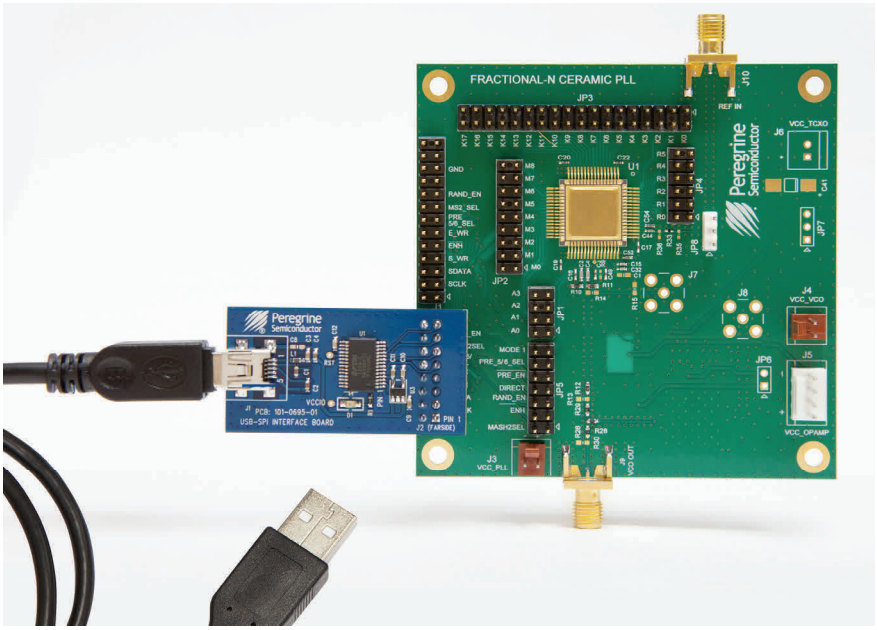
Evaluation Kit
User's Manual

Fractional-N PLL Frequency Synthesizer
PE97640



9380 Carroll Park Drive • San Diego, CA 92121 USA • Phone 858-731-9400 • Fax: 858-731-9499

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Introduction

The PE97640 is a high-performance fractional-N PLL capable of frequency synthesis up to 5 GHz. The device is designed for superior phase noise performance for use in commercial space applications. The PE97640 includes a dual modulus prescaler capable of dividing the VCO frequency by either 5/6 or 10/11, depending on the value of the modulus selected.

The PE97640 PLL evaluation kit includes the application software and hardware required to control and evaluate the functionality of the PLL using a PC running the Windows operating system to control the USB interface board.

Applications Support

For any technical inquiries regarding the evaluation kit or software, please visit applications support at www.psemi.com (fastest response) or call **(858) 731-9400**.

Evaluation Kit Contents and Requirements

Kit Contents

The PE97640 evaluation kit includes all of the specific software and hardware required to evaluate the PLL frequency synthesizer. Included in the evaluation kit:

Quantity	Description
1	PE97640 fractional-N ceramic evaluation board assembly (PRT-54990)
1	Peregrine PLL USB interface board assembly (DOC-02635)
1	USB 2.0 micro B cable
1	Power cable for PE97640
1	Power cable for the VCO
1	Power cable for the op amp loop filter

Software Requirements

The application software will need to be installed on a computer with the following minimum requirements:

- PC compatible with Windows® XP, Vista, 7 or 8
- Mouse
- USB port
- HTML browser with internet access

Hardware Requirements

In order to evaluate the phase noise performance of the evaluation board, the following equipment is required:

- DC power supplies
- DC cables
- External TCXO or other low-noise source (see Appendix A)
- Phase noise test set or signal source analyzer

CAUTION: The PE97640 PLL evaluation kit contains components that might be damaged by exposure to voltages in excess of the specified voltage, including voltages produced by electrostatic discharges. Handle the board in accordance with procedures for handling static-sensitive components. Avoid applying excessive voltages to the power supply terminals or signal inputs or outputs.

PE97640 PLL Evaluation Board Assembly

Overview

The evaluation board is assembled with a PE97640 fractional-n frequency synthesizer, an on-board VCO and a third order active loop filter. The loop filter is followed by a low pass filter to filter out high frequency noise. The VCO tuning range is from 3901–4101 MHz. The active loop filter is designed for a 50 MHz comparison frequency, a 4000 MHz output frequency with unity gain crossover at 300 kHz and a phase margin of 45 degrees. The data provided was measured with an external 100 MHz TCXO for best phase noise performance.

Figure 1. PE97640 Evaluation Board Showing Front-side Assembly

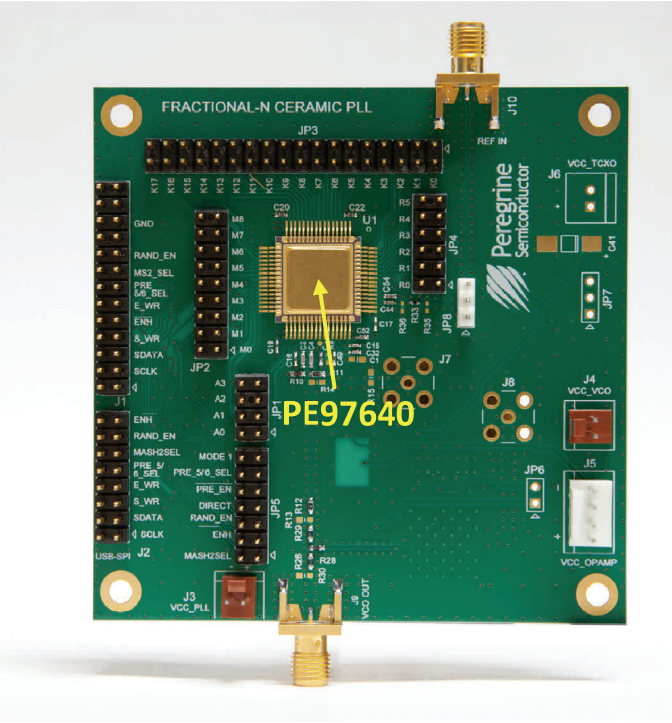
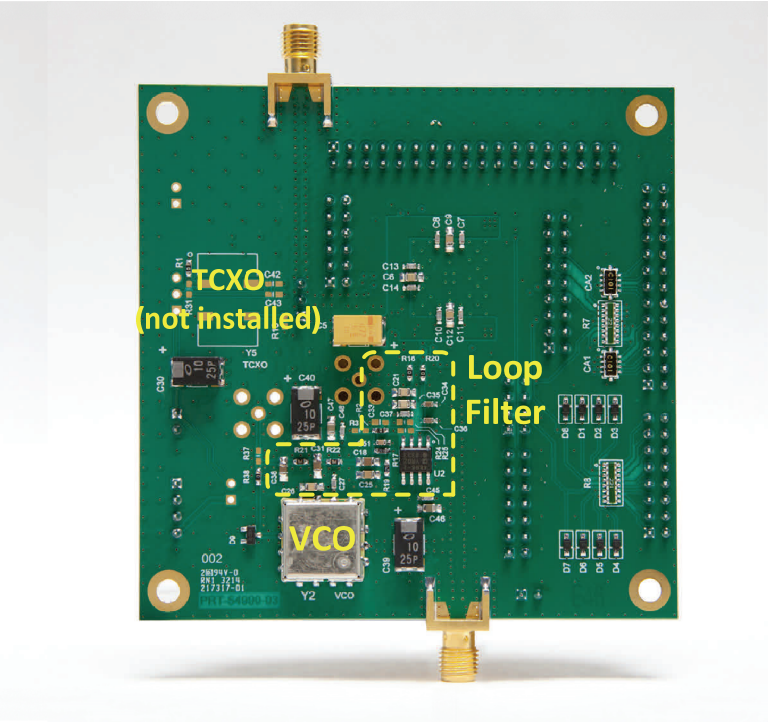


Figure 2. PE97640 Evaluation Board Showing Back-side Assembly

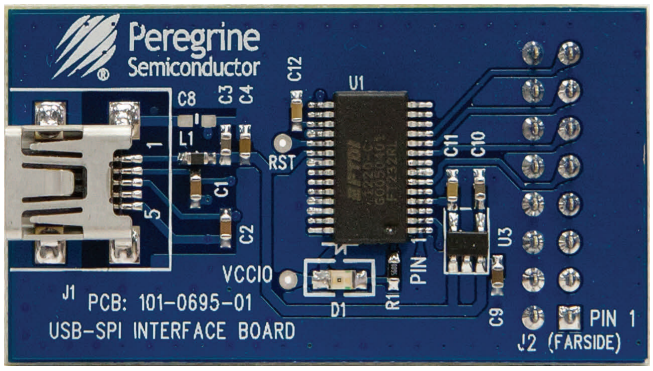


USB Interface Board

USB Interface Board Overview

A USB interface board is included in the evaluation kit. This board allows the user to send SPI commands to the device under test by using a PC running the Windows® operating system. To install the software, extract the zip file to a temporary directory and follow the installation procedure included.

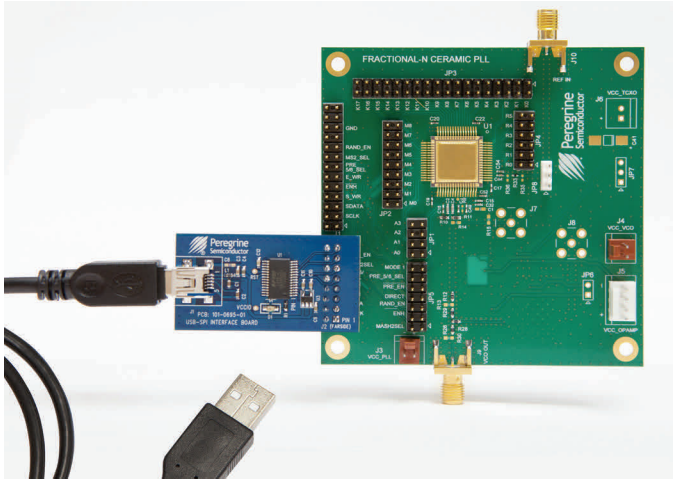
Figure 3. PLL USB Interface Board



Connection of the USB Interface Board to the Evaluation Board

The evaluation board and the USB interface board contain a keyed 16-pin header. This feature allows the USB interface board (socket) to connect directly to the evaluation board (pin) on the front-side as shown in *Figure 4*.

Figure 4. PLL USB Interface Board Connected to the PE97640 Evaluation Board for Serial Programming

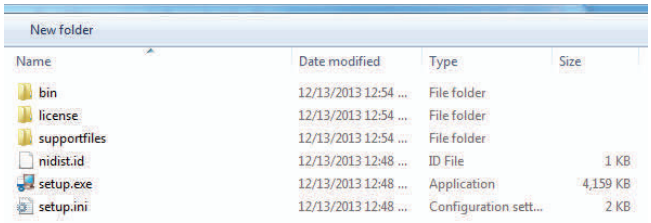


EVK Software Installation

In order to evaluate the PE97640 performance using Serial programming mode, the application software has to be installed on your computer. The USB interface and PLL application software is compatible with computers running Windows® XP, Vista, 7 or 8—32-bit or 64-bit configurations. This software is available directly from Peregrine's website at www.psemi.com.

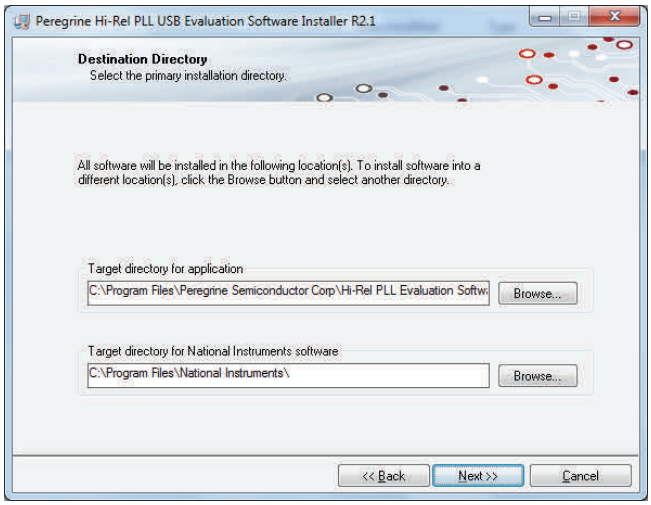
To install the PLL evaluation software, unzip the archive and execute the "setup.exe."

Figures 5(a)-(c). Application Software Installation Procedure



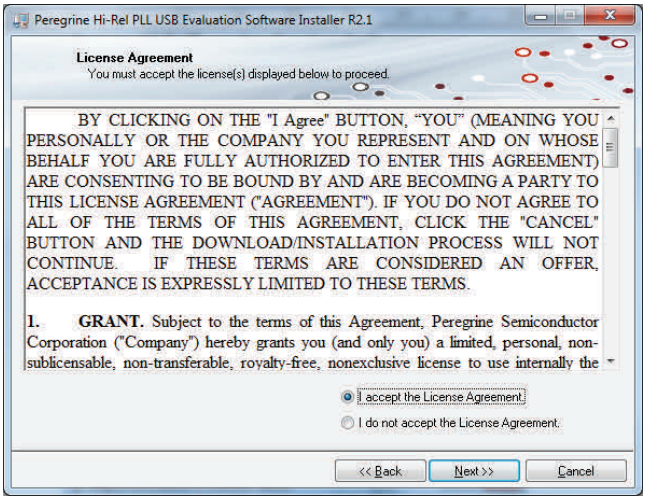
After the setup.exe file has been executed, a welcome screen will appear. It is strongly recommended that all programs be closed prior to running the install program. Click the "Next>>" button to continue.

For most users the default install location for the program files is sufficient. If a different location is desired, the install program can be directed to place the program files in an alternate location. Once the desired location is selected, click the "Next >>" button to proceed.

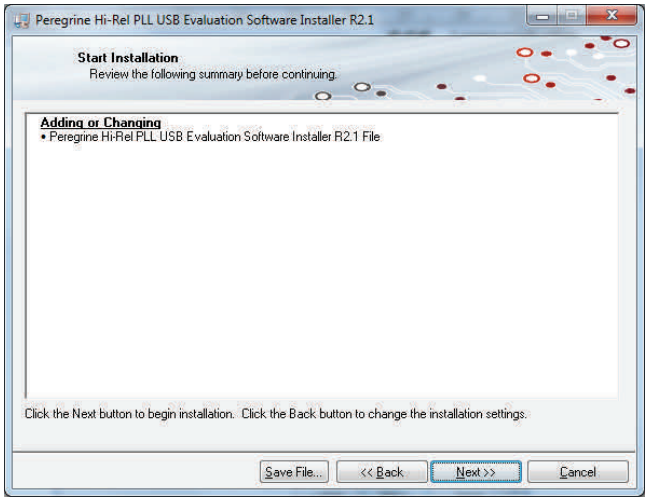


Figures 5(d)-(f). Application Software Installation Procedure

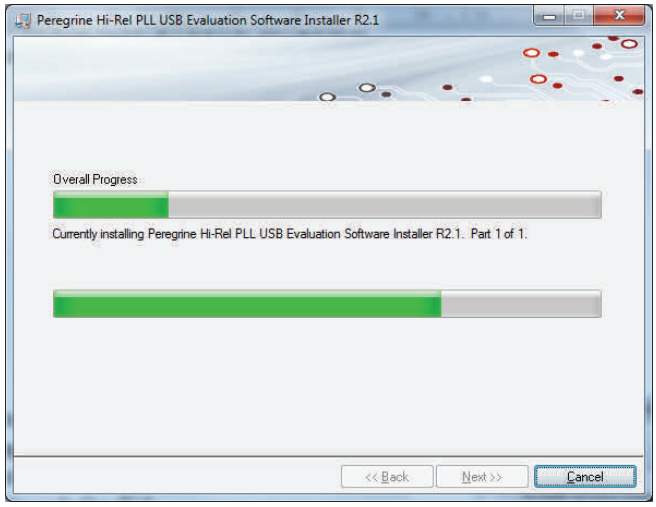
Take a moment to read the License Agreement, then click “I accept the License Agreement” and “Next>>.”



The next installation screen starts the installation process. If the PLL application software is already installed, the installer will update the files to the newest version.



As the software files are installed, a progress indicator will be displayed. On slower computers, installation of the software may proceed for a few moments.



Once the program is installed a new Start Menu item under Peregrine Semiconductor will appear in the start menu of your computer. Select “PLL Hi-Rel Evaluation Software” to launch the graphical user interface (GUI).

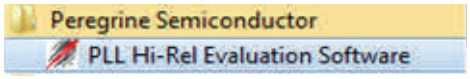
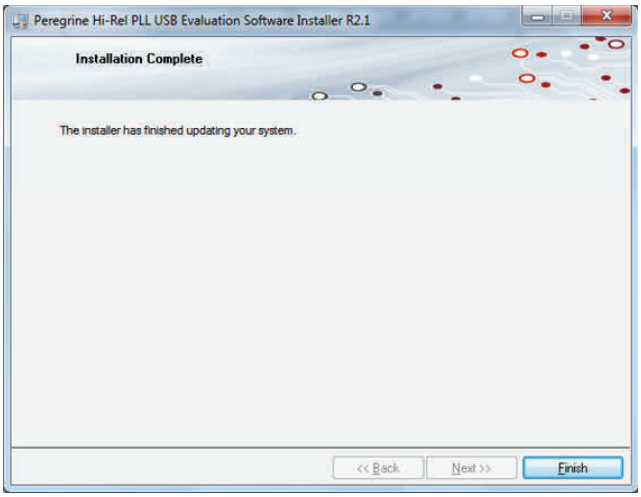


Figure 5(g). Application Software Installation Procedure



Using the Application Software Graphical User Interface

Ensure the USB interface board is plugged into the computer and connected to the EVK before launching the software. Upon execution, the PLL control screen will be displayed. If the USB interface board is not connected when the application software is launched, the message "The USB interface board is not connected. Please connect it and restart the program." will appear at the bottom of the screen.

In the upper left corner, under the Peregrine logo, there is a drop-down menu item to select the part for evaluation. This is an important drop-down item as it determines which serial peripheral interface and telegram structure the program will send to the parts under test. It is important to select the part being evaluated. Selecting the wrong part number may result in sending improper commands to the PLL under test, yielding unpredictable test results.

Once the part number to test has been selected, the part number will appear in place of the Select Part location on the GUI. The software is now ready to use.

Figure 6. PLL Application Software GUI

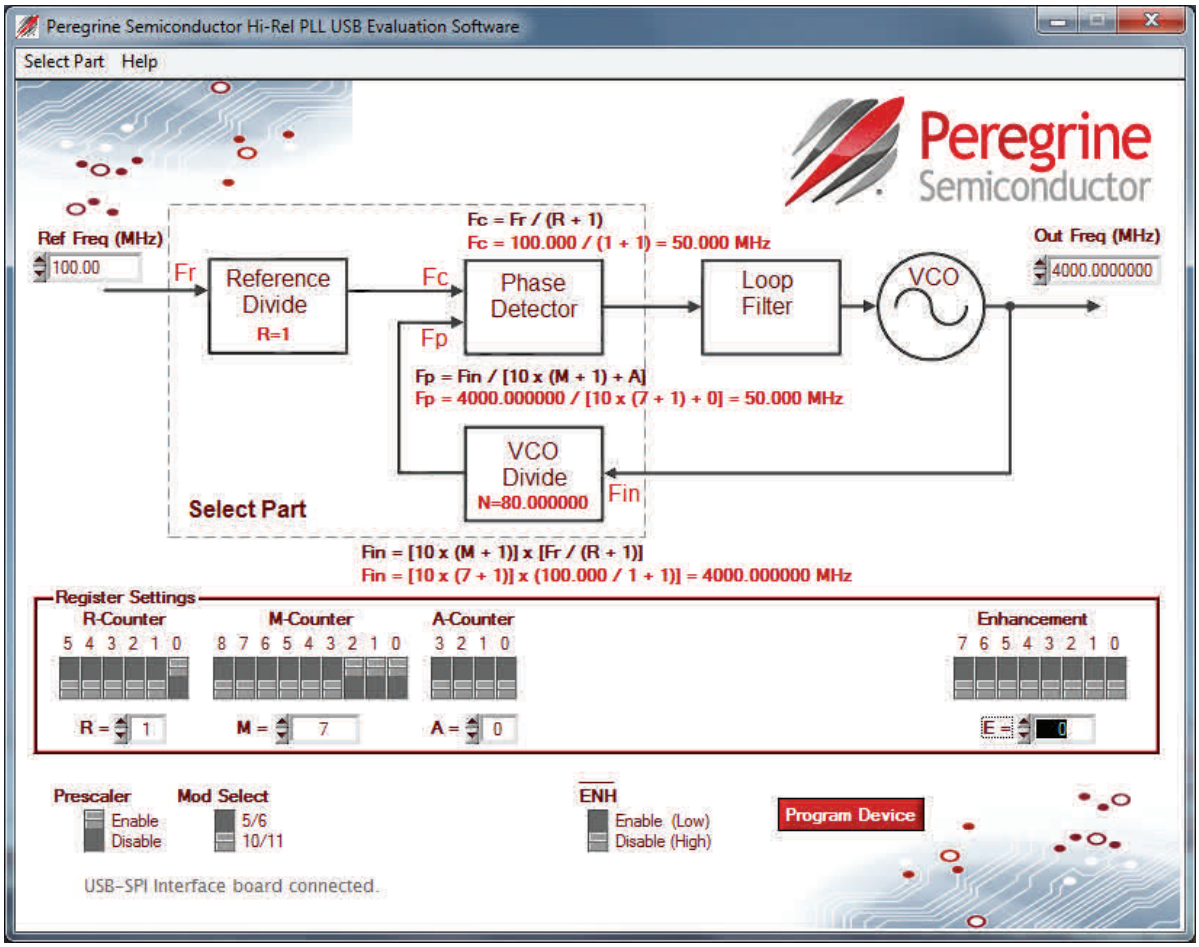


Figure 7. PLL GUI Control Bits

Prescaler

Enabling the prescaler control bit activates the 5/6 or 10/11 prescaler. The prescaler can be set to either a 5/6 or 10/11 modulus based on the Mod Select pin. Disabling the prescaler control bit allows F_{IN} to bypass the 5/6 or 10/11 modulus. In this mode, the prescaler and A counter are powered down and the input VCO frequency is divided by the M counter directly.

Mod Select

Selects prescaler modulus of 5/6 or 10/11. 10/11 prescaler modulus is recommended for 4 GHz to 5 GHz operation only.

RAND_EN

K register LSB toggle enable. Enabling this control is equivalent to having an additional bit for the LSB of K register and has the benefit of reducing the spurious levels. However, a small, positive frequency offset will occur which is calculated from $F_{OFFSET} = [F_R / (R + 1)] / 2^{19}$.

In the fractional operation of the part, if K values are chosen such that there are several trailing zeros (like K = 65536), there will be an accumulation of random values in any lower unused bits. This accumulation causes additional fractional spurs to show up. Enabling the RND_SEL bit will cause the DSM to spread this spur energy over frequency. If the frequency offset or alternate K value cannot be tolerated, the accumulated values may be cleared by toggling bit 4 of the enhancement register and then re-programming the K register.

MASH2SEL

MASH is a **M**ulti-st**A**ge noise **SH**aping decimation structure for reducing fractional spurs. Setting the MASH2SEL control 1-1 enables MASH-1-1 mode and 1-1-1 enables MASH-1-1-1 mode. MASH-1-1 has a 40 dB/dec slope away from the carrier while MASH-1-1-1 has a 60 dB/dec slope.

$\overline{\text{ENH}}$

Enhancement mode. When enabled (“Low”), the enhancement register bits become functional. Setting the control bit “Low” will either put the part into a shutdown state and the phase detector output will have no output pulse, or it will go into a reset state and the phase detector will have no output pulse similar to the shutdown state. Refer to *Table 9* in the PE97640 datasheet for the enhancement register bit functionality.

Low Noise Mode

The low noise mode (LNM) jumper located on the Mode 1 position of JP5 is used to improve the phase noise of the PE97640. During normal operation, the charge pump can generate digital noise, which can result in slightly higher phase noise. LNM can be used to keep noisy digital events consistently the same at critical moments when the charge pump is on. The following conditions apply to the programming of the M and A counters for each mode of operation.

5/6 Prescaler

Normal mode

Sometimes simply using A > 4 alone without activating LNM can achieve similar phase noise improvement as LNM. In these cases, using normal mode is preferred because the limitation of equation (12) under LNM will not apply. What will apply for A > 4 becomes $M \geq A-2$ or equivalently, $A \leq M+2$, which is less restrictive.

Minimum N = 23 (M=3, A=3) ***(1)***
$\boldsymbol{A \leq 4}$ ***(2)***

LNM

For 5/6 prescaler mode, the M and A counters in normal mode are equivalent to M–1 and A+5 in LNM. In normal mode, A=0 to 4 are typically used, which has only five A codes needed to fully program contiguous frequencies. In LNM, A=3 to 7 or A=4 to 8 can be used, which still guarantees five A codes to provide fully contiguous frequencies.

$\boldsymbol{3 \leq A \leq 11}$ ***(3)***
$\boldsymbol{M \geq A+3}$ ***or equivalently,*** $\boldsymbol{A \leq M-3}$ ***(4)***

10/11 Prescaler

Normal mode

In 10/11 prescaler mode, the M and A counters in normal mode are equivalent to M–1 and A+10 in LNM. In normal mode, A=0 to 9 are typically used and in most cases, A=0, 1, 2, 7, 8 and 9 may exhibit slightly higher phase noise compared to LNM. In these cases, a user should program both M and A=0 to M–1 and A=10, and M and A=1 to M–1 and A=11.

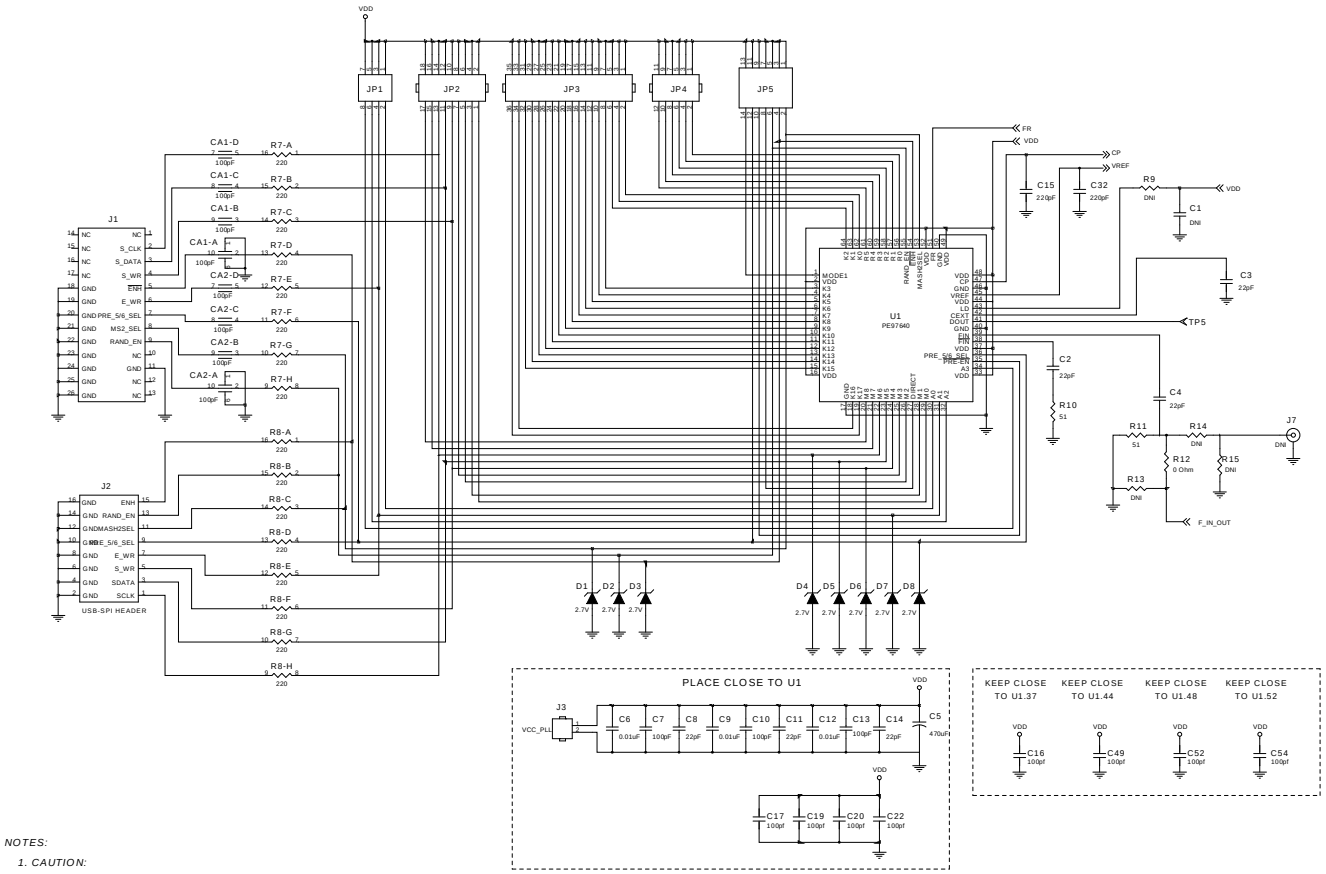
Minimum N = 93 (M=8, A=3) ***(5)***
$\boldsymbol{A \leq 9}$ ***(6)***

For all other A values except for A=2, simply enable LNM if the phase noise improvement in LNM is significant compared to normal mode. The following equations define the programming range limitations for the LNM. For A=2, it can only be operated in normal mode.

$\boldsymbol{3 \leq A \leq 11}$ ***(7)***
$\boldsymbol{M \geq A+3}$ ***or equivalently,*** $\boldsymbol{A \leq M-3}$ ***(8)***

Evaluation Board Overview

Figure 8. PE97640 Evaluation Board Schematic



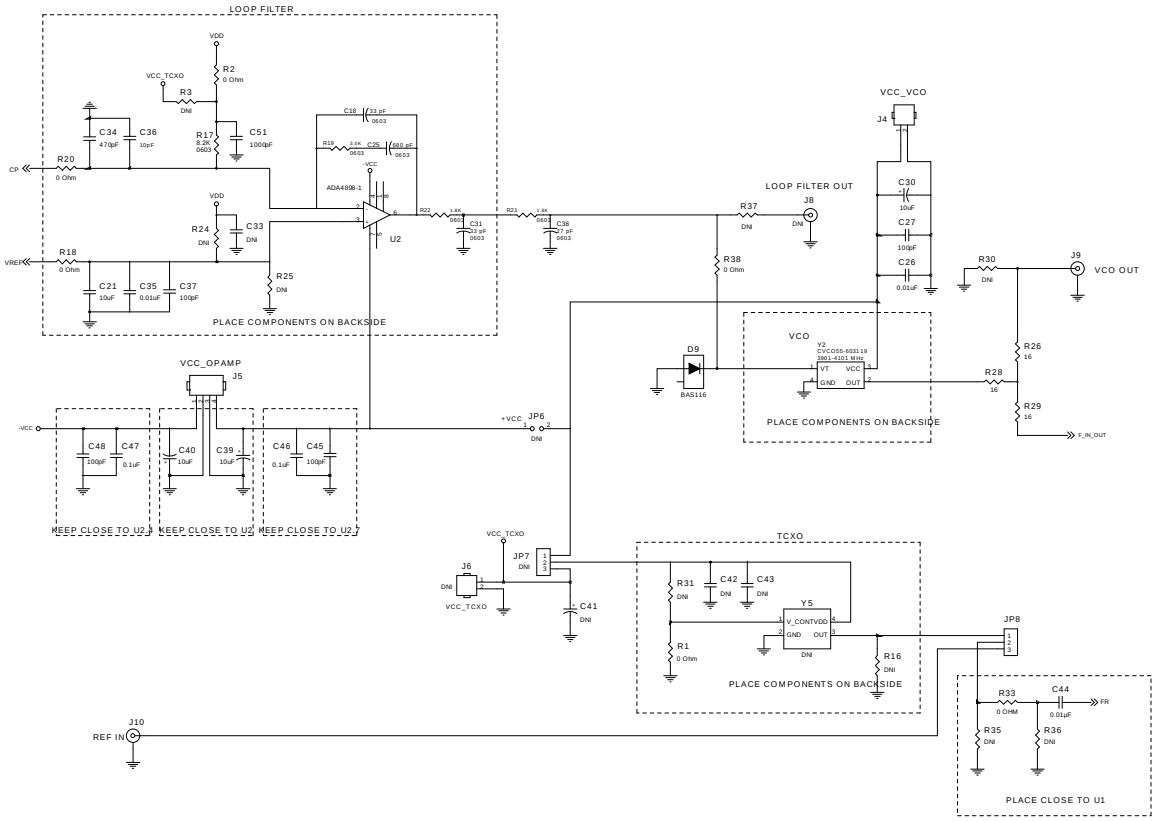
NOTES:

1. CAUTION:

CONTAINS PARTS AND ASSEMBLIES SUSCEPTIBLE TO DAMAGE BY ELECTROSTATIC DISCHARGE (ESD).

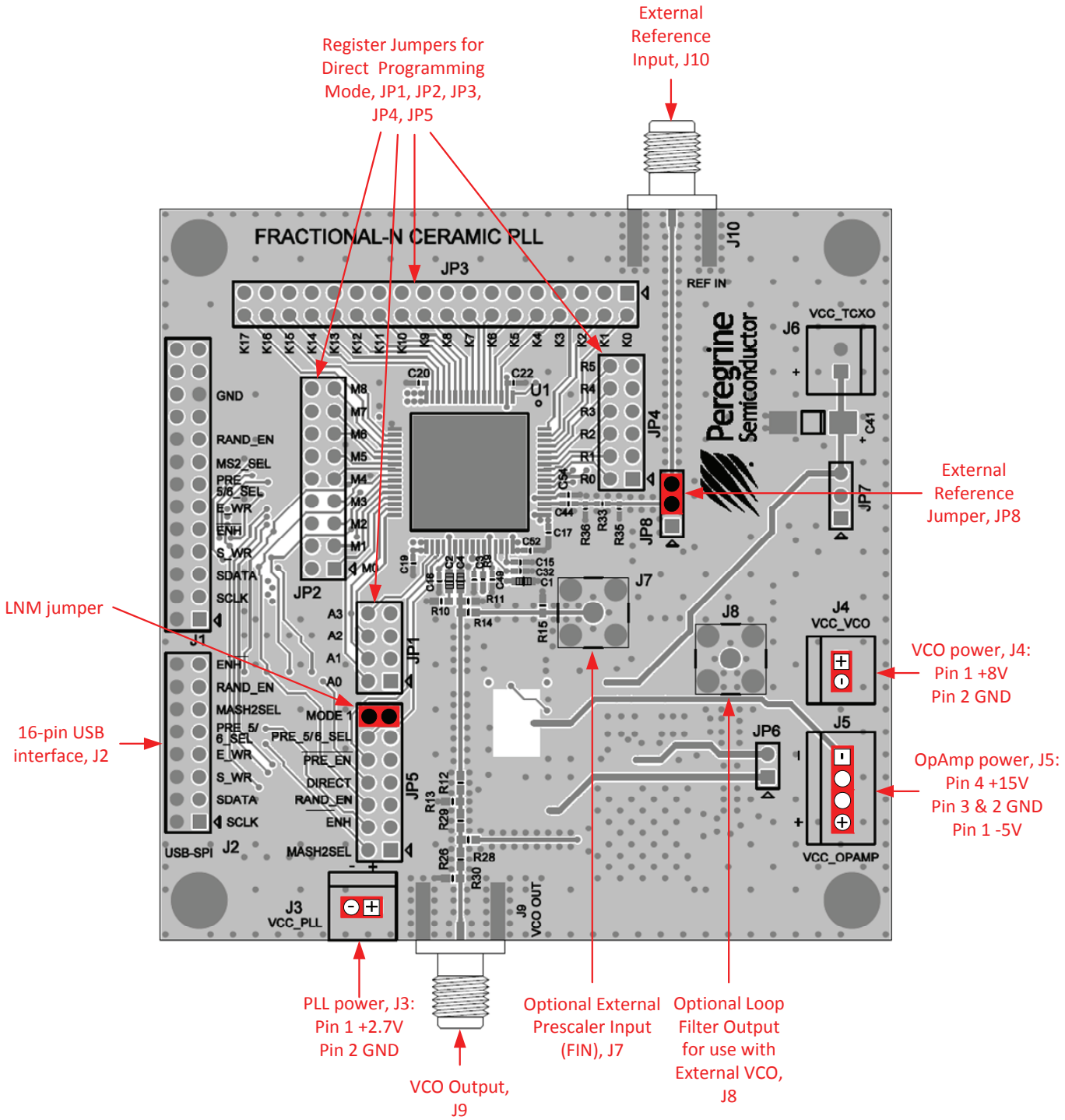
Evaluation Board Overview

Figure 8. PE97640 Evaluation Board Schematic (cont.)



Evaluation Board Overview

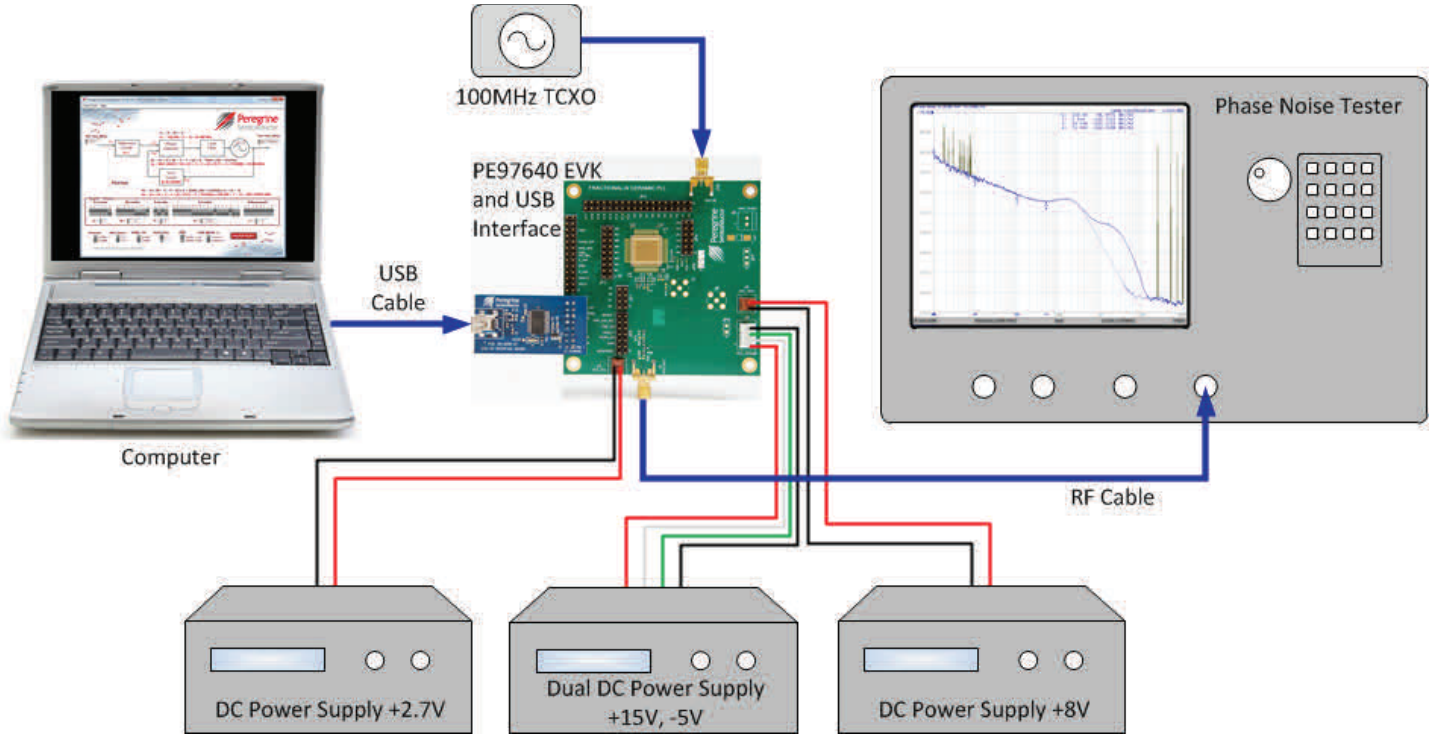
Figure 9. PE97640 Evaluation Board Outline Showing Functional Overview



Hardware Operation

1. Refer to the test setup shown in *Figure 10*.
2. Verify that all DC power supplies are turned off before proceeding.
3. Connect +2.7 VDC and GND to J3 on the evaluation board to power the PE97640.
4. Connect +8 VDC and GND to J4 on the evaluation board to power the VCO.
5. Connect +15V, –5 VDC and GND to J5 on the evaluation board to power the Op Amp.
6. Connect the reference source (TCXO) to the external reference port (J10).
7. Connect the phase noise tester to the evaluation board using an RF cable.
8. Turn on the DC power supplies in the following order:
    a. PLL (+2.7V)
    b. VCO (+8V)
    c. Op Amp (+15V and –5V)
9. Connect from the USB interface board to the computer using the USB cable. The red LED on the USB interface board should blink a few times indicating that the hardware is recognized.
10. Connect the USB interface board to J2 on the evaluation board.
11. Launch the application software. Once the GUI is open, the red LED on the USB interface board should remain on. The evaluation software is now ready to use.
12. Select the part to be tested from the menu bar on the GUI.
13. Set the registers values and control bits on the GUI to obtain the required frequency and operation modes.
14. Click the Program Device button on the GUI to program the PLL.

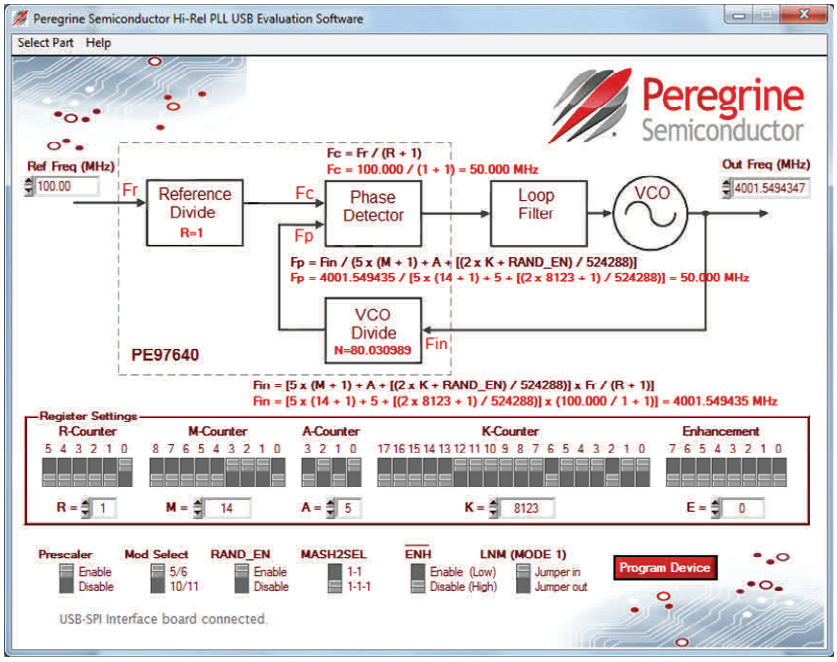
Figure 10. Suggested Test Setup for Evaluating Phase Noise

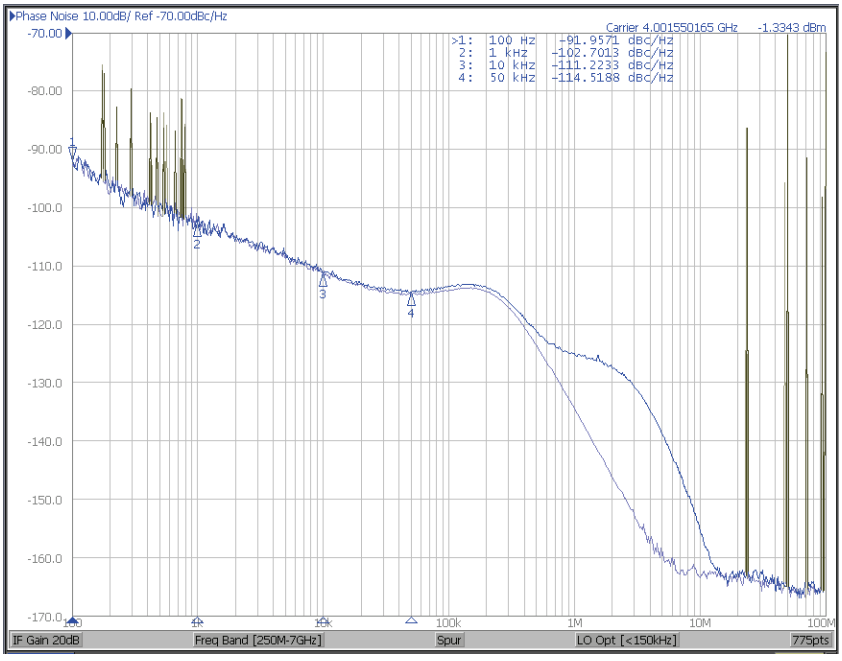


EVK Testing Using the Graphical Interface

Figure 11 shows the resulting phase noise measurement with the PE97640 evaluation board operating at a 50 MHz comparison frequency with a 4 GHz VCO in low noise mode and the 5/6 prescaler mode selected. (R = 1, M = 14, A = 5, K = 8123, Prescaler = Enable, Mod Select = 5/6, RAND_EN = Enable, MASH2SEL = 1-1-1, $\overline{\text{ENH}}$ = Disable and LNM [mode 1] Jumper in). The second trace shows phase noise response in integer-n mode (K = 0, RAND_EN = Disable).

Figure 11. PE97240 Evaluation Board Test Example

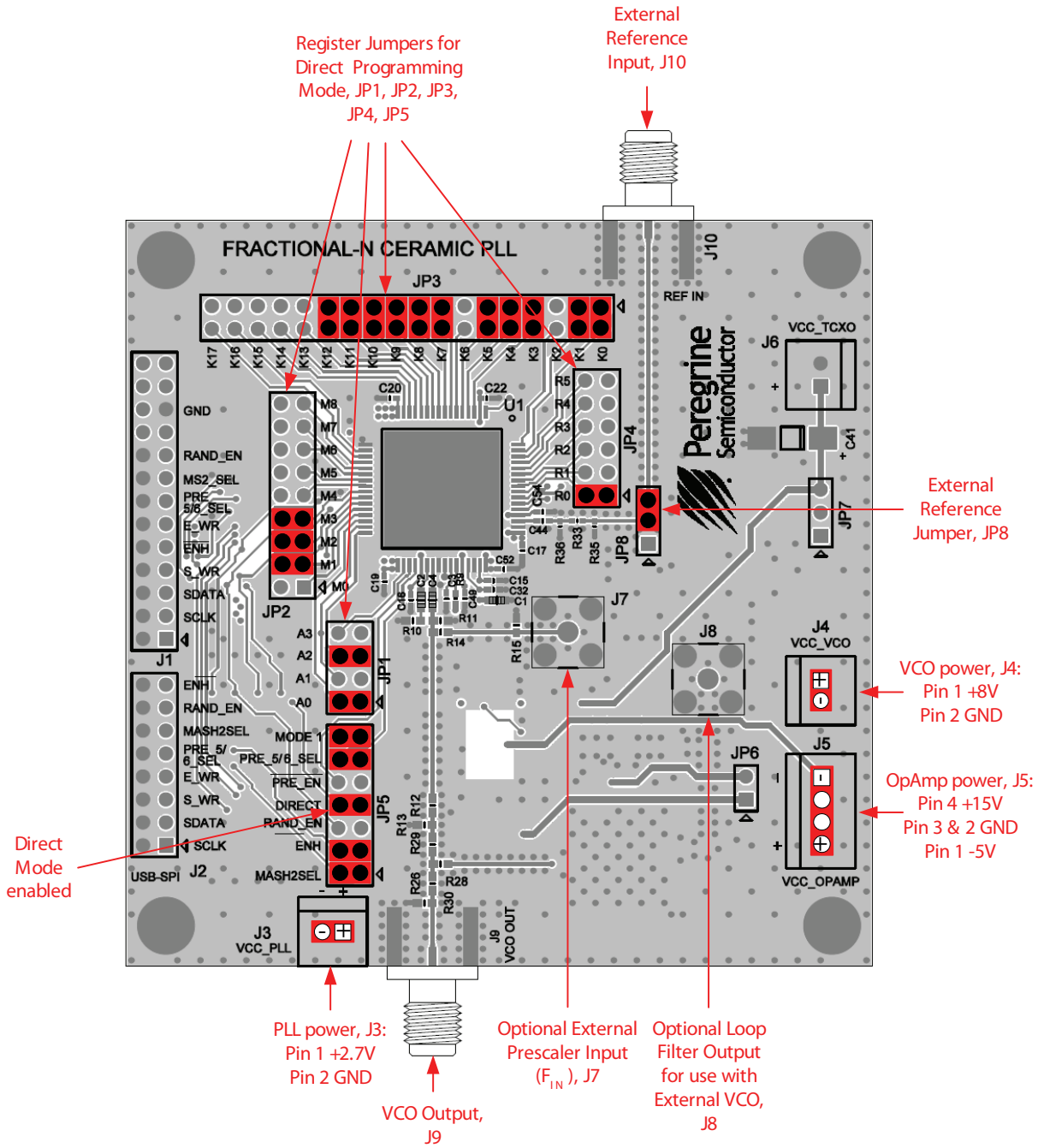




Direct Programming Mode

Direct programming mode allows for manual evaluation of the EVK without the application software. However, it is handy to have the GUI open to determine the values of the R, M and A register settings needed. The counters can then be set directly with on-board jumpers (JP1, JP2, JP4 and JP5) as shown in *Figure 12*. To enable direct mode programming, both the $\overline{\text{ENH}}$ and the Direct programming jumpers (JP5) should be installed.

Figure 12. Direct Programming Mode Settings from Test Example



Troubleshooting Tips

The message, "The USB interface board is not connected. Please connect it and restart the program," re-appears after closing and restarting the application software.

1. Close the program. Make sure the USB interface board is connected. Restart the application software.
2. Verify that the USB interface board is well connected. Remove the USB cable from the computer and reinsert it. Restart the application software.
3. Go to http://www.ftdichip.com/Drivers/D2XX.htm and follow the instructions for downloading the latest version of the D2XX driver software for your computer's operating system. Repeat step 1.

If any of the following occur, go to http://www.ftdichip.com/Drivers/D2XX.htm and follow the instructions for downloading the latest version of the D2XX driver software for your computer's operating system.

- An error message states the driver software not found for FT232R USB UART.
- The application software does not close or causes the computer to lock up.
- The application software does not work with Windows 8 or on a 64-bit operating system.

Technical Resources

Additional technical resources are available for download in the Products section at www.psemi.com. These include the Product Specification datasheet, evaluation kit schematic and bill of materials, PC-compatible software file, evaluation kit instruction manual, phase noise loop filter calculation spreadsheet and application notes.

Sales Contact and Information

Contact Information:
e2v ~ http://www.e2v-us.com ~ inquiries@e2v-us.com

Appendix A

The PE97640 is characterized using a 100 MHz, ultra low noise OCXO frequency reference. An exceptionally clean reference oscillator will ensure that the reference noise does not limit the phase noise measurement results. The following table shows the typical phase noise of the OCXO operating at 100 MHz.

Appendix Figure 1. Typical Specifications for the PE97640

Typical Specifications:						
Frequency *(Specify)*		30 to 130 MHz				
Frequency		50		100		MHz
Output Level		+13				dBm
Aging		$\pm 1 \times 10^{-6}$ / year				
Phase Noise						
	100 Hz	-130	-136	-125	-130	dBc/Hz
	1 kHz	-160	-164	-150	-158	dBc/Hz
	10 kHz	-174	-176	-174	-176	dBc/Hz
	20 kHz	-174	-176	-174	-176	dBc/Hz
Temperature Stability *(Specify)*		$\pm 5 \times 10^{-7}$ to $\pm 2 \times 10^{-7}$				
Range A	0 to +50C					
Range B	0 to +65C					
Range C	0 to +70C					
Range D	-20 to +70C					
Range E	-40 to +70C					
Range F	-55 to +85C					
Electrical Tuning Range *(Specify)*		$\pm 2 \times 10^{-7}$ to $\pm 4 \times 10^{-6}$				
Tuning A	0 to +10 VDC					
Tuning B	±5 VDC					
Supply Voltage *(Specify)*		+12 or +15				VDC
Warm-up Power		5 for 5 minutes				Watts
Total Power *typical*		2.5 at 25°C				Watts
Crystal Type		SC				
Dimensions		44.4 x 74.7 x 25.4				mm
		1.75 x 2.94 x 1				inches
Connectors		SMA on side and solder pins on base				

Sales Contact and Information

Contact Information:
e2v ~ http://www.e2v-us.com ~ inquiries@e2v-us.com