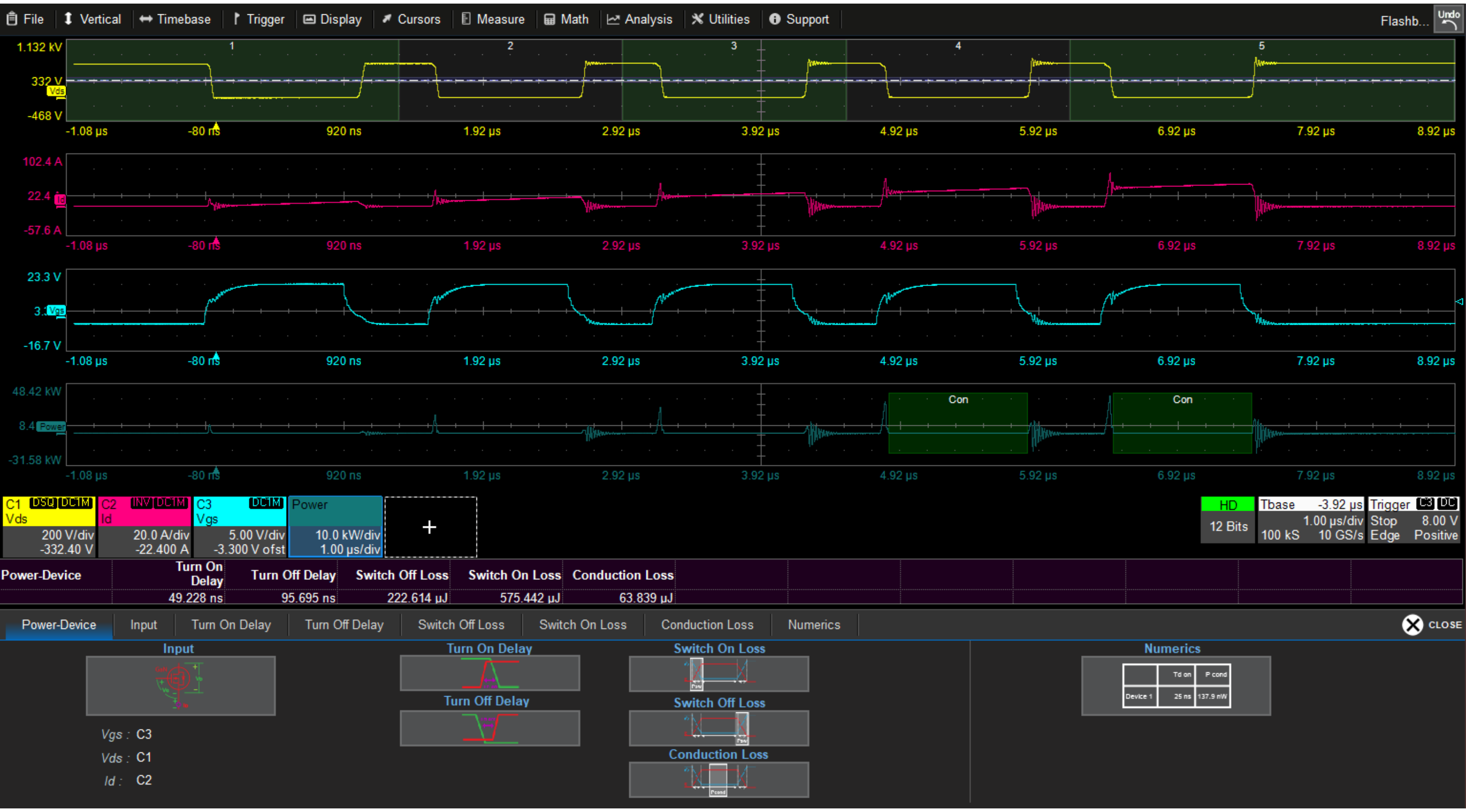
TELEDYNE LECROY
Everywhereyoulook™



Power-Device Software Instruction Manual

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Contents

About This Software Manual

This manual describes the operation of the Power-Device software option for Teledyne LeCroy MAUI oscilloscopes.

It is assumed that you have a basic understanding of power electronics measurements and how to use the oscilloscope on which the option is installed. Only features specific to this product are explained in this manual.

While some images may have been taken on a different model oscilloscope and do not exactly match the appearance of your oscilloscope display, be assured that the functionality is identical. Product-specific exceptions will be noted in the text.

Power-Device Software Overview

The Power-Device Software option for Teledyne LeCroy oscillosocpes is designed to enable you to easily make power measurements of electronic devices in conformance with JEDEC® standards:

- Turn On/Turn Off Delay
- Switch Off/Switch On Loss
- Conduction Loss

Measurements can be made according to the industry-standard methods (Auto Level Configuration) or using custom measurement thresholds (Manual Level Configuration) to adjust to noisy signals.

Results are displayed in an interactive Numerics table. The table allows you to generate power waveforms that track the measurements over all pulses in the selection region of the acquisition.

You can also display a Power Waveform calculated from the V and I waveforms.

The Power-Device dialog acts as a summary of the measurement configuration. Touch any shortcut button to open the setup dialog.

Double Pulse Test Set Up

Required Equipment

The following table shows the equipment required for double pulse test (DPT) measurements, with recommended Teledyne LeCroy models. The examples shown in this manual were taken using the equipment listed here.

Equipment	Minimum Requirements	Examples
Oscilloscope	4 channels 350 MHz to 1 or 2 GHz bandwidth 12-bit resolution preferred	HDO4000A HDO6000B WaveRunner/MDA 8000HD WavePro HD
Arbitrary Waveform Generator (AWG)	Burst generation capability Built-in double-pulse generation preferred Square wave frequency few to 100 MHz	T3AWG3K
High-Voltage Power Supply	800 V to 1500 V output Low-current capability Current limiting capability preferred	T3PS8000111P
Auxiliary Power Supply	Up to 24 V output Dual output preferred	T3PS
Probes (3): 1 voltage probe for Vgs 1 voltage probe for Vds 1 current probe/shunt for Ids	Probe specifications depend on the voltage and frequency of the signals measured. Passive voltage probes can be used for measuring the Lower FET only if it can be ascertained that the board is equal to ground. Passive voltage probes should never be used for measuring the Upper FET.	See table below
Gate Drivers	See MOSFET manufacturer 2-output gate driver IC options for appropriate voltage class/current.	Infineon 2ED20106-FI half-bridge gate driver IC

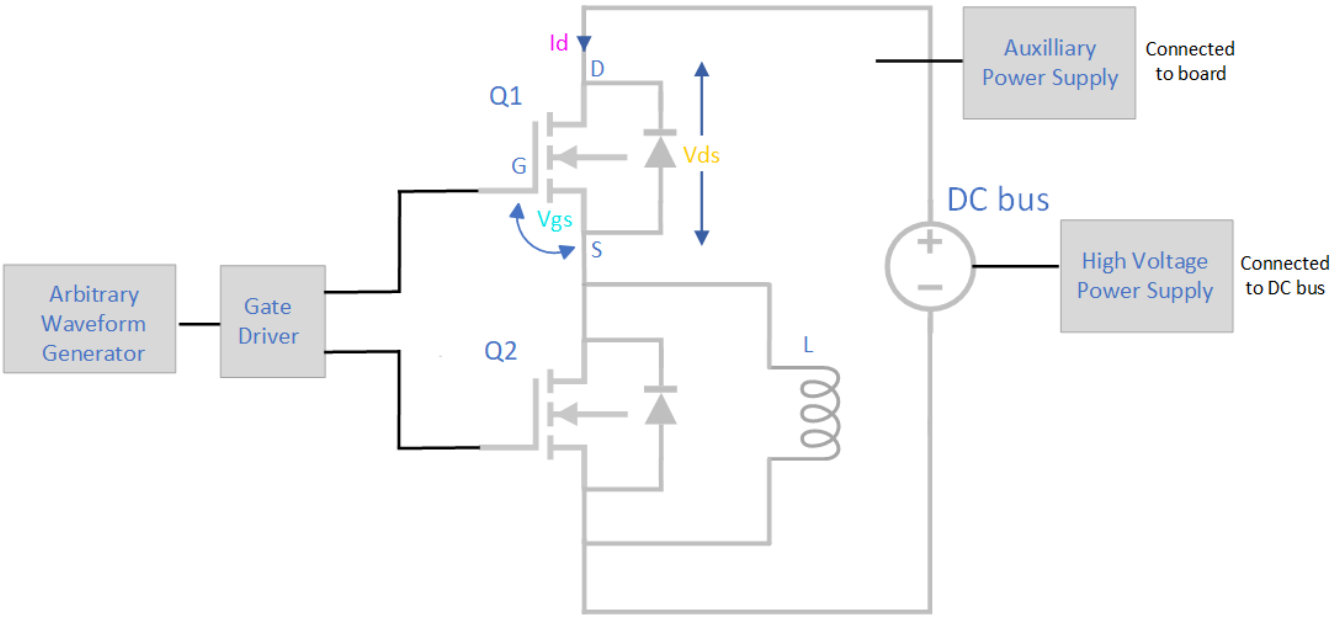
Probe Selection

DC Bus Voltage	Suitable Teledyne LeCroy Probes	
	Vgs	Vds
≤48 Vdc	DL-HCM	DL-HCM or passive probe[1]
170 - 1500 Vdc	DL-ISO	DL-ISO, PPE6kV-A or HVP120[2]
1501 - 6000 Vdc	HVFO108 or DL-ISO	HVD3000

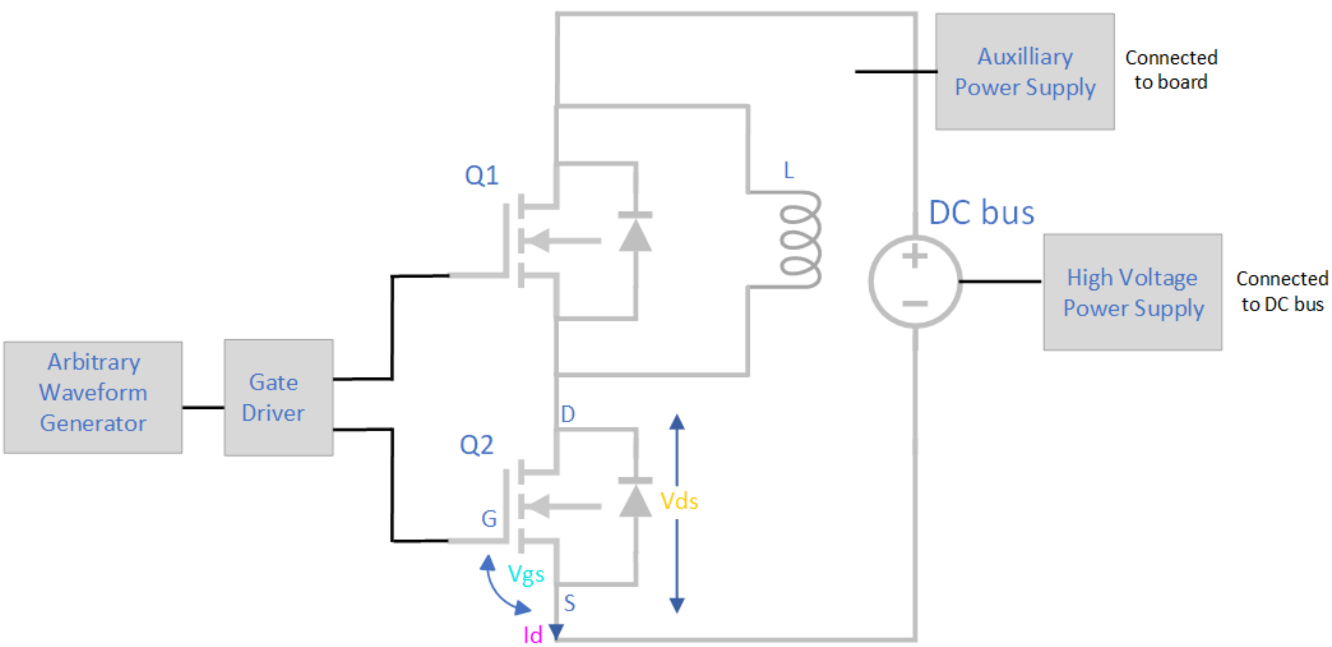
1) For a low-side device under 48 Vdc (board REF = oscilloscope GND), you may use a passive probe for the Vds measurement. Note that passive probe frequency is limited to 500 MHz.

2) For a low-side device above 48 Vdc (board REF = oscilloscope GND), you may use a high-voltage passive probe for the Vds measurement. Please exercise caution and check with your lab manager whether you are allowed to use a passive probe for this measurement in your lab.

Test Set Up One: Upper FET Measurements



Test Set Up Two: Lower FET Measurements



Deskewing Probes

Prior to connecting the probes into the test environment, it is good practice to deskew them relative to each other using a known source. The horizontal skew time discovered during this procedure can be later entered into the Power-Device Software to deskew the signals from each probe.

The DCS025 Deskew Fixture can be used to accomplish this. The DCS025 is a calibration source that generates time-aligned 5 V and 100 mA signals with a 10 ns fall time for deskewing probes.

1. Connect a differential voltage probe to any open Channel (C*n*) input. On the voltage probe C*n* dialog, select Auto Zero.
2. Connect the current probe to any other open Channel input. On the current probe C*n* dialog, select Degauss.
3. Connect the DCS025 to the oscilloscope EXT input.
4. Attach the voltage probe to the negative left (black) and positive right (red) ports on the deskew fixture. The correct polarity is marked by each port.
5. Clamp the current probe around the loop on the DCS025.
6. On the oscilloscope, press Auto Setup. You should now see two signals on the screen similar to the first image at right.
7. Open either C*n* dialog and select the Deskew field to activate it. Using the front panel Adjust knob, or by typing in the field, enter positive or negative deskew time to move the traces into alignment. Ideally, they should intersect at the voltage probe zero level, as shown in the second image at right.
8. Repeat the procedure using the other voltage probe.

Voltage and current waveforms prior to deskew.

Voltage and current waveforms following deskew.

Acquiring Power Signals

Once the test equipment is in place and probes are deskewed, follow the process here to acquire power signals for measurement.

Acquire Waveforms

We recommend the following workflow for acquiring power signals.

1. Test that the AWG/AFG, which should be operating in bursted mode, is working properly. If possible, set it to generate only the number of pulses needed, rather than to work in continuous mode.
2. Connect the Vds, Vgs and Id signals to oscilloscope channels.
3. Set the oscilloscope for a 50% Negative Edge trigger on the Vds signal using Normal trigger mode.

> Note: The software will measure N-1 pulses, so be sure to set a long enough acquisition time to capture at least six pulses if you wish to measure five.

4. Turn on the low-voltage power supply first, then the high-voltage power supply second.
5. Trigger the AWG to generate pulses.
6. Turn off the high-voltage power supply first, then the low-voltage power supply second.
7. With the acquisition in buffer, in the Power-Device software configure the inputs used for Vgs, Vds and Id, and enable the desired pulse measurements.

Configure Inputs

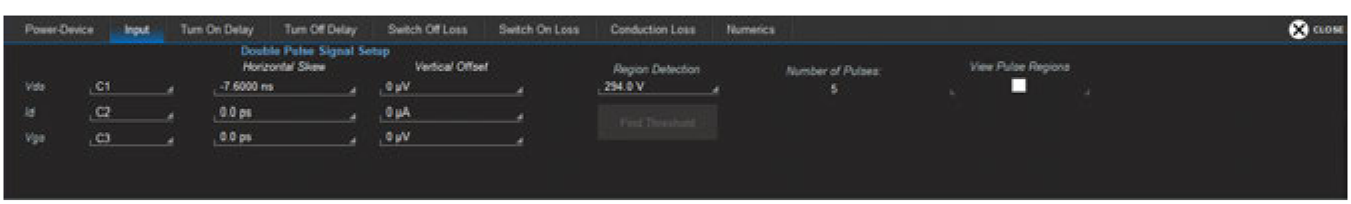
To access the software, choose **Analysis > Power-Device** from the oscilloscope menu bar. The top dialog in the group summarizes the current configuration, with shortcut buttons to each of the other setup dialogs.

Open the **Inputs** dialog and enter the signal sources for:

Vds - drain-source voltage

Id - drain/output current

Vgs - gate-source voltage



Note: The software does not perform any checks to ensure the signal is the correct "type," so check to make sure you have entered the correct sources in each field. Any type of analog waveform trace (e.g., channel or memory) can be used as the input source, in case you wish to save acquired channels to memory and measure them later.

Correct Horizontal Skew and Vertical Offset

For each input, the software will pull in any deskew time you entered on the channel dialogs when deskewing the probes. Enter any amount of positive or negative **Horizontal Skew** (delay time) required to refine the Vds and Id waveform positions. Accurate power measurements depend on a careful positioning of the input waveforms, so it is worthwhile spending some time making sure that the rise and fall of your Vds and Id waveforms are aligned.

In general, if you have Auto Zero'd the voltage probes before acquiring, the signals should show a consistent zero level, and any departure from zero at the base is due to the settling time of the signal.

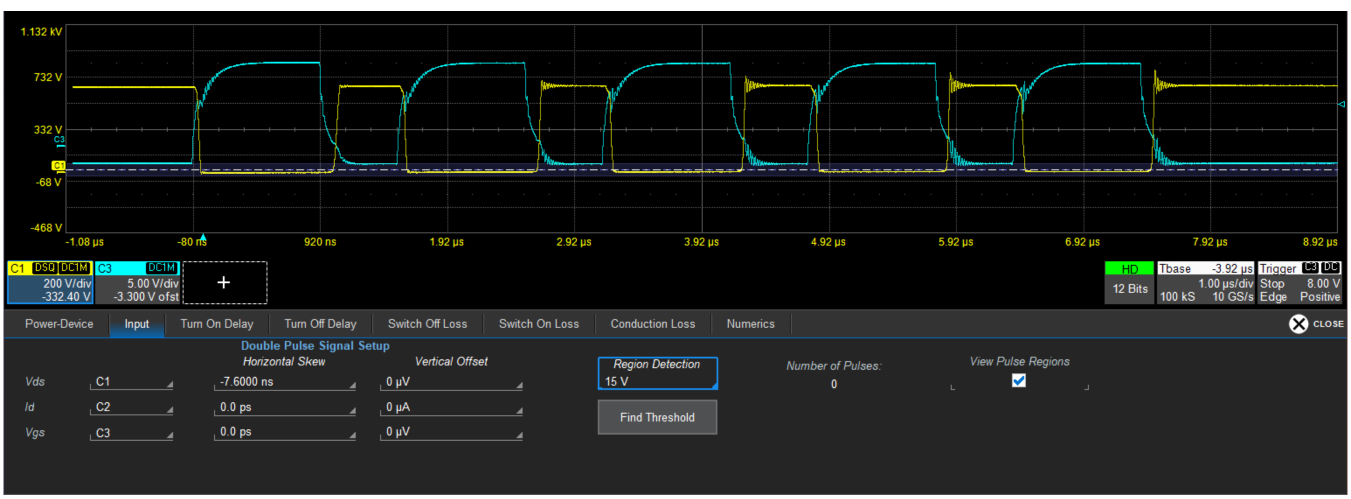
However, time and changes in the test environment can cause some offset drift in the acquisition system. If that occurs, or if you did not Auto Zero the probes prior to acquisition, enter the amount of **Vertical Offset** (in V) required to zero the waveforms.

Set Pulse Region Measured

The software can identify and measure up to five contiguous pulses within the overall acqisition. It is important to be sure that the desired number of pulses are recognized by the software and appear within the acquisition window being measured.

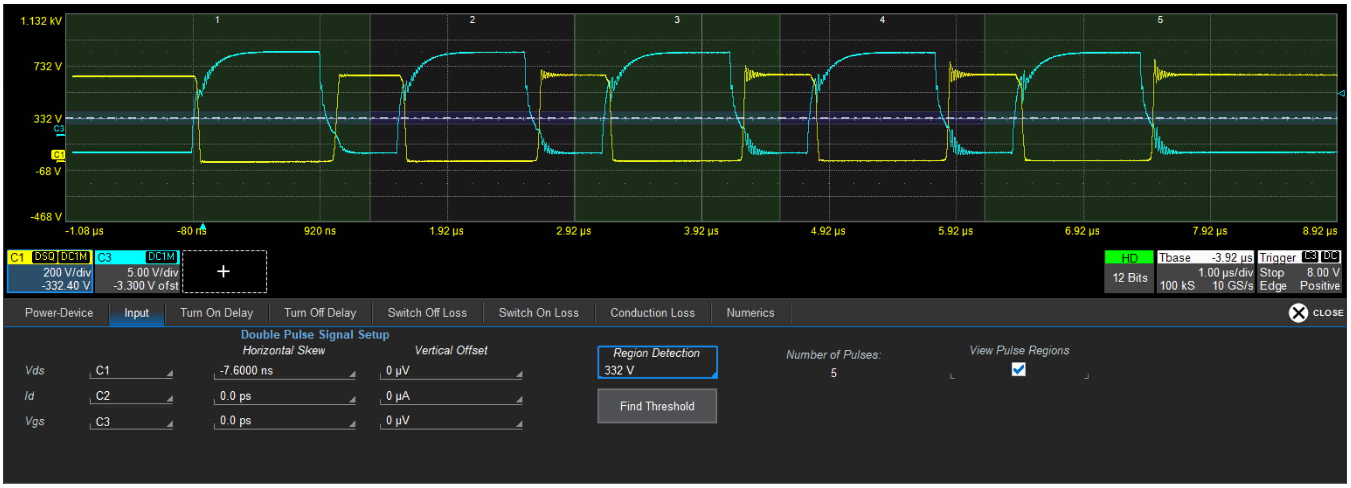
Note: You are not limited to acquiring five pulses, but only five contiguous pulses can be identified and selected for measurements.

To do this, check **View Pulse Regions**. A dashed line is placed on the input waveforms that shows the vertical level at which pulses are being measured.



The Number of Pulses is 0 because the pulse region marker is set at too low a level to register any pulses.

Drag the dashed marker to about the vertical median of the Vds waveform. The **Number of Pulses** field should now match either the number visible in the acquisition window or five, whichever is less. These pulses can be individually selected for measurements. The **Region Detection** field shows the voltage level at which the pulses are identified.



By moving the marker to the Vds median level, the Number of Pulses identified is five.
The waveform overlay shows the region of each pulse.

Measuring Power Signals

Following acquisition and input setup, configure all the measurements you wish to make using the Power-Device software. Use the tabs or the shortcut buttons to open the dialog for each measurement.

Turn On/Off Delay and Switch Off/On Loss

For each of these measurements, you will select the:

- **Start** and **Stop** points on the circuit to be measured
- **Level** at which to measure, using either Auto or Manual settings
- **Pulse Region** to measure

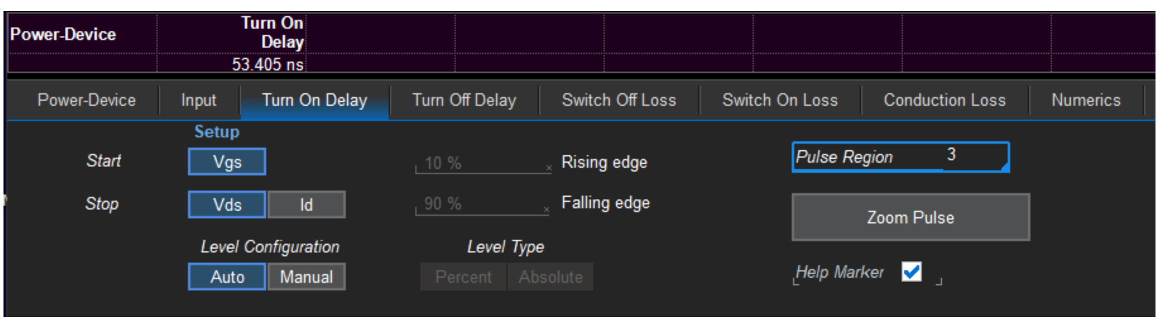
Each different measurement can be made on different pulses at different levels.

Auto is the default configuration selection for each measurement, which measures signals at the default levels shown on the dialog. The levels used have been based on JEDEC and industry standards for these measurements.

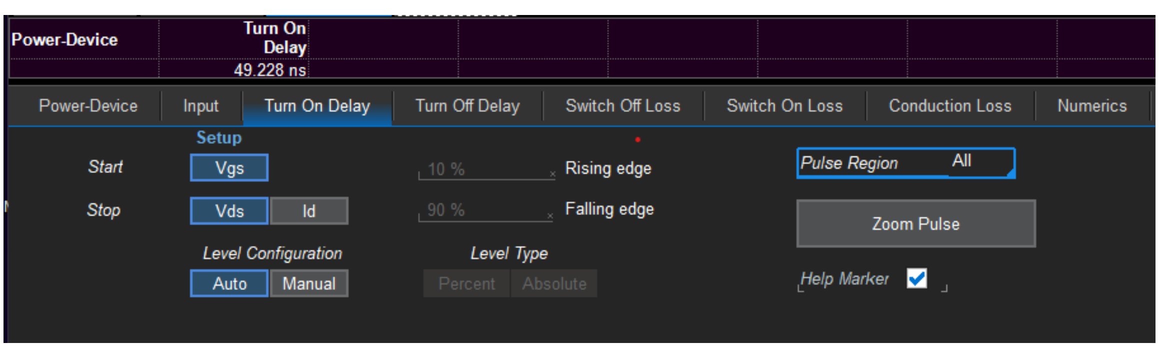
> **Note:** The percent amplitudes you see for each measurement are calculated using IEEE Top and Base, rather than Max and Min. This is to help reduce error due to noise perturbations.

However, the JEDEC levels may not be best for your signal. If the signal is too noisy to result in good measurements at the default levels, or if you simply wish to measure at a different level, select **Manual** Level Configuration and enter your own thresholds. Manual levels can be set in either percent amplitudes or absolute voltages.

The **Pulse Region** you select determines which pulses of all those identified are measured. This can be individual pulses 1 to 5 or All pulses that were detected at the level you set on the Inputs dialog. Selecting All will show the average calculated for all pulses, and values for all pulses will be plotted if you choose to track the measurement.



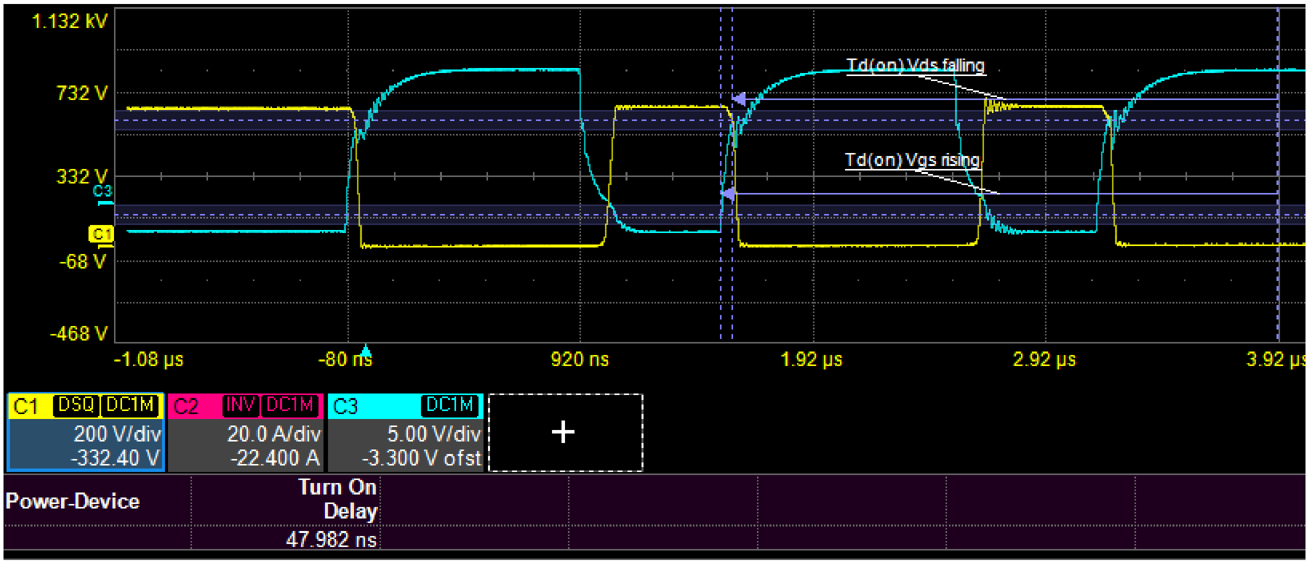
Turn on Delay measured only for Pulse Region 3 is 53.405 ns.



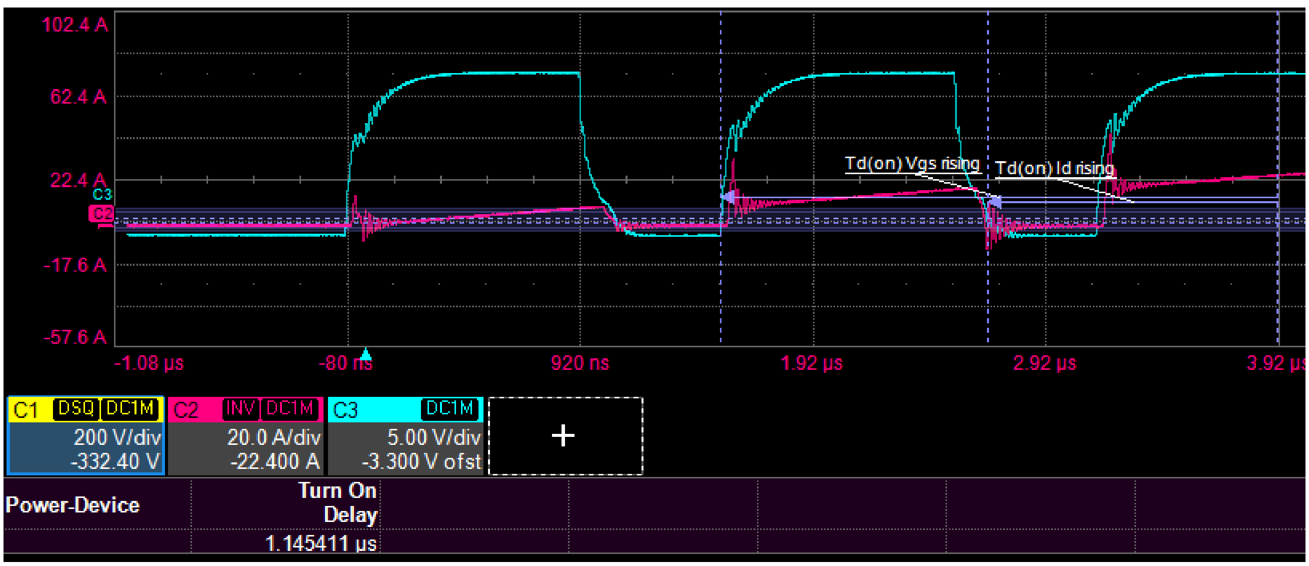
Same measurement averaged for All pulses is 49.228 ns.

Turn On Delay

In Auto configuration, this measurement shows the time from the 10% rising edge of Vgs to the 90% falling edge of Vds:

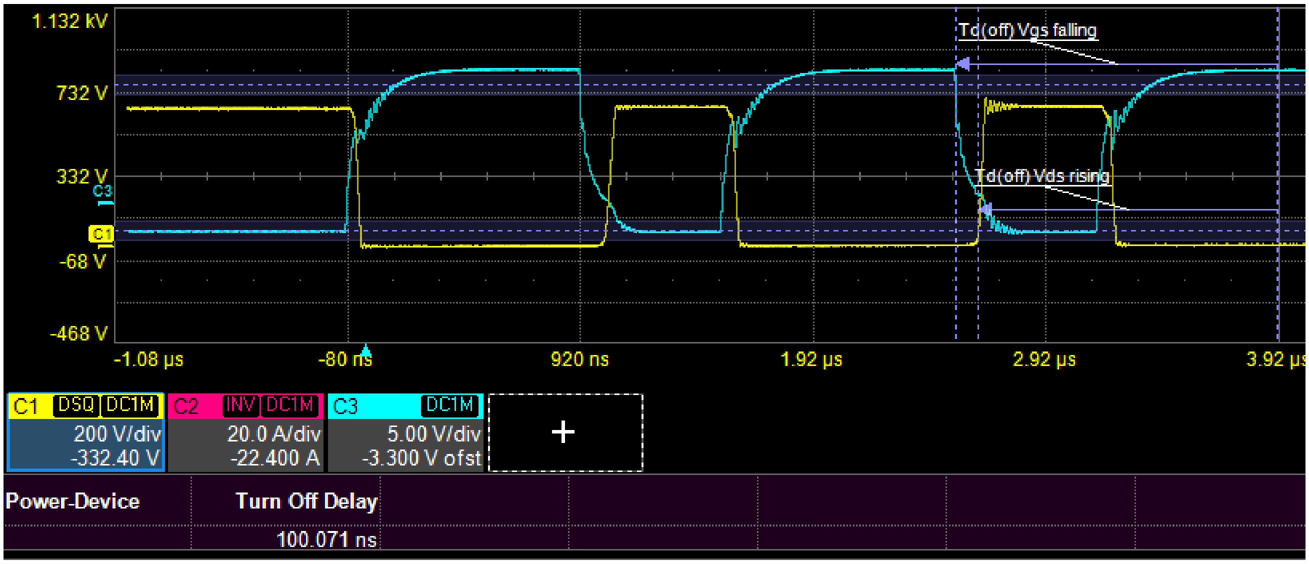


Or from the 10% rising edge of Vgs to the 10% rising edge of Id:

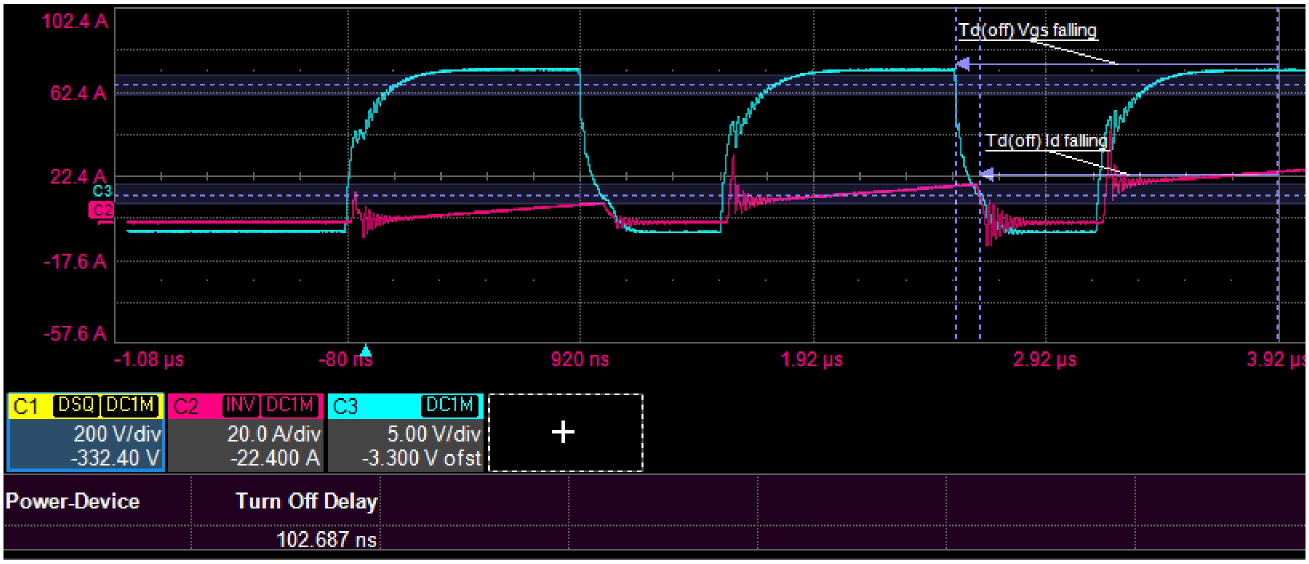


Turn Off Delay

In Auto configuration, this measurement shows the time from the 90% falling edge of Vgs to the 10% rising edge of Vds:

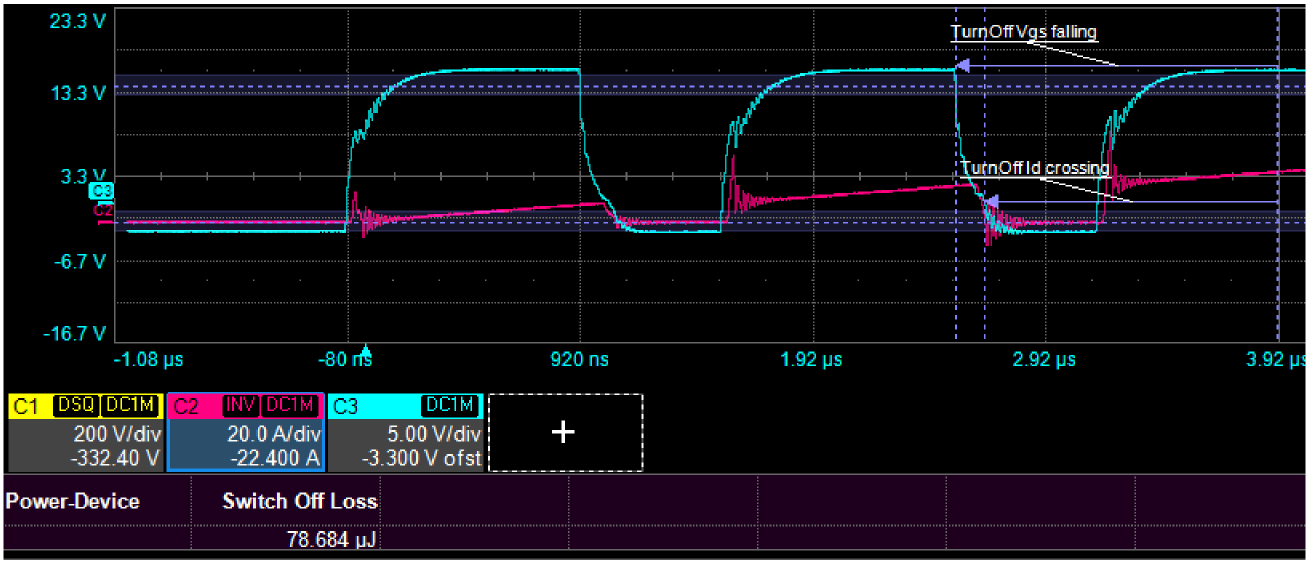


Or from the 90% falling edge of Vgs to the 90% falling edge of Id:

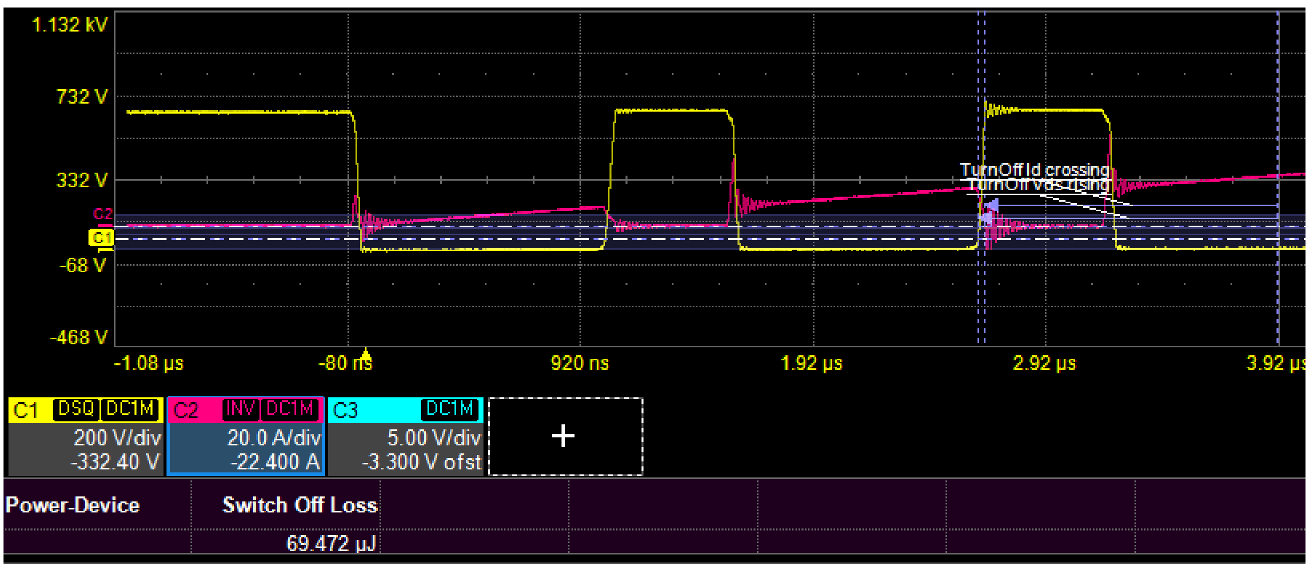


Switch Off Loss

Switch Off Loss is calculated according to JEDEC standard JESD24-1. In Auto configuration, this measurement shows the power lost (in Watts or Joules) from the 90% falling edge of Vgs to the 0-crossing of Id:



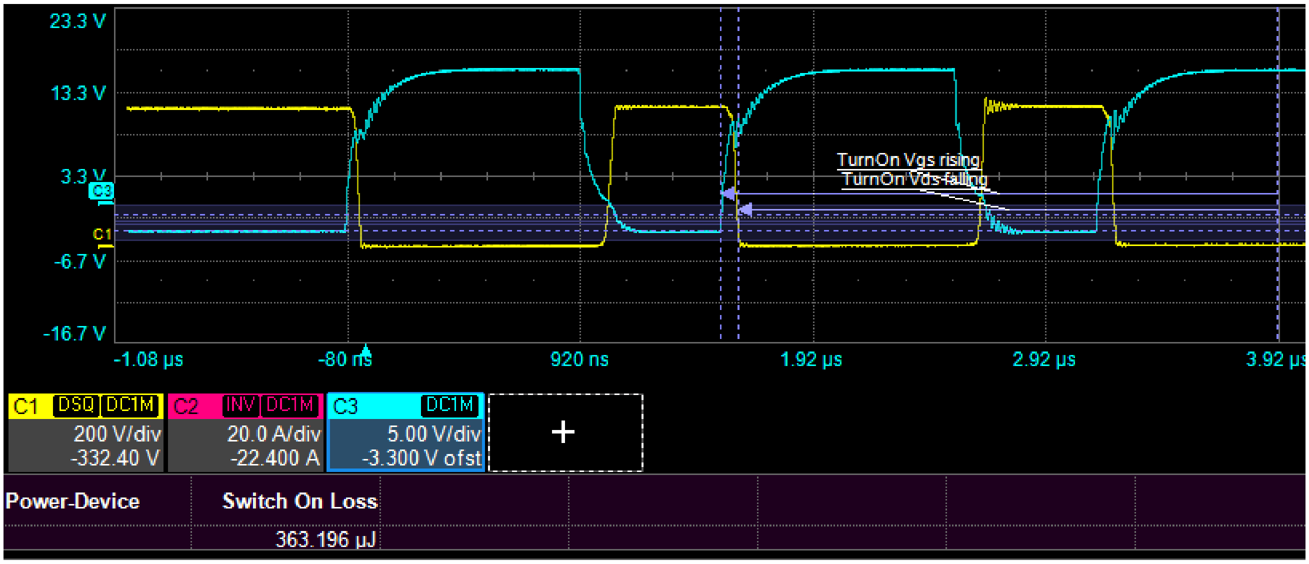
Or from the 1% rising edge of Vds to the 0-crossing of Id:



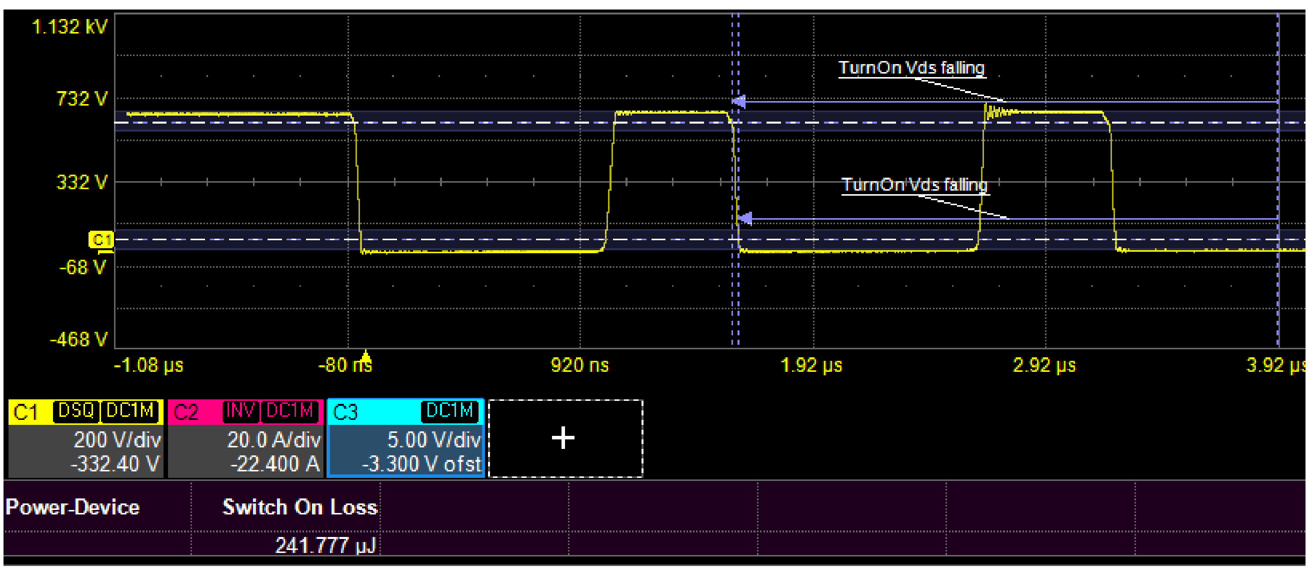
Note: The Switch Off Loss measurement may require manual adjustment to raise the threshold at which Vds is measured. If you do not see a measurement at the Auto level, switch to Manual and drag the Vds level marker up until you see a value in the table.

Switch On Loss

In Auto configuration, this measurement shows the power lost (in Watts or Joules) from the 10% rising edge of Vgs to the 10% falling edge of Vds:



Or from the 99% falling edge of Vds to the 10% falling edge of Vds:

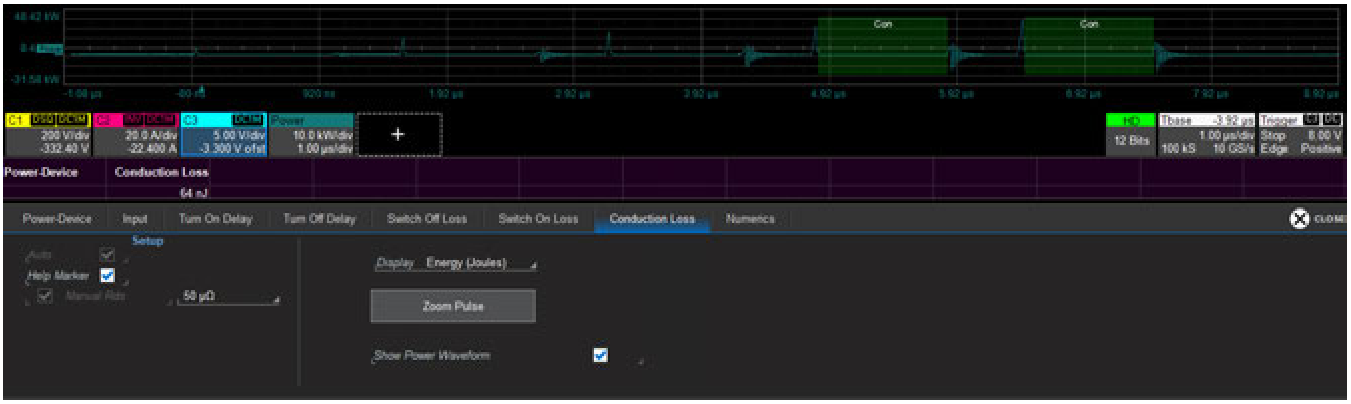


Note: As with the Switch Off Loss measurement, if the Vds signal is noisy, the Switch On Loss measurement may require manual adjustment to raise or lower the threshold at which Vds is measured.

Conduction Loss

Conduction Loss (in Watts or Joules) can be calculated from the Switching Loss measurement using the R value supplied by the chip manufacturer. Enter this value in the **Manual Rds** field.

Conduction Loss is marked on the Power Waveform, so select **Show Power Waveform** to see the loss zone.



Power Waveform

A Power Waveform calculated from I^2*R can be added to the display by checking **Show Power Waveform** on any measurement dialog. Be sure to enter the correct R value on the Conduction Loss dialog.

The Vertical Scale controls on the Numerics dialog can be used to control the Watts/div and Center of the Power Waveform display. First select the Power Waveform descriptor box to activate the trace.

Help Markers

Labels and overlays highlighting the measurement points can be displayed over the source waveforms by checking **Help Markers** on any measurement dialog. Help Markers are set per measurement—you can show as many or as few as you wish.

Zoom Pulse

The **Zoom Pulse** button will create 1/10 zooms of all the power input signals. Zooms display the same Help Markers that you have selected for the source signals.

All zooms created using the button are automatically placed in a multi-zoom group to be scaled synchronously. Just touch the Z*n* descriptor box of any of the waveforms to open the Zoom controls and adjust zoom Vertical or Horizontal scale.

Numerics Dialog and Table

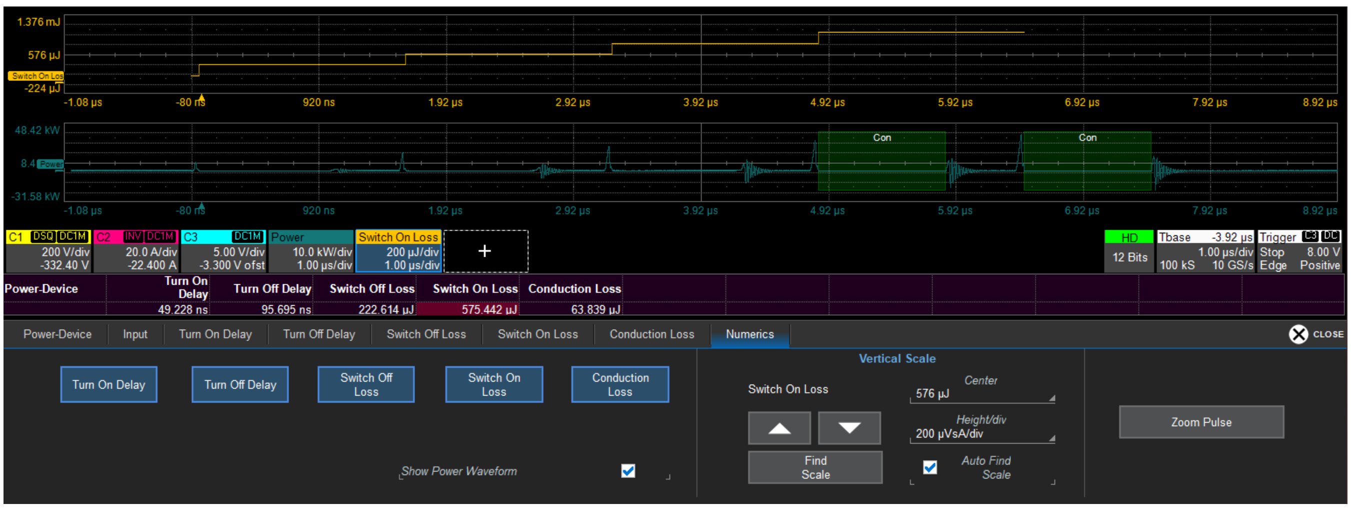
After configuring measurements, use the Numerics dialog to build the Power-Device result display.

Enabling Measurements

Select all the pulse measurements you wish to make concurrently. The calculated result is added to the Numerics table. To toggle off any measurement, touch its button again to deselect it.

Tracking Power Measurements

The interactive Numerics table both shows the measurement results and allows you to track measurement values over time. The Vertical axis of the track is shown in the unit selected for the measurement. Simply touch the table cell of a measurement to plot the value for each pulse measured. Those measurements that are plotted are shown in the table with a dark red background.



The power tracks are best used for measurements that are made on all pulses. Any spike in values will identify problematic pulses.

The Vertical Scale controls on the Numerics dialog can be used to adjust the units/div and center of the power tracks as well as the power waveform. First, select the waveform descriptor box to activate the trace, then use the controls to adjust scale.

Tip: The currently active power trace is shown in the Vertical Scale section of the dialog. Rescale input traces on the respective Channel dialogs.

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