Power-Added Efficiency Measurement Library User Manual

2025-03-26

Contents

Power-Added Efficiency Measurement Library User Manual

The Power-Added Efficiency Measurement Library User Manual provides detailed descriptions of the product functionality and the step by step processes for use.

Looking for Something Else?

For information not found in the User Manual for your product, such as specifications and API reference, browse ***Related Information***.

Related information:

- Power-Added Efficiency Measurement Library LabVIEW VI Reference
- Electronically Scanned Array Characterization Reference Architecture User Manual
- NI Hardware and Software Operating System Compatibility
- Software and Driver Downloads
- License Setup and Activation
- NI Learning Center

Power-Added Efficiency Measurement Library Overview

The Power-Added Efficiency Measurement Library (PAEML) is a software add-on that includes integration of DC and RF measurement examples and programmatic APIs, and sub-nanosecond synchronization between PXI modules.

The featured power-added efficiency (PAE) measurement relies on the combined use of PXI Source Measure Units (SMUs) and PXI Vector Signal Transceivers (VSTs) to help you measure the device-under-test (DUT) RF input and output power concerning the DC supply.

Key Features

Power-Added Efficiency Measurement Library has the following features and capabilities:

- Simultaneously take PAE and PxdB measurements using a VST and SMU
- Operation up to 26.5 GHz (defined by the VST system used)
- Designed to measure PAE and PxdB for pulsed RF and pulsed power supply
- Synchronizes the VST and SMU through the backplane, allowing fast device characterization

Power-Added Efficiency Measurement Library New Features and Changes

Learn about updates, including new features and behavior changes, introduced in each version of Power-Added Efficiency Measurement Library.

Discover what is new in the latest releases of Power-Added Efficiency Measurement Library.

> **Note** If you cannot find new features and changes for your version, it might not include user-facing updates. However, your version might include non-visible changes such as bug fixes and compatibility updates. For information about non-visible changes, refer to your product ***Release Notes***.

Related information:

- Software and Driver Downloads

Power-Added Efficiency Measurement Library 2024 Q3 Changes

Introduced October 2024

New Features

The initial version of the Power-Added Efficiency Measurement Library provides support for the following features:

- Extracted the PAE API from the Pulsed RF Measurement Library into a separate software package, Power-Added Efficiency Measurement Library.
- Added support for the PXIe-5842 Vector Signal Analyzer.

Hardware Support

The initial version of the Power-Added Efficiency Measurement Library provides support for the following instruments:

- PXI-4130
- PXIe-4137
- PXIe-4139
- PXIe-5831
- PXIe-5841
- PXIe-5842

System Requirements

Power-Added Efficiency Measurement Library has the following requirements:

- **Processor**— 1 GHz 64-bit (x64)
- **RAM**— 4 GB RAM

> **Note** Depending on the amount of data acquired and/or processed, a larger amount of memory may be required.

- **Screen Resolution**—Minimum 1,024 × 768
- **Operating System**—Any supported OS, with all available critical updates and service packs

Supported Operating Systems

Determine which versions of Power-Added Efficiency Measurement Library are compatible with your Windows operating system.

Table 1. Compatibility Information for Power-Added Efficiency Measurement Library and Windows Operating Systems

Software Name	Supported Operating System (64-bit)
Power-Added Efficiency Measurement Library 2024 Q3	Windows 11/10

Supported Application Development Environment Versions

Determine which versions of NI application development environment (ADEs) are compatible with Power-Added Efficiency Measurement Library.

Table 2. Compatibility Information for Power-Added Efficiency Measurement Library and NI ADEs

Power-Added Efficiency Measurement Library API	Earliest Supported ADE Version
API	LabVIEW 2021
InstrumentStudio Plugin	InstrumentStudio 2024 Q3

Note The Power-Added Efficiency Measurement Library installation includes InstrumentStudio.

Supported Hardware

Power-Added Efficiency Measurement Library provides support for the following hardware models.

Vector Signal Transceivers (VSTs)

- **PXIe-5831**—44 GHz, 1 GHz Bandwidth PXI Vector Signal Transceiver
- **PXIe-5841**—6 GHz, 1 GHz Bandwidth, RF PXI Vector Signal Transceiver
- **PXIe-5842**—26.5 GHz or 54 GHz, Up to 2 GHz BW, RF PXI Vector Signal Transceiver

Source Measure Units (SMUs)

- **PXI-4130**—±20 V, ±2 A DC, 40 W PXI Source Measure Unit
- **PXIe-4137**—PXIe, ±200 V, ±1 A DC, ±3 A Pulsed, Up to 40 W DC, 100 fA Precision System PXI Source Measure Unit
- **PXIe-4139**—PXIe, ±60 V, ±3 A DC, ±10 A Pulsed, 40 W DC, 100 fA Precision System PXI Source Measure Unit

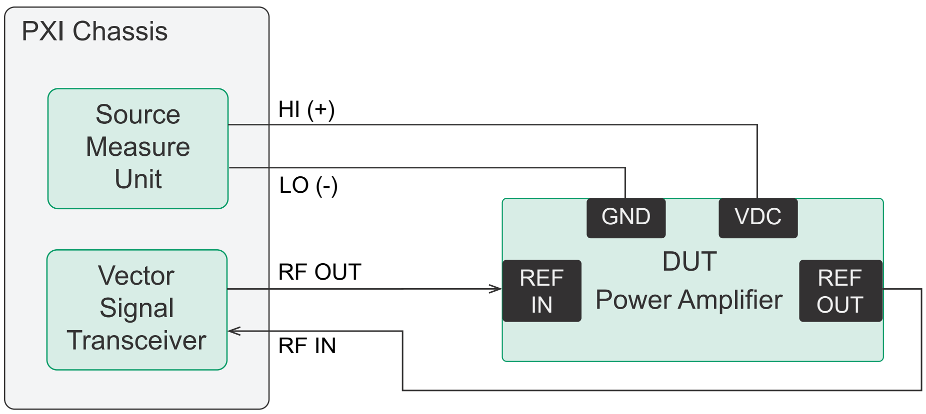
Hardware Requirements

The Power-Added Efficiency Measurement Library (PAEML) provides several recommended hardware configurations to accomplish PAE measurements, including a choice between the PXIe-5831, PXIe-5841, or PXIe-5842 and the ability to use internal or external local oscillation (LO).

Use PAEML to design a test system comprised of a source measurement unit (SMU) and a combination of one or more vector signal transceivers (VSTs) for RF generation and analysis. Use the Power-Added Efficiency Measurement Library to customize and automate measurements.

The following figure demonstrates how NI hardware is connected to perform a power-added efficiency (PAE) measurement.

Figure 1. Power-Added Efficiency Diagram



A VST is a combination of a one-port generator and a one-port analyzer with an onboard FPGA. A VST can simultaneously generate a stimulus and receive back the response from the coupled port with minimal phase noise impact due to the LO sharing capabilities between the transmission and receiving path.

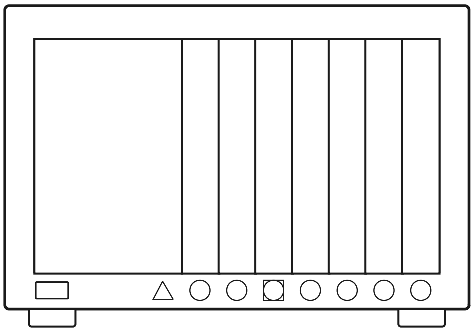
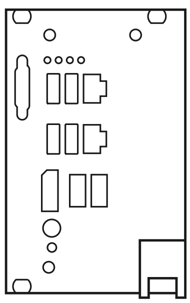
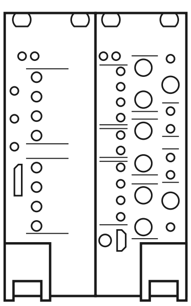
A source measure unit (SMU) is used to power the DUT and measure the power consumption.

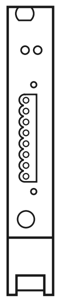
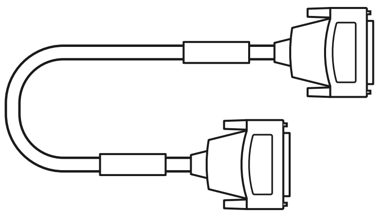
The Power-Added Efficiency Measurement Library system includes the following hardware components.

Notice A system and the surrounding environment must meet the requirements defined in the specifications documents for each hardware component.

Table 3. System Hardware Components

Component	Description and Recommendations
PXI Chassis	A PXI chassis houses the RTG system and supplies power,

Component	Description and Recommendations
	communication, and timing/synchronization for the RTG functions. Required Model: PXIe-1095
PXI Controller 	A PXI controller, installed in the same PXI chassis as the VST instruments, interfaces with the instrument using NI device drivers. Minimum Requirements: 16 GB/s bandwidth and 16 GB RAM
Vector Signal Transceiver (VST) Instrument(s) 	The VST instrument. • PXIe-5831 • PXIe-5841 or PXIe-5841 (with PXIe-5655) • PXIe-5842 (VST Only)
Source Measure Unit (SMU)	The SMU instrument. • PXI-4130 • PXIe-4137 • PXIe-4139

Component	Description and Recommendations
	**Note** The PXI-4130 supports Constant DC Stimulus and CW RF Stimulus measurements only, and does not support Pulsed DC Stimulus or Pulsed CW RF Stimulus measurement operations.
Cables and Accessories 	Cables and accessories not included in the hardware kits that allow connectivity to/from the instruments for measurements. Visit ***NI SMU Cable and Accessory Compatibility*** for more information about supported cables and accessories for your SMU.

Related information:

- PXIe-1095 Specifications
- PXI-4130 Specifications
- PXIe-4137 Specifications
- PXIe-4139 Specifications
- PXIe-5831 Specifications
- PXIe-5841 Specifications
- PXIe-5842 Specifications
- NI SMU Cable and Accessory Compatibility

Theory of Operation

The Power-Added Efficiency Measurement Library helps you set up PXI modules for synchronous RF pulsing, DC triggering, and DUT control to measure PAE, compression point, and gain.

Power-Added Efficiency

Power-added efficiency (PAE) is a measure of how efficiently a power amplifier converts a DC and RF input to a higher power RF output.

The following formula shows how PAE is calculated:

$$PAE = \frac{PRFoutput - PRFinput}{PDCsupply}$$

This calculation requires the power usage of the DC supply and the input and output powers on the ports of the DUT. To see how different frequency and power levels affect PAE, you can make several measurements across a sweep of frequencies or power levels. The data collected helps identify the ideal operating range of the DUT.

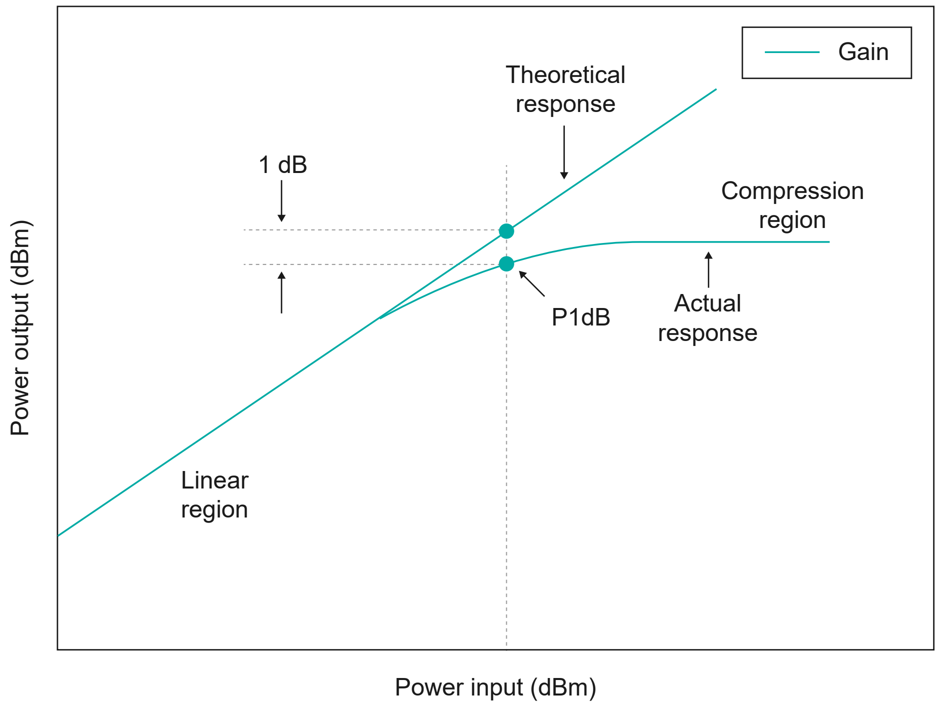
Compression Point Measurement

The compression point is the power level at which the amplifier enters a saturation region where the output power does not grow in proportion to the input power. In this scenario the proportion constant is equal to the gain of the amplifier.

The most common compression points are the 1 dB, 2 dB, and 3 dB points (often written as P1dB, P2dB, and P3dB). Although a device's actual response diverges from the theoretical response outside the linear range, P1dB is where the ideal linear response and measured data diverge by 1 dB.

The following graph shows an example of a PAE measurement with a compression point labeled.

Figure 1. Compression Points



Gain Measurement

Gain measurement determines the difference in power between the input and output of the device for each frequency. The gain is defined as:

$$\text{Gain (dB)} = 10\log\left(\frac{\text{PRFoutput}}{\text{PRFinput}}\right) = \text{PRFoutput (dBm)} - \text{PRFinput (dBm)}$$

It is measured in the linear range of the device, and it is obtained for each frequency, showing the gains over frequency or the gains over input power.

Setting Up the PAEML System

The following topics show you how to set up the Power-Added Efficiency Measurement Library system for performing PAE measurements.

1. Installing the Software
   Complete the following steps to install the Power-Added Efficiency Measurement Library.
2. Connecting the Hardware for PAE Measurements
   Complete the following steps to set up your hardware to perform PAE measurements.

Installing the Software

Complete the following steps to install the Power-Added Efficiency Measurement Library.

1. Download NI Package Manager from `ni.com/support`.

   > **Note** Refer to the ***Package Manager User Manual*** for complete information about using Package Manager.

2. Use the search field in Package Manager to find and install the following packages:
   - LabVIEW
   - Power-Added Efficiency Measurement Library

   > **Note** Package Manager may recommend additional software by default. NI recommends that you accept these additional items.

Related information:

- Software and Driver Downloads
- Package Manager User Manual
- License Setup and Activation

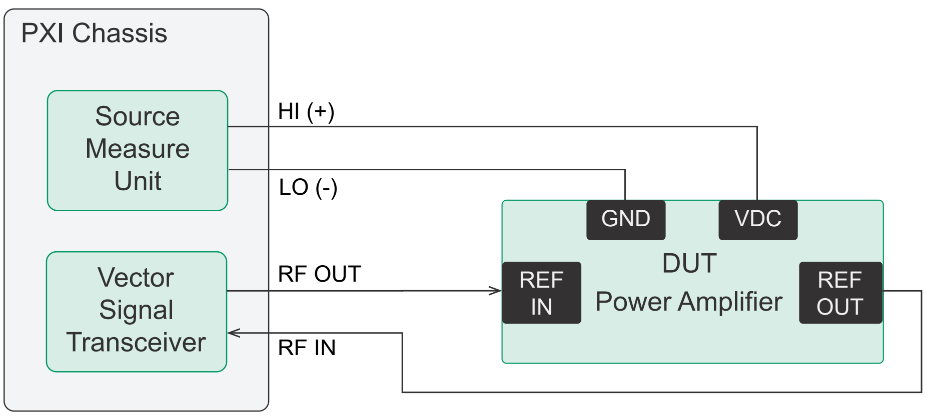
Connecting the Hardware for PAE Measurements

Complete the following steps to set up your hardware to perform PAE measurements.

Refer to the hardware requirements listed in ***System Requirements***. Ensure all modules are installed in the chassis before completing the following steps.

1. Connect the HI port of the SMU to the VDC port of the DUT.
2. Connect the LO port of the SMU to the GND port of the DUT.
3. Connect the RF OUT (or IF IN/OUT 0) port of the vector signal transceiver (VST) to the RF IN port of the DUT using an SMA cable.
4. Connect the RF IN (or IF IN/OUT 1) port of the VST to the RF OUT port of the DUT using an SMA cable.

Figure 1. Connecting for Power-Added Efficiency Measurements



Related reference:

- System Requirements

Related information:

- PXIe-1095 User Manual
- PXI-4130 Features
- PXIe-4137 User Manual
- PXIe-4139 User Manual
- PXIe-5831 User Manual
- PXIe-5841 User Manual
- PXIe-5842 User Manual

Using the RF System Calibration Assistant for the PAEML System

Use the RF System Calibration Assistant to de-embed any test fixture between the VST and the DUT. RF System Calibration Assistant installs with PAEML.

> **Note** Before performing system-level calibration, you must independently calibrate each component of your test system.

1. Launch the executable from the start menu or from the following file path on your machine: `<Program Files>\National Instruments\RF System Calibration\RF System Calibration Assistant.exe`.
2. Click **Start Calibration/Verification** to begin calibration.
3. When the Load Configuration dialog box opens, click **Configure new calibration**.
4. Click the **Resources** tab and update the following controls in the Resources section.
    a. Change the resource type using the **Power Meter Type** drop-down menu. This causes the **Power Meter Resource Name** to automatically populate with the supported hardware for this type.
    b. Enable the **Enable Power Meter Zero** checkbox.
    c. Set the Signal Generator Type to **NI5831 SG** when using a PXIe-5831, or **NIRFSG RF** when using other hardware.
    d. Input the name of your signal generator as it appears in Measurement & Automation (MAX).
    e. Set the Signal Analyzer Type to **NI5831 SA IQPOWER** when using a PXIe-5831, or **VST NIRFMX TXP** when using other hardware.
    f. Input the name of your signal analyzer as it appears in MAX.
    g. Choose from the following options:
        - If you are using a VST, enable **Self Calibrate Generator** to calibrate both the hardware and the analyzer.
        - If you are not using a VST, enable **Self Calibrate Generator** and **Self Calibrate Analyzer**.
    h. Do not modify the **External Path Resources** section unless the external path resources are RF accessories such as amplifiers or switches that exist in the

system's RF path.

i. Update the **RF SG System Calibration Data XML File Path** and the **RF SA System Calibration File Path** fields to select where you want to save your calibration results.
j. Click **Next**.

5. Click the **(De-)Embedding Resource** tab and define any de-embedding resource. Leave this section blank if you are not using this feature.
6. Click the **Generator Paths** tab to define the generator path(s) that will be calibrated.
   a. Enter a path in the **Path Name** input field.

   > **Note** You must enter the **Path Name** first for other fields to autocomplete.

   b. Verify the source and destination port. Enter an alias in the **Instrument Alias** input field.
   c. If you are using a PXIe-5831, select the correct port in the **SG Port** column.

   > **Note** If you are using a PXIe-5841, PXIe-5841 with PXIe-5655, or PXIe-5842, the **SG Port** column should not appear. However, if the SG Port column does appear, enter `NA` for the port.

   d. Click **Next**.
7. Click the **Generator Calibration Settings** tab to define the generator calibration sweep settings.
   a. Configure the **Frequencies (Hz)** and **Powers (dBm)** controls.
   Do not specify more than one power. The PRFM API doesn't support loading a file containing multiple powers.
   b. Click **Append**. If nothing is added to the table, ensure that generator path names were added in the **Generator Paths** tab.
   c. Click **Next**.
8. Click the **Analyzer Paths** tab to define the analyzer path(s) that will be calibrated.
   a. Enter a path in the **Path Name** input field.

   > **Note** You must enter the **Path Name** first for other fields to autocomplete.

   b. Verify the source and destination port. Enter an alias in the **Instrument Alias** input field.

c. Select an option from the **Cal Tone Path Name** drop-down menu.
d. If you are using a PXIe-5831, select the correct port in the **SA Port** column.

> **Note** If you are using a PXIe-5841, PXIe-5841 with PXIe-5655, or , or PXIe-5842 the **SA Port** column should not appear. However, if the **SA Port** column does appear, input `NA` for the port.

e. Click **Next**.

9. Click the **Analyzer Calibration Settings** tab to define the analyzer's calibration sweep settings.
   a. Configure the **Frequencies (Hz)**, **Reference Level (dBm)**, and **Cal Tone Power (dBm)** controls.
   b. Click **Append**. If nothing is added to the table, ensure that analyzer path names were added in the **Analyzer Paths** tab.

   > **Note** If using the Simulation mode, you must manually enter `NA` for the SA Path Name column in order for the simulation to function correctly.

   c. Click **Next**.
10. Click **Calibrate** to begin the calibration you have defined.
11. Click **Yes** in the window that appears if you want to save the calibration configurations.
12. Once the calibration begins, follow the instructions in the user prompts.
13. Once the calibration is complete, click **File » Exit** to close the RF System Calibration Assistant.

Related information:

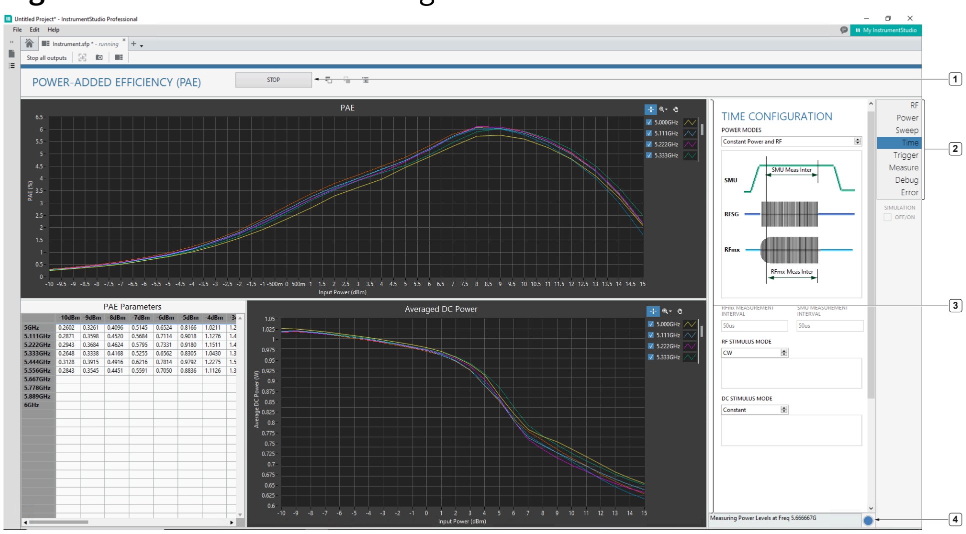
- PXIe-5831 Specifications
- PXIe-5841 Calibration Procedure
- PXIe-5841 Specifications
- PXIe-5842 Calibration Procedure
- PXIe-5842 Specifications

Performing Measurements Using the PAE Measurement Plugin

The PAE Measurement Plugin for InstrumentStudio provides an interactive panel you can run to easily perform measurements that help you determine device efficiency performance.

You configure the parameters specific to your DUT, signal generator, signal analyzer, and SMU and select the measurement configurations before running the application.

Figure 4. PAE Measurement Plugin Interactive Panel



1. Run/Stop Button
2. Configuration Pane
3. Display Pane
4. Message Bar

Run/Stop Button

Click the **Run** button to run the measurement once. Click the down arrow to select **Run** or **Run continuously**. After clicking **Run**, the button becomes the **Stop** button.

Configuration Pane

Use the parameters on the **Configuration** pane to specify the VST and SMU hardware, power, and measurement settings used for the PAE measurement.

- **RF**—Click to open the **RF Signal Generator** and **RF Signal Analyzer** panes. Use these panes to select the RF signal generator settings and RF signal analyzer settings for your VST hardware.
- **Power**—Click to open the **SMU/Power Supply** pane. Use this pane to select DC power settings required by the DUT.
- **Sweep**—Click to open the **Frequency Configuration** and **Power Configuration** panes. Use these panes to select the frequency and power sweep options of the measurement sweep.
- **Time**—Click to open the **Time Configuration** pane. Use this pane to select the DC power and RF signal options used to stimulate the DUT, and the RFmx/SMU measurement intervals for each option.
- **Trigger**—Click to open the **Trigger Configuration** pane. Use this pane to select the trigger settings for the PAE measurement.
- **Measure**—Click to open the **Measure Configuration** and **Results Configuration** panes. Use these panes to configure the compression point of measured data and to specify the data to show on the **Display** pane.
- **Debug**—Click to open the **Monitor Measurements** pane. Use this pane to view the I/O power (dBm) plot, TXP trace plot, and real-time power values read from the PAE measurement.
- **Error**—Click to open the **Error Message** pane. If an error occurs during configuration or execution, the **Error Message** pane displays the applicable error code and message, and the application automatically reverts to the last safe state. Correct the error and repeat any actions necessary to clear the error. Errors are automatically logged as a text file to `\Documents\LabVIEW Data\PAE Measurement\System Level Errors\System Errors.txt`.

Display Pane

The **Display** pane includes an upper graph, a lower graph, and a table. The information that displays in each area dynamically updates according to the options selected on the Measure pane of the **Configuration** pane.

- **Upper Graph**—Shows the efficiency curve of acquired data. You can select the type

of curve to plot:
  - **PAE**—Plots PAE (%) over input power (dBm). You can select one or more frequency points to display.
  - **PxdB**—Plots the compression point measurement as the power output (dBm) and the power input (dBm) at the compression point defined by x value of PxdB over the different frequencies in Hz. Generates a vertical bar if the compression point cannot be located.
  - **Gain over Frequency**—Plots gain (dB) over frequency (Hz).
- **Lower Graph**—Displays acquired data according to its configuration. You can configure the lower graph to plot RFmx Average Power, SMU Average Power, or Gain.
- **Table**—Displays acquired data in tabulated form. You can configure the table to display PAE or PxdB data.

Message Bar

Displays actions or status related to the state, such as the power and frequency measured at a specific time of the application.

Related information:

- InstrumentStudio User Manual

Taking a Measurement with the PAE Measurement Plugin

The PAE Measurement Plugin enables you to perform power-added efficiency (PAE) measurements without interacting directly with the Power-Added Efficiency Measurement Library API. Use the plugin to determine the performance of the device being tested.

Perform a system-level calibration to de-embed any test fixture between the VST and the DUT before beginning these steps. Refer to ***Using the RF System Calibration Assistant for the PAEML System*** for instructions.
The following steps provide a common user workflow for interacting with the PAE Measurement Plugin.
Related tasks:

- Using the RF System Calibration Assistant for the PAEML System

Open the PAE Measurement Plugin

Access the PAE measurement panel in InstrumentStudio.

1. On the InstrumentStudio Home screen, select **Manual Layout**.
2. In the Edit Layout window, locate **Power-Added Efficiency (PAE)** from the Measurements list and select **Create large panel** in the drop-down list.
3. Click **OK**.

Configure Hardware Settings

Perform the following steps to configure and commit changes to your VST and SMU/power supply with the RF and Power parameters on the Configuration pane.

1. Click the **RF** parameter on the Configuration pane to access VST configuration settings.
2. Configure the RF Signal Generator of your VST by defining the following settings on the **RF Signal Generator** pane.
   a. Select the device identifier you configured in the Measurement & Automation Explorer (MAX) using the **RFSG Name** drop-down menu.
   b. If your VST has more than one port on the generator side, enter the name of the port to use in the **RFSG Port** input field. If your VST has only one generator port, leave this field empty.
   c. To correct for gains/losses in the connection network, choose one of the following options in the **RFSG Attenuation** drop-down menu.
      - Select **RF System Calibration** and enter the file path of the generator calibration XML file created with the NI RF System Calibration Assistant in the **RFSG Attenuation XML File** input field, and then enter the name of the generator path you are using in the **RFSG Attenuation Path Name** input field.
      - Select **Constant Attenuation** and enter the amount of attenuation (in dB) between the DUT and the analyzer in the **RFSG External Attenuation** input field.
      - Select **s2p File** and enter the file path of the S2P file in the **RFSG S2P File** input field, and then enter the name of the analyzer path you are using in the **RFSG Attenuation S2P Path Name** input field. Enter the orientation in

the **RFSG S-Parameters Orientation** drop-down menu.

3. Configure the RF Signal Analyzer of your VST by defining the following settings on the **RF Signal Analyzer** pane.
   a. Select the device identifier you configured in MAX using the **RFmx Name** drop-down menu.
   b. If your VST has more than one port on the analyzer side, set the port name you want to use with the **RFmx Port** input field. If your VST has only one analyzer port, leave this field empty.
   c. Enter the bandwidth (in Hz) in the **RBW** input field.

      > **Note** The bandwidth has to take into account the value specified by the RFmx Measurement Interval. Both values define some form of averaging for the RF Power Measurement but can define different results. At a minimum, the RBW needs to be high enough that multiple samples, especially when taken during pulsed RF signals, and the measurement interval has to be short enough to stay on the same pulse. For more information about RBW, refer to ***Resolution Bandwidth*** in the ***NI RF Signal Analyzers User Manual***.

   d. To correct for gains/losses in the connection network, choose one of the following options in the **RFmx Attenuation** drop-down menu.
      - Select **RF System Calibration** and enter the file path of the analyzer calibration XML file created with the NI RF System Calibration Assistant in the **RFmx Attenuation XML File** input field, and then enter the name of the analyzer path you are using in the **RFmx Attenuation Path Name** input field.
      - Select **Constant Attenuation** and enter the amount of attenuation (in dB) between the DUT and the analyzer in the **RFmx External Attenuation** input field.
      - Select **s2p File** and enter the file path of the S2P file in the **RFmx S2P File** input field, and then enter the name of the analyzer path you are using in the **RFmx Attenuation S2P Path Name** input field. Enter the orientation in the **RFmx S-Parameters Orientation** drop-down menu.
4. Click the **Power** parameter to access SMU/Power Supply settings and define the following settings on the **SMU/Power Supply** and **Pulsed DC Power** panes.
   a. Select the device identifier you configured in MAX using the **SMU Name** drop-down menu.

   b. Set the channel of the SMU to use for the measurement with the **SMU Channel** input field.
   c. Set the voltage level (in V) according to your DUT needs and specifications with the **On Voltage Level** input field.
   d. Set the current level (in A) according to your DUT needs and specifications with the **On Current Limit** input field.
   e. When the DC Stimulus Mode (set on the **Time** parameter page) is set to **Pulsed**, set the voltage level (in V) and current limit (in A) for the off portion of the DC pulse in the **Off Voltage Level** and **Off Current Limit** input fields.

Related information:

- Resolution Bandwidth

Configure Sweep Settings

Perform the following steps to configure the frequency and power sweep settings for your PAE measurement with the Sweep parameter on the Configuration pane.

1. Click the **Sweep** parameter on the Configuration pane to access sweep settings.
2. Configure a frequency sweep by defining the following settings on the **Frequency Configuration** pane.
   a. Enter the number of iteration steps between the start and end frequency of your sweep in the **Frequency Steps** input field.
   b. Enter the start and end frequencies (in Hz) of the sweep using the **Tx Start Frequency** and the **Tx Stop Frequency** input fields.
   c. If you expect a different frequency domain at the output of the DUT than the input of the DUT, disable the **Make RFmx range the same as RFSG?** checkbox to enable mixer mode. Mixer mode allows you to set different frequency value steps for each side of the DUT.
3. Configure a power sweep by defining the following values on the **Power Configuration** pane.
   a. Configure the starting and stopping power (in dBm) of the sweep using the **Initial Power** and **Final Power** input fields.
   b. Configure the step size (in dBm) of the power sweep using the **Power Step Size** input field.
   c. Configure the expected gain (in dB) of the DUT using the **Expected DUT Gain** input field. Always set the expected gain of the DUT properly to avoid

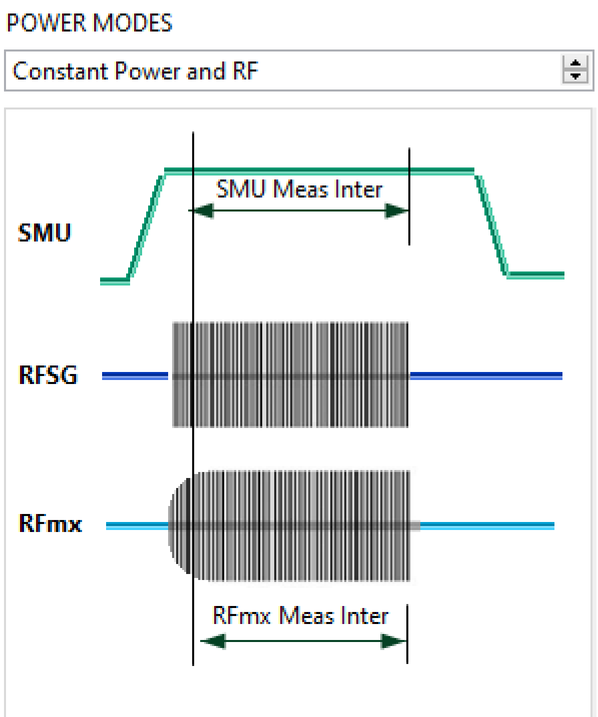
overloading any device ports.

Configure Time Settings

Perform the following steps to configure the time settings for your PAE measurement with the Time parameters on the Configuration pane.

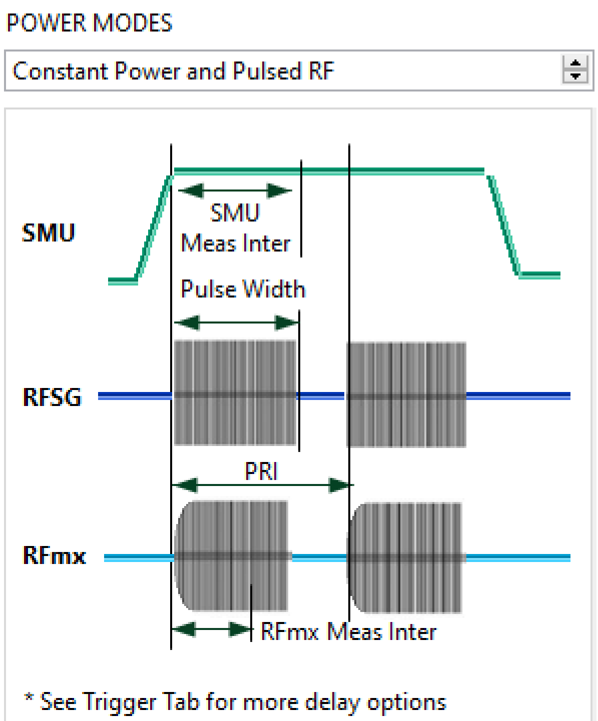
1. Click the **Time** parameter on the Configuration pane to access time settings and define the following settings on the **Time Configuration** pane.
2. Choose one of the following options for the type of DC Power and RF signal you want to stimulate your DUT in the **Power Modes** drop-down menu.
   - Select **Constant Power and RF** when you want to generate a continuous wave RF signal with Continuous Power.

     Figure 1. Constant Power and RF

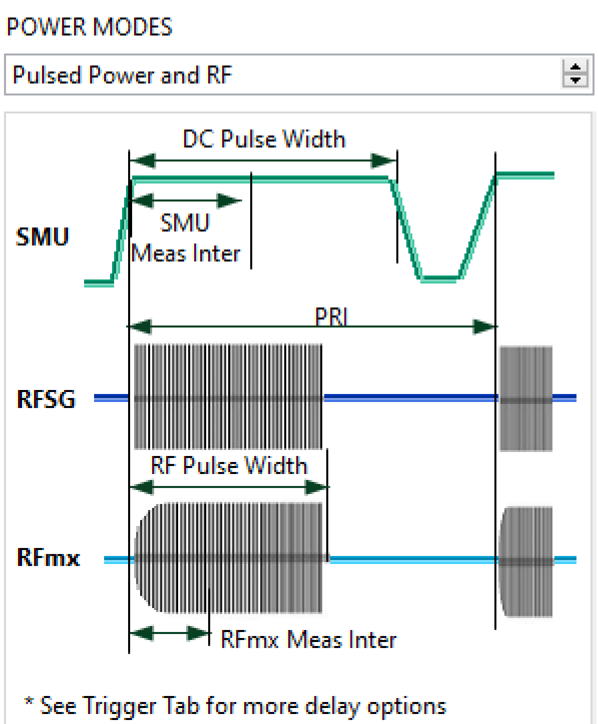
   - Select **Constant Power and Pulsed RF** when your DUT needs constant power and your RF signal is pulsed.

Figure 1. Constant Power and Pulsed RF



- Select **Pulsed Power and RF** when your DUT uses pulsed RF Signals and can operate or require Pulsed DC Power.

Figure 1. Pulsed Power and RF



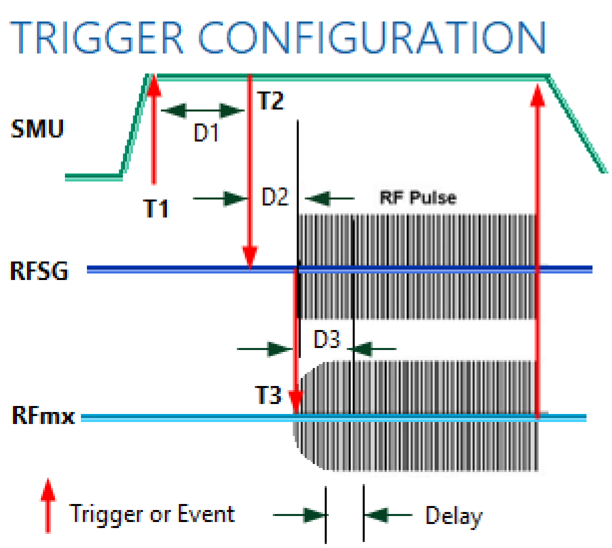
3. Configure the measurement intervals for each option:
   a. Specify the time (in seconds) to measure the RFmx Transmission Power (TXP)

from the **RFmx Measurement Interval** input field.
   b. Specify the time (in seconds) to measure the SMU output power from the **SMU Measurement Interval** input field.
4. When **Constant Power and Pulsed RF** is selected, configure the following additional required settings:
   a. Enter the time interval (in seconds) between pulses in the **PRI** input field.
   b. Enter the pulse width (in seconds) of the RF signal in the **RF Pulse Width** input field.
5. When **Pulsed Power and RF** is selected, configure the following additional required settings:
   a. Enter the time interval (in seconds) between pulses in the **PRI** input field.
   b. Enter the pulse width (in seconds) of the RF signal in the **RF Pulse Width** input field.
   c. Enter the pulse width (in seconds) of the DC pulse in the **DC Pulse Width** input field. The PRI of the DC Pulse is equal to the PRI of the RF Pulse.

Configure Trigger Settings

Perform the following steps to configure the trigger and event settings for your PAE measurement with the Trigger parameter on the Configuration pane.

Figure 1. Trigger Configuration



Supported triggers and events are depicted in the figure and are as follows:

- **T1**—A trigger generated after the SMU is in steady state.
- **T2**—A trigger generated between SMU and RFSG with the ability to add delay (D1)

before the trigger and add delay (D2) after the trigger. D1 allows the DUT to get into steady state, even after the SMU is in steady state. D2 allows time to start generating the signal.

- **T3**—A trigger generated between RFSG and RFmx when the signal generation started. The delay (D3) allows time for the DUT to get into the RF steady state before performing the measurement.

1. Click the **Trigger** parameter on the Configuration pane to access trigger settings on the **Trigger Configuration** pane.
2. Click the **SMU to RFSG** tab to configure the trigger settings that synchronize the RF signal to the DC power.
   a. Select the source of the trigger that starts each DC pulse using the **DCPower Pulse Trigger Input Terminal** input field. An empty string indicates no trigger is used and the SMU generates each pulse based on the configured PRI.
   b. Enter the time (in seconds) between the start of the DC pulse and when the SMU exports the source complete event using the **DCPower Source Delay (D1)** input field.
   c. Enter the time (in seconds) between when RFSG receives the pulse trigger and when it starts generating the pulse using the **RFSG Pulse Trigger Delay (D2)** input field.
   d. Choose the trigger routing method in the **SMU to RFSG Routing Mode** drop-down list. Select from the following options.
      - Select **Automatic** to use dynamic routing to set the DCPower Source Complete event as the input to the RFSG Pulse Trigger using an available PXI backplane trigger line when in Pulsed DC stimulus mode and to use no trigger when in constant DC stimulus mode.
      - Select **Manual** to choose where the DCPower source complete event is routed to using the **DCPower Source Complete Event Out Terminal** input field, and to choose where the RFSG pulse trigger is sourced from using the **RFSG Pulse Trigger In Terminal** input field. An empty string indicates to not export the event or to not use the trigger. The **RFSG Pulse Trigger In Terminal** is ignored if the RF stimulus mode is set to CW.

   > **Note** The stimulus mode is set on the **Time Configuration** pane.

3. Click the **RFSG to RFmx** tab to configure the trigger settings that synchronize the RF measurement to the RF generation.
   a. Select the time (in seconds) between RFmx receiving a trigger input and the

start of the RFmx measurement using the **RFmx Trigger Delay (D3)** input field.

b. Choose one of the following options for the trigger routing method in the **RFSG to RFmx Routing Mode** drop-down menu.
   - Select **Automatic** to use dynamic routing to set the RFSG pulse trigger as the input to the RFmx Trigger using an available PXI backplane trigger line when in Pulsed CW stimulus mode. No trigger is used in CW stimulus mode.
   - Select **Manual** to choose where the DCPower source complete event is routed to using the **DCPower Source Complete Event Out Terminal** input field.
     - Choose where the RFSG pulse trigger is sourced from using the **RFSG Pulse Trigger In Terminal** input field. An empty string indicates to not export the event or to not use the trigger. The **RFSG Pulse Trigger In Terminal** is ignored if the RF stimulus mode is set to CW.
     - Specify the input terminal for the digital edge trigger in the **RFmx Reference Trigger Input Terminal** drop-down menu. An empty string indicates no trigger is used.
     - Specify where to export the pulse trigger in the **RFSG Pulse Trigger Output Terminal** drop-down menu.
     - Choose the type of trigger exported from RFSG using the **RFSG Trigger Type** drop-down menu. Select **Pulse** to export a pulse trigger from RFSG at the start of each RF pulse. Select **Gate** to export a gate trigger around the RF Pulse. Set how long the gate is high before the RF pulse using the **RFSG Pre-Trigger Time** input field. Set how long (in seconds) the gate remains high after the RF pulse using the **RFSG Post-Trigger Time** input field.

4. Click the **RFmx to SMU** tab to configure the trigger settings that synchronize the DC measurement to the RF measurement.
   - Choose one of the following options for the trigger routing method in the **RFmx to DCPower Routing Mode** drop-down menu.
     - Select **Automatic** to use dynamic routing to set the RFmx reference trigger as the input to the DCPower measure trigger using an available PXI backplane trigger line when in Pulsed CW stimulus mode and to use no trigger when in CW stimulus mode.
     - Select **Manual** to choose where the RFmx reference trigger is exported to using the **RFmx Reference Trigger Output Terminal** input field and to choose where DCPower measure trigger is sourced from using the **DCPower Measure Trigger Input Terminal** input field. An empty string

indicates no trigger is used.

Configure Measure Settings

Perform the following steps to configure compression point measurement settings and to select what data to display on the Display Pane with the Measure parameter on the Configuration pane.

1. Click the **Measure** parameter on the Configuration pane to access measurement settings.
2. Select the compression point measurement settings on the **Measure Configuration** pane.
   a. Set the compression point you are looking for using the **x Value of PxdB** input field. Specify `1` to measure P1db.
   b. Set the maximum linear range (in dBm) of the DUT input power using the **Max Linear Range** input field. Refer to the specifications of the DUT for this information.
3. Select the data to display using the options on the **Results Configuration** pane.
   - Select the configuration to display the efficiency curve of acquired data in the **Upper Graph Configuration** drop-down menu. Select **PAE**, **PxdB**, or **Gain over Frequency**.
   - Select the configuration to display the secondary measurement data in the **Lower Graph Configuration** drop-down menu. Select **RFmx Average Power**, **SMU Average Power**, or **Gain**.
   - Select the configuration to display the acquired data in tabulated form in the **Table Configuration** drop-down menu. Select **PAE** or **PxdB**.

Connect to the Instrument and Start Measurements

Perform the following steps.

1. Click the **Run** button or select and then click the **Run Continuously** button to begin the measurement.
2. Click the **Stop** button to stop the measurement.
3. Close the project tab or use **File » Exit** to exit the application.

Accessing Power-Added Efficiency Measurement Library API

The Power-Added Efficiency Measurement Library includes a LabVIEW API, and a C library and header files for use in C and other text-based programming languages.

LabVIEW API

The Power-Added Efficiency Measurement Library VIs are available on the Measurement I/O palette in LabVIEW.

C API

The Power-Added Efficiency Measurement Library C API header files, import libraries, and DLL are available in the `<Program Files>\National Instruments\PAEML` directory.

Related information:

- Power-Added Efficiency Measurement Library LabVIEW VI Reference

PAEML Example Locations

The Power-Added Efficiency Measurement Library installs LabVIEW API programming examples that you can modify to automate and customize measurements to determine device performance.

Use the NI Example Finder to locate examples within LabVIEW.

1. Select **Help » Find Examples**.
2. Click **Directory Structure** on the Browse tab.
3. Double-click the **niPAEML** folder to expand the examples.

You can modify an example VI to fit an application, or copy and paste from one or more examples into a VI that you create.

Related Documentation

You can find the most up-to-date documentation for your NI products online on `ni.com/docs`.

Software Documentation

Refer to the following documentation for information about how to install, configure, and use the software for your system.

Related information:

- Power-Added Efficiency Measurement Library LabVIEW VI Reference
- Electronically Scanned Array Characterization Reference Architecture User Manual
- LabVIEW User Manual
- InstrumentStudio User Manual

PAE Measurement Hardware Documentation

Refer to the following documentation for information about hardware components used for power-added efficiency measurements:

- How to install and configure hardware
- How to use hardware
- Specifications

Related information:

- PXIe-1095 User Manual
- PXIe-1095 Specifications
- PXI-4130 Features
- PXI-4130 Specifications
- PXIe-4137 User Manual
- PXIe-4137 Specifications
- PXIe-4139 User Manual
- PXIe-4139 Specifications

- PXIe-5831 User Manual
- PXIe-5831 Specifications
- PXIe-5841 User Manual
- PXIe-5841 Specifications
- PXIe-5841 Calibration Procedure
- PXIe-5842 User Manual
- PXIe-5842 Specifications
- PXIe-5842 Configuration Guide
- PXIe-5842 Calibration Procedure