N *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 (via modem or the internet) 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 LMX2325//LMX2320//LMX2315//LMX1511 series single PLL Evaluation Board is an implementation of the schematic shown in Appendix A. The board, shown in Appendix B, consists of locations for an LMX series single PLL, a modular RF 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. Loop filter components and the RF VCO are not listed in the bill of materials. These components are determined by the user depending upon his/her application. A list of VCO manufacturers can be found in Appendix D of this document. 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 RF VCO is assumed AC coupled. Resistor R13 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 RF 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.

OBTAINING THE EVALUATION BOARD SOFTWARE

The evaluation board software can be obtained via an anonymous ftp site at National Semiconductor. This method is the easiest approach. If you do not have access to the internet, the evaluation software can also be obtained via modem by using National's Dial-A-Helper service. The two files of interest for single PLL users are:

LMX2325.EXE	**Evaluation software for the LMX2325**
LMX2320.EXE	**Evaluation software for all other single PLLs**

Access from the Internet

Ftp to **nscmicro.nsc.com (139.187.71.5)** and login as **anonymous**. The files can be found in **/pub/wireless/pll/software**. Remember to set file transfer type to BINARY before downloading the files. If you are unfamiliar with ftp, please see your local system administrator.

Access from Modem

Dial-A-Helper has four modems that operate at V.42bis (14,400 bits per second data transfer). The phone number for these four modems is 1-800-NSC-MICRO (1-800-672-6427). This is available 24 hours, 7 days a week from Canada/U.S. only. The modems are universally compatible with all ITU-T (formerly CCITT) standard V.42bis, V.32bis, V.32, V.22bis, Bell 211A/V.22, V.23, V.25 and Bell 103/V.21 modems. They are set for the following modes:

- 8 data bits, No parity, 1 Stop Bit.
- V.42/MNP2-4 Error Control.
- V.42bis/MNP 5 data compression.
- Supports 14400, 12000, 9600,4800, 2400, 1200, 300 bps data transmission.

Download the software by following these steps:

1. If it is your first time using Dial-A-Helper, type **new** at the login prompt.
2. Next, sign-up as a new user by typing **apply** and then following the prompts given to you. During the process, you will choose a user-id and password. On subsequent logins, type **akcs** and then login in using your user-id and password.
3. After logging in, type **join nsc.wless.pll**
4. Now type **read** followed by the number of the filename you want to download.
5. Next, type **attach**. The system will then ask if you want to queue the specified file. Type **Y**.
6. Type **download**
7. The system will then ask you to select a downloading protocol (Kermit, Zmodem, Xmodem).

8. After selecting a protocol, escape back to your local computer and invoke a receive command from your communications software. **Make sure that the transfer is a BINARY transfer**, an ASCII transfer will not properly download an executable file.
9. The system will notify you when the transfer has been completed.

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".
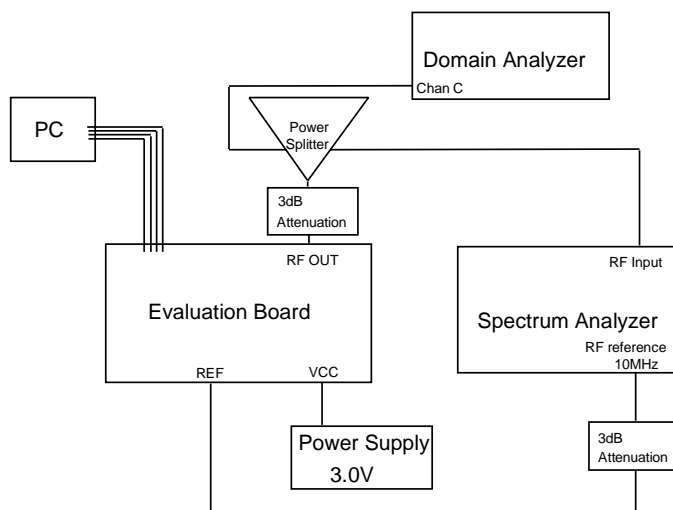
PLLATINUM™ **E**VALUATION **B**OARD
SINGLE **PLL** (20 **PIN**) **V**ERSION

Using the Evaluation Software

There are two LMX Series Single PLL programs available. LMX2320.EXE is used for all Single PLLs except for the LMX2325. The LMX2325 uses a different prescaler and requires its own evaluation software. (LMX2325.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 LMX2320 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. The LMX2325 software behaves similarly to the LMX2320 software in regards to P. However, with the LMX2325 software, the values for P are 32 and 64, selecting the 32/33 and 64/65 prescalers respectively. 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 Series PLL Evaluation Board Schematic
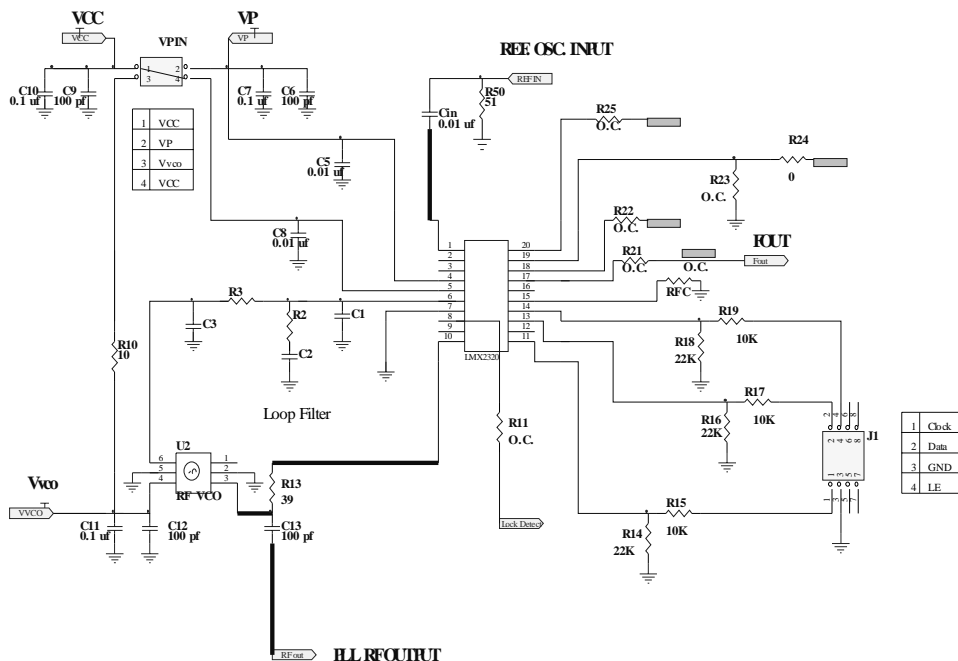
LMX Series Single PLL (20 pin)
3 Volt Operation

APPENDIX B: LMX Series PLL Evaluation Board Layout

N a t i o n a l
S e m i c o n d u c t o r ™
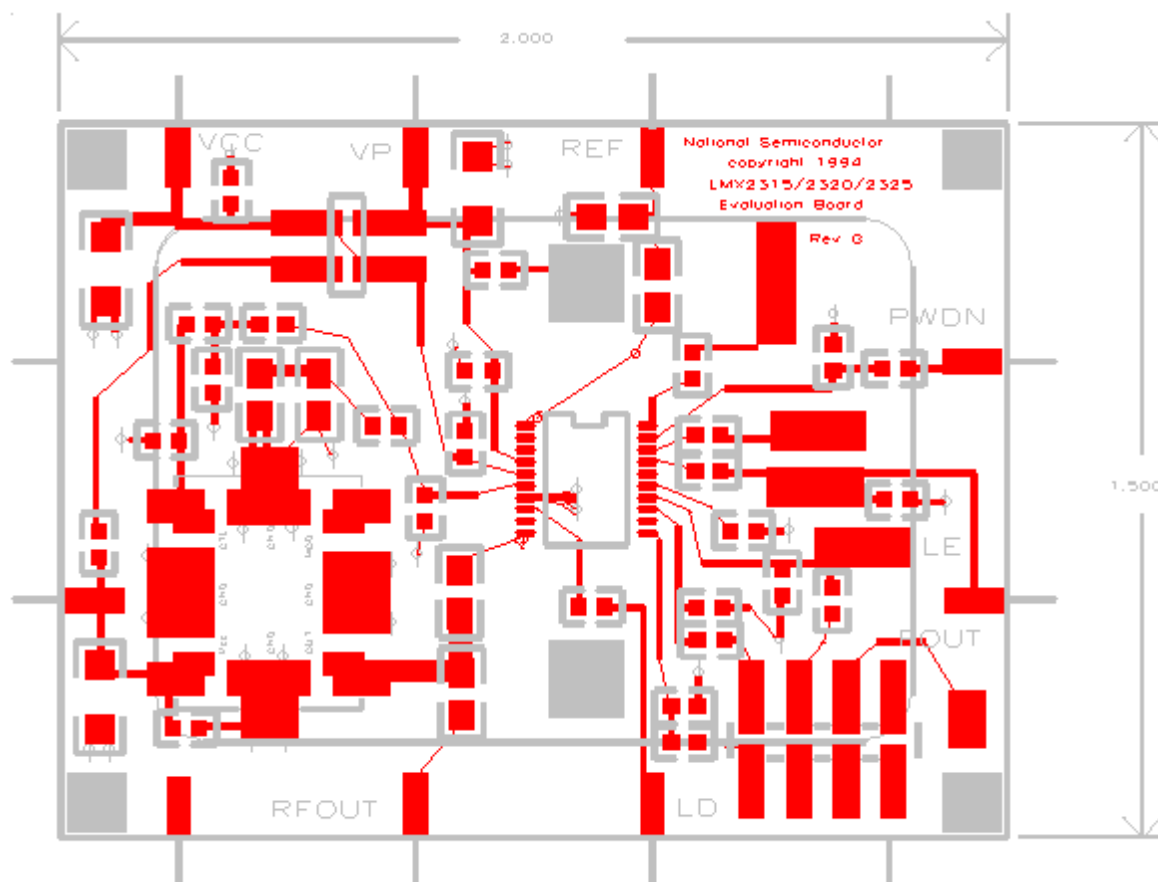
APPENDIX C: LMX Series PLL Evaluation Board - Bill of Materials

QTY	DESCRIPTION	SIZE	LOCATION
4	100 pF	603	C6, C9, C12, C13
2	0.01 uF	603	C5, C8
1	0.01 uF	805	Cin
3	0.1 uF	805	C7, C10, C11
1	10 Ω	603	R10
1	39 Ω	603	R13
1	51 Ω	805	R50
3	10 KΩ	603	R15, R17, R19
3	22 KΩ	603	R14, R16, R18

2	Shunts 0.100" Doublewipe contacts
1	Surface mount Header 0.100" X 0.100" Double Row, 8 position
1	Surface mount Header 0.100" X 0.100" Double Row, 4 position
3	SMA PC Mount End Launch Jack Receptacles for RF out, REF, VCC

Change the following components for specific devices.

LMX1511 and LMX2315   5 volt operation

Alps 934a Vco   C1 1000pF   C2 8200pF   C3 100pF   R2 3.3K   R3 33K   R15,R17,R19 0 ohms remove R16 and R14.

LMX2320   3 volt operation

Murata 1780 Vco   C1 470pF   C2 4700pF   C3 39 pF   R2 6.8K   R3 100K   R15,R17,R19 10K R14,R16,R18 22K.

LMX2325   3 volt operation

Alps 926a Vco   C1820pF   C2 .01uF   C3 10pF   R2.2K   R3 100K   R15,R17,R19 10K R14,R16,R19 22K.

APPENDIX D: VCO Suppliers

ALPS Electric CO., LTD.
1-7 Yukigaya Otsuka-Cho
Ota-Ku Tokyo, Japan 143
Phone: (03) 3726-1211
FAX: (03) 3728-1741

ALPS Components
8141 Kaiser Blvd.
Anaheim, Ca. 92808
Phone (714) 279-1554
Fax (714) 279-1570

Prime Electro Products Co.
(Northern California ALPS Distributor)
653 East Campbell Ave. Suite #2
Campbell, CA 95008
Phone: (408) 374-0707

muRata Manufacturing CO., LTD.
26-10 2-Chome, Tenjin,
Nagaokakyo-shi
Kyoto 617, Japan
Phone: 075-951-9111
FAX: 075-954-7720

muRata Marketing Communications
2200 Lake Park Dr.
Smyrna, GA 30080
Phone: (404) 436-1300
FAX: (404) 436-3030

muRata Europe
Phone: 44 252 811666

Varil
11101 East 51st Ave.
Denver, Co. 80239
Phone (303) 371-1560
Fax (303) 371-0845

APPENDIX E: Parallel port to MICROWIRE™ Interface Cable

1	Clock	2
2	Data	3
3	Ground	18
4	LE	4

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

DB25 P
Male Connector