Power Measurement Application

Online Help

Agilent Technologies

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Agilent Technologies, Inc.
1900 Garden of the Gods Road
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WARNING

A WARNING notice denotes a hazard. It calls attention to an operating procedure, practice, or the like that, if not correctly performed or adhered to, could result in personal injury or death. Do not proceed beyond a WARNING notice until the indicated conditions are fully understood and met.

Power Measurement Application—At a Glance

The Agilent U1881A or U1882A Power Measurement and Analysis Software, along with a 6000/7000 Series or 8000 Series oscilloscope, lets you quickly and easily analyze switching power supply efficiency and reliability.

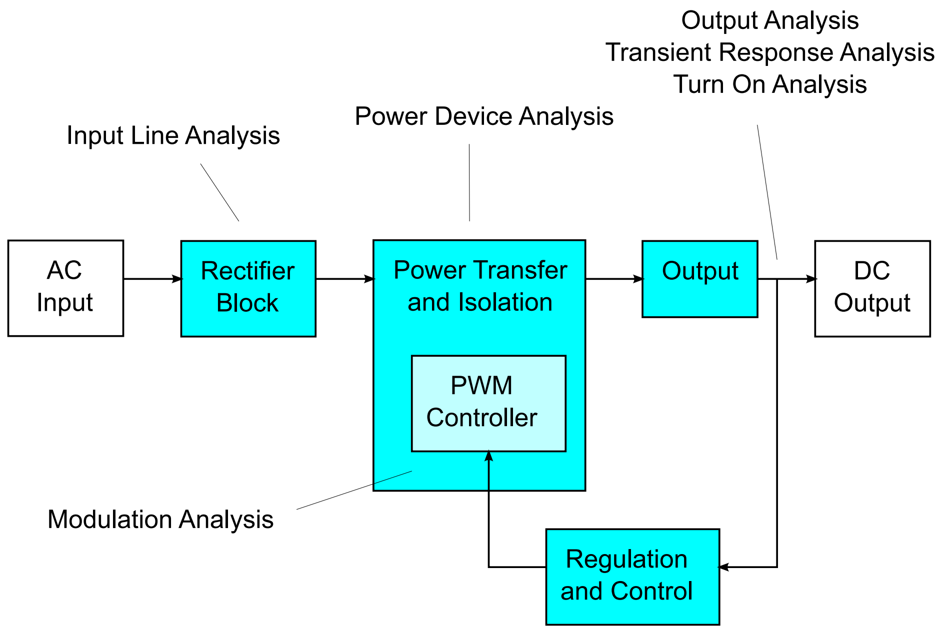


Figure 1 Switch-Mode Power Supply (SMPS) Block Diagram and Types of Measurements

With the Power Measurement Application, you can:

- Measure switching loss at the switching device and power loss at the magnetic component (to help improve efficiency).
- Analyze Safe Operating Area (SOA), dI/dT, and dV/dT (for reliable operation).
- Automate oscilloscope set up for ripple measurements (to eliminate tedious manual oscilloscope set up).
- Perform pre-compliance testing to IEC 61000-3-2 or RTCA DO-160E standards (to reduce compliance testing time).
- Analyze line power with total harmonic distortion, true power, apparent power, power factor, and crest factor tests (to quickly provide power quality information)
- Measure output noise.

- Analyze modulation using the on-time and off-time information of a Pulse Width Modulation (PWM) signal (to help characterize the active power factor).

The power measurement and analysis software, oscilloscope, high-voltage differential probe, current probe, probe deskew fixture, and passive probe, form a complete power measurement system for power supply design and testing.

This software can run on an external PC connected to a 6000/7000 Series or 8000 Series oscilloscope via GPIB, LAN, or USB, or it can run on 8000 Series oscilloscopes (which have the Windows XP Professional operating system).

This online help describes:

- "Prerequisites" on page 9
- "Getting Started" on page 19
- "Performing Other Tasks" on page 39
- "About the Measurements" on page 55
- "Reference" on page 99

For a printable version of this help file, see: *"Power Measurement Application Online Help"*.

Contents

4 About the Measurements

1
Prerequisites

This chapter describes safety considerations and the necessary requirements in order to use the Power Measurement Application.

Safety

WARNING **When connecting to a circuit with hazardous voltages, see the warnings for the individual products, and verify that the probes and other components are used within their ratings.**

Oscilloscope Requirements

The Power Measurement Application works with 6000, 7000, and 8000 Series digital storage oscilloscopes (DSO).

- The 6000 Series oscilloscopes come in 100 MHz, 300 MHz, 500 MHz, and 1 GHz bandwidth models, with 2 Mpts or 8 Mpts of memory.
- The 7000 Series oscilloscopes come in 350 MHz, 500 MHz, and 1 GHz bandwidth models, with 8 Mpts of memory.
- The 8000 series oscilloscopes come in 600 MHz and 1 GHz bandwidth models, with 8, 16, 32, 64, or 128 Mpts of memory.

Characteristics of the power supply under test determine the oscilloscope bandwidth and memory required.

- “Bandwidth Requirements" on page 11
- “Memory Requirements" on page 11
- “Software Version Requirements" on page 12

Bandwidth Requirements

The bandwidth requirements of the oscilloscope and probe are driven by the slew rate (rise/fall times) of the switching device.

For oscilloscopes with Gaussian response (typical for 1 GHz and lower bandwidth oscilloscopes), the oscilloscope's rise time is commonly related to the oscilloscope's bandwidth using the formula: rise time = 0.35/bandwidth. To measure an input signal's rise time with ±5% error, the oscillosope's rise time must be 1/3 of the input signal's rise time. Therefore, the oscilloscope bandwidth required is:

BW = [0.35 / (input signal rise time / 3)]

For example, a switching device whose rise time is 10 ns requires oscilloscope (and probe) bandwidth of 105 MHz.

Memory Requirements

The memory requirements of the oscilloscope depend on the time range and the types of signals to capture:

memory depth = time range * sample rate

- For switching device signals: If you need to capture the switching signals for the duration of half the mains cycle (60 Hz), with a slew rate of 50 ns (using a sampling rate that is four times the required bandwidth), memory depth = 8.333 ms * 21 MHz * 4 = 699972 points.

With 6000 and 7000 Series oscilloscopes, the sampling rate is determined by time range setting. In the above case, the sample rate in High Resolution mode for the time range of 8.333 ms is 100 MSa/s; therefore, the memory depth needed is 833300 points.

- For input AC line signals: You need to capture a few cycles in order to plot the FFT. Resolution of the FFT plot = sampling rate / data size. The expected harmonics are in multiples of 50/60 Hz.

  Because the input signals have low frequency components, a high sampling rate is unnecessary. The RTCA-DO-160E specification states that a sampling rate of 100 kSa/s and higher should be sufficient. For a 60 Hz signal, to capture 10 cycles you need to capture a duration of 83.33 ms.

  The 6000 and 7000 Series oscilloscopes set the sampling rate to be 1 MSa/s for the above time range. The memory depth required is 83330 points with an FFT resolution of 12 Hz.

- For safe operating area (SOA) measurements, you may want to capture many switching cycles (you can select up to 20000) to see any variation of Vds versus Id over a long time.

Software Version Requirements

Table 1 Oscilloscope Software Version Required

Oscilloscope Family	Software Version Required
6000 Series	4.10 or later
7000 Series	5.00 or later
8000 Series	5.30 or later

Probe Requirements

- "Voltage Probe" on page 13
- "Current Probe" on page 14
- "De-Skewing the Voltage and Current Probes" on page 14

Voltage Probe

You can use the following voltage probes:

- Agilent N2772A high-voltage differential probe, 20 MHz bandwidth, 1.2 kV dynamic range.
- Agilent 1153A differential probe, 200 MHz bandwidth, 400 V dynamic range.
- Agilent 1141A differential probe, 200 MHz bandwidth, 400 V dynamic range.
- Sapphire SI-9110 high-voltage differential probe, 100 MHz bandwidth, 1.4 kV dynamic range.
- Tektronix P5205 high-voltage differential probe, 100 MHz bandwidth, 1.3 kV dynamic range.
- Agilent 10076A high-voltage passive probe, 250 MHz bandwidth, 4 kV max. input.
- Agilent 10074A/B/C passive probe, 150 MHz bandwidth, 400 V max. input.
- Agilent 10073A/B/C passive probe, 500 MHz bandwidth, 400 V max. input.
- Agilent 10070A/B/C passive probe, 20 MHz bandwidth, 400 V max. input.
- Agilent N2862A passive probe, 150 MHz bandwidth, 300 V max. input.
- Agilent N2863A passive probe, 300 MHz bandwidth, 300 V max. input.
- Agilent 1160A passive probe, 500 MHz bandwidth, 300 V max. input.
- Agilent 1161A passive probe, 500 MHz bandwidth, 300 V max. input.
- Agilent 1162A passive probe, 25 MHz bandwidth, 300 V max. input.
- Agilent 1165A passive probe, 600 MHz bandwidth, 300 V max. input.

For voltage probe bandwidth requirements, see "Bandwidth Requirements" on page 11.

The probe's voltage range required depends on the input signals to measure. An AC-DC switch mode power supply needs a high voltage range probe because the switching signals and input line signals can go up to 700 Vpp. For a DC-DC switch mode power supply, a smaller probe voltage range is sufficient because the signal amplitudes are much smaller.

A passive probe is typically used to measure DC output and transient response.

Current Probe

You can use the following Agilent current probes:

- 1147A 50 MHz bandwidth, 15A peak.
- N2774A 50 MHz bandwidth, 15A peak.
- N2780A 2 MHz bandwidth, 500A peak.
- N2781A 10 MHz bandwidth, 150A peak.
- N2782A 50 MHz bandwidth, 30A peak.
- N2783A 100 MHz bandwidth, 30A peak.

For current probe bandwidth requirements, see “Bandwidth Requirements" on page 11.

De-Skewing the Voltage and Current Probes

To ensure accurate power loss measurements, use the U1880A deskew fixture to adjust the skew for any time delay differences between the current probe and voltage probe signal paths.

The procedure on de-skewing probes is described in “Getting Started" on page 19.

Table 2 U1880A Deskew Fixture Environmental Characteristics

Temperature	Operating: –10 °C to +55 °C Non-operating: –20 °C to +60 °C
Humidity	Operating: 95% RH at 40 °C for 24 hr Non-operating: 90% RH at 65 °C for 24 hr
Altitude	Operating: to 4,570 m (15,000 ft) Non-operating: to 15,244 m (50,000 ft)
Indoor use	Rated for indoor use only

Installing Agilent IO Libraries Suite

The Agilent IO Libraries Suite is already installed on 8000 Series oscilloscopes.

If you are using the Power Measurement Application on a PC, download the Agilent IO Libraries Suite software from the web at:

- "http://www.agilent.com/find/iolib"

Installing and Licensing the Power Measurement Application Software

- "Installing the Power Measurement Application" on page 16
- "Licensing the Power Measurement Application" on page 16

Installing the Power Measurement Application

Install the Power Measurement Application software from one of the download web pages:

- Infiniium 8000 Series: "http://www.agilent.com/find/scope-apps-sw"
- 7000 Series: "http://www.agilent.com/find/7000sw"
- 6000 Series: "http://www.agilent.com/find/6000sw"

Follow the instructions on your entitlement certificate to redeem and install the Power Measurement Application license.

Licensing the Power Measurement Application

The Power Measurement Application uses node-locked licenses (not floating or counted licenses). You can install the Power Measurement Application on any PC or Windows-based oscilloscope; however, the license type determines how the application can be used with oscilloscopes. Two types of licenses are available:

- *Oscilloscope-locked license* (Option 001) — This enables any Power Measurement Application to connect to and use a licensed oscilloscope. This type of license permits multiple users to share an oscilloscope using a single license.
- *PC-locked license* (Option 002) — This enables the Power Measurement Application on a licensed PC to connect to and use any Agilent 6000/7000 Series or 8000 Series oscilloscope covered by the license. This type of license permits a single user to access different oscilloscopes using a single license and to perform offline analysis.

To license the Power Measurement Application

1. Follow the instructions on the Entitlement Certificate you received with your software purchase.
   - If you purchased an oscilloscope-locked license, you will need the unique identifier for the oscilloscope.
   - If you purchased a PC-locked license, you will need the License Host ID (see "To get the License Host ID" below).
2. Your license will be delivered via e-mail.
   - If you ordered an oscilloscope-locked license, the e-mail will contain an alphanumeric code. Enter this code directly into your instrument using the oscilloscope's interface (see the oscilloscope documentation for instructions on how to install feature licenses).

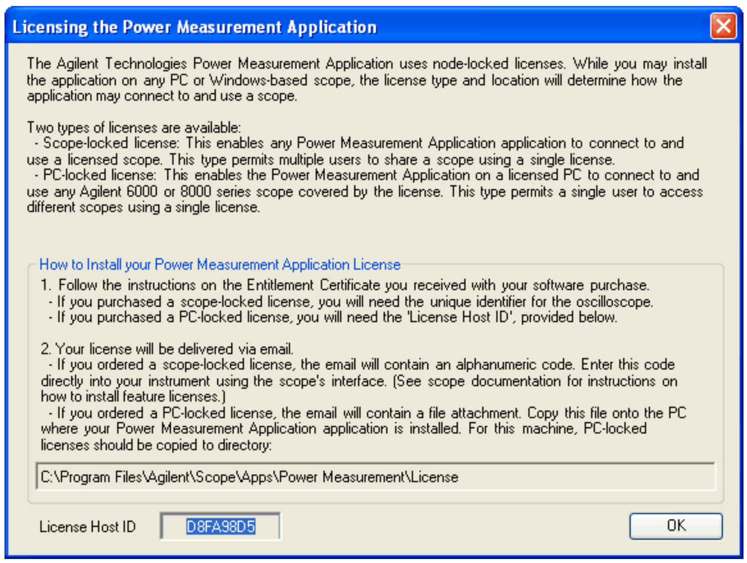
- If you ordered a PC-locked license, the e-mail will contain a file attachment. Copy this file to where your Power Measurement Application is installed. For example, the default license file location is:

  C:\Program Files\Agilent\Scope\Apps\Power Measurement\License\

To get the License Host ID

1 In the Power Measurement Application's main window, choose **Help>Licensing...**.

2 In the Licensing the Power Measurement Application dialog, the License Host ID is highlighted at the bottom.



2
Getting Started

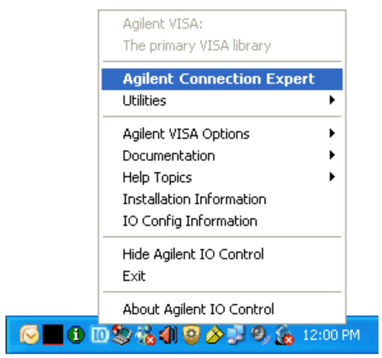
This chapter gives an overview of the steps you must take when first performing power measurements.

Step 1: Add the instrument using Agilent Connection Expert

This procedure only needs to be performed once for each oscilloscope used to make power measurements.

NOTE The menus and dialogs shown here may differ slightly depending on the version of the Agilent IO Libraries Suite.

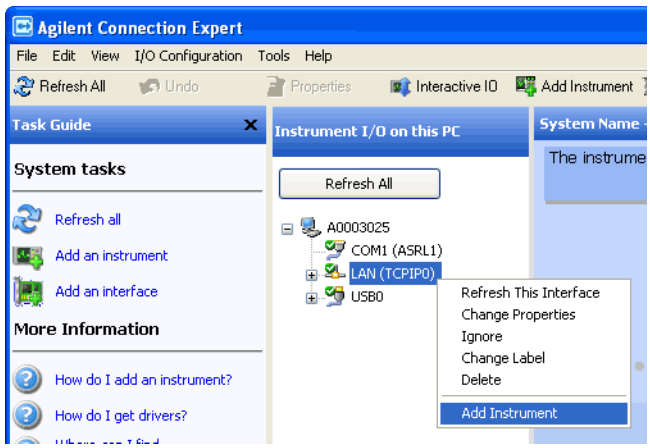
1 On the 8000 Series oscilloscope or PC that will run the Power Measurement Application, choose **Start>All Programs>Agilent IO Libraries Suite>Agilent Connection Expert** from the Windows Start menu. Or, click on the Agilent IO Control icon in the taskbar, and choose Agilent Connection Expert from the popup menu.



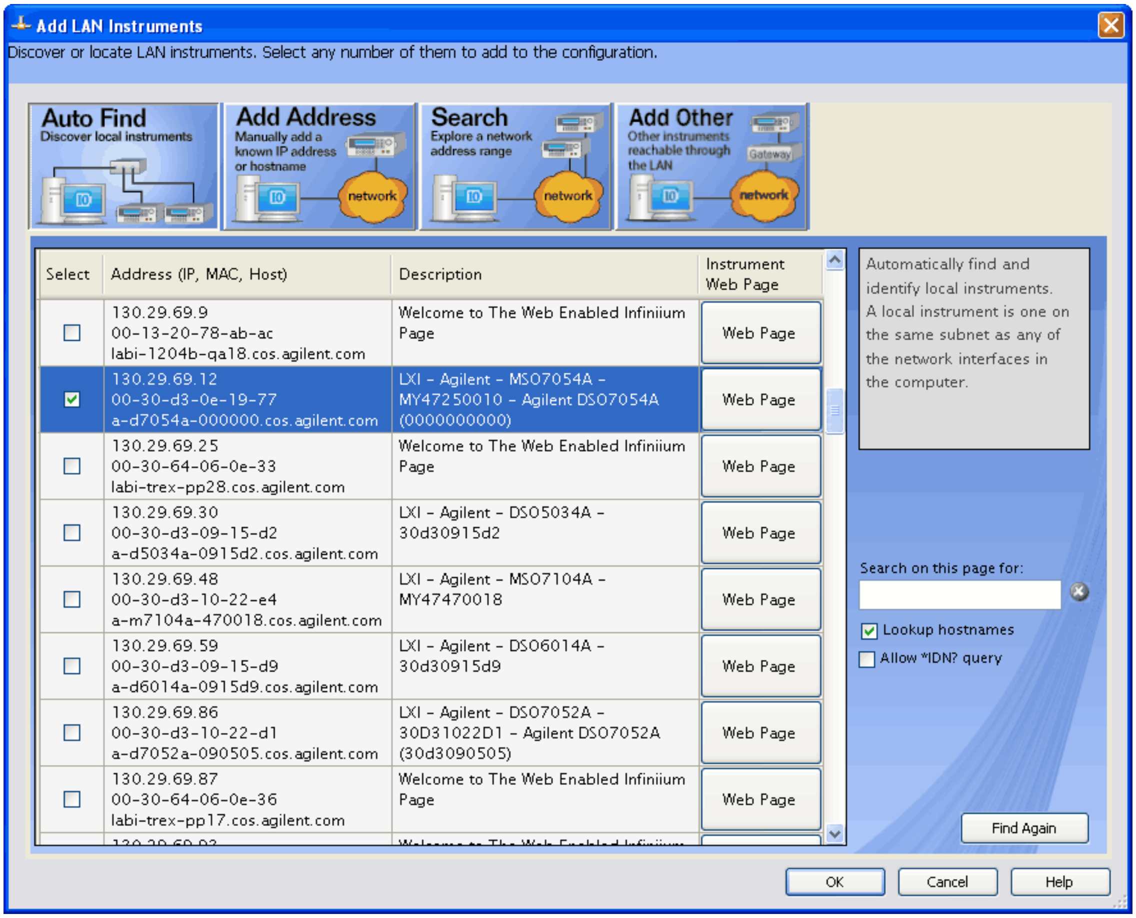
2 In the Agilent Connection Expert application, instruments connected to the controller's USB and GPIB interfaces should automatically appear. (You can click Refresh All to update the list of instruments on these interfaces.)

You must manually add instruments on LAN interfaces:

a Right-click on the LAN interface, choose **Add Instrument** from the popup menu, and click **OK** in the resulting dialog (because the desired interface is already selected).



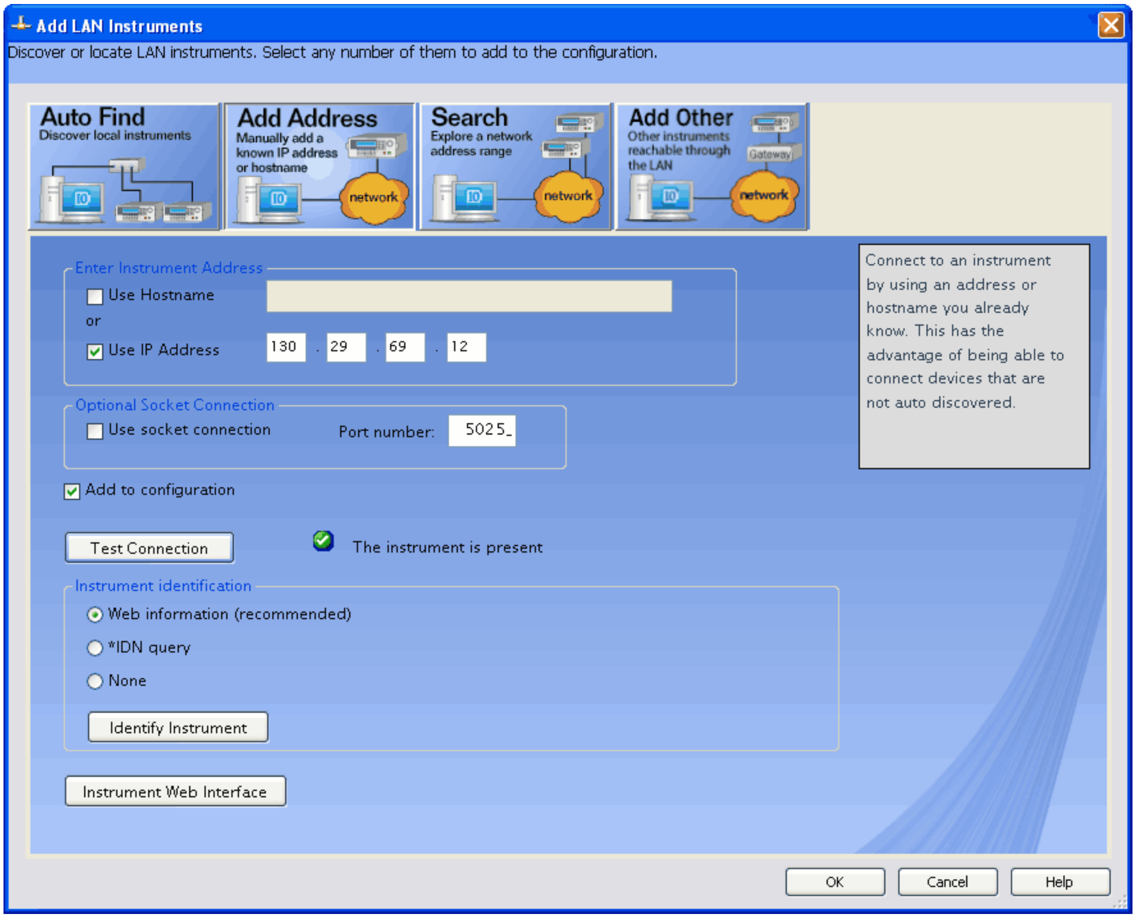
b If the oscilloscope is on the same subnet, select it and click **OK**.



Otherwise, click **Add Address** (or if you have a version of the IO Libraries that doesn't have Auto Find, select the LAN interface and click **OK**).

c In the next dialog, select either **Hostname** or **IP address**, and enter the oscilloscope's hostname or IP address.

d Click **Test Connection**.



e If the instrument is successfully opened, click **OK** to close the dialog. If the instrument is not opened successfully, go back and verify the LAN connections and the oscilloscope setup.

3 In the Agilent Connection Expert application, choose **File>Exit** from the menu to exit the application.

Next • "Step 2: Start the Power Measurement Application" on page 24

Step 2: Start the Power Measurement Application

Start the Power Measurement Application in one of these ways:

- By double-clicking the Power Measurement Application icon on the Windows Desktop.

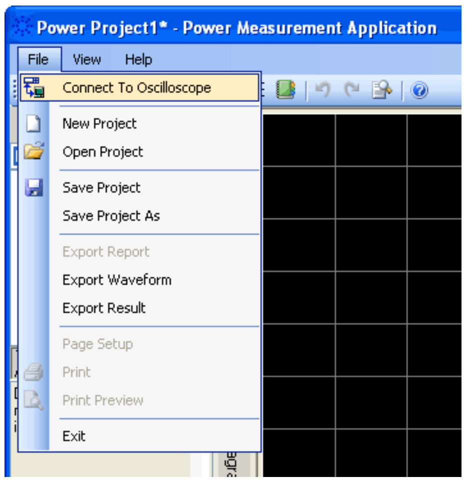
- By choosing **Start>All Programs>Agilent Scope Applications>Power Measurement>Power Measurement Application** from the Windows Start menu.
- From within the Infiniium Oscilloscope application on an 8000 Series oscilloscope, choose **Analyze>Automated Test Apps>Power Measurement**.

Next

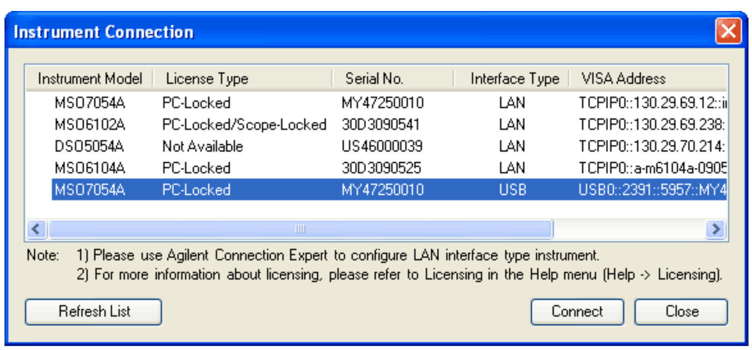
- "Step 3: Connect to the oscilloscope" on page 25

Step 3: Connect to the oscilloscope

1 In the Power Measurement Application, choose **File>Connect To Oscilloscope**.



2 In the Instrument Connection dialog, select the oscilloscope you want to connect to; then, click **Connect**.



If the connection is successful, "Connected" will appear at the bottom of the dialog.

If the connection is not successful, see "If there are problems connecting to the oscilloscope" on page 26.

3 Click **Close** the Instrument Connection dialog.

The status bar at the bottom of the Power Measurement Application also displays the connection status.

The Power Measurement Application remembers your oscilloscope connection, and will attempt to make the same connection the next time you start the application.

Next • "Step 4: Perform channel deskew" on page 27

If there are problems connecting to the oscilloscope

The oscilloscope list in the Instrument Connection dialog is synchronized from Agilent Connection Expert. If the Agilent Connection Expert is unable to detect the oscilloscope, the Power Measurement Application is also unable to detect the oscilloscope. There are two reasons this could happen:

- The oscilloscope is being used by others when the Power Measurement Application is trying to query it for information. If the application is unable to query the oscilloscope, it will not display in the list.
- The oscilloscope LAN connection is not stable. The oscilloscope LAN interface might disconnect for a small time interval before connecting back to the network.

Step 4: Perform channel deskew

To make accurate power loss measurements, you must perform current and voltage channel deskew using the U1880A deskew fixture. The channel deskew procedure calibrates the time delay between current and voltage probes.

You need to perform the deskew procedure once initially, and you should re-run the procedure when any part of the hardware setup changes (for example, a different probe, different oscilloscope channel, etc.) or when the abmient temperature changes.

The first time you run a measurement in each Power Measurement Application session, you are asked whether you want to perform the deskew procedure. There is an option in the Scope Settings configuration to turn this question off or on.

To perform the channel deskew:

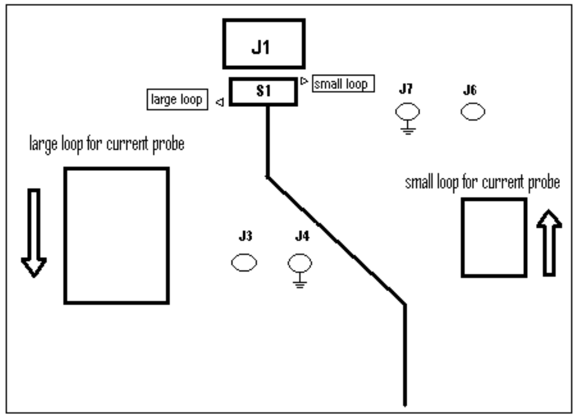
1 First, demagnetize and zero-adjust the current probe. Refer to the current probe's documentation for instructions on how to do this.

2 Make connections to the U1880A deskew fixture:

	Small Loop	**Large Loop**
For current probes:	• 1147A (50 MHz, 15A) • N2774A (50 MHz, 15A) • N2782A (50 MHz, 30A) • N2783A (100 MHz, 30A)	• N2780A (2 MHz, 500A) • N2781A (10 MHz, 150A)
Connect high-voltage differential probe to either:	• J5 (2.54 mm connector) • J6 and J7 (alligator type)	• J2 (2.54 mm connector) • J3 and J4 (alligator type)

   a Connect D+ and D- of the high-voltage differential probe to the deskew fixture.

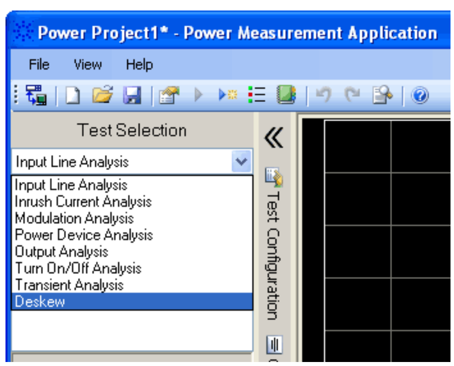
   b Connect the current probe to the current loop with the direction of the arrow pointing towards the current flow.



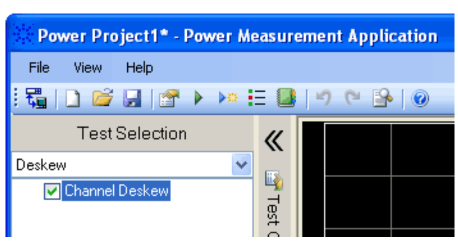
c Make sure the switch on the deskew fixture is set to the appropriate side of the fixture (either "small loop" or "large loop").

d Connect the deskew fixture to a USB port on your oscilloscope or a PC using a USB cable. The USB port supplies power to the deskew fixture.

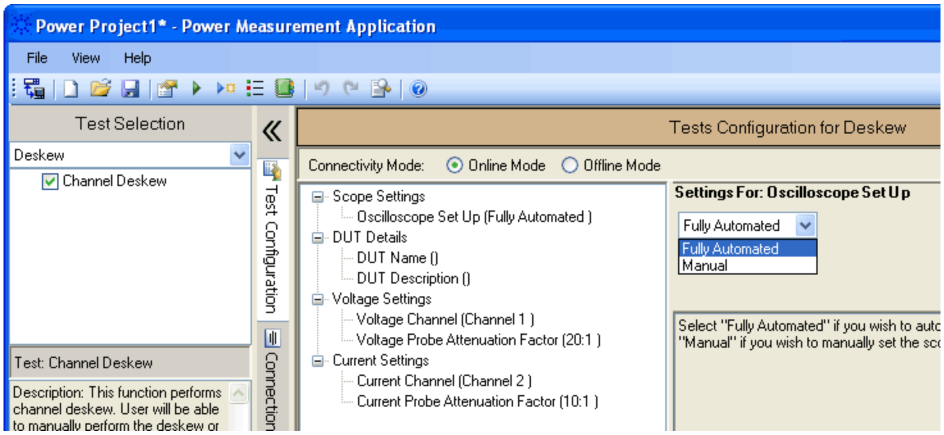
3 In the Power Measurement Application's **Test Selection** area, select **Deskew**.



4 Select the **Channel Deskew** check box.



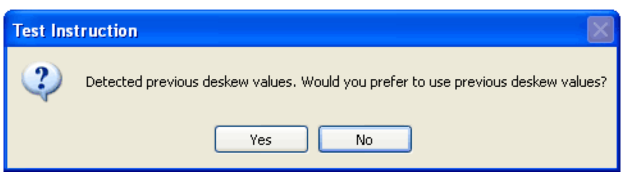
5 Make sure **Fully Automated** is selected for the Oscilloscope Set Up parameter.



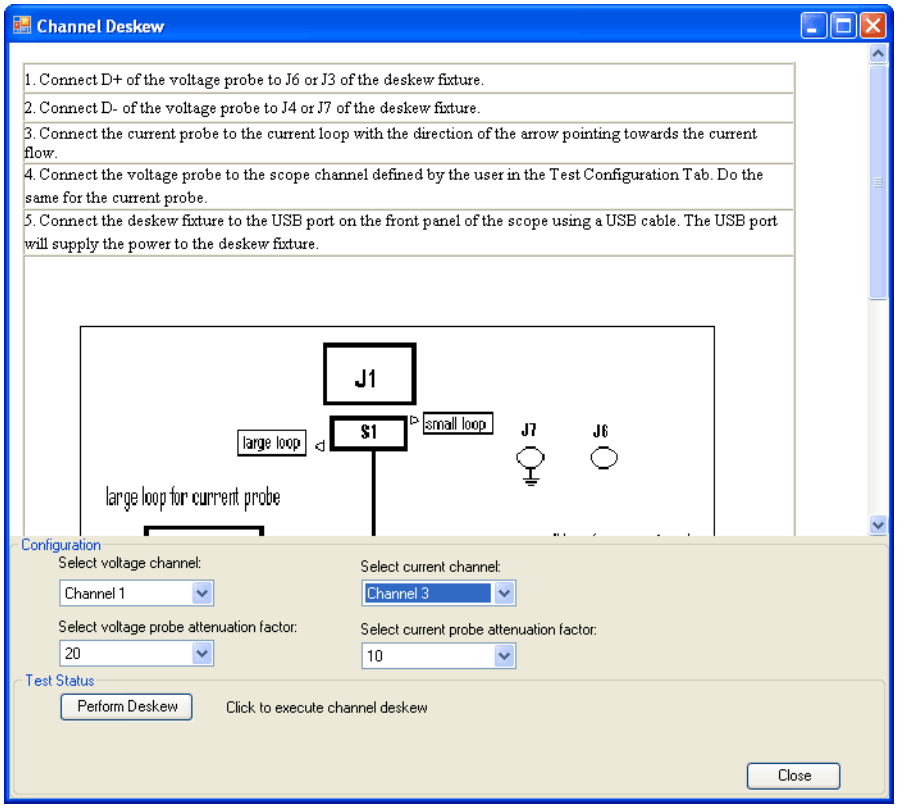
For more information on test parameter settings, see "Global Test Configuration Parameters" on page 56.

6 Click **Run Tests**.

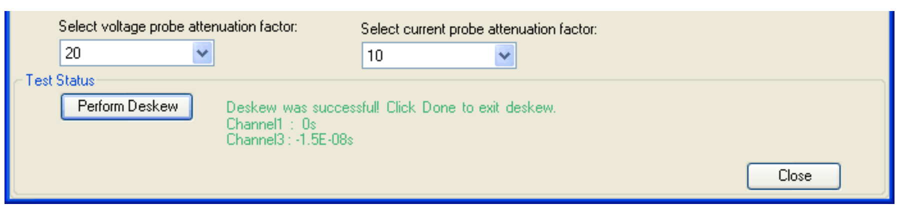
7 If you are asked whether you would like to use previous deskew values, click **No**.



8 In the Channel Deskew dialog, select the voltage and current channels and attenuation factors; then, click **Perform Deskew**.



When the deskew process completes, you see a message at the bottom of the dialog indicating whether the deskew was successful.



9 Click **Done** to close the Channel Deskew dialog.

The deskew values are saved.

The next time you launch the Power Measurement Application, you can use the saved deskew values or perform the deskew again.

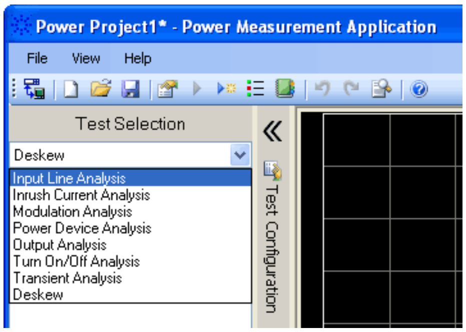
Generally, you need to perform the deskew again when part of the test setup changes (for example, a different probe, different oscilloscope channel, etc.) or when the ambient temperature has changed.

See Also • *"U1880A Deskew Fixture User's Guide"*.

Next • "Step 5: Select the tests to run" on page 31

Step 5: Select the tests to run

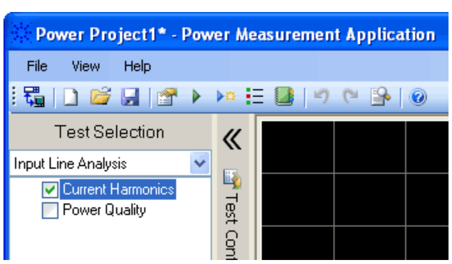
1 In the Power Measurement Application's **Test Selection** area, select the test group.



The following test groups are available:

- Input Line Analysis
- Inrush Current Analysis
- Modulation Analysis
- Power Device Analysis
- Output Analysis
- Turn On/Off Analysis
- Transient Analysis

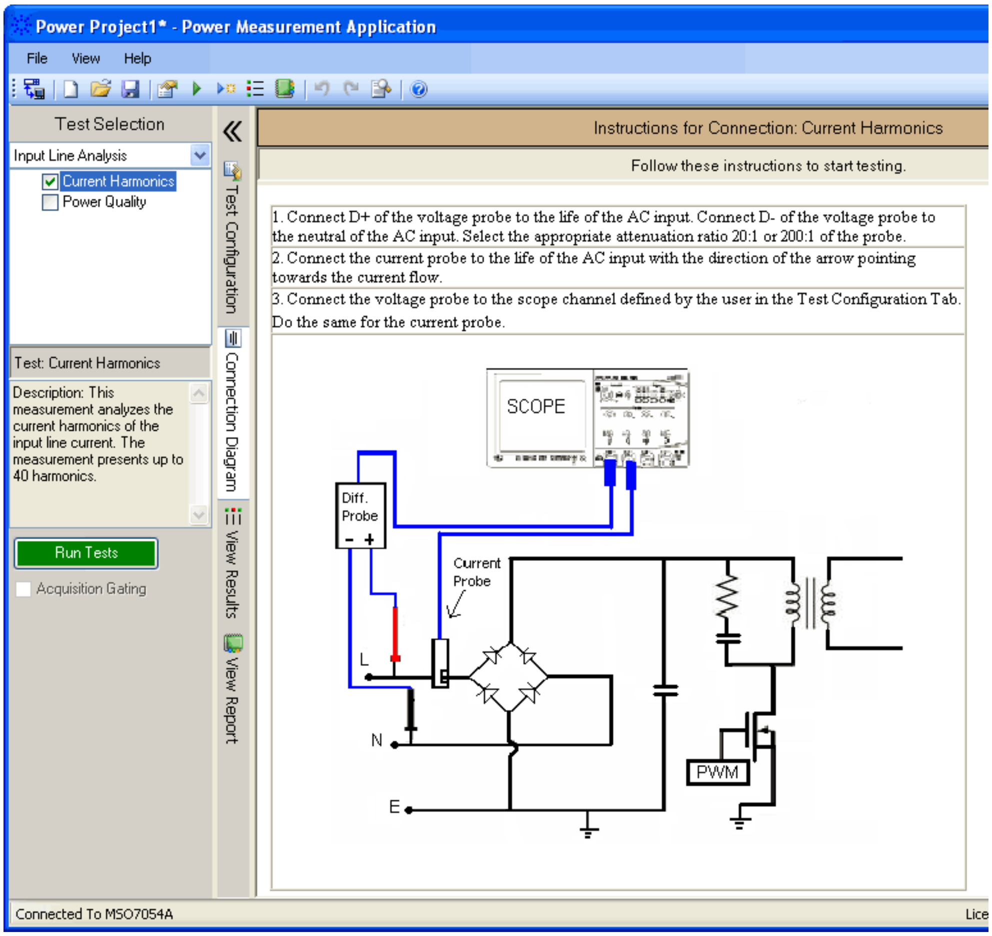
2 To select individual tests within a test group, select their check boxes.



Next • "Step 6: Make connections to the device under test" on page 32

Step 6: Make connections to the device under test

1 Connect the oscilloscope probes to the device under test. See the Connection Diagram tab.

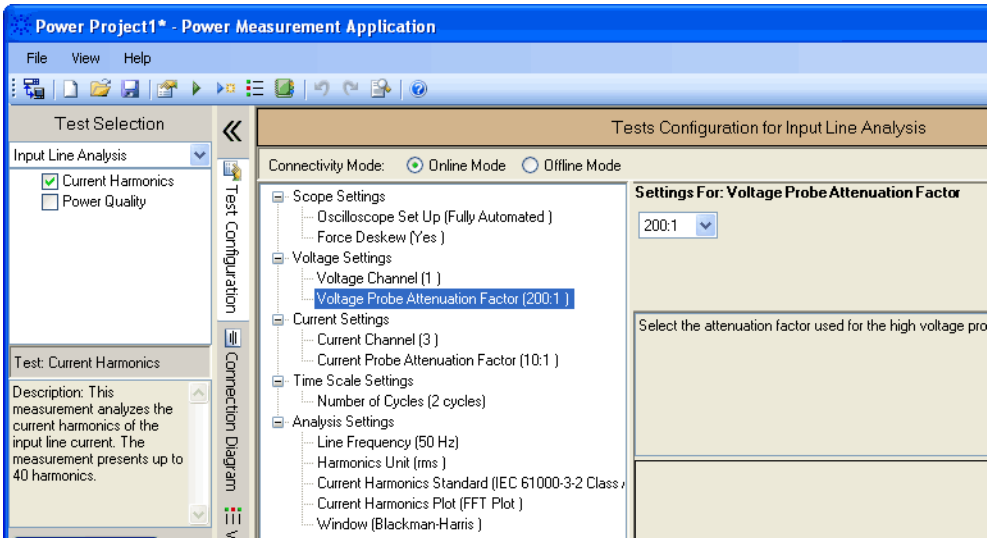


The same connection is used for all the tests within a group.

Next • "Step 7: Change the test parameters (if desired)" on page 33

Step 7: Change the test parameters (if desired)

1 If you want to change any test parameters, go to the Test Configuration tab, and enter the new parameter values.



Each test group can have unique configuration parameters. Other configuration parameters are used for all measurements.

For more information on test parameter settings, see "Global Test Configuration Parameters" on page 56.

Next • "Step 8: Run the tests" on page 34

Step 8: Run the tests

1 Click **Run Tests**.

Next • "Step 9: View the test results" on page 35

Step 9: View the test results

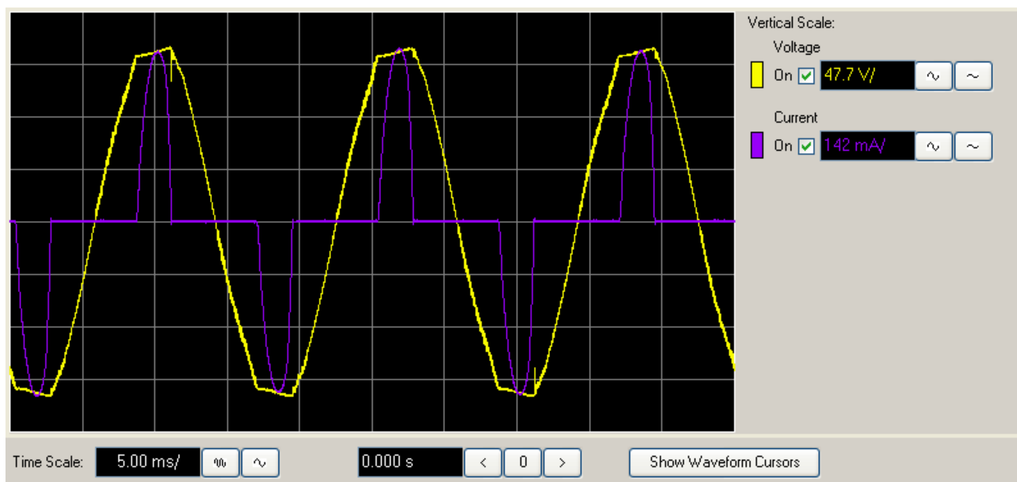
Once the test is completed, you can view the results in the following ways:

- By viewing waveforms (see page 35).
- By looking at the calculated results (see page 35).
- By viewing the test report (see page 36).

You can click the View Results tab to view the waveforms and the calculated results.

Viewing Waveforms

You can view waveforms in the waveform display area.

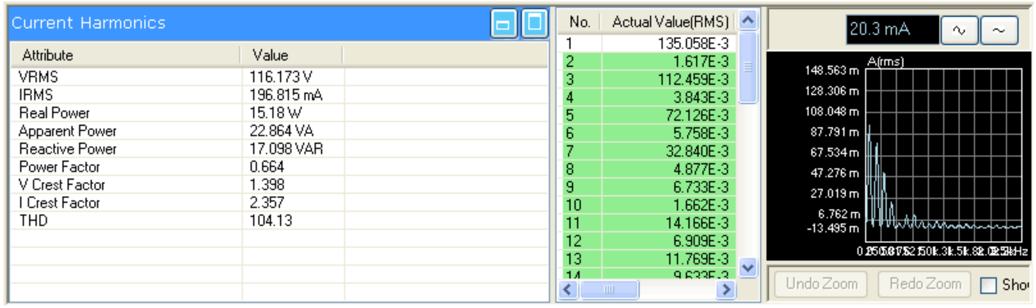


In the waveform area, you can also:

- View multiple waveform graphs (see page 40).
- Use cursors (see page 46).
- Zoom in on waveforms (see page 41).
- Scale waveforms (see page 43).
- Re-run measurements on portions of the captured waveforms (cursor measurements) (see page 45).

Looking at the Calculated Results

Below the waveforms are the test result values.



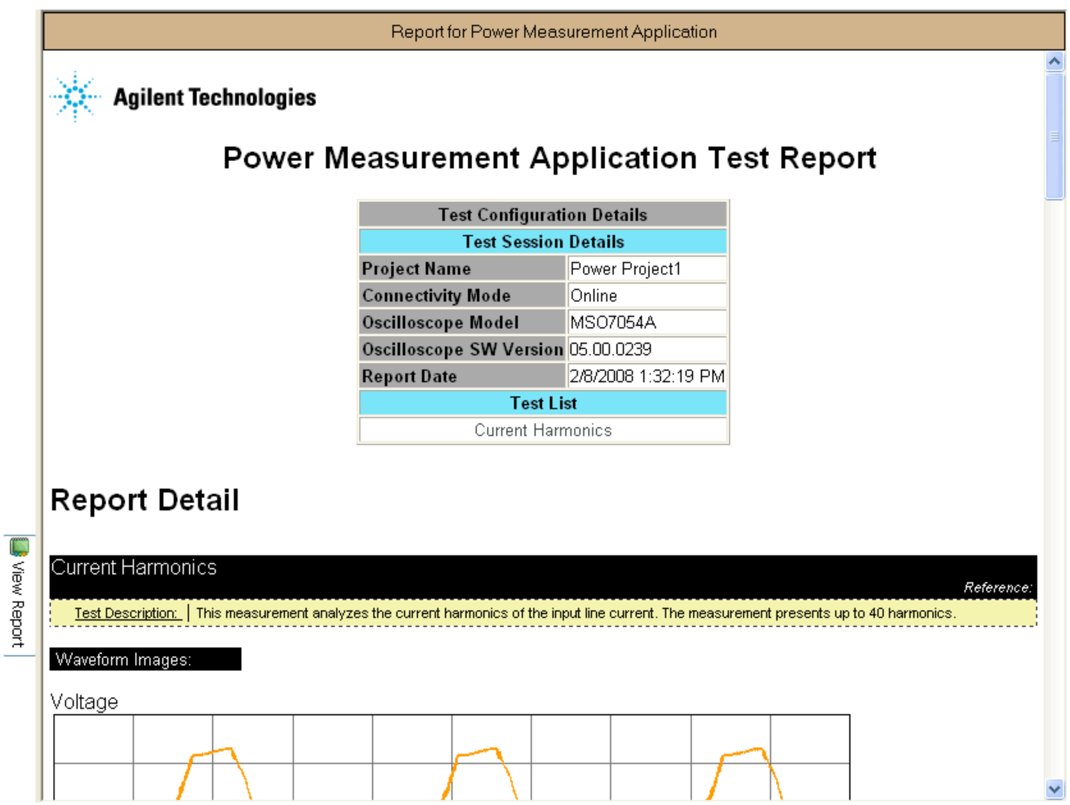
When results have time stamps, clicking those rows will place markers in the waveform view.

To learn more about the tests, their results, and how the results are calculated, see "About the Measurements" on page 55.

Viewing the Test Report

You can:

- View the test report by clicking the **Test Report** tab.
- Print the test report by choosing **File>Print**.
- Export the test report by choosing **File>Export Report**.



See Also

- "Performing Other Tasks" on page 39

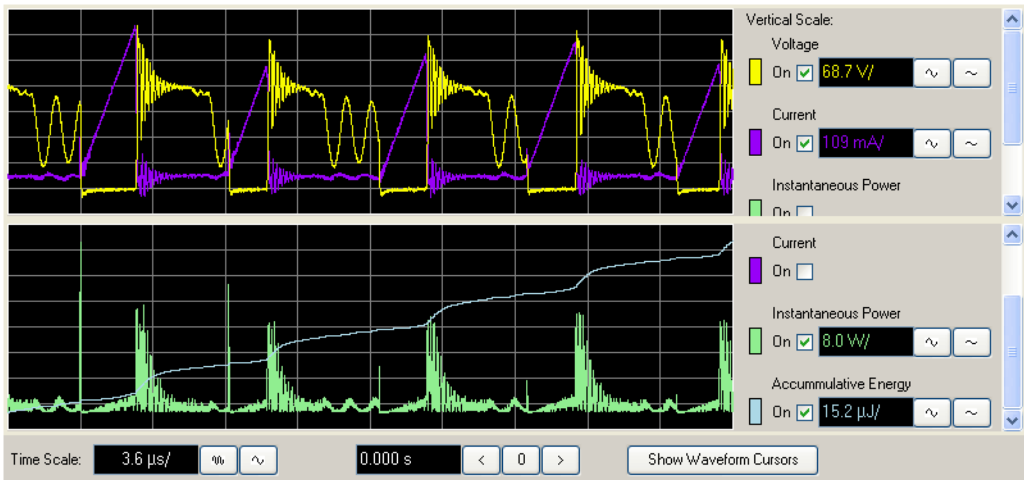
- "About the Measurements" on page 55
- "Reference" on page 99

3
Performing Other Tasks

This chapter shows you how to use additional Power Measurement Application features.

Viewing Multiple Waveform Graphs

When viewing waveforms, you can split the waveform view into two or four panels.



1 Click one of the following icons or choose one of the following commands:

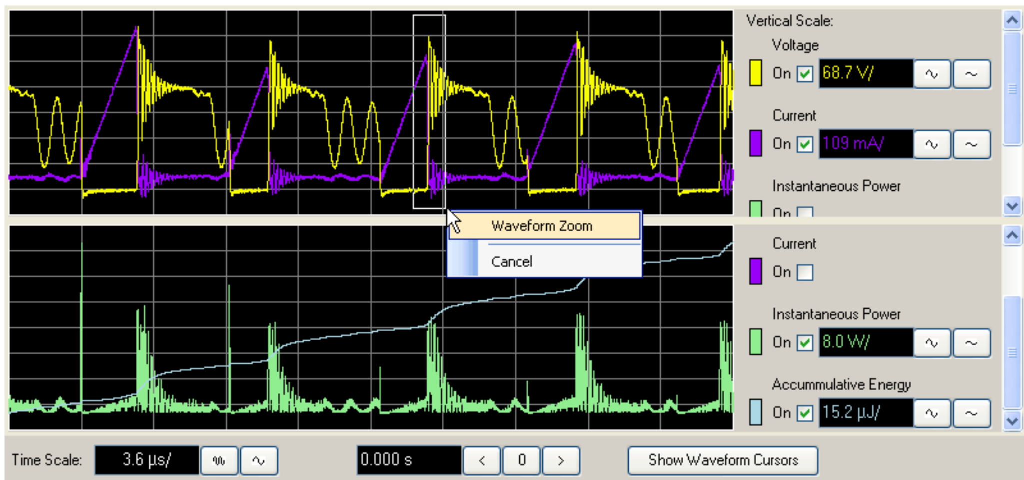
Click the icon:	Or choose the command:
	**View>Two Graphs**
	**View>Four Quadrant Graphs**
	**View>Four Grid Graphs**

2 Use the check boxes to select the waveforms you want to view in each graph.

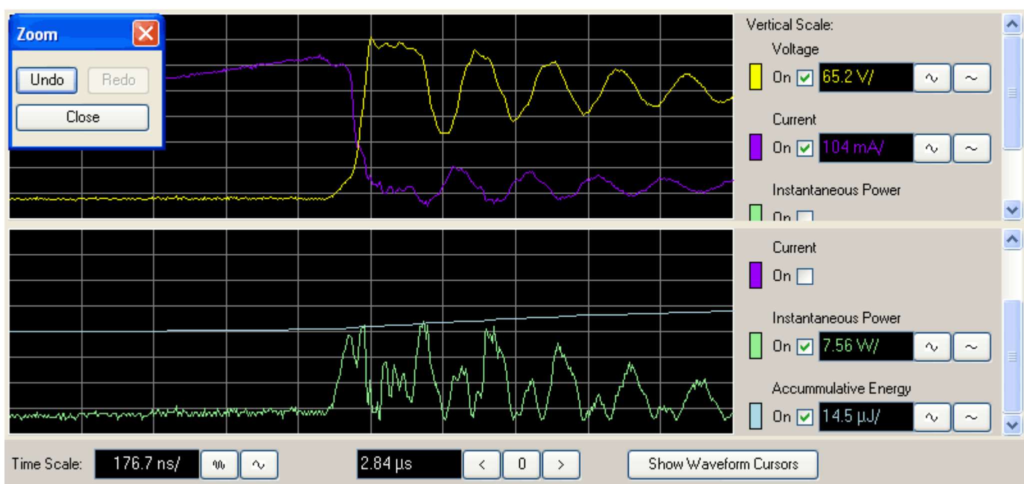
Zooming in on Waveforms

When viewing waveforms, you can zoom in on them.

1 In a waveform graph, hold down the mouse button and drag over the area you want to zoom in on; release the mouse button, and click **Waveform Zoom** in the popup menu.



The resulting waveform graph displays the area you highlighted.



2 You can continue to highlight and zoom in on areas of the waveform.

3 To undo or redo zoom, click **Undo** or **Redo** in the Zoom dialog, click the undo zoom or redo zoom buttons in the toolbar, or choose **View>Undo Zoom** or **View>Redo Zoom** from the menu.

4 To return to the original view, click the  autoscale button in the toolbar or choose **View>Autoscale** from the menu.

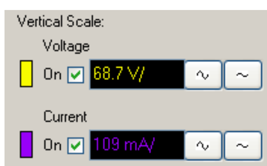
Scaling Waveforms

In addition to zooming in on waveforms and undoing waveform zoom, you can scale waveforms by clicking buttons or entering scale values.

To change a waveform's time scale

Click the button:	To:
	Increase the time scale per division.
	Decrease the time scale per division.
	Offset the time scale to the left.
	Zero the time scale offset.
	Offset the time scale to the right.

To change a waveform's vertical scale

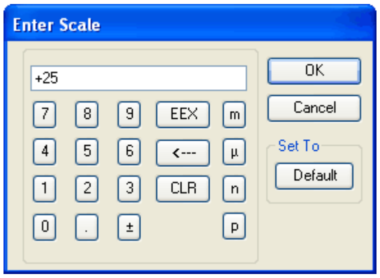


Click the button:	To:
	Increase the vertical scale for the waveform.
	Decrease the vertical scale for the waveform.

To enter scale values

1 Click a scale value.

2 In the Enter Scale dialog, either click buttons or type in a value.



3 Click **OK**.

To return to the original view

Click the  autoscale button in the toolbar or choose **View>Autoscale** from the menu.

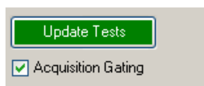
Making Gated Measurements

With the Power Device Analysis and the Modulation Analysis tests, you can make gated measurements. These measurements let you re-run tests on portions of the captured waveforms.

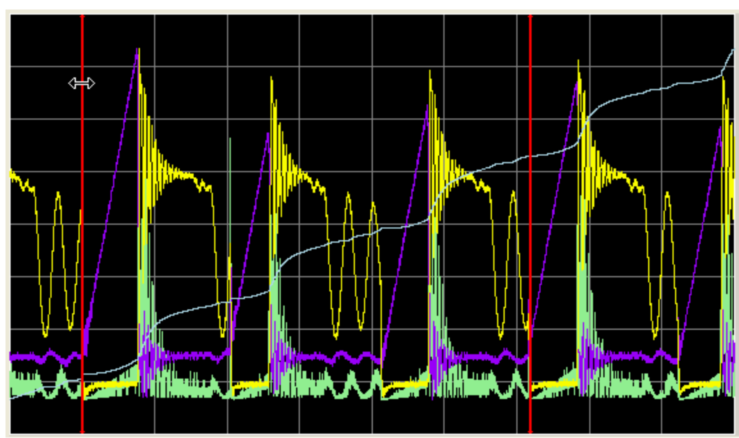
To make gated measurements:

1 Run a normal Power Device Analysis or Modulation Analysis test to capture waveforms.

2 Check the box to enable **Acquisition Gating**.



3 Drag the red vertical bars in the waveform display to select the portion of the captured waveforms on which you want to re-run the tests.



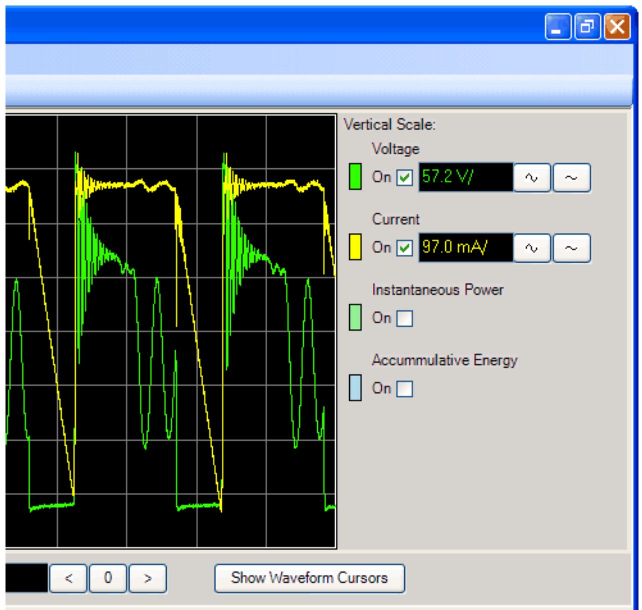
4 Click **Update Tests**.

If results are displayed for the test, they are re-calculated for the selected portion of the waveforms.

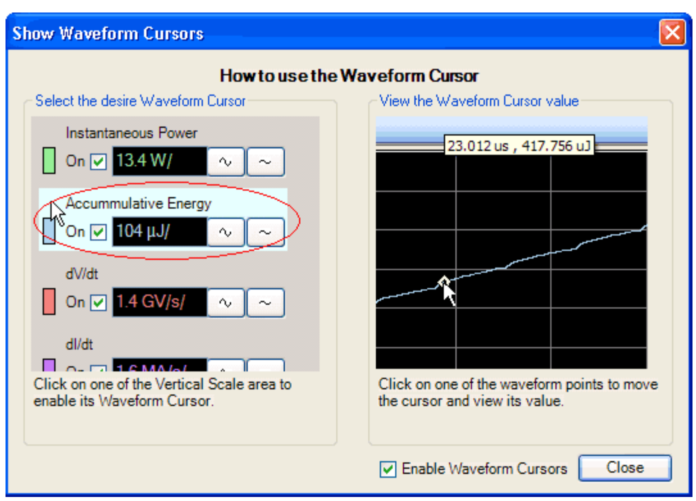
Showing Cursors

You can enable and view cursors on a selected waveform.

1 Click **Show Waveform Cursors**.



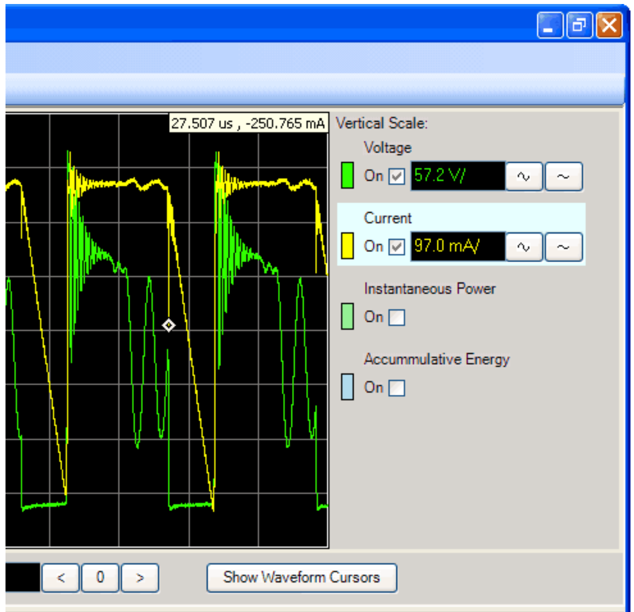
2 In the Show Waveform Cursors dialog, check **Enable Waveform Cursors**, and click **Close**.



3 Click one of the waveforms in the vertical scal area to highlight it .

4 Then, click on the waveform to place the cursor.

The cursor values are displayed in a tool tip popup.

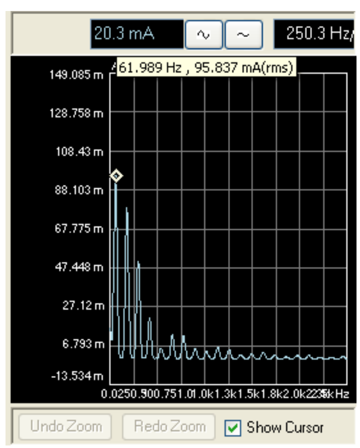


When waveforms are displayed for calculated results, you can show a cursor to display waveform values.

1 Check the **Show Cursor** check box.

2 Click on the waveform to place the cursor.

The waveform values at the cursor are displayed in a tool tip popup.



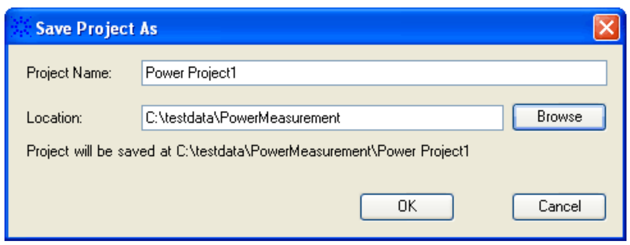
Saving and Opening Projects

- "To save a project" on page 48
- "To open a project" on page 48

To save a project

1 Choose **File>Save Project As**.

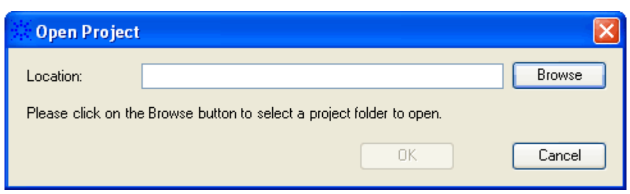
2 In the Save Project As dialog, enter the **Project Name** and **Location**; then, click **OK**.



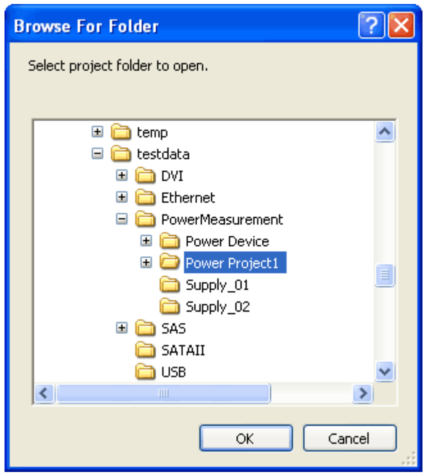
To open a project

1 Choose **File>Open Project**.

2 In the Open Project dialog, click **Browse**.



3 In the Browse for Folder dialog, select the project's folder; then, click **OK**.



4 Back in the Open Project dialog, click **OK**.

Performing Tests Offline with Saved Waveforms

When the Power Measurement Application has a *PC-locked license*, you can re-run tests on saved waveforms when offline, that is, when no oscilloscope is connected.

Before you can perform offline analysis of waveforms, they must first be saved from the Power Measurement Application.

Then, to perform analysis on saved waveforms, select Offline Mode in the Test Configuration tab and select the waveforms as the Voltage Channel and Current Channel parameters.

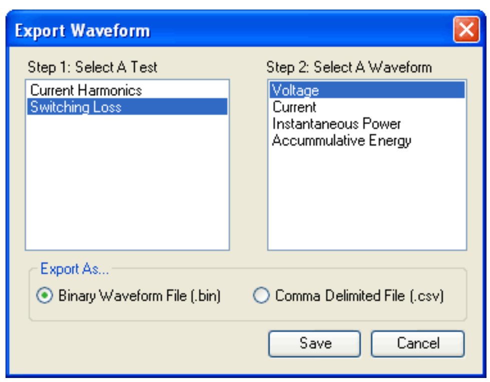
- "To export waveforms" on page 50
- "To select waveforms in the Test Configuration" on page 51

Because of its interactive nature, the Load Transient Response test cannot be performed when offline.

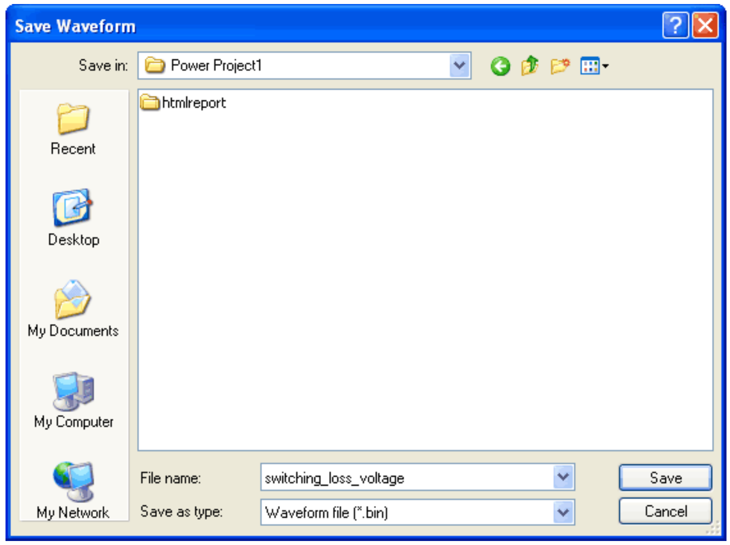
To export waveforms

1 Choose **File>Export Waveform**.

2 In the Export Waveform dialog, select the test and waveform; then, click **Save**.



3 In the Save Waveform dialog, enter the name of the .wfm file; then, click **Save**.



4 Click **Cancel** to close the Export Waveform dialog.

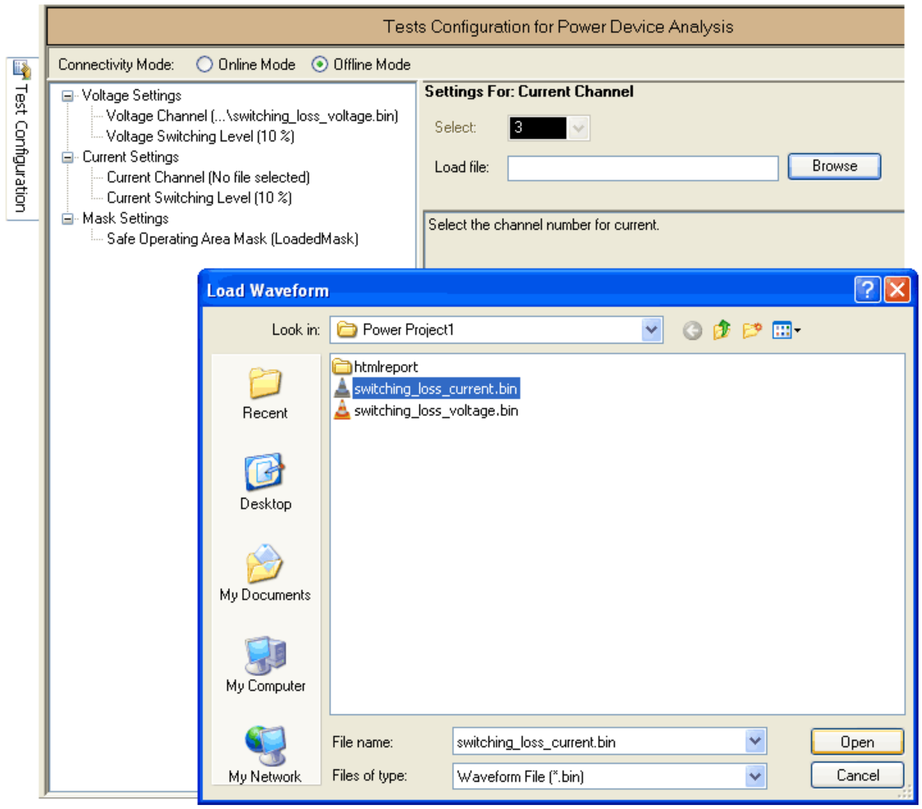
To select waveforms in the Test Configuration

To perform offline analysis of waveforms:

1 Set up the test as you would normally, but skip the step of making connections to the device under test.

2 In the Test Configuration tab, select **Offline Mode**.

3 For the **Voltage Channel** and **Current Channel** parameters, browse for the saved waveform file to open; then, click **Open**.



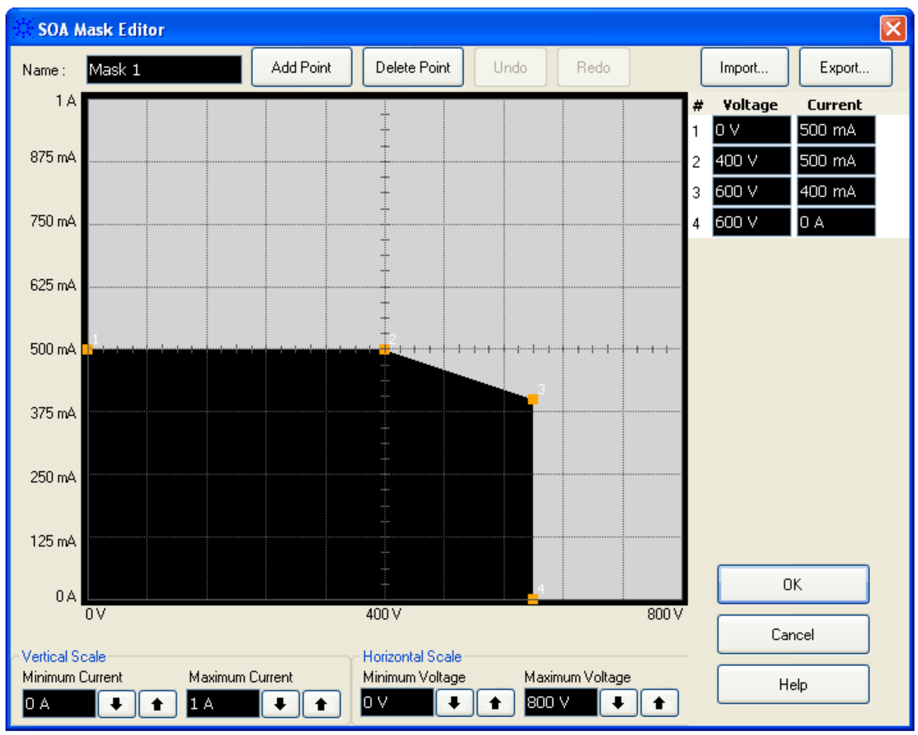
4 Click **Run Tests** to perform analysis on the saved waveforms.

Building Safe Operating Area Masks

You can define your own masks using the Safe Operating Area Mask Editor.

To start the Safe Operating Area Mask Editor:

- In the Test Configuration tab for the Power Device Analysis tests, select the Safe Operating Area Mask parameter and click **Edit** to edit the selected mask.



You can specify the minimum and maximum values for the current and voltage axes by clicking in the fields and entering new values.

When drawing the mask area:

- To add points to the mask polygon, click **Add Point**; then, move the mouse pointer to the desired location and click to add the point.
- To remove points from the mask polygon, click **Delete Point**; then, click the point you want to delete.
- You can drag points or enter their voltage and current values in fields on the right-hand side of the display.
- You can **Undo** and **Redo** actions.

You can export masks to save them, and you can import masks to edit previously saved masks.

When you are done editing a mask, click **OK**.

You can select saved masks in the Test Configuration tab for the Power Device Analysis tests.

4
About the Measurements

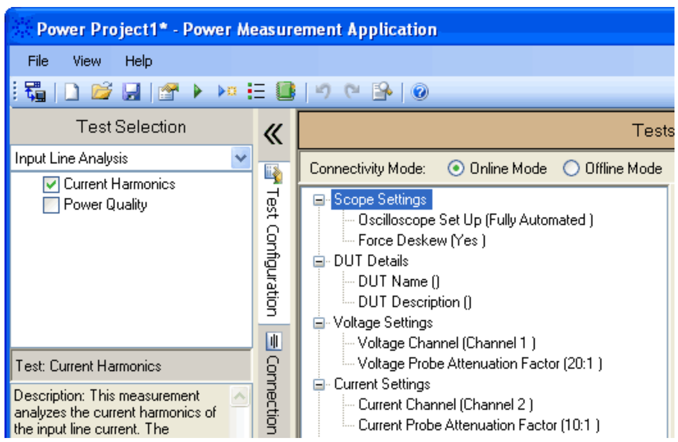
This chapter describes the tests you can perform with the Power Measurement Application, their configuration parameters, and their results.

Global Test Configuration Parameters

The following test configuration settings apply to all measurements.

- "Scope Settings" on page 56
- "Online Mode vs. Offline Mode" on page 56
- "Device Under Test (DUT) Details" on page 57
- "Global Voltage Settings" on page 57
- "Global Current Settings" on page 57

Scope Settings



The "Scope Settings" test configuration category contains these parameters:

Table 3 Scope Settings

Parameter	Description
Oscilloscope Set Up	Select "Fully Automated" if you wish to automatically set up the oscilloscope and capture waveforms. Select "Manual" if you wish to manually set the oscilloscope to capture the waveform for analysis.
Force Deskew	Select "Yes" if you wish the application to run the channel deskew at the start of every session. Select "No" if you wish to skip channel deskew.

Online Mode vs. Offline Mode

In offline mode, the Voltage Channel and Current Channel parameters use previously saved waveforms instead of specified oscilloscope channels (see "To select waveforms in the Test Configuration" on page 51).

To perform measurements in offline mode, see "Performing Tests Offline with Saved Waveforms" on page 50.

Device Under Test (DUT) Details

Table 4 DUT Details

Parameter	Description
DUT Name	Enter the name of the device under test. If entered, the name is copied to the test report.
DUT Description	Enter a description of the device under test. If entered, the description is copied to the test report.

Global Voltage Settings

Table 5 Voltage Settings

Parameter	Description
Voltage Channel	Select the channel number for the voltage.
Voltage Probe Attenuation Factor	Select the attenuation factor used for the high-voltage probe. The attenuation factor multiplied by the probe's maximum output voltage gives the maximum input signal. For example, the N2772A probe's maximum output voltage is ±6.5V, so a 200:1 attenuation ratio gives a maximum input signal of ±1,300V.

Global Current Settings

Table 6 Current Settings

Parameter	Description
Current Channel	Select the channel number for current.
Current Probe Attenuation Factor	Select the attenuation factor used for the current probe.

Input Line Analysis Tests

Perform measurement analysis on the input line signals.

- "Current Harmonics" on page 60
- "Power Quality" on page 62

Connection for Input Line Analysis Tests

1 Connect D+ of the voltage probe to the live wire of the AC input. Connect D- of the voltage probe to the neutral wire of the AC input. Select the appropriate attenuation ratio of the probe.

2 Connect the current probe to the live wire of the AC input with the direction of the arrow pointing towards the current flow.

3 Connect the voltage probe to the oscilloscope channel defined by the user in the Test Configuration tab. Do the same for the current probe.

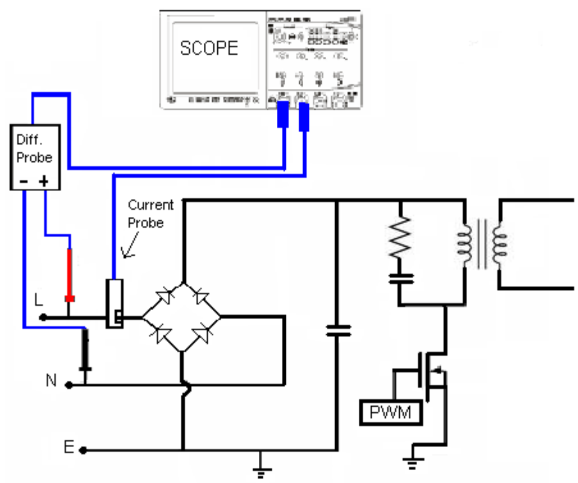


Figure 2 Typical Configuration for Input Line Analysis Tests

Configuration Parameters for Input Line Analysis Tests

The input line analysis tests have the following configuration parameters in addition to the global test configuration parameters (see page 56).

Table 7 Time Scale Settings

Parameter	Description
Number of Cycles	Enter the number of cycles to capture in one acquisition.

Table 8 Analysis Settings

Parameter	Description
Line Frequency	Enter the line frequency.
Harmonics Unit	Select the unit in which to display the current harmonics. • RMS — FFT(RMS) = FFT magnitude * 0.7071 • dBuA — dBuA = 20 log (Irms/1uA) • dBm — measures signal power with reference power = 1mW. dB = 10 log (power/reference_power) dBm = 10 log (Pin/1mW) With a fixed load: P = (V * V) / R P1/P2 = [(V1 * V1) / R] / [(V2 * V2) / R] 10 log (P1/P2) = 10 log [(V1 * V1)] / [(V2 * V2)] = 20 log (V1/V2) So: dBm = 20 log (Vin/Vref) Assuming a standard 50 ohm load: Vref = Vpeak = Vrms/0.7071 = sqrt(P * R)/0.7071 = sqrt(1mW * 50 ohms)/0.7071 Vref = Vpeak = 0.316228V Finally: dBm = 20 log (Vin/0.316228V)
Current Harmonics Standard	Select the standard to perform compliance testing on the current harmonics. • IEC 61000-3-2 Class A — for balanced three-phase equipment, household appliances (except equipment identified as Class D), tools excluding portable tools, dimmers for incandescent lamps, and audio equipment. • IEC 61000-3-2 Class B — for portable tools. • IEC 61000-3-2 Class C — for lighting equipment. • IEC 61000-3-2 Class D — for equipment having a specified power according less than or equal to 600W, of the following types: personal computers and personal computer monitors, television receivers. • RTCA DO-160E Single Phase Electrical Equipment — for airborne equipment. • RTCA DO-160E Single Phase Electrical Equipment With Distorted Input Voltage Waveform — for airborne equipment. • RTCA DO-160E Balanced 3-Phase Phase Electrical Equipment — for airborne equipment.

Table 8 Analysis Settings (continued)

Parameter	Description
Current Harmonics Plot	Select whether to display harmonics plot in bar graph format or FFT plot.
Window	Select window to use for the FFT analysis. • Blackman-Harris — for minimal spectral leakage. This is typically used for current harmonics measurements. • Hanning — for better frequency resolution and low spectral leakage. • Hamming — for better frequency resolution and moderate spectral leakage.

Current Harmonics

This measurement analyzes the current harmonics of the input line current. The measurement presents up to 40 harmonics.

Current Harmonics Test Results

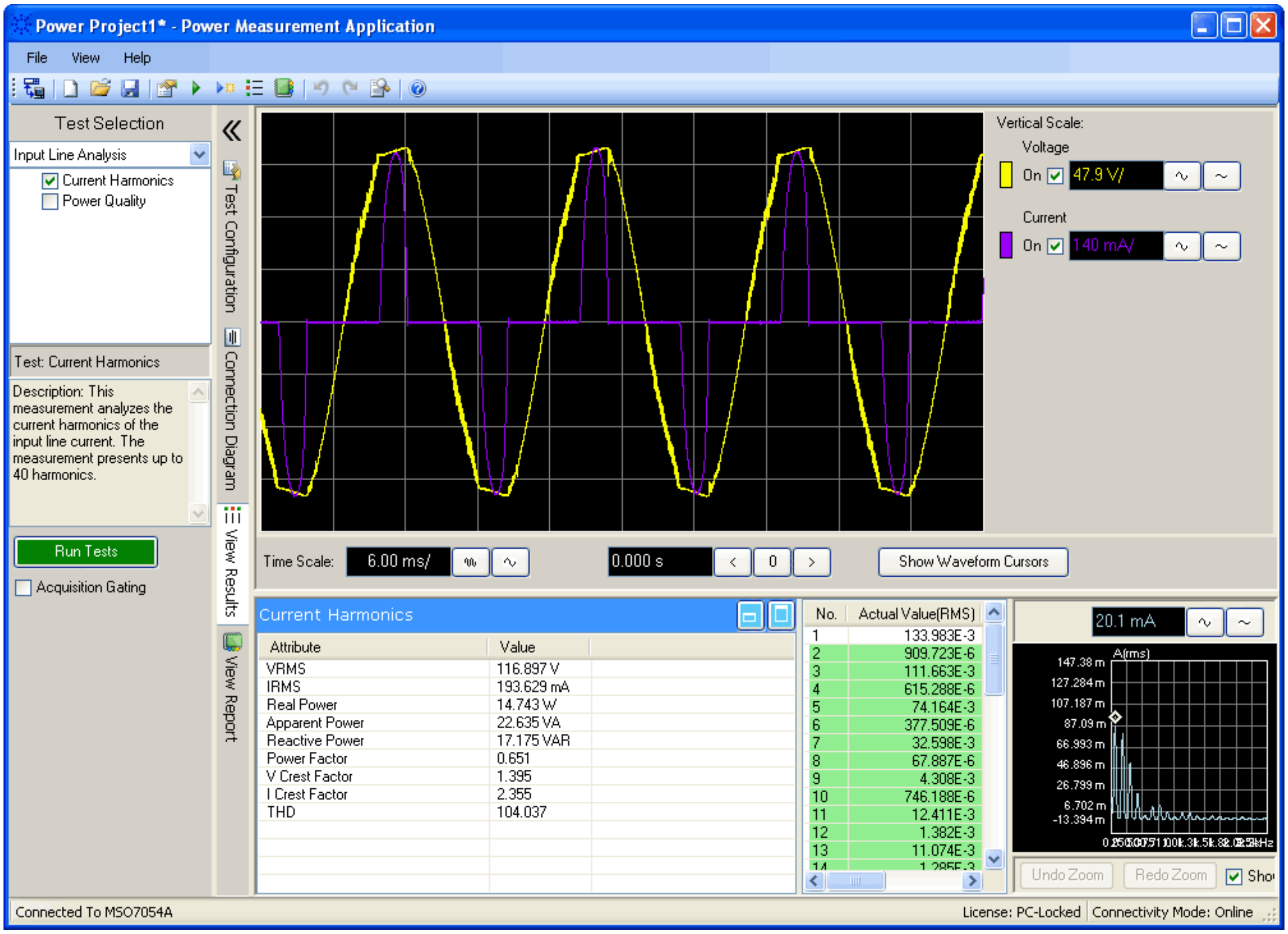


Table 9 Current Harmonics Test Result Waveforms

FFT	Shows the frequency components in the input current. The FFT is calculated using the selected Window parameter and plotted according to the selected Current Harmonics Plot parameter. The unit for plot magnitude is selected with the Harmonics Unit parameter. You can drag over an area to zoom and enable a cursor as in the main waveform displays.

Table 10 Current Harmonics Test Result Values

VRMS	$VRMS = \sqrt{\frac{1}{N}\sum_{n=0}^{N-1} v^2(n)}$
IRMS	$IRMS = \sqrt{\frac{1}{N}\sum_{n=0}^{N-1} i^2(n)}$
Real (Actual) Power	$\text{Real Power} = \sqrt{\frac{1}{N}\sum_{n=0}^{N-1} V_n I_n}$
Apparent Power	IRMS * VRMS
Reactive Power	$\text{Reactive Power} = \sqrt{\text{Apparent Power}^2 - \text{Real Power}^2}$ Measured in VAR (Volts-Amps-Reactive)
Power Factor	Real Power / Apparent Power
V Crest Factor	Vpeak / VRMS
I Crest Factor	Ipeak / IRMS
THD (Total Harmonic Distortion)	$\text{THD} = 100 \times \frac{\sqrt{X_2^2 + X_3^2 + X_n^2 + \ldots}}{X_1}$ Where: • X_n = voltage or current of each harmonic • X_1 = fundamental voltage or current value
Harmonic, Actual Value (RMS), Limit (RMS), Margin, Pass/Fail	For the first 40 harmonics, these values are displayed: • Actual Value (RMS) — the measured value in the units specified by the Harmonics Unit parameter. • Limit (RMS) — the limit specified by the selected Current Harmonics Standard parameter. • Margin — the margin specified by the selected Current Harmonics Standard parameter. • Pass/Fail — whether the value passes or fails according to the selected Current Harmonics Standard. Rows in the table are color-coded according to pass/fail values.

Power Quality

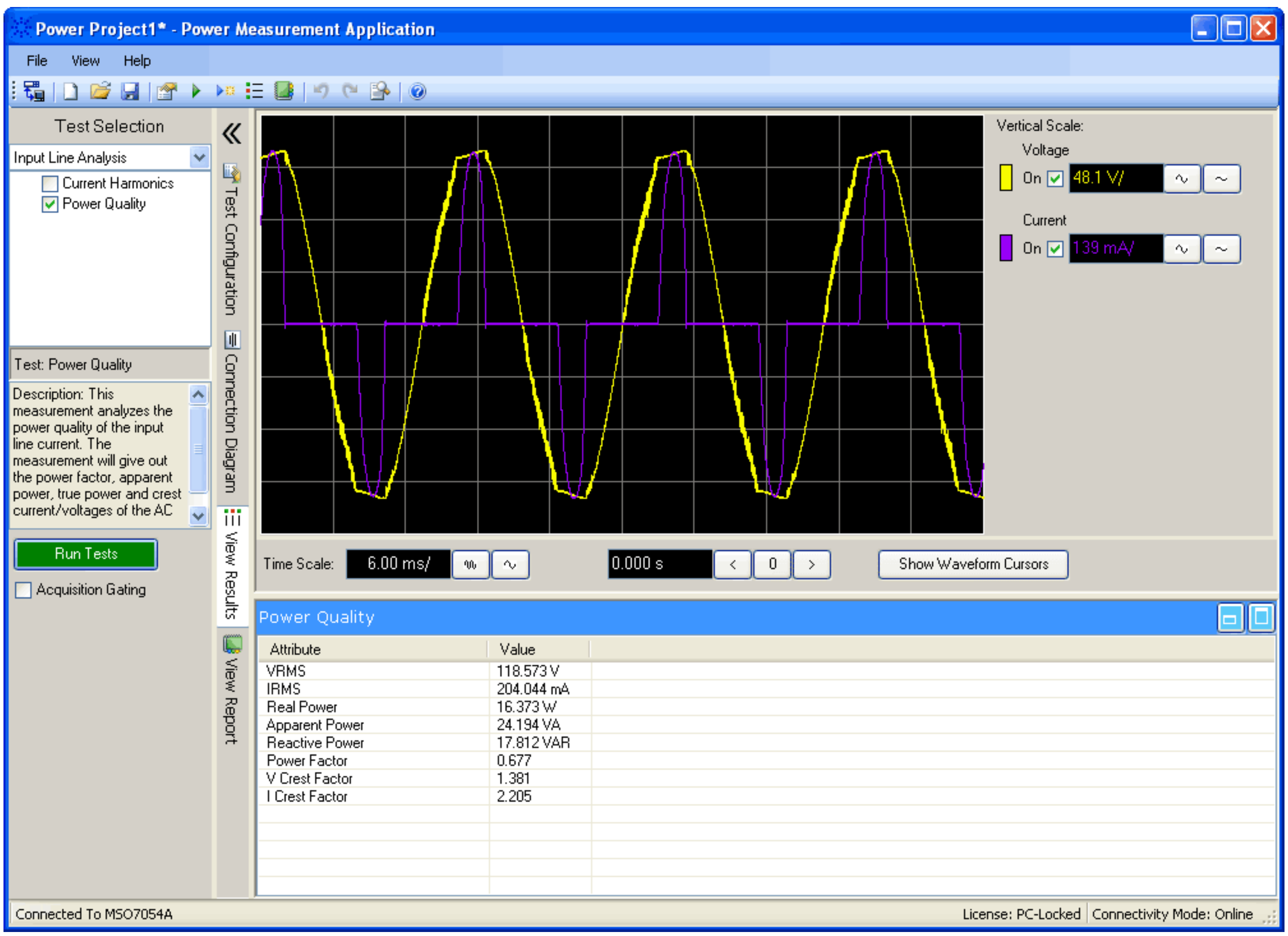
This measurement analyzes the power quality of the AC input line current.

Some AC current may flow back into and back out of the load without delivering energy. This current, called reactive or harmonic current, gives rise to an "apparent" power which is larger than the actual power consumed. Power quality is gauged by the following:

- **Apparent Power** — The portion of power flow due to stored energy, which returns to the source in each cycle.
- **Real (Actual) Power** — The portion of power flow that, averaged over a complete cycle of the AC waveform, results in net transfer of energy in one direction.
- **Power Factor** — Ratio of the actual power to the apparent power.
- **Crest Factor** — Crest factor is the ratio between the instantaneous peak current/voltage required by the load and the RMS current/voltage (RMS stands for Root Mean Square, which is a type of average).

The measurement gives the power factor, apparent power, true power, and crest current/voltages of the AC line.

Power Quality Test Results



Power quality measurements are calculated using the captured voltage and current waveforms over the number of cycles specified.

Table 11 Power Quality Test Result Values

VRMS	$VRMS = \sqrt{\frac{1}{N}\sum_{n=0}^{N-1} v^2(n)}$
IRMS	$IRMS = \sqrt{\frac{1}{N}\sum_{n=0}^{N-1} i^2(n)}$
Real (Actual) Power	$\text{Real Power} = \sqrt{\frac{1}{N}\sum_{n=0}^{N-1} V_n I_n}$
Apparent Power	IRMS * VRMS
Reactive Power	$\text{Reactive Power} = \sqrt{\text{Apparent Power}^2 - \text{Real Power}^2}$ Measured in VAR (Volts-Amps-Reactive)
Power Factor	Real Power / Apparent Power
V Crest Factor	Vpeak / VRMS
I Crest Factor	Ipeak / IRMS

Inrush Current Analysis Tests

Perform inrush current measurement analysis.

- "Inrush Current" on page 66

Connection for Inrush Current Analysis Tests

1 Connect D+ of the voltage probe to the live wire of the AC input. Connect D- of the voltage probe to the neutral wire of the AC input. Select the appropriate attenuation ratio of the probe.

2 Connect the current probe to the live wire of the AC input with the direction of the arrow pointing towards the current flow.

3 Connect the voltage probe to the oscilloscope channel defined by the user in the Test Configuration tab. Do the same for the current probe.

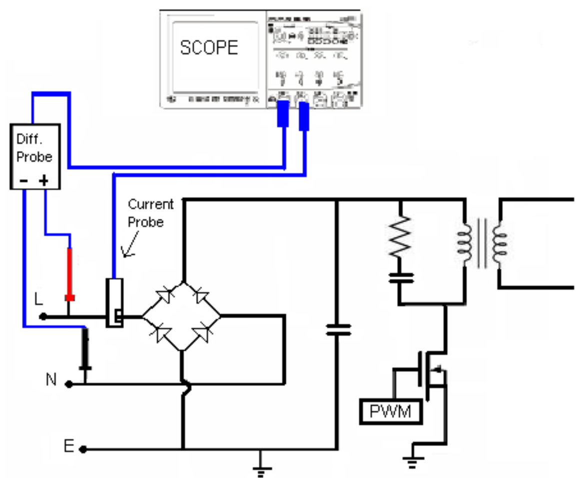


Figure 3 Typical Configuration for Inrush Current Analysis Tests

Configuration Parameters for Inrush Current Analysis Tests

The inrush current analysis tests have the following configuration parameters in addition to the global test configuration parameters (see page 56).

Table 12 Time Scale Settings

Parameter	Description
Duration	Enter the duration of time to capture signal. This parameter will set the time scale of the oscilloscope.

Table 13 Vertical Scale Settings

Parameter	Description
Expected Inrush Current	Enter the expected inrush current amplitude. This value will be used to adjust the vertical scale of the oscilloscope.

Inrush Current

This measurement analyzes the inrush current of the power supply when the power supply is first turned on.

Inrush Current Test Results

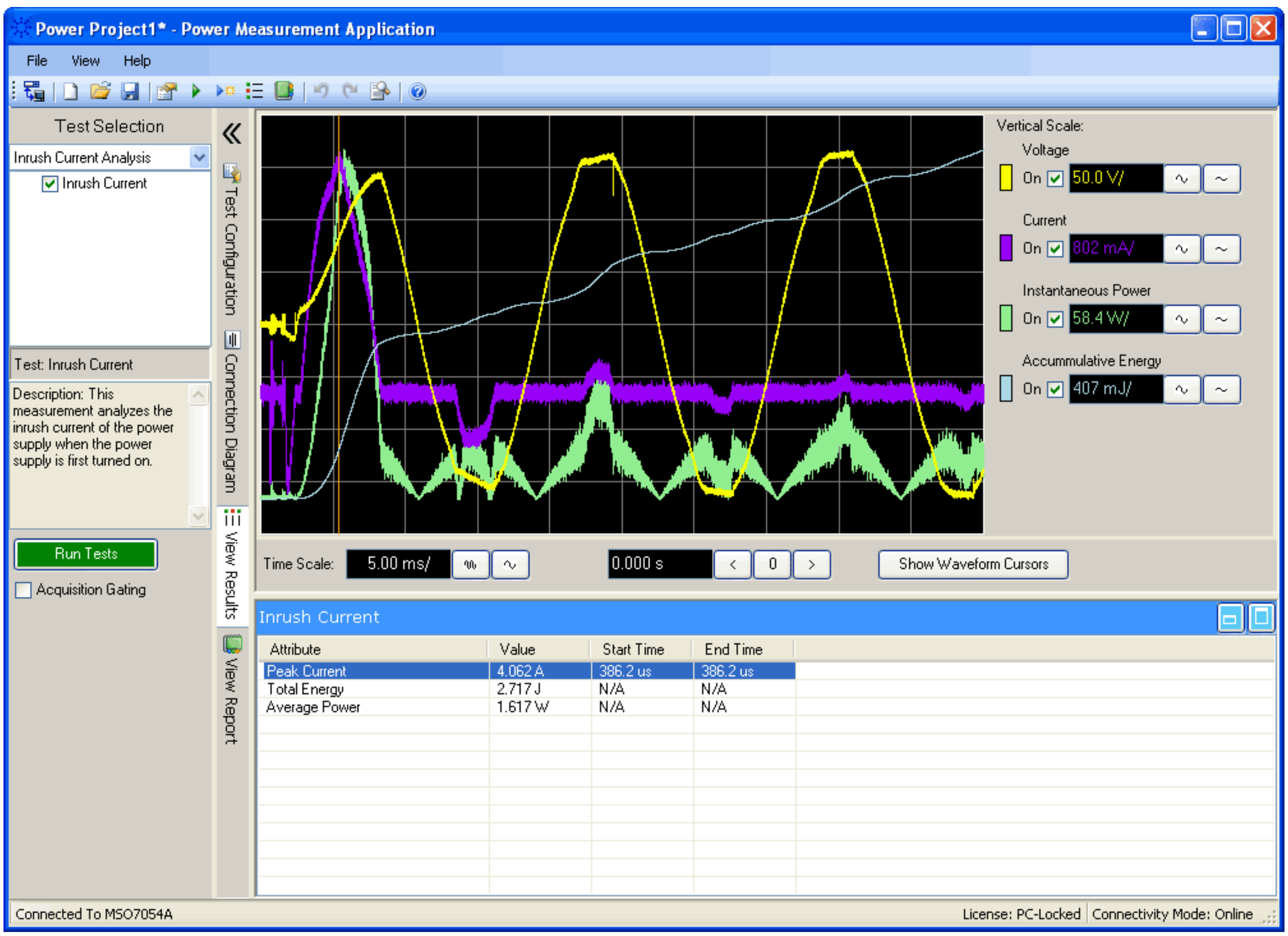


Table 14 Inrush Current Test Result Waveform

Instantaneous Power	$P_n = Vin_n * Iin_n$, where n is each sample.
Accumulative Energy	$= \sum (Vin_n * Iin_n) *$ sample size, where n is each sample.

Table 15 Inrush Current Test Result Values

Peak Current	The Peak Current can be a positive or negative value, so the result is the larger of the measured maximum or minimum.
Total Energy	The total energy for the acquired waveform in Joules.
Average Power	The average power for the acquired waveform in Watts.

Modulation Analysis Tests

Perform data trending on the switching variation of the acquired waveform.

- "Frequency" on page 69
- "Period" on page 71
- "Duty Cycle" on page 72
- "Positive Pulse Width" on page 73

Connection for Modulation Analysis Tests

1 Connect D+ of the voltage probe to the source of the MOSFET. Connect D- of the voltage probe to the drain of the MOSFET. Select the appropriate attenuation ratio of the probe.

2 Connect the voltage probe to the oscilloscope channel defined by the user in the Test Configuration tab.

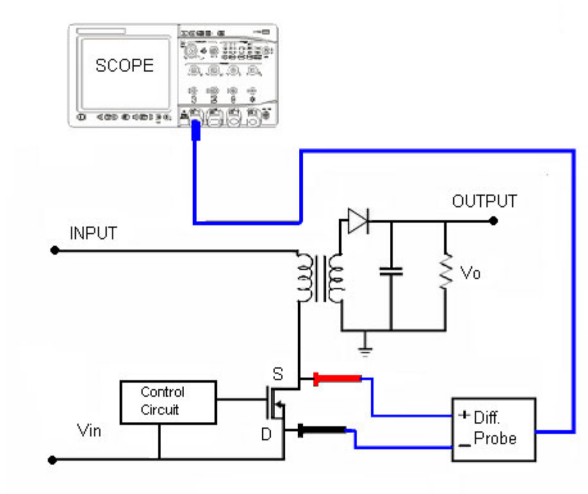


Figure 4 Continuous Mode Connection for Modulation Analysis Tests

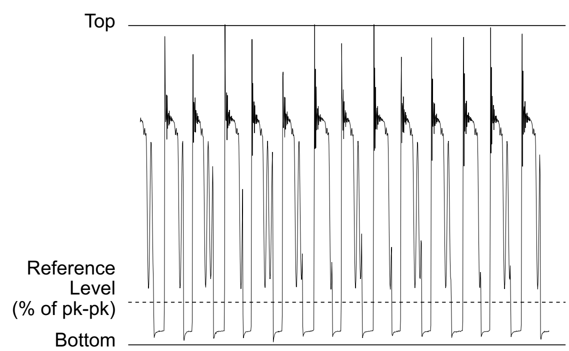
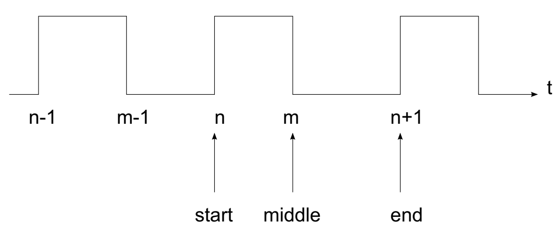
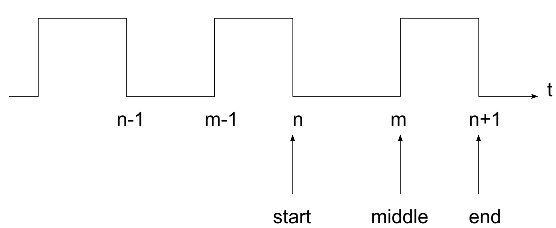
Configuration Parameters for Modulation Analysis Tests

The modulation analysis tests have the following configuration parameters in addition to the global test configuration parameters (see page 56).

Table 16 Time Scale Settings

Parameter	Description
Duration	Enter the duration of time to capture the signal. This parameter will set the time scale of the oscilloscope.

Table 17 Analysis Settings

Parameter	Description
Reference Level	Enter the edge reference level. This reference level will be used as the cross-over level for frequency, duty cycle, period, and pulse width calculation. 
Slope	Specify the start of each cycle as the rising edge or the falling edge. When RISING is selected:  When FALLING is selected: 

Frequency

Trends and plots the frequency variation of the acquired waveform.

Frequency Test Results

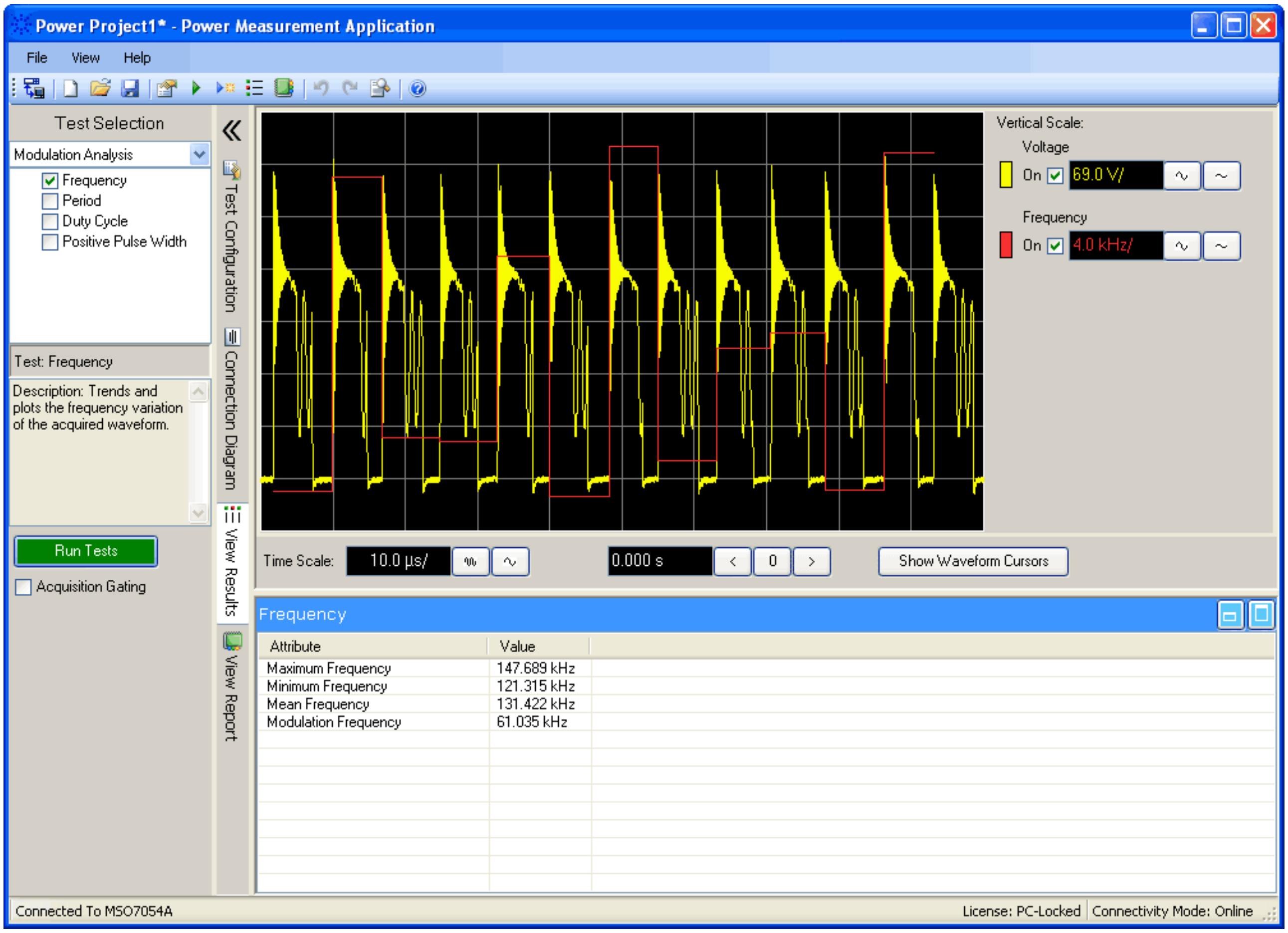


Table 18 Frequency Test Result Waveform

Frequency	Using the Reference Level parameter value to determine the signal cross-over point, this waveform shows the measured frequency for each cycle. $f_n = 1 / (t_{n+1} - t_n)$

Table 19 Frequency Test Result Values

Maximum Frequency	The highest frequency measured.
Minimum Frequency	The lowest frequency measured.
Mean Frequency	The average of measured frequencies.
Modulation Frequency	Shows the rate of change of the signal frequency across the waveform.

Period

Trends and plots the period variation of the acquired waveform.

Period Test Results

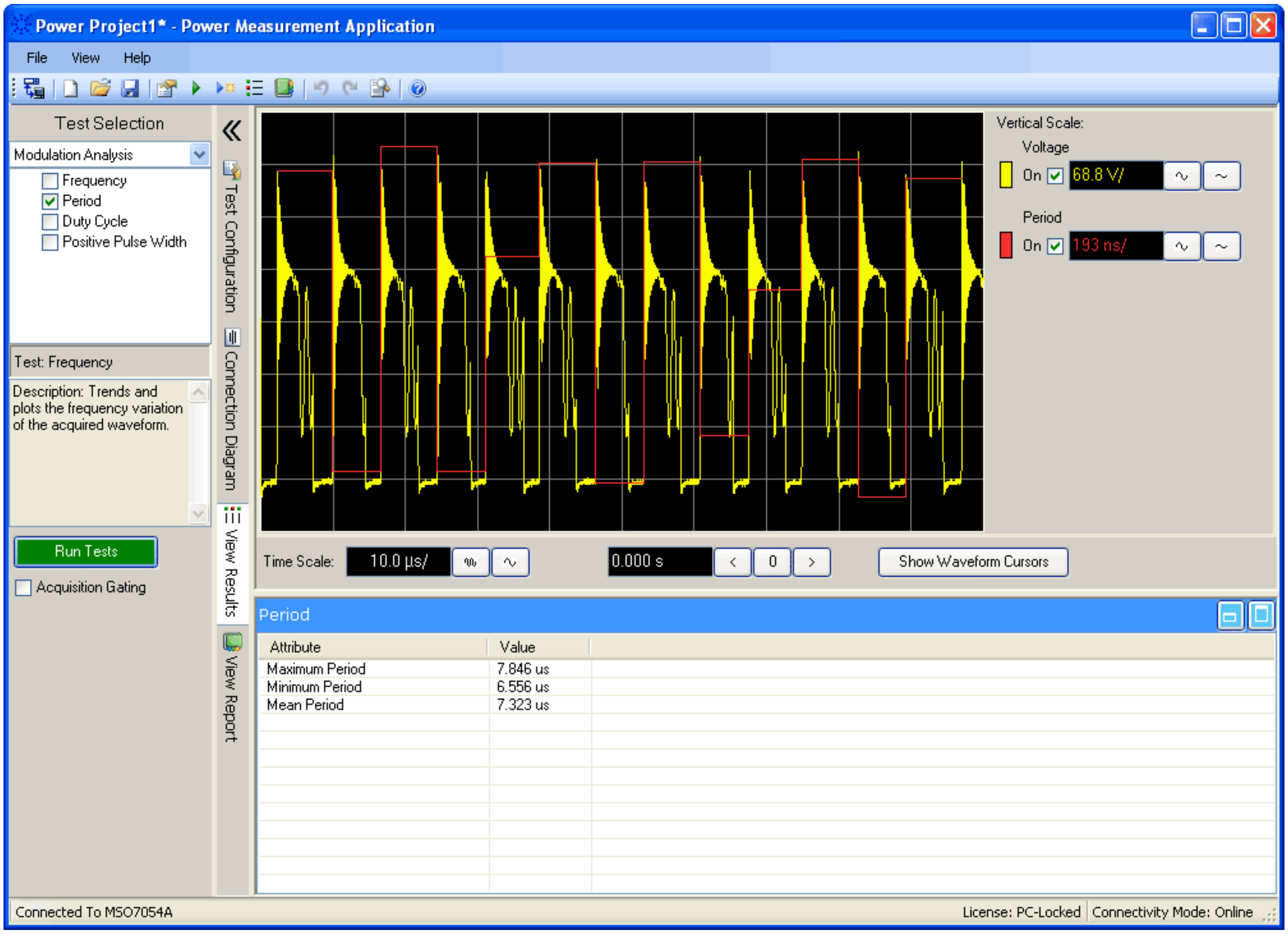


Table 20 Period Test Result Waveform

Period	Using the Reference Level parameter value to determine the signal cross-over point, this waveform shows the measured period for each cycle. $T_n = t_n - t_{n-1}$

Table 21 Period Test Result Values

Maximum Period	The longest period measured.
Minimum Period	The shortest period measured.
Mean Period	The average of measured periods.

Duty Cycle

Trends and plots the duty cycle variation of the acquired waveform.

Duty Cycle Test Results

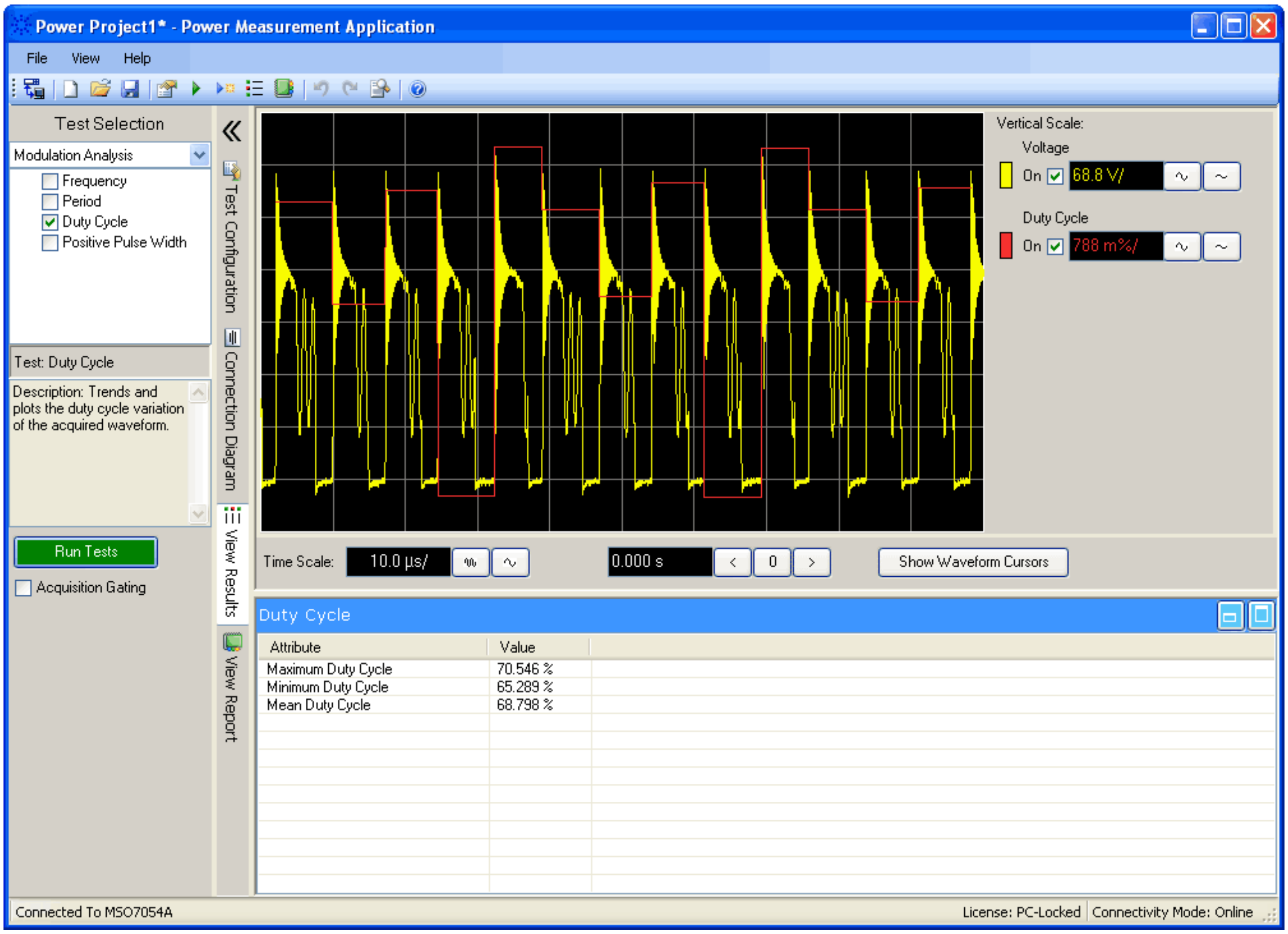


Table 22 Duty Cycle Test Result Waveform

Duty Cycle	Using the Reference Level parameter value to determine the signal cross-over point, this waveform shows the measured duty cycle for each cycle. $DC_n = 100 * [(t_m - t_n) / (t_{n+1} - t_n)]$

Table 23 Frequency Test Result Values

Maximum Duty Cycle	The largest duty cycle measured.
Minimum Duty Cycle	The smallest duty cycle measured.
Mean Duty Cycle	The average of measured duty cycles.

Positive Pulse Width

Trends and plots the positive pulse width variation of the acquired waveform.

Positive Pulse Width Test Results

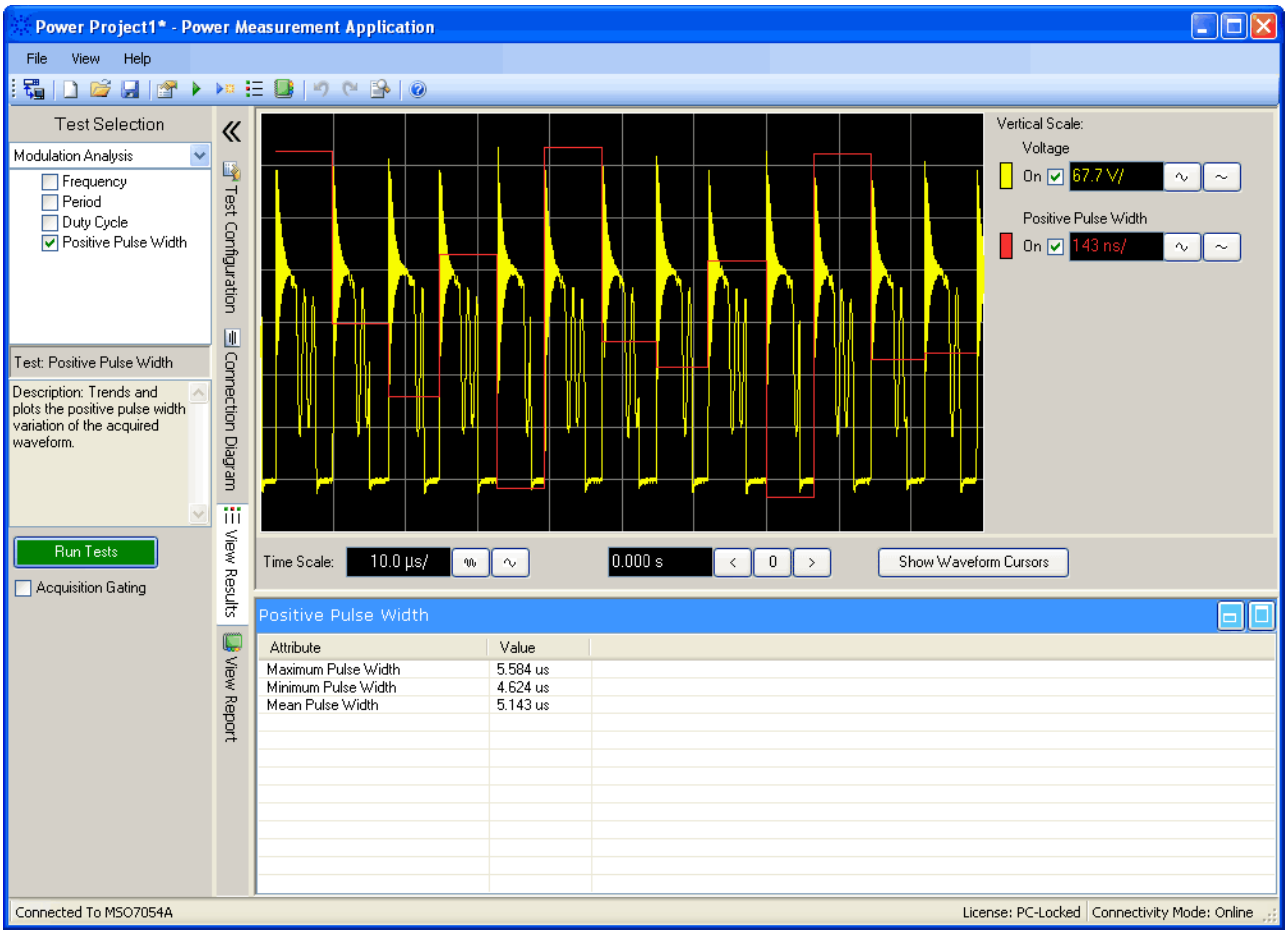


Table 24 Positive Pulse Width Test Result Waveform

Positive Pulse Width	Using the Reference Level parameter value to determine the signal cross-over point, this waveform shows the positive pulse width for each cycle. $P_n = t_m - t_n$

Table 25 Positive Pulse Width Test Result Values

Maximum Pulse Width	The widest pulse width measured.
Minimum Pulse Width	The most narrow pulse width measured.
Mean Pulse Width	The average of measured pulse widths.

Power Device Analysis Tests

Perform measurement analysis on the power device signals.

- "Switching Loss" on page 76
- "Safe Operating Area" on page 79
- "dV/dT" on page 81
- "dI/dT" on page 83
- "Dynamic On Resistance, Rds" on page 85

Connection for Power Device Analysis Tests

1 Connect D+ of the voltage probe to the source of the MOSFET. Connect D- of the voltage probe to the drain of the MOSFET. Select the appropriate attenuation ratio of the probe.

2 Connect the current probe to the drain of the MOSFET with the direction of the arrow pointing towards the current flow.

3 Connect the voltage probe to the oscilloscope channel defined by the user in the Test Configuration tab. Do the same for the current probe.

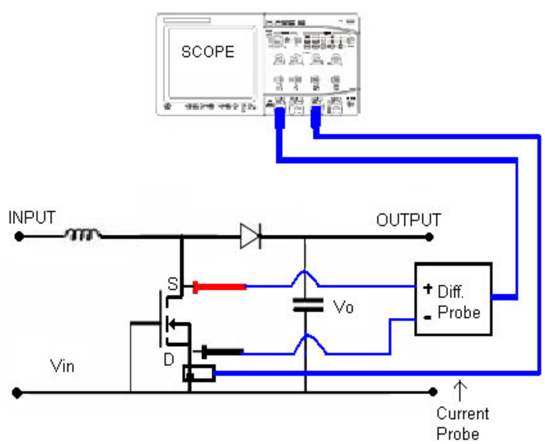


Figure 5 Typical Configuration for Power Device Analysis Tests

Configuration Parameters for Power Device Analysis Tests

The power device analysis tests have the following configuration parameters in addition to the global test configuration parameters (see page 56).

Table 26 Voltage Settings

Parameter	Description
Voltage Switching Level	Enter the switching level for the switching edges. The value is in percentage of the maximum switch voltage. You can adjust this value to ignore noise floors. This value specifies the threshold that is used to determine the switching edges.

Table 27 Current Settings

Parameter	Description
Current Switching Level	Enter the switching level for the start of switching edges. The value is in percentage of the maximum switch current. You can adjust this value to ignore noise floors or null offset that is difficult to eliminate in current probes. This value specifies the threshold that is used to determine the switching edges.

Table 28 Time Scale Settings

Parameter	Description
Number of Cycles	Enter the number of cycles to capture in one acquisition.
Switching Frequency	Enter the frequency of the switching device.

Table 29 Mask Settings

Parameter	Description
Safe Operating Area Mask	The **Select** drop-down field lets you select the mask file that will be used for the Safe Operating Area measurement. The **New** button lets you edit a new mask. The **Edit** button lets you edit the selected mask. See "Building Safe Operating Area Masks" on page 53.

Switching Loss

This measurement analyzes the power dissipated in the switching cycles across the switching device. Typical power losses include:

- Switching losses that occur during switching of Vds and Id.
- Conduction losses that occur when the switching device (MOSFET) is ON.

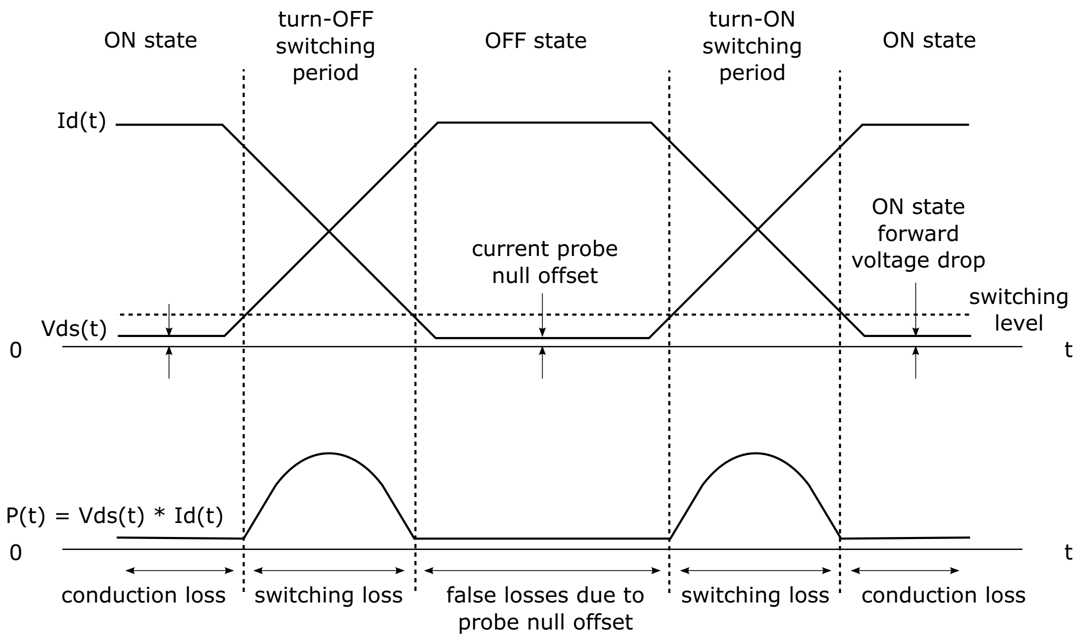


Figure 6 Loss Occurrence in the Power Device

Switching Loss Test Results

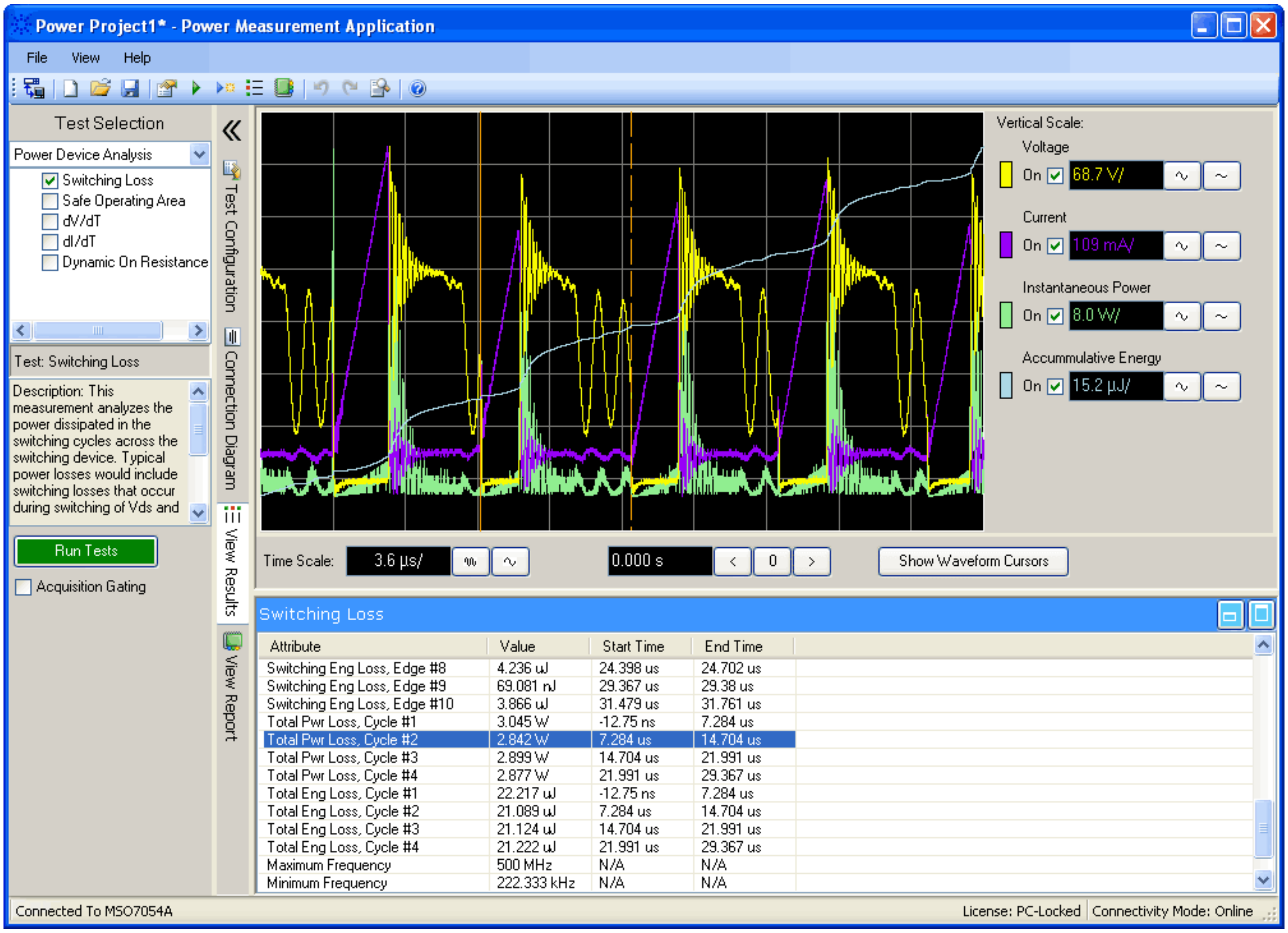


Table 30 Switching Loss Test Result Waveforms

Instantaneous Power	$P_n = Vds_n * Id_n$, where n is each sample.
Accumulative Energy	$= \sum (Vds_n * Id_n) *$ sample size, where n is each sample.

Table 31 Switching Loss Test Result Values

Maximum Switching Power Loss	Maximum switching period power loss.
Minimum Switching Power Loss	Minimum switching period power loss.
Average Switching Power Loss	Average switching period power loss.

Table 31 Switching Loss Test Result Values (continued)

Maximum Switching Energy Loss	Maximum switching period energy loss.
Minimum Switching Energy Loss	Minimum switching period energy loss.
Average Switching Energy Loss	Average switching period energy loss.
Maximum Total Power Loss	Maximum cycle power loss (switching loss + conduction loss).
Minimum Total Power Loss	Minimum cycle power loss (switching loss + conduction loss).
Average Total Power Loss	Average cycle power loss (switching loss + conduction loss).
Maximum Total Energy Loss	Maximum cycle energy loss (switching loss + conduction loss).
Minimum Total Energy Loss	Minimum cycle energy loss (switching loss + conduction loss).
Average Total Energy Loss	Average cycle energy loss (switching loss + conduction loss).
Switching Pwr Loss, Edge #N	Power loss for each switching period.
Switching Eng Loss, Edge #N	Energy loss for each switching period.
Total Pwr Loss, Cycle #N	Power loss for each cycle (switching loss + conduction loss).
Total Eng Loss, Cycle #N	Energy loss for each cycle (switching loss + conduction loss).
Maximum Frequency	Maximum switching frequency.
Minimum Frequency	Minimum switching frequency.
Mean Frequency	Average switching frequency.

Safe Operating Area

This measurement performs a Safe Operating Area (SOA) test of the power device by plotting an I-V curve and comparing it against mask limits you define (according to the power device's specifications).

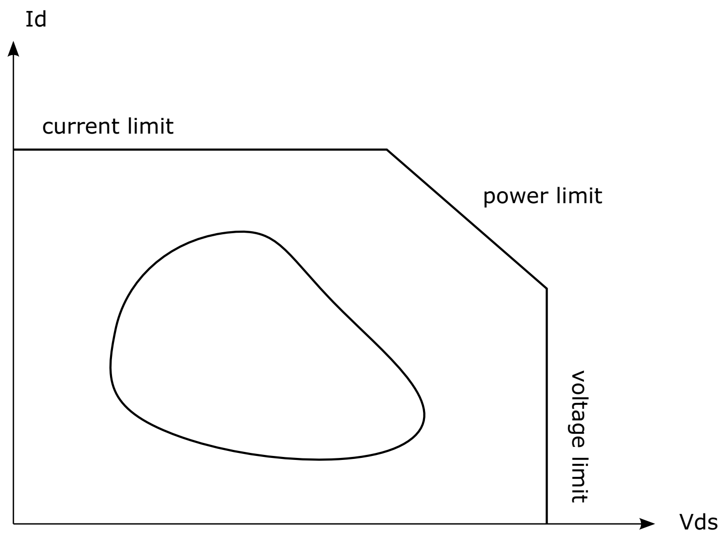
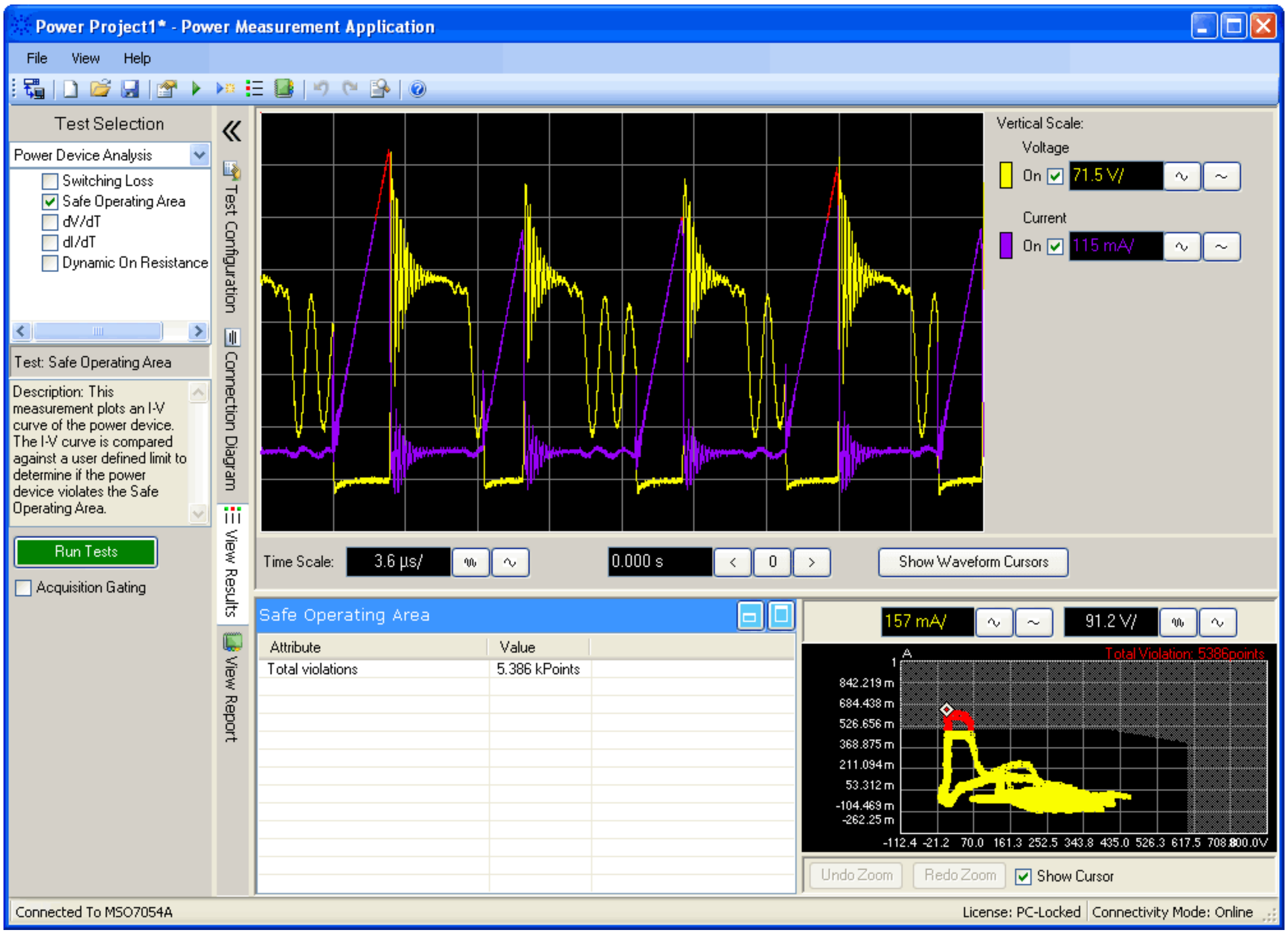


Figure 7 Safe Operating Area (SOA)

Safe Operating Area Test Results



Given the Safe Operating Area Mask you supply (see "Building Safe Operating Area Masks" on page 53), the violating points are displayed on the mask and in the current waveform in red, and the total number of violating points are listed.

dV/dT

This measurement measures the slew rate of Vds of the power device (MOSFET).

dV/dT Test Results

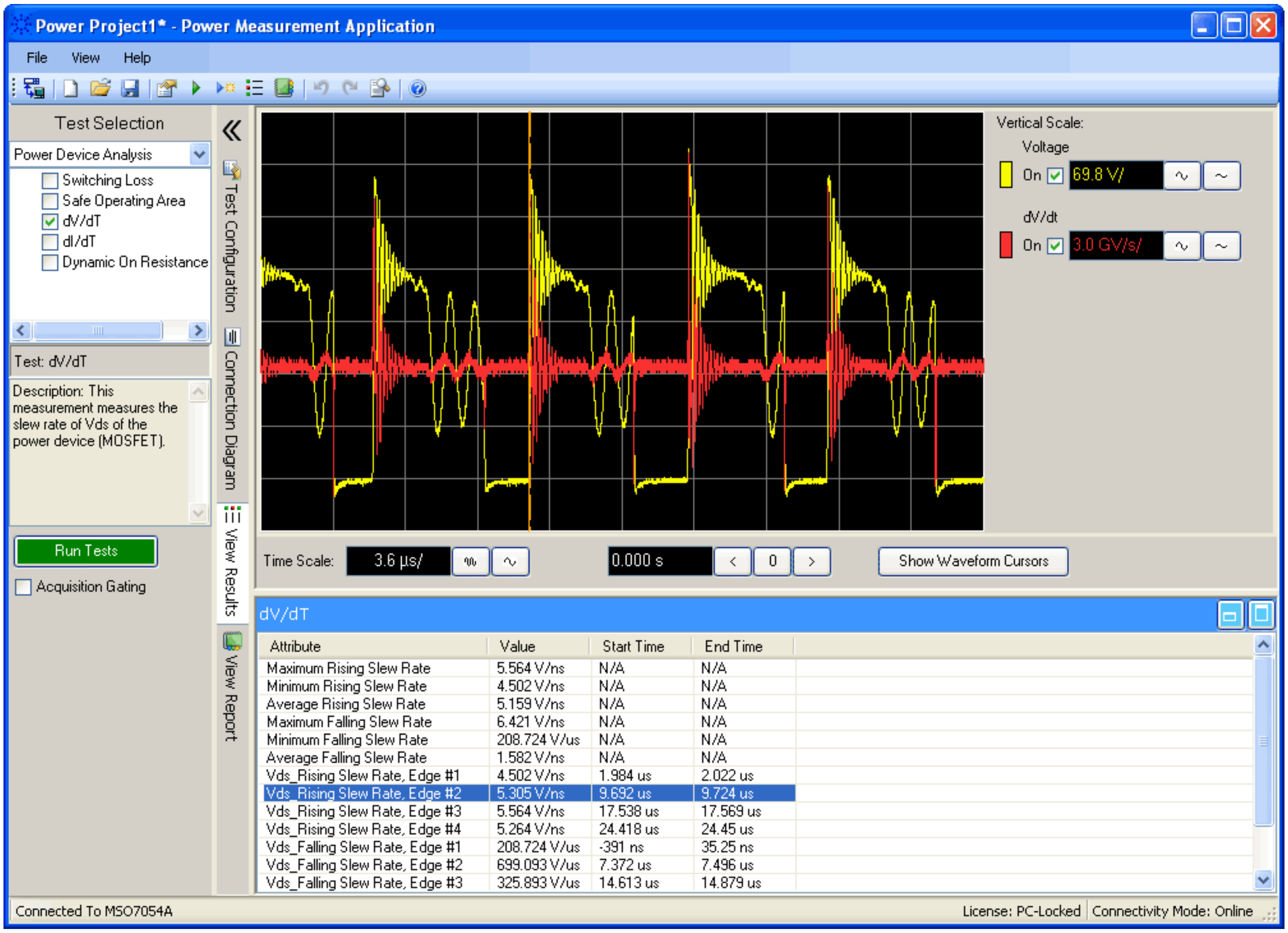


Table 32 dV/dT Test Result Waveforms

dV/dT	$[y_{(n)} - y_{(n-1)}] / [x_{(n)} - x_{(n-1)}]$

Table 33 dV/dT Test Result Values

Maximum Rising Slew Rate	The largest of the measured rising edge slew rates.
Minimum Rising Slew Rate	The smallest of the measured rising edge slew rates.
Average Rising Slew Rate	The average of the measured rising edge slew rates.
Maximum Falling Slew Rate	The largest of the measured falling edge slew rates.
Minimum Falling Slew Rate	The smallest of the measured falling edge slew rates.
Average Falling Slew Rate	The average of the measured falling edge slew rates.

Table 33 dV/dT Test Result Values (continued)

Vds_Rising Slew Rate, Edge #N	Slew rate calculation for a rising edge depends on the topology: • For boost/buck/flyback topologies, rising edge slew rate is calculated from 20% to 80%. • For push-pull topologies, rising edge slew rate is calculated from 20% to 40% and 60% to 80%. See "Slew Rate Calculation for Various Topologies" on page 83.
Vds_Falling Slew Rate, Edge #N	Slew rate calculation for a falling edge depends on the topology: • For boost/buck topologies with continuous mode, falling edge slew rate is calculated from 20% to 80%. • For flyback topologies with continuous mode, falling edge slew rate is calculated from 20% to 40%. • For boost/buck/flyback topologies with discontinuous mode, falling edge slew rate is calculated from 20% to 40% and 60% to 80%. • For push-pull topologies, falling edge slew rate is calculated from 20% to 40% and 60% to 80%. See "Slew Rate Calculation for Various Topologies" on page 83.

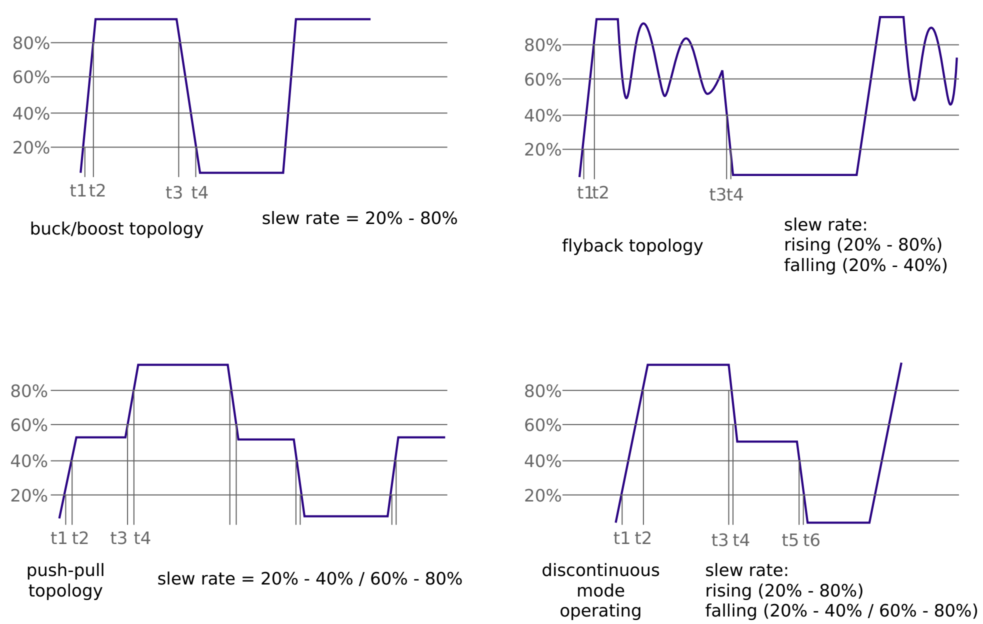


Figure 8 Slew Rate Calculation for Various Topologies

dI/dT

This measurement measures the slew rate of Id of the power device (MOSFET).

dI/dT Test Results

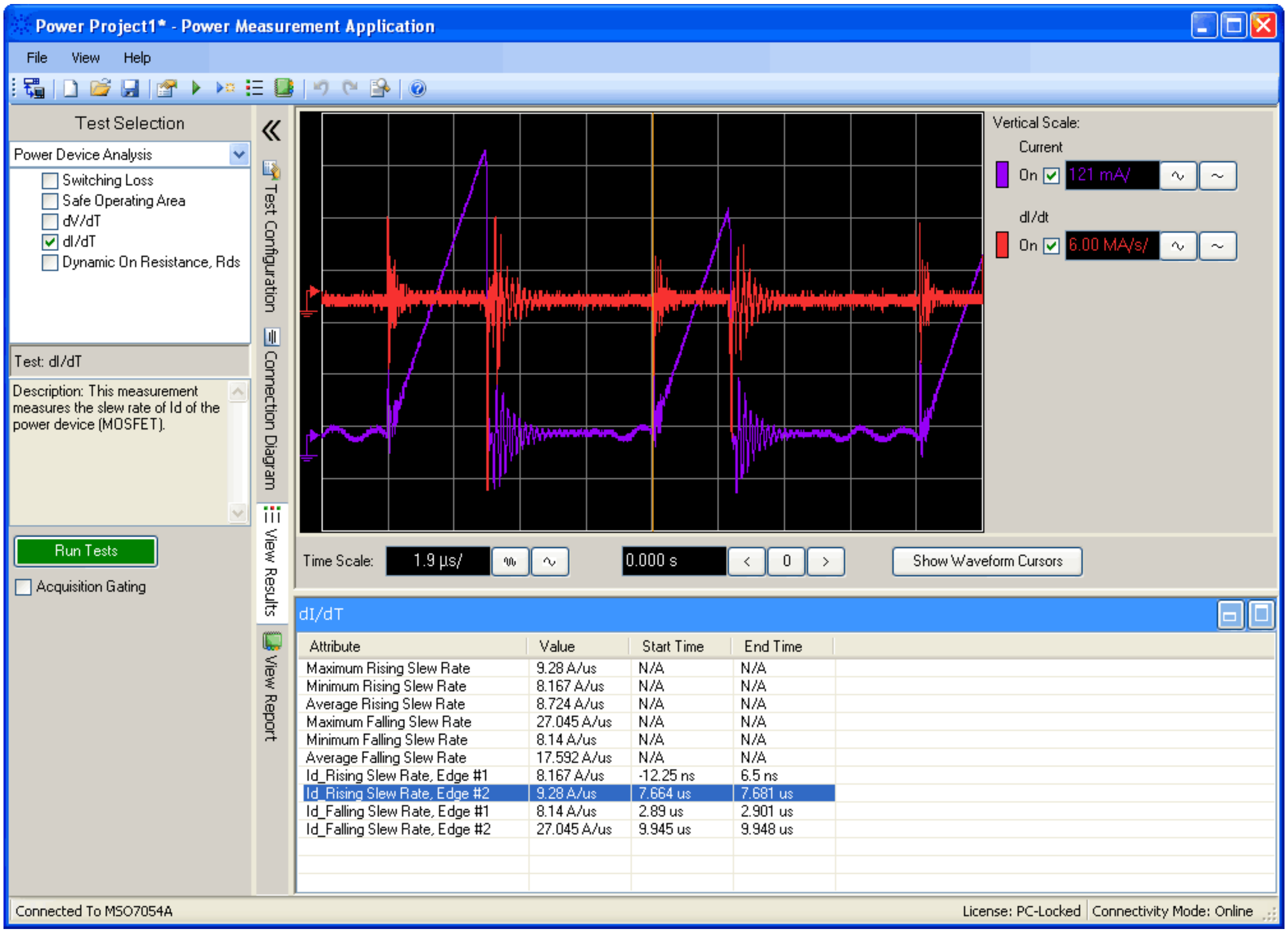


Table 34 dI/dT Test Result Waveforms

dI/dT	$[y_{(n)} - y_{(n-1)}] / [x_{(n)} - x_{(n-1)}]$

Table 35 dI/dT Test Result Values

Maximum Rising Slew Rate	The largest of the measured rising edge slew rates.
Minimum Rising Slew Rate	The smallest of the measured rising edge slew rates.
Average Rising Slew Rate	The average of the measured rising edge slew rates.
Maximum Falling Slew Rate	The largest of the measured falling edge slew rates.
Minimum Falling Slew Rate	The smallest of the measured falling edge slew rates.
Average Falling Slew Rate	The average of the measured falling edge slew rates.

Table 35 dI/dT Test Result Values (continued)

Id_Rising Slew Rate, Edge #N	Peak dI/dT value for each rising edge. The measurement looks at groups of dI/dT peaks that are >30% of the maximum dV/dT and reports the maximum within each group.
Id_Falling Slew Rate, Edge #N	Peak dI/dT value for each falling edge. The measurement looks at groups of dI/dT peaks that are <30% of the minimum dV/dT and reports the minimum within each group.

Dynamic On Resistance, Rds

The dynamic ON resistance (Rds) is the resistance of the power (switching) device (MOSFET) in its ON state. This resistance contributes to conduction losses due to the ON state forward voltage drop.

Dynamic On Resistance, Rds Test Results

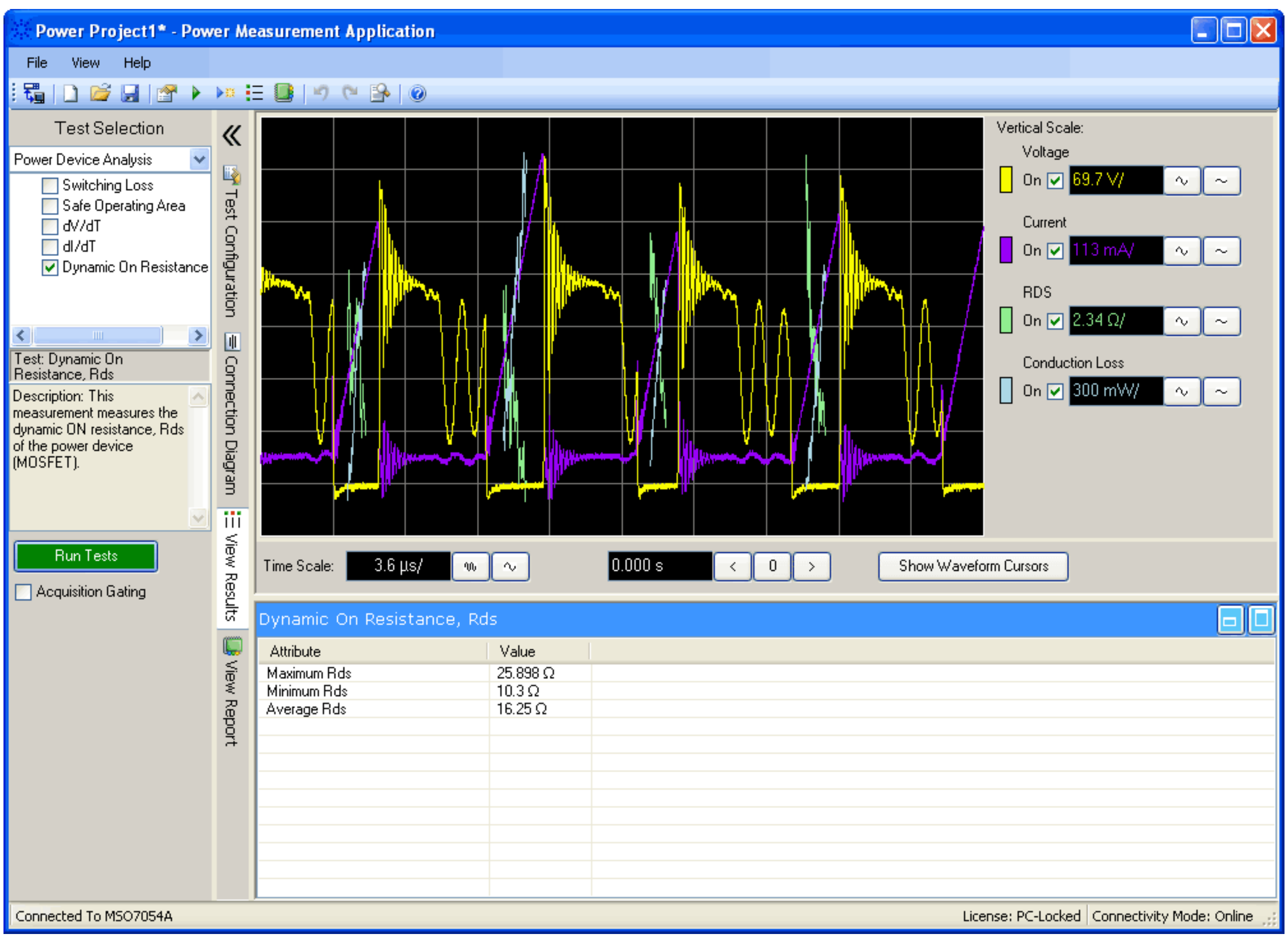


Table 36 Dynamic ON Resistance, Rds Test Result Waveforms

Rds	Rds = Vds/Id
Conduction Loss	Conduction Loss = Vds * Id

Rds and Conduction Loss are measured between 25% and 75% of each ON pulse.

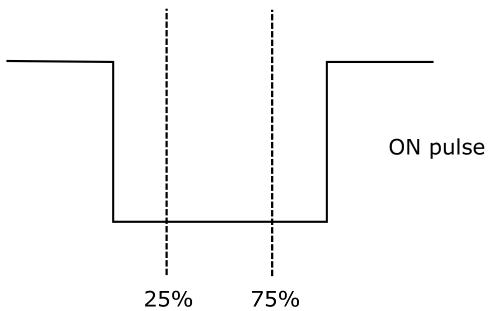


Figure 9 Rds and Conduction Loss Measurements

Table 37 Dynamic ON Resistance, Rds Test Result Values

Maximum Rds	Maximum dynamic ON resistance.
Minimum Rds	Minimum dynamic ON resistance.
Average Rds	Average dynamic ON resistance.

Output Analysis Tests

Test the power output voltage ripple.

- "Output Voltage Ripple" on page 87

Configuration Parameters for Output Analysis Tests

The output analysis tests have the following configuration parameters in addition to the global test configuration parameters (see page 56).

Table 38 Output Voltage Settings

Parameter	Description
Output Voltage Channel	Select the channel number for the output voltage.
Passive Probe Attenuation Factor	Select the attenuation factor used for the passive probe.

Table 39 Time Scale Settings

Parameter	Description
Duration	Enter the duration of time to capture signal. This parameter will set the time scale of the oscilloscope.

Table 40 Analysis Settings

Parameter	Description
Low Pass Filter	Enter the cut off frequency for the low pass filter.
High Pass Filter	Enter the cut off frequency for the high pass filter.

Output Voltage Ripple

This measurement analyzes the output voltage ripple and presents the peak-to-peak value as well as the frequency response of the captured signal.

Connection for the Output Voltage Ripple Test

1 Connect the voltage probe (passive or differential) to the DC output of the power supply.
2 Connect the voltage probe to the oscilloscope channel defined by the user in the Test Configuration tab.

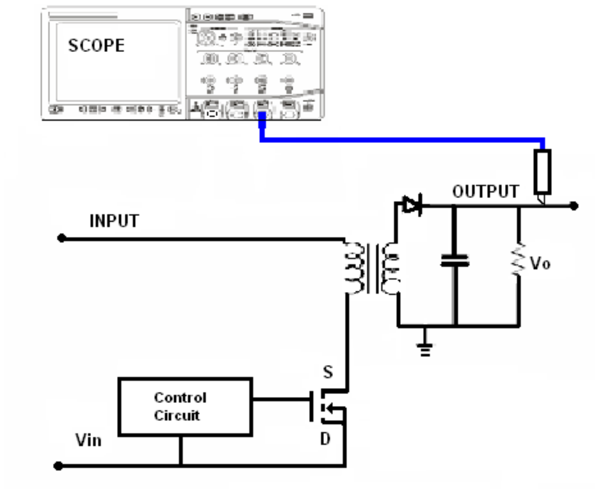


Figure 10 Typical Configuration for Output Voltage Ripple Test

Output Voltage Ripple Test Results

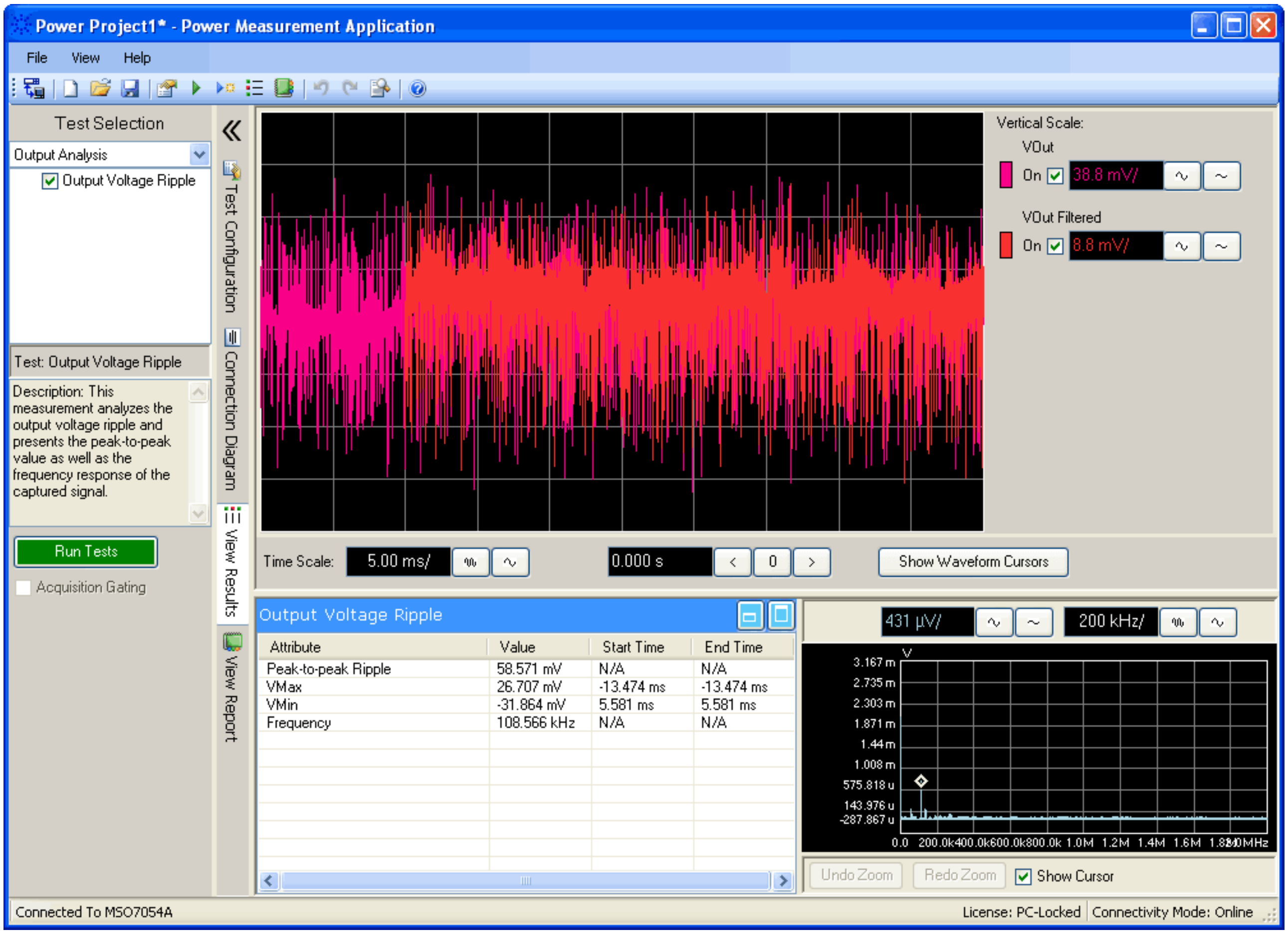


Table 41 Output Voltage Ripple Test Result Waveforms

VOut Filtered	Shows the output voltage with the applied filters specified by the Low Pass Filter and High Pass Filter test configuration parameters. If the High Pass Filter cut off frequency is less than the Low Pass Filter cut off frequency, the High Pass Filter is applied first. Fourth-order Butterworth filters are used.
FFT (VRMS)	Shows the frequency components in the output voltage ripple. The FFT is calculated using the Blackman-Harris Window (because of its minimal spectral leakage) and plotted as a FFT plot using VRMS units for magnitude. You can drag over an area to zoom and enable a cursor as in the main waveform displays.

Table 42 Output Voltage Ripple Test Result Values

Peak-to-peak Ripple	VMax - VMin
VMax	The maximum measured output voltage.
VMin	The minimum measured output voltage.
Frequency	

Turn On/Off Analysis Tests

Test the power output turn on time.

- "Turn On Time" on page 92
- "Turn Off Time" on page 93

Connection for the Turn On/Off Analysis Tests

1 Connect D+ of the voltage probe to the live wire of the AC input. Connect D- of the voltage probe to the neutral wire of the AC input. Select the appropriate attenuation ratio of the probe.

2 Connect the voltage probe (passive or differential) to the DC output of the power supply.

3 Connect the voltage probe to the oscilloscope channel you have selected in the Test Configuration tab. Do the same for the voltage probe connected to the DC output.

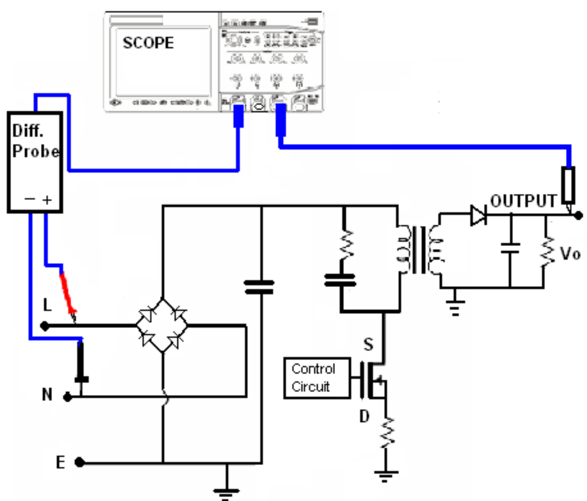


Figure 11 Typical Configuration for Turn On/Off Analysis Tests

Configuration Parameters for Turn On/Off Analysis Tests

The turn on/off analysis tests have the following configuration parameters in addition to the global test configuration parameters (see page 56).

Table 43 Output Voltage Settings

Parameter	Description
Output Voltage Channel	Select the channel number for the output voltage.
Passive Probe Attenuation Factor	Select the attenuation factor used for the passive probe.

Table 44 Time Scale Settings

Parameter	Description
Duration	Enter the duration of time to capture signal. This parameter will set the time scale of the oscilloscope.

Table 45 Vertical Scale Settings

Parameter	Description
Maximum source voltage	Enter the maximum (peak-to-peak) source voltage amplitude. The source voltage will be used to trigger the oscilloscope in "Turn On Time" test.
Steady state DC output voltage	Enter the expected output voltage amplitude. This value will be used to adjust the vertical scale of the oscilloscope.

Turn On Time

This measures the time taken to get the output voltage of the power supply after the input voltage is applied.

Turn On Time Test Results

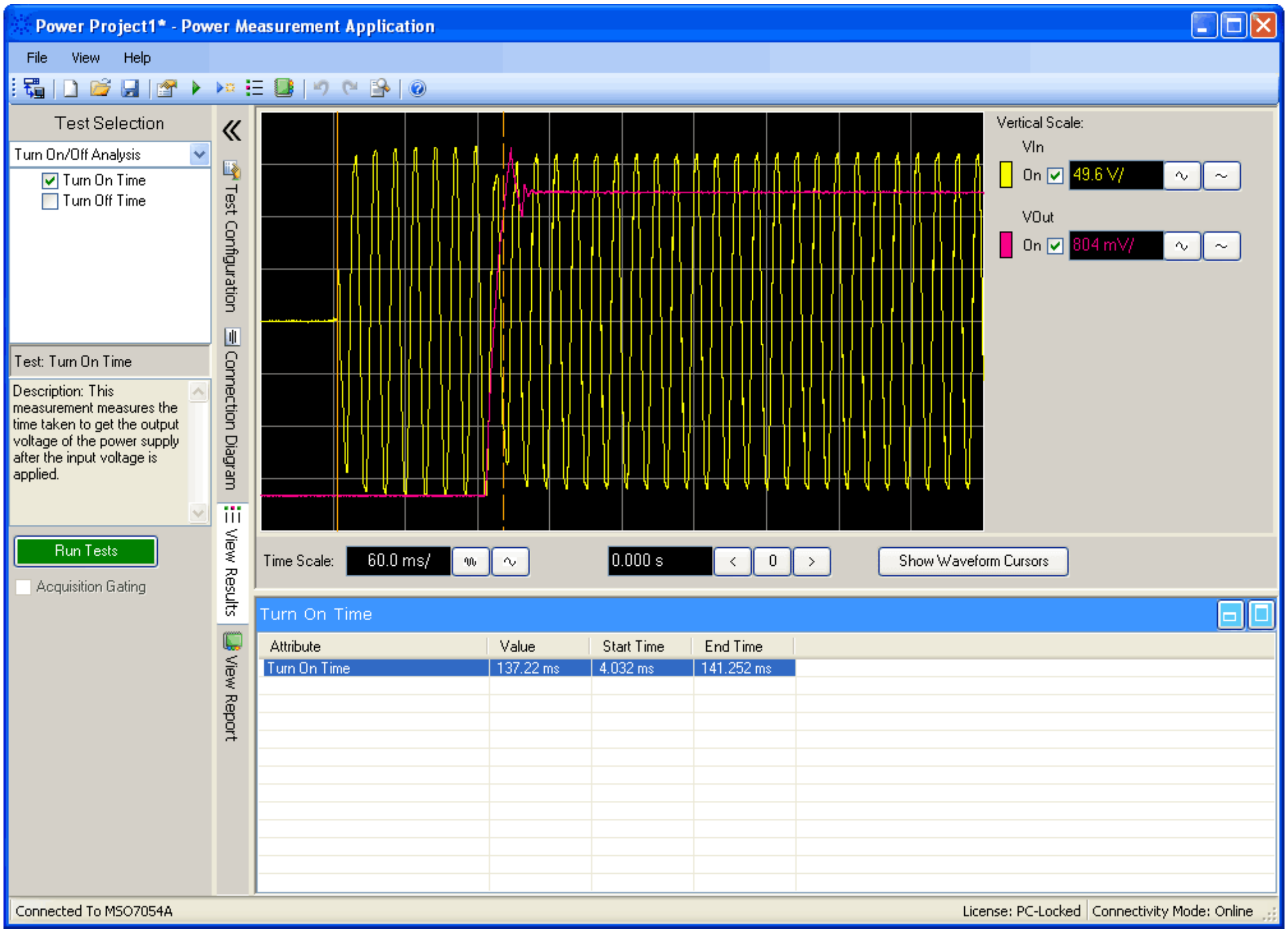


Table 46 Turn On Time Test Result Values

Turn On Time	t2 -t1 Where: • t1 = AC input voltage rises to 10% of its maximum amplitude (Start Time). • t2 = DC output voltage rises to 90% of its maximum amplitude (End Time).

Turn Off Time

This measures the time taken for the output voltage of the power supply to turn off after the input voltage is removed.

Turn Off Time Test Results

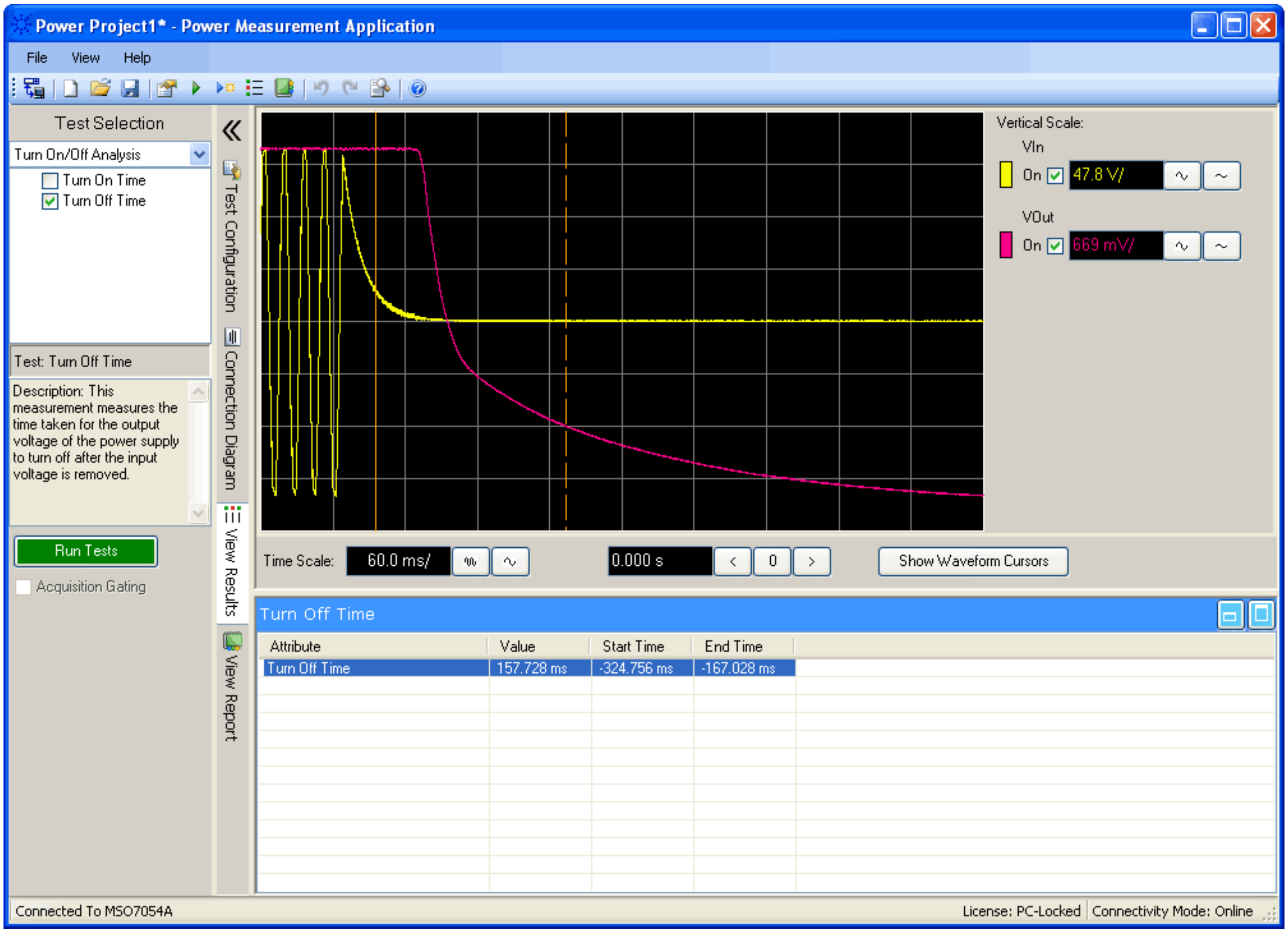


Table 47 Turn Off Time Test Result Values

Turn Off Time	t2 -t1 Where: • t1 = AC input voltage goes below 20% of its positive peak (or negative peak which ever occurs first) (Start Time). • t2 = DC output voltage drops to 20% of its steady state value (End Time).

Transient Analysis Tests

Test the load transient response of the power supply's DC output.

- "Load Transient Response" on page 96

Connection for Transient Analysis Tests

1 Connect the voltage probe (passive or differential) to the DC output of the power supply.

2 Connect the voltage probe to the oscilloscope channel defined by the user in the Test Configuration tab.

3 Connect the current probe to the output load of the power supply. The change in the load current will be used to trigger the oscilloscope to capture the transients.

4 Connect the current probe to the oscilloscope channel defined by the user in the Test Configuration tab.

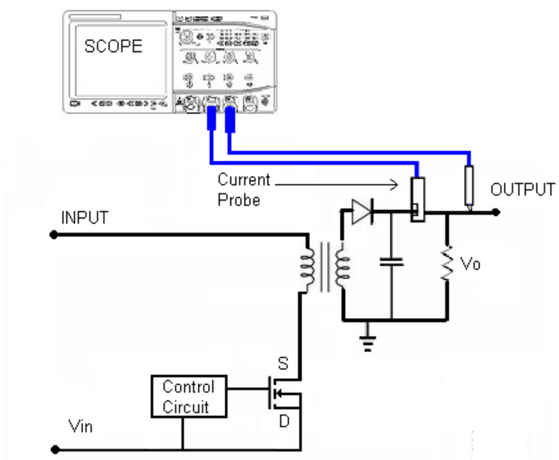


Figure 12 Typical Configuration for Input Line Analysis Tests

Configuration Parameters for Transient Analysis Tests

The transient analysis tests have the following configuration parameters in addition to the global test configuration parameters (see page 56).

Table 48 Output Voltage Settings

Parameter	Description
Output Voltage Channel	Select the channel number for the output voltage.
Passive Probe Attenuation Factor	Select the attenuation factor used for the passive probe.

Table 49 Trigger Settings

Parameter	Description
Initial Load Current	This parameter is used to measure the transient load response of the DC output. The load current will be used as a reference and to trigger the oscilloscope. Enter the initial load current value.
New Load Current	This parameter is used to measure the transient load response of the DC output. The load current will be used as a reference and to trigger the oscilloscope. Enter the new load current value.
Load Change	For programmable loads, please select "Do not prompt to change load". The software will assume the load is increasing/decreasing constantly. The oscilloscope will trigger in the load change automatically, and you will not be prompted to increase/decrease the load between the test. If the load change is done manually please select "Prompt to change load". You will be prompted to increase/decrease the load to trigger the oscilloscope.

Table 50 Time Scale Settings

Parameter	Description
Duration of Load Change	This parameter is used to measure the transient load response of the DC output. Enter the duration for current change. This parameter will set the time scale of the oscilloscope.

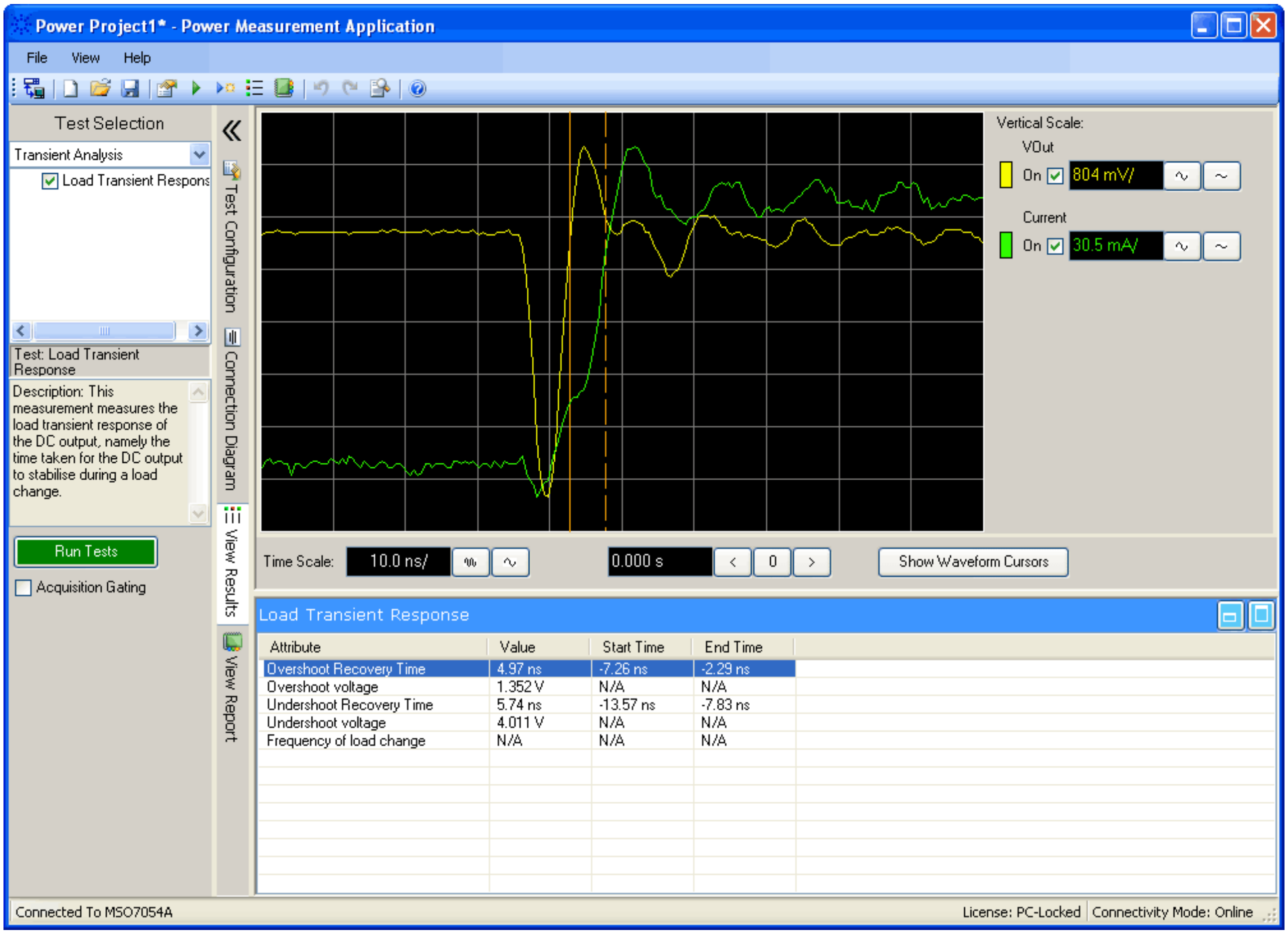
Table 51 Vertical Scale Settings

Parameter	Description
% Overshoot	Enter the % of overshoot of the output voltage. This value will be used to adjust the vertical scale of the oscilloscope.
Steady State DC Output Voltage	Enter the expected output voltage amplitude. This value will be used to adjust the vertical scale of the oscilloscope.

Load Transient Response

This measurement measures the load transient response of the DC output, namely the time taken for the DC output to stabilize during a load change.

Load Transient Response Test Results



If the load current increases and decreases in one acquisition, you should see both a negative and positive peak. The transient response is measured from the time VOut overshoots above 20% of its positive/negative peak to the time VOut settles within 20% of its positive/negative peak. There are start and end time stamps that mark the measured area.

Table 52 Load Transient Response Test Result Values

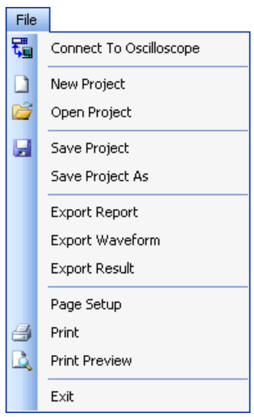
Overshoot Recovery Time	Positive transient time.
Overshoot Voltage	Positive transient peak voltage.
Undershoot Recovery Time	Negative transient time.
Undershoot Voltage	Negative transient peak voltage.
Frequency of Load Change	When there is a programmable load, this shows how often there is a load change.

5
Reference

This chapter describes the menus and dialogs in the Power Measurement Application.

Menus

File Menu



Connect To Oscilloscope

Lets you identify the oscilloscope used to perform the power measurements.

New Project

Creates a new project.

Open Project

Opens a previously saved project.

Save Project

Saves the current project to a file.

Save Project As

Saves the project to a new file.

Export Report

Saves the test report to a single file.

Export Waveform

Saves waveforms for later offline analysis.

Export Results

Saves measurement results to a .csv (comma-separated value) file.

Page Setup

Sets up the page for printing.

Print

Prints the application's test report.

Print Preview

Previews the application's test report print out.

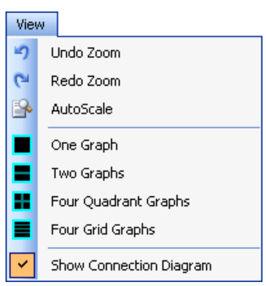
Exit

Exits the Power Measurement Application.

See Also

- "Saving and Opening Projects" on page 48
- "Performing Tests Offline with Saved Waveforms" on page 50

View Menu



Undo Zoom

Undoes the most recent zoom in the waveform graphs.

Redo Zoom

Repeats the most recent undone zoom in the waveform graphs.

AutoScale

Returns the waveform graphs to the original view (that is, with no zoom).

One Graph

Displays one waveform graph.

Two Graphs

Displays two waveform graphs, splitting the waveform display horizontally.

Four Quadrant Graphs

Displays four waveform graphs, splitting the waveform display in quadrants.

Four Grid Graphs

Displays four waveform graphs, splitting the waveform display horizontally.

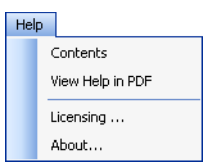
Show Connection Diagram

Specifies whether the connection diagram dialog is displayed when running a test that requires a different connection than the previous test.

See Also

- "Step 9: View the test results" on page 35

Help Menu



Contents

Opens the online help with the Contents tab selected for browsing topics by their hirearchy.

View Help in PDF

Opens the PDF version of this online help for printing.

Licensing...

Opens the Licensing dialog that describes the types of licenses available, how to get them, and how to install them.

About...

Opens the About the Power Measurement Application dialog that displays version information.

See Also

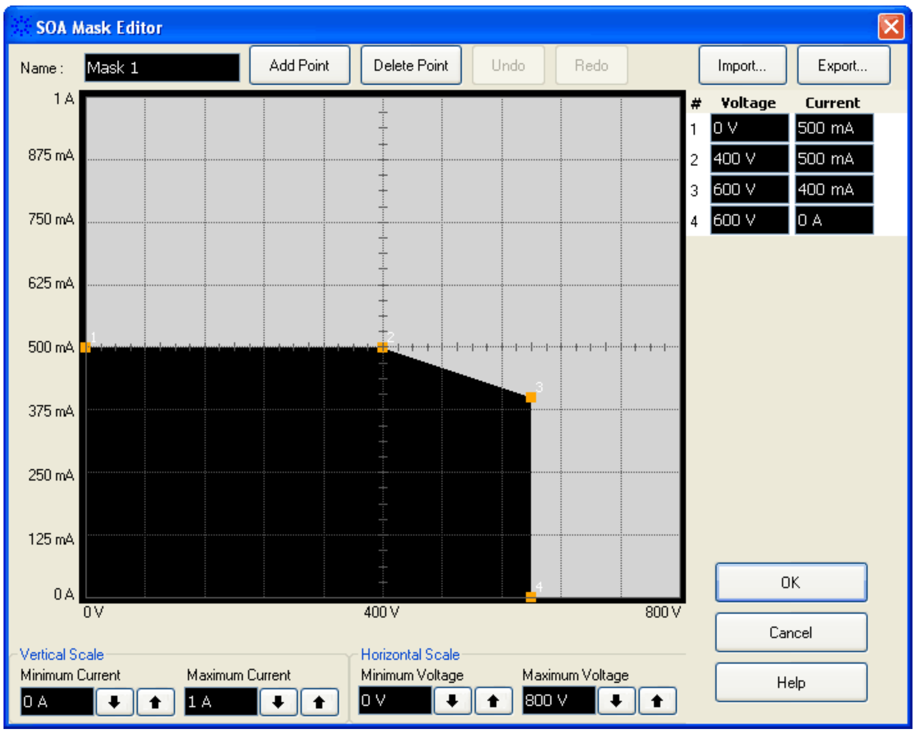
- "Licensing the Power Measurement Application" on page 16

Dialogs

- "Safe Operating Area Mask Editor Dialog" on page 104

Safe Operating Area Mask Editor Dialog

The Safe Operating Area Mask Editor dialog lets you edit the mask used with the SOA measurement.



See Also

- "Building Safe Operating Area Masks" on page 53

Glossary

A

apparent power The portion of AC line power flow due to stored energy, which returns to the source in each cycle.

C

crest factor Crest factor is the ratio between the instantaneous peak AC line current/voltage required by the load and the RMS current/voltage.

D

DUT Device Under Test.

I

I_D Drain current.

P

power factor Ratio of the actual AC line power to the apparent power.

PWM Pulse Width Modulation.

R

R_{DSON} Resistance when transistor is on.

real (actual) power The portion of power flow that, averaged over a complete cycle of the AC waveform, results in net transfer of energy in one direction.

RMS Root Mean Square, a type of average.

S

SOA Safe Operating Area.

V

V_{DS} Drain-to-source voltage.

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