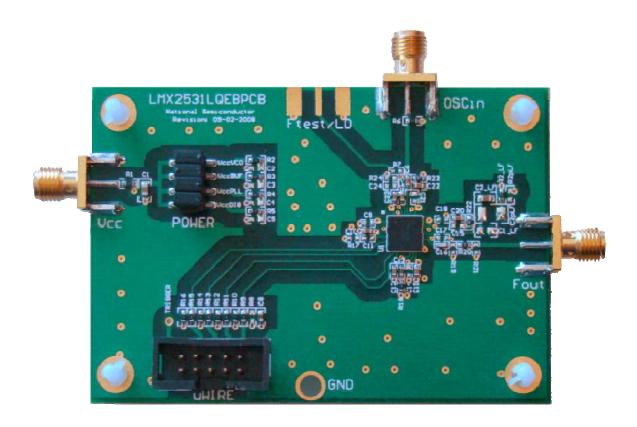


LMX2531LQ3010E

Evaluation Board Operating Instructions



National Semiconductor Corporation Timing Devices Business Group

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LMX25313010EVAL Instructions Rev 6.24.2009



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Loop Filter

| | 1 | • | | |
|-------------------|---|------------------|--|--|
| Loop Bandwidth | 13.8 kHz | Kφ | 1440 uA (16X) | |
| Phase Margin | 54.5 ° | F _{PD} | 10 MHz | |
| Crystal Frequency | 10 MHz | Output Frequency | 2910 to 3132 MHz (DIV2=0) 1455 to 1566 MHz (DIV2=1) | |
| Supply Voltage | 3.0 Volts | VCO Gain | 13 to 29 MHz/Volt | |
| T wado | Chont Arms 1000 | 20 KΩ 20 KΩ | VCO T 100 pF | |

Quick Setup

- Install the CodeLoader software which is available at www.national.com/timing/software/.
- Attach the parallel cable or USB <--> uWire cable to the computer and the evaluation board.
- Connect 3.0 volts to the *Vcc* connector.
- Connect the *Fout* connector to a spectrum analyzer or phase noise analyzer.
- Connect a clean 10 MHz source to the *OSCin* pin. Typically, the 10 MHz output from the back of the RF test equipment is a good source. Signal generators tend to be very noisy and should be used with caution. If a signal generator is used, the signal generator phase noise contribution can be reduced by setting the signal to 80 MHz and dividing this down to a phase detector frequency of 10 MHz.
- Set up the CodeLoader software.
 - Select the proper part from the menu as Select Part->PLL+VCO->LMX2531LQ3010E
 - Select the proper mode from the Mode menu.
 - Load the part by pressing Ctrl+L or selecting Keyboard Controls->Load Device from the menu.
- It is recommended to ensure proper communication with the device.
 - Click the REG_RST bit on the bits/pins page and observe the current go to 0 mA.
 - Unclick the REG_RST bit AND press Ctrl+L. The current should be approximately 35 mA.
 - o If device does not respond to this, consult the troubleshooting section.



Troubleshooting

Software does not communicate with the evaluation boards LPT or USB Mode

- Ensure a valid signal is presented to the **OSCin** connector. If a signal generator is used, ensure the RF is ON.
- Consult the CodeLoader instructions for more detailed information on communication issues.

LPT Mode (Uses Parallel Port Cable)

- Ensure that CodeLoader is selected to LPT mode on the Port Setup tab
- Ensure the proper port number is selected (LPT1, LPT2, LPT3). CodeLoader does NOT automatically detect this.
- Ensure the LPT cable is securely connected to the computer and board.
- Exit and Restart CodeLoader.
- Ensure the parallel port is in the correct mode.
 - Windows often requires Administrative access to write to the parallel port.
 - Ensure that the parallel port is set to "Enabled" in windows device manager.
 - A reboot upon installation of CodeLoader is sometimes necessary to get the parallel port to work.
 - Standard mode is the most reliable. This can be set in the BIOS mode of the computer as "Normal", "Output Only", or "AT."

USB Mode (Uses USB <--> uWire Interface Board, NSID = USB2UWIRE)

- On the menu, select LPT/USB->Version to verify communication with the board.
- Ensure the Green LEDs are lit on the USB board.
- Ensure there are no conflicts with other USB devices and reinstall the board.

Part responds to programming, but does not lock to the correct frequency

- Ensure that there is a valid signal presented to the **OSCin** connector. If a signal generator is used, ensure that the RF is set to ON.
- If using the lower frequency band (DIV2=1), the VCO frequency in CodeLoader should be twice the frequency at the Fout pin.
- Ensure that the VCO FREQUENCY CAL bits on the Bits/Pins tab are correct.
- Ensure that the loop filter is optimized if the charge pump current, phase detector frequency, or loop filter values have been changed from their original settings. Ensure that the integrated loop filter components on CodeLoader are set to their proper settings.

Close-in phase noise is worse than evaluation board instructions show

- Ensure the signal presented to OSCin connector is clean. Try another source, or if it is a signal generator, try using a higher frequency and dividing it down to the phase detector frequency.
- Ensure the OSCin signal after the connecting cable provides sufficient power level.
- If the phase detector frequency or charge pump current are lowered from their original settings, the in-band phase noise can be degraded, even if the loop filter is re-designed for the same loop bandwidth.
- If the loop bandwidth is decreased, in-band phase noise can be degraded



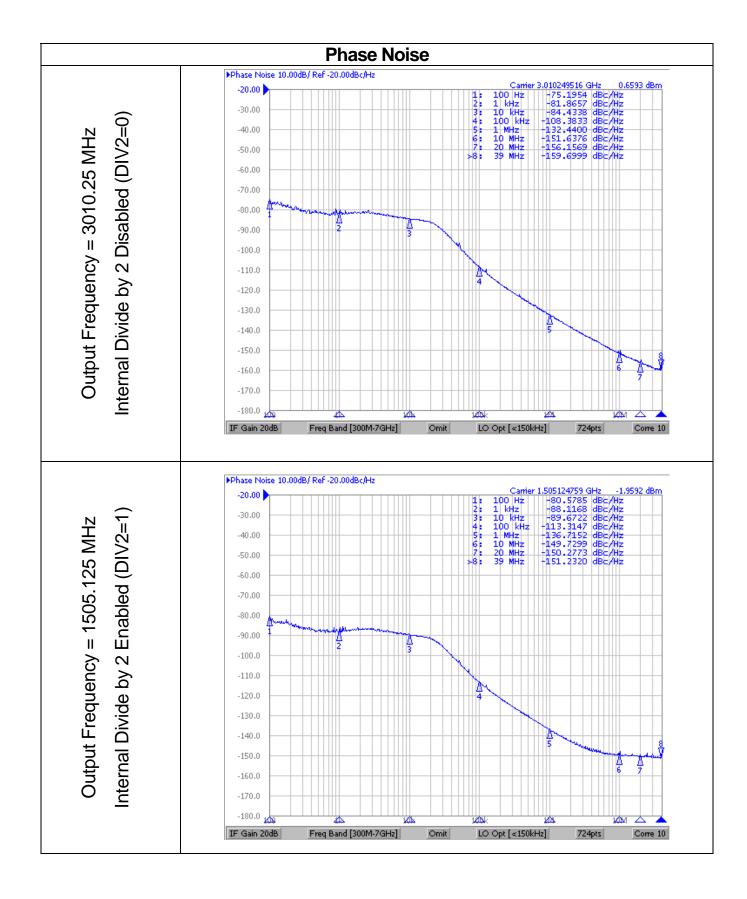
Far-out Phase noise is worse than evaluation board instructions show

- Ensure the measurement equipment noise floor is not limiting the measurement. For spectrum analyzers, the noise floor at a particular setting can be measured by removing the RF input signal
- If the settings are changed from what the board was designed for, ensure the delta-sigma modulator is not increasing the far-out noise. To determine this, tune to an integer channel and set the ORDER bit to "Reset Modulator". The far out phase noise should not decrease. If it does, try a loop filter with more attenuation or select a lower order delta-sigma modulator.

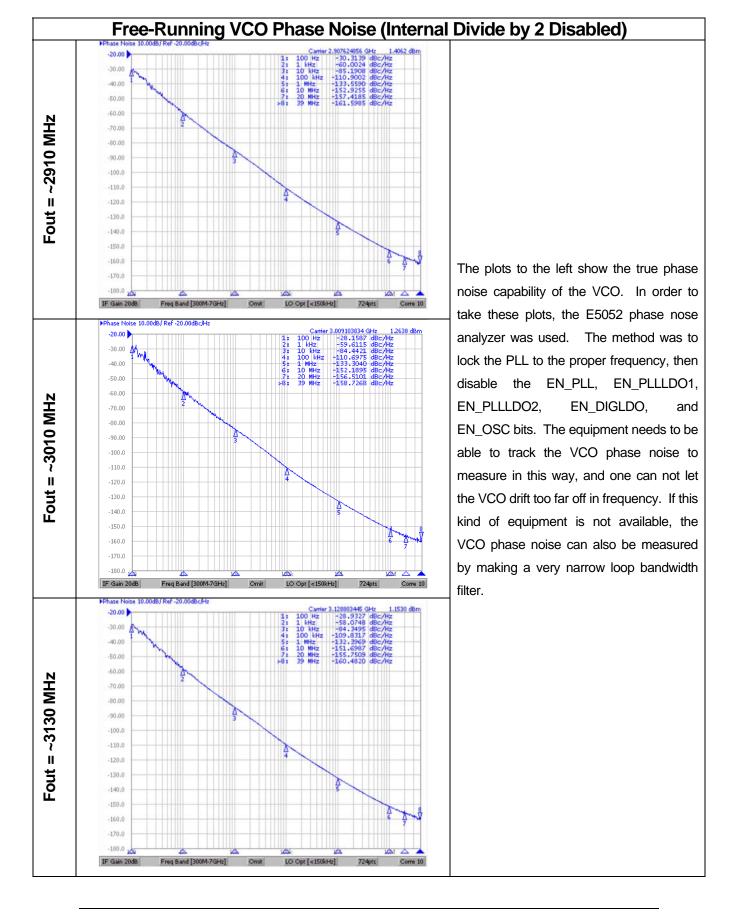
Device Data

The next few pages show data collected from the LMX2531LQ3010 evaluation board.

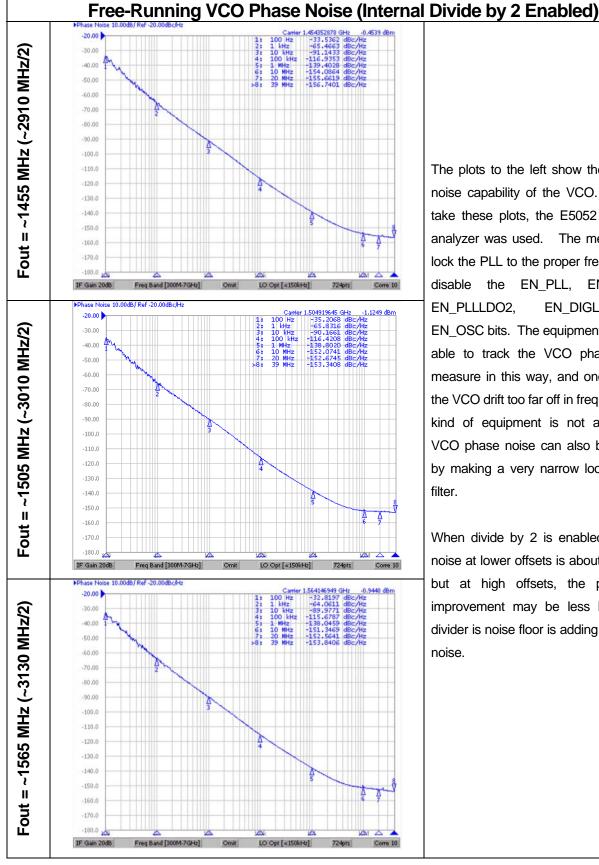










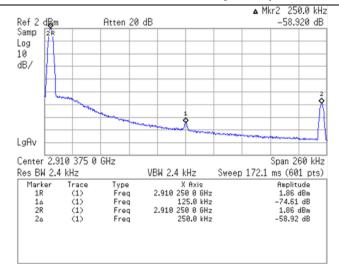


The plots to the left show the true phase noise capability of the VCO. In order to take these plots, the E5052 phase nose analyzer was used. The method was to lock the PLL to the proper frequency, then the EN_PLL, EN_PLLLDO1, disable EN PLLLDO2, EN DIGLDO, and EN OSC bits. The equipment needs to be able to track the VCO phase noise to measure in this way, and one can not let the VCO drift too far off in frequency. If this kind of equipment is not available, the VCO phase noise can also be measured by making a very narrow loop bandwidth filter.

When divide by 2 is enabled, the phase noise at lower offsets is about 6 dB better; but at high offsets, the phase noise improvement may be less because the divider is noise floor is adding to the phase noise.

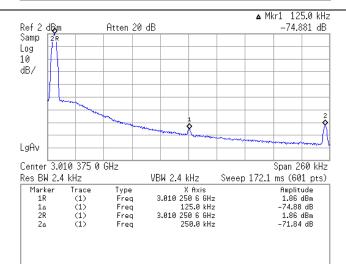


Fractional Spurs (Internal Divide by 2 Disabled)



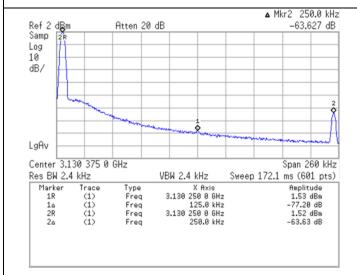
The -58.9 dBc fractional spur at 250 kHz offset is at a worst case frequency of 2910.25 MHz. The -74.6 dBc sub-fractional spur at 125 kHz offset is also visible.

Worst case channels occur at exactly one channel spacing above or below a multiple of the crystal frequency.



The -71.8 dBc fractional spur at 250 kHz offset is at a worst case frequency of 3010.25 MHz. The -74.9 dBc sub-fractional spur at 125 kHz offset is also visible.

Worst case channels occur at exactly one channel spacing above or below a multiple of the crystal frequency.

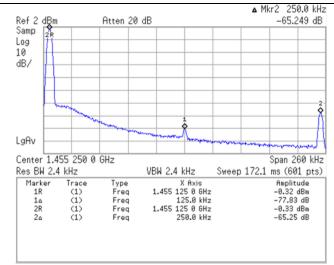


The -63.6 dBc fractional spur at 250 kHz offset is at a worst case frequency of 3130.25 MHz. The -77.2 dBc sub-fractional spur at 125 kHz offset is also visible.

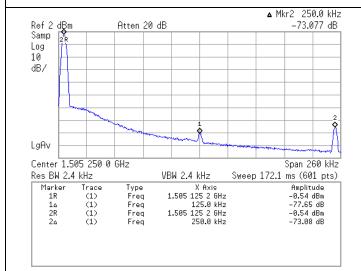
Worst case channels occur at exactly one channel spacing above or below a multiple of the crystal frequency.



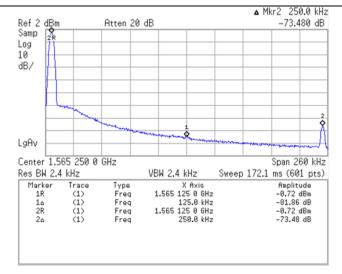




The -65.2 dBc fractional spur at 250 kHz offset is at a worst case frequency of 1455.125 MHz. The -77.8 dBc sub-fractional spur at 125 kHz offset is also visible.

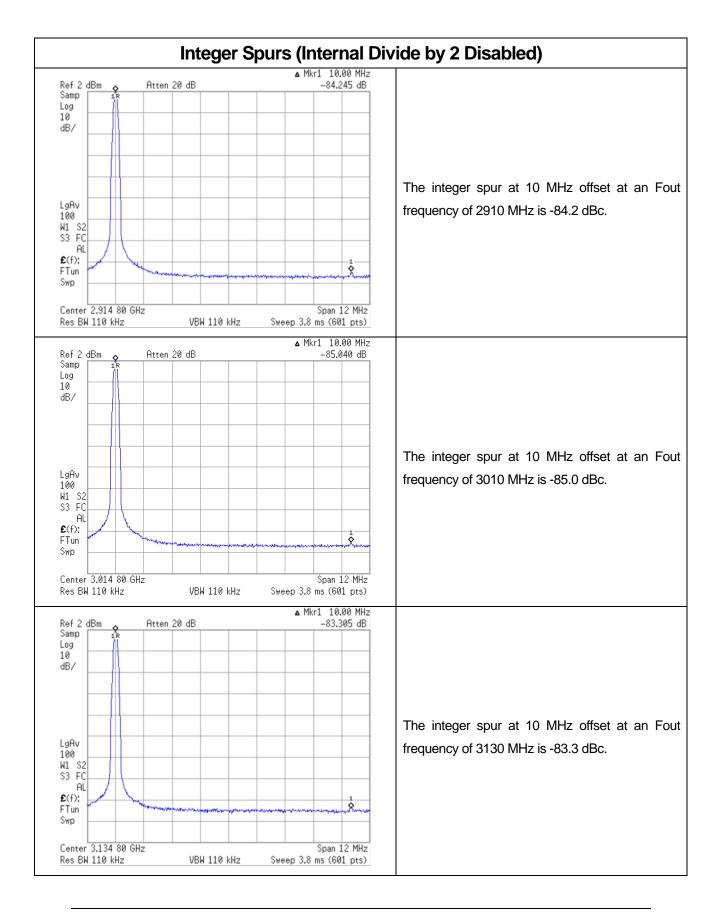


The -73.1 dBc fractional spur at 250 kHz offset is at a worst case frequency of 1505.125 MHz. The -77.6 dBc sub-fractional spur at 125 kHz offset is also visible.

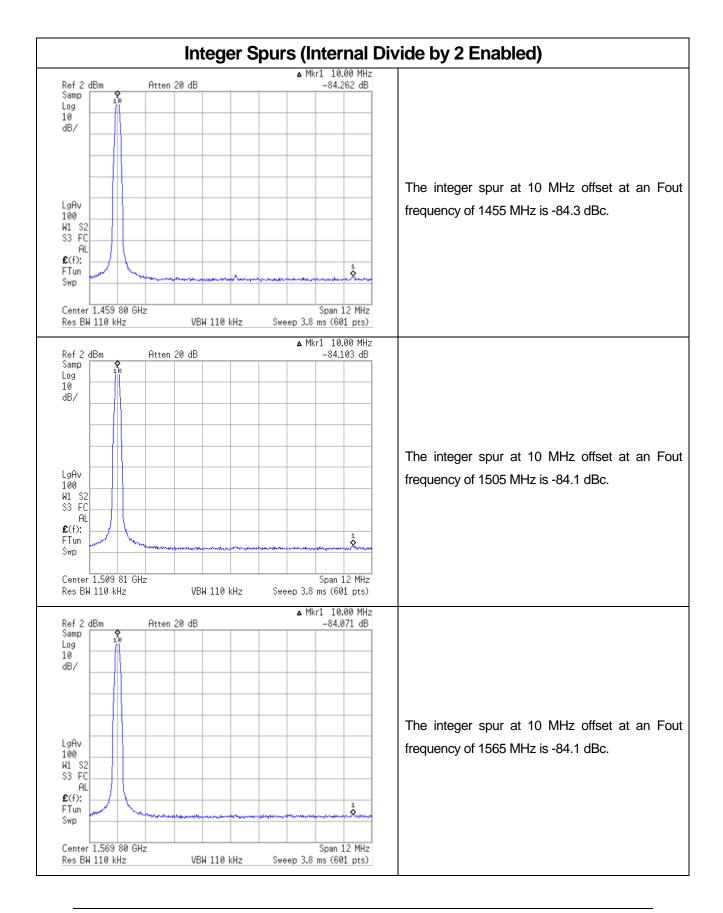


The -73.5 dBc fractional spur at 250 kHz offset is at a worst case frequency of 1565.125 MHz. The -81.9 dBc sub-fractional spur at 125 kHz offset is also visible.



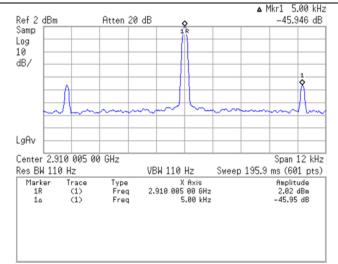






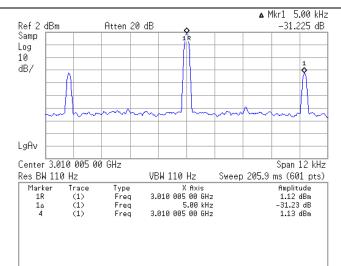






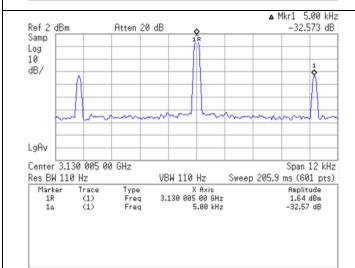
The In-band fractional spur at 5 kHz offset at an Fout frequency of 2910.005 MHz is -46.0 dBc.

ORDER = 4th Order Modulator
Fractional numerator = 500
Fractional denominator = 1,000,000



The In-band fractional spur at 5 kHz offset at an Fout frequency of 3010.005 MHz is -31.2 dBc.

ORDER = 4th Order Modulator Fractional numerator = 500 Fractional denominator = 1,000,000

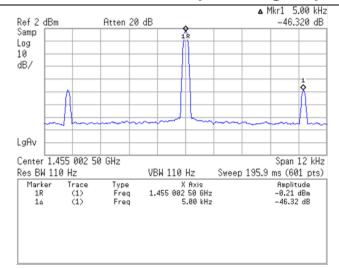


The In-band fractional spur at 5 kHz offset at an Fout frequency of 3130.005 MHz is -32.6 dBc.

ORDER = 4th Order Modulator Fractional numerator = 500 Fractional denominator = 1,000,000

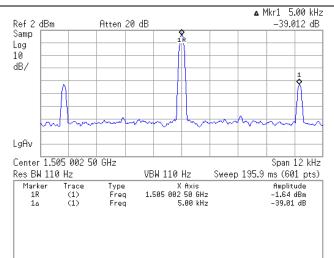






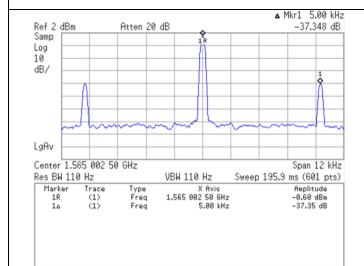
The In-band fractional spur at 5 kHz offset at an Fout frequency of 1455.0025 MHz is -46.3 dBc.

ORDER = 4th Order Modulator
Fractional numerator = 500
Fractional denominator = 1,000,000



The In-band fractional spur at 5 kHz offset at an Fout frequency of 1505.0025 MHz is -39.0 dBc.

ORDER = 4th Order Modulator Fractional numerator = 500 Fractional denominator = 1,000,000



The In-band fractional spur at 5 kHz offset at an Fout frequency of 1565.0025 MHz is -37.35 dBc.

ORDER = 4th Order Modulator Fractional numerator = 500 Fractional denominator = 1,000,000



Inter-modulation Spurs

The LMX2531 features an output divider which may divide the VCO frequency by two. The result is an Fout frequency half the VCO frequency. When this VCO divider is enabled a spur will occur between a multiple of the phase detector frequency and the Fout frequency.

In the example below the phase detector frequency (F_{PD}) is 10 MHz. The VCO frequency is 3020.005 MHz. The divide by two is enabled and the output frequency (Fout) is 1510.0025 MHz

1510 MHz = 10 MHz * 151, which is a multiple of the F_{PD} .

1510.0025 MHz is the divided output frequency.

Therefore a spur will occur at 2.5 kHz offset = (1510.0025 - 1510 MHz)

If the frequency was set to 1509.9975 MHz there would be a spur at 2.5 kHz because:

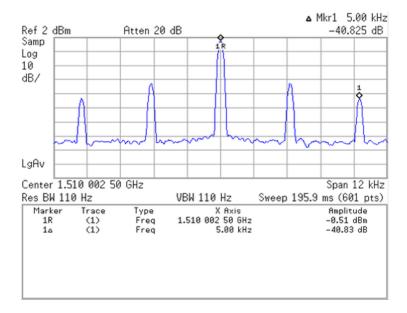
1510 MHz = 10 MHz * 151, which is a multiple of the F_{PD} .

1509.9975 MHz is the divided output frequency.

Therefore a spur will occur at 2.5 kHz offset = (1509.9975 – 1510 MHz)

Technically there are spurs at caused by mixing with all multiples of the phase detector frequency but they will be far away from the carrier and the loop filter will eliminate them.

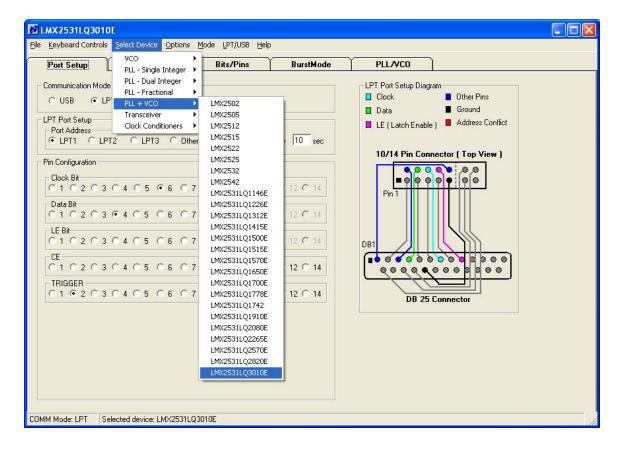
The spur shown below at 2.5 kHz off from 1510.0025 MHz is an example of inter-modulation that occurs. This only happens when the VCO divider is enabled.





CodeLoader Settings

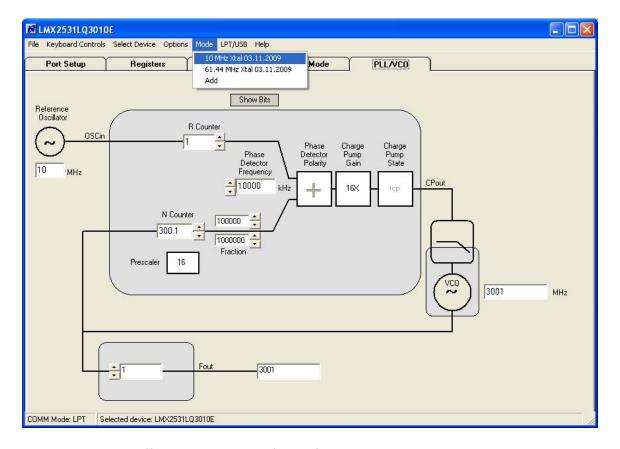
Select Device



CodeLoader runs many devices. When CodeLoader is first started, it is necessary to select the correct device.



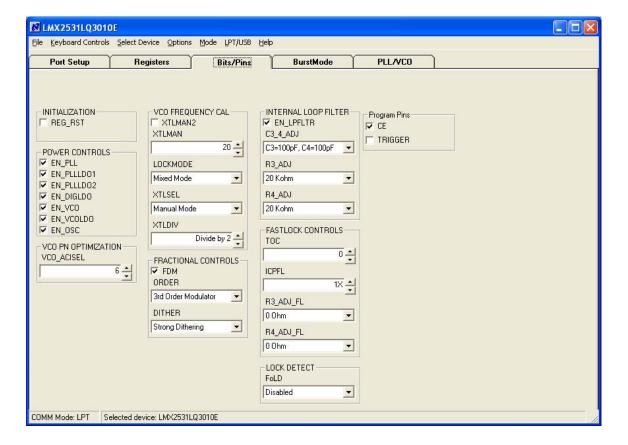
Select Mode



There can be different modes defined for a particular part. A mode can be recalled easily from the menu. This restores bit settings and frequencies, but not the Port Setup information. For the CodeLoader program, the default reference oscillator used for these instructions was 10 MHz, but there is a mode for a 61.44 MHz oscillator as well. If the bits become scrambled, their original state may be recalled by choosing the appropriate mode.



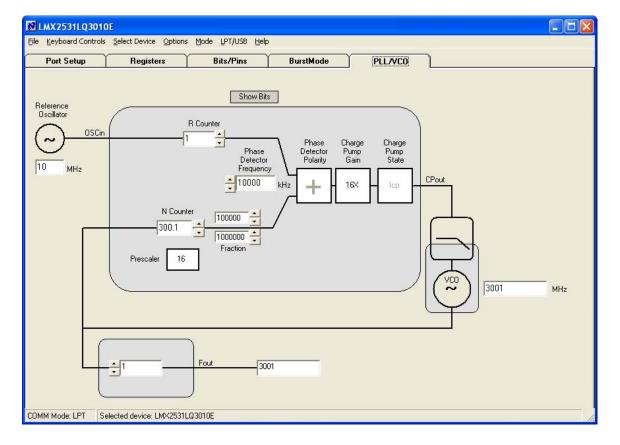
Bits/Pins



The Bits/Pins tab displays many of the bits used to program the part. Right mouse click any bit to view more information about what this does.



PLL/VCO

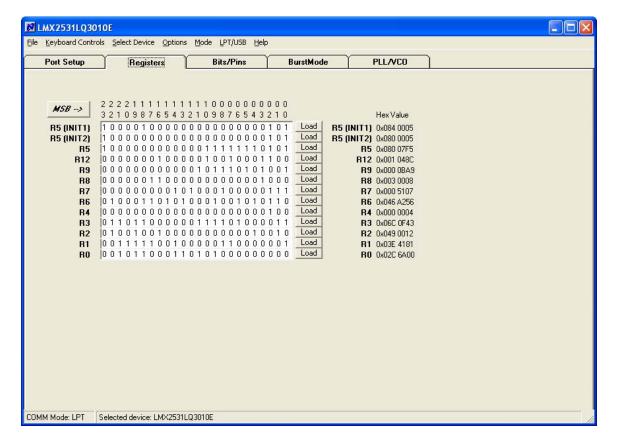


The PLL/VCO tab shows all the important PLL controls. Reference Oscillator should be programmed to the reference frequency connected to the OSCin of the evaluation board. R Counter, Phase Detector Frequency, N Counter, and Charge Pump Gain should be set to provide the desired output frequency with an optimized loop filter. The desired VCO frequency may also be entered directly into the VCO frequency box.

The LMX2531 also has an output divider which can be enabled by change divide value from 1 to 2 by Fout frequency box. Be sure to load the device (Ctrl+L) after changing this divider to allow the VCO to calibrate for optimal phase noise performance.



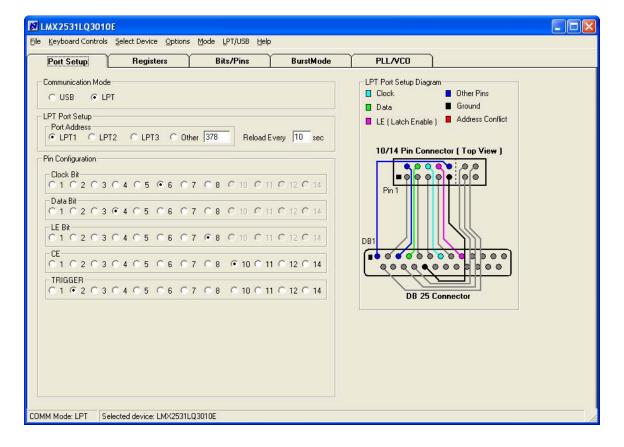
Registers



The Registers tab shows the literal bits that are being sent to the part. These are the registers every time the PLL is loaded by using the menu command or Ctrl+L. R5 (INIT1) and R5 (INIT 2) are just the R5 register being used to properly initialize the part. So a single Ctrl+L will load the part.



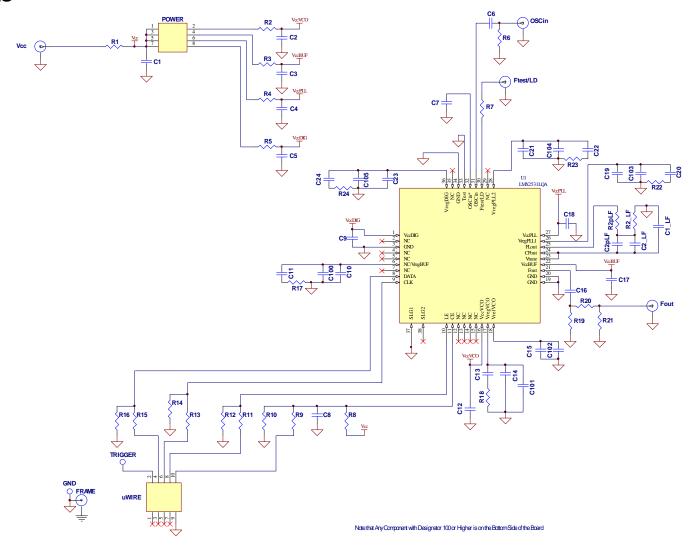
Port Setup



The port setup tells CodeLoader what information goes where. If this is wrong, the part will not program. Although LPT1 is usually correct, CodeLoader does NOT automatically detect the correct port. On some laptops, it may be LPT3.



Schematic



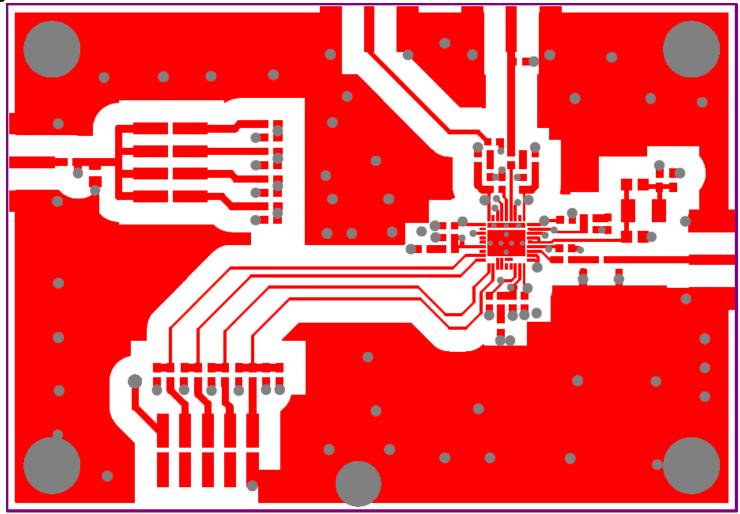


Bill of Materials

| Bill of Materials | | | | LMX2531_HF | | | | Revision 3.28.2008 | |
|-------------------|-----|---------------------------|------------------|------------|-----|---------|---------------------|--------------------------------|---|
| Item | QTY | Manufacturer | Part # | Size | Tol | Voltage | Material | Value | Designators |
| 0 | 20 | | n/a | | | | | Open Capacitors | C1_LF, C2pLF, C2, C3, C4, C5, C9, C11, C14, C17, C18, C19, C21, C24, C100, C101, C102, C103, C104, C105 |
| | 7 | | | | | | | Open Resistors | R2pLF,R7, R8, R17, R19, R21, R24 |
| | 1 | | | | | | | Open Miscellaneous | Ftest/LD |
| 1 | 1 | Kemet | C0603C101J5GAC | 603 | 5% | 50V | C0G | 100pF | C16 |
| 2 | 2 | Kemet | C0603C103J5RAC | 603 | 5% | 50V | X7R | 10nF | C10, C23 |
| 3 | 1 | Kemet | C0805C104K5RACTU | 805 | 5% | 25V | C0G | 100nF | C2_LF |
| 4 | 6 | Kemet | C0603C104J3RAC | 603 | 5% | 25V | X7R | 100nF | C6, C7, C12, C15, C22, C20 |
| 5 | 1 | Kemet | C0603C105K4RAC | 603 | 10% | 16V | X5R | 1uF | C8 |
| 6 | 1 | Kemet | C0603C475K9PAC | 603 | 10% | 6.3V | X5R | 4.7uF | C13 |
| 7 | 1 | Kemet | C0805C106K8PAC | 805 | 10% | 10V | X5R | 10uF | C1 |
| 8 | 1 | Vishay | CRCW0603000ZRT1 | 603 | 5% | 0.1W | Thick Film | 0Ω | R20 |
| 9 | 2 | Panasonic | P.22AHCT-ND | 603 | 10% | 0.1W | Thick Film | 0.22Ω | R22, R23 |
| 10 | 2 | Vishay | CRCW06033R3JRT1 | 603 | 5% | 0.1W | Thick Film | 3.3Ω | R1, R18 |
| 11 | 4 | Vishay | CRCW0603100JRT1 | 603 | 5% | 0.1W | Thick Film | 10Ω | R2, R3, R4, R5 |
| 12 | 1 | Vishay | CRCW0603510JRT1 | 603 | 5% | 0.1W | Thick Film | 51Ω | R6 |
| 13 | 1 | Vishay | CRCW0603102JRT1 | 603 | 5% | 0.1W | Thick Film | 1ΚΩ | R2_LF |
| 14 | 4 | Vishay | CRCW0603103JRT1 | 603 | 5% | 0.1W | Thick Film | 10KΩ | R9, R11, R13, R15 |
| 15 | 4 | Vishay | CRCW0603123JRT1 | 603 | 5% | 0.1W | Thick Film | 12ΚΩ | R10, R12, R14, R16 |
| 16 | 1 | Comm Con Connectors | HTSM3203-8G2 | 2X4 | n/a | n/a | Metal/Plastic | Header | POWER |
| 17 | 1 | FCI Electronics | 52601-S10-8 | 2X5 | n/a | n/a | Metal/Plastic | Header | uWire |
| 18 | 3 | Johnson Components | 142-0701-851 | SMA | n/a | n/a | Metal | SMA | Fout, OSCin, Vcc |
| 19 | 1 | National Semiconductor | LMX2531LQEBPCB | n/a | n/a | n/a | FR4 62 mil Thick | PCB Board 1st Layer 10 mils | n/a |
| 20 | 1 | National Semiconductor | LMX2531 | LLP36 | n/a | 2.7 | Silicon | LMX2531 | U1 |
| 21 | 4 | Com Con Connectors | CCIJ255G | 2-Pin | n/a | n/a | Metal/Plastic | Shunt | Place Across: POWER: 1-2, 3-4, 5-6, 7-8 |
| 22 | 4 | SPC Technology | SPCS-8 | 0.156" | n/a | n/a | Nylon | Nylon Standoffs | Place in 4 Holes in Corners of Board |

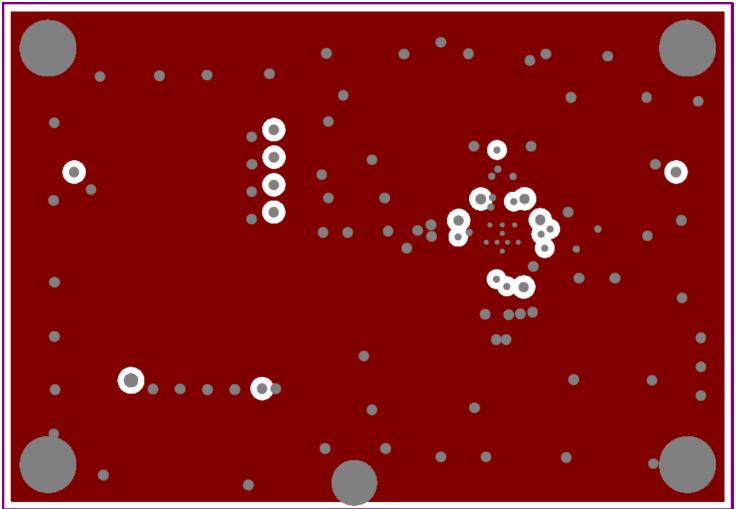


Top Layer





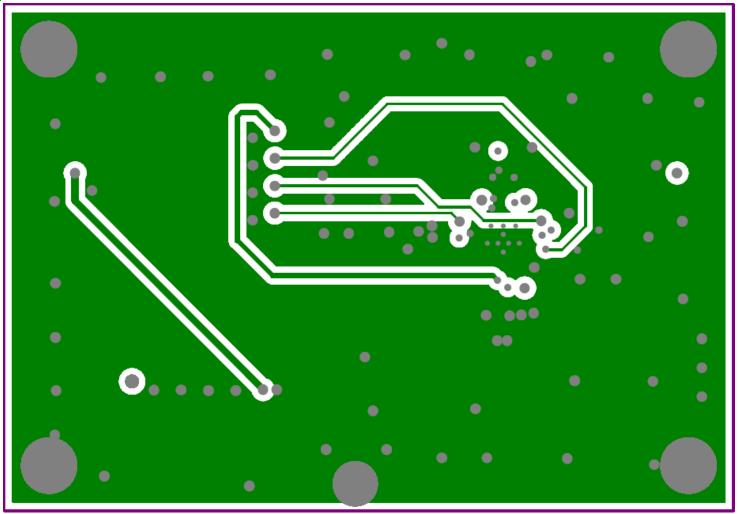
Mid Layer 1 "Ground Plane"



(15 mils below top FR4 layer)

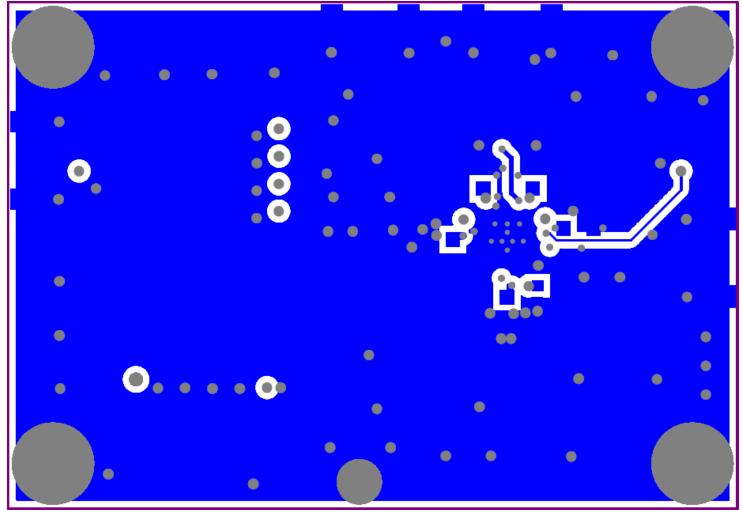


Mid Layer 2 "Power"





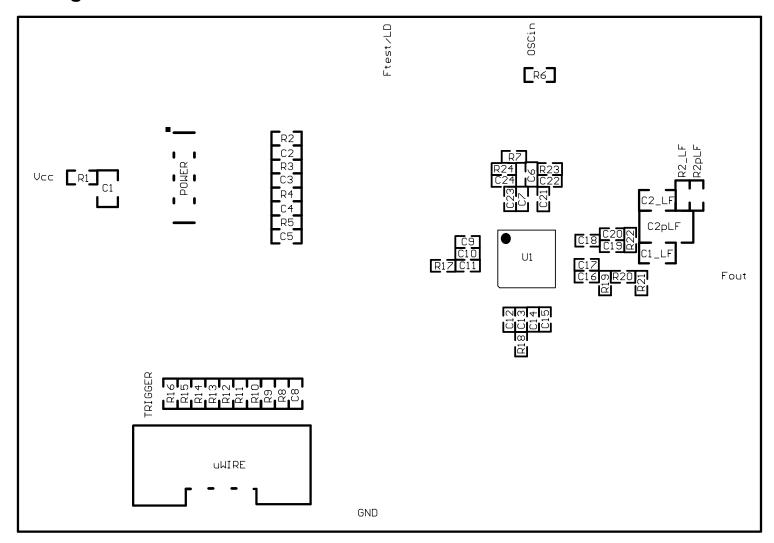
Bottom Layer "Signal"



Note: Total Board Thickness = 61 mils



Top Build Diagram



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