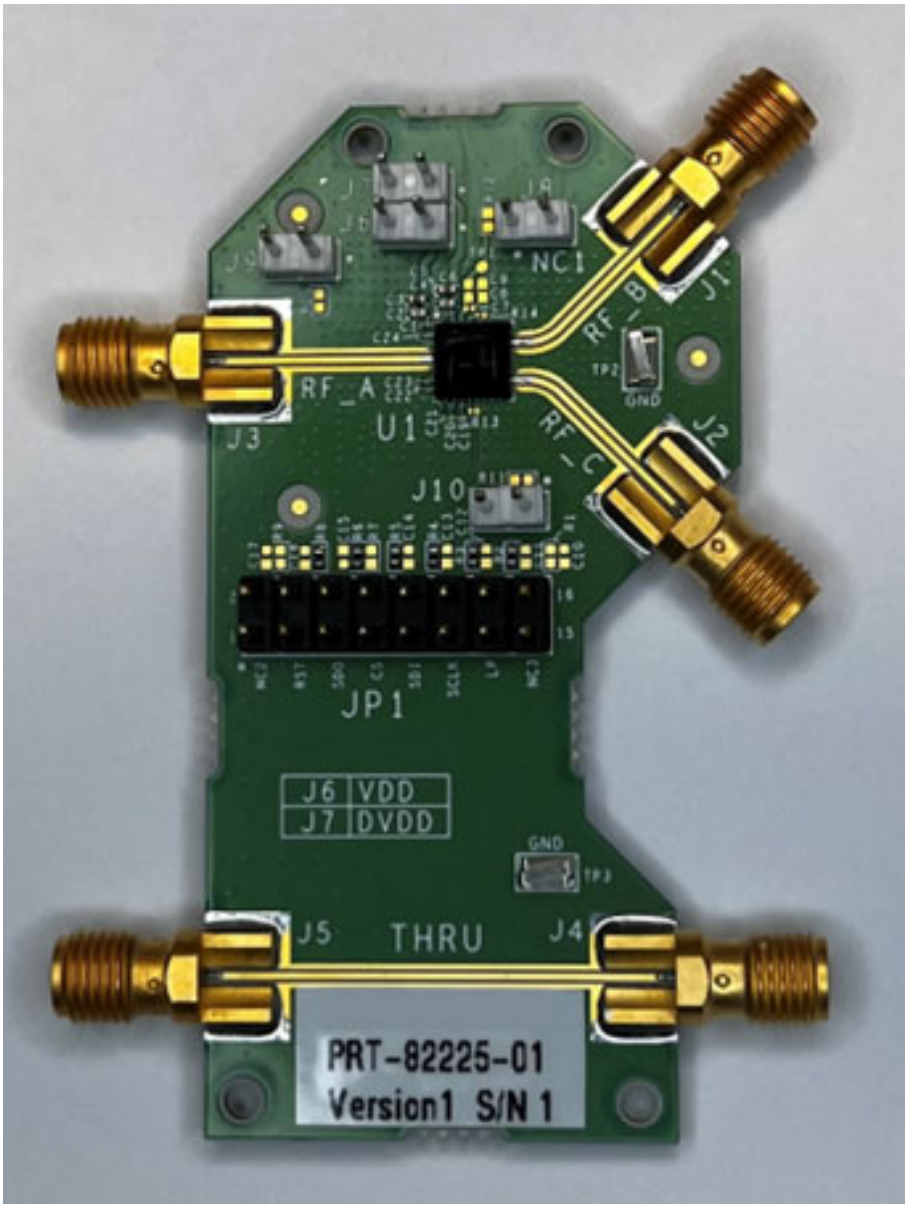
PE44951

Evaluation Kit User's Manual

Two-way Phase Shifter with Digital Step Attenuator



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Introduction

The PE44951 is a highly integrated two-way phase shifter with digitally controlled step attenuators for use across the 6.42–7.21 GHz frequency range. Each path is controlled through its respective Serial Peripheral Interface (SPI) control pins. The PE44951 is ideal for wireless infrastructure applications, such as massive multiple input, multiple output (mMIMO) macro and micro base stations, next generation 5G solutions, and small cell applications.

pSemi manufactured this phase shifter and attenuator using the pSemi UltraCMOS® process, a patented variation of silicon-on-insulator (SOI) technology on a sapphire substrate, which features high compactness, excellent isolation, and low insertion loss.

The PE44951 implements two RF paths with independent digital phase shift and digital step attenuation. Each phase shift value is set by the sum of an 8-bit beamformer phase buffer and an 8-bit AC phase buffer. The on-chip digital logic automatically computes these sums. An 8-bit register sets each attenuation value. The latch phase (LP) input pin provides precise control of the switching time of the phase shifters.

An SPI slave interface that operates at up to 50 MHz provides access to the beamformer, AC phase buffers, and the attenuator control registers.

PE44951 Functional Diagram

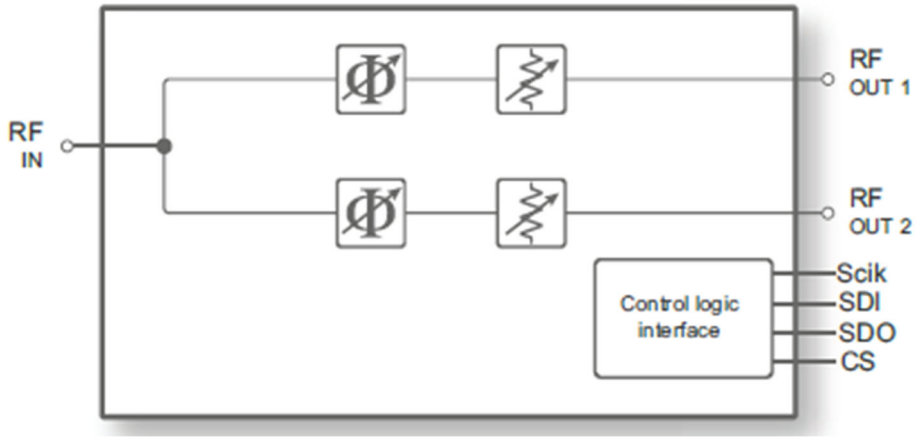


Figure 1. PE44951 Functional Diagram

Evaluation Kit Overview

pSemi designed the PE44951 evaluation kit to ease your evaluation of the PE44951. You operate the evaluation board using a USB interface dongle and the associated pSemi software.

Document Overview

This *PE44951 Evaluation Kit (EVK) User's Manual* includes information about the hardware required to control and evaluate the functionality of the two-way phase shifter. This document also includes the pin configuration, schematic diagrams, cable connections, and software instructions.

Evaluation Kit Contents and Requirements

EVK Contents

Table 1 lists the hardware you need to evaluate the PE44951 two-way phase shifter.

Table 1. EVK Contents

Quantity	Description	Part Number
1	PE44951 evaluation board assembly	EK44951-01
1	USB interface dongle	PRT-50865
1	Ribbon cable	–
1	USB cable	–

Hardware Requirements

To evaluate the performance of the evaluation board, you need the following equipment:

- Bench supply capable of providing 3.3V at 1A, with the current limit set to 100 mA
- Multimeter for checking V_{DD}
- Vector network analyzer, ideally with three ports

Warning: The PE44951 two-way phase shifter EVK contains components that could be damaged by exposure to voltages higher than the maximum 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 to signal inputs and outputs.

Before you connect the EVK to the source power supply, verify that the power supply is off. Connecting the EVK to a live power supply could induce failures.

Quick Start Guide

pSemi designed the evaluation board to ease your evaluation of the PE44951 two-way phase shifter. This section guides you through the hardware configuration and the startup process.

Evaluation Board Overview

The evaluation board contains the following:

- J6 and J7 V_{DD} input terminals
- JP1 connector for the interface dongle, which controls the SPI interface
- J3 common RF input
- J1 and J2 RF outputs
- Sense points and the power good (PGOOD) signal

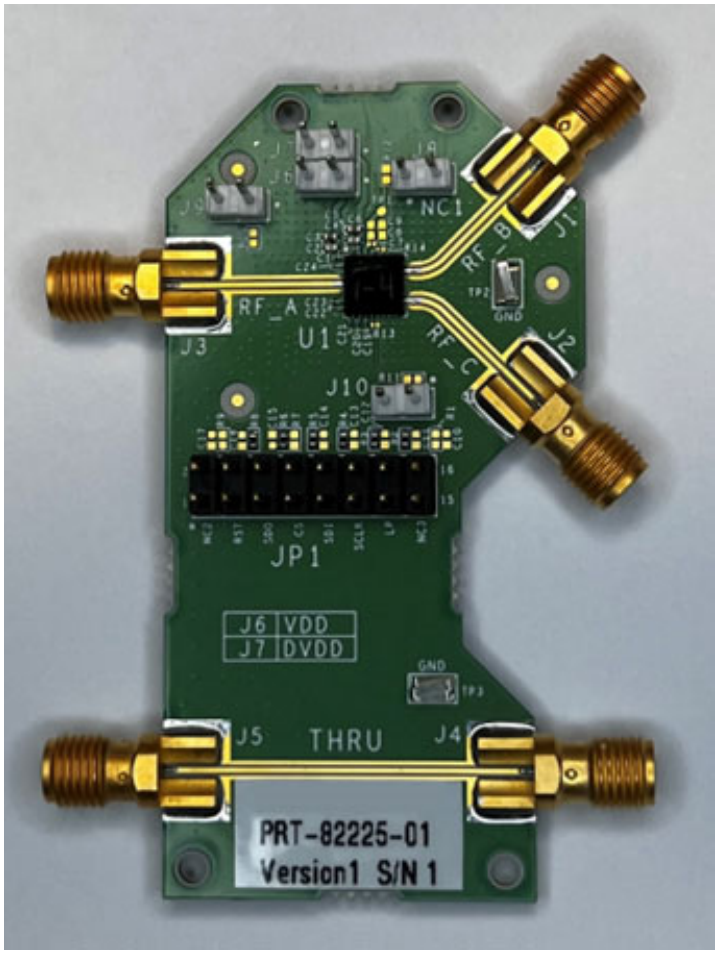


Figure 2. PE44951 EVK Evaluation Board Assembly

USB Interface Dongle and Cables

Figure 3 shows the PE44951 interface dongle (part number EK600000).

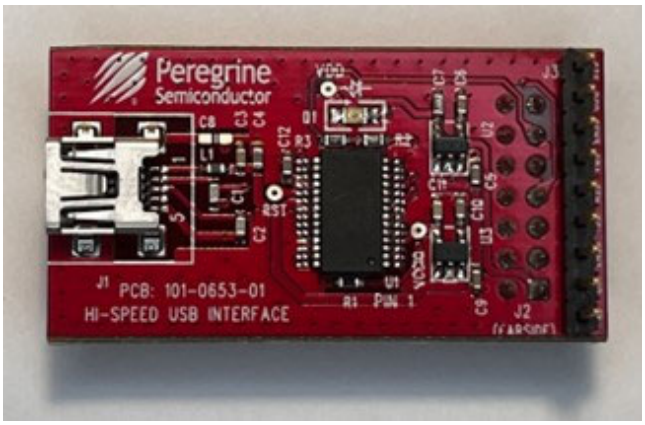


Figure 3. PE44951 Interface Dongle

Figure 4 shows the PE44951 evaluation board ribbon cable.

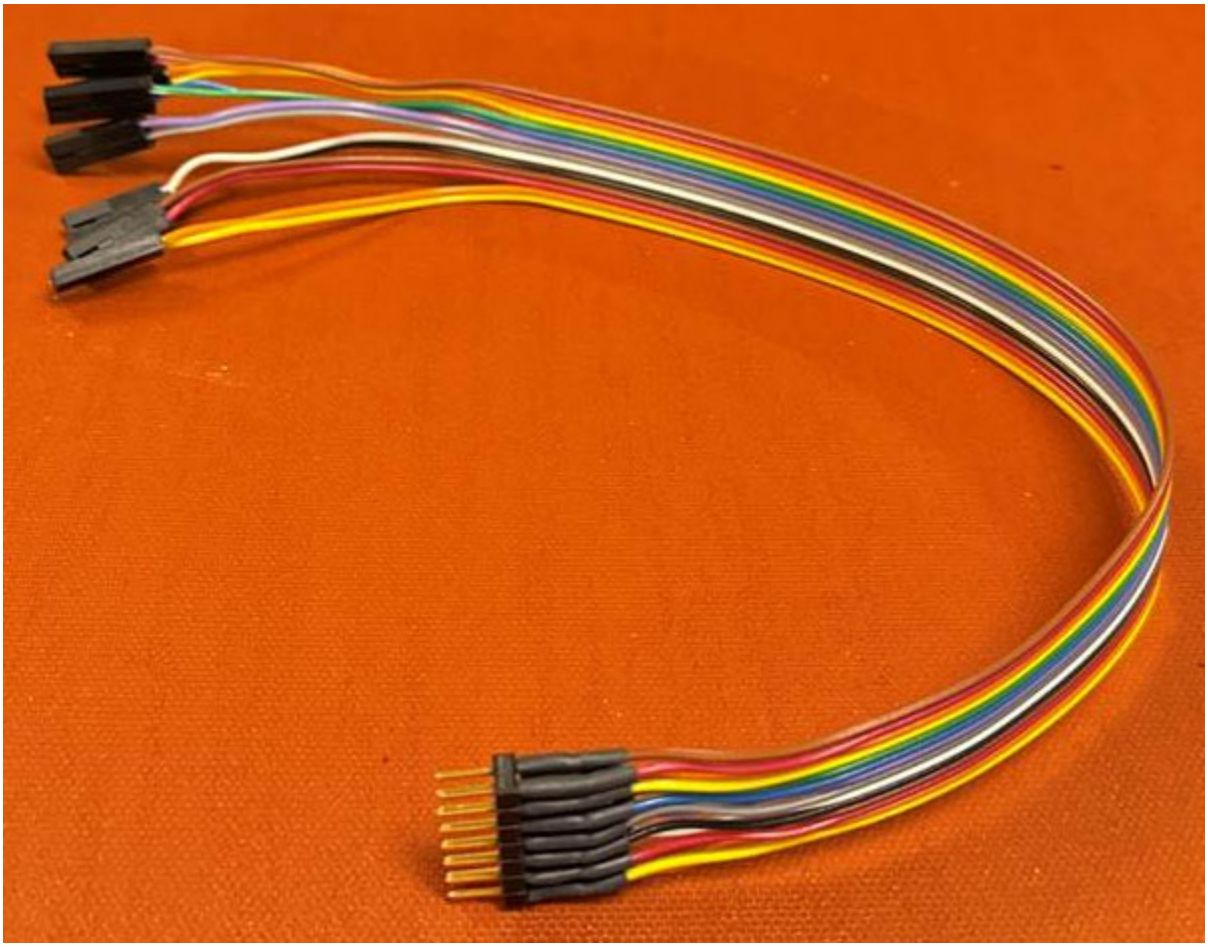


Figure 4. PE44951 EVK Ribbon Cable

Figure 5 shows the PE44951 evaluation board USB cable.

Figure 5. PE44951 EVK USB Cable

Figure 6 shows the PE44951 evaluation board supply voltage and ribbon connectors.

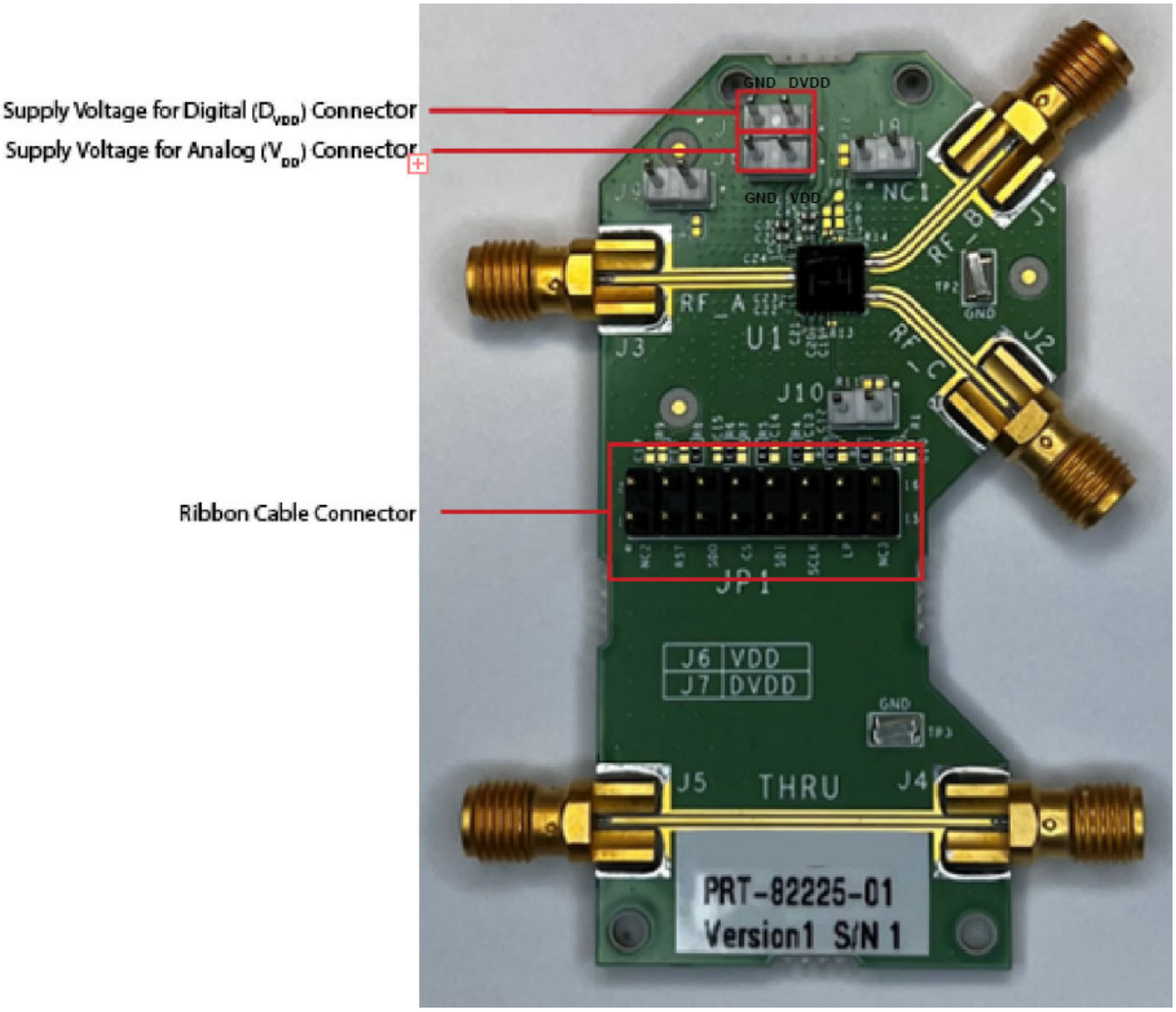


Figure 6. PE44951 Evaluation Board Supply Voltage and Ribbon Cable Connectors

Connecting the Ribbon Cable

1. Connect the external power supplies to the V_{DD} connector (J6) and the D_{VDD} connector (J7).
2. Connect the ribbon cable to JP1 on the evaluation board, as shown in Figure 7.

Note that one orange/yellow pair of wires and one brown/red pair of wires are *not* connected to JP1.

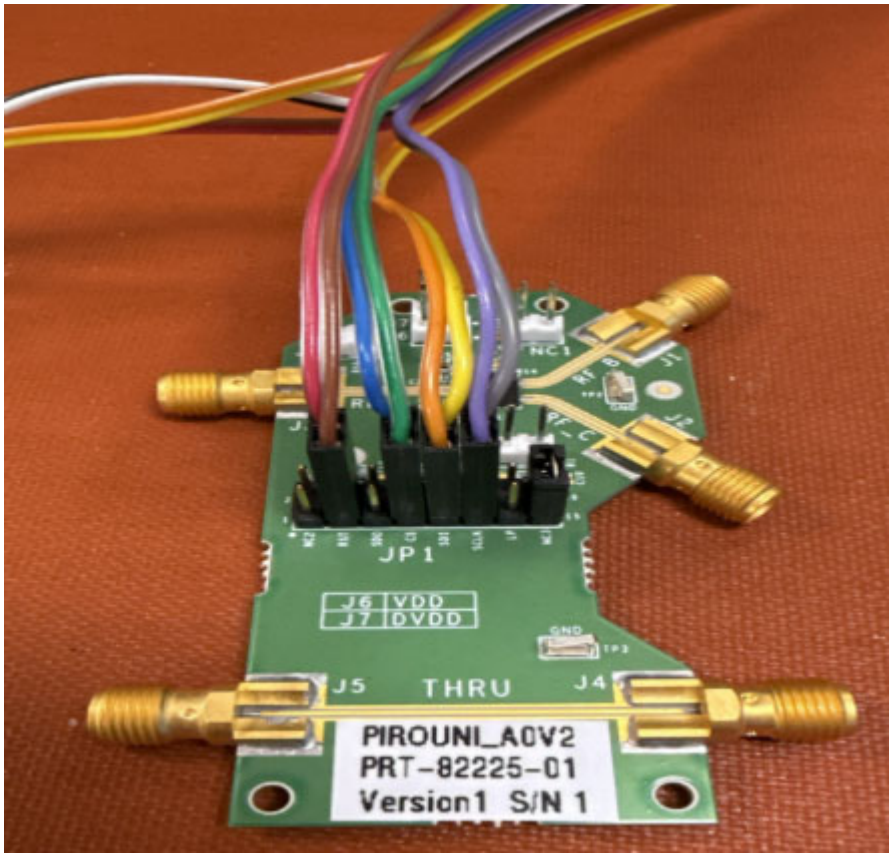


Figure 7. Connect the External Power Supplies and Ribbon Cable to the PE44951 Evaluation Board

3. Connect the ribbon cable to the interface dongle as shown in Figure 8 using the connection map in Table 2.

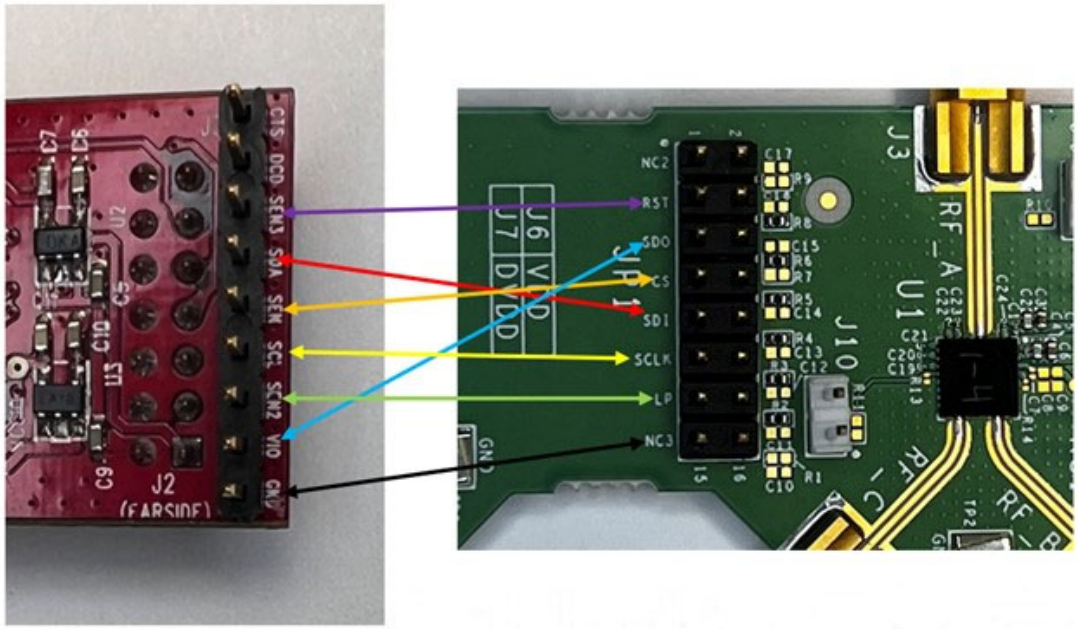


Figure 8. Connect the Ribbon Cable to the Evaluation Board

Table 2. PE44951 Ribbon Cable Connections

Interface Dongle Connection	Evaluation Board Connection
GND	NC3
SCL	SCLK
SDA	SDI
SEN	CS
VIO	SDO
SEN2	LP
SEN3	RST

Figure 9 shows the ribbon cable connected to the red dongle.

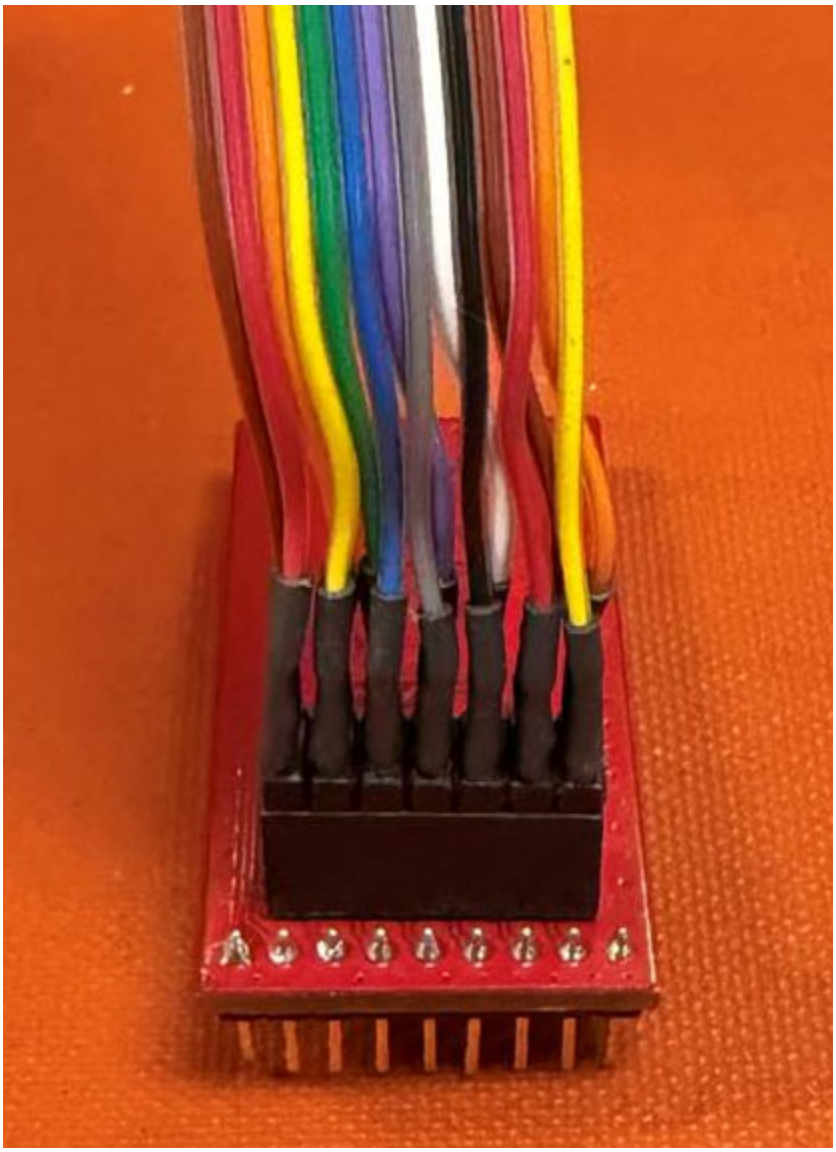


Figure 9. Ribbon Connected to the Red Dongle

Operating the Hardware Evaluation Board

1. Install the jumper on JP8, JP9, and JP10.
2. Use JP6 to provide the V_{DD} to the part.
3. Use JP7 to provide D_{VDD} to the part. For the range of voltages that can be applied to V_{DD} and D_{VDD}, see Table 3.
4. Plug in the USB interface board.
5. To calibrate the board trace loss and phase, use the THRU trace between connectors J4 and J5. This THRU calibration is sufficient for the initial measurements.
6. To drive the PE44951 using your own SPI setup, see the *PE44951 Data Sheet* for details on the SPI word structure, register addresses, and phase summation feature. To access the *PE44951 Data Sheet*, see the pSemi website.

Table 3. Recommended Operating Conditions

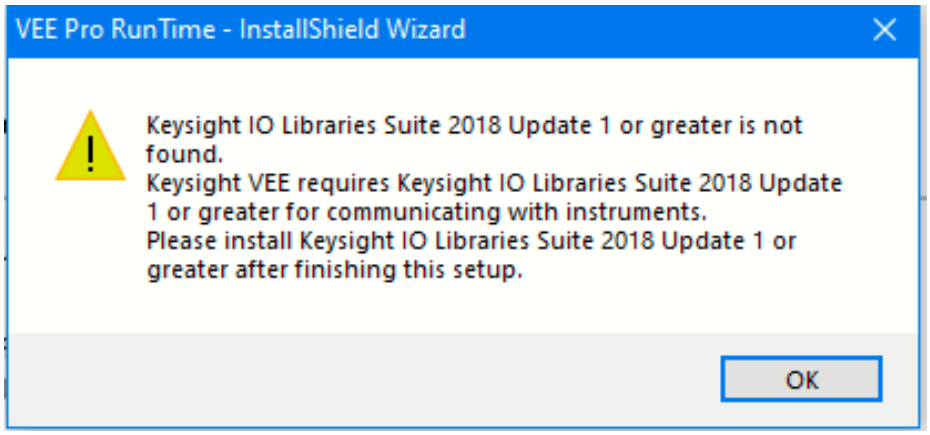
Parameter	Min	Typ	Max	Unit
Supply voltage for analog, VDD	3.15	3.3	3.45	V
Supply voltage for digital, D_{VDD}	1.7	–	3.45	V
Supply current	–	–	1	mA
Digital input high	1.17	–	D_{VDD}	V
Digital input low	0	–	0.63	V
Operating temperature range: @ Package case, full functionality @ Package case, full performance	 -40 -33	–	 +115 +115	 °C °C
D_{VDD} supply current(1) Standby Operation	–	–	 TBD TBD	 µA mA
Digital output high level, I_{OUT} = 2 mA	TBD	–	–	–
Digital output low level, I_{OUT} = 2 mA	–	–	TBD	–
RST pulse width, RST = low (active)	10	–	–	ns
LP pulse width, high or low	4	–	–	ns
LP lead/lag SPI command(2)	20	–	–	ns

Notes:
1) RST = CD = high, SCLK = SDI = LP = low, 50-MHz SCLK frequency, CL = 34 pF at the SDO pin.
2) LP low-to-high or high-to-low before/after the SPI command 20 ns.

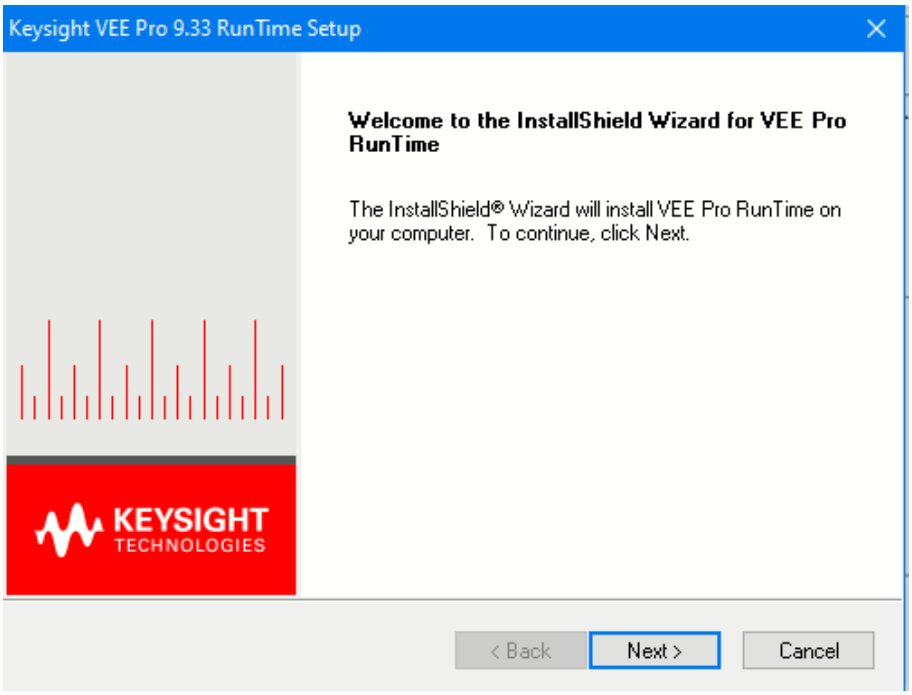
Installing the Software

Install the Keysight VEE Pro 9.33 RunTime software

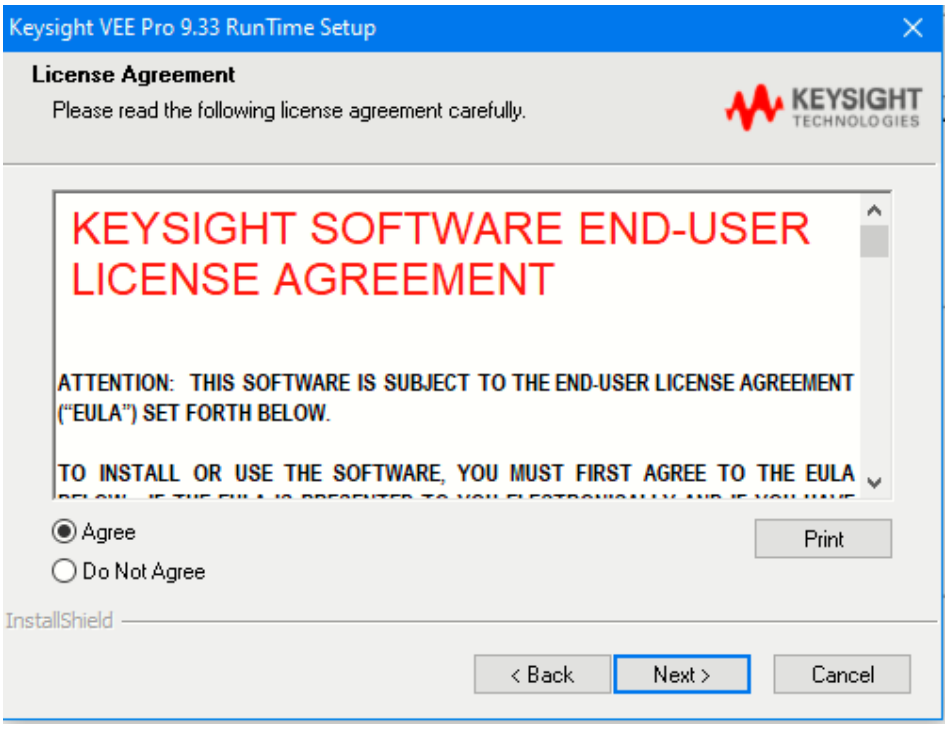
8. Download the Keysight VEE software from the Keysight Technologies website.
9. To start the software installation, run the downloaded **Keysight_VEE_Pro_9.33_RunTime_setup.exe** file. The InstallShield Wizard displays.



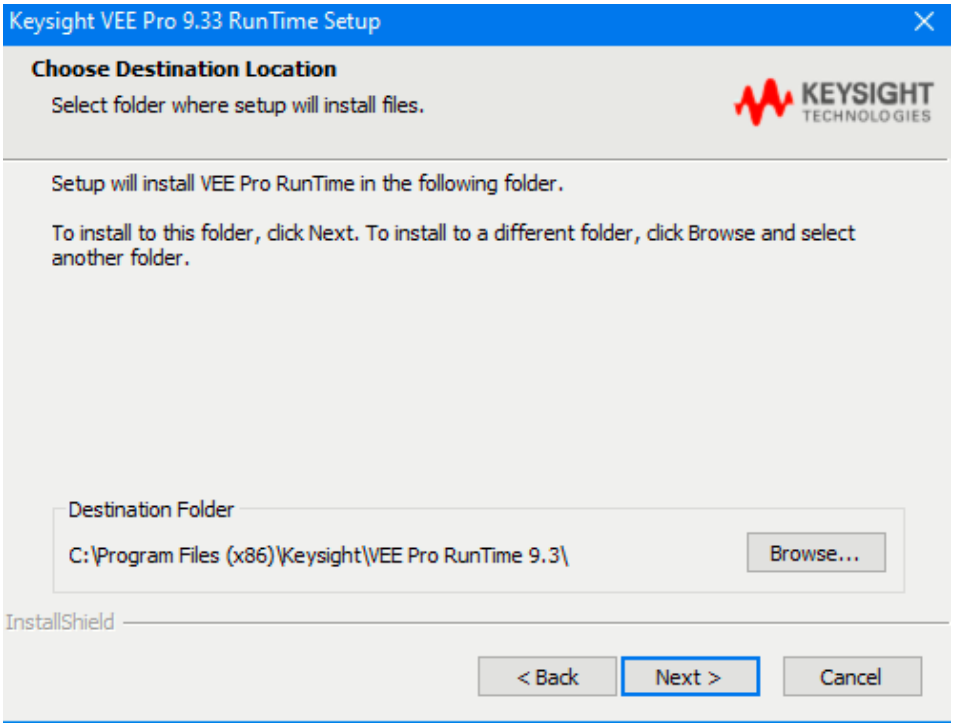
10. Select **OK**. The Welcome screen displays.



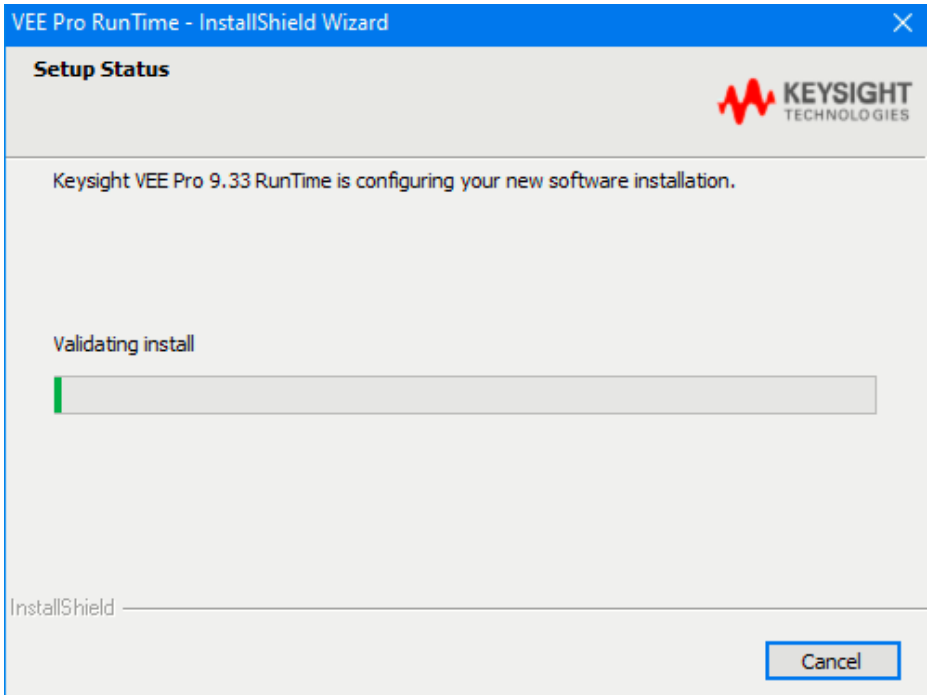
11. Select **Next**. The License Agreement screen displays.



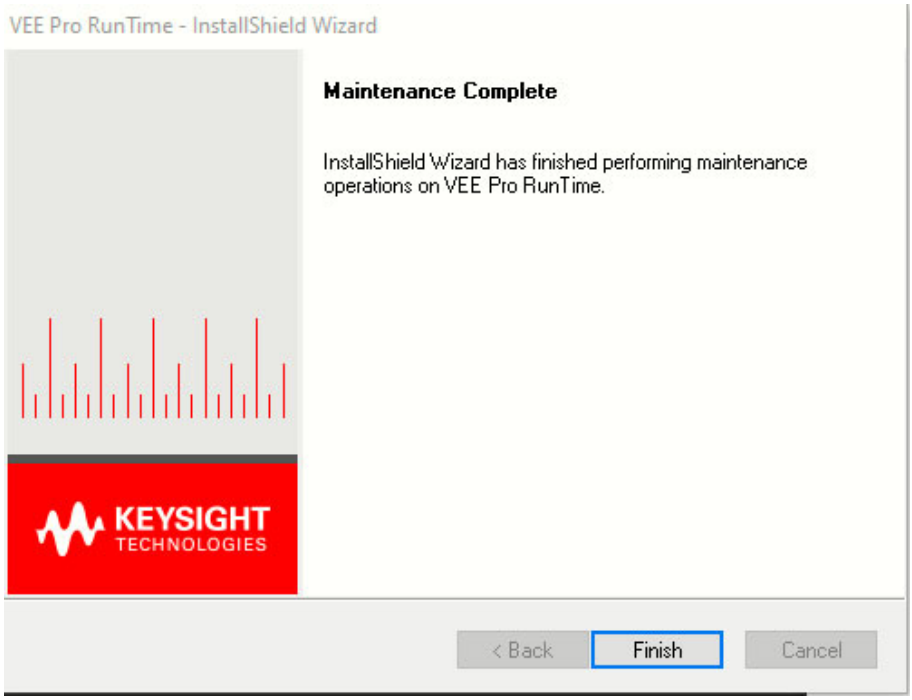
12. Select **Agree**, then select **Next**. The Choose Destination Location screen displays.



13. Select the preferred destination folder, then select **Next**. The Setup Status screen displays, and the installation begins.



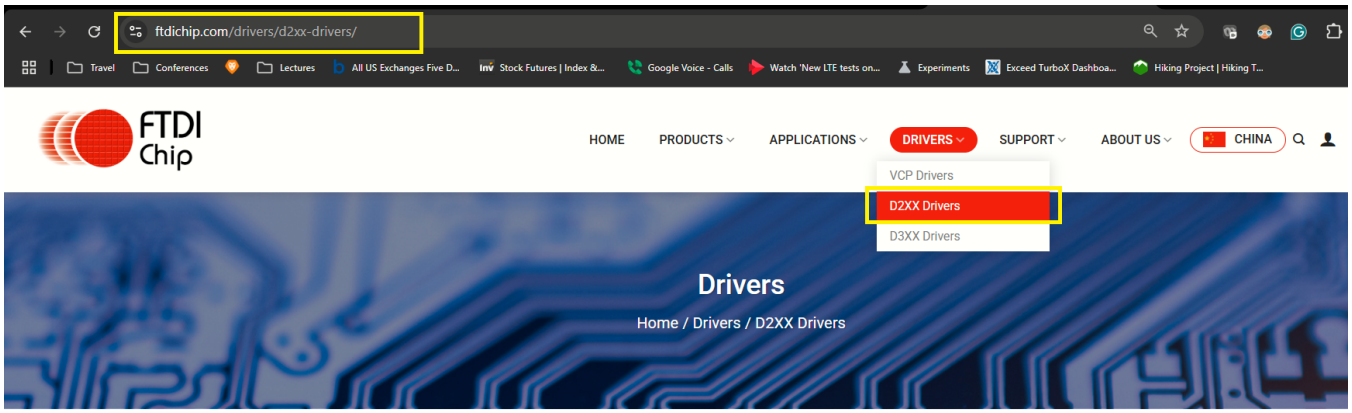
14. After the installation is completed, the Maintenance Complete screen displays.

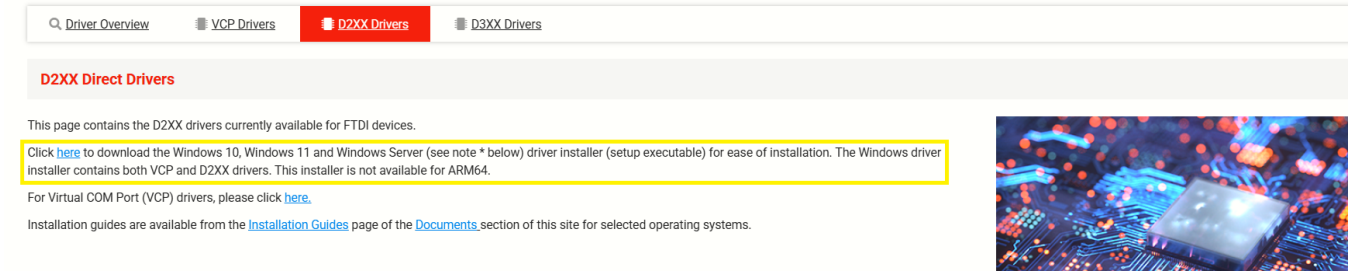


15. To complete the VEE Pro RunTime software installation, select **Finish**.

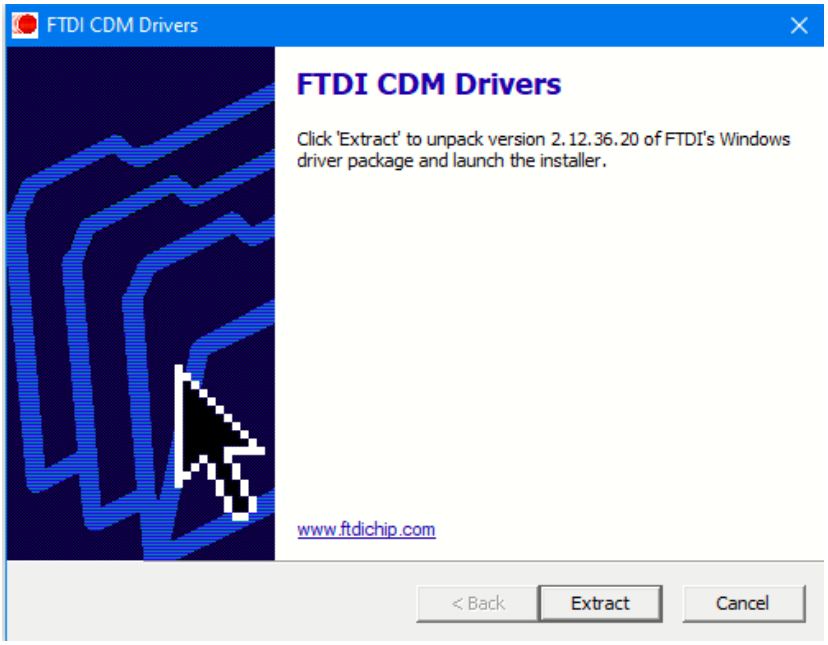
Installing the FTDI Drivers

1. Download the FTDI driver from the FTDI website at https://ftdichip.com/drivers/d2xx-drivers/.
2. From the *Drivers* menu of the website, select **D2XX Drivers**, then scroll down to the D2XX Direct Drivers section of the page and select the **Select here** link. The **CDM2123620_Setup.zip** file downloads to your PC.



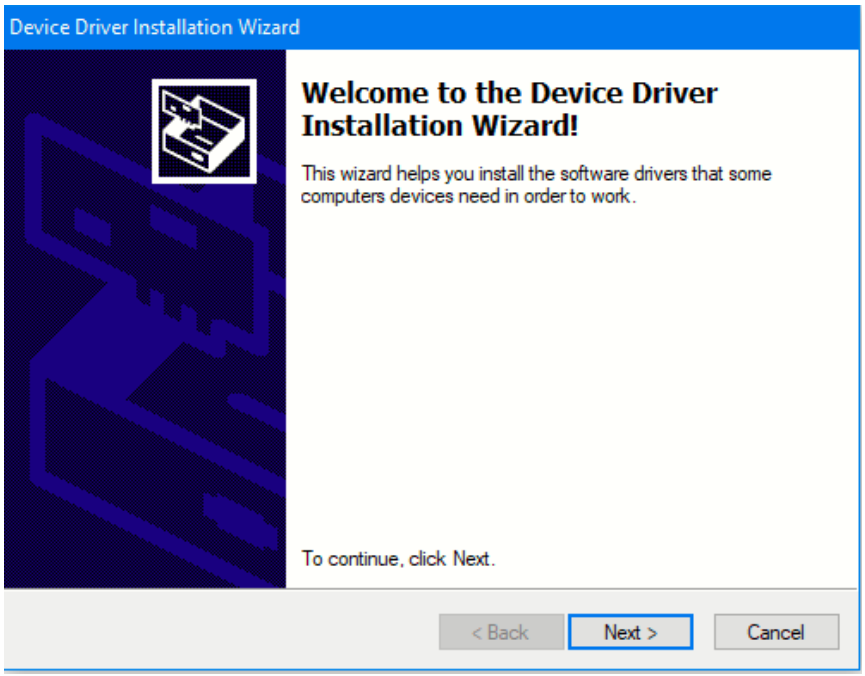


3. In the Downloads folder, extract the **CDM2123620_Setup.zip** file, then select the **CDM2123620_Setup.exe** file. The FTDI CDM Drivers screen displays.

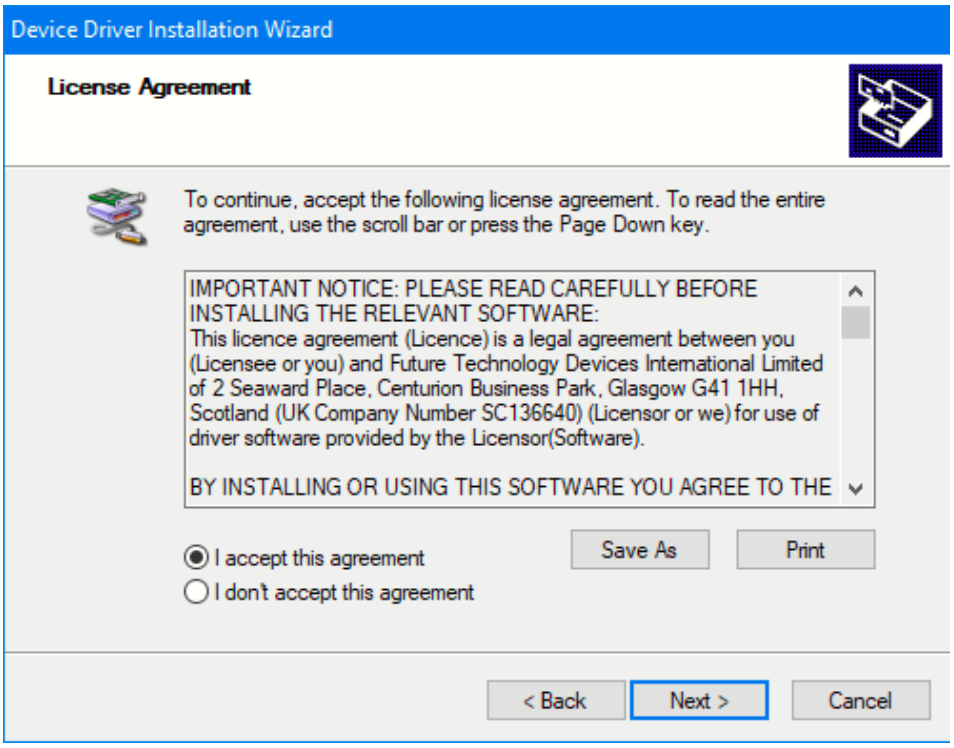


4.

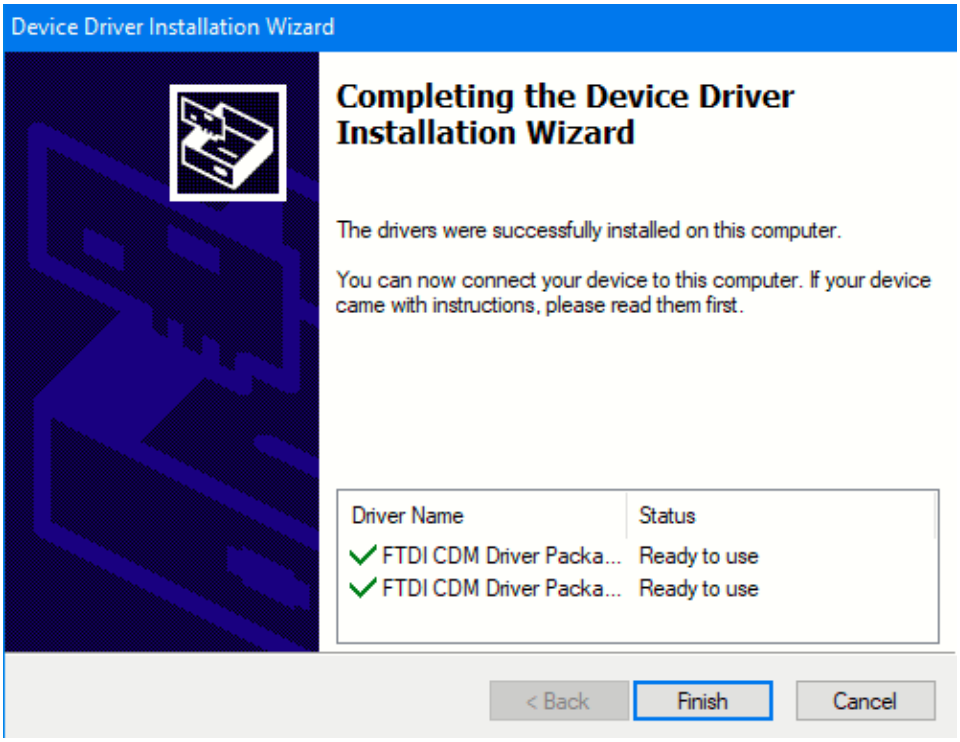
5. Select **Extract**. The Device Drive Installation Wizard Welcome screen displays.



6. Select **Next**. The License Agreement displays.



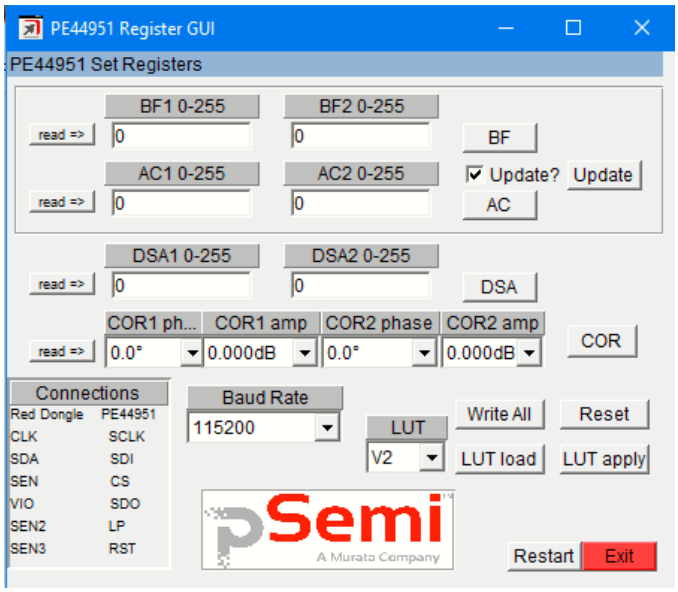
7. Select **I accept this agreement**, then select **Next**. The software installs the device drivers, and the Device Drive Installation Wizard screen displays.



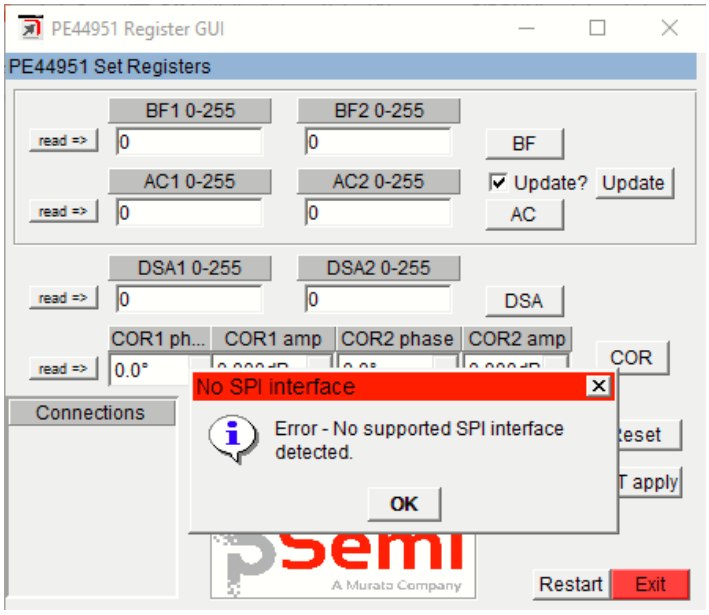
8. To complete the device driver installation, select **Finish**.

Installing the Red Dongle Interface Files on the PC

1. Download the **PE44951 folder** from the shared folder present at the FTP build.
2. Navigate to \\StandaloneUtilities\PE44951\PE44951_SetRegisters.vxe, and create a desktop shortcut for the **PE44951_SetRegisters.exe** file.
3. Connect the red dongle to the PC using the USB cable provided, then wait for one minute.
4. Select **PE44951_SetRegisters.vxe**. If the red dongle is properly connected to the PC, the PE44951 Register Gui screen displays, and the *Connections* section of the screen displays all the connections.



5. If the red dongle is not properly connected to the PC, the following pop-up displays.

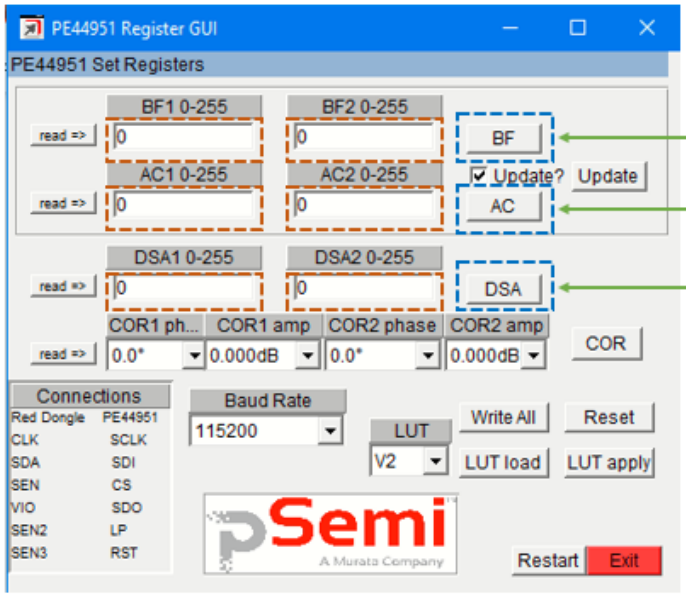


6. If the red dongle is still connected to the PC and the error message still displays, select **OK** and then select **Restart**.

Using the Graphical User Interface

For detailed information about the beamformer (BF) phase buffer, amplitude control (AC) phase buffer, and digital step attenuation (DSA) settings, see the “Detailed Description” section of the *PE44951 Data Sheet*.

In the screen images that follow, select the **Update?** check box and the **Update** button to latch in the phase (the LP line goes high). The phase values are not activated until you select the **Update** button, or you select the **Update?** check box, which latches the values automatically. Do *not* select the **COR** button.

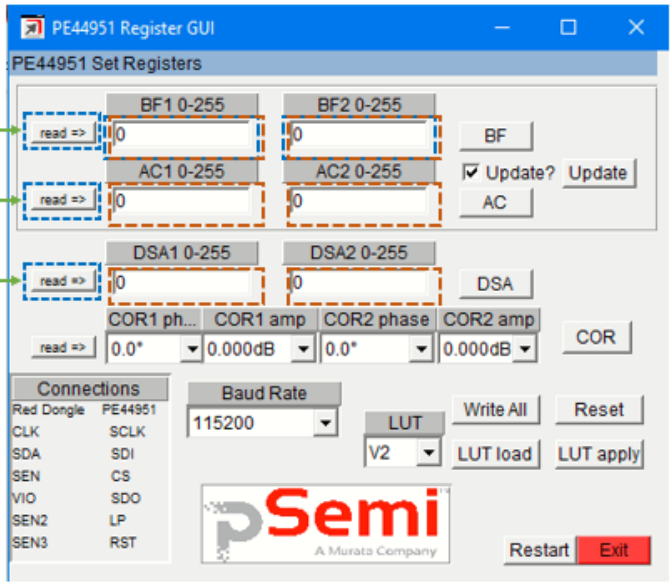


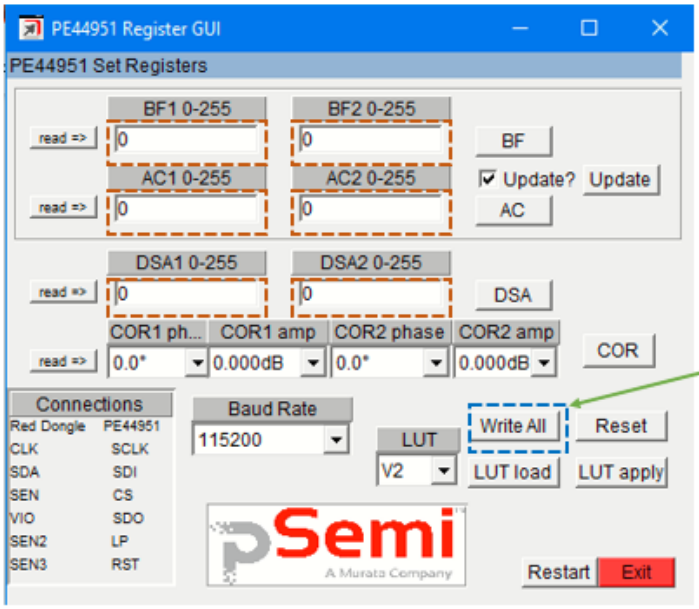
In the text boxes marked by a red rectangle, enter the desired phase state number and DSA state number.

Click the BF or AC and DSA buttons (marked by blue rectangles) to send the appropriate command to the part.

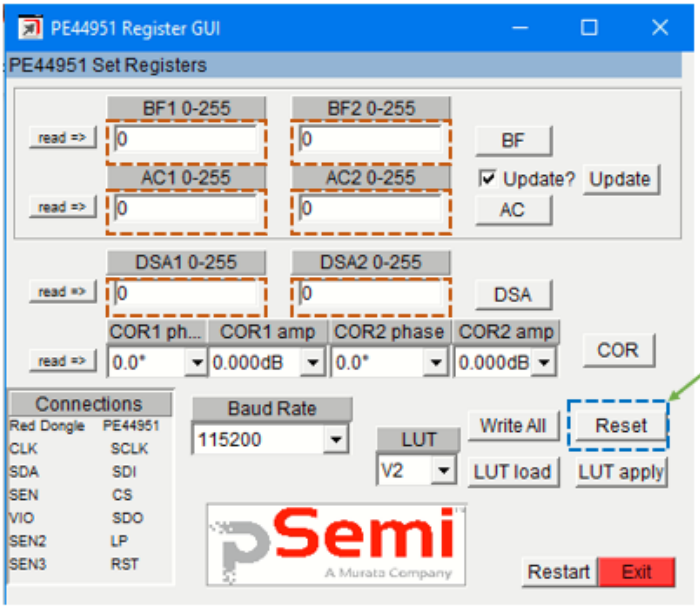
The range of the values is also shown.

To perform a read-back operation from the part, click the read boxes next to the appropriate section. The BF/AC and DSA value already present in the part appears in the text boxes.

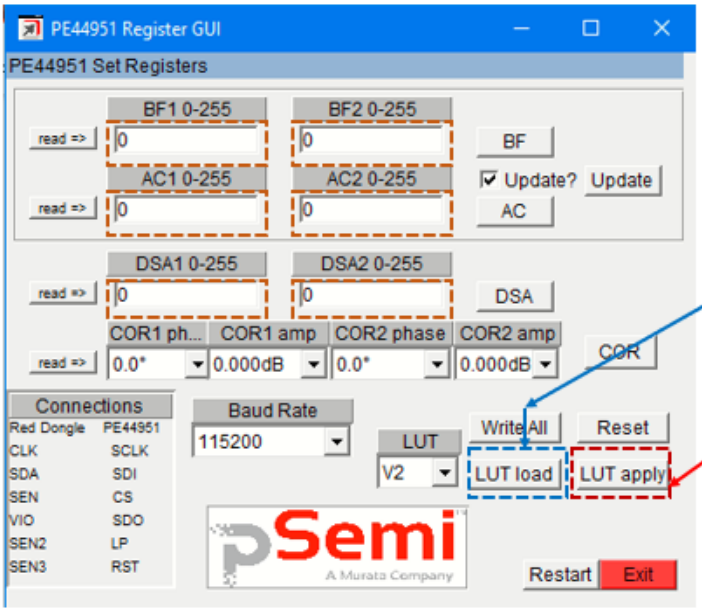




Instead of selecting each BF/AC and DSA individually, you can write all the data at once to the part.



You can reset the internal registers using this button.



The lookup tables (LUT) reside in the same location as the installer for the PE44951 Register GUI: Location: \\StandaloneUtilities\PE44951\LUT\

Click **LUT apply** to instantiate the lookup table. After the lookup tables are applied, the phase steps and the amplitude steps become more accurate for the part.

Pin Information

Figure 10 shows the PE44951 pin map for the 32-lead 5 × 5 × 0.7 mm FCLGA package, and Table 4 lists the description for each pin.

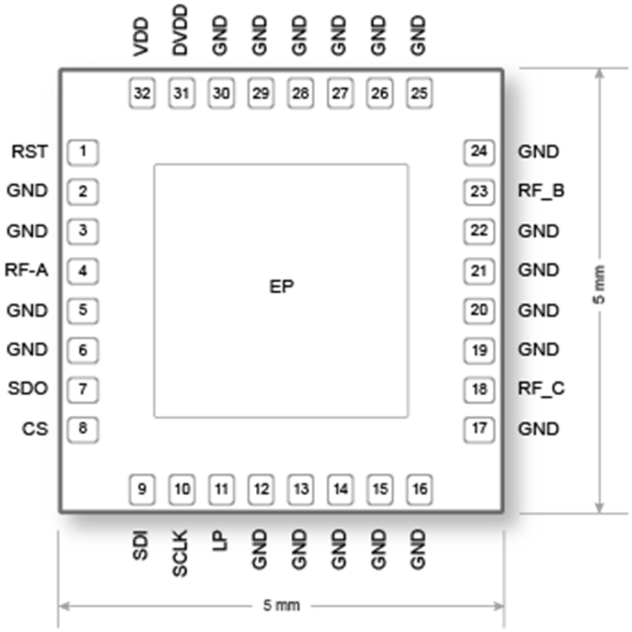


Figure 10. Pin Configuration (Top View)

Table 4. PE44951 Pin Descriptions

Pin No.	Pin Name	Description
–	EP	Exposed ground pad
1	RST	Reset (active low)
2, 3, 5, 6, 12, 13, 14, 15, 16, 17, 19, 20, 21, 22, 24, 25, 26, 27, 28, 29, 30	GND	Ground
4	RF_A	RF input
7	SDO	Serial data output
8	CS	Chip select (active low)
9	SDI	Serial data input
10	SCLK	Serial data block
11	LP	Latch phase (active high)
18	RF_C	RF output 2
23	RF_B	RF output 1
31	DVDD	Supply voltage for digital
32	VDD	Supply voltage for analog

Evaluation Board Schematic

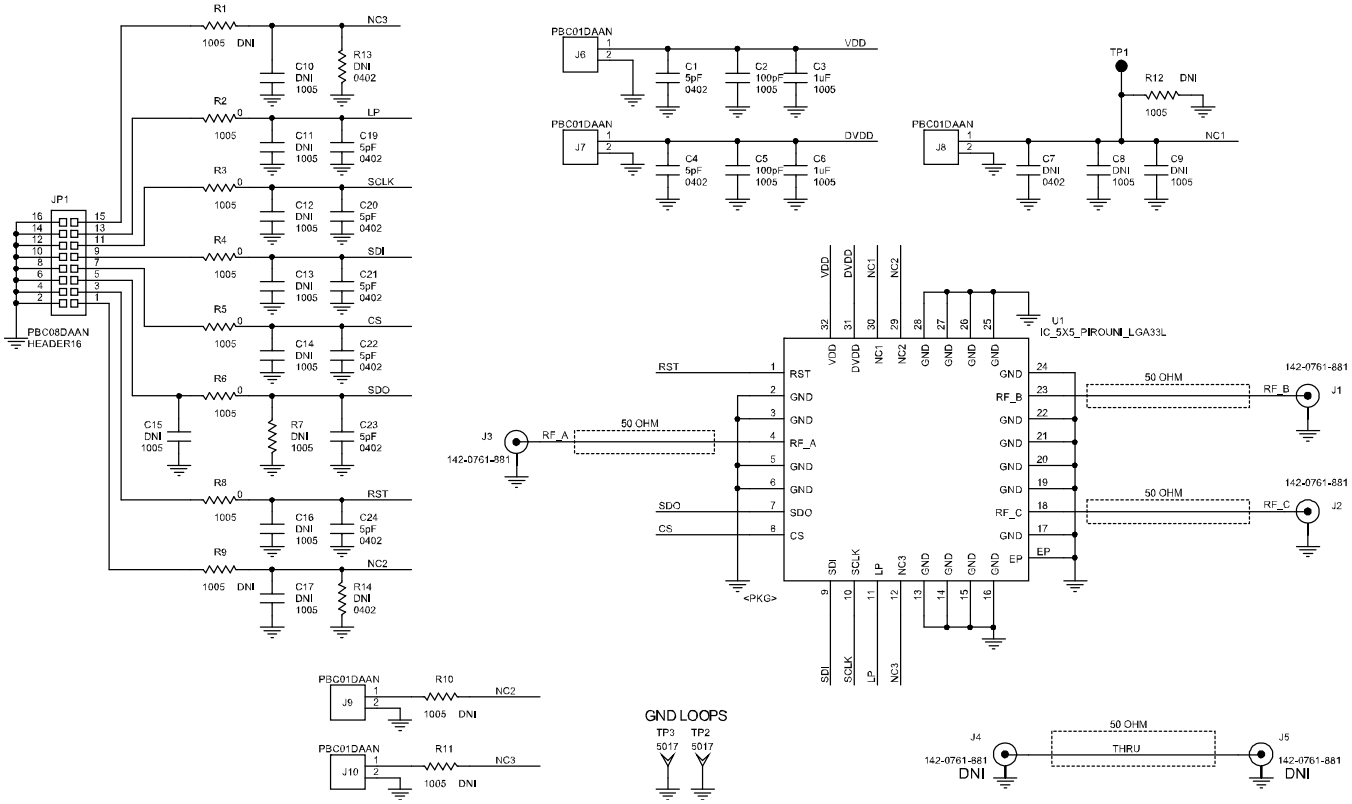


Figure 11. PE44951 Evaluation Board Schematic

Technical Resources

Additional technical resources are available for download in the Products section at www.psemi.com. These include the product specification datasheet, S-parameters, zip file, evaluation kit schematic, bill of materials, material declaration form, and PC-compatible software file.

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