VCO Input Capacitance	120 pF

RF PLL Phase Noise

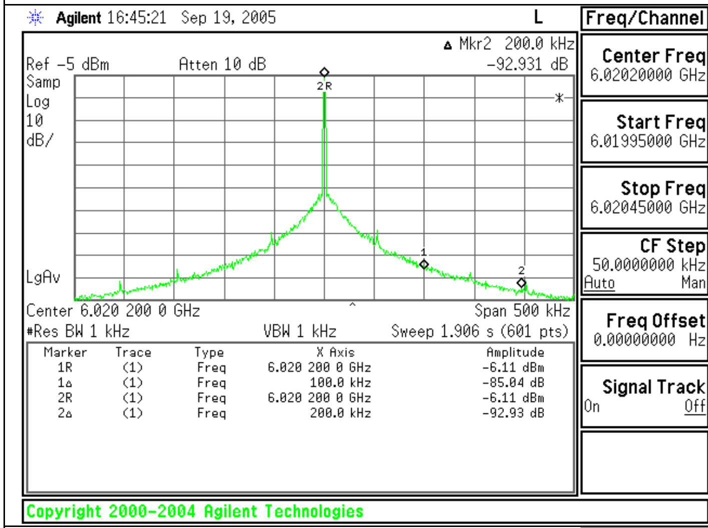


Loop Bandwidth is about 10 kHz. Note that the phase noise gradually improves as one goes farther from the carrier. This was taken with the IF PLL powered up and IF VCO connected.

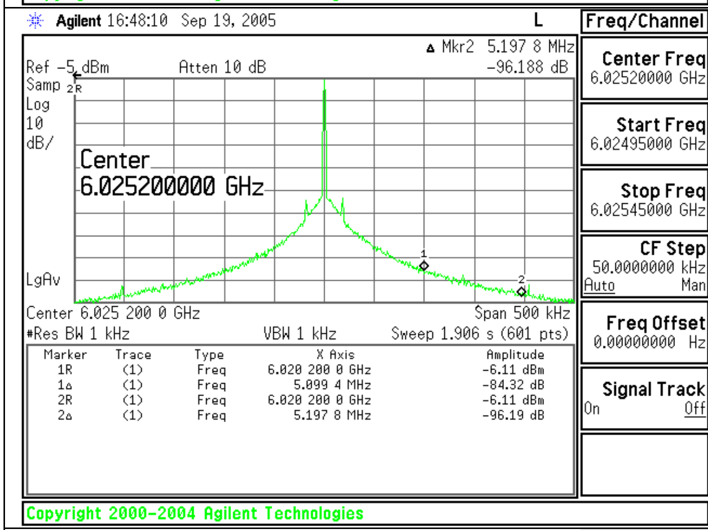


For this plot, the charge pump was increased to 16X and the other conditions were the same.

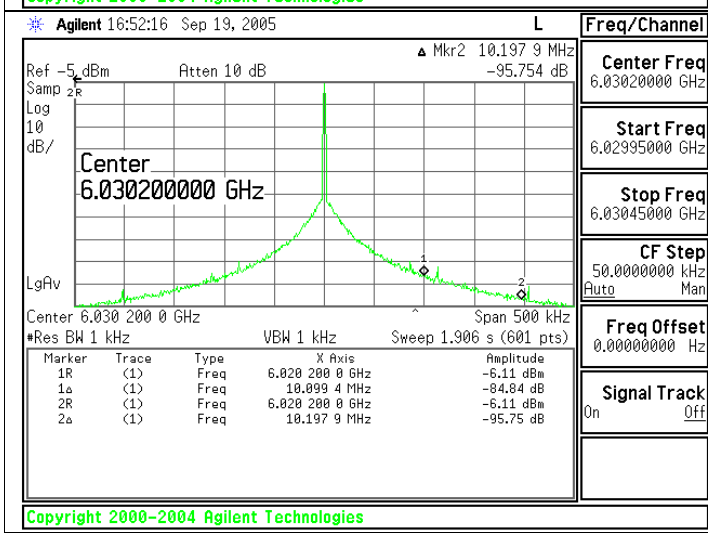
RF PLL Fractional Spurs



At 6020.2 MHz output frequency, the primary fractional spur at 200 kHz and the sub-fractional spur at 100 kHz are below the noise floor.

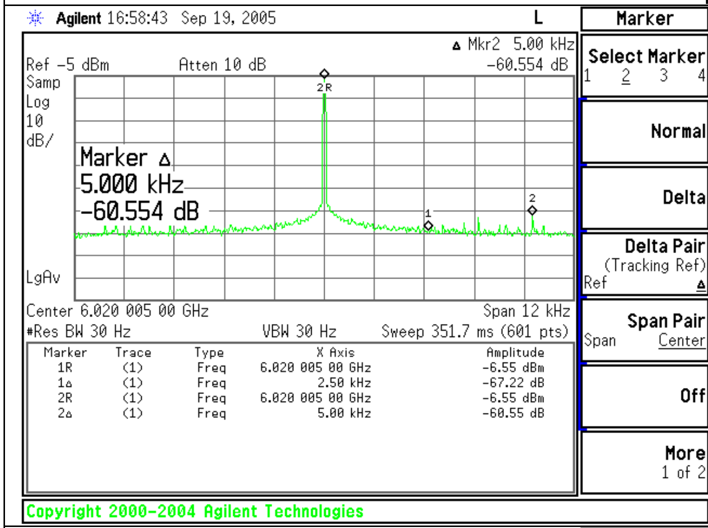


At 6025.2 MHz output frequency, the primary fractional spur at 200 kHz and the sub-fractional spur at 100 kHz are below the noise floor.

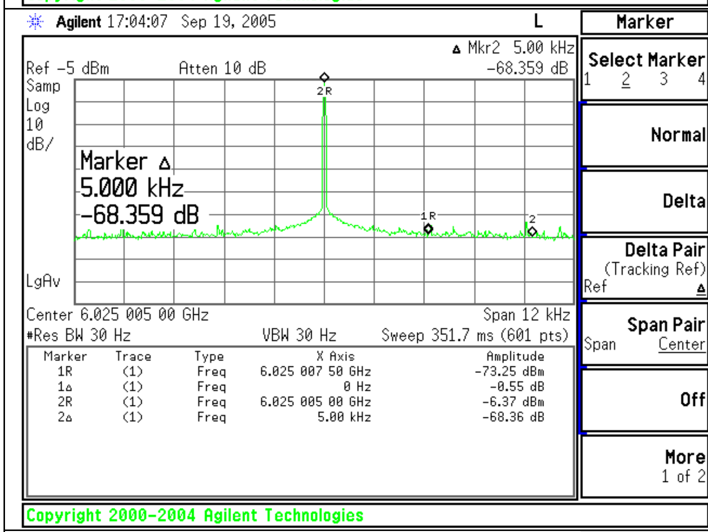


At 6030.2 MHz output frequency, the primary fractional spur at 200 kHz and the sub-fractional spur at 100 kHz are below the noise floor.

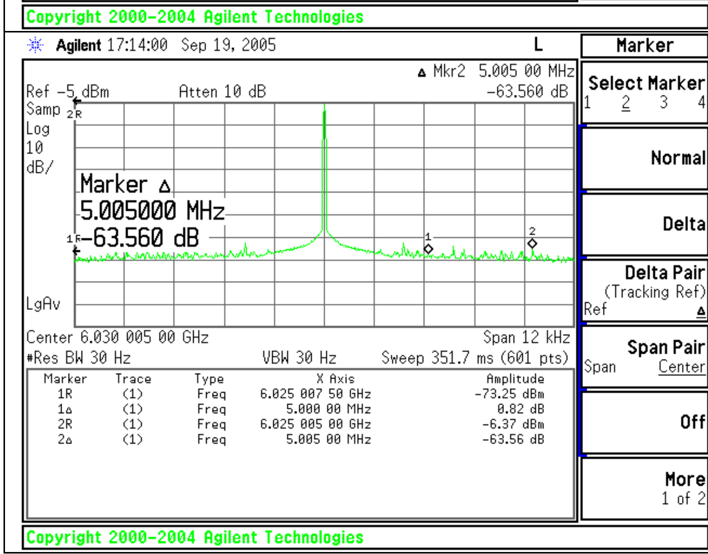
RF In-Band Spurs



At 6020.005 MHz output frequency the ½ sub-fractional spur is below the noise, and the first fractional spur is –60.6 dBc. For this measurement, the fraction was 25/1000000, which is theoretically the worst case for the 5 kHz spur.



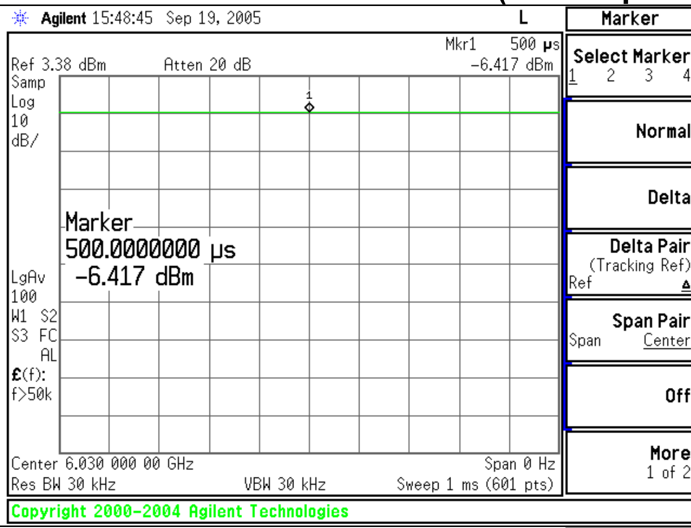
At 6025.005 MHz, both the ½ sub-fractional and the primary fractional spurs are below the noise floor.



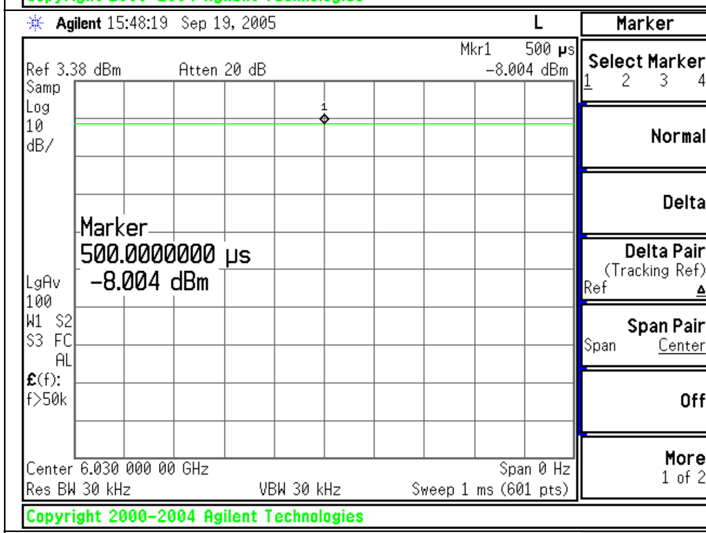
At 6030.005 MHz output frequency the ½ sub-fractional spur is below the noise, and the first fractional spur is –63.6 dBc. For this measurement, the fraction was 50025/1000000, which is theoretically the worst case for the 5 kHz spur.

RF PLL Lock Time (With a Specturm Analyzer)

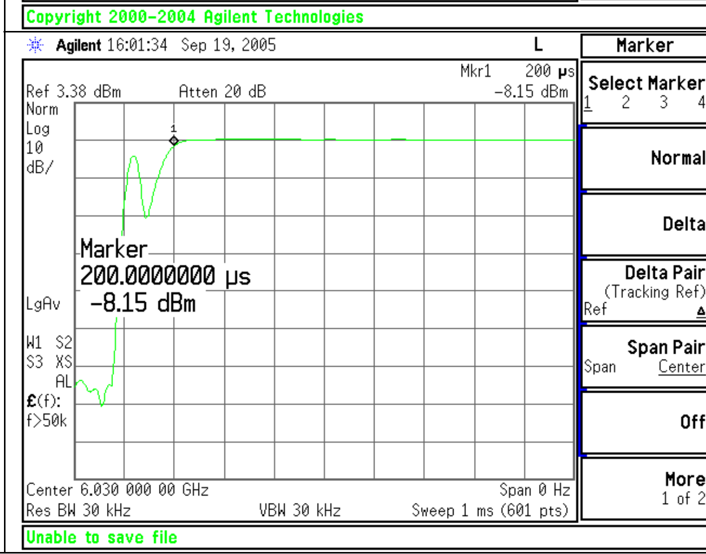
Cycle Slip Reduction Disabled. RF_TOC=000



The first step is to tune the PLL to the final frequency. On the spectrum analyzer, set span to 0 Hz and the frequency to the final frequency. Then set the resolution bandwidth. If it is too small, then it will make your lock time look longer. If it is too large, frequency resolution is lost. For this measurement, 30 kHz seems just about right. Now adjust the sweep time to match the time interval for the lock time measurement, 1 mS in this case. The power is –6.4 dBm

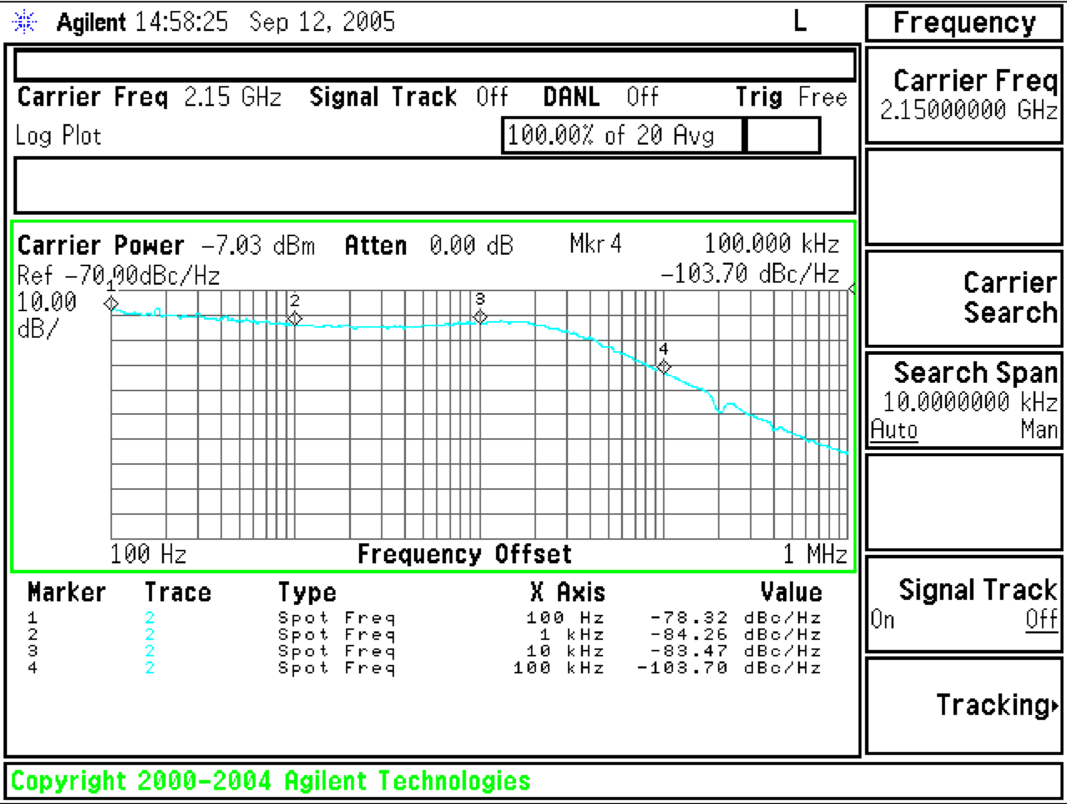


Now tune the PLL slightly off frequency. If the PLL is tuned 10 kHz off frequency, the output power drops to –8.0 dBm. So when the output power is –8.0 dBm or higher, we are theoretically within 10 kHz. If the PLL can not be tuned to fine enough resolution, the center frequency of the spectrum analyzer can also be offset.

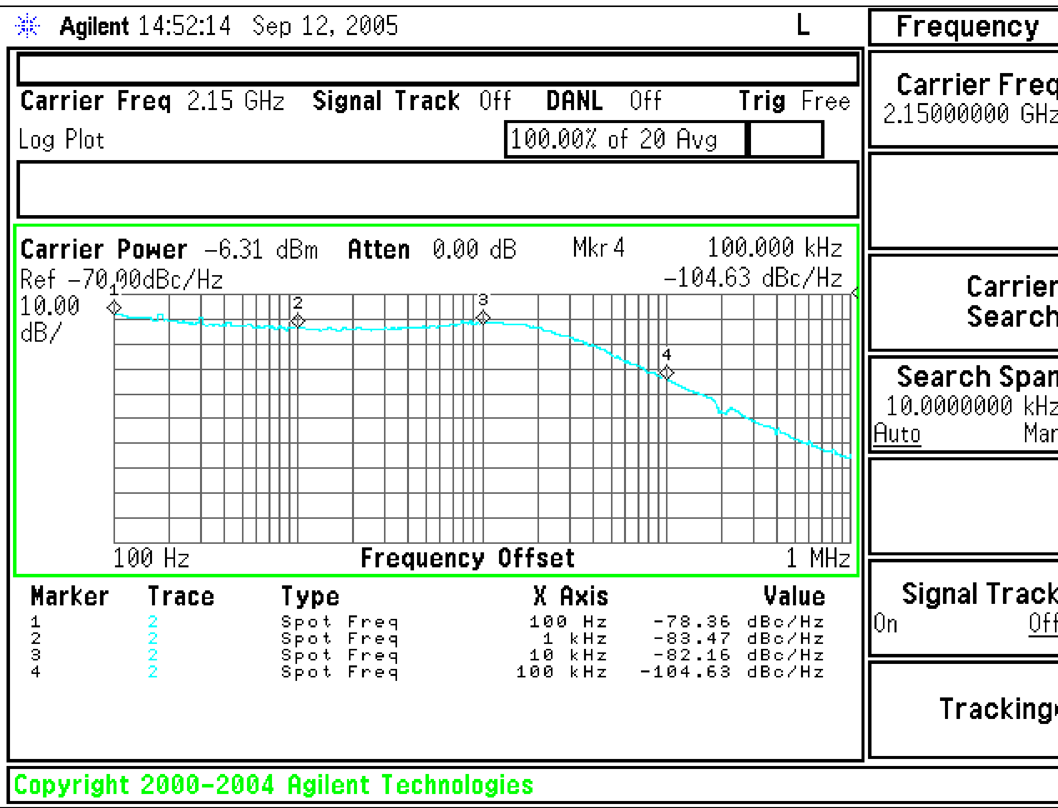


Using the external trigger to trigger off the LE pulse, we measure the time it takes to get and stay high enough in power to be about 200 uS to a 10 kHz tolerance.

IF PLL Phase Noise

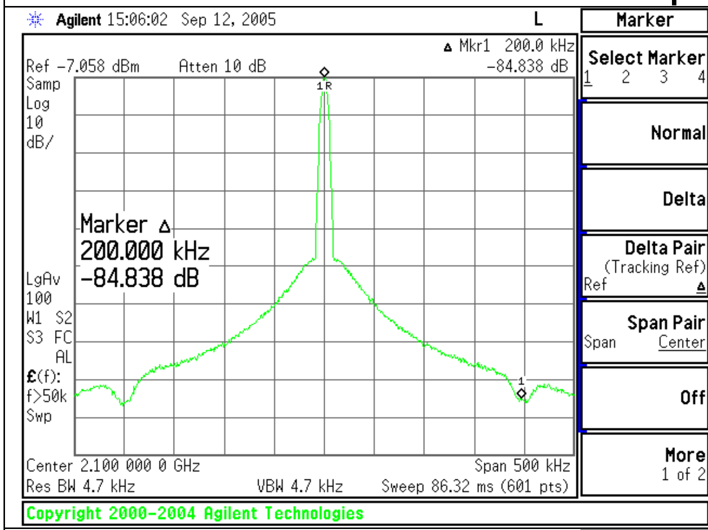


Above is the IF PLL phase noise with the RF PLL powered up.



The above plot was taken with the RF PLL powered down and IF VCO disconnected.

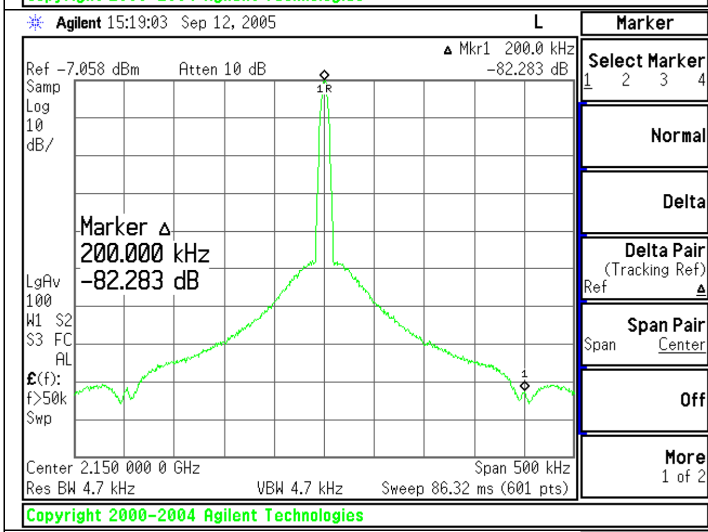
IF PLL Spurs



Fout = 2100 MHz

Not only are the spurs below the noise, but they are actually improving the phase noise near the offset of the spur!

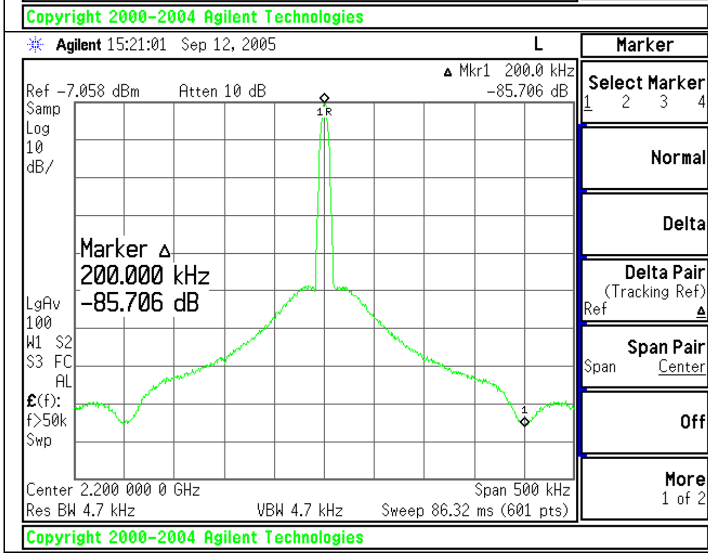
This cusping effect is due to discrete sampling effects of the phase detector/charge pump that occur if the loop bandwidth is wide relative to the comparison frequency.



Fout = 2150 MHz

Spurs at 200 kHz output frequency are

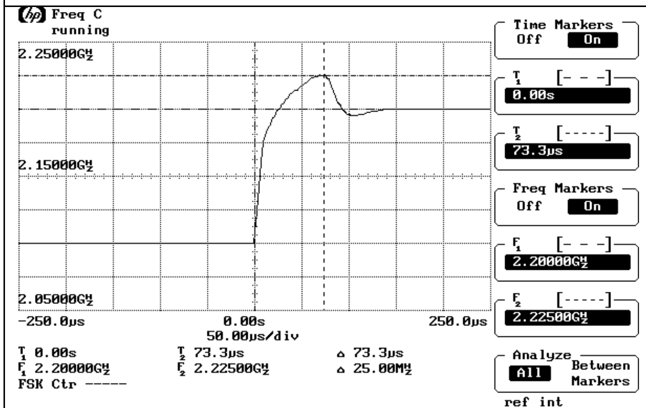
–82 dBc, although the noise is still being pulled down due to this cusping effect.



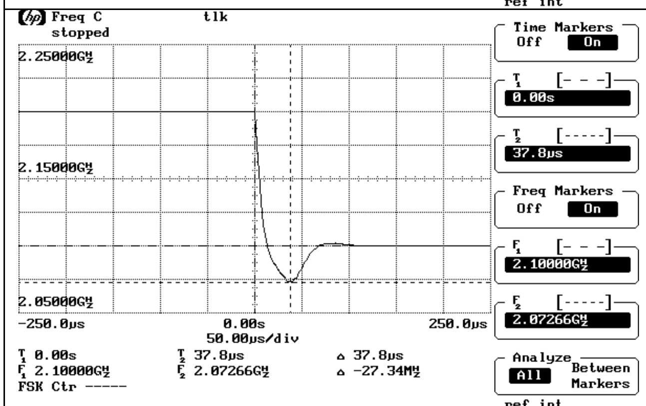
Fout = 2200 MHz

Spurs at 200 kHz are not there and actually reducing the noise due to discrete sampling effects.

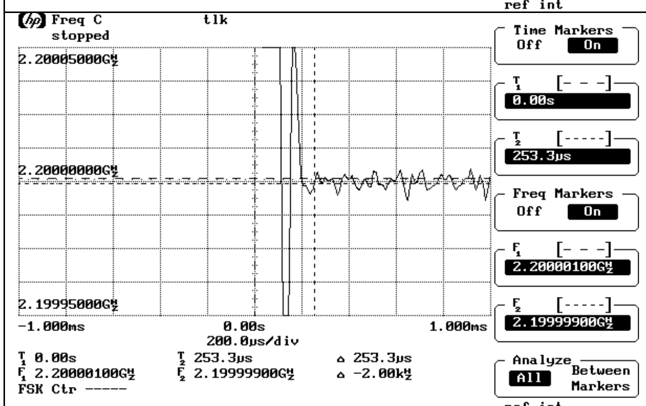
IF PLL Lock Time



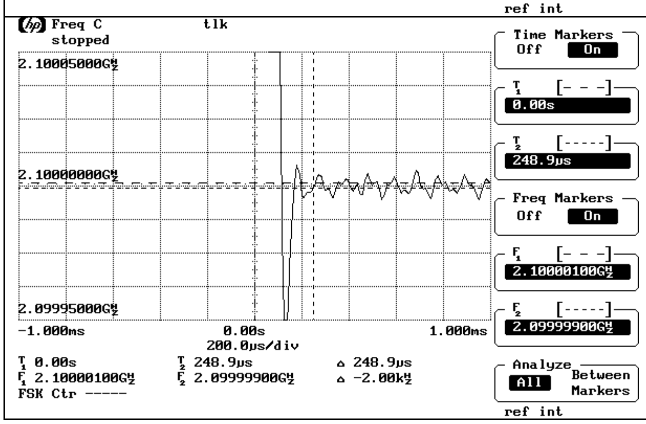
Peak time is 73.3 uS. This peak time is increased because the VCO tuning voltage is approaching the rail of the charge pump when the PLL overshoots.



Peak Time is 37.8 uS

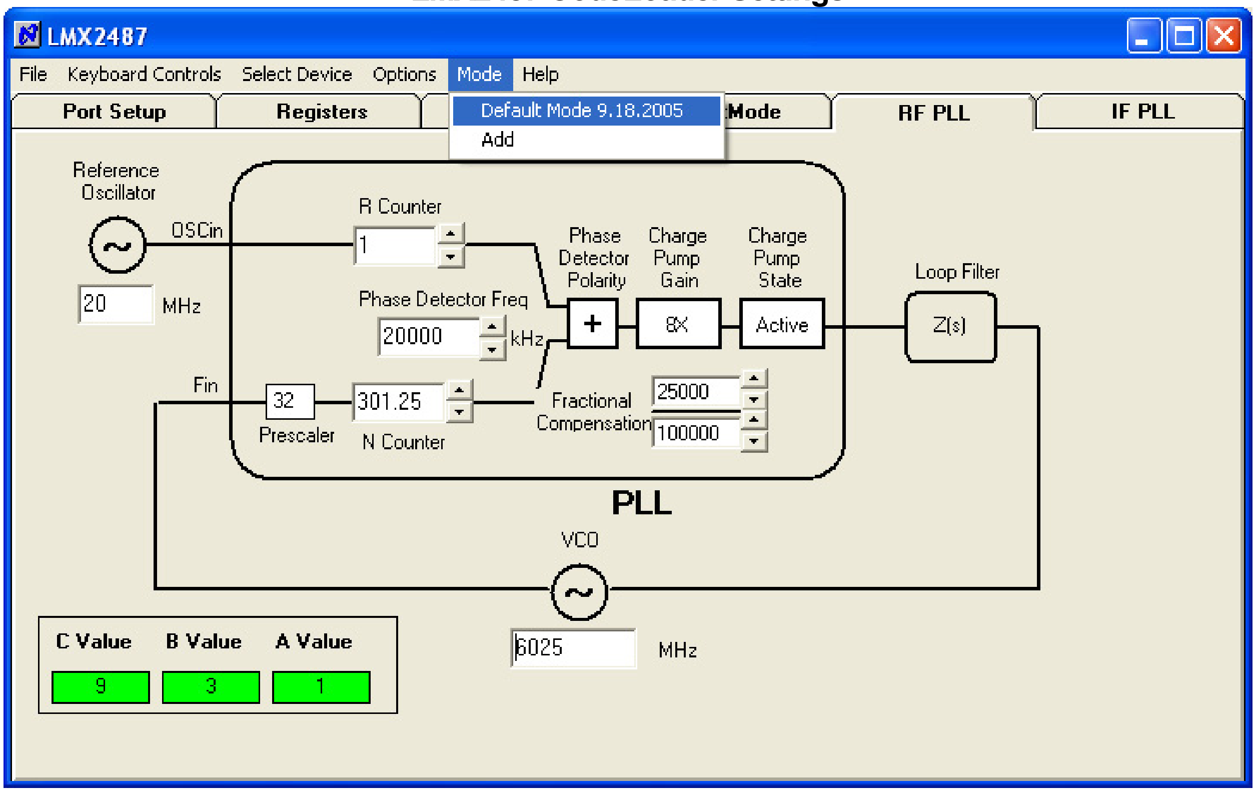


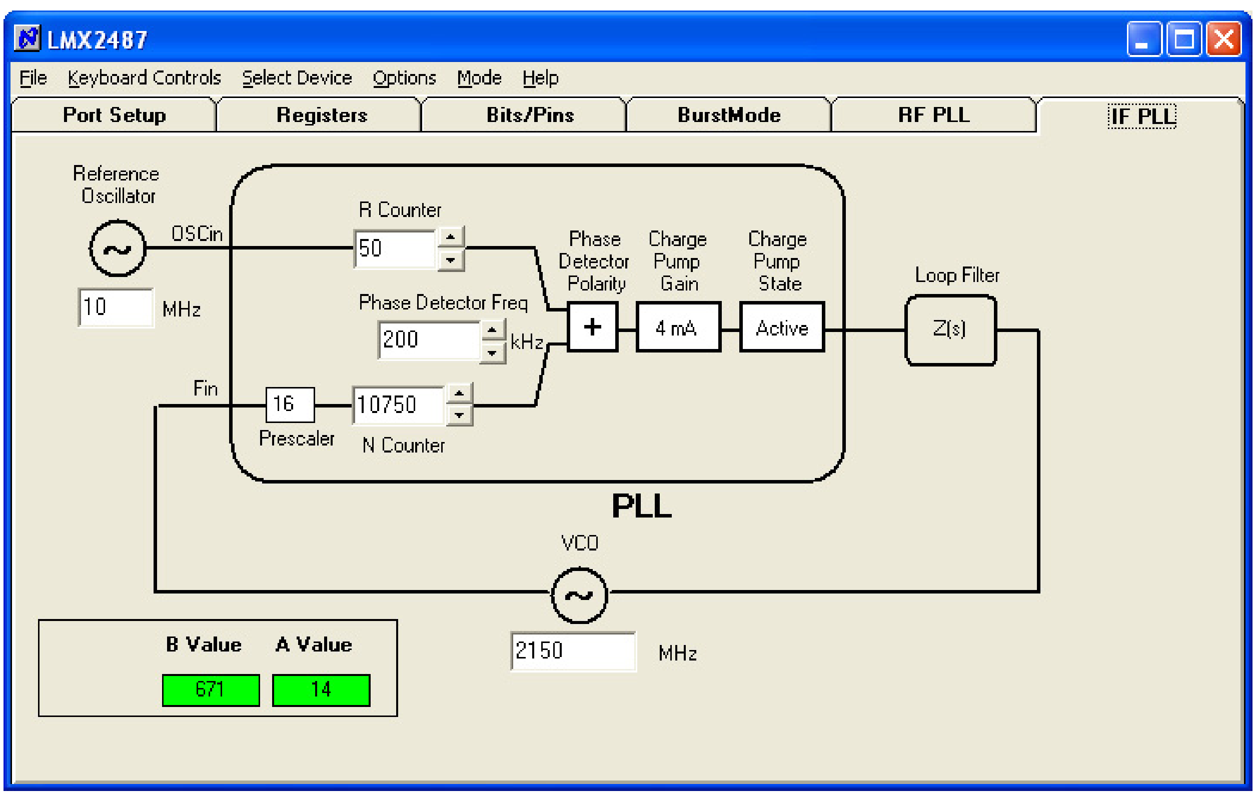
Positive Lock time is 253 uS

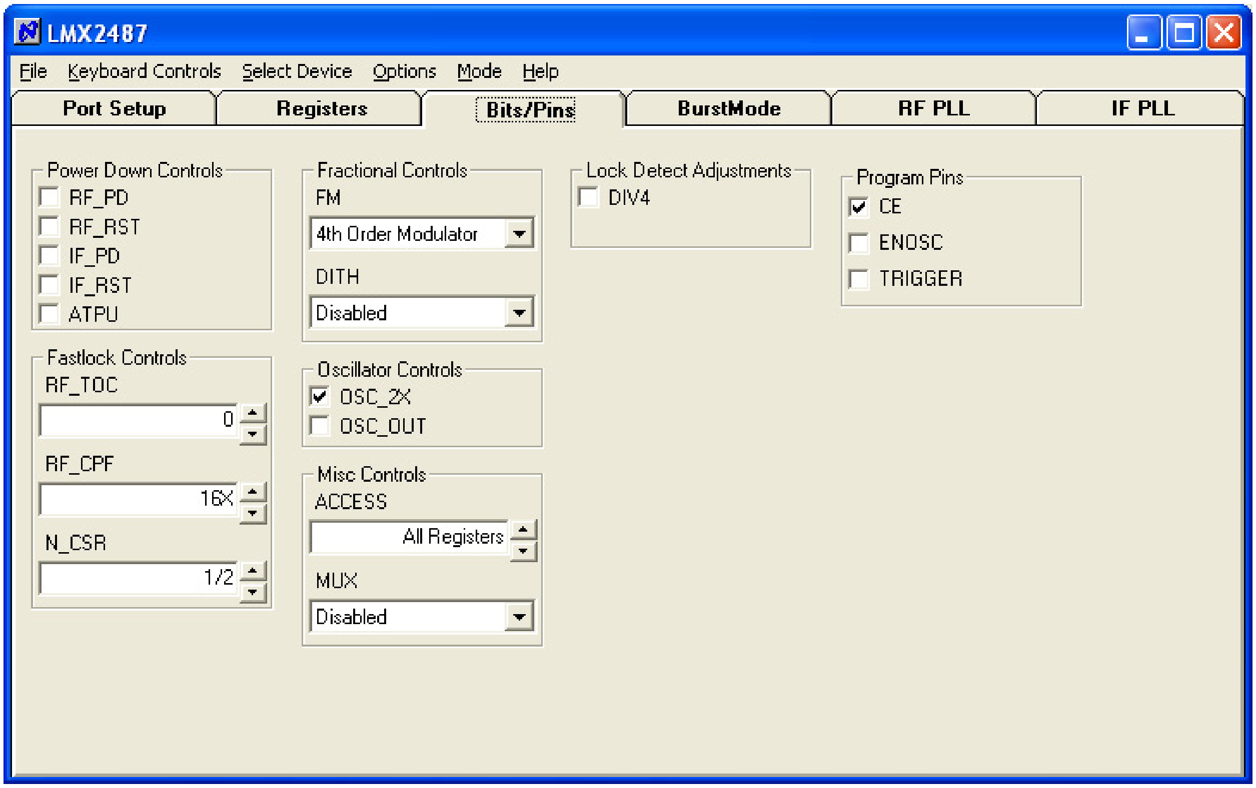


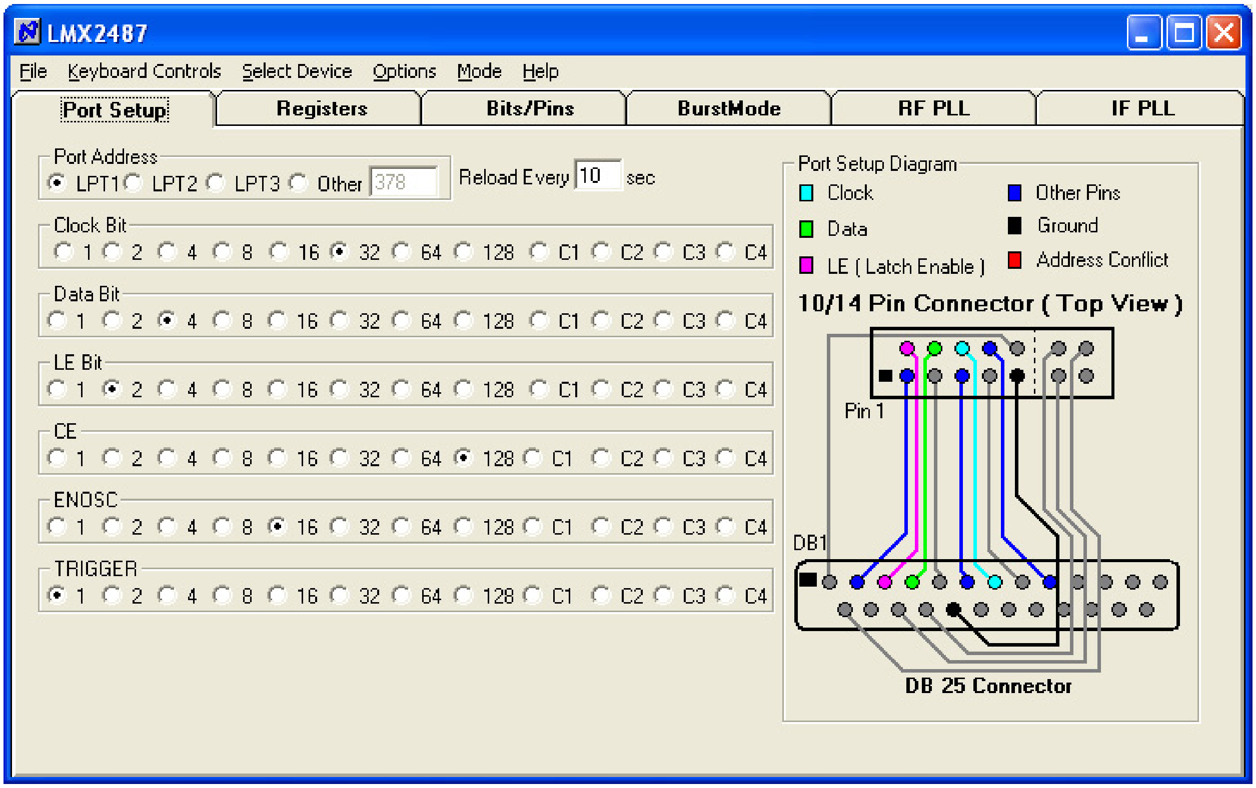
Negative Lock Time is 249 uS

LMX2487 CodeLoader Settings

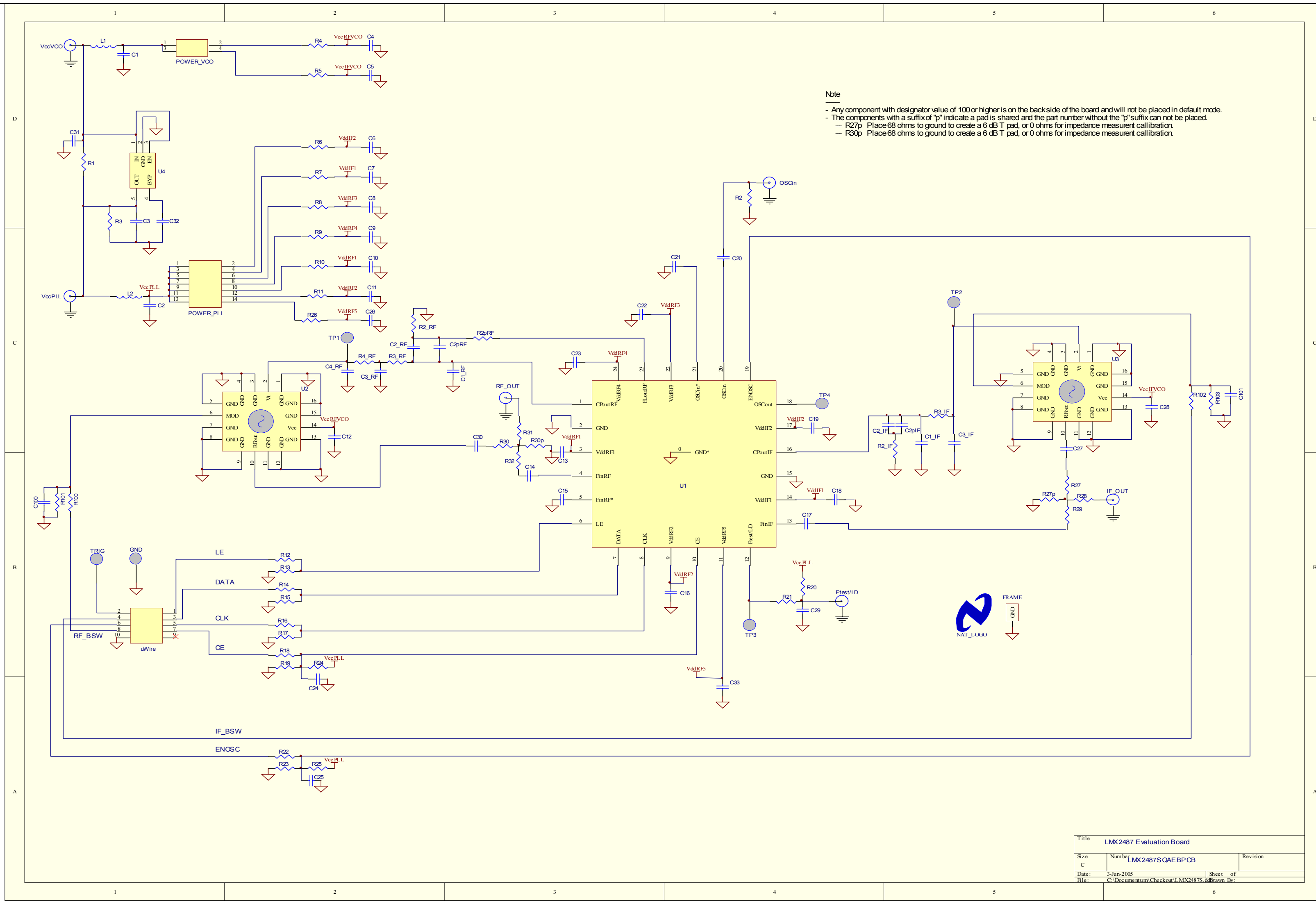




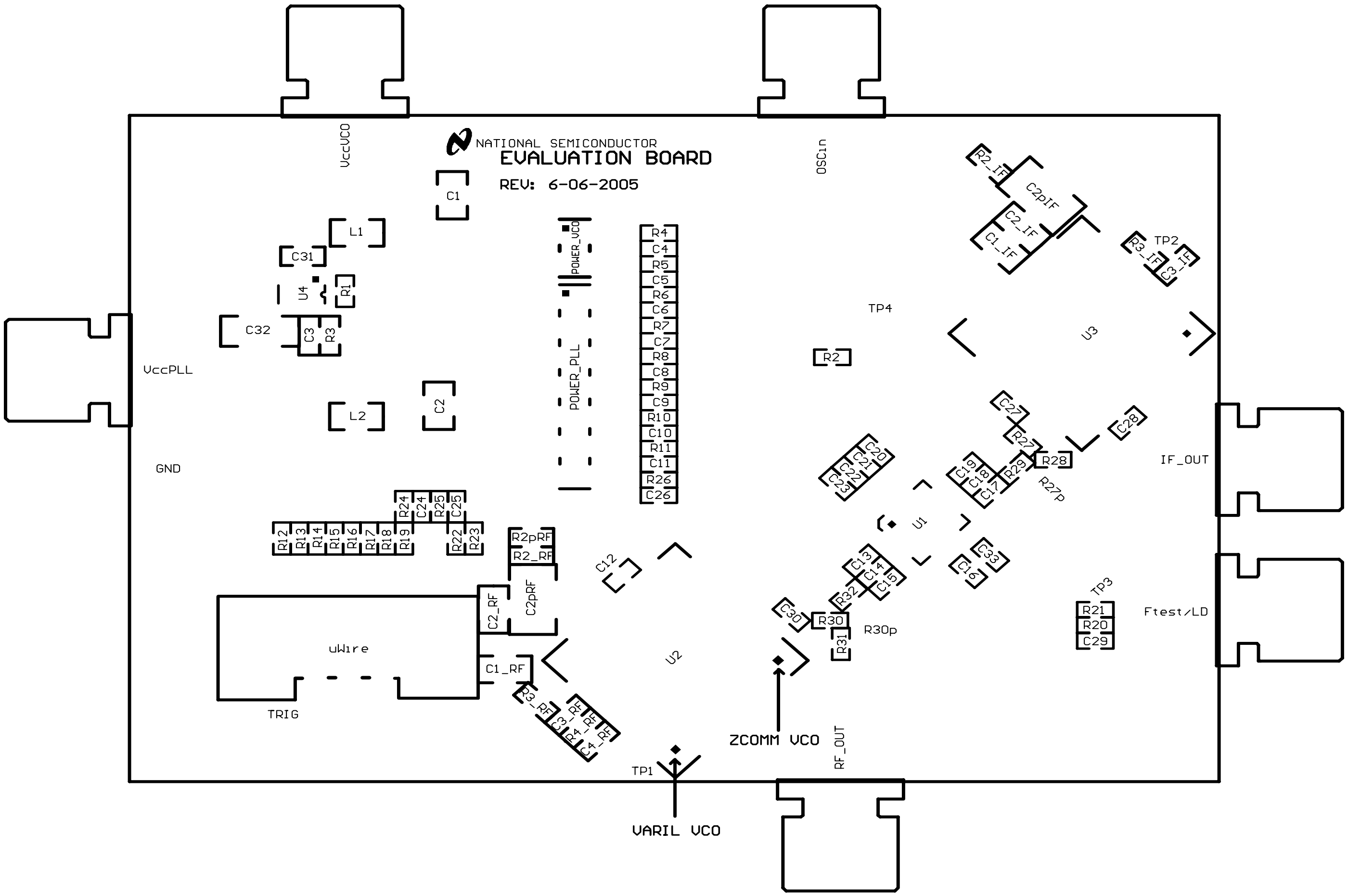

LMX2487
File Keyboard Controls Select Device Options Mode Help
Port Setup
Registers
Bits/Pins
BurstMode
RF PLL
IF PLL
Power Down Controls
RF_PD
RF_RST
IF_PD
IF_RST
ATPU
Fastlock Controls
RF_TOC
0
RF_CPF
16X
N_CSR
1/2
Fractional Controls
FM
4th Order Modulator
DITH
Disabled
Oscillator Controls
OSC_2X
OSC_OUT
Misc Controls
ACCESS
All Registers
MUX
Disabled
Lock Detect Adjustments
DIV4
Program Pins
CE
ENOSC
TRIGGER


LMX2487
File Keyboard Controls Select Device Options Mode Help
Port Setup
Registers
Bits/Pins
BurstMode
RF PLL
IF PLL
Port Address
LPT1 LPT2 LPT3 Other 378
Reload Every 10 sec
Clock Bit
1 2 4 8 16 32 64 128 C1 C2 C3 C4
Data Bit
1 2 4 8 16 32 64 128 C1 C2 C3 C4
LE Bit
1 2 4 8 16 32 64 128 C1 C2 C3 C4
CE
1 2 4 8 16 32 64 128 C1 C2 C3 C4
ENOSC
1 2 4 8 16 32 64 128 C1 C2 C3 C4
TRIGGER
1 2 4 8 16 32 64 128 C1 C2 C3 C4
Port Setup Diagram
Clock
Data
LE (Latch Enable)
Other Pins
Ground
Address Conflict
10/14 Pin Connector (Top View)
Pin 1
DB1
DB 25 Connector

Schematic


Note
- Any component with designator value of 100 or higher is on the backside of the board and will not be placed in default mode.
- The components with a suffix of "p" indicate a pad is shared and the part number without the "p" suffix can not be placed.
— R27p Place 68 ohms to ground to create a 6 dB T pad, or 0 ohms for impedance measurent callibration.
— R30p Place 68 ohms to ground to create a 6 dB T pad, or 0 ohms for impedance measurent callibration.
VccVCO
POWER_VCO
VccPLL
POWER_PLL
OSCin
RF_OUT
IF_OUT
TRIG
GND
LE
DATA
CLK
CE
RF_BSW
uWire
IF_BSW
ENOSC
Ftest/LD
NAT_LOGO
FRAME
U1
U2
U3
U4
Title LMX2487 Evaluation Board
Size C
Number LMX2487SQAEBPCB
Revision
Date: 3-Jun-2005
Sheet of
Drawn By:

Top Build Diagram



Bill of Materials

Revision	6/24/2005

Item	Qty	Manufacturer	Part Number	Value	Unit	Size	Voltage	Tolerance	Material	Designator
0	21	Open (No Component)								C2pRF, C2_IF, C3_IF, C29 C100, C101 R1, R2pRF, R3, R20, R21, R24, R25, R27p, R30p R100, R101, R102, R103,Ftest/LD,VccPLL
1	1	National Semiconductor	LMX2487SQAEBPCB	εr = 3.38		4 Layer board. Mid Layer 1 is 16 mils down. Total Thickness is 62 mils.			Rogers 4003	n/a
2	4	SPC Technology	SPCS-8	Stand-Offs					Nylon	Place in 4 holds in edge of board
3	9	Com Con Connectors	CTIJ-255G	2-Pin	Shunt				Plastic	Place accross POWER_PLL (1-2, 3-4, 5-6, 7-8, 9-10, 11-12, 13-14) and POWER_VCO (1-2, 3-4)
4	1	Com Con Connectors	HTSM3203-4G2	4-Pin	Header				Plastic	POWER_VCO
5	1	Com Con Connectors	HTSM3203-14G2	14-Pin	Header				Plastic	POWER_PLL
6	1	FCI Electronics	52601-S10-8	10-Pin	Header				Plastic	uWire
7	4	Johnson Components	142-0701-851	Edge SMA					Metal	IF_OUT, OSCin, RF_OUT, VccVCO
8	14	Kemet	C0603C470J5GAC	47	pF	603	50 V	5%	C0G	C12, C13, C14, C15, C16, C17, C18, C19, C22, C23, C27, C28, C30, C33
9	1	Kemet	C0603C101J5GAC	100	pF	603	50 V	5%	C0G	C4_RF
10	1	Kemet	C0603C221J5GAC	220	pF	603	50 V	5%	C0G	C3_RF
11	1	Kemet	C0603C681J3GAC	680	pF	603	25 V	5%	C0G	C1_IF
12	1	Kemet	C1206C472J5GAC	4.7	nF	1206	50 V	5%	C0G	C2pIF
13	1	Kemet	C0805C222J3GAC	2.2	nF	805	25 V	5%	C0G	C1_RF
14	1	Kemet	C1206C103J3GAC	10	nF	1206	25 V	5%	C0G	C32
15	2	Kemet	C0603C104K3RAC	100	nF	603	25 V	10%	X5R	C20, C21
16	1	Panasonic	ECHU1C393JX5	39	nF	805	16 V	5%	Film	C2_RF
17	13	Kemet	C0603C105K3PAC	1	uF	603	25 V	10%	X5R	C3, C4, C5, C6, C7, C8, C9, C10, C11, C24, C25, C26, C31
18	2	Kemet	C0805C106K8PAC	10	uF	805	10 V	10%	X5R	C1, C2
19	1	Vishay	CRCW0603000ZRT1	0	ohm	0603	10 V	5%	Cermaic	R3_IF
20	9	Vishay	CRCW0603100JRT1	10	ohm	0603	10 V	5%	Cermaic	R4, R5, R6, R7, R8, R9, R10, R11, R26
21	8	Vishay	CRCW0603180JRT1	18	ohm	0603	10 V	5%	Cermaic	R27, R28, R29, R30, R31, R32, L1, L2
22	1	Vishay	CRCW0603510FRT1	51	ohm	0603	10 V	1%	Cermaic	R2
23	1	Vishay	CRCW0603122JRT1	1.2	Kohm	0603	10 V	5%	Cermaic	R2_RF
24	2	Vishay	CRCW0603472JRT1	4.7	Kohm	0603	10 V	5%	Cermaic	R2_IF, R3_RF
25	6	Vishay	CRCW0603103JRT1	10	Kohm	0603	10 V	5%	Cermaic	R4_RF, R12, R14, R16, R18, R22
26	5	Vishay	CRCW0603123JRT1	12	Kohm	0603	10 V	5%	Cermaic	R13, R15, R17, R19, R23
27	1	National Semiconductor	LMX2487SQ	PLL	n/a	24P	3.6	n/a	Silicon	U1
28	1	ZCOMM	CRO6030A	6020-6040	MHz	T	5 V		Can	U2
29	1	VARIL	VCO190-2200T	2100-2200	MHz	T	5 V		Can	U3
30	1	National Semiconductor	LP3985IM5X-3.3	3.3	V	SOT23	3.3V		Silicon	U4

Appendix A: Additional Features of the LMX2487 Evaluation Board

HYBRID VCO FOOTPRINT

Although the evaluation board is created to support a particular VCO, the footprint is flexible and designed such that other VCOs are easy to put on the board. To mount a smaller VCO on the board, scratch off the soder mask with the flat edge of a screwdriver and then put solder on the pads such that it covers the exposed copper.

TEST POINTS

Test Point	Function
TP1	RF Charge Pump voltage
TP2	RF Fastlock output
TP3	Ftest/LD output
TP4	OSCout pin
TP5	IF Charge Pump Output
TRIG	Microwire trigger

BANDSWITCH VCO SUPPORT

The board is also configured so that CodeLoader can control a bandswitch VCO for either the RF or IF PLL. In order to do this, one can use the trigger pin. Don't forget to stuff the components on the bottom layer from this.

COMPONENT OPTIONS

Some components have a 'p' suffix to denote it as an option. These usually have shared footprints and can not both be stuffed. Below is a list of these options.

Component	Option
C2_RF & C2pRF	These components both add in parallel. There are 2 footprints here to allow for different sizes of capacitors
C2_IF & C2pIF	These components both add in parallel. There are 2 footprints here to allow for different sizes of capacitors
R2_RF & R2pRF	During fastlock, the chip switches R2pRF in parallel with R2_RF
R26 & R26p	For normal operation, R26p should be open. However, for sensitivity measurements, 68 Ω may be placed in R26p and R26 can be removed in order to form a 6 dB T-Pad.
R27 & R27p	For normal operation, R27p should be open. However, for sensitivity measurements, 68 Ω may be placed in R27p and R27 can be removed in order to form a 6 dB T-Pad.

Appendix B: Modifying the LMX2487 Board for Higher Frequency Operation

Due to the limited selection of high frequency VCOs, with a standardized foot print, we will be using the LMX2487EVAL evaluation board along with a user provided VCO as a vehicle for evaluating the extended version LMX2487E.

There are two approaches that can be used to demonstrate the performance of the LMX2487E. If the substitute VCO is one that has a footprint that is the same or pin out compatible, the best approach would be to remove the VCO from the existing LMX2487 evaluation board and replace it with the substitute VCO. If the substitute VCO's foot print or pin out is not compatible, it can be configured externally. Another consideration to be addressed is with the 6.0 GHz LMX2487 device supplied with the evaluation board. The LMX2487 is used as the base part for both the LMX2487 and LMX2487E through frequency selection testing. The LMX2487 will function out to 8 GHz under bench conditions but is only guaranteed for production use at 6.0 GHz for the LMX2487 and 7.5 GHz for the LMX2487E.

User Supplied VCO

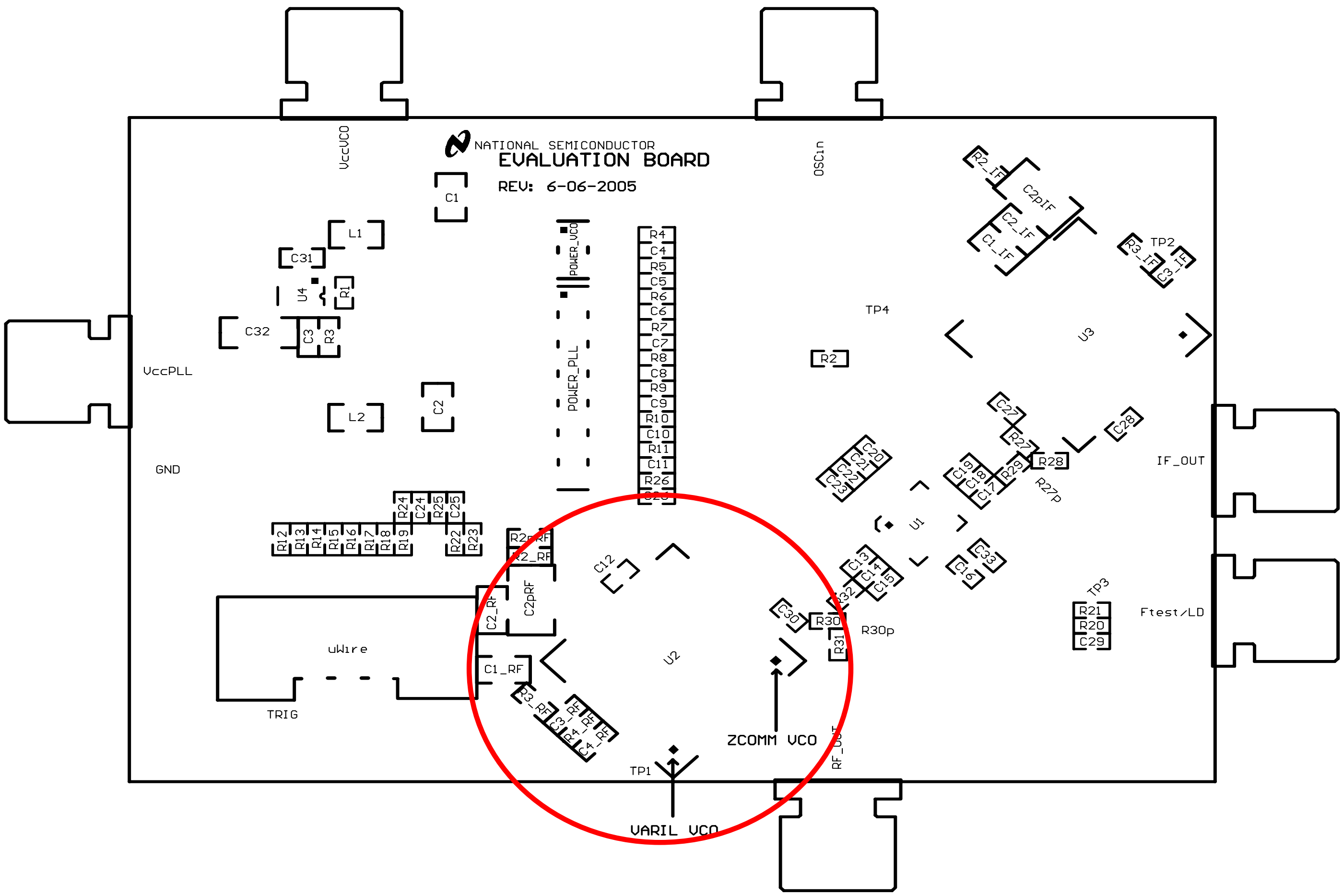
Many high frequency VCOs require higher tuning voltages. For VCOs that specify a higher tuning voltage than the LMX2487E can supply, there are two options. One is to use an active filter that would provide the specified tuning voltage. Another solution is to use a traditional passive filter with the understanding that the upper frequency range of the VCO will be less, since the highest tuning voltage can not be achieved. A small selection of VCOs are listed in the table below.

Manufacturer	Part No.	Freq. Range (MHz)	Tuning Voltage
Universal Microwave	UMT-1051-I12	7150 - 7550	0.5 – 6.0
Universal Microwave	UMT-1050-I12	6800 - 6800	0.5 – 4.5
Spectrum Microwave	HVA103SM-22	6800 - 8000	0 - 20
Hittite	HMC532LP4	7100 - 7900	1 -13

Replacing the VCO with a Footprint Compatible VCO

In order to replace the VCO, take component U2 and replace it with the desired VCO. The VCO must be of the VARIL-T style footprint, which is used by manufactures like Sirenza (VARIL), Minicircuits, Universal Microwave, and ZCOMM. However, it is suggested that before the LMX2487 board is modified, the bench setup should be verified using the non-modified evaluation board.

Note: For the ZCOMM style VCO, the dot is typically the output frequency. For the Varil/Sirenza style VCO, the dot is typically the tuning voltage.



Using an External VCO Board

If the VCO to be used is an external VCO evaluation board, the LMX2487 evaluation board should be modified. To configure the board, proceed using the following steps:

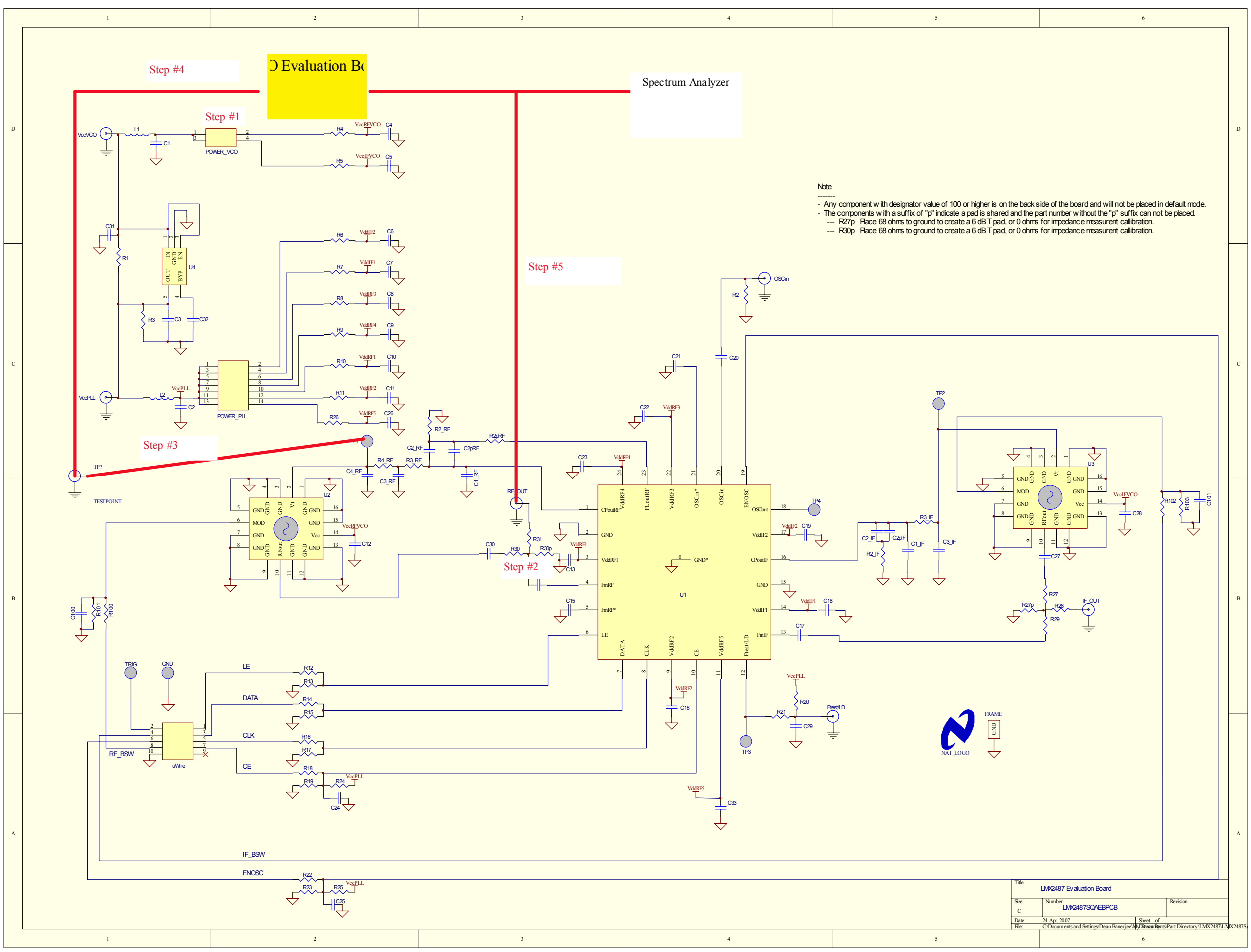
Step #1: Remove the jumper for the RF VCO Power supply.

Step #2: Remove R33 and place 68 ohms for R33p. This forms a 6 dB pad.

Step #3: Mount an edge mount SMA connector on the side of the board and connect it using TP1.

Step #4: Connect this tuning voltage with an SMA cable to the tuning voltage input to the VCO board. Be careful about using clip leads, because they can introduce large amounts of noise.

Step #5: Connect the output of the VCO board to a splitter. One side goes to the spectrum analyzer, the other side goes to the RFout connector.



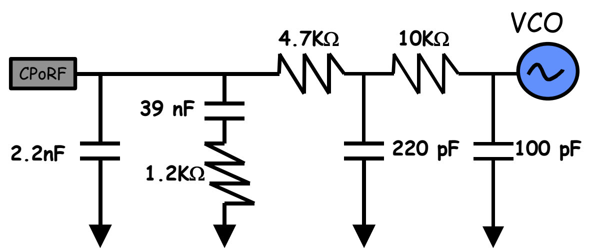
LMX2487E Performance Demonstration from 7.2 to 8 GHz

Introduction

For this experiment, an LMX2487E board was used with a Hittite HMC506LP4 evaluation board ordered from the internet. Note that the VCO tuning voltage was connected with an SMA cable, the VCO was connected to the input of the PLL board with an SMA barrel connector, and a semi-rigid cable was used to view the output. In other words, the layout was far from optimized, but the PLL had no problems locking.

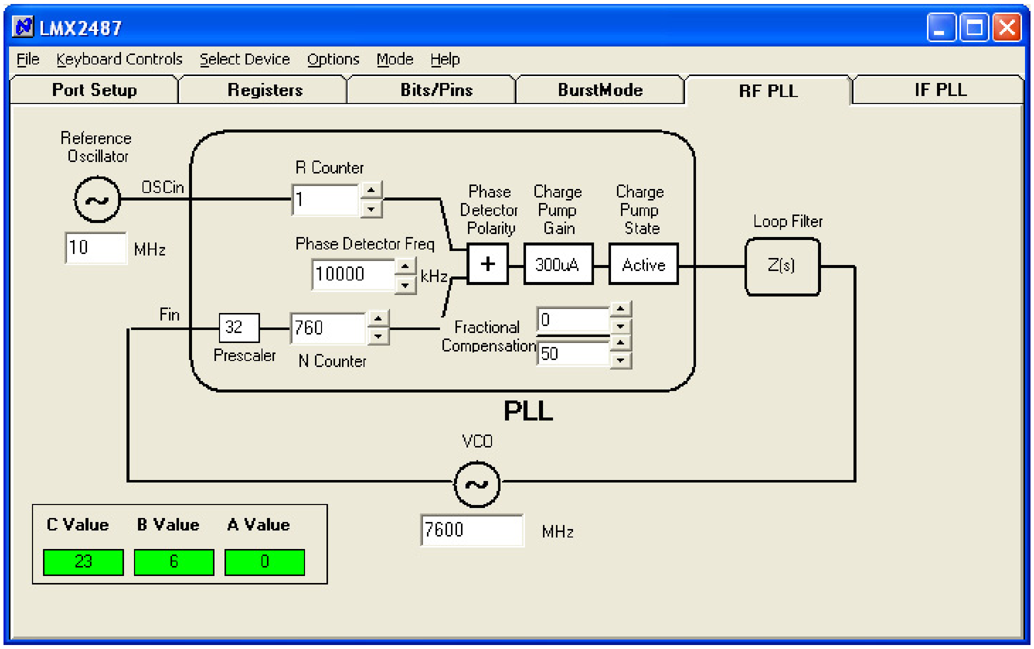
The VCO upper tuning range was limited by the maximum output voltage of the charge pump. Usable tuning range was about 7.2 – 8.0 GHz.

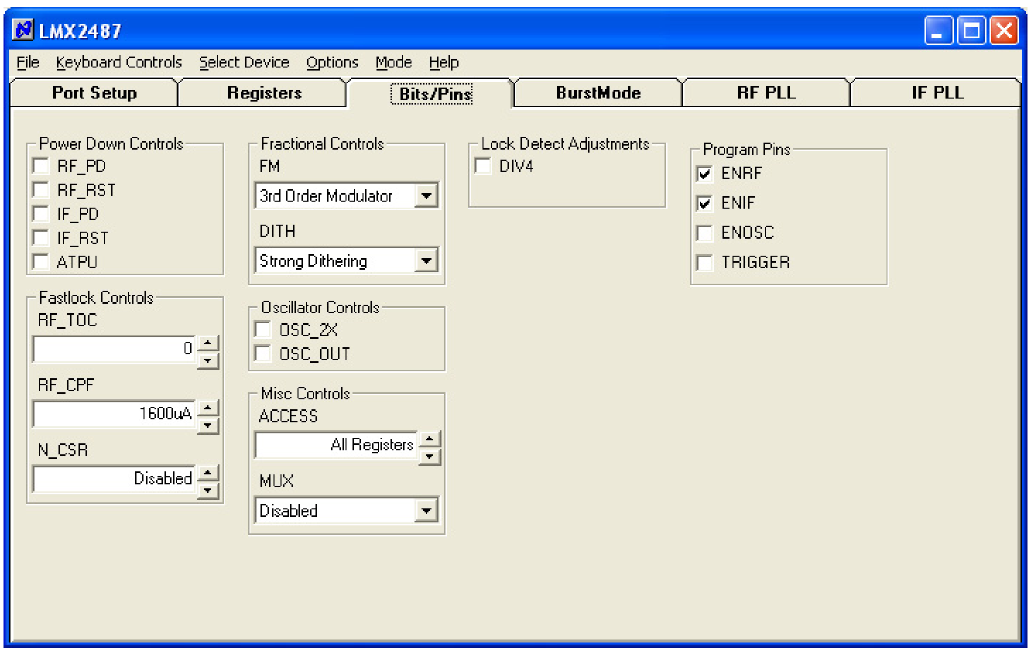
RF LOOP FILTER



Settings for Operation	
Kϕ	300 uA
Comparison Frequency	10 MHz
Output Frequency	6350 - 6420
PLL Supply	By LDO
VCO Supply	5.5 Volts
Other Information	
VCO Used	HMC506LP4
VCO Sensitivity	~200 MHz/V

High Frequency Setup



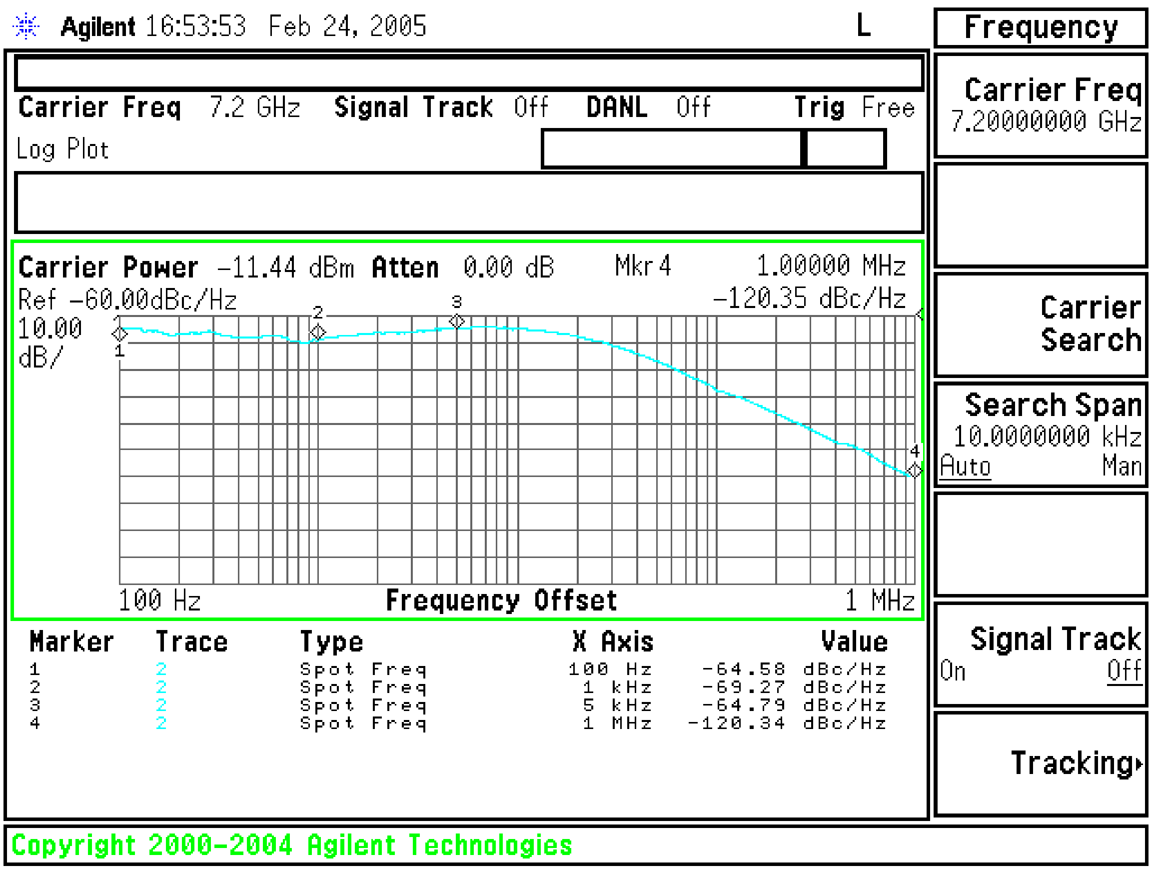


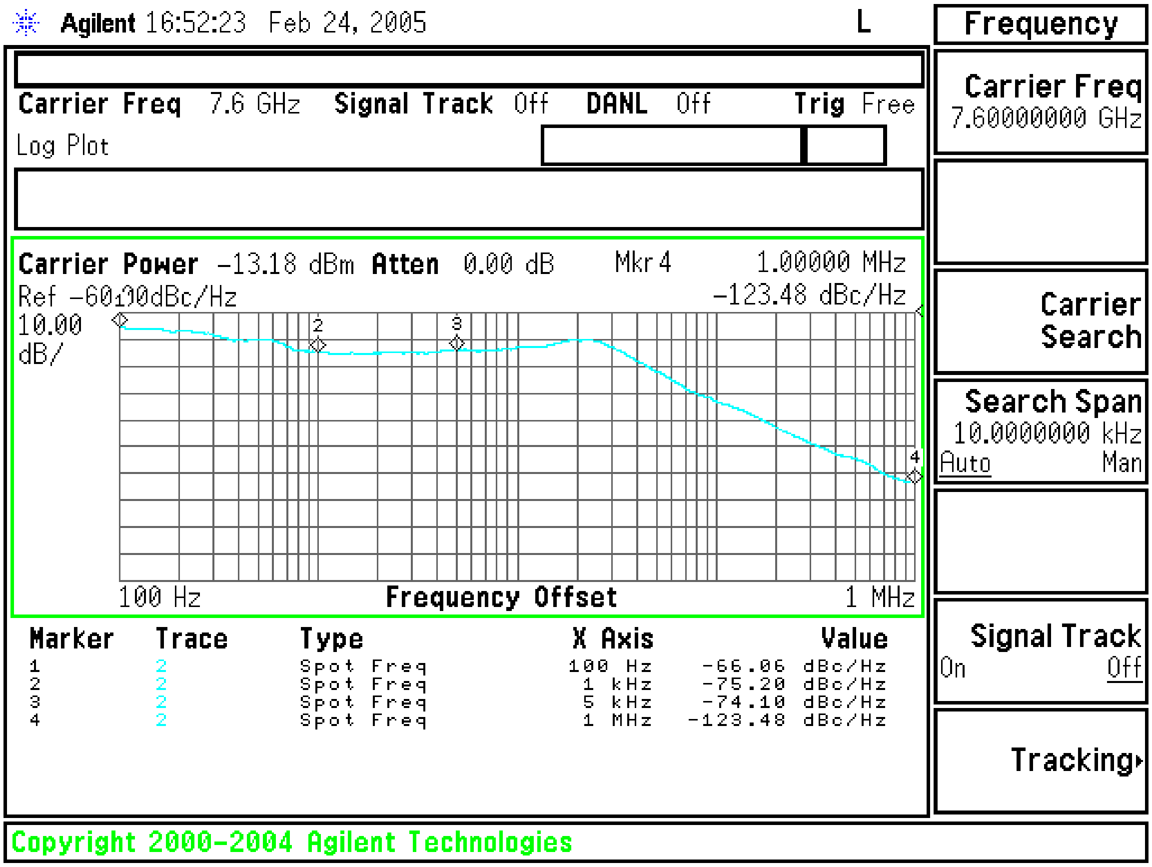
High Frequency Spur Performance

Spurs were measured with a fraction of 1/50, which is the worst case for the 200 kHz spur. The results are as follows:

Frequency MHz	Offset kHz	Spur Level dBc
7200.2	200	-80.9
7400.2	200	-79.7
7600.2	200	-83.3
7800.2	200	-91.7
8000.2	200	-95.9

High Frequency Phase Noise Performance

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L
Frequency
Carrier Freq 7.6 GHz Signal Track Off DANL Off Trig Free
Log Plot
Carrier Power -13.18 dBm Atten 0.00 dB Mkr 4 1.00000 MHz
Ref -60.00dBc/Hz -123.48 dBc/Hz
10.00
dB/
100 Hz Frequency Offset 1 MHz
Marker Trace Type X Axis Value
1 2 Spot Freq 100 Hz -66.06 dBc/Hz
2 2 Spot Freq 1 kHz -75.20 dBc/Hz
3 2 Spot Freq 5 kHz -74.10 dBc/Hz
4 2 Spot Freq 1 MHz -123.48 dBc/Hz
Carrier Freq
7.60000000 GHz
Carrier
Search
Search Span
10.0000000 kHz
Auto Man
Signal Track
On Off
Tracking
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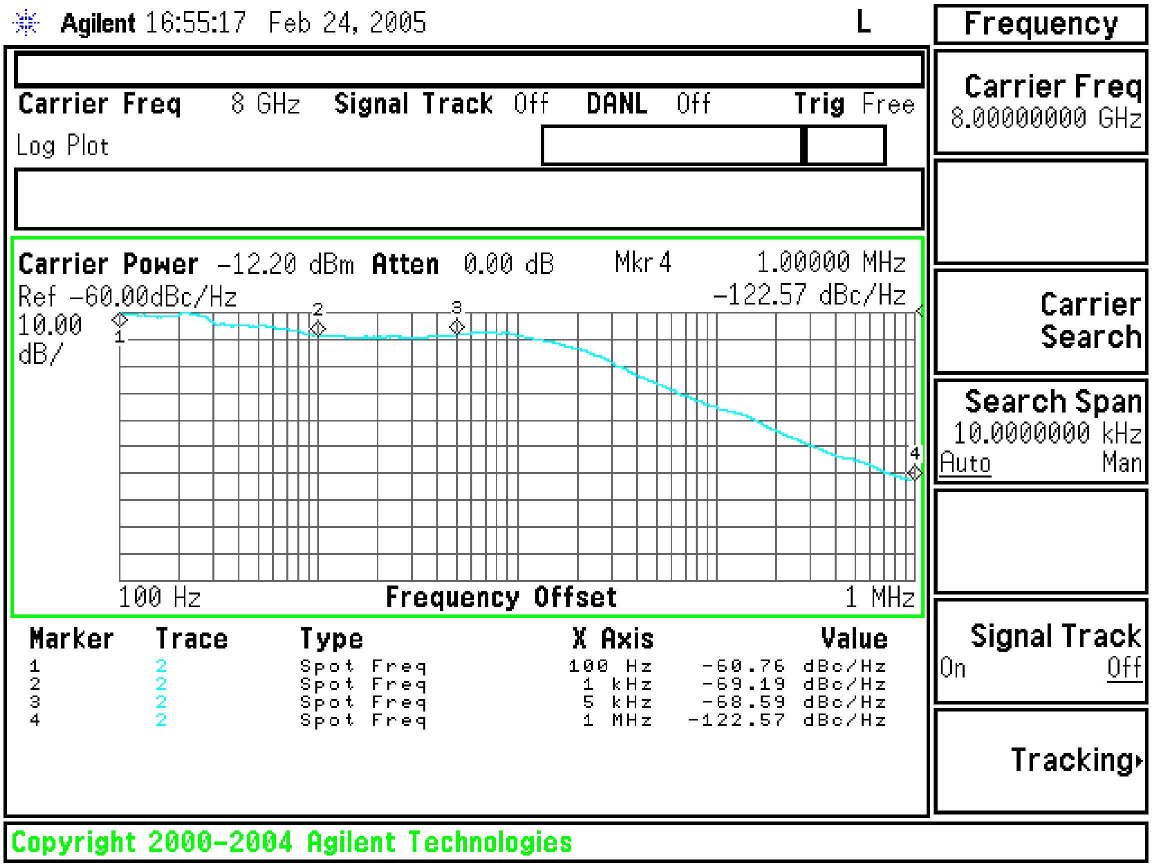
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Frequency
Carrier Freq 8 GHz Signal Track Off DANL Off Trig Free
Log Plot
Carrier Freq
8.00000000 GHz
Carrier Power -12.20 dBm Atten 0.00 dB Mkr4 1.00000 MHz
Ref -60.00dBc/Hz -122.57 dBc/Hz
10.00
dB/
Carrier Search
Search Span
10.0000000 kHz
Auto Man
100 Hz Frequency Offset 1 MHz
Marker Trace Type X Axis Value
1 2 Spot Freq 100 Hz -60.76 dBc/Hz
2 2 Spot Freq 1 kHz -69.19 dBc/Hz
3 2 Spot Freq 5 kHz -68.59 dBc/Hz
4 2 Spot Freq 1 MHz -122.57 dBc/Hz
Signal Track
On Off
Tracking
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