Keysight B1505A
Power Device Analyzer/Curve Tracer

Quick Start and
Demonstration
Guide

KEYSIGHT
TECHNOLOGIES

WARNING

High Voltage

is used in the operation of this equipment.

LETHAL VOLTAGE on CONTACT

may be present at measurement terminals,
if you fail to take in all safety precautions!

- **When the RED indicator lights, lethal voltage (±10 kV dc/pulse) may appear at measurement terminals.**
- **Usually use the interlock function**
- **Do not operate the instrument unless another person is around the work space who is familiar with instrument operation and hazards or administering first aid.**
- **Potentials less than ±500 V may cause death under certain conditions. Therefore, adequate preventive measures must be taken at all times!**

Introduction

Agilent B1505A Power Device Analyzer/Curve Tracer is a powerful tool for measuring and characterizing power devices.

This quick start/self-paced demonstration guide for high-power devices up to 1500A and 10 kV covers the high power measurement capability and the unique features of the B1505A in step by step instructions.

Each test included in this guide is covered with step by step instructions of cable connections to the test device and the parameter setting of the test, and you can easily set up the test and execute it by just following the guide.

The target system configuration of this B1505A demo guide is newly introduced Ultra High Current Unit (UHCU), High Voltage Medium Current Unit (HVMCU) and Ultra High Voltage Unit (UHVU).

The step by step demo guide covers;

- A cable connection from the instrument to the device terminal,
- A test setup of the measurement parameters and the data extraction scheme,
- A test execution and analysis on EasyEXPERT software which is resident in B1505A and provides all the control of the B1505A.

Measuring high-power devices sometimes requires special knowledge of both the devices and the measuring instruments.
For example, UHCU and HVMCU have the series resistor in the output port as like the so called curve tracer in the market, and it shows slightly different output V/I characteristics compared to the SMUs which output the exact V/I value as specified.
The voltage and the current waveform in ultra high current measurement in pulsed test are easily distorted by the parasitic inductance of the measurement cables and the stray capacitance between the measurement cables. Sometimes the device oscillates very easily in high current operation region. Because of these effects, unexpected or doubtful test data may be coming out.

There are many features in the B1505A to overcome these challenges, and these topics are covered in this demo guide.

You can perform accurate measurement by following the steps of setup and the measurement instructions of this demo guide.

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Chapter 1. Basic Knowledge of the B1505A

N1268A Ultra High Voltage Expander

B1505A Power Device Analyzer/Curve Tracer

N1265A Ultra High Current Expander/Fixture
N1266A HVSMU Current expander

Objective:

This chapter provides basic information related to the B1505A that is better to know before you start with the B1505A.
The B1505A requires relatively complicated system configuration to fully utilize its high-power ranges.

The objective of this chapter is to know the basic information of the B1505A test components that is essential to perform a successful measurement and to understand the measurement results.

This chapter covers the following topics;

1. Agilent B1505A Power Device Analyzer/Curve Tracer
   - The B1505A test module information
   - The overall output V/I ranges of the B1505A
   - Output V/I ranges by each test module
2. Agilent N1265A Ultra High Current Expander/Fixture
   - Built-in test module selector
3. The effect of output R of UHCU and HVMCU
   - The effect of output R
   - The difference between SMU (no output R)
4. EasyEXPERT Software
   There are following four test mode provided in the EasyEXPERT software. Each test mode has its unique features, and its key points are introduced in this guide.
   - Tracer Test
   - Application Test
   - Classic Test
   - Quick test

1-1. Agilent B1505A Power Device Analyzer/Curve Tracer

Agilent B1505A Power Device Analyzer / Curve Tracer is designed to measure state of the art high-power devices from 1500 A to 10 kV, and the EasyEXPERT measurement software resident on the B1505A is a specially-designed MS Windows® application program.

The B1505A mainframe can measure wide range of power devices from 10 fA to 1500 A and 2 μV to 10 kV with 3,000 V CV measurement features.
With the N1265A Ultra High Current Expander, the N1266A HVSMU Expander and the N1268A Ultra High Voltage Expander, the output range can be expanded to 1500A and 10 kV.

The EasyEXPERT software, which is resident on the B1505A, provides the real time curve tracer interface and an intuitive and flexible data management and analysis environment.

B1505A Test modules:

B1505A has 10 module slots, which support the following modules

B1510A High Power SMU (HPSMU) 10 fA~1 A/2 μV~200 V

B1511A Medium Power SMU (MPSMU) 10 fA~100 mA/0.5 μV~100 V

B1512A High Current SMU (HCSMU) 10 pA~1 A/200 nV~40V (DC) or 10 pA~20 A/200 nV~20 V (Pulse)

B1513B High Voltage SMU (HVSMU) 10 fA~4 mA/200 μV~3000 V or 10 fA~8 mA/200 μV~1500 V

B1514A Medium Current SMU (MCSMU) 10 pA~100 mA/200 nV~30V (DC) or 10 pA~1 A/200 nV~30V (Pulse)

B1520A Multi Frequency CMU (MFCMU) 1 fF~10 nF @ 1 MHz with 0~3000 V DC bias by using High Voltage Bias-Tee with HVSMU.

By adding the following expander box, the output voltage and current of the B1505A can be expanded.

N1265A Ultra High Current Expander/Fixture (UHCU) 500 μA~1500 A/100 μV~60 V (Pulse only)

N1266A HVSMU Current Expander (HVMCU) 200 nA~110 mA/3 mV~2200V (DC) or 4 μA~2.5 A/3 mV~2200 V (Pulse)

N1268A Ultra High Voltage Expander (UHVU) 10 pA~10 mA/10 mV~10 kV (DC) or 10 pA~20 mA/10 mV~10 kV (Pulse)

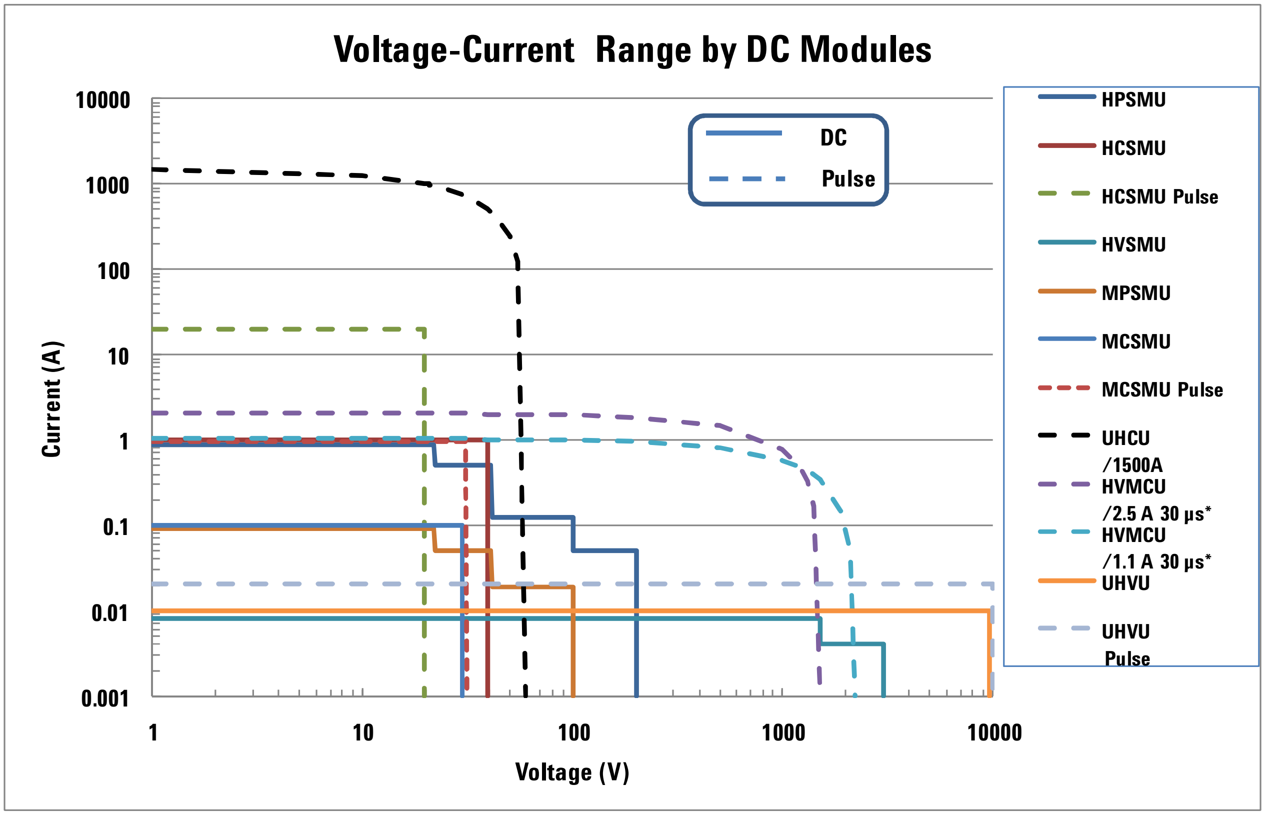
Note:

Two MCSMUs are used to control each expander. If there is not enough MCSMUs installed in the B1505A, MCSMUs are shared between the expander.

The overview of the output voltage and current range is shown in figure 1-1.

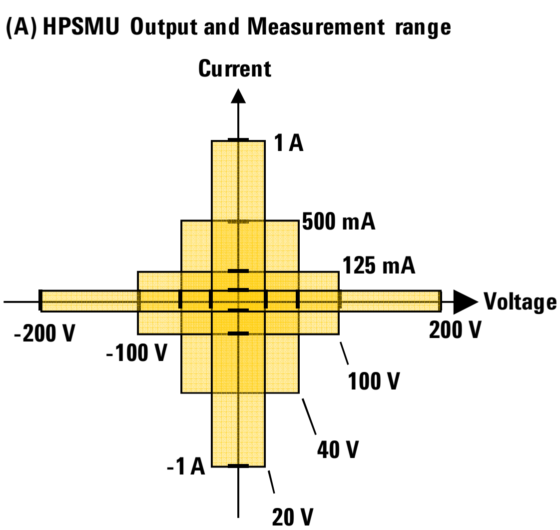
The detail of the output and measurement range of each module are visually shown in figure 1-2.

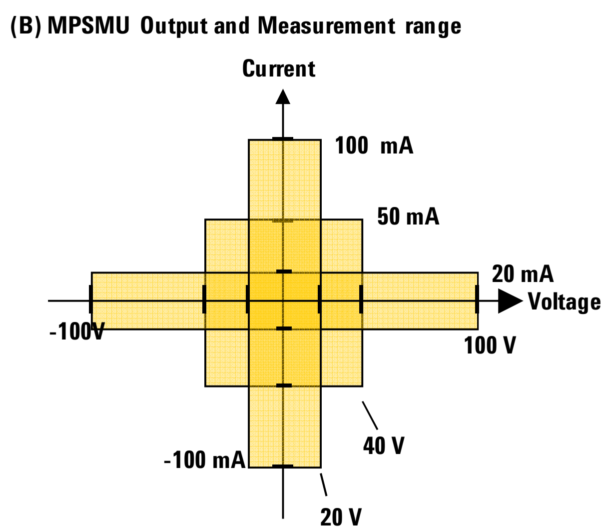
Figure 1-1. B1505A output range with the Expander.



* Decreases from the time zero value by the ratio of exp(-PW/(0.22 μF x (Ro + R load)) where, PW: pulse width, Ro: 600 Ω or 2 k Ω.

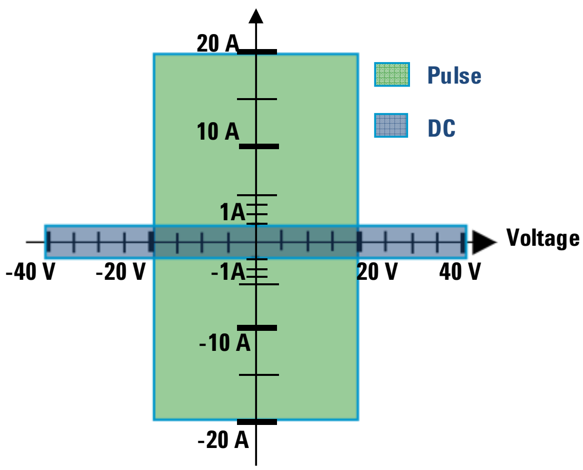
Figures 1-2(a). Output and measurement range (part 1).



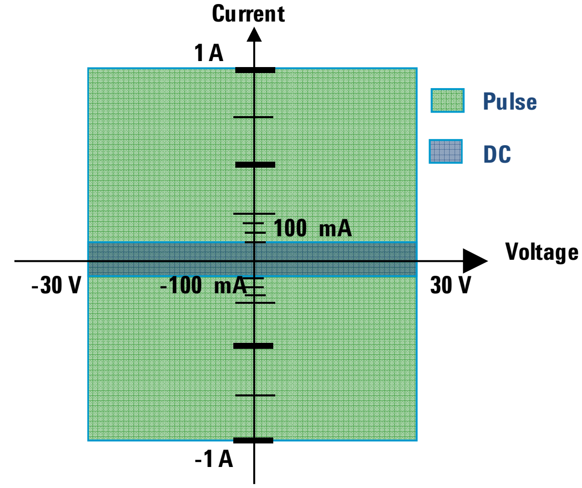


Figures 1-2(b). Output and measurement range (part 2).

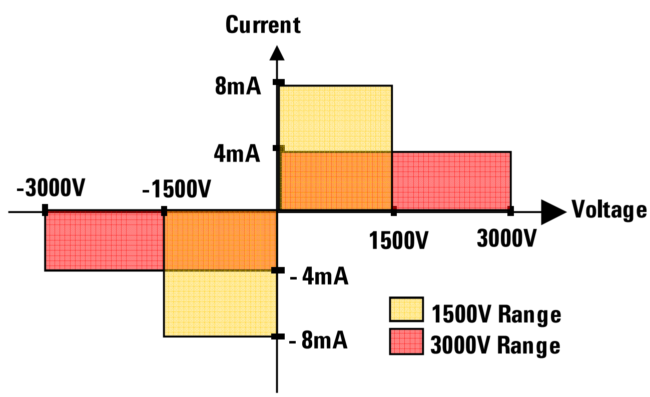
(C) HCSMU Output and Measurement range



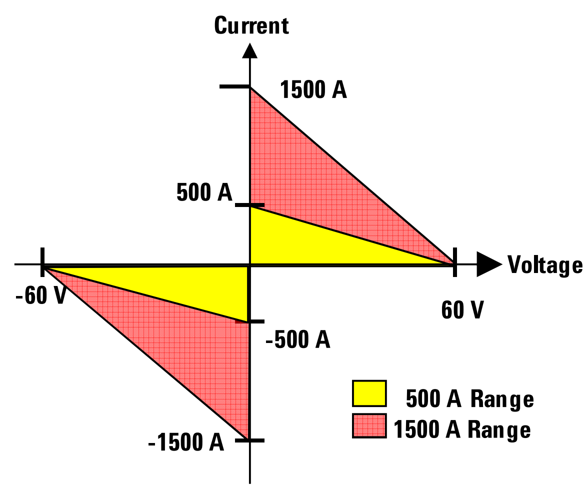
(D) MCSMU Output and Measurement range



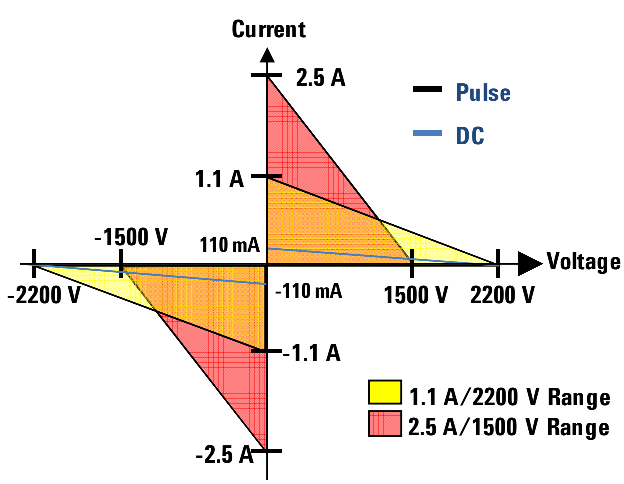
(E) HVSMU Output and Measurement range



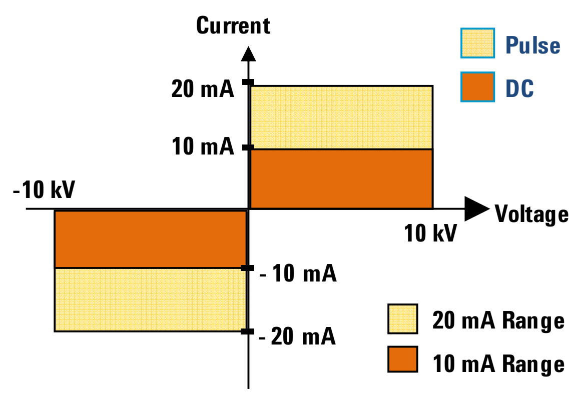
(F) UHCU Output and Measurement range (Pulse only)



(G) HVMCU Output and Measurement range



(H) UHVU Output and Measurement range



1-2. Agilent N1265A UHC Expander/Fixture

Agilent N1265A UHC Expander (UHCE)/Fixture shown in figure 1-2 is used for measuring packaged power devices, It can basically covers the B1505A`s maximum output range; 1500 A and 10 kV.

UHCU is a built-in test unit in N1265A, and it comes automatically in the configuration.

The other measurement units are connected to N1265A UHCE/Fixture for packaged power device testing.

We use N1259A option 020 High Voltage Bias-Tee for capacitance measurement.

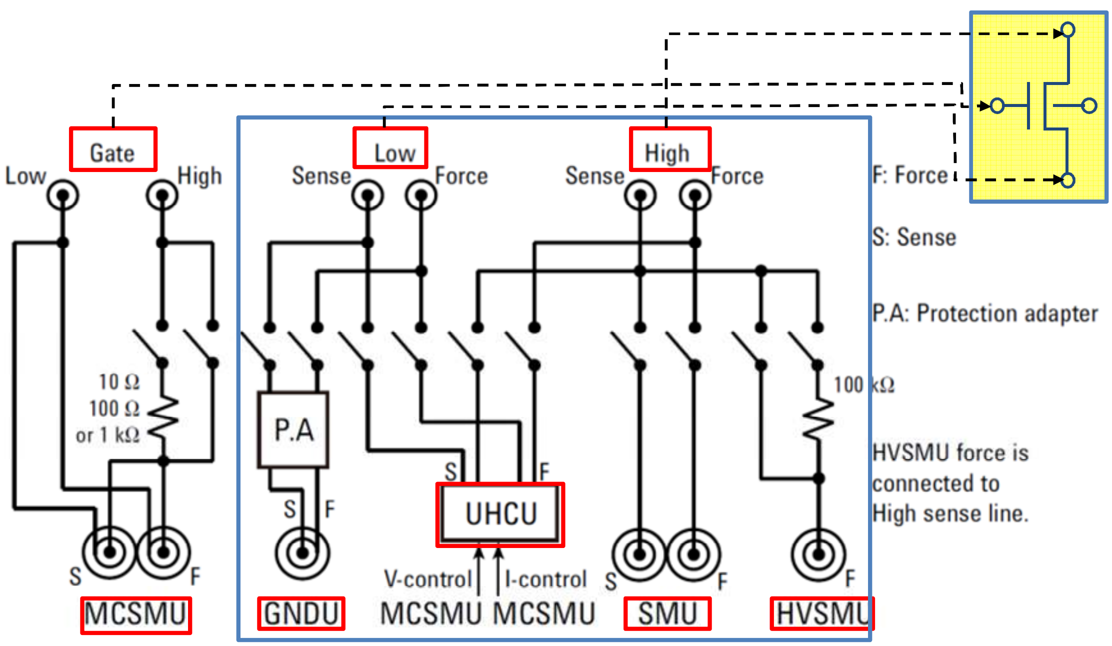
Figures 1-2. Agilent N1265A UHC Expander/Fixture.

Drain/Collector supply is automatically switched between the modules

N1265A includes a built-in selector as shown in figure 1-3, and the drain/collector supply can be switched between UHCU, HVSMU/HVMCU and MPSMU/HPSMU. Therefore, the measurement can be continued without changing the wire connection between the each measurement unit, and it eliminates any errors related to the cable reconnection and it also reduces the test time.

In the HVSMU path, a 100 kΩ series resistor can be inserted for breakdown test.

In the gate channel, a series resistor from the choice of 0 Ω, 10 Ω, 100 Ω and 1 kΩ can be selected to control the stability of the measurement.



Figures 1-3. Example connection of the built-in selector of N1265A Expander/Fixture

1-3. The effect of output R of UHCU and HVMCU

There is an output series resistor (Rout) in the Hi Force output of UHCU and HVMCU outside the voltage source (Vcomp) as shown in figure 1-4(a). The cable resistance Rcbl is also connected in series to the Rout.
Since there is no mechanism to compensate the voltage drop by these resistors, the voltage appears at the DUT terminal is different from the Vcomp value which is set by the user.

Figure 1-4(b) shows a typical measurement curve measured by the circuit shown in figure 1-4(a). The drain sweep end points for each gate steps align on a strait line determined by Vcomp/Rout or Vcomp/(Rout+Rcbl).

It is generally not a problem if you just want to check a curve, but it will be a problem if you want to;

- Add specific voltage without knowing the current value
- Measure high current, but do not want to apply a high voltage (close to Vcomp) as shown in figure 1-4(b).

Figure 1-4. The effect of output resistor.

Tips:

Measured voltage is accurate because the actual voltage at the DUT terminal is sensed and used for plotting the curve.

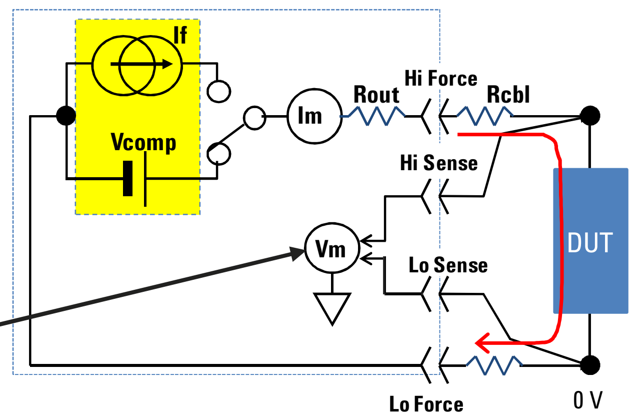


Figure 1-4 (a). Simplified block diagram

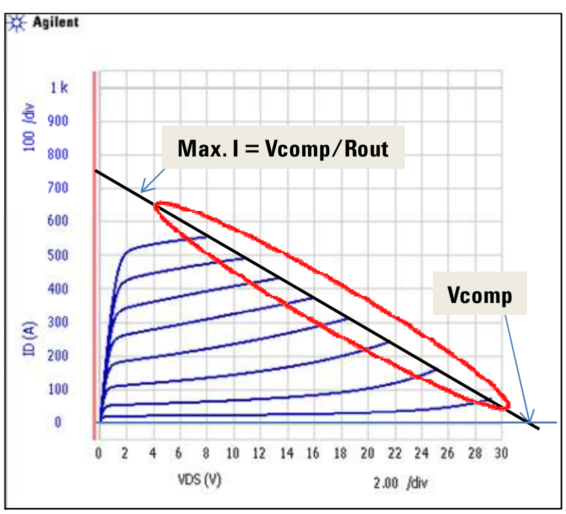


Figure 1-4 (b). Typical measurement curve under the Rout.

Reference information:

- **SMU case**

Figure 1-5(a) shows a simplified block diagram of HP SMU and MP SMU.
The resistive components in the output block of these modules including the resistance in the test cable are located inside the sense loop (refer to 1 and 2 of figure 1-5), and an accurate set voltage appears at the DUT terminal.

Figure 1-5(b) shows a typical Id-Vd measurement example of SMU.
The sweep end points for each secondary gate step parameter are aligned in vertical at the sweep end voltage.
It means, in the case of SMU, you can make measurement at the specific voltage which you set independently to the load condition.
This is a big difference compared to the results in figure 1-4(b) where the sweep end voltage varies depending on the load current and the output resistance.

Note: Since there is no passive resistive component which works as a protective component when DUT breakdowns or sudden short in the SMU side, this architecture may be not the best choice in high power applications.

Figure 1-5(a). Simplified Block Diagram of HP/MPSMU.

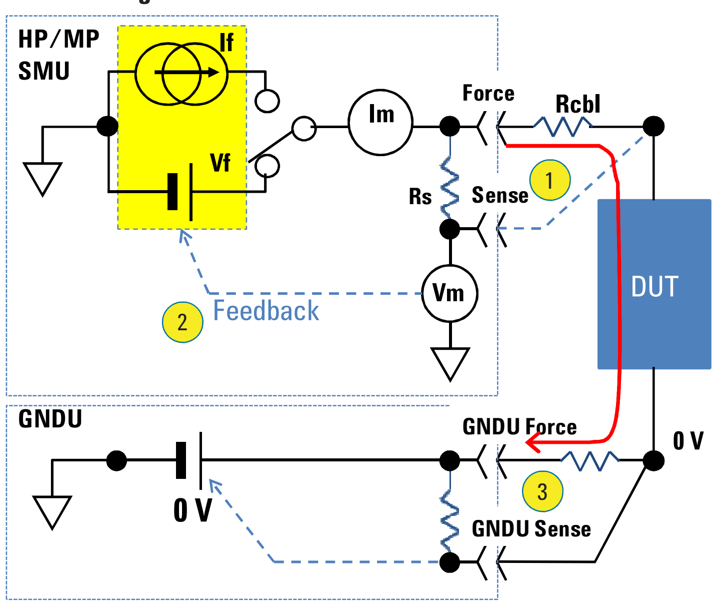
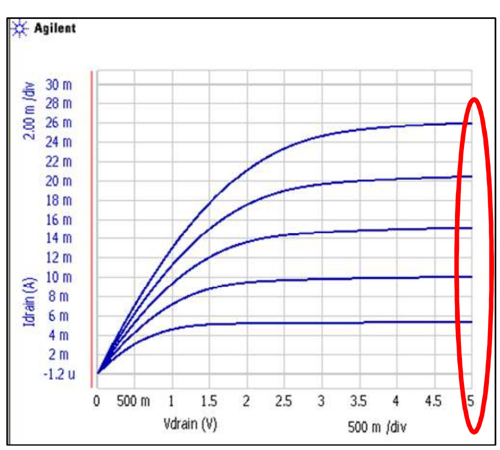


Figure 1-5(b). Typical Id-Vd example of SMU.



1-4. EasyEXPERT Software

Four Test modes available

The EasyEXPERT software as a graphical user interface (GUI) of the B1505A has four types of TEST mode available: Tracer Test, Application Test, Classic Test and Quick Test.

Each TEST mode has its unique capabilities and using an appropriate TEST mode that fits to your test requirement is important for getting a better result sooner. Following describes briefly about the B1505A`s TEST mode.

1. Tracer Test mode

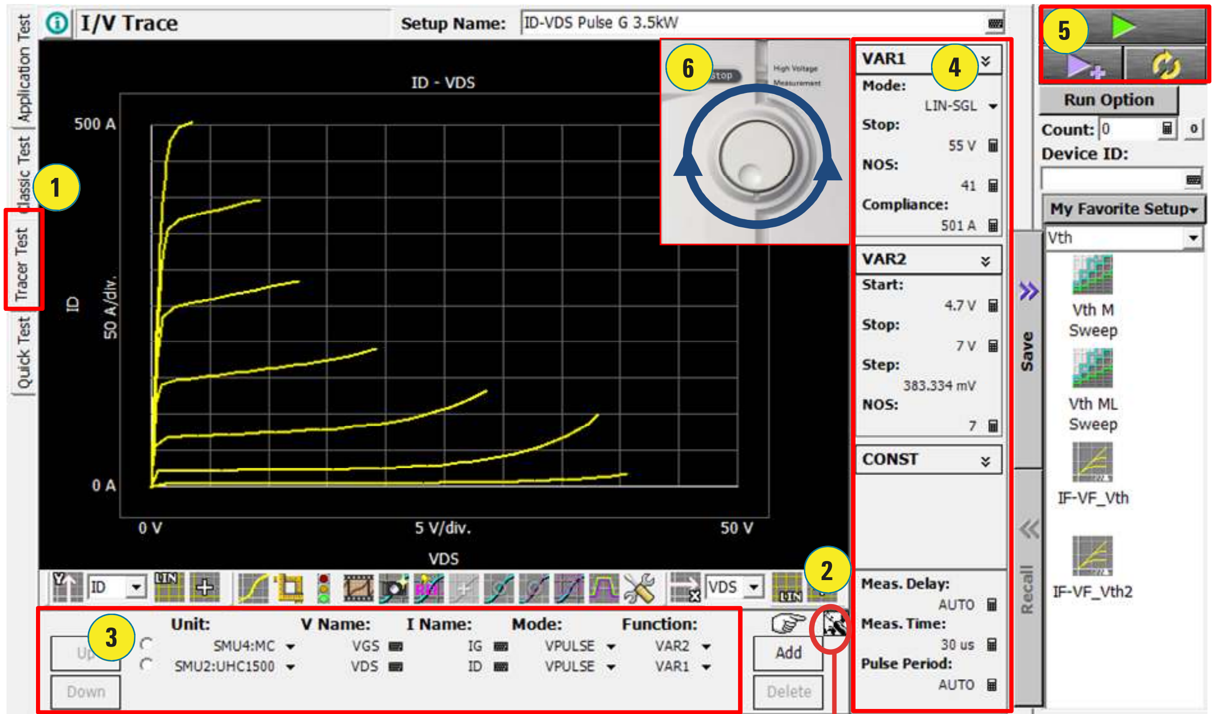
In high-power test application that requires more than 20A, UHCU is a main measurement module.
If the maximum current is 1 ~ 2 A in a few hundreds voltage, then HVMCU is a choice in the measurement.

If you use UHCU or HVMCU, Tracer Test mode is definitely the first priority choice of the Test mode.
Tracer Test mode shown as an example in figure 1-6 provides an interactive curve tracer interface that allows parameters to be modified in real time during a measurement using the B1505A's front panel knob. For example, the drain voltage of the Id-Vd sweep can be manually changed by rotating a knob of the B1505A like rotating a voltage dial of the curve tracer.
The other parameter can be also changed while in measurement on the fly, and you can determine your test condition and the result quickly.

Tracer test includes the following nice capabilities to support your test;

- Sample setup for MOSFET, Diode, IGBT and BJT for typical measurement.
  You can start measurement by just filling in the measurement parameters.
- Oscilloscope view that monitors the pulse waveforms of both the voltage and the current of your selected measurement point.
- Stop condition where the measurement automatically aborted when the set condition met. This function is useful for breakdown test.
- Reference trace that is shown in background of the measurement display, and you can compare the change between the reference and the current measurement traces.
- Replay traces function recalls the past measurement traces. For example, you can recall the past measurement traces until the device is breaks down and destroyed.
- Compliance to limit the primary sweep steps (VAR1) after a specified value
  - Power compliance
  - Current compliance
  - Voltage compliance
- Marker and line function

Figure 1-6. Example Tracer Test mode GUI.

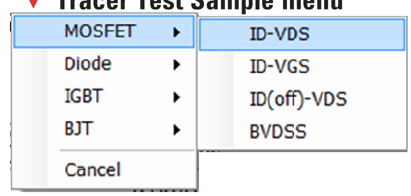


Note of the Tracer Test GUI:

The following number shows the basic steps to start measurement.

1. Tracer Test selection tab
2. Tracer Test Sample menu
3. Channel definition area
4. Measurement parameter setup area
5. Single/Repeat measure button
6. Rotary knob to control sweep/measurement parameters

Tracer Test Sample menu



Tracer Test Sample menu:

The Tracer Test Sample menu is a good start point to create a high-power device test setup. If you choose a test sample from the menu, it is already filled out by a default test setups and parameters reflecting the B1505A configuration. Therefore, you can start editing your test setup from that point, and start measurement faster. You can refine the test setup by following the step numbers shown in figure 1-6.

Tips:

There is another way to use the Tracer Test mode.
Since the Tracer Test setup can be easily converted to a Classic Test setup, you can use Tracer Test mode as an easy test setup and test debugging tool.

The example test setup will automatically create a complicated test setup, and the interactive curve tracer interface helps for refining the final new test setup.
Then, you can convert the completed setup to a Classic test for repeated use with a fixed measurement parameters or adding extra display traces and analysis functionalities such as the automatic marker or lines.

2. Application Test mode

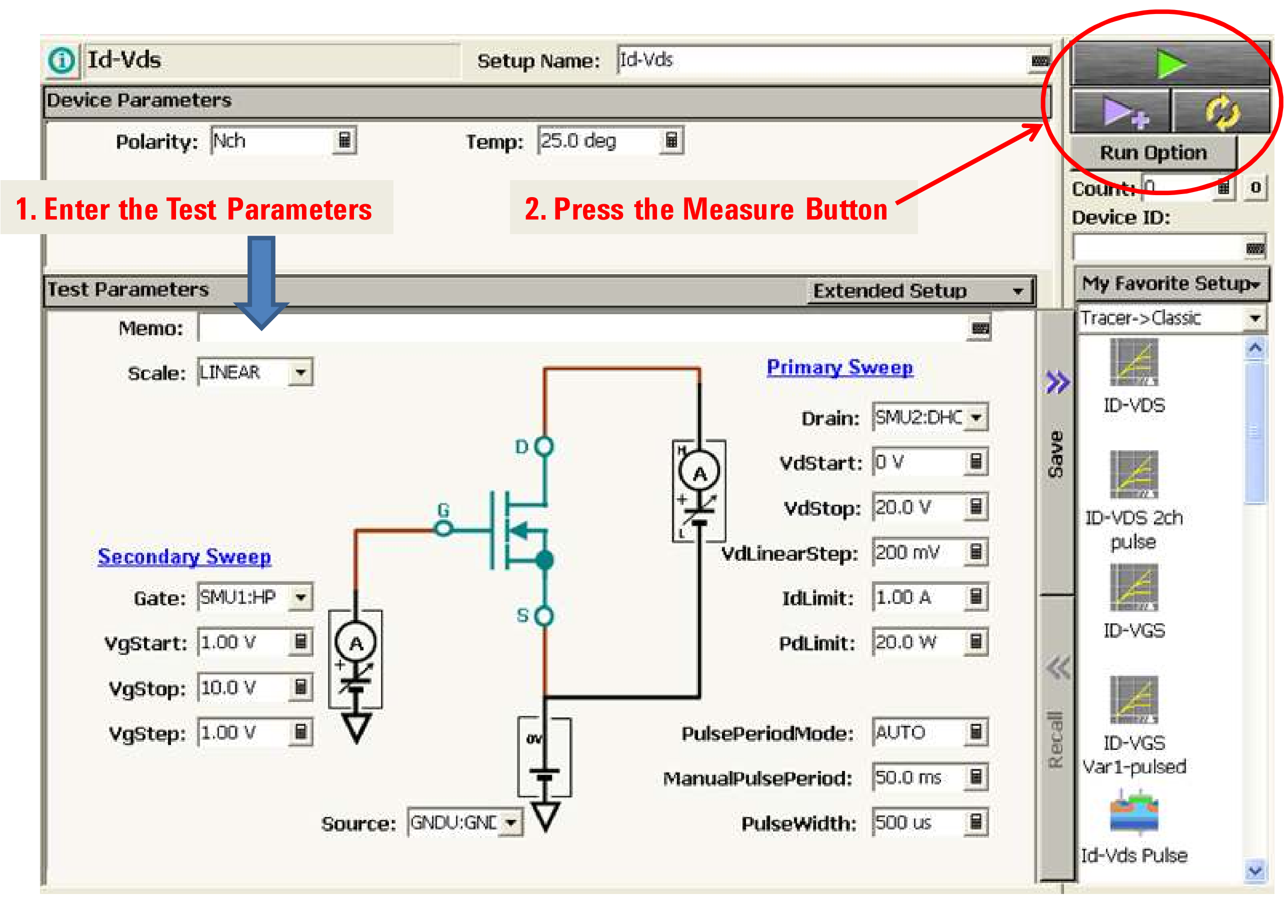
Application Test mode includes a library of pre-defined tests that eliminate the need to manually set up most instrument parameters for common device tests (such as Ic -Vce measurements). The user can perform a measurement through an intuitive "fill in the blanks" process. Measurements are performed and parameters are automatically extracted with just a simple click of the measurement button.

The Application Test mode shown in figure 1-7 is a pre-defined test library coming with the B1505A and it includes a basic and frequently used test, for example, Id-Vd measurements. The user can start measurements by just typing in the measurement parameters and the test results with a proper data which is automatically extracted by the measurement is coming out by just pressing the Measure button.

It is simple and very easy for adding modifications like the example. You can refer to the application note B1500A-4 "Customizing Agilent B1500A EasyEXPERT Application Tests", Agilent P/N: 5989-5167EN.

As a conclusion, Application Test is the best choice if it satisfies your requirement. If not, there are two choices; one is to modify the existing Application Test definition, and the other is going to Classic Test mode.

Figure 1-7. Application Test GUI.



3. Classic Test mode

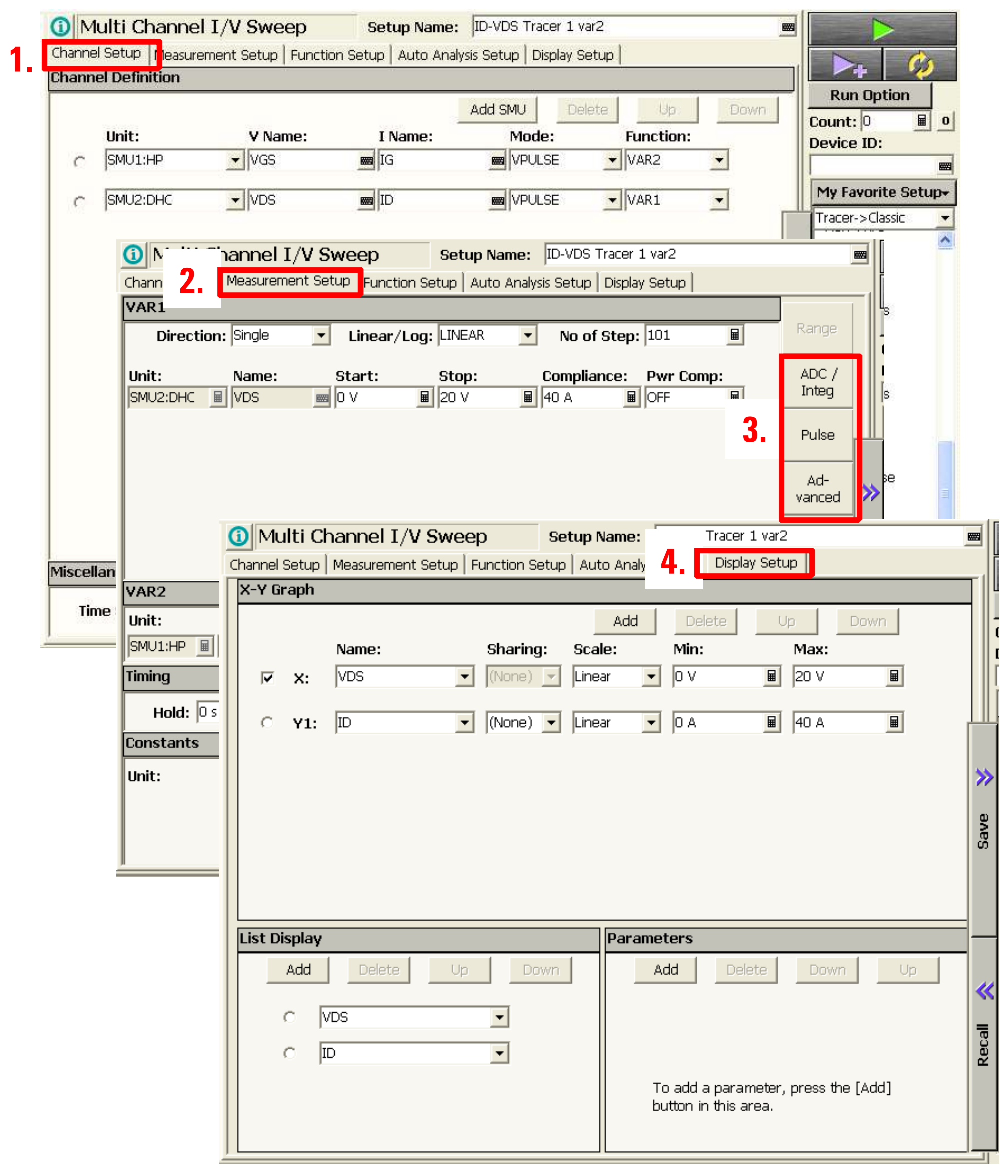
Classic Test mode provides complete access to all of EasyEXPERT software's measurement and analysis capabilities.
Measurement setups created in tracer test mode can be imported into classic test mode and auto-analysis calculations can be added to them. The resulting Classic Test setups can then be used both interactively and for automated testing.

Any application that is not covered in the Application Test library can be covered by using the Classic Test mode.

Figure 1-8 shows an example Classic test setup window where;

1. Channel Setup page,
2. Measurement Setup page and
3. optional SMU parameter setup sub-panels and
4. Display setup page that is minimum pages you have to fill in before starting measurements.

Figure 1-8. Example Classic Test measurement parameter setup panels.

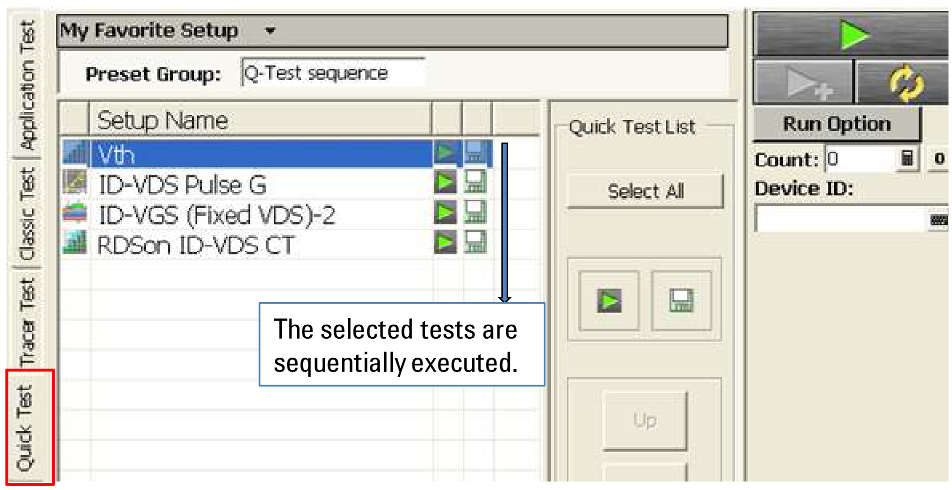


Setting up a new Classic Test definition requires more knowledge as like the connection between the device and SMUs of the B1505A and the function setup of the SMUs as shown in figure 1-8 compared to the pre-defined Application Test. Generally speaking, the user can interact more directly to the SMU control in the case of Classic Test compared to the Application Test which is somewhat black box to the user until knowing the inside setup by sneaking in the Application Test definitions.

4. Quick Test mode

Quick Test mode provides a convenient means to automate test setups created in Tracer Test, Application Test or Classic Test modes without the need to do any programming. You can automate test sequences for both a test fixture and for on-wafer testing across an entire wafer using the wafer prober drivers furnished with EasyEXPERT.

Figure 1-9. Quick Test executes selected test sequentially.



Chapter 2. Preparation for the Measurements

Objective: Chapter 2 covers the following preparation of the B1505A before starting B1505A measurement.

1. Before using the B1505A
2. Instruments and Accessories used in the demo
3. Devices used in the demo
4. Cable Connection between the B1505A and the Expanders/Fixture
5. Starting the B1505A
6. Updating the Application Test Library for EasyEXPERT rev. A.05.00

The objective of this chapter is to start the B1505A and setup EasyEXPERT to prepare for the measurement.

2-1. Before using B1505A

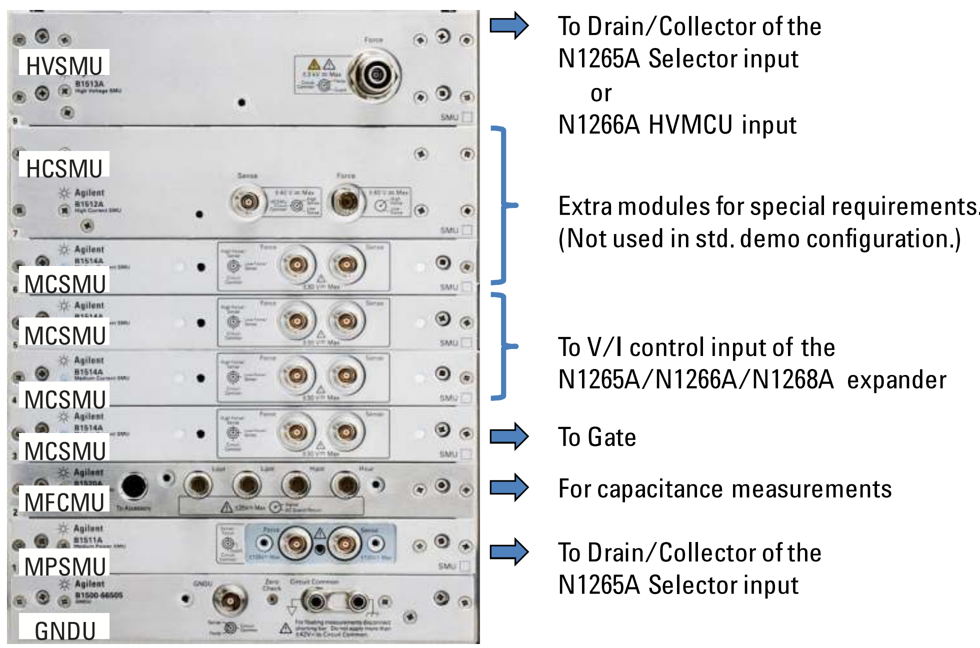
WARNING **There are potentially hazardous voltages (10 kV for UHVU, 3 kV for HVSMU, 2.2 kV for HVMCU, and 200 V for HPSMU) present at the Force, Sense, and Guard terminals of Agilent B1505A. To prevent electrical shock, the following safety precautions must be observed during the use of B1505A.**

- Use a three-conductor AC power cable to connect the cabinet (if used) and B1505A to an electrical ground (safety ground).
- You must connect an interlock cable between B1505A and the test fixture.
- Confirm periodically that the interlock function is functional.
- Do not modify the interlock circuit.
- Do not use extension cables for connecting the DUT the outside of the test fixture except a wafer prober which provides the equivalent safety of the test fixture..
- Before touching the connections on the Force, Guard, and Sense terminals, turn the B1505A off and discharge any capacitors. If you do not wish to turn the B1505A off, complete all of the following items, regardless of the B1505A settings.
  - Press the Stop key to turn the module output off.
  - Confirm that the High Voltage indicator is not lit.
  - Open the shielding box access door.
  - Discharge any capacitors connected to an SMU.

2-2. Instruments and Accessories used in the measurement examples

We use the following B1505A configuration in the measurement example,

Figure 2-1. B1505A configuration used in the example.



Agilent B1505A Power Device Analyzer/Curve Tracer configuration:

The standard B1505A demo configuration includes the following test modules.

- 1 X HVSMU (B1513B) High Voltage SMU
- 1 X HCSMU (B1512A) High Current SMU
- 4 X MCSMU (B1514A) Medium Current SMU
- 1 X MFCMU (B1520A) Multi-Frequency CMU
- 1 x MPSMU (B1511A) Medium Power SMU
- 1 x GNDU Ground Unit (furnished in the B1505A main frame)

Expanders and Cables used in the demo:

Figure 2-2 shows the N1265A UHC Expander/Fixture, N1266A HVMC Expander and N1268A UHV Expander.

Figure 2-3 shows the cables used for connecting between these Expanders/Fixture and the B1505A.

Figure 2-4 shows the test wires/cables used inside the test fixture.

Figures 2-2. Agilent N1265A UHC Expander/Fixture, N1266A HVMC Expander and n1268A UHV Expander.


N1265A UHC Expander/Fixture


N1266A HVMC Expander


N1268A UHV Expander

Figure 2-3. Cables used for connecting between the B1505A and N1265A/N1266A/N1268A Expander/ Fixture.


16493T HV Triax Cable


16493L GNDU Triax Cable


16494A Triax Cable


16493S HCSMU Cable


16493V UHV Cable:
High side


16493V SHV cable:


N1300A CMU Cable


16493J Interlock Cable


16493G Digital I/O Cable

Figure 2-4. Cables/Wires used for connecting inside the fixture.

Collector/Drain & Emitter/Source Force line wire

SHV cable and SHV-Banana Adaptor for capacitance measurement

Universal Force/Sense line wire

UHVU test cable

N1265A-041 Thermocouple

N1260A High Voltage Bias tee

2-3. Devices used in the measurement examples

The following devices are used for measurements through this guide.
The device types are selected to cover the maximum output range of the B1505A as;

- High current MOSFET (HCMOS): IRFP4004 to cover over 500A.
- High voltage MOSFET (HVMOS): IXTH1N250 to cover over 2500 V.
- IGBT: FGA180N33ATD to cover medium voltage and current (330 V, 450 A)
- High voltage diode: GP-02-40 to cover 4 k ~ 8 kV (2ea. series connected).

Figure 2-4. devices used in this guide.

IRFP4004
HC MOS

IXTH1N250
HV MOS

FGA180N33ATD
IGBT

GP02-40
4 kV Diode

Typical specifications of demo devices

1. High Current Power MOSFET: IRFP4004Pbf
   - o VDSS: 40 V
   - o Rds(on): Typ. 1.35 mΩ   (1.70 mΩ max.) @ Vgs=10 V, Id=195 A)
   - o ID max.: 350A @ 100 µs pulse, VD=10V
     1390 A @ Vd=2.5 V
   - o SOA: 3.5 kW @ Tc=25 °C, 100 µs pulse
   - o Vth: 2~4 V @ Id=250 µA
   - o Coss: 2360 pF typ. @ Vd=25 V
2. High Voltage Power MOSFET: IXTH1N250
   - o VDSS: 2500 V
   - o Rds(on): Max. 40 Ω
   - o ID max.: 6 A @ 100 µs pulse, 5 kW @ Tc=25 °C
   - o SOA: 3 kW @ Tc=25 °C, 100 µs pulse
   - o Vth: 2~4 V @ Id=250 µA
   - o Coss: 77 pF typ. @ Vd=25 V
3. IGBT : FGA180N33ATD
   - o VCES: 330 V
   - o VCE(sat): Typ. 1.68 V @ Ic=180A
   - o ID max.: 450 A @ 100 µs pulse, VC=16V
   - o SOA: 7.5 kW @ Tc=25 °C, 100 µs pulse
   - o Vth: 2.5~5.5 V (typ.=4 V) @ Ic=250 µA
   - o Coss: 305 pF typ. @ Vc=30 V
4. Ultra High Voltage Diode: GP02-40
   - o VRRM: 4,000 V
   - o IF (AV): 0.25 A
   - o IR @ 4 kV: 5 µA @ 25 °C

2-4. Cable Connection between the B1505A and the Fixture/Expanders for basic DC demo

Before starting the measurements, connect the cables between the B1505A, the N1265A Ultra High Current Expander (UHCE)/Fixture and the N1266A HVSMU Current Expander (HVCE).

The connection which is shown in this section is common for all the DC measurements using the N1265A UHCU.

Note:
The configuration for ultra high voltage demo using the UHVU and the capacitance measurements demo uses different configurations. They are separately shown in that demo section.

Figure 2-5. Back side view of the B1505A and Expanders.

B1505A std. Demo configuration (back)

N1265A (back)

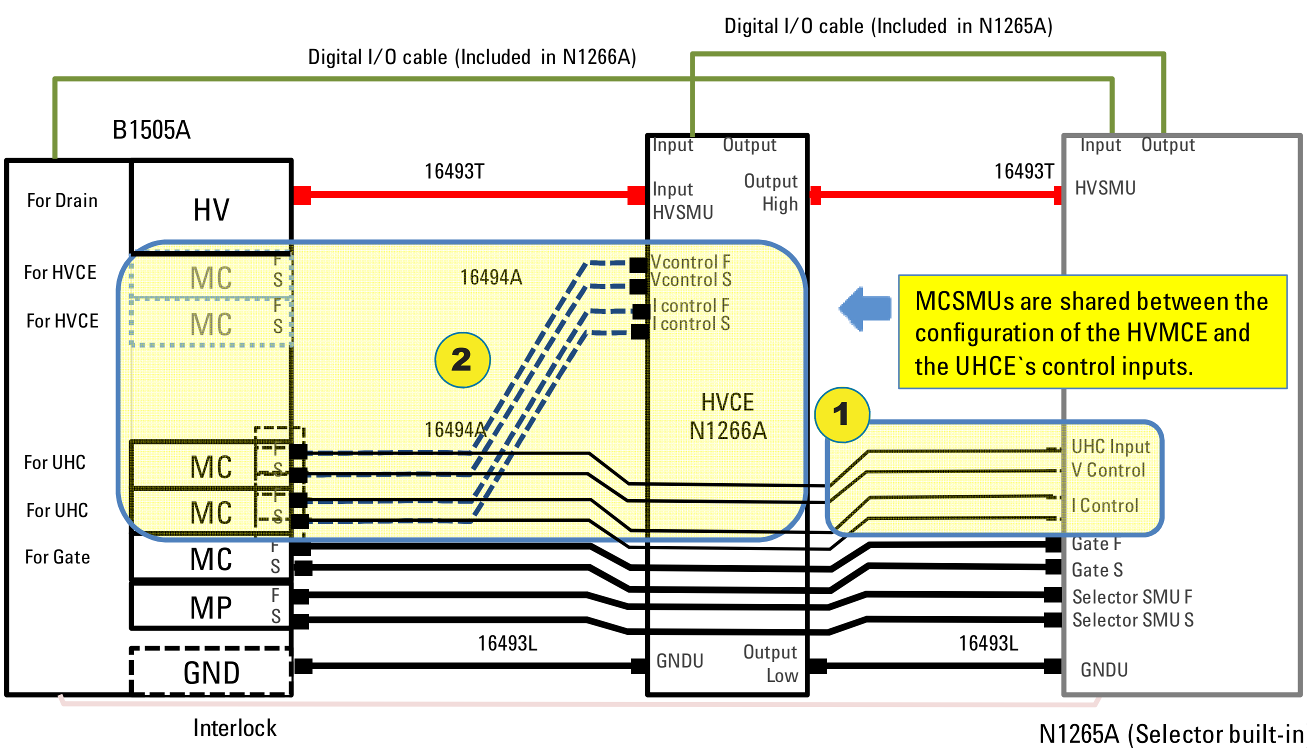
N1266A (back)

Cabling block diagram

Figure 2-6 shows the basic cabling block diagram between the B1505A and the N1265A UHCE and the N1266A HVCE.

Note:
In the demo setup, we basically share only two V/I control MCSMUs between the N1266A HVCE and the N1265A UHCE. Therefore, four cable connection lines from two MCSMUs to control the N1265A UHCE are shown in solid line (see 1).
The four dotted lines (see 2) to the N1266A HVCE mean that they are switched between the N1265A UHCE, but not connected this time.

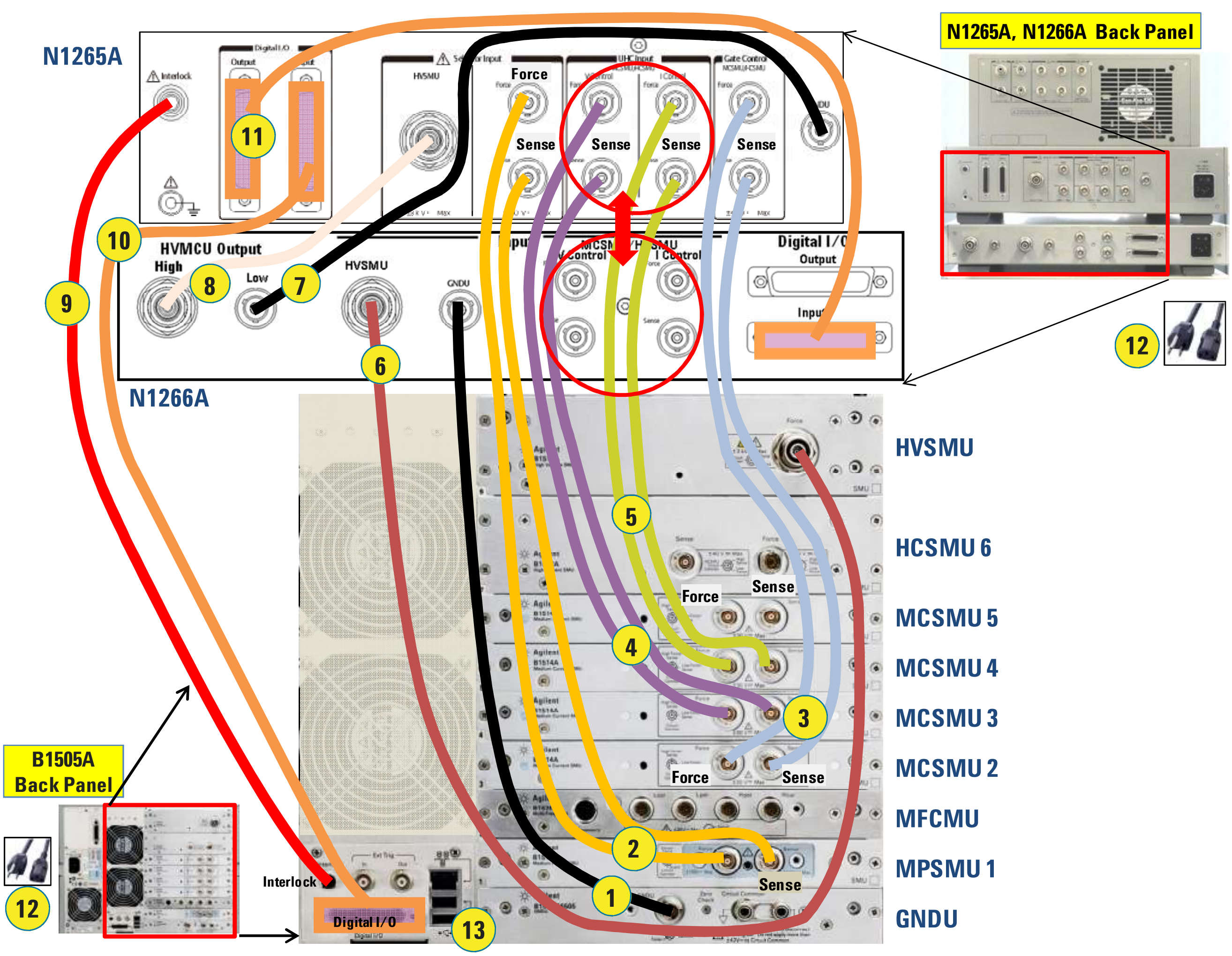
Figure 2-6. Basic cabling block diagram for UHCU and HVMCU.



Connect the cables between the B1505A and the Expanders as shown in figure 2-7 by following the step number 1 to 13 of figure 2-7.

The breakdown of each steps with cable figures and the connector locations are shown in figure 2-9.

Figure 2-7. Cable Connection for N1265A UHCE and Test Fixture.



Step number 1:

Using a 16493L GNDU Cable, connect the GNDU on the B1505A to the GNDU Input on the N1266A.

Step number 2:

Using a 16494A Triax Cable, connect the Force and Sense connectors on the lower B1511A MPSMU (SMU1) to the respective connectors on the selector input on the N1265A.

Step number 3:

Using a 16494A Triax Cable, connect the Force and Sense connectors on the 2nd SMU from the bottom (MCSMU2) to the “Gate Connect” input connectors of the N1265A.

Step number 4:

Using a 16494A Triax Cable, connect the Force and Sense connectors on the 3rd SMU from the bottom (MCSMU3) to the “V control” connectors of the UHC input of the N1265A.

Step number 5:

Using a 16494A Triax Cable, connect the Force and Sense connectors on the 4th SMU from the bottom (MCSMU4) to the “I control” connectors of the UHC input of the N1265A.

Step number 6:

Using a 16493T HV Triax Cable, connect the Force connector on the B1513A HVSMU to the HVSMU input of the N1266A

Tips:

Make sure to screw in the connector firmly by hand to the end point where you feel some resistance.

Step number 7:

Using a 16493L GNDU Cable, connect the Low output of the N1266A HVMCU to the GNDU Input of the N1265A.

Step number 8:

Using a 16493T HV Triax Cable, connect the High output connector of the N1266A to the HVSMU connector of the selector input of the N1265A

Step number 9:

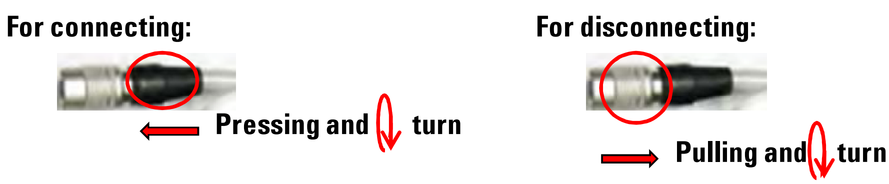
Using a 16493J Interlock Cable, connect the Interlock on the B1505A and the Interlock on the N1265A

Tips:

For connecting the interlock cable, hold the black plastic part and then turn the connector by pressing toward the interlock connector in the instrument side as shown in figure 2-8.

For disconnecting the interlock cable, hold the metal part and then pull the connector by turning it.

Figure 2-8. Interlock connection.



Step number10:

Using a 16493G Digital I/O Cable, connect the Digital I/O connector on the B1505A to the Digital I/O Input connector on the N1265A UHCE/Fixture.

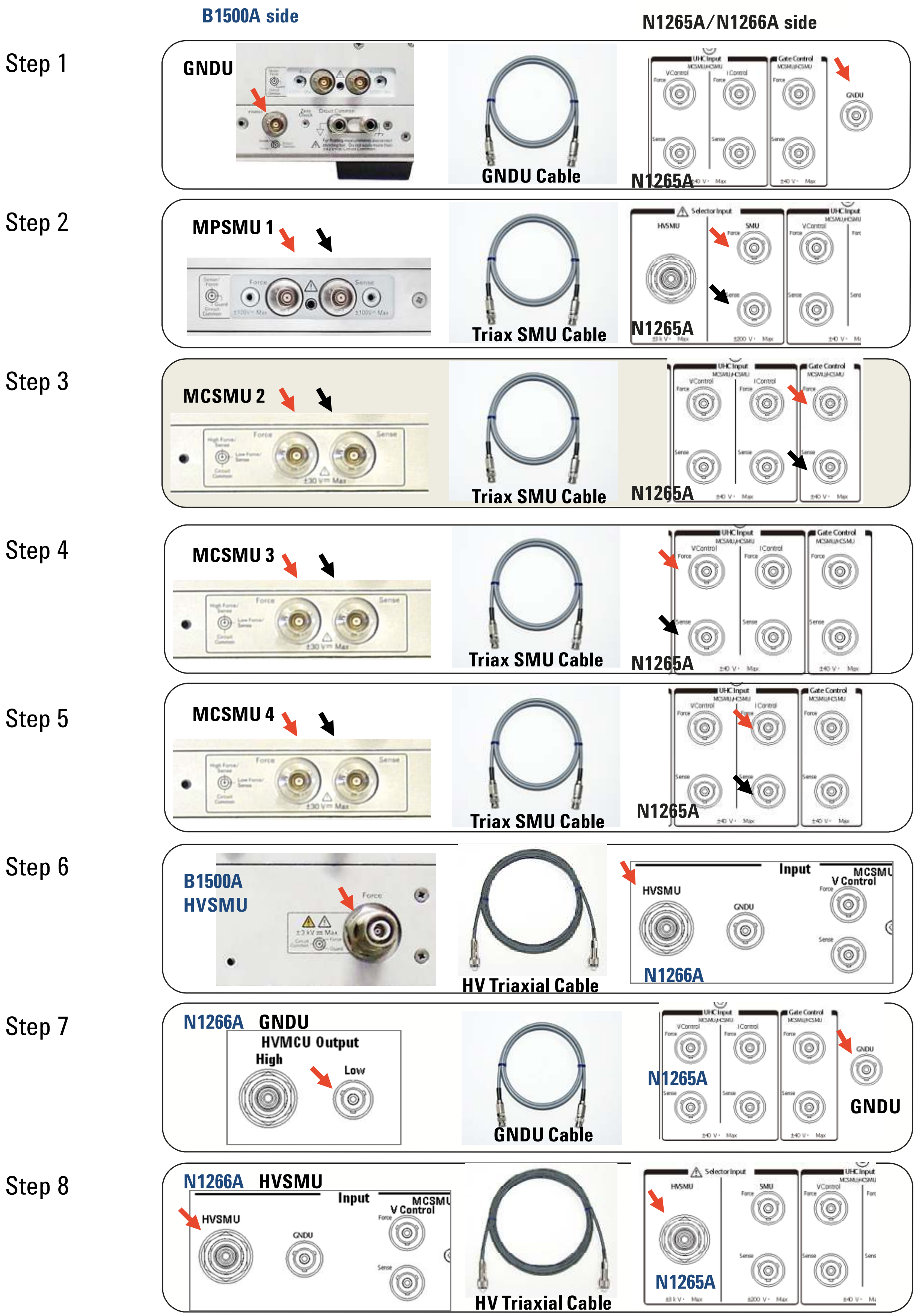
Step number11:

Using a 16493G Digital I/O Cable, connect the Digital I/O Output connector on the N1265A to the Digital I/O Input connector on the N1266A HVCE.

Step number 12:

Connect power cable to the B1505A, N1265A and N1266A.

Figure 2-9.


B1500A side
N1265A/N1266A side
Step 1
GNDU
GNDU Cable
N1265A
Step 2
MPSMU 1
Triax SMU Cable
N1265A
Step 3
MCSMU 2
Triax SMU Cable
N1265A
Step 4
MCSMU 3
Triax SMU Cable
N1265A
Step 5
MCSMU 4
Triax SMU Cable
N1265A
Step 6
B1500A
HVSMU
HV Triaxial Cable
Input
MCSMU
V Control
HVSMU
GNDU
N1266A
Step 7
N1266A GNDU
HVMCU Output
High
Low
GNDU Cable
N1265A
GNDU
Step 8
N1266A HVSMU
Input
MCSMU
V Control
HVSMU
GNDU
HV Triaxial Cable
N1265A

Step 9

Step 10

Step 11

Step 12 Connect Power Cables to all the B1505A, B1265A and B1266A

Keyboard and mouse: Step number 13:

Be sure to connect the keyboard and a mouse before starting the B1505A.

Key Board

Mouse

2-5 Starting the B1505A

2-5-1 Starting the B1505A

The following operations are covered in this section.

Step 1. Turn on the Agilent B1505A.
Step 2. Starting the EasyEXPERT software.
Step 3. Preparing for user specific work area in the EasyEXPERT Workspace.

Step 1. Turning on the Agilent B1505A

After you receive the B1505A, perform the following setup.

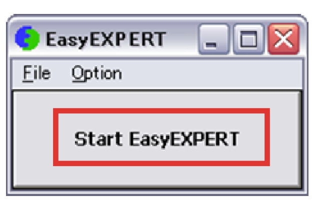
1. Make sure that the Standby switch is set to off.
2. On the B1505A rear panel, make sure the Circuit Common terminal is connected to the frame ground terminal with a shorting-bar.
3. Connect the Agilent 16444A-001 USB keyboard and the 16444A-002 USB mouse to the USB port of the B1505A.
4. Connect the power cable from the B1505A to an AC power outlet.
5. Open the measurement terminals (disconnect measurement devices if they are attached), and press the Standby switch (lower right corner of the front panel) to turn on the B1505A.
   Windows, measurement module initialization, and self-calibration will start.
6. The default Windows setup logs on to Windows automatically by the "***Agilent B1500 User***" which should be default user of the B1505A.

Note:

If you are the first user of the B1505A shipped from the Agilent factory, then you are required to perform the initial setup of the Windows operating system of the B1505A.

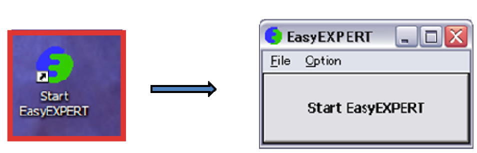
Step 2. Starting EasyEXPERT

After logging on, click the **Start EasyEXPERT** button.
Wait until EasyEXPERT is activated.



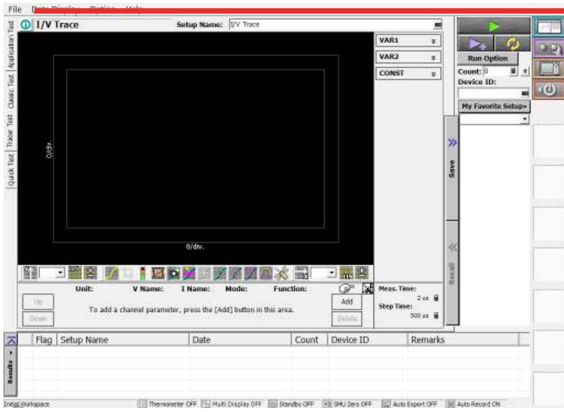
Note:

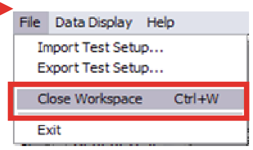
If you close the Start EasyEXPERT window, you can run it again by clicking the following Start EasyEXPERT short cut on the Windows desktop.



Just after the Windows initialization, the EasyEXPERT start up window opens with one of the following three cases.
Follow the instruction to setup the EasyEXPERT demo workspace.

Case 1: First time use

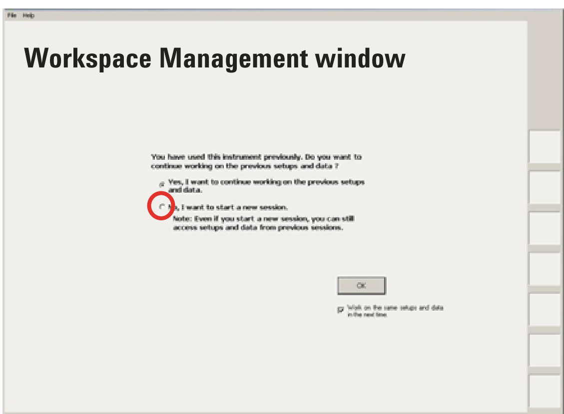




Close Workspace by selecting "Close Workspace" from the "File" menu, and return to the EasyEXPERT work-space management window.

Click "Close Workspace" change the panel to "Case 2" Workspace Management window.

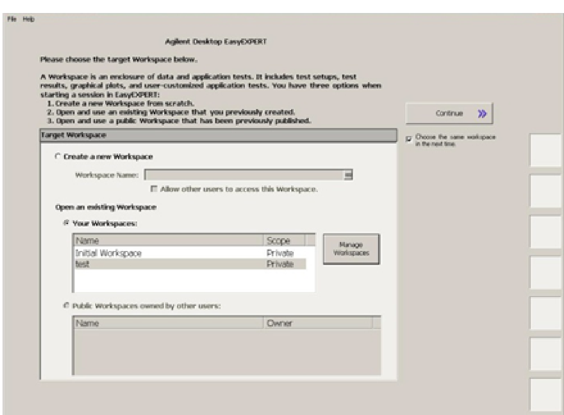
Case 2: One existing workspace



Check the "No, I want to start a new session" radio button.

Go to Step 3 of next page to create a new Workspace for demo use.

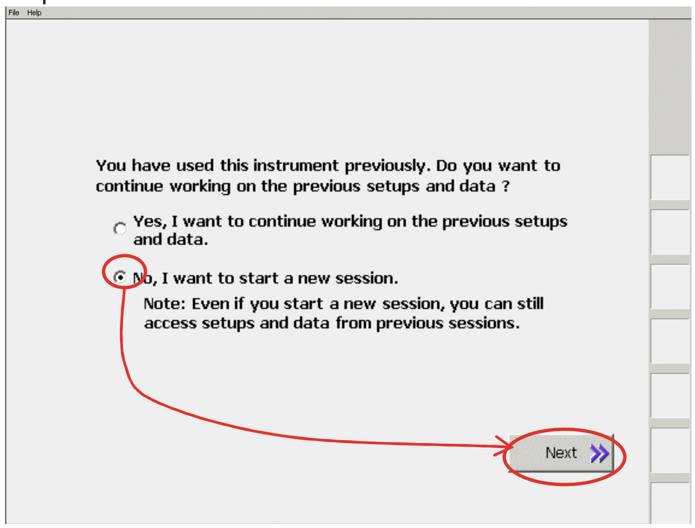
Case 3: More than two existing workspace



Go to Step 3f of two pages from this page and create a new Workspace for demo use.

Step 3. Preparing for user specific Workspace of EasyEXPERT

Step 3a. Select the "No" radio button and click Next

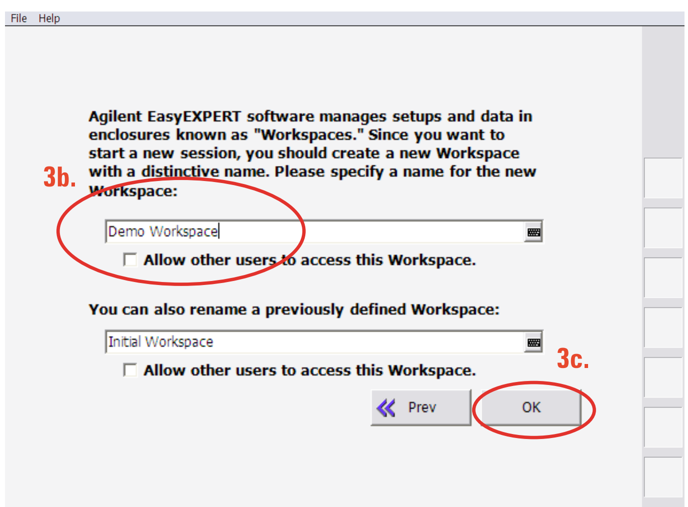


Step 3b. The following Workspace Configurator appears.

We create a new workspace, and this workspace will be deleted on demo B1505A return.

Enter, say, *"Demo Workspace XX"* as a unique name new workspace in the new workspace entry field.

Step 3c. Click OK.

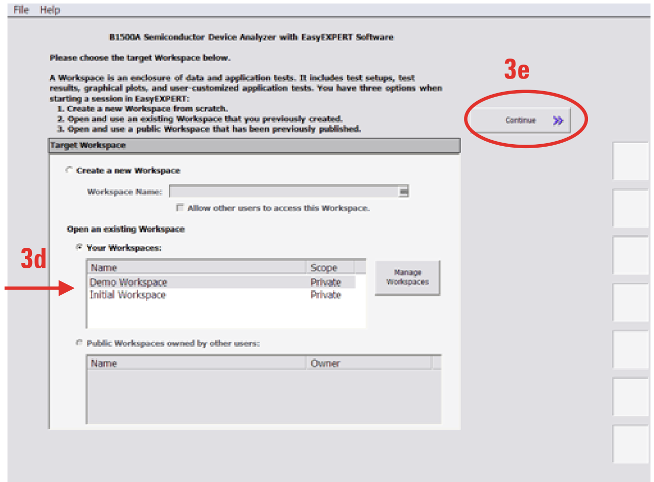


Go to Step 3d of next page.

(Continued : Demo Workspace setup)

Step 3d. Click the new "*Demo Workspace XX*" to highlight it.

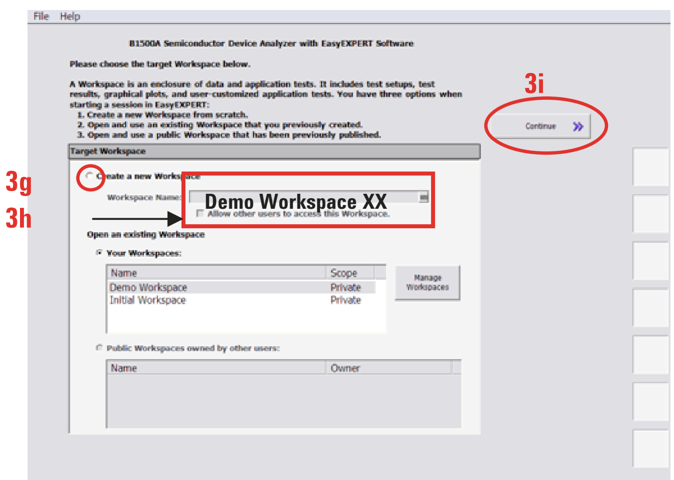
Step 3e. Click Continue.



Go to "Step 3j" of next page.

Step 3f. Creating a new Workspace.

If two or more workspaces already exist, B1505A displays the following Workspace Configurator.



Step 3g. Click "Create a new Workspace radio button

Step 3h. Enter, say, “Demo Workspace XX” as a unique name new workspace in the new work-space in the new workspace entry field.

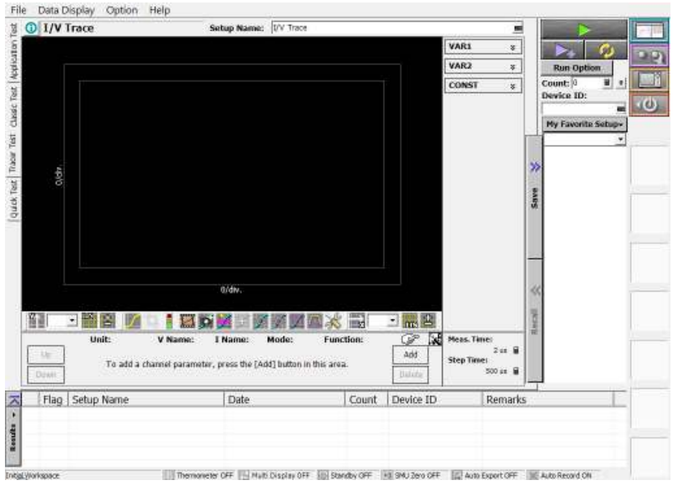
Step 3i. Click Continue

Go to "Step 3j" of next page.

Note:

Workspace means the space created in the Agilent B1505A’s internal hard disk drive, and is used to store the measurement setup, measurement result data, and so on. The workspace can be created and allocated for each user .

Step 3j. The following new EasyEXPERT initial window opens.



Now, new “Demo Workspace XX” is created and the User Demo Setup is completed.

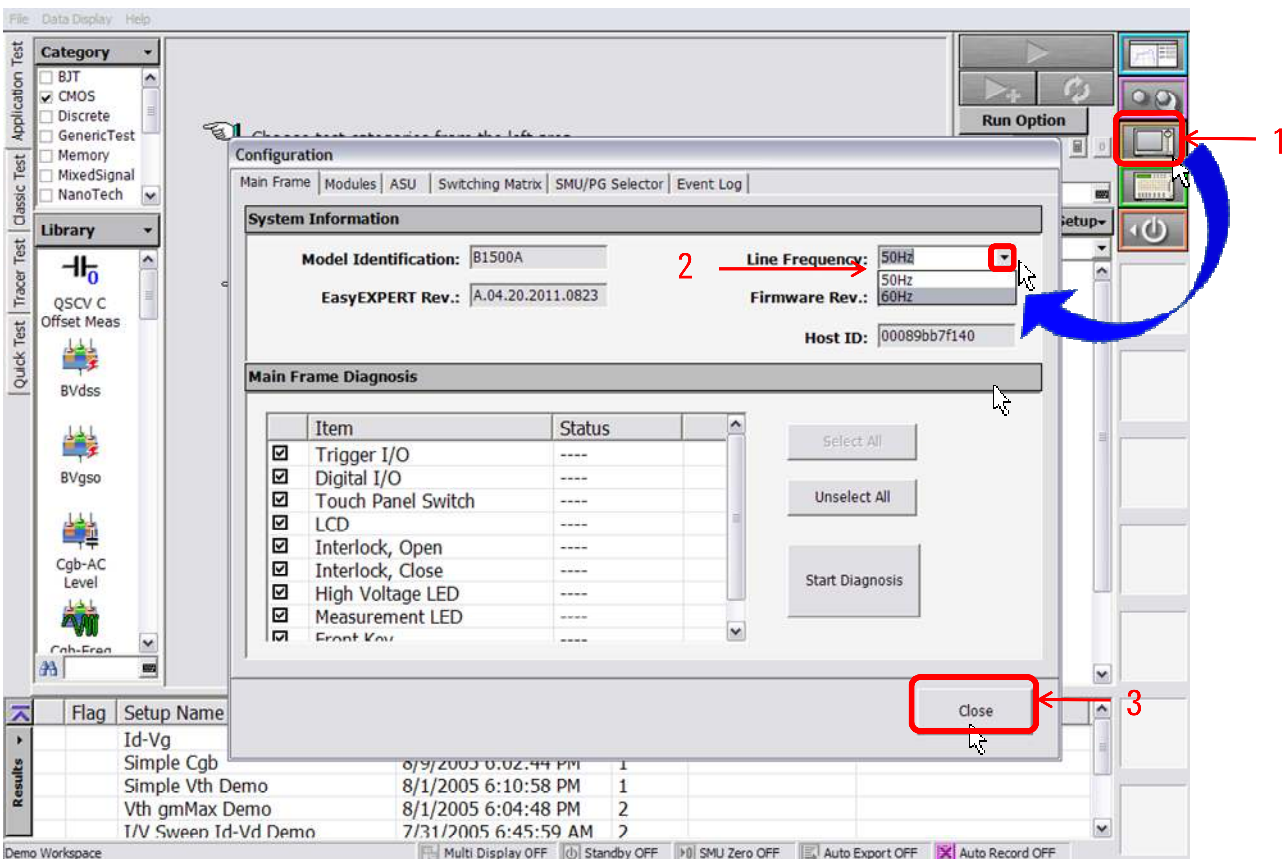
2-5-2 Power line frequency setting

Power line frequency setting is very important for accurate and stable measurements in low signal voltage or current.

Please check your line frequency setting of your Demo B1505A.

If the line frequency is set differently from your area's line frequency, please set it correctly by following the following steps.

- **To Change:**
  1. Click "Configuration" button.
     Configuration window opens.
  2. Click Line frequency button to open the line frequency list.
     Select 50Hz or 60Hz.
  3. Click "Close" button.



2-5-3 Online Help

Online Help is available for EasyEXPERT.

Select "Help > EasyEXPERT Help menu" to display the online help window.

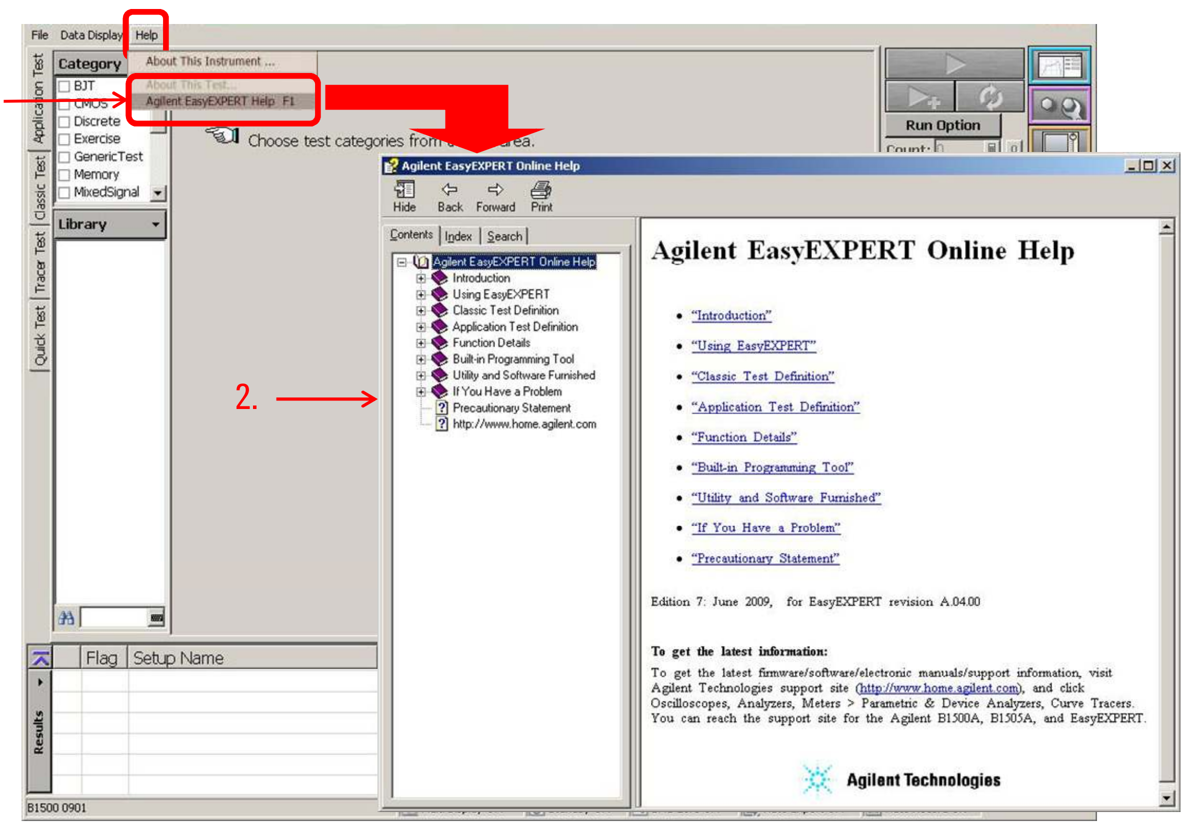
The online help provides the following information.

- Introduction
- Using EasyEXPERT
- Function Details
- Built-in Programming Tool
- If You Have a Problem

◆ **To Display Help:**

Follow the next steps to display Online Help.

1. Select "Help > EasyEXPERT Help menu".
2. "Help" window opens.



2-6. Updating the Application Test Library for EasyEXPERT rev. A.05.00

Earlier demo B1505A system requires to modify and add the following EasyEXPERT Application Test library to satisfy the demo condition;

Addition:

- Id-Vgs for Expanders (A.05.01)
- Ic-Vge for Expanders (A.05.01)

Modification:

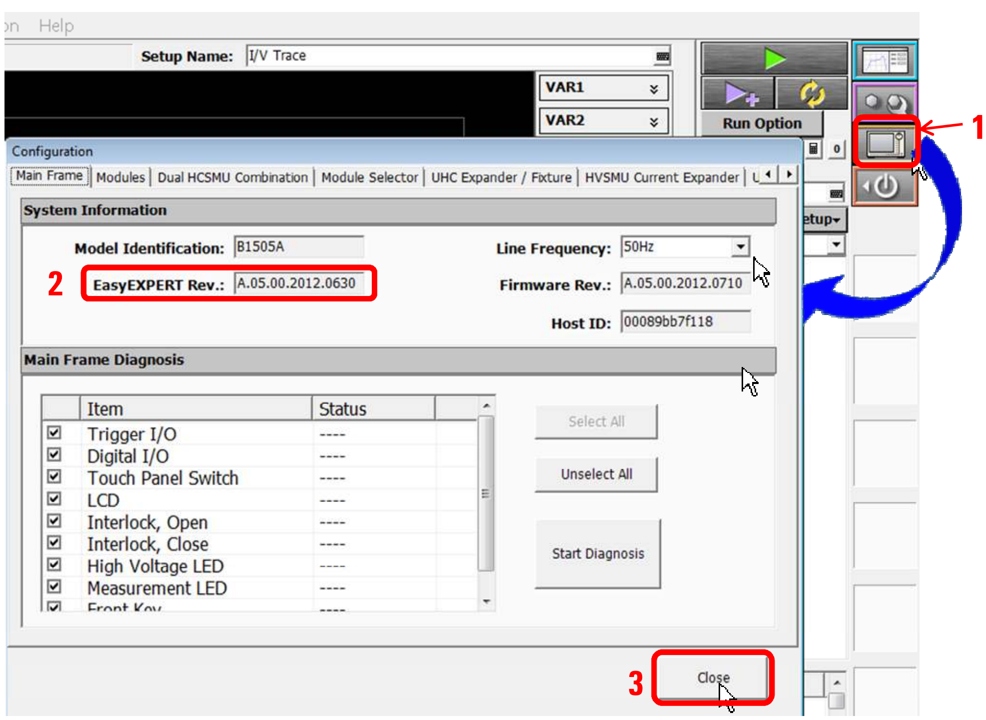
- Vth Vgs(off): Vth or Vgs(off) measurement (A.05.00)
- Vth Vge(off): IGBT Vth or Vge(off) measurement (A.05.00)

You can check your EasyEXPERT revisions as follows.

1. Click "Configuration" button.
   Configuration window opens.
2. Check EasyEXPERT revisions here.
   If the first 5 letters are "A.05.00" as shown in the following figure, please go to Appendix 1, and make necessary changes.

   Note:
   If it is "A.05.01" or larger, there is no extra action required.

3. Click "Close" button



Chapter 3. Demonstration 1: Vth Measurement

Getting familiar with the B1505A and the EasyEXPERT Test operation

Objective:

This chapter covers the following topics.

1. Wiring and Device setting on the N1265A Fixture.
2. EasyEXPERT configuration for expanders.
3. The use of the Gate Rs to prevent oscillation (Tips).
4. Vth measurement using the Application Test (Vd=Vg)
5. Vth measurement using the Application Test (Vd=Const)

The objective of this chapter is to become able to measure Vth of the demo devices by using the Application Test Library by following the above topics.

Features:

By using the Application Test mode, you can expect to touch the following features;

- GUI based: Easily understand the device connection.
- Measurement parameters only: Typically, only the test condition parameters are enough to start measurements. Hardware setup is usually not required.
- Auto-analysis: Generally the measurement includes the auto-analysis results of the device parameter.

Device used:

Demo 1 uses the following devices;

- IPFP4004 PbF HC MOSFET
- FGA180N33ATD IGBT (optional)
- IXTH1N250 HV MOSFET (optional)

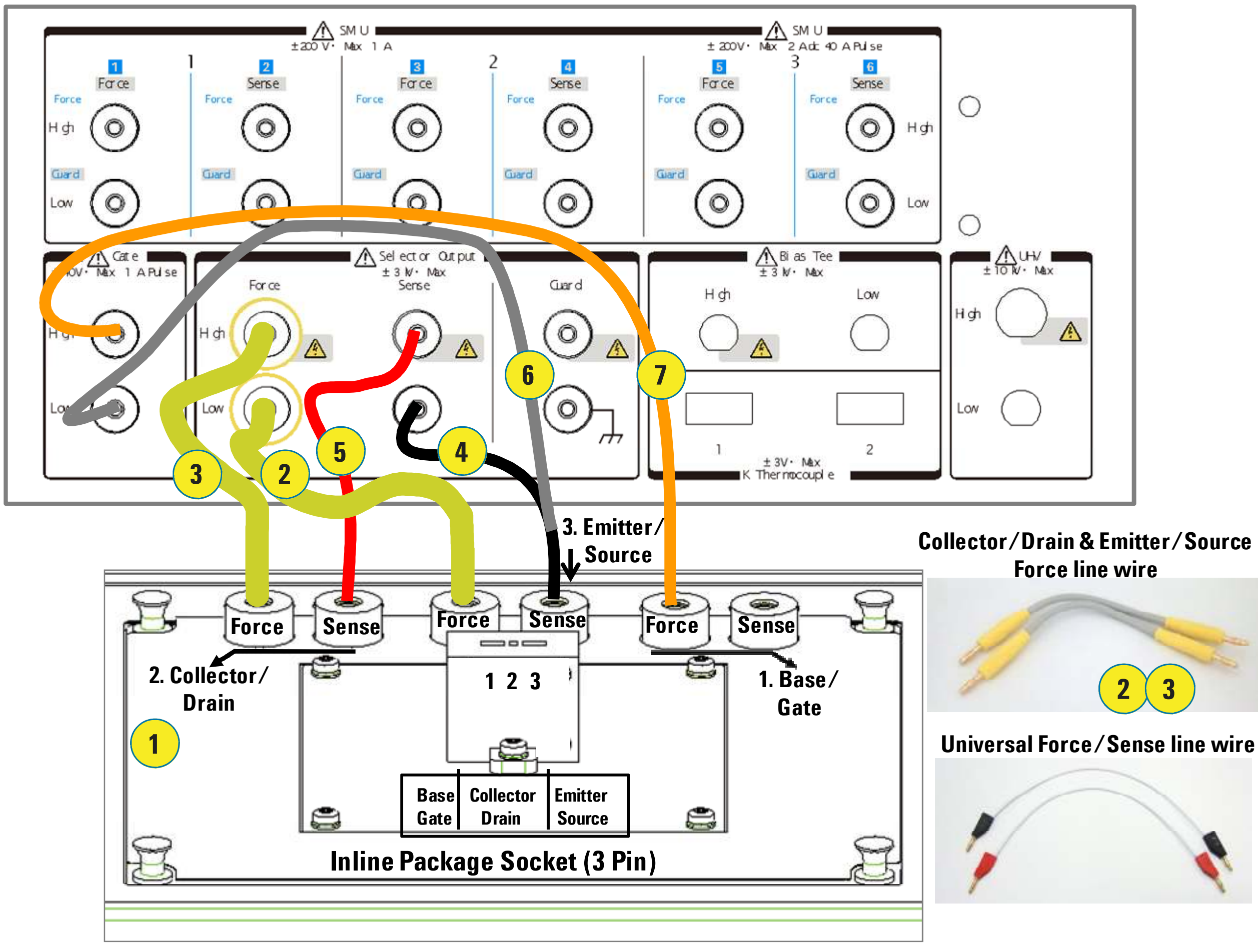
Note:

If your EasyEXPERT revision is A.05.00, you have to modify the application test definition before starting the Vth measurement.
Refer to chapter 2-6 if you have not yet modified the Vth application test definition.

3-1. Wiring and Device setting inside of the N1265A Fixture

Figure 3-1 shows the wiring inside of the N1265A UHC Expander/Fixture. Route the wire between the output terminal panel of the N1265A Test Fixture and the inline package socket module as shown in the figure.

Figure 3-1. Wiring inside of the N1265A Fixture.



Follow the next steps to set up the wires inside the fixture by following the numbers on figure 3-1.

Note:

Use thick wire for 2 *and* 3 *that can withstand up to 1500 A.*
Use the thinner wire for other connections.

Step 1. Make sure 3-pin inline socket module is set to the N1265A Fixture. If not, set the socket module as shown in figure 3-1, and tights the module by fixing the four pins located on the four corners of the socket module.

Step 2. Connect the Low-Force of the Selector Output to the terminal 3 Low-Force (Emitter/Source) on the Inline Package Socket.

Step 3. Connect the High-Force of the Selector Output to the terminal 2 High-Force (Collector/Drain) on the Inline Package Socket.

Step 4. Connect the Low-Sense of the Selector Output to the terminal 3 Low-Sense (Emitter/Source) on the Inline Package Socket.

Step 5. Connect the High-Sense of the Selector Output to the terminal 2 High-Sense (Collector/Drain) on the Inline Package Socket.

Step 6. Connect the Low of the Gate Output to the terminal 3 Low-Sense (Emitter/Source) on the Inline Package Socket.

Step 7. Connect the High of the Gate Output to the terminal 1 Force (Base/Gate) on the Inline Package Socket.

Note:
The connections shown in this section are common for all the DC measurement using the N1265A UHCU and 1266A HVMCU.

3-2. Test Device setup

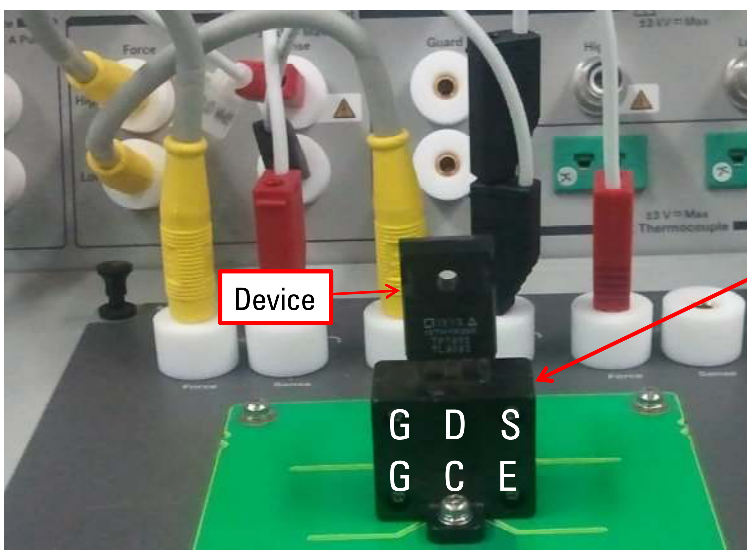
Set the test device (DUT) as shown in figure 3-2.

This time, we set the HC MOSFET: IRFP4004Pb.

Insert the MOSFET to the 3-pin socket (From the left, it is Gate, Drain and Source).

Figure 3-2. DUT setup.

IRFP4004
HC MOS



G: Gate
D: Drain
S: Source
C: Collector
E: Emitter

3-2. EasyEXPERT Configuration for Expanders

◆To Configure UHCU:

Each expander has to be configured before the use after the power on-state.

Note: Before proceeding to the configuration, make sure the cable connection is properly made as shown in figure 2-7

Follow the next instruction by following the steps shown in figure 3-3.

Step 1. Click Configuration icon.

Step 2. Click "UHC Expander / Fixture" tab.

Step 3. Click and mark the check box of "Enable Ultra High Current Unit".

Step 4. Select exact the same Control SMUs for the V/I control SMUs` drop down list as you have configured in the B1505A cabling section.
i.e. SMU3:MC for V Control SMU, and SMU4:MC for I Control SMU.

Step 5. Click and mark the check box of "Enable Selector".

Step 6. Leave blank for HVSMU if HVSMU is not yet configured in the “HVSMU Current Expander” tab.
Note: Select SMU5:HV for HVSMU if it is available.

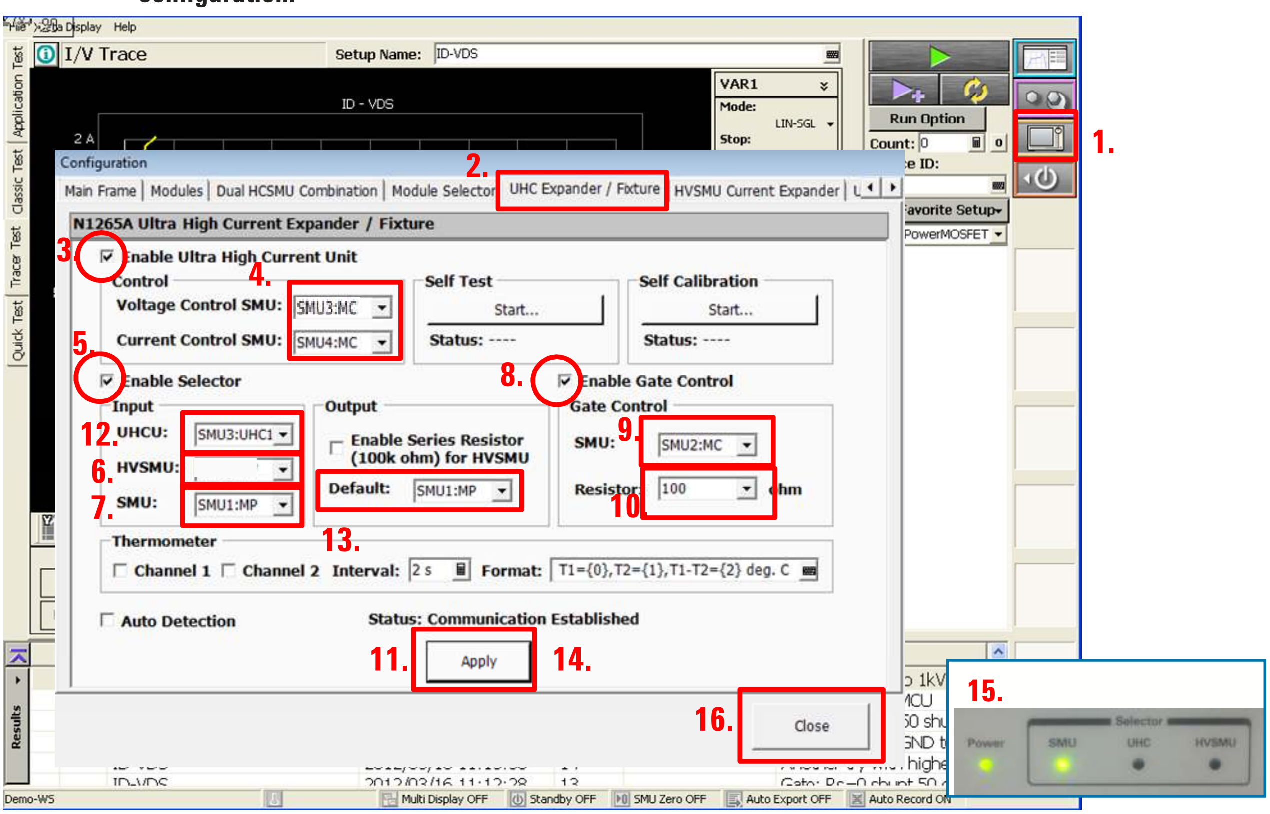
Step 7. Select SMU1:MP for SMU.

Step 8. Click and mark the check box of "Enable Gate Control".

Step 9. Select SMU2:MC for gate control SMU.

Step 10. Set 100 ohm to the output of the Gate Control SMU as a default value.
There are 0, 10, 100 and 1000 ohm choice.
Note: Selecting 0 ohm easily shows device oscillation and it is not recommended.

Figure 3-3. UHCE/Fixture configuration.



Step 11. Click "Apply" button.
The configuration is checked, and step 12 follows.

Step 12. Field #12 and #13 are filled automatically depending on previous EasyEXPERT setting.
The power indicator changes from orange to yellow, and the selector output indicator shows the currently active unit as shown in #15.

Step 13. You can change the default output module here.
Set SMU1:MPSMU as a default in this section.

Note: This setting will generate the switching relay sound when switching from the default to UHC.

Step 14. Click "Apply" button to renew the active selected module.

Step 15. The selector indicator of N1265A front panel changes to the current selector status: SMU.

Step 16. Click "Close" button to close the Configuration window.

3-3. The use of the Gate Rs to prevent oscillation (Tips).

There are three built-in switchable gate resistors and one short path in the Gate control of the N1265A UHC Expander/Fixture as shown in figure 3-4.

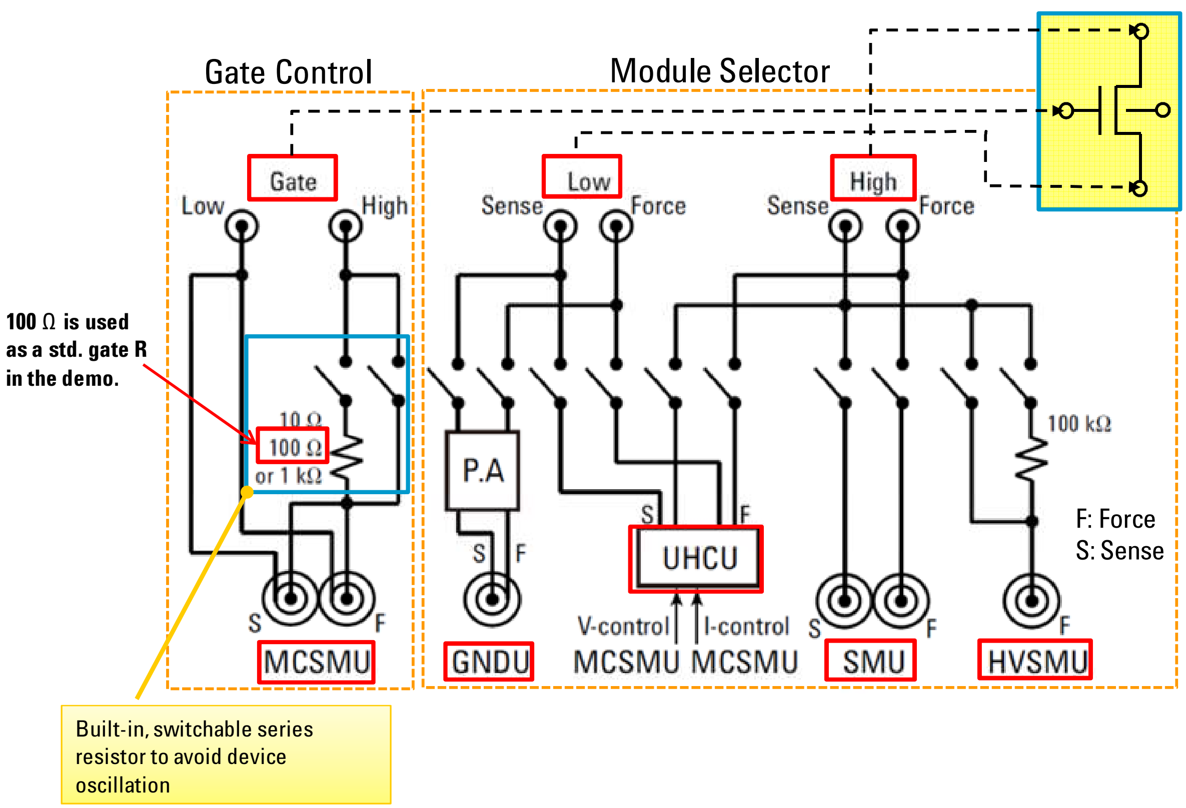
This resister is used to prevent device oscillation, and the resistor value is chosen by considering the circuit stability (margin to an oscillation), pulse width and the device capacitor component between the drain gate of power MOSFET and collector gate of IGBT.

Generally speaking, when the capacitor component is larger and pulse width is shorter, a smaller gate resistor is required.

Note:

We typically use 100 Ω in the demonstration except if it is specified a different value on a demo instruction.

Figure 3-4. Gate R.



Demo 1. Vth measurement using the Application Test

First step of the power device measurement is to know the gate threshold voltage (Vth) or cutoff voltage.
Vth measures the gate voltage which turns on the drain/collector to source/emitter channel, and can be considered as the reference point to set the gate parameters of the power MOSFET/IGBT.

There are several ways to measure and characterize the Vth as shown in figure 3-5.

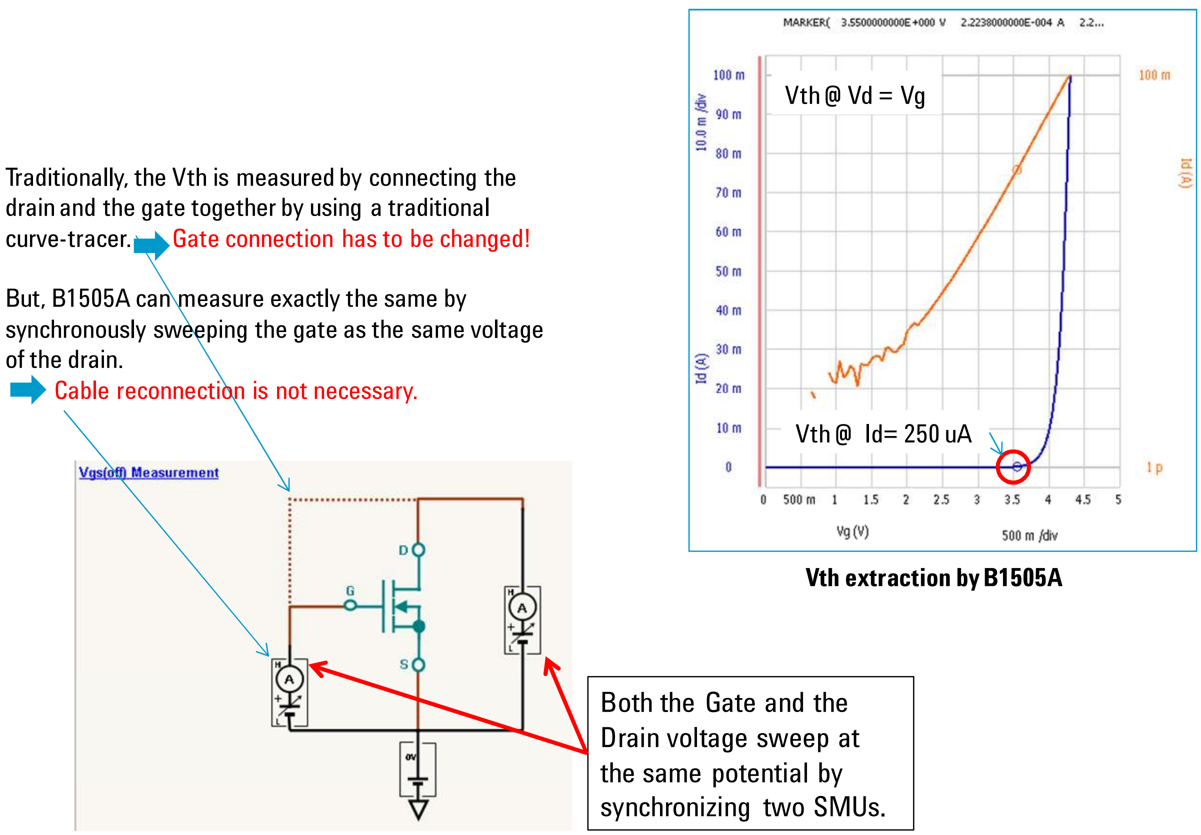
In the power device measurement, the Vth is traditionally measured by connecting the gate and the drain/collector together to overcome the measurement resource limitation of the traditional curve-tracer.
Because of this, typically, the datasheet specification of the power MOSFET uses this test method for Vth extraction.

But this method requires the extra connection between the gate and the drain/collector pins, and it complicates the test setup.

The B1505A can make measurement with the same way, but we have a better way. By emulating this measurement by using two SMUs, we can extract the exact Vth without changing the cable connections of the device, and the capability without manually changing the cable connection is an important point for measuring the device parameters.

We demonstrate Vth extraction by using two SMUs.

Figure 3-5. Vth measurement.



Demo 1-1. Vth Vgsoff Application Test

Vgsoff measurement using the Application Test (@ Vd=Vg)

Demo 1-1 demonstrates the Vgs(off) test of the Vth Vgs(off) Application Test. This test sweeps both the gate and the drain in the same voltage.

Follow the next steps to measure vgs(off) of IRFP4004 high current power MOSFET by following the number of figure 3-6.

Step 1. Click “Application Test” mode tab.

Step 2. Click PowerMOSFET Category.

Step 3. Enter “Vth” to the search field.

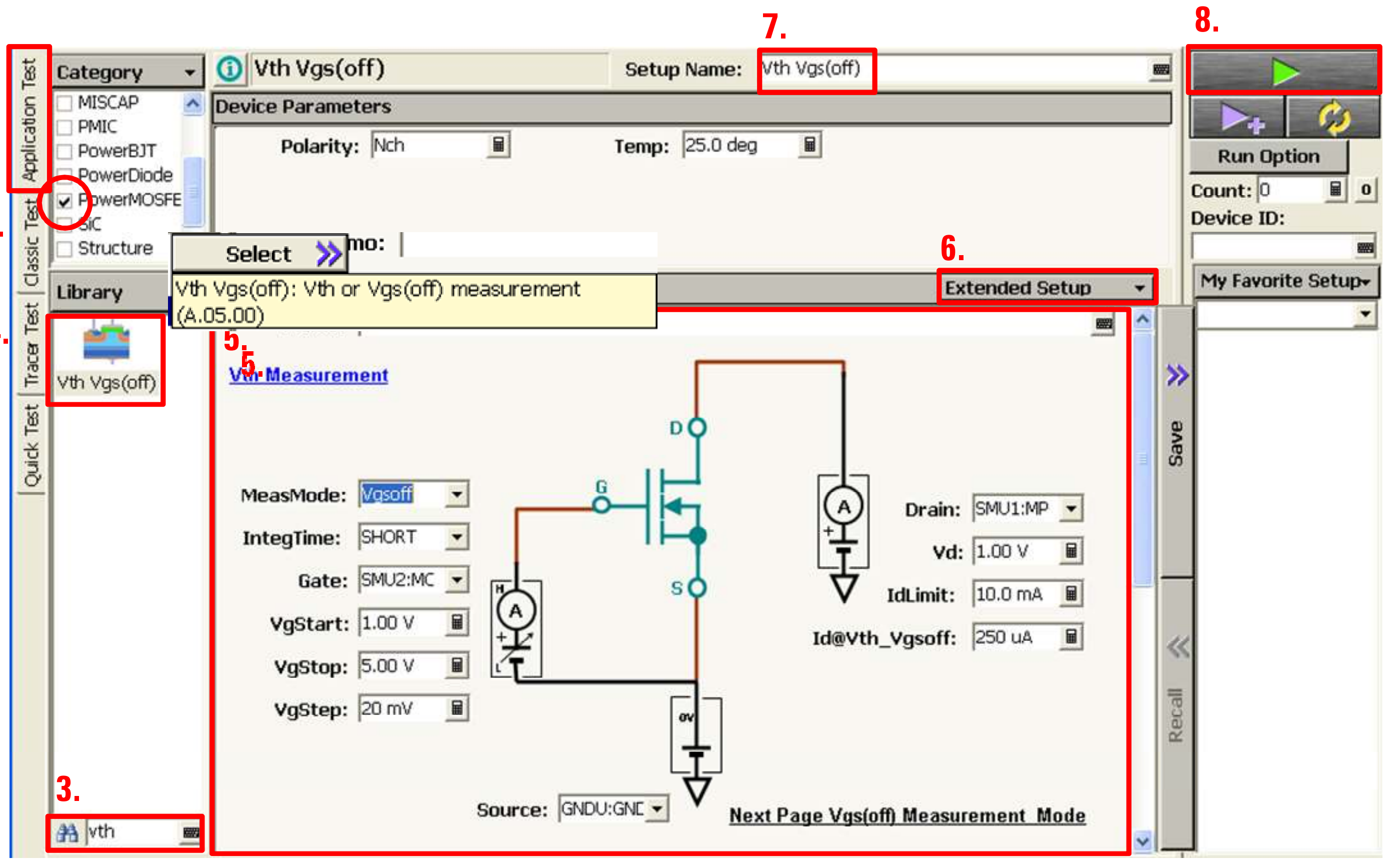
Step 4. Click “Vth Vgs(off)” Application Test, and click Select.

Step 5. Vth Vgs(off) Application Test definition GUI opens.
Enter or select the next test parameters to the GUI.

MeasMode	Vgsoff	Drain	SMU1:MPSMU
IntegTime	SHORT	Vd	1 V
Gate	SMU2:MCSMU	IdLimit	10 mA
VgStart	1 V	Id@Vth_Vgsoff	250 uA
VgStop	5 V		
VgStep	20 mV	Source	GNDU

Note: Vd setup is ignored in the Vgsoff MeasMode, and the gate term is applied to the drain.

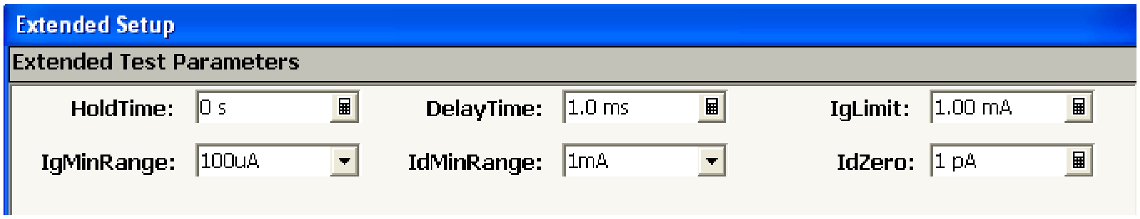
Figure 3-6. Vth Vgs(off) application Test.



Step 6. Click the Extended Setup.

Extended Setup window opens.

Set the parameters as the same shown in the following picture.



Step 7. Change the Setup Name as “Vgs(off)”.

Step 8. Click Single measure  button.

The measurement starts.

Step 9. The measurement results are shown up in the Data Display window with Automatic analysis of markers (see #11) and the Vgoff parameter extraction in the Parameters area (see #12).

Step 10. Test Result Editor opens.

You can add remarks, flags and select Save/Delete decisions.

Click OK to reflect your decision.

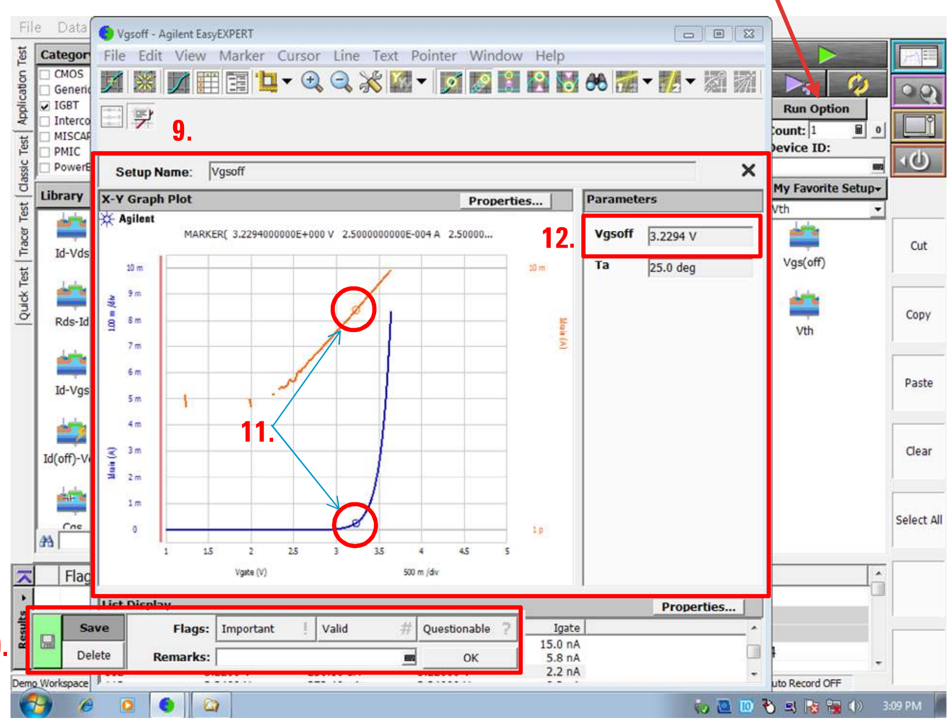
The default of this editor is OK when you make any other action, and the data is automatically saved in the Result area (The bottom of EasyEXPERT GUI).

Note: You can set your save options in the “Run Options” button.

Step 11. The markers automatically located at Id=250 μA for both linear Y1 axis and log Y2 axis.

Step 12. Vgsoff measured at the marker position (interpolation) is displayed: 3.23 V.

Figure 3-7. Vgs(off) application Test result.



After the measurement is made and the results are satisfactory, you can save the test setup for the future use.

Follow the next steps to save your test setup by following the number in figure 3-8..

Step 1. Click “My Favorite Setup.

Step 2. Click “Preset group”.

Step 3. Click Add New Preset group.

Step 4. Enter a group name, for example “Demo”.

A new preset group name shows up in My Favorite Setup group.

Note: You can export or import the test setup with a unit of the preset group.

Step 5. Click “Save” will save your test setup with the name in “Setup name:” field.

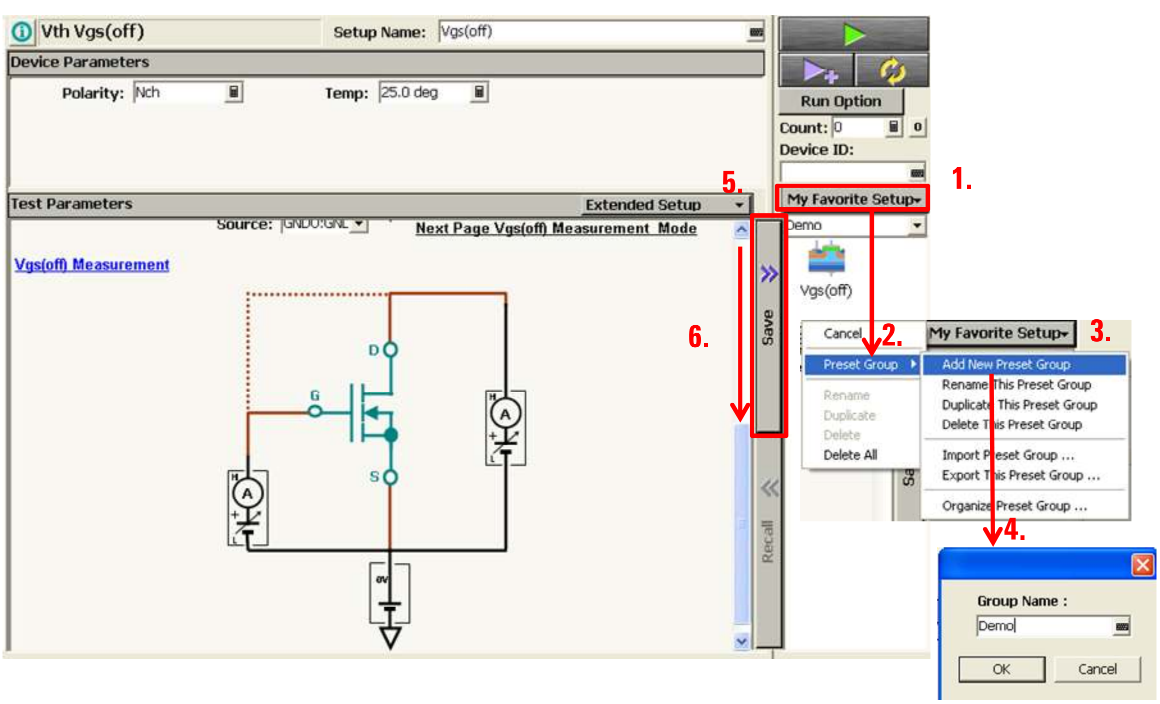
Step 6. Optional

If you scroll the vertical bar of the Test Parameters GUI, the Vgs(off) GUI with a dotted line connection that indicates the gate and the drain SMUs are synchronized in the sweep.

Review:

- The measured Vgsoff at Id=250 µA is 3.23 V.
  The specification is between 2 to 4 V, and the measurement result is reasonable.
- Application test is handy and very convenient if the application test definition meets the requirement.

Figure 3-8. Save the setup to “My Favorite Setup”.



Demo 1-2. Vth Vgsoff Application Test

Vth measurement using the Application Test (@ Vd=constant)

This demo uses the same setup of demo 1-1, but Vd is set to a constant voltage, at 1 V.

Change the demo 1-1 setup by following the next steps and the numbers shown in figure 3-9.

Step 1. Change MeasMode to “Vth”.

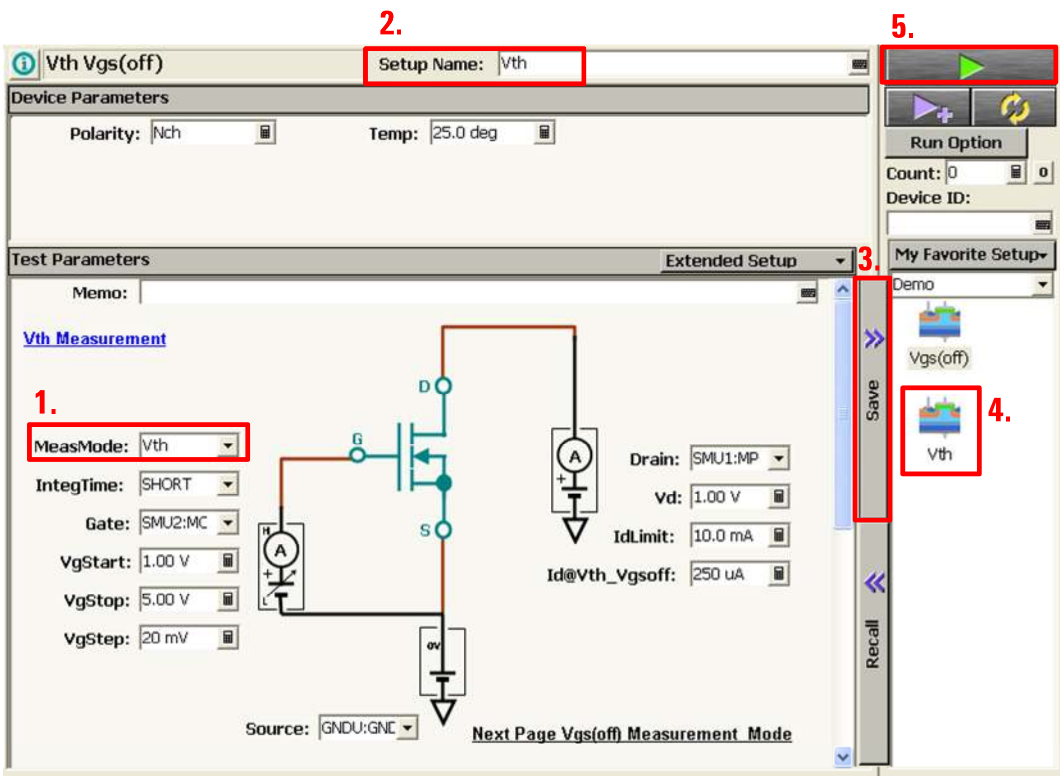
Step 2. Change Setup name to “Vth”.

Step 3. Save the test setup to Demo preset group.

Step 4. The setup is saved.

Step 5. Press Single Measure button.
Measurement starts.

Figure 3-9. Vth Vgs(off) application Test: Vth measurement.

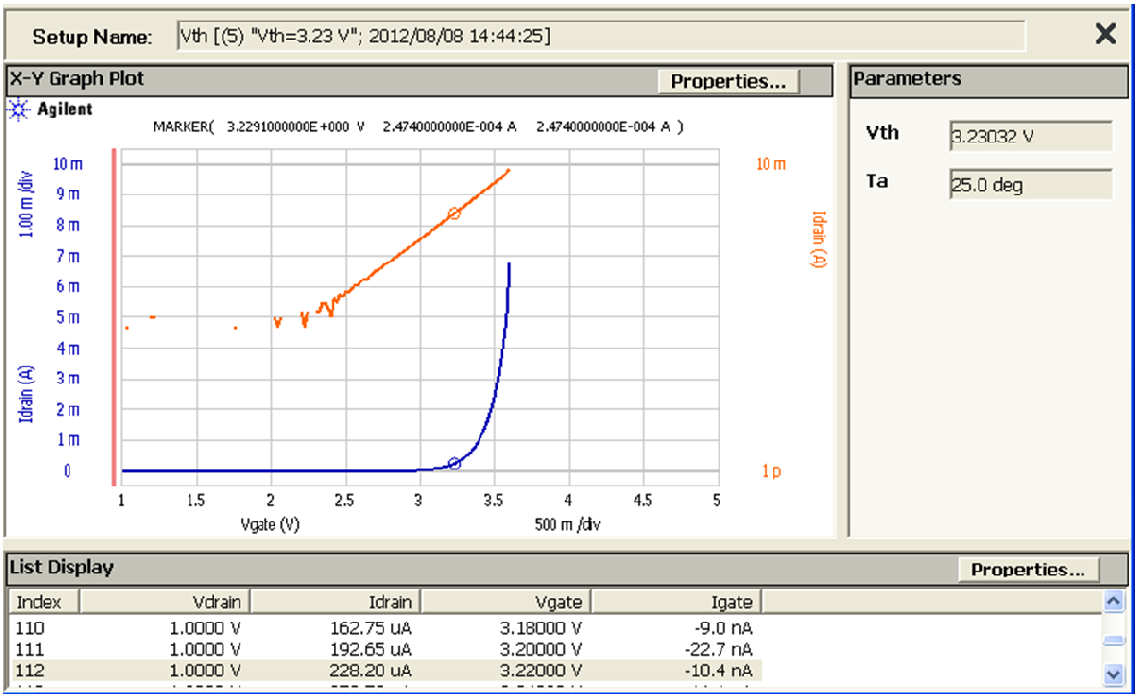


Test result is shown in figure 3-10.

Vth is extracted as 3.23 V and the result is almost the same as figure 3-7 display though the Vd is fixed to 1 V.

- Save the test results.

Figure 3-10. Vth test result.



Review:

Generally speaking, Vth or Vgs(off) measurement shows almost the same data if Vth measurement is made at saturation region. Usually Vd=1 V satisfies this condition.

Other assignment of the demo:

- Try Vth or Vgs(off) measurement to IGBT and HV-MOSFET.
  - IGBT: Use "Vth Vge(off) application test definition.
    Use the same test parameter of demo 1.
  - HV MOSFET: Use the same Application Test and parameters used in Demo 1.

Tips:

- For Id-Vd or Id-Vg measurement, it is a good idea to set the Vg start voltage as close value of Vth.

Chapter 4. Demonstration 2: UHCU Tracer Test

Ultra High-Current Measurement using UHCU with Tracer Test mode

Contents:

Chapter 4. Demonstration 2: UHCU Tracer Test

Ultra High-Current Measurement using UHCU by using Tracer Test mode

Objective: This chapter covers the following test.

1. Id-Vd (HC MOSFET)
2. Oscilloscope View
3. Rds on (HC MOSFET)
4. Ic-Vc (IGBT)
5. Vcesat (IGBT)

The objective of this chapter is to perform the above test and understand B1505A`s unique measurement capabilities by using the Tracer Test mode.

Features: This section covers following B1505A features;

- 1500A measurement capability through 500 A test (Current limited by the test fixture capacity)
- Both the current and voltage compliance mode
- Power compliance mode
- Arithmetic operation function (Rds extraction)
- I force capability (Vce-sat measurement)
- Oscilloscope View
- Replay Traces

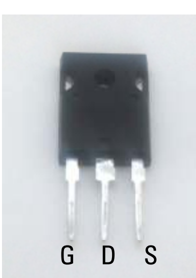
Device used: Demo 2 uses the following devices;

- IPFP4004 PbF HC MOSFET
- FGA180N33ATD IGBT

4-1. Wiring and Device setting inside of the N1265A Fixture

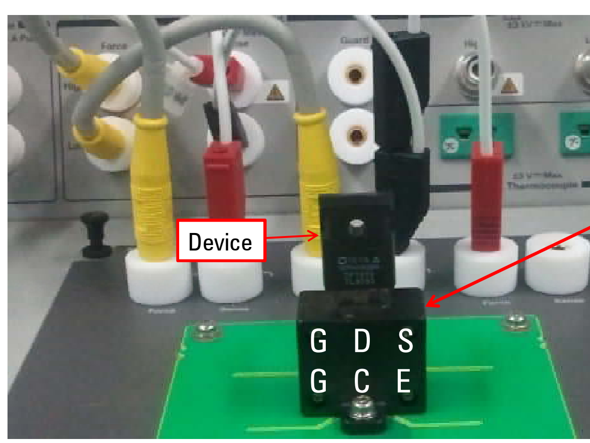
Use the same setup of section 3-1 and figure 3-1.

Figure 4-1. DUT setup.



IRFP4004
HC MOS

FGA180N33ATD
IGBT



G: Gate
D: Drain
S: Source
C: Collector
E: Emitter

4-2. EasyEXPERT Configuration for Expanders

◆To Configure UHCU:

Each expander has to be configured before the use after the power on. state.

Note: Before proceeding to the configuration, make sure the cable connection is properly made as shown in figure 2-7.

Follow the next instruction by following the steps shown in figure 4-2.

Note: If SMU3:UHC is active in step 12, then you can skip the following step 1 to step 12, and start from step 13 of next page.

Step 1. Click Configuration icon.

Step 2. Click "UHC Expander / Fixture" tab.

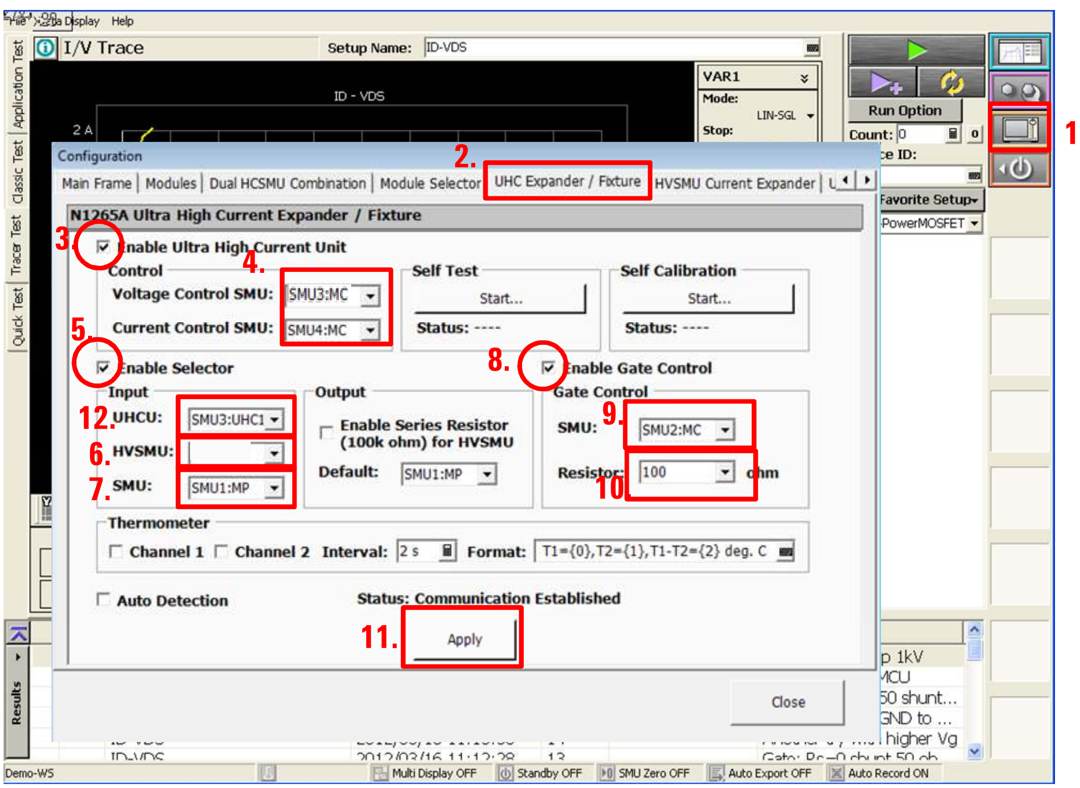
Step 3 to 10:

The setup should be the same if you come from the demo 1.
If not, please set the configuration by following the steps shown in section 3 -2.

Step 11. Click Apply button.

Step 12. SMU3:UHC1 appears as active module.

Figure 4-2. UHCE/Fixture configuration 1.



Refer to Figure 4-3 for the following steps.

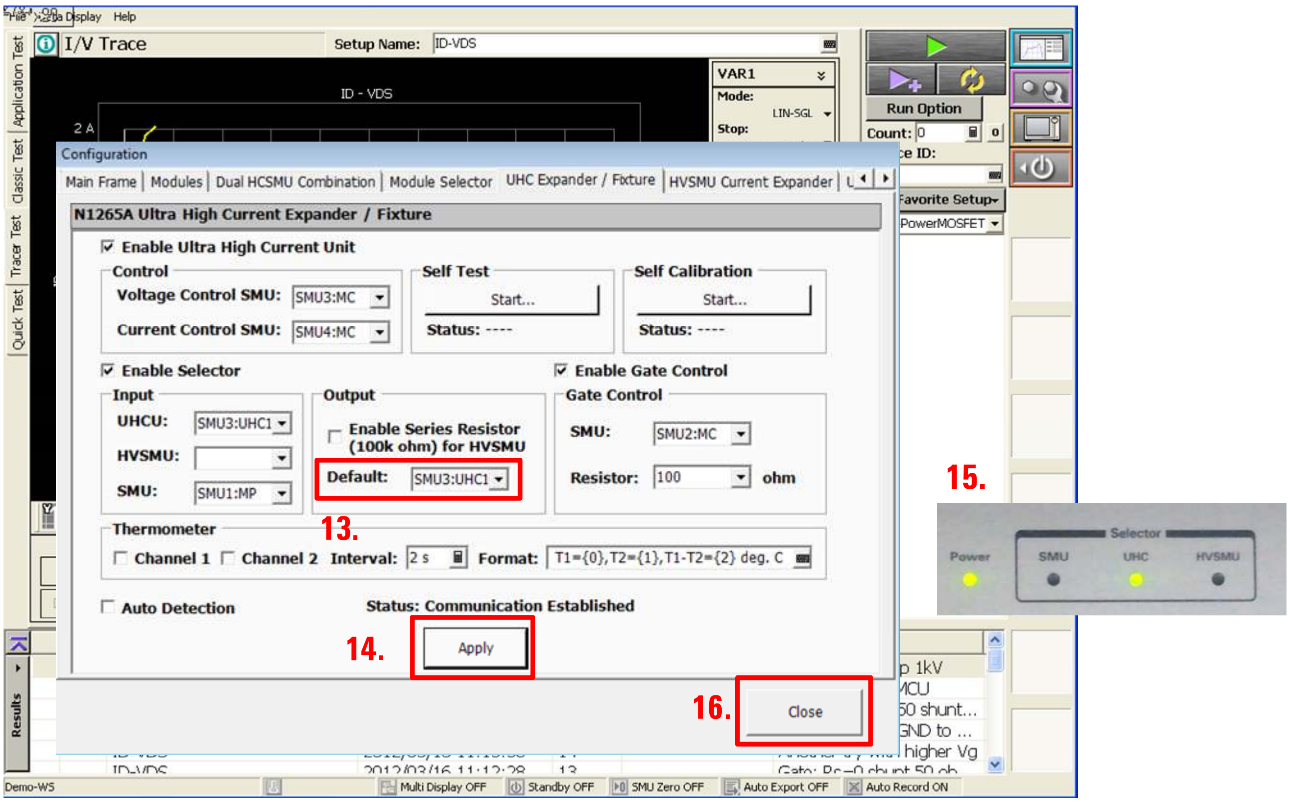
Step 13. Change Output Default SMU from “SMU1:MP to “SMU3: UHC1”

Step 14. Click "Apply" button to renew the active selected module.

Step 15. The selector indicator of N1265A front panel changes to the current selector status: UHCU.

Step 16. Click "Close" button to close the Configuration window.

Figure 4-3. UHCE/Fixture configuration 2.



4-3. What is Tracer Test Execution mode

The Tracer Test mode provides traditional and familiar curve tracer functionality, permitting quick device characterization with minimal measurement setup effort.

An Oscilloscope view allows you to monitor the pulse measurement waveforms with 2 μs resolution.
Large current signals applied to the collector can be distorted by parasitic components (such as the cable inductance of the test setup), and these parasitic components can lead to unexpected measurement results.
The Oscilloscope View helps to prevent this by providing the exact waveform shapes as well as the relative positions of the collector and the gate signals. This allows you to adjust your timing parameters so as to achieve optimal measurement conditions.

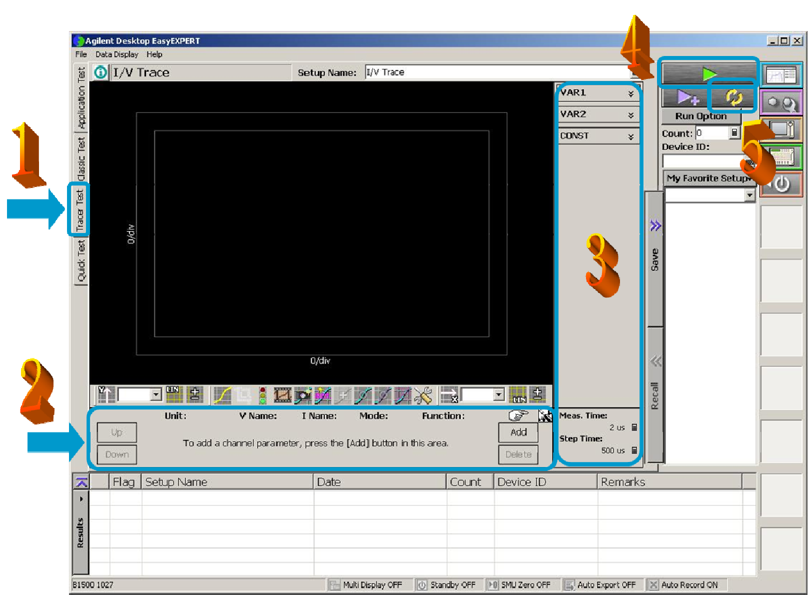
An innovative automatic recording feature prevents data loss even if the device under test (DUT) is inadvertently destroyed.

In addition to these impressive measurement capabilities, the intuitive EasyEXPERT software environment makes data analysis a snap. You can also easily export data into your PC-based work environment and use this data to generate presentations and reports.

The pre-defined setup menu of the Tracer mode makes the IV test setup a lot easier especially in complicated setups such as pulsed measurement.
This setup can be converted to the Classic Test mode test definition, and it is a convenient functionality for creating a classic test from a scratch.

To perform Tracer Test:

Step 1: Click Tracer Test tab.
Tracer Test mode screen shown in next figure opens.
Step 2: Define the source and measurement channels.
Step 3: Set the source output parameters.
Step 4: Connect DUT, and click the Single button to start a single measurement.
Step 5. Note: Repeat measurement is used to change the measurement parameters while in measurement.



Demo 2-1: Id-Vd measurement using the Tracer Test

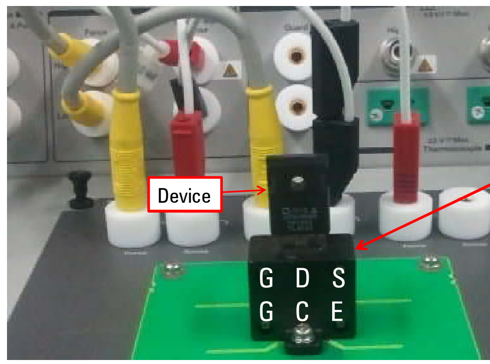
Objective: To learn the following topics;

- How to setup test
- How to execute the interactive sweep
- Current and voltage compliance mode
- Power compliance mode
- Replay Traces

Demo 2-1-1. Demo device

Set IRFP4004PbF to the 3 pin in-line Socket as shown in the next figure.

IRFP4004
HC MOS

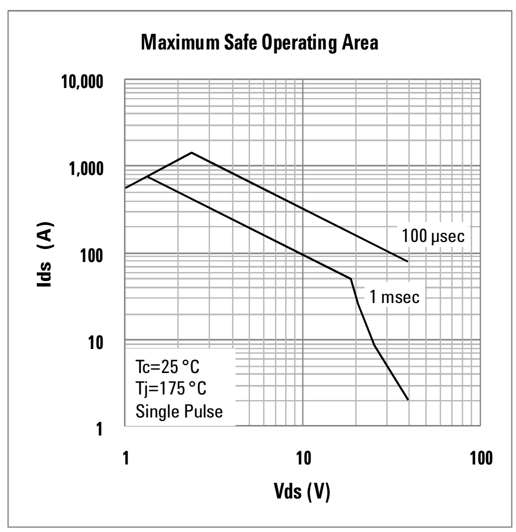


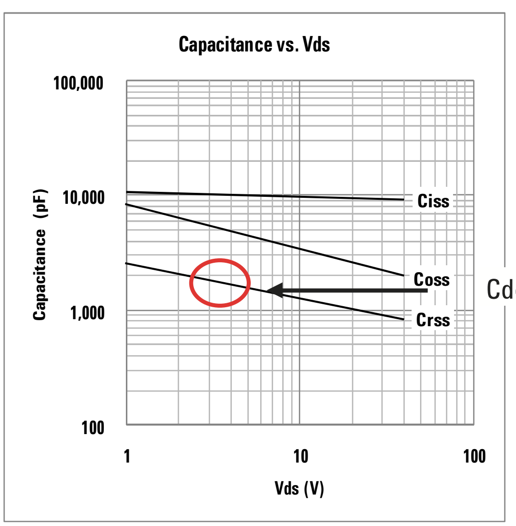
G: Gate
D: Drain
S: Source
C: Collector
E: Emitter

Following shows a brief information of SOA area and the capacitance information of the device. Refer to section 2-3 for the device specification.

Vdss	40 V
Rds (on) typ.	1.35 mΩ
max.	1.70 mΩ
Id (pulse)	1390 A *

* Tj<175 °C





Cdg

- Since the feedback capacitor from the drain to the gate (Cdg) is large, the gate is better to use a pulse drive rather than DC.
  The gate voltage is over driven by the charge from the drain pulse, and excessive Id may flow at the timing of Vd pulse rise-up if the gate is driven by DC.

Demo 2-1-2. Demo setup:

Setup the Id-Vd Tracer Test setup for IRFP4004PbF by following the steps shown next and the numbers in figure 4-4.

To setup the SMU resources:

Step 1. Click "Sample setups" menu. Sample setup menu pops up.

Step 2. Select "MOSFET" category opens MOSFET tracer test definition menu.

Step 3. Click "ID-VDS" setup. ID-VDS setup appears.

Step 4. Make sure the SMUs are set as in the figure.
If different, re-assign the Drain and the Gate SMU appropriately.

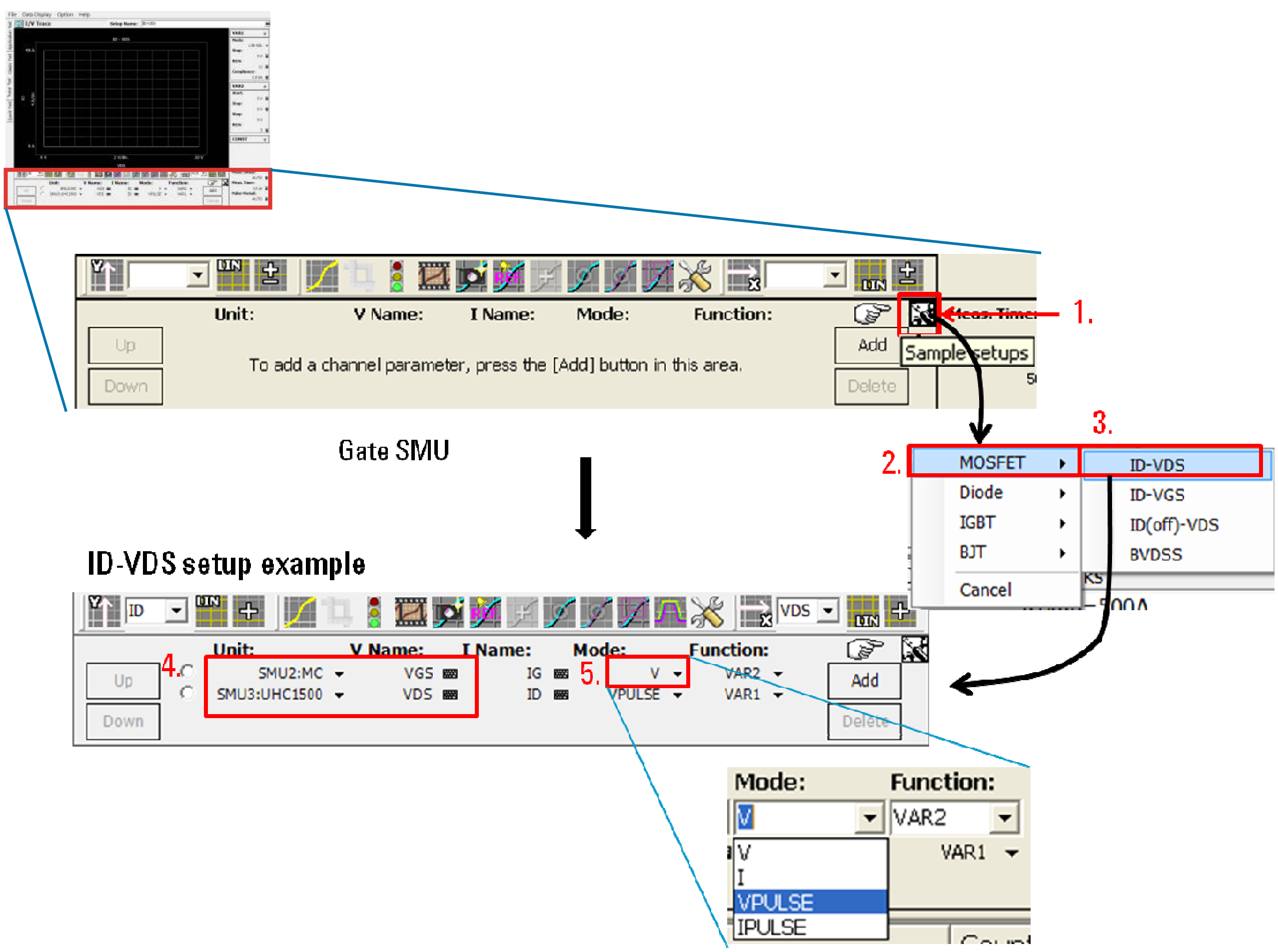
Step 5. Change the VGS Mode from V to VPULSE Mode from the list by clicking the Mode list. Other parameters should be the same as the parameters shown in figure 4-4 (or the following table).

- **Setup parameters of SMUs:**

  Set the SMU names, mode and function as follow.

Unit	V name	I Name	Mode	Function
SMU2: MC	VGS	IG	VPULSE	VAR2
SMU3: UHC	VDS	ID	VPULSE	VAR1

Figure 4-4. Id-Vd Tracer Test setup of SMU resources.



To Setup X-Y scales:

Follow the next steps and the numbers in figure 4-5.

To set X axis:

Step 1. Click on the maximum X scale value.

Note: The focus area to detect your touch is very narrow. Click exactly on the character area to pop up the scale input box.

Step 2. Horizontal Max. input box pops up.

- Enter 60 V, then click X mark of the input box or press Enter key.

Note: Clicking other area cancels your input.

- Horizontal max. scale is changed to 60 V.

To set Y axis:

Step 3. Click on the maximum Y scale value.

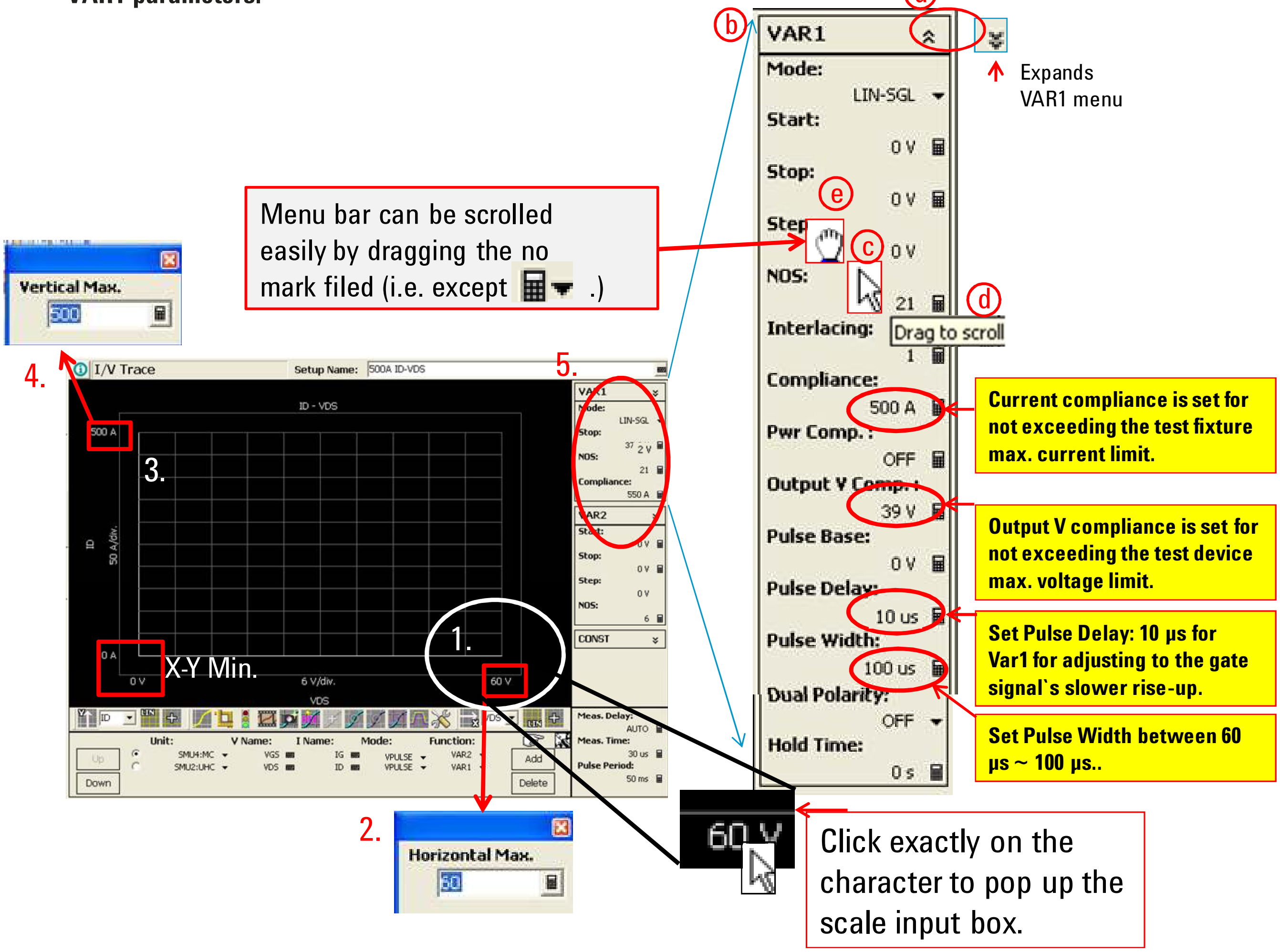
Step 4. Vertical Max. input box pops up.

- Enter 500 A, then click X mark of the input box or press Enter key.
- Vertical max. scale is changed to 500 A.

To set X-Y min. value:

Repeat the same steps shown above for min. scale, too.

Figure 4-5. Id-Vd Tracer Test setup of X-Y scales and VAR1 parameters.



To Setup VAR1:

Step 5. Set VAR1 parameters:

a. Click down arrow icon  .
VAR1 field expands.

b. Set the following parameters:

Mode	Start	Stop	NOS	Interlacing	Compliance	Pwr comp	Output V Comp
LIN-SGL	0 V	5 V	21	1	501 A	OFF	39 V

Pulse Base	Pulse Delay	Pulse Width	Dual Polarity	Hold Time
0 V	10 us	100 us	OFF	0 s

Tips: To scroll the measurement parameter input field:

c. By focusing (pointing) the parameter input field, "Drag to scroll" sign appears (see #d).

e. By dragging the bar, the mouse cursor changed to "hand " mark, and you can scroll the bar, and can see hidden part of the bar.

To Setup Var2

Follow the next steps and the numbers in figure 4-6.

Step 6. Set VAR2 parameters

f. Click down arrow icon  .
VAR2 field expands.

Start	Stop	NOS	Compliance	Pwr comp	Pulse Base	Pulse Delay	Pulse Width	Hold Time
3.5 V	6 V	6	100 mA	OFF	0 V	0 s	120 us	0 s

g. Set the following parameters:

Note:

- Scroll up the Menu bar by dragging the bar as illustrated in figure 4-5.
- For VAR2 START: Enter the Vth value measured in lab 1.
  Round up Vth in 0.5 V units. For example, if Vth = 3.1 V, enter 3.5 V.
- For VAR2 STOP, add 2.5 V to the START V, so as the STEP V becomes to 500 mV.

To Setup Meas. Time and Pulse Period:

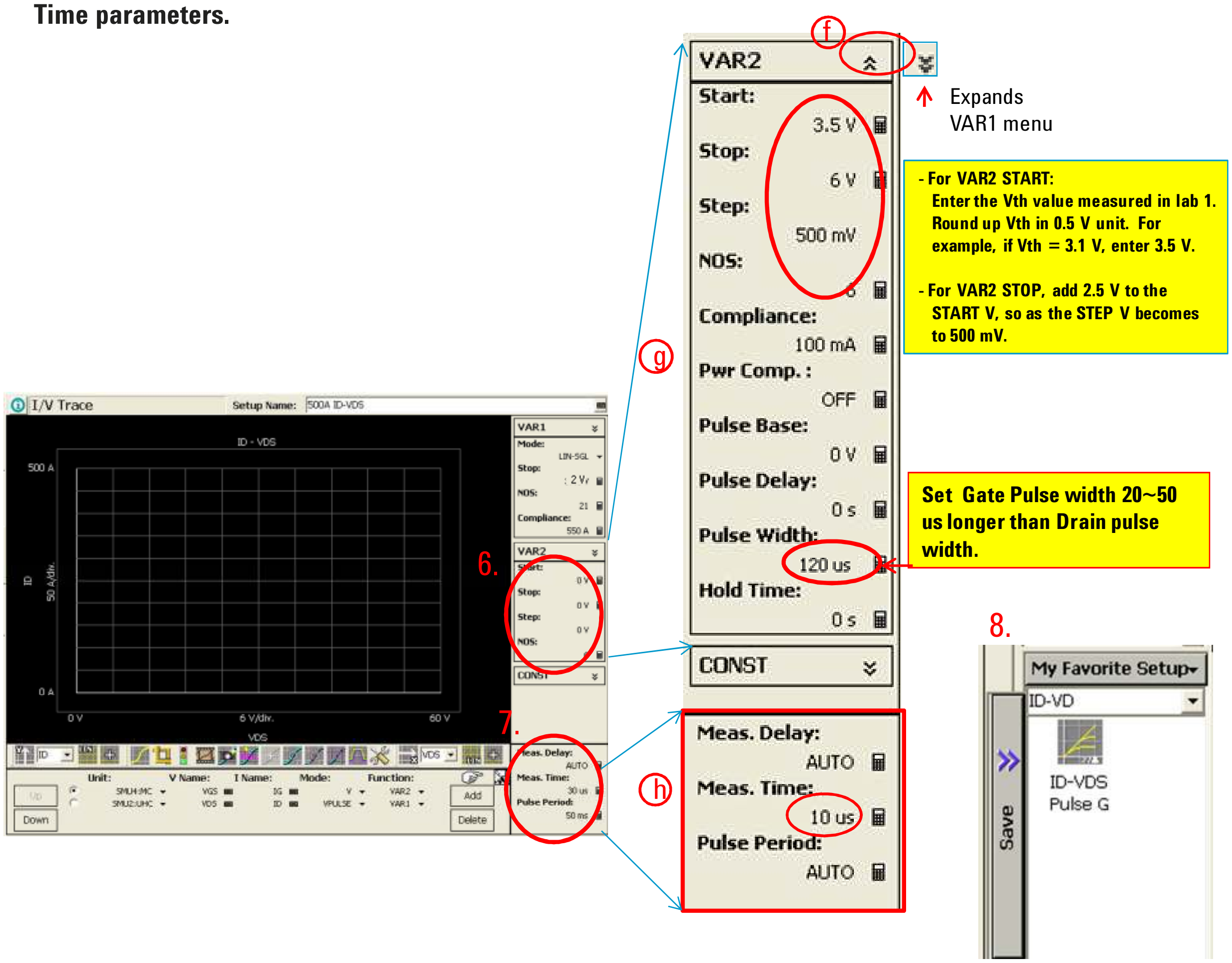
Step 7. Set Meas. Time (Integ Time) and Pulse Period:

h. Set following parameters.

Meas. Time	Pulse Period
10u~50us	AUTO

Step 8. Save the test setup as a unique name, say "ID-VD Pulse G", means Id-Vd measurement with gate pulse.

Figure 4-6. Id-Vd Tracer Test setup of VAR2 AND Meas. Time parameters.



Demo 2-1-3. To Start Id-Vd Repeat Measurement:

Follow the next steps by following the numbers of figure 4-7 to start repeat measurement.

Step 1. Close the test fixture cover before starting a test.♂ This is especially important for protecting any hazard from high current and high voltage.

Step 2. Click Repeat Measure button. 

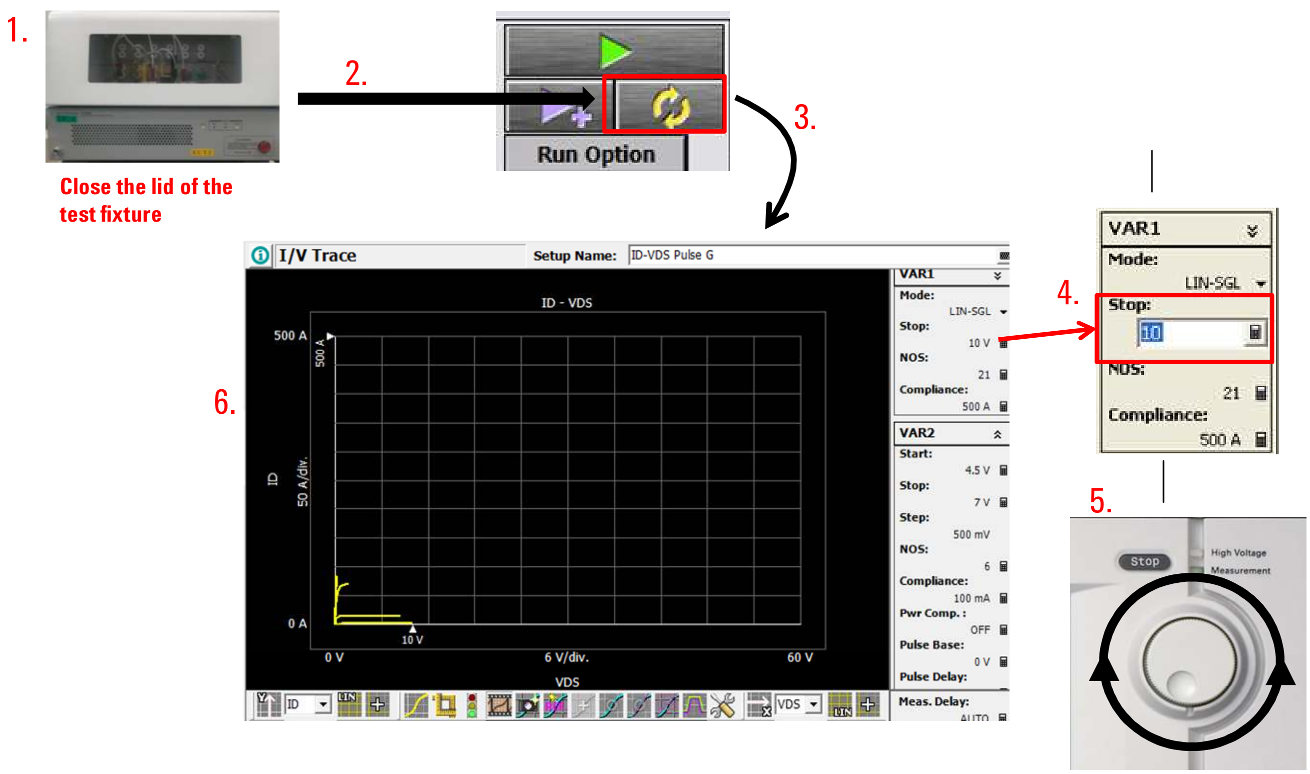
Step 3. Repeat measurement starts.

Step 4. Highlight the VAR1 Stop entry field and leave it in active status.

Step 5. Rotate the rotary knob to the right to increase the VAR1 sweep voltage. How is the trace changed?

Step 6. The Id-Vd real time sweep trace appears as shown in figure 4-7.

Figure 4-7. Id-Vd Tracer Test repeat measurement.



To perform interactive Sweep:

Follow the next steps to perform the Id-Vd interactive sweep.

Step 1. The measurement is progressed in mid way, at the stop V is 30 V.
- The output V compliance is set at 39 V, and the maximum sweep point is limited to one extra measurement step over this voltage.
- The final sweep points of VAR1 for each VAR2 sweep step are limited to the maximum load line determined by the output resistance of UHCU and 30 V output voltages.

Step 2. This figure shows the Id-Vd curve at VD is increased to 45 V.♂ Maximum sweep voltage for VAR2 step 1 is limited at about 40 V by output V compliance.

Step 3. Now VD is increased to 50 V.♂ You can see near-breakdown curve in VAR2 step 2 and 3.

Step 4. This is the measurement at VD stop V is 60 V, the maximum power of UHCU.

Step 5. Note the VAR2 step 1 sweep is stopped at around 40 V of the maximum VD specification of the MOSFET.
If there is no output V compliance functionality, the MOSFET will be damaged.

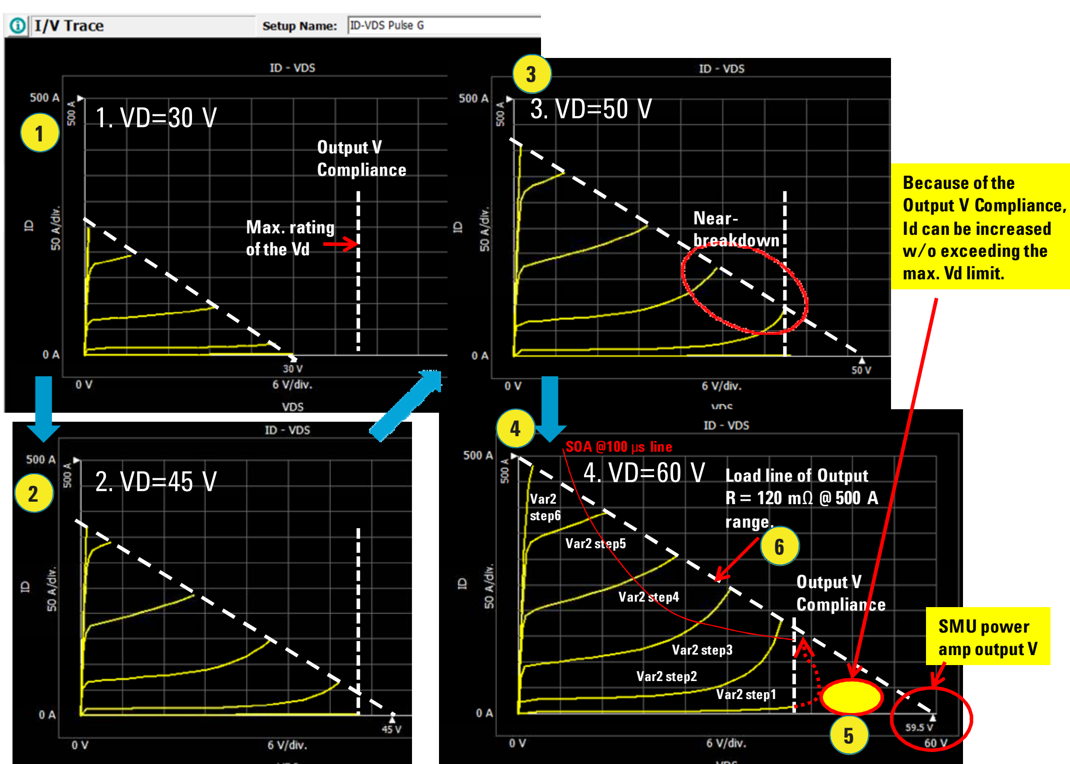
Step 6. Another note is that load line at Vd=60 V exceeds the MOSFET 100 μs SOA limit at Tc=25 °C.

If you continue the measurement at this level, the MOSFET will be damaged permanently soon.

Do not attempt to leave the measurement in this level for more than a few seconds, or avoid doing this level of measurement.

Try the measurement adding by 3.5 kW power compliance instead of performing this measurement.
The measurement with power compliance follows in next part.

Figure 4-8. Id-Vd Interactive Sweep.



Note: This test at 1,500 A range may damage the device in high possibility.

- *To prevent the device damage:*
  - *Keep the max. STOP V to 30 V!*

    Note: The data with 40V Stop V is for reference only!

Using 1,500 A Range:

If the drain UHCU current compliance exceeds 500 A, say 501 A, then the current range changes to 1,500A range.

The output resistance of the UHCU changes to 40 mΩ, and the maximum allowable current increases three times compared to 500 A range.

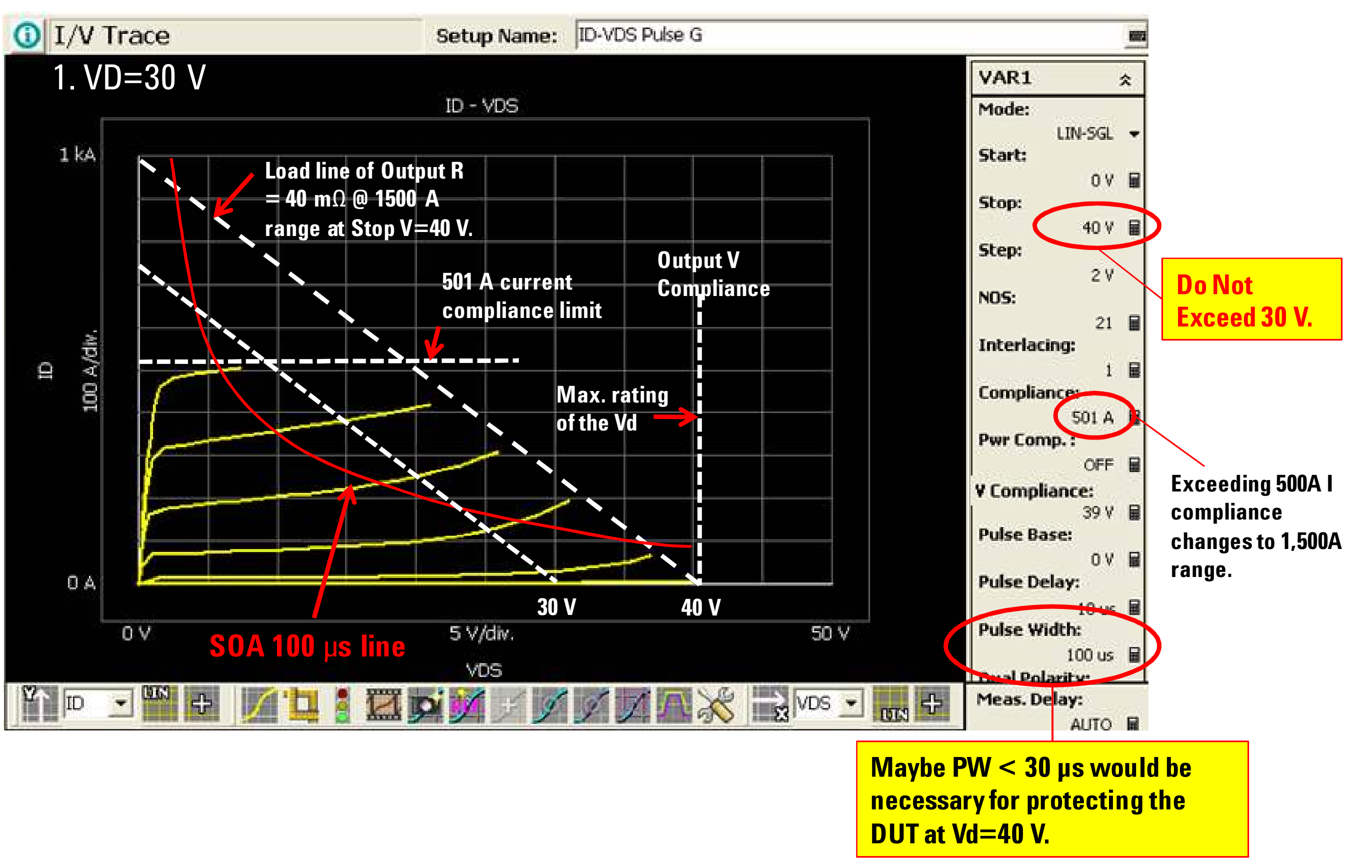
The red line of figure 4-9 shows the safe operating area (SOA) in the operation at 100 µs pulse width.

As you can see some portion of the Id-Vd curve exceeds the SOA.

Please keep the maximum Stop V to 30 V for not destroying the demo device.

Following page shows an example that the device is damaged by exceeding SOA limit.

Figure 4-9. Id-Vd Interactive Sweep.



Demo 2-1-4. An example of a device damaging trace using Replay Traces function:

You can record the measurement traces, and recall them by using Replay Traces function.

Figure 4-10 is an example of the Replay Traces which was recorded the moment of the IRFP4004PgF MOSFET was damaged by applying too high power as shown in previous page.

To use Replay Traces:

Follow the next steps to use Replay Traces function after the sweep stops.

Step 1. Clicking Replay Traces icon.

Step 2. The Replay Traces window opens.

Step 3. By moving the slide bar, you can recall the recorded traces.
You can save the record to your file and recall it later if you save the record.

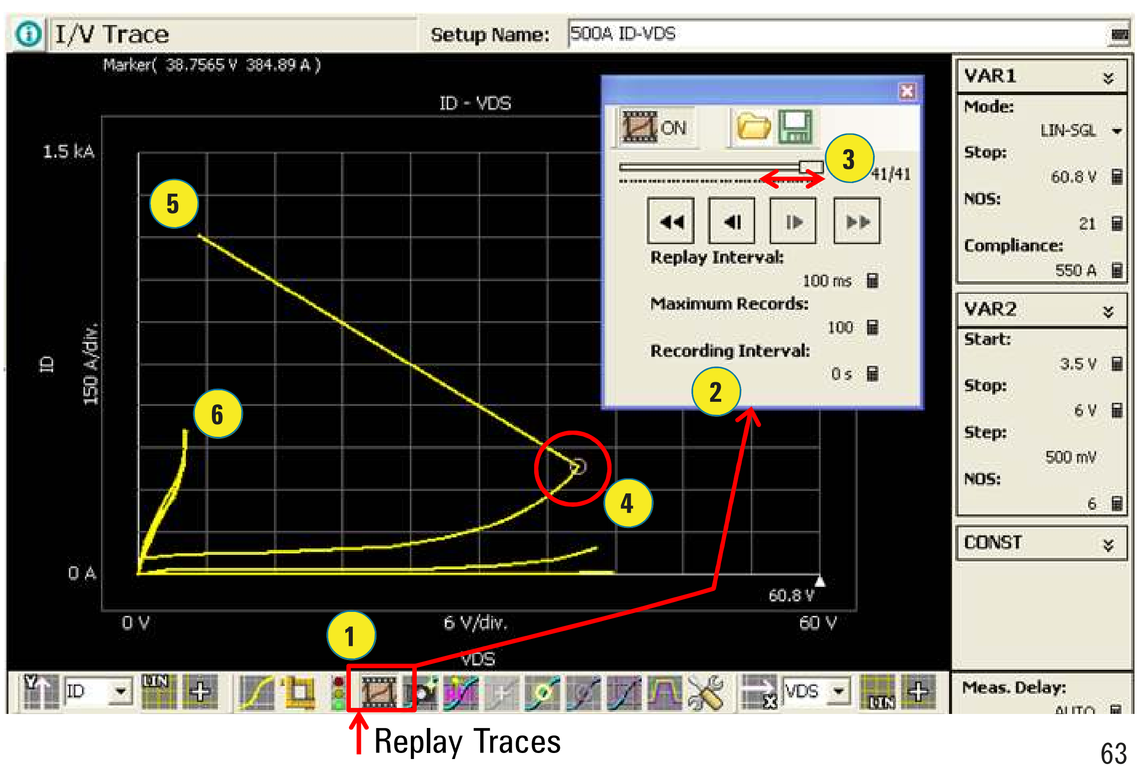
The following explains the traces that the device is damaged. (Example only.)

Step 4. The trace shows the sweep when the device is broken at VD=38.7 V and ID=365 A. (See marker data)
Note: that you can use the marker function even in the replay traces.
Note: The power at the device failure was 38.7 V x 365 A = 14 kW that was way high of the 3.5 kW allowed in 100 μs pulse.

Step 5. Probably the junction is damaged by the heat, and the device is shorted.
The current and the voltage of this point is at 1,200 A and 5.3 V.
The current compliance can not limit the current because the breakdown speed is so fast!

Step 6. The next sweep traces are shown.
It is obviously that the MOSFET is damaged in short mode failure.
Probably it is short mode failure.

Figure 4-10. Example of Replay Traces of capturing the device damaged moment.



Demo 2-1-5. To Set Power Compliance: 3.5 kW

In the previous page, an example of the device damage that the MOSFET was destroyed because too high power was applied even in the pulsed measurement.

If you set a proper Power compliance in the measurement setup, you can avoid exceeding the SOA limit and possibly preventing the damage of the device.

Figure 4-11 shows an example to set power compliance and measurement curve with 3,500 W power compliance.

As you can see, the SOA area of 100 μs pulse overlaps to the 3.5 kW power limited measurement curve and it is also limited inside of the 40 mΩ load line.

◆ **How to set Power compliance:**

- Set Pwr Comp. in VAR1 parameter field as shown in figure 4-11.

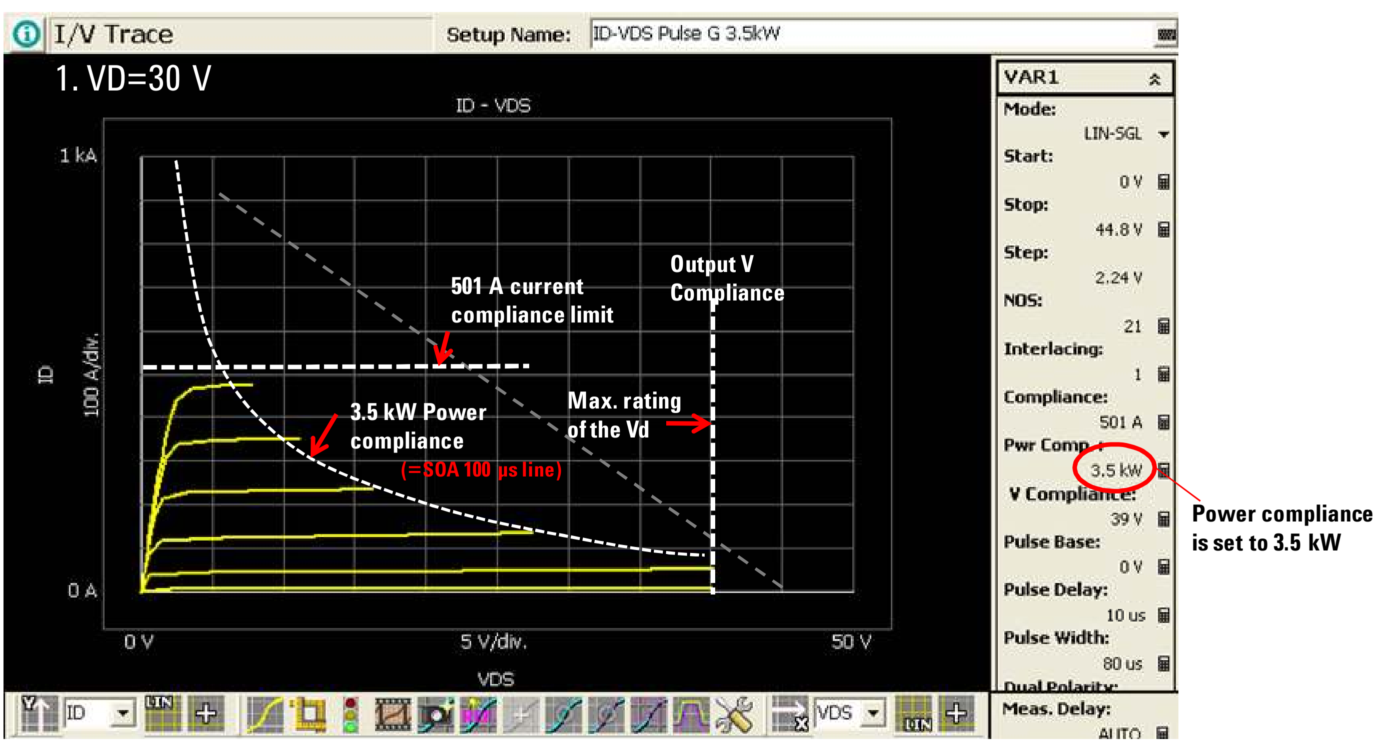
The effect of Current Compliance, Power Compliance and the V Compliance:

Figure 4-11 shows three compliance setting; the Current Compliance, the Power Compliance and the V Compliance.

- **Output V Compliance:**
  You can measure devices at high current and low voltage, but you also have to take into consideration the maximum voltage limit in the low current measurement region because higher voltage is applied due to the smaller voltage drop at the output resistor. Output V Compliance can limit the high voltage in low current region.

- **Current Compliance:**
  The current compliance ensures that you do not exceed the maximum current rating of the device.

Figure 4-11. 3.5 kW Power compliance, Output V compliance and Current compliance.



Demo 2-2 Id-Vd Tracer Test measurement using Oscilloscope View

Objective: The objective of the Oscilloscope View demo is to be able to use the oscilloscope View function and interpret the Oscilloscope View waveform to judge if the pulse set parameters are appropriate or not.

If there are any issues found, preferably, to be able to take a corrective action is desirable.

The following topics are covered:

- How to set the Oscilloscope View
- How to use the result from the Oscilloscope View

Demo 2-2-1. Demo device and demo setup

We use the same device and the setup of demo 2-1. Id-Vd test.

Demo 2-2-2. What is Oscilloscope View

EasyEXPERT (Rev. 5 and higher) supports an Oscilloscope View (refer to figure 4-12) on the B1505A that allows you to monitor pulse measurement waveforms with 2 μs resolution.

It has the following features;

- I/V curves and pulse waveforms are displayed simultaneously.
- Waveform measurement pulses can be monitored at any point.
- Both voltage and current can be read using the Marker line.
- The pulse measurement conditions can be changed during measurement and the resultant waveforms can be verified on the fly.

Large current signals applied to the drain/Collector can be distorted by parasitic components (such as the cable inductance of the test setup), and these parasitic components can lead to unexpected measurement results.

The Oscilloscope View helps to prevent this by providing the exact waveform shapes as well as the relative positions of the drain and the gate signals. This allows you to adjust your timing parameters so as to achieve optimal measurement conditions. The Oscilloscope View reduces debugging time while also improving the quality of your measurement data.

Demo 2-2-3. How to set Oscilloscope View:

Figure 4-12 shows an example of an Oscilloscope View for Id-Vd Tracer Test measurement.
You can monitor the waveform of the output voltage and current on the specified measurement point.

In the pulsed measurement, it is very important to check the pulse waveform, pulse current and the relation of the measurement point in the pulsed signal to assure the measurement quality.

◆To monitor the pulse waveform:

Step 1. Click the Oscilloscope View icon.

Step 2. Oscilloscope view window opens.
You can change most of the parameters by clicking on the Oscilloscope view parameters.

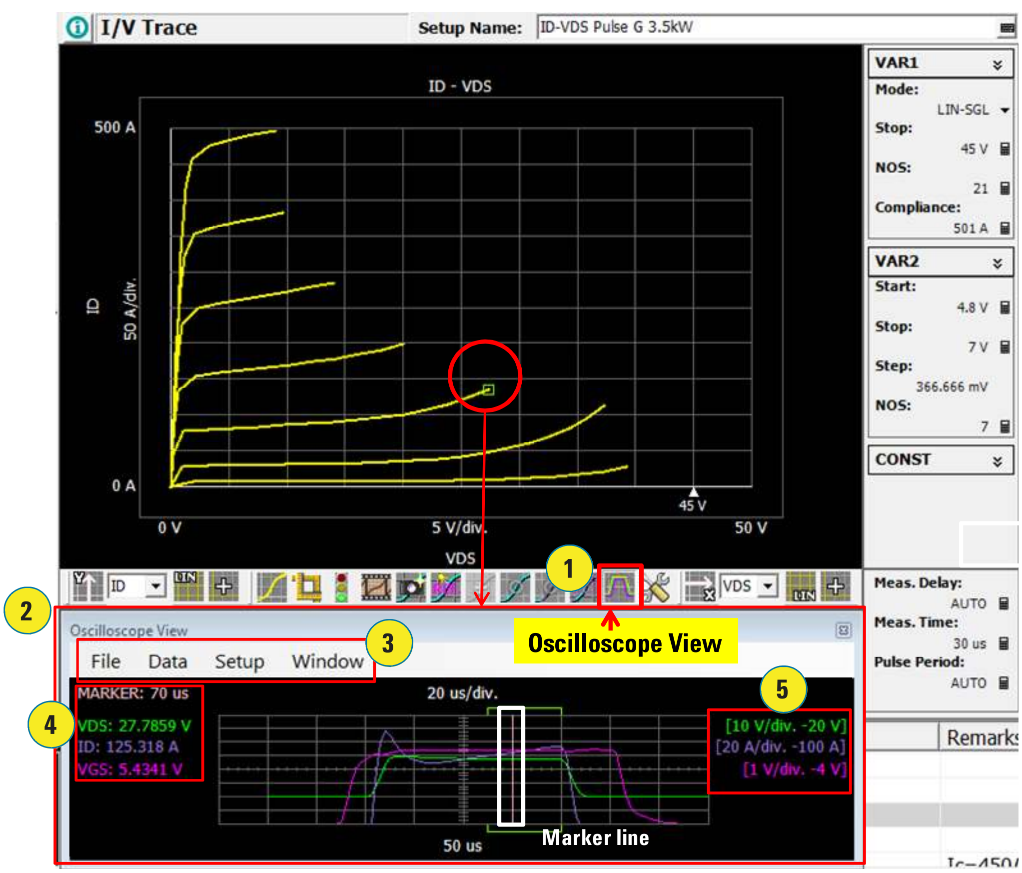
Step 3. Sampling parameter selection and the parameter setup can be made through the view menu.

Step 4. Marker field shows the time and the readout at the marker position.

Step 5. The scales of each parameter are shown.

The Oscilloscope View of figure 4-12 shows the VDS waveform of the 16th Var1 sweep point of the third Var2 step which is marked on the I/V curve

Figure 4-12. Pulsed Id-Vd: Oscilloscope View example.



- **How to set the Oscilloscope View parameters:**

To set the Oscilloscope View, follow the next steps by following the number of figure 4-13.

Step 1. Click Data menu.

Step 2. Click a parameter to view on the oscilloscope.

Step 3. The popup menu closes one at a time and the selected parameter is added on the marker view field.
Repeat #2 & 3 action to set all the parameters to view.

Step 4. Scale parameter also appears in this area.

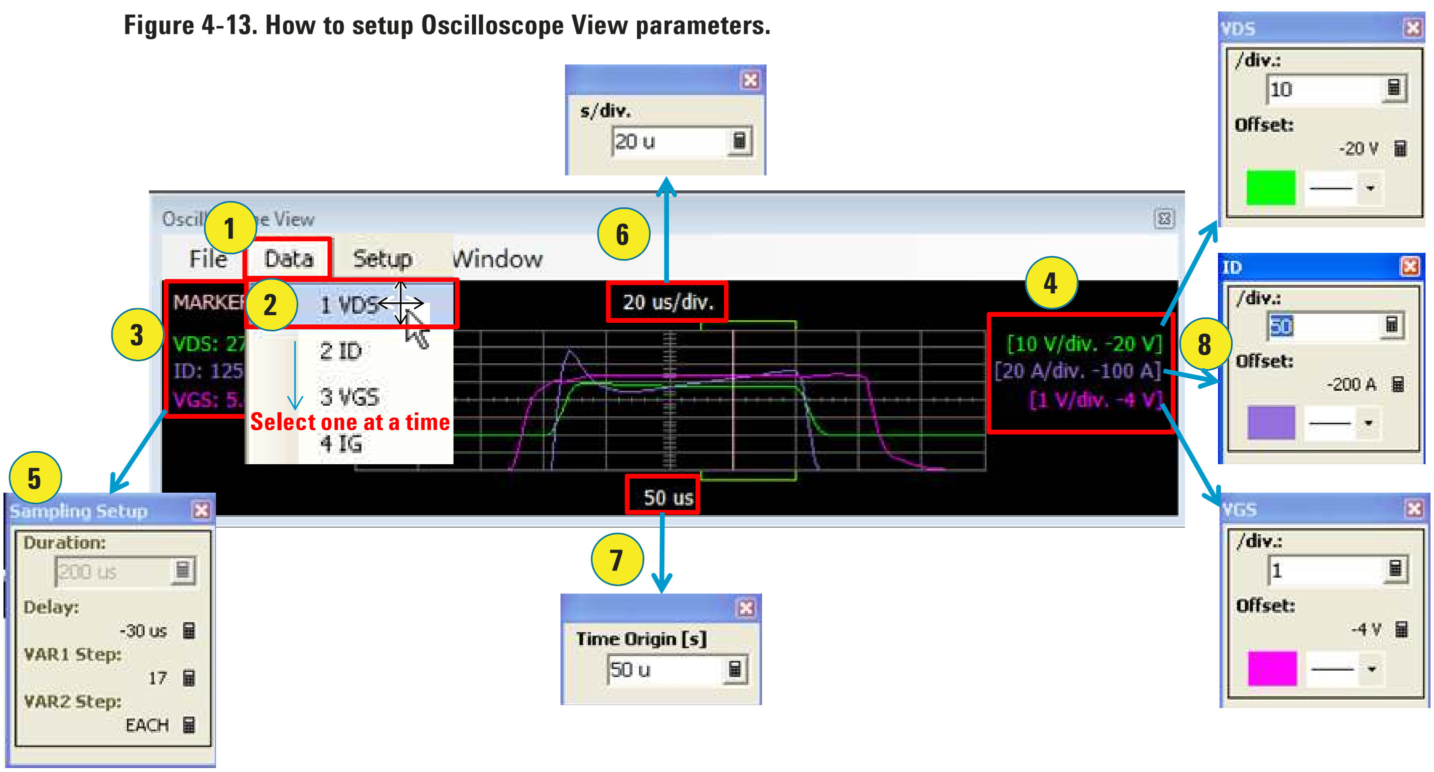
Step 5. The sampling point parameter can be set by clicking on the marker view field.

Step 6. Time scale can be changed by clicking on the s/div field.

Step 7. Time origin can be changed by clicking on the Time origin number.

Step 8. If you click one of the parameter of #4 field or Setup menu, a vertical scale setting window pops up.
Each parameter window displays, from the top, the vertical scale, the center reference level and the line color.
These vertical scale parameters can be set by clicking on each parameter.

Figure 4-13. How to setup Oscilloscope View parameters.



◆**How to use the Oscilloscope View or the waveform monitor.**

Figure 4-14 shows an example of how to use the Oscilloscope View.

Follow the next steps and the numbers in figure 4-14 to display the waveform.

Step. 1. The oscilloscope view parameters are shown in #1.

Step. 2. The data point to view is shown in #2, that is 27th Var1 sweep point of the 7th Var2 step.

Step. 3. The data point is shown on the graph. (see #3)

Step. 4. Var1 Pulse delay and width are 10 us and 80 us respectably.

Step. 5. The oscilloscope view shows VDS, ID and VGS.

Step. 6. The oscilloscope view can be enlarged as in the figure (see #5)

a. Shows the trace color and the marker point value.

b. The horizontal scale can be changed by clicking on the value.

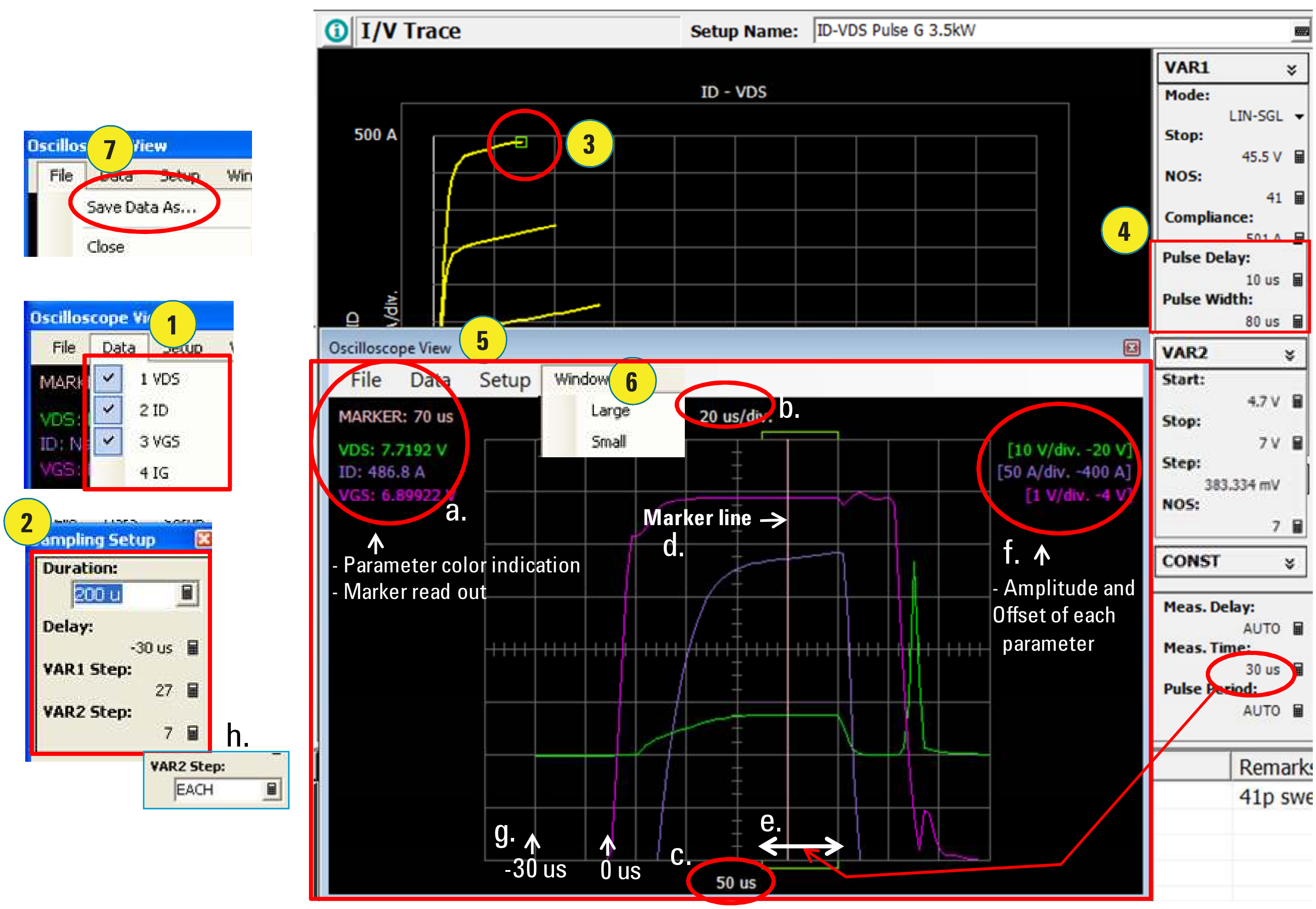
c. The horizontal center time can be changed by clicking on the value.

d. Marker can be set by clicking on any point on the graph.

e. The green line indicates the measurement time window.

f. This area shows the amplitude and the offset (shift of the measurement curve) of each parameter`s trace.

Figure 4-14. How to use the Oscilloscope View?



g. Indicates the actual sampling start time (= Delay that is set in #2 flame).

h. Optional:
If you change the Var2 step to "EACH", then the waveform monitor refreshes for each Var2 step for specified Var1 sweep point.

Step. 7. You can save the Oscilloscope view data in both the text and graphic format.

The setup data is saved in the test setup data.

Note: Unfortunately, there is no independent save -recall function.

Demo 2-2-4. ◆Tips: How to use the Oscilloscope view waveform to Var1 Pulse Delay setting

Figure 4-15 shows an example use of the waveform to set Var1 pulse delay time.

Follow the next steps and the numbers shown in figure 4-15.

Step 1. The var1, drain pulse delay is changed from 10 us (of figure 4-14 setting) to 0 µs (no delay relative to the gate pulse because the gate pulse delay is set to 0 µs).
The pulse width is the same.

Step 2. The data point to view the waveform is shown on the graph. (see #2)

Step 3. The enlarged Oscilloscope View is shown.

Note: The size can be changed from the Oscilloscope view menu -> Window, or by dragging the window.

Step 4. The drain voltage pulse (green) is faster than the gate pulse to hit Vth around the wave surrounded by a red circle.
Because there flows relatively small current (an order of less than 100 A), there appears a smaller voltage drop between the UHCU output resistor, resulted in higher voltage applied to the drain.

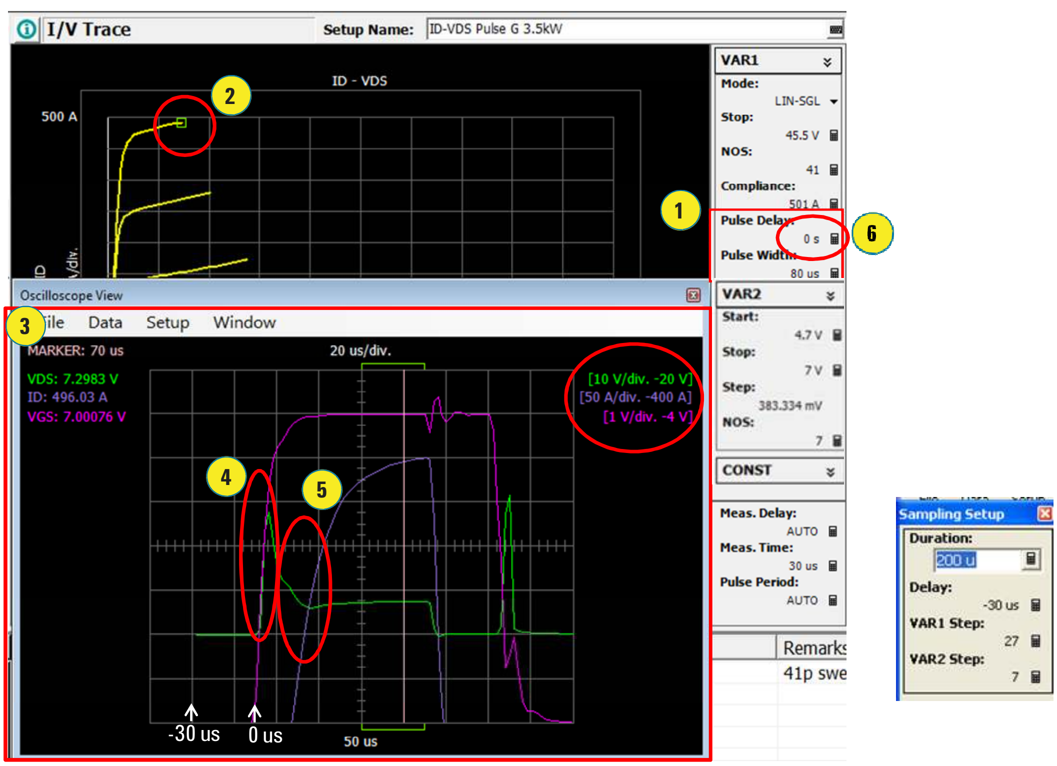
Step 5. The drain voltage is gradually decreases to the voltage that is determined by the load line of the UHCU output resistor, UHCU output voltage (45.5V) and the MOSFET impedance until an expected large drain current is settled down.

Step 6. Try changing the delay (maybe <20 µs), and check how the waveform changes.

In this way, you can control the voltage to be applied to your device by controlling the pulse parameters.

In this example, you can avoid unexpected large transient voltage is applied and damages your device.

Figure 4-15. How to use the Oscilloscope View waveform?



Demo 2-3 Rds ON Characteristics

Demo 2-3-1 Rds ON Characteristics (Rds On vs. Id)

Demo 2-3-2 Rds ON Characteristics (Rds On vs. Vg)

Objective:

The objective of Rds ON demo is to learn the followings;

- UHCU can output current source, and Rds ON measurement typically uses current source to the drain.
- Arithmetic operation function calculates the Rds in real time, and Rds can be displayed on the curve tracer display.

Note:

Applying a constant current is not possible using a traditional curve tracer, as it only has a voltage source mode. Previously, this measurement could only be performed using a very expensive production power device tester.
However, the B1505A's UHCU can easily perform this measurement.

◆How to measure Rds ON characteristics:

There are two methods to calculate the Rds as shown in figure 4-16.

This demo extracts Rds ON resistance by using the calculation: Rds= Vds/Id (the first approach shown in figure 4-16).

We use a new arithmetic operation function to calculate the Rds.

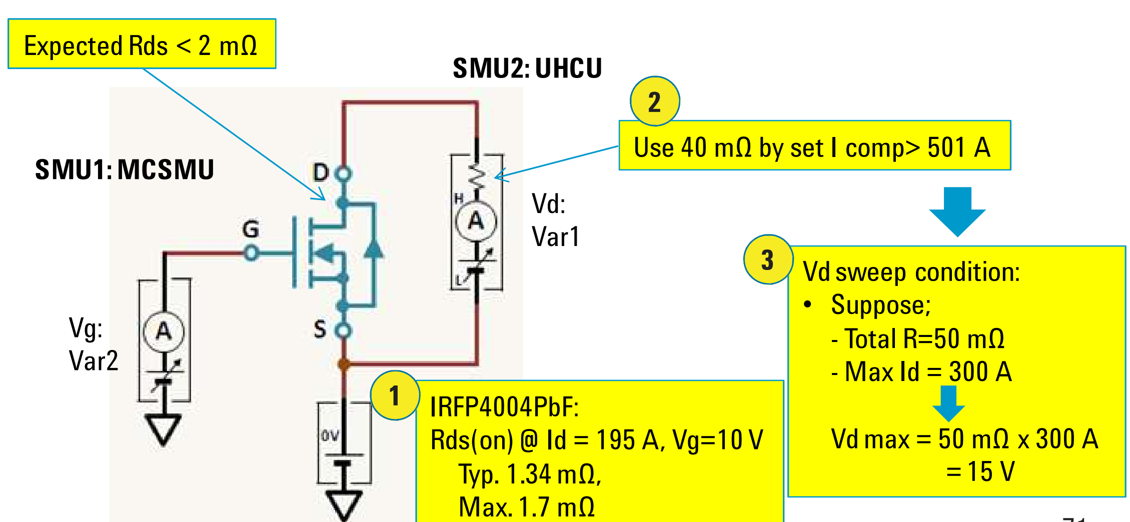
Note:

1. The second approach using delta function is not supported in the Tracer Test mode.

2. The delta function can be used in Classic Test mode.
You can convert the Tracer Test setup to a Classic Test definition easily. For detail, refer to chapter 10.

Figure 4-16. Rds ON characteristics.

Two methods to extract Rds_on:
- Rds = Vds/Id, if R is linear vs. Id
  or
- Rds = delta Vds/ delta Id, if R is non-linear vs. Id



- **Demo device:**

  WE use IRFP4004 PbF power MOSFET in this demonstration.

  The Rds(on) specification is shown in section 2-3 and 4. Demo 2-1, and it is maximum 1.7 mΩ at Vgs=10 V and Id=195 A.

Demo 2-3-1. Rds ON Characteristics (Rds On vs. Id)

- **Rds ON vs. Id (Rds_on - Id) Tracer Test setup and measurement**

  To Measure Rds on vs. Id characteristics, we use V force sweep measurement to the drain source. Since UHCU has built in output resistor, the actual voltage and the drain current is determined by the on resistance of the MOSFET.

  Follow the next instructions to setup the test by following the numbers of figure 4-17.

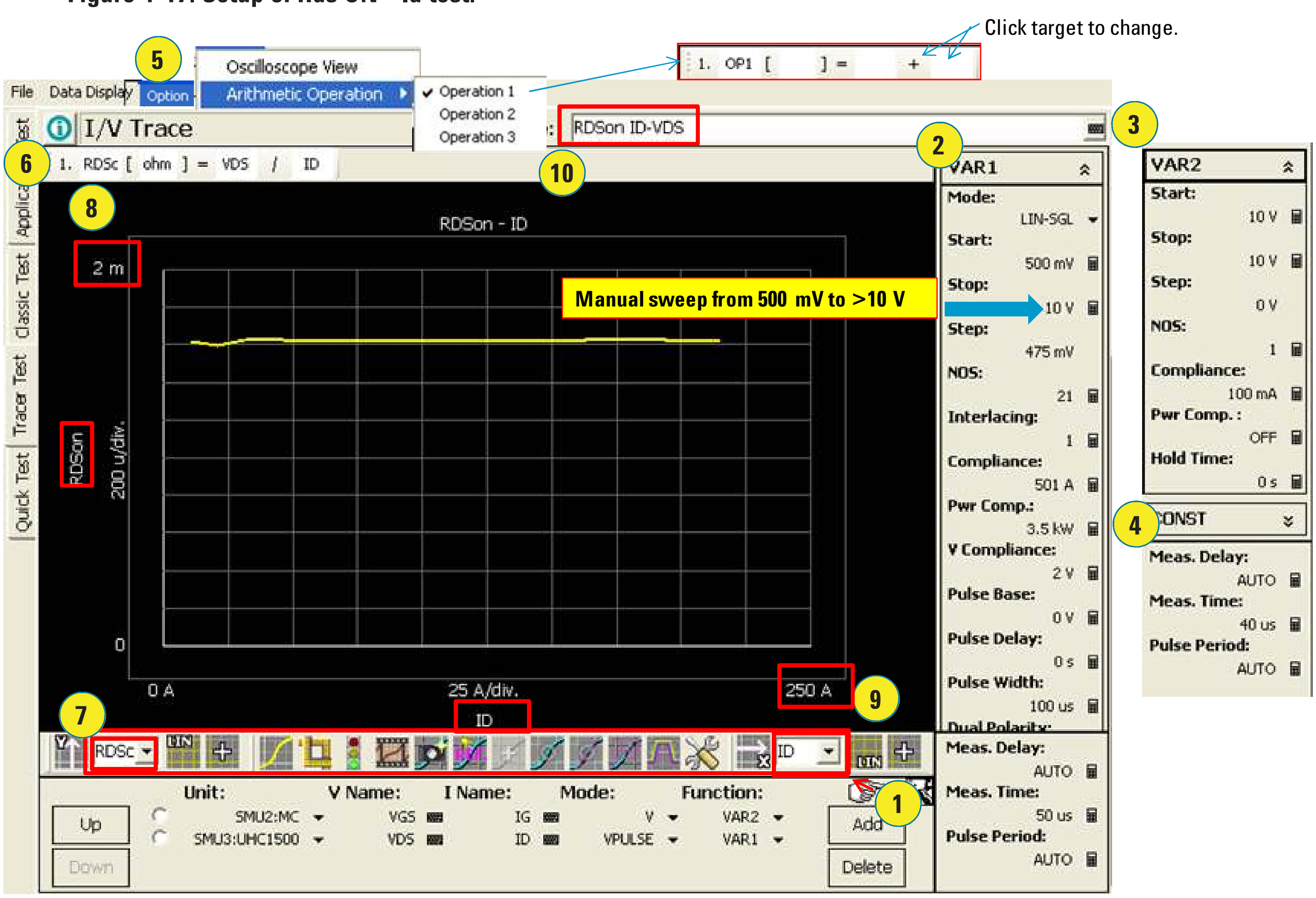
  Step 1. The "Sample setups" menu uses MOSFET -> Id-Vds.

  Step 2. Set VAR1 parameters as shown in figure 4-17, or in the following VAR1 list.

Mode	Start	Stop	NOS	Interlacing	Compliance	Pwr comp	Output V Comp
LIN-SGL	500 mV	10 V	21	1	501 A	3.5 kW	2 V

Pulse Base	Pulse Delay	Pulse Width	Dual Polarity	Hold Time
0 V	0 s	100 us	OFF	0 s

Figure 4-17. Setup of Rds ON - Id test.



Step 3. Set VAR2 parameters as shown in figure 4-17, or in the following VAR2 list:

Start	Stop	NOS	Compliance	Pwr comp
10 V	10 V	1	100 mA	OFF

Step 4. Set Meas. parameters:
- Meas. Time to 50 us.

Step 5. Click Tool bar menu -> Option -> Arithmetic Operation -> Operation 1.
Arithmetic Operation 1 appears.

Step 6. Set the following equation:
RDSon [ohm] = VDS / ID
Click target to edit the name or change operation.

Step 7. Change Y-axis to RDSon, and X-axis to ID.

Step 8. Change Y axis max. to 2m (ohm).

Step 9. Change X-axis max. to 250 A.

Step 10. Change Setup Name to "RDS0n ID-VGS".

Step 11. Start measurements by pressing single measure button, or sweep manually.
The measurement curve similar to figure 4-18 should be obtained.

After the measurement, follow the next steps in figure 4-18 to extract Rds.

Step 1. Click Marker.

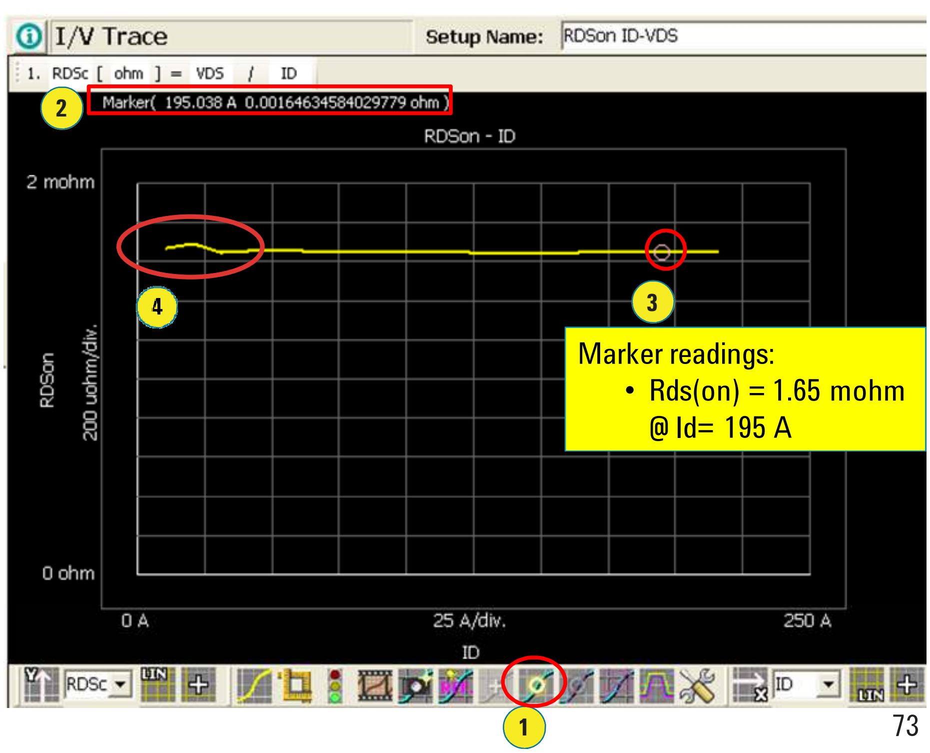
Step 2. Marker appears on the measurement start position and the marker data is shown.

Step 3. Move the marker to around Id = 195 A.

Step 4. Rds(on) can be read from the marker readout.

Note: You can read closer to target 195 A if you set more measurement points by increasing the VAR1 steps.

Figure 4-18. Rds_on vs. Id characteristics.



Note: (see #4)

Start V should be not zero volts because theoretically the resistor becomes infinity since R=V/I, where I=0 A at V=0 V.

Also, considering the offset voltage and the offset current of the SMU, it is desirable to set the start voltage as like 1/10th of the stop voltage to minimize the measurement error to a negligible level.

Review:

- The measured ON resistance is 1.65 mΩ and it is within the maximum specification limit; 1.7 mΩ.

- Try another measurement by changing the insertion height of the MOSFET to the fixture socket.
  If you insert the leads deeper, then the resistor should show lower resistance because the measurement includes the leads resistance of the drain and the source terminal.

  Note: The fixture socket uses Kelvin connection, and the effect of contact resistance between the fixture socket and the MOSFET leads should be minimal.

Demo 2-3-2. Rds ON Characteristics (Rds On vs. Vg)

The datasheet of power MOSFET typically expresses Rds ON characteristics by Rds ON versus Vg.

This section demonstrates this test approach.

◆ Rds ON vs. Id (Rds_ON - Vg) Tracer Test setup and measurement

To Measure Rds on vs. Vg characteristics, we use I force mode to the drain and sweeps the gate. Since UHCU can force current, this measurement can be done quite easily.

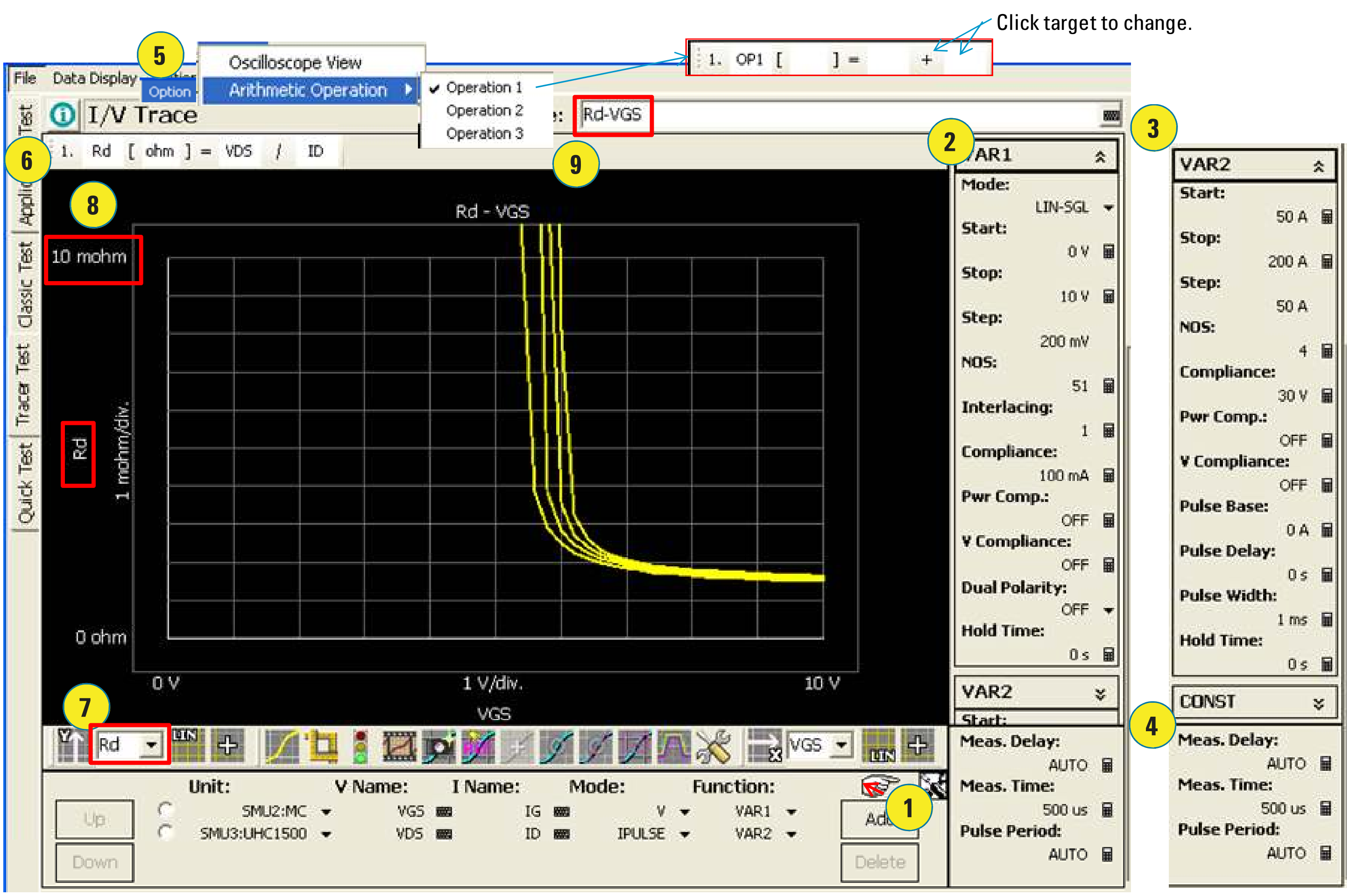
Follow the next instructions to setup the test by following the numbers of figure 4-19.

Step 1. The "Sample setups" menu uses MOSFET -> Id-Vgs.

Step 2. Set VAR1 parameters as shown in figure 4-19, or in the following VAR1 list.

Mode	Start	Stop	NOS	Interlacing	Compliance	Pwr comp	Output V Comp
LIN-SGL	0 V	10 V	51	1	100 mA	OFF	OFF

Figure 4-19. Setup of Rds ON - VGS test.



Step 3. Set VAR2 parameters as shown in figure 4-19, or in the following VAR2 list:

Start	Stop	NOS	Compliance	Pwr comp	V Compliance
50 A	200 A	4	30 V	OFF	OFF

Pulse base	Pulse Delay	Pulse Width	Hold Time
0 A	0 s	1 ms	0 s

Step 4. Set Meas. parameters:
- Meas. Time to 500 us.

Step 5. Click Tool bar menu -> Option -> Arithmetic Operation -> Operation 1.
Arithmetic Operation 1 appears.

Step 6. Set the following equation:
Rd [ohm] = VDS / ID
Click target to edit the name or change operation.

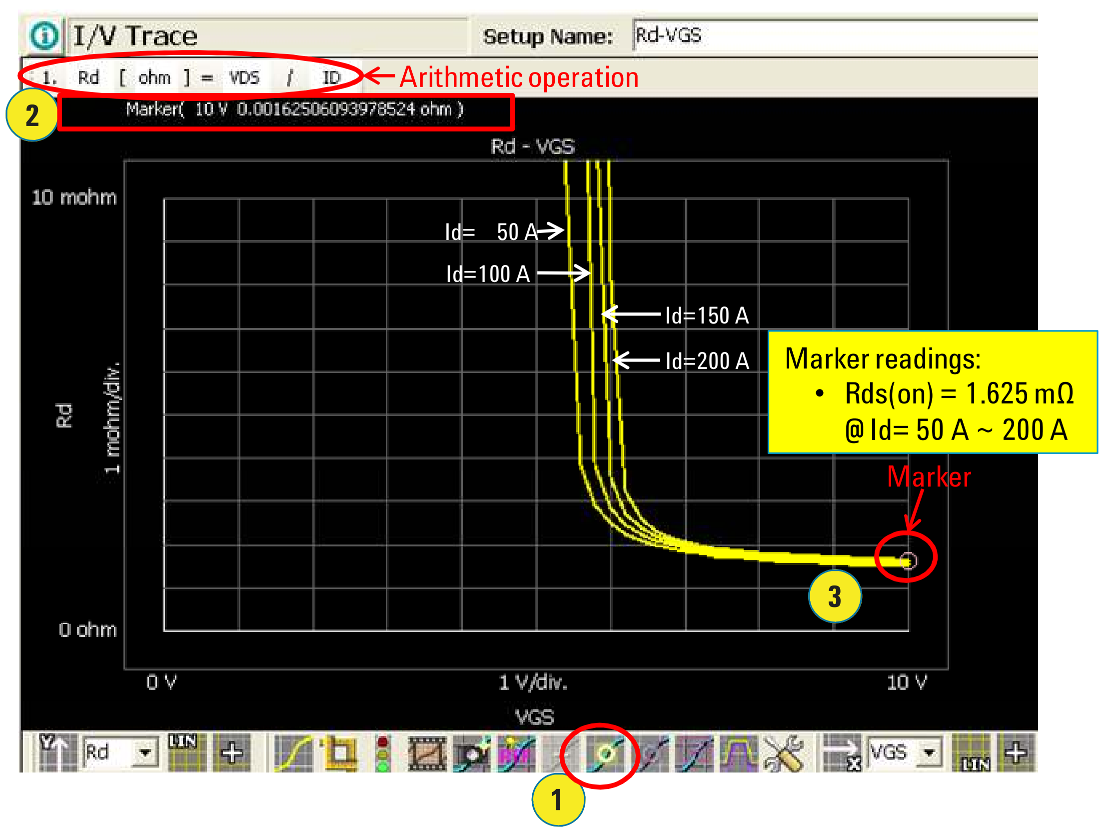
Step 7. Change Y-axis to Rd.

Step 8. Change Y axis max. to 10 m (ohm).

Step 9. Change Setup Name to Rd-VGS.

Step 10. Start measurements by pressing single measure button, or sweep manually.
The measurement curve similar to figure 4-20 should be obtained.

Figure 4-20. Rd-VGS characteristics.



After the measurement, follow the next steps to extract Rds.

Step 1. Click Marker.

Step 2. Marker appears on the measurement start position and the marker data is shown.

Step 3. Move the marker to V_{GS}=10 V.

Step 4. Rd on can be read from the marker readout: 1.625 mΩ.
The Rds on value is almost the same at Vg=10 V for four Id current at 50, 100 , 150 and 200 A in the example.

Review:

- The Rd-Vg graph indicates that the MOSFET becomes turn on around Vg=5.5 ~ 6 V depending on the drain current.
- Then Rd on converges to about 1.6 mΩ when Vg increases to 10 V.

The measured results agree to the results from the demo 2-3-1 and the datasheet specification.

Demo 2-4 IGBT Ic-Vc measurement using the Tracer Test

Objective: To learn that IGBT test is the same as the power MOSFET demo shown in demo 2-1. Check section 4-4 Demo 2-1 for detail.

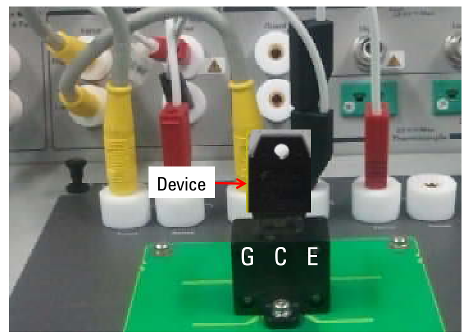
Before the demo:

Make sure the cable connection between the test module and the B1505A, EasyEXPERT configuration setup.

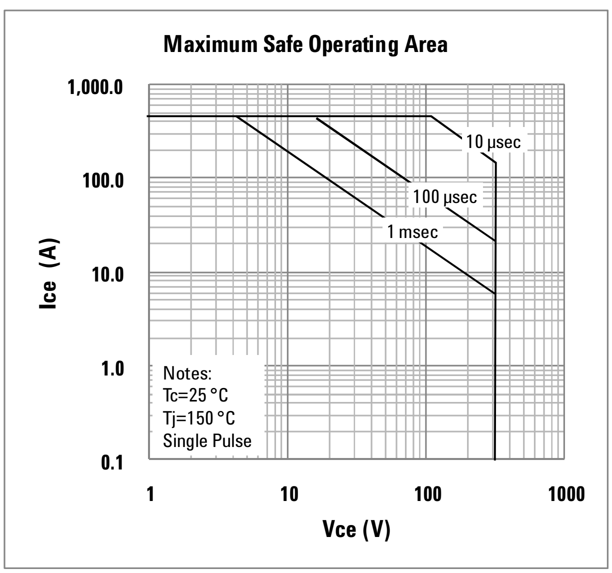
◆To set demo device

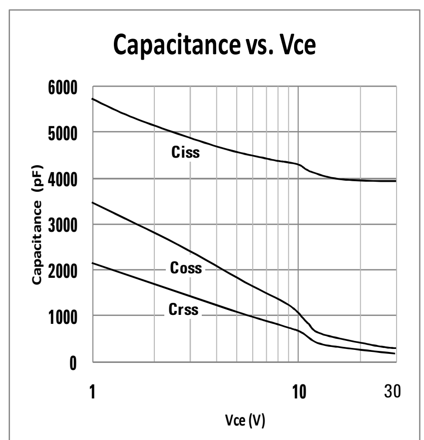
Set the demo IGBT to the fixture as shown in the next figure.

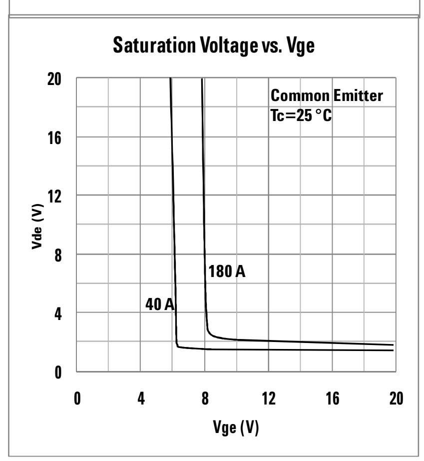
FGA180N33ATD
IGBT



Following shows brief information of SOA area, capacitance information and the saturation characteristics of the device. Refer to section 2-3 for the device specifications.







Demo setup:

The setup of the Ic-Vc Tracer Test setup for FGA180N33ATD IGBT is almost the same as HC power MOSFET in demo 2-1.

Basically refer to demo 2-1 except for the unique portion regarding the IGBT setup shown next.

◆ To setup the SMU resources:

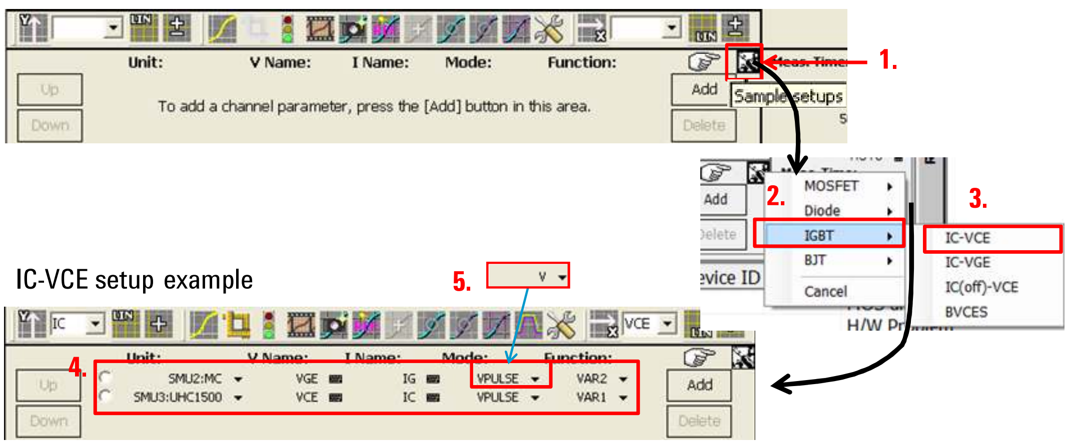
Step 1. Click "Sample setups" menu. Sample setup menu pops up.

Step 2. Select "IGBT" category opens IGBT tracer test definition menu.

Step 3. Click "IC-VCE" setup. IC-VCE setup appears.

Step 4. Make sure the SMUs are set as in the figure.
If different, re-assign the Drain and the Gate SMU appropriately.

Step 5. Change the VGE Mode from V to VPULSE Mode from the list by clicking the Mode list. Other parameters should be the same as the parameters shown in the next figure.



IC-VCE setup example

◆ To Setup X-Y scales:

Follow Figure 4-5 of demo 2-1 to setup the X-Y graph.

◆ To Setup VAR1 and VAR2 parameters:

Setup VAR1, VAR 2 and Meas. Time parameters as same as the following tables.

VAR1

Mode	Start	Stop	NOS	Interlacing	Compliance	Pwr comp	Output V Comp
LIN-SGL	0 V	5 V	21	1	501 A	7 kW	OFF

Pulse Base	Pulse Delay	Pulse Width	Dual Polarity	Hold Time
0 V	20 us	80 us	OFF	0 s

VAR2

Start	Stop	NOS	Compliance	Pwr comp	Pulse Base	Pulse Delay	Pulse Width	Hold Time
6 V	11.5 V	7	200 mA	OFF	0 V	0 s	150 us	0 s

Meas. Delay	Meas. Time	Pulse Period
AUTO	6 us	AUTO

Note:

For VAR2 Start and Stop voltage, adjust them while in measurement depending on the Vth of the demo IGBT.

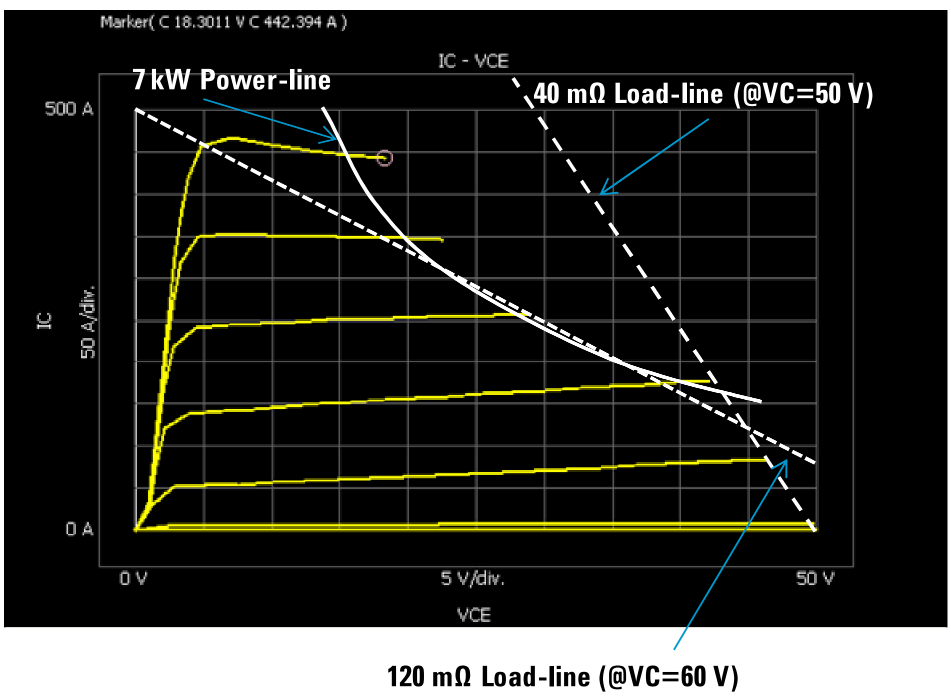
Measurement and the result:

1. Click Single Measure button.
2. After the measurement, you are expected to obtain the output as shown in figure 4-21.

◆ **Review:**

1. There is no need to set V Compliance because the breakdown voltage if the demo IGBT is 330 V, and it is much higher than the maximum voltage of UHCU (= 60 V).
2. The SOA of the demo IGBT is about 7 kW at 100 μs width pulsed collector current, and you can demonstrate more power range of UHCU compared to the RFP4004 MOSFET.

Figure 4-21. IC-VCE characteristics.



Demo 2-5 Vce(sat) Characteristics

Objective: The objective of Vce(sat) demo is to learn the followings;

- UHCU can output current source, and Vce(sat) measurement typically uses current source to the collector.
- The B1505A can easily measure Vce(sat) parameter.

Note:

Applying a constant current is not possible using a traditional curve tracer, as it only has a voltage source mode. Previously, this measurement could only be performed using a very expensive production power device tester.
However, the B1505A's UHCU can easily perform this measurement.

◆How to measure Vce(sat) characteristics:

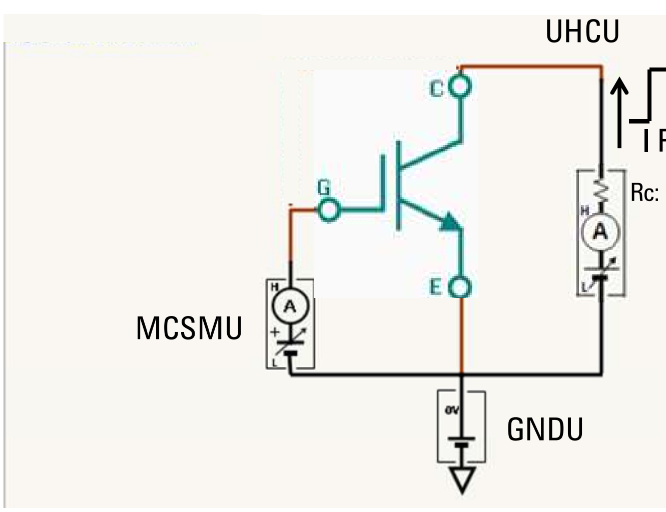
A constant current is applied while the gate is swept.
Since there is a built-in output resistor in the output of UHCU, the maximum voltage compliance value is desirable to obtain before the measurement.

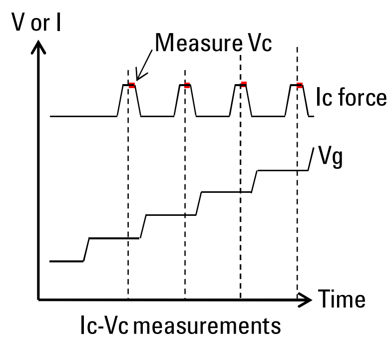
Figure 4-16 shows such an example calculation.

We use a 500 A range to force a constant current, and the output resistance of UHCU is 120 mΩ in that case.

The right bottom column of figure 4-16 shows the maximum voltage requirement for UHCU is 32 V to force around 250A with a little margin to the 180A specification condition of the collector current.

Figure 4-16. Rds ON characteristics.





Measurement condition:
- @ Ic=40 A, Vge=15 V Vce-sat max.=1.4V
- @ Ic=180A, Vge=15 V Vce-sat typ.=1.68 V

⇩

Ic SMU meas. condition: Vc comp
- Vc: 2 V min.
- Rc: 120 mΩ
- I max sweep: 250 A (>180 A)

Vc comp = 2 V + 0.12 Ω x 250 A

⇨ >= 32 V

◆ **Demo device:**

WE use FGA180N33ATD IGBT in this demonstration.

The Vce(sat) specification is shown in section 2-3 and 4. Demo 2-4, as, VCE(sat): Typ. 1.68 V @ Ic=180A.

Demo 2-5. Rds ON Characteristics (Rds On vs. Id)

◆ **Vce(sat) Tracer Test setup and measurement**

Follow the next steps and the numbers shown in figure.

Step 1. Select Sample Setups -> IGBT -> IC-VGE.

Step 2. Change SMU3:UHC Mode: from "VPULSE" to "IPULSE".

Step 3. Set VAR1 parameters as shown in figure 4-17, or in the following VAR1 list.

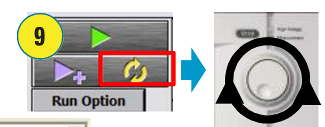
Mode	Start	Stop	NOS	Interlacing	Compliance	Pwr comp	Output V Comp
LIN-SGL	0 V	10 V	51	1	100 mA	OFF	OFF

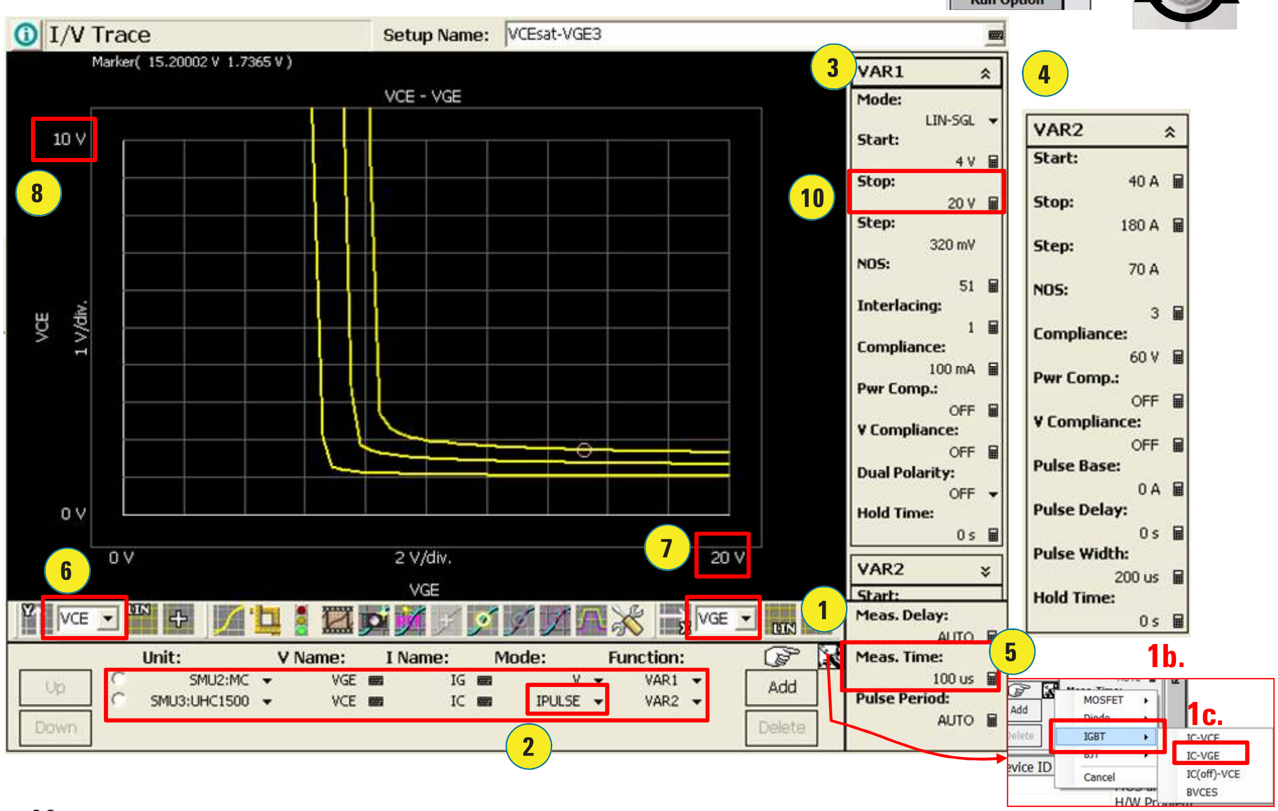
Step 4. Set VAR2 parameters as shown in figure 4-17, or in the following VAR2 list.

Start	Stop	NOS	Compliance	Pwr comp	V Compliance
40 A	180 A	3	60 V	OFF	OFF

Pulse base	Pulse Delay	Pulse Width	Hold Time
0 A	0 s	200 us	0 s

Figure 4-17. Vce(sat) setup.





Step 5. Set Meas. Time to 100 us.

Step 6. Change the Y axis display parameter from IC -> VCE.

Step 7,8. Change axis max. scale to 20 V for both X and Y.

Step 9. Click repeat measurement button.

Step 10. Click Var1 stop value to activate the parameter change.
Gradually increase the gate voltage to 20V.
The Vce-sat curve can be obtained as shown in figure 4-18.

◆ **To Analyze Vce-sat voltage:**

Step 11. Click Marker button. The marker appears on the sweep start point.

Step 12. Move the marker to the 15 V on the top line (VAR2=180 A) that is the Vce-sat measurement condition of this IGBT.

Step 13. Read the Vce-sat.
It is about 1.736 V in the example, and very close to the typical value at IC=180 A (1.68 V).

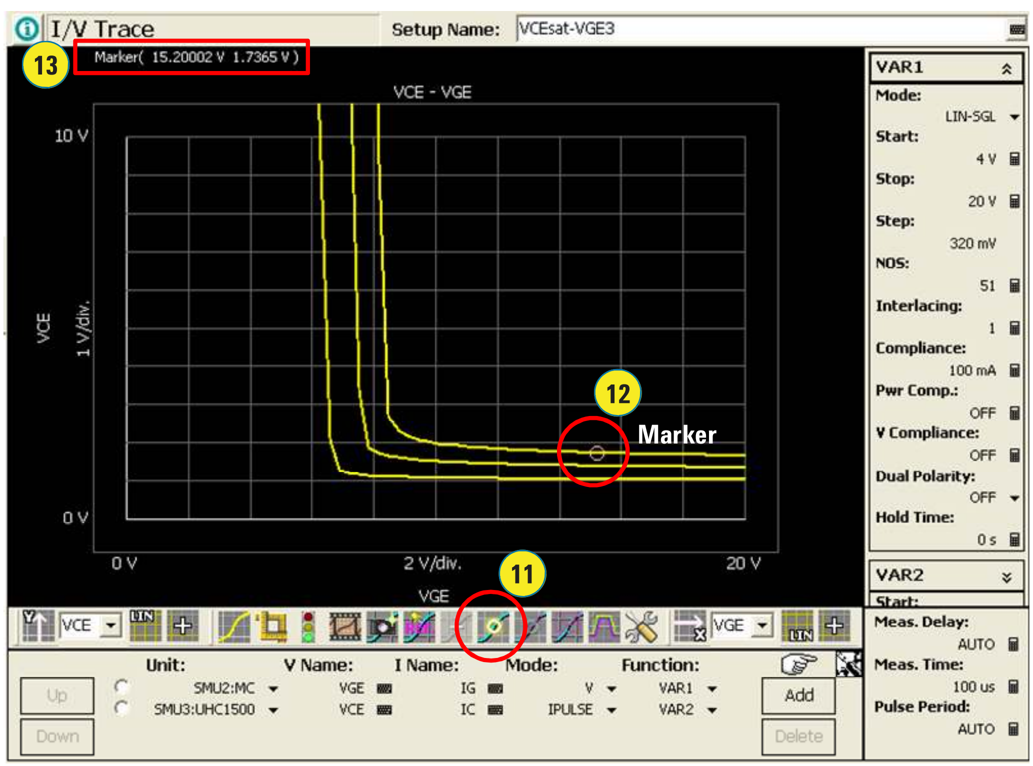
Review:

The Vce(sat) graph indicates that the saturation voltage becomes lower when the gate voltage becomes higher even the gate voltage exceeds the specified 15 V.

Note: The specification of the max. Vge is 30 V.

The measured curve agrees to the data sheet curve shown in the beginning of the section: Demo 2-4.

Figure 4-18. Vce(sat) analysis.



Summary of Demo 2

In the demo 2, following topics are covered:

Demo 2-1: Id-Vd Tracer Test

- Id-Vd Tracer Test with High Current MOSFET.
- How to set the wire and the device on the test fixture.
- How to configure the UHCU in EasyEXPERT configuration window.
- How to setup the Tracer Test using the sample menu.
- How to execute the interactive Tracer Test mode sweep.
- How to use the three Compliance mode:
  - Current compliance
  - Voltage compliance
  - Power compliance
- How to use the Replay Traces function.

Demo 2-2. Oscilloscope View:

- How to set and how to use the Oscilloscope View.
- Simultaneous four channel waveform monitor for both the voltage and current waveform is very unique, and available only on for the B1505A in curve tracer mode.

Demo 2-3. Rds ON characteristics, and Demo 2-5 Vce(sat) characteristics:

- These measurements using a current source mode are only possible with the B1505A.
- The maximum current in the demo was around 200 ~ 300 A, but it can be expanded to more than 1000 A if a customer prepares such a device and the test socket.

Demo 2-4. Ic-Vc Tracer Test (IGBT):

- The demo showed that the measurement is almost the same as power MOSFET except choosing the test setup example from the IGBT sample menu.
- IGBT module in the market is a good target of the 1500 A UHCU, and it can be connected by using a test leads with a washer plug of the N1265A.

Chapter 5. Demonstration 3: Id-Vgs & Ic-Vge Transfer Characteristics

Ultra High-Current Measurement using UHCU with Application Test mode

Contents:

Objective:

This chapter covers the following test.

1. Id-Vg Application Test (HC MOSFET)
2. Ic-Vg Application Test (IGBT)

The objective of this chapter is to perform the above test and understand B1505A`s test sequence programming capabilities by using the Application Test mode.

Features:

- Id-Vg or Ic-Vg measurement requires constant voltage source in drain or collector supply.
  But it is difficult under the curve tracer mode (UHCU) because there is a voltage drop by the output resistor of the power supply. The voltage drop by the resistor is unknown because the current flowing to the resistor cannot be determined before the measurement.
- The EasyEXPERT application test definition furnished with the B1505A solves this problem by using the programming capability of the Application Test mode.

Device used:

Demo 3 uses the following devices;

- IPFP4004 PbF HC MOSFET
- FGA180N33ATD IGBT

Wiring and Device setting inside of the N1265A Fixture

Use the same setup of section 3-1 and figure 3-1.

EasyEXPERT Configuration for Expanders

Use the same configuration of section 4-2 or demo 2.

5-1. How the Id-Vg transfer characteristics measurement is done?

Figure 5-1 shows the basic measurement block diagram and the measurement result of Id-Vgs measurement using UHCU.

Id-Vgs at fixed Vd is an important test so as you can check the gain of the power MOSFET (Transfer characteristics from the gate voltage to the drain current).

Demo 3 shows that you can make Id-Vgs test with a fixed Vd by using a sample application test definition.

The basic idea hidden under the "Id-Vgs for Expanders)" application test is explained next. (You can skip the explanation, though.)

Follow the next step numbers by following the same number in figure 5-1 to understand the explanation:

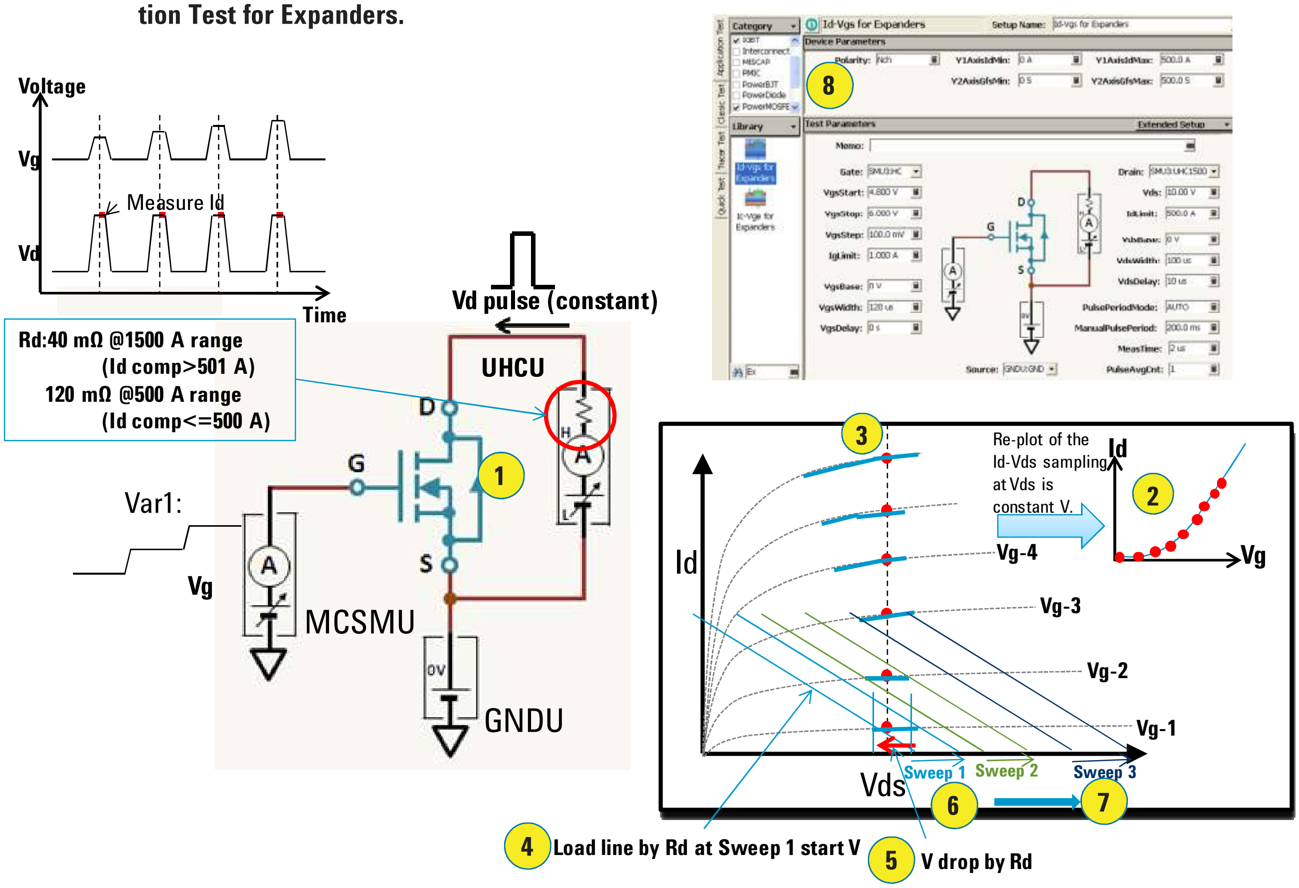
Step 1. Unfortunately, there is a series output resistor in the UHCU output, and you cannot generate a constant voltage at the UHCU output if there is unknown collector current. This is because there is a voltage drop in the output resistor Rd of UHCU.

Step 2. The Id-Vgs curve is equivalent of the re-plot points of (continues to step 3)

Step 3. the sampling points at Vds of the Id-Vds measurement curve.

Step 4. The UHCU output voltage is actually applied to the collector by following the load line determined by Rd, UHCU set V and IGBT output impedance.

Figure 5-1. The internal operation of Id-Vg Application Test for Expanders.



Step 5. The voltage set to the UHCU is different at the collector pin by the voltage dropped through Rd.

Step 6. You can extract the Id at the target Vds by searching the Id at constant Vds from the Id-Vds measurement curve at arbitral Vg step.

Step 7. By repeating the Id-Vgs sweep for different Vg as shown in figure 5-1, the accurate Id-Vgs measurements can be made easily, though it takes a little bit more time than directory measuring Id-Vg test with SMUs.

Step 8. The B1505A provides EasyEXPERT application test by using this approach.

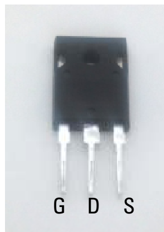
Demo 3-1: Id-Vgs Transfer Characteristics

Objective:

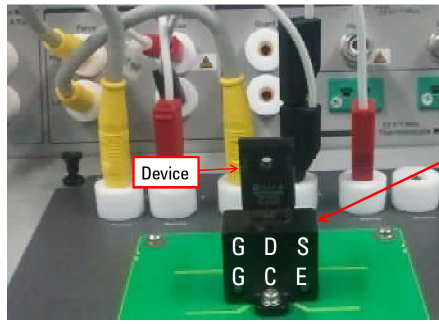
- To understand Id-Vg Transfer characteristics with constant Vd can be performed even there is an output resistor in the power supply.
- To experience that you can add analysis on the data display (output data) window.

Demo 3-1-1. Demo device

Set IRFP4004PbF to the 3 pin in-line Socket as shown in the next figure.



IRFP4004
HC MOS



G: Gate
D: Drain
S: Source
C: Collector
E: Emitter

Demo 3-1-2. Demo setup:

Setup the Id-Vg Application Test for IRFP4004PbF by following the steps shown next and the numbers in figure 5-2.

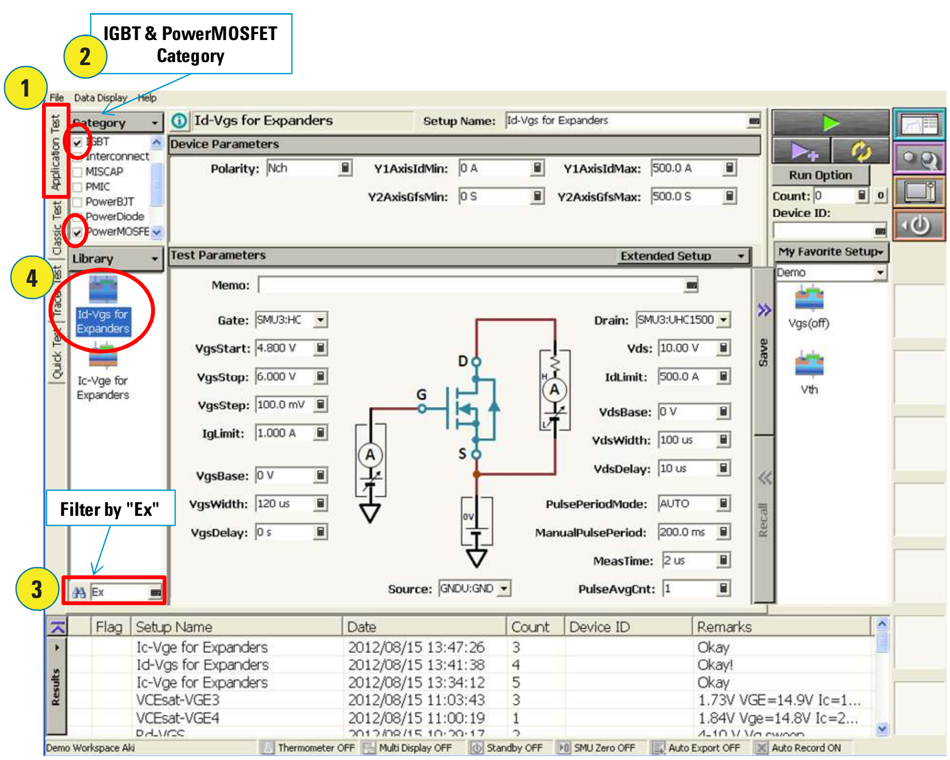
Step 1. Click Application Test Tabs.

Step 2. Check IGBT and PowerMOSFET Category

Step 3. Enter "Ex" in the search field.
Only the application test definition with "ex" will show up in the Library field.

Step 4. Click and select "Id-Vgs for Expanders".
The application test GUI shows up.

Figure 5-2. Id-Vgs Application Test.



Demo 3-1-3. Test parameter setup:

Follow the next instructions to setup the test by following the numbers of figure 5-3.

Step 1. Enter the test parameters listed in the next tables by referring to the input locations shown in figure 5-3.

Device Parameters:

Polariy	Y1AxisIdMin	Y1AxisIdMax	Y2AxixGfsMin	Y2AxixGfsMax
Nch	0 A	500 A	0 S	500 S

Test Parameters: Gate SMU2:MC

VgsStart	VgsStop	VgsStep	IgLimit	VgsBase	VgsWidth	VgsDelay
3V	8 V	200 mV	1A	0 V	100 us	0 s

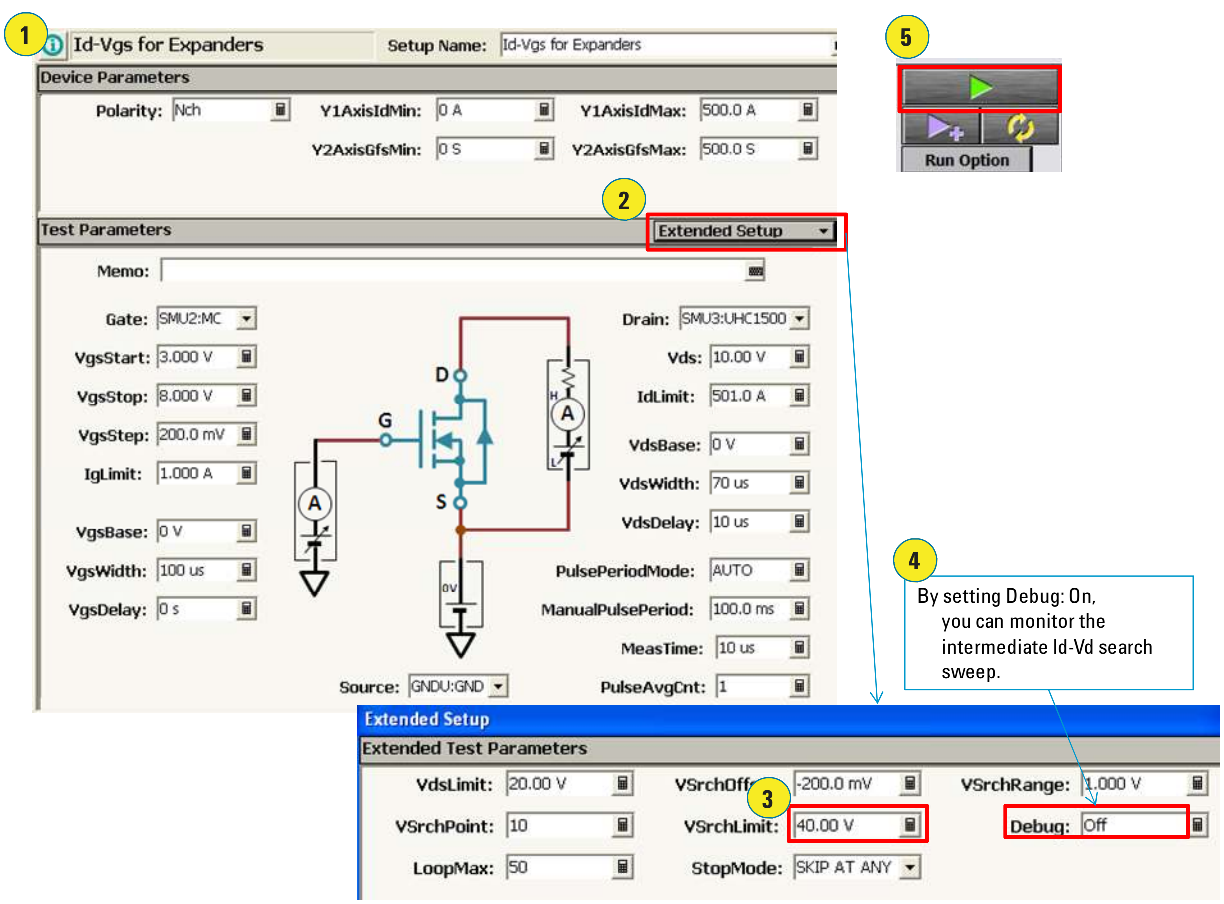
Test Parameters: Drain SMU3: UHC

Vds	IdLimit	VdsBase	VdsWidth	VdsDelay	Pulse P Mode	Man P Period	Meas Time	Pulse Ave Count
10 V	501 A	0 V	70 us	10 us	AUTO	100 ms	10 us	1

Step 2. Click Extended Setup

Extended Setup window opens.

Figure 5-3. Id-Vg Application Test parameters.



Step 2. Click Extended Setup

Extended Setup window opens.

Step 3. Enter the following parameters.

Leave the other parameters as is.

VsrchLimit	Debug
40 V	Off

Step 4. Note

By setting the Debug field to "On", you can monitor the intermediate Id-Vd search sweep measurement. Refer to figure 5-1 step number 6 to 7.

Step 5. Click single measure button.

Display Data window opens, and the measurement starts.

Note: Since there is one or more search sweep runs between one Id-Vg spot measurements, it takes for a while until the entire Id-Vg sweep is finished.

Finally, the Id-Vg and Gfs curve is measured as shown in figure 5-4.

Step 6. Click Marker icon.

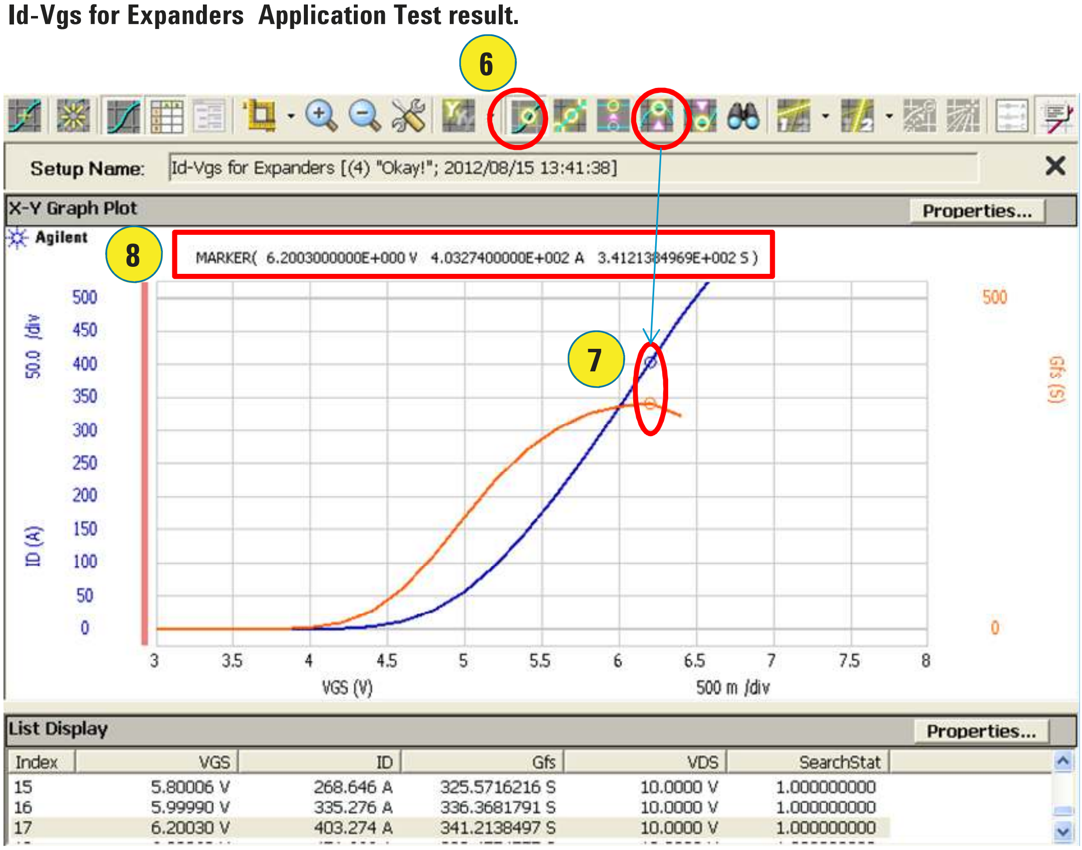
Marker shows up at the first measurement point.

Step 7. Move the marker to an appropriate data point.

For example, click Y2 axis, and then "Marker Maximum" icon will jump the marker to Gfs maximum position.

Step 8. Marker data from the left, X value, Y1 value and Y2 value can be read.

Figure 5-4. Id-Vgs for Expanders Application Test result.



◆ **Post Analysis:**

You can add post analysis on the Data Display window.
In this section, let`s try adding Log Id curve in Y2 axis.

- **To add different scale parameter:**

  Follow the next steps by referring to the numbers in figure 5-5.

  Step 1. Click View menu.

  Step 2. Click Display setup.

  Step 3. Display setup window opens.

  Step 4. Add different parameter; Example ID in log scale, Min.= 1 A, Max.= 1 kA.

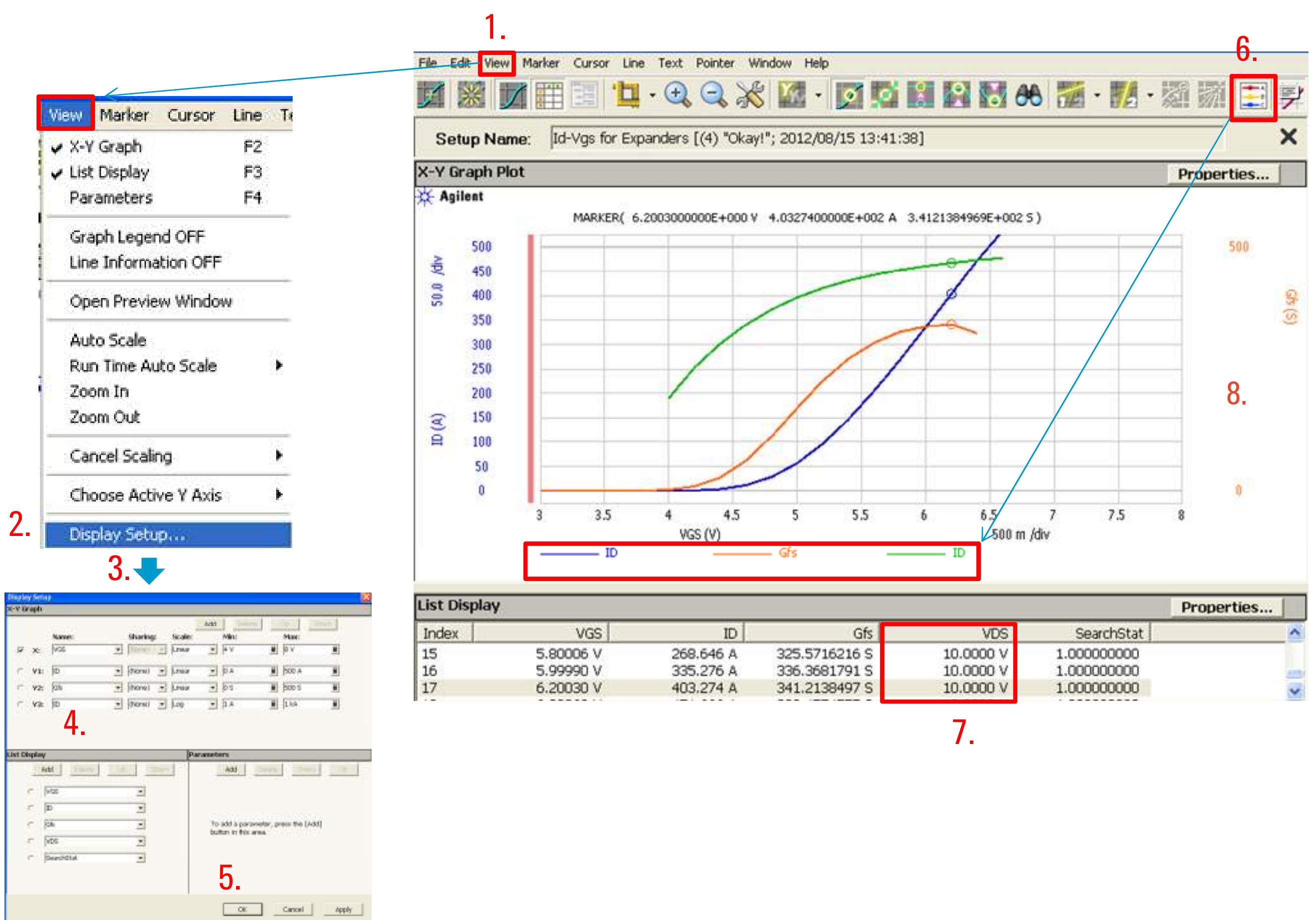
  Step 5. Click OK will add new Log ID parameter in the graph display (Y3 axis shown in green line).
  You can toggle Y2, Y3 by clicking right side Y axis.

  Step 6. You can add legend of the line.

  Step 7. You can see the test condition that VDS is a constant 10 V in the List Display.

  Step 8. Clicking Y2 axis toggles the Y2 axis between Y2 and Y3

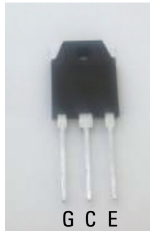
Figure 5-5. Post analysis on Data Display window.



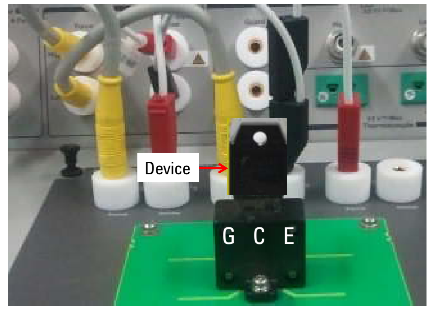
Demo 3-2: Ic-Vge Transfer Characteristics

Demo 3-2-1. Demo device

Set FGA180N33ATD IGBT to the 3 pin in-line Socket as shown in the next figure.



FGA180N33ATD
IGBT



Demo 3-2-2. Demo setup:

Follow the same instruction of Demo 3-1-1.

In the step 4, click and select "Ic-Vge for Expanders". to set the application test GUI.

Demo 3-2-3. Test parameter setup:

The steps to enter the test parameter is enactory the same as the power MOSFET in section Demo 3-2-3.

Step 1. Enter the test parameters listed in the next tables.

Device Parameters:

Polariy	Y1AxisIdMin	Y1AxisIdMax	Y2AxixGfsMin	Y2AxixGfsMax
Nch	0 A	500 A	0 S	100 S

Test Parameters: Gate SMU2:MC

VgeStart	VgeStop	VgeStep	IgLimit	VgsBase	VgeWidth	VgeDelay
4V	10 V	250 mV	1A	0 V	100 us	0 s

Test Parameters: Drain SMU3: UHC

Vce	IcLimit	VceBase	VceWidth	VceDelay	Pulse P Mode	Man P Period	Meas Time	Pulse Ave Count
20 V	501 A	0 V	70 us	10 us	AUTO	100 ms	10 us	1

Extended Parameters:

VsrchLimit	Debug
60 V	Off

Step 2. Click single measure button.

Display Data window opens, and the measurement starts.

The results shown in figure 5-6 is obtained.

◆ **Post Analysis:**

To display markers on the peak of the Gfs, follow the next steps by referring to the numbers of figure 5-6.

Step 3. Click Marker icon.

Marker shows up at the first measurement point.

Step 4. Click Y2 axis.

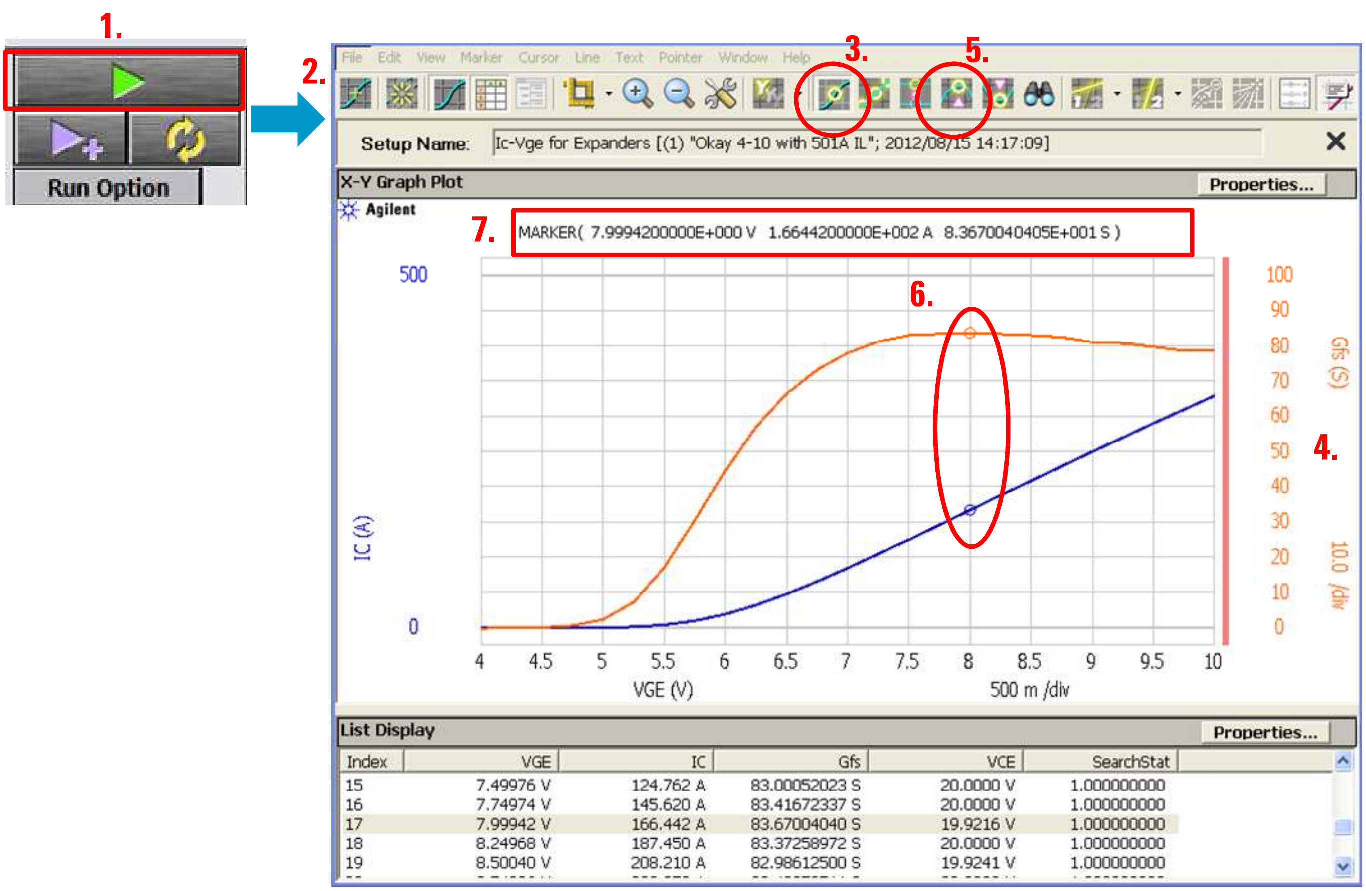
The focus to control the graphics analysis moves to Y2 axis.

Step 5. Click "Marker Maximum" icon.

Step 6. Marker jumps to Gfs maximum measurement point.

Step 7. Marker data from the left, X value, Y1 value and Y2 value can be read.

Figure 5-6. IGBT Ic-Vge for Expanders Application Test result.



Summary of Demo 3

In the demo 3, following topics are covered:

- Two application tests are demonstrated.
  - Id-Vgs for Expanders
  - Ic-Vce for Expanders
- Both tests measure the transfer characteristics quite easily.
  These tests in ultra high current region were not so easy to perform before the introduction of UHCU of the B1505A.
- These tests equivalently provide a constant voltage for Drain/Collector supply while sweeping the gate voltage.
- The post analysis can be easily added after the measurement.

Chapter 6. Demonstration 4: High-Voltage Measurement using HVSMU and HVMCU

Idss/Vdss and High-voltage medium current Id-Vd characteristics

Contents:

6-1. Demo setup

6-Demo 4-1. IDSS & BVDSS Demo with HVSMU

6-Demo 4-2. Id-Vd 1.1 A/2.2 kV & 2.5 A/1.5 kV Demo with HVMCU

Objective:

The objective of this chapter is the followings:

- To perform the high-voltage test using HVSMU and HVMCU.
- To learn the effect of 100 kΩ built-in series resistor.
- To learn HVMCU operation and tips in high voltage and narrow pulse measurements.

Features:

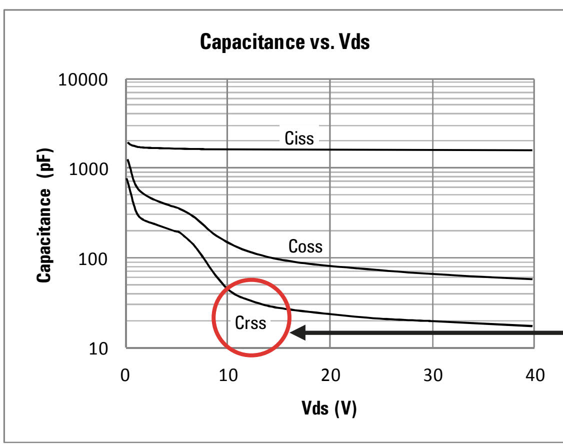
- 3 kV maximum voltage of HVSMU
- 1.1 A/2.2 kV or 2.5 A/1.5 kV maximum output of HVMCU

Device used:

Demo 4 uses the following device;

IXTH1N250 high voltage power MOSFET

- MOSFET: IXTH1N250
  - o VDSS: 2500 V
  - o Rds(on): Max. 40 Ω
  - o ID max.: 6 A @ 100 μs pulse, 5 kW @ Tc=25 °C



- Since the feedback capacitor from the drain to the gate is small, it is less important to consider the effect of injection charge to the gate caused by the drain pulse.

Wiring and Device setting inside of the N1265A Fixture:

Use the same setup of section 3-1 and figure 3-1.

6-1. Cable Connection between the B1505A and the Fixture/Expanders for HVMCU

In the demo system, two MCSMUs are shared between the HVMCU configuration and the UHCU configuration as shown in figure 6-1.

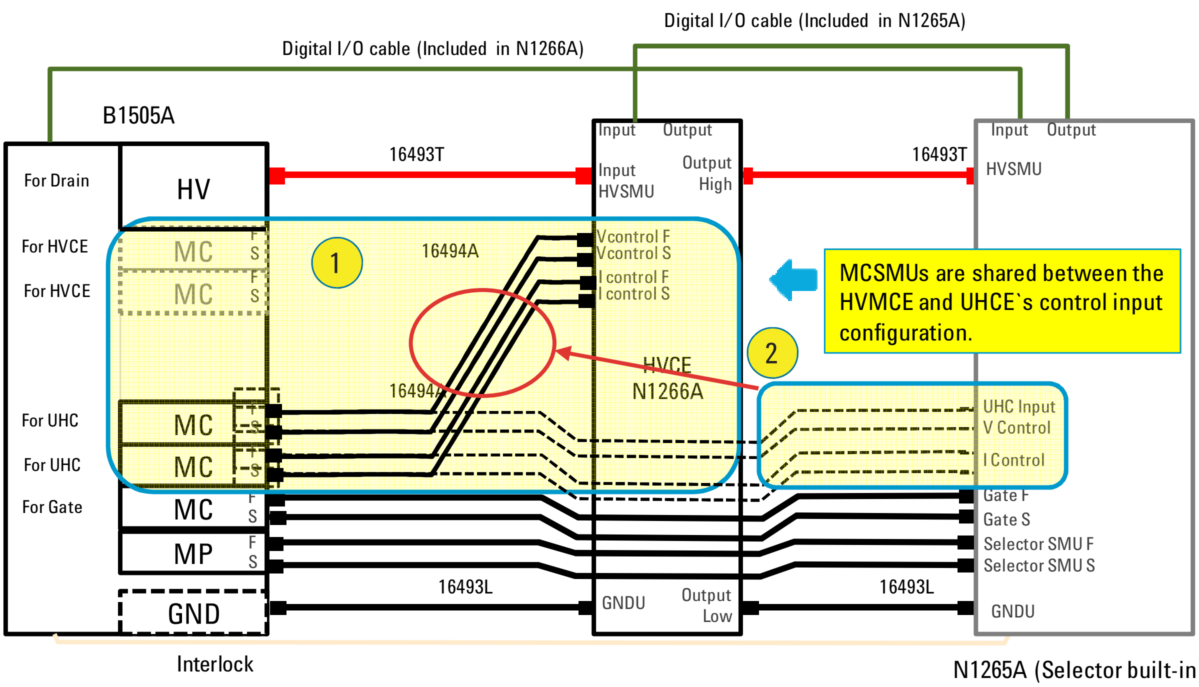
The MCSMU cables are to be connected to the HVCE connectors for V/I control inputs (see 1 of figure 6-1).
These cables are shared between the two modules (UHCE and HVCE), and have to be switched to the same named inputs of N1266A HVCE connectors from N1265A UHCE as shown in figure 6-1.

This section, we assume the cable connection to the UHCE is already made.

Therefore, we cover how to switch from the N1265A UHCE to N1266A HVCE in this section.

Note: If you start B1505A system setup from the HVCE (HVMCU), then please make a cable setup by referring to the section 2-4, and continue the HVCE control VI cable connection by following the steps here after.

Figure 6-1. Basic cabling block diagram for UHCU and HVMCU.



◆ **Switching the V/I control cables of the N1265A to N1266A:**

Follow the next steps and corresponding numbers shown in figure 6-2 to re-route the V/I control cables.

Step 1. Remove the 16494A Triax Cable connected to the Sense of “V control” connector of the N1265A input.

Step 2. Connect the removed cable to the Sense of “V control” connector of the N1266A input.

Step 3. Remove the 16494A Triax Cable connected to the Force of “V control” connector of the N1265A input.

Step 4. Connect the removed cable to the Force of “V control” connector of the N1266A input.

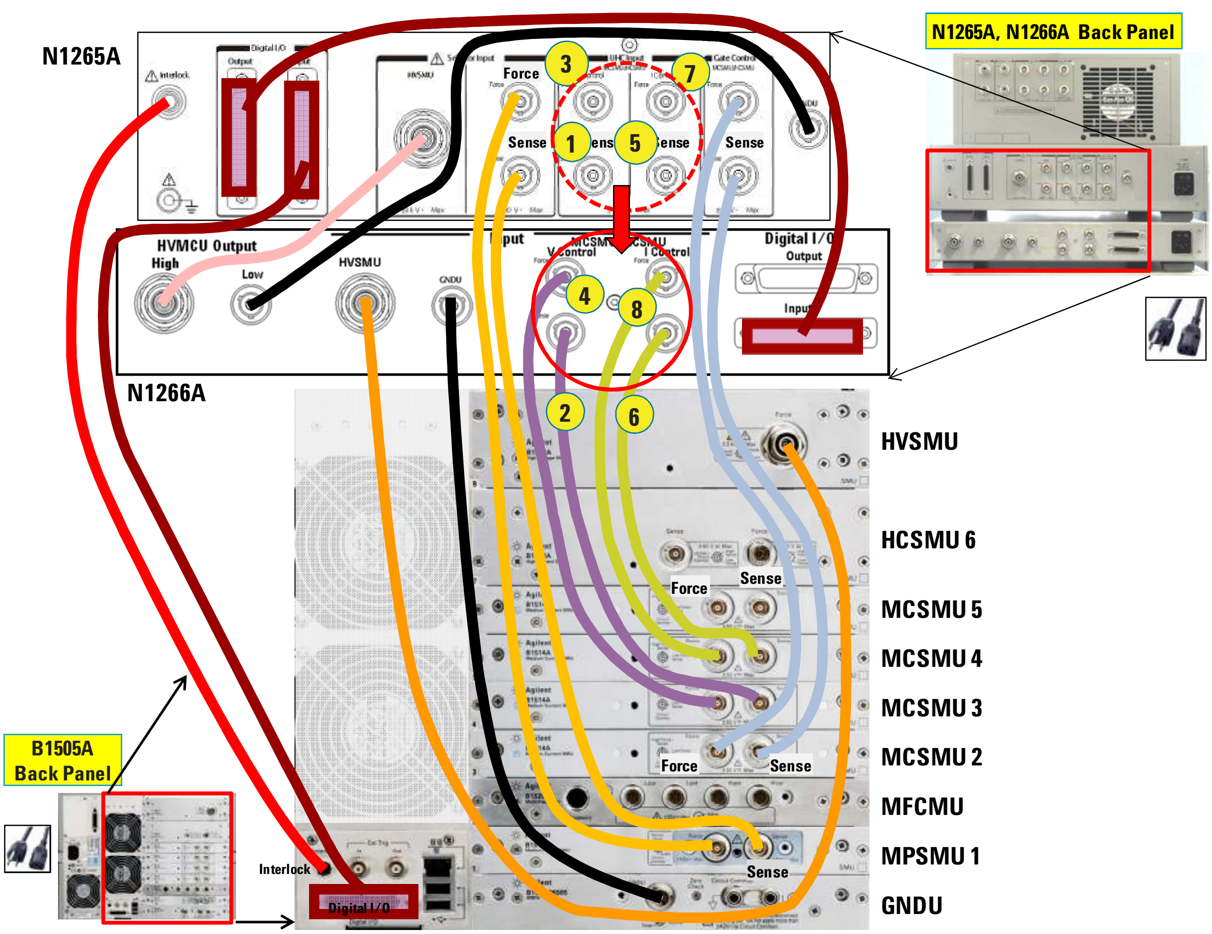
Step 5. Remove the 16494A Triax Cable connected to the Sense of “I control” connector of the N1265A input.

Step 6. Connect the removed cable to the Sense of “I control” connector of the N1266A input.

Step 7. Remove the 16494A Triax Cable connected to the Force of “I control” connector of the N1265A input.

Step 8. Connect the removed cable to the Force of “I control” connector of the N1266A input.

Figure 6-2. Cable connection for N1266A HVCE by switching from N1265A UHCE and Fixture.



Wiring and Device setting inside the N1265A Fixture

Use the same setup of section 3-1 and figure 3-1.

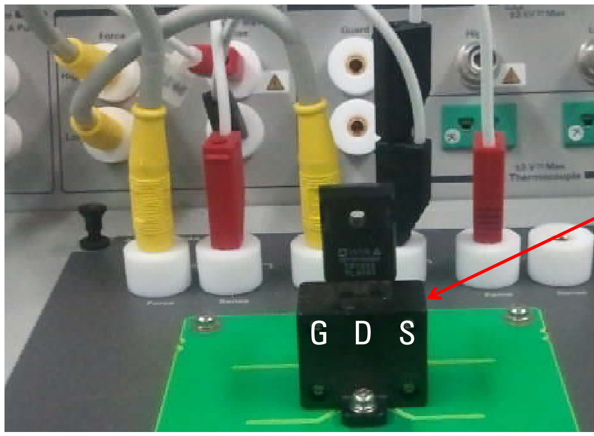
Test Device setup

Set the test device (DUT) as shown in the next figure.

We use the HV MOSFET: IXTH1N250 in demo 4 .

Insert the MOSFET to the 3-pin socket (From the left, it is Gate, Drain and Source).

IXTH1N250
HV MOS



Note:
The maximum voltage of the socket is ***limited to 3 kV*** !

6-2. EasyEXPERT Configuration for Expanders to use HVSMU/HVMCU

◆To Re-configure UHCU configuration (Pre-requisite):

Before the configuration for the HVSMU/HVMCU, UHCU configuration has to be reconfigured to release the V/I control MCSMUs because these SMUs are shared between the two expander modules.

Follow the next instruction by following the steps shown in figure 6-3.

Step 1. Click Configuration icon.

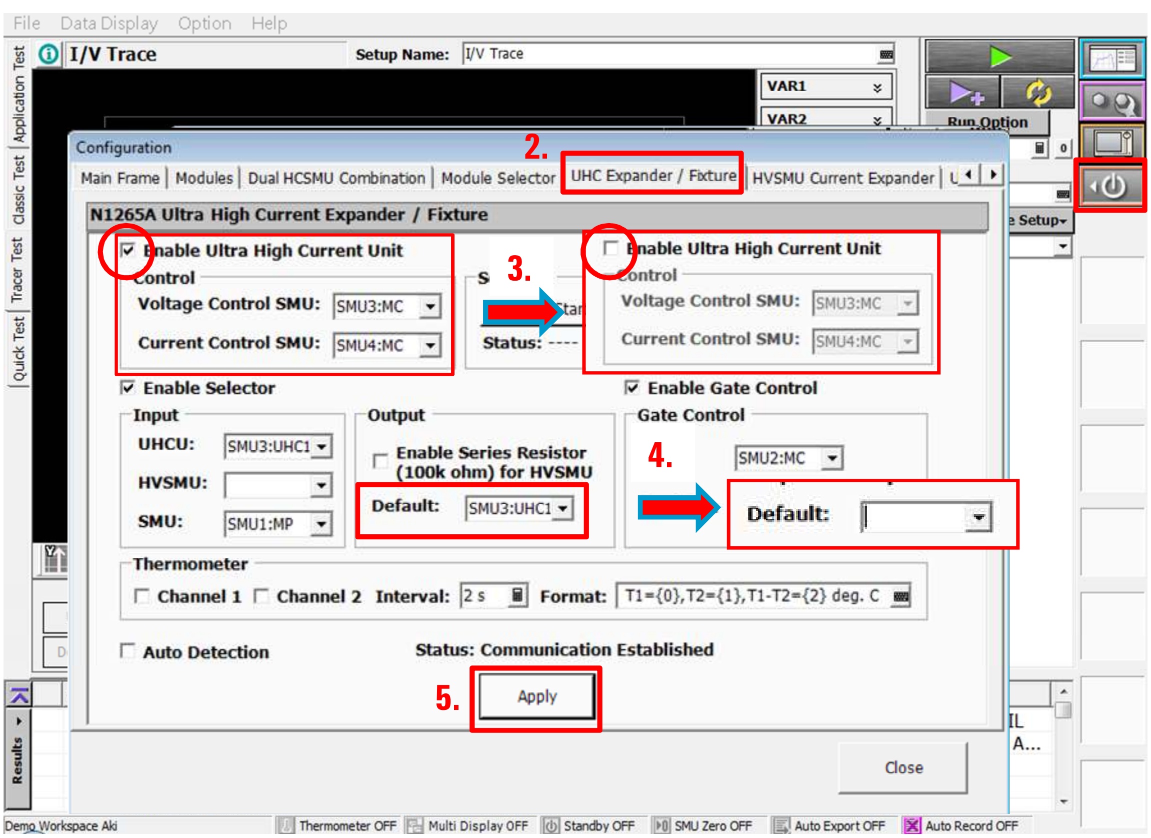
Step 2. Click "UHC Expander / Fixture" tab.

Step 3. Click and disable the check box of "Enable Ultra Current Unit" as shown in the figure.
This action will deactivate the control SMUs; i.e. SMU3 for V Control SMU, and SMU4:MC for I Control SMU.

Step 4. Change Default Output from UHC to NO selection (Blank)

Step 5. Click "Apply" button.
The UHCU is disabled in the configuration.

Figure 6-3. Reconfigure UHC Expander to release the UHCU control SMUs.



◆ **To configure the HVSMU Current Expander (HVSMU/HVMCU):**

Follow the next instruction by following the steps shown in figure 6-4.

Step 1. Click Configuration icon.

Step 2. Click "HVMCU Expander" tab.

Step 3. Click and mark the check box of "Enable High Voltage Medium Current Unit".

Step 4. Select SMU5:HVSMU in the HVSMU Input select box.

Step 5. Select exact the same Control SMUs for the V/I control SMUs` drop down list as you have configured in the B1505A cabling section.
i.e. SMU2:MC for V Control SMU, and SMU3:MC for I Control SMU.

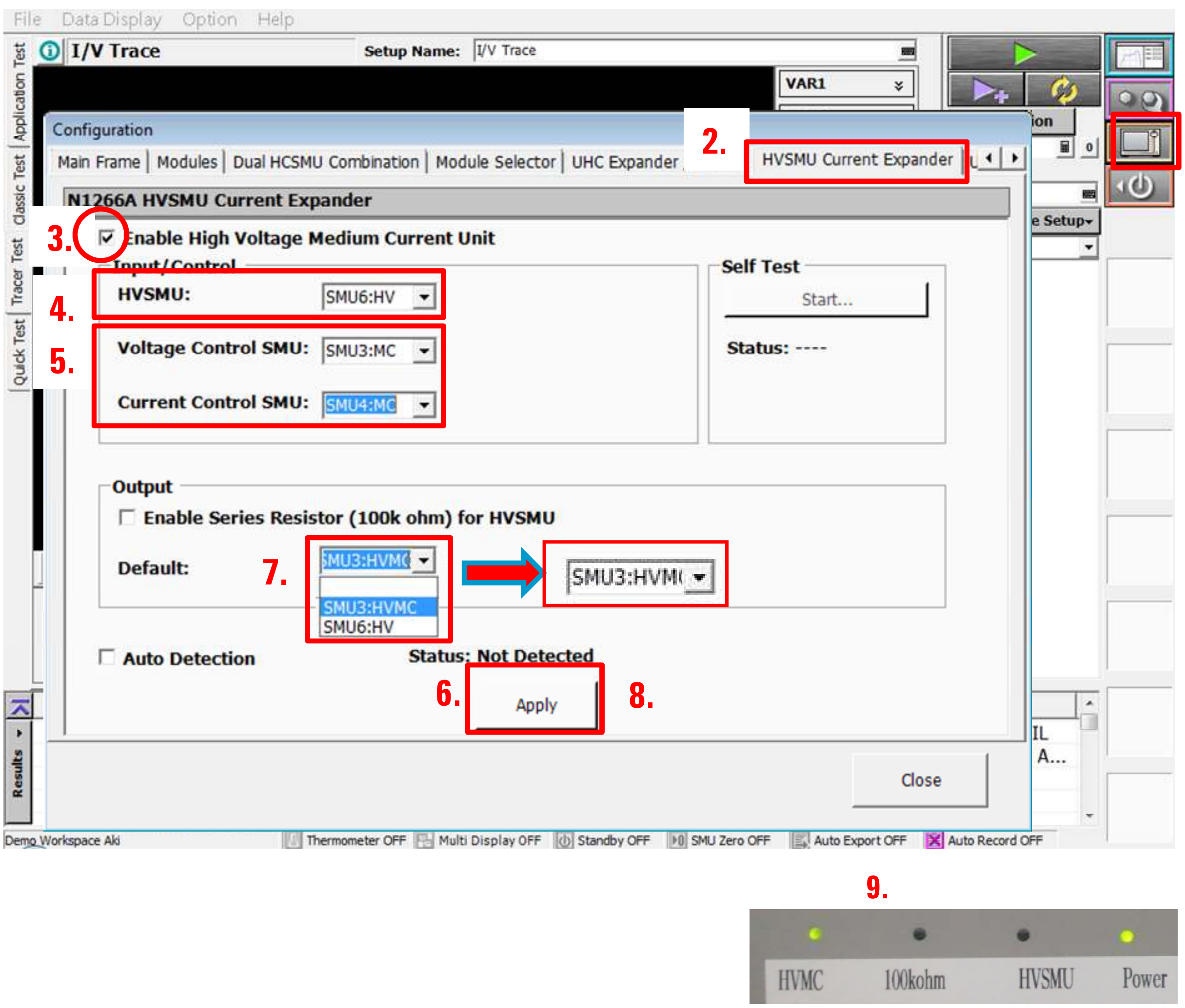
Step 6. Click "Apply" button.
The configuration is checked and applied.

Step 7. Change the Default Output to SMU2: HVMCU.

Step 8. Click "Apply" button renews the active selected module.

Step 9. The selector indicator of N1266A on the front panel shows the current selector status.
The example setup indicates the HVMC LED.

Figure 6-4. Configure the HVSMU Current Expander (HVSMU/HVMCU).



Setup of the N1265A Fixture`s selector configuration:

Finally we have setup the N1265A Fixture`s selector configuration.

Figure 6-5 shows the final configuration of the selector setup.

◆ **Final setup for N1265A selector:**

Follow the next instruction by following the steps shown in the figure.

Step 1. Click "UHC Expander / Fixture" tab.

Step 2. Set "HVSMU" in the input for HVSMU.

Step 3. Set "HVSMU" in the default output of the selector.

Step 4. Select "100 ohm" resistor from the list.

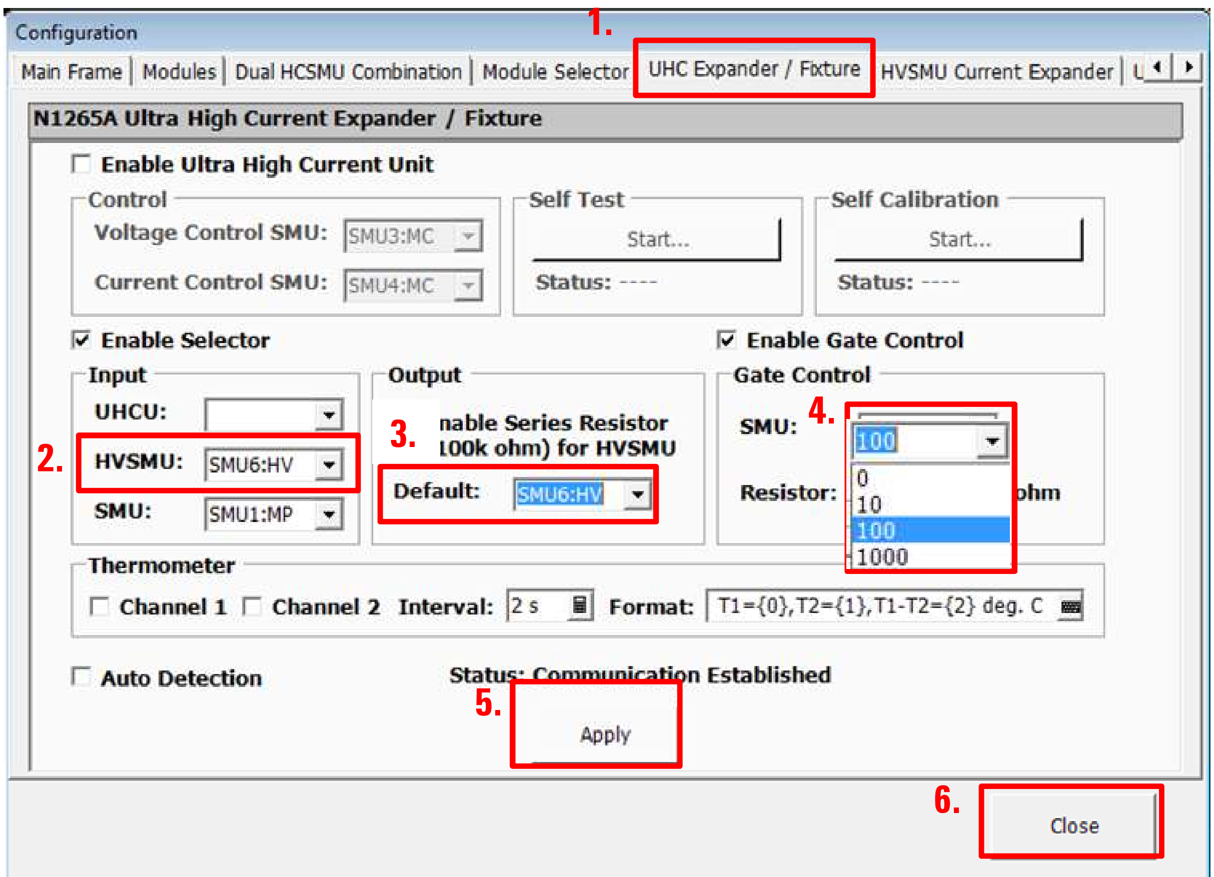
Step 5. Click "Apply" button.

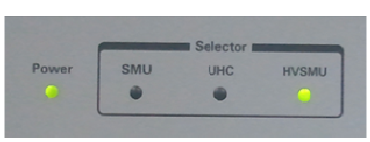
Step 6. Click "Close" button to close the Configuration window.

This is the end of the configuration to use HVSMU/HVMCU with the selector of the N1265A Fixture.

The HVSMU LED should be lit on in the indicator of the N1265A as shown in the figure in the bottom.

Figure 6-5. Final Configuration by setting HVSMU to N1265A Selector.





Demo 4-1. IDSS & BVDSS Demo with HVSMU

Demo 4-1-1. IDSS Measurement

◆ To setup and measure the IDSS Tracer Test:

Follow the next steps and the corresponding numbers shown in figure 6-6.

Step 1. We use sample test setups.
Click sample setups, then select MOSFET -> ID(off)-VDS.

Step 2. Set the VAR1 sweep parameter as shown in the next table.
The stop V is set as specified in the data sheet. (=BVDSS * 0.8 = 2,000 V)

Mode	Start	Stop	NOS	Interlacing	Compliance	Pwr comp	Output V Comp	Hold Time
LIN-SGL	0 V	2 kV	101	1	1 mA	OFF	OFF	1 s

Step 3. Set Meas. time and Step time as shown in the figure (Default value).
Meas. Time - 20 ms, Step Time= 20.1 ms.
If you set very fast Meas. time, the measurement becomes noisy and may show higher leakage current.

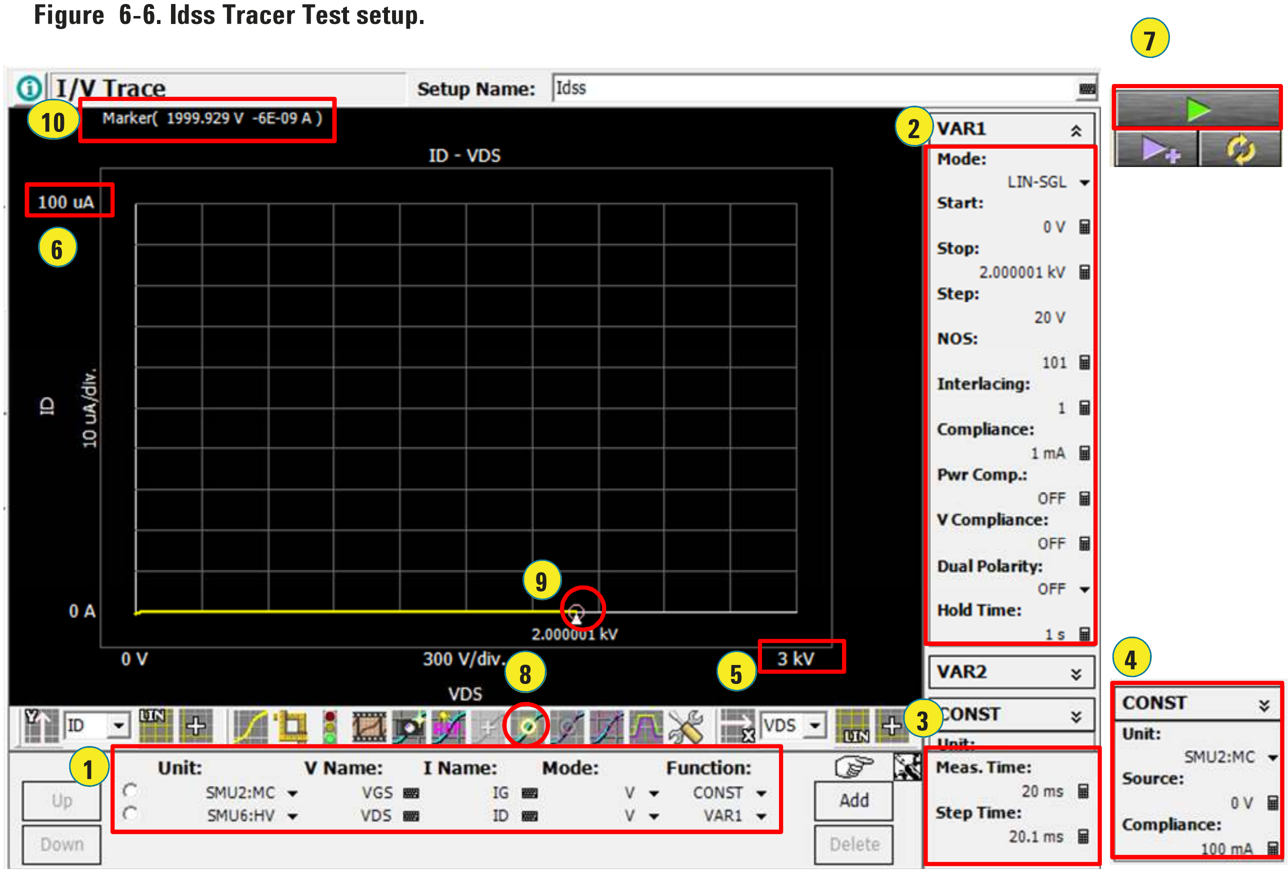
Step 4. Set CONST for SMU 2 as 0 V and 100 mA compliance.

Step 5. Change X axis max. value to 3 kV.

Step 6. Change Y axis max. value to 100 uA (Max. specification @ 25 °C is 25 μA).

Step 7. Click Single measure button.
The measurement trace is shown in the display.

Figure 6-6. Idss Tracer Test setup.



Step 8. Click the marker button. The marker appears at 0 V.

Step 9. Move the marker to 2.0 kV.

Step 10. Read the marker value as IDSS at 2,000 V.
The readout of the example shows -6 nA at 2,000 V, but this value can be considered as the noise level of the 1 mA range of HVSMU.
Since the specification limit is 25 μA, the example device shows a very low leakage current.

◆ **To detect rough BVdss:**

Continue the next steps to figure out the breakdown voltage by following the corresponding numbers if figure 6-7.

Step 11. Change Meas. Time and the Step Time to 1 ms and 1.1 ms relatively.
Note: If these time is too ling, the response time after you change the stop voltage by the rotary knob becomes very slow.
The fastest Meas. Time is 500 μs.

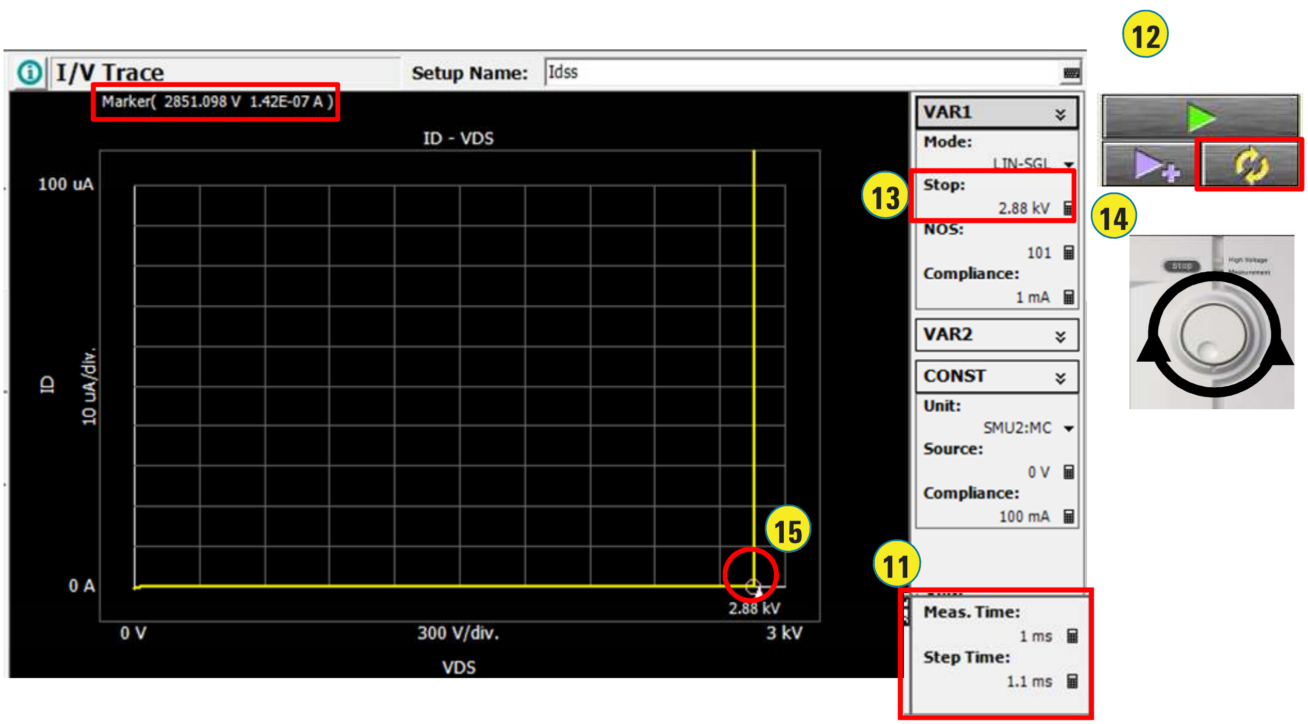
Step 12. Click repeat measure.

Step 13. Click Stop V field to activate to change the parameter by rotary knob.

Step 14. Rotate the rotary knob to increase the maximum sweep V to check rough breakdown voltage.

Step 15. In the example, the breakdown voltage is about 2,850 V.

Figure 6-7. BVdss detection by using the Tracer Test knob sweep.



If your demo device does not show the breakdown as shown in figure 6-7.

Sometimes IXTH1N250 shows very high voltage breakdown characteristics as shown in figure 6-8.

In that case, try the following workaround.

Workaround 1: Try another IXTH1N250 sample if it shows the breakdown at below 3 kV.

Workaround 2: If workaround 1 does not work, try more demo 1XTH1N250 if you have more demo devices.

Workaround 3: If above workarounds do not work, please try to change the HV MOSFET to the demo IGBT: FGA180N33ATD.
FGA180N33ATD breakdowns at around 400 V (*See* the next figure).
You can just replace the device and set the target voltage to about 400 V, or highest 450 V.

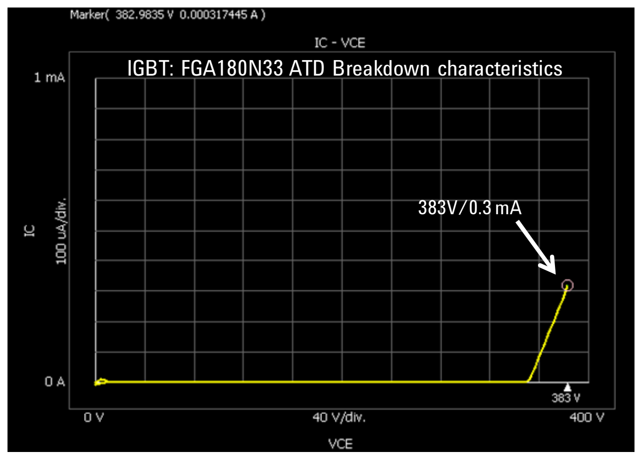
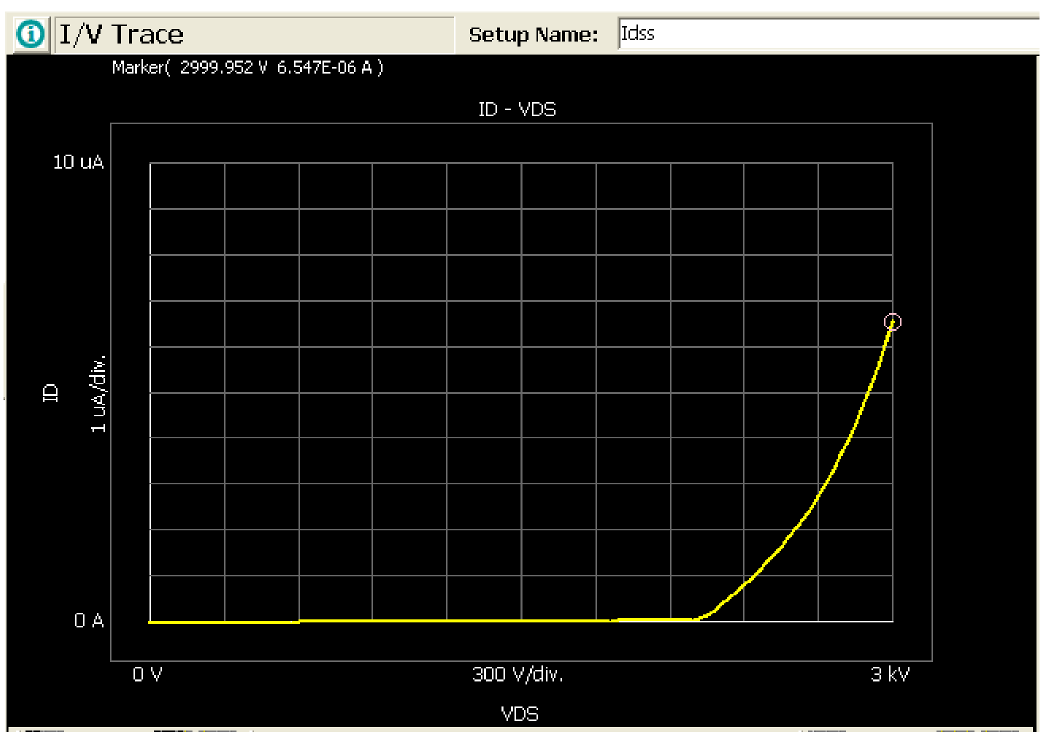


Figure 6-8. Example of higher than 3 kV breakdown of IXTH1N250 HV-MOSFET.



Demo 4-1-2. BVDSS Measurement

◆ **To setup and measure the BVDSS Tracer Test:**

Since we understand the breakdown voltage is higher than 2.5 kV, and the example HV MOSFET is about 2.85 kV, we will investigate the breakdown characteristics of the MOSFET in more detail.

Follow the next steps and the corresponding numbers of the figure 6-9.

Step 1. Change start voltage to 2.5 kV, and stop voltage to 2.6 kV.

Step 2. Change the Compliance to 4 mA.

Note: HVSMU can output maximum 4 mA in 3 kV range. Since the measurement is very close to 3 kV, 4 mA is the largest current that we can use for this MOSFET test.

Note that HVSMU can output 8 mA in 1.5 kV range.

Step 3. Set the max, ID scale to 5 mA.

Step 4. Set the min. VDS scale to 2.5 kV.

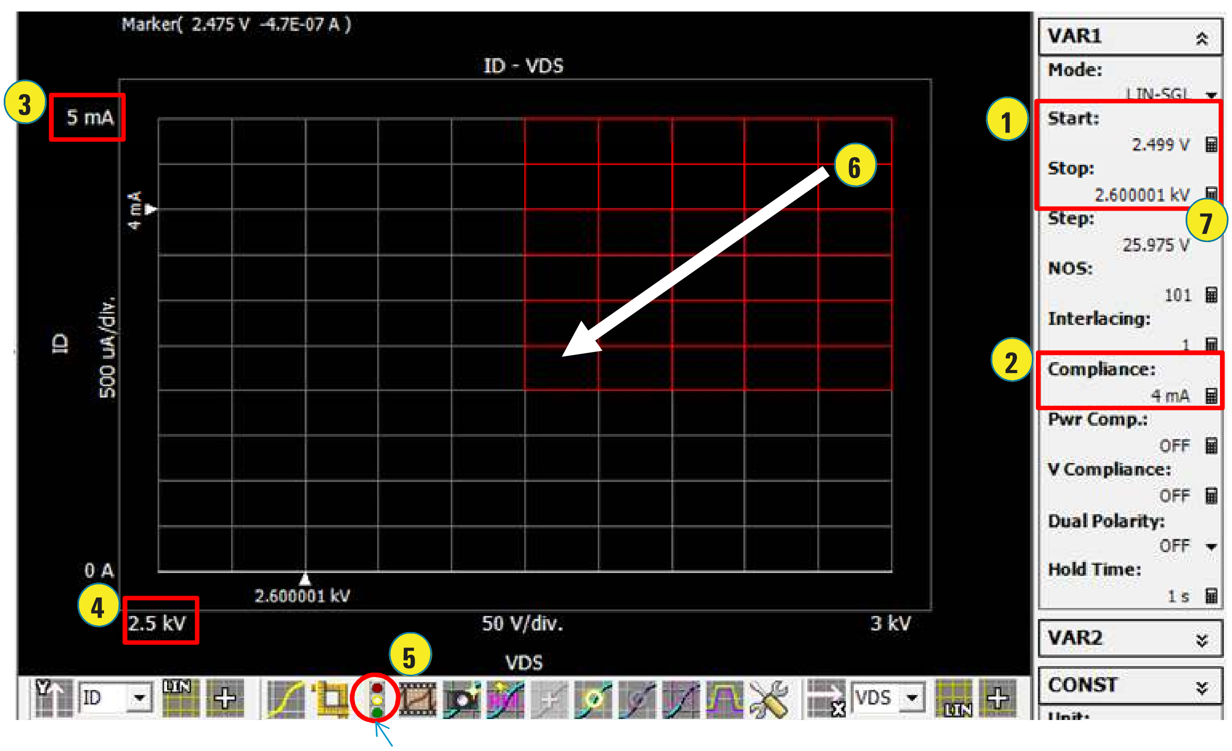
Step 5. Click "Set stop condition area" icon, and change the yellow signal lit on.

Step 6. Drag mouse to set the sweep stop condition area where a sweep stops when the measurement data once get in this area.

Step 7. Click repeat measurement button, and activate the stop voltage field by clicking the VAR1 Stop field.

The example test result shown in figure 6-10 can be obtained.

Figure 6-9. BVdss Tracer Test setup.



Click until Yellow signal turns on.

Step 8. Increase the voltage by rotating the knob.

Step 9. When the measured data hit the stop condition area, the stop process starts, but there is some time delay until actually the measurement is terminated.

Step 10. Click Marker icon, and check the breakdown voltage.

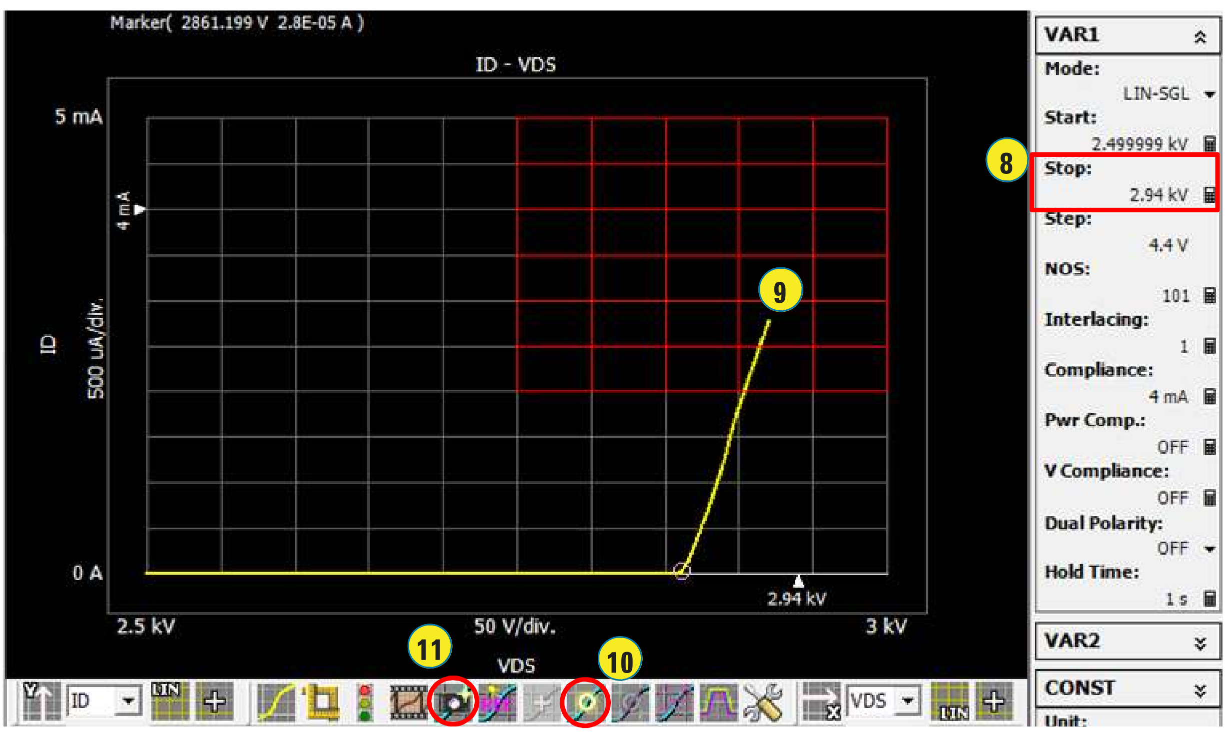
Step 11. Click "Capture the reference trace" icon.
The current trace is captured as a reference to compare the other measurement results.

Note: This reference trace is used in the next demo.

Review:

- Stop condition is useful to stop the sweep when it is difficult to detect the sudden current increase such as device breakdown.
- V compliance can be used to limit the maximum voltage in knob sweep measurement.

Figure 6-10. Tracer Test knob sweep and detection of BVdss by hitting the stop condition area.



Demo 4-1-3. Comparison of BVDSS with a series 100 kΩ drain resistor.

For BVDSS measurement, we can insert 100 kΩ series resistor to the output of the HVSMU output.

By using 100 kΩ resistor, you can characterize a device with a negative resistance or a device that shows a snap back characteristics.

The following demonstrates how the B1505A use the 100 kΩ resistor, and compensate the voltage drop by the resistor.

◆ To Setup the series 100 kΩ series resistor:

Follow the next steps and the corresponding numbers in figure 6-11.

Step 1. Open the Configuration of EasyEXPERT and click HVSMU Current Expander tab.

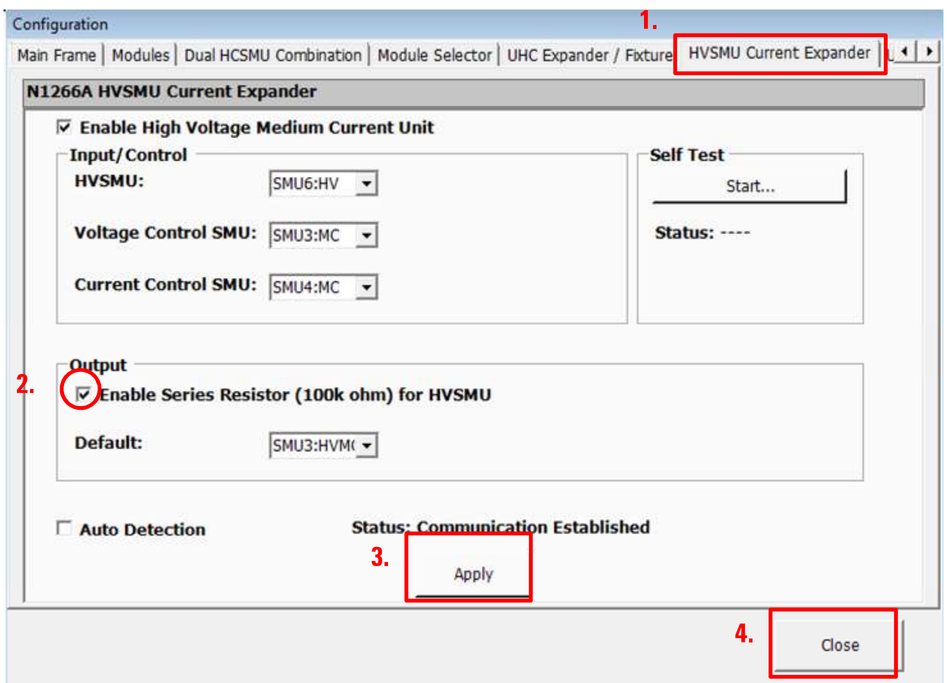
Step 2. Check "Enable Series Resistor (100 kohm) for HVSMU" check box.

Step 3. Click Apply button.

Step 4. Click Close button.

Note: In addition, adding the 100 kΩ series resistor to the drain HVSMU can prevent any potential damage to the DUT when abnormal breakdown status happens.

Figure 6-11. To configure 100 kΩ resistor.



◆ **To perform Breakdown test with 100 kΩ series resistor:**

Note: This test continues from the previous test.

Follow the step numbers shown in figure 6-12.

Step 1. Set stop V to 3 kV.

Step 2. Click Option -> Arithmetic Operation, and then select Operation 1 and Operation 2.

Step 3. Arithmetic Operation input field opens.
Enter to #1 operation: Vdrp [V] = ID * Series R value. (98.7 k Ω in the example)
where Vdrp=V drop by 100 kΩ series R.
Note: The nominal 100 kohm R must be calibrated for accurate breakdown measurement.

Step 4. Enter to #2 operation: VD_cmp = VDS - Vdrp
Where Vd_cmp stands compensated VD. You may use VD because VD_cmp does not fit in the column.

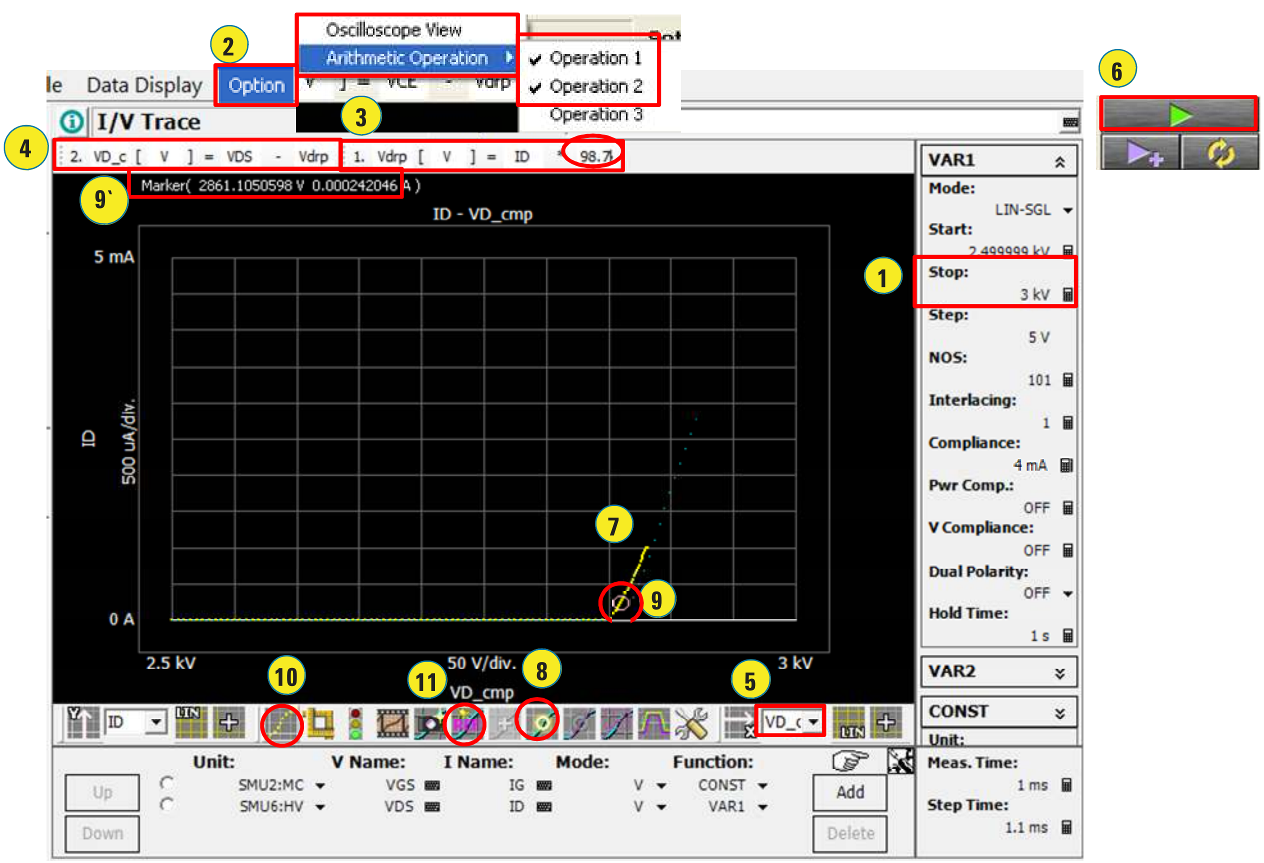
Step 5. Click X axis name field and select VD_cmp.

Step 6. Click single measure button.
Measurement starts.

Step 7. Sweep ends at 3 kV and breakdown curve is traced.

Step 8. Click the marker button. The marker appears at 0 V.

Figure 6-12. To setup Arithmetic Operation function.



Step 9. Move the marker to about ID= 0.25 mA that is the breakdown specification point, and read the marker value as VDSS.
It is 2.861 kV at 242 μA in the example.
The specification is min. 2.5 kV at 250 μA, and this device used in the example meets the specification.

Step 10. Click Line/Dot icon. You can change the line type, and you can see exact measurement points in Dot line curve display as in the figure.
As you can see, the measurement interval in reference trace without series R (blue) is much wider than the yellow trace with the 100 kΩ series resistor.
This is also a good point for using the series resistor when I/V curve is very steep.

Step 11. You can on/off or delete or save reference traces by clicking "Select reference traces" icon

Note: If you increase the measurement points, then you can get narrower steps in current reading.

Review:

- Series resistor is useful to precisely characterize the steep I/V portion to the devices with a sudden steep change of V/I characteristics, such as breakdown.
- With the series resistor, a breakdown characteristics with a negative impedance can be observed such as snap back characteristics.
- Arithmetic function in the Tracer Test mode is useful for this type of measurement.

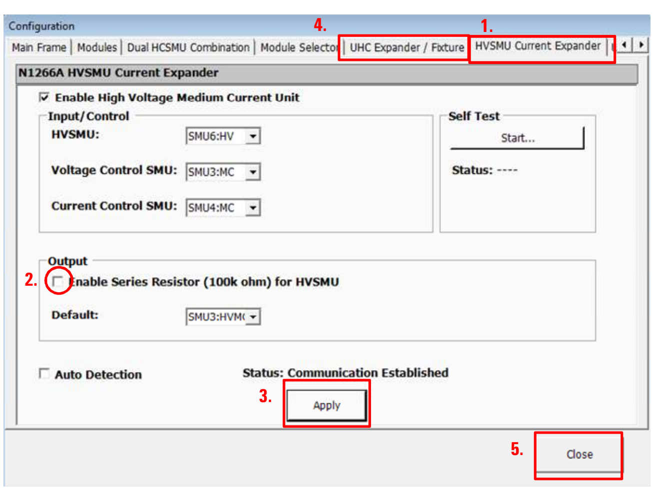
◆ **To Disable the 100 kΩ series resistor:**

Disable the 100 kΩ resistor before going to the next demo.

Follow the next steps and numbers in the figure.

Step 1. Open the Configuration of EasyEXPERT and click HVSMU Current Expander tab.

Step 2. Un-check the "Enable Series Resistor (100 kohm) for HVSMU" check box.



Step 3. Click Apply button.

Step 4. *Note:*
Make sure the UHC Expander is active by checking the N1265A LED status.
If it is not active, make the UHC Expander to active status.

Step 5. Click Close button.

Demo 4-2. Id-Vd 1.1 A/2.2 kV & 2.5 A/1.5 kV Demo using HVMCU

Demo 4-2-1. Id-Vd 1.1 A/2.2 kV Demo

◆ **To setup and measure 2.2 kV Id-Vd characteristics:**

Follow the next steps and the corresponding numbers in figure 6-13 to setup the parameters.

Step 1. Select Id-Vd sample setup.

Step 2. Change SMU2:MC Mode to VPULSE.

Step 3. Set VAR1 parameter as shown in next table by referring to figure 6-13.

Mode	Start	Stop	NOS	Interlacing	Compliance	Pwr comp	Output V Comp
LIN-SGL	0 V	10 V	21	1	1.1 A	OFF	OFF

Pulse Base	Pulse Delay	Pulse Width	Dual Polarity	Hold Time
0 V	10 us	40 us	OFF	0 s

Step 4. Set initial stop voltage, say, to 10 V.

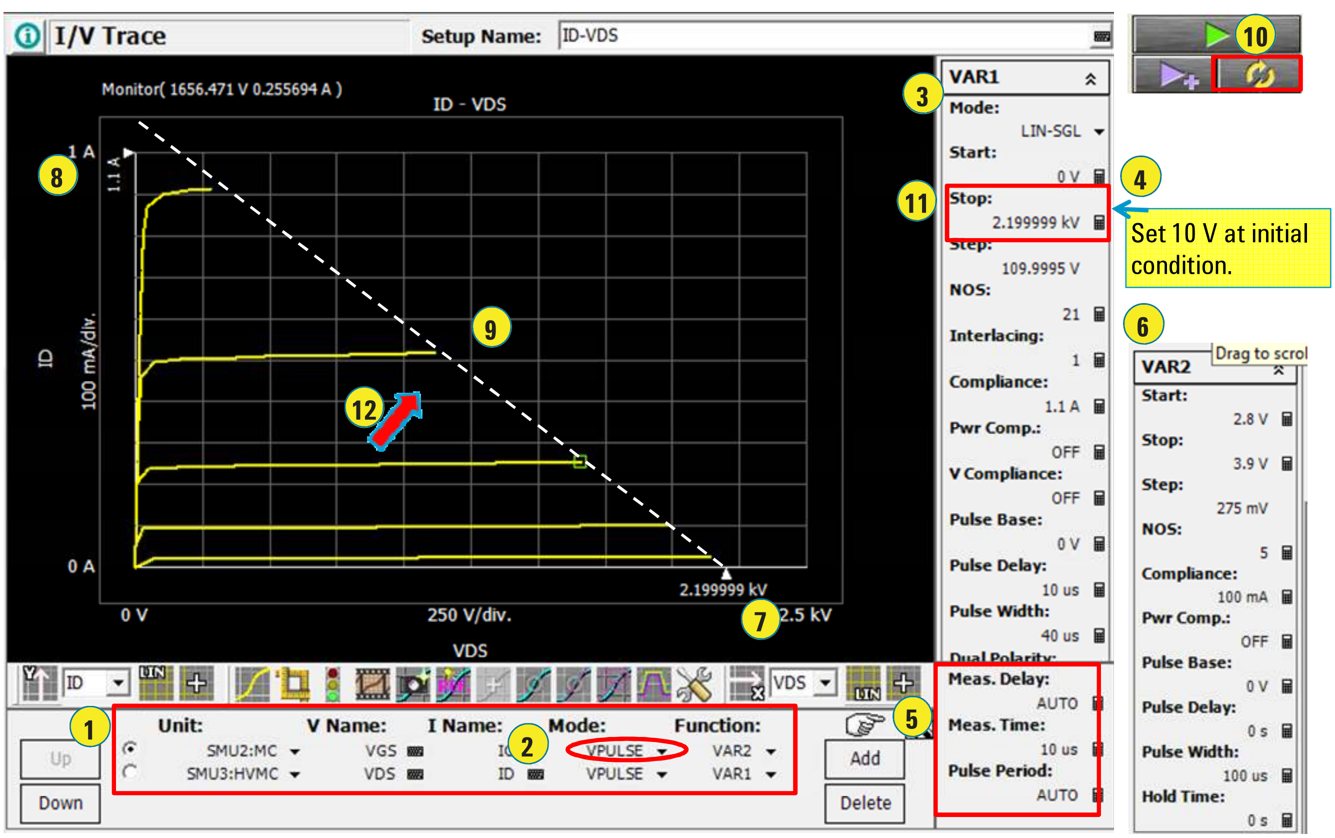
Step 5. Set Measurement time setting as follows.

Meas. Time = 10 us

Step 6. Set VAR2 parameters as follows.

Start	Stop	NOS	Compliance	Pwr comp	Pulse Base	Pulse Delay	Pulse Width	Hold Time
2.8V	3.9 V	5	100 mA	OFF	0 V	0 s	100 us	0 s

Figure 6-13. To setup 2.2 kV Tracer Test using HVMCU.



Note: The Start and Stop voltage may require an adjustment depending on the Vth of you demo MOSFET.

Step 7. Set VDS X axis max. scale to 2.5 kV.

Step 8. Set ID Y axis max. scale to 1 A.

Step 9. You can sweep up to 2.2 kV under the 1.1 A current compliance. The output resistance of the HVMCU is set t o 2.2 kΩ.
The white dotted line is a load line determined by the maximum 2.2 kV drain supply voltage and the output resistance.
The maximum I/V sweep area is limited surrounded by this dotted line, X=0 V line and Y=0 A line.

Step 10. Click repeat measure button.

Step 11. Click Stop V to activate the modification.
Rotate the rotary knob to increase the max sweep V to 2.2 kV by monitoring the measurement trace.

Note: You may be required to change the VAR2 start and stop V to get the similar results as shown in the graph.
You can change these parameters by focusing the mouse to these parameters, too.

Step 12. The measurement trace moves toward the arrow direction.
Finally you should achieve the similar results as shown in figure 6-13.

Tips:

Note: Pulse width could be narrowed down to around 30 μs with 2 μs Meas. Time setting.

Trouble shooting!

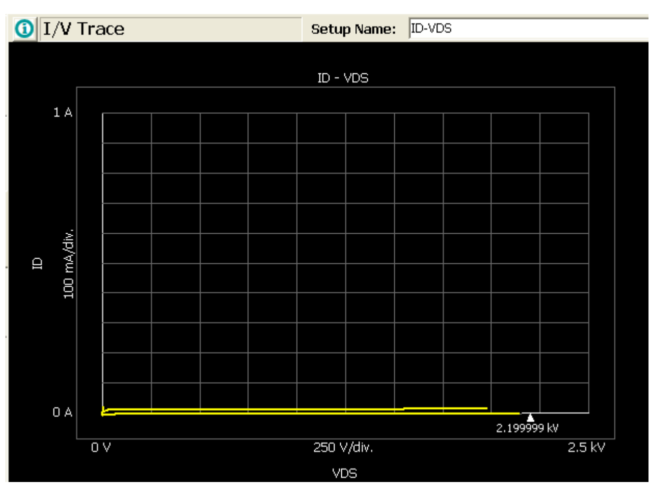
If your measurement sticks on the base line as shown in figure 6-14.

Try the following actions to measure the graph shown in figure 6-13.

- For VAR2 START: Measure Vth of demo IXTH1N250 HV-MOSFET by referring the Demo 1 setup.
Then set VAR2 START by rounding up the Vth in 0.5 V units. For example, if Vth = 3.1 V, enter 3.5 V.

- For VAR2 STOP: Set VAR2 STOP by adding 1 V to 1.5 V to the START V value.
Or gradually increase VAR2 STOP by 0.5 to 1 V step to maximum 6 V.

Figure 6-14. Example when VAR2 STOP V is too small.



◆ **Oscilloscope view example:**

This demonstration uses relatively narrow pulse (40 μs) in the drain supply.

In such a case, monitoring the pulse waveform is important.

Following shows the steps to view the Oscilloscope View waveform. Refer the corresponding number shown in figure 6-15.

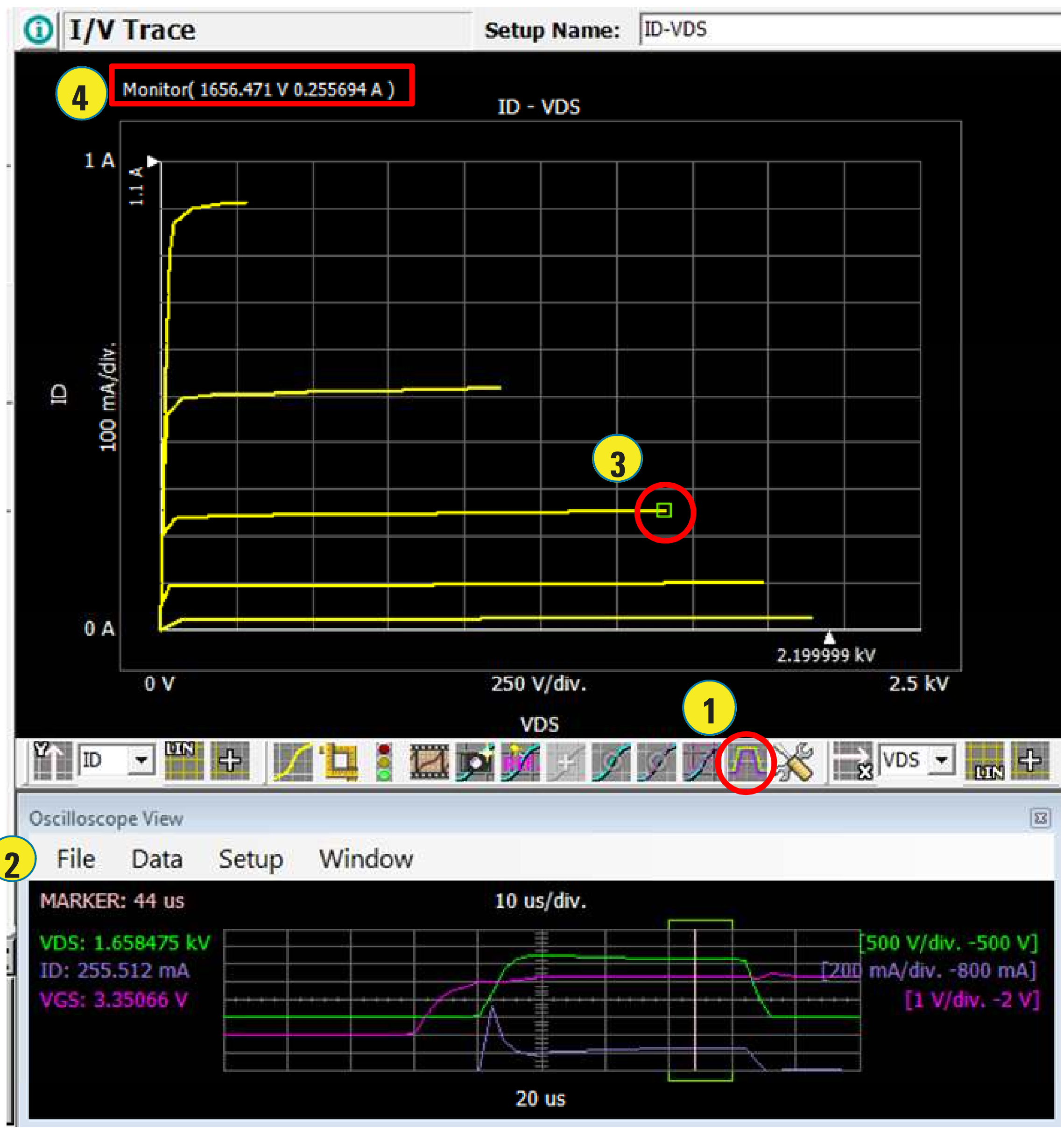
Step 1. Click Oscilloscope View icon.

Step 2. Oscilloscope View window opens.
Set Oscilloscope View parameters.
Refer to Demo 2-2 for setting the parameters.

Step 3. Starting the measurement displays the monitor point.

Step 4. The voltage and Current value of the monitored point are displayed, and the waveform in the Oscilloscope view.

Figure 6-15. Oscilloscope View of Id-Vd Tracer Test using HVMCU.



Demo 4-2-2. Id-Vd 2.5 A/1.5 kV Demo

◆ **To setup and measure 1.5 kV Id-Vd characteristics:**

Step 1. The stop voltage must less than 1.5 kV to use 2.5 A range.
Set 1.5 kV for Stop V.

Step 2. Set Compliance to 2.5A. The output resistance of the HVMCU is set to 600 Ω.

Step 3. Change pulse width to 30 us.
Note: narrower the pulse width can generate more current in HVMCU, but too short pulse width tends to increase a measurement uncertainty.

Step 4. Change Meas. Time to 6 us.

Step 5. Change X axis max. value to 1.5 kV.

Step 6. Change Y axis max. value to 2.5 A.

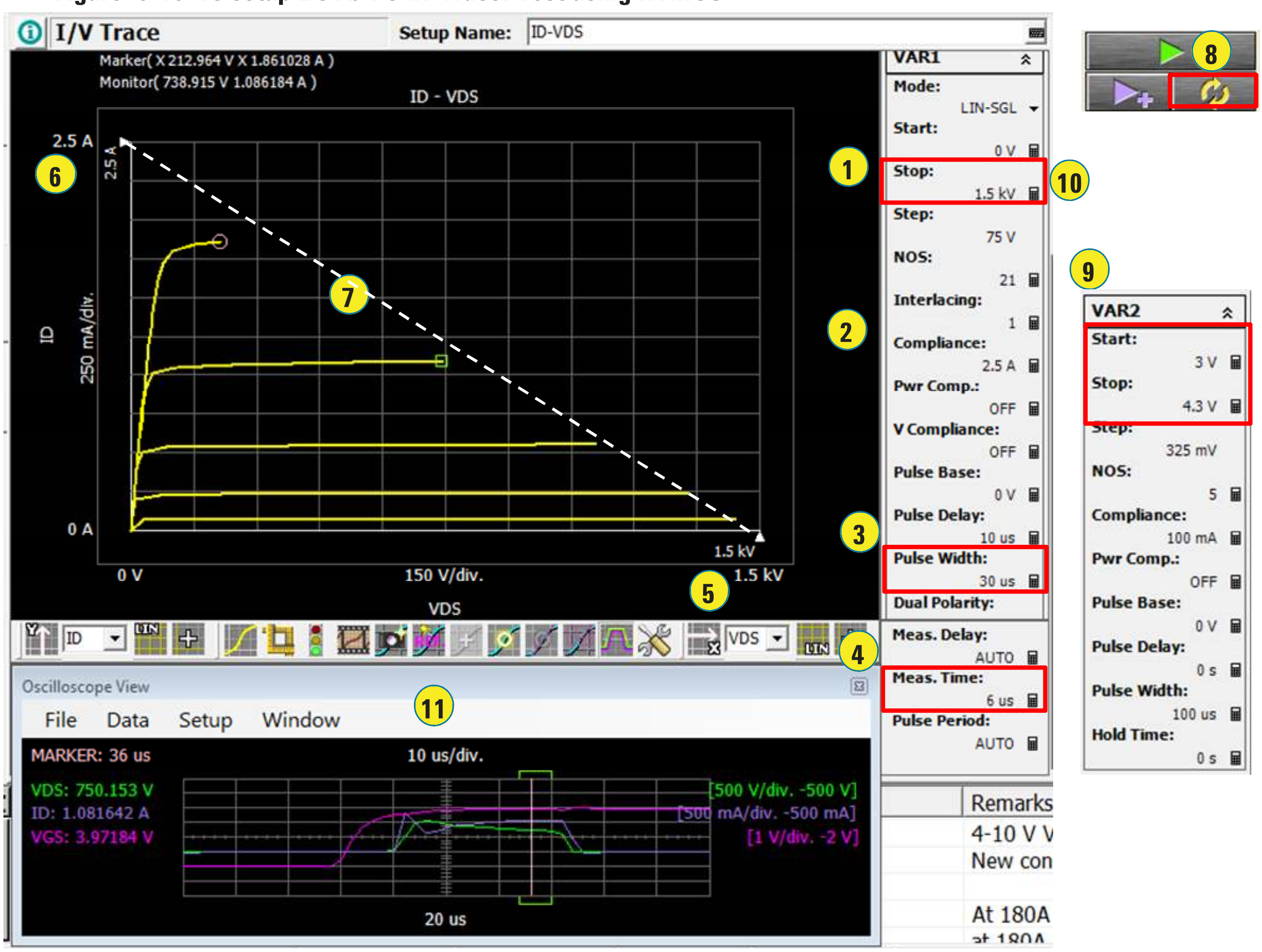
Step 7. maximum V/I load line is shown.

Step 8. Click repeat measure button.

Step 9. The start and stop V of VAR2 require a small increase to increase the maximum current.
Increase the current in 0.1 or 0.2 volts step so as you can make a similar measurement results as shown in figure 6-16.

Step 10. Note: You can change stop V of VAR1, but once it exceeds 1.5 kV, the current compliance changes to 1.1 A, and you will see unexpected results.

Figure 6-16. To setup 2.5 A/1.5 kV Tracer Test using HVMCU.



Step 11. If you continue from the previous demo, there should be an Oscilloscope View window.
Change the vertical and horizontal axis scale for properly monitoring the waveform.

Review:

- HVMCU covers a unique power range which covers 2 A and 2 kV range that were not covered in the past curve tracer.
- The medium current coverage of this voltage range is useful for investigating the breakdown characteristics in high current condition, or SOA study on wafer level.
  - HVSMU has a built-in output resistor, and it is useful to protect the DUT in such a case of sudden device breakdown.
- Oscilloscope view is useful for narrow pulsed measurement such as less than 30 μs range using HVMCU

Summary of Demo 4

In the demo 4, following topics are covered:

- Maximum 3 kV test is possible with HVSMU.
  - Stop area setting is useful for breakdown test.
  - 100 kΩ series resistor and the arithmetic function are useful for breakdown characterization.
- HVMCU. covers unique power range: 2.5 A/1.5 kV or 1.1 A/2.2 kV.
- HVMCU can output higher current at when the pulse width is narrower.

Chapter 7. Demonstration 5: High Voltage C-V Measurement

Contents:

Objective:

The objective of this chapter is the followings:

- To be able to perform the C-V measurement using the B1505A.
- To be able to use AC guard technique to measure Cdg, Cds, Cgs.

Features:

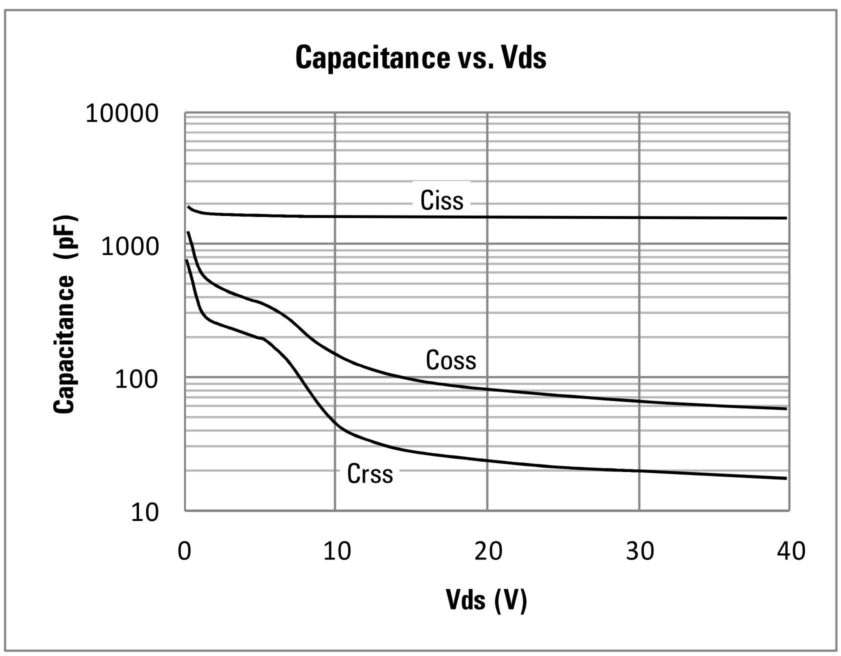
- 3 kV maximum DC bias voltage
- Integrated C-V measurement capability on a ultra high power DC measurement instrument.

Device used:

Demo 5 uses the following device;

- IXTH1N250 high voltage power MOSFET

Capacitance vs. Temperature data extracted from IXTH1N250 datasheet



7-1. C-V Measurement using MFCMU and High Voltage Bias Tee

7-1-1. Definition of Capacitance Parameters

Next three capacitive components of the power MOS-FETs are typically listed in the power MOS-FET datasheet.

- Crss Reverse Transfer capacitance
- Coss Output capacitance
- Ciss Input capacitance

Figure 7-1 shows the intrinsic capacitive components of power MOS-FET which are gate- Drain capacitor Cgd, drain-source capacitor Cds and gate-source capacitor Cgs.

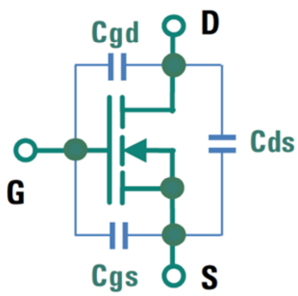
Crss, Coss and Ciss capacitive components can be calculated by using Cgd, Cds and Cgs components as shown in the figure.

This section provides how to measure the intrinsic capacitive components of power MOS-FET (Cgd, Cds, and Cgs).

The demo exercises Cgd measurement.

Each component can be measured independently by using the AC guard technique.

Figure 7-1.



Ciss: Input Capacitance

Ciss = Cgs + Cgd

Coss: Output Capacitance

Coss = Cds + Cgd

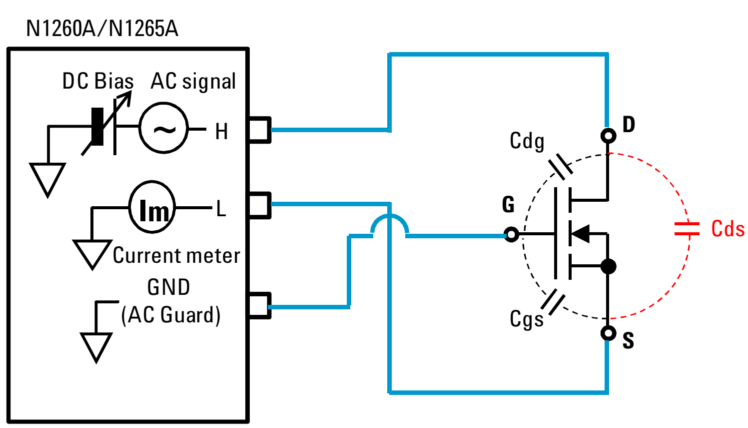
Crss: Reverse Transfer Capacitance

Crss = Cgd

◆ **AC Guard and capacitive component measurement of MOSFET**

Following shows a basic MOSFET capacitive component measurement block diagram for each parameter using the B1505A MFCMU, HVSMU, N1260A High Voltage Bias .Tee and N1265A Fixture.

Cds Measurement

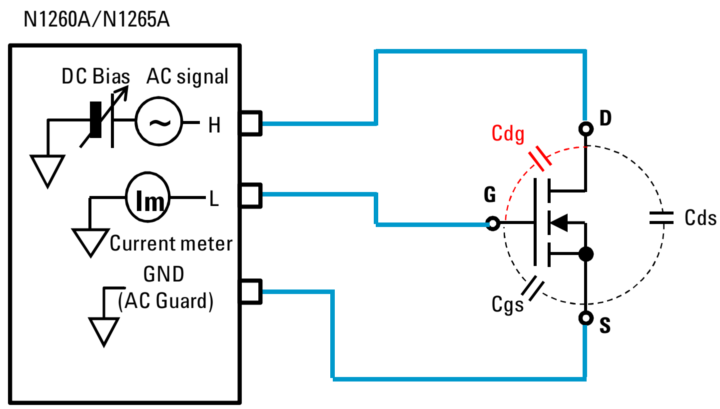


The picture shows the Cds measurement block diagram.

Only the AC measurement signal passing through Cds component is measured by the Im current meter, and converted to Cds.

The AC current passing through Cdg flows in AC Guard, and it does not affects to the Cds component.

Cdg Measurement



The picture shows the Cdg measurement block diagram.

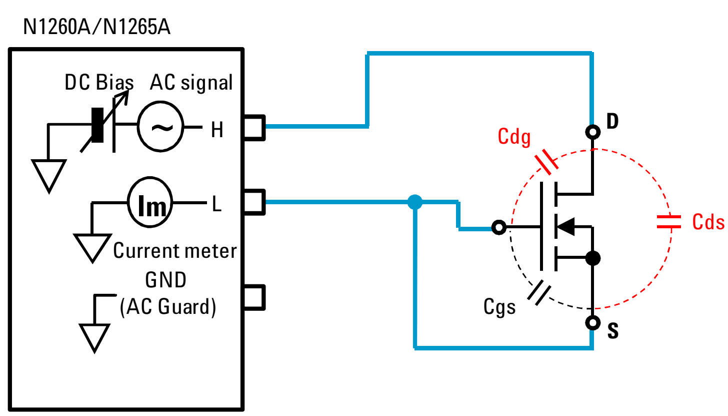
Only the AC measurement signal passing through Cdg component is measured by the Im current meter, and converted to Cdg.

The AC current passing through Cds flows in AC Guard, and it does not affects to the Cdg component.

Also the potential of L input is almost GND level, and the Cgd current branching off to Cgs component can be ignored since the potential between the Cgs is close to zero volts.

Note: Due to the potential increase of the AC Guard impedance at higher frequency, sometimes the measurement signal leaks to Cgs component , and it cannot be ignored. This effect may add errors in Cdg measurement accuracy.

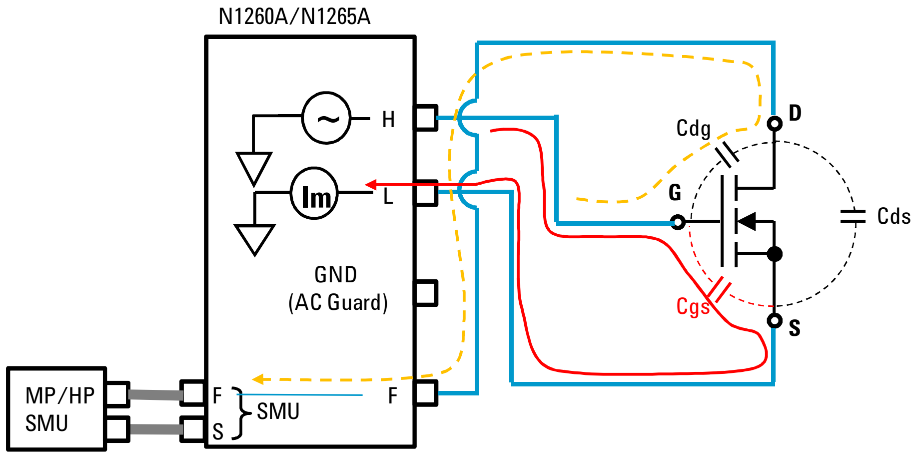
Coss Measurement



The picture shows the Coss measurement block diagram.

Since the Gate and the source is connected together, all the current flowing through Cdg and Cds (equals to Coss) are measured by the Im current meter, and converted to Coss.

Cgs Measurement



The figure shows an example configuration to measure the Cgs capacitive component with a simple measurement setup.

When measuring Cgs, one SMU is used to apply the drain bias parameter and it also provides the AC guard capability.

At 100 kHz or lower frequency, the SMU impedance can be considered very low, and it can be used as an equivalent AC guard.

The AC signal flowing through Cdg flows in to SMU, and only the AC measurement signal passing through the Cgs component is measured by the Im current meter, and converted to Cgs.

Note:
At higher frequency than 100 kHz, the SMU and the cable impedance becomes higher, and cannot be considered as AC guard.
To measure Cgs at 1 MHz, the drain has to be equivalently guarded at that frequency by connecting a large capacitor from the drain to the AC Guard.

7-2. Demo setup

◆ **N1260A High Voltage Bias Tee**

To extend the DC bias voltage to maximum 3 kV, N1260A High Voltage Bias-Tee as shown in figure 7-2 is used.

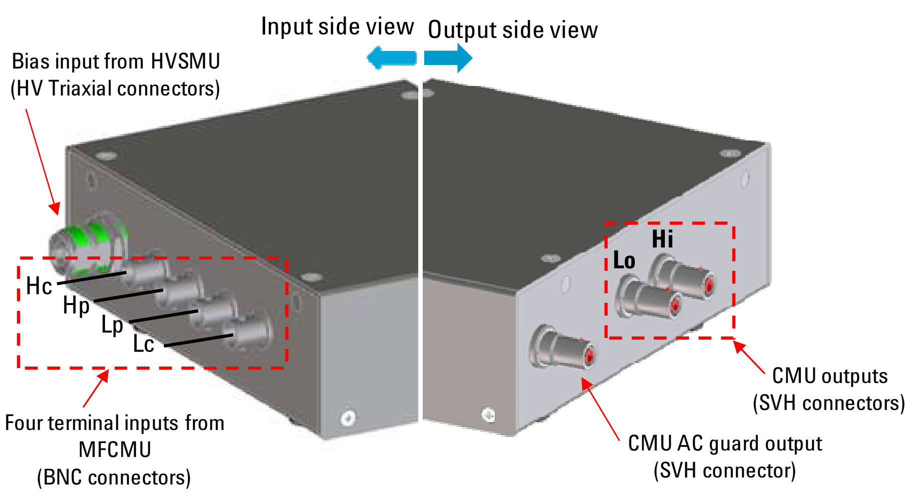
Note that the picture is cut in two parts to show both the input signal terminal and the output signal terminal.

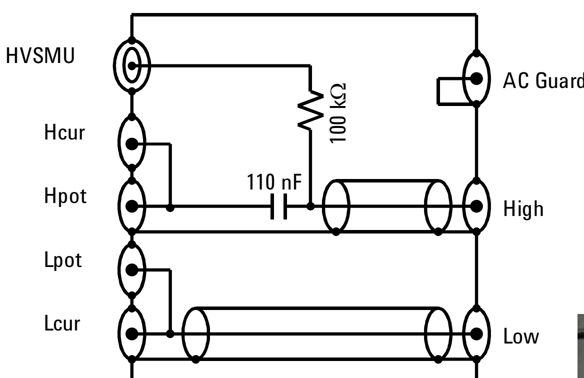
The DC bias is supplied by the HVSMU through a 100 kΩ resister.

The AC measurement signal is provided through 110 nF capacitor to high output terminal. Since 110 nF capacitor is measured as a series connection with the measurement capacitor, this adds about 1 % additional capacitance error if the measured capacitance is about 1 nF.

Note: The additional error can be considered roughly as "Measured capacitance/110 nF x 100 %" when the measured capacitance is smaller than 10 nF.

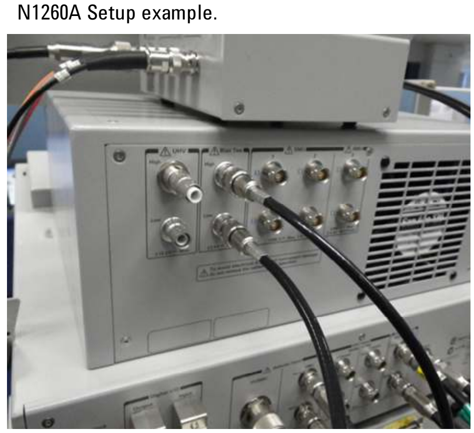
Figure 7-2. N1260A High Voltage Bias Tee.





Right figure shows the images of N1260A configuration with N1265A UHCE/Fixture.

N1260A Setup example.



7-2-1. High Voltage C-V Measurement setup

◆ **Connection overview between the N1265A, the N1260A and the B1505A**

Figure 7-3 shows a HV C-V configuration block diagram of the B1505A.

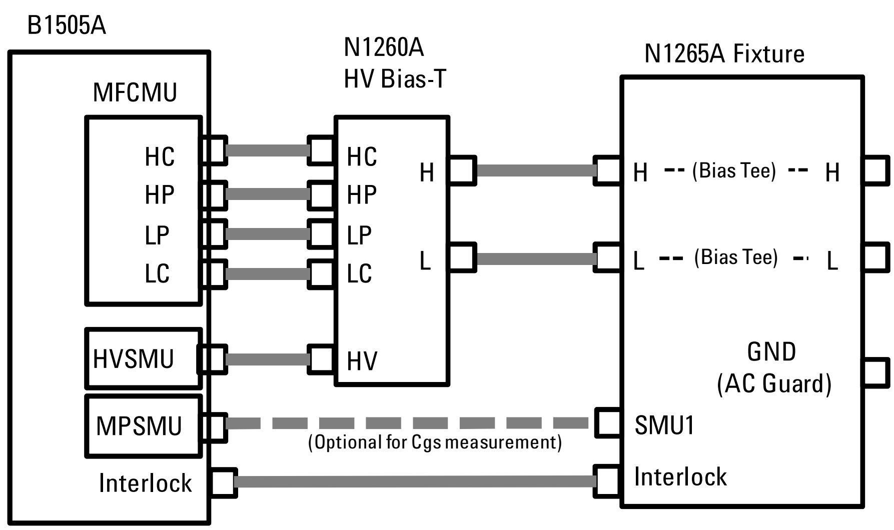
The MFCMU of the B1505A measures the impedance and HVSMU provides the maximum 3 kV DC bias.
These signals are integrated as the C-V measurement signal inside the N1260A HV Bias-Tee, and it is routed to the N1265A`s Fixture section to connect with the DUT.

The connection between the MFCMU and N1260A HV Bias-Tee uses 4 terminal pair configuration.

The connection between the HV Bias-Tee and the N1265A UHCE/Fixture is two terminal pair configuration. The error associated to this cable is reduced by performing the Open and Short calibration after the power on of the B1505A.

The Interlock circuit is provided to protect from the hazardous voltage.

Figure 7-3. B1505A HV C-V measurement block diagram.



◆ **Cable connection of the 3 KV CV measurement configuration**

Figure 7-4 shows the overview of the cable connection for HV C-V measurement configuration.

Cabling instruction:

Follow the next steps and the numbers shown in the figure to route the cables.

Step 1. Using a N1300A CMU cable, connect the connectors block side of the N1300A to B1520A MFCMU.
First, mate all the connectors, and then insert the connector block to the B1502A MFCMU module as shown in the figure.
After fitting the N1300A connecter block, tighten two screw to firmly fit the block to the B1502A MFCMU module.

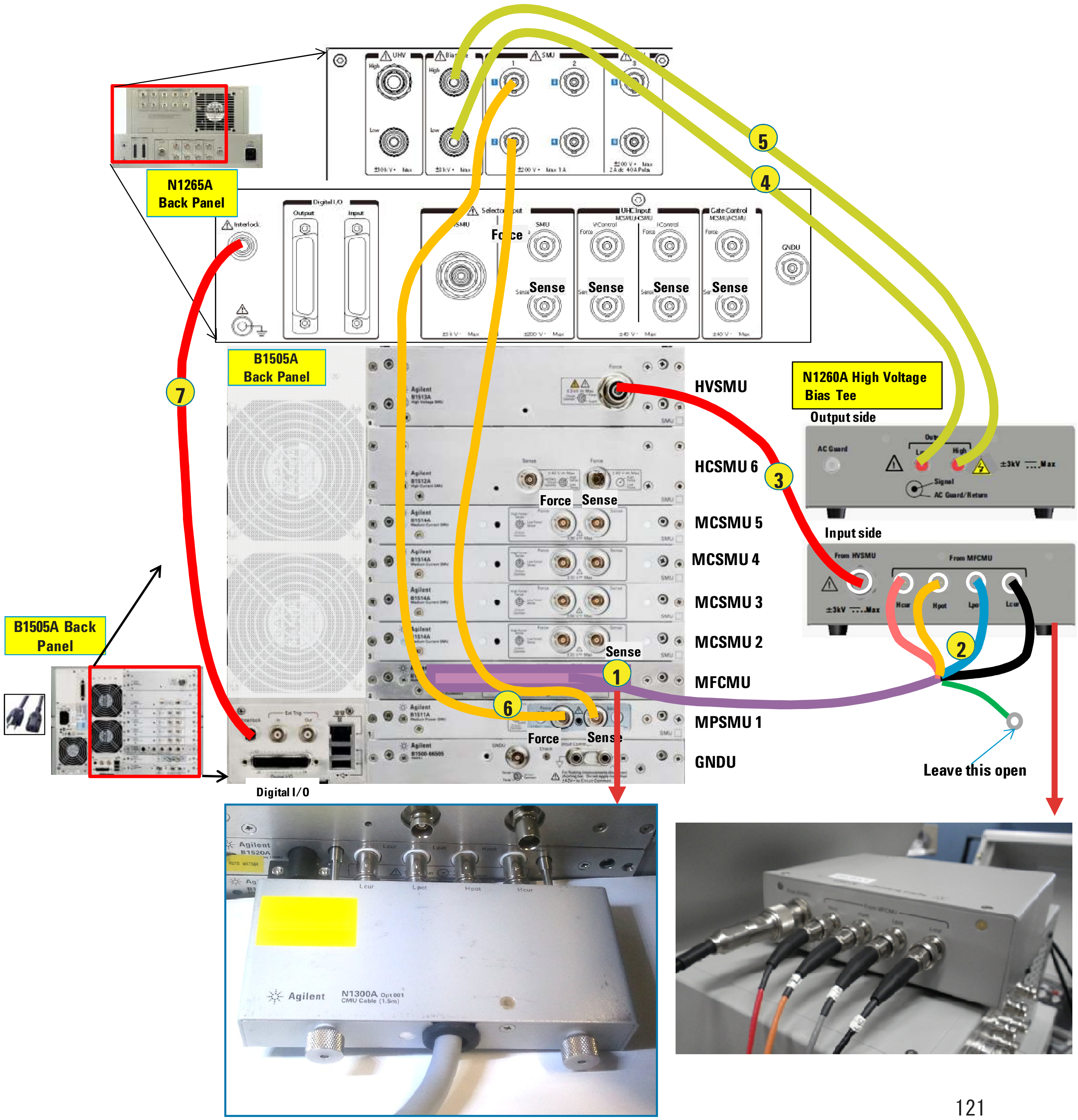
Step 2. Connect the other end of the four connectors of N1300A CMU cable to the N1260A HV Bias-T input as shown in the figure.

- Connect Red wire to Hcur
- Connect Orange wire to Hpot
- Connect Gray wire to Lpot
- Connect Black wire to Lcur connector.

Note: Leave the Green wire open.

Step 3. Using a 16493T HV Triax Cable, connect the Force connector on the B1513A HVSMU to the HVSMU input of the N1260A

Figure 7-4. Cable connection for HV C-V setup.



Step 4. Using 16493V SHV cable, connect Low output of the N1260A to the Low of the Bias Tee input of the N1265A Fixture.

Step 5. Using 16493V SHV cable, connect High output of the N1260A to the High of the Bias Tee input of the N1265A Fixture.

Step 6. *Optional for Cgs measurements:*
Using a 16494A Triax Cable, connect the Force and Sense connectors on the lower B1511A MPSMU (SMU1) to the respective connectors on the SMU input 1 on the N1265A.

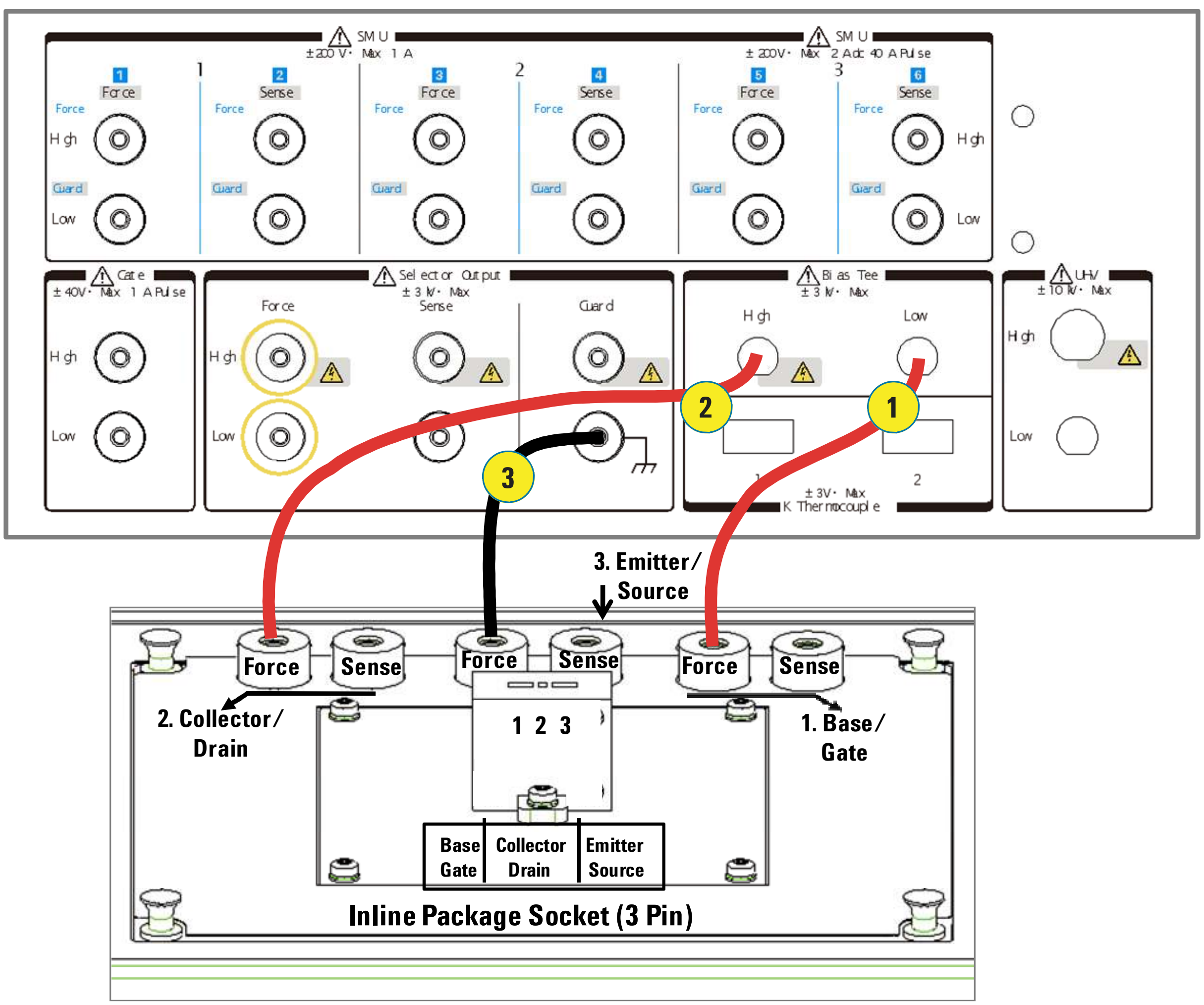
Step 7. Using a 16493J Interlock Cable, connect the Interlock on the B1505A and the Interlock on the N1265A.

7-2-2. Wiring inside of the N1265A Fixture

Figure 7-5 shows the wiring example of inside the N1265A UHC Expander/Fixture for Cgd measurement.

Route the cables/wire between the output terminal panel of the N1265A Test Fixture and the inline package socket module as shown in figure 7-5.

Figure 7-5. Cable connection of the Cgd C-V measurement for N1265A Test Fixture.



◆ **Wiring instruction: (Cgd)**

Follow the next steps and numbers in the figure to setup the wires inside the fixture

Note: Use SHV cables for Bias Tee output that can withstand the 3 kV output of the HV C-V.
Use the thinner wire for other connections.

Step 1. Using the SHV cable, connect the Low of the Bias tee Output to the terminal 1 Force
(Base/Gate) on the Inline Package Socket.

Step 2. Using the SHV cable, connect the High of the Bias Tee Output to the terminal 2 Force
(Collector/Drain) on the Inline Package Socket.

Step 3. Using the universal wire, connect the GND/(AC Guard) Output of the N1265A Fixture to the terminal 3 (Emitter/Source) on the Inline Package Socket.

SHV cable and SHV-Banana Adaptor

Universal Force/Sense line wire

7-2-3. MFCMU Open-Short compensation

◆ **To perform MFCMU calibration for "Open" compensation.**

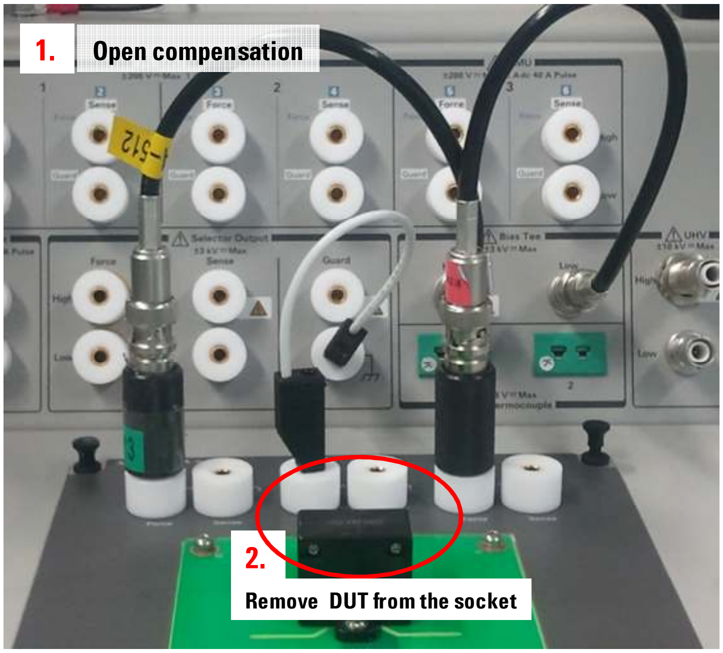
Follow the next steps to calibrate the open compensation.

Step 1. Setup the wiring of the test fixture.

Step 2. Open the test fixture by removing any DUT from the socket.

Step 3. Perform open calibration.

Figure 7-6. Setup for Open compensation.



◆ **To start CMU "Open" calibration:**

Follow the next steps by following the numbers in figure 7-7.

Step 1. Click Calibration ICON.
Calibration window opens.

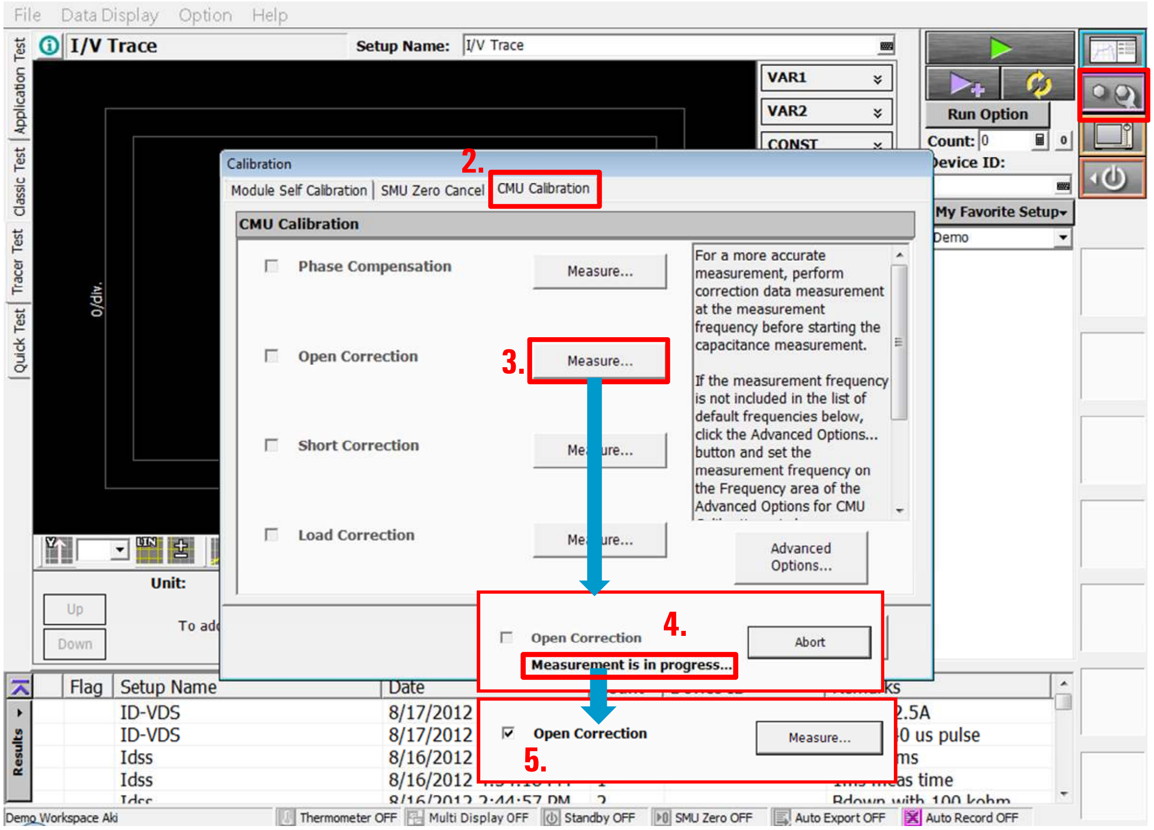
Step 2. Click CMU Calibration tabs.

Step 3. Make sure to "Open" the DUT terminal.
Then click "Measure ..." button of "Open Correction"

Step 4. Open correction starts.
While in calibration "Measurement is in progress ..." is displayed.

Step 5. A Check mark appears in the check box of "Open Correction" at when the correction is completed.

Figure 7-7. Open calibration-compensation.



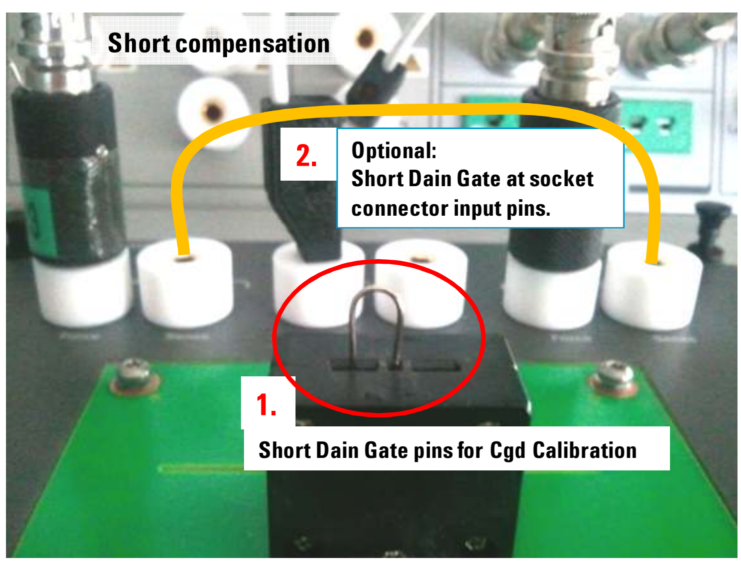
◆ **To perform MFCMU calibration for "Short" compensation.**

Follow the next steps by following the numbers in figure 7-8..

Step 1. Short between the pins of the test fixture socket using a short wire as shown in the figure.
If you cannot find a proper wire, then use the method of next step.

Step 2. (Optional in case step 1 is skipped.)
Short between the input terminals of the socket module by using a short cable as shown in the figure.
For Cgd short calibration, short between the sense input terminals of the Drain and the Gate.

Figure 7-8. Setup for Short compensation.



◆ **To start CMU "Short" calibration:**

Follow the next steps by following the numbers in figure XX.

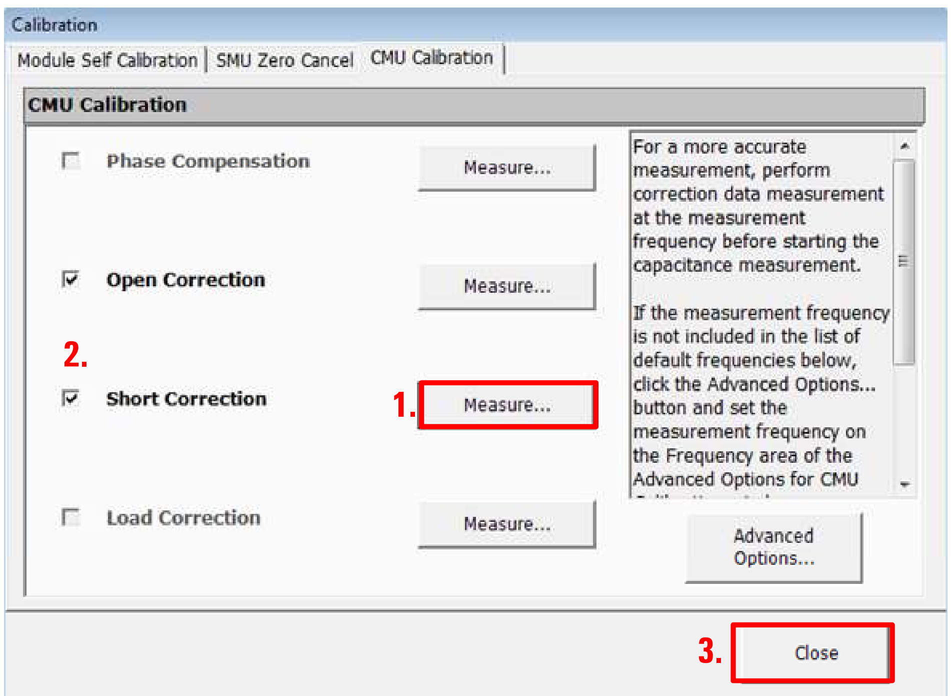
Step 1. Make sure to "Short" the DUT terminal.
Then click "Measure ..." button of "Short Correction"
Open correction starts.

Step 2. After "Measurement is in progress ..." is displayed for a while,
a check mark appears in the check box of "Open Correction" at when the correction is completed.

Step 3. Click Close button to finish the CMU Open-Short calibration.

Step 4. Remove the short wire from the socket module.
Set IXTH1N250 HV MOSFET to the 3 terminal inline socket.

Figure 7-9. Short calibration-compensation.



IXTH1N250
HV MOS

Demo 5-1. Low voltage Cdg measurement (40 V)

1. **To setup the C-V sweep measurement (Classic test):**

   Follow the next steps by following the numbers of Figure 7-10.

   Step 1. Click Classic Test tabs.

   Step 2. Click C-V Sweep icon.

   Step 3. C-V sweep setup, Channel Setup page opens.

   Step 4. Click Add SMU.
   New Unit field opens.

   Step 5. Click Unit field.
   Available modules are listed in the pull down menu.

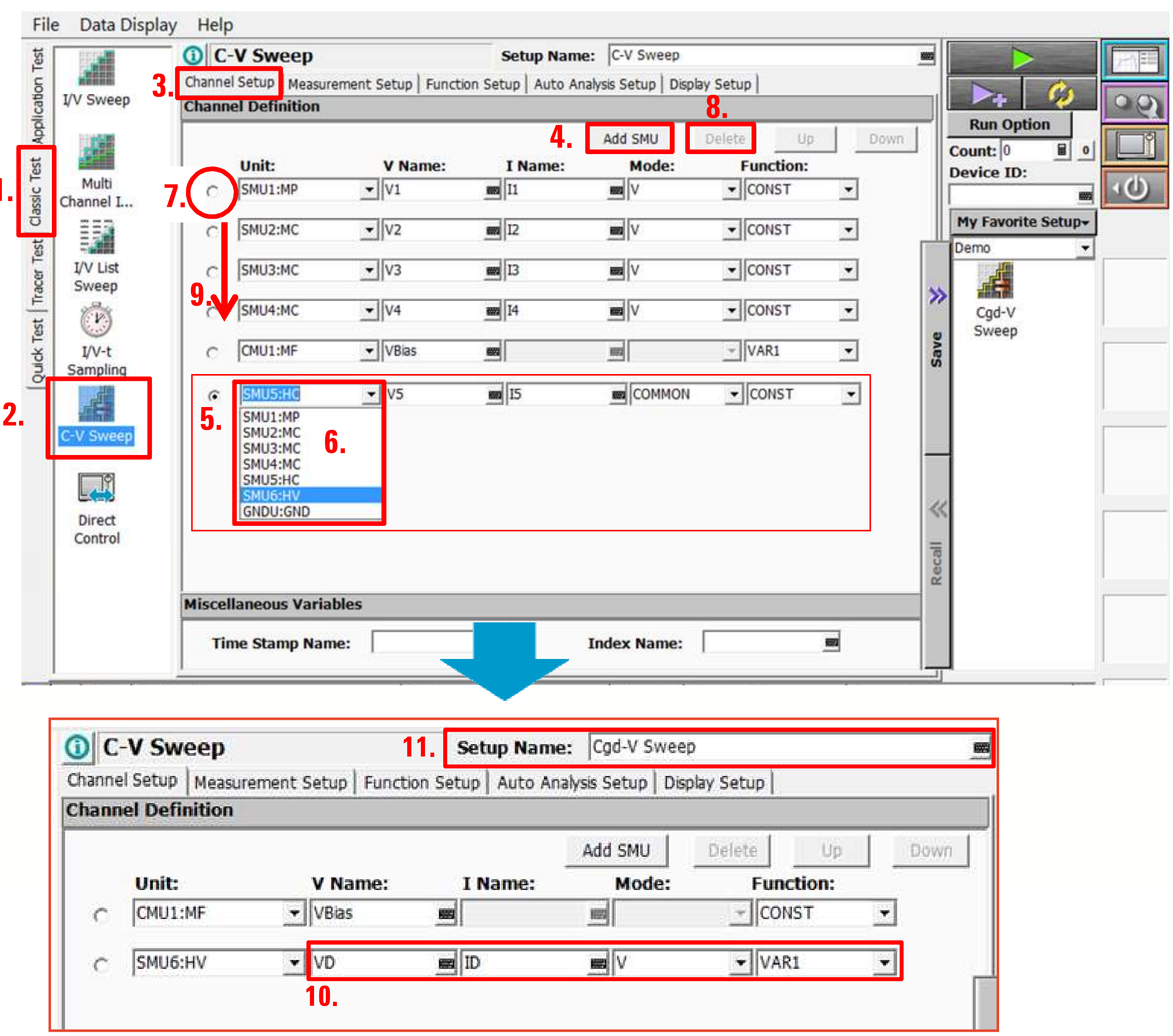
   Step 6. Click SMU6: HV to setup HVSMU as a DC sweep source.

   Step 7. Click SMU1:MP check radio button.

   Step 8. Click Delete button.
   SMU1:MP field is deleted.

   Step 9. Repeat steps 7 and 8, by leaving two lines for CMU1:MF and SMU6:HV.

Figure 7-10. Cdg Classic test setup - Channel Setup tabs.



Step 10. Change the SMU6:HV parameters as follows:

- VBias: VD
- I Name: ID
- Mode: V
- Function: VAR1

Step 11. Change Setup name to "Cgd-V Sweep"

2. To setup the measurement parameters.

Follow the next steps by following the numbers of Figure 7-11.

Step 1. Click Measurement Setup tabs.

Step 2. Change the Start, Stop, Step and Compliance parameters as shown in the figure.

- Start: 0 V
- Stop: 40 V
- Step: 200 mV
- Compliance: 8 mA

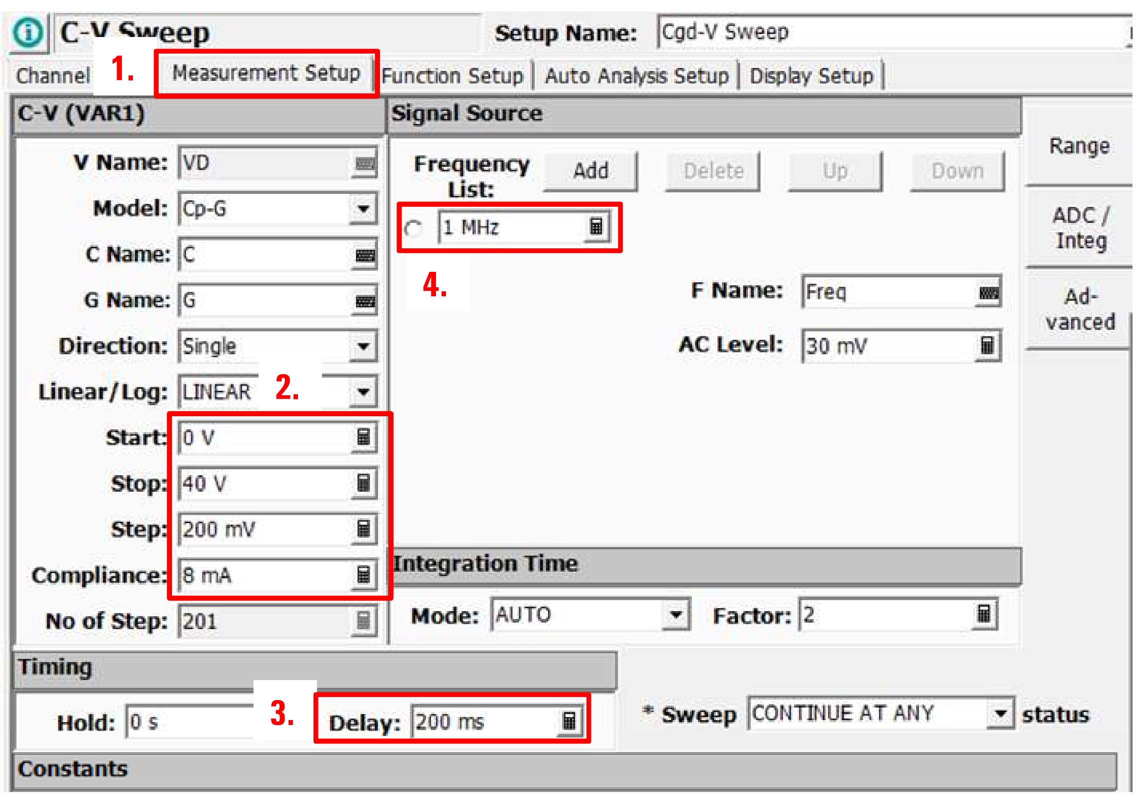
Step 3. Set Delay time:

- Delay: 200 ms

Step 4. Set Frequency;

- List: 1 MHz

Figure 7-11. Cdg Classic test setup - Channel Setup tabs.



3. To setup the display parameters.

Follow the next steps by following the numbers of Figure 7-12.

Step 1. Click Display Setup tabs.

Step 2. Set X and Y1 X-Y Graph parameters as shown in the figure.

Step 3. Set List Display parameters as shown in the figure.

Step 4. Make sure the HV MOSFET is set in the test module socket.
Click Single Measure button.
The Cgd sweep measurement starts, and Display window pops up.

Step 5. Figure 7-13 shows an example Cgd sweep measurement curve of IXTH1N250 HV MOSFET.

Figure 7-12. Cdg Classic test setup - Display Setup tabs.

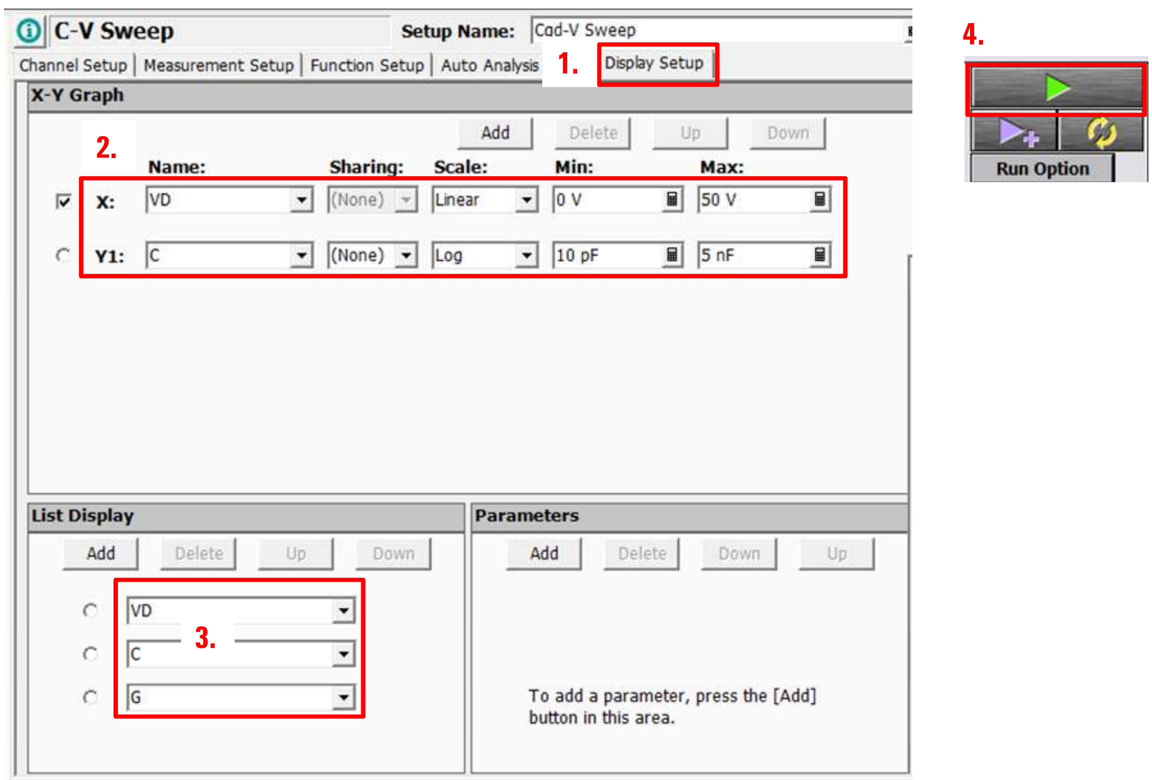
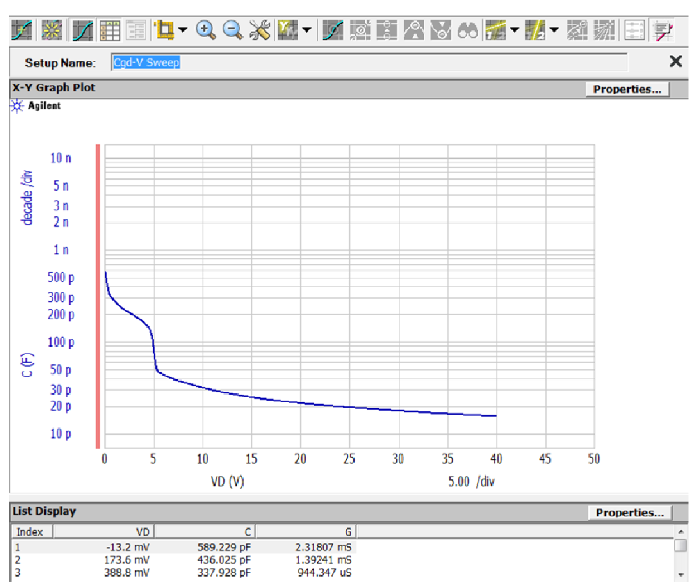


Figure 7-13. Cdg measurement example.



Demo 5-2. High voltage Cdg measurement (1500 V)

◆ **To measure 1500 V Cgd characteristics:**

Follow the next steps to measure the high voltage CV characteristics by following the numbers in figure 7-14.

Step 1. Click Measurement Setup tabs.

Step 2. Change VAR1 parameters as follows;

- Linier/Log: LOG10
- Start: 100 mV
- Stop: 1.5 kV

Step 3. Change Timing parameters as follow;

- Delay: 500 ms

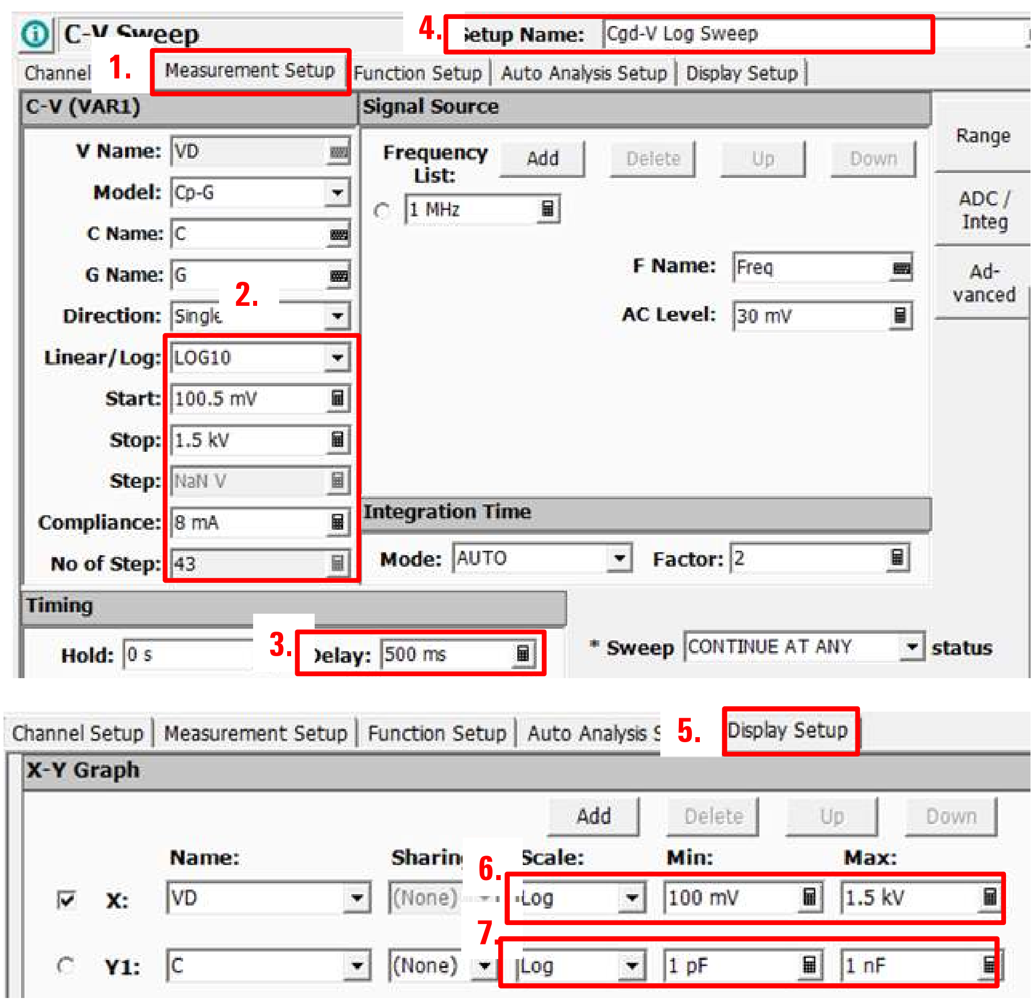
Step 4. Change Setup Name as Cgd-V Log sweep

Step 5. Click Display Setup tabs.

Step 6. Change X parameters as follows;

- Scale: Log
- Min: 100 mV
- Max: 1.5 kV

Figure 7-14. Modification for 1500V Cdg Classic test setup - Measurement Setup tabs.



Step 7. Change Y1 parameters as follows;
- Scale: Log
- Min: 1 pF
- Max: 1 nF

Step 8. Click Single Measure button

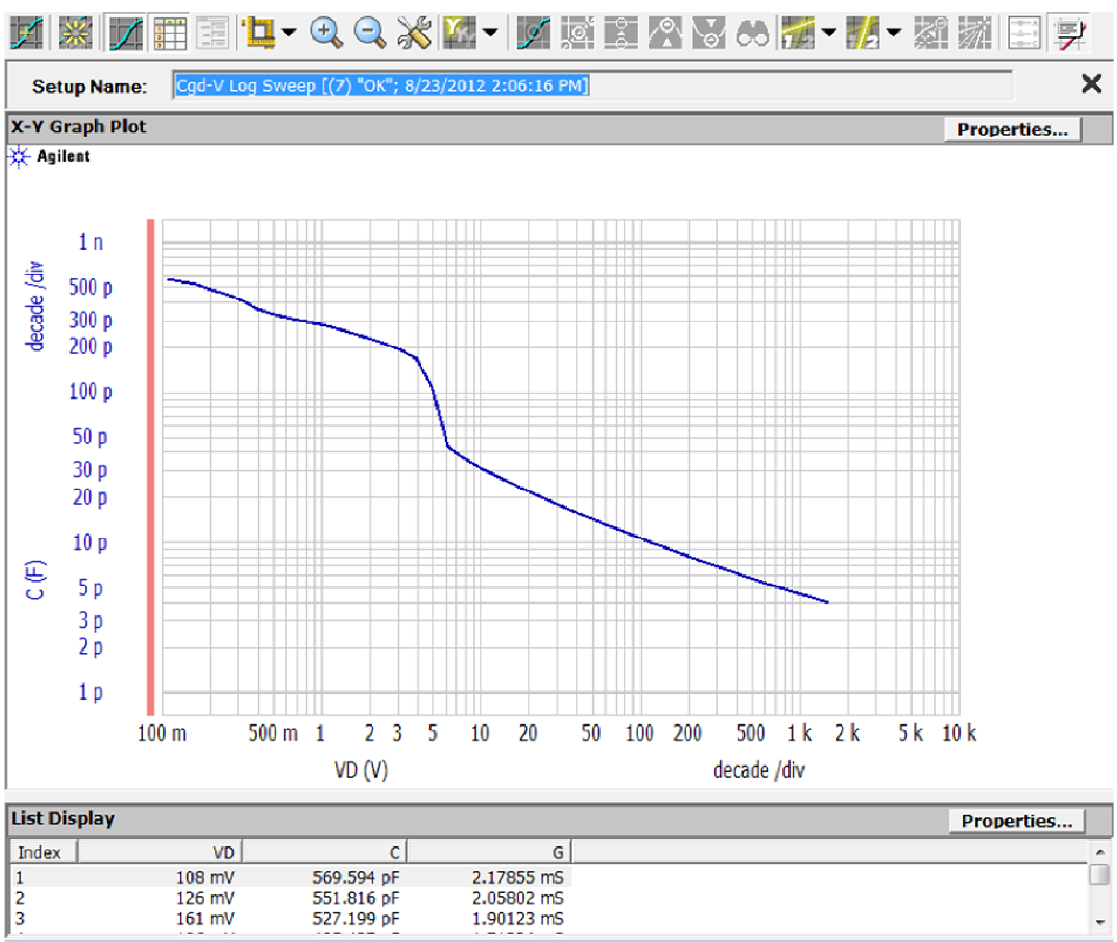
1.5 kV log sweep measurement starts.

Figure 7-15 shows an example 1.5 kV Cgd log sweep curve of the IXTH1N250 HV MOSFET.

Review:

- The CV measurement can be easily performed for both from low voltage to high voltage.
- The maximum voltage can be going up to 3 kV.
- Higher capacitance, say over 2 nF, can measure in better accuracy by connecting the 4 terminal pair cables direct to the N1265A fixture by passing through the N1260A HV Bias Tee.
  Though, the maximum bias voltage is limited to 25 V in this case,.

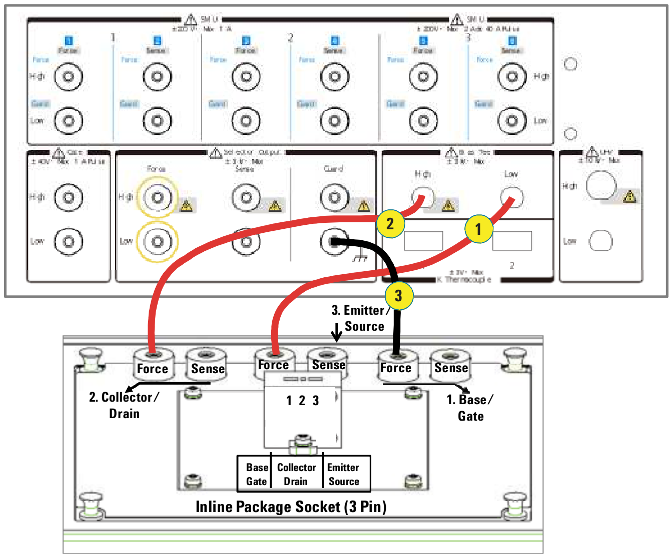
Figure 7-15. 1500 V Cdg log sweep measurement example.



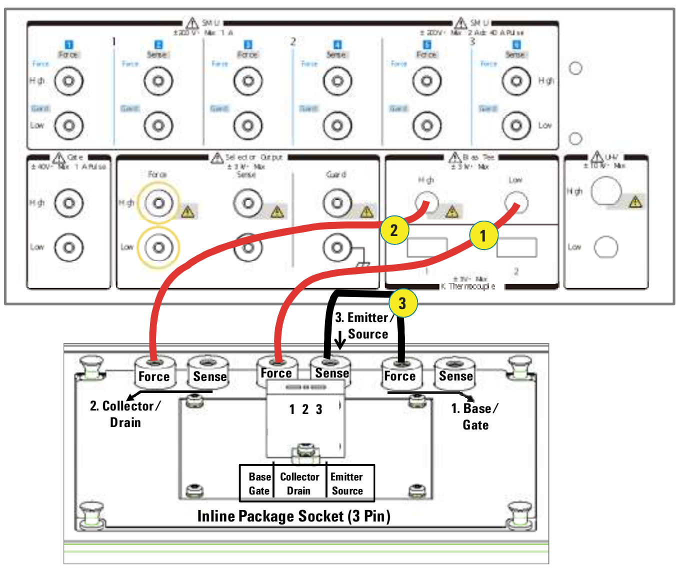
Demo 5-3. Test fixture connection for Cds, Coss and Cgs measurements

This section provides the test fixture connection for other CV parameter measurement.

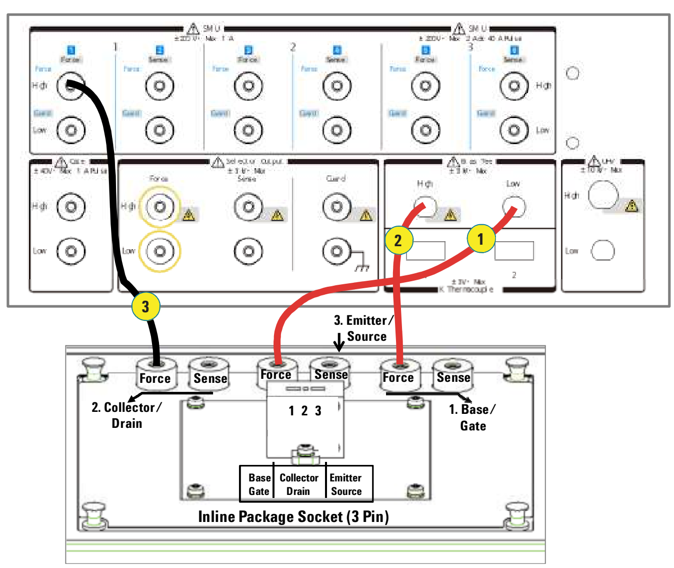
Cds Measurement:



Coss Measurement:



Cgs Measurement:



Note:

1. *The Cgs measurement requires to connect SMU1: MP to the SMU 1 Force input of the N1265A Fixture.*
   - Set SMU 1 as VAR1.
   - Set HVSMU as Const=0 V.
2. *The maximum measurement frequency is limited to 100 kHz.*
3. *Use the maximum fixed current range of MPSMU.*

Summary of Demo 5

In the demo 5, following topics are covered:

- How to configure the high voltage C-V setup.
- How to perform the Open-Short error compensation/calibration.
- The maximum voltage of B1505A C-V measurement is 3 kV with the N1260A High Voltage Bias Tee .
  - We made the demo at 1.5 kV.
  - IXTH1N250 MOSFET can apply voltage to maximum 2.5 kV.
- The reasonable maximum capacitance measured using the N1260A HV Bias Tee is about 2 nF if about 2% additional error is allowed.

  Note: Standalone use of MFCMU provides better accuracy for much higher capacitance measurements.
  But, the direct connection of MFCMU`s maximum DC bias voltage is limited to 25 V.

Chapter 8. Demonstration 6: 10 kV Measurement using UHVU

Contents:

Objective:

The objective of this chapter is the followings:

- To be able to perform the ultra high voltage measurement using the N1268A Ultra High Voltage Expander of the B1505A.
- We use two serial connected high voltage diode and experience a breakdown measurement at about 8 kV.

Features:

- 10 kV maximum DC output for high voltage device testing.
- Provides complete solution from 1500 A to 10 kV test for such device as IGBT

Device used:

Demo 6 uses the following device;

- GP02-40 high voltage junction rectifier

Major Ratings and Characteristics	
$I_{F(AV)}$	0.25 A
V_{RRM}	4000 V
I_{FSM}	15 A (60 Hz half sine-wave)
I_R	5.0 μA
V_F	30 V
T_j max.	175 °C

8-1. Demo setup

8-1-1. UHVU Configuration: Cable connection

◆ **Connection overview between the N1265A, the N1268A and the B1505A**

Figure 8-1 shows the Ultra High Voltage Expander configuration block diagram of the B1505A.

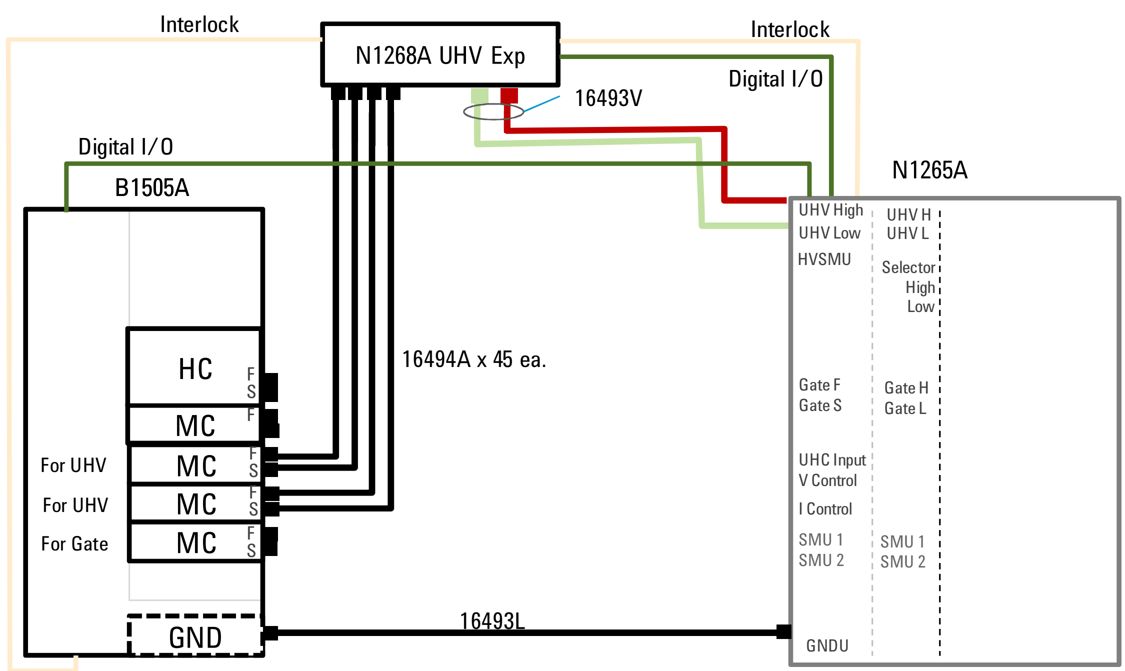
Two MCSMUs are used to control the N1268A Ultra High Voltage Expander.

The UHVU output is connected to the UHVU input of the N1265A Fixture.

The digital I/O control is connected in serial by routing the N1265A and to the N1268A.

The interlock circuit is routed the same way to control the output by both the UHVU and the test fixture.

Figure 8-1. B1505A UHVU measurement block diagram.



◆ **UHVU cable configuration**

Figure 8-2 illustrates the cable connection from the B1505A through the N1268A UHVU Expander to the N1265A test fixture.

Cabling instruction:

Follow the next steps and the numbers shown in the figure to route the cables.

Step 1. Using a 16494A Triax Cable, connect the Force and Sense connectors on the 3rd SMU from the bottom (MCSMU3) to the corresponding “Vset/Vm SMU” connectors of the UHV input of the N1268A.

Step 2: Using a 16494A Triax Cable, connect the Force and Sense connectors on the 4th SMU from the bottom (MCSMU4) to the corresponding “Irtn SMU” connectors of the UHV output of the N1268A.

UHV cable: High side

SHV cable: Low side

Step 3. Using 16493V UHV cable, connect the HV Output of the N1268A to the UHV High connector of the N1265A Fixture.

Step 4. Using 16493V SHV cable, connect the HV Return Input of the N1268A to the UHV Low connector the N1265A Fixture.

Step 5. Using a 16493G Digital I/O Cable, connect the Digital I/O connector on the B1505A to the Digital I/O Input connector on the N1265A UHCE/ Fixture.

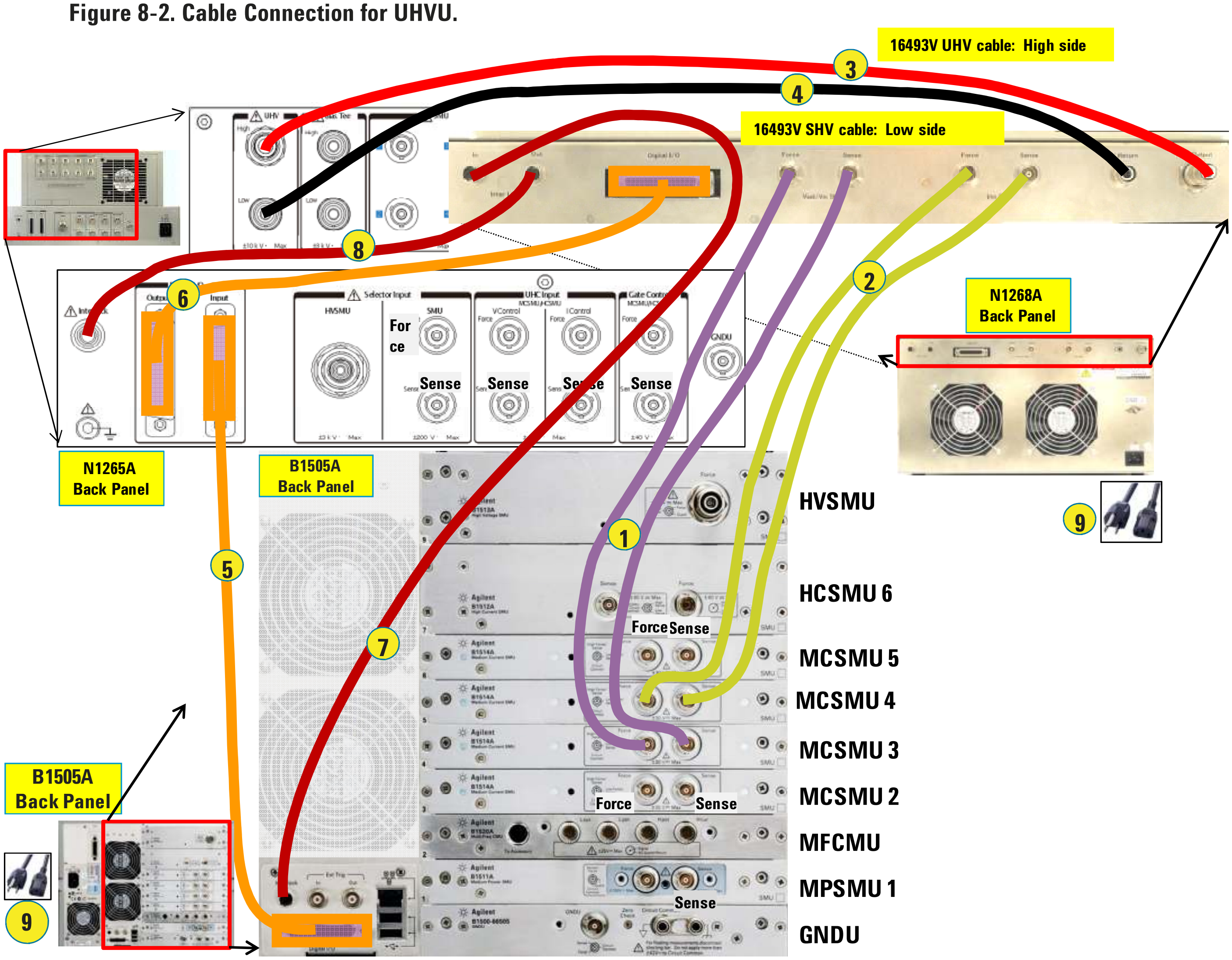
Step 6. Using a 16493G Digital I/O Cable, connect the Digital I/O Output connector on the N1265A to the Digital I/O connector on the N1268A.

Step 7. Using a 16493J Interlock Cable, connect the Interlock on the B1505A and the Interlock In on the N1268A.

Step 8. Using a 16493J Interlock Cable, connect the Interlock Out on the N1268A and the Interlock on the N1265A.

Step 9. Connect power cable to the B1505A, N1265A and N1268A.

Figure 8-2. Cable Connection for UHVU.



8-1-2. UHVU Configuration: Test Fixture

◆ **Preparation of the Test Fixture**

Follow the next steps by referring to the numbers in figure 8-3.

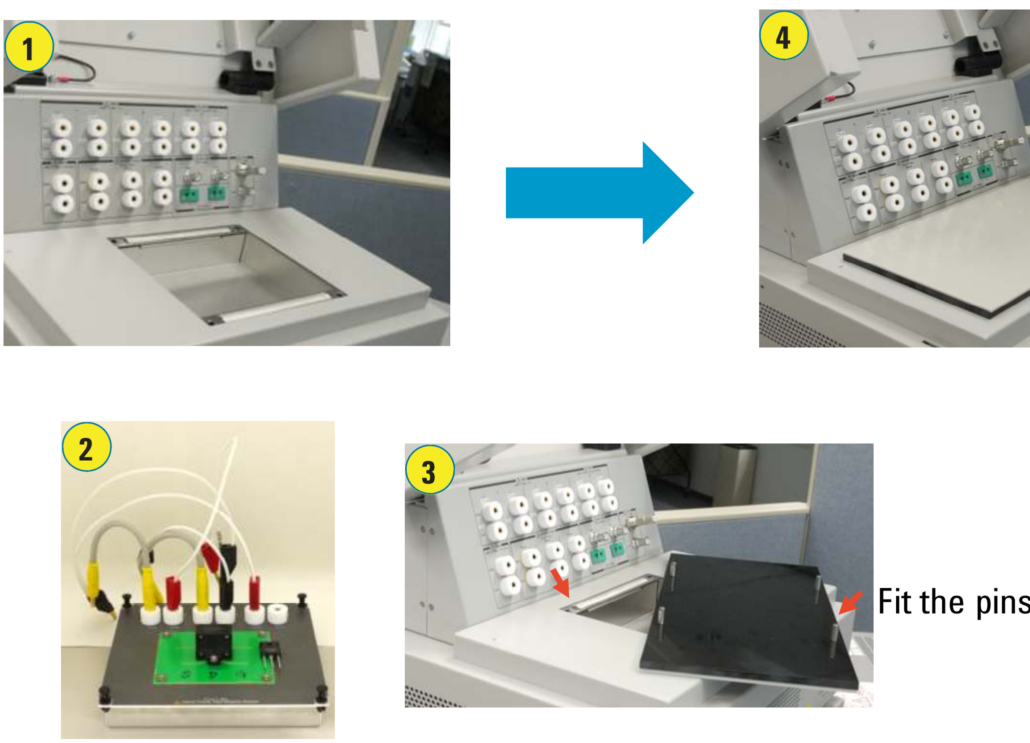
Step 1. Remove the test fixture socket module that is shown in #2.
Unplug the cables only from the Test fixture side.

Step 2. You can keep the cables as shown in the socket module.
By leaving the cables as it is, you can re-configure the socket easier.

Step 3. Insulation plate shown in back side in the figure has to set on the fixture for UHVU application.
When set the insulation plate on the test fixture, meet the four pins of the insulation plate to the holes of the test fixture side.

Step 4. The figure shows the picture after the insulation plate is set on the N1265A Test Fixture.

Figure 8-3. N1265A Fixture setup for UHVU.



8-1-3. De-select or un-activate the UHC and HVMCU configuration

We first deselect or inactivate the UHC and HVMCU to free the MCSMUs.

Step 1. You can scroll the Configuration menu tabs by clicking the right-left direction arrows.
Use this button and find the necessary configuration tab if it is hidden from the window.

Step 2. Click UHC Expander/Fixture tab.

Step 3. Un-check the "Enable Ultra High Current Unit" check box.

Step 4. Un-check the "Enable Selector" check box.

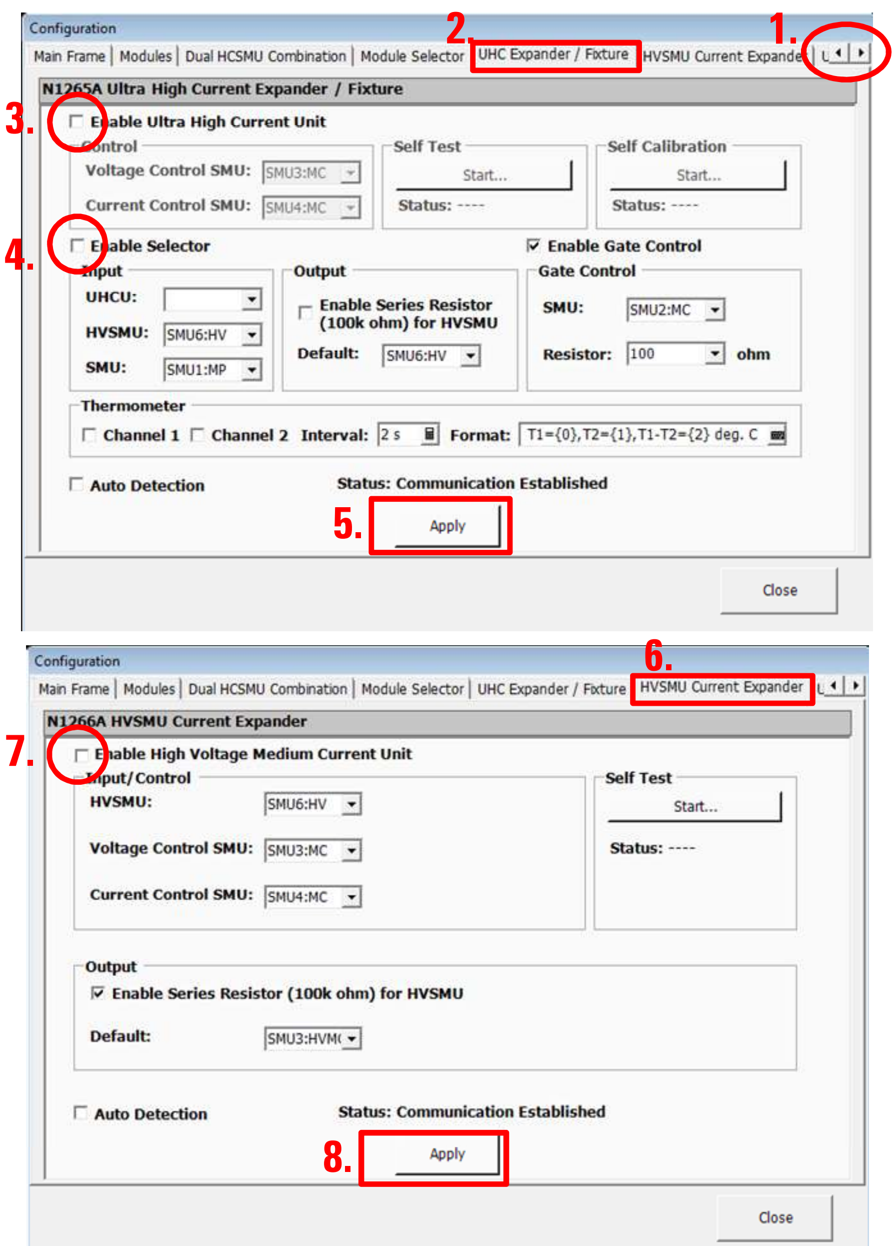
Step 5. Click "Apply".

Step 6. Click "HVSMU Current expander" tab.

Step 7. Un-check the "Enable High Voltage medium Current Unit" check box.

Step 8. Click "Apply".

Figure 8-4.
EasyEXPERT Configuration.



◆ UHVU Configuration

Follow the next steps and the numbers in figure 8-5 to configure EasyEXPERT for UHVU.

Step 1. You can scroll the Configuration menu tabs by clicking the right-left direction arrows.
Use this button and find the necessary configuration tab if it is hidden from the window.

Step 2. Click UHV Expander tab.

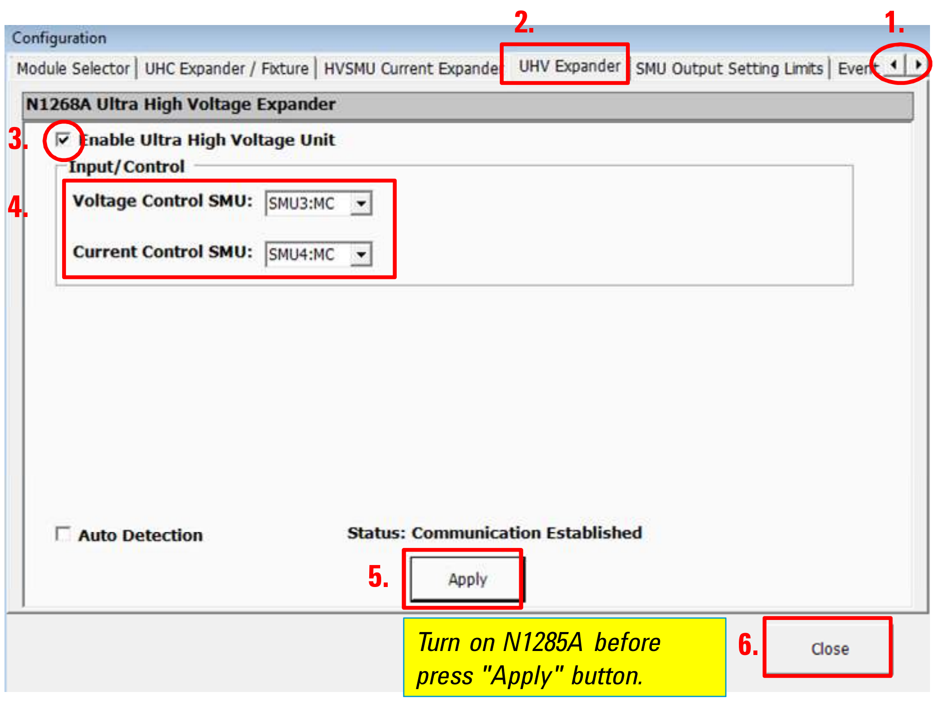
Step 3. Check the "Enable Ultra High Voltage Unit" check box.

Step 4. Set the Voltage and Current Control SMUs as shown in the figure.

Step 5. Click "Apply".
Please remember to turn on the N1268A before this action.

Step 6. Click Close button.

Figure 8-5.
EasyEXPERT Configuration for UHVU.



Demo 6. High Voltage Diode Breakdown Test

◆ **UHV cable set and demo Diode Setup in the fixture:**

Route the wire between the output terminal panels of the N1265A Test Fixture and clip the test diode as shown in figure 8-6.

Follow the next steps and the number shown in the figure.

Step 1. Set the SHV cable with an alligator clip to the Low output connector of UHV of the N1265A Fixture.

Step 2. Set the UHV cable with an alligator clip to the High output connector of UHV of the N1265A Fixture.

Step 3. Connect the Serial connected diode as shown in the figure in a direction that the Cathode side (with a white belt on one end) to High side alligator clip and the other end to Low side alligator clip.

Note: To serially connect the diode, twist the diode leads as the diode`s current direction become the same.
The reason to make serial connection of the diode is to make the breakdown voltage about twice to show the UHVU capability at very close to the 10 kV maximum output.

Step 4. Close the N1265A fixture cover.
Make sure that any metal portion of the High and Low terminal of the diode side does not touch to the cover of the N1265A fixture as shown in figure 8-7.

Figure 8-6. UHV Diode setup inside the fixture.

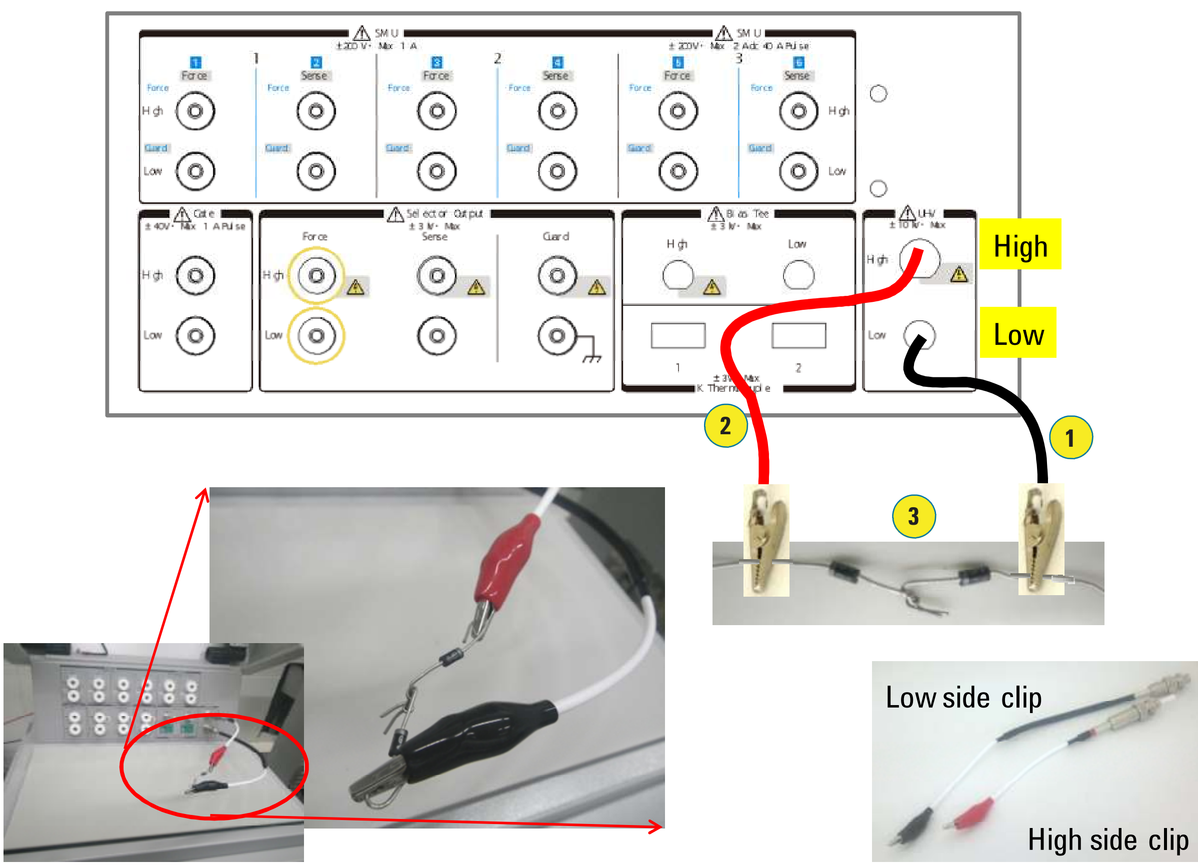
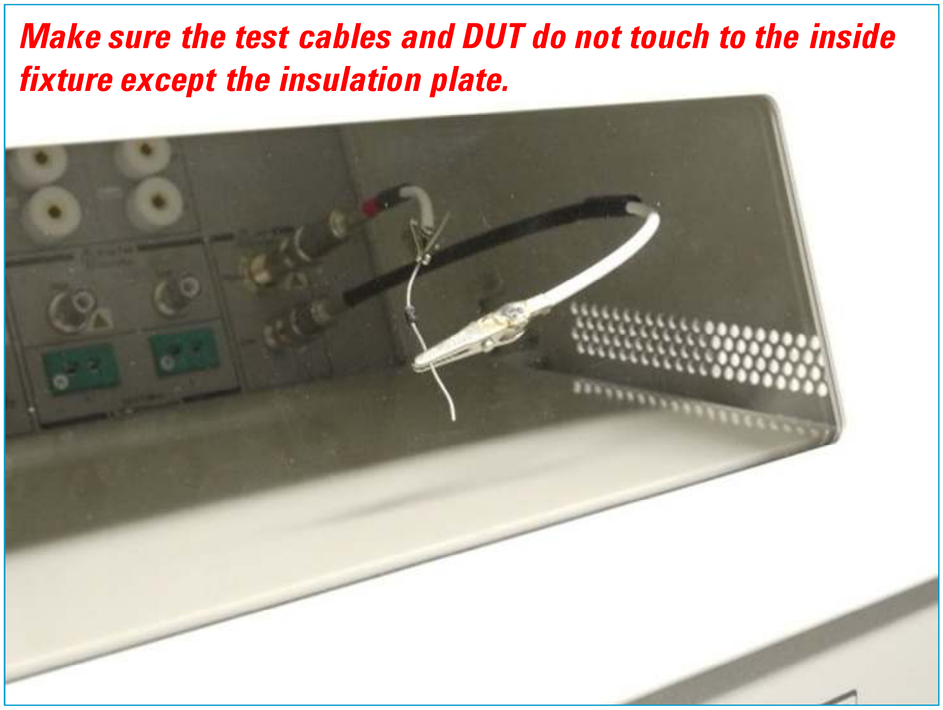


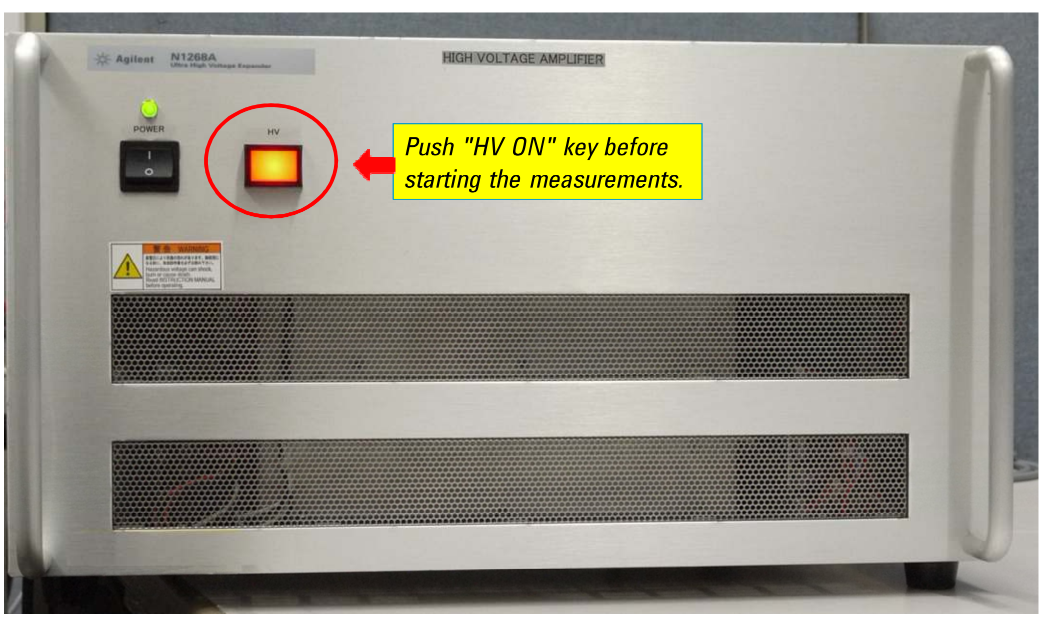
Figure 8-7. Diode view when N1265A fixture cover is closed.



◆ **To activate the output of the N1268A High Voltage Amplifier:**

Push "HV" button to activate the output of the N1268A High Voltage Amplifier before starting any measurements as shown in figure 8-8.

Figure 8-8. HV indicator/button is lighted when UHVU is activated.



◆ **To Set Diode Breakdown Tracer test:**

Follow next steps and the numbers in figure 8-9 to setup the diode breakdown Tracer Test.

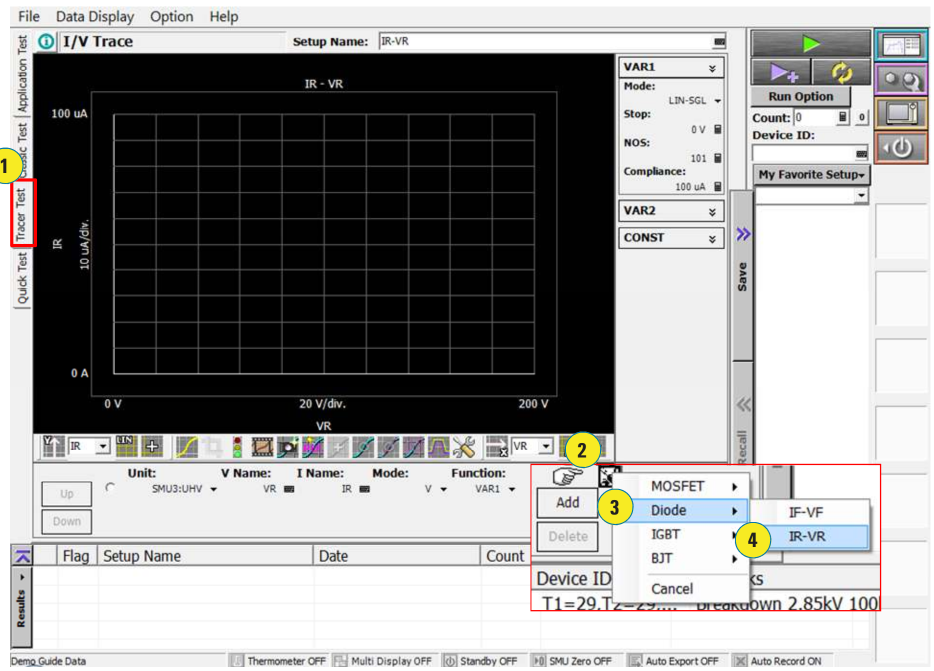
Step 1. Click Tracer Test tab.

Step 2. Click Sample Setups Icon.

Step 3. Press Diode

Step 4. Press IR-VR for measuring breakdown characteristics.

Figure 8-9. IR-VR Diode breakdown sample menu.



◆ **To setup and measure 10 kV Breakdown Test:**

Follow the next steps and numbers shown in figure 8-10.

Step 1. Make sure that UHVU is set in the Unit field.

Step 2. Set stop voltage;

- Say 1V as a start up check of the measurement.

Step 3. Set the parameter as shown in the figure.

- NOS: 101
- Compliance: 100 uA

Step 4. Set the parameter as shown in the figure.

- Meas. Time: 10 us
- Step Time: 500 us

Step 5. Set X axis max. to 10 kV.

Step 6. Set Y axis max. to 100 uA.

Step 7. Y axis Minimum is 0 A.

Optional: Set Y axis min. to -10 uA to show the trace, if the leakage current measurement shows a negative value and the trace does not appears on the display.

Refer to figure 8-11 from step 8.

Step 8. Click the stop condition set icon (Yellow signal turns on).

Step 9. Drag the area where you do want to stop the sweep when the measurement data hit in the area.

Step 10. Press Repeat measurement button.

Step 11. Crick Stop voltage to activate the input

Step 12. Rotate the knob to the right turn direction to increase the sweep maximum voltage.
The sweep width grows to the right direction.

Step 13. The sweep trace is growing to the right direction.

Figure 8-10. UHV 10 kV test parameter setup 1.

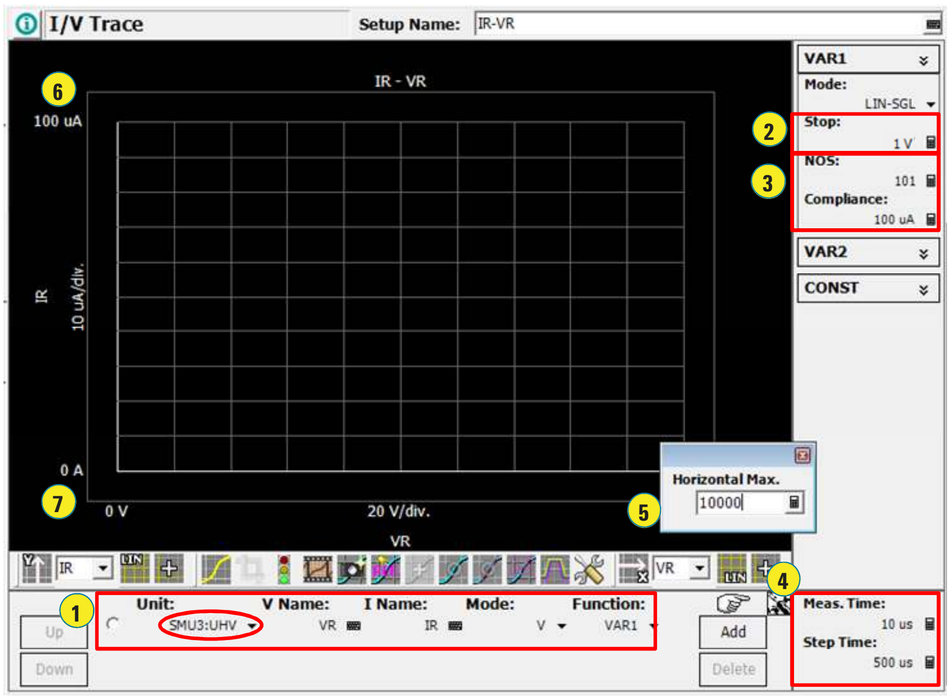
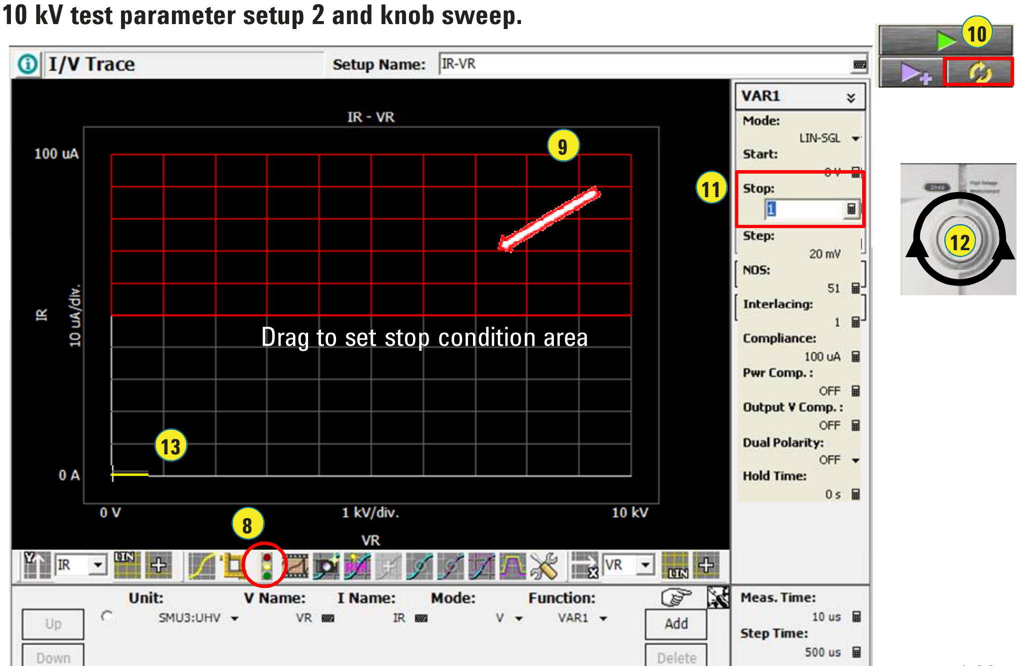


Figure 8-11. UHV 10 kV test parameter setup 2 and knob sweep.



Refer to figure 8-12 from step 14.

Step 14. Finally, the diode breaks down and the sweep stops automatically when the measurement hit the stop condition area.

Step 15. Click Marker icon.
Marker appears on the measurement start point.

Step 16. Move the marker to the breakdown start point.

Step 17. You can read the breakdown voltage and the current of the marker.

Step 18. Click Replay Traces icon.

Step 19. Replay Trace control window opens.

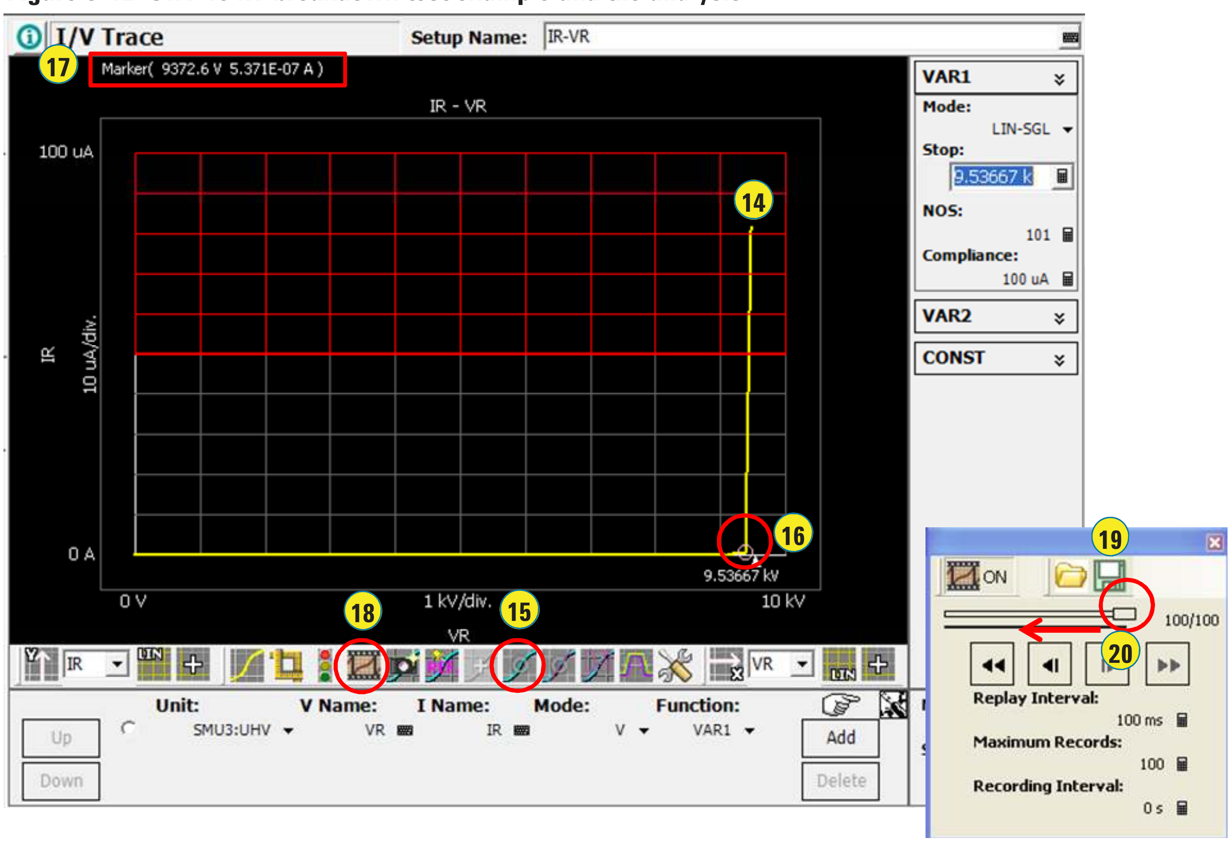
Step 20. Grab and move the bar to the left side will recall the measurement traces until the breakdown occurs.
Replay Traces function is very useful, especially when the device is broken or damaged where you cannot re-create the same test.

Note: You can save the trace and recall it later for offline review.

Review:

- The example shows the breakdown at around 9.4 kV.
  Since the breakdown voltage in the diode specification is minimum 4 kV, 9.4 kV breakdown in the demo example is reasonable with two diodes connected in series.

Figure 8-12. UHV 10 kV breakdown test example and the analysis.



Chapter 9. Demonstration 7: Thermo-trigger function

Contents: **Demo 7. Vth shift measurement using the Thermo-triggering**

Objective: The objective of this chapter is the followings:

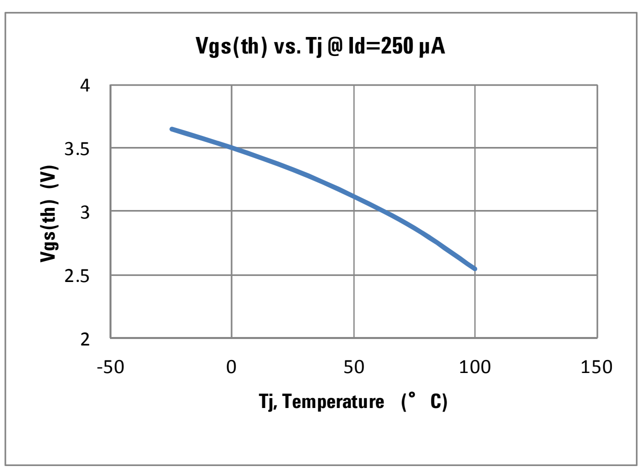
- Learn Thermo-trigger function.
- Experience Vth shift versus case temperature measurement using Thermo-trigger function.

Features:

- Temperature dependent parameters can be easily taken by using the Thermo-trigger function.
- Temperature dependent parameter example:
  - Transfer Characteristics (Vth, Vgs-off)
  - Saturation voltage
  - ON resistance
  - Breakdown voltage
  - Forward voltage drop (Diode)

Device used: IRFP4004 HC MOS

Vth vs. Temperature data extracted from IRFP4004PbF datasheet



Test flow of Vth shift measurement using the Thermo-trigger function:

Thermo-trigger demo measures the Vth drift of the power MOSFET.

The test procedure is shown in figure 9-1.

Follow next steps by referring to the numbers shown in the figure.

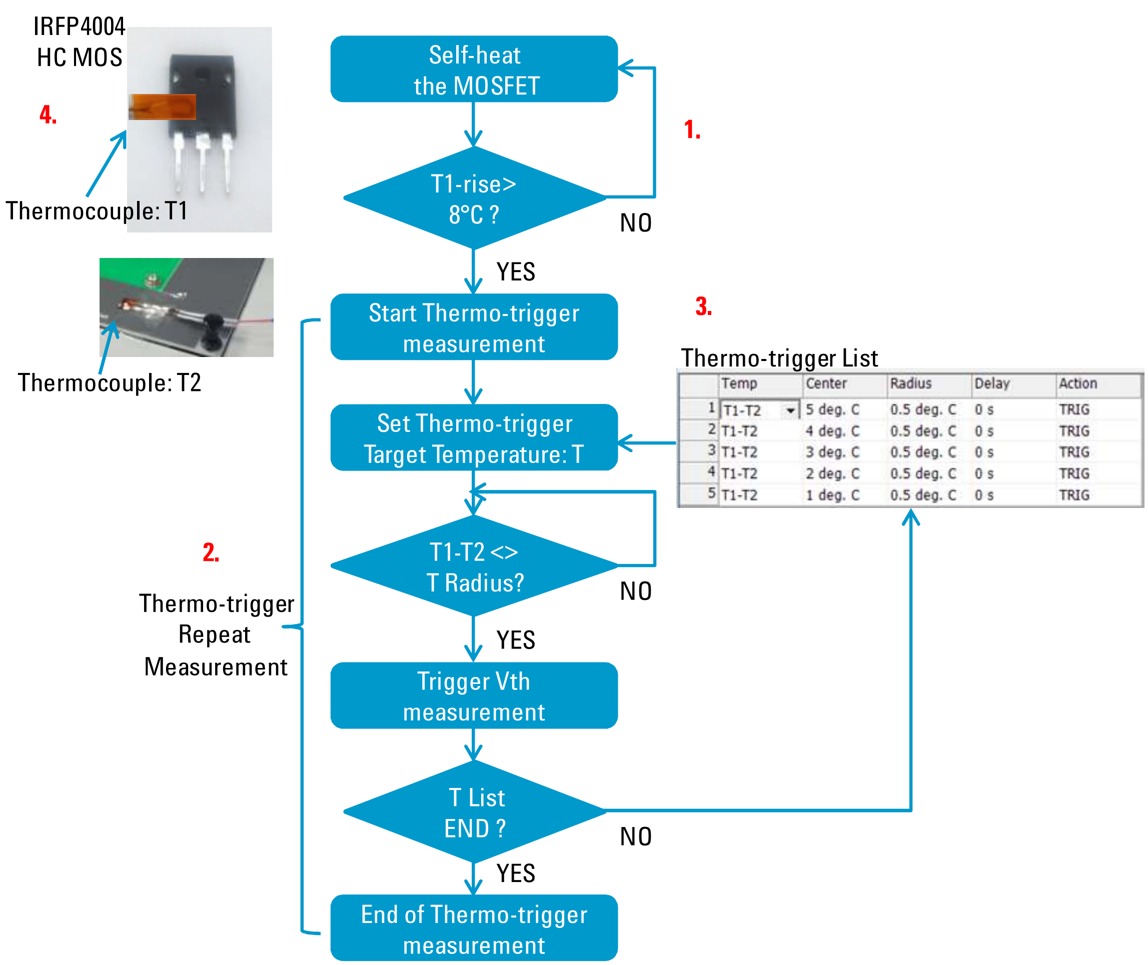
Step 1. First, the MOSFET case/body temperature is heat up by using self heating of the Ig-Vd repeated measurement.

Step 2. After about 8 °C temperature rise, we start Vth measurement by using the thermo-trigger function.

Step 3. Each Vth measurement is triggered by following the pre-defined Thermo-trigger list.

Step 4. In the demo, two thermocouples are used, one to measure the MOSFET body temperature and the other to measure the test fixture temperature as a reference to measure the relative temperature rise of the MOSFET.

Figure 9-1. Test flow of the Vth shift measurement.



	Temp	Center	Radius	Delay	Action
1	T1-T2	5 deg. C	0.5 deg. C	0 s	TRIG
2	T1-T2	4 deg. C	0.5 deg. C	0 s	TRIG
3	T1-T2	3 deg. C	0.5 deg. C	0 s	TRIG
4	T1-T2	2 deg. C	0.5 deg. C	0 s	TRIG
5	T1-T2	1 deg. C	0.5 deg. C	0 s	TRIG

Route the wire between the output terminal panel of the N1265A Test Fixture and the inline package socket module as shown in the figure.

◆ **Wiring instruction:**

The SMU wiring is the same as the Vth measurement in section 3-1.
Refer to section 3-1 to set the wiring inside the test fixture.

To set the thermocouple to the N1265A Fixture:

- Set two thermo couples to the "K. Thermocouple #1 and #2 inputs socket as shown in figure 9-2.
  Note: The detail is shown in next.

Figure 9-2. Thermo-trigger wiring.

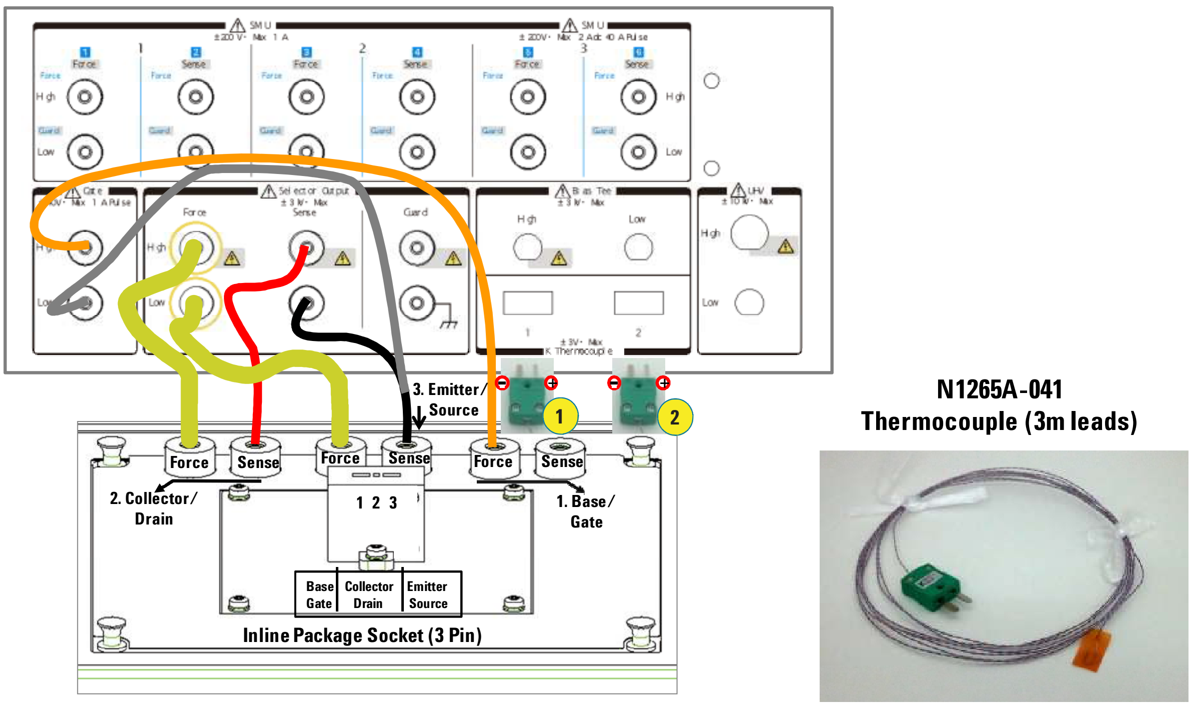
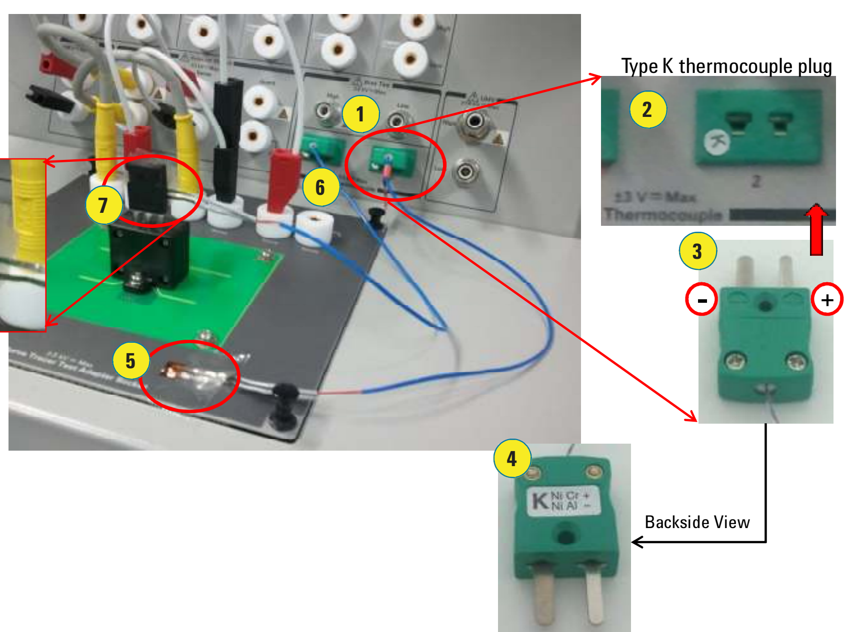


Figure 9-3. Thermocouple setup.



◆ **Thermocouple setup:**

Set the thermocouples by following the next steps and numbers shown in figure 9-3.

Step 1. Set thermocouple K socket to the N1265A #2 thermocouple input socket.

Step 2. The enlarged socket is shown.

Step 3. Insert the thermocouple socket as shown in the figure.
There are thick (- mark) and thin (+ mark) side in the socket, and meet the same type when mating the socket module.

Step 4. The picture shows the enlarged back side of the socket.

Step 5. Put #2 thermocouple to the base of the socket module by using sellotape.

Step 6. Set another thermocouple to #1 socket of the N1265A.

Step 7. Put #1 thermocouple to the back side plate of the MOSFET.

◆ **EasyEXPERT Configuration setup**

Before starting the measurements with UHCU, UHC Expander/Fixture configuration is necessary.

To Configure UHCU:

Follow the next instruction by following the steps shown in figure 9-4.

Step 1. Click Configuration icon.

Step 2. Click "UHC Expander / Fixture" tab.

Step 3. Click and mark the check box of "Enable Ultra High Current Unit".
Note: V/I control SMU should be set already.

Step 4. Click and mark the check box of "Enable Selector".

Step 5. Make sure check mark is set for Enable Gate Control.

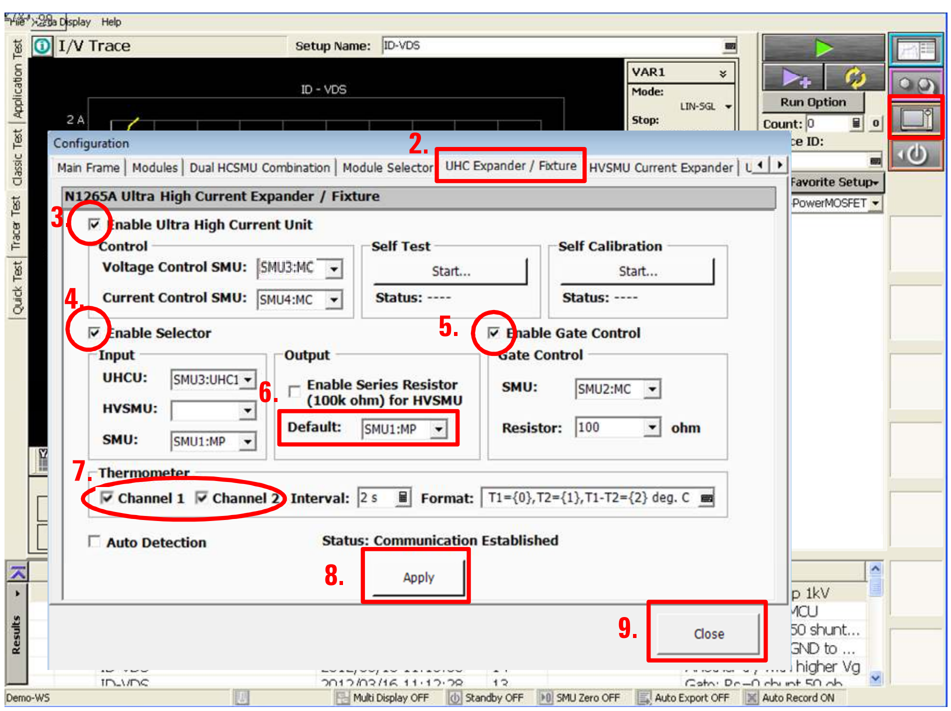
Step 6. Select SMU1:MP for default output.

Step 7. Check both the Channel 1 and 2 of the Thermometer field.

Step 8. Click "Apply" button.
Click "Apply" button renews the active selected module.

Step 9. Click "Close" button to close the Configuration window.

Figure 9-4. EasyEXPERT Configuration: UHC.



◆ **Setup of "Vth Vgs(off)" Application test:**

For measuring the Vth, we use the same setup used in chapter 3 Demo 1 as shown in figure 9-5.

Follow the steps shown in figure 9-5.

Step 1 to 5:

Use the same setup of Demo 1, Vth measurement.

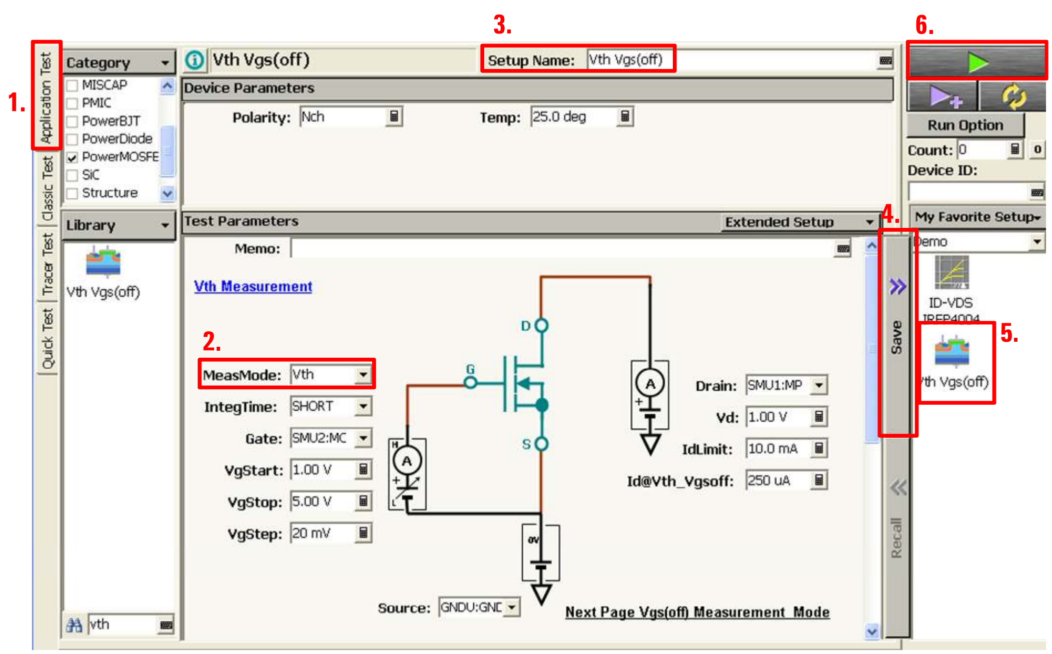
Note: Make sure the following two points:

- MeasMode : Vth

-Vth is defines at Id = 250 uA.

Step 6. Click Single Measure button, and check if the Vth obtained is reasonable.

Figure 9-5. Vth setup of Vth Vgs(off) application test.



◆ **To setup the Thermo trigger list:**

Follow the next steps and the numbers in figure 9-6.

Step 1. Click Application Test tabs.

Step 2. Click Run Options button.
Run Option window opens.

Step 3. Check "Record Test Data Automatically" check box.
Note: If this check box is set and repeat measurement is executed except the Tracer Test mode, Repeat measurement Setup window opens when the repeat measure button is clicked.

Step 4. Click Repeat Measure button.

Step 5. Repeat measurement Setup window opens

Step 6. Check "Automatically fill in Device ID" check box.

Step 7. Check "Enable Thermo-trigger" check box.

Step 8. Click "N1265A Thermo-trigger List ..." button.

Step 9. Thermo-trigger List box pops up.

Step 10. Click #1 line of Temp cell.

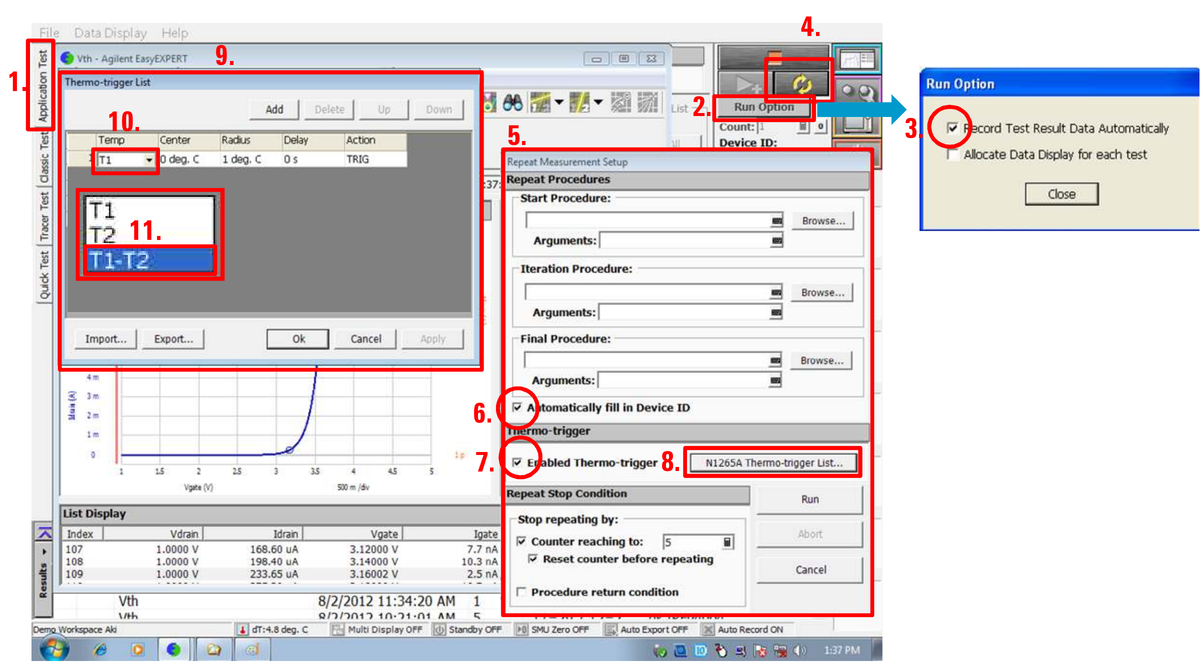
Step 11. click T1-T2 setup.

Follow the steps shown in figure 9-7 from step 12.

Step 12. Set the parameter of #1 line as follows;
- Center: 5 deg. C
- Radius: 0.5 deg. C
- Leave the other parameters as the default set.

Step 13. Click Add button.
New entry field opens.
Set the parameters as shown in column 2 of Thermo-trigger List of figure 9-7.

Figure 9-6. Setup the Thermo-trigger List 1.



Step 14. Repeat step 13 for column 3 to 5 of the Thermo-trigger List and fill the parameters as shown in the following table.

	Temp	Center	Radius	Delay	Action
1	T1-T2	5 deg. C	0.5 deg. C	0 s	TRG
2	T1-T2	4 deg. C	0.5 deg. C	0 s	TRG
3	T1-T2	3 deg. C	0.5 deg. C	0 s	TRG
4	T1-T2	2 deg. C	0.5 deg. C	0 s	TRG
5	T1-T2	1 deg. C	0.5 deg. C	0 s	TRG

Step 15. After setup all the thermo-trigger list, Click OK button.
Now the temperature list is setup in the EasyEXPERT menu.
Note: If you re-use the list, you can use the Export and Import function.

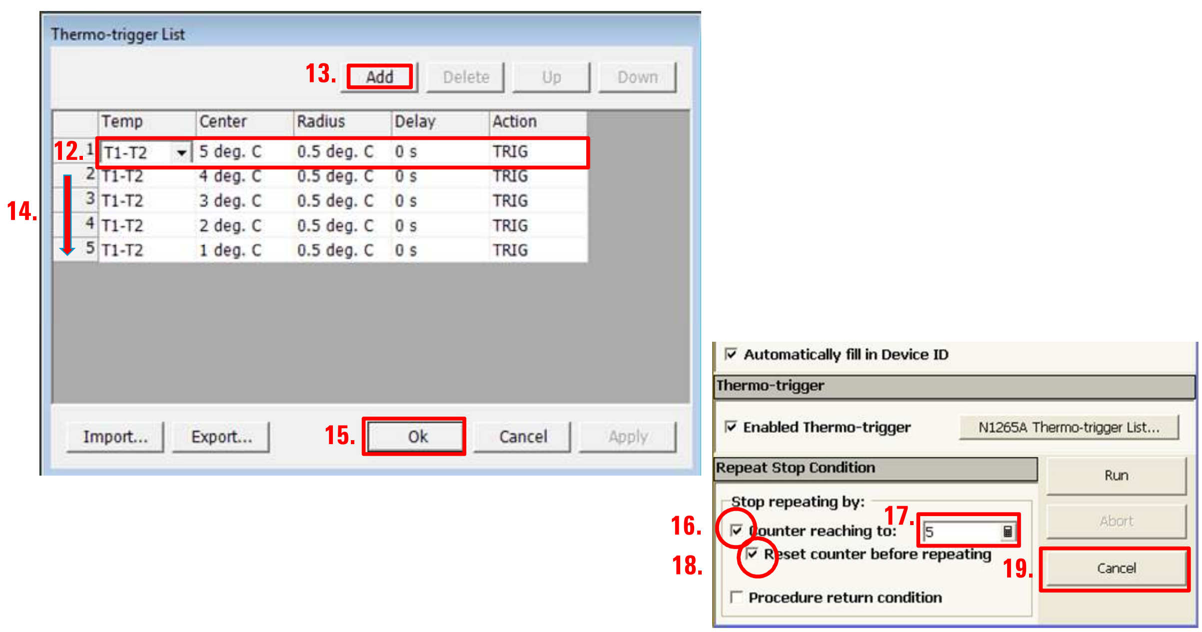
Step 16. Check "Counter reaching to:" check box.

Step 17. Set counter number to 5.
Since the Thermo-trigger list is 5, the measurement stop condition is set to 5.

Step 18. Check "Reset counter before repeating" check box.
By this setup, the repeat counter is reset to zero when starting the repeat measurement, and the counter increment one at each repeat measurement

Step 19. Now, we click "cancel" at this time to return to setup, because we have to start the self-heating measurement at first..

Figure 9-7. Setup the Thermo-trigger List 2.



◆ **ID-VDS Tracer Test setup for self-heating:**

Set ID-VDS Tracer Test by following the next steps and numbers shown in figure 9-8.

Step 1. Set the following VAR1 and VAR2 test parameters by selecting ID-VDS sample menu.

VAR1

Mode	Start	Stop	NOS	Interlacing	Compliance	Pwr comp	Output V Comp
LIN-SGL	0 V	60 V	21	1	501 A	3 kW	35 V

Pulse Base	Pulse Delay	Pulse Width	Dual Polarity	Hold Time
0 V	0 s	100 us	OFF	0 s

VAR2

Start	Stop	NOS	Compliance	Pwr comp	Pulse Base	Pulse Delay	Pulse Width	Hold Time
4.5 V	6.5 V	5	100 mA	OFF	0 V	0 s	120 us	0 s

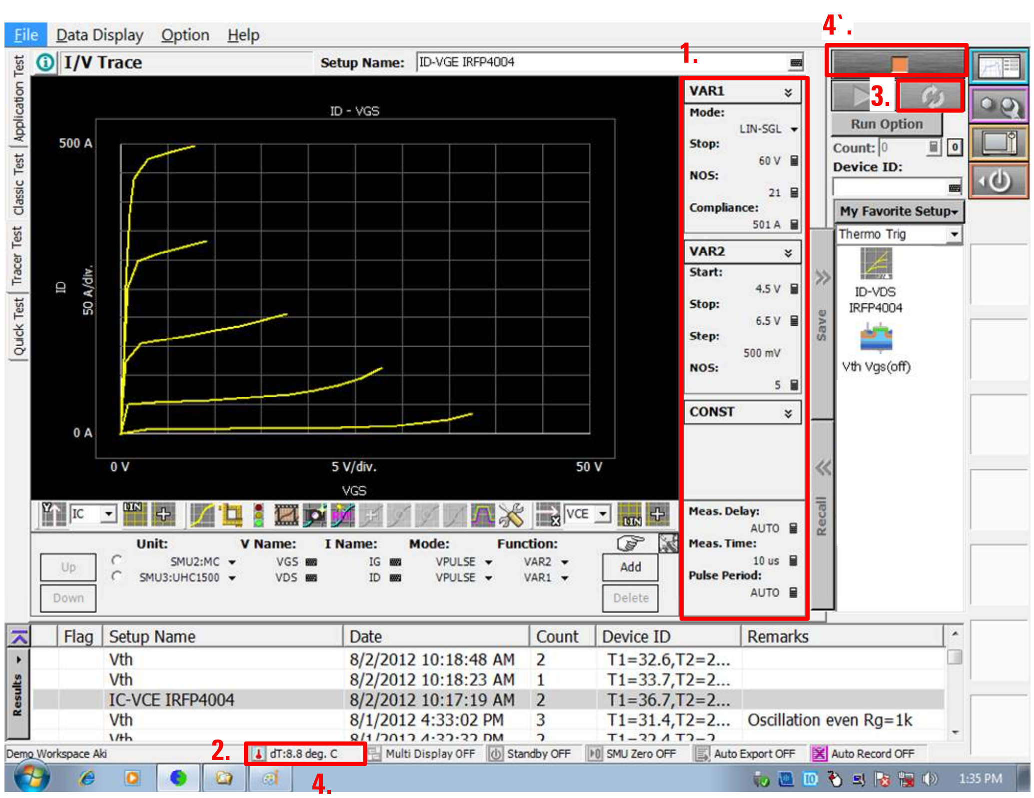
Step 2. Now the thermo-couple temperature is shown in real time in this field.
Click the field and set to show dT: T1-T2 deg. C.

Step 3. Click Repeat measure button.
The repeat measurement starts, and temperature of the MOSFET starts to rise.

Step 4. The temperature rise is shown in real time in Thermometer field.
When the dT reaches about 8 deg. C, Click Stop Measure button for changing to the thermo-trigger Vth measurement.

Note: The temperature of the MOSFET starts to cooling down, and we have to start the thermo-trigger Vth measurements before the MOSFET cools down to 6 deg. C dT.

Figure 9-8. ID-VDS Tracer Test Setup.



◆ To start Thermo-triggered Vth measurement:

Follow the steps shown in figure 9-9 from step 5.

Step 5. Click Application Tab.

The Vth measurement setup should be there.

If not, maybe you can recall from My Favorite setup or from the Result data area.

Step 6. Click Repeat Measure button.

Repeat Measurement Setup window opens with the previously set condition.

Step 7. Click Run button.

Step 8. The first measurement starts when the dT is reached within the radius of the target temperature.

Step 9. While waiting the trigger temperature, the target temperature is displayed.

Step 10. The real time temperature is shown.

Step 11. The Vth measurements are repeated and the status of the thermo-trigger list is renewed to the latest one.

Step 12. dT is renewed also.

Figure 9-9. Thermo-triggered Vth Test.

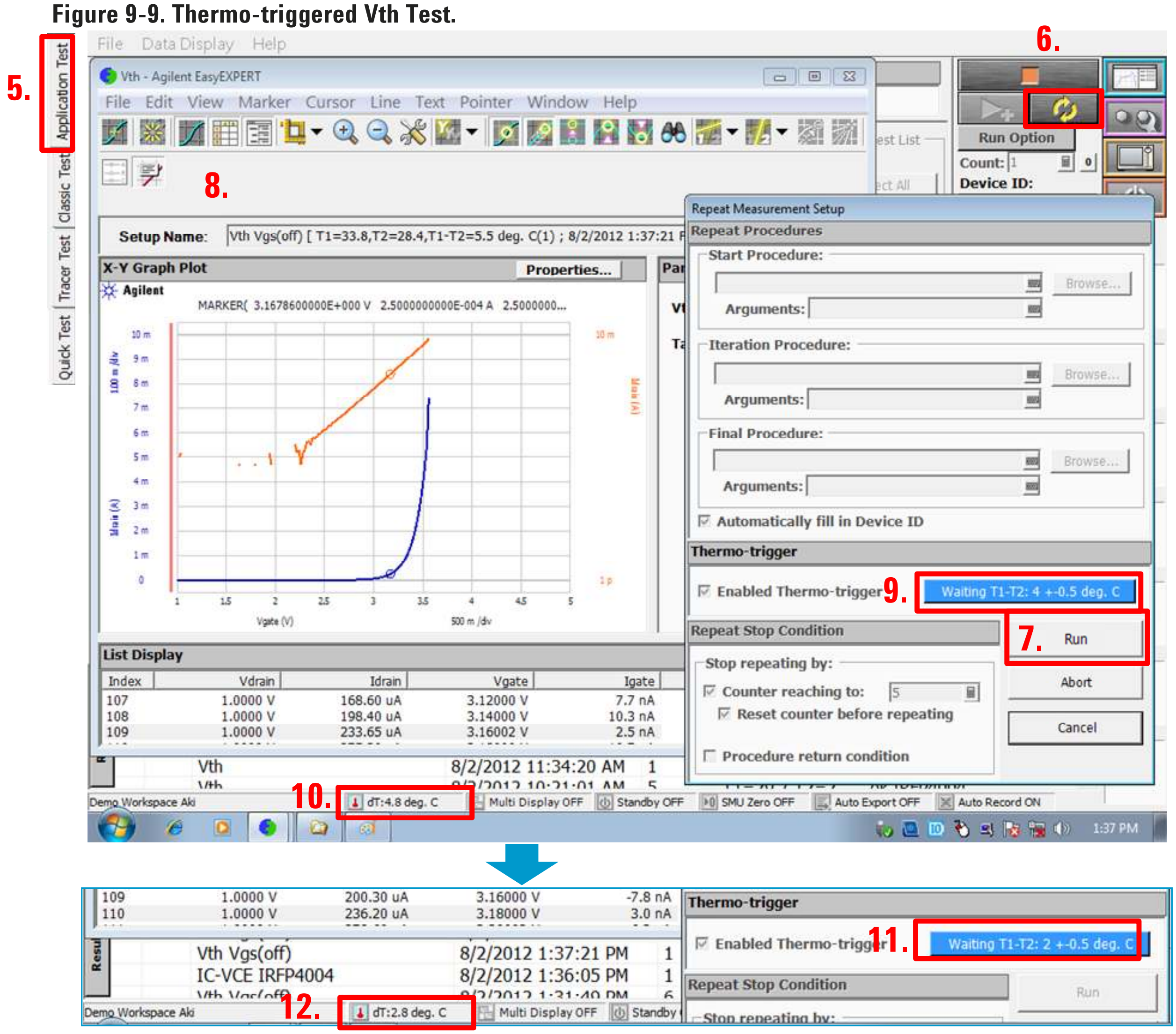


Figure 9-10 shows an example data display of Vth measurements.

#1. The Vth measurements triggered by the thermal-trigger list are saved in the Results area.

#2. Each measurement extracts Vth in the Parameter field.

#3. The T1, T2 and dT (=T1-T2) are automatically saved in the Device ID field.

We can easily extract the Vth and the T1 data, and figure 9-11 shows an example Vth plot from this demo results.

Figure 9-11 plots T1 versus Vth that is extracted from the demo measurements.

The linear regression line is drawn, and it shows the Vth temperature coefficient of IRFP4004 is -9.2 mV/°C.

Figure 9-10. Vth Display Data by Thermo-triggering.

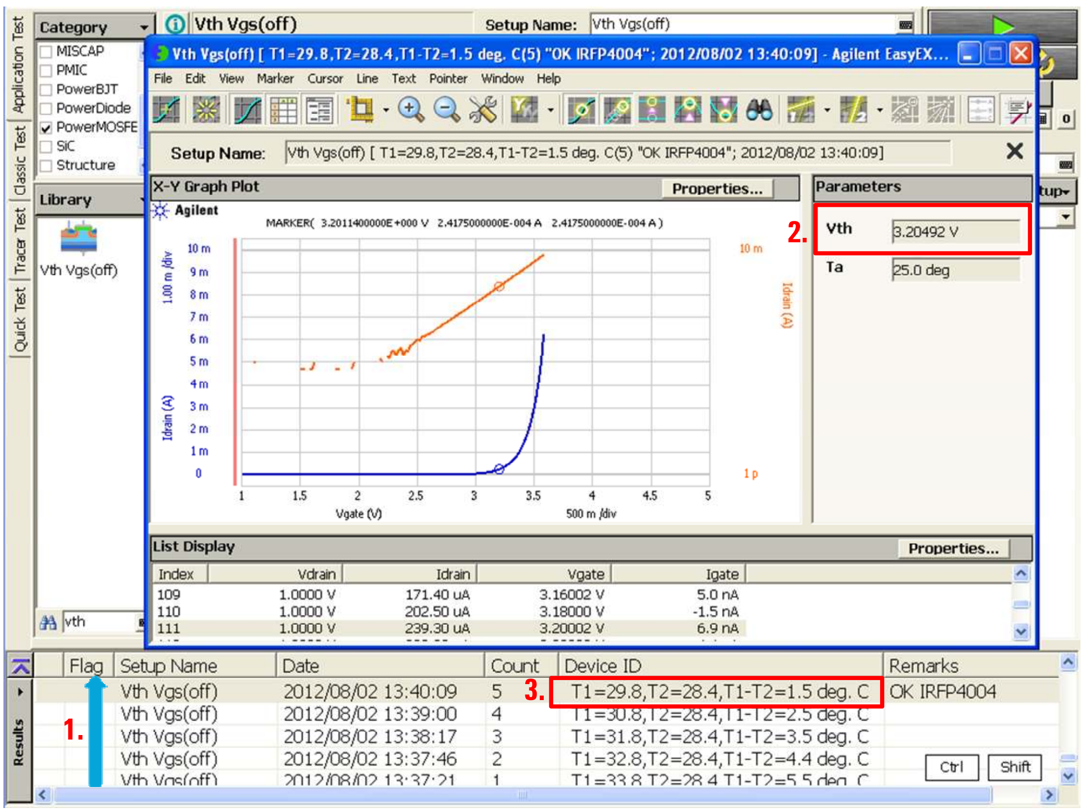
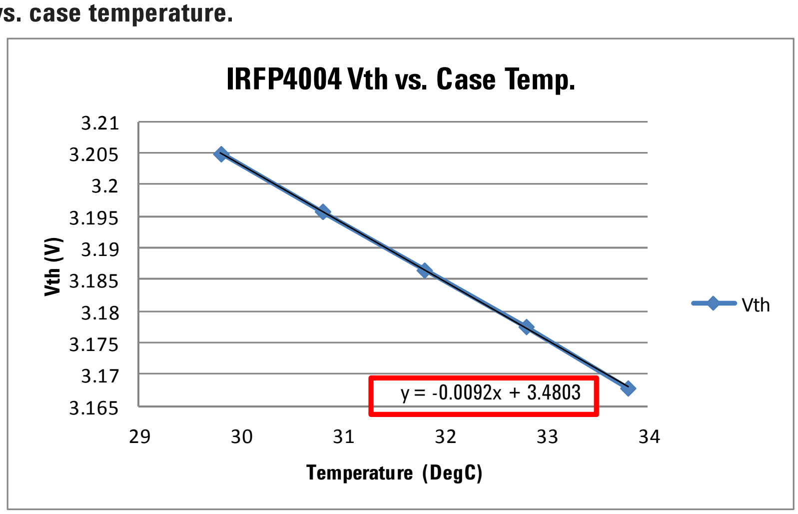


Figure 9-11. Vth shift vs. case temperature.



Review:

- The extracted temperature coefficient of Vth in figure 9-11 is -9.2 mV/°C. The value from the datasheet (see the first page of chapter 9) can be read about -9 mV/°C temperature coefficient for ID=250 μA curve at around 25°C case temperature.
- It is a good match with the test result from the B1505A.
- We used self heating to increase the MOSFET temperature, but there would be another choice such as to use hear dryer to warm up the MOSFET.

Summary of Demo 7

Through the demonstration, the following items are covered;

- How to use the thermocouple.
- How to operate the Thermo-trigger function.
- Using auto-analysis, the automatic Vth extraction in the Application Test is very easy to extract device parameter.

  Note: Using Classic Test mode can implement the auto analysis capability quite easily.
  Next chapter demonstrates such an example.
- The demo results can expect a good much with the datasheet parameter.

Chapter 10. Demonstration 8: Tracer Test to Classic Test conversion

Automatic parameter extraction

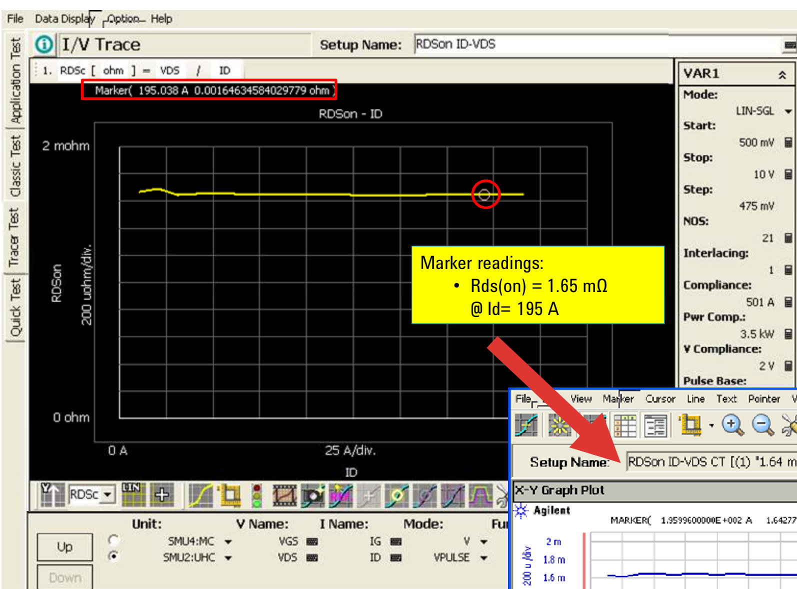
Contents: **10. Demo 8: Tracer Test to Classic Test conversion.**

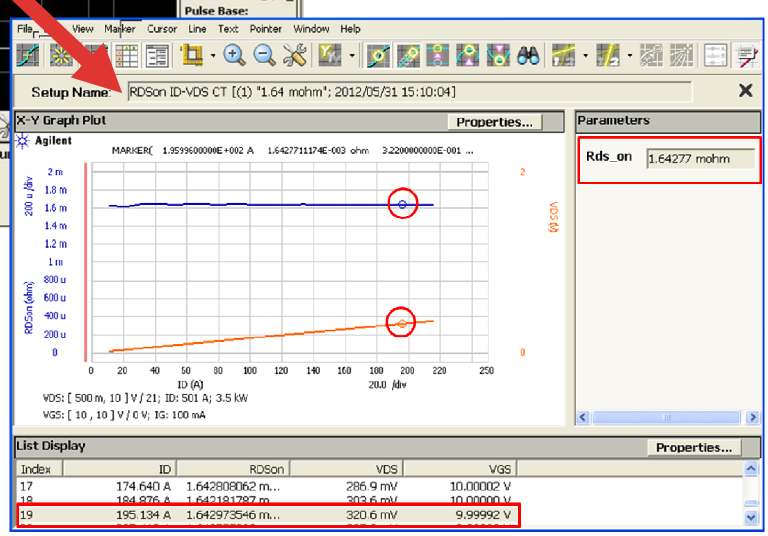
Automatic parameter extraction.

Objective: This demo covers the conversion of the Tracer Test setup to a new Classic Test mode test definition.

Features: By converting the Tracer test to a Classic test definition, the following merit can be obtained.

- Auto ranging mode for current measurement is applied (as default) to cover wide range and accurate measurement.
  Note: Tracer Test mode uses fixed range to keep the maximum speed.
- Auto analysis can be added easily.
- More X-Y graph display format can be added for each test.
- List Display can check many data and data status.
- Tracer Test sample setup menu can be used to setup the measurement portion of the Classic test mode definition.
  By using this approach, a tedious setup process of the basic test setup of the Classic Test mode can be eliminated.





In the Demo 2-3-1, we measured RDSon ID-VDS (see Tracer Test in previous page). In this demo, we convert this Tracer test definition to a Classic test definition, and then, add an auto-analysis capability.

In the Classic test definition, we are adding the following operations to extract Rds.

1. Activate Marker.
2. Move the marker to Id = 195 A.
3. Read Rds(on) value at the marker position.
4. Display Rds (on) to the Parameter display field.

◆ **To Convert Test Definition from Tracer Test to Classic Test:**

You can easily convert the Tracer Test mode definition to the Classic Test mode. Please recall the Rds(on) Tracer Test setup for converting it to a Classic test mode .

Follow the next steps and numbers shown in figure 10-1.;

Step 1. Set a proper test name in Setup Name field. (RDSon ID-VDS)

Step 2. Click Save button on your proper group of My Favorite Setup.

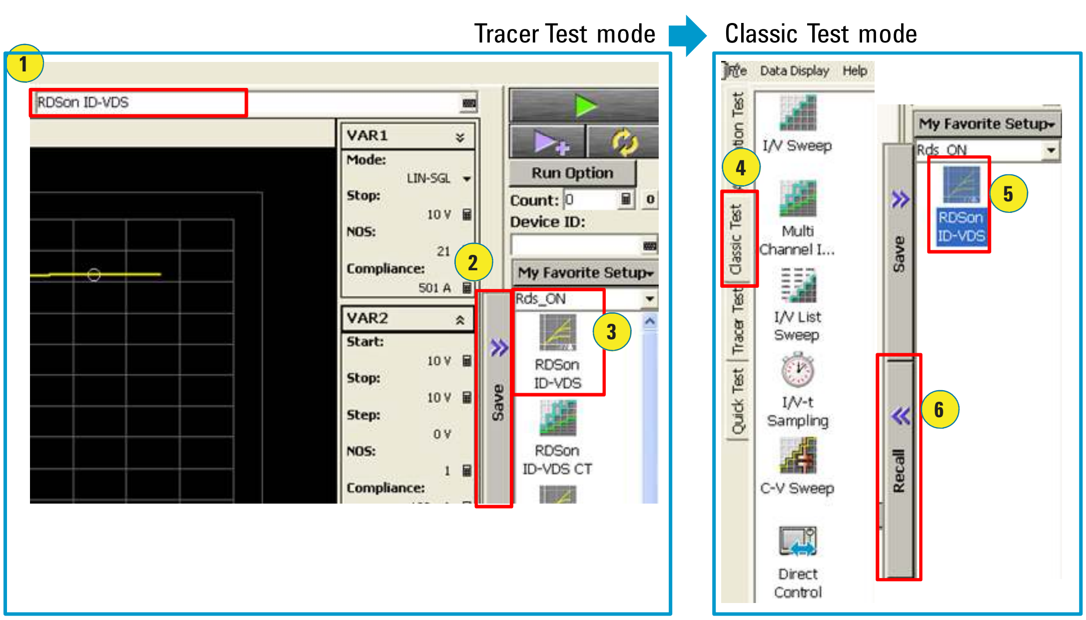
Step 3. The Tracer Test definition is saved to Rds_ON My Favorite group in the example.

Step 4. Click Classic Test mode tab.
Classic Test mode GUI opens.

Step 5. Select target Tracer test definition by clicking on the icon in My Favorite Setup area.
Click RDSon ID-VDS Tracer Test icon in the example.

Step 6. Click Recall button.
Tracer Test mode definition is automatically converted to Classic Test mode definition.

Figure 10-1. Tracer Test mode to Classic Test mode test definition conversion.



Let`s check the converted classic test definition.

All of the parameters are converted as shown in figure 10-2 for;

Step 1. Channel Setup,

Step 2. Measurement Setup.

Step 3. Sweep status is the same.

Step 4. ADC time is 50 us.

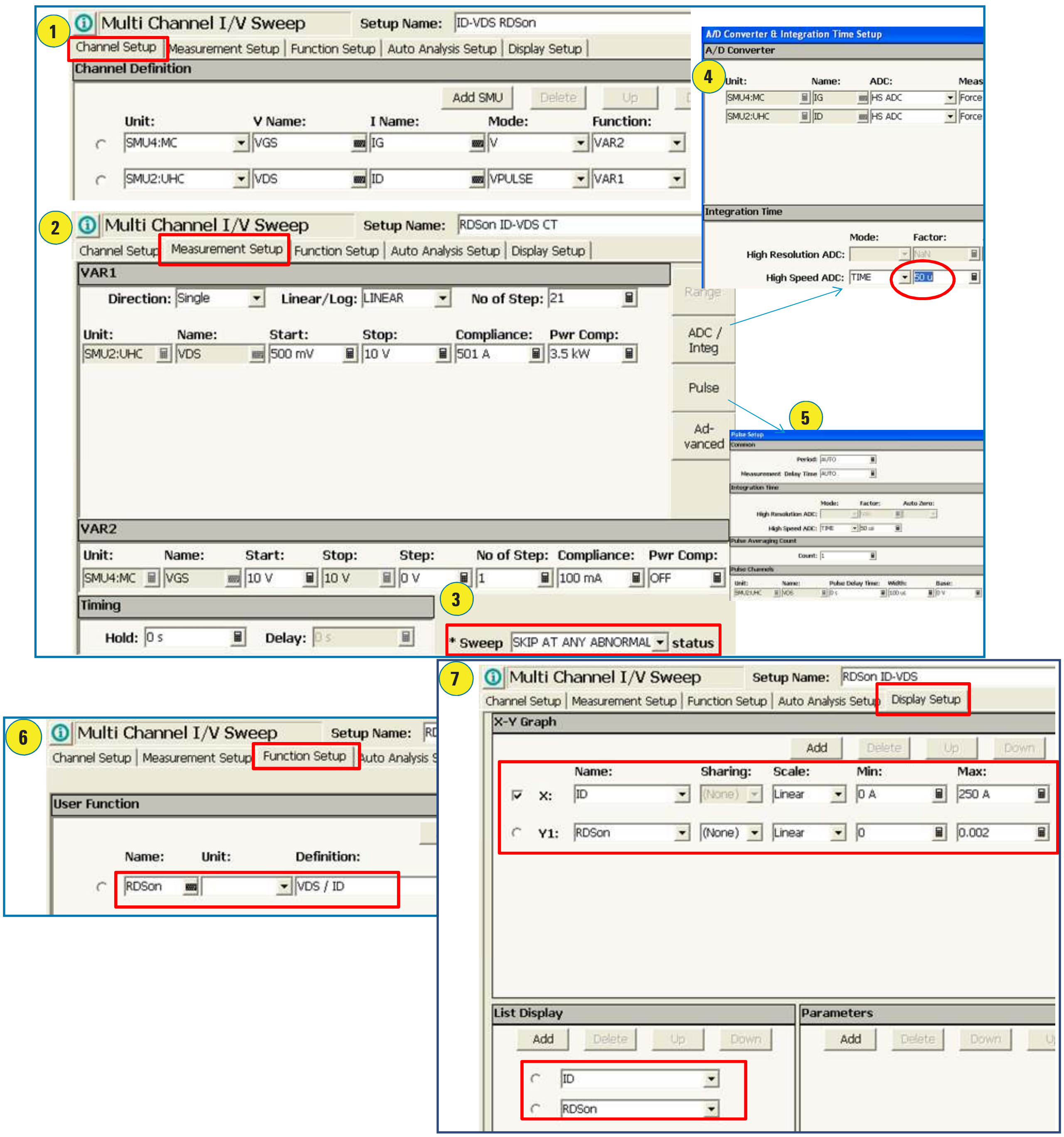
Step 5. Pulse settings are the same.

Step 6. User Function: RDSon is converted.

Step 7. Display set up for X-Y Graph is converted.

Note that List Display is added for the same parameter of X-Y Graph.

Figure 10-2. Tracer Test mode to Classic Test mode test definition conversion.



You can add an automatic analysis capability in the Classic Test mode.

◆ **To Add Automatic Analysis Function:**

Follow the next steps and the numbers in figure 10-3 to add the automatic analysis capability.

Step 1. Click Auto Analysis Setup tab.

Step 2. Set Marker as shown in the figure:

- Check Enable Maker check box.
- Enter the marker analysis condition to ID = 195 A that is the specification condition of the Power MOSFET.

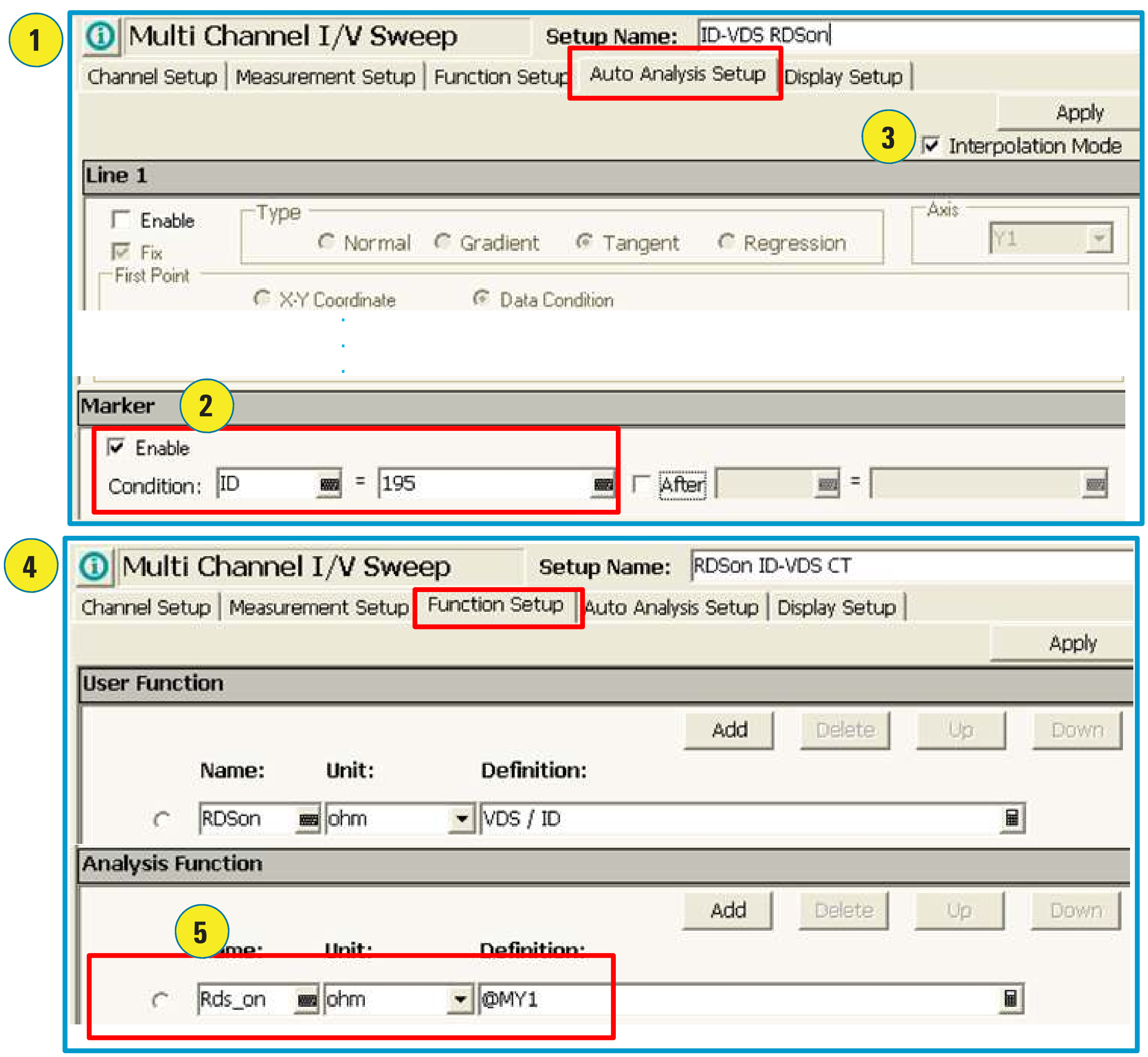
Step 3. Set Interpolation Mode to active by clicking the check box.

Step 4. Click the Function Setup page.

Step 5. Set Analysis Function as shown in the figure.

Note: @MY1 function reads the Y1 axis data of the marker, and the equation set the @MY1 value to the Rds_on variable.
We are going to display this data in the Parameter Display field.

Figure 10-3(a). Adding Auto Analysis on Classic test definition.



Continued from the previous page.

Step 6. Open the Display Setup page by clicking the tab.

Step 7. Add X-Y Graph parameter as shown in figure 10-3(b).

Step 8. Add parameters in List Display.

Step 9. Add the Rds_on parameter to the Parameters field.

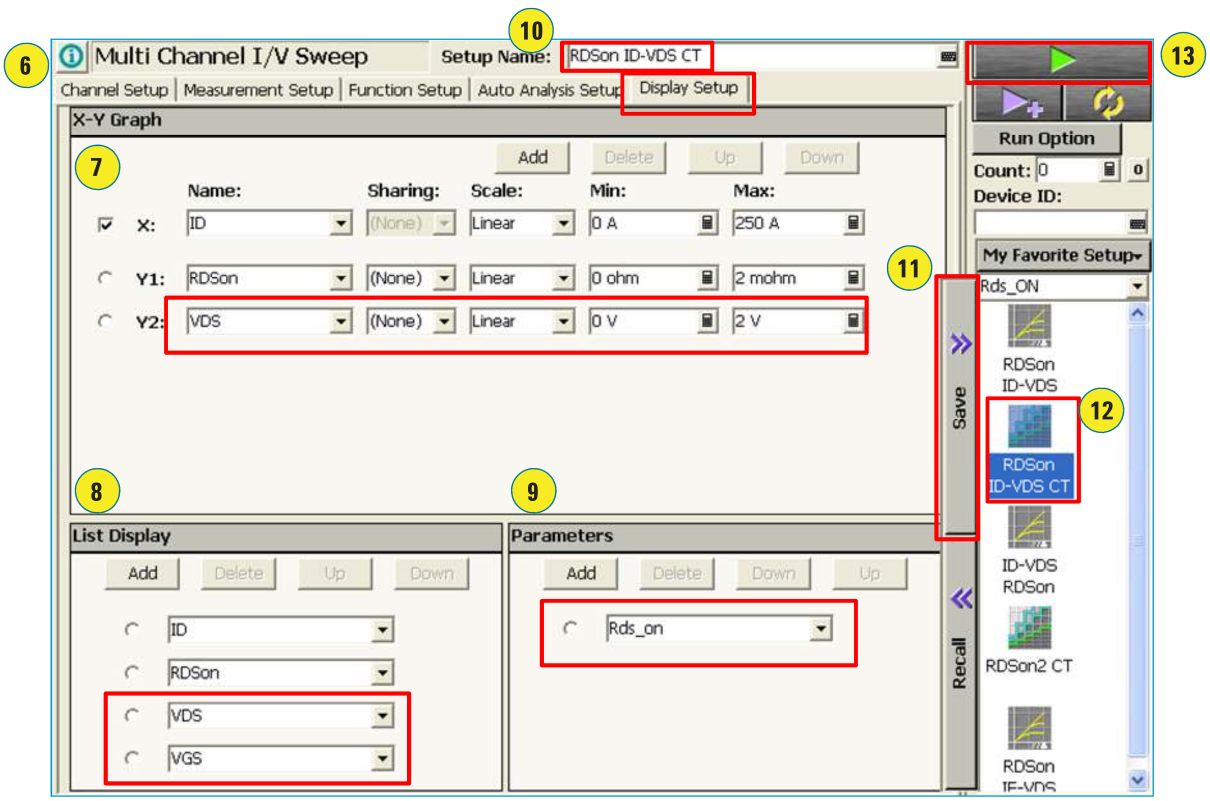
Step 10. Set a proper Classic Test Setup Name.
The example put "CT" that denote Classic Test.

Step 11. Click Save button.

Step 12. This action will save the new test definition to My Favorite Setup group in classic Test mode.

Step 13. Click Single Measure button.

Figure 10-3(b). Adding display parameters on the Display Setup tabs.



The ID-VDS CT classic test results are shown in figure 10-4..

The demo example output is explained by following the next steps and the numbers shown in figure 10-4.

Step 1. X-Y Display plots RDS0n - ID curve.

Step 2. Marker is automatically locates at specified ID=195 A point.

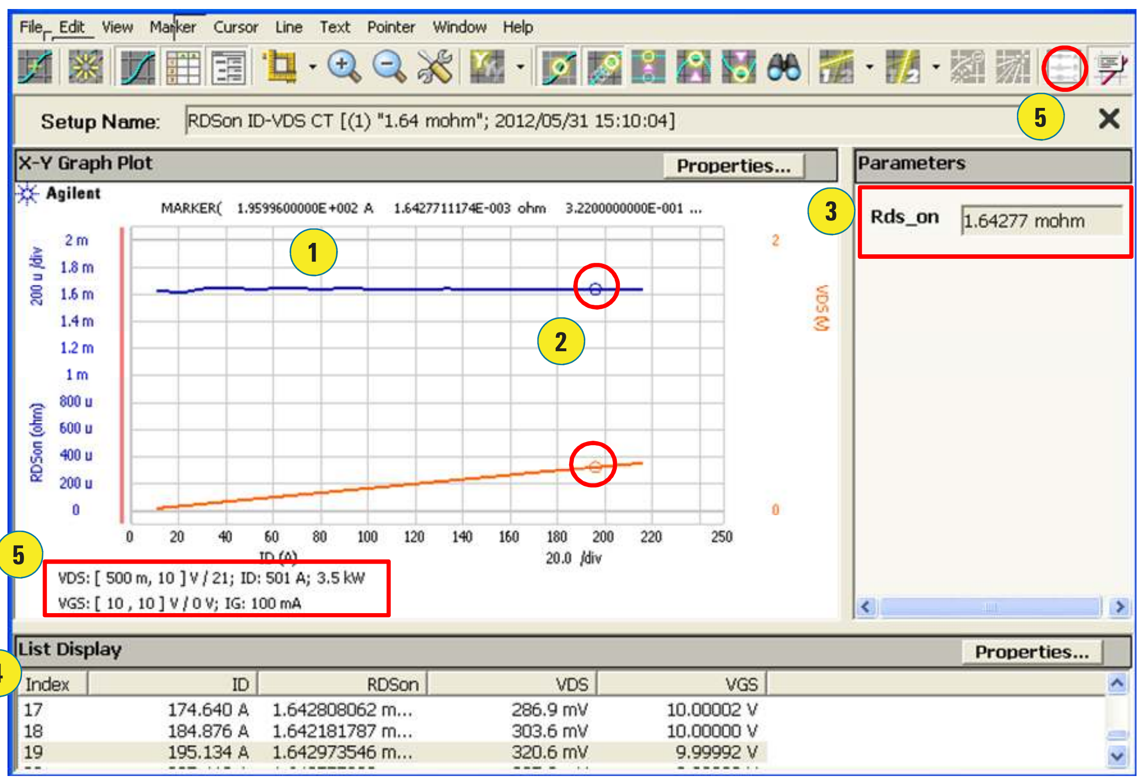
Step 3. The marker Y1 axis data is shown as extracted parameter in the Parameters field.
On resistance is 1.64 mΩ that is lower than the 1.7 mΩ specification at ID=195 A.

Step 4. List display lists all the specified parameters with marker position with a highlight.

Now, you can refer to these parameters handy without any additional operations.

Step 5. *Note, optional:*
Clicking "Show Graph Legend" displays the setup parameters on the X-Y graph.

Figure 10-4. Rds_on vs. Id characteristics: Classic test result with auto analysis capability.



Conclusion:

- Converting Tracer Test to Classic test definition is quite simple
- Adding Automatic Analysis and Display parameters are also a very easy task.
- The combination use of the Tracer Test mode and the Classic Test mode provides easy to use environment on the B1505A.

Chapter 11. Demonstration 9: Reporting
Data Analysis on your PC

Contents:

Demo 9: Reporting

This demo handles the topics relating the reporting.

When you make a repot, such activity as analyzing data, converting data and transferring data between your application software, is necessary.

Demo 9 covers the following topics.

1. Desktop EasyEXPERT
2. Display/Recall Data
3. Copy Graph
4. Copy List data
5. Export/Import Results Data
6. Export/Import My Favorite Preset group

1. Use of Desktop EasyEXPERT

- **Off-line* test & analysis environment**
- **Benefit:**
  - **Improve the efficiency**
    - **Can access to EasyEXPERT and the measurement data at any time.**
    - **On your PC environment**
      - **Measured data processing for familiar Windows application.**
      - **Maybe, large screen work area**
  - **Off-line**
    - **No B1500A H/W required**
    - **Test library development.**

***: Can be used on-line if connected to the B1500A via GPIB**

Option: Use of Desktop EasyEXPERT

Using Desktop EasyEXPERT for reporting purpose is a good alternative idea.

- Because it is off-line, you can access to your measurement data at anytime if once your measurement data is exported from the B1505A and imported to your Desktop EasyEXPERT.
- Since you can use your PC, you can use your familiar application for farther analyzing the measurement data and creating your report.
- If your desktop area is large, it surely improves the data handling inside Desktop EasyEXPERT and your applications.

Note: This demo does not require Desktop EasyEXPERT.
If to use Desktop EasyEXPERT, refer to Appendix 2.

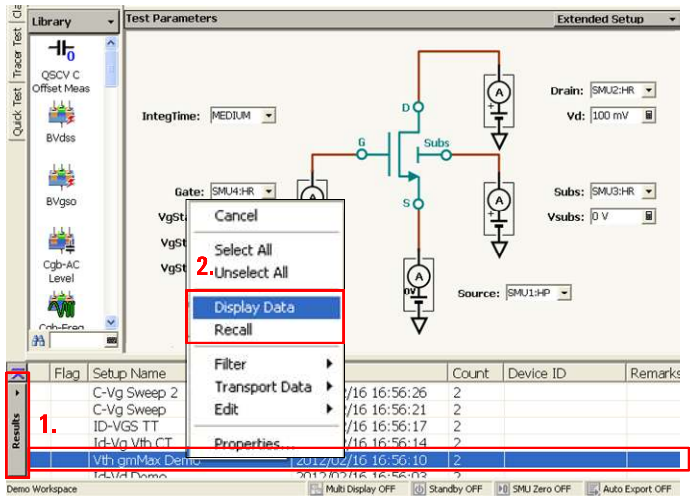
Note: On-line use of the Desktop EasyEXPERT software

Desktop EasyEXPERT can be used on line as exactly the same way as EasyEXPERT on the B1505A if your PC and the B1505A is connected via GPIB.

Therefore you can access to the B1505A measurement recourses without exporting your test library which is developed on your off-line PC or new setups.

The measurement data is automatically saved on your Desktop EasyEXPERT, and there is no need to export the Results data from the B1505A and importing to your PC.

2. Recall/Display Data



Recall or Re-Display Result Test Data For Analysis

The Test results saved in the List data area of EasyEXPERT can be recalled or displayed in any time.

The data recalling capability is useful for analyzing your data and making a report after all the data is taken or after you move the data to Desktop EasyEXPERT.

There are following two ways to display the test result.

Display Data: Displays only the test data in data display window.
You can make analysis on the displayed data.

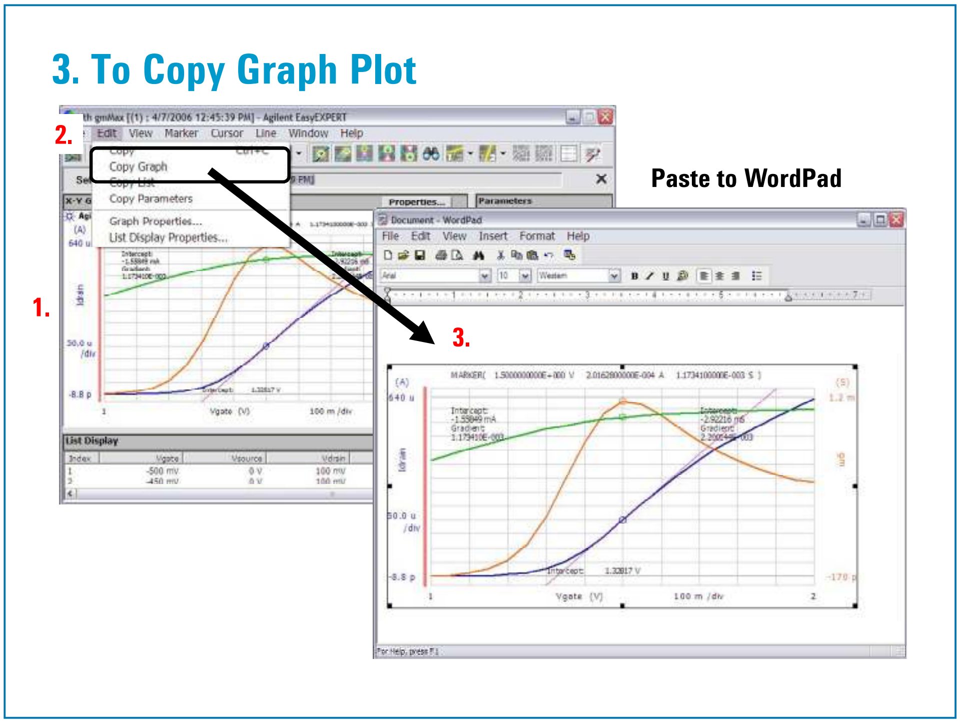
Recall: Recalls both the data display window and the setup data.

Recalling data is useful when you need to check the measurement setup, or want to make a measurement again after reviewing your data.

◆ **To Recall/Display Data:**

To Recall/Display Data in the Results area, follow the next steps by referring to the numbers in the slide.

1. Right click on the data line, or
   select a line -> click Results bar opens the function menu.
2. Click Display Data or Recall.



To Copy Graph Plot

The above slide shows an example of the copy and paste operation.

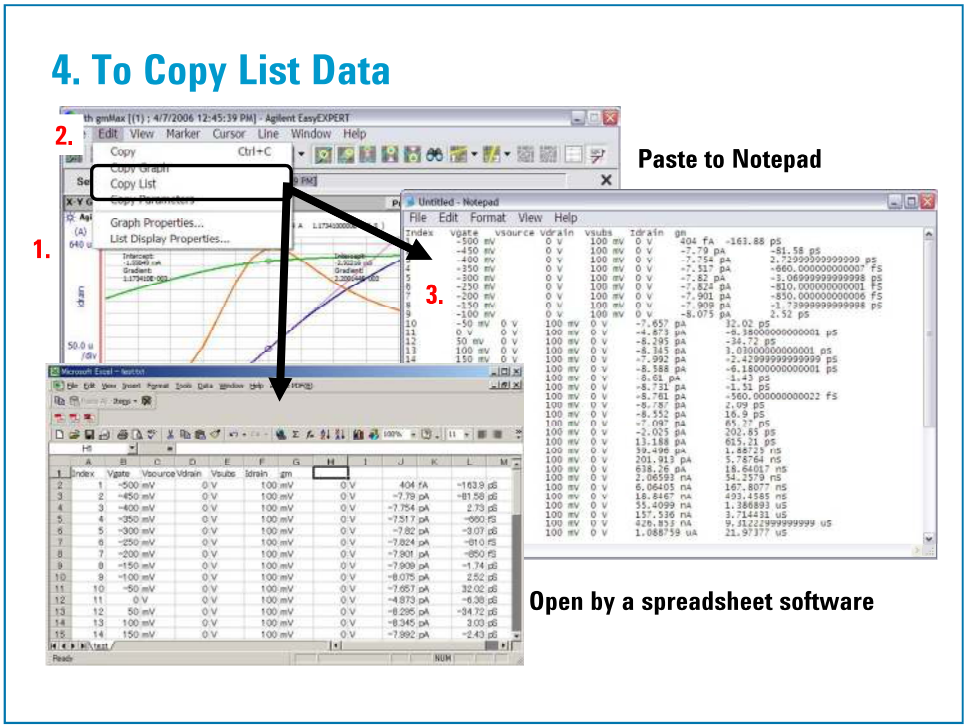
The graph displayed on the data display window can by copied to the clipboard.

You can paste the graphic image to other Windows application, for example, a word processing software.

◆ **To Copy Graph:**

In the above example, the graph image is pasted to the WordPad.
To copy Graph, follow the next steps by referring to the numbers in the slide.

1. Open the data display window to copy.
2. From the file menu, select the "Edit > Copy Graph menu" on the Data Display window.
3. Open WordPad (or other application)
   - Select the Edit > Paste menu on the WordPad.



To Copy List Data

The above slide shows an example of the copy and paste operation.

The data list shown on the data display window can be copied to the clipboard.

You can paste the data to other Windows application, for example, Window Notepad software.

◆ **To Copy List Data:**

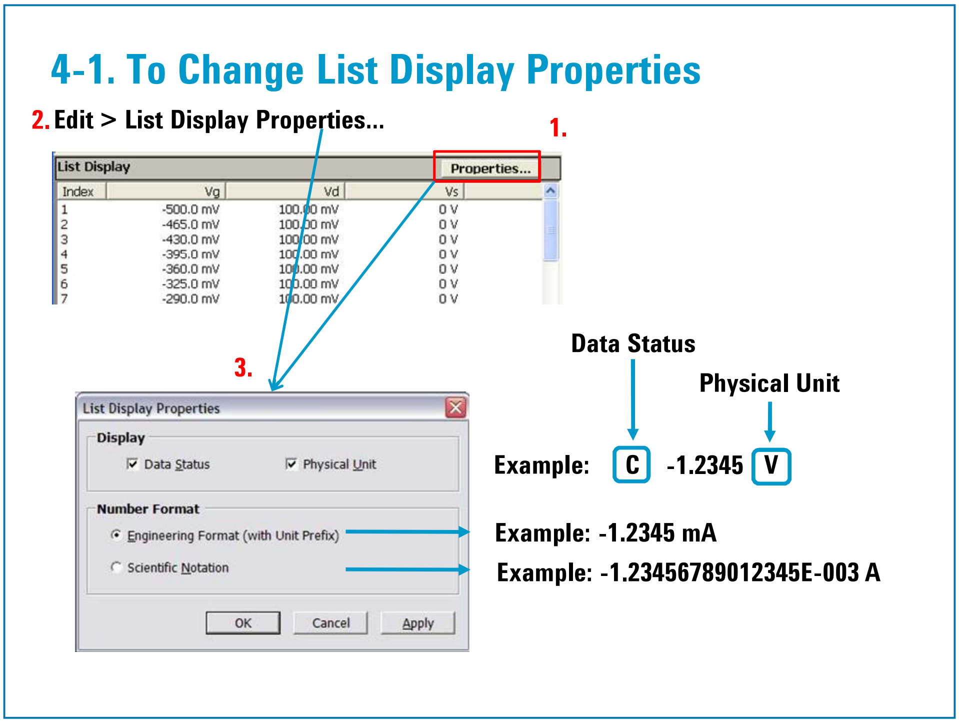
In the above example, the data list is pasted to the Notepad.

To copy List data, follow the next steps by referring to the numbers in the slide.

1. Open the data display window to copy.
2. From the file menu, select the "Edit > Copy List" menu on the Data Display window.
3. Open Notepad (or other application)
   - Select the Edit > Paste menu on the Notepad.

Note: The copied data is the same format as displayed in the List display area.
If you past the data to a spreadsheet for analysis, you may need to change the number format in List area.
(See next page.)

Note: Copy Parameters function
As same as the Copy List function, the Copy Parameters function is used to copy the data in the Parameters area.



To Copy List Data in a Different Format to use with Spread Sheet Application

There are several formats in displaying the List Display.

The dialog box shown in above slide is used to set the data display format in the List Display area.

◆ **To Open the List Display Properties Dialog box:**

To open the List Display Properties dialog box, follow the next steps by referring to the numbers in the slide.

1. Click the "Properties..." button in the List Display area or
2. Select "Edit > List Display Properties..." menu of the Data Display window.
3. List Display Properties box opens.

Display area:

Check the following check box to add the data status or the physical unit to data. Un-checking the box removes it.

- Data Status: Adds or removes the status code before data.
- Physical Unit: Adds or removes the physical unit after data.

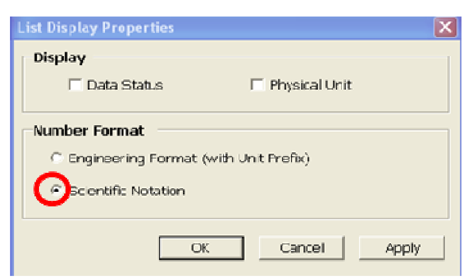
Number Format area:

Selects the data display format from the following formats.

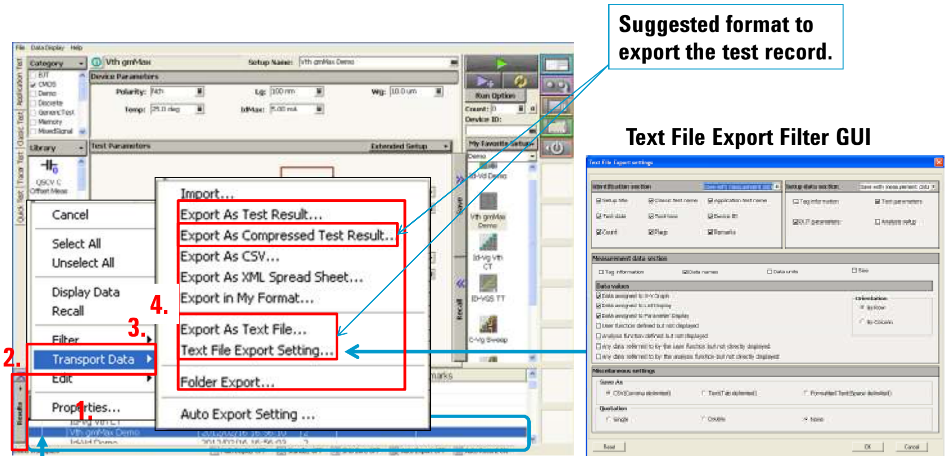
- Engineering Format (with Unit Prefix):
  Data display with arithmetic point, SI prefix, and unit.
  Example: -1.2345 mA
- Scientific Notation:
  Data display with arithmetic point, exponential part (E, +/- sign, and three-digit number), and unit.
  Example: -1.23456789012345E-003 A

Note:

For Spread sheet calculation, use these properties:
(Check only "Scientific Notation")



5-1. To Export Test Record



1. Select data record to export, and right click.
2. Select Transport Data > Export As xxxx.

   To export multiple data, select Transport Data > Folder Export.

To Export Measurement Data Record

The measurement data can be exported to the external file in a format that the other application can be used.

◆ **To Export the Test Record:**

To export the test result record, follow the next steps by referring to the numbers in the slide.

1. Specify the data records to export.
2. Click Result button and display the function menu.
3. Select the "Transport Data > Export As xxxx" from the menu list.
   xxx denotes the available format.
   Windows Explore opens.
4. Specify the file name and the directory to save the data.

   Note: Multiple test records can be exported in one file by using "Transport Data > Folder Export..." menu.

There are the following five formats to export the test record:

- (Compressed) Test Result file: Used to transfer between EasyEXPERT.
- CSV file: Comma delimited text file.
- XML spreadsheet file: A XML file created by using the specified XML style sheet.
- My Format: Delete some part of unnecessary data by using a filter file.
- Text File format: Export only the necessary data by using a GUI based filter.

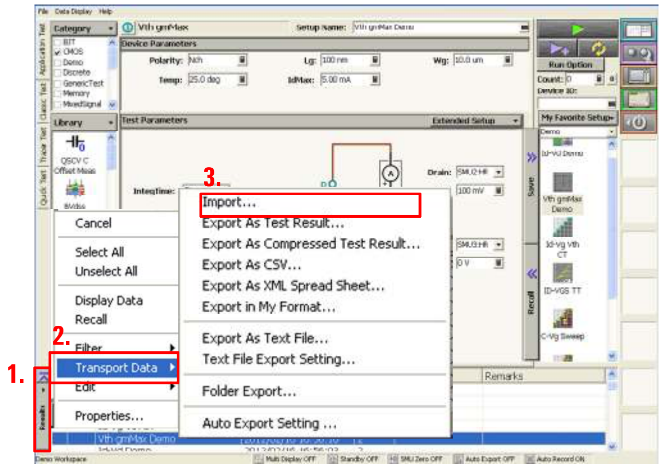
◆ **Export File Suggestion:**

There are many export file format and filter combination. The filter is used to extract the necessary data element from the EasyEXPERT internal database.

The following format is suggested for easy-of-use and satisfactory result for first step users.

- "Export as Compressed Test Result ...": Used to transfer between EasyEXPERT.
- "Export as Text File...": Used to transfer data between the Windows application.
  Make sure to set the "Text File Export Setting ..." when using this format.

5-2. To Import Test Record



To Import Test Record to EasyEXPERT

The measurement data can be imported to the EasyEXPERT.

This operation would be useful when you move the data to Desktop EasyEXPERT for off-line analysis and creating a report.

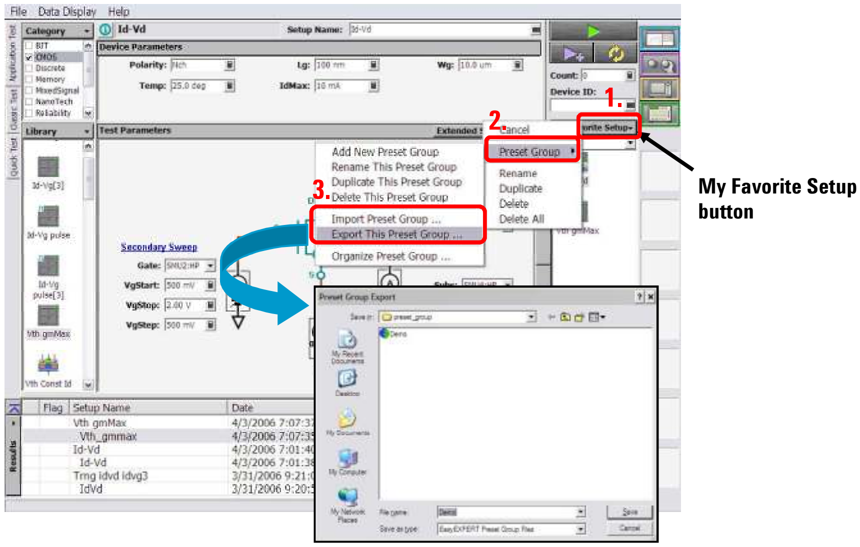
Note:
Only the file exported as "Test Result" or "Compressed Test Result" format can be imported.

◆To Import the Test Record:

To import the test result record, follow the next steps by referring to the numbers in the slide.

1. Click Result button and display the function menu.
2. Select the "Transport Data > Import..." from the menu list.
   The Test Result Import dialog box is opened.
3. Select the file to import.

6. To Export/Import Your Preset Group



Export/Import My Favorite Preset group

You can export/import your preset group.

This operation would be useful when you move the preset group between the B1505A and Desktop EasyEXPERT.

◆ **To Export:**

To export the present preset group, follow the next steps by referring to the numbers in the slide..

1. Click the My Favorite Setup button
2. Click Preset group
3. Select "Export This Preset Group...", and specify the folder and the name of the preset group to export.

◆ **To Import:**

To import the preset group, follow the next steps by referring to the numbers in the slide..

1. Click the My Favorite Setup button
2. Click Preset group
3. Select "Import Preset Group...", and specify the preset group to import.

Demo 9: Summary

We learned following in this lab:

1. **Desktop EasyEXPERT**
   - **Off-line data handling is important to improve the job efficiency in many ways.**
   - **It can be used on-line (to control B1500A from your PC), too.**
2. **Display/Recall Data is essential for post processing your data.**
3. **Following functionality is useful for making a report:**
   - **Copy Graph**
   - **Copy List data**
   - **Export/Import Results Data**
   - **Export/Import My Favorite Preset group**

Demo 9: Summary

We learned the topics/items listed in above slide.

To Turn off the B1505A

- **To Turn off the B1505A:**

If this is today`s final demo work on the B1505A,

1. Take off the demo device from the test fixture.
2. Then turn off the B1505A.

2A. Press the Standby switch (lower right corner of the front panel), or perform Windows shutdown from the Start menu.

2B. EasyEXPERT is closed and Windows will be safely shut down and the Agilent B1505A will enter the standby state.

Appendix

Table of Contents:

Appendix 1. Supplemental Information for Preparation

Earlier shipment of the demo B1505A did not include the revision A.05.01 EasyEXPERT Application Test Library that is used in the demonstration. We are also required to modify two existing Application Test libraries to meet the demo requirements.

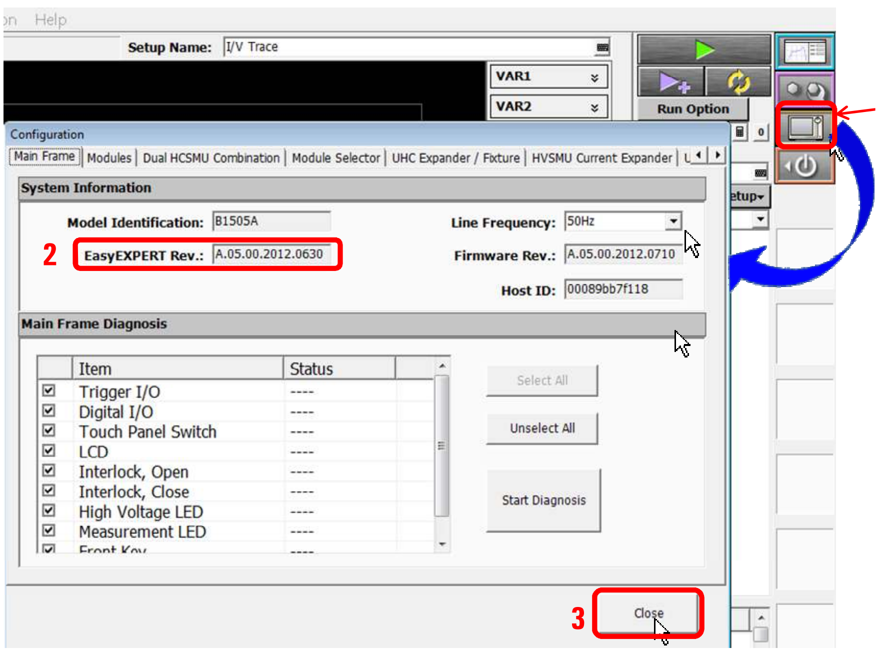
If your EasyEXPERT revision is A.05.00, then please download the necessary files from Agilent web site, and install them before starting the demo.

- **To check the EasyEXPERT revision**

  Open the configuration window of the EasyEXPERT as shown in figure A1-1.

  The following section instructs the download and installation procedure. Please follow the next instructions.

Figure A1-1.



A1-1. New Application Test installation for EasyEXPERT revision A.05.00

A1-1-1. Download the example file-set from the Agilent web site

Download the application test definition file-set from the Agilent web site by following the next procedure.

Procedure:

- Web site:
  Visit www.agilent.com/find/B1505A and go to Technical Support area.
  Find “B1505A MB3 Demo” and zip file indicator.
- Download:
  By clicking the link, you can download "B1505A_MB3_Demo_AT.zip" Application Test Library file.
  Save it to a proper folder of the B1505A`s Windows system, say D:/tmp or desktop.

A1-1-2 Extracting from zip compressed file

The downloaded file has to be extracted to the regular Windows file format for reading from EasyEXPERT.

Follow the steps shown in figure A1-2 for extracting files from the downloaded zip file.

Step 1: Right click the B1505A_P-BJT_HB_Library.zip file.

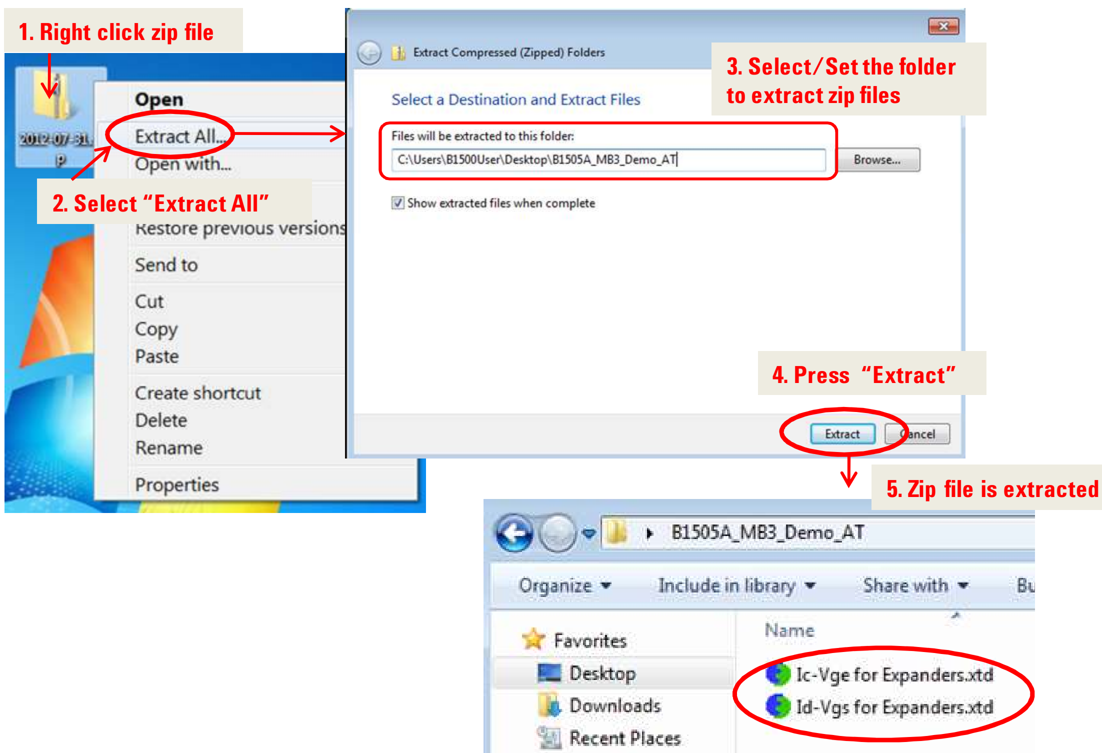
Step 2: Select "Extract All ..." menu from the pop up window.

Step 3: Extraction Window opens, and click "Next".

Step 4: Select desktop for extracting from the downloaded zip file.
Then click "Next".

Step5. Windows Explore opens.
All the files are extracted under the specified folder.
In the example, "B1505A_MB3_Demo_AT" folder on the desktop.

Figure A1-2. Extracting the downloaded zip file.



A1-1-3 Setup of the downloaded Application Test files to the EasyEXPERT software

Import the Application Test definition to EasyEXPERT by following the next steps.

[PROCEDURE] - See figure A1-3

Step 1: Press “Application Test” tab.

Step 2: Press “Library” bar of EasyEXPERT.
Library menu opens

Step 3: Select “Import Test Definition” from the Library menu.
Windows Explorer opens.

Step 4: Find the folder where you extract the example file set.
And select two Application Test definitions as shown in the figure.

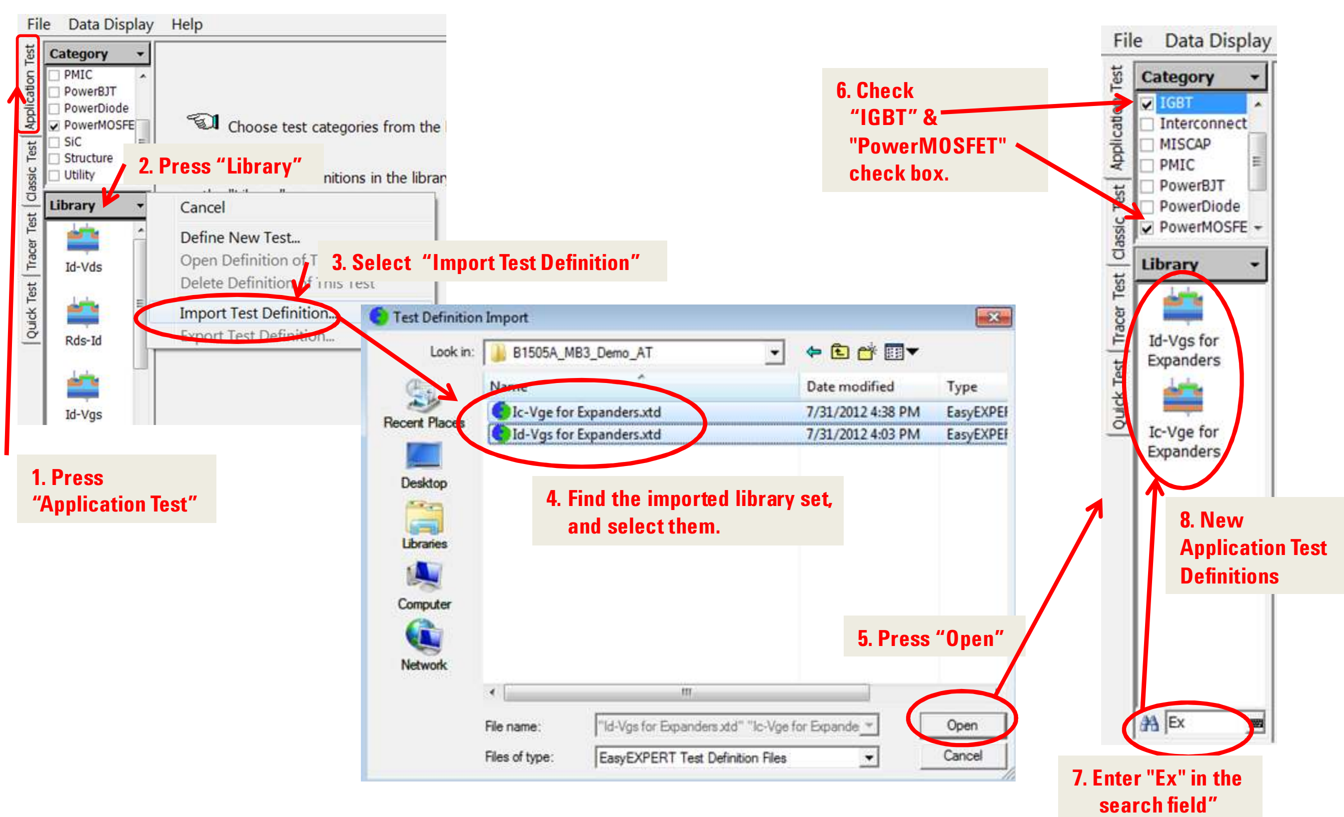
Step 5: Press “Open” of the Windows Explorer button.
All the Application Test definitions are imported in to the EasyEXPERT Application Test Library.

Step 6: Check IGBT and PowerMOSFET check box of the Application Category field.
All the Application Test definitions included to theses categories show up in the Library field.

Step 7: Enter “Ex” to the search box.
Only the Application Test definitions with “ex” in the test name appears on the Library field.

Step 8: The new Application Test definitions appear in the Library window.
Check if these Application Test definition exist.

Figure A1-3. Importing the Application Test definitions.



A1-2. Modifying the Vth measurement Application Test definitions

The following two Application Test Definitions included in the EasyEXPERT revision A.05.00 do not support MPSMU that is used in the demonstration to measure Vth of the IGBT and the power-MOSFET.

- Vth Vgs(off): Vth or Vgs(off) measurement (A.05.00)
- Vth Vge(off): IGBT Vth or Vge(off) measurement (A.05.00)

These two Application Test definitions have to be modified before the demo.

Note: MPSMU is supported in later revision than EasyEXPERT Rev. E.A.05.01, and you do not need to make the modifications described in this section.

A1-2-1. Modification of Vth Vgs(off) - Power MOSFET:

Follow the next steps and the numbers of figure A1-4 to modify the Application Test definition for Vth Vgs(off).

Step 1. Click “Application Test” tab.

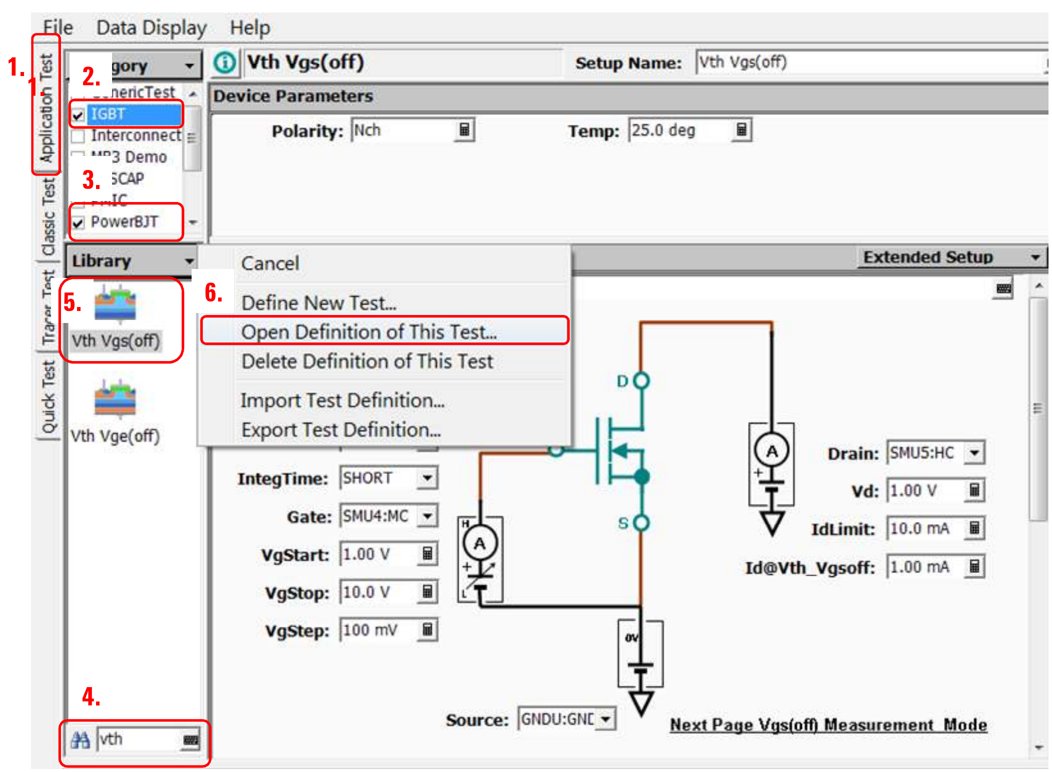
Step 2.& 3. Check “IGBT” and “PowerMOSFET” Application category.

Step 4. Enter “Vth” in the search field.

Step 5. Right click the Vth Vgs(off) test definition.
Application Test definition menu opens.

Step 6. Click “Open Definition of This Test ... ”
Test definition editor window opens (Figure A1-5)

Figure A1-4. To open the Application Test definition.



Step 7. Test definition editor is shown.

Step 8. Scroll down the vertical bar of the Test Parameter Definitions area until Drain term shows up.

Step 9. Click line area of the drain term to focus the control.

Step 10. Click Resource Types button.

Step 11. Define Resource Type window opens.

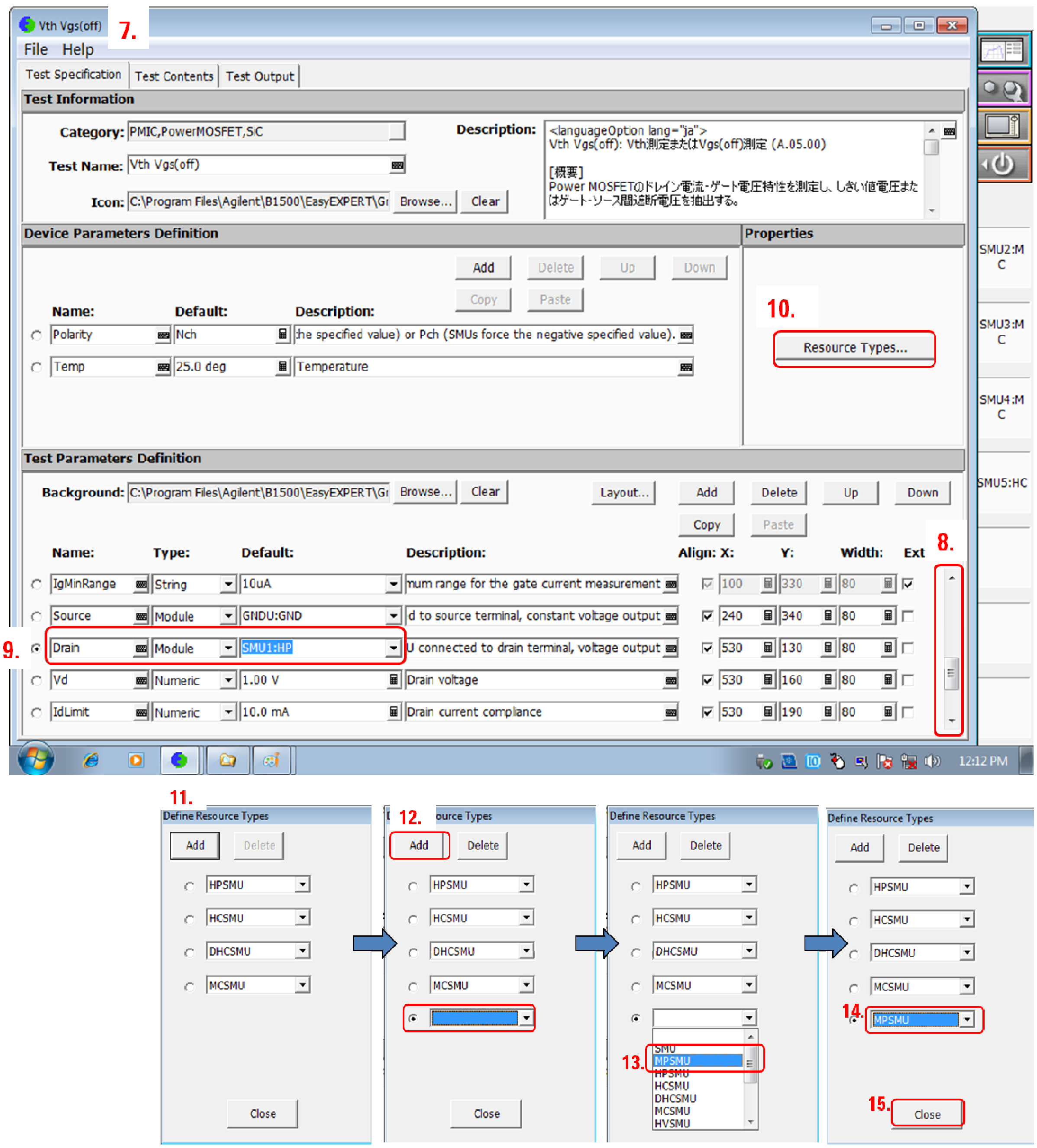
Step 12. Click “Add” button.
New resource input field is added.

Step 13. Select MPSMU from the resource menu.

Step 14. MPSMU is set as an available resource type.

Step 15. Click Close button.

Figure A1-5. To modify the Application Test definition.

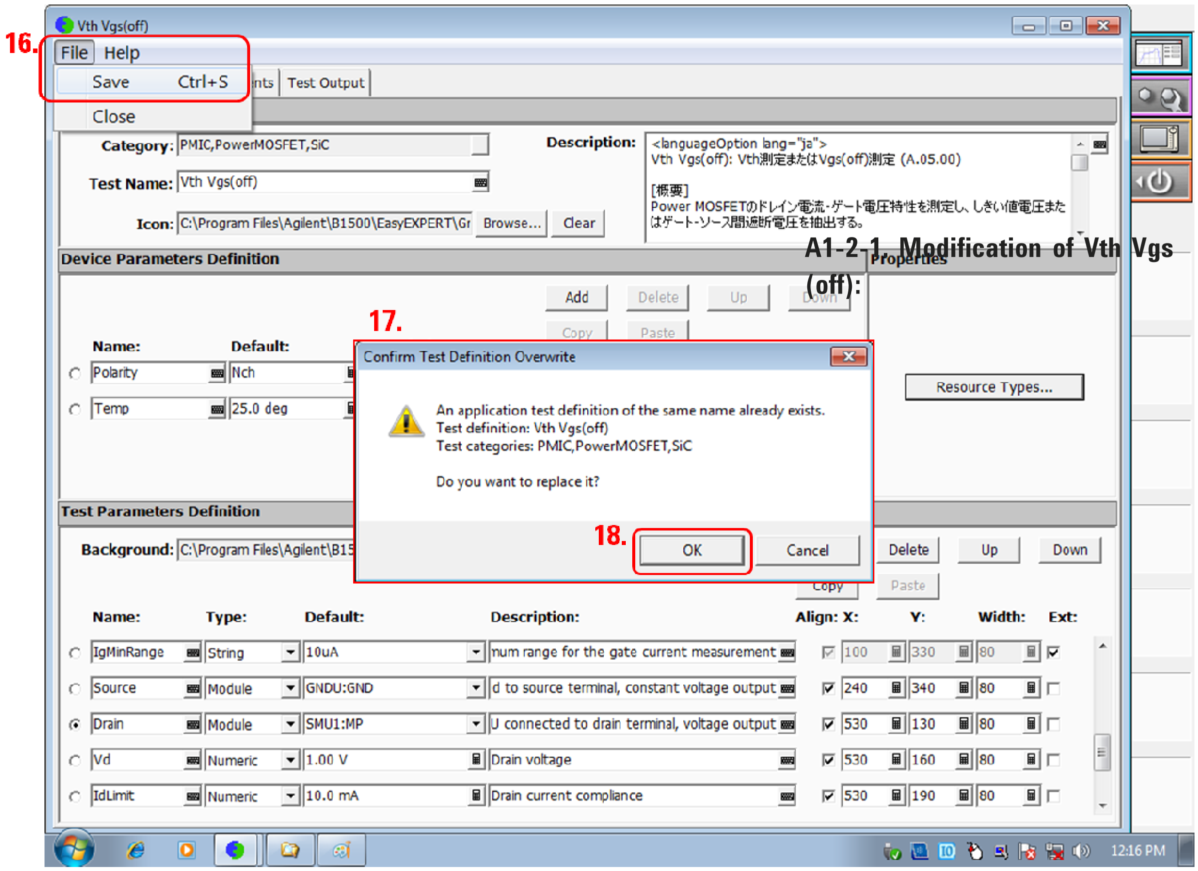


Step 16. Click File -> Save

Step 16. "Confirm Test Definition Overwrite" window pops up.

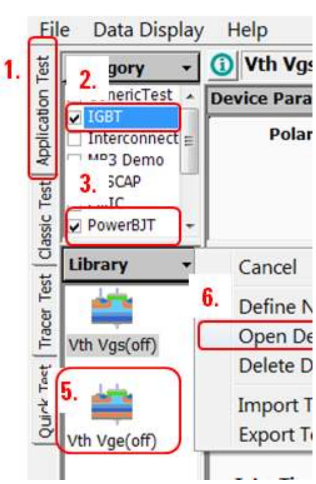
Step 17. Click "OK" to confirm the overwrite of the test definition.
Close the Application Test editor.

Figure A1-6. To save the new Application Test definition.



A1-2-1. Modification of Vth Vgs (off):

A1-2-2. Modification of Vth Vge(off) - IGBT:



Modify the Vth Vge(off) Application Test definition by following the same steps for the Vth Vgs(off) from figure A1-4 to A1-6 by changing the step 8 as follows:.

Replace step 8 line of figure A1-5 with the following step.

Step 8. Scroll down the vertical bar of the Test Parameter Definitions area until ***Collector*** term shows up.

Appendix 2. Desktop EasyEXPERT Software

You can install Desktop EasyEXPERT software on your Windows PC.

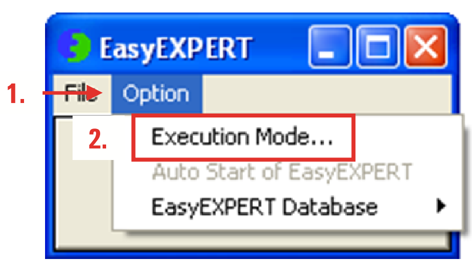
Desktop EasyEXPERT holds exactly the same capability of the B1505A`s EasyEX-PERT, and it expands your B1505A demonstration in the following aspects;

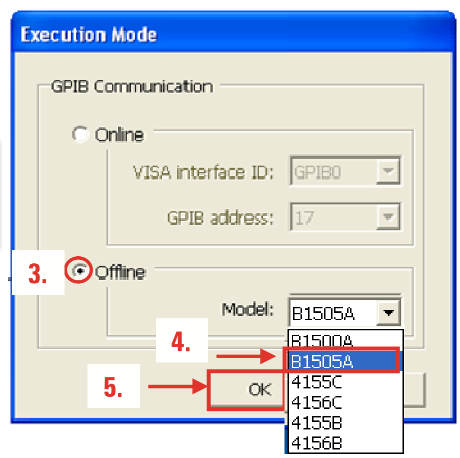
1. You can keep all the measurement results made on demo B1505A, and recall the test results after you return the demo B1505A or even in offline.
2. You can check EasyEXPERT functionality in offline.
3. You can use a larger window area of your PC when analyzing your data with the PC software.
4. If you want, you can control B1505A from your PC as the same way as the native B1505A`s EasyEXPERT.

- To Install Desktop EasyEXPERT Software
  Follow the instruction of the Desktop EasyEXPERT installation.

- To Start Desktop EasyEXPERT (Offline Mode):
  1. Click the "Desktop EasyEXPERT" icon on your Windows desktop.

  2. Start EasyEXPERT window opens





  3. Before starting Desktop EasyEXPERT, we set Desktop EasyEX-PERT options as shown next.

Step 1. Click "Option".

Step 2. Click "Execution Mode..."
Execution Mode window opens.
Desktop EasyEXPERT has following two operation mode;

1. Online mode:
   Such as B1505A, B1500A and 4155/56 B/C can be controlled via GPIB.
2. Offline mode:
   Creating application library and data analysis can be made.

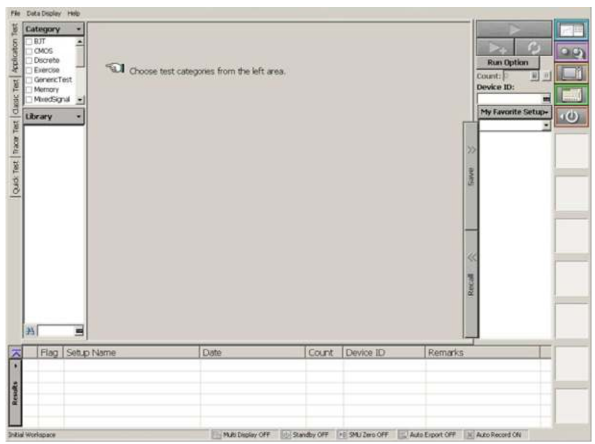
Step 3. We`ll select offline mode.
Check "Offline".

Step 4. Select measurement model: Click "B1505A"

Step 5. Click "OK", and close the Execution Mode window.

4. Click Start EasyEXPERT button.

Offline mode B1505A Desktop EasyEXPERT opens.



Appendix 3. Before returning the Demo B1505A

If your practice of this measurement handbook is with an Agilent Demo B1505A, you may want to keep your measurement data for future reference and want to delete your foot print from the Demo B1505A before returning it to Agilent.

This section provides information about this topic.

A3-1. Saving the measurement data

You can save the measurement data in several formats.
This section introduces to save the data in EasyEXPERT format so that you can import the data to B1505A or Desktop EasyEXPERT for keeping the maximum flexibility for managing the data.

You can download Desktop EasyEXPERT software and can install to your Windows PC.

Please keep the original Application Test library of this measurement handbook if you are exporting your data as EasyEXPERT format.
When you upload your data to Desktop EasyEXPERT software, you are required to install the Application Test library first before importing the measurement data in case where the parent application library is not installed in the EasyEXPERT.

[Exporting procedure]

Follow the instructions shown in figure A3-1. The number in the figure corresponds to the following step number.

Step 1. Click the upper arrow for expanding the results area.

Step 2. Results area expands as shown in the right side figure.

Step 3. Select the data to export. Selected data changes the background color to blue as shown in the figure.

Step 4. Left click "Results" bar.
Result area menu opens.

Step 5. Select "Transport Data".
Next menu appears.

Step 6. Select "Export As Compressed Test Result ...".
Then "Compressed Test Result Export" Explore opens.
Enter file name and save your data to an appropriate recording media.

Note: Your saved data is the same format as the example results data used in this measurement handbook.
Use the same steps when you recover your data in different EasyEXPERT software.

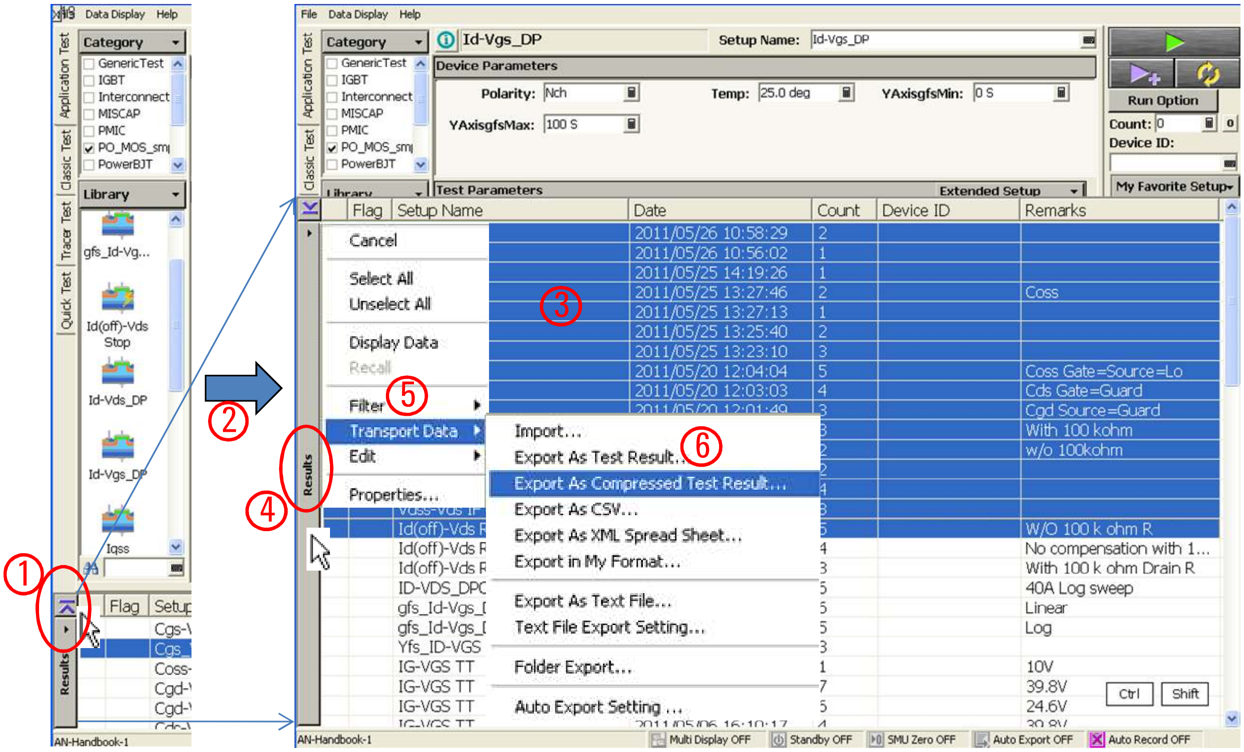


Figure A3-1. Expanding the Results area and select measurement data sets.

A3-2. Deleting the workspace and measured data

Deleting of your foot print from the Demo B1505A is easiest by deleting your workspace from the Workspace management page.

You can open the Workspace management page by standard startup process or using the methods shown in section 2-5-1. figure case 1.

Figure A3-2 shows the steps for deleting existing Workspace.
Follow the instruction steps as follows. The instruction steps match the number in the figure.

Please be careful doing your work since there is no way for recovering the data once it has been erased.

[Deleting procedure]

Step 1. Check "Your Workspaces:".

Step 2. Press "Manage Workspace" button.

Step 3. Workspace manager sub window opens.

Step 4. Select the Workspace name from the "Available Workspaces:" list.

Step 5. Press "Delete" button. Confirmation sub-window pops up.

Step 6. Press "OK" button in the Confirmation sub-window.

Your Workspace is deleted with all of your data and setups from EasyEXPERT.

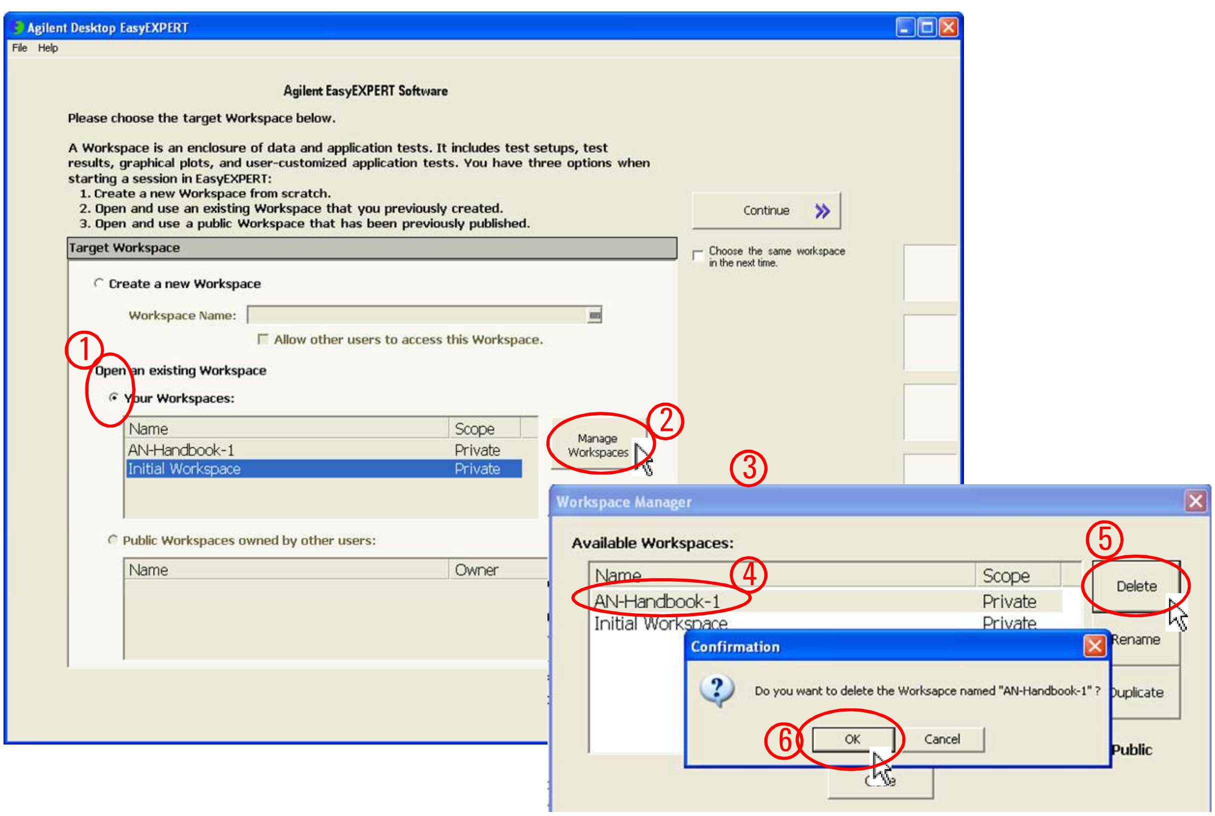


Figure A3-2. Deleting existing Workspace from EasyEXPERT.

Appendix 4. Returning the Demo B1505A

When returning the Demo B1505A, please make sure all the items are packed as delivered to you.

Please make sure to delete your workspace created for the demonstration for protecting any of your private data.
Refer to appendix B section for deleting your workspace.

In addition, please be sure to delete any confidential data stored in the EasyEXPERT or Windows file system.

Note:

Agilent technologies will not delete any of the data when renting the demonstration B1505A to the next user.

B1505-90060
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