National Semiconductor™

**PLLATINUM™ EVALUATION BOARD**
**SINGLE PLL (20 PIN) VERSION**

# INTRODUCTION

In order to assist in your evaluation of National Semiconductor's LMX series single PLL, a blank printed circuit board is included with this product sample kit. The PCB is designed to reduce the time required to construct a working evaluation environment for the LMX series PLL while still providing the flexibility needed to create a circuit that matches your specific application. This document provides the information necessary to populate the board, build the parallel interface cable that allows PC control of the board, and download PC compatible control software from National. The documentation also includes set-up and operating instructions for the hardware and software. Finally, a troubleshooting section is provided.

# PREPARING THE EVALUATION BOARD HARDWARE

The LMX2301//LMX2305 series single PLL Evaluation Board is an implementation of the schematic shown in Appendix A or B. The board, shown in Appendix A or B, consists of locations for an LMX series single PLL, a descrete IF VCO and its loop filter. Space for an eight pin header is provided for MICROWIRE™ programming of the PLL divider ratios. A ribbon cable connects to the evaluation board pin header and the parallel port of a PC XT (or better).

A bill of materials list for the board can be found in Appendix C. Information on loop filter design can be found in the paper titled, **"An Analysis and Performance Evaluation of a Passive Filter Design Technique for Charge Pump Phase-Locked Loops"** which is also included in the product sample kit.

The board has two kinds of interconnections. SMA or SMC connectors should be used for the external reference and VCO output, while power supply biasing and ground can be attached to the board either by mounting connectors or by directly soldering to the pads. A four pin header allows VCC, VP, and Vvco to be driven separately or from a single power supply. Resistors denoted as O.C. / S.C. (Open Circuit / Short Circuit) in the schematic are for connecting various outputs to output pads or to ground by using OΩ resistors as shorts.

A simple four wire interface cable can be used to interface a PC XT (or better) and the evaluation board. The cable, which is described in Appendix E, connects from the PC's parallel port to the eight pin header on the evaluation board. The cable provides the MICROWIRE™ signals (i.e. Data, Clock, and Load Enable) needed to program the LMX series PLL. Since most PC's parallel ports have an output level of 5V, pads for resistive dividers on the Clock, Data, and Load Enable are also included. This will allow low voltage operation of the PLL without overdriving the MICROWIRE™ inputs.

The IF VCO is assumed AC coupled with C21. Resistor R3 in the schematic increases impedance so that VCO output power is provided to the load rather than the PLL. Typical values are 10Ω to 200Ω depending on the VCO power level. Fin IF real impedance ranges from 40Ω to 100Ω. A 50Ω termination is often used on test boards to allow use of a signal generator as the external reference oscillator. For actual manufactured products, a TTL or CMOS clock is typically used and no terminating resistor is required. OSCin may be AC or DC coupled. AC coupling is recommended because the input circuit provides its own bias. Proper use of grounds and power supply decoupling is essential to achieve a high level of performance. Pads for power supply decoupling capacitors are provided.

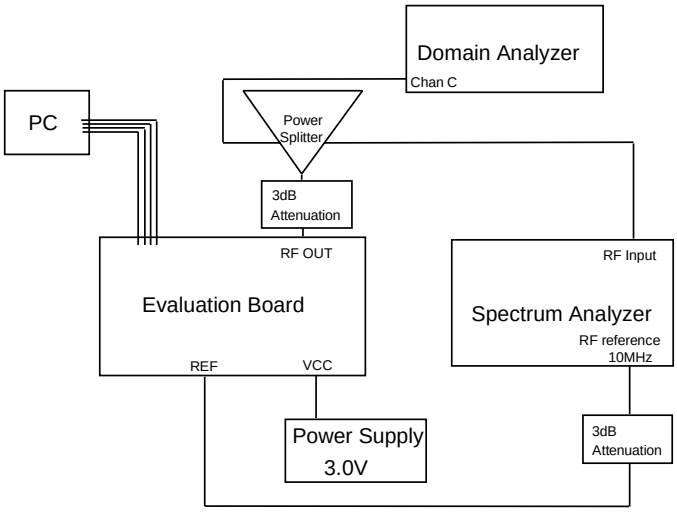
**The LMX series PLL is a static sensitive device. It should be handled only at static free work stations.**

# USING THE EVALUATION BOARD

### Hardware Set-Up Instructions

The user should make the following connections to operate the evaluation board in standard mode: (1) Connect the VCO output **(RF OUT)** to a spectrum analyzer, (2) Connect a reference input within the range 5 MHz to 40 MHz at 0 dBm to the **REF IN** port, (3) Connect the interface cable to the parallel port of the PC and to the pin header on the evaluation board, (4) and connect a power supply to the VCC input (2.7 -5.5 V depending on your application). With both jumpers on the 4 pin voltage header, the VCO and the PLL will run off the same supply. The board is now ready to operate. This configuration is for evaluation purposes only and is not meant to show how the PLL would be used in a system.

The following block diagram shows a typical equipment set-up for evaluating a LMX series PLL. The Spectrum Analyzer can be used to obtain phase noise and reference spur measurements. The Domain Analyzer is used for lock time measurements. For more details on PLL measurements please see National Semiconductor Application Note #885, “Introduction to Single Chip Microwave PLLs”.



**Using the Evaluation Software**

There are two LMX Series Single PLL programs available. LMX2301.EXE is used for LMX2301 PLL. The LMX2305 uses a dual modulus prescaler and requires its own evaluation software. (LMX2305.EXE). Because the programs use extended precision real numbers in their calculations, they may not operate on some older DOS computers. A PC-AT or equivalent is recommended. Although the programs can be run from a DOS shell in Windows 3.1, the preferred method is to run them directly from DOS. Windows 3.1 interrupts can cause variances in the delay time between frequency switches when in the “Switch” tuning mode (see below).

The evaluation programs control the LMX series PLL Evaluation Board via a standard parallel port (see Appendix E). The programs are intended to be easy to install and use, exercise the PLL, and demonstrate typical performance. They are not intended to be representative of the control code which the customer will implement within their application.

Upon power-up, the programs will detect the number and location of parallel ports available to the system. The user will be prompted to select one port. The evaluation programs are menu driven. All menu selections may be made by pressing "Enter" when a menu is highlighted. Up, down, left and right arrows are used to change which menu ID highlighted. Speed keys are also included for each active menu item. The Speed keys are used by typing the letter displayed in red corresponding to the mode desired. The top menu pane consists of pull down menus titled "Set (F)requency", "Set (R)egister", "(T)uning", and "(Q)uit" where the speed keys are listed in parentheses. To exit from a menu at anytime press "Escape". A status panel is included at the bottom of the screen to give on-line help descriptions of highlighted menu items.

The programs display a block showing the present tuning parameters for VCO, Crystal Reference, and Phase detector reference frequency for the PLL. Activate the "Set Frequency" pulldown menu to control these values. To the right of this block is the "Scratchpad", showing the values as you enter them. The programs will issue a warning and a suggestion if a value is selected which does not maintain an integer relationship between the VCO or crystal frequency and the reference frequency. The suggestion will be the nearest value of the parameter just changed which will produce an integer relationship. The user may select this value, or any other, so long as the integer relationship is established. 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 to download the values to the PLL is entering "Load Frequencies”.

The program displays, and allows modification of, the binary values for the VCO divider (N), Reference Divider(R), and control codes. In the LMX2305 software, the value of P (either 64 or 128) shows the present status of the prescaler control bit which enables either the 64/65 prescaler or the 128/129 prescaler. When an N value is entered which is invalid for P=64, the program will display an error message and automatically switch to P=128. To modify N, R or P directly, activate the "Set Register" menu, select the desired mode and use the arrow keys to move horizontally or to change values ("up" changes "0" to "1", "down" changes "1" to "0"). You may also type in "1" or "0".

Users will find items in the "Tuning" menu useful. In "Hand Tune" mode the user may step up or down in single increments by using the up or down arrows, or in increments of 10 by using the left and right arrows. Other steps, 2 up to 9, are taken by pressing any number from 2 to 9. Steps downward are taken by pressing the down or left arrow keys or by holding down the shift key when pressing any number from 2 to 9.

The "Switch" mode in the "Tuning" menu allows measurement of PLL switching time by initiating switching between the presently tuned frequency and a frequency an arbitrary number of steps away. In "Switch" mode, the user will be prompted for an integer (+ or -) number of steps and a delay (msec). The delay will allow the user to specify the time delay between switching. The "Enable" input forms a fairly good trigger (it is written twice, once for N and once for R). Load time will vary depending upon the processing speed of the computer being used.

The "Auto Tune" mode in the "Tuning" menu allows the user to switch to a set frequency and specify the interval to step in. Entering this mode, the user will be prompted for an integer to step up to, an integer to step by and a delay (msec). The delay allows the user to specify the time delay between steps. This allows a user to verify operation at all channels of interest.

The programs are exited by choosing "Yes, Quit" in the "Quit" menu, which saves the current parameters in a log file. Any mode may be exited by pressing "Enter".

## TROUBLESHOOTING TIPS

- Using magnification, visually inspect the board for cold solder joints, broken, misplaced or partially soldered components, and solder bridges. These items are common causes for partially or non-working boards.

- Verify that the correct voltage levels for Vcc, Vp and Vco are actually getting to the places they need to (i.e. measure the voltage at the PLL and VCO pins, not at the edges of the board). Also verify that the Jumpers are set properly for the number of power supplies being used (i.e. if only one supply is being used, both power supply jumpers should be in place).

- Verify that OSCin is getting the proper XTAL frequency and that OSCout is an amplified version of it. Both OSCin and OSCout should have a DC offset.

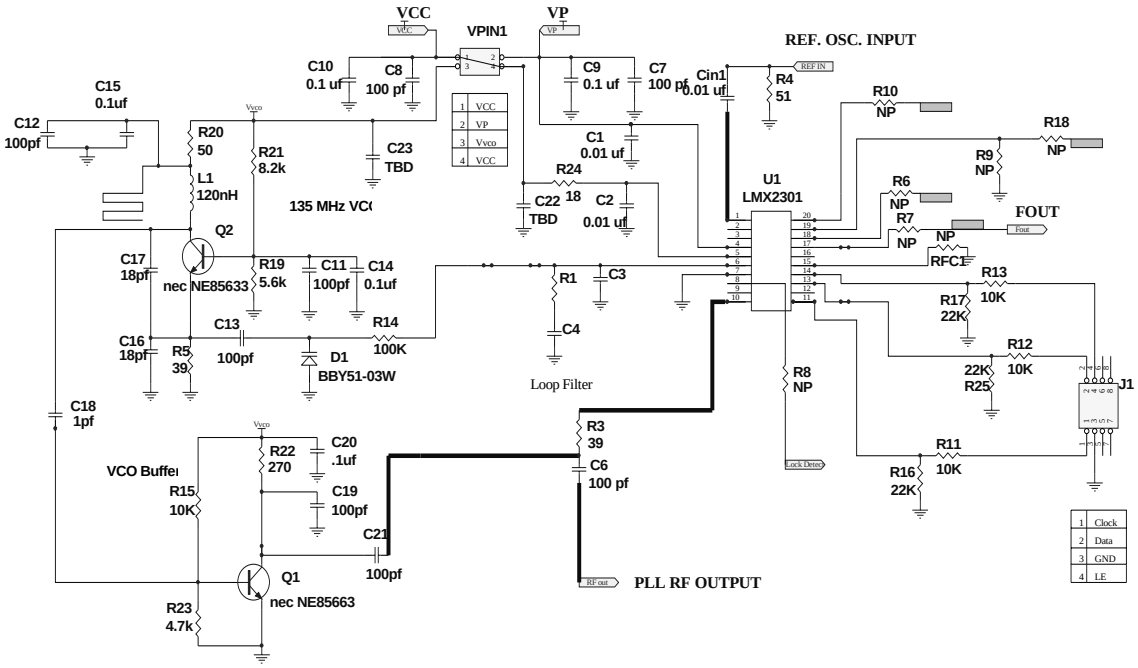
- Verify that the LMX series PLL is getting the proper programming signals by putting the software in “switch” mode and probing the CLOCK, DATA, and LE pins with an oscilloscope. Also verify that the programming signals are at the appropriate level for your application (i.e. if your application is a 3V one, make sure that the 5 volt signals from the PC are being resistivly divided so that they don’t overdrive the PLL inputs.)

- Verify proper values for VCO frequency, Reference frequency, and crystal frequency in the evaluation software.

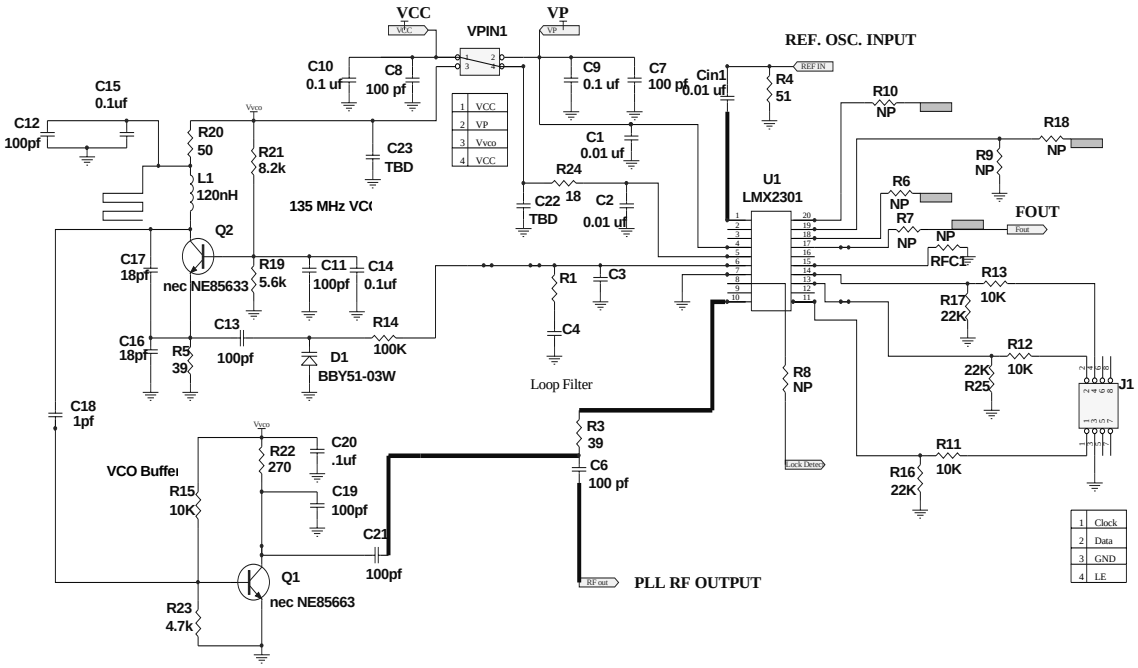
- Verify proper operation of the divider outputs (Fr and Fp).

- Computer monitors and other lab equipment have 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 getting onto the signal through the cable that connects to the parallel port of the computer.

# APPENDIX A: LMX 2301 PLL Evaluation Board Schematic



# APPENDIX B: LMX 2305 PLL Evaluation Board Schematic

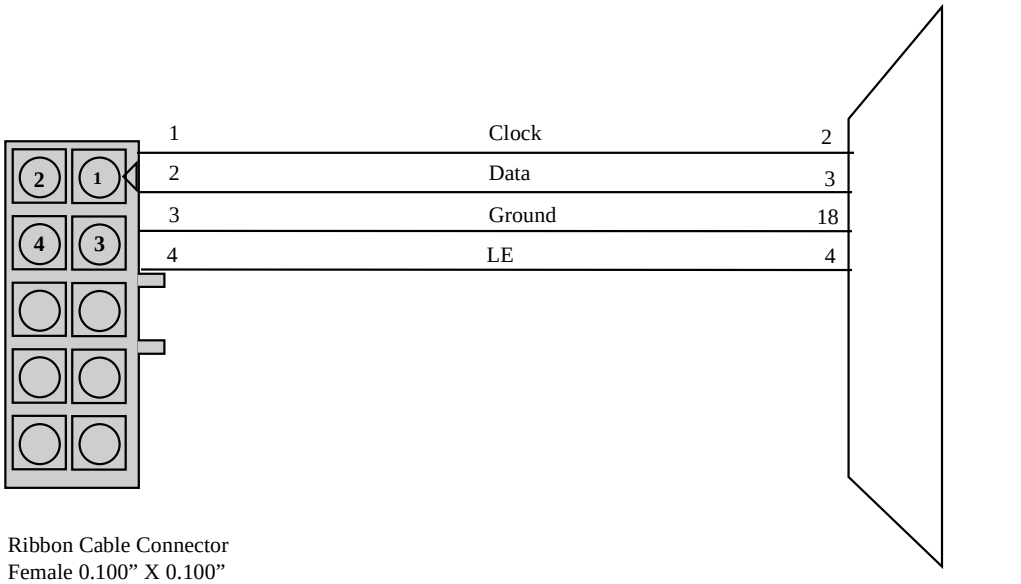


# APPENDIX C: LMX 2301 PLL Evaluation Board - Bill of Materials

| Part | Used | PartType | Designators |
|---|---|---|---|
| 1 | 3 | | C5 J1 VPIN1 |
| 2 | 3 | .01uf | C1 C2 C3 |
| 3 | 1 | .1uf | C4 |
| 4 | 4 | .01uf | C20 C22 C23 Cin1 |
| 5 | 2 | 0.1uf | C14 C15 |
| 6 | 1 | 0 ohm | R2 |
| 7 | 1 | 1pf | C18 |
| 8 | 2 | 1uf | C9 C10 |
| 9 | 1 | 3.3K | R23 |
| 10 | 1 | 3.9K | R1 |
| 11 | 1 | 5.6K | R21 |
| 12 | 2 | 5.6pf | C16 C17 |
| 13 | 4 | 10K | R11 R12 R13 R15 |
| 14 | 1 | 18 | R24 |
| 15 | 3 | 22K | R16 R17 R25 |
| 16 | 1 | 27pf | C21 |
| 17 | 1 | 39 | R5 |
| 18 | 2 | 51 | R4 R20 |
| 19 | 1 | 56K | R19 |
| 20 | 1 | 82nh | L2 |
| 21 | 1 | 100K | R14 |
| 22 | 7 | 100pf | C6 C7 C8 C11 C12 C13 R3 |
| 23 | 1 | 220nh | L1 |
| 24 | 1 | 680 | R22 |
| 25 | 1 | 8200pf | C19 |
| 26 | 2 | B12V105 | Q1 Q2 |
| 27 | 1 | BBY51-03W | D1 |
| 28 | 1 | LMX2301 | U1 |
| 29 | 8 | NP | R6 R7 R8 R9 R10 R18 R26 RFC1 |
| | 2 | Shunts 0.100 Doublewipe contacts | |
| | 1 | Surface mount Header 0.100X0.100 Double Row 6 position | |
| | 1 | Surface mount Header 0.100X0.100 Double Row 4 position | |
| | 3 | SMA PC Mount End Launch Jack Recepticles for RF out,REF, and VCC | |

# Change the following components for the LMX2305

| | | | | | | |
|---|---|---|---|---|---|---|
| C3 1500pf | C4 .022uf | C5 150pf | C16 4.7pf | C17 15pf | C19 100pf | C21 100pf |
| Cin1 100pf | L1 0ohm | L2 270ohm | U1 LMX2305 | R1 15K | R2 120K | |
| R3 39ohm | R5 75ohm | R20 390ohm | R21 8.2K | R22 0ohm | R23 4.7K | |




Ribbon Cable Connector
Female 0.100” X 0.100”
Double Row 10 Positions
(Only 4 positions are used)

DB25 P
Male Connector