

Keysight Technologies

Making Field Effect Transistor Characterization Using SMU

B2900A Precision Source/Measure Unit

Demo Guide



Introduction

The Keysight's B2900A Series Precision Source/Measure Unit (SMU) is a compact and cost-effective bench-top SMU with the capability to output and measure both voltage and current. The B2900A SMU enables you to make a wide range of current versus voltage (IV) measurements more accurately and quickly than ever before. In addition, the B2900A SMU comes with an intuitive graphical user interface (GUI) and free PC-based application software that make it easy for you to begin making productive measurements immediately. In general, Field effect transistor (FET) characterization requires applying different voltages and currents under either constant or swept conditions to the transistor terminals. The B2902A and B2912A have two SMU channels, with each channel possessing accurate IV measurement capabilities as well as the ability to supply either constant or swept voltage/current. This makes the B2902A and B2912A excellent choices for accurate IV characterization of FETs.

This demonstration guide shows how easily you can make undertake FET characterization using the B2900A SMU.

Required Instrument and Accessories

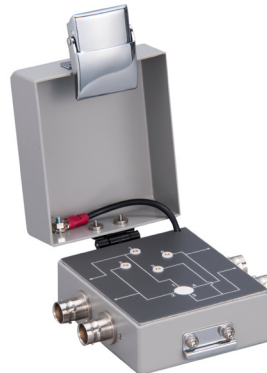
All of the accessories required to perform the demos described in this demonstration guide are provided as a low current demo kit that is included with some of Keysight B2902A/12A demo units except for a field effect transistor.



B2902A/12A 2Ch SMU



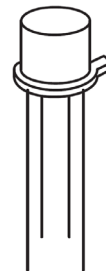
N1294A-001 Banana-to-Triax Adapter x2



N1295A Test Fixture



16494A-001 Triax cable x4



Field Effect Transistor

Measurement Concept

An IV characteristics measurement of a field effect transistor is made based on the following:

- Sourcing voltage from two channels to activate a transistor.
- The two channels work simultaneously to make measurements.
- The limit value feature prevents the instrument from sourcing too much even if the Source value is increased.
- Stepping voltages from start voltage to stop voltage to make current measurements at each voltage step.
- Voltage steps are sourced from internal voltage sources.
- Current measurements are made by internal current meters.
- Complicated measurements can be easily configured using Intuitive Graphical User Interface (GUI).
- The current-voltage curve can be easily seen by changing View mode.

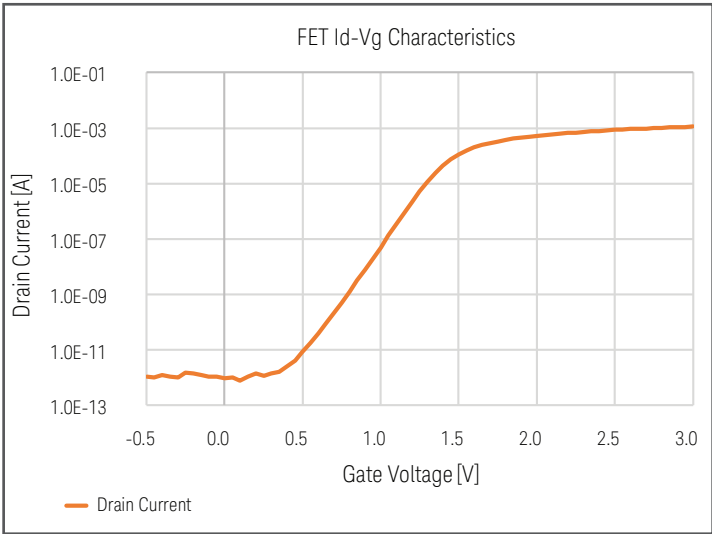


Figure 1. FET Id-Vg Characteristics

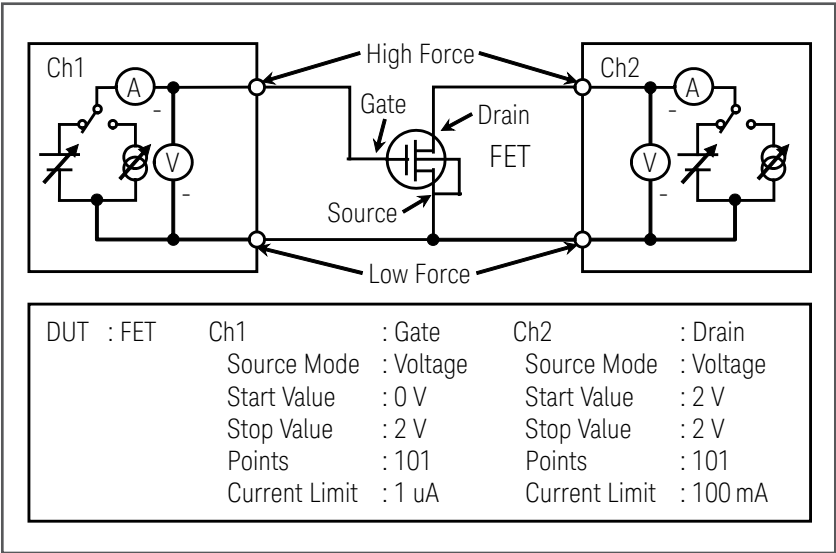
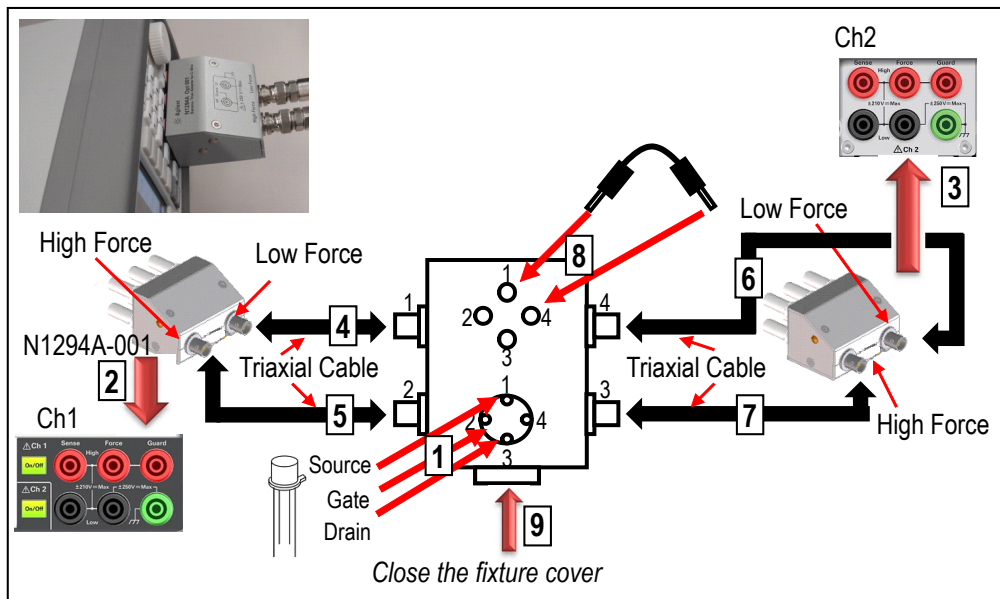


Figure 2. Connection diagram

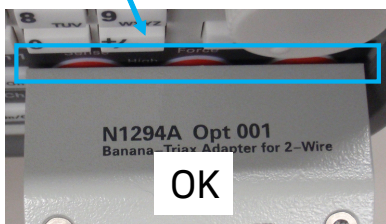
Setup

1. Put the **device** on the **device socket** in the fixture
(The FET Source, Gate and Drain are connected to 1, 2 and 3 respectively. If device has a substrate terminal, it is connected to 4.)
2. Put the **N1294A-001** on the **Ch 1 output** terminals of the B2900A SMU.
3. Put the **N1294A-001** on the **Ch 2 output** terminals of the B2900A SMU.
4. Connect the **N1294A-001 Ch 1 Low** terminal to the **fixture terminal 1** with a triaxial cable.
5. Connect the **N1294A-001 Ch 1 High** terminal to the **fixture terminal 2** with a triaxial cable.
6. Connect the **N1294A-001 Ch 2 Low** terminal to the **fixture terminal 4** with a triaxial cable.
7. Connect the **N1294A-001 Ch 2 High** terminal to the **fixture terminal 3** with a triaxial cable.
8. Connect terminals 1 to 4 on the fixture with a black Pin-Plug Cable.
9. Close the fixture cover.



Make sure that the connection between the output terminals and the N1294A-001 Banana to Triax Adaptor is secure, because a loose connection can affect the measurement results.

There is no space between the adaptor and the output terminals



Proper connection

There is some space between the adaptor and the output terminals



Improper connection

LAB: Make Field Effect Transistor Characterization using SMU

Demonstration

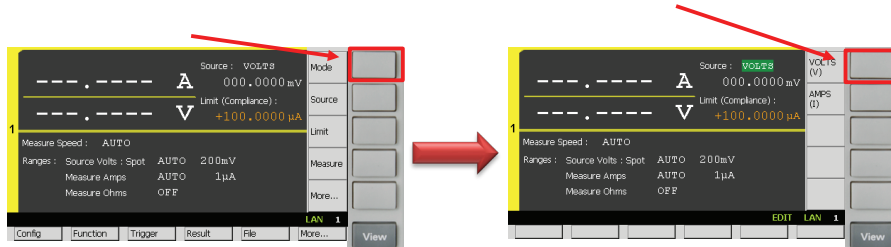
1. Change View mode to Channel 1 Single View

- 1) Press **View** repeatedly until the Channel 1 Single View is displayed.

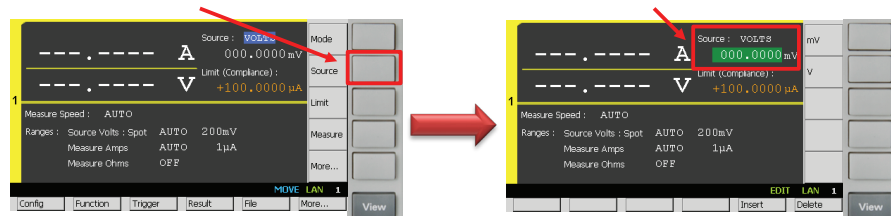


2. Configure the Channel 1 condition to source and measure

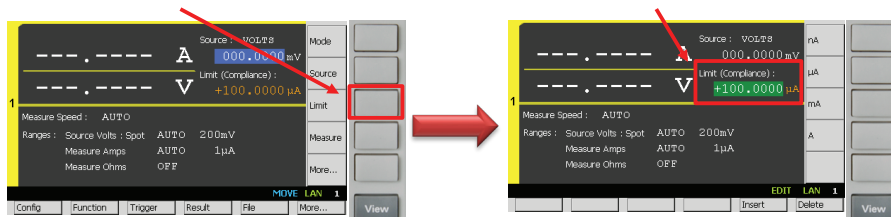
- 1) Press **Mode** to edit the **Source function**, and then select **VOLTS (V)** to set the **Source function** to **Voltage source**.



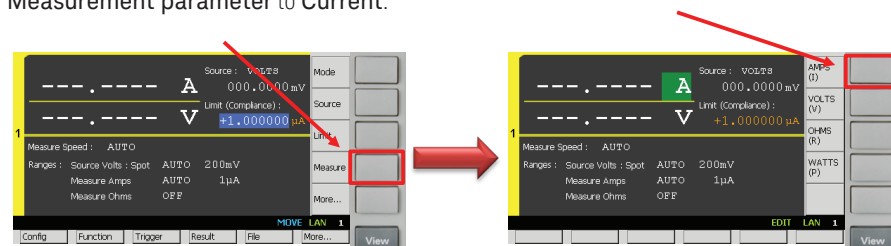
- 2) Press **Source** to edit the **Source value**, and then enter **0 V** to set the **Source value** to **0 V**.



- 3) Press **Limit** to edit the **Limit value**, and then enter **1 μ A** to set the **Limit value** to **1 μ A**.



- 4) Press **Measure** to configure the **Measurement parameter**, and then select **AMPS (I)** to set the **Measurement parameter** to **Current**.



Objective



This demo explains how to make a voltage sweep measurement synchronously using 2 channels to make a field effect transistor IV characterization

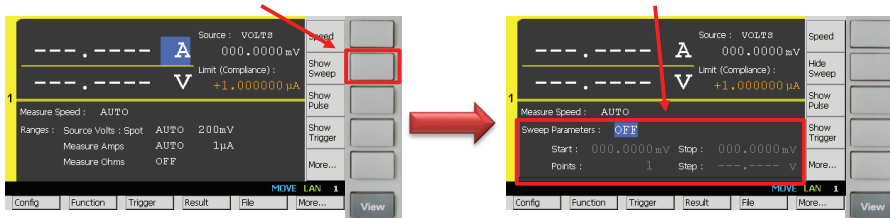
Procedure



1. Change the View mode to the Channel 1 Single View.
2. Configure the Channel 1 condition to source and measure.
3. Change the View mode to the Channel 2 Single View.
4. Configure the Channel 2 condition to source and measure.
5. Change the View mode to Graph View.
6. Perform the measurement.
7. View the measurement result graph.

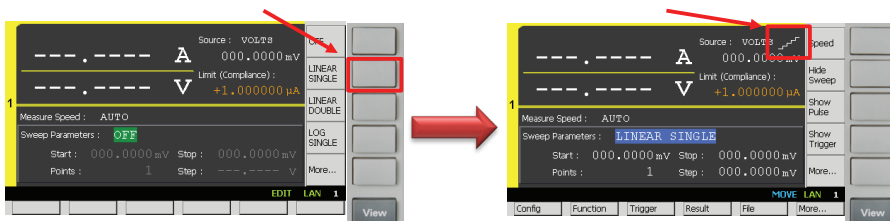
(Optional)


8. Configure the measurement speed.
9. Configure the measurement range operation.
10. Configure the measurement trigger delay time.
11. View the list of measurement results.

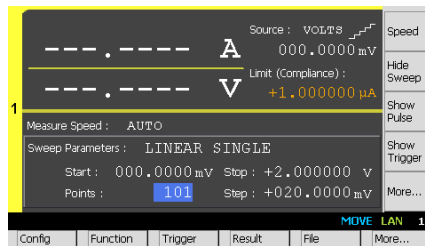
5) Press  to change the keys shown in Assist keys, and then press  to show Sweep Sub-Panel.



6) Press , then press  to turn on **Single Linear Sweep Mode**. After turning on **Single Linear Sweep Mode**, you can see **Source Shape** which shows the single linear sweep mode.



7) Rotate  to select Channel 1 Sweep Parameters and set them up as below.
(Start: 0 V, Stop: 2 V, Points: 101, Step: 20 mV)



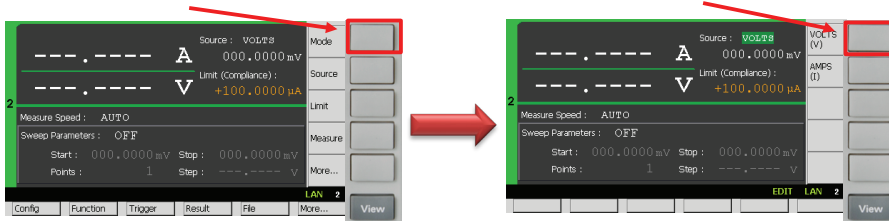
3. Change the View mode to the Channel 2 Single View

1) Press  repeatedly until the Channel 2 **Single View** is displayed.

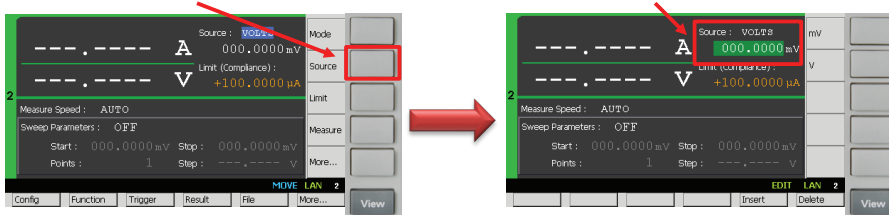


4. Configure the Channel 2 condition to source and measure

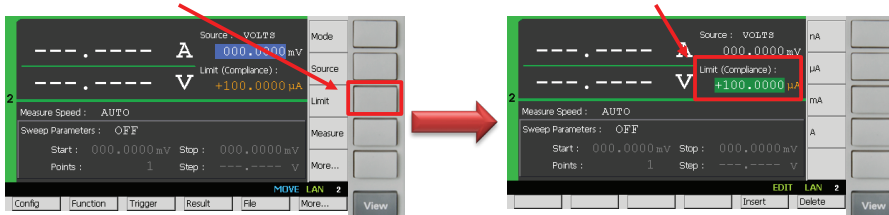
- 1) Press **Mode** to edit the **Source** function then select **VOLTS (V)** to set the **Source** function to **Voltage source**.



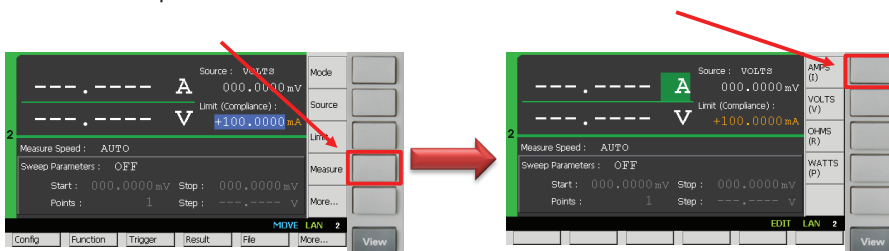
- 2) Press **Source** to edit the **Source** value, and then enter **0 V** to set the **Source** value to **0 V**.



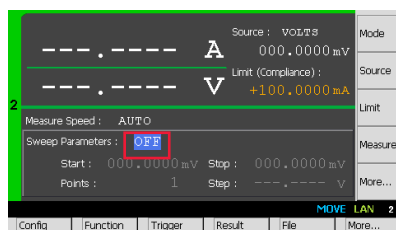
- 3) Press **Limit** to edit the **Limit** value, and then enter **100 mA** to set the **Limit** value to **100 mA**.




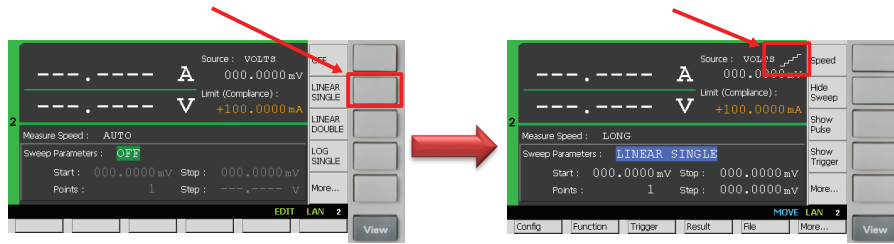
- 4) Press **Measure** to configure the **Measurement** parameter, and then select **AMPS (I)** to set the **Measurement** parameter to **Current**.




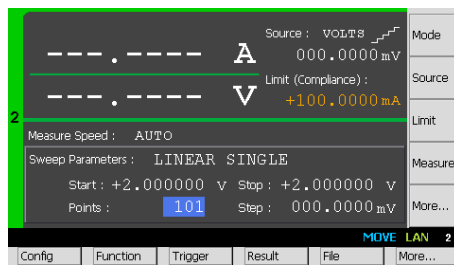
- 5) Rotate and press **Mode** to edit the Channel 2 sweep parameters



6) Then press  to turn on the **Single Linear Sweep Mode**. After turning on the **Single Linear Sweep Mode**, you can see the **Source Shape** which shows single linear sweep mode.

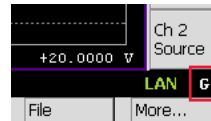



7) Rotate  to select the Channel 2 Sweep Parameters and set them up as below. (Start: 2 V, Stop: 2 V, Points: 101, Step: 0 mV)

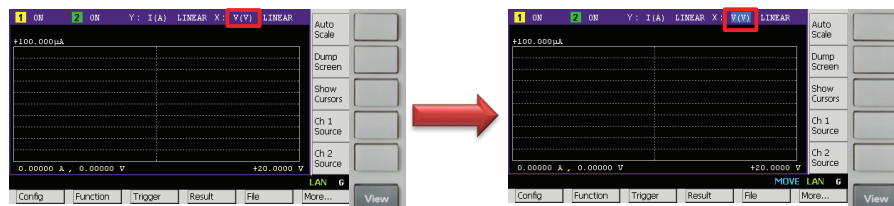




5. Change the View mode to Graph View

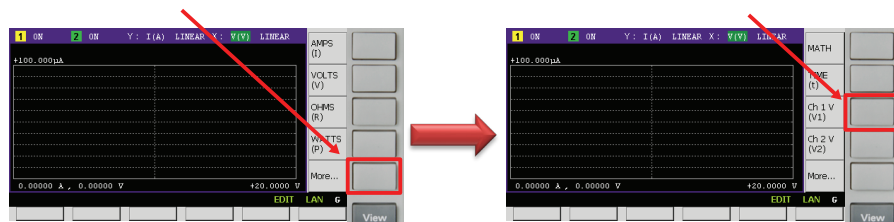
1) Press  repeatedly until **Graph View** is displayed.



2) Rotate and press  to edit the X-axis data type.




3) Press , and then select  to set the X-axis data type to Channel 1 voltage.




6. Perform the measurement

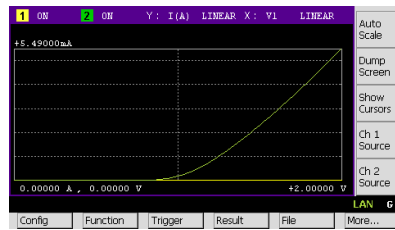
1) Press Ch1 and Ch2  to turn on both Channel Output relays.


2) Press  to perform a sweep measurement.
(The status information will show **ARM** during the measurement.)

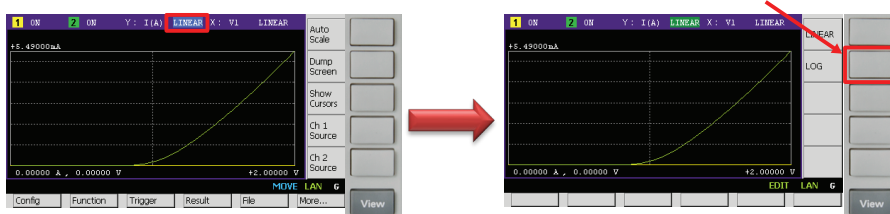



7. View the measurement result graph

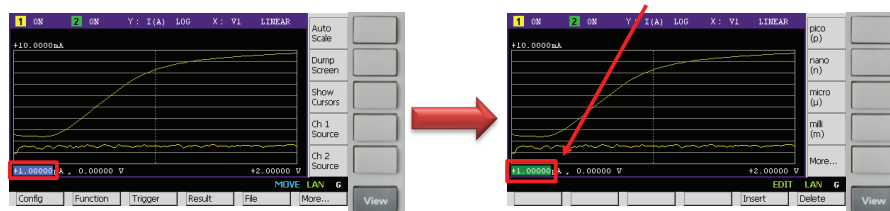
1) Press  to adjust the scale of the graph after finishing the measurement. Now you can see the measurement result on the GUI of the B2900A SMU as below.



2) To change the **Graph scaling of the Y-axis** from LINEAR to LOG, rotate and press  to select the Y-axis scaling.



3) To change the **Graph scale value of the Y-axis**, rotate and press  to modify the Y-axis scale value.







8. (Optional) Configure the measurement speed

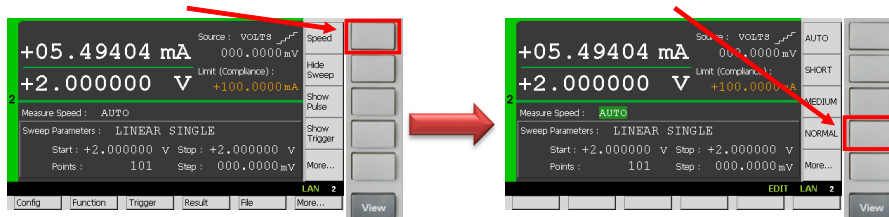
In the default setting, the instrument selects the appropriate measurement speed and range automatically to get the fine accuracy. However, you can also specify these parameters on the GUI of the B2902/12A to meet a variety of the requirement to the measurement conditions.

For example, let's try to change the measurement speed to NORMAL to make a measurement more carefully. If you select NORMAL, the aperture time is set to 1 PLC. Here, PLC stands for power line cycle and the specified number of power line cycles is used per a measurement.

- 1) Press  repeatedly until the Channel 2 **Single View** is displayed.



- 2) Press  to edit the **Measurement speed**, and then select  to set it to **NORMAL**. (If you can't see  in Assist keys, press  to change the keys shown in Assist keys.)



9. (Optional) Configure the measurement range operation

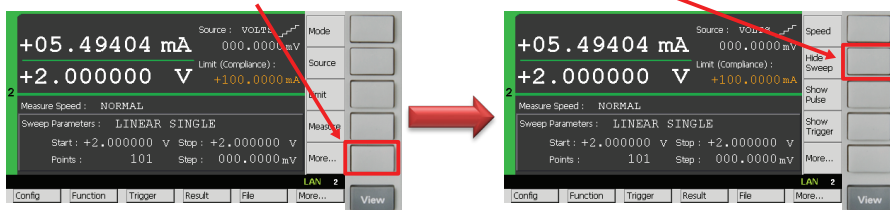
The parameters which configure the measurement range operation can be displayed in the Range Sub-panel in the Single View, although the Sweep Sub-Panel is shown at this moment. In the default setting, the B2902/12A performs the current measurement using a 1 μA current minimum measurement range with AUTO range operation. With AUTO range operation, the B2902/12A selects the proper range for the measurement with the specified minimum measurement range so that you don't need to take care about it. To know how to change the measurement range setting, try to configure to use 10 nA current minimum measurement range with AUTO range operation.

- 1) Press **View** repeatedly until the Channel 2

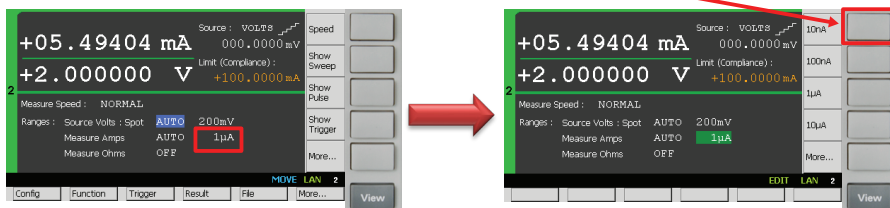
Single View is displayed.



- 2) Press **Hide Sweep** to show Range Sub-Panel. (If you can't see **Hide Sweep** in Assist keys, press **More...** to change the keys shown in Assist keys.)

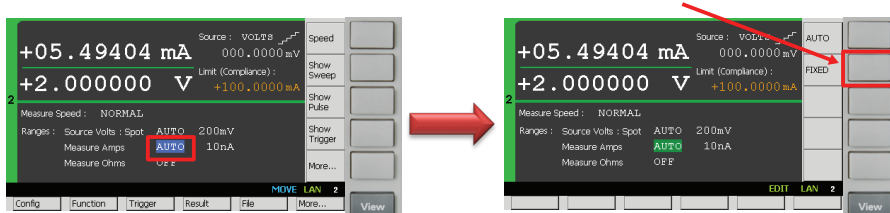


- 3) Rotate and press **10nA** to edit the Current minimum measurement range then select **10nA** to set the Current minimum measurement range to 10 nA.



If you'd like to fix the measurement range, you can select FIXED range operation as below.

- 4) Rotate and press **FIXED** to edit the Current measurement range operation. Then Select **FIXED** to set the Current measurement range operation to FIXED.



10. (Optional) Configure the measurement trigger delay time

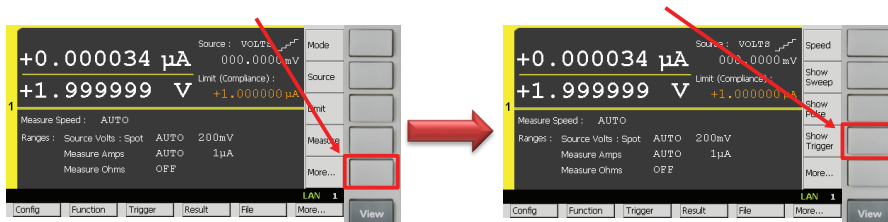
The trigger parameters including the measurement trigger delay time and the trigger period can be displayed in the Trigger Sub-panel in the Single View, although Range Sub-Panel is shown at this moment. In the default setting, the trigger type is set to the automatic trigger type (AUTO) so that you don't need to specify these trigger parameters.

To specify the measurement trigger delay time, follow the steps below:

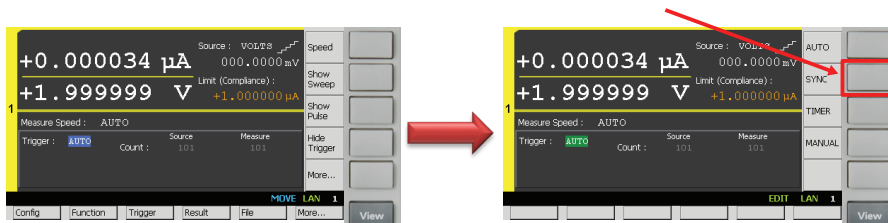
- 1) Press **View** repeatedly until the Channel 1 **Single View** is displayed.



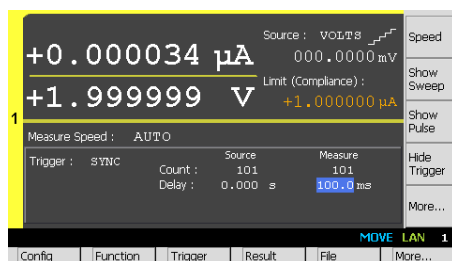
- 2) Press **Show Trigger** to show **Trigger Sub-Panel**. (If you can't see **Show Trigger** in Assist keys, press **More...** to change the keys shown in Assist keys.)




- 3) Press **SYNC** to edit the **Trigger type** then select **SYNC** to set the **Trigger type** to **SYNC**.





- 4) Rotate **MOVE** to select the Channel 1 Trigger Parameters and set them up as below. (Source Trigger Count: 101, Measurement Trigger Count: 101, Measurement Trigger Delay Time: 100ms)

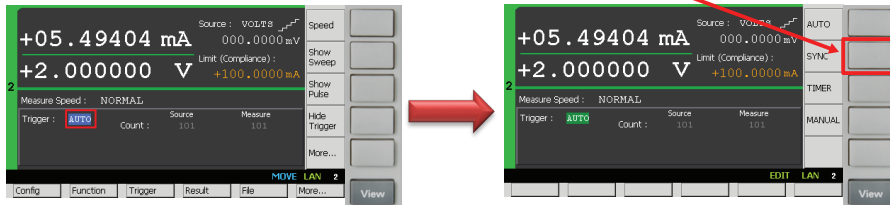


Note. Source and Measurement Trigger Count should be the same number as Sweep Points.

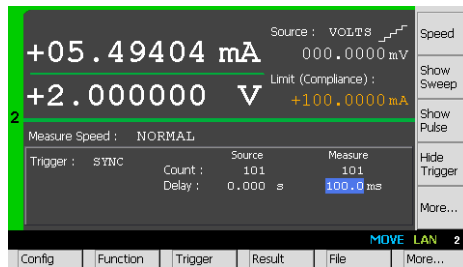
5) Press  repeatedly until the Channel 2 **Single View** is displayed.



6) Rotate and press  to edit the **Trigger** type then select  to set the **Trigger type** to **SYNC**.



7) Rotate  to select the Channel 2 Trigger Parameters and set them up as below. (Source Trigger Count: 101, Measurement Trigger Count: 101, Measurement Trigger Delay Time: 100ms)




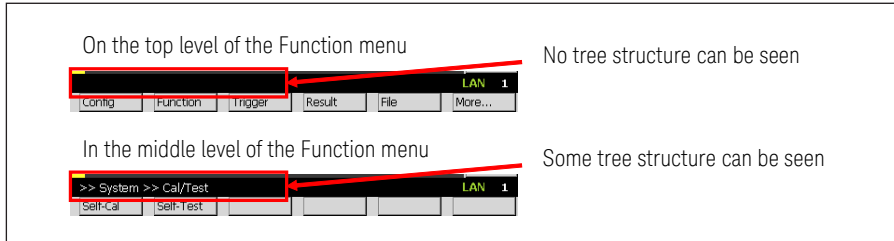
Note. Source and Measurement Trigger Count should be the same number as Sweep Points.


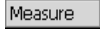
Now you've configured 100 ms measurement trigger delay time.

11. (Optional) View the list of measurement results



The measurement results can be viewed by following the steps below:

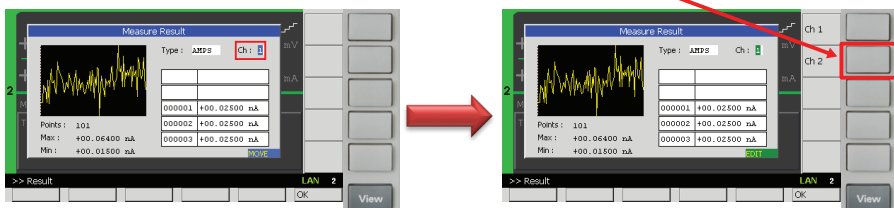
- 1) If you are not at the top of the Function menu, press  repeatedly to return to the top level.





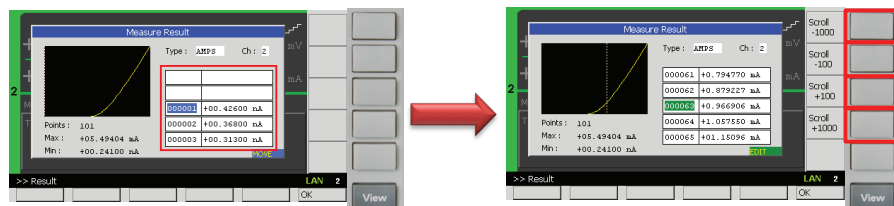
- 2) To view the **List of the measurement result**, press , then press  to open the **Measure Result** dialogue.



- 3) Rotate and press  to select the **Channe** field. Then press  to select the Channel 2.



- 4) Rotate and press  to select the **Data** field. Then rotate  to scroll the Data list.



Conclusion

The Keysight's B2900A Series Precision Source/Measure Unit (SMU) is a compact and cost-effective bench-top SMU with the capability to output and measure both voltage and current. In general, field effect transistor (FET) characterization requires the application of different voltages and currents under either constant or swept conditions to the transistor terminals. The B2902A and B2912A have two SMU channels, with each channel possessing accurate IV measurement capabilities as well as the ability to supply either constant or swept voltage/current. This makes the B2902A and B2912A excellent choices for accurate IV characterization of FETs.

B2900 Precision Instrument Family

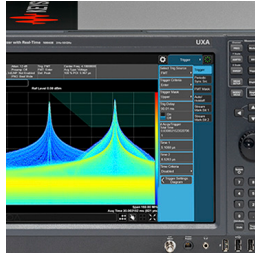
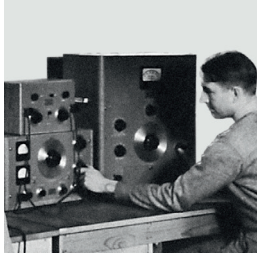
The B2900 family contains products that perform both precision sourcing and precision measurement. www.keysight.com/find/b2900a



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Japan	0120 (421) 345
Korea	080 769 0800
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Europe & Middle East

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Spain	800 000154
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