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PE461X0 Evaluation Kit (EVK) User's Manual

Monolithic Phase & Amplitude Controller



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Introduction



Introduction

The PE461X0 is a HaRP™ technology-enhanced monolithic phase and amplitude controller (MPAC) designed for precise phase and amplitude control of two independent RF paths. It optimizes system performance while reducing manufacturing costs of transmitters that use symmetric or asymmetric power amplifier designs to efficiently process signals with large peak-to-average ratios.

This monolithic RFIC integrates a 90° RF splitter, digital phase shifters and a digital step attenuator along with a low voltage CMOS serial interface. It can cover a phase range of 87.2° in 2.8° steps and an attenuation range of 7.5 dB in 0.5 dB steps, while providing excellent phase and amplitude accuracy from 1.8–2.2 GHz (PE46120), 2.3–2.7 GHz (PE46130) and 3.4–3.8 GHz (PE46140).

The PE461X0 also features exceptional linearity, high output port-to-port isolation and extremely low power consumption relative to competing module solutions. It is offered in a 32-lead 6 × 6 mm QFN package.

The PE461X0 evaluation kit (EVK) includes hardware required to control and evaluate the functionality of the MPAC. The MPAC evaluation software can be downloaded at www.psemi.com and requires a PC running Windows® operating system to control the USB interface board.

Application 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 PE461X0 EVK includes the following hardware required to evaluate the MPAC.

Table 1 • PE461X0 Evaluation Kit Contents

Quantity	Description
1	PE461X0 MPAC evaluation board assembly (PRT-55151)
1	Peregrine USB interface board assembly (PRT-50866)
1	USB 2.0 Type A to Type B mini cable

Software Requirements

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

- PC compatible with Windows XP, Vista, 7, 8 or 10
- Mouse or other pointing device
- USB port
- HTML browser with internet access
- Administrative privileges

Hardware Requirements

In order to evaluate the performance of the evaluation board, a Vector network analyzer is required.

Caution: The PE461X0 MPAC EVK 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.

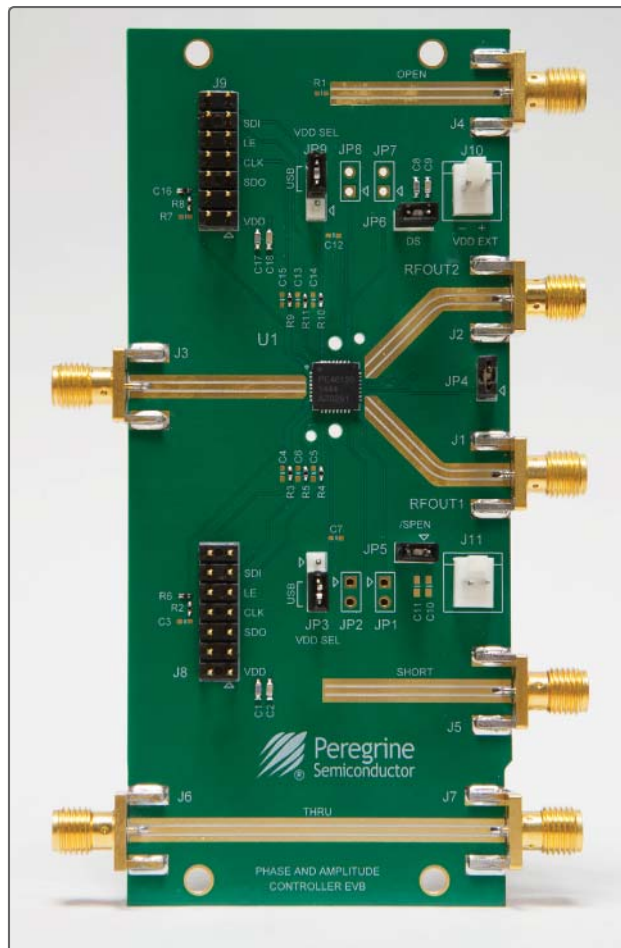
Evaluation Board Assembly

2

Evaluation Board Assembly Overview

The evaluation board (EVB) is assembled with a PE461X0, several headers and SMA connectors, as shown in Figure 1.

Figure 1 • PE461X0 Evaluation Board Assembly



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Quick Start Guide



Quick Start Overview

The EVB was designed to ease customer evaluation of the PE461X0 MPAC. This chapter will guide the user through the software installation, hardware configuration and using the graphical user interface (GUI).

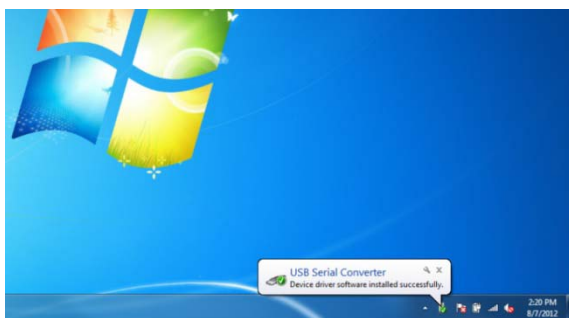
Software Installation

USB Driver

The latest USB interface board drivers are available via Microsoft Windows update. Internet connectivity is required to download the drivers. Connect the USB interface board to the PC and select the Windows Update option to obtain and install the drivers (Figure 2).

If the USB board drivers are not installed, it will not be possible to complete the installation of the MPAC EVK software. A USB interface board (Figure 11) is included in the evaluation kit.

Figure 2 • USB Driver Installation (Detecting)



EVK Software

In order to evaluate the PE461X0 performance, the application software has to be installed on your

computer. The USB interface and MPAC application software is compatible with computers running Windows® XP, Vista, 7, 8 and 10 in 32- or 64-bit configurations. This software is available directly from Peregrine's website at www.psemi.com.

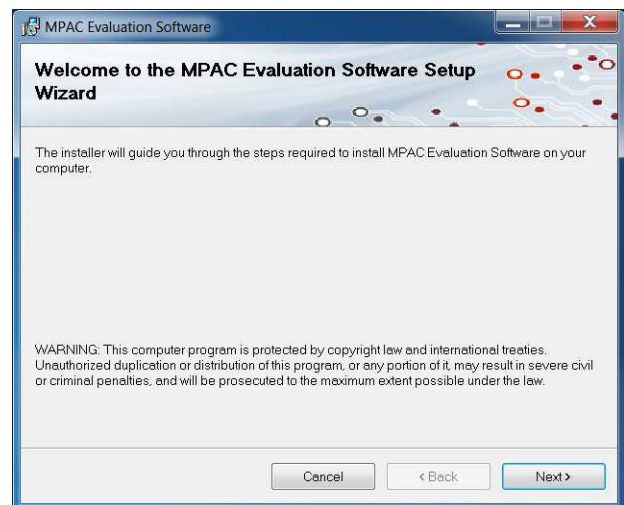
To install the MPAC evaluation software, unzip the archive and execute the "setup.exe" (Figure 3).

Figure 3 • MPAC Evaluation Software Installer



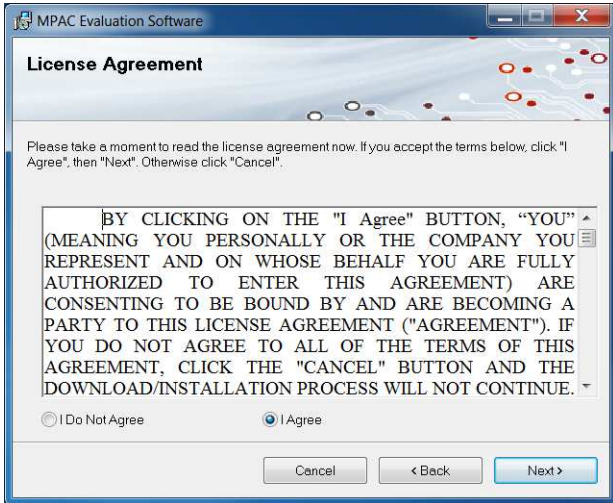
After the setup.exe file has been executed, a welcome screen will appear. It is strongly recommended that all programs be closed prior to running the install program. Click the "Next>" button to proceed.

Figure 4 • MPAC Evaluation Software Setup



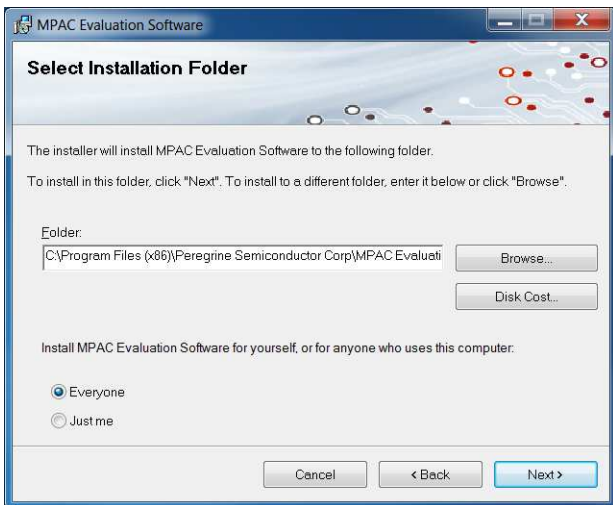
Take a moment to read the license agreement, then click "I Agree" and "Next>."

Figure 5 • License Agreement



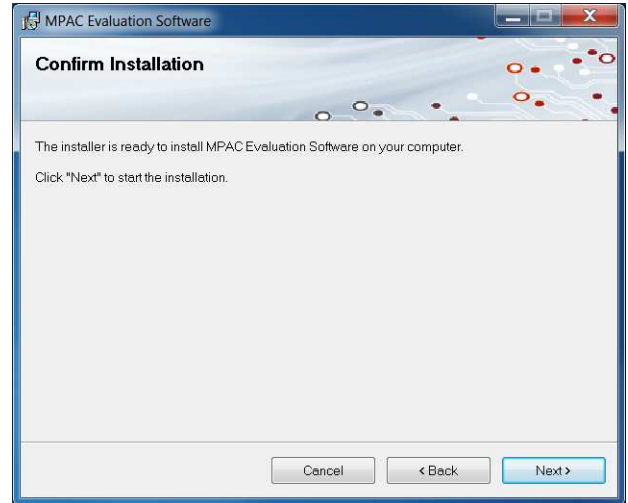
For most users the default install location for the program files is sufficient. If a different location is desired, the install program can be directed to place the program files in an alternate location. The software is installed for "Everyone" by default. Once the desired location is selected click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

Figure 6 • Select Installer Folder



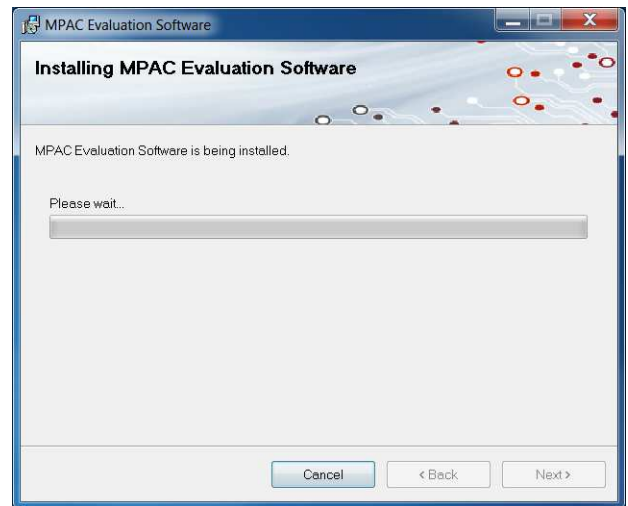
In the window of Confirm Installation, click "Next>" to proceed with the software installation.

Figure 7 • Confirm Installation



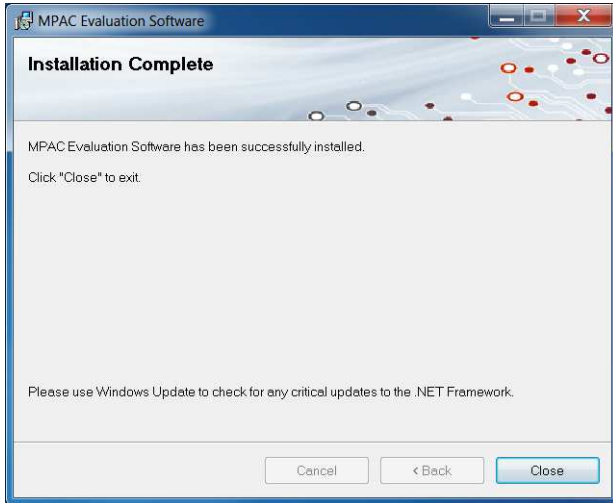
As the software files are installed, a progress indicator will be displayed. On slower computers, installation of the software may proceed for a few moments.

Figure 8 • Progress Indicator



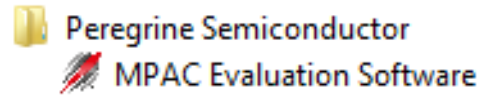
Once the evaluation software is installed, click "Close" to exit.

Figure 9 • Installation Complete



A new Start Menu item under Peregrine Semiconductor will appear in the start menu of your computer. Select "MPAC Evaluation Software" to launch the GUI.

Figure 10 • MPAC Evaluation Software Launch

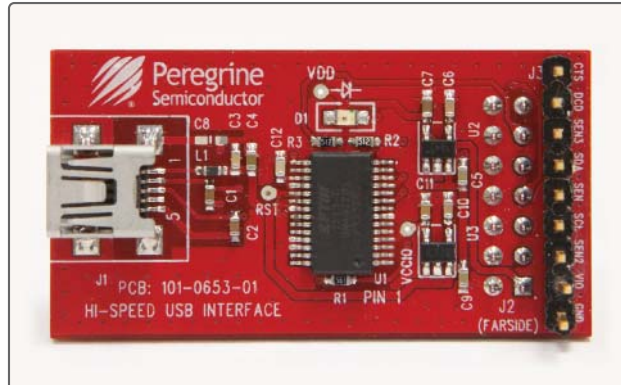


Hardware Configuration

USB Interface Board Overview

The USB interface board (**Figure 11**) is included in the evaluation kit. This board allows the user to send serial peripheral interface (SPI) commands to the device under test by using a PC running the Windows operating system. To install the software, refer to “**Software Installation**”.

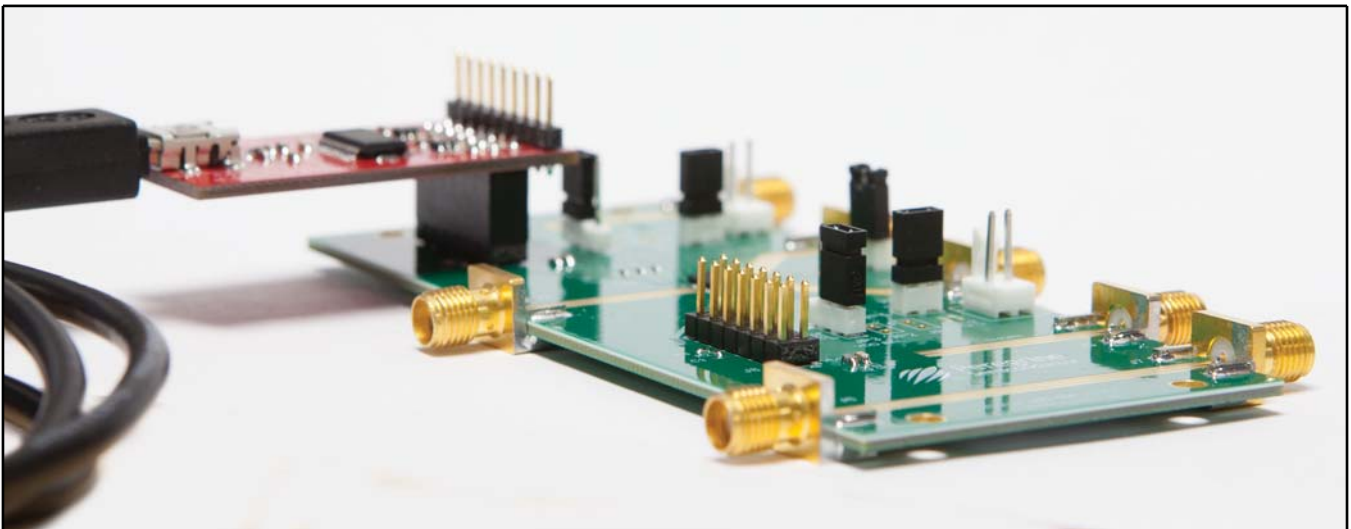
Figure 11 • USB Interface Board



Connection of the USB Interface Board to the Evaluation Board

The EVB and the USB interface board contain a 14-pin header. This feature allows the USB interface board (socket) to connect directly to the EVB (pin) on the front side as shown in **Figure 12**. Use caution when making the connection to ensure the USB interface board is aligned and connected to both rows of pins properly.

Figure 12 • USB Interface Board Connected to the Evaluation Board



Evaluation Board Overview

The evaluation board is designed to ease customer evaluation of Peregrine's products. The board contains:

- 1) Standard 0.1 inch headers are provided for power supply, digital control signals and USB interface board.
- 2) SMA connectors are provided for RF performance verification and connecting the THRU trace to calibrate board trace loss.

The schematic and evaluation board outline are provided in this user manual.

Figure 13 • PE461X0 Evaluation Board Schematic

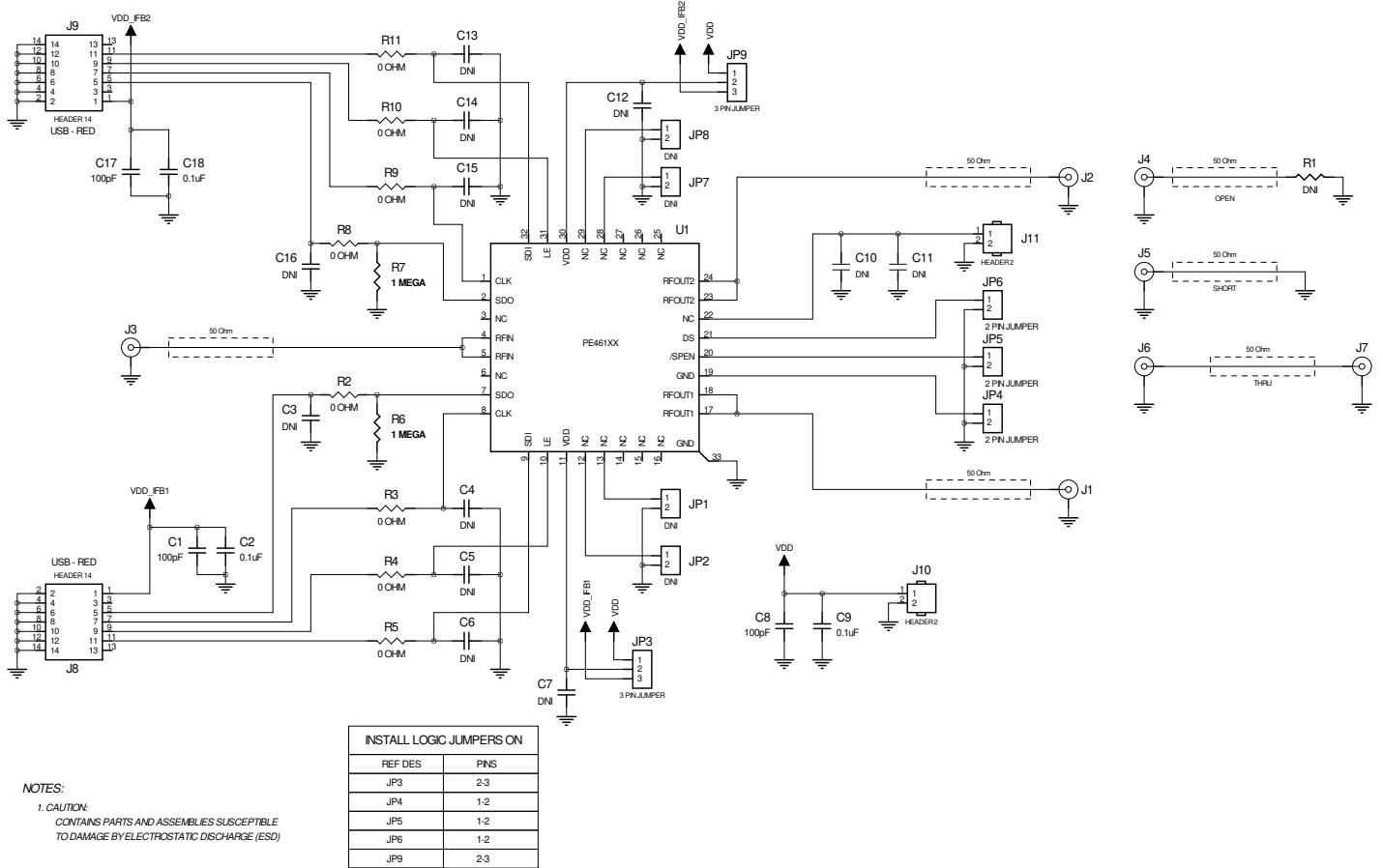
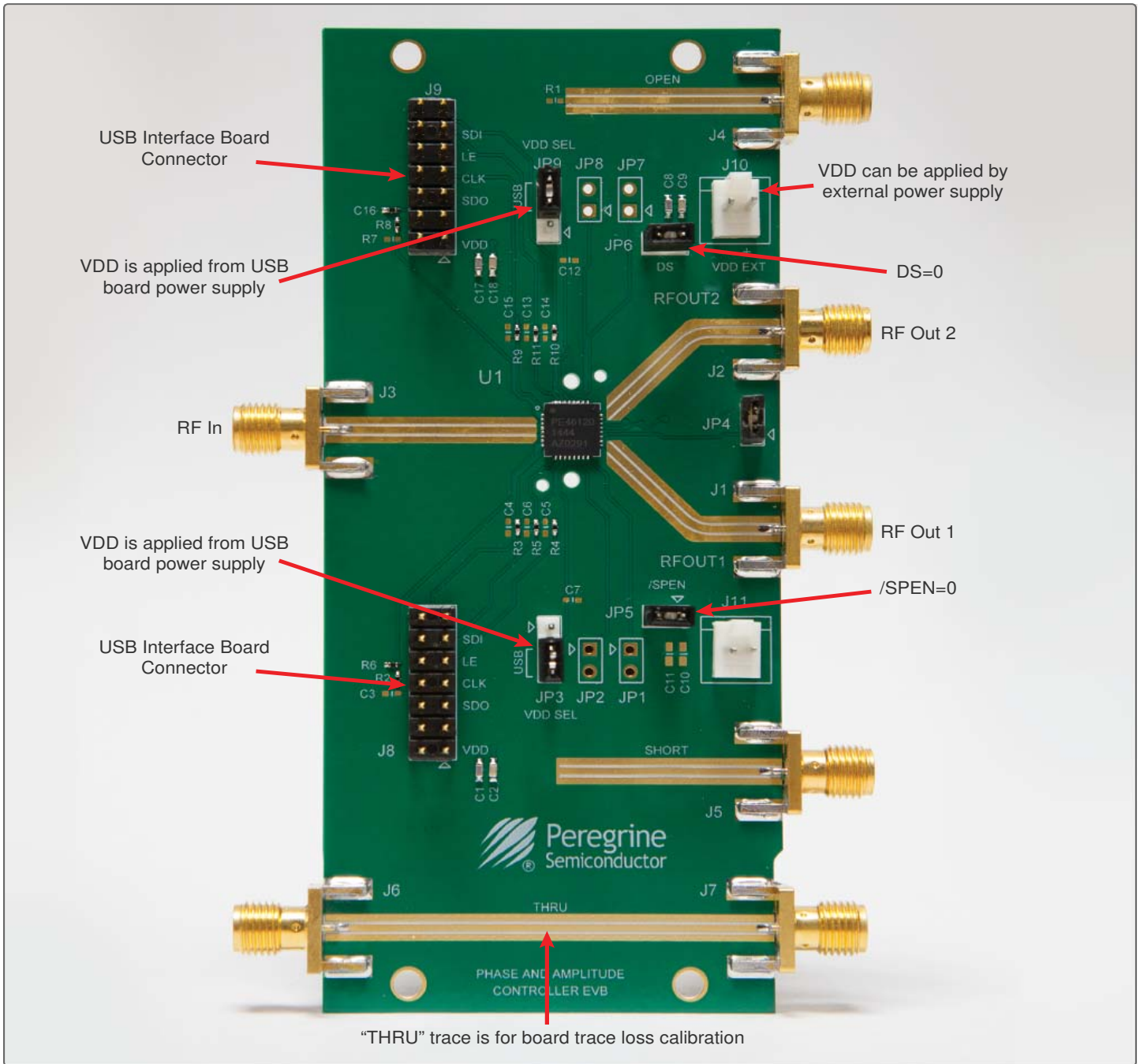


Figure 14 • PE461X0 Evaluation Board Outline Showing Functional Overview



Hardware Operation

The general guidelines for operating the hardware evaluation board are listed in this section. Follow the steps below to configure the hardware for basic evaluation.

- 1) Install the jumper on JP4, JP5 and JP6.
 - a) JP4 connects to PE461X0 pin 19 (GND) to ground.
 - b) JP5 connects to PE461X0 pin 20 (/SPEN) to ground for normal SPI operation.
 - c) JP6 connects to PE461X0 pin 21 (DS) to ground as DS = 0 setting.
- 2) There are two options to provide PE461X0 a power supply. They are:
 - a) Option 1: Power up through USB interface board. The evaluation board is configured for this option by installing a jumper on JP3 pin 2–3 and a jumper on JP9 pin 2–3 (refer to **Figure 14**).
 - b) Option 2: Power via external power supply. The evaluation board is configured for this option by installing a jumper on JP3 pins 1–2 and a jumper on JP9 pins 1–2 (refer to **Figure 14**). Connect the external power supply to V_{DD_EXT} J10 or J11 (pin 1+, pin 2–).
- 3) Plug in USB interface board on J8 or J9, as shown in **Figure 11**. J8 and J9 provide identical control to the device.
- 4) Calibrate board trace loss and phase with THRU trace between J6 and J7. THRU calibration is sufficient for initial measurements. If more accurate results are desired, the full set of SOLT standards can be used.

Table 2 • Recommended Operating Condition for PE461X0

Parameter	Min	Typ	Max	Unit
Supply voltage, V _{DD} ⁽¹⁾	2.3		5.5	V
Supply current		350	500	μA
Digital input high	1.17		3.6	V
Digital input low	0		0.6	V
Digital input leakage		10	20	μA
RF input power, CW			29	dBm
RF input power, pulsed ⁽²⁾			32	dBm
Operating temperature range	–40	+25	+105	°C
Notes:				
1) Product performance does not vary over V _{DD} .				
2) Pulsed, 5% duty cycle of 4620 μs period.				

Table 3 • Bit Descriptions

C0	Channel register select
	C0 = L, channel RF _{OUT1} register select
	C0 = H, channel RF _{OUT2} register select
M0–M3	Attenuation setting
P0–P4	Phase shift setting per channel
S0–S3	Spare bits (PE46120) Insertion loss stabilizer (ILS) setting per channel (PE46130/PE46140)

Table 4 • 14-bit Word (PE46120)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0
1	—	—	—	—	—	—	45°	22.5°	11.2°	5.6°	2.8°	—	—
2	—	—	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	—	—

Table 5 • Serial Truth Table—Phase Setting (PE46120)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Phase Shift Setting
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
1/2	—	—	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	—	—	
X	X	X	X	X	X	X	L	L	L	L	L	X	X	Ref phase
X	X	X	X	X	X	X	L	L	L	L	H	X	X	2.8 deg
X	X	X	X	X	X	X	L	L	L	H	L	X	X	5.6 deg
X	X	X	X	X	X	X	L	L	H	L	L	X	X	11.25 deg
X	X	X	X	X	X	X	L	H	L	L	L	X	X	22.5 deg
X	X	X	X	X	X	X	H	L	L	L	L	X	X	45 deg
X	X	X	X	X	X	X	H	H	H	H	H	X	X	87.2 deg

Table 6 • 14 Bit Word (PE46130)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0
1	—	—	—	—	—	—	45°	22.5°	11.2°	5.6°	2.8°	—	—
2	—	0.2	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.1	0.05

Table 7 • Serial Truth Table—Phase Setting (PE46130)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Phase Shift Setting
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
1/2	—	0.2	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.1	0.05	
X	L	X	X	X	X	X	L	L	L	L	L	X	X	Ref phase
X	L	X	X	X	X	X	L	L	L	L	H	X	X	2.8 deg
X	L	X	X	X	X	X	L	L	L	H	L	X	X	5.6 deg
X	L	X	X	X	X	X	L	L	H	L	L	X	X	11.25 deg
X	L	X	X	X	X	X	L	H	L	L	L	X	X	22.5 deg
X	L	X	X	X	X	X	H	L	L	L	L	X	X	45 deg
X	L	X	X	X	X	X	H	H	H	H	H	X	X	87.2 deg

Table 8 • 14-bit Word (PE46140)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0
1	—	—	—	—	—	—	45°	22.5°	11.2°	5.6°	2.8°	—	—
2	—	0.25	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.125	0.0625

Table 9 • Serial Truth Table—Phase Setting (PE46140)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Phase Shift Setting
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
1/2	—	0.25	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.125	0.0625	
X	L	X	X	X	X	X	L	L	L	L	L	X	X	Ref phase
X	L	X	X	X	X	X	L	L	L	L	H	X	X	2.8 deg
X	L	X	X	X	X	X	L	L	L	H	L	X	X	5.6 deg
X	L	X	X	X	X	X	L	L	H	L	L	X	X	11.25 deg
X	L	X	X	X	X	X	L	H	L	L	L	X	X	22.5 deg
X	L	X	X	X	X	X	H	L	L	L	L	X	X	45 deg
X	L	X	X	X	X	X	H	H	H	H	H	X	X	87.2 deg

Table 10 • Serial Truth Table—Attenuation Setting RF_{OUT2} (PE46120)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Amplitude Setting
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
2	—	—	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	—	—	
H	X	X	L	L	L	L	X	X	X	X	X	X	X	Ref insertion loss
H	X	X	L	L	L	H	X	X	X	X	X	X	X	0.5 dB
H	X	X	L	L	H	L	X	X	X	X	X	X	X	1 dB
H	X	X	L	H	L	L	X	X	X	X	X	X	X	2 dB
H	X	X	H	L	L	L	X	X	X	X	X	X	X	4 dB
H	X	X	H	H	H	H	X	X	X	X	X	X	X	7.5 dB

Table 11 • Default State Settings at Power Up RF_{OUT1} (PE46120)

DS Setting	Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Default Setting at Power Up
	C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
	1/2	—	—	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	—	—	
DS = 0	—	—	—	—	—	—	—	L	L	L	L	L	—	—	0 dB 0 deg
DS = 1	—	—	—	—	—	—	—	H	L	L	L	L	—	—	0 dB 45 deg

Table 12 • Default State Setting at Power Up RF_{OUT2} (PE46120)

DS Setting	Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q4	Q3	Q2	Q1	Default Setting at Power Up
	C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
	1/2	—	—	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	—	—	
DS = 0	—	—	—	L	L	L	L	L	L	L	L	L	—	—	0 dB 0 deg
DS = 1	—	—	—	H	H	H	H	H	L	L	L	L	—	—	7.5 dB 45 deg

Table 13 • Serial Truth Table—Attenuation Setting RF_{OUT2} (PE46130)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Amplitude Setting
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
2	—	0.2	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.1	0.05	
H	L	X	L	L	L	L	X	X	X	X	X	X	X	Ref insertion loss
H	L	X	L	L	L	H	X	X	X	X	X	X	X	0.5 dB
H	L	X	L	L	H	L	X	X	X	X	X	X	X	1 dB
H	L	X	L	H	L	L	X	X	X	X	X	X	X	2 dB
H	L	X	H	L	L	L	X	X	X	X	X	X	X	4 dB
H	L	X	H	H	H	H	X	X	X	X	X	X	X	7.5 dB

Table 14 • Default State Settings at Power Up RF_{OUT1} (PE46130)

DS Setting	Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Default Setting at Power Up
	C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
	1/2	—	0.2	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.1	0.05	
DS = 0	—	—	—	—	—	—	—	L	L	L	L	L	—	—	0 dB 0 deg
DS = 1	—	—	—	—	—	—	—	H	L	L	L	L	—	—	0 dB 45 deg

Table 15 • Default State Settings at Power Up RF_{OUT2} (PE46130)

DS Setting	Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Default Setting at Power Up
	C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
	1/2	—	0.2	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.1	0.05	
DS = 0	—	L	L	L	L	L	L	L	L	L	L	L	L	L	0 dB 0 deg
DS = 1	—	L	L	H	H	H	H	H	L	L	L	L	L	L	7.5 dB 45 deg

Table 16 • Serial Truth Table—Attenuation Setting RF_{OUT2} (PE46140)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Amplitude Setting
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
2	—	0.25	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.125	0.0625	
H	L	X	L	L	L	L	X	X	X	X	X	X	X	Ref insertion loss
H	L	X	L	L	L	H	X	X	X	X	X	X	X	0.5 dB
H	L	X	L	L	H	L	X	X	X	X	X	X	X	1 dB
H	L	X	L	H	L	L	X	X	X	X	X	X	X	2 dB
H	L	X	H	L	L	L	X	X	X	X	X	X	X	4 dB
H	L	X	H	H	H	H	X	X	X	X	X	X	X	7.5 dB

Table 17 • Default State Settings at Power Up RF_{OUT1} (PE46140)

DS Setting	Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Default Setting at Power Up
	C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
	1/2	—	0.25	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.125	0.0625	
DS = 0	—	—	—	—	—	—	—	L	L	L	L	L	—	—	0 dB 0 deg
DS = 1	—	—	—	—	—	—	—	H	L	L	L	L	—	—	0 dB 45 deg

Table 18 • Default State Settings at Power Up RF_{OUT2} (PE46140)

DS Setting	Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Default Setting at Power Up
	C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
	1/2	—	0.25	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.125	0.0625	
DS = 0	—	L	L	L	L	L	L	L	L	L	L	L	L	L	0 dB 0 deg
DS = 1	—	L	L	H	H	H	H	H	L	L	L	L	L	L	7.5 dB 45 deg

Insertion Loss Stabilizer

The PE46130/PE46140 offer greater insertion loss stability (ILS) by compensating for known variations between phase states. Three attenuation bits are used to reduce the variation seen in the insertion loss across all phase states for the RF_{OUT2} path. ILS bits S0–S2 are accessible for creating a custom lookup table in applications where insertion loss variation between phase states is critical. PE46120 does not support this feature.

Table 19 • Insertion Loss Stabilizer Bit Definition (PE46130)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Amplitude Setting
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
2	—	0.2	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.1	0.05	
H	L	L	X	X	X	X	X	X	X	X	X	L	L	Ref IL
H	L	L	X	X	X	X	X	X	X	X	X	L	H	0.05 dB
H	L	L	X	X	X	X	X	X	X	X	X	H	L	0.1 dB
H	L	H	X	X	X	X	X	X	X	X	X	L	L	0.2 dB
H	L	H	X	X	X	X	X	X	X	X	X	H	H	0.35 dB

Table 20 • Insertion Loss Stabilizer Bit Definition (PE46140)

Q13	Q12	Q11	Q10	Q9	Q8	Q7	Q6	Q5	Q4	Q3	Q2	Q1	Q0	Amplitude Setting
C0	S3	S2	M3	M2	M1	M0	P4	P3	P2	P1	P0	S1	S0	
1/2	—	0.25	4	2	1	0.5	45°	22.5°	11.2°	5.6°	2.8°	0.125	0.0625	
H	L	L	X	X	X	X	X	X	X	X	X	L	L	Ref IL
H	L	L	X	X	X	X	X	X	X	X	X	L	H	0.0625 dB
H	L	L	X	X	X	X	X	X	X	X	X	H	L	0.125 dB
H	L	H	X	X	X	X	X	X	X	X	X	L	L	0.25 dB
H	L	H	X	X	X	X	X	X	X	X	X	H	H	0.4375 dB

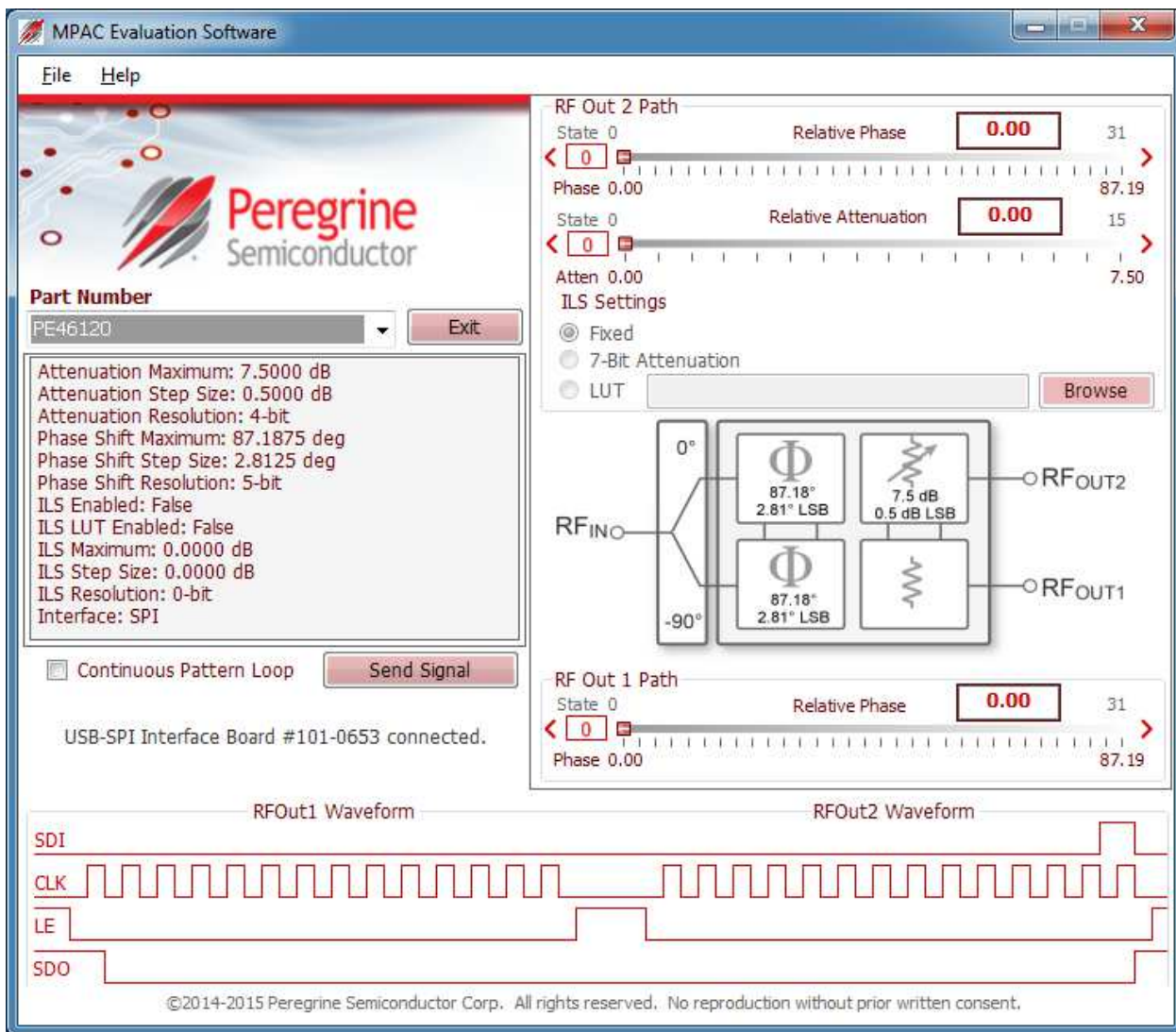
Using the Graphical User Interface

Figure 15 displays the MPAC application software graphical user interface (GUI), which has the USB interface board plugged into the computer. The message “USB-SPI Interface Board #101-0653 connected” will indicate that the USB interface board is connected and recognized. See “**Hardware Operation**” on page 11 for detailed information regarding hardware configuration for use with the GUI control software. If the USB interface board is not connected when the application software is launched, the message “No interface board connected! Please connect USB-SPI Interface #101-0653” 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 number for evaluation and the part description is below the part number box.

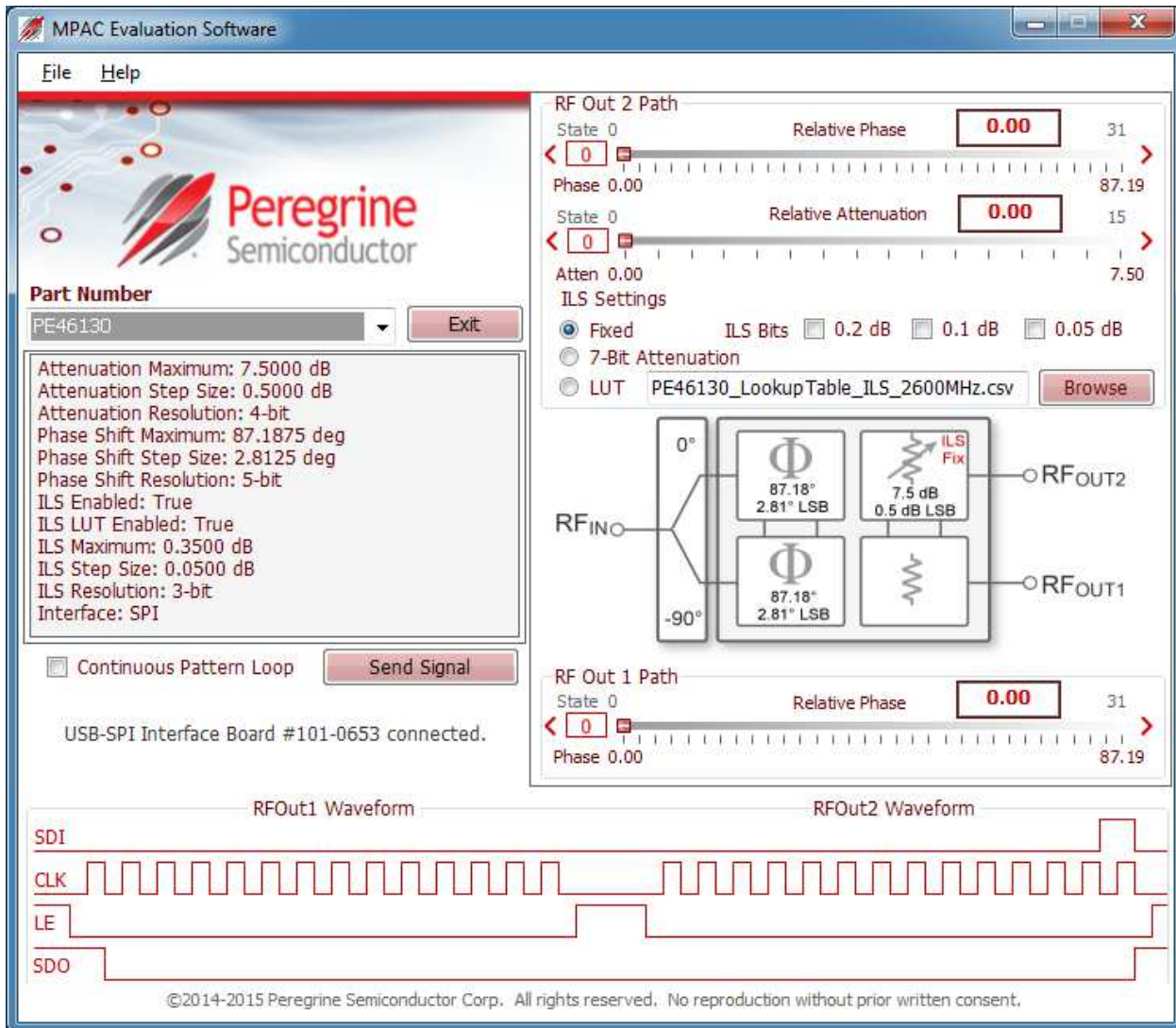
The MPAC application software GUI is displayed in Figure 15 and illustrates the available controls and messages available to the user.

Figure 15 • PE46120 Application Software Graphical User Interface^(*)



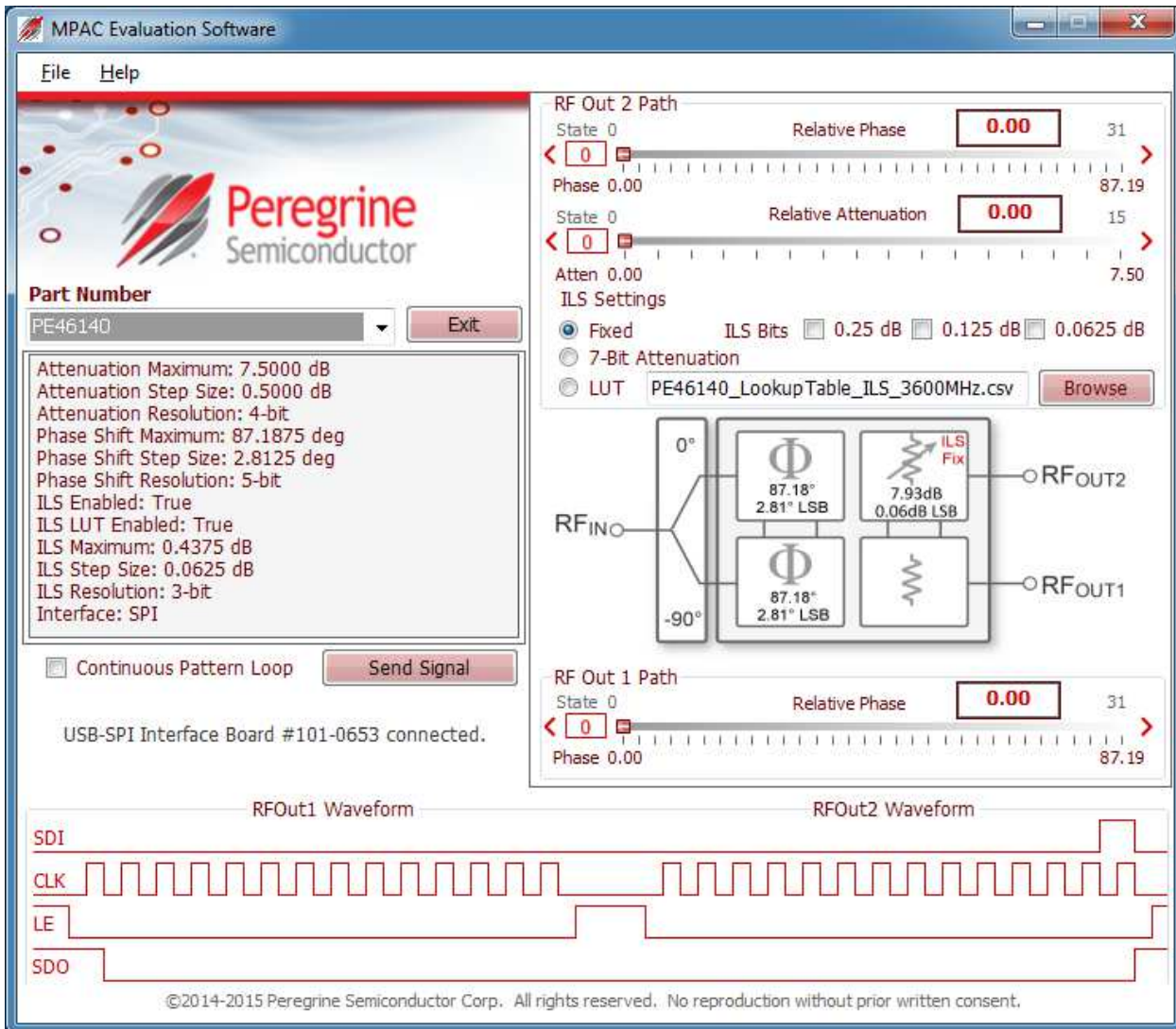
Note: * SDO in the serial interface waveform is read back from the MPAC to verify SDO toggling to indicate proper communication with the MPAC.

Figure 16 • PE46130 Application Software Graphical User Interface^(*)



Note: * SDO in the serial interface waveform is read back from the MPAC to verify SDO toggling to indicate proper communication with the MPAC.

Figure 17 • PE46140 Application Software Graphical User Interface^(*)



Note: * SDO in the serial interface waveform is read back from the MPAC to verify SDO toggling to indicate proper communication with the MPAC.