OPERATING INSTRUCTIONS FOR THE NATIONAL SEMICONDUCTOR LMX3161 EVALUATION BOARD

SET-UP INSTRUCTIONS

The LMX3161 Evaluation Board is an implementation of the schematic shown as Appendix A. The board, shown in Appendix B (note: Mid Layer 1 is not shown since it is a solid ground plane with no traces), consists of the LMX3161, a modular RF VCO, 2 ceramic RF filters, a discrete LNA, and an IF SAW filter. This board is not intended to be a DECT reference design, rather as a means to demonstrate the general performance and functionality of the LMX3161. To evaluate a solution that meets DECT type approval, please inquire about the LMX8914/8915 DECT Radio Transceiver Module demonstration kit.

The board has two kinds of interconnections. SMA flange mount connectors are supplied for the external reference, VCO output, power supply biasing, and grounding. A six pin header allows VCC (for the various sections of the LMX3161), VP, and Vvco to be driven off either a single voltage supply, or separately. The cable provided connects to the evaluation board pin header and the parallel port of a PC XT (or better) equivalent. Since most P.C.'s parallel port output level is 5 V, resistive dividers for the Clock, Data, and Load Enable are included. This will allow low voltage operation of the LMX3161 without overdriving the *Microwire* inputs. The power supply requires connection through the SMA connector labeled Vcc.

For receiver mode, configure the evaluation board as follows: (1) Connect an RF source to RF_{IN}, (2) Determine if the LO signal will be a CW or a burst signal. If the input is a CW signal, it is suggested to use a signal generator connected to the Fin pin. (Verify the supply line to the VCO and the VCO output are disconnected from the circuit.) For a burst signal, the onboard VCO can be utilized by installing components C11, R11 and R21 and by connecting a reference input from 5 MHz to 40 MHz at 0 dBm to the **OSC IN** port. A 50 ohm termination is already on the board for using an external signal generator. (3) Connect the power supply at the appropriate biasing (3.6V) to the SMA connector labeled **Vcc**. Verify shorting bars are on the pin headers (see schematic). Connect the cable assembly to the parallel port of the PC and to the 10 pin header on the evaluation board. Connect the cable with the arrow on the connector facing the pin 1 designator on the board. The board is now ready to operate. This configuration is for evaluation purposes only and not intended as a system solution. The loop filter was designed for a comparison frequency of 864 kHz, prescalar of modulo 32, and charge pump current of 1.5 mA (1X I_{cpo}). The evaluation board has been designed to accept other configurations of loop filters.

USING LMX3161 SOFTWARE

Insert Disk #1 and run setup.exe to install the software. You will be prompted to insert Disk #2. Because the program uses extended precision real numbers in its calculations, the program may not operate on some older DOS computers. A PC-AT or equivalent is recommended. The program is initiated by double clicking on the LMX3161 icon.

The LMX3161 evaluation program controls the LMX3161 Evaluation Board via a standard parallel port. A cable is provided to make the connection from the computer to the board. The program is intended to exercise the Receiver, Transmitter, and PLL and to demonstrate typical performance of the LMX3161. It is not intended to be representative of the control code which the customer will implement within their application.

Upon power-up the program will detect the number and location of parallel ports available to the system. The user can select the correct parallel port in the Configuration sub menu under the Options pull down menu. The evaluation program is icon driven. All selections may be made by clicking the mouse pointer on the desired button or text box.

The program displays a block showing the present status of the various blocks of the LMX3161. The buttons on the left are the “mode” buttons which control the hardwired signals for S-Field, CE (Chip Enable), PLL PD (PLL Power Down) and Trigger. The Rx and Tx can be powered up/down via *Microwire* or configured to be controlled via hardwire through the CMOS output pins. All PLL settings are controlled by changing the parameters in the PLL block diagram.

Upon successful selection of tuning parameters, the download values are calculated and loaded. The board must be powered up in order for the values to be loaded. If power is applied after the software is on or power is turned off for some reason, all that is required is clicking on "Reload" to program the values for the device.

The display is broken into blocks or functions internal and external to the LMX3161 as shown in Figure 1. The boxes located within the boundary of the dashed line are considered internal to the part. The current mode and or condition of the part can be changed by simply clicking on the desired block. For example, to change the polarity of the phase detector, simply click the Phase Detector box. You should see the polarity toggle between + and -.

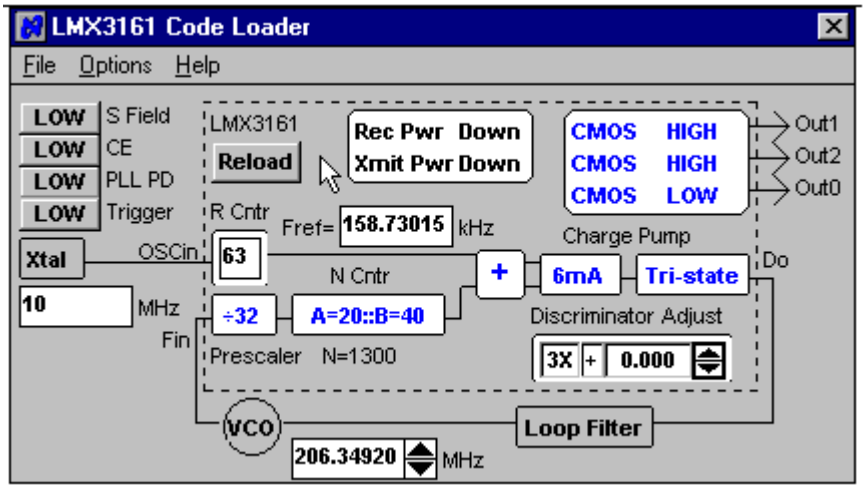


Figure 1 LMX3161 Code Loader Window

Control Buttons (S Field, CE, PLL PD & Trigger):

There are four buttons in the upper left corner of the form which control output bits of the parallel port which when configured and wired correctly correspond to control pins of the part. The control lines can be toggled by simply clicking on the corresponding button. The button displays the current condition of the control line. Clicking on the *CE* button toggles the chip enable pin of the device. The *Trigger* line can be used to trigger test equipment for measurements and will be described in further detail in the burst mode setup.

Reload Button:

The *Reload* button located in the upper left corner of the dashed box will reload all three registers in the LMX3161 .

Phase Detector Reference Frequency:

To change the reference frequency of the phase detector click within the edit box labeled *Fref* located above the N Counter box. Type in the desired phase detector reference frequency in kHz and press return. The reference frequency will change to the nearest legal value and the N and R registers should update to show their new values.

R Counter Register:

To change the value of the R counter register, click in the text box labeled R Counter. Enter the new value for the R register and press return.

N Counter Register:

Clicking in the N Counter box will display a new window that will allow the bits in the A & B counters, which make up the N counter, to be changed.

CMOS I/O 0, 1 & 2 Control:

The upper right box controls the three CMOS I/O pins Out0, Out1/RX PD and Out2/TX PD. The transmit and receive modes can be controlled by internal registers or by input pins of the part.

Programmable CMOS Output Mode:

When the transmit and receive modes are setup to be controlled via internal registers, the upper right box will display CMOS followed by the condition of the output (HIGH/LOW). The pin labels will also display Out1 and Out2 with arrows indicating output. The box to the left will have a white back ground indicating that it is enabled and allow the receive mode and transmit mode to be enabled/disabled. When in this state, the receive mode and transmit mode can be toggled by clicking on the Up/Down text. The CMOS output conditions can be changed in a similar manor by clicking on the HIGH/LOW text. To change to the mode where the receive and transmit modes are controlled by hardwire, simply click on the CMOS text in the upper right box.

Hardwire Receive/Transmit Control Mode:

When the transmit and receive modes are configured to be hardwire controlled, the upper right box will display Rec PC Input and Xmit PC Input. The pin labels will display the same with arrows indicating inputs. The box to the left will have a gray background to indicate that it is disabled from controlling the receive and transmit functions. To change to the mode where the receive and transmit modes are controlled by internal registers click on the text in the upper right box.

Configuring the LMX3161 code loader

The Code Loader normally uses the parallel port to load data into the LMX3161 registers. However, any port can be configured to output data. To configure the correct output, select the sub menu *Configure* under the *Options* pull down menu. This displays a new window labeled Configuration. Select the *Port Setup* tab located on the top portion of the form as seen in Figure 2.

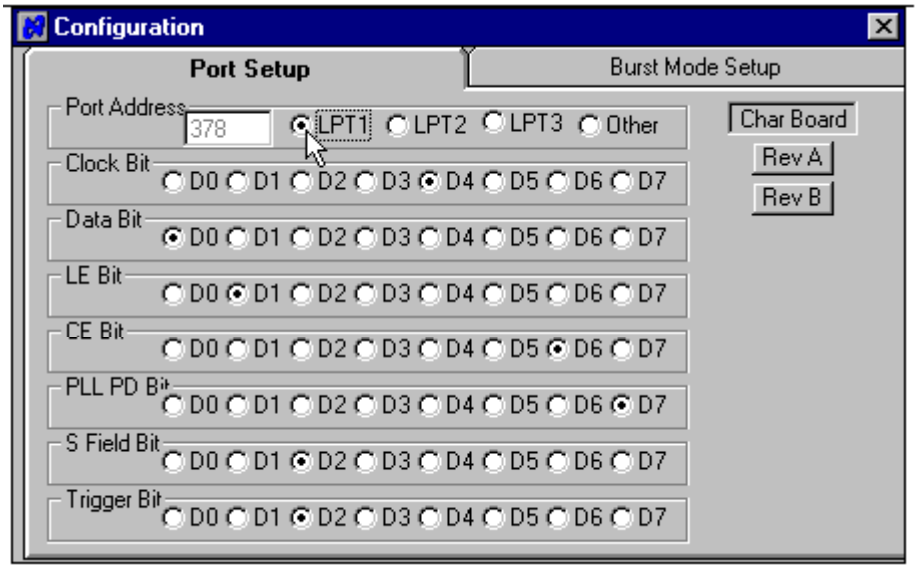


Figure 2 LMX3161 Code Loader Port Setup

Change Port Address

The port address is selected by clicking on the option buttons. LPT1 corresponds to address 378 hex and LPT2 is port address 278 hex. To configure for port addresses other than line printer ports, select the other option and enter the desired port address in the text box.

Change Output Bit Function

The bits labeled D0 through D7 represent the 8 output data bits of the parallel line printer port. The cable that is included with the evaluation board can be quickly configured by clicking on the button labeled *Rev A,* located on the right side of the form. However, this configuration can be changed by simply clicking on the desired bit for each function.

Setting up and Using Burst Mode

The burst mode allows the program to cycle the part through different modes for analysis and evaluation. The burst mode can be viewed as a programmable macro which changes the conditions and states of the part. There are three functions which can be used in the burst cycle, one function to load a particular register, another to change the control line modes, and a delay function. To setup a burst mode macro, choose the sub menu *Configure* from the pull down menu *Options* and choose the *Burst Mode Setup* tab located at the top of the Configuration window as shown in Figure 3. Position the two windows so that both the Part Setup form and the Configuration form can be seen so that you can easily switch between the two windows. Setup the conditions desired in the Part Setup form and click on the desired function button located in the lower section of the Burst Mode Setup Configuration form. Below is a detailed example that builds a burst macro.

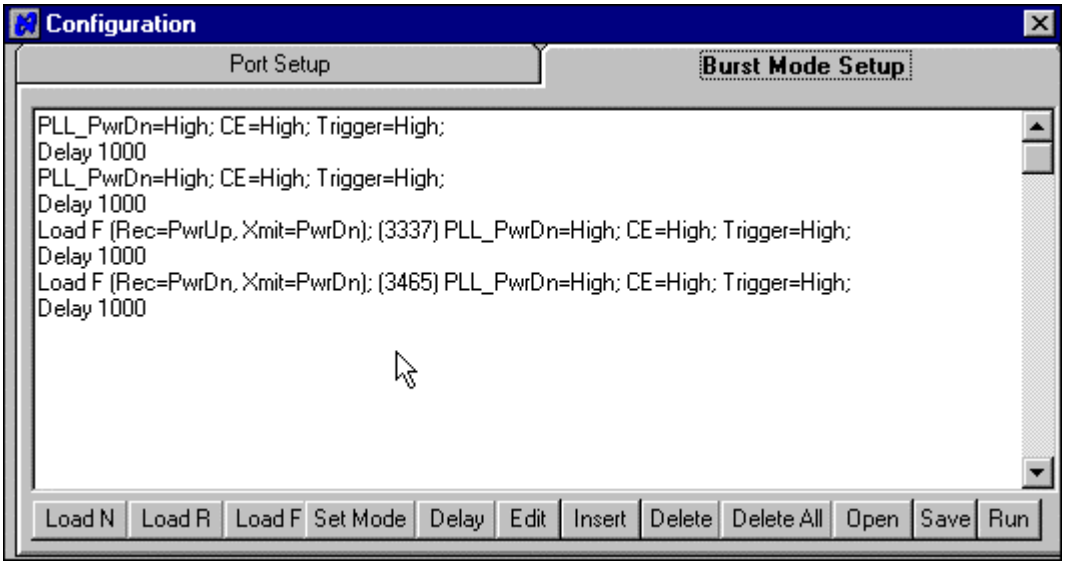


Figure 3 LMX3161 Burst Mode Setup

Example 1: can be used to simulate a burst cycle.

1. Clear the existing burst macro by clicking on the *Delete All* button.
2. Switch to the Part Setup form and set the following:

   Ref Freq = 500kHz

   VCO Freq = 820MHz

   Xtal Freq = 10MHz

   CE = HIGH

   PLL PD = HIGH

   Receiver Powered Down

   Transmit Powered Down
3. Switch back to the Burst Mode Setup Configuration form and press *Load N*, *Load R* & *Load F*.
4. Switch back to the Part Setup form and set PLL PD = LOW.
5. Switch back to the Burst Mode Setup Configuration form and press the *Set Mode* button
6. Click on the *Delay* button to insert a delay to allow the PLL to lock. Note: the delay button inserts a loop of x many counts to create a delay, so some experimentation is required with the count value to set the desired delay. The minimum delay will be affected by the CPU clock speed.
7. Switch back to the Part Setup form and set PLL PD = HIGH and Receiver Powered Up.
8. Switch back to the Burst Mode Setup Configuration form and press the *Load F* button.
9. Click on the *Delay* button to insert a delay to allow the part to stay in the receive mode for some time.
10. Repeat Step 2 through Step 9 except at a different VCO frequency and for Transmit Powered Up rather than Receive Powered Up.
11. Press the *Run* button to start looping through the burst mode macro. The *Run* button changes to display *Stop*. Press the *Stop* button to stop looping through the burst mode macro.

Other Burst Mode Buttons:

Edit:

To change a particular function/command located within the burst mode macro, first switch to the Part Setup form and make the desired changes, Then switch back to the Burst Mode Setup Configuration form and press the Edit button. A box will be displayed in the lower right hand corner of the large text window inquiring which command to edit. Click anywhere on the text line of the desired function to change. The box in the lower right corner will now inquire which command to select. Press the desired function button to change the highlighted command.

Insert:

To insert a new function/command located within the burst mode macro, first switch to the Part Setup form and make the desired changes, then switch back to the Burst Mode Setup Configuration form and press the *Insert* button. A box will be displayed in the lower right hand corner of the large text window instructing you to select the command to insert before. Click anywhere on the text line of the desired function to insert before. The box in the lower right corner now instructs you to select a new command. Press the desired function button to insert a new command in front of the highlighted command.

Delete:

To delete a function/command located within the burst mode macro, first select the desired function to delete by clicking anywhere on the text line of the desired function to delete. Then press the *Delete* button.

Open:

Pressing the *Open* button will display a new window for loading in a previously saved burst mode macro.

Save:

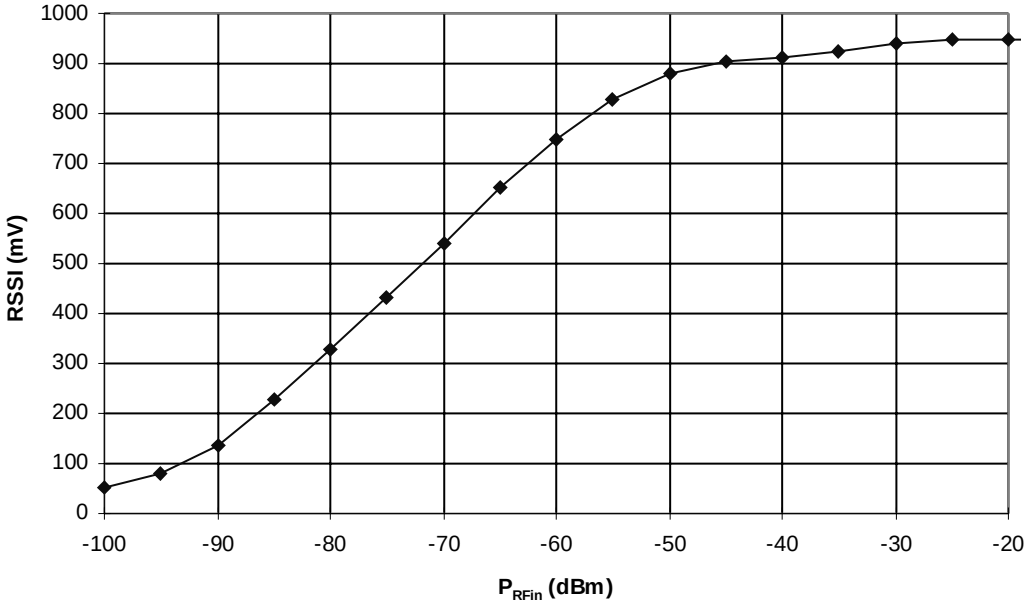
Pressing the *Save* button will display a new window that will allow you to save the current burst mode macro.

TYPICAL MEASURED PERFORMANCE OF THE LMX3161 EVALUATION BOARD

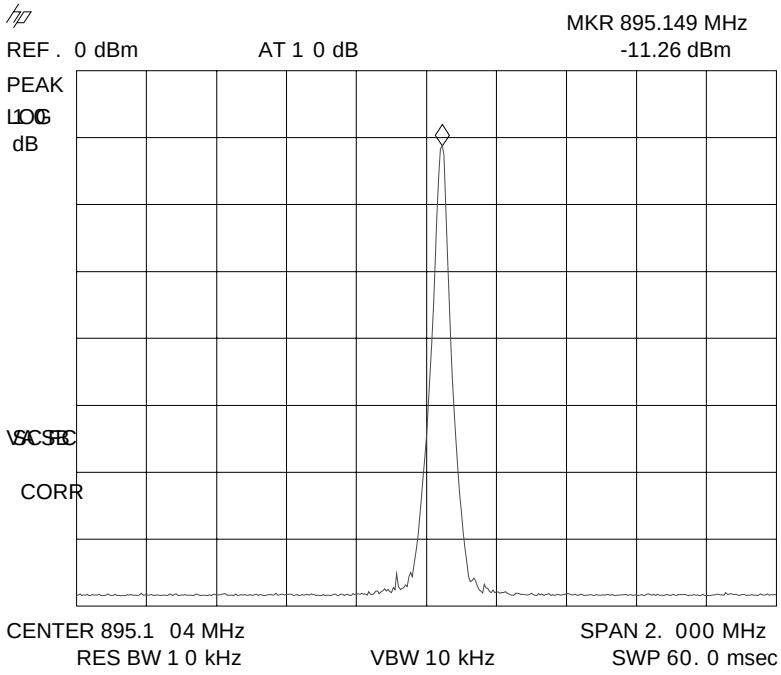
Various measurements can be made on the LMX3161 evaluation board. Since the LMX3161 is designed for open loop operation, the most important PLL measurements are the output spectrum during open loop and the open loop frequency drift. All PLL measurements, such as spectrum plots, lock times and frequency drift, are made using a wide band VCO (880 to 950 MHz). Receiver measurements such as RSSI, discriminator eye diagram, and sensitivity can easily be made using this evaluation board. Typical receiver sensitivity measurements using this evaluation board are about -90 dBm for a BER of 10^{-3}. For the transmitter, the spectrum plot of Tx Out shows the signal levels of the fundamental, 2^{nd} harmonic and 3^{rd} harmonic frequencies with a continuous signal supplied by a signal generator connected to the Fin pin. The following pages show some of the typical measurements made with the LMX3161 evaluation board.

NOTE: Computer monitors and other lab equipment has been shown to cause noise spikes. If you see noise spikes on the signal, try turning off the monitor or other equipment to verify that they are not the cause. Also, noise may be induced onto the cable that connects to the parallel port of the computer.

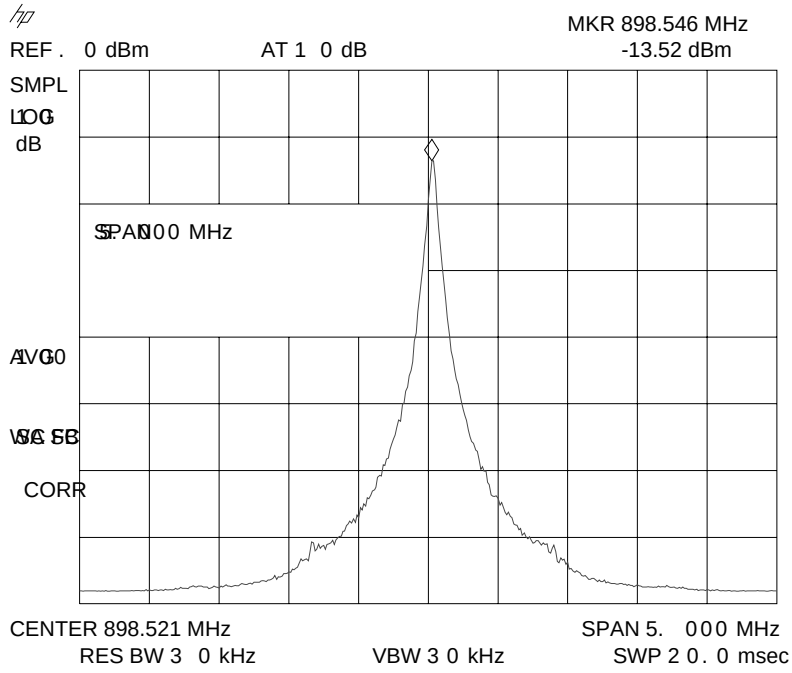
TYPICAL MEASURED DATA



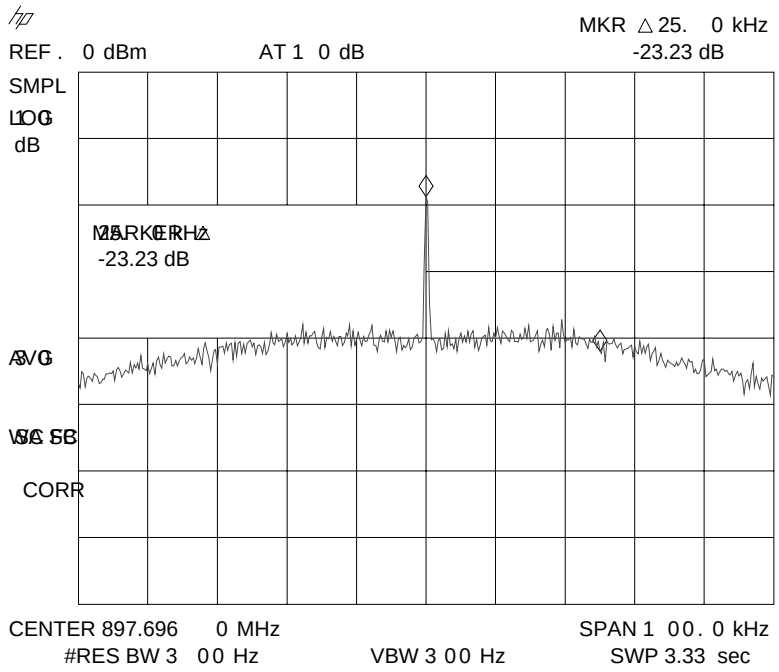
RSSI vs RF Input Power



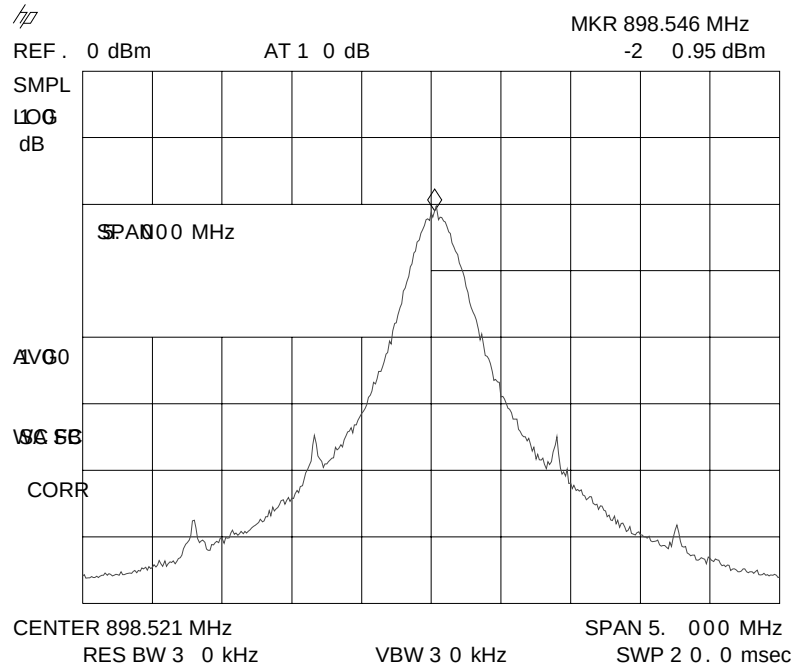
PLL Output Spectrum During Open-Loop



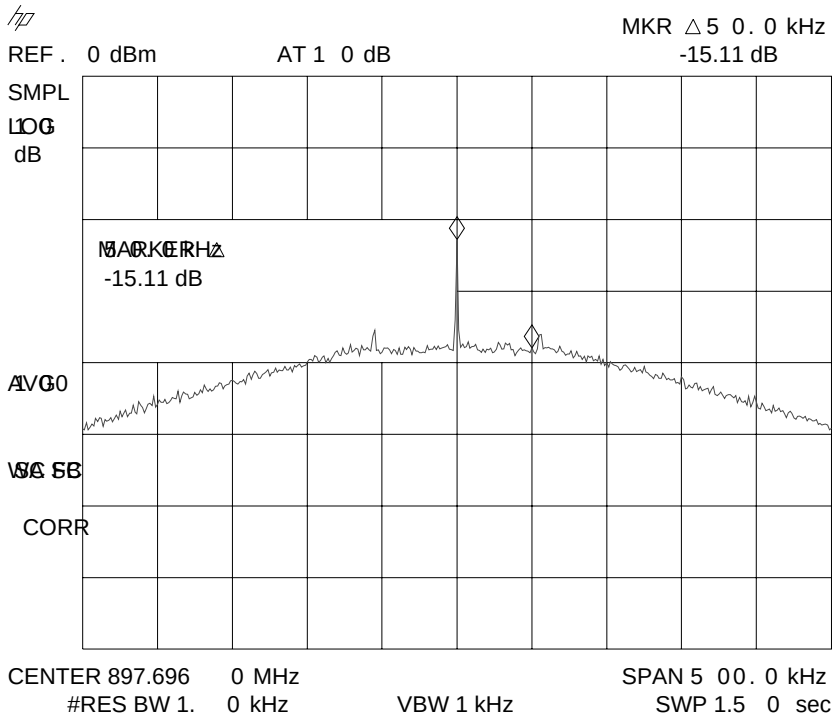
PLL Output Spectrum with I_{D0} = 1.5 mA



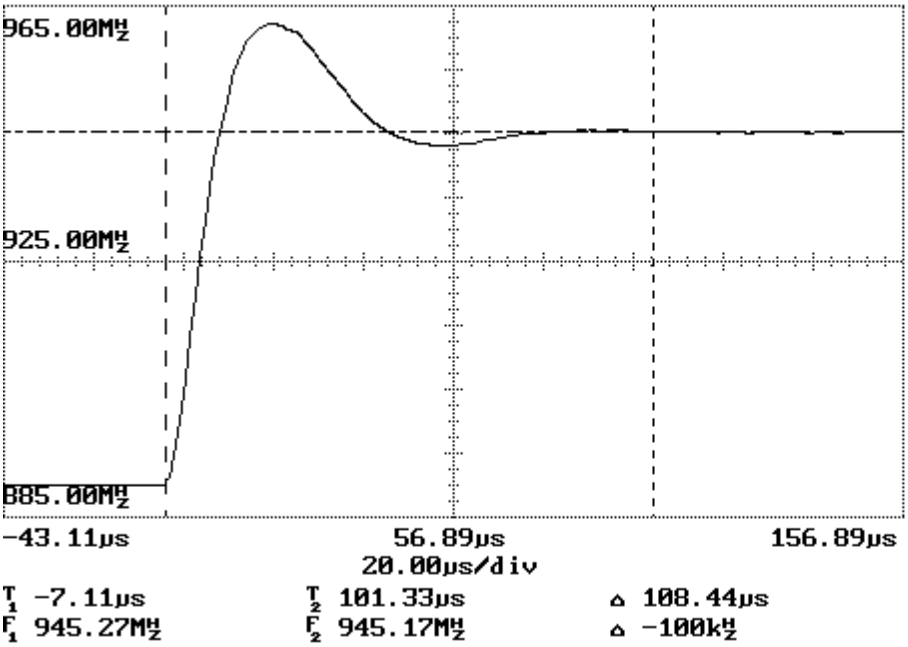
PLL Loop Bandwidth with I_{D0} = 1.5 mA



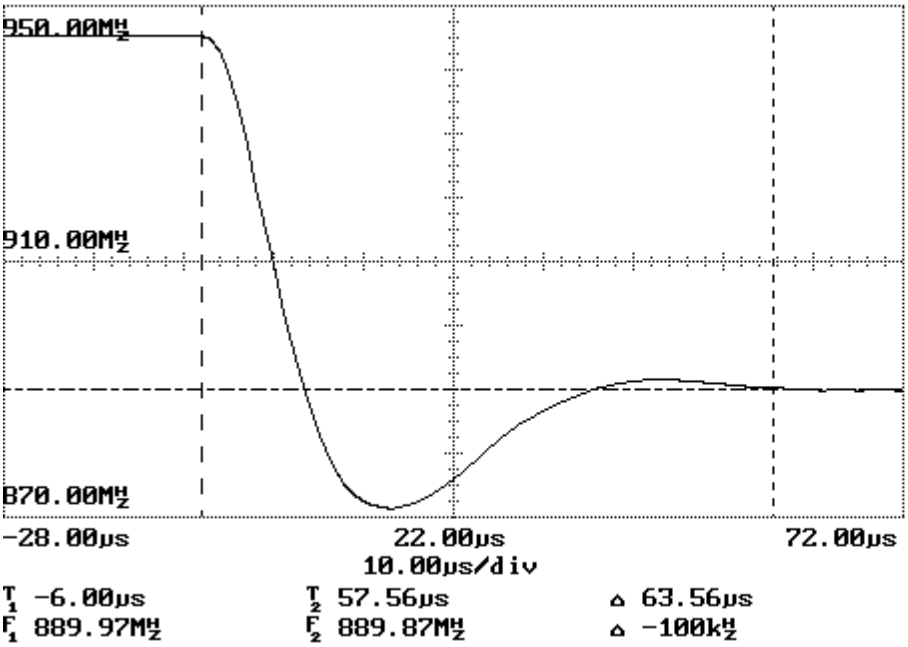
PLL Output Spectrum with I_{D0} = 6mA



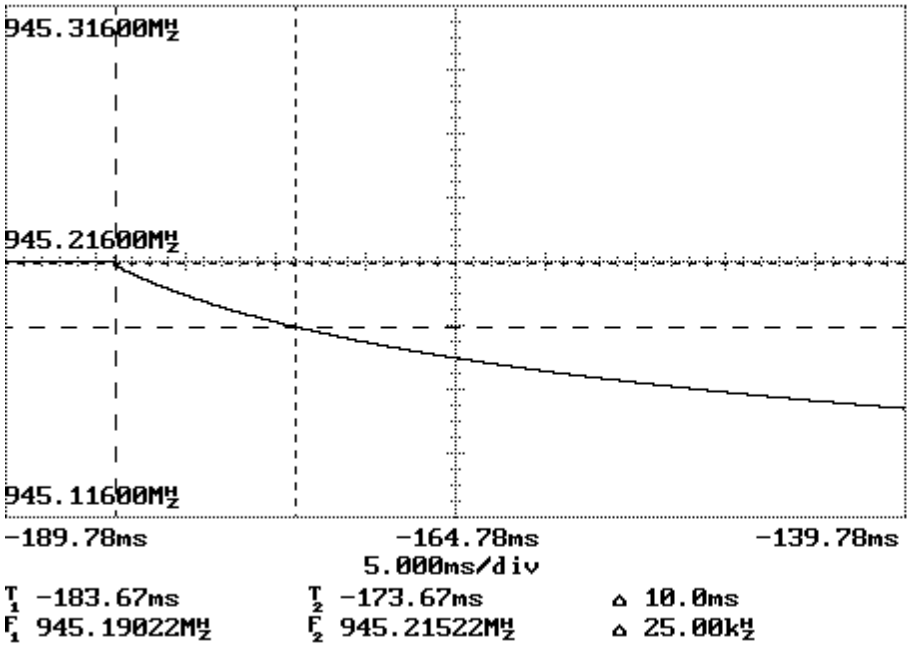
PLL Loop Bandwidth with I_{D0} = 6 mA



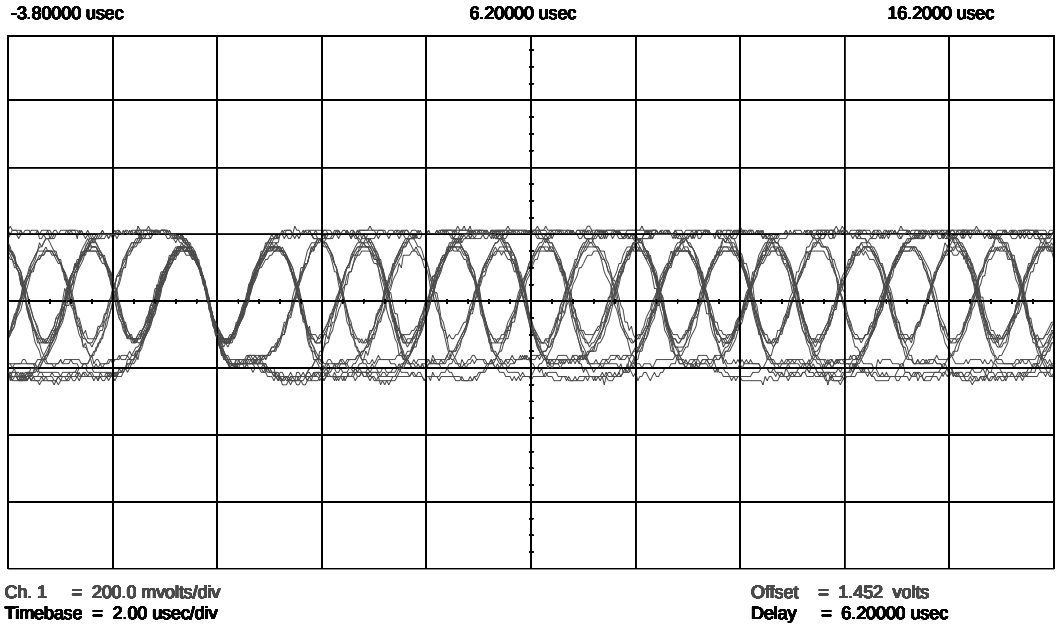
Lock Time (Low to High - Rx to Tx)



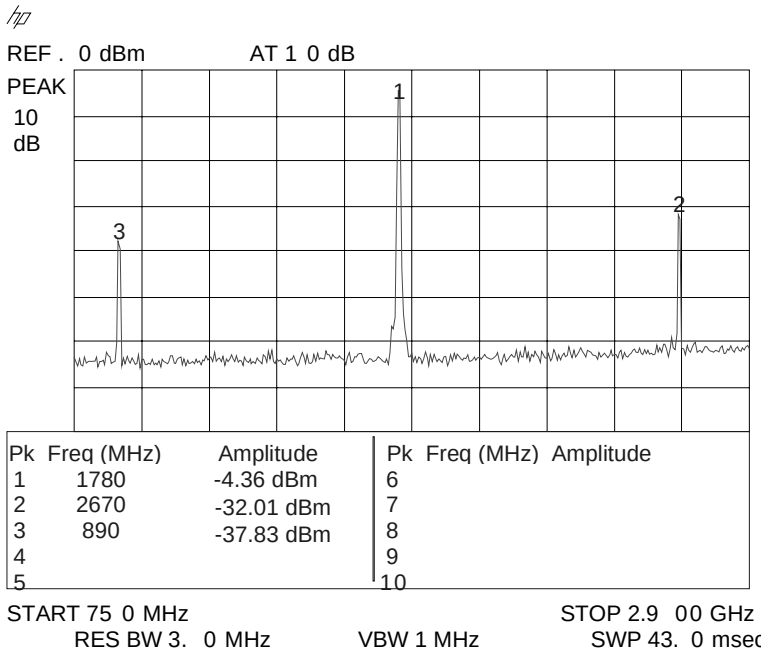
Lock Time (High to Low - Tx to Rx)



Open Loop frequency drift (2.5 kHz/ms)

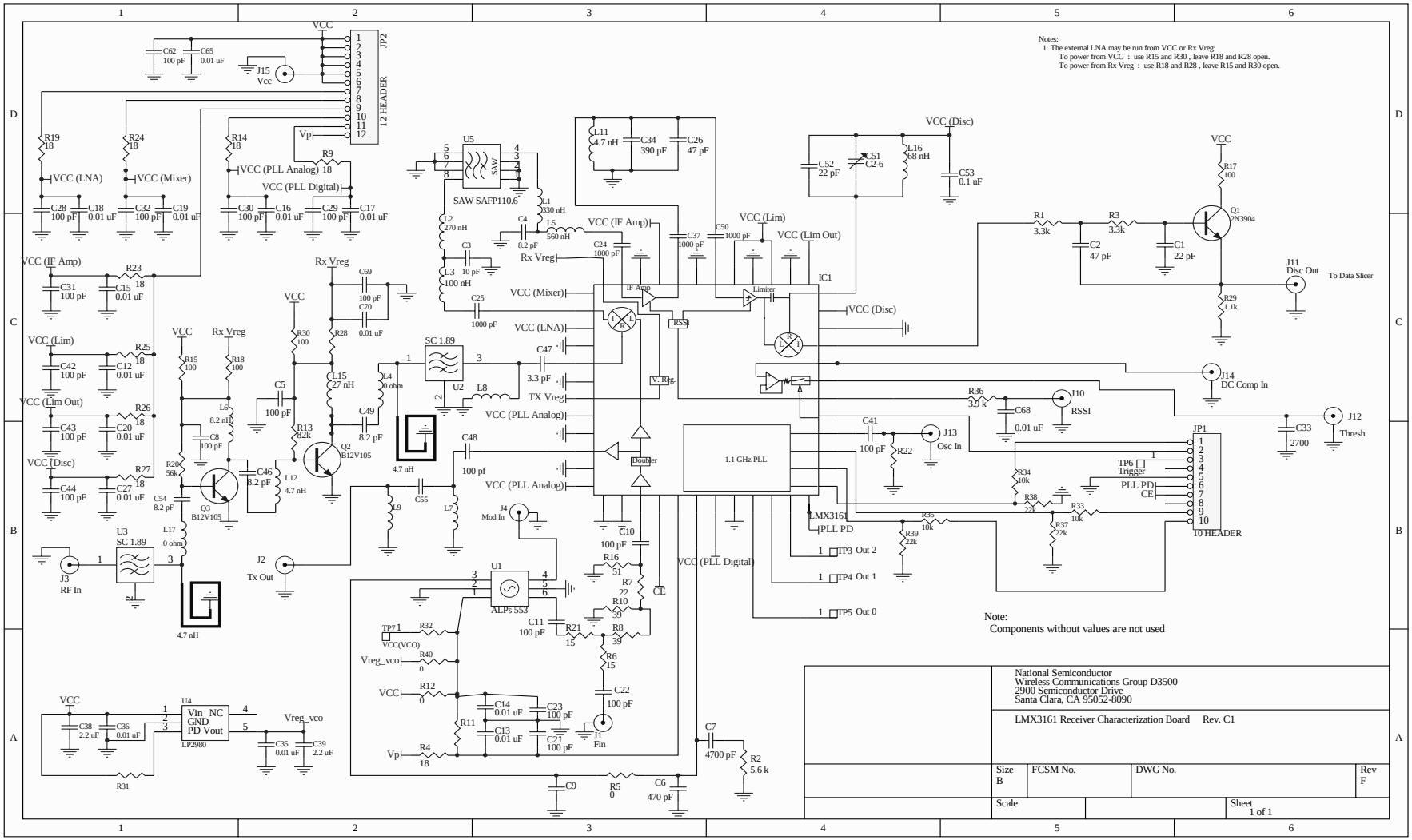


Disc_Out Eye Opening for Disc Gain 3X Mode

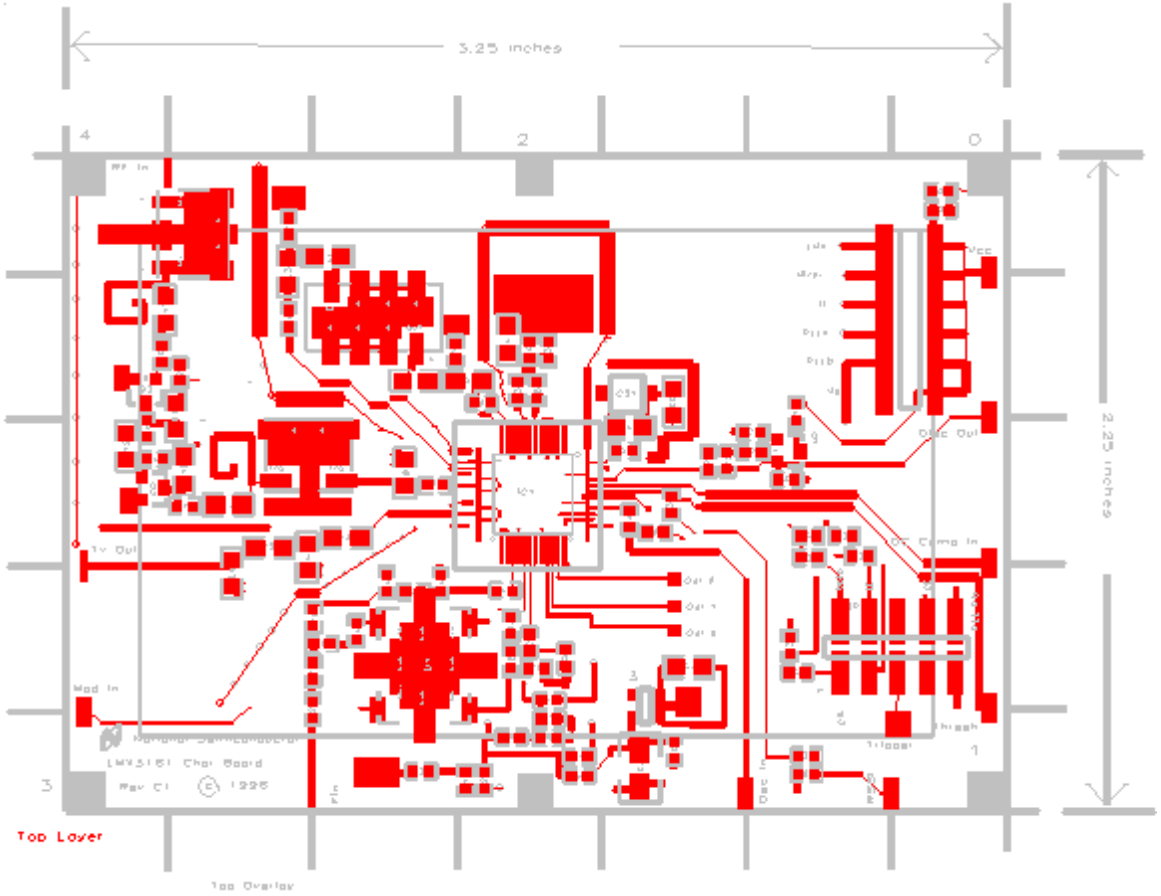


Frequency Doubler Output Spectrum (Fin @ 890 MHz and -10 dBm)

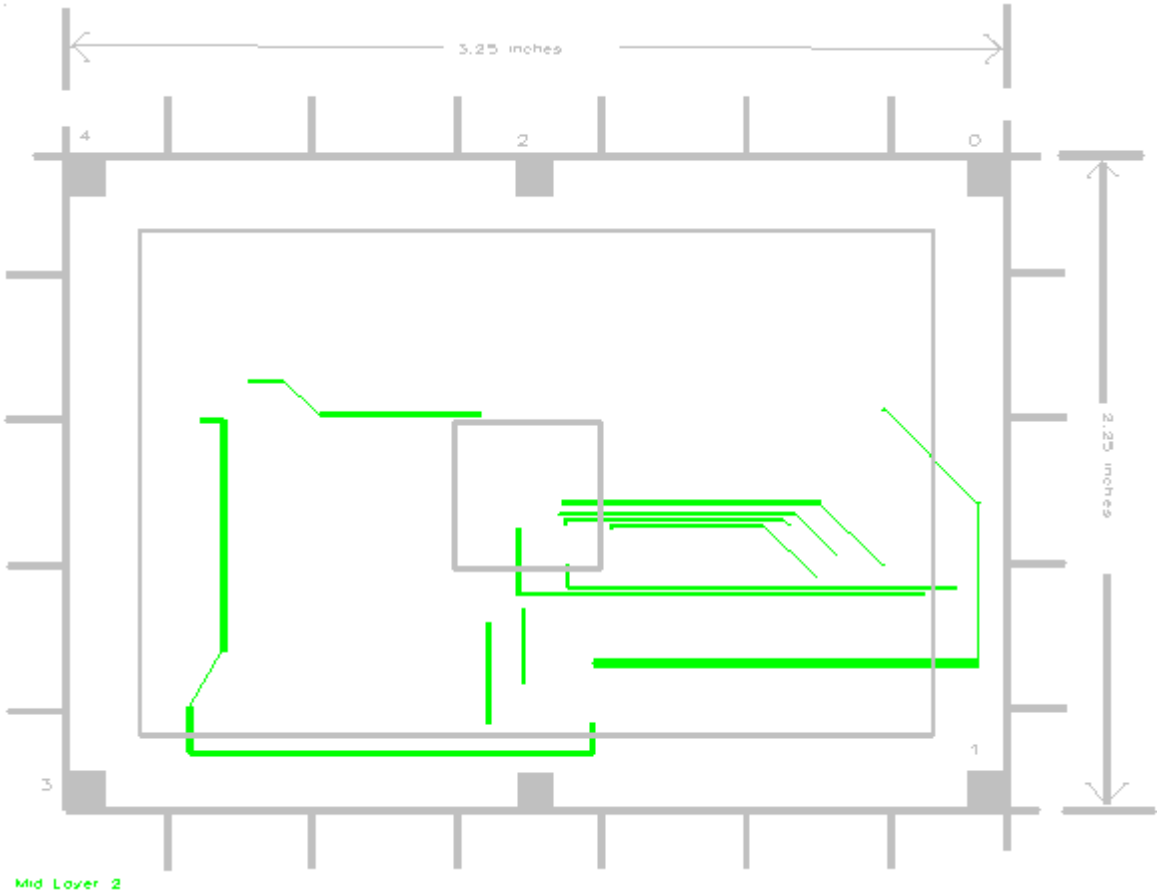
Appendix A : LMX3161 Evaluation Board Schematic



Appendix B: LMX3161 Evaluation Board Layout (Top Layer and Top Silkscreen)



Appendix B: LMX3161 Evaluation Board Layout (Mid Layer 2)



Appendix B: LMX3161 Evaluation Board Layout (Bottom Layer and Bottom Silkscreen)