Keysight B1505A
Power Device Analyzer/Curve Tracer

For the tests up to 40 A/
3000 V by Dual HCSMU/
HVSMU

KEYSIGHT
TECHNOLOGIES

Quick Start Guide

NOTICE: This document contains references to Agilent Technologies. Agilent's former Test and Measurement business has become Keysight Technologies. For more information, go to **www.keysight.com.**

Contents

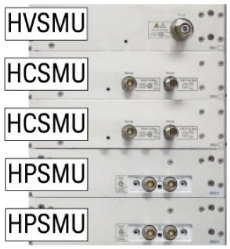
Before Using B1505A

WARNING **There are potentially hazardous voltages (3000 V for HVSMU, and 200 V for HPSMU) present at the Force, Sense, and Guard terminals of Keysight 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).
- 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 to connect the DUT to the outside 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, regardless of the B1505A settings.
  - Press the Stop key to turn off the module output.
  - Confirm that the High Voltage indicator is not lit.
  - Open the shielding box access door.
  - Discharge any capacitors connected to an SMU.

Instruments and Accessories Used in This Demo

- Keysight B1505A Power Device Analyzer / Curve Tracer
  - 1 x HVSMU (B1513A) High Voltage SMU
  - 2 x HCSMU (B1512A) High Current SMU
  - 2 x HPSMU (B1510A) High Power SMU
- Keysight N1259A High Power Test Fixture
  - N1259A-020 High Voltage Bias Tee
  - N1259A-300 Module Selector
  - N1259A-010 Inline package socket module (3 pin)
  - N1259A-022 100 kΩ R-Box
  - N1259A-033 1 kΩ R-Box
  - 11 x Test leads
- Keysight 16493S-021 Dual HCSMU Combination Adapter
- Cables
  - 2 x 16493S-001 HCSMU Cable, 1.5m
  - 1 x 16493T-001 HVSMU Triax Cable, 1.5m
  - 4 x 16494A-001 Triax Cable, 1.5m
  - 1 x 16493L-001 GNDU Cable, 1.5m
  - 1 x 16493J-001 Interlock Cable, 1.5m
  - 1 x 16493G-001 Digital I/O Cable, 1.5m



B1505A Modules


N1259A Test Fixture


16493S-021
Dual HCSMU Combination Adapter


16493S-001
HCSMU Cable


16493T-001
HVSMU Cable


16494T-001
Triax Cable


16493J-001
Interlock Cable


16493G-001
Digital I/O Cable

Demo Devices for 40 A/3000 V Application

Power MOSFET: International Rectifier IRFP2907

- Max Id: 209 A (25 °C), 148 A (100 °C)
- Max Pd: 470 W (25 °C)
- BVdss: >75 V (Id = 250 µA, Vgs = 0 V)
- Idss: <20 µA (Vds = 75 V, Vgs = 0 V)
- Igss: <200 nA (Vgs = ±20 V, Vds = 0 V)
- Vgs(off): 2.0 V – 3.5 V (Vds = 10 V, Id = 250 µA)
- gfs: >130 S (Vds = 25 V, Id = 125 A)
- Rds(on): <4.5 mΩ, typ. 3.6 mΩ (Id = 125 A, Vgs = 10 V)
- Ciss: typ. 13000 pF (Vds = 25 V, f = 1 MHz)
- Coss: typ. 2100 pF (Vds = 25 V, f = 1 MHz)
- Crss: typ. 500 pF (Vds = 25 V, f = 1 MHz)

Power MOSFET: Sanyo 2SK3745LS

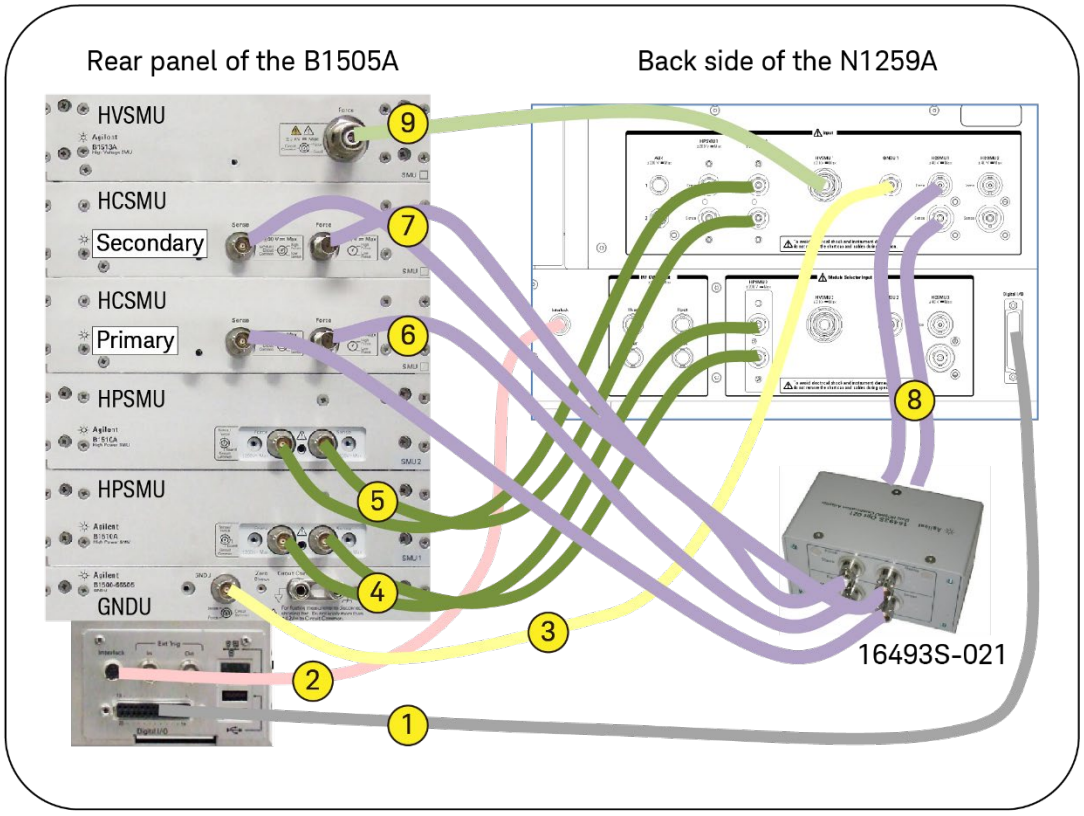
- Max Id: 4 A (25 °C, pulsed)
- Max Pd: 35 W (25 °C)
- BVdss: >1500 V (Id = 1 mA, Vgs = 0 V)
- Idss: <100 µA (Vds = 1200 V, Vgs = 0 V)
- Igss: <10 µA (Vgs = ±16 V, Vds = 0 V)
- Vgs(off): 2.5 V – 3.5 V (Vds = 10 V, Id = 1 mA)
- |yfs|: >0.7 S, typ. 1.4 S (Vds = 20 V, Id = 1 A)
- Rds(on): <13 Ω, typ. 10 Ω (Id = 1 A, Vgs = 10 V)
- Ciss: typ. 380 pF (Vds = 30 V, f = 1 MHz)
- Coss: typ. 70 pF (Vds = 30 V, f = 1 MHz)
- Crss: typ. 40 pF (Vds = 30 V, f = 1 MHz)

Power Bipolar Junction Transistor: On-semiconductor MJL4281AG

- Max Ic: 15 A (25 °C, DC)
- Max Pd: 230 W (25 °C)
- Vce(sus): >350 V (Ic = 50 mA, Ib = 0 A)
- Iceo: <100 µA (Vce = 200 V, Ib = 0 A)
- Icbo: <50 µA (Vcb = 350 V, Ie = 0 A)
- Iebo): <5.0 µA (Veb = 5.0 V, Ic = 0 A)
- hFE: 80 - 250 (Ic = 0.1 - 5 A, Vce = 5 V)
- Vce(sat): <1 V (Ic = 8 A, Ib = 0.8 A)
- Vbe(sat): <1.4 V (Ic = 8 A, Ib = 0.8 A)
- Vbe(on): <1.5 V (Ic = 8 A, Vce = 5 V)
- Cob: <600 pF (Vcb = 10 V, Ie = 0 A, f = 1 MHz)

Connections for the Demo

Before starting the demo, connect the cables between the B1505A and the N1259A.

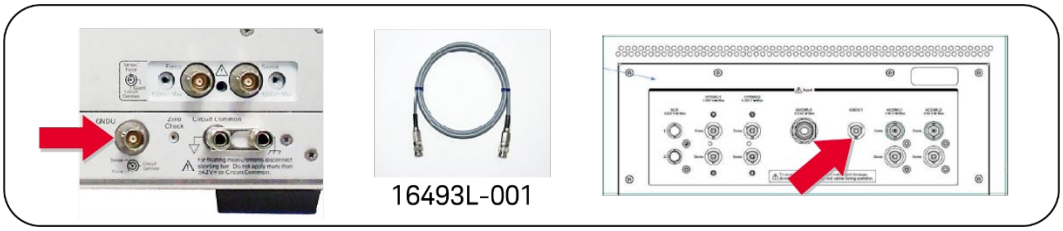


Procedure:

1. Using a 16493G Digital I/O Cable, connect the Digital I/O connector on the B1505A to the Digital I/O connector on the N1259A test fixture.

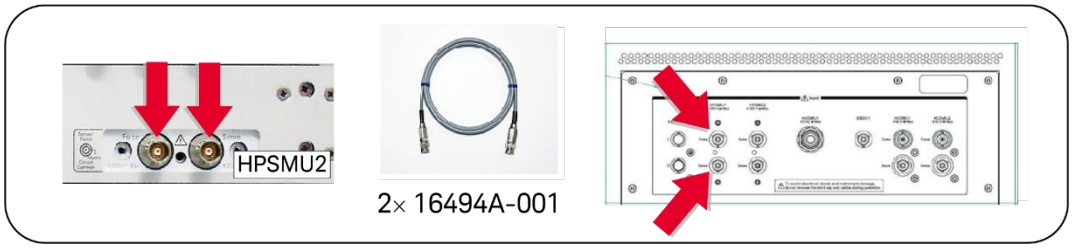
2. Using a 16493J Interlock Cable, connect the Interlock on the B1505A to the Interlock on the N1259A.

3. Using a 16493L GNDU Cable, connect the GNDU on the B1505A to the GNDU1 input on the N1259A.



4. Using two 16494A Triax Cables, connect the Force and Sense connectors on the lower B1510A HPSMU (SMU1) to the respective connectors on the HPSMU3 (built-in module selector input) of the N1259A.

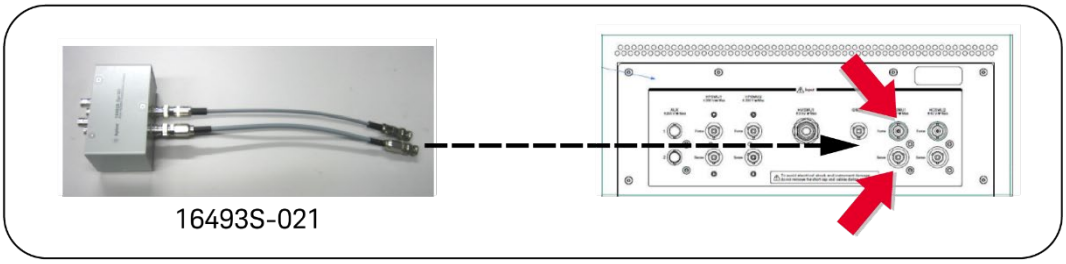
5. Using two 16494A Triax Cables, connect the Force and Sense connectors on the upper B1510A HPSMU (SMU2) to the respective connectors on the HPSMU2 of the N1259A.



6. Using a 16493S HCSMU Cable, connect the Force and Sense connectors on the lower B1512A HCSMU to the *primary* input of 16493S-021 Dual HCSMU Combination Adapter.

7. Using a 16493S HCSMU Cable, connect the Force and Sense connectors on the upper B1512A HCSMU to the *secondary* input of 16493S-021 Dual HCSMU Combination Adapter.

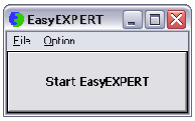
8. Connect BNC and Triax connecters from the 16493S-021 to the respective connectors on the HCSMU1 of the N1259A.



9. Using a 16493T HV Triax Cable, connect the Force connector on the B1513A HVSMU to the HVSMU1 of the N1259A.

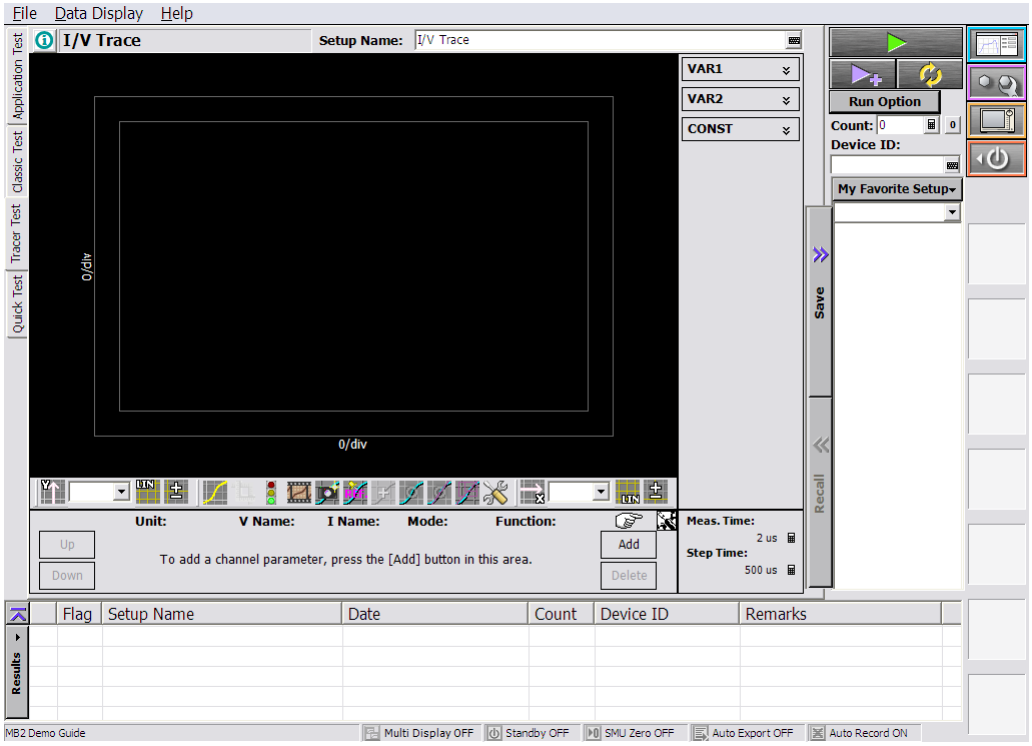
Start B1505A

After connecting the cables, power on the B1505A, and then start the EasyEXPERT software.



If you experience any problem, refer to the manuals (B1505A User's Guide, EasyEXPERT Software User's Guide, EasyEXPERT Application Library Reference, etc.) for more details on the EasyEXPERT software.

You will see the following start-up screen.



Lab 1. 40 A Measurements in Tracer Test Mode

Objective

B1505A has a Tracer Test mode, designed for a simpler, more intuitive, and easier operation than on the traditional curve tracers. It is also much easier to use and offers more functions than traditional curve tracers. B1505A also has a Classic Test mode that offers a user interface compatible with the 4155C/4156C Semiconductor Parameter Analyzer. This section describes how to make 40 A measurements by using the dual HCSMU mode.

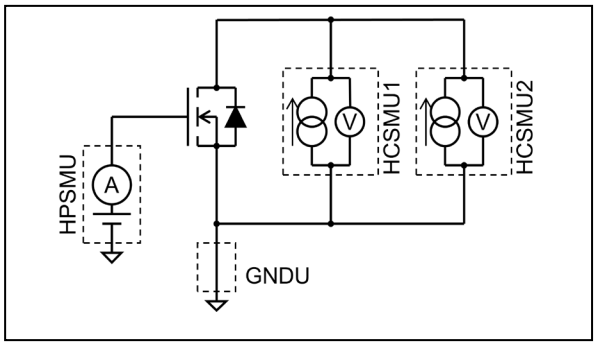
Key points

- Dual HCSMU mode for 40 A and 2 A coverage in pulsed and DC mode, respectively
- Snapshot for observing the thermal drift effect
- Power compliance to reduce self-heating
- Dual polarity sweep

Device

MOSFET (IRFP2907)

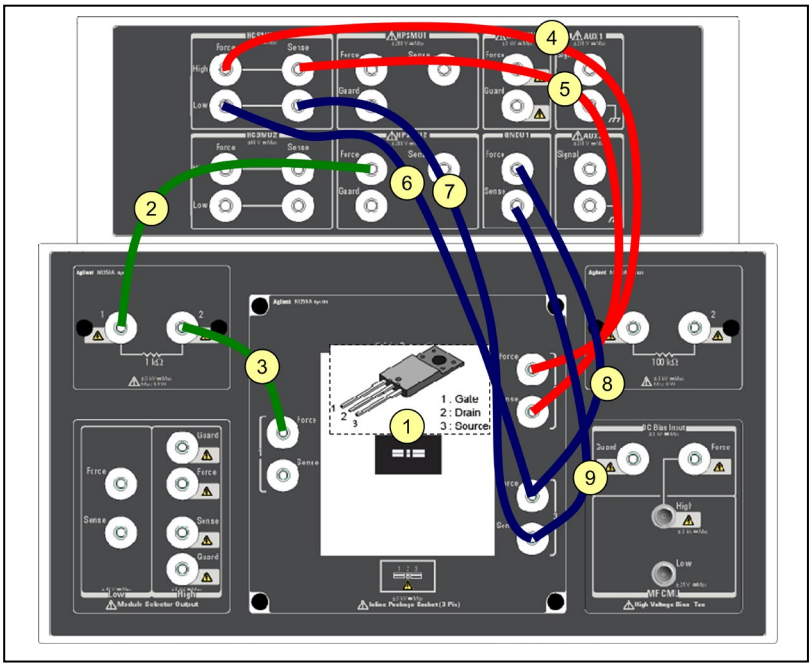
Connection diagram



Setup

First, make sure the output of 16493S-020 Dual HCSMU Combination Adapter is connected to the HCSMU1 on the rear panel of the N1259A.

Then, open the N1259A test fixture cover, and connect the test leads (banana-banana wires), referring to the drawing on the right. The numbers on the



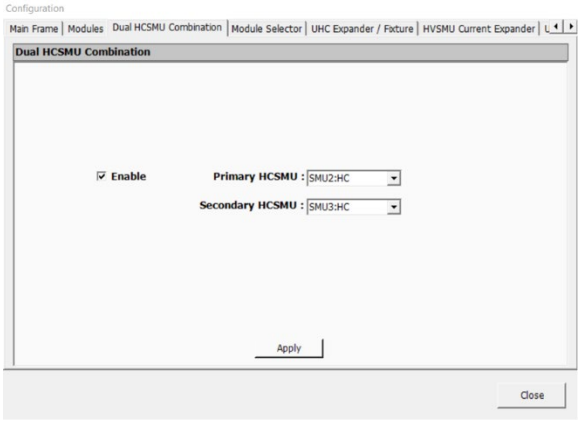
drawing correspond to the procedure steps.

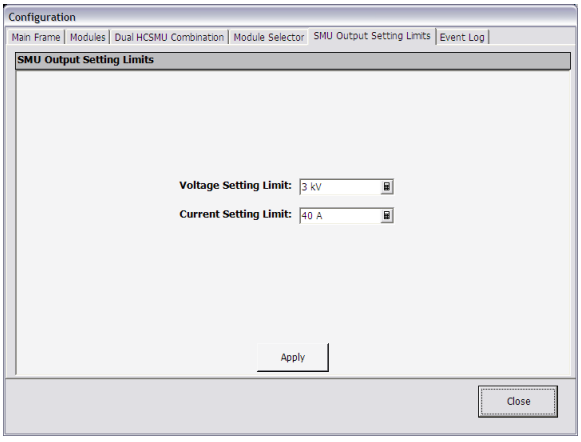
1. Insert the device (IRFP2907) into the socket on the N1259A.
2. Connect the HPSMU2 Force to terminal 1 on the 1 kΩ resistor.
3. Connect terminal 2 on the 1 kΩ resistor to the terminal 1 Force (Gate) on the Inline Package Socket.
4. Connect the High Force of the HCSMU1 to the terminal 2 Force (Drain) on the Inline Package Socket.
5. Connect the High Sense of the HCSMU1 to the terminal 2 Sense (Drain) on the Inline Package Socket.
6. Connect the Low Force of the HCSMU1 to the terminal 3 Force (Source) on the Inline Package Socket.
7. Connect the Low Sense of the HCSMU1 to the terminal 3 Sense (Source) on the Inline Package Socket.
8. Connect the Force of the GNDU1 to the terminal 3 Force (Source) on the Inline Package Socket.
9. Connect the Sense of the GNDU1 to the terminal 3 Sense (Source) on the Inline Package Socket.

Preparation

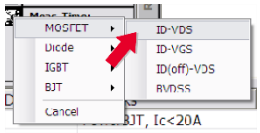
Setting two HCSMUs to dual HCSMU mode

1. Click the Configuration button  to open the Configuration window.
2. Click the Dual HCSMU Combination tab.
3. Check the Enable checkbox, and specify the correct HCSMU assignments for the Primary and Secondary HCSMUs.
4. Click the Apply button to complete the Dual HCSMU configuration.
5. Click the SMU Output Setting Limits tab.
6. Change the Current Setting Limit to 40 A.
7. Click the Apply button to complete the SMU Output Setting Limits configuration.
8. Click the Close button to close the Configuration window.

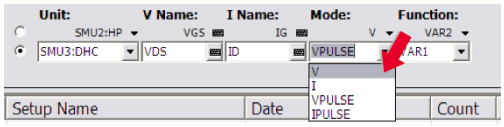


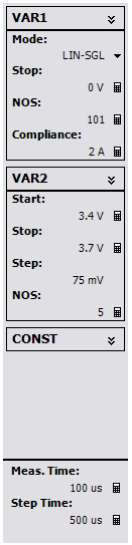


Procedures 1-1. Id-Vds measurements in DC mode

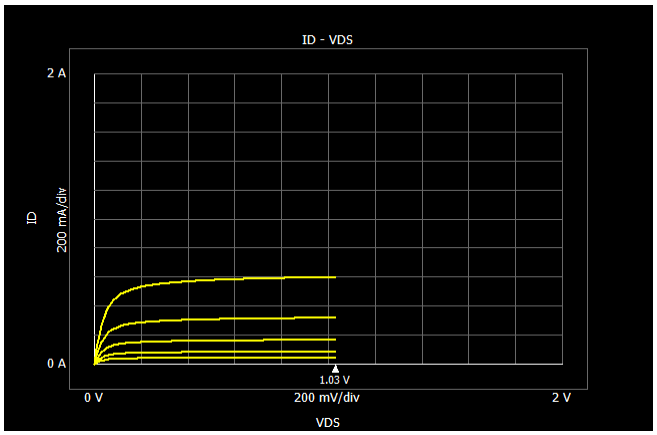


1. Click the (wrench and screw driver) icon .
2. Select the sample setup, MOSFET – ID-VDS.
3. Change the Mode of the SMU3:DHC (VAR1) from VPULSE to V.



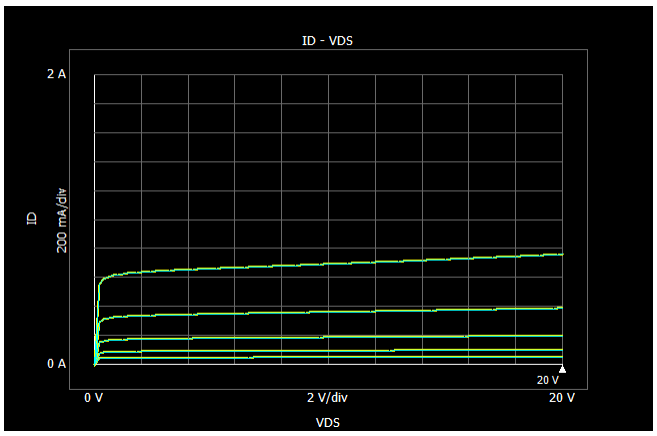


4. Set Compliance to 2 A in the VAR1 area.
5. Change the following fields in the VAR2 (VG) area.
   - VAR2 Start to 3.4 V.
   - VAR2 Stop to 3.7 V.
6. Change the Meas. Time field to 100 us.
7. Confirm that the settings are as shown in the picture on the right.
8. Click the Repeat button .
9. Click (select) the VAR1 (VD) Stop voltage.
10. Rotate the rotary knob on the front panel of the B1505A in the clockwise direction.
11. When the stop voltage increases to about 1 V, its graph is shown on the screen.



12. Increasing the stop voltage to 10 V drifts the families of traces to higher current regions.

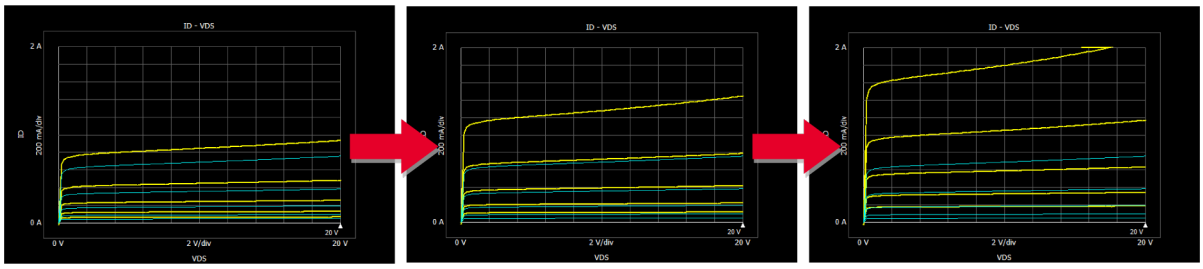
    You may hear some high pitched sound from the SMU. This is normal.



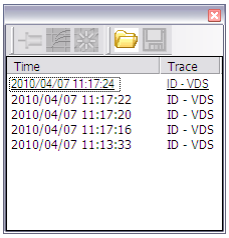
13. Click the Stop button to stop the measurements.
14. Enter “20” from the keyboard to the stop the voltage and then click the Single button . Then the measurements start one time and families of traces are drawn.

Snapshot for observing thermal drifts

15. Click the Capture button . You can capture the (reference) traces using this button. The captured traces are shown with blue lines.
16. Click the Repeat button . The families of traces will drift faster due to the self-heating effect. This is because of larger power dissipation at the MOSFET. You can also easily compare the families of traces for the captured traces in blue lines.

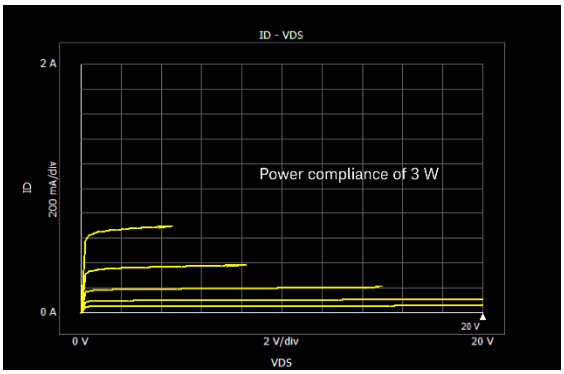


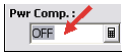
17. You can save multiple traces by clicking the Capture button .
18. The reference traces window (shown right) pops up when the Reference trace button is clicked. You can enable or disable the traces for the graph display.
19. Click the Stop button to stop the stimulus and measurement.



Power compliance

20. Click the VAR1 title bar VAR1 to see the details of the settings (Full mode).
21. Set the Pwr Comp. (power compliance) to 3 W.
22. Wait for the DUT to cool.
23. Start the measurement again. (Click the Repeat button .)
24. You will now see the graph on the right, which is limited to 3 W, with smaller drifts.
25. Click the Stop button to stop the stimulus and measurement.



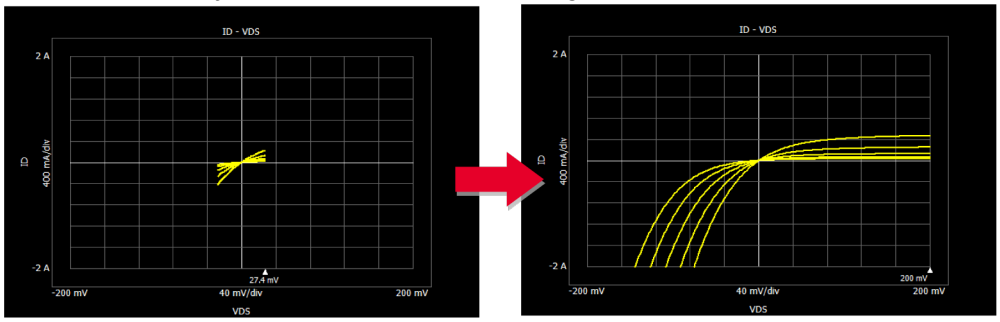


26. Change the Pwr Comp. to OFF.
27. Wait for the DUT to cool.

Dual polarity sweep

28. Click the Horizontal polarity icon VDS LIN twice to be plus-minus .
29. Click the Vertical polarity icon Y ID LIN twice to be plus-minus .
30. Change the VAR1 Dual Polarity to ON ON.
31. Click the VAR1 title bar VAR1 to hide the details of the settings.

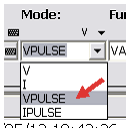
32. Click the VAR1 Stop and enter 0.
33. Click the Repeat button  to start the measurements.
34. Click the VAR1 Stop and rotate the rotary knob on the front panel of the B1505A in the clockwise direction. You will see a family of traces spreading in the four quadrants.
35. Rotate the rotary knob to increase the voltage.



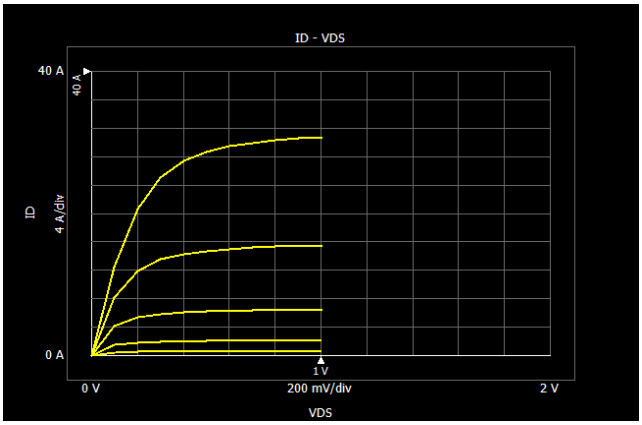
36. Click the Stop button  to stop the stimulus and measurement.

Procedures

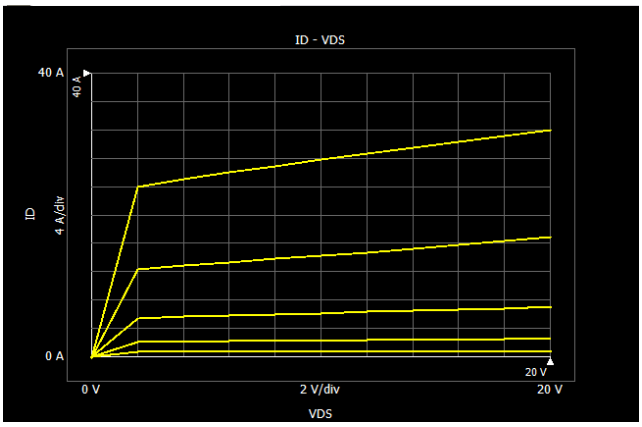
1-2. Id-Vds measurements in pulsed mode



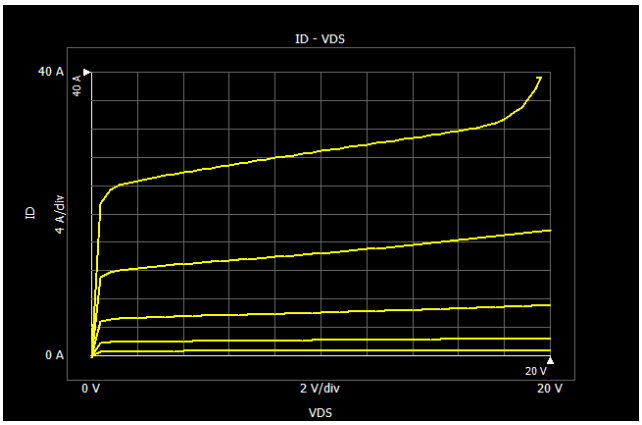
1. Change the Mode of the SMU3:DHC (VAR1) from V to VPULSE.
2. Click the VAR1 (VD) title bar  to see the details of the settings (Full mode), and change the settings as follows.
   - Stop to 1 V
   - Interlacing to 1
   - Compliance to 40 A
   - Pulse Width to 500 us
3. Change the following settings in the VAR2 (VG) area.
   - Start to 3.7 V
   - Stop to 4.4 V
4. Start the measurement again. (Click the Repeat button  .)
5. The graph is shown on the screen. The self-heating effect will be smaller than under the DC mode.



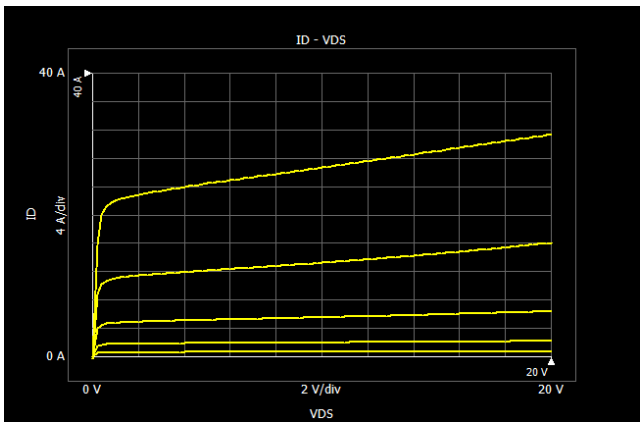
6. You can use the knob to change the stop voltage, etc. (Before changing voltage with the knob, you must click and select the stop voltage field.) For example, the right graph is the result of changing the VAR1 Stop to 20 V and VAR2 Stop to 4.3 V with the Pulse Width increased to 1 ms.



7. Increasing the number of steps (NOS) to 51 will result in the graph shown on the right. As you can see, some saturated area is observed at high voltage and current area. This is due to the self-heating effects with the 1% duty cycle.



8. When you increase Pulse Period to 1 s (duty = 0.1%) and NOS to 101, you will see a smooth graph, as shown on the right. Note that this measurement will take some time to complete (505 seconds).



9. Click the Stop button  to stop the stimulus and measurement.

Lab 2. Tracer Test Mode with Module Selector

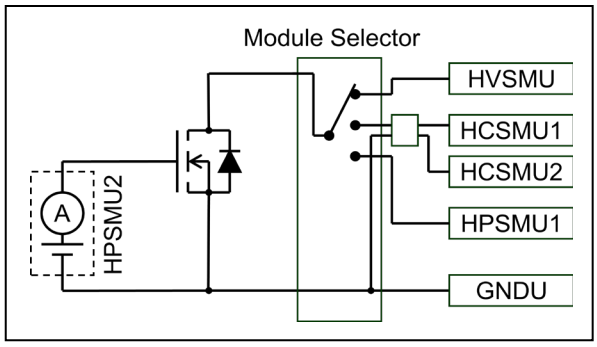
Objective B1505A has a Tracer Test Mode, designed for a simpler, more intuitive, and easier operation than on the traditional curve tracers. It is also much easier to use and offers more functions than traditional curve tracers. This section explains the usage and functions of the Tracer Test Mode with the module selector.

Key points

- Usability of the Trace Test mode
- Sample setup library for easy operation
- DC and pulse modes
- Snapshot for reference traces
- Auto data recording for breakdown measurements
- High voltage measurement
- Module selector to automatic switching

Device MOSFET (2SK3745LS)

Connection diagram



Setup The following procedures describe the connections between the N1259A Test Fixture and B1505A's modules. Note that changes from the settings for Lab 1 are covered.

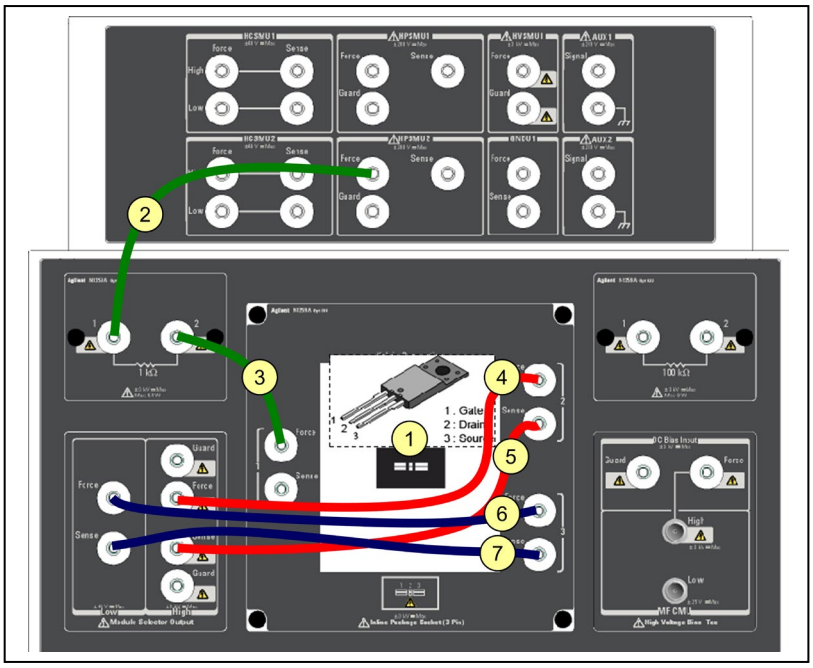
1. Disconnect the Force (BNC) and Sense (Triax) connecters of the 16493S-021 Dual HCSMU Combination Adapter from the HCSMU1 input of the N1259A, and reconnect them to the respective connectors on the HCSMU3 (HCSMU input of built-in module selector) of the N1259A.
2. Disconnect the Triax connector of the 16493L GNDU Cable from the GNDU1 input, and reconnect it to the GNDU2 (GNDU input of built-in module selector) of the N1259A.
3. Disconnect the Force (HV Triax) connecter of the 16493T HVSMU Triax Cable from the HVSMU1 input of the N1259A test fixture, and reconnect it to the HVSMU2 connector (HVSMU input of built-in module selector) of the N1259A.

Next, open the N1259A test fixture cover, and connect the test leads as follows. Refer to the drawing on the next page. The numbers on the drawing correspond to the procedure steps.

1. Insert the device (2SK3745LS) into the socket on the N1259A.

2. Connect the HPSMU2 Force to terminal 1 on the 1 kΩ resistor.
3. Connect the terminal 2 on the 1 kΩ resistor to the terminal 1 Force (Gate) on the Inline Package Socket.
4. Connect the High Force of the Module Selector Output to the terminal 2 Force (Drain) on the Inline Package Socket.
5. Connect the High Sense of the Module Selector Output to the terminal 2 Sense (Drain) on the Inline Package Socket.
6. Connect the Low Force of the Module Selector Output to the terminal 3 Force (Source) on the Inline Package Socket.
7. Connect the Low Sense of the Module Selector Output to the terminal 3 Sense (Source) on the Inline Package Socket.

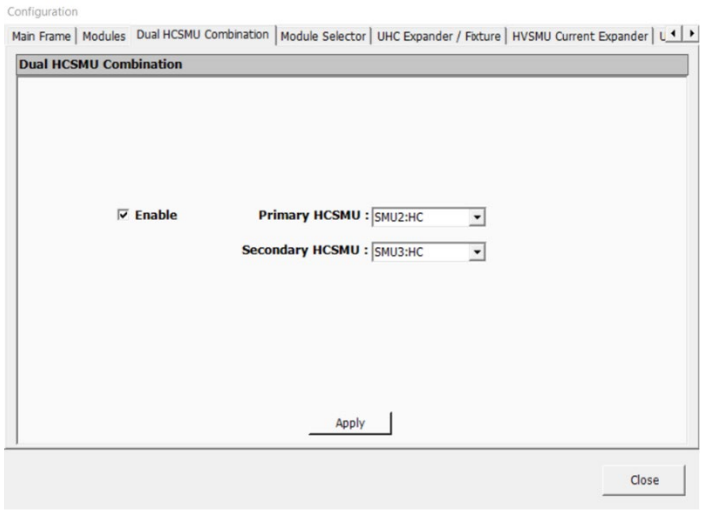
Close the N1259A fixture cover.



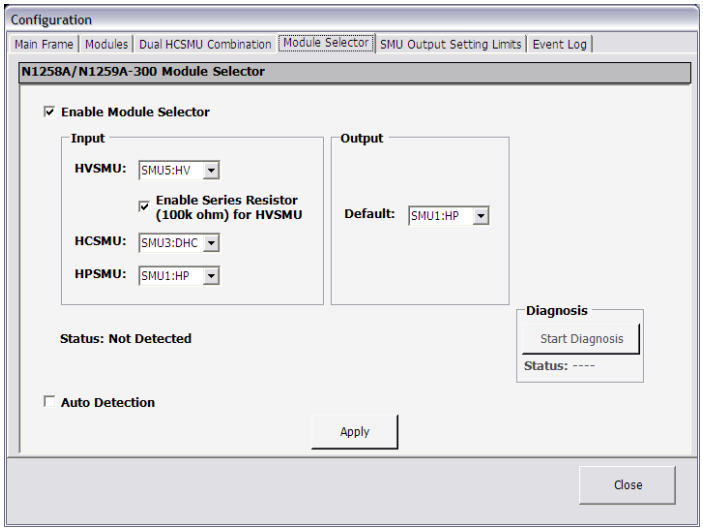
Preparation

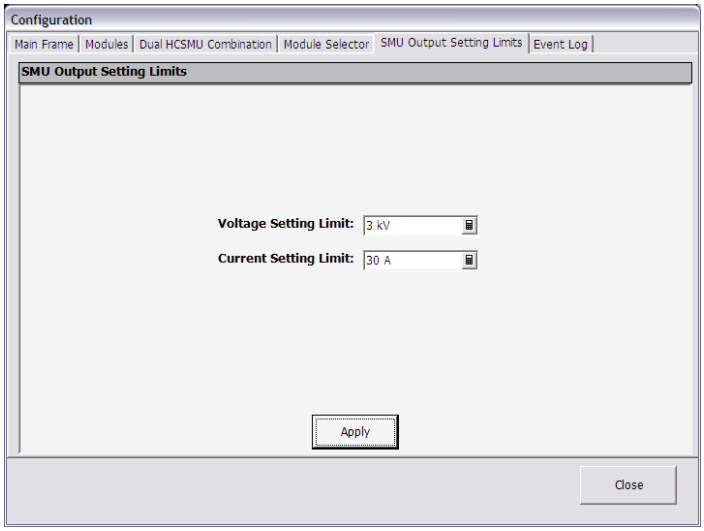
Setting two HCSMUs to dual HCSMU mode with using the module selector

1. Click the Configuration button to open the Configuration window.
2. Click the Dual HCSMU Combination tab.
3. Check the Enable checkbox, and specify the correct HCSMU assignments for the Primary and Secondary HCSMUs.



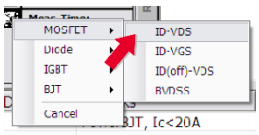
4. Click the Apply button to complete the Dual HCSMU configuration.
5. Click the Module Selector tab.
6. Change the module selector settings as shown in the figure on the right.
7. Click the Apply button to complete the module selector settings.
8. Click the SMU Output Setting Limits tab.
9. Change the Current Setting Limit to 30 A.
10. Click the Apply button to complete the SMU Output Setting Limits configuration.
11. Click the Close button to close the Configuration window.



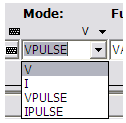


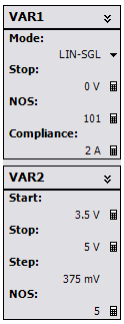
Procedures

2-1. Id-Vds measurements

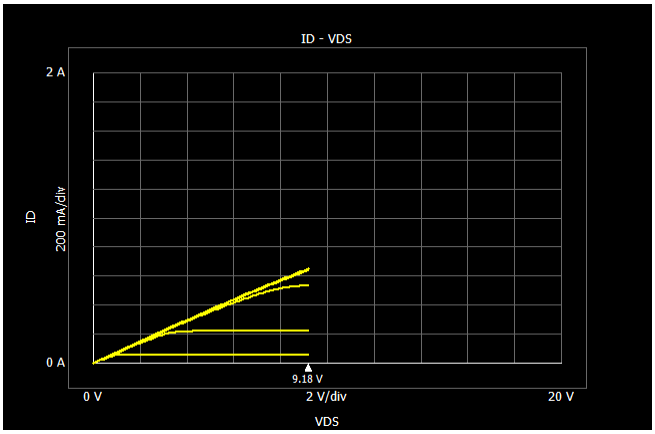


1. Click the (wrench and screw driver) icon .
2. Select the sample setup, MOSFET – ID-VDS.
3. Change the Mode of the SMU3:DHC (VAR1) from VPULSE to V.

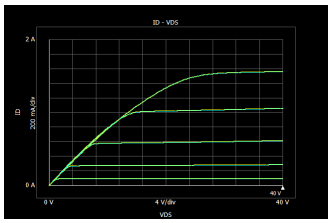


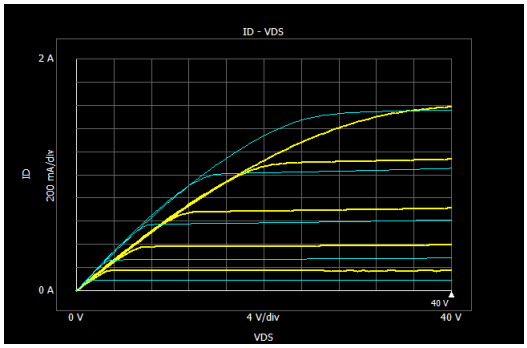


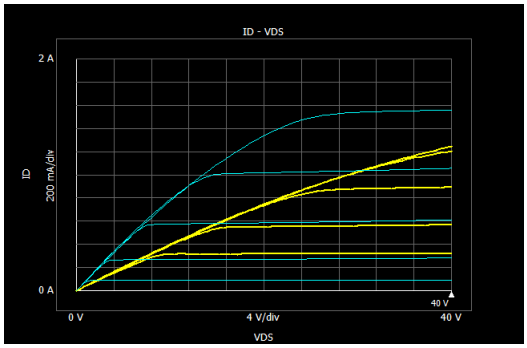
4. Change the VAR1 (ID) Compliance to 2 A.
5. Change the VAR2 Start (VG) to 3.5 V.
6. Change the VAR2 Stop (VG) to 5 V.
7. Confirm that the settings are as shown in the picture on the left.
8. Change the Meas. Time to 10 us.
9. Click the Repeat button .
10. Click (Select) the VAR1 (VD) Stop voltage.
11. Rotate the rotary knob on the front panel of the B1505A in the clockwise direction.
12. The stop voltage increases, and its graph is shown on the screen.
13. Click the Stop button to stop the stimulus and measurement.



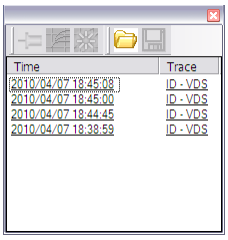
14. Set the VAR1 Stop to 40 V, and click the Single button .
15. Click the Capture button . You can capture the (reference) traces using this button. The captured traces are shown with blue lines.
16. Click the Repeat button again, then the graph will drift due to the self heating effect.



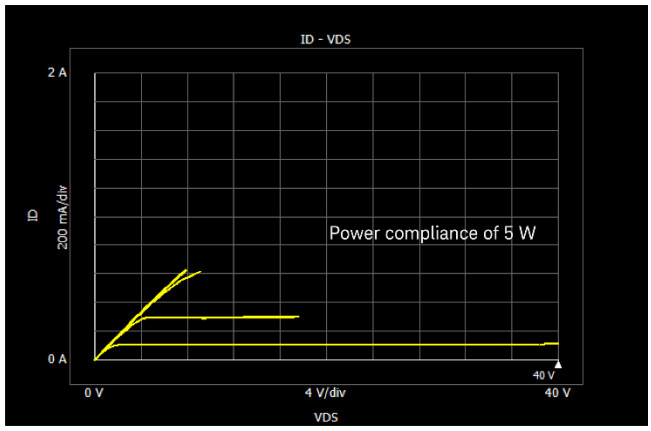


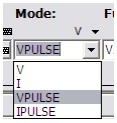


17. You can save multiple traces by clicking the Capture button .

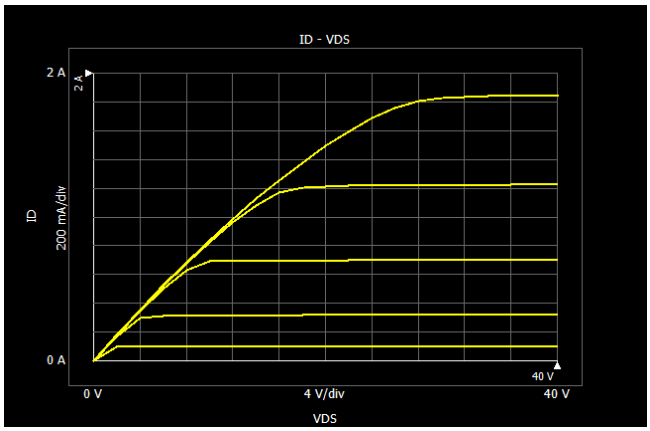


18. The reference traces window (shown left) pops up when the Reference trace button is clicked. You can enable / disable the traces for the graph display.
19. Click the Stop button to stop the stimulus and measurement.
20. Click the VAR1 title bar VAR1 to see the details of the settings (Full mode).
21. Set the Pwr Comp. (power compliance) to 5 W.
22. Wait for the DUT to cool.
23. Start the measurement again. (Click the Single button .)
24. You will now see the graph limited to 5 W.
25. Change the Pwr. Comp. to OFF.





26. Change the Mode of the SMU3:DHC (VAR1) from V to VPULSE.
27. Click the VAR1 title bar VAR1 to see the details of the settings (Full mode), and make the following changes.
    - NOS to 21
    - Interlacing to 1
    - Pulse Width to 500 us
    - Pulse Period to 50 ms (1% of pulse duty).
28. Click the Single button to start the measurement. Then you can see the following characteristics.

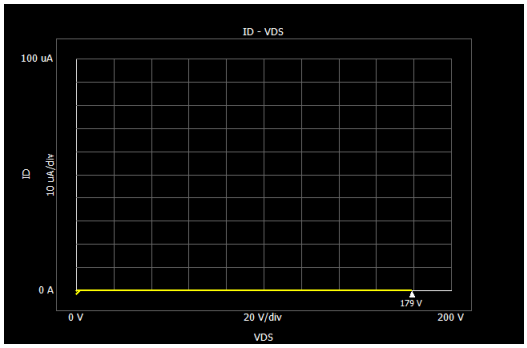


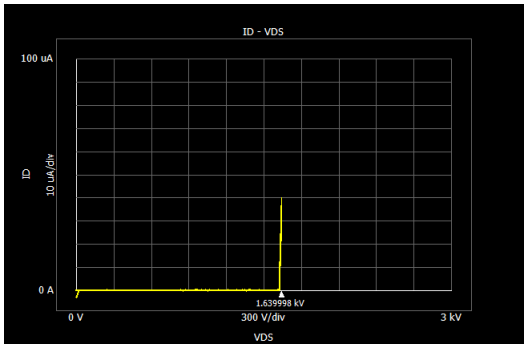
Procedures 2-2. BVdss measurements

We will configure the setups for a breakdown measurement (BVdss), and then, measure the device. Change these settings as follows.

1. Click the (wrench and screw driver) icon .
2. Select the sample setup, MOSFET – ID(off)-VDS.
3. Change the VAR2 Compliance to 1 mA.
4. Click the Repeat button .

5. Click (Select) the VAR1 (VD) stop voltage.
6. Rotate the rotary knob on the front panel of the B1505A in the clockwise direction. The stop voltage increases, and its graph is shown on the screen as shown below.
7. Since the DUT breakdown voltage is around 1600 V, you can rotate the knob quickly up to about 1400 V, but should slow down past 1400 V to see the breakdown.
8. Click the Stop button  to stop the stimulus and measurement.

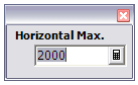




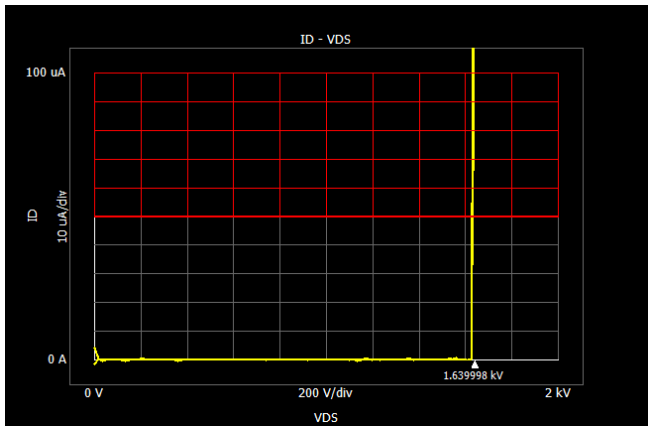
Auto recoding function

Next, we will setup the auto recording feature. Auto recording is a waveform recording function similar to the segment memory of an infiniium oscilloscope. It is commonly used for recording and reviewing the state before the breakdown.

9. Change the Meas. Time to 100 us.
10. Click the maximum number of X-axis to pop up a small numerical input window, and enter 2000.

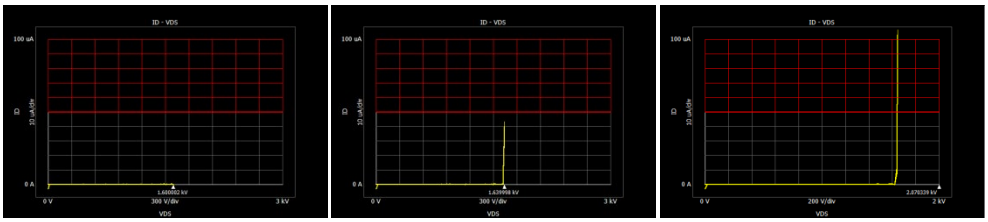


11. Set the stop region. When the stop region is effective, the measurement is automatically stopped when the measurement data enters the region. Click the signal button  , at the bottom of the graph. The button's signal changes to yellow  after clicking the button. (If the original signal color is not green, click the button a few times until the color change to yellow) You can now set the stop region.

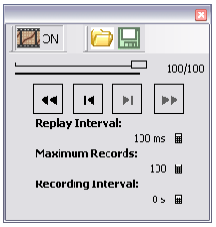


12. Click and drag on the graph. The selected grids will turn red to indicate the stop area.
13. Change the VAR1 Stop to 0 V.
14. Click the Repeat button  .

15. Click (Select) the VAR1 (Vd) Stop voltage.
16. Rotate the rotary knob on the front panel of the B1505A in the clockwise direction.
17. When the measured value enters the red area, the measurement will stop automatically.



18. Click the film icon (record and replay button) to review the measured data.
19. The following window will pop up. You can view the previous traces using the position indicator and the play back & forward buttons.



Lab 3. Application Test Mode
- Easy setups for Id-Vds, Id(off)-Vds, and Id-Vgs measurements

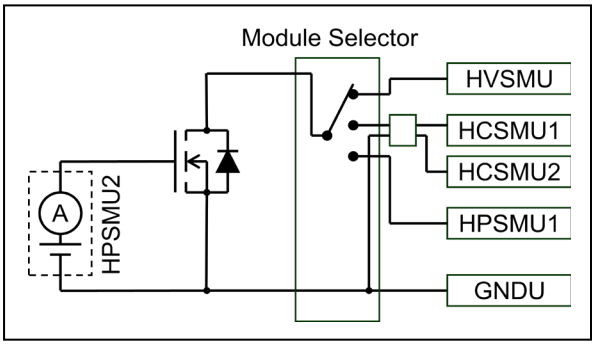
Objective In this section, you can experience the easy-to-use concept of the EasyEXPERT, and also learn about the performance of the HVSMU.

Key points

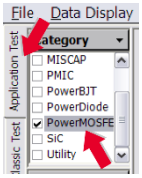
- Usability of the Application Test
- Low current measurement capability of the HVSMU.
- Automatic analysis

Device MOSFET (2SK3745LS)

Connection diagram



Setup The setup is identical to that for lab 2.

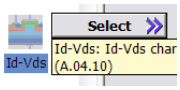


Procedures

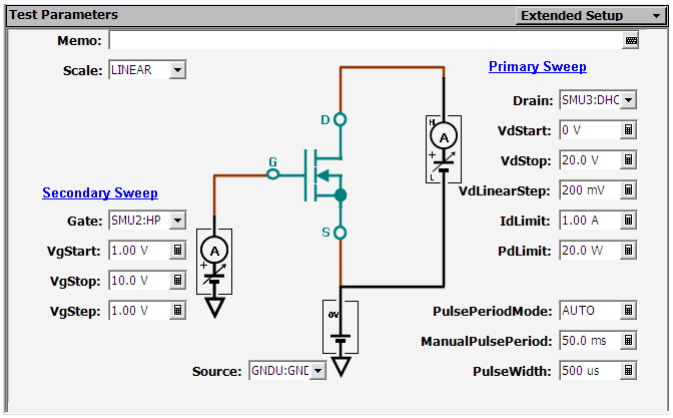
3-1. Id-Vds measurements

1. Click the Application Test tab.
2. Check the PowerMOSFET category.
3. Select Id-Vds (Click the Id-Vds then click Select 

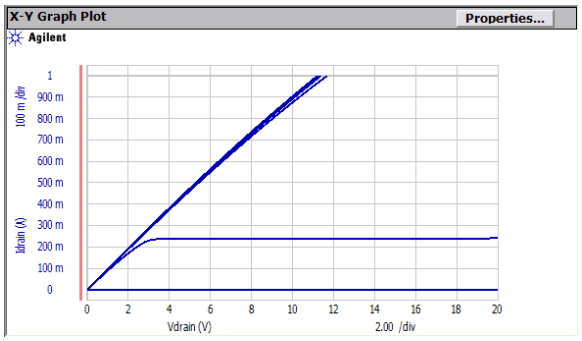
)

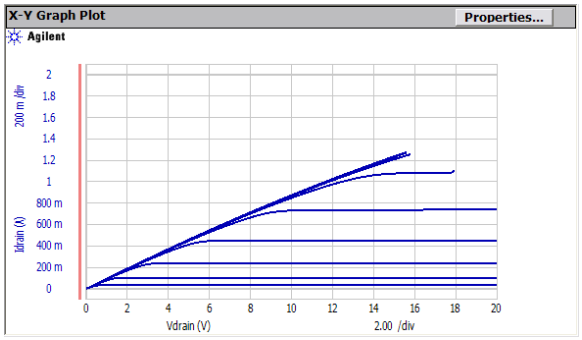


4. Select SMU3:DHC for Drain and SMU2:HP for Gate.
5. Confirm that the test parameters as shown in the picture below.



6. Start the measurement. (Click the Single button  .)
7. The graph window pops up and the measurement starts.
8. You will see the Id-Vd graph.
9. Since the gate voltage settings are not so good, change the gate voltage settings (VgStart = 3.5 V, VgStop = 5.5 V, VgStep = 250 mV, IdLimit = 2 A)
10. Measure again. (Click the Single button  .)
11. You can see more details on the graph.



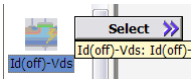


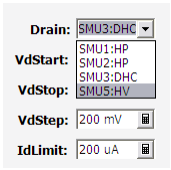
EasyEXPERT has many default applications for basic measurements. You can measure the device easily, by simply selecting the desired application. With an illustrative user interface, you can intuitively modify the parameters to suit your DUT.

Next, we will perform another measurement, again by simply selecting an application.

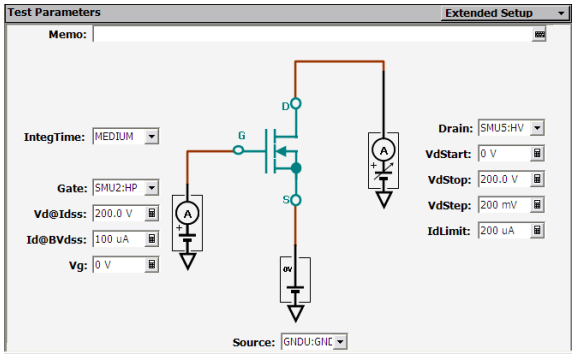
Procedures

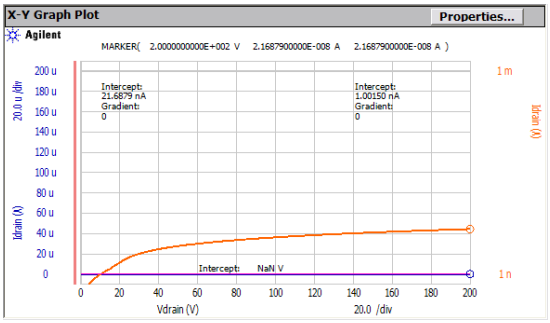
3-2. Id(off) - Vds measurements



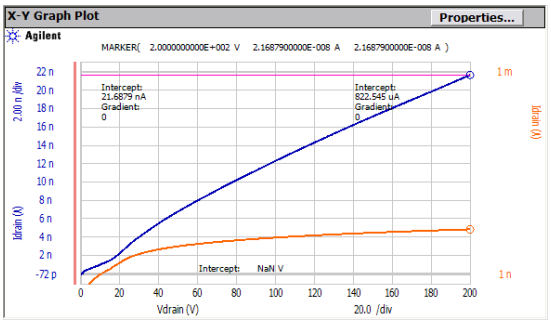


1. Select the application test, Id(off)-Vds.
2. Change Drain SMU to SMU5:HV.
3. Confirm that the settings are as shown in the picture below.



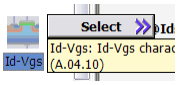


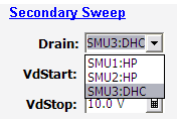
4. Start the measurement. (Click the Single button .)
5. The graph window pops up and the measurement starts.



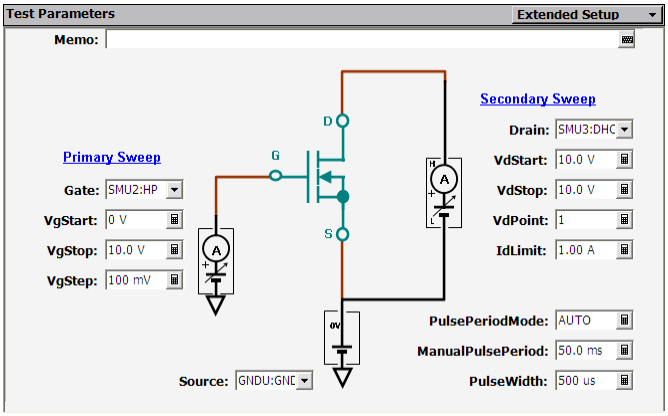
6. Since the vertical range of the graph is too large, change it by clicking the auto scale icon .

Procedures 3-3. Id - Vgs measurements

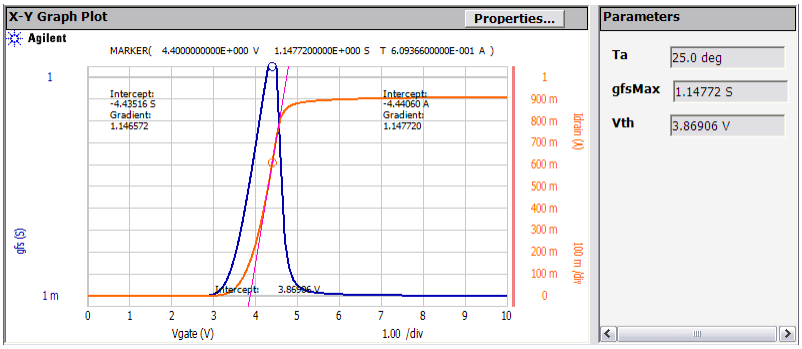




1. Select the application test, Id-Vgs.
2. Change Drain SMU to SMU3:DHC.
3. Confirm that the settings are as shown in the picture below.



4. Start the measurement. (Click the Single button .)
5. The graph window pops up and measurement starts.
6. After the measurement is completed, automatic analysis calculates the Vth and gfsMax.



Lab 4. Classic Test Mode
- Calculate emitter resistance (Re) from Ib-Vce measurements

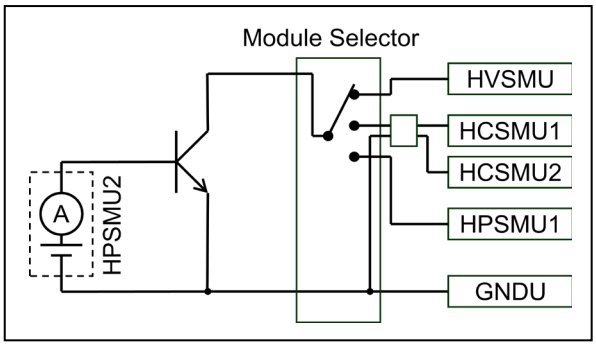
Objective In this section, HCSMU is used to measure a low voltage. Auto analysis is then used to measure and calculate the emitter resistance (Re).

Key points

- Low voltage measurement performance of the HCSMU
- Measurement function
- Analysis Function

Device Power Bipolar Transistor (MJL4281AG)

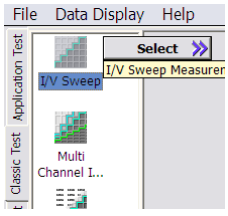
Connection diagram



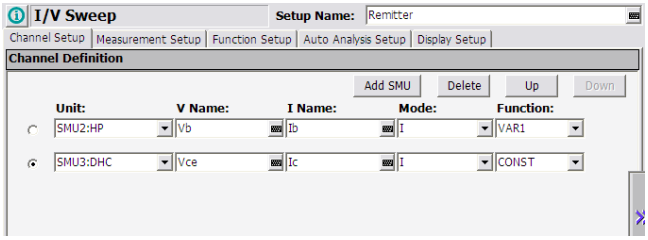
Setup The setup is identical to that for lab 3, except for the following change in the device and base connections.

1. Insert the device (MJL4281AG) into the socket on the N1259A.
2. Connect the HPSMU2 Force to terminal 1 Force (Base) on the Inline Package Socket.
3. Connect the HPSMU2 Sense to terminal 1 Sense (Base) on the Inline Package Socket.

Procedures **Emitter resistance (Re) measurements**



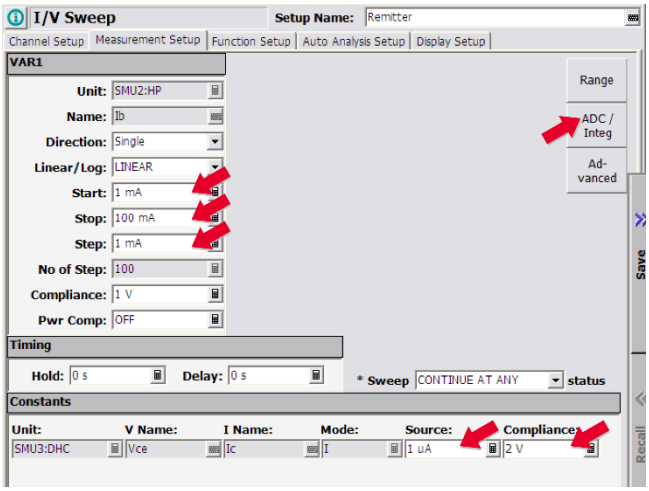
1. Click the Classic Test tab.
2. Select I/V Sweep.
3. Enter a measurement name, for example, “Remitter” in the Setup Name field.
4. Configure the Channel Setup as shown below.



5. Configure the Measurement Setup as follows.

   VAR1 (Ib sweep) Start 1 mA, Stop 100 mA, Step 1 mA

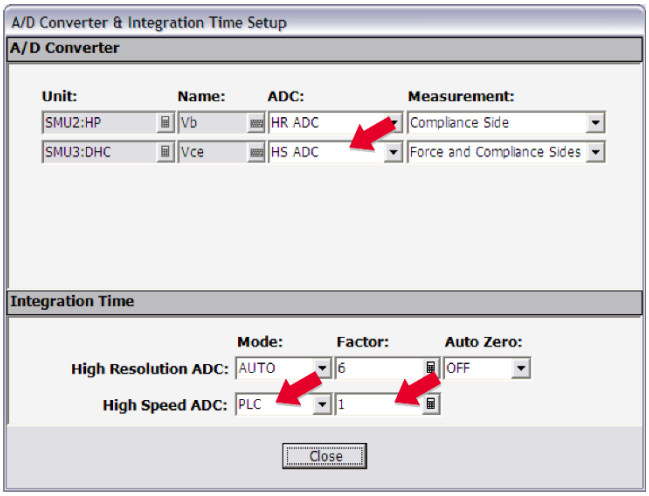
   Constants SMU3:HC Source:1 mA, Compliance: 2 V



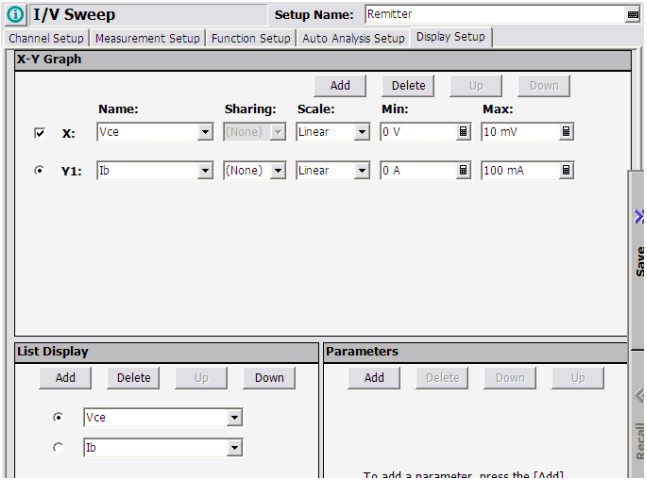
6. Click the ADC/Integ button on the Measurement Setup, and configure the A/D converter as follows.

   SMU3:HC HSADC

   Hi Speed ADC Mode = PLC, Factor =1

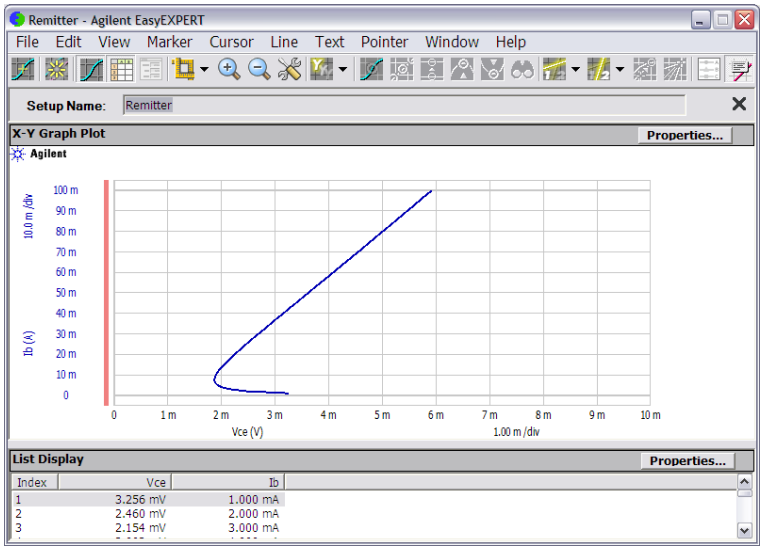


7. Next, Configure the Display setup as follows.



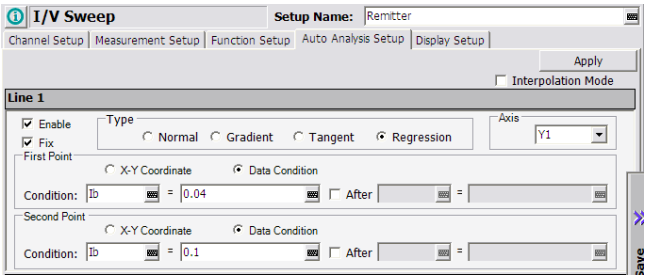
8. Start the measurement. (Click the Single button)

9. The graph window pops up, and the Ib - Vce trace is shown in the low Vce region.

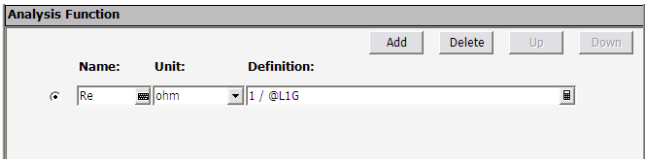


Next, we will use the auto analysis function to calculate the emitter resistance Re (ohm). The Re is calculated from the gradient of the Ib–Vce curve. In this case, the curve of the Ib from 40 mA to 100 mA is almost straight, so we can use the data in that area to make a regression line.

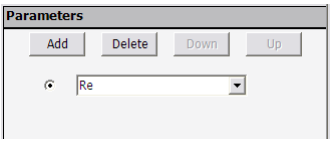
10. Click the Auto Analysis Setup tab.
11. Check Enable for Line 1.
12. Select the Regression as the Type.
13. Select Data Condition for the First Point and the Second Point.
14. Set the conditions as shown below.



15. Select the Function Setup tab.
16. Write an Analysis Function (NOT a User Function) as follows.

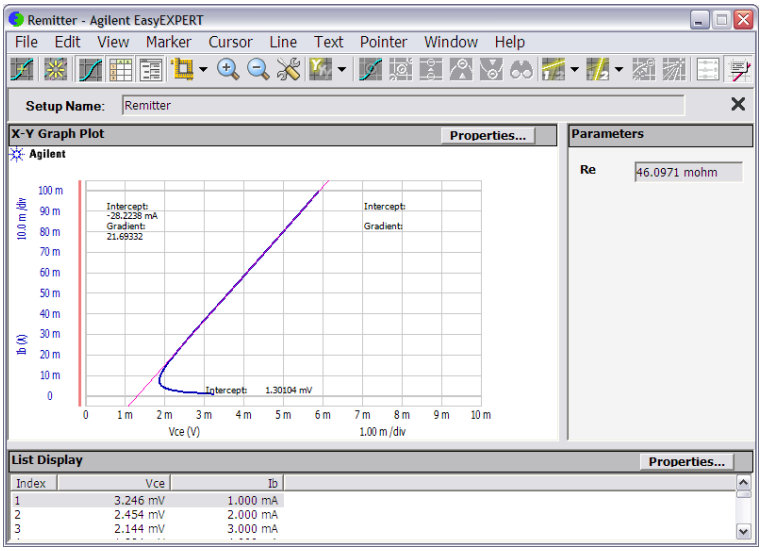


17. Click the Display Setup tab, and add the Parameter Re.



18. Start the measurement. (Click the Single button .)

19. The graph window pops up. After finishing the measurement, two cursors and a regression line are automatically drawn. Then the Parameter Re is calculated.



Lab 5. Data Analysis on Your PC with EasyEXPERT group+ - Easy data transfer and analysis

Objective

EasyEXPERT group+ software is also available on your PC. It offers almost the same environment as B1505A. Using EasyEXPERT group+, you can control B1505A from your PC. You can also check and analyze data, collected with B1505A.

B1505A is designed for the Windows OS environment, and has high affinity with other Windows software such as Microsoft Excel.

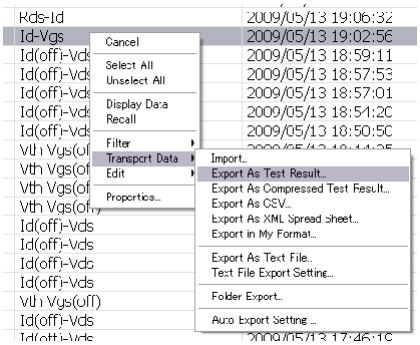
Key points

- EasyEXPERT group+ usability
- Compatibility
- Exporting data for other software

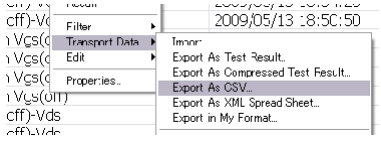
Procedures

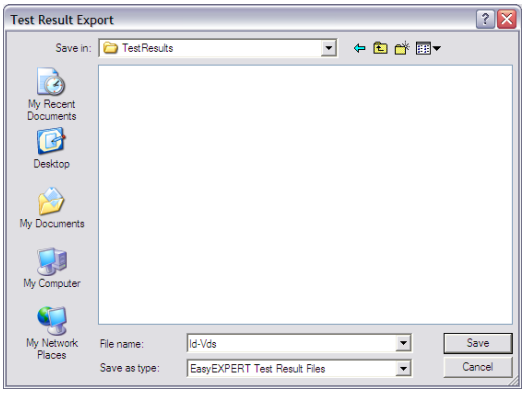
B1505A to EasyEXPERT and Excel on your PC

1. Insert a USB flash drive into the B1505A.
2. Select the measurement data you want to export.
3. Right click and select Transport Data - Export As Test Result. (This is for EasyEXPERT.)



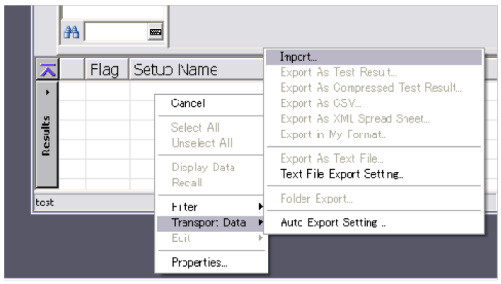
4. Save the file onto the USB flash drive. (Specify the directory and file name as you desire)
5. Repeat steps 2 through 4 to export the data in CSV format (this time, select Export As CSV... instead of Export As Test Result)

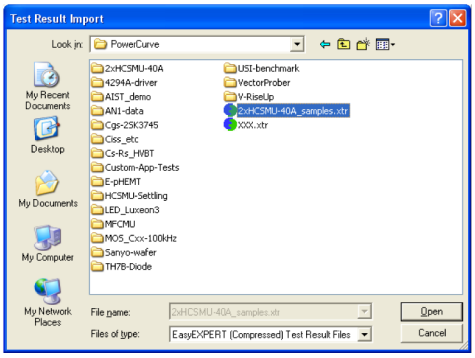




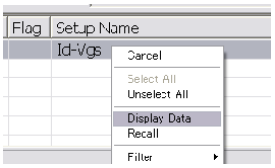
6. Remove the USB flash drive from the B1505A. (NOTE: Be sure to remove the USB memory according to the safe removal procedure of Windows.)
7. Turn on your PC and start EasyEXPERT.
8. Insert the USB flash drive into the PC.

9. Right click on a Results field.
10. Select Transport Data - Import.

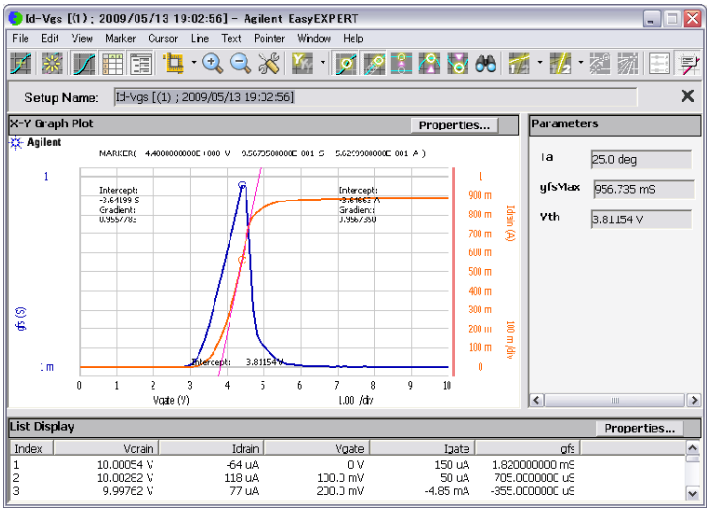




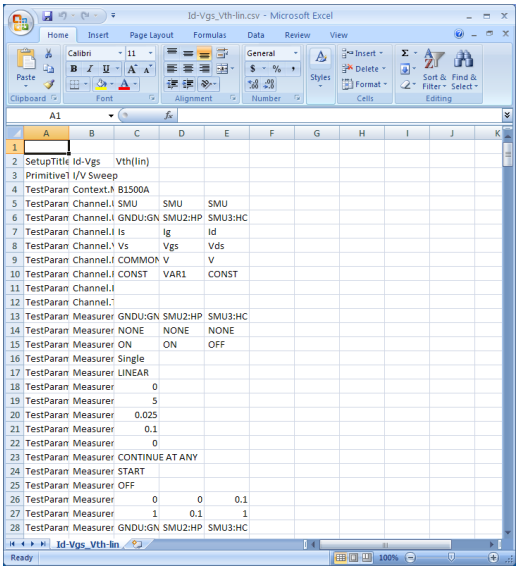
11. Right click the transported data and select Display Data.



12. The graph window pops up.

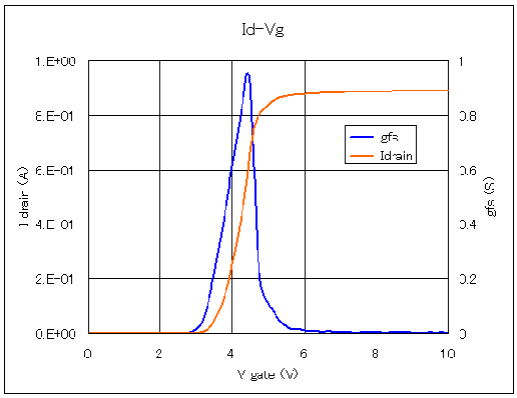


13. Start Microsoft Excel on your PC.
14. Load the saved CSV file.



15. Select the area for which you want to see a graph.
16. Click the graph button  to plot the graph. (Select the graph type, change graph properties, etc.)

sion1	101	101	101	101	101	101	
sion2	1	1	1	1	1	1	
ame	Vgate	Igate	Idrain	Vdrair	Ta	gfs	g
alue	0	0.00015	-3.40E-05	1.000054	25	0.00182	0
alue	0.1	5.00E-05	0.000118	1.000282	25	0.000705	
alue	0.2	-0.00485	7.70E-05	9.99762	25	-0.00036	
alue	0.3	-0.00985	4.70E-05	1.000316	25	0.000165	
alue	0.4	-0.01748	0.00011	9.99532	25	0.00021	
alue	0.5	-0.01975	3.80E-05	1.000596	25	-0.00026	
alue	0.6	-0.02475	5.80E-05	9.99892	25	-0.00059	
alue	0.7	-0.0297	-2.90E-05	9.99656	25	0.00015	
alue	0.8	-0.0347	3.90E-05	9.9997	25	0.00021	
alue	0.9	-0.03975	1.30E-05	9.99978	25	-0.00034	
alue	1	-0.04465	2.10E-05	9.99652	25	-5.00E-06	
alue	1.1	-0.0496	1.20E-05	9.99864	25	1.00E-05	
alue	1.2	-0.05455	2.30E-05	9.99902	25	-5.00E-05	
alue	1.3	-0.05955	2.00E-06	1.000458	25	0.000145	
alue	1.4	-0.06455	5.20E-05	9.99732	25	0.000105	
alue	1.5	-0.0695	2.30E-05	1.000136	25	-0.00061	
alue	1.6	-0.0745	-3.90E-05	9.99792	25	-0.00015	
alue	1.7	-0.0795	-3.00E-06	1.00009	25	0.00082	
alue	1.8	-0.08445	3.50E-05	1.000256	25	6.00E-05	
alue	1.9	-0.0894	4.00E-06	1.000166	25	-1.50E-05	



Appendix Pulsed Measurements at Both Gate and Drain of MOSFET by Using Two HCSMUs

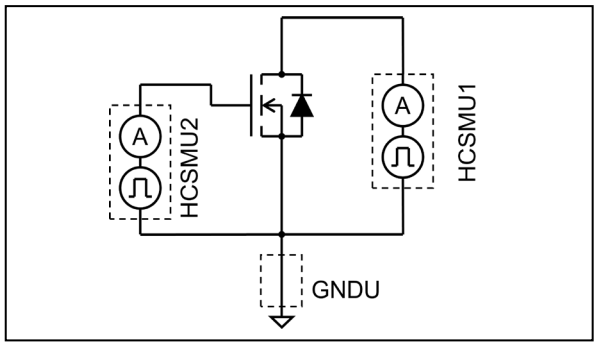
Objective B1505A can have two HCSMUs installed, and can force and measure the gate and drain terminals of both in pulsed mode. Since the HCSMU has a capability to delay pulse output timing at a time resolution of 2 μs, you can optimize the pulse timing at both the gate and drain terminals in order to minimize the self-heating effect. This section demonstrates how you can optimize the pulse timing.

Key points

- Effectiveness of drain-gate pulse timing against gate-drain pulse timing
- Snapshot for comparing traces

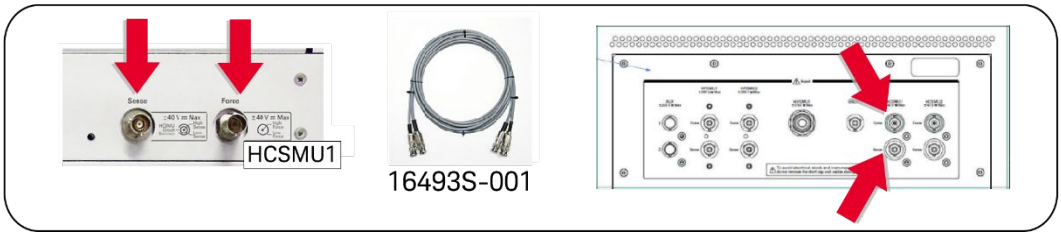
Device MOSFET (IRFP2907)

Connection diagram

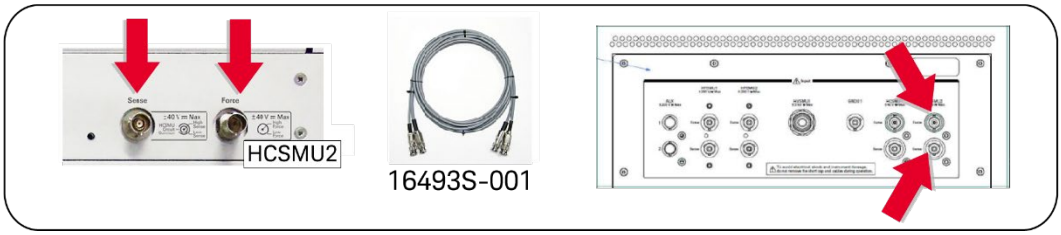


Setup Make HCSMU cable connections between the N1259A test fixture and the two HCSMUs in the B1505A by using the following procedures.

1. Using a 16493S HCSMU Cable, connect the Force and Sense connectors on the lower B1512A HCSMU to the HCSMU1 input of the N1259A test fixture.

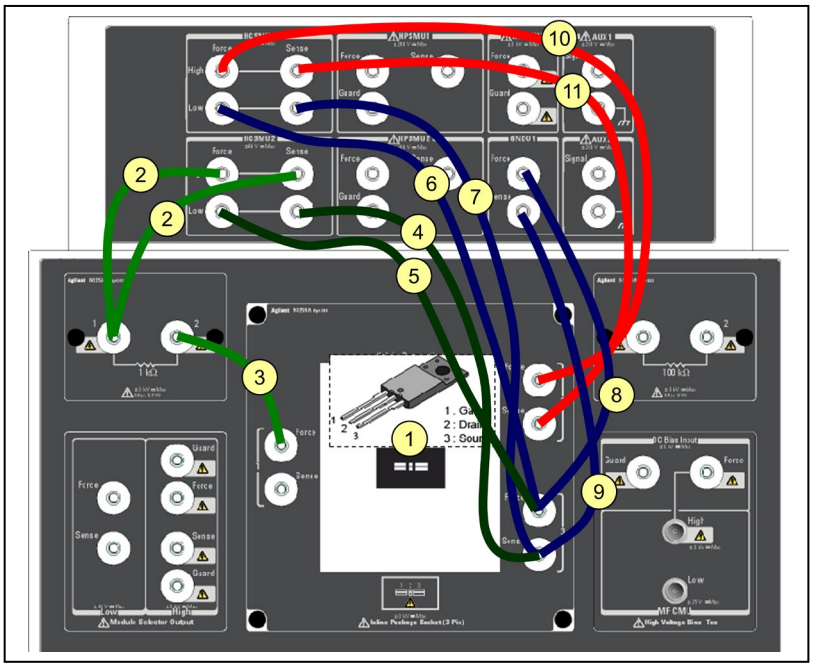


2. Using a 16493S HCSMU Cable, connect the Force and Sense connectors on the upper B1512A HCSMU to the HCSMU2 input of the N1259A test fixture.



Next, open the N1259A test fixture cover, and connect the test leads as follows. The numbers on the drawing correspond to the procedure steps.

1. Insert the device (IRFP2907) into the socket on the N1259A.
2. Connect the HCSMU2 Force and Sense to terminal 1 on the 1 kΩ resistor.
3. Connect terminal 2 on the 1 kΩ resistor to the terminal 1 Force (Gate) on the Inline Package Socket.



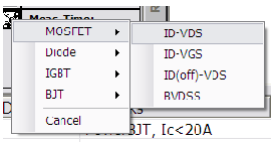
4. Connect the Low Force of the HCSMU2 to the terminal 3 Force (Source) on the Inline Package Socket.
5. Connect the Low Sense of the HCSMU2 to the terminal 3 Sense (Source) on the Inline Package Socket.
6. Connect the Low Force of the HCSMU1 to the terminal 3 Force (Source) on the Inline Package Socket.
7. Connect the Low Sense of the HCSMU1 to the terminal 3 Sense (Source) on the Inline Package Socket.
8. Connect the Force of the GNDU1 to the terminal 3 Force (Source) on the Inline Package Socket.
9. Connect the Sense of the GNDU1 to the terminal 3 Sense (Source) on the Inline Package Socket.

10. Connect the High Force of the HCSMU1 to the terminal 2 Force (Drain) on the Inline Package Socket.
11. Connect the High Sense of the HCSMU1 to the terminal 2 Sense (Drain) on the Inline Package Socket.

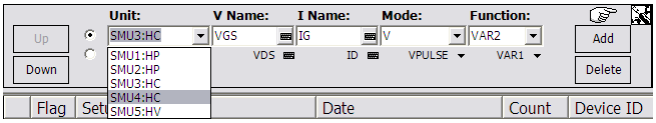
Procedures

A-1. Id-Vds measurements in Tracer Test mode (drain first gate pulse)

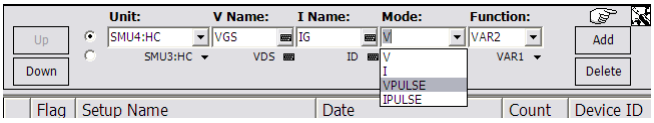
Setup of pulsed measurements at both gate and drain.

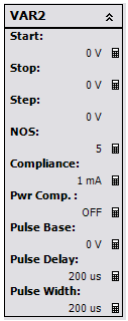


1. Click the (wrench and screw driver) icon .
2. Select the sample setup, MOSFET – ID-VDS.
3. Change the Unit of the gate from SMU3:HC to SMU4:HC.



4. Change the Mode of the SMU4:HC (VAR1) from V to VPULSE.

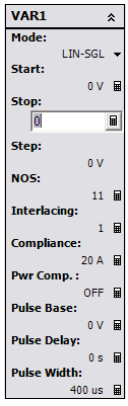




5. Click the double down-arrow to expand the setup fields for VAR2 and make the following changes.
   - Pulse Delay to 200 us.
   - Pulse Width to 200 us.

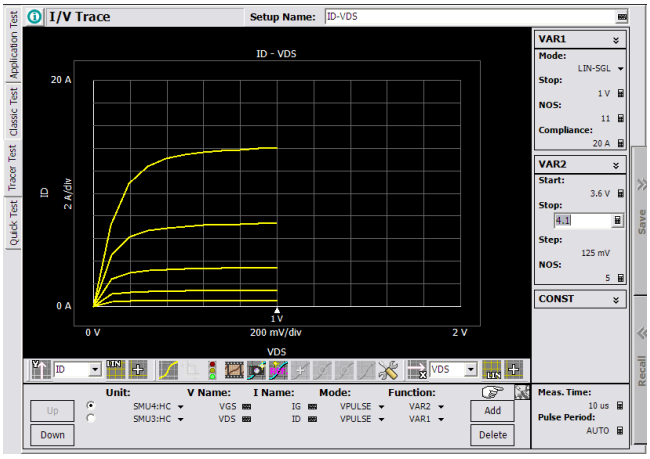
   Click the double up-arrow to retract the setup fields.
6. Click the double down-arrow to expand the setup fields for VAR1 and make the following changes.
   - Interlacing to 1.
   - Pulse Width to 400 us.

   Click the double up-arrow to retract the setup fields.

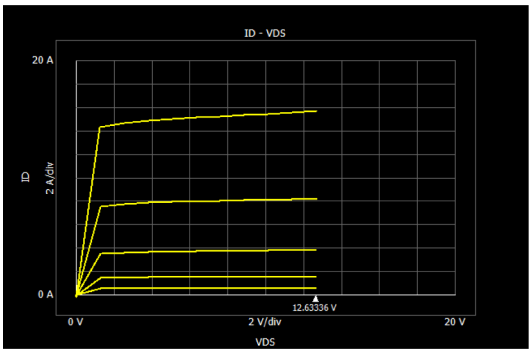


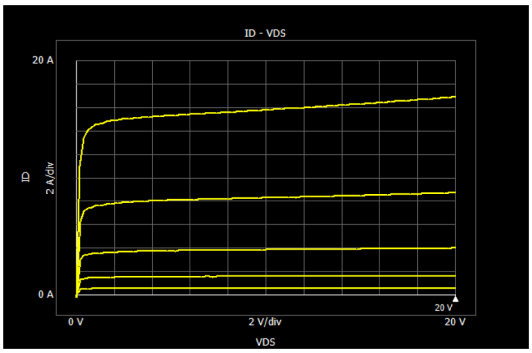
7. Click the Repeat button .
8. Make the following changes.
   - VAR1 Stop to 1.
   - VAR2 Start to 3.6 V.
   - VAR2 Stop to 4.1 V.

   The Id-Vds characteristics are as shown on the right.

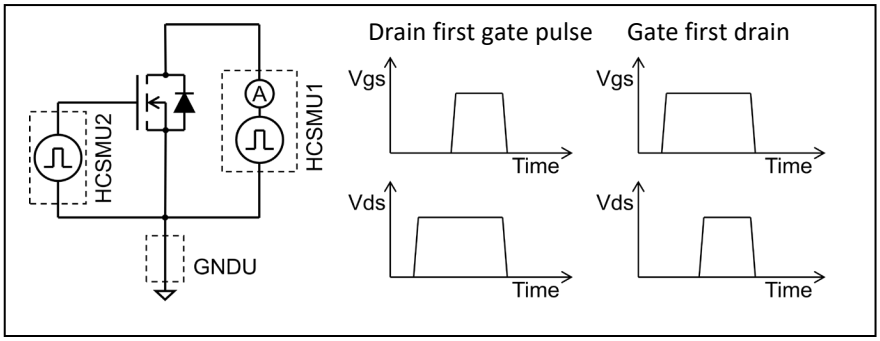


9. Click the Stop field of VAR1 to activate, and rotate the rotary knob to increase the drain voltage VDS. For example, you will see the traces shown in the graph on the below at a VDS of about 12 V.
10. Increase the Stop of VAR1 to 20 V, and increase the NOS (number of samples) to 101.



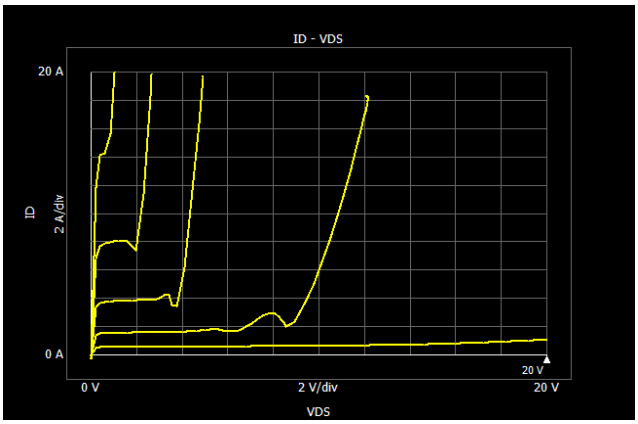


Now the gate pulse rise 200 μs after the drain pulse rise-up, and drain current measurement is made for 10 μs during the pulse width of 200 us.



A-2. Id-Vds measurements in Tracer Test mode (gate first drain pulse)

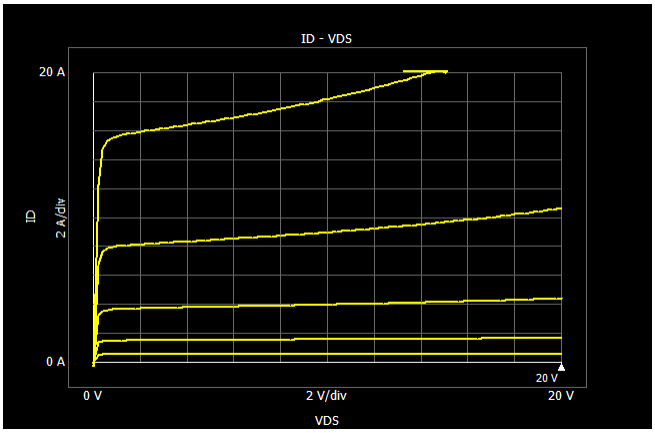
11. Click the Stop button  to stop the measurements.
12. Change the pulse delay and width settings as follows.
    - VAR1 (drain) Pulse Delay to 200 us.
    - VAR1 (drain) Pulse Width to 200 us.
    - VAR2 (gate) Pulse Delay to 0.
    - VAR2 (gate) Pulse Width to 400 us.
13. Click the Single button  . The measurements start one time and families of traces are drawn.



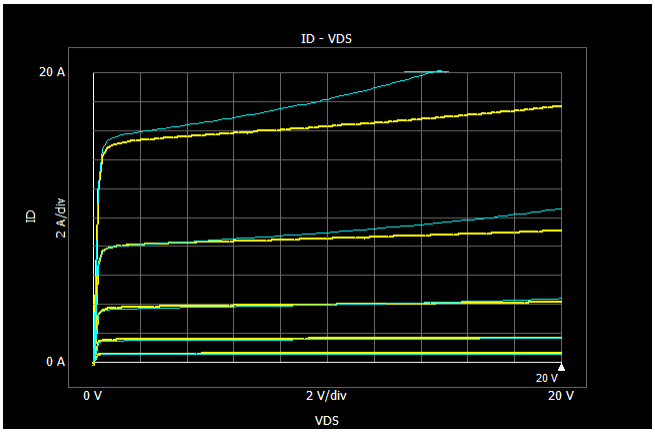
These traces show that measurements are made before the pulse rises up to the peak voltage.

A-3. Id-Vds measurements in Tracer Test mode (gate first drain pulse – long pulse and self-heating effects)

14. Change the pulse delay and width settings as follows.
    - VAR1 (drain) Pulse Delay to 0.
    - VAR1 (drain) Pulse Width to 1 ms.
    - VAR2 (gate) Pulse Delay to 0.
    - VAR2 (gate) Pulse Width to 900 us.
15. Click the Single button . The measurements start one time and families of traces are drawn.



16. Click the Capture button  . You can capture the (reference) traces using this button. The captured traces are shown with blue lines.
17. Change the pulse delay and width settings as follows.
    - VAR1 (drain) Pulse Delay to 0.
    - VAR1 (drain) Pulse Width to 400 us.
    - VAR2 (gate) Pulse Delay to 150 us.
    - VAR2 (gate) Pulse Width to 250 us.
18. Click the Single button . The measurements start one time and families of traces are drawn.



You can see that the shorter pulse width reduces the effect of self-heating.

Summary of appendix: Pulsed Measurements at Both Gate and Drain of MOSFET

- Pulsed measurements of drain first gate pulse is effective for reducing the self-heating effect.
- Pulse output capability of HCSMU is flexible in arranging the pulse output timing – gate first or drain first.
- Snapshot function is useful for comparison with reference traces.

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