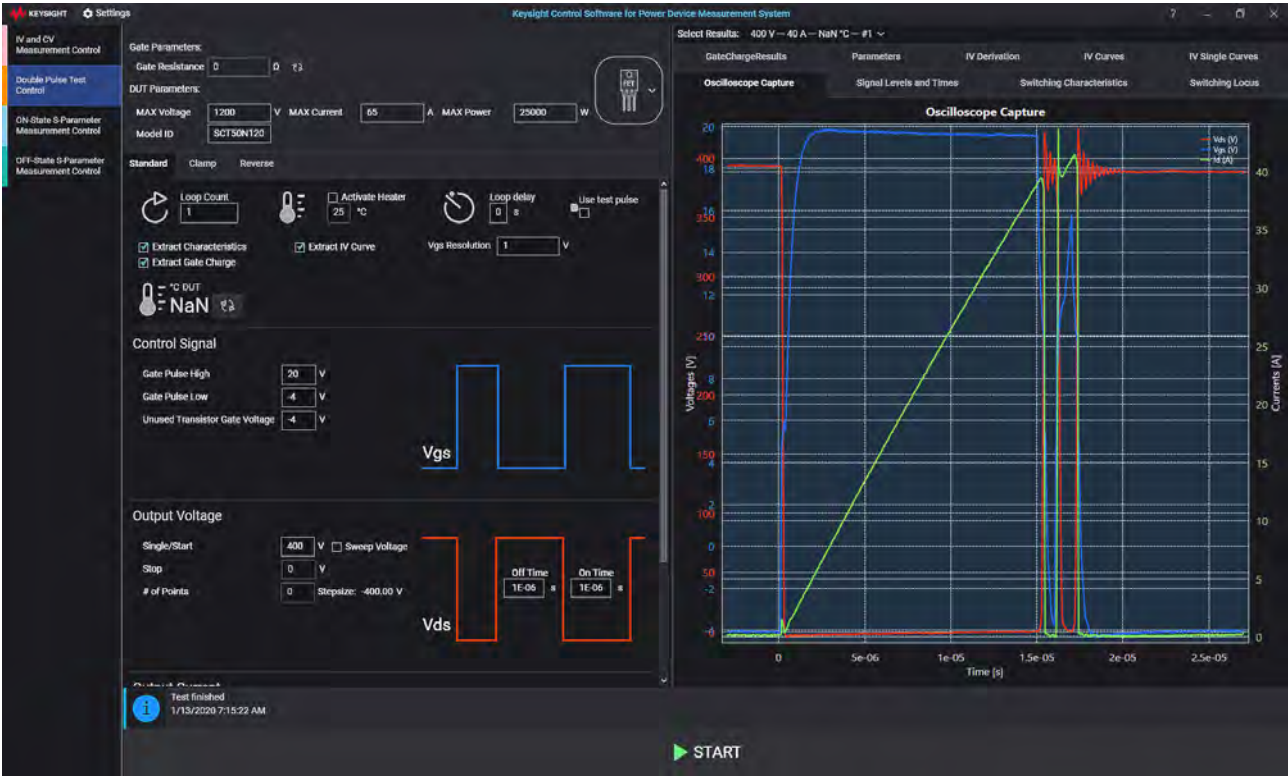


# Startup Guide

# Keysight PD1000A Power Device Measurement System for Advanced Modeling





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## Manual Part Number

PD1000-90001

## Edition

Fourth Edition, August 2020

## Published by

Keysight Technologies, Inc.  
900 S. Taft Ave.  
Loveland, CO 80537 USA

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# 1 Introduction

Keysight's PD1000A Power Device Measurement System for Advanced Modeling is a state-of-the-art characterization and modeling suite of power circuit simulator tools. This suite of tools allow Wide Band Gap (WBG) semiconductor device designers to easily create models never before possible. The test suite, which consists of IV/CV curve-tracing, S-Parameter, and Double Pulse Test (DPT) hardware, takes measurements from actual WBG devices and uses advanced modeling software to build sophisticated device models that are exclusive to Keysight. IV/CV and S-Parameter models can then be used in Keysight's Electronic Design Automation (EDS) software to simulate and analyze the effects that high frequency components have on the reliability and EMI of the design. Changes in design can be made before the first prototype, saving time and costs by eliminating unnecessary design cycles.

The following high power semiconductor device types are supported in the W8598BP/BT Power Electronics Model Generator modeling software:

- FET (such as Si or SiC MOSFET, GaN ASM-HEMT<sup>1</sup>, and GaN FET)
- IGBT (Insulated Gate Bipolar Transistor)

This User Guide provides hardware setup and configuration information for the PD1000A system. Refer to the PD1000A Control Software Help file for detailed information regarding using the software.

Follow these steps to install your PD1000A system:

- Step 1: Gather All PD1000A Required Equipment [page 16](#)
- Step 2: Install System Software on Host PC [page 19](#)
  - Download and Install IO Libraries Suite on your Host PC [page 19](#)
  - Download and Install PD1000A Control Software [page 22](#)
  - Download Setup and Configuration Files [page 22](#)
  - Install Control Software Licenses [page 24](#)
- Step 3. Prepare for Device Characterization Tests [page 27](#)
  - IV and CV Device Characterization [page 29](#)
  - On-State and Off-State S-Parameter Characterization [page 65](#)
  - Double Pulse Test Characterization [page 65](#)
- Step 4. Power Electronics Model Generator (PEMG) Software [page 107](#)  
(used with the IV/CV and S-Parameter tests)

## PD1000A Test System Overview

Figure 1 shows the hardware components of a complete PD1000A Power Device Measurement System for Advanced Modeling System. Depending on the device characterizations you run, you may or may not have all of the test instruments shown. Figure 1 is best printed on an 11x17" paper.

Figure 2 on page 12 shows the software components of a complete PD1000A System. The PEMG, ADS, EMPro, and Momentum software are not included and must be purchased separately. Figure 2 is best printed on an 11x17" paper.

The PD1000A System consists of three hardware subsystems, all controlled by the PD1000A Control Software:

- IV/CV Curve Tracer System (B1506A or B1505A Power Device Analyzer)
- Double Pulse Test System (Rack and Safety Enclosure with installed instruments). For WBG devices, DPT tests measure behavior at higher voltage and current operating points providing accurate modeling.
- S-Parameter Measurement System (E5080A/B ENA, B2902A SMU, and Bias-Ts, Test Fixtures, etc.). The S-Parameter measurement system measures the frequency response of the device under zero-bias and biased conditions.

The PD1000A Control Software automates almost all of the measurement process. For the IV/CV and S-parameter tests, it creates files that can be loaded into the Keysight Power Electronics Model Generator (PEMG) software. The PEMG software creates the model using the measurement data and the modeling formula chosen. The model can then be used in Keysight's Advanced Design System, EMPro, or Momentum for precise, real-world simulation. Note that DPT characterization data is not used in the PEMG software.

## System Documentation

This *PD1000A Power Device Measurement System for Advanced Modeling Startup Guide* provides system hardware installation and setup information. Refer to the individual instrument documentation for specific instrument calibration instructions as well as specific warranty and support information.

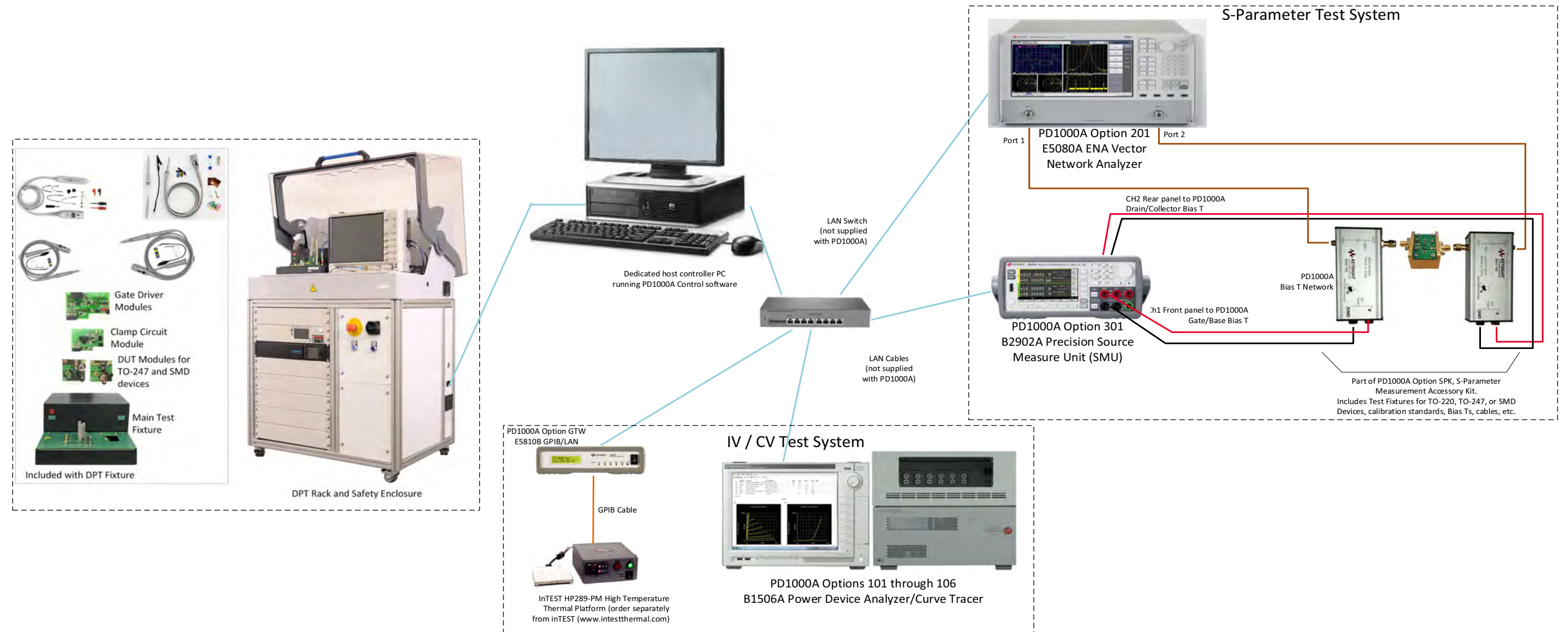
Refer to the *PD1000A Control Software Help* file for detailed information on using the PD1000A Control Software.

All PD1000A documentation is available at: [www.keysight.com/find/PD1000A](http://www.keysight.com/find/PD1000A).

## Support

Refer to the individual instrument documentation and help files provided with your system for warranty and support information. Hardware support (repairs and calibration) is provided for each of the individual instruments in the system.

# Keysight PD1000A Power Device Measurement System for Advanced Modeling



## PD1000A System Software Components

Required PD1000A system software includes the following:

- PD1000A Control Software. This software controls the test equipment to make the characterization measurements.
- PEMG Power Electronics Model Generator (Integrated Circuit Characterization and Analysis). This software provides semiconductor device characterization and modeling.
- Keysight Advanced Design System (ADS)

All system software is available on Keysight websites: [www.keysight.com/find/PD1000A](http://www.keysight.com/find/PD1000A) (for Control Software), [www.keysight.com/find/eda](http://www.keysight.com/find/eda) (for modeling and simulation)

**Figure 1** Complete PD1000A Power Device Measurement System for Advanced Modeling Hardware Overview

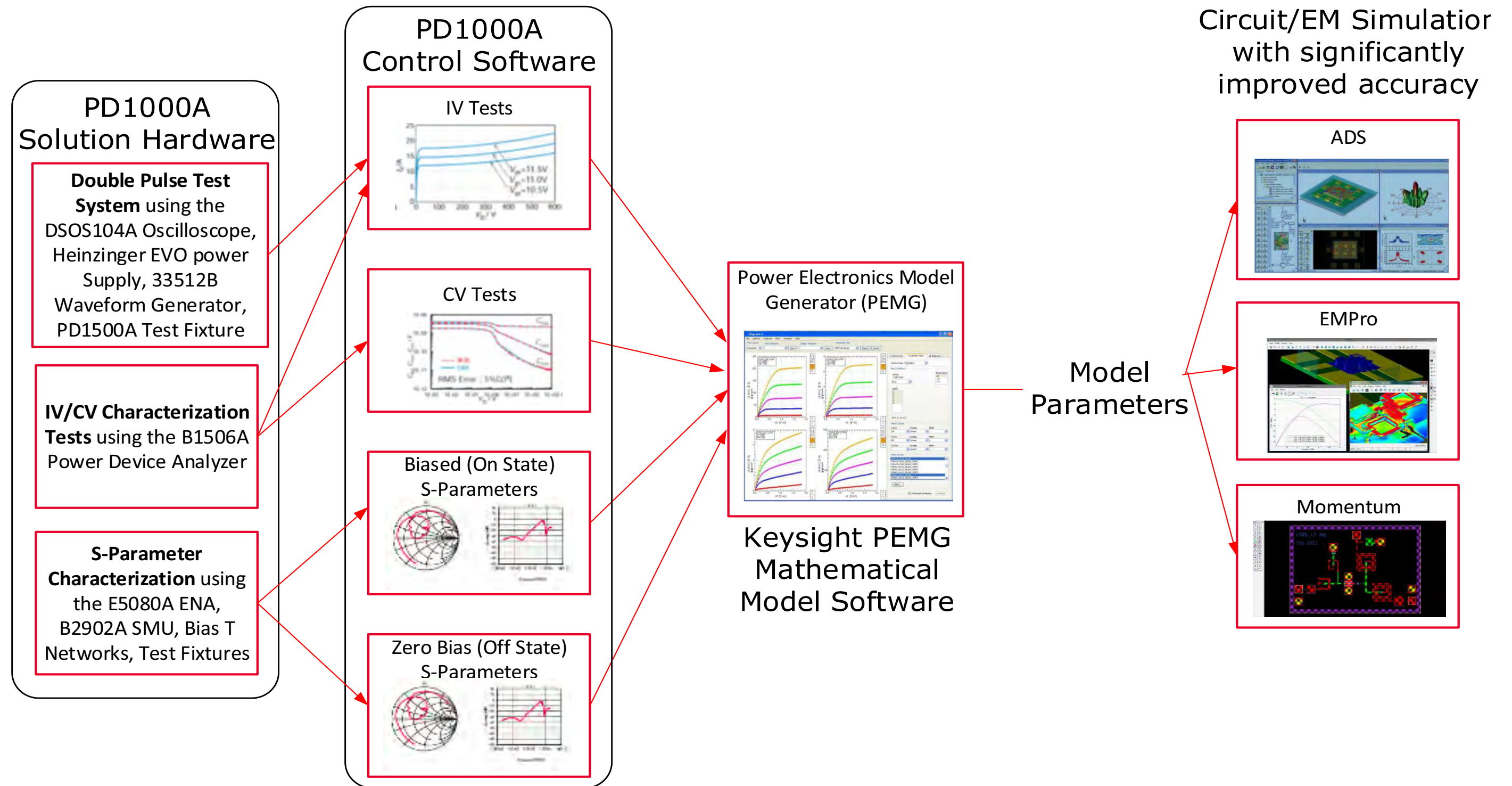


Figure 2 PD1000A Software Overview

## System Requirements

The host controller should be dedicated solely to running the PD1000A and device modeling software. It should have Internet access to download Keysight IO Libraries Suite and all software and license files. Keysight IO Libraries Suite is the largest software component in the software installation. Therefore, the host controller requirements in the following are based on optimizing the installation and performance of the IO Libraries Suite.

**Table 1 Host Controller Hardware and Software Requirements**

Operating System	Windows 10
OS versions:	32-bit and 64-bit.
Processor Speed:	1 GHz 32-bit (x86), 1 GHz 64-bit (x64), Itanium64 not supported
Computer memory:	1 GB minimum
Available hard disk space <sup>1</sup> :	1.5 GB available hard disk space, includes: 1 GB available for Microsoft .NET Framework 4.5.2 100 MB for Keysight IO Libraries Suite
Video:	Screen resolution -- Full HD (1920x1080) at 100%. Support for DirectX 9 graphics with 128 MB graphics memory recommended

1. Because of the installation procedure, less memory may be required for operation than is required for installation.

Click here for the [Keysight ADS system requirements](#). They are more stringent than the PD1000A Control Software requirements. Note that the ADS software is used only with IV/CV and S-Parameter characterization tests; not with DPT tests.

## Static-safe Handling Procedures

Electrostatic discharge (ESD) can damage or destroy electronic components. Use a static-safe work station to perform at work on electronic assemblies. This figure shows a static-safe work station using two types of ESD protection:

- Conductive table-mat and wrist-strap
- Conductive floor-mat and heel-strap



Both types, when used together, provide a significant level of ESD protection. Of the two, only the table-mat and wrist-strap combination provides adequate ESD protection when used alone. To ensure user safety, the static-safe accessories must provide at least 1 M $\Omega$  of isolation from ground.

## AC Power and Environmental Requirements

Refer to the individual instrument data sheets and user manuals for detailed AC power and environmental requirements.

### WARNING

**When installing the instruments, ensure there is sufficient free space around the units to permit quick removing of the AC power cord in case of emergency.**

For the Double Pulse Test Rack and Safety Enclosure AC requirements:

Input Voltage	Operating Temperature	Operating Humidity	Operating Environment
200-240 VAC, $\pm 10\%$ , 50/60 Hz, <b>???? W</b>	20 °C to +30 °C	50% to 80% RH, Non-condensing	Indoor location only

### CAUTION

The Double-Pulse Test Rack and Safety Enclosure is designed to operate on 200 to 240 VAC, split phase in United States, single phase elsewhere. Do not attempt to operate the DPT Rack and Safety Enclosure on 120VAC.

## Steps to Running Device Characterization Tests

- Step 1: Gather All PD1000A Required Equipment [page 16](#)
  - PD1000A System Hardware Components [page 16](#)
  - PD1000A System Software Components [page 18](#)
- Step 2: Install System Software on Host PC [page 19](#)
  - Download and Install IO Libraries Suite on your Host PC [page 19](#)
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- Step 3: Prepare for Device Characterization Tests [page 27](#)
  - Running the PD1000A System Software [page 28](#)
  - IV and CV Device Characterization [page 29](#)
  - Double Pulse Test Characterization [page 65](#)

## Steps to Running Device Characterization Tests

- On-State and Off-State S-Parameter Characterization [page 65](#)
- Step 4. Power Electronics Model Generator (PEMG) Software [page 107](#)

## Step1: Gather All PD1000A Required Equipment

Your PD1000A shipment arrives in separate boxes. Carefully inspect each shipment for any shipping damage. Report any damage to the shipping agent immediately, as such damage is not covered by warranty.

Refer to [Figure 1](#), “Complete PD1000A Power Device Measurement System for Advanced Modeling Hardware Overview,” on page 11 for overall system configuration.

### PD1000A System Hardware Components

Verify that your PD1000A system includes the following hardware items:

#### IV/CV Curve Tracer Tests

Keysight B1506A<sup>1</sup> Power Device Analyzer/Curve Tracer with one of the following options:

B1506A Option 101 or 102, includes opt. H21 20A/3 kV/C-V/Gate Charge/Thermal Chamber

B1506A Option. 103 or 104, includes opt. H51 500A/3 kV/C-V/Gate Charge/Thermal Chamber

B1506A Option 105 or 106, includes opt. H71 1500A/3 kV/C-V/Gate Charge/Thermal Chamber

Keysight B1505A (Alternative to B1506A) Power Device Analyzer/Curve Tracer with one of the following options:

B1505AP-H21 3 kV / 20 A / C-V / Fixture Pack

B1505AP-H51 3 kV / 500 A / C-V / Fixture Pack

B1505AP-H71 3 kV / 1500 A / C-V / Fixture Pack

Optional InTEST Thermal Platform model HP289-PM. Available separately, contact: [www.inTESTthermal.com](http://www.inTESTthermal.com).

Requires qty. 1, PD1000A Option GTW: Keysight E5810B LAN/GPIB/USB Gateway

Requires qty. 1 GPIB Cable. When ordering the PD1000A, select optional GPIB cable (0.5 m to 8.0 m).

#### S-Parameter Tests

Keysight E5080A or E5080B ENA Vector Network Analyzer

Keysight B2902A Precision Source/Measure Unit

Keysight PD1000A-SPK Accessory Kit. Includes:

Quantity 2, Keysight PD1000A High Current Bias T Networks

Three device test fixtures: Test Fixture for TO-220 devices, Fixture for TO-247 devices, Fixture for Surface Mount Devices)

Quantity 2, Type ‘N’ Male to SMA Female Adapter

Quantity 2, 7 inch SMA connector cables

Quantity 8, Banana plug to Banana plug cables (4 red, 4 black)

#### Double Pulse Tests

-- DPT Test Rack and Safety Enclosure with the following instruments<sup>2</sup>:

DSOS104A Oscilloscope

N2873A 10:1 Oscilloscope Probe

33512B Waveform Generator

10076C 100:1 High Voltage Oscilloscope

Probe

B2902A Precision Source/Measure Unit

N2819A Differential Oscilloscope Probe, 10:1

Heinzinger EVO High Voltage Power Supply

PD1000-60002 Oscilloscope Protection Probe

DPT Test Fixture and test modules

Misc. other cables

<sup>1</sup> Requires EasyEXPERT version 6.1.1738.9870 or later.



2 See PD1500A Double-Pulse Tests Installation Guide for detailed list of instruments

## PD1000A Test Instrument Documentation

Each instrument comes complete with its own documentation, an appropriate power cord for your location, and other cables or accessories. Refer to the individual Keysight instrument documentation and help files for operation and use instructions as well as specific warranty and support information.

This *PD1000A Getting Started Guide* is the only system documentation. All PD1000A documentation and individual instrument documentation are available on-line: [www.keysight.com/find/PD1000A](http://www.keysight.com/find/PD1000A).

IV/CV Device Characterization Tests	
B1506A Power Device Analyzer/Curve Tracer	<a href="http://www.keysight.com/find/B1506A">www.keysight.com/find/B1506A</a>
B1505A Power Device Analyzer/Curve Tracer (Alternative to B1506A)	<a href="http://www.keysight.com/find/B1505A">www.keysight.com/find/B1505A</a>
E5810B LAN/GPIB Gateway	<a href="http://www.keysight.com/find/E5810B">www.keysight.com/find/E5810B</a>
S-Parameter Tests	
B2902A Precision Source/Measure Unit	<a href="http://www.keysight.com/find/B2902A">www.keysight.com/find/B2902A</a>
E5080B ENA Vector Network Analyzer	<a href="http://www.keysight.com/find/E5080B">www.keysight.com/find/E5080B</a>
Dual Pulse Tests Device Characterization	
DSOS104A 4-Channel Oscilloscope	<a href="http://www.keysight.com/find/DSOS104A">www.keysight.com/find/DSOS104A</a>
33512B Waveform Generator	<a href="http://www.keysight.com/find/33512B">www.keysight.com/find/33512B</a>
B2902A Precision Source/Measure Unit	<a href="http://www.keysight.com/find/B2902A">www.keysight.com/find/B2902A</a>
Heinzinger EVO High Voltage Power Supply	<a href="https://www.heinzinger.com/products">https://www.heinzinger.com/products</a>

## What is not Supplied

- An HP289-PM Thermal Platform (Hot Plate) including Controller is required for thermal device testing. (The B1505A requires the Keysight N1265A text fixture to work with the InTEST platform.) The HP289-PM is sold separately by InTEST Corp. Contact: [www.inTESTthermal.com](http://www.inTESTthermal.com)
- Dedicated host computer and LAN Cable. See **System Requirements** on [page 13](#)
- 5-port (minimum) LAN Switch (required for PD1000A IV/CV and S-Parameter Tests)
- Quantity 5, standard CAT5e LAN cables for IV/CV and S-Parameter Tests, Quantity 1 for Double-Pulse Tests system

## PD1000A System Software Components

### NOTE

Keysight IO Libraries is required for the PD1000A system hardware. It is free software and available at: [www.keysight.com/find/iosuite](http://www.keysight.com/find/iosuite)

---

PD1000A Control System software includes the following:

- **PD1000A Control Software for Power Device Measurement System.** This is the software that controls the test equipment to make the IV/CV, S-Parameter, and Double-Pulse Tests device characterization measurements. See: [www.keysight.com/find/PD1000A](http://www.keysight.com/find/PD1000A)

The following modeling software are used with the :

- **PEMG Power Electronics Model Generator.** This software provides semiconductor device characterization and modeling. See: [www.keysight.com/find/PEMG](http://www.keysight.com/find/PEMG)
- **PD1000A-ADS Keysight Advanced Design System (ADS).** See [www.keysight.com/find/ADS](http://www.keysight.com/find/ADS)

## Step 2: Install System Software on Host PC

To communicate with the PD1000A test equipment, Keysight I/O Libraries Suite must also be installed on your host computer. IO Libraries Suite is a collection of libraries and utilities that enable you to connect your instruments to the host computer and run programs on the computer that interact with the instruments. The IO Libraries Suite is used with all Keysight instruments

### Download and Install IO Libraries Suite on your Host PC

Download the latest version from: [www.keysight.com/find/iosuite](http://www.keysight.com/find/iosuite). Always install IO Libraries Suite before installing any instrument driver or software. Use the latest version of the IO Libraries Suite.

#### NOTE

Run the *Connection Expert* utility of IO Libraries Suite and ensure the host PC can communicate with each test instrument. *Connection Expert* lists the VISA address of each instrument which is needed when configuring the hardware for the tests.

#### NOTE

IO Libraries Suite Connection Expert may not find the B1506A or B1505A PDA until EasyEXPERT is running. Run EasyEXPERT before using Connection Expert.

## Obtain the Instrument VISA Addresses

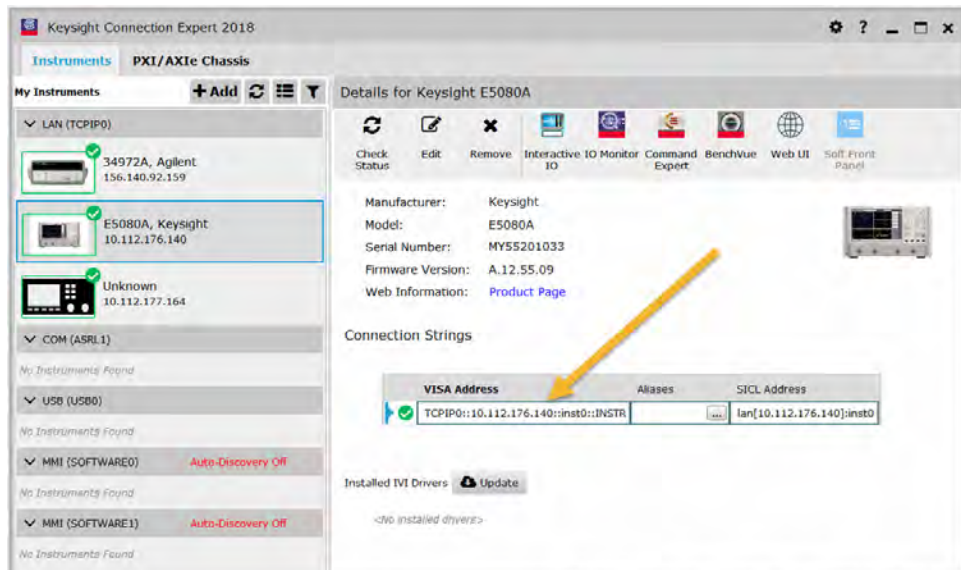
Use the Connection Expert utility in IO Libraries Suite to obtain the VISA address of each IV/CV and S-Parameter test instrument in the PD1000A system. If one or more instruments do not automatically appear in the *My Instruments* list in Connection Expert, select the LAN (TCPIP0) group in *My Instruments* and then click the **+Add** button. If the instruments were found on the local subnet, they should be listed. If they are not listed, you must manually add each instrument's IP address.

#### NOTE

The Double-Pulse Test system uses a different addressing scheme. Refer to the PD1500A Installation Guide for addressing information.

Depending on the device characterization test you want to run, you may not have or need all of the following PD1000A test equipment.

The following graphic shows the location of the VISA Address for the E5080 ENA in the IO Libraries Suite Connection Expert instrument screen.



**Figure 3** Keysight IO Libraries Connection Expert Showing VISA Address

**NOTE**

**Important:** If you are not going to run the complete suite of IV/CV, S-Parameter, or Double Pulse Test device characterizations, you may not need or have all of the following equipment. For the test instruments that you do have, locate and record the VISA addresses in [Table 2](#) below.

Record the VISA address of each instrument in the following table.

**Table 2** Record VISA Addresses of the PD1000A Test Instruments (IV/CV & S-Parameter Tests)

IV/CV Device Characterization Instruments	Record the VISA Address (from IO Libraries)
B1506A Power Device Analyzer/Curve Tracer (EasyExpert must be running to obtain the VISA address)	
B1505A Power Device Analyzer/Curve Tracer (Alternative to B1506A)	
E5810B LAN/GPIB Gateway (for inTest thermal platform)	
S-Parameter Test Instruments	
B2902A Precision Source/Measure Unit	
E5080A/B ENA Vector Network Analyzer	

**NOTE**

The VISA address for the EasyEXPERT on the B1506A must be a **::5025::SOCKET** connection. For example: **TCPIP0::10.114.11.226::5025::SOCKET**. Other IV/CV test instruments use a HiSLIP connection.

**Table 3** VISA Addresses for Double-Pulse Tests

DPT Test Instruments	VISA Addresses
DSOS104A 4-Channel Oscilloscope	Refer to the <i>PD1500A System Installation Guide</i> for VISA addressing information
33512B Waveform Generator	
B2902A Precision Source/Measure Unit	
Heinzinger High Voltage Power Supply	
DPT Test Fixture	

## If IO Libraries Does Not Find an Instrument

If IO Libraries does not find one or more test instruments or the test fixture, you may need to locate it using the instrument's IP address. In IO Libraries, use **+ADD** to add a LAN Instrument using the instrument's IP address.

### Locate IP Address of the B1506A Power Device Analyzer

- 1 On the analyzer, press **Network > Open Network & Sharing Center > Local Area Network > Network Connection Details**.
- 2 The IP Address appears in the display.

### Locate the VISA address of the InTEST Hot Plate Controller

Since the InTEST Hot Plate controller is a GPIB instrument and not a standard LAN-connected instrument, the VISA address has the form: **GPIB4::4::INSTR**. Use the process described in, [Appendix B](#), "Configure the InTEST Thermal Platform Controller" on [page 125](#).

### Locate IP Address of the E5080A/B ENA Network Analyzer

- 1 On the E5080A or B, press the **System** button on the E5080 front panel.
- 2 Touch **System Setup > LAN Status** on the display.
- 3 The IP Address appears in the LAN Status display.

### Locate IP Address of the B2902A Precision Source/Measurement Unit

- 1 On the B2902A, touch the **More** button on the lower right of the screen.
- 2 Touch: **I/O > LAN > Status** softkeys.
- 3 The IP Address appears at the bottom of the LAN Status Display.

## Download and Install PD1000A Control Software

The PD1000A software may be downloaded from Keysight at any time. A free trial version of the software is available. Download the software from the following website: [www.keysight.com/find/PD1000A](http://www.keysight.com/find/PD1000A)

### NOTE

This trial version may be used for 30 days with no obligation. After 30 days, you must purchase software licenses to continue running S-Parameter tests or Double-Pulse Tests. Each host controller PC requires a separate license. For purchasing information, go to the PD1000A website: [www.keysight.com/find/PD1000A](http://www.keysight.com/find/PD1000A)

- 1 Click **Visit Technical Support** .
- 2 Click the **Drivers, Firmware & Software** tab.
- 3 Click the **Control Software for PD1000A Power Device Measurement System** link.
- 4 Read the instructions and click the red **Download** button. Follow all on-screen instructions.

## Download Setup and Configuration Files

In addition to the PD1000A Control Software, for the IV/CV and S-Parameter tests, you need to download and install several additional configuration files. These files are in the *PD1000A\_Setup\_Files.zip* file. Access the .zip file from [www.keysight.com/find/PD1000A](http://www.keysight.com/find/PD1000A) software download page. Look for **Prerequisites** on the right side.

Keysight recommends that you save these downloaded files to a memory stick for later use during system installation.

### Download the required IV/CV B150xA Configuration Files:

- **PD1000A ConfigurationTool.exe** – Sets up environment variables on for the B1506A (for IV and CV measurements).
- **UHC Selector Input Selection.xtd** – for IV and CV tests
- **Temperature Sensor 1.xtd** – for use with the inTest thermal platform.
- **Temperature Sensor 2.xtd** – for use with the inTest thermal platform.
- **Gate Diode PD1000A.xtd** – for IV/CV gate diode tests
- **Ic-Vge PD1000A.xtd** – for IV/CV Ic-Vge tests
- **Id-Vgs PD1000A.xtd** – for IV/CV Id-Vgs tests
- **Rg, Cgg for IGBT PD1000A.XTD** – for IV/CV Rg, Cgg tests
- **Rg, Cgg for PowerMOSFET PD1000A.XTD** – for IV/CV Rg, Cgg Power MOSFET
- **PD1000ACom.exe** – This file must be installed on the B1505A or B1506A hard drive in the root directory, C:.

### Download for the S-Parameter Calibration Kit Files:

- **TO\_Fixture\_In.xkt** – E5080A/B Calibration Kit file for S-Parameter measurements. For instructions, see *PD1000A Power Device Test Fixtures for S-Parameter Measurements - Operating Guide*, available at: <https://literature.cdn.keysight.com/litweb/pdf/PD1000-90005.pdf?id=2959097>
- **TO\_Fixture\_Out.xkt** – E5080A/B Calibration Kit file for S-Parameter measurements. For instructions, see *PD1000A Power Device Test Fixtures for S-Parameter Measurements - Operating Guide*, available at: <https://literature.cdn.keysight.com/litweb/pdf/PD1000-90005.pdf?id=2959097>

Additional instructions for using these files are presented at different parts of this guide.

#### NOTE

The additional configuration files listed above are required only for the IV/CV and S-Parameter tests. The Double-Pulse Tests require a Coaxial Shunt Transfer File. Refer to the *PD1500A Installation Guide* for detailed instructions to obtain and install this transfer file.

---

## Install Control Software Licenses

### NOTE

Ignore this section if you are not going to make On State/Off State S-Parameter or Double Pulse Test measurements. If you intend to run only IV/CV characterization tests proceed directly to “**Step 3. Prepare for Device Characterization Tests**” on page 27

All aspects of the PD1000A Control Software can be installed and used for 30 days without a license. However, after 30 days a permanent software license is required to continue running On State/Off State S-Parameter tests and DPT tests. For software and licensing information, go to:  
[www.keysight.com/find/PD1000A](http://www.keysight.com/find/PD1000A).

Other than the initial trial software license, there is one available license for the PD1000A Control Software for S-Parameter tests:


- **PD1010A** -- A perpetual fixed license for S-parameter test software. This license enables the software only on the host controller PC the license is originally assigned to; without a time limit.
- **PD1020A** -- A perpetual fixed license for DPT test software. This license enables the software only on the host controller PC the license is originally assigned to; without a time limit.

### NOTE

You must install the Keysight License Manager software on your host controller PC (if it was not previously installed by other Keysight software). [www.keysight.com/find/licensemanager](http://www.keysight.com/find/licensemanager).

- 1 Once you purchase the PD1010A S-Parameter Test software license or PD1020A DPT software license, you can choose to receive a printed copy of an Entitlement Certificate, an email with the certificate, or both.
- 2 On the host controller PC where you have installed and plan to run the PD1000A software (you must be logged on with Administrator privileges), log onto Keysight’s Licensing website at:  
[www.keysight.com/find/softwaremanager](http://www.keysight.com/find/softwaremanager). Note, you must register if you don’t have an account.
- 3 Follow the instructions in the Entitlement Certificate to redeem the license. You must enter the Entitlement Certificate number and the host ID of the PC (see “Your PC Host ID” on page 26 of this guide for host ID information).
- 4 Once you have entered the information, a license file is emailed (as an attachment) to the PC. The license file has a *.lic* file extension; for example: 10000996212\_829728.lic.



- 5 From this email, save the attached license file to a temporary location on the **C:** drive of the computer where you have installed the PD1000A Control Software.
- 6 Start the Keysight License Manager on your computer. Click Windows **Start > All Programs > Keysight License Manager > Keysight License Manager**.
- 7 Use **File > Install** to browse and open the license file that was attached to the email and then minimize Keysight License Manager. **Note:** on newer versions of Keysight License Manager, select the wrench icon () , then **Install License File...**
- 8 An **Install License File(s)** window appears. In this window, browse to the location of the license file. Select the license file, and click the **Open** button.

The license automatically installs and now appears in the Tree View of the Keysight License Manager as an installed license under the host system. The PD1000A software is now licensed and ready for use for continued S-Parameter measurements.

### Transporting a license to another host PC

To easily transport a license, Keysight recommends that you configure your system so that the host system running Keysight License Manager (KLM) connects both to the Internet and to the LAN connecting the source and target systems.


- The system running KLM can be either the source system, the target system, or a separate Windows-based computer.
- When the source system and the target system both have LAN connectivity, you can use a simple drag-and-drop action to transport a license using KLM.

#### NOTE

To transport a license, KLM must connect to the services available on the Keysight Software Manager Transport License Web site. This connection takes up to 90 seconds to complete a license transport operation.

KLM automatically removes a transported license from the source system. The license is then re-issued by the Keysight Software Manager Transport License Web Service, and then installed onto a target system

For additional information and procedures to transport a license, refer to the **Keysight License Manager Help**. Open the **About Keysight License Service** dialog box:

- 1 Double-click the **Keysight License Manager** icon  in the Windows toolbar. (If the icon is hidden, click the “Show hidden icons” button on the right side of the toolbar.)
- 2 Click **Help > Keysight License Manager Help**.

## Your PC Host ID

Host ID is a permanent, unique identifier to a computer or a Keysight instrument or application that locks licenses to that particular computer, instrument or application.


### NOTE

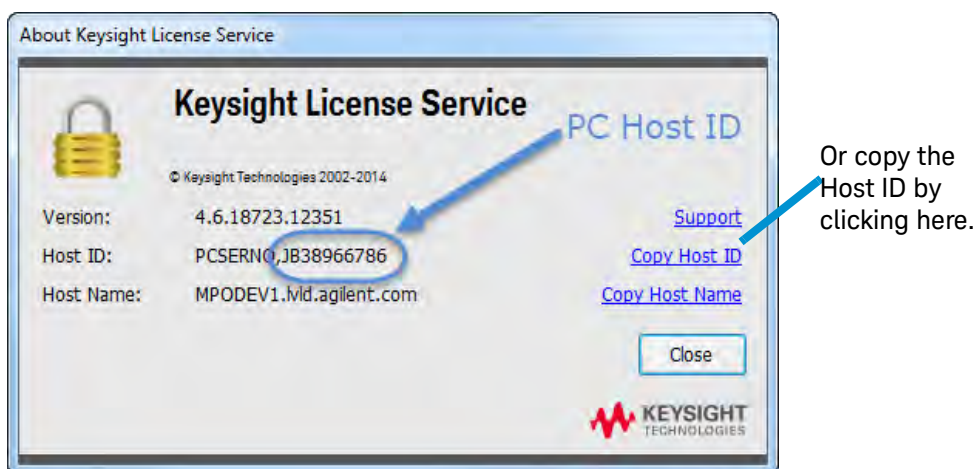
It is important that you enter the correct host ID information. Your license cannot enable the software if the host information does not exactly match your instrument or application.

### Where can I find the Host ID?

You must install the Keysight License Manager software on your host controller PC (if it was not previously installed by other Keysight software).

To obtain a Host ID from the Keysight License Manager (KLM) application, follow these steps:

- 1 Open the **About Keysight License Service** dialog box:
  - a Right-click the Keysight License Manager icon  in the Windows toolbar. (If the icon is hidden, click the “Show hidden icons” button on the right side of the toolbar.)
  - b Select the **About Keysight License Service**.
- 2 Click the **Copy Host ID** link to copy the host ID to the Windows clipboard.



**Figure 4** Keysight License Service Dialog Box

- 3 You can request a license file from: [www.keysight.com/find/softwaremanager](http://www.keysight.com/find/softwaremanager). A Keysight order number, Entitlement Certificate numbers and Host ID, from the preceding step above, are required.

## Step 3. Prepare for Device Characterization Tests

### CAUTION

Follow these procedures to ensure safety and to minimize the possibility of damaging electrical components:

- These instruments are designed for use in Installation Category II and Pollution Degree 2, per IEC 61010 Second Edition and 664 respectively.
  - These instruments are designed for indoor use only.
  - Mains wiring and connectors shall be compatible with the connector used in the premise electrical system. Failure to ensure adequate earth grounding by not using correct components may cause product damage and serious injury.
  - Use only the power cord supplied with the instruments. Keysight power cords ensure continuity between the chassis grounding-type power plug and the safety ground terminal at the power outlet.
  - Install the instruments so that the detachable power cord is readily identifiable and is easily reached by the operator. The detachable power cord is the disconnecting device. It disconnects the mains circuits from the mains supply to the instrument. The front panel switch is only a standby switch and is not a LINE switch. Alternatively, an externally installed switch or circuit breaker (which is readily identifiable and is easily reached by the operator) may be used as a disconnecting device.
-

## Running the PD1000A System Software

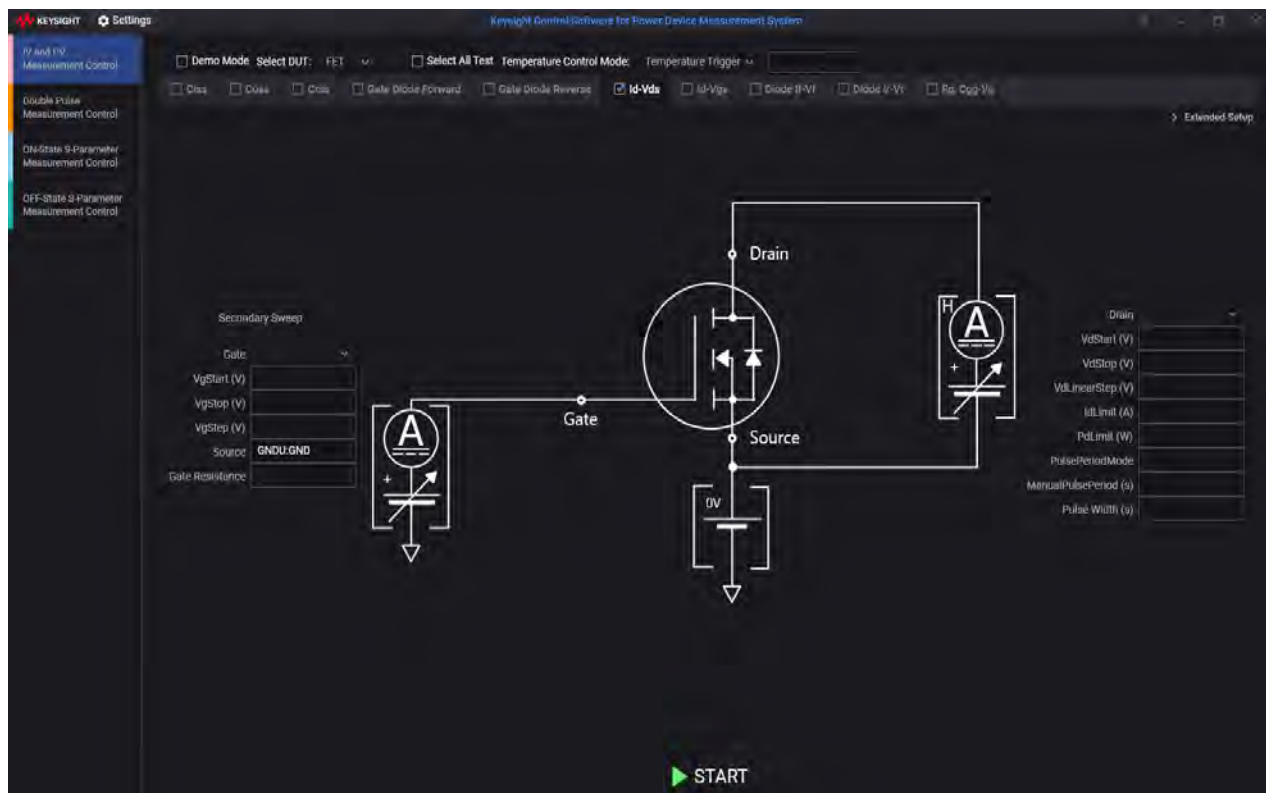
From the Windows **Start** button, select **PD1000A Control**.

As described previously, the PD1000A Control Software provides two basic groups of device characterization tests. For detailed test information, see the following:

**IV and CV Device Characterization** [page 29](#)

**Double Pulse Test Characterization** [page 65](#)

**On-State and Off-State S-Parameter Characterization** [page 65](#)



**Figure 5** PD1000A Test Application Software Startup Screen

### NOTE

Characterization data is saved in **\*.mdm** files. You specify the location for the data files in the **Configure Common Settings** dialog of the respective tests.

## 2 IV and CV Device Characterization

The Keysight B1506A or B1505A Power Device Analyzer for Circuit Design is the heart of the IV and CV device characterization tests. It can evaluate all relevant device parameters under a wide range of operating conditions, including IV parameters such as breakdown voltage and on-resistance, as well as three terminal FET capacitances, gate charge and power loss.

Keysight's Power Device Analyzers (PDAs) have a wide range of capabilities that help can help you identify substandard semiconductor devices and components under actual circuit operating conditions, including a wide voltage and current range (up to 3 kV and 1500 A), a wide temperature measurement range (-50 to +250 °C), fast pulsing capability, and sub-nA level current measurement capability. Integrated switching circuitry within the test fixture supports fully automated testing, with the ability to automatically change between both high voltage and high current testing as well as between IV and CV measurements. In addition, a unique plug-in style device test fixture socket adapter eliminates cable connection and other human-related errors. The B1506A and B1505A also support the automation of thermal characterization with the InTEST Thermal Platform model HP289-PM (available separately, contact: [www.inTESTthermal.com](http://www.inTESTthermal.com); not orderable from Keysight). (Note that the B1505A requires the Keysight N1265A text fixture to work with the InTEST platform.)

Since the DUT is in close proximity to the PDA's measurement resources, large parasitics caused by cable extensions leading to a temperature chamber do not exist. For this reason, oscillation free ultra-high currents of up to 1500 A can be accurately evaluated at both low and high temperature.

### In this Chapter

- B150xA Specification Conditions [page 31](#)
- IV and CV Test Requirements [page 32](#)
  - IV and CV General Test Setup [page 33](#)
  - Setup and Configure the Keysight B1506A and EasyEXPERT [page 37](#)
  - Enable Temperature Regulation Loop [page 48](#)
- Running the IV and CV Tests [page 49](#)
  - Configure Common Settings [page 51](#)
  - Configure System Hardware [page 52](#)
  - B150xA Settings: [page 53](#)

## The PD1000A System Test Instruments

- **IV and CV Device Characterization Tests:** The Current/Voltage (IV) and Capacitance/Voltage (CV) tests require the B1506A or B1505A power device analyzer with its test chamber. These tests may also use the optional *InTEST HP289-PM* Thermal Platform for characterization tests performed over a wide temperature range. See [Chapter 2](#), “IV and CV Device Characterization”.

The following table lists the test equipment used for the tests.

Tests	Equipment Used for Test	Requires
Device IV and CV characterization measurements over temperature	B1505A or B1506A Power Device Analyzer/Curve Tracer <b>Note:</b> Must have EasyEXPERT version 6.1.1738.9870 or later.	Refer to the analyzer documentation to install and connect the analyzer to its test chamber.  For high temperature characterization, the analyzer requires the InTEST HP289-PM Thermal Platform (Hot Plate). The B1505A requires the Keysight N1265A test fixture to work with the InTEST platform.
	InTEST HP289-PM High Temperature Thermal Platform	The InTEST HP289-PM is a temperature controlled platform designed for use with the Keysight B1506A analyzer (or B1505A analyzer with the Keysight N1265A test fixture). The platform permits automated control of plate temperature, from room temperature of enclosure to 250 °C.
	E5810B LAN/GPIB/USB Gateway	Connects the Gateway to the InTEST Thermal Platform Controller.

For detailed information about any of the instruments listed above, refer to the documentation provided with each instrument. Install and setup each instrument per instructions in its Operating or User Guide.

## B150xA Specification Conditions

The measurement and output accuracy are specified under the conditions listed below. Note: The SMU measurement and output accuracy are specified at the output terminals in the test fixture except for capacitance measurement that is specified at the output terminals of the MFCMU.

- Temperature: 23 ±5 °C.
- Humidity: 20 to 70%, No condensation.
- Self-calibration after a 40 minute warm-up is required.
- Room temperature change less than ±1 °C after self-calibration execution. (Note: This does not apply to the MFCMU).
- Measurement made within one hour after self-calibration execution. (Note: This does not apply to the MFCMU).
- Calibration period: 1 year.
- SMU integration time setting: 10 PLC (1 nA to 1 A range, voltage range), 200 μs (20 A range) Averaging of high-speed ADC: 128 samples per 1 PLC.
- SMU filter: ON for MPSMU.
- The accuracy of the drain output current measurement specification is not guaranteed until 20 seconds after a voltage change.

## B150xA Operating Conditions

The B1506A or B1505A Power Device Analyzer must to be used under the conditions listed below.

- Temperature: +5 to +40 °C
- Humidity: 20 to 70%, No condensation
- When used with InTEST Thermal plate:
  - Temperature: +5 to +30 °C
  - Humidity: 20% to 70%, No condensation
- The B1505A requires the Keysight N1265A text fixture to work with the InTEST platform.

### NOTE

**Important:** Always use the latest firmware in the analyzer. Firmware updates are available at: [www.keysight.com/find/B1506A](http://www.keysight.com/find/B1506A) or [www.keysight.com/find/B1505A](http://www.keysight.com/find/B1505A)

Use EasyEXPERT Software version 6.1.1742.9630 (or later).  
Software updates are available at:  
[www.keysight.com/find/EasyEXPERT](http://www.keysight.com/find/EasyEXPERT).

## IV and CV Test Requirements

The IV (Current / Voltage) and CV (Capacitance / Voltage) applications require the Keysight power device analyzer with a test chamber. For additional information, see:

- *B1506A Operation and Demonstration Guide (Keysight part number B1506-90500)*
- *B1505A Quick Start and Demonstration Guide (Keysight part number B1505-90060)*

If these characterization tests are to be performed over a wide range (room temperature to +250 °C), they also require the InTEST HP289-PM Thermal Platform. Refer to the InTEST documentation for detailed installation and setup information. Note that the B1505A analyzer requires the Keysight N1265A test fixture to work with the InTEST platform.

### **Note on SMD Devices**

There is no standard B150xA test fixture for SMD devices. You need to create your own test fixture or solder wires to your SMD devices and use a standard test fixture.



## IV and CV General Test Setup

**WARNING**

**To avoid electrical shock and instrument damage, turn all instruments off before connecting cables or inserting a device to be tested.**

---

### B1506A Setup

**1** The B1506A SMU Measurement Resources depend on which option you purchased. Verify that the following SMUs are installed in the correct slots.

-- B1506A option H21 (20 A) has the following SMUs:

Slot 1: B1511B MPSMU (SMU1)  
Slot 2: B1520A MFCSMU  
Slot 3: B1514A MCSMU (SMU2)  
Slot 4: B1514A MCSMU (SMU3)  
Slot 5: B1514A MCSMU (SMU4)  
Slot 6: Not Used  
Slot 7: B1513C HVSMU (SMU6)  
Slot 8: Not Used

-- B1506A options H51 (500 A) and H71 (1500 A) are identical with the following SMUs:

Slot 1: B1511B MPSMU (SMU1)  
Slot 2: B1520A MFCSMU  
Slot 3: B1514A MCSMU (SMU2)  
Slot 4: B1514A MCSMU (SMU3)  
Slot 5: B1514A MCSMU (SMU4)  
Slot 6: B1514A MCSMU (SMU5)  
Slot 7: B1513C HVSMU (SMU6)  
Slot 8: Not Used

**NOTE**

The H51 and H71 options configure the UHCU (Ultra High Current Unit) by using the test chamber to merge the currents of two MCSMUs installed in the B1506A mainframe. The UHCU is not available with option H21.

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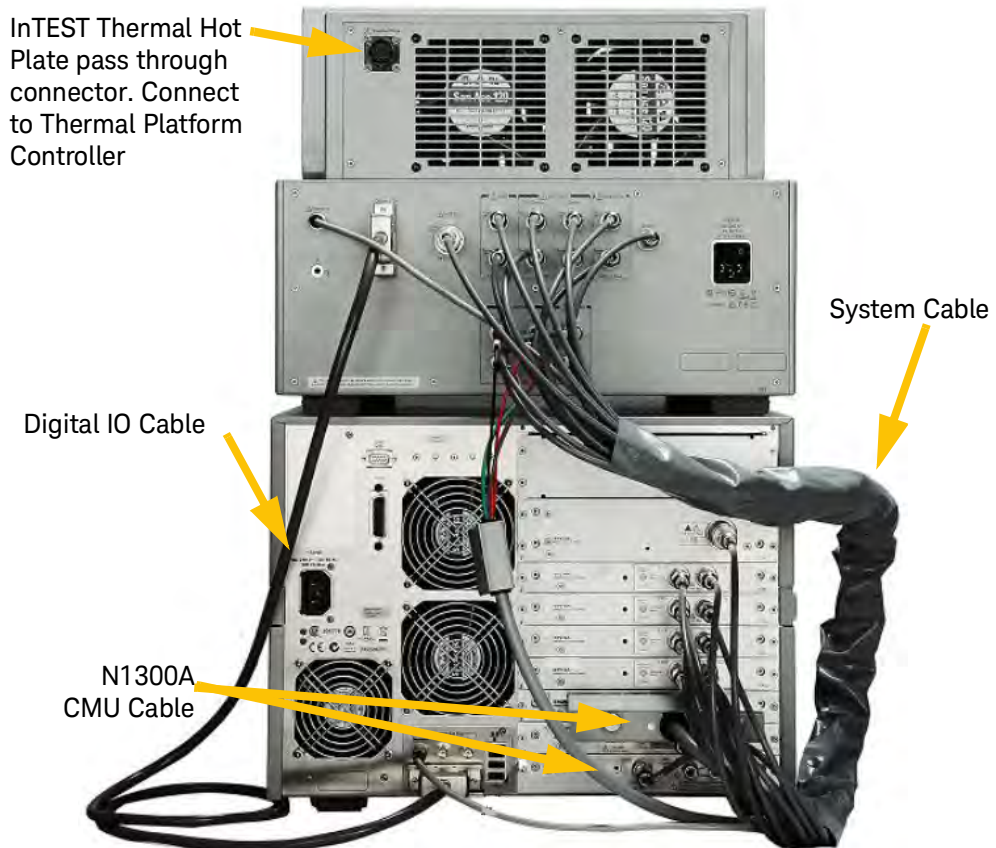
**2** Connect the analyzer to its Test Chamber as described in the B1506A or B1505A documentation. See Figure 6 below, which shows a B1506A.

**a** Connect the Digital I/O cable first.

**b** Connect the N1300 CMU cable; used on the MFCSMU in the B1506A Slot 2.

**c** Connect the System cable in the order of the label numbers. On the B1506A, for example, start at the bottom with the **GNDU** cable and work

your way up. The cables labeled **2S** (SMU2 Sense) and **2F** (SMU2 Force) connect to the Medium Current SMU2 installed in Slot 3; **3S** and **3F** connect to SMU3 in slot 4, etc.



**Figure 6** B1506A Rear View: Connect B1506A Test Chamber to the Mainframe

- 3** After completing the cable connections described above, verify the operation of the B1506A Test Chamber. Refer to the *B1506A User Guide*, Section 2.
- 4** Install the InTEST Hot Plate in the B1506A Test Chamber and connect the Thermal Platform Controller. See **Thermal Platform** below.

### B1505A Setup

- 1** Unlike the B1506A, the B1505A doesn't have a fixed configuration. To use the B1505A with the SAKE system requires at least following hardware options and setup:
  - For H21 (20 A) configuration:
    - N1259A test fixture with module selector option
    - B1514A MCSMU, B1511B MPSMU or B1510A HPSMU for Gate Control

- B1513C HVSMU for high-voltage measurement on drain/collector
- B1512A HCSMU for high-current measurement on drain/collector
- B1511B MPSMU for low-current measurement on drain/collector
- B1520A MFCMU for capacitance measurement
- N1272A device capacitance selector
- N1273A capacitance test fixture
- Cables and adapters for the connection
- For H51 (500 A) or H71 (1500 A) configuration:
  - N1265A Ultra High Current Expander/Fixture
  - B1514A MCSMU\* or B1514A MCSMU\* for gate
    - MCSMU or HCSMU for Icon (I control) of N1265A
    - MCSMU or HCSMU for Vcon (V control) of N1265A
  - B1513C HVSMU for high-voltage measurement on drain/collector
  - B1511B MPSMU for low-current measurement on drain/collector
  - B1520A MFCMU for capacitance measurement
  - N1272A device capacitance selector
  - N1273A capacitance test fixture
  - Cables and adapters for the connection
- 2** Connect the analyzer to its test chamber and make cable connections as described in the B1505A documentation:
  - *B1505A Configuration and Connection Guide*,  
<https://literature.cdn.keysight.com/litweb/pdf/B1505-90000.pdf>
- 3** After completing the cable connections described above, verify the operation of the test chamber. For instructions, see:
  - B1505A User Guide, Section 3. See:  
<https://literature.cdn.keysight.com/litweb/pdf/B1505-90000.pdf?id=1355658>
- 4** Install the InTEST hot plate in the test chamber and connect the thermal platform controller. See **Thermal Platform** below.

### Thermal Platform

The B1506A or B1505A test chamber can be equipped with a Thermal Platform (Hot Plate) from InTEST (model HP289-PM) for controlling DUT temperature. The Thermal Platform is not available from Keysight. The platform consists of a temperature controller and a hot plate that is installed inside the B1506A Test

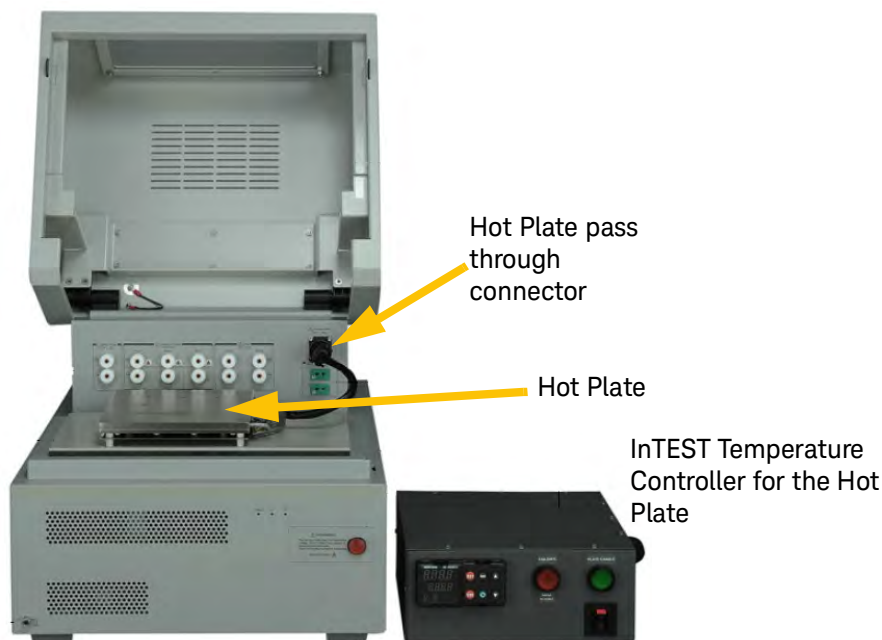
\* Requires qty. 2

Chamber. The controller connects to the Hot Plate inside the B1506A Test Chamber via a pass through connection harness incorporated in the Test Chamber. The plate sits on the Test Chamber's Silicone Plate minimizing cable length and risk of oscillation.

The B1505A requires the Keysight N1265A test fixture to work with the InTEST platform.

**NOTE**

Refer to the B1506A or B1505A User Guide and the documentation supplied with the HP289-PM for detailed Thermal Plate installation.



**Figure 7** B1506A Test Chamber with InTEST Thermal Platform

- 5** Connect the host controller PC, the power device analyzer, and the E5810B Gateway to the LAN switch. Refer to Figure 1 on page 11.
- 6** If you are using the InTEST Thermal Platform (Hot Plate), use a GPIB cable to connect the Keysight E5810B LAN/GPIB/USB Gateway to the Thermal Platform controller. Refer to “Configure the InTEST Thermal Platform Controller” on page 125.
- 7** Power on the analyzer, the E5810B Gateway, and the InTEST Controller.
- 8** Make certain the Host PC can communicate with each test instrument. You can use *Keysight IO Libraries Suite Connection Expert* to verify communication or troubleshoot communication problems.

## Setup and Configure the Keysight B1506A and EasyEXPERT

The following B1506A and EasyEXPERT setup and configuration needs to be only once.


### NOTE

**Important:** Always use the latest firmware in the B1506A Analyzer. Firmware updates are available at:

[www.keysight.com/find/B1506A](http://www.keysight.com/find/B1506A).

EasyEXPERT Software version 6.1.1742.9630 (or later) must be installed in the B1506A. Software updates are available at:

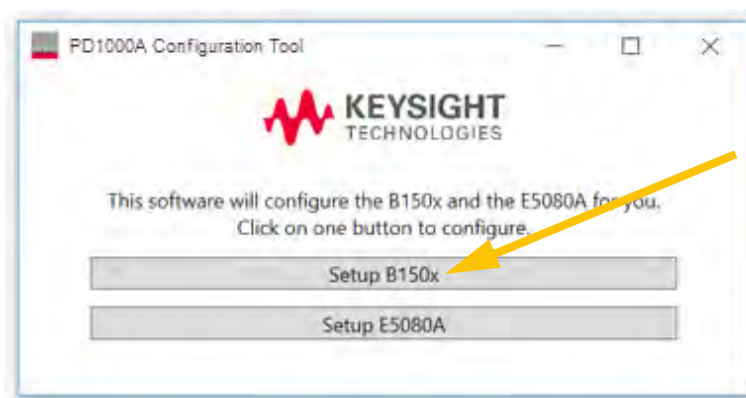
[www.keysight.com/find/EasyEXPERT](http://www.keysight.com/find/EasyEXPERT).

- 1 Turn the B1506A on. For specified accuracy, allow the B1506A to warm up for a minimum of one hour before running any IV and CV tests.
- 2 Check the EasyEXPERT software version and update if the version is less than 6.1.1742.9630. After updating the EasyEXPERT software, reboot the B1506A.
- 3 When the B1506A is first powered on, it opens with the **Easy Test Navigator** software. Close the **Easy Test Navigator** by right clicking on its icon (  ) and selecting **(X) Close Window**.

### Set B150xA Environment Variables

This section uses the ConfigurationTool.exe file that you downloaded to a memory stick. See “Download Setup and Configuration Files” on page 22.

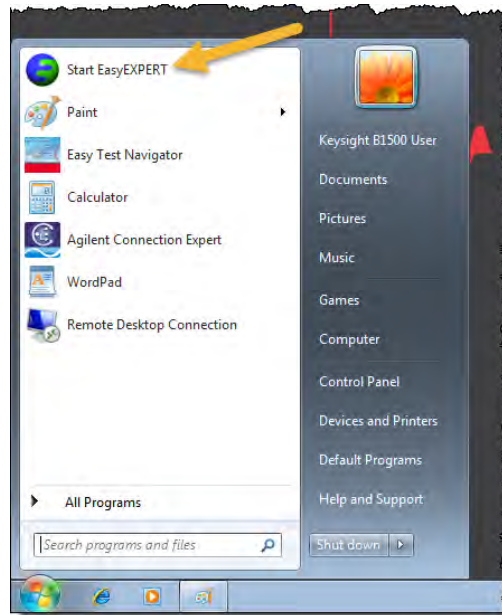
- 1 Insert the memory stick into the B1506A front panel. Run the **PD1000A ConfigurationTool.exe**.
- 2 Click the **Setup B150x** button to run the Environment Variables configuration. This utility needs to be run one time only.



**Figure 8** PD1000A Configuration Tool

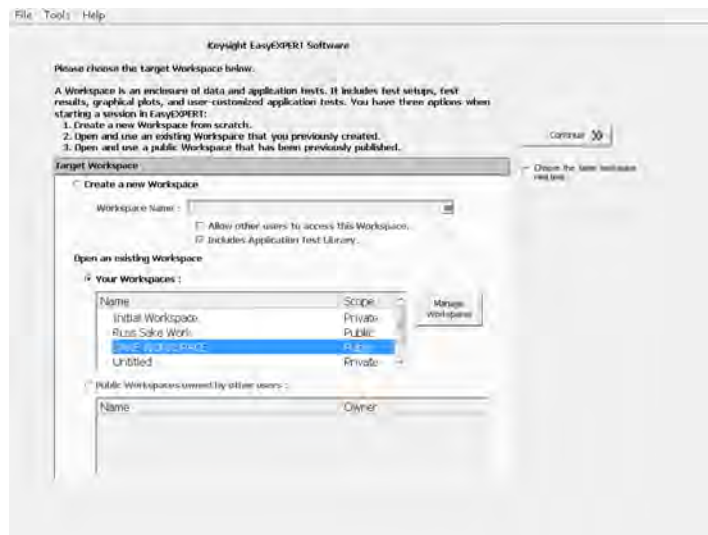
## Start EasyEXPERT

- 1 Start the **EasyEXPERT** software by clicking the Windows **Start** button and clicking **Start EasyEXPERT**.



**Figure 9** Start **EasyEXPERT**

- 2 Select an existing Workspace or create a new Workspace.



**Figure 10** Select or Create a Workspace

Record this Workspace name for use later (see “Configure System Hardware” on page 52),

3 Click **Continue**. This opens the main screen on the power device analyzer.

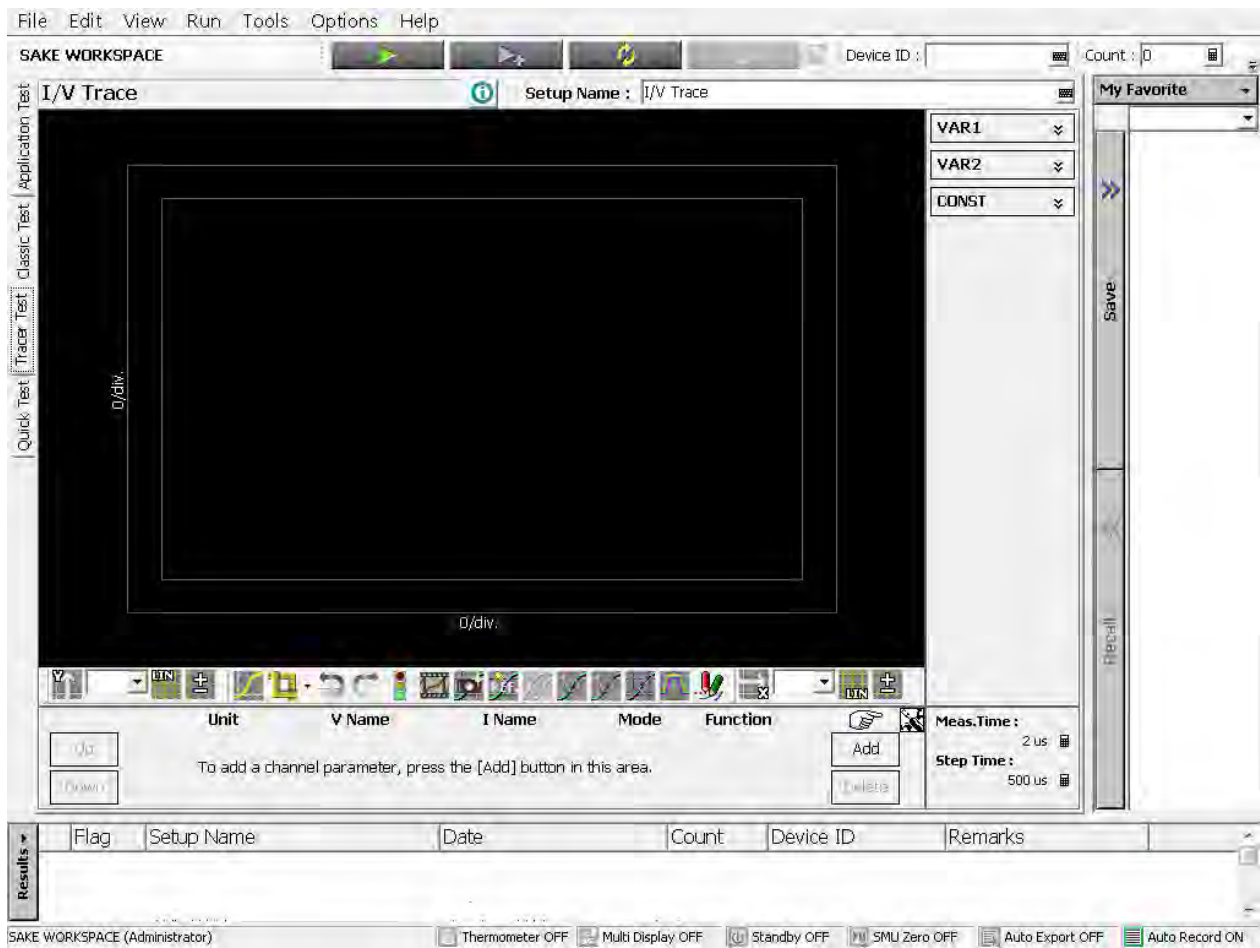
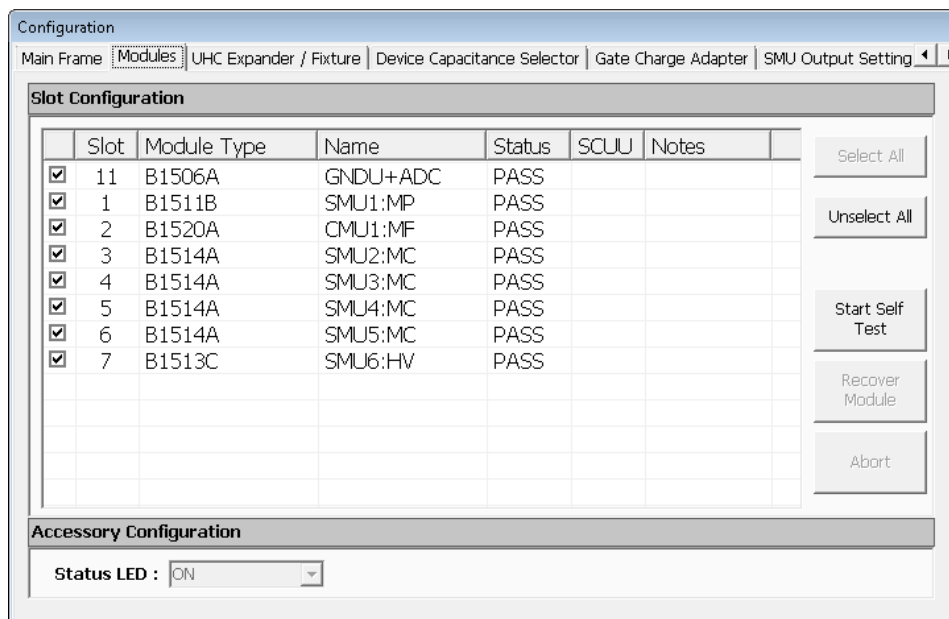


Figure 11 B1506A Main Screen

### Configure EasyEXPERT

- 1 Select **Tools > System > Configuration....** This opens the EasyEXPERT Configuration Editor screen.
- 2 Select the **Modules** tab.



**Figure 12** Modules Tab of Configuration Editor for the B1506A Options H51 and H71. (Option H21 is different.)

- 3 Verify that the modules listed match the modules actually installed in your power device analyzer and the status of every SMU is **“PASS”**.

**NOTE** Write down or make a screen capture of the **Configuration** window Modules tab so that you can easily enter SMU name information for the following steps (through “Enable Temperature Regulation Loop” on page 48).

**NOTE** The following steps (through “Enable Temperature Regulation Loop” on page 48) are required for B1506A Options H51 and H71 only. They are not required for Option H21.



4 Select the **UHC Expander / Fixture** tab.

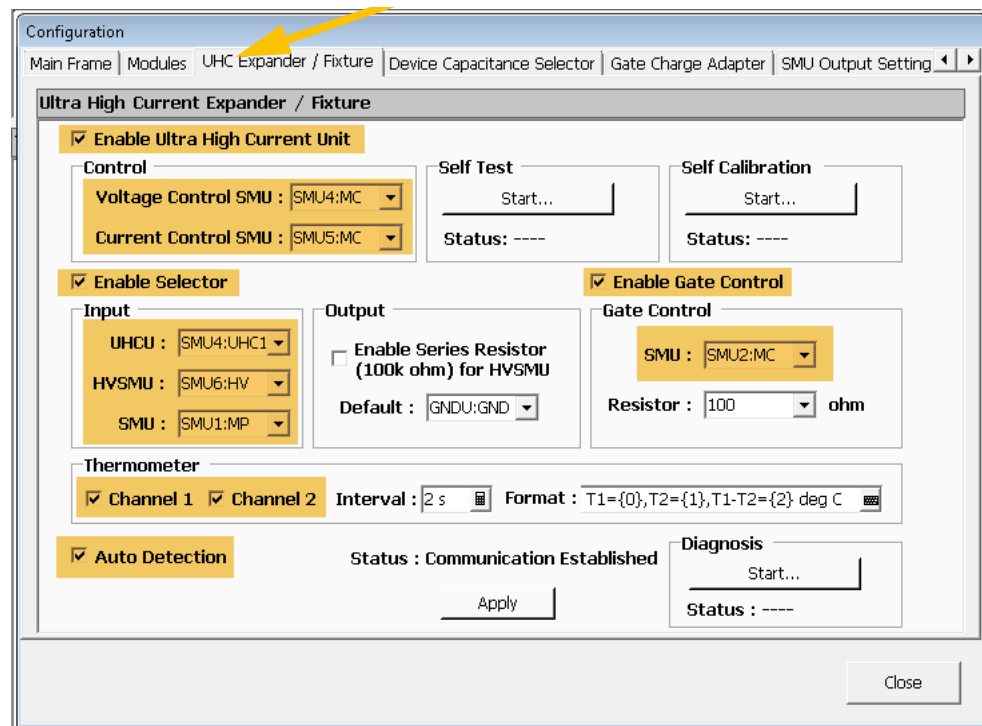


Figure 13 UHC Expander / Fixture tab of Configuration Editor (for B1506A H71)

5 Ensure the following fields are checked or complete:

- **Enable Ultra High Current** checkbox is checked.
- **Voltage Control SMU:** field is complete.
- **Current Control SMU:** field is complete.
- **Enable Selector** checkbox is checked.
- **Enable Gate Control** checkbox is checked.
- **UHCU:** field is complete (confirm after clicking the Apply button).
- **HVSMU:** field is complete.
- **SMU:** field in both the Input and Gate Control boxes are complete.
- **Thermometer:** Channels 1 and 2 are checked
- **Auto Detection:** checkbox is checked.

6 Click the **Apply** button.

**NOTE**

Copy or make a screenshot of the preceding information so that you can use it later for **PD1000A Hardware Configuration** and to configure PD1000A test settings.

7 Select the **Device Capacitance Selector** tab.

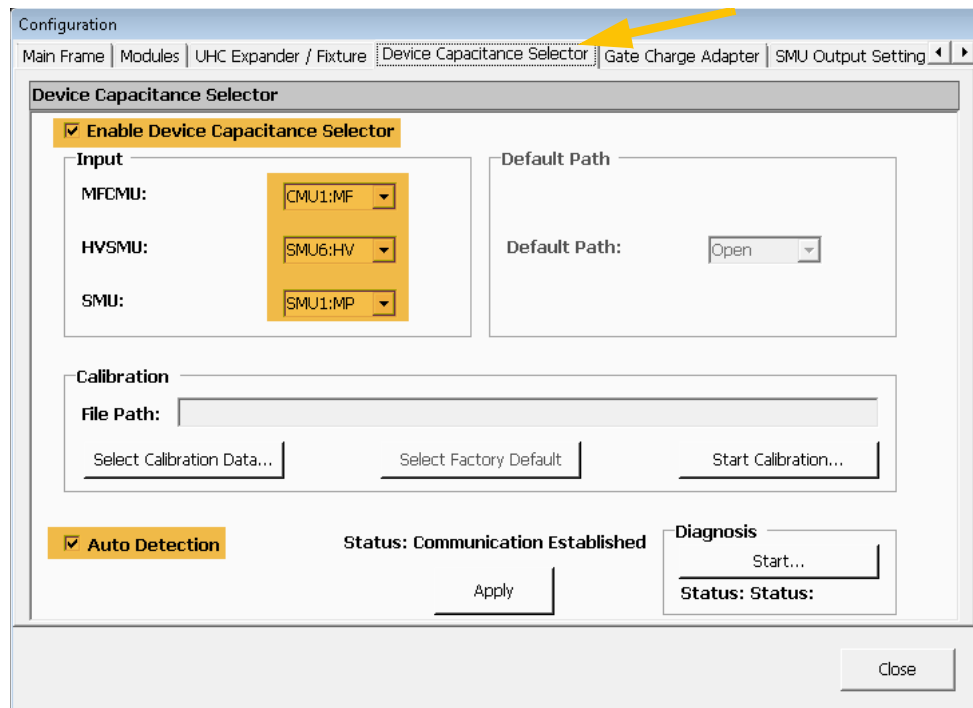


Figure 14 Device Capacitance Selector tab of Configuration Editor

8 Ensure the following fields are specified:

- **Enable Device Capacitance Selector** checkbox is checked.
- **MFCMU**: field is complete.
- **HVSMU**: field is complete.
- **SMU**: field is complete.
- **Auto Detection** checkbox is checked.

9 Click the **Apply** button.

## Import Setup and Configuration Files

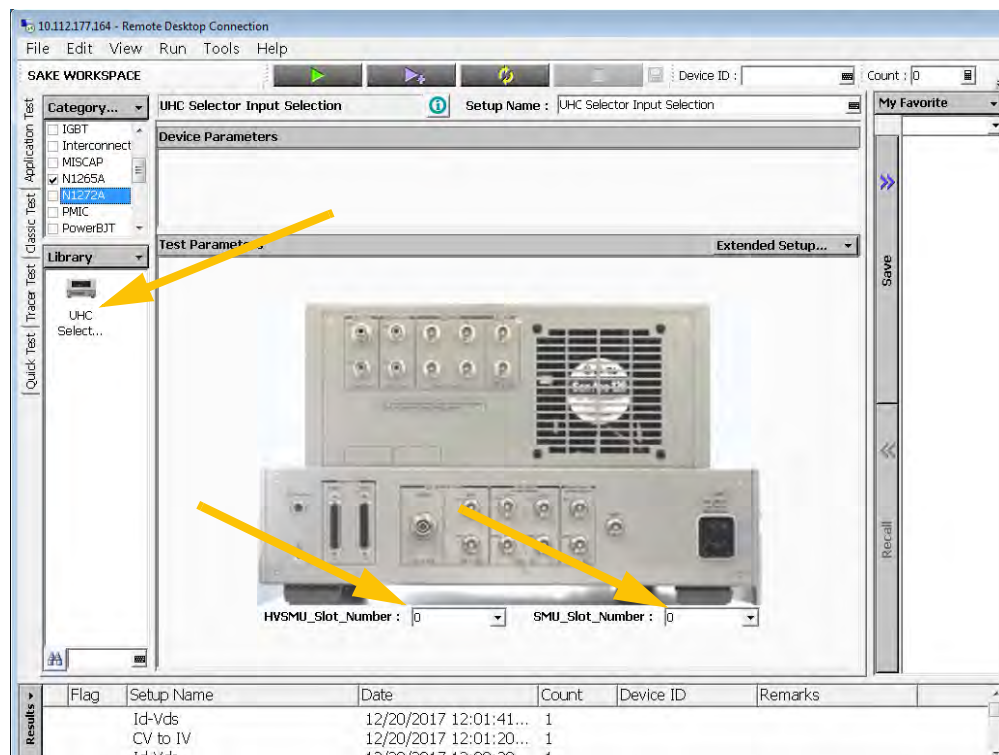
This section uses the setup files that you downloaded to a memory stick to perform a one-time installation of various utility files. (See “Download Setup and Configuration Files” on page 22.)

- 1 Insert the memory stick into the front panel.
- 2 In the tabs on the left of the EasyEXPERT screen, select **Application Test**.
- 3 Scroll down under **Category...**
- 4 Select the **Utility** checkbox.
- 5 Click on the **Library** drop-down menu.
- 6 Select **Import...** This opens a file selection dialog.
- 7 Navigate to the location where you saved the PD1000A configuration setup files.
- 8 Select all of the following B150xA configuration files:
  - **Gate Diode PD1000A.xtd**
  - **Ic-Vge PD1000A.xtd**
  - **Id-Vgs PD1000A.xtd**
  - **Rg, Cgg for IGBT PD1000A.XTD**
  - **Rg, Cgg for PowerMOSFET PD1000A.XTD**
  - **Temperature Sensor 1.xtd**
  - **Temperature Sensor 2.xtd**
  - **UHC Selector Input Selection.xtd**
- 9 Click **Open**. This imports the selected files and makes them available for tests, thermal platform support, and ultra-high current (UHC) support.

## Create the IV and CV and CV-IV Switching Setups in the Library

This section uses the UHC Selector Input Selection.xkd file that you downloaded to a memory stick. See “Download Setup and Configuration Files” on page 22.

- 1 For the B1506A, insert the memory stick into the front panel.
- 2 In the tabs at the left, select **Application Test**.
- 3 Then select **Library > Import.... Show All Files**.
- 4 Locate and import the **UHC Selector Input Selection.xtd** file.
- 5 Under Library, locate the **UHC Selector Input Selection** icon and select it.



**Figure 15** Configure the IV to CV and CV to IV Switch Parameters

### Setup the IV to CV Switch

- 1 Specify the HVSMU slot. (See Figure 15 above and refer to the Modules tab in “Configure EasyEXPERT” on page 40. Typically, the HVSMU slot is Slot 7.)
- 2 For the SMU Slot Number, enter **0** (zero).
- 3 Click the **Save** tab (right side of screen) to save it to My Favorite.
- 4 Right click the icon and rename it as **IV to CV**. IMPORTANT: use this exact file name as shown, including the spaces between words and capitalization.

**Setup the CV to IV Switch.**

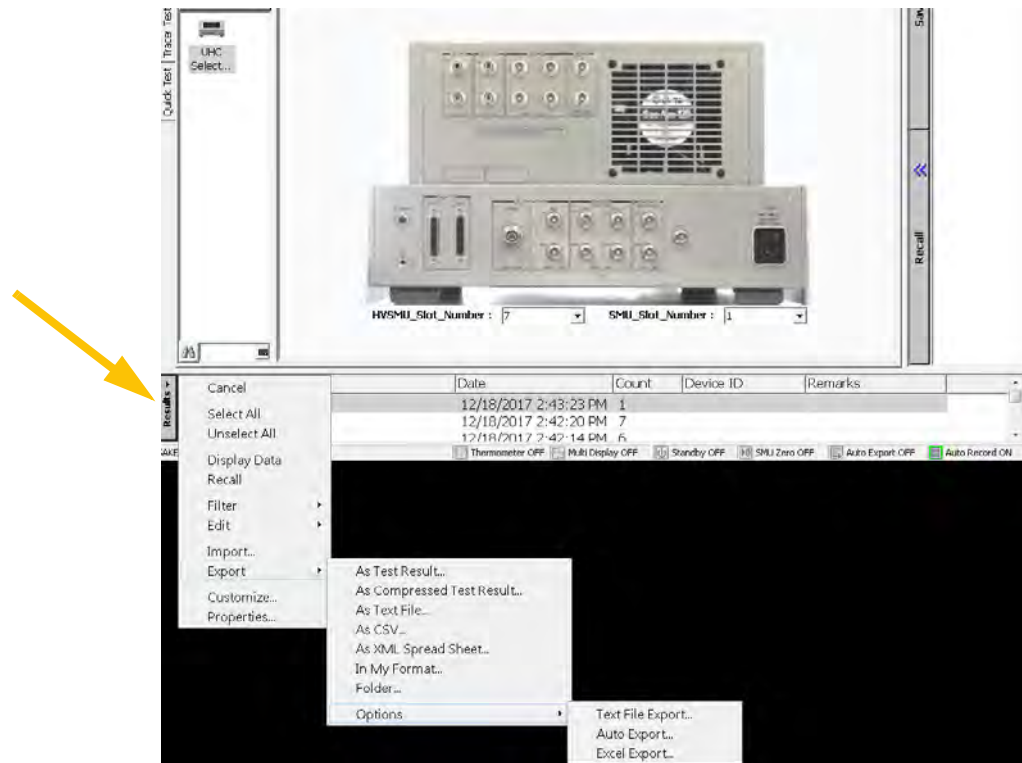
- 1 Specify the HVSMU slot. (See Figure 15 above and refer to the Modules tab in “Configure EasyEXPERT” on page 40. Typically, the HVSMU slot is Slot 7.)
- 2 Enter **1** for the SMU Slot Number.
- 3 Click the **Save** tab (right side of screen).
- 4 Right-click and rename as **CV to IV**. IMPORTANT: use this exact file name as shown, including the spaces between words and capitalization.

**Testing the Switch Setup**

- 1 Select the **IV to CV** Favorite.
- 2 Click the **Recall** button.
- 3 Click the green **Play** arrow or **RUN > Single**.
- 4 You should hear clicking in the test chamber.
- 5 Select **Tools > System > Configuration**.
- 6 Select the **UHC Expander / Fixture** tab. The Input SMU field should be empty.
- 7 Click **Close** to close the Configuration screen.
- 8 Select the **CV to IV** Favorite.
- 9 Click the **Recall** button.
- 10 Click the green **Play** arrow or **RUN > Single**.
- 11 You should hear clicking in the test chamber.
- 12 Click **Tools > System > Configuration**.
- 13 Click the **UHC Expander / Fixture** tab. The Input SMU field should have the SMU name.
- 14 Click **Close** to close the Configuration screen.

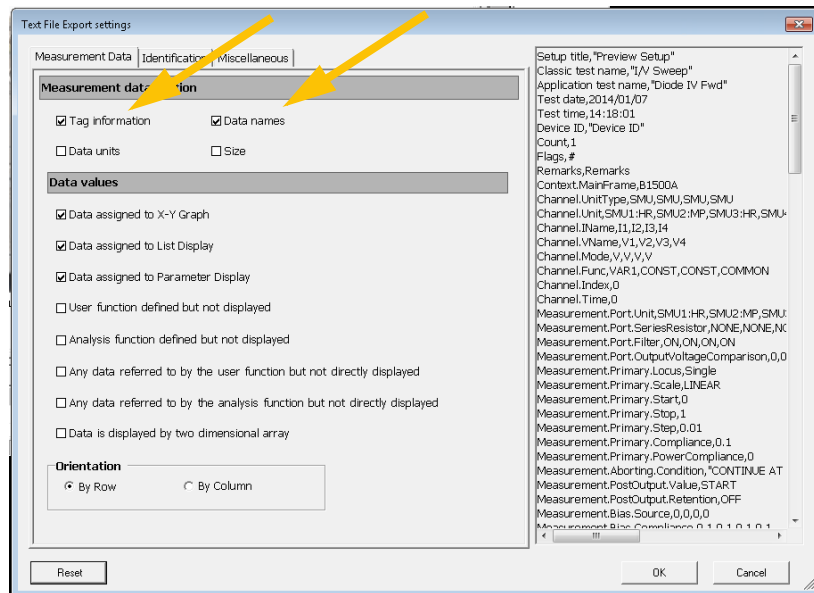
Configure the EasyEXPERT Text File Export

- 1 In EasyEXPERT, click in the **Results** tab (lower left of the screen).
- 2 Select **Export > Options >Text File Export**.



**Figure 16** Text File Export

3 This opens the **Text File Export Settings** screen.



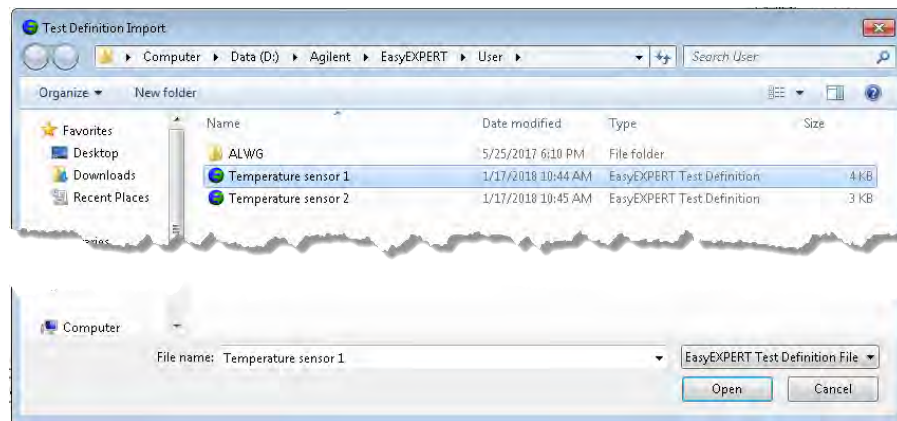
**Figure 17** Test File Export Settings

- 4 Check the first two check boxes: **Tag Information** and **Data Names**.
- 5 Click **OK**.

## Enable Temperature Regulation Loop

To set up the temperature regulation loop, you need to install two applications that retrieve the sensor temperature information. This section uses the two Temperature Sensor files that you downloaded to a memory stick. (See “Download Setup and Configuration Files” on page 22.)

- 1 For the B1506A, insert the memory stick into the front panel.
- 2 In the tabs at the left, select **Application Test**.
- 3 Then select **Library > Import....**
- 4 Locate and click on both the **Temperature Sensor 1.xtd** and the **Temperature Sensor 2.xtd** files. This opens and installs the test definitions in the Utility category.



**Figure 18** Temperature Sensor 1 and 2 Applications

**Congratulations, your power device analyzer and EasyEXPERT are now configured!**

This completes the one-time setup.



## Running the IV and CV Tests

**CAUTION**

IV and CV characterization tests with InTEST HP289-PM Thermal Platform are done over a wide temperature range in the test chamber. These tests can take several hours as the temperature must stabilize within the test chamber.

---

- 1 For specified accuracy, allow the power device analyzer to warm up for a minimum of one hour before running any IV and CV tests.
- 2 Select and install the appropriate B1506A accessory module or adapter for connecting your device under test.
- 3 Install your device to be tested (Device Under Test or DUT) in the Test Chamber in the selected B1506A or B1505A accessory.

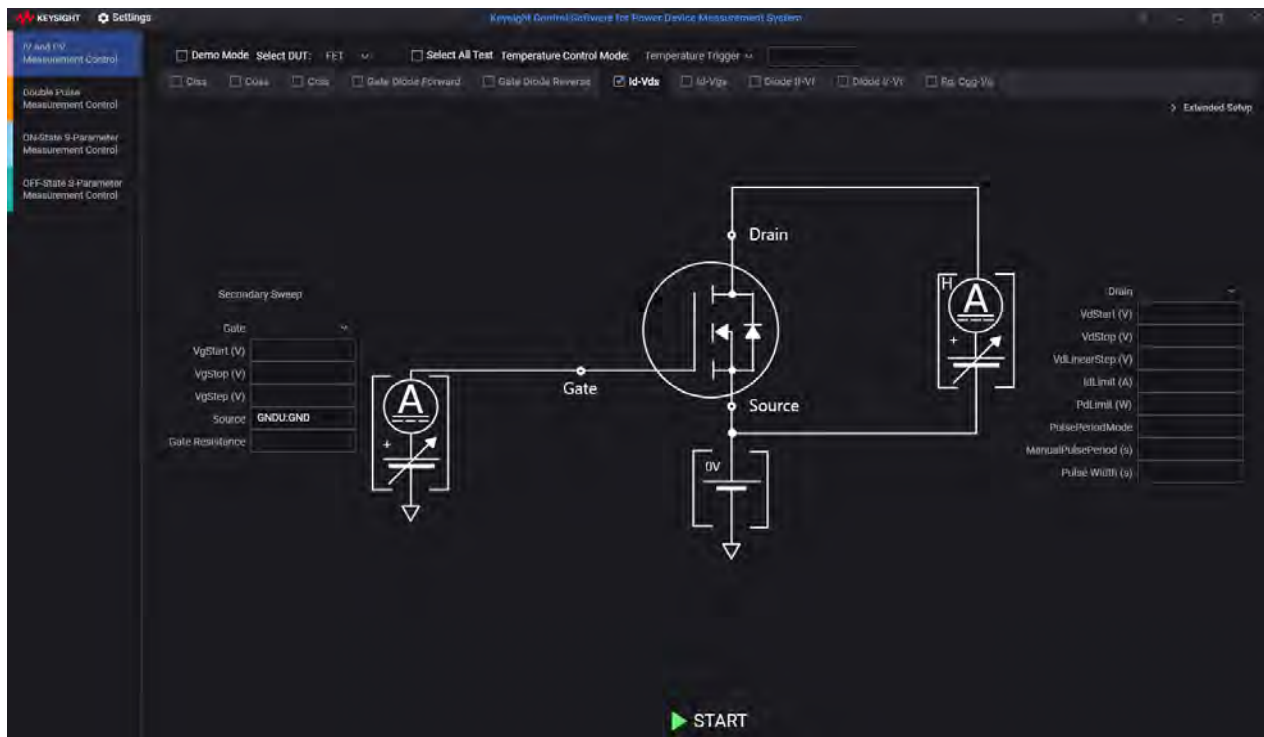
**WARNING**

**To avoid electrical shock and instrument damage, turn all instruments off before connecting cables or inserting a device to be tested.**

---

- 4 From the Windows **Start** button, select **All Programs > Keysight > PD1000A Control**.

5 Select the **IV and CV Measurement Control** tab on the left side of the display.



**Figure 19** PD1000A Control Software with IV and CV Application, FET Device Type selected

- 6 (Optional) Load any previously saved settings from a file:
- Select **Load Settings from File** to display a file selection dialog.
  - Use the file selection dialog to browse to the directory where you have saved a settings file. The file must be a Keysight Test Settings file (.kts) with the correct filename and extension, for example:
    - **IVCV.kts** - for IV-CV tests
  - Select the file you want.
  - Click **Open**. This loads the contents of the file and overwrites the current test settings.

## Configure Common Settings

- 7 Select **Settings > Global Settings** This displays the Global Settings dialog.
  - a **Debug Mode:** Causes the system to send a SCPI *SYST:ERR?* command after each command to identify any errors in the system measurements. Use the **IO Monitor** utility in the IO Libraries Suite to view the error messages.
  - b **Output Directory:** Enter the complete directory (folder) path on the host PC to which the IV and CV characterization data gets saved. Keysight's PD1000A Control Software uses the *EasyEXPERT* format and saves the IV and CV test data with the Keysight IC-CAP Model Data Manager\*\* file (\*.mdm). There is no default path or folder, so you must specify the path.

---

**NOTE**

You must supply this directory path when you import the characterization data into the PEMG software. See [“Power Electronics Model Generator \(PEMG\) Software”](#) on page 107

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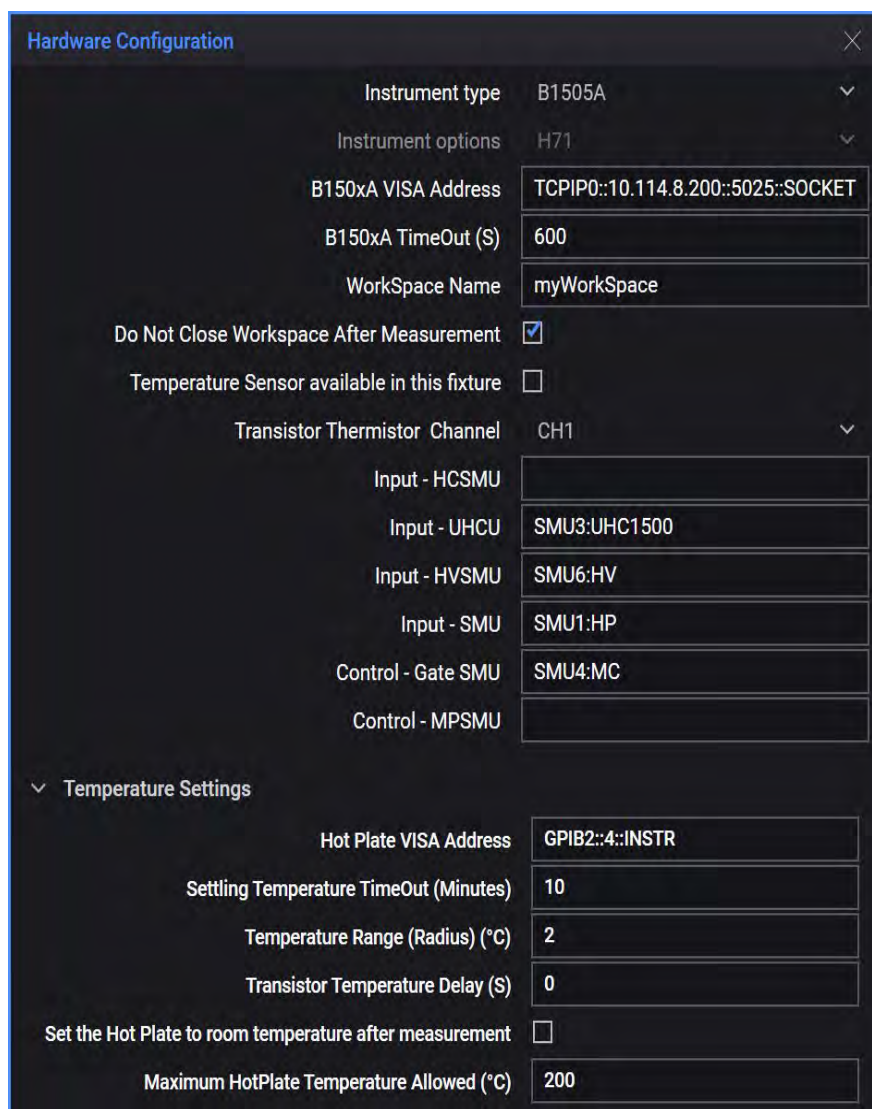
To save settings and close the dialog, click the **Done** button at the bottom of the dialog.

For file structure information, see [“IV and CV Test Output File Structure”](#) on page 63.

\*\*MDM data files are an industry standard file format used by the Keysight ADS modeling program for statistical analysis of device characterization data.

## Configure System Hardware

- 1 Select the **IV and CV Measurement Control** tab on the left side of the screen.
- 2 From the **Settings** menu, select **Instrument Configuration for IV and CV Measurement Control**. Use this dialog to specify the B150xA VISA address and SMU Module configuration, the InTEST Thermal Platform VISA addresses, etc.



**Figure 20** IV and CV Hardware Configuration Editor (for B1506A-H71)

**NOTE**

The B1506A configures the UHCU (Ultra High Current Unit) by using the test chamber and two MCSMUs installed in the mainframe.

### B150xA Settings:

Specify the B150xA VISA address, timeout, and in which slots the B150xA Measurement Resources (SMUs) are installed. For example, in the previous graphic, the Control - Voltage Control SMU (an MCSMU) is installed as SMU4 (therefore it is entered as: SMU4:MC).

- 1 Instrument type:** Use this drop-down menu to select either **B1505A** or **B1506A**.
- 2 Instrument options:** Use this drop-down menu to select the SMU module configuration option: **H21**, **H51**, or **H71**.
- 3 B150xA VISA Address:** VISA Address of the B150xA. See [“Download and Install IO Libraries Suite on your Host PC”](#) on page 19.
- 4 B150xA TimeOut (s):** Maximum time that the PD1000A waits for the B150xA to respond to commands. (Note that some measurements take two to three minutes; therefore set the Timeout time accordingly (300 s min.)).
- 5 Workspace Name:** Enter the WorkSpace Name you selected when first starting the EasyEXPERT software on the B150xA. (If necessary, re-run the EasyEXPERT software on the B150xA to set up this value.
- 6 Do not close Workspace after Measurement:** Default is checked. The system does not close the B150xA EasyEXPERT Workspace after completing tests.
- 7 Temperature Sensor available in this fixture:** Select this checkbox if your test fixture has a temperature sensor.
- 8 Transistor Thermistor Channel:** Use this drop-down menu to select either thermistor **Channel 1** or **Channel 2** to monitor temperature.
- 9 Input HCSMU:** Enter the name of the HCSMU used for input, for example, **SMU3:HC**.
  - Available only with the H21 option.
  - Leave this field blank for options H51 and H71.
  - Look up the module name from the HCSMU input field in the **Module Selector** tab of the Configuration dialog in EasyEXPERT. (See [“Configure EasyEXPERT”](#) on page 40.)
- 10 Input - UHCU:** Enter the name of the UHCU (Ultra High Current Unit) SMU, for example, **SMU4:UHC1500**.
  - Use with B150xA options H51 and H71 (500 A or 1500 A) only.
  - Leave this field blank for option H21 (20 A).
  - Look up the module name from the **UHC Expander / Fixture** tab of the Configuration dialog in EasyEXPERT. (See [“Configure EasyEXPERT”](#) on page 40.)
  - For the B1506A:
    - The UHCU uses the test chamber and two MCSMUs .
    - For the H51 option, use the UHCU named: **SMU:n:UHC500**.
    - For the H71 option, use the UHCU named: **SMU:n:UHC1500**.

**11 Input - HVSMU:** Enter the name of the HVSMU used for input (for example, SMU3:HV).

- Use with the B150xA option H21 (20 A) only.
- Leave this field blank for options H51 and H71.
- Look up the module name from the HVSMU input field in the **Module Selector** tab of the Configuration dialog in EasyEXPERT. (See “Configure EasyEXPERT” on page 40.)

**12 Input - SMU:** Enter the name of SMU used for SMU input (for example, SMU3:MF).

- Use with the B150xA option H21 (20 A) only.
- Leave this field blank for options H51 and H71.
- Look up the module name from the HVSMU input field in the **Module Selector** tab of the Configuration dialog in EasyEXPERT. (See “Configure EasyEXPERT” on page 40.)

**13 Control - Gate SMU:** Enter the Gate SMU name:

- For the B1506A: always use **SMU2:MC**.
- For the B1505A:
  - Identify the SMU that connects to the gate of the DUT.
  - Look up the SMU/module name from the Modules tab of the Configuration dialog in EasyEXPERT. (See “Configure EasyEXPERT” on page 40.)

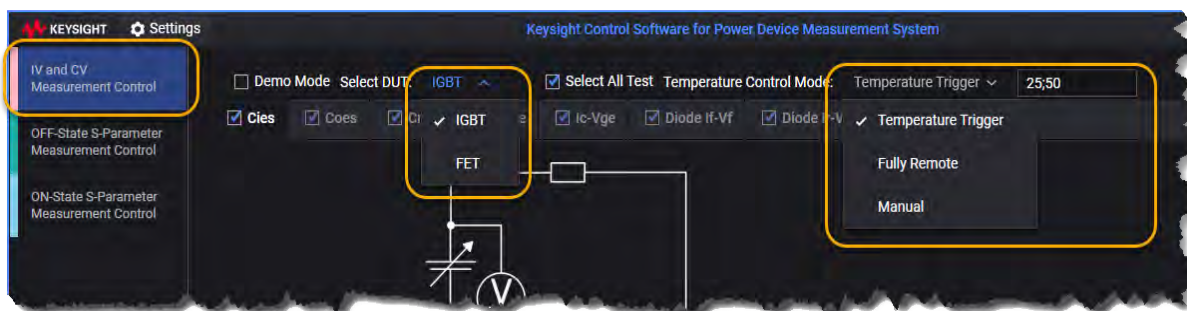
**14 Control - MPSMU:** Enter the medium power B1511B MPSMU. Used with H51 (500 A) or H71 (1500 A) configuration.

### Temperature Settings:

- 1 Hot Plate VISA Address:** From the appendix, “Configure the InTEST Thermal Platform Controller,” starting on page 125.
- 2 Settling Temperature Timeout (in minutes):** The maximum time that you allow for the Hot Plate to reach the specified temperature.
- 3 Temperature Range (Radius) (°C):** The acceptable tolerance of the measured temperature.
- 4 Transistor Temperature Delay (S):** The time to wait (in seconds) after the target temperature is reached.
- 5 Set the Hot Plate to room temperature after measurement:** Check the box if you want the Hot Plate reset to ~23 °C after temperature measurements complete. Leave the box unchecked to retain the existing temperature.
- 6 Maximum Hot Plate Temperature Allowed:** Specify the maximum temperature for the Hot Plate (°C).
- 7** Click the **X** icon to close the Hardware Configuration dialog.

## Set Initial Test Settings

For detailed information about each test, refer to the PD1000A Control Software Help File. (Click the help (?) icon in the upper right corner of the display.)



**Figure 21** Select Initial Test Settings

- 1 **Demo Mode:** Check this box if you want to run the IV/CV Demonstration. This provides a simple current/voltage plot and result (\*.mdm) file. See “IV and CV Demo” on page 114.
- 2 **Select DUT Type:** Choose **FET** or **IGBT** from the drop-down list. (If you are using a B1505A power device analyzer, you must also select the test type: **IV**, **CV**, or **Gate Diode**.)
- 3 Set the **Temperature Control Mode**, depending on whether you have the InTEST Thermal Platform (HP289-PM, available separately, contact [www.inTESTthermal.com](http://www.inTESTthermal.com))
  - **Fully Remote:** If you have the InTEST Thermal Platform, enter the temperature(s) you want tested in the temperature field, separated by semicolons (;). The software automatically heats the test chamber and triggers the measurements when each temperature is reached.
  - **Temperature Trigger:**
    - a Enter the temperature(s) you want tested in the temperature field, separated by semicolons (;).
    - b Finish selecting tests and setting up the device parameter information for each test, as described in this chapter.
    - c Manually heat the test chamber to more than the highest value you entered and then stop heating the chamber. When you start the test (as described below), the software automatically triggers measurements when the test chamber cools to each value that you entered.

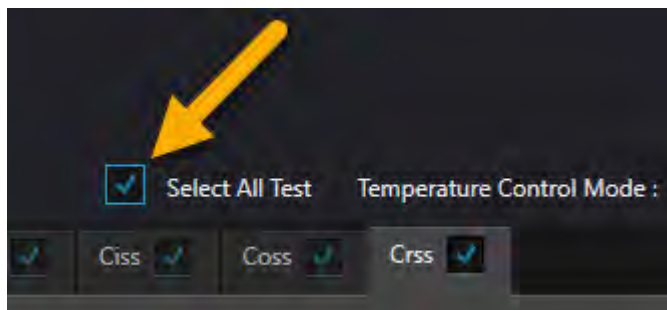
### NOTE

This method takes longer (on the order of hours) because of the time required for the test chamber to cool between each measurement.

- **Manual:** Use this option if you have your own thermal control solution or if you do not plan to use a thermal platform.
  - If you have your own thermal control solution:
    - a Enter a single value for the temperature at which you want to run the test.
    - b Finish selecting tests and setting up the device parameter information for each test, as described in this chapter.
    - c Use your thermal controller to heat the test chamber to the temperature value you entered.
    - d When the chamber reaches the correct temperature, run the test manually as described below.
    - e Repeat this procedure to run additional tests at different temperatures, as needed.
  - If you do not have a thermal platform:
    - a Enter the average temperature of the room in which you perform the tests. (If you don't know the average temperature, use 25 °C as a typical value.)
    - b Finish selecting tests and setting up the device parameter information for each test, as described in this chapter.
    - c Run the test manually as described below.
- 4 Select the checkbox for each test that you want to run. (Available tests depend on the DUT type and the type of SMU available. Refer to the control software help file for a full list.) Note that the screen graphic schematic changes to illustrate the test that is running.

**NOTE** The Gate Diode Forward and Gate Diode Reverse tests are applicable only to GaN FET devices. If you click the Select All Tests check box, these two tests will not be selected.

- 5 (Optional) Click the **Select All Test** check box to run *all* of the IV and CV tests.





- 6 Provide the device parameter information for each test. See “Setting Device Parameters in the PD1000A Control Software” on page 59 below. For details on these parameters, refer to the PD1000A Control Software Help File.

**CAUTION**

When setting the test parameters in the PD1000A test screens, do not exceed device limits specified in the device’s data sheet.

**NOTE**

If you are not using the InTEST Thermal Platform to provide heat in the B1506A Test Chamber, make certain the Temperature Control Mode is set to **Manual** and set the temperature to 25 °C in the temperature field.

**NOTE**



**Gate Resistance.** Specify the desired Gate Resistance for the device, either 0 (default), 10, 100, 1000 Ω. The Gate Resistor value must be set in two places, here for the specific test and also in the B1506A EasyEXPERT. See “Oscillations in the IV Plot,” starting on page 61. You must use the same values in both places.

## Run the IV and CV Tests

- 1 Install your Device Under Test (DUT) to the test chamber by using the correct B1505A or B1506A accessory. Refer to the B1505A or B1506A user guide for guidance on connecting your DUT to the test chamber.

**WARNING**

**To avoid electrical shock and instrument damage, turn all instruments off before connecting cables or inserting a device to be tested.**

- 2 Click the **Start** button () to start device characterization. IV and CV device characterization plots appear on the B1506A or B1505A network analyzer screen, not on the host PC display. The device characterization data is stored on the host PC in the output directory that you specify in the **Settings > Global Settings** menu. (See “[Configure Common Settings](#)” on page 51.)
  - After starting a measurement, you can stop a measurement by clicking the **Stop** () button.

**NOTE**

The PD1000A Help file provides detailed information about each test. In the PD1000A Control Software, press **F1** or click on the help icon (?) in the upper right corner of the software display.

**WARNING**

Always set the instrument output off before connecting or disconnecting connection wire.

Press the mainframe front panel Stop key to set the source output off. And confirm that the mainframe front panel High Voltage indicator is not lit.

---

**WARNING**

To prevent electrical shock and DUT damage, do not connect or disconnect the DUT while the instrument is applying voltage or current.

---

**WARNING**

**Hazardous Voltage:** The instrument maximum output voltage may appear at the High Force, High Sense, and Guard terminals when the Test Chamber cover is closed.

---

**CAUTION**

Allow the chamber to cool before opening. Do not touch the Hot Plate until it has cooled.

IV characterization tests can be done over a wide temperature range in the B1506A test chamber (room temperature to +250 °C). These tests can take several hours as the temperature must stabilize within the test chamber.

---

**CAUTION**

The Hot Plate can reach temperatures in excess of +255 °C. The hot plate surface is cooled slowly by the local environment. It is not automatically cooled after a test completes. Always verify that the Hot Plate surface is at room temperature before touching or handling. A heat shield is located approximately 6.35 mm below the lower surface of the Hot Plate. Even with the heat shield, the bottom of the Hot Plate can be unsafe to touch.

---

**NOTE**

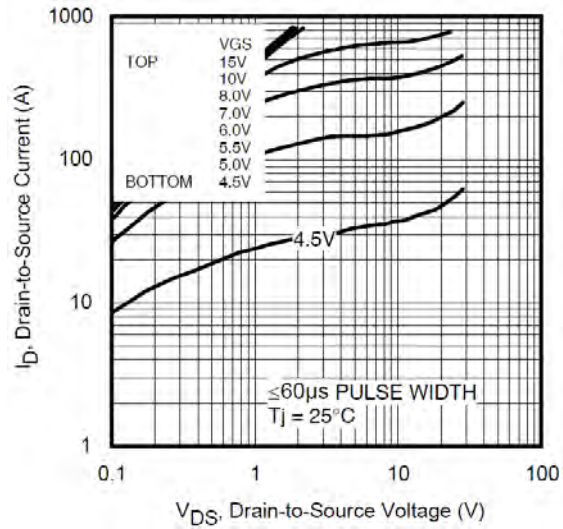
Do not apply voltage/current over the maximum limit of the socket module or adapter. Use a socket module or adapter rated for the temperature range of your test.

---

## Additional Test Information

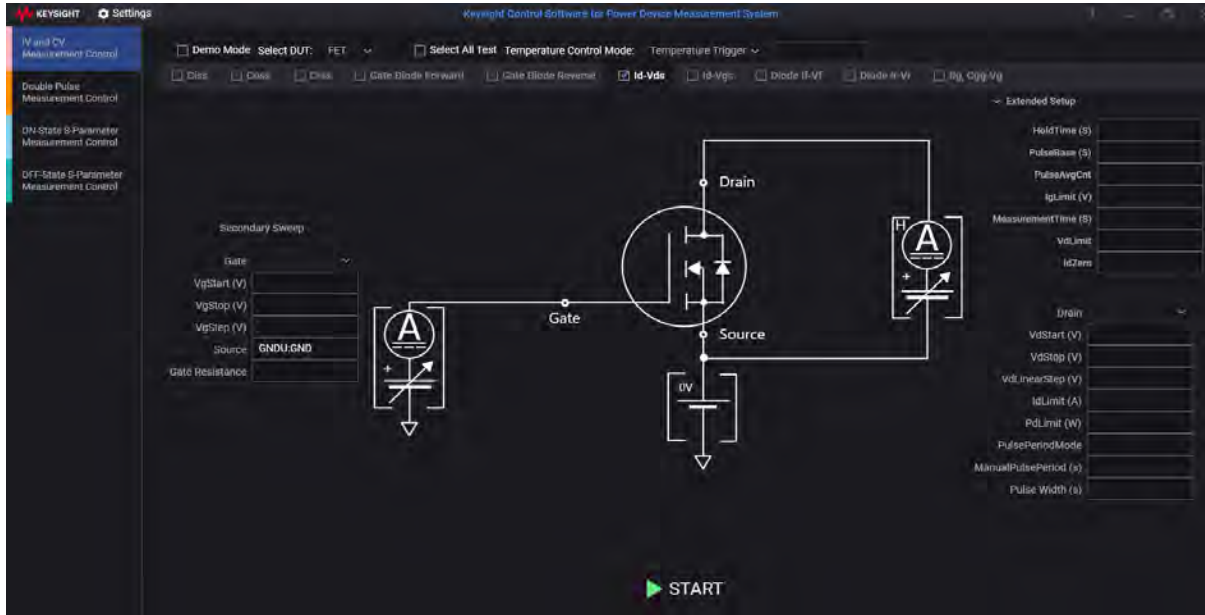
### Setting Device Parameters in the PD1000A Control Software

When running a device test, refer to the device data sheet to set PD1000A device test parameters. For example, suppose that you are testing a FET device and the data sheet shows the following  $I_D$ - $V_{DS}$  output characteristic:



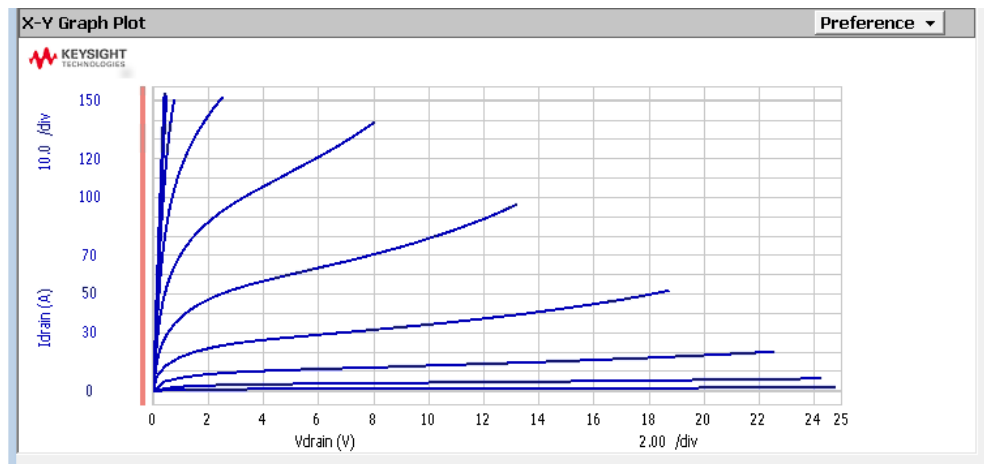
**Figure 22**  $I_D$ - $V_{DS}$  Characteristics of a FET Device from the Data Sheet

You would then set the PD1000A  $I_d$ - $V_{ds}$  test parameters accordingly. For example:



**Figure 23**  $I_d$ - $V_{ds}$  Test Parameters for FET Device shown above

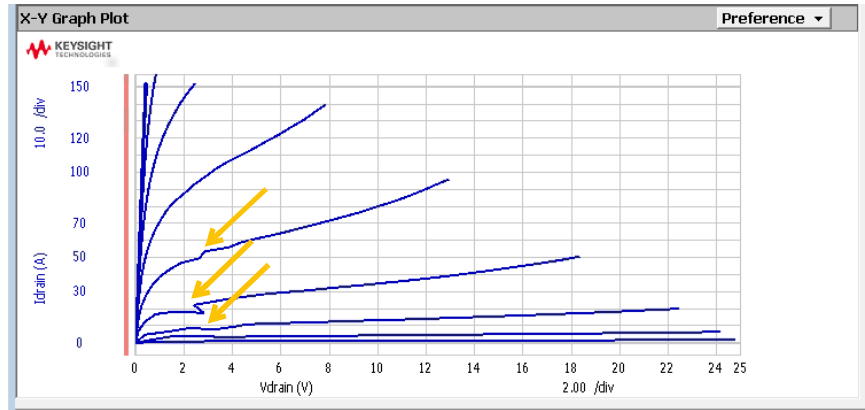
This test setup produces the following  $I_d$ - $V_{ds}$  plot on the B1506A display:



**Figure 24** Normal  $I_d$ - $V_{ds}$  Plot

## Oscillations in the IV Plot

If an IV test indicates oscillations (see Figure 25 below), you may need to set a Gate Resistor value in the B1506A EasyEXPERT and PD1000A Control Software.



**Figure 25** Oscillations in the IV Test Plot

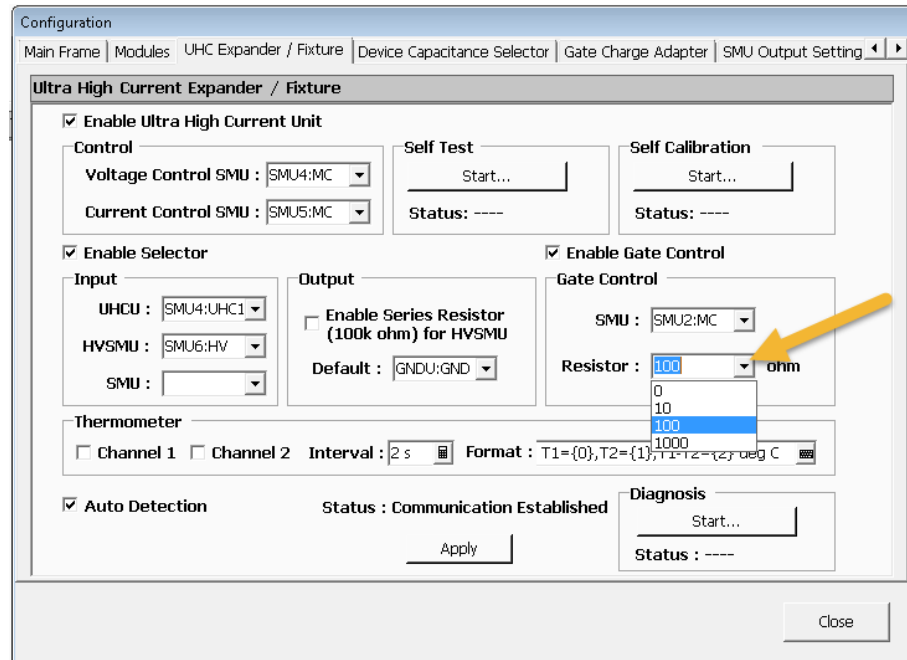
Note this is the same device and test settings as shown in Figure 24 above but with the Gate Resistor set to 0  $\Omega$ .

As mentioned above, you must change the Gate Resistor value in two places: in the PD1000A Control Software for the test parameter, and in the B1506A EasyEXPERT. Make sure that you use the same value in both places.

To change the Gate Resistor value:

- 1** Go to the B1506A EasyEXPERT software.
- 2** Click **Tools > System > Configuration**.
- 3** Select the **UHC Expander / Fixture** tab.

- Under **Gate Control**, change the resistor value to **10**, **100**, or **1k**  $\Omega$ . See Figure 26 below. You may need to try different values to eliminate the oscillation.

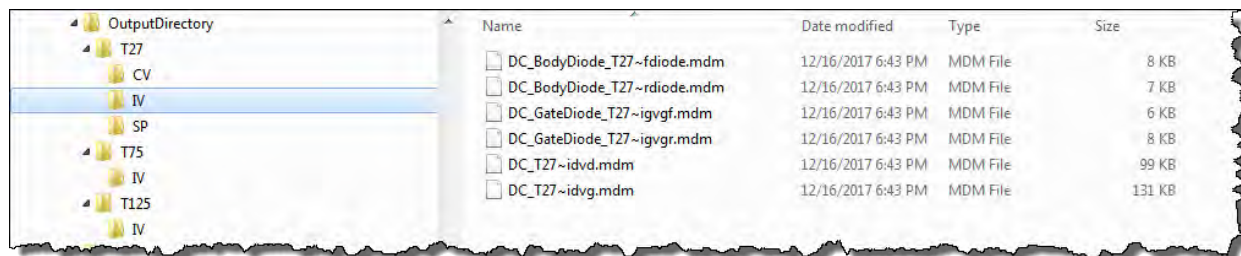


**Figure 26** Set the Gate Control Resistor Value

- Rerun the test. The oscillations should be gone and smooth plots appear. See Figure 24 above.

## IV and CV Test Output File Structure

The file structure for IV and CV tests is:



**Figure 27** IV and CV File Structure showing Sample IV .mdm Files

Notes:

- The *Output Directory* is set in the **Settings > Global Settings** dialog for each test.
- The first level sub-folders (T27, T75, and T125 in the example above) represent the temperatures the device was tested at for IV tests only. The first subfolder is sometimes named “Tnom” for room temperature measurements.
- Multiple \*.mdm files exist in each second level sub-folder. The actual file names to be different depending on whether you are testing an IGBT or a FET. The specific temperature and type of measurement are encoded in the file names.
- S-Parameter tests (both on-state and off-state) and most CV tests are done at room temperature only. Hence, they exist only in the first “T” sub-folder (T27 in this example).
- There are additional .mdm files for the GateDiode Forward [*DC\_GateDiode\_(temperature)~igvgf.mdm*] and GateDiode Reverse [*DC\_GateDiode\_(temperature)~igvgr.mdm*] tests





# 3 On-State and Off-State S-Parameter Characterization

Network analyzers are the fundamental instrument for characterization of the devices and components used in RF and microwave systems. Swept frequency instruments, like network analyzers, provide a direct measurement of transfer functions by sweeping a signal source and a tuned receiver across a range of frequencies. Two-port measurements provide explicit characterization of linear system blocks with a single input and a single output, by far the most common type of element.

In its simplest format, a reference excitation is applied to one port, and the response from the other port is recorded as a function of the sweep frequency. Scattering Parameters, or S-parameters for short, are the working language of network analyzers (NA). They provide a complete description of any linear, time-invariant element which then fully represents the behavior of that element within any system that it may be connected to. Scattering parameters involve phase information, and are thus complex phasor quantities. They are also frequency dependent. Once known, they can be transformed into other network parameters for circuit design, optimization, or tuning.

## In this Chapter:

General S-Parameter Test Requirements	page 67
Download Setup and Configuration Files	page 22
E5080A/B ENA Network Analyzer Setup	page 68
General Test Setup	page 69
Running the S-Parameter Characterization	page 73
Configure Common Settings	page 73
Configure System Hardware	page 74
Additional Information	page 83

### NOTE

**Important Licensing Information:** The PD1000A Control Software requires a license, PD1010A, to run the S-Parameter tests. Refer to “[Install Control Software Licenses](#)” on page 24 for detailed licensing information.

## The PD1000A System Test Instruments

- **On State (Biased) and Off State (Zero Bias) S-Parameter Characterization Tests:**  
 These tests are performed at room temperature. They require the E5080A or E5080B ENA Network Analyzer, the B2902A Precision Source, two PD1000A Bias T Networks, and the DUT Test Fixture. See [Chapter 3](#), “On-State and Off-State S-Parameter Characterization”.

The following table lists the PD1000A Control Software device characterization tests and the test equipment used for the tests.

Tests	Equipment Used for Test	Requires
On State (Biased) and Off State (Zero Biased) S-Parameter measurements	E5080A/B ENA Vector Network Analyzer	PD1000A Option SPK includes the following: Qty. 2 Bias T Networks Qty. 3 Test Fixtures -- One for each, TO-220, TO-247, and Surface Mount Devices. Calibration Standards for Test Fixtures Qty. 2 Type N, Male to SMA Female Adapter 50 Ω Nominal Qty. 2 SMA male to SMA Male Cable. 7 inch cable Qty. 8 Dual Banana Plug (each end) Cables (4 red and 4 black) Qty. 1 SMA 0.56 N-m (5 lb-in) 5/16 in Break-over torque wrench
	B2902A Precision Source/Measure Unit	
	PD1000A Option SPK	

For detailed information about any of the instruments listed above, refer to the documentation provided with each instrument. Install and setup each instrument per instructions in its Operating or User Guide.

## General S-Parameter Test Requirements

On State (biased) and Off State (zero biased) S-Parameter tests require the following instruments:

- E5080A/B ENA Vector Network Analyzer
- Keysight B2902A Precision Source/Measure Unit (used for On State tests only but should remain in circuit for Off State tests.)
- PD1000A Option -SPK includes the following:
  - Quantity 2, PD1000A Bias T Networks
  - Three DUT Test Fixtures\*:
    - Test Fixture for 3-terminal TO-220 style devices
    - Test Fixture for 3-terminal TO-247 style devices
    - Test Fixture for Surface Mount (SMD) devices.
  - Quantity 2, Type N Male – SMA Female Adapter (Keysight pn 5062-6682)
  - Quantity 2, SMA connector cables (7", Keysight pn 5062-6682)
  - Quantity 8, Banana plug to Banana plug cables (4 red and 4 black, for connecting the B2902A SMU to Bias T)

### NOTE

S-Parameter tests are performed at room temperature and thus do not require the B1506A or the InTEST Thermal Platform. However, you do need to specify the room temperature in the Hardware Setup.

### NOTE

Do not apply voltage/current over the maximum limit of the Bias T networks, the socket module or adapter. Use a socket module or adapter rated for the temperature range of your test.

## Set AC Line Frequency and Date/Time on the B2902A

The Keysight B2902A Source Measure Unit (SMU) is used only for the system Autocal. Its factory default line frequency is set to 50 Hz and must be changed to 60 Hz in those countries with a 60 Hz line frequency. To change the line frequency from the instrument front panel, press the following keys:

- For setting to 50 Hz: **More > System > PLC > 50 Hz**
- For setting to 60 Hz: **More > System > PLC > 60 Hz**

Optional: To set the Date and Time press the following: **System > Info > Date/Time**

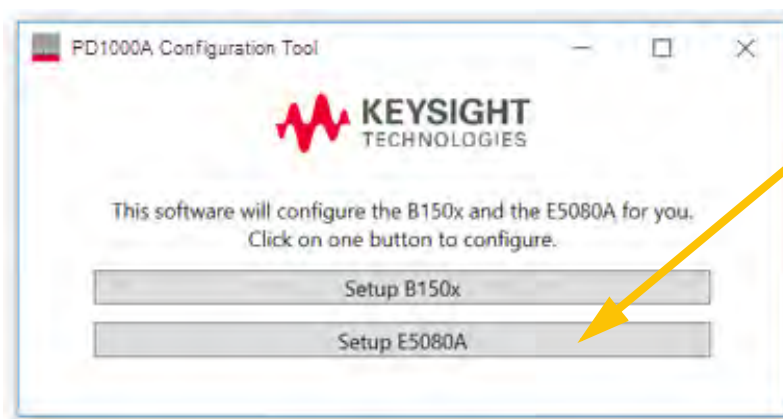
\* Refer to the *PD1000A Test Fixture User Guide* for installation and use information.

## E5080A/B ENA Network Analyzer Setup

**NOTE**

Prior to running the **On State** and **Off State S-Parameter** tests, you must install an executable file on the E5080A/B ENA Network Analyzer. This needs to be done only one time for the ENA. See “Download Setup and Configuration Files” on page 22 for instructions on creating a memory stick with the required files.

- 1 Insert the memory stick into the E5080A/B front panel. Run the **PD1000A ConfigurationTool.exe**. (See “Download Setup and Configuration Files” on page 22.)

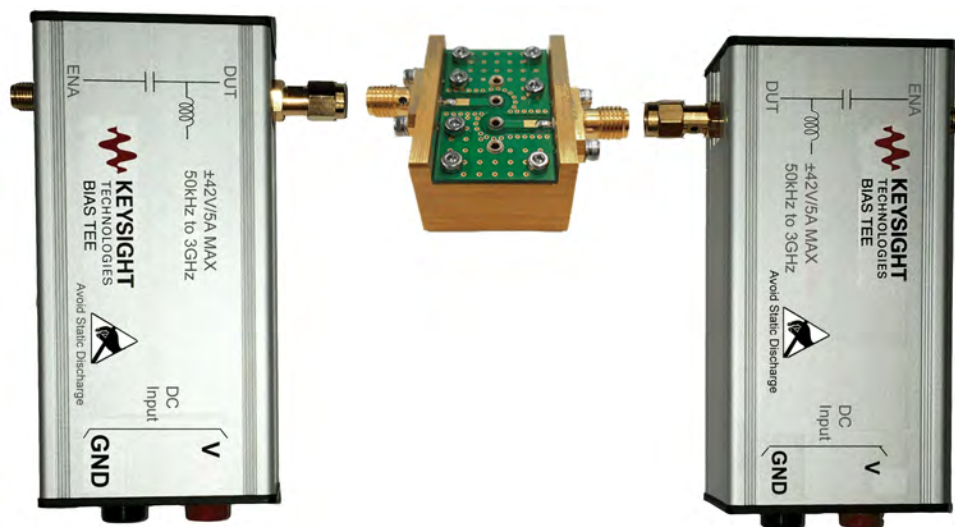


**Figure 28** PD1000A Configuration Tool

- 2 Click the **Setup E5080A** button to run the configuration.
- 3 **Important:** Cycle the E5080A/B ENA power after installing the executable file.

## General Test Setup

- 1 Connect two PD1000A Bias T networks to your PD1000A Test Fixture as shown below:

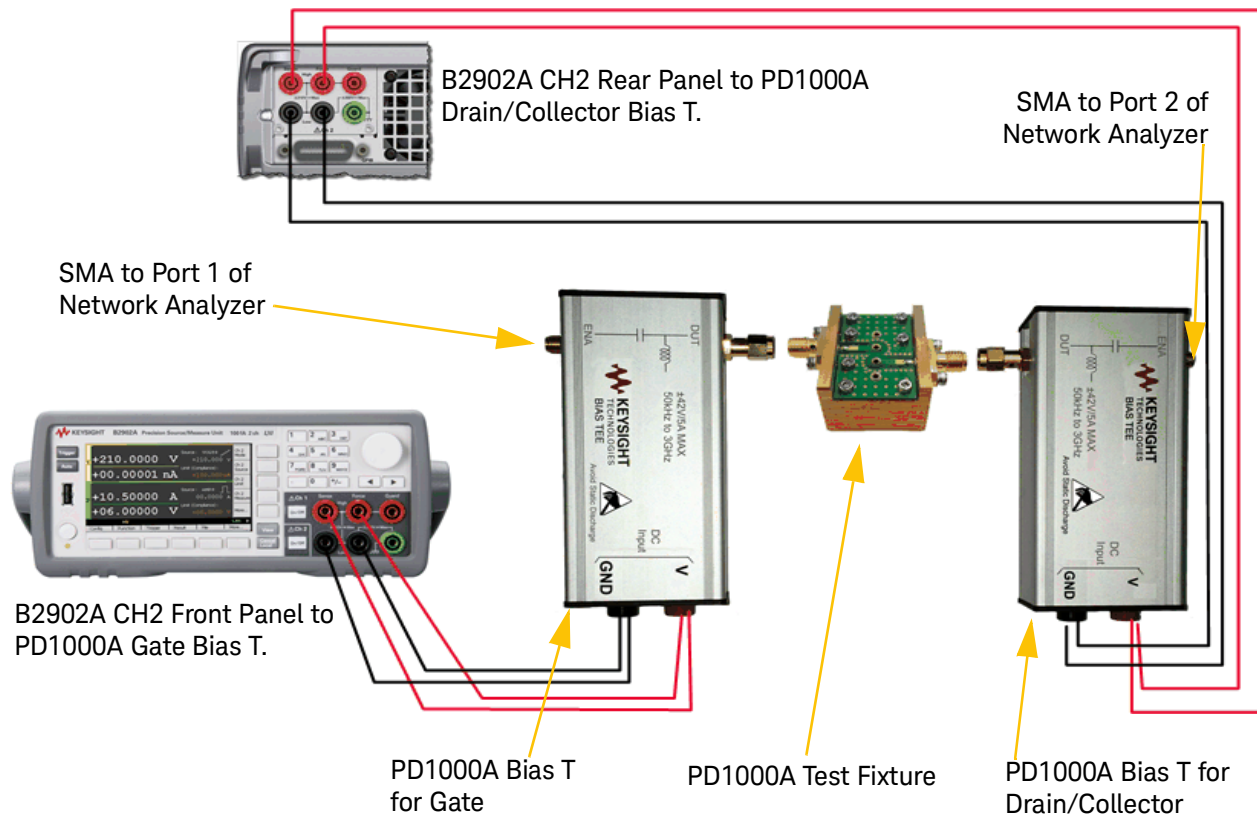


**Figure 29** Connecting Two Bias Ts to the Test Fixture (TO-247 fixture shown, cable not shown)

### NOTE

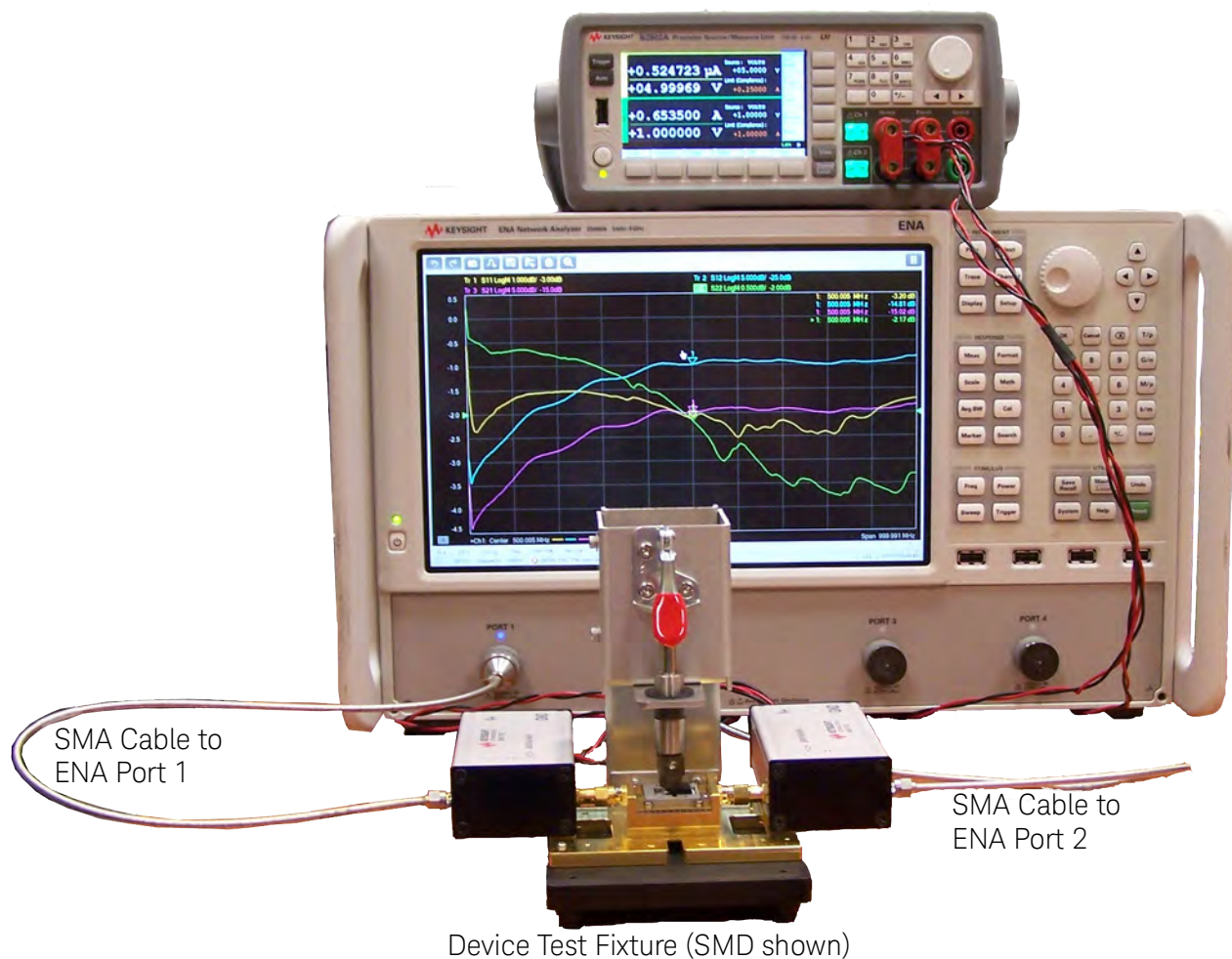
The Bias Ts and the Test Fixture must be supported on a table or bench top.

- 2 Refer to Figure 30 below. From the B2902A Precision SMU, connect the dual banana plug cables to the two PD1000A Bias T networks as follows:
  - a Connect four (two red and two black) dual banana plug cables to the Bias T that provides bias voltage to the gate of the Device Under Test (DUT).
  - b The other ends of the dual banana plug cables connect to the B2902A front panel Force High, Force Low, Sense High, and Sense Low connectors.
  - c Connect four (two red and two black) dual banana plug cables to the Bias T that provides bias to the drain/collector of the DUT.
  - d The other ends of the dual banana plug cables connect to the B2902A rear panel Force High, Force Low, Sense High, and Sense Low connectors.



**Figure 30** Connecting the B2902A SMU and the PD1000A Bias T Networks (not all cables shown)

- 3 From the E5080A/B ENA Analyzer, connect the “N” Adapters and SMA cables to the two PD1000A Bias T networks as shown in Figure 31 below:



**Figure 31** E5080A/B ENA with Bias Ts and Test Fixture (used for on-state and off-state S-parameter measurements)

- 4 Ensure that the PC can communicate with the B2902A SMU and the E5080A/B ENA using the Keysight Connection Expert utility in the IO Libraries Suite.

**NOTE**

To communicate with the B2902A SMU and the E5080A/B ENA, Keysight IO libraries must be installed on your external controller. To obtain the latest version of Keysight IO libraries, go to [www.keysight.com/find/IOSuite](http://www.keysight.com/find/IOSuite).

Every E5080A/B ENA is shipped with the Keysight IO libraries installed. Do *NOT* upgrade the Keysight IO libraries on the ENA. Unexpected results may occur.

---



## Running the S-Parameter Characterization

- 1 For specified accuracy, allow the E5080 to warm up for a minimum of one hour before running any S-Parameter tests.
- 2 From the Host PC's Windows **Start** button, **All Programs > Keysight > PD1000A Control**.
- 3 In the PD1000A Control Software, select either the **On State S-Parameter Measurement Control** (biased) test or the **Off State S-Parameter Measurement Control** (zero bias) tab.

### NOTE

Even though the PD1000A Bias Ts do not have a DC voltage applied during off-state S-parameter tests, you may need to leave them in the circuit being tested if the test fixture was calibrated with the Bias Ts in place.

- 4 (Optional) Load any previously saved settings from a file:
  - a Select **Load Settings from File** to display a file selection dialog.
  - b Use the file selection dialog to browse to the directory where you have saved a settings file. The file must be a Keysight Test Settings file (.kts) with the correct filename and extension, for example:
    - **ONSTATE.kts** - for On-State S-Parameter tests
    - **OFFSTATE.kts** - for Off-State S-Parameter tests
  - c Select the file you want.
- 5 Click **Open**. This loads the contents of the file and overwrites the current test settings.

## Configure Common Settings

- 6 Select **Settings > Global Settings**.
  - a **Debug Mode:** Causes the system to send a SCPI `SYST:ERR?` command after each command to identify any errors in the system measurements. Use the **IO Monitor** utility in the IO Libraries Suite to view the error messages.
  - b **Output Directory:** Lists the directory (folder) on the host PC to which the IV and CV characterization data gets saved. Keysight's PD1000A Control Software uses the *EasyEXPERT* format and saves the IV and CV test data with the Keysight IC-CAP Model Data Manager <sup>\*\*</sup> file (\*.mdm). There is no default path or folder, so you must specify the path.
    - Click **Select** to choose a folder on the Host PC. For example, you might create a folder such as: *PD1000AControl*.

<sup>\*\*</sup>MDM data files are an industry standard file format used by the Keysight ADS modeling program for statistical analysis of device characterization data.

-- If you have already chosen a folder and want to see it displayed in a File Explorer window, click **Show in Explorer** to display the folder contents.

#### NOTE

- You must supply the output directory path when you import the characterization data into the PEMG software. See [“Power Electronics Model Generator \(PEMG\) Software”](#) on page 107.
- For file structure, see [“S-Parameter Test Output File Structure”](#) on page 83.

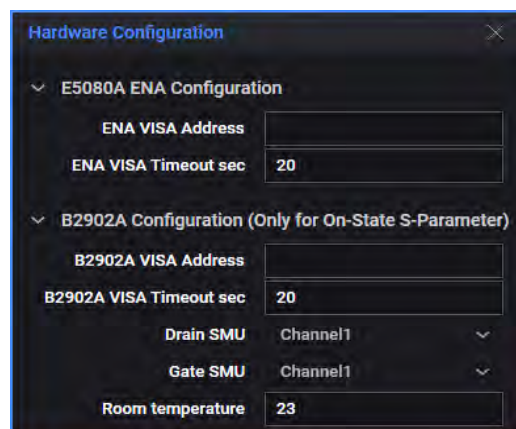
**c** To save settings and close the dialog, click the **DONE** button at the bottom of the dialog.

## Configure System Hardware

- 1 Click **Settings** (upper left in the display window).
- 2 Select either:
  - **Instrument Configuration for ON-State Measurement Control**
  - **Instrument Configuration for OFF-State Measurement Control**

This opens the Hardware Configuration dialog.

- 3 **Configure Hardware.** Use the **Settings** dialogs to specify test instrument VISA addresses, timeout, SMU channels, etc.



**Figure 32** S-Parameter Hardware Configuration Screen

### E5080A/B ENA Configuration

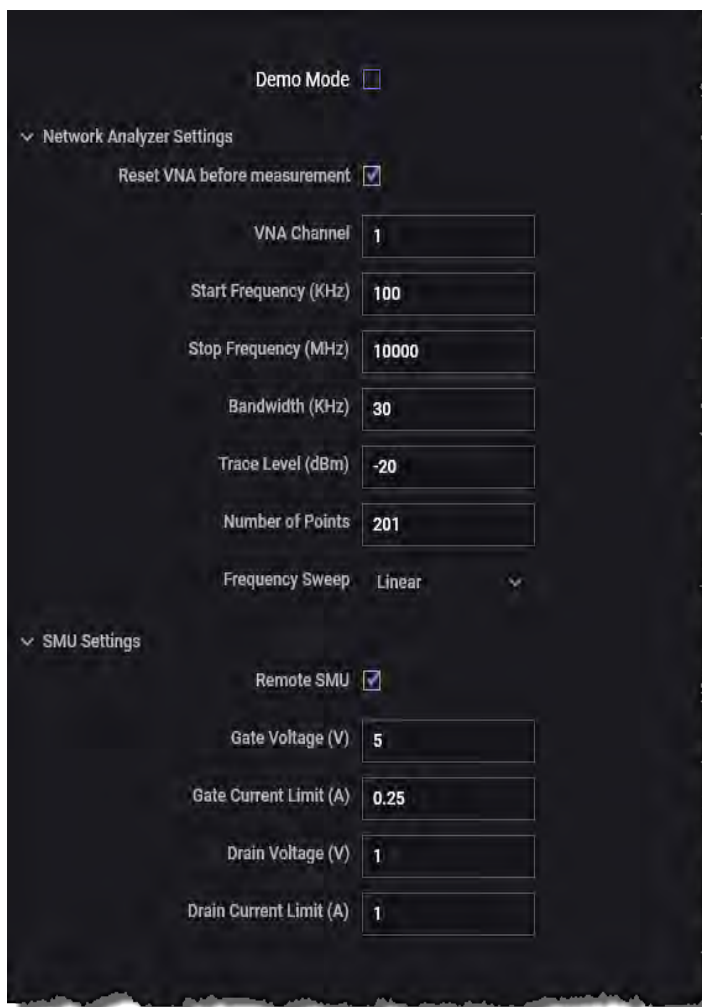
- a ENA VISA Address:** VISA Address of the ENA. See [“Download and Install IO Libraries Suite on your Host PC”](#) on page 19.
- b ENA VISA Timeout (in seconds):** Maximum time that the PD1000A waits for the ENA to respond to commands. (Typical value is 30 seconds.)

**B2902A Configuration (Only for On-State S-Parameter)**

- a B2902A VISA Address:** Locate the B2902A VISA address in the Connection Expert utility in the Keysight IO Libraries Suite.
- b B2902A VISA Timeout (in seconds):** Maximum time that the PD1000A waits for the B2902A to respond to commands. 10 seconds is typical.
- c Drain SMU:** Use the drop-down menu to choose which channel to use for biasing the DUT drain/collector. Typically, this is **Channel 2** of the SMU.
- d Gate SMU:** Use the drop-down menu to choose which channel to use for biasing the DUT Gate. Typically, this is **Channel 1** of the SMU.
- e Room temperature:** Specifies the temperature in °C for the room in which the tests are made. (This information is used in the output .mdm file.)
- f** To save settings and close the dialog, click the **DONE** button at the bottom of the dialog.

## Configure Test Parameters

- 1 Enter the Network Analyzer and SMU settings for the test (for example, frequency range, ENA channel, SMU voltages and current limits, etc.).



The screenshot displays a configuration window with a dark background. At the top, there is a 'Demo Mode' checkbox which is currently unchecked. Below this, the 'Network Analyzer Settings' section is expanded, showing several parameters: 'Reset VNA before measurement' (checked), 'VNA Channel' (1), 'Start Frequency (KHz)' (100), 'Stop Frequency (MHz)' (10000), 'Bandwidth (KHz)' (30), 'Trace Level (dBm)' (-20), 'Number of Points' (201), and 'Frequency Sweep' (Linear). The 'SMU Settings' section is also expanded, showing: 'Remote SMU' (checked), 'Gate Voltage (V)' (5), 'Gate Current Limit (A)' (0.25), 'Drain Voltage (V)' (1), and 'Drain Current Limit (A)' (1).

**Figure 33** Select the Device Type to be Measured Drop-Down Menu

- **Demo Mode:** (Optional) Check this box if you want to run the S-Parameter Demonstration. This provides a simple S-parameter plot and result (\*.mdm) file. See “S-Parameter Demo” on page 116.

- **Network Analyzer Settings:**

-- **Reset VNA before measurement:** sets the option to recalibrate the analyzer when you run a new test/measurement. When this box is checked (default), the software prompts you to calibrate the network analyzer when you start a measurement. You must recalibrate:

**A)** Before your first use of the system.

**B)** Any time you have changed the configuration settings (frequency, power, sweep type, filter bandwidth, trace level, frequency sweep).

**C)** Periodically, because test fixture contacts may degrade slightly over time, especially with frequent use.

Deselect (uncheck) this box only if you want to skip the option to calibrate the network analyzer. This can save time if you want to measure identical DUTs using the same measurement settings. You can simply connect another DUT between each measurement. See more information.

-- **VNA Channel:** Channels contain traces. The analyzer can have up to maximum 500 independent channels. Channel settings determine how the trace data is measured. All traces that are assigned to a channel share the same channel settings.

-- **Start Frequency (KHz):** Specifies the start frequency of the swept measurement range.

-- **Stop Frequency (MHz):** Specifies the end frequency of the swept measurement range.

-- **Bandwidth (kHz):** Sets the bandwidth of the digital IF filter to be used in the measurement.

-- **Trace Level (dBm):** Sets the power level for the specified network analyzer port.

-- **Number of Points:** Enter the number of data points to be displayed.

-- **Frequency Sweep:** Select either Linear or Logarithmic display

- **SMU Settings:**

-- **Remote SMU:** If this box is checked (default) the test uses the following SMU settings to configure the B2902A SMU for the test. If the box is unchecked, you must setup up the SMU manually. However, you still must enter values for the Gate Voltage (V) and Drain Voltages (V) fields (to correctly record the S-parameter device characterization data to the output directory).

-- **Gate Voltage (V):** Enter the voltage for SMU Channel 1 (front panel) of the B2902A SMU. Typically, this connects to the Gate of the FET or IGBT.



-- **Gate Current Limit (A):** Enter the Current Limit for SMU Channel1 (front panel) of the B2902A SMU.

- **Drain Voltage (V):** Enter the voltage for SMU Channel 2 (rear panel) of the B2902A SMU. Typically, this connects to the drain of the FET or collector of the IGBT.
  - **Drain Current Limit (A):** Enter the Current Limit for SMU Channel 2 (rear panel) of the B2902A SMU.
- 2** (Optional) To save set-up time, you can save all configuration settings and general settings to a file that you can re-use to skip the configuration process the next time you test a DUT that uses the same settings.
- a** Click on **Settings** on the main screen.
  - b** Select **Save Settings to File**. This displays a file save dialog.
  - c** Use the dialog to browse to the directory where you want to store the settings.
  - d** Type a file name for the settings file using one of the following formats:
    - **ONSTATE.kts** - for on-state S-parameter tests
    - **OFFSTATE.kts** - for off-state S-parameter tests
  - e** Click **Save**. This saves your current settings into a Keysight Test Settings file (.kts).

## Calibration

Calibrate the ENA with the appropriate PD1000A Test Fixture connected. Use the Calibration Standards supplied with the test fixture. Refer to the *PD1000A Test Fixture User Guide* or the PD1000A Help file for calibration details.

## Run the Test/Measurement

- 1** Click the **Start** button () to start a measurement.
- You can stop an active measurement by clicking the Stop () button.

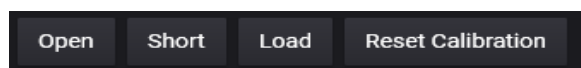
- 2 The PD1000A Control Software system prompts you to calibrate the Network Analyzer.



**Figure 34** Calibrate Network Analyzer Prompt

Calibrate the ENA with the appropriate PD1000A Test Fixture connected. Use the Calibration Standards supplied with the test fixture. Refer to the *PD1000A Test Fixture User Guide* for calibration details.

- If you have already calibrated the analyzer, click the **Continue** button.
- If you want to check the existing calibration or recalibrate for a different DUT, click the **Check Calibration** button. This opens the calibration wizard on the analyzer and adds four new buttons to the Calibration Check dialog. These buttons are designed to help you with the calibration procedure.



- Click the **Open**, **Short**, or **Load** button to display a correct calibration pattern for the network analyzer during the calibration process.
  - Click **Reset Calibration** to reset all calibration settings for the analyzer and fixture.
  - After calibrating, remove the calibration standards from the test fixture and insert the DUT. Click **Continue**.
- 3 After initialization, etc. the test runs and the S-Parameter plots appear on PD1000A software display (on the host PC). Refer to Figure 35 and Figure 35.

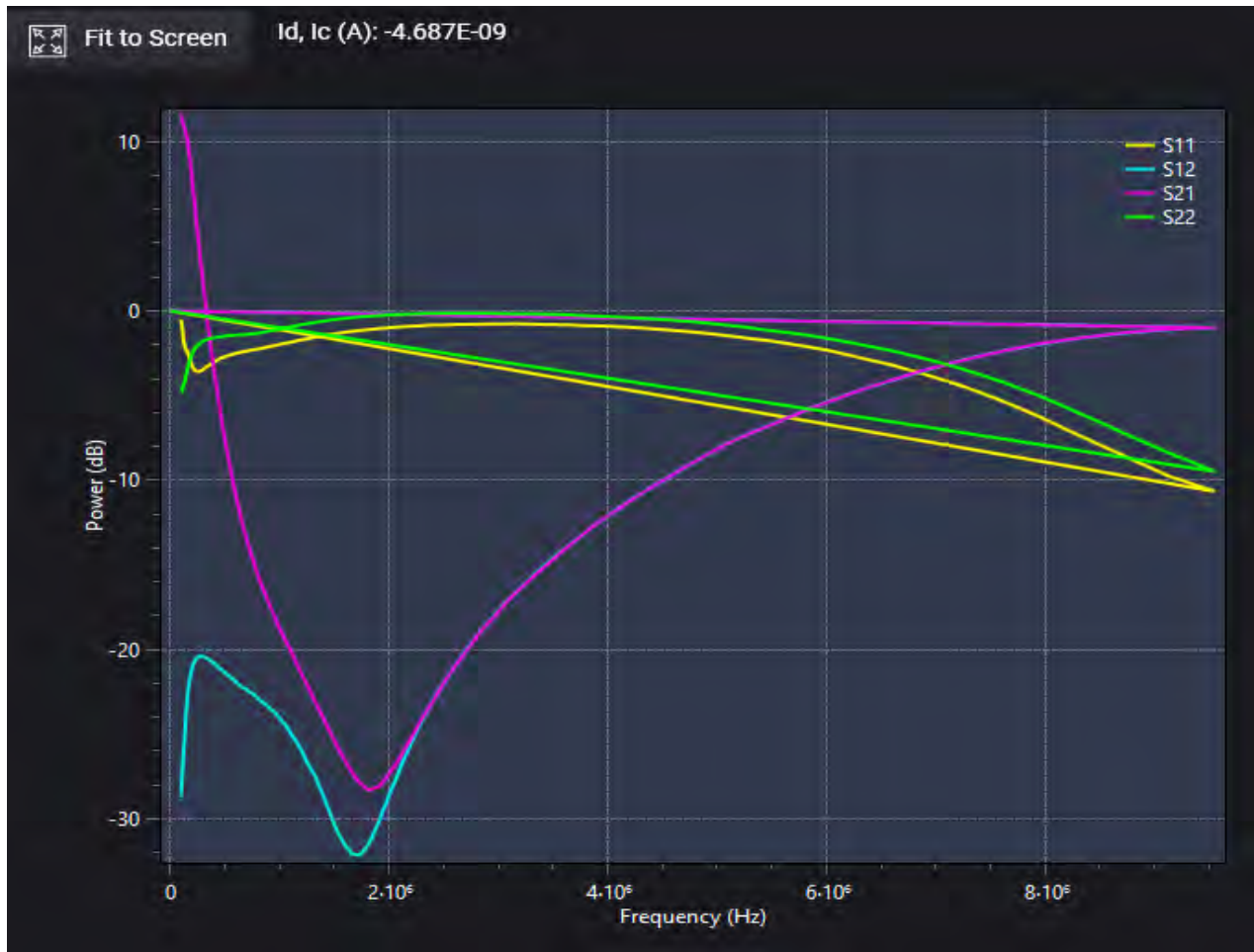
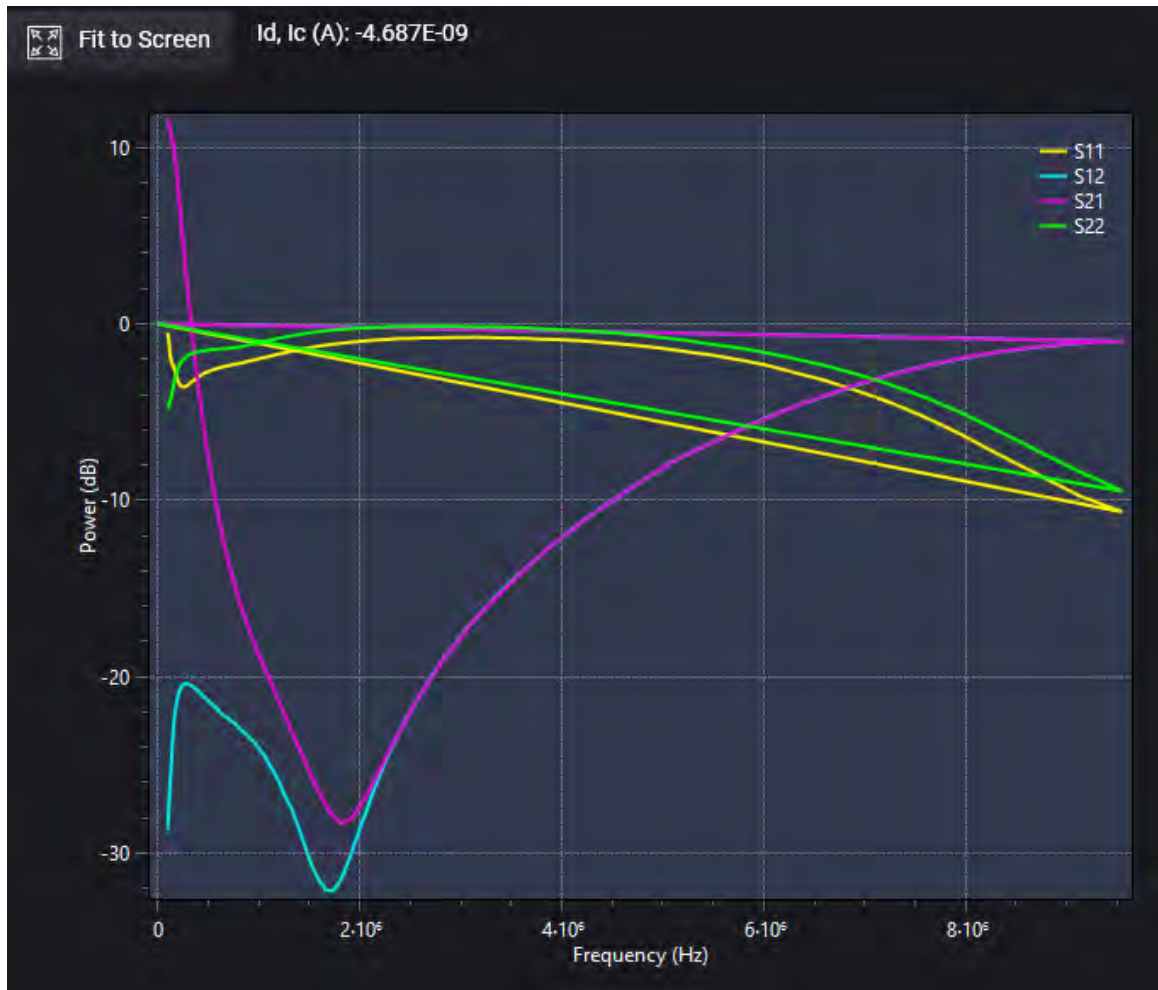


Figure 35 Sample On State Plot for a FET device





**Figure 36** Sample Off State Plot for a FET device

## Capacitance Measurements

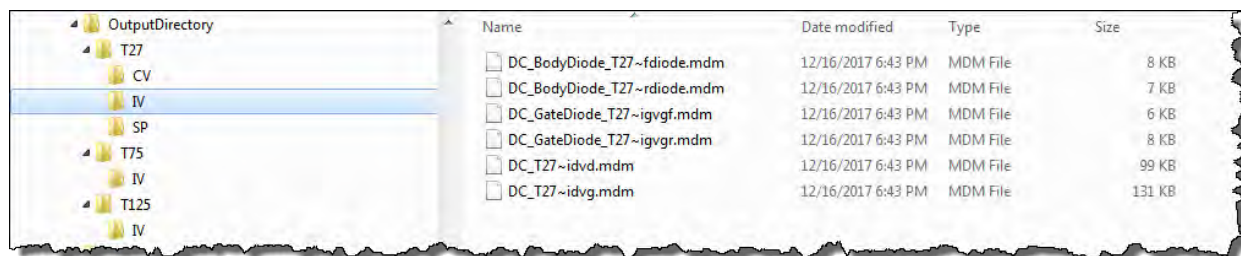
Both the On-State and Off-State S-Parameter measurements provide for making  $C_{dg}$ ,  $C_{gs}$ , and  $C_{ds}$  measurements. The E5080A/B ENA Network Analyzer first extracts the S-Parameter measurements; the Control Software transforms these S-Parameters into Admittance or Y-Parameters and resolves them into the capacitance measurements.

For additional information on measuring Power MOSFET device capacitances, refer to: <http://literature.cdn.keysight.com/litweb/pdf/5990-7145EN.pdf>.

## Additional Information

### S-Parameter Test Output File Structure

The file structure for S-Parameter tests is:



**Figure 37** IV and CV File Structure showing Sample .mdm Files

Notes:

- The *Output Directory* is set in the drop down menu, **Configure Common Settings...** for each test.
- The first level sub-folders (T27, T75, and T125 in the example above) represent the temperatures the device was tested at for IV tests only. The first subfolder is sometimes named “Tnom” for room temperature measurements.
- Multiple \*.mdm files exist in each second level sub-folder. The actual file names to be different depending on whether you are testing an IGBT or a FET. The specific temperature and type of measurement are encoded in the file names.
- The SP sub-folder in the T27 folder is for the On State and Off State S-Parameter tests.
- CV tests and S-Parameter tests are done at room temperature only. Hence, they exist only in the first “T” sub-folder.



## 4 Double-Pulse Test Device Characterization Tests

**IMPORTANT:** This chapter summarizes the operation of the PD1000A Control Software as it is used for the PD1500A Dynamic Power Device Analyzer/Double-Pulse Tester. For detailed information to set-up, configure and use the PD1500A Double-Pulse Test System, refer to the PD1500A specific documentation:

- **PD1500A Control Software Guide:** Provides detailed information to install, configure, and use the PD1000A Control Software for the PD1500A DPT system. PN: PD1500-90001
- **PD1500A System Installation Guide:** Provides detailed information to install the Double-Pulse Rack and Safety Enclosure at a customer's site. PN: PD1500-90002
- **PD1500A Rack and Safety Enclosure Operation Guide:** Provides detailed information to operate and maintain the PD1500 Test Rack and Safety Enclosure. PN: PD1500-90003
- **PD1500A Si/SiC Test Fixture User Guide:** Provides detailed information to install and use the Double-Pulse Test Modules for testing Si/SiC devices in the DPT Test Fixture. PN: PD1500-90004

Documentation and PD1000A Control Software are available at:  
[www.keysight.com/find/PD1500A](http://www.keysight.com/find/PD1500A)

### NOTE

The information in this chapter applies to PD1500A Control Software version 2020.820 (and later) and requires the PD1500A Double-Pulse Test Fixture Firmware version

In this Chapter:

- Run the PD1000A Control Software [page 86](#)
- Configure Common Settings [page 86](#)
- Hardware Configuration: Hardware Tab [page 88](#)
- Measurement Preparation – Calibration & Compensation [page 93](#)
- Standard Double-Pulse Characterization Test [page 94](#)
- Clamped Double-Pulse Test [page 95](#)
- DPT Reverse Recovery Test [page 96](#)
- Set Double-Pulse Test Parameters [page 97](#)
- Measurement Parameters for Standard, Clamp, and Reverse Tests [page 101](#)
- Run the Characterization Test [page 104](#)

## Run the PD1000A Control Software

**NOTE**

For specified system accuracy, allow all of the instruments in the Double-Pulse Test Rack and Safety Enclosure to warm up for a minimum of one hour (60 minutes) before running any DPT tests.

- 1 From the Host PC's Windows **Start** button, select:  
**Keysight > Keysight PD1000A Control.**
- 2 In the PD1000A Control Software, select the **Double-Pulse Measurement Control** tab.

**NOTE**

**IMPORTANT.** VISA addresses for all of the Double-Pulse Test test instruments (DSOS104 Oscilloscope, Waveform Generator, Test Fixture, etc.) must be established before configuring and running the DPT tests. Refer to the *PD1500A System Installation Guide*.

## Configure Common Settings

Click on the **Settings** icon at the top of the screen.

**Global Settings** This opens the Global Settings dialog.

- **Debug Mode:** Used to troubleshoot software problems.
- **Output Directory:** Enter the complete path and directory (folder) on the host PC to which the DPT characterization data gets saved. There is no default path or folder, so you must specify the path.

To save settings and close the dialog, click the Done button.

Characterization data is saved with the following folder structure:

**Device > Model ID > Meas. Type > Voltages Tested > Currents Tested > Temperatures Tested > Date\Time > Test Data Files**

**Hardware Configuration for Double-Pulse Measurement Control:** Allows you to specify instrument connections, Probe Setup, Shunt settings and more. See "Hardware Configuration: Hardware Tab" on page 88 for detailed information. This menu has four tabs:

- **Hardware:** See "Hardware Configuration: Hardware Tab" on page 88.
- **Oscilloscope:** See the PD1000A on-line Help file.
- **Extractions:** See the PD1000A on-line Help file.
- **Calibration:** See the PD1000A on-line Help file.

**Load Settings from File:** Opens a Windows Explorer dialog to the folder specified in **Global Settings > Output Directory**. This allows you to reload saved DPT test settings into the Control Software.

**Save Settings to File:** Opens a Windows Explorer dialog to the folder specified in **Global Settings > Output Directory**. Settings files are saved as .kts files.

**Calibration & Compensation:** Runs the DPT system calibration procedure; including oscilloscope probe compensation. Refer to the *PD1000A Control Software Help File* for additional information. Follow all on-screen instructions.

**About:** Displays a screen showing the Control Software version.

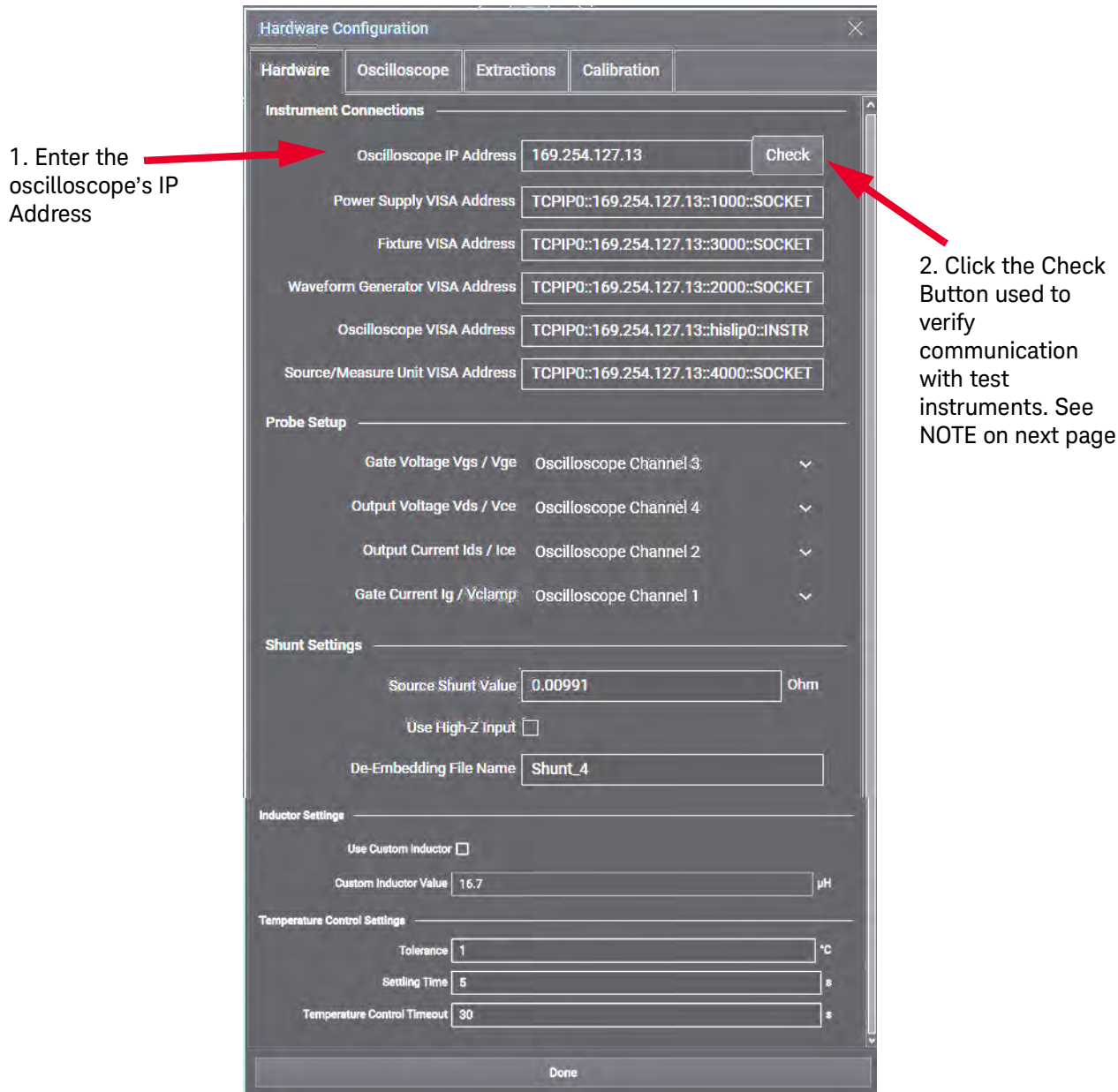
**NOTE**

**IMPORTANT:** If you are using a laptop computer, turn the Wireless Network Connection off in the laptop before connecting to the PD1500A system.

---

## Hardware Configuration: Hardware Tab

Selecting the **Instrument Configuration Hardware** tab opens the following dialog.



**Figure 38** Double-Pulse Test Hardware Configuration Screen

**NOTE**

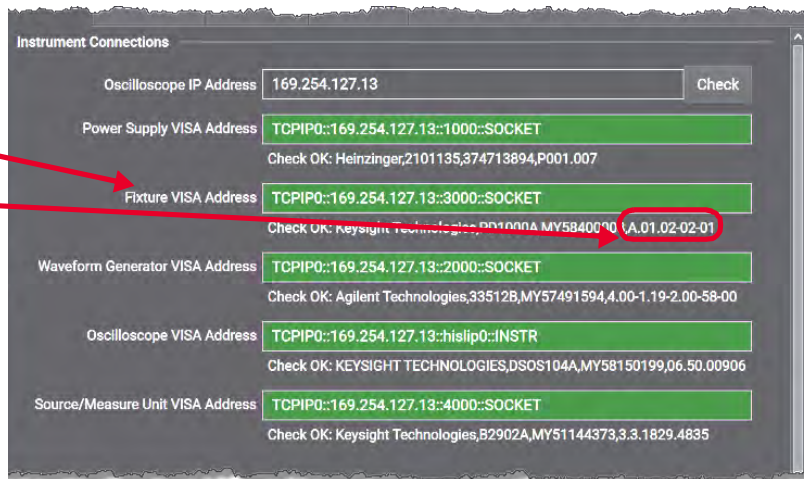
**IMPORTANT:** If you are using a laptop computer, turn the Wireless Network Connection off in the laptop before connecting to the PD1500A system.



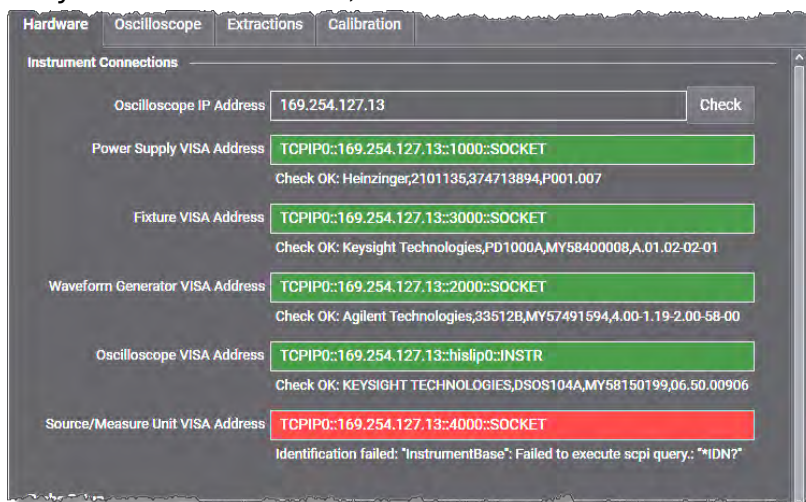
**NOTE**

Click the Check button to verify that the Control software can communicate with all of the DPT system instruments. It sends a SCPI \*IDN? command to each instrument and expects the correct identification string from each instrument. After a few moments, all of the addresses should update and turn green:

Fixture VISA Address shows the firmware version of the PD1500A Test Fixture. In this example, it is A.01.01-02-01.



If any or all of them are red, it indicates a failure to communicate.



**IMPORTANT:** If you are using a laptop computer, turn the Wireless Network Connection off in the laptop before connecting to the PD1500A system.

## Instrument Connections

Instrument VISA addresses should be automatically populated during the initial PD1500A Installation. If not, refer to the *PD1500A System Installation Guide*. See Note below.

- **Oscilloscope IP Address:** Enter the IP address of the DSOS Oscilloscope. This was initially entered by the Keysight Application Engineer when the PD1500A system was installed. If the system is moved or the IP address changes, you must enter the new IP Address:
  - a On the DSOS 104 Oscilloscope, touch the **Utilities** soft key at the top of the screen.
  - b Touch **Remote**.
  - c Locate the **Web Interface** field. Do **NOT** use the 192.168.25.2 address. Use the other address as the **Oscilloscope IP Address**.
- **Power Supply VISA Address:** Shows the VISA address of the Henizinger EVO Power supply.
- **Fixture VISA Address:** Shows the VISA address of the DPT Test Fixture. This address is fixed and cannot be changed.
- **Waveform Generator VISA Address:** Shows the VISA address of the 33512 Waveform Generator.
- **Oscilloscope VISA Address:** Shows the VISA address of the DSOS104A Oscilloscope.
- **Source/Measure Unit VISA Address:** Shows the VISA Address of the B2902A Source/Measure Unit. The B2902A is used for system calibration only. Double-Pulse tests will run without error if this address is red.

## Probe Setup

Refer to “Connect Oscilloscope Probes to Oscilloscope” in the PD1500A Software Guide for an explanation of the various probe locations.

- **Gate Voltage  $V_{GS}/V_{GE}$ :** Specify oscilloscope channel (Channel 1 through 4) for the Control Signal measurement. This is the Gate Voltage measured on the Low-Side Gate Drive Module by the N2873A 10:1 Oscilloscope Probe.
- **Output Voltage  $V_{DS}/V_{CE}$ :** Specify oscilloscope channel for the Output Voltage measurement. This is the Source Voltage measured on the DUT Module with the 10076C 100:1 High Voltage Probe.
- **Output Current  $I_{DS}/I_{CE}$ :** Specify oscilloscope channel for Output Current measurement. This is the current measured across the Coaxial Shunt Resistor with the PD1000-60002 Oscilloscope Probe.

- **Gate Current  $I_G/V_{CLAMP}$ :** Specify oscilloscope channel for Gate current measurement  $I_G$  or the  $V_{CLAMP}$  measurement.  $I_G$  is the current measured across the Gate Current Shunt Resistor (Low-Side Gate Drive Module) with the N2819A Differential Probe.  $V_{CLAMP}$  is the Clamped Output Voltage measured with an N2873A 10:1 Oscilloscope Probe. **NOTE:**  $V_{CLAMP}$  tests require use of the Clamp Test Module (PD1000-66505).

**NOTE**

For the Clamp DPT test, use the Clamp Circuit Module and do not install the N2819A Differential Probe. Instead, install one N2873A 10:1 Oscilloscope Probe that connects to the Clamp Test Module ( $V_{CLAMP}$ ) probe socket. Do not exceed 400 Volts  $V_{DS}$  or  $V_{CE}$ .

### Shunt Settings

- **Source Shunt Value:** Enter value, in Ohms, of the Coaxial Shunt Resistor. This value is printed on the shunt label. The default/nominal value for the Keysight PD1000-61901 Shunt is 0.01  $\Omega$ .
- **Use High Impedance Input** (checkbox): Leave the box unchecked when using the Coaxial Current Shunt with the PD1000-60002 Oscilloscope Protection Probe. Check the box if you are not using the PD1000-60002 Oscilloscope Protection Probe and the top of the Coaxial Shunt connects directly to the oscilloscope (High Z input).
- **De-embedding File:** Enter the full path and de-embedding file name (for example, *PD1000-61901\_xxxx.tf2* (where “xxx” is the shunt’s serial number). The file should be installed in the DS104A oscilloscope in the folder:  
*C:\Users\Public\Documents\Infiniium\Filters.*

### Inductor Settings

With software version 2020.820 (and later) you have the option to use the standard, internal inductor (internal to the PD1500A Test Fixture) or an external, custom inductor. To use the internal inductor, leave the checkbox unchecked. If you choose to use an external inductor, check the **Use Custom Inductor** checkbox. Enter the value of the inductor, in microHenrys ( $\mu\text{H}$ ), in the **Custom Inductor** Value field. Recommended rang of inductors is from 16.7  $\mu\text{H}$  to 120  $\mu\text{H}$ .

Refer to PD1500A Using an External Inductor (PD1500-90006) for detailed information about designing or selecting, and installing a custom, external inductor on the PD1500A Test Fixture DUT module.

**CAUTION**

When using an external inductor, the internal inductor must be disconnected. Automatic switching between normal double pulse test and reverse recovery test is not possible with an external inductor.

## Temperature Control Settings

See Appendix A for a detailed description about using the device heater with the Double-Pulse Test Control Software.

- **Tolerance:** Specify a range ( $\pm$ ) around the specified temperature for triggering the DPT measurement. For example, if you specify making a DPT measurement at 50 °C and a 1 °C Tolerance, then the measurement is triggered somewhere between 49 °C and 51 °C.
- **Settling Time:** Specify a time period (in seconds) to wait after the DUT reaches the specified temperature (withing the specified range) before triggering the DPT measurement.
- **Temperature Control Timeout:** Specify the maximum time period (in seconds) to wait for the device to reach the specified temperature before triggering the measurement. If the device does not reach the specified temperature within this time period, the DPT test aborts.

For example, to go from ambient temperature (~25 °C) to 100 °C with a 2 °C Tolerance may take up to 60 seconds. To go from Ambient to 100 °C with a 1 °C Tolerance may take up to 90 seconds.

## Measurement Preparation – Calibration & Compensation

Oscilloscope probe compensation, Deskew, and De-embedding are not formal calibration procedures. They are additional steps that the Double-Pulse Test (DPT) system operator should perform periodically to achieve the most accurate measurements. System Calibration is a formal calibration procedure. For accurate DPT measurements, it is very important to calibrate the DPT system to insure that all delays are equivalent.

### NOTE

It is not necessary to set the oscilloscope probe compensation, or run Deskew before each DPT test. However, a complete calibration should be performed whenever the Gate Drive modules are changed, ambient temperature changes more than  $\pm 5$  °C or when any change is made to the DPT system.

### Oscilloscope Probe Compensation

Prior to running Deskew, system calibration, or DPT tests, the oscilloscope probes must be adjusted for low frequency compensation. The 10076C and N2873A passive probes have built-in compensation RC divider networks. The N2819A Active Differential Probe also requires offset compensation. See “Oscilloscope Probe Compensation” on page 93.

### DPT System Calibration

System calibration is a formal calibration of the DPT system. For detailed instructions, refer to the *PD1500A Service Guide*.

### Oscilloscope Probe Deskew

Deskew is a process of applying a square wave from the Waveform Generator to all four channels of the oscilloscope simultaneously. The DPT Control Software measures the time difference between channels relative to Channel 1 and sends a command to the oscilloscope to automatically calculate and set the channel-to-channel skew factor. Deskew should be performed anytime the ambient temperature changes  $\pm 5$  °C.

### De-embedding

The Coaxial Shunt should be calibrated annually and its transfer file (.t2f) installed in the DSOS104 Oscilloscope. This provides frequency compensation correction for the shunt. Coaxial Shunt De-embedding is applied to the oscilloscope channel you specify for the **Output Current**.

## Standard Double-Pulse Characterization Test

A Standard Double-Pulse Test is a common method for characterizing WBG power transistors. In general, it characterizes the turn-on and turn-off behavior for different supply voltages and different current levels. Two power transistors are configured in a totem-pole configuration (also called a half-bridge configuration). The Low-Side transistor is referred to as the Device Under Test (DUT). For proper operation, the body diode of the High-Side transistor is mandatory and is also used for the Reverse Recovery test.

### Use these Double-Pulse Test Modules and Oscilloscope Probes

The Standard DPT test uses the following Test Modules and Oscilloscope Probes:

- Any Keysight Low-Side and matching High-Side Gate Drive Module.
- Either the PD1000-60901 DUT Module for TO-247 3-pin devices or the PD1000-62401 DUT Module for D<sup>2</sup>PAK (TO-263) SMD devices.
- N2819A 10:1 Differential Oscilloscope Probe to measure Gate Current, I<sub>G</sub>.
- PD1000-60002 Protection Probe for measuring I<sub>D</sub>.
- N2873 10:1 Standard Oscilloscope Probe for measuring V<sub>GS</sub> on the Low-Side Gate Drive Module.
- 10076C 100:1 High Voltage Probe for measuring V<sub>DS</sub> on the DUT Module.
- **IMPORTANT:** Remove the PD1000-66505 Clamp Module. Cycle power if necessary.

## Clamped Double-Pulse Test

The DPT Clamp Test is the same as the Standard test but uses the Clamp Circuit module (PD1000-66505). For accurate  $R_{bs(on)}$  measurements the clamping circuit limits the applied voltage level to the oscilloscope probe while the DUT is turned off. This way an oscilloscope probe with a lower divider ratio (10:1) can be used for accurately measuring  $V_{DS}$  while the transistor is turned on.

### Use these Double-Pulse Test Modules and Oscilloscope Probes

This Clamped DPT test uses the following Test Modules and Oscilloscope Probes:

- Any Low-Side and High-Side Gate Drive Module.
- Either the PD1000-60901 TO-247 3-pin DUT Module or the PD1000-62401 DUT Module for D<sup>2</sup>PAK (TO-263) SMD devices.
- PD1000-66505 Clamp Circuit Module. Use only when running the Clamp test; otherwise remove it.
- 10076C 100:1 High Voltage Probe for measuring  $V_{DS}$  on the DUT Module.
- PD1000-60002 Protection Probe for measuring  $I_D$ .
- N2873 10:1 Standard Oscilloscope Probe for measuring  $V_{GS}$  on the Low-Side Gate Drive Module.
- N2873 10:1 Standard Oscilloscope Probe for measuring  $V_{DS}$  on the Clamp Circuit Module.

The Clamp Circuit Module provides the following:

- Clamps voltage to levels suitable for using the N2873A 10:1 passive probe.
- Characterized systematic errors so that they can be taken into account.
- Quantified achievable accuracy.

For detailed information about the Clamp Circuit Module and its use, refer to the *PD1500A DPT Test Fixture and Modules Installation and Use Guide*.

#### CAUTION

The maximum  $V_{DS}$  or  $V_{CE}$  test voltage that may be applied to the Clamp Circuit Module is 400 V. This for both IGBT ( $V_{CE}$ ) and FET ( $V_{DS}$ ) devices.

#### NOTE

When installing or removing the PD1000-66505 Clamp Module, you must cycle power on the PD1500A rack in order for the change to be discovered.

#### CAUTION

The maximum test voltage that may be applied to the Clamp Circuit Module is 400 V. This for both IGBT and FET devices.

## DPT Reverse Recovery Test

Reverse Recovery tests characterize the body diode in the High-Side device on the DUT Test Module. If a diode is conducting in a forward direction and immediately switched to a reverse bias condition, the diode continues to conduct in the reverse bias state for a very short time as the forward voltage bleeds off. The current through the diode is fairly large in the reverse direction during this small recovery time.

After the carriers are flushed and the diode is acting as a normal blocking device in the reverse bias condition, the current flow drops to normal leakage levels.

### Use these Double-Pulse Test Modules and Oscilloscope Probes

This Reverse Recovery DPT test uses the following Test Module and Oscilloscope Probes:

- Any Keysight Low-Side and matching High-Side Gate Drive Module.
- Either the PD1000-60901 DUT Module for TO-247 3-pin devices or the PD1000-62401 DUT Module for D<sup>2</sup>PAK (TO-263) SMD devices.
- N2819A 10:1 Differential Oscilloscope Probe to measure Gate Current, I<sub>G</sub>.
- PD1000-60002 Protection Probe for measuring I<sub>D</sub>.
- N2873 10:1 Standard Oscilloscope Probe for measuring V<sub>GS</sub> on the Low-Side Gate Drive Module.
- 10076C 100:1 High Voltage Probe for measuring V<sub>DS</sub> on the DUT Module.
- **IMPORTANT:** Remove the PD1000-66505 Clamp Module. Cycle power if necessary.



## Set Double-Pulse Test Parameters

Most DUT test parameters can be obtained from the DUT data sheet.


### Gate Resistance:

All of the Keysight Gate Drive Modules have two series resistors for the Gate Resistor. Both resistors are the same value. For example, the PD1000-66544 10  $\Omega$  Gate Drive Module has two 4.99  $\Omega$  resistors in series for the 9.98  $\Omega$   $R_G$ . The Control Software reads the value of one of the two gate resistors from the Low-Side Gate Drive module and displays the value here. For the Low-Side gate resistance, the actual measured/calibrated value is displayed; for the High-Side gate resistance, only the nominal value is displayed.

Remember, both the High-Side and Low-Side Gate Drive modules should have gate resistors,  $R_G$ , of the same resistance.

For Gate Drive modules with no installed gate resistor (the PD1000-66540 and -66541 modules),  $R_G$  is measured during system calibration which must be done prior to running Double-Pulse tests

#### NOTE

Click the refresh button (  ) next to the Gate Resistance to force the software to read the current gate resistor value. Do this when you first start the Control Software and anytime you change the Gate Drive Modules. This also ensures the resistor has not failed.

### Custom Inductor Value:

Inductance: With software version 2020.820 (and later) you have the option to use the standard, internal inductor (internal to the PD1500A Test Fixture) or an external, custom inductor. Custom Inductor Value appears only if you have specified using a custom inductor in the **Hardware Configuration > Inductor Settings** dialog.

If you are using an external inductor, enter the value of the inductor in the Hardware Setting screen. The value appears in the **Custom Inductor Value > Inductance** field.

Refer to *PD1500A Using an External Inductor* for detailed information about selecting (or designing your own) and installing an external inductor on the PD1500A Test Fixture DUT module.

#### CAUTION

When using an external inductor, the internal inductor must be disconnected. Automatic switching between normal double pulse test and reverse recovery test is not possible with an external inductor.

## DUT Parameters

- **MAX Voltage:** Specify the maximum voltage ( $V_{DSS}$  or  $V_{CES}$ ) that may be applied across the device (Drain to Source or Collector to Emitter). Obtain value from the device data sheet.
- **MAX Current:** Specify the maximum current ( $I_D$  or  $I_C$ ) that may be used to test the DUT (Drain to Source or Collector to Emitter). Obtain value from the device data sheet.
- **MAX Power:** Specify the maximum power that may be applied to the DUT. This value is generally not specified on the device data sheet.

### NOTE

As a general guideline, the typical operating voltage for a FET or IGBT is much lower than the Maximum Rated voltage ( $V_{DSS}$  or  $V_{CES}$ ). The following examples are typical and not hard rules:

$V_{DSS}$ Rating:	Typical Operating Voltage:
600 V	400 V
1200 V	600 V
1700 V	900 V

- **Model ID:** A text field to enter the model or device type of the DUT, or any other text information you want to record. Characters not legal for file paths (e.g., \, /, ?, <, >, ...) are replaced by the character “\_”. If nothing is entered, the word “*Unknown*” is used.
- **Device Type:** (Drop-down menu item): Select either FET, IGBT, or GaN for the device to be tested (DUT).

### NOTE

**IMPORTANT:** Testing GaN devices esquires a special Test Fixture and DUT module that are not available at this time. Contact your local Keysight Application Engineer for availability and information.

### NOTE

GaN devices have different system limits that FET or IGBT devices. GaN devices are limited to:

Maximum System Voltage ; 500 V  
 Minimum System Current: ; 1 A  
 Maximum System Current ; 100 A

- **Loop Count:** Specify number of times to repeat the DPT test with the current parameter settings. See Note, “**Looping or Sweeping Multiple DPT Tests**” below.

- **Activate Heater:** Turns the heater circuit on or off. Remember to set the Temperature Control Settings in the Hardware Configuration Menu (see “Temperature Control Settings” on page 92). See Appendix A for a detailed description about using the device heater with the Double-Pulse Test Control Software.
- **Temperatures:** Enter a single value or a semicolon (;) delimited list of temperatures to heat the device to when running the DPT tests. 175 °C<sup>a</sup> Maximum. This box is grayed-out unless **Activate Heater** is checked. See Note, “**Looping or Sweeping Multiple DPT Tests**”.
- **Loop delay:** Specify the delay time (in seconds) for the DPT test to idle before running each DPT test in a loop. This time allows the device to cool if you use the heater. See Note, “**Looping or Sweeping Multiple DPT Tests**” below.

**NOTE**

**Looping or Sweeping Multiple DPT Tests.** When running multiple tests on a device, loops are nested:

```

Loop Count {
  Temperature {
    Sweep Voltage Values (VDS) {
      Sweep Current Values (IDS)
    }
  }
}


```

That is, all “Sweep Current Values” are tested before incrementing the “Sweep Voltage Value”. All “Sweep Voltage Values” are tested before incrementing “Temperature”. All “Temperatures” are tested before incrementing “Loop Count”. When looping DPT tests, all measurement data is saved in the directory specified in the **Settings > Global Settings** menu.

- **Use Test Pulse** (checkbox): When checked, click **Start** to run a low voltage/low current Double-Pulse Test (50 V<sub>DS</sub>) before the actual measurement begins. This verifies that the DUT is functional and has not been destroyed. Note, because of the low voltage/low current, the I<sub>G</sub> and I<sub>DS</sub> measurements will appear noisy on the oscilloscope. If the Test Pulse measurement succeeds, the complete test runs at full voltage and current.
- **Extract Characteristics** (checkbox): If not checked, only the *Oscilloscope Capture* view and test Parameters are available. If checked, additional device characterization data is extracted and saved. See the *PD1500A Control Software Help* file for additional information.

<sup>a</sup> Requires Software version 2020.820 or later. Ambient to +175 °C for T0-247 device packages only; ambient to +150 °C for SMD devices.

- **Extract IV Curve** (checkbox, available only in Standard DPT Test): This checkbox is grayed-out (not available) unless the **Extract Characteristics** box is checked. If checked, the complete I/V derivation is extracted and saved. If a Gate Drive Module with a gate resistor ( $R_G$ )  $10\ \Omega$  or greater was used in the DPT test, then the Gate Charge data is displayed. **Note:**  $100\ \Omega$  Gate Resistor ( $R_G$ ) is recommended for IV derivation.
- **Vgs Resolution:** This field is grayed-out (not available) unless the **Extract IV Curve** box is checked. Enter a single value to be used for the extraction of the IV curves.
- **Extract Gate Charge:** (available only in Standard DPT Test) Extracts and plots Gate Charge information.
- **Clamp Voltage:** (available only in Clamp DPT Test). Clamp voltage is fixed at  $8\ V_{DC}$  and cannot be changed.
- **Expected I<sub>rrm</sub>:** (available only in Reverse DPT Test). Maximum Reverse Recovery Current of a fast or ultrafast diode; such as often used in switch-mode power supplies). Enter the maximum current the body diode is rated for.
- **DUT °C:** Indicates the temperature of the DUT if the Heater/Thermocouple assembly is connected to the Test Fixture. If the Heater/Thermocouple assembly is not connected to the test fixture or if Activate Heater is not selected, NaN (Not a Number) is shown.
- **Ambient °C:** Indicated the ambient temperature inside the Safety Hood enclosure. Sources for the temperature readings are three internal fixture sensors and scope temperature reading to make sure it is not overheating.

Click the Refresh button (  ) to read the current temperatures. See Appendix B for a detailed description about using the device heater with the Double-Pulse Test Control Software.

## Measurement Parameters for Standard, Clamp, and Reverse Tests

Control Signal (Gate Voltage ( $V_{GS}$  or  $V_{GE}$ )):

- **Gate Pulse High:** A single voltage level for the turn-on Gate Pulse. For the *Standard* and *Clamp* tests, this is for the Low-Side device (DUT). For the *Reverse Recovery* test, this is for the High-Side device. Minimum value for the Gate Pulse High = +13 V. Maximum value = +29 V. The difference between Gate Pulse High and Gate Pulse Low must be less than 30 V.
- **Gate Pulse Low:** The voltage level of the Gate Pulse; used to ensure the DUT is fully turned off. For the *Standard* and *Clamp* tests, this is for the Low-Side device (DUT). For the *Reverse Recovery* test, this is for the High-Side device. Minimum value = -10 V. Maximum value = 0 V

**NOTE**

The maximum difference between Gate Pulse High and Gate Pulse Low must not exceed 30 V.

---

- **Unused Transistor Gate Voltage:** This sets the Gate Voltage for the device *not* being tested. For the *Standard* and *Clamp* tests, this is the High-Side device (DUT). For the *Reverse Recovery* test, this is the Low-Side device.
- **2nd On Time:** Enter the time, in microseconds, when the DUT is turned on a second time (and  $V_{DS}$  is minimum). For example, 2 microseconds is expressed as "2E-6". Minimum 200 nS, Maximum 10  $\mu$ S.
- **Off Time:** Enter the time, in microseconds, between when the DUT is turned off (and  $V_{DS}$  is maximum) and when the DUT is turned on a second time. For example, 2 microseconds is expressed as "2E-6". Minimum 200 nS, Maximum 10  $\mu$ S.

**NOTE**

Keep **2nd On Time** and **Off Time** as short as possible. IGBT and some other slow devices may require longer times. The pulse width must be long enough that the transistor turns fully on (e.g., > 1  $\mu$ S). However, the pulse width must not be too long, otherwise, the measurement will be influenced by self-heating of the transistor. 200 nS is the minimum time.

---

## Output Voltage ( $V_{DS}$ or $V_{CE}$ ):

The Double-Pulse Test can either test at a single  $V_{DS}/V_{CE}$  Output Voltage or sweep a series with multiple  $V_{DS}/V_{CE}$  Output Voltages.

### CAUTION

The maximum test voltage that may be applied to the Clamp Circuit Module is 400 V. This for both IGBT and FET devices.

- **Single/Start:** Either a single voltage value. If **Sweep Voltage** is not checked, then the test runs with only this single voltage value. However, if **Sweep Voltage** is checked, this becomes the beginning voltage for sweeping. Minimum Voltage = 50 V<sup>b</sup>, Maximum Voltage = 1200 VDC. See **Looping or Sweeping Multiple DPT Tests** note above.
  - **Sweep Voltage:** Check this box to allow sweeping at multiple voltages. See Sweeping note below.
  - **Stop:** Sets the last or maximum voltage for sweep measurements. See Sweeping note below.
  - **# of Points:** Sets the number of voltages between **Single/Start** and **Stop** for sweeping. See Sweeping Voltage Example note below.

### NOTE

**Sweeping Voltage Example:** As a sweep example, suppose you want to run Double-Pulse Tests at the following  $V_{DS}/V_{CE}$  voltages: 100, 150, 200, 250, 300, 350, 400 Volts.

- Check the **Sweep Voltage** box.
- Set **Single/Start** voltage at 100.
- Set the **Stop** voltage at 400,
- Set the **# of Points** at 7. This sets the Step Voltage to 50 V.
- Then click **Start** to run the test.

<sup>b</sup> Values less than 50 V are possible but have not been tested. Current is limited by the energy in the capacitor.

## Output Current ( $I_{DS}$ or $I_{CE}$ ):

The Double-Pulse Test can either test at a single  $I_{DS}$  or  $I_{CE}$  Output Current or test with sweep with multiple  $I_{DS}$  or  $I_{CE}$  Output Currents.

- **Single/Start:** Either a single current value. If **Sweep Current** is not checked, then the test runs with only this single current value. However, if **Sweep Current** is checked, this becomes the beginning current for sweeping. Minimum current = 10 A<sup>c</sup>, Maximum current = 200 A. See **Looping or Sweeping Multiple DPT Tests** note above.
- **Sweep Current:** Check this box to allow sweeping at multiple currents. See Sweeping note below.
- **Stop:** Sets the last or maximum current for sweep measurements. See Sweeping note below.
- **# of Points:** Sets the number of current values between **Single/Start** and **Stop** for sweeping. See Sweeping Current Example note below.

### NOTE

**Sweeping Current Example:** As a sweep example, suppose you want to run Double-Pulse Tests at the following  $I_{DS}$  or  $I_{CE}$  currents: 10, 15, 20, 25, 30, 35, 40 Amps.


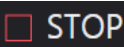

- Check the **Sweep Current** box.
- Set **Single/Start** voltage at 10.
- Set the **Stop** voltage at 40,
- Set the **# of Points** at 7. This sets the Step Current to 5.00 A.
- Then click **Start** to run the test.

- 
- **Current Tolerance %:** Specify a Tolerance value used is setting the pulse width to obtain current values. For example, if you specify a current of 40 A and a tolerance of 5% then the actual current used in the test will be between 38 and 42 A. Value must be greater than zero (0).

<sup>c</sup> Values less than 10 A are possible but have not been tested. Current is limited by the energy in the capacitor.

## Run the Characterization Test

After selecting the type of test (Standard, Clamp, or Reverse Recovery) setting the test parameters:

- 1 Click the **Start** button (  ) to start a measurement or a loop of measurements.  
– Stop an active measurement by clicking the **Stop** (  ) button.
- 2 The DPT Control Software calculates the amount of energy that it needs to store in the inductor for the complete test and sets the width of the first pulse accordingly.
- 3 Watch the Progress details just above the  button. Tests progress in the following order:

### Configure Instruments

**Instrument configuration complete**

**Executing double-pulse test at xxx A, xxx V, xxx °C**

**Adjusted configuration to yyy A, yyy V, yyy °C**

**All tests completed, Last Configuration zzz A, zzz V, zzz °C**

**Test Finished** *date / time*

- 4 After the test runs, the Oscilloscope Capture plot and other test data appear in the software display (upper right-hand corner) on the host PC.

Test result data is automatically stored in the file specified in the **Global Settings > Output Directory** (see “Configure Common Settings” on page 86).

### NOTE

If a Gate Drive Module with a gate resistor ( $R_G$ ) equal to or greater than  $10\ \Omega$  was used in the DPT test, then the Gate Charge data is also calculated and displayed. If  $R_G$  is 0 Ohms, then the gate current cannot be measured.

### NOTE

Waveforms from the PD1500A Double-Pulse Tests system are different from waveforms shown in various test standards. This is because of issues such as gate plateau, ringing due to parasitic inductances and capacitances, voltage drop due to stray inductances, overshoot, etc.



## Frequently Asked Questions

### How do I change the Gate Drive Resistor ( $R_G$ )?

The PD1500A DPT system provides different Gate Drive Modules, each with a different value Gate Drive Resistor:

- Isolated Low-Side Gate Drive Modules for Si/SiC devices.
  - PD1000-66540 No Gate Resistor installed on module for users to install their own gate Drive resistors. See the PD1500A Test Fixture User Guide for detailed information.
  - PD1000-66542 0  $\Omega$  (2x 0  $\Omega$ ) Gate Resistor installed on module.
  - PD1000-66544 10  $\Omega$  (2x 4.99  $\Omega$ ) Gate Resistor installed on module.
  - PD1000-66546 100  $\Omega$  (2x 50  $\Omega$ ) Gate Resistor installed on module.
- Isolated High-Side Gate Drive Modules for Si/SiC devices.
  - PD1000-66541 No Gate Resistor installed on module for users to install their own gate Drive resistors. See the PD1500A Test Fixture User Guide for detailed information.
  - PD1000-66543 0  $\Omega$  (2x 0  $\Omega$ ) Gate Resistor installed on module.
  - PD1000-66545 10  $\Omega$  (2x 4.99  $\Omega$ ) Gate Resistor installed on module.
  - PD1000-66547 100  $\Omega$  (2x 50  $\Omega$ ) Gate Resistor installed on module.

#### NOTE

Refer to the *PD1500A Si/SiC Test Fixture and Modules Installation and Use Guide* for information on selecting and installing custom gate resistors.

**How are general electrical characteristics measured:** General FET characteristics, such as  $V_F$ ,  $I_R$ , and  $C$  are measured with the PD1000A system using the Keysight B1505A or B1506A.  $Q$  and Reverse Recovery parameters are measured with the PD1500A Double-Pulse Test system.

**What is the stray inductance in the power loop circuits?** approximately 38 nH.

**How is system discharge accomplished?** Automatically, through a bleed resistor in the test fixture.

**High Voltage Detection?** In the Rack and Safety Enclosure, there is a voltage detection circuit that works with the interlock system. Additionally, the Heinzinger HV power supply displays the output voltage.



# 5 Power Electronics Model Generator (PEMG) Software

## Device Modeling and Simulation Software

Keysight's PD1000A Control Software generates semiconductor device characterization data that can be passed to the W8598BP/BT Power Electronics Model Generator and Analysis Program (also known as the PEMG software). The PEMG software creates a mathematical model of the device based on the Control Software device characterization data. This mathematical model data can then be passed to circuit simulation tools such as the PD1000A-ADS (Keysight's Advanced Design System (ADS)). The PEMG software requires a license.

### In this Chapter:

PEMG Introduction	page 108
PEMG System Requirements	page 108
Supported Model Versions	page 109
Power Electronic Model Generator (PEMG) Software	page 110
Before Running the PEMG Software	page 110
Model Generator Workflow	page 111
Circuit Simulation Software	page 112

#### NOTE

**IMPORTANT:** You must have Keysight's ADS Simulation software installed and licensed prior to running the PEMG software. For detailed information, click here: [www.keysight.com/find/eda](http://www.keysight.com/find/eda) then click *Advanced Design System (ADS)*.

## PEMG Introduction

The Power Electronics Model Generator software (PEMG) is an advanced device modeling software tailored toward the model extraction requirements of discrete semiconductor power electronic devices. It offers device modeling engineers and circuit designers the most advanced and customizable software environment for all modeling needs including data visualization, simulation, optimization, verification and reporting.

### Key Features

- Advanced ASM-HEMT model support for GaN
- Keysight SiC and IGBT models that do not require process parameter information
- Automatic import of measured data (
- New UI, fast data visualization, preconfigured and automated model extraction
- Temperature dependent modeling
- Model verification and quality check
- Result report generation (HTML, PDF)

The Model Generator (MG) supports simple, fast and highly accurate automated model extraction for a selection of discrete power electronic specific compact and circuit models.

### PEMG System Requirements

The following are Keysight recommended configurations:

CPU	Minimum 2.0 GHz, recommended 2.9 GHz or higher (Intel i3 7th generation or higher, AMD phenom II x4 / FX / A12 or higher.)
Display	High-resolution color only (Super VGA, 1024x768, 15-inch monitor minimum and at least 1280x1024 is required for Extraction packages).
RAM	Minimum is 2 GB RAM, recommended is 4 GB RAM. Minimum 4 GB RAM is required for Windows 10.
Acrobat Reader	Acrobat Reader 5.0 or higher to view the PDF files.
Hard Disk	1.5 GB for complete installation.
External Interpreter	Python 2.7 - only for external user specific code

For the latest information, refer to our website at:  
[www.keysight.com/find/eesof-docs](http://www.keysight.com/find/eesof-docs).

## Supported Model Versions

This section provides information on the currently supported model version in the Model Generator tool.

Device Type	Supported Model
Discrete GaN based high electron mobility transistor (GaN HEMTs)	GaN ASM-HEMT
Discrete SiC Power metal-oxide-semiconductor field-effect transistor (MOSFET)	Keysight Si / SiC PowerMOS
Discrete insulated-gate bipolar transistor (IGBT)	Keysight IGBT

It imports simple and advanced measurement data and automatically extract a model that can be used in Keysight's Advanced Design System (ADS).

IV and CV characterization data and the S-Parameter data are saved in the **\*.mdm** file format<sup>1</sup>. You specify the location for the data files in the PD1000A Control Software **Configure Common Settings...** dialog prior to running characterization tests.

<sup>1</sup> MDM data files are an industry standard file format used by the Keysight ADS modeling program for statistical analysis of device characterization data.

# Power Electronic Model Generator (PEMG) Software

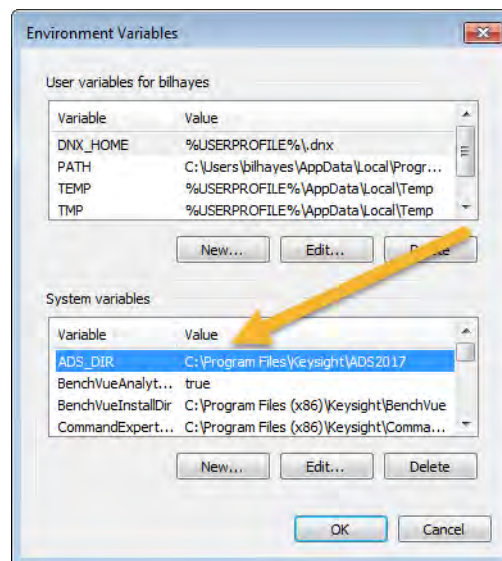
## Before Running the PEMG Software

Prior to running the PEMG software, you must have Keysight's Advanced Design System (ADS) Simulation software installed on your system. For detailed information, click here: [www.keysight.com/find/eda](http://www.keysight.com/find/eda) then click *Advanced Design System (ADS)*.

### NOTE

You must also set an environment variable named “**ADS\_DIR**” at the Windows System Environment level with the path to the ADS installation. Note: your ADS installation path may be different than that shown below.

- 1 To open the Environment Variables window, type “**Environment Variables**” in the Windows Search Field. In the **Advanced** tab, select the **Environment Variables** button.



**Figure 39** Setting the ADS Environment Variable

- 2 Click the **New...** button.
- 3 Enter “**ADS\_DIR**” as the *Variable name*.
- 4 Enter the path name where the Keysight ADS was installed as the *Variable value*.
- 5 Click **OK** twice to exit the Environment Variables setup dialog.

## Model Generator Workflow

After installing and licensing the PEMG software, launch the software from the Windows **Start > IC-CAP 2018 > Power Electronics Model Generator**. Select either a **New Project**, open an **Existing Project**, or you can open an **Example Project**.

To extract a model in the Model Generator follow sequentially the five steps visible in the Tab bar on the left side. For detailed information about each step, refer to the PD1000A Help Files or the PEMG software help file.



Each step depends on the previous step(s). Once they are all completed, it is possible to jump between steps to make modifications to individual items.

## Circuit Simulation Software

After running the PEMG software to create a model of your device, use one of the following software packages to complete the simulation or modeling process.

### Advanced Design System (ADS)

Keysight's Advanced Design System (ADS) is the leading RF, microwave, Signal Integrity, and Power Integrity electronic design automation software for wireless communications and networking, aerospace and defense, and signal integrity application. For detailed information, click here: [www.keysight.com/find/eda](http://www.keysight.com/find/eda) then click *Advanced Design System (ADS)*.

### Electromagnetic Professional (EMPro)

Electromagnetic Professional (EMPro) is the first 3D Electromagnetic EM simulation software platform that integrates 3D EM simulation and the ADS circuit simulation software. For detailed information, click here: [www.keysight.com/find/eda](http://www.keysight.com/find/eda) then click *EMPro 3D EM Simulation Software*.

### Momentum Simulator

Momentum is the 3D planar electromagnetic (EM) simulator used for passive circuit modeling and analysis. For detailed information, click here: [www.keysight.com/find/eda](http://www.keysight.com/find/eda) then click *Momentum 3D Planar EM Simulator*.



## 6 Running the PD1000A Control Software Demonstration Mode

The host PC does not need to be connected to any test equipment hardware to run the demonstration plots (Demo Mode). The Demo mode provides sample characterization plots of FET and IGBT devices.

### NOTE

Even though actual hardware does not need to be connected to the host PC to run the Demo modes, you must still provide VISA addresses and test parameter data in the setup and configuration fields.

In this chapter:

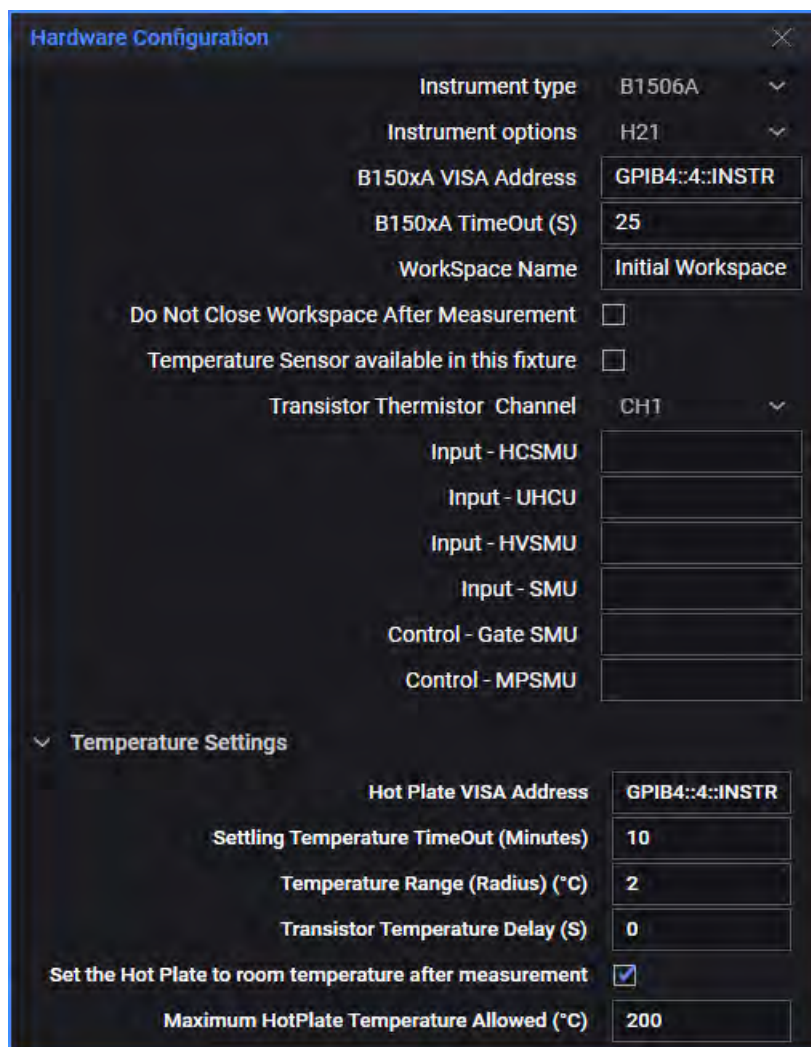
IV and CV Demo [page 114](#)

S-Parameter Demo [page 116](#)

Double Pulse Test Demo [page 118](#)

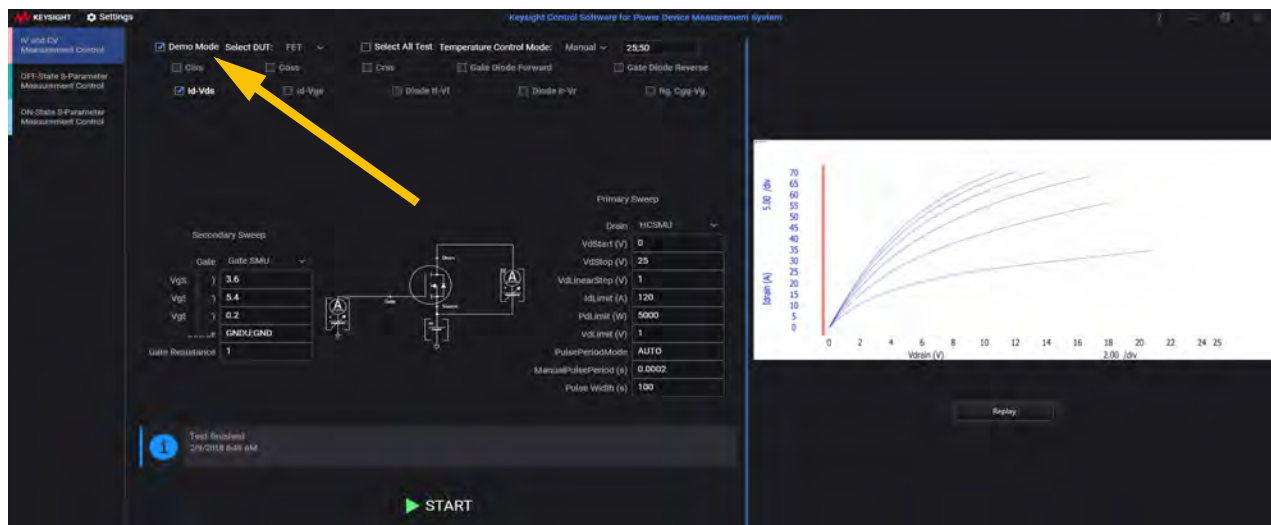
## IV and CV Demo

Although the demo runs without any test equipment attached to the host PC, you must provide a slot address for each SMU in the Hardware Configuration dialog. Refer to “B150xA Settings:” on page 53 for more information. Here is a typical Hardware Configuration dialog (you can use these addresses if necessary):



**Figure 40** Sample Hardware Configuration Dialog

- 1 To run the PD1000A demonstrations, check the **Enable Demo Mode** check box on the display screen.
- 2 Select one or more tests for demo plots. If you select multiple tests, the demos to run sequentially.
- 3 Click the **START** button at the bottom of the screen. As with a full test, the graphic schematic changes to show the different test that is running. A sample result (\*.mdm) format file is also produced.



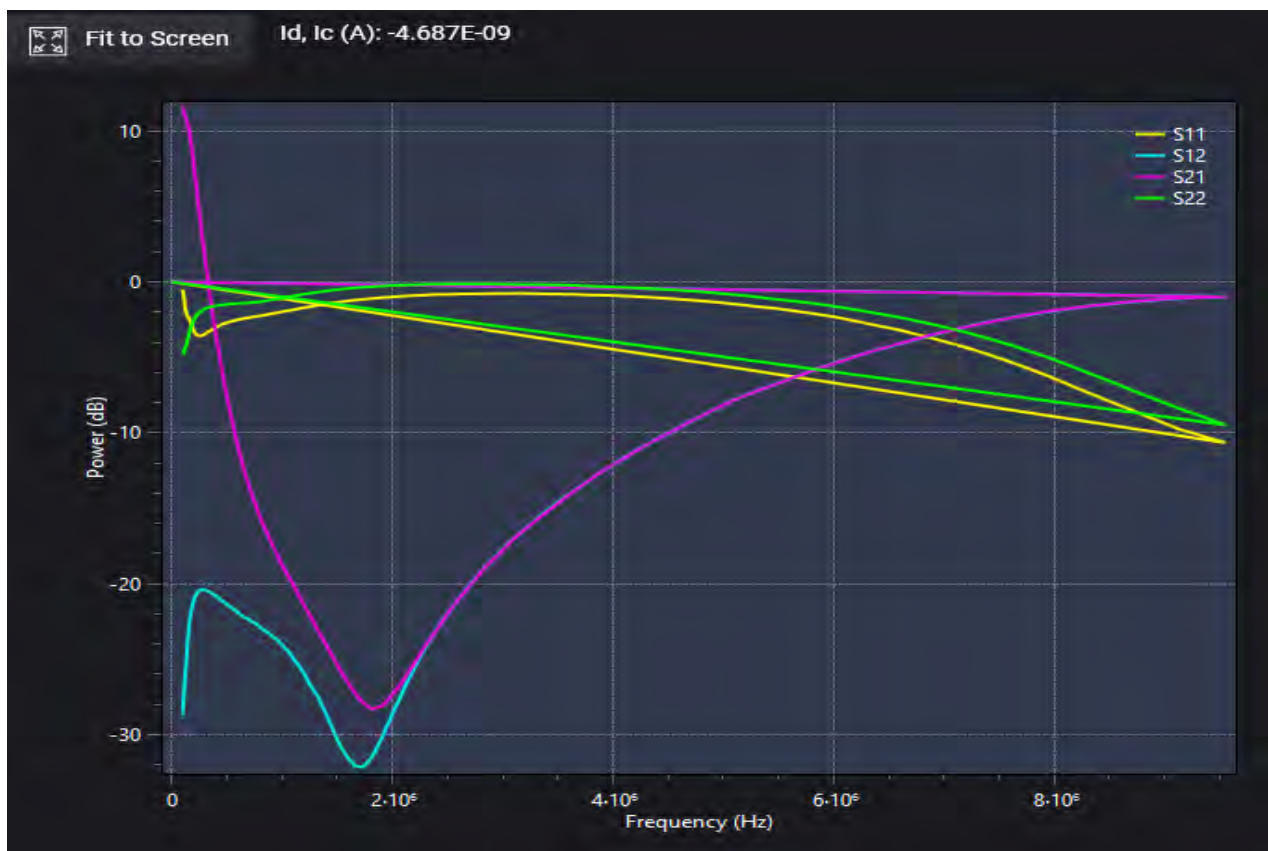
**Figure 41** IV and CV Demo Display

Click the **Replay** button to run the demo program again.

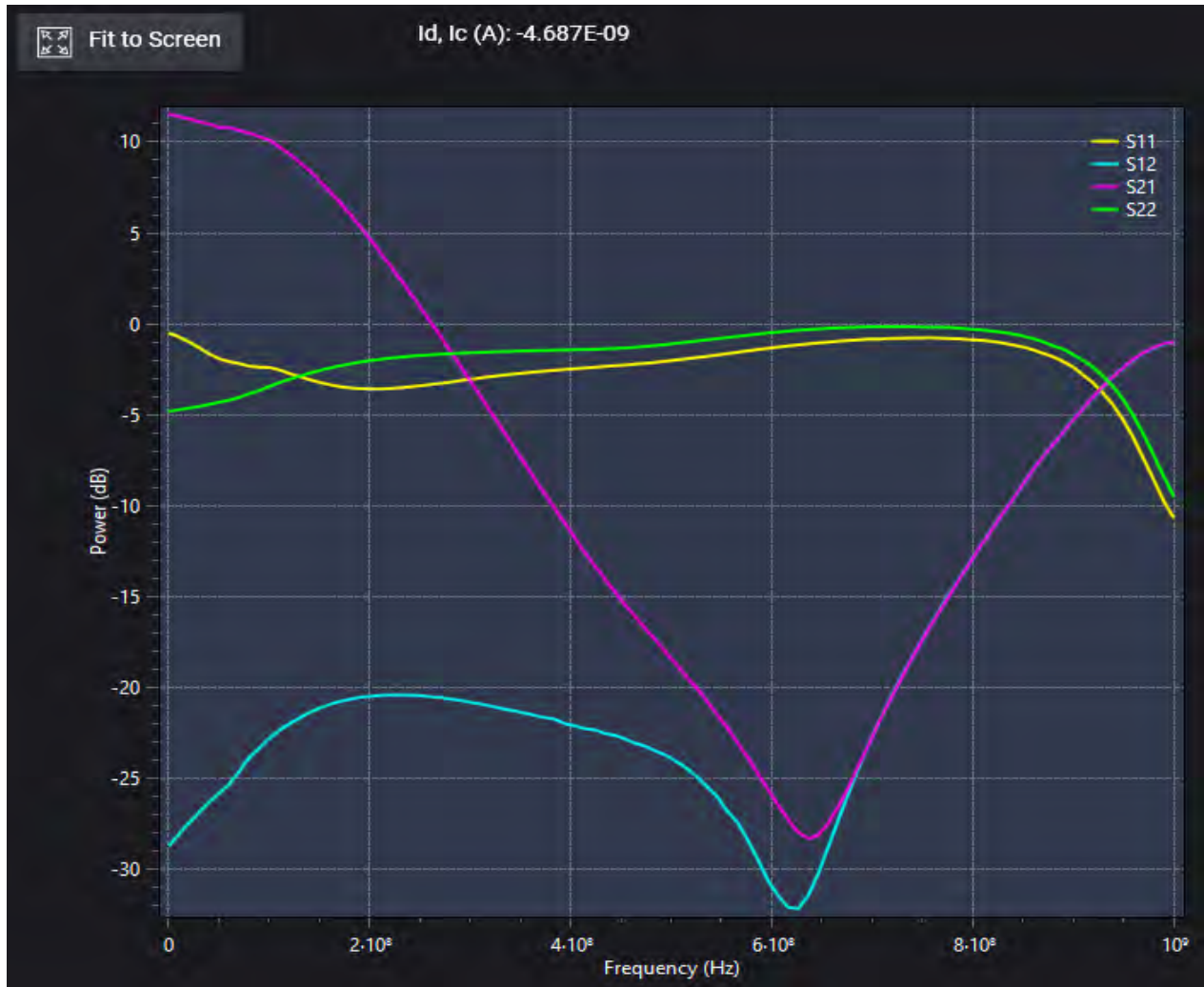
## S-Parameter Demo

- 1 To run the PD1000A S-Parameter demonstrations, select either the **On State** or the **Off State S-Parameter** test tab.
- 2 Check the **Demo Mode** check box on the display screen.
- 3 Select **Frequency Sweep** - either **Linear** or **Logarithmic**.
- 4 Click the **▶ STAR** button at the bottom of the screen.

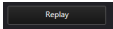
Just as in running a full device characterization test, the system prompts you to calibrate the Network Analyzer. For the demo, you do not need to calibrate the ENA. Click the **Continue** button. The following graphics show the S-Parameter demonstration displays. A sample result (\*.mdm) format file is also produced.



**Figure 42** On State S-Parameter Demo Display



**Figure 43** Off State S-Parameter Demo Display

Click the  to run the demo program again.

## Double Pulse Test Demo

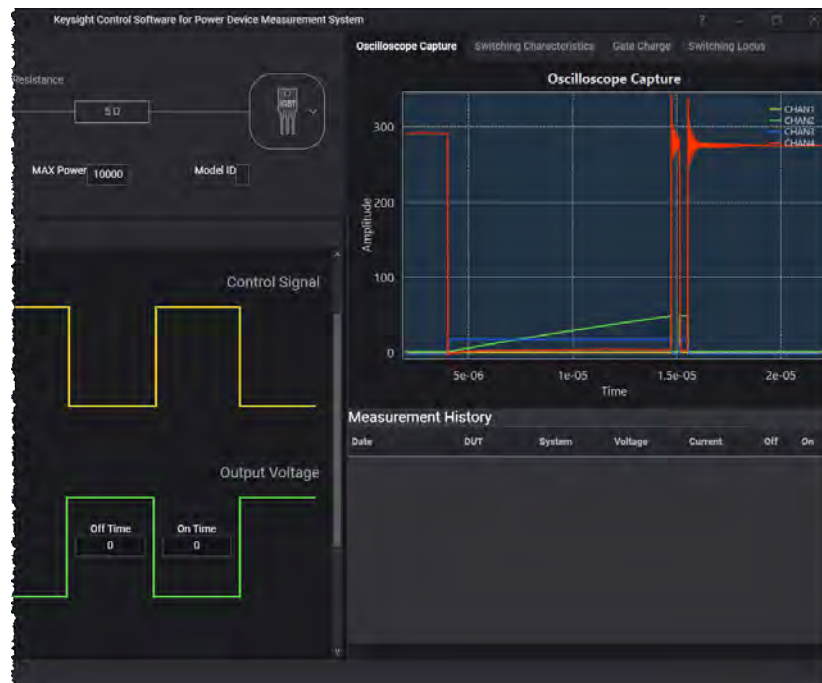
The Demo mode provides a sample characterization plot (Oscilloscope Capture), Switching Characteristic data, Gate Charge data, and Switching Locus plots for a power MOSFET device.

The host PC does not need to be connected to any test equipment hardware to run the Double-Pulse Test Demo Mode. However, you must set the following items prior to running the Demo:

- Set an Output Directory: **Settings > Global Settings**
- Set Hardware Configuration set: **Settings > Instrument Configuration for Double Pulse Measurement Control**. You must set the following:
  - Test instruments VISA Addresses
  - Transistor Drive (Waveform Generator) Channels
  - Probe Setup (Oscilloscope Channels)
- Current Tolerance must not be zero (0). 5.0% is a common value.

Run the Demo:

- 1 To run the PD1000A Double-Pulse Test demonstration, select Double-Pulse Measurement Control tab in the PD1000A Control Software.
- 2 Check the **Demo Mode** check box on the display screen.
- 3 Click the **START** button at the bottom of the screen.



**Figure 44** DPT Test Demo Screen

The Oscilloscope Capture screen is the default display. Select the Switching Locus, Gate Charge, or Switching Characteristics tabs for additional **DEMO** displays.





# 7 Software, Instrument Firmware Updates, Related Documentation

Instrument documentation, data sheets, firmware updates, software updates, and more can be found on the product web pages listed below.

For the latest versions of the above documents, visit the individual product websites:

[www.keysight.com/find/PD1000A](http://www.keysight.com/find/PD1000A) (for general product information including the PD1000A Bias T networks and Test Fixtures, the PD1000A Control software, etc.)

[www.keysight.com/find/easyexpert](http://www.keysight.com/find/easyexpert) EasyEXPERT software for the B1506A

[www.keysight.com/find/B1506A](http://www.keysight.com/find/B1506A) Power Device Analyzer/Curve Tracer

[www.keysight.com/find/B2902A](http://www.keysight.com/find/B2902A) Precision Source/Measure Unit

[www.keysight.com/find/E5080B](http://www.keysight.com/find/E5080B) ENA Vector Network Analyzer

[www.keysight.com/find/DSOS104A](http://www.keysight.com/find/DSOS104A) 4-Channel Oscilloscope

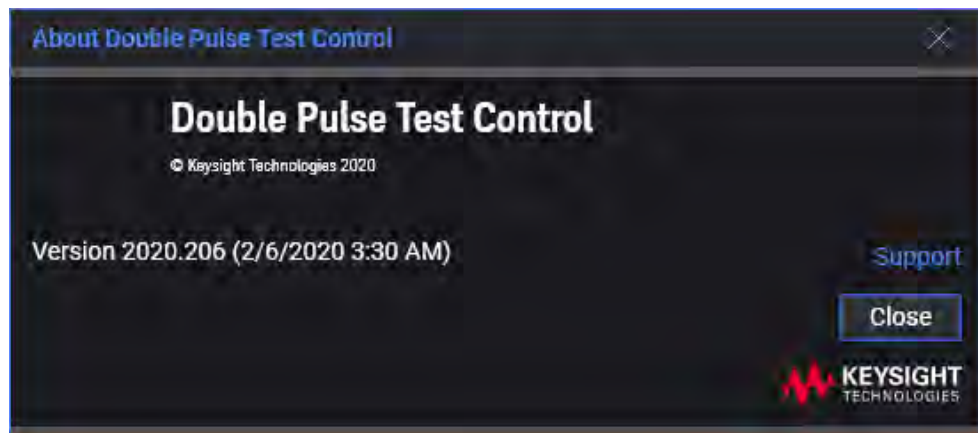
[www.keysight.com/find/33512B](http://www.keysight.com/find/33512B) Waveform Generator, 2-Channels

[www.??????????](http://www.keysight.com/find/33512B) High Volt Power Supply

Product specifications, available accessories, firmware and software may change over time. Check the individual chassis web pages for the most current documentation.

## PD1000A Control Software Version Number

To determine the version of the PD1000A Control Software you currently have, click the drop-down menu (upper right hand corner of the display window), then click **About...**



**Figure 45** Sample PD1000A Control Software About Box with Version Number

### NOTE

The PD1500A Double Pulse Test requires PD1000A Control Software version 2020.206 (2/6/2020) or later.

### Additional Reference Material

Keysight's "*The Parametric Measurement Handbook*", Edition 4, 2018  
PN: 5992-2508EN, Also available in Japanese, Simplified Chinese, and traditional Chinese.

To download a PDF copy, click [here](#).

# A PD1000A System Specifications

There are no specific PD1000A system-wide specifications. This *PD1000A Getting Started Guide* is the only system documentation. All other PD1000A documentation and individual instrument documentation are available on-line. Refer to the individual Keysight instrument data sheets, user guides and help files for detailed specifications, operation, and use instructions as well as specific warranty and support information.

[www.keysight.com/find/PD1000A](http://www.keysight.com/find/PD1000A) (for general product information including the PD1000A Bias T networks and Test Fixtures, the PD1000A Control software, etc.)

[www.keysight.com/find/B1506A](http://www.keysight.com/find/B1506A) Power Device Analyzer/Curve Tracer  
For the full list of specifications and characteristics, please see: The B1506A Power Device Analyzer for Circuit Design – Data Sheet, Literature number 5991-4441,  
(<http://literature.cdn.keysight.com/litweb/pdf/5991-4441EN.pdf>).

[www.keysight.com/find/B2902A](http://www.keysight.com/find/B2902A) Precision Source/Measure Unit  
For the full list of specifications and characteristics, please see the Data Sheet, literature number 5990-7009,  
(<http://literature.cdn.keysight.com/litweb/pdf/5990-7009EN.pdf>).

[www.keysight.com/find/E5080B](http://www.keysight.com/find/E5080B) ENA Vector Network Analyzer  
For the full list of characteristics, please see the Keysight E5080A or E5080B ENA Vector Network Analyzer – Data Sheet, literature number 5992-0291,  
(<http://literature.cdn.keysight.com/litweb/pdf/5992-0291EN.pdf>)



## B Configure the InTEST Thermal Platform Controller

### Configure the E5810B Gateway for the InTEST Controller

The following process ensures that the InTEST Thermal Platform Controller can communicate with the host PC.

- 1 Connect the E5810B to the host PC with a LAN Cable and the InTEST Thermal Platform Controller with a GPIB Cable.
- 2 Plug in the E5810B power adapter to the E5810B DC power port.
- 3 Turn on the PC, the E5810B, and the InTEST Thermal Platform controller.
- 4 After searching for a DHCP, the E5810B displays its IP address on its front panel display.



**Figure 46** E5810B Front Panel showing IP Address

- 5 Open a Web Browser window on the host PC. Enter the E5810B IP Address in a web browser address line (default address is: 169.254.58.10). Click **Enter**. This opens the E5810B Web *Welcome* page.

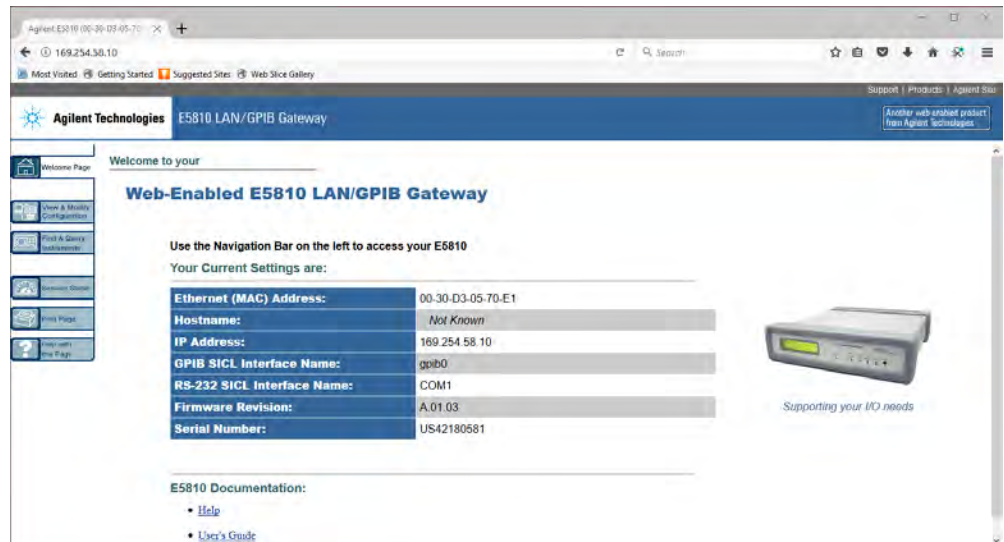


Figure 47 E5810B Web Welcome Page

- 6 Find and click on the **Find & Query Instruments** button on the left side of the display. Note, the default password is: *E5810*.
- 7 See Figure 48. Click **Find** to list all instruments connected to the E5810B.
- 8 Select the **GPIBx,xx** instrument.

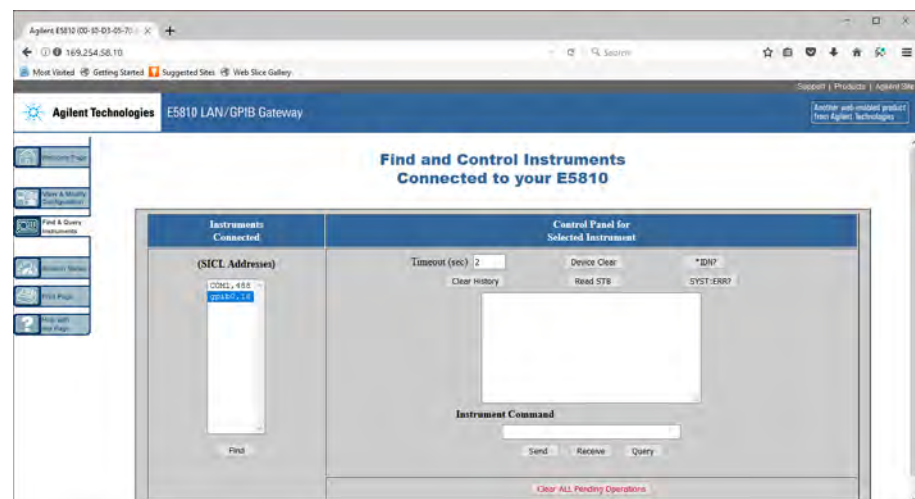
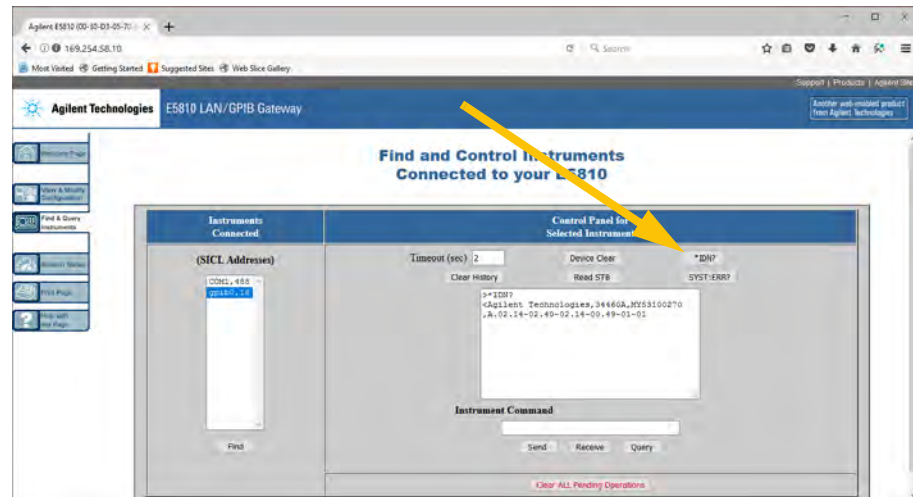


Figure 48 Click the **Find** Button

- Click the **IDN?** button to read the identification string for the InTEST Thermal Platform Controller.



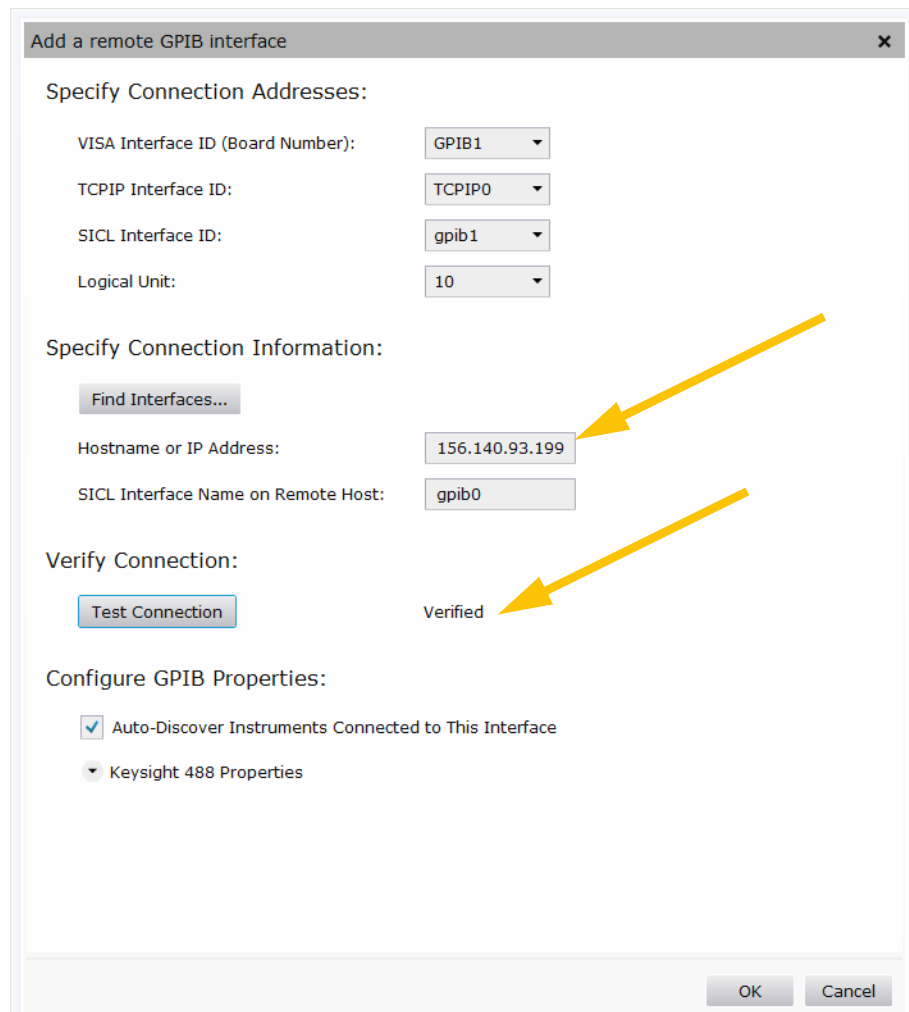
**Figure 49** IDN? String for the InTEST Thermal Platform Controller

## Configure the Remote GPIB Interface in Connection Expert

In the Keysight IO Libraries Suite Connection Expert utility, make certain that Connection Expert can communicate with the InTEST Thermal Platform controller. Identify the VISA address of the Controller. Use this VISA address when configuring the PD1000A Power Device Measurement System for Advanced Modeling Power Control Software.

- Launch Keysight Connection Expert from the Start menu.
- If a Remote GPIB Interface is not listed in the Connection Expert My *Instruments* list, select **+Add > Remote GPIB Interface** to display the Remote Interface dialog.
- Enter the IP address from the E5810B into the Hostname or IP Address field.

- 4 Click the **Test Connection** button. The word, “**Verified**” should appear to the right of the button.



**Figure 50** Remote GPIB Interface Connected and Verified

- 5 Click **OK**. In a moment, the InTEST Thermal Platform controller should appear in the list of instruments.
- 6 **Note the VISA Address in the Connection Strings table (right half of the display).** This is the address that you need to enter in the PD1000A IV and CV Hardware Configuration.



# Glossary

Typical capacitance parameters of power devices are not always the same as the physical parameters of the device terminal capacitances ( $C_{gd}$ ,  $C_{gs}$ ,  $C_{ds}$  as an example) as shown next. It requires some interpretation to convert them to the data sheet parameters. For example,  $C_{iss}$  is sum of  $C_{gd}$  and  $C_{gs}$  device terminal capacitances.

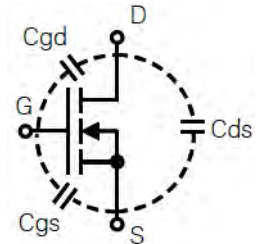
## Power FET Capacitance

Device terminal capacitance:

- $C_{gs}$ : Gate to source capacitance
- $C_{gd}$ : Gate to drain capacitance
- $C_{ds}$ : Drain to source capacitance

Capacitance parameters described in device data sheet:

- $C_{iss}$ : Input capacitance
- $C_{oss}$ : Output capacitance
- $C_{rss}$ : Reverse transfer capacitance



$$C_{iss} = C_{gd} + C_{gs}$$
$$C_{oss} = C_{gd} + C_{ds}$$
$$C_{rss} = C_{gd}$$

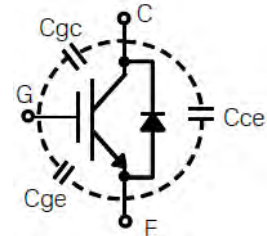
## IGBT Capacitance

Device terminal capacitance:

- $C_{ge}$ : Gate to emitter capacitance
- $C_{gc}$ : Gate to collector capacitance
- $C_{ce}$ : Drain to emitter capacitance

Capacitance parameter described in device data sheet:

- $C_{ies}$ : Input capacitance
- $C_{oes}$ : Output capacitance
- $C_{res}$ : Reverse transfer capacitance



$$C_{ies} = C_{gc} + C_{ge}$$
$$C_{oes} = C_{gc} + C_{ce}$$
$$C_{res} = C_{gc}$$

## FET Terms

Symbol	Units	Description
$V_{gs}$	V	Gate-source voltage
$V_{ds}$	V	Drain-source voltage
$I_d$	A	Drain current
PulseWidth	nS	Pulse width of drain current/voltage
f	Hz	AC signal frequency
$I_s$	A	Body diode forward current (source current)
$V_{sd}$	V	Body diode forward voltage (source-drain voltage)
$R_{ds}$	W	Drain-source resistance
$C_{iss}$	pF	Input capacitance
$C_{oss}$	pF	Output capacitance
$C_{rss}$	pF	Small signal reverse transfer capacitance
$C_{gs}$	pF	Gate to source capacitance
$C_{gd}$	pF	Gate to drain capacitance
$C_{ds}$	pF	Drain to source capacitance
$Q_g$		Gate charge
$V_{gs}$	V	Gate-source voltage (gate charge measurement)
$V_{gs(on)}$	V	Gate-source "On State" voltage (gate charge measurement)
$V_{gs(off)}$	V	Gate-source "Off State" voltage (gate charge measurement)
$V_{ds}$	V	Drain-source "Off State" voltage (gate charge measurement)
$I_d$	A	Drain "On State" current (gate charge measurement)

## IGBT Terms

Symbol	Units	Description
V <sub>GE</sub>	V	Gate-emitter voltage
V <sub>CE</sub>	V	Collector-emitter voltage
I <sub>C</sub>	A	Collector current
PulseWidth	nS	Pulse width of collector current/voltage
f	Hz	AC signal frequency
I <sub>F</sub>	A	Free-wheel diode forward current
V <sub>F</sub>	V	Free-wheel diode forward voltage
C <sub>ge</sub>	pF	Gate to emitter capacitance
C <sub>gc</sub>	pF	Gate to collector capacitance
C <sub>ce</sub>	pF	Drain to emitter capacitance
C <sub>ies</sub>	pF	Input capacitance
C <sub>oes</sub>	pF	Output capacitance
C <sub>res</sub>	pF	Reverse transfer capacitance
Q <sub>g</sub>		Gate charge
V <sub>ge</sub>	V	Gate-emitter voltage (gate charge measurement)
V <sub>ge(on)</sub>	V	Gate-emitter "On State" voltage (gate charge measurement)
V <sub>ge(off)</sub>	V	Gate-emitter "Off State" voltage (gate charge measurement)
V <sub>ce</sub>	V	Collector-emitter "Off State" voltage (gate charge measurement)
I <sub>c</sub>	A	Collector "On State" current (gate charge measurement)



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Printed in Malaysia

Fourth Edition, August 2020



PD1000-90001

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