Keysight Technologies
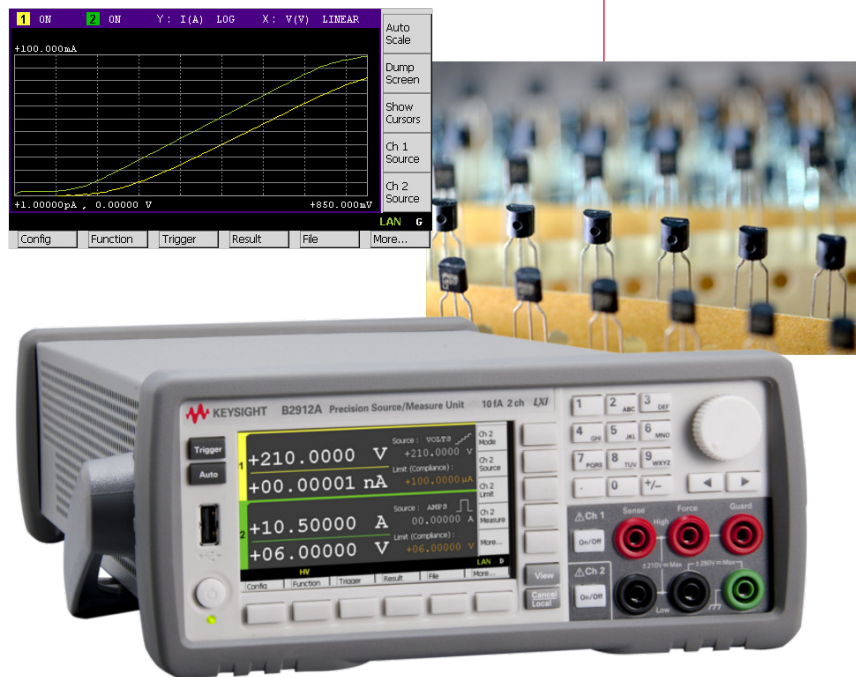## Making Bipolar Transistor Characterization using SMU

B2900A Precision Source/Measure Unit

Demo Guide

KEYSIGHT
TECHNOLOGIES

Unlocking Measurement Insights

Introduction

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, bipolar transistor (BJT) 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 BJTs.

This demonstration guide shows how easily you can undertake BJT 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.

B2902A/12A 2 Ch Source/
Measure Unit

N1295A Test Fixture

N1294A-001 Banana-to-Triax
Adapter x2

Bipolar Transistor

16494A-001 Triax Cable x4

Measurement Concept

An IV characteristics measurement of a BJT (Gummel Plot) is made based on the following:

– Sourcing a 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 the Intuitive Graphical User Interface (GUI).
– The current-voltage curve can be easily seen by changing View mode.
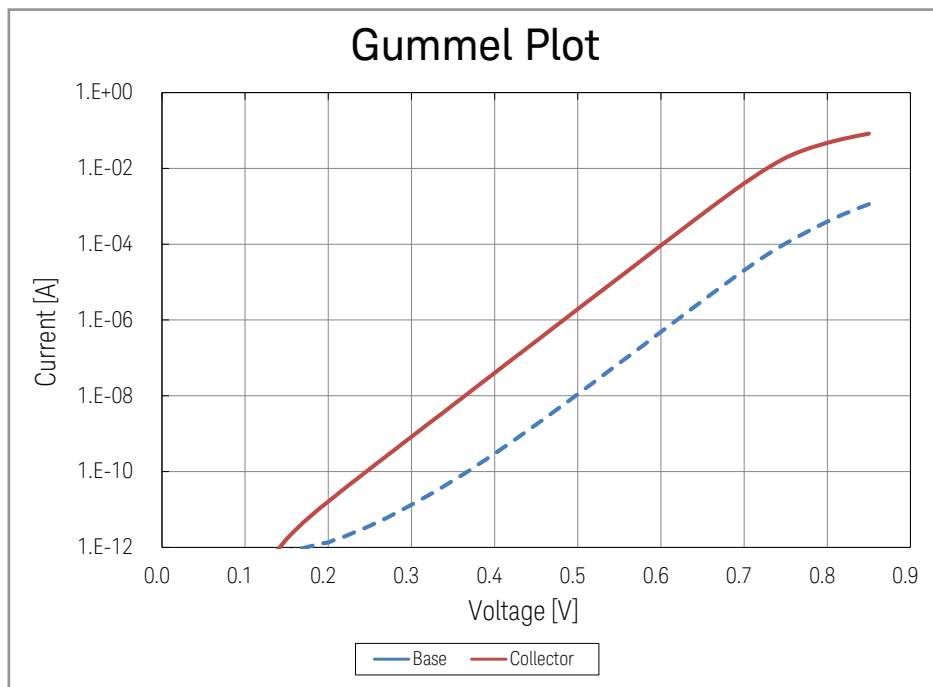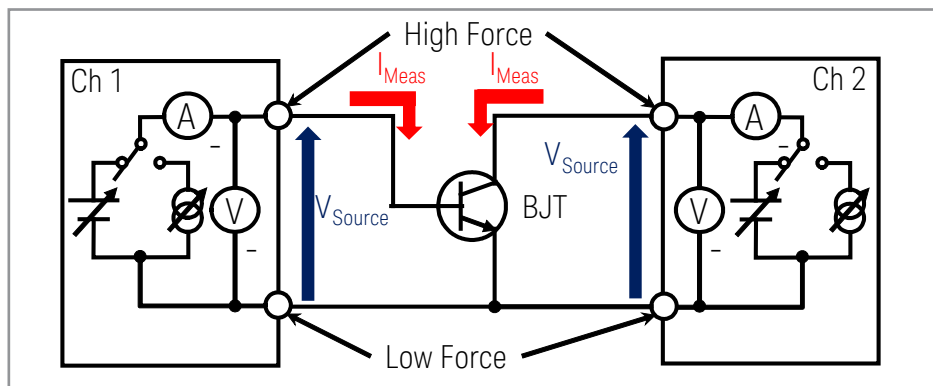

Figure 1. Gummel Plot


Figure 2. Connection diagram

Setup

1. Put the **device** on the **device socket** in the fixture (The BJT Emitter, Base and Collector are connected to 1, 2 and 3 respectively).
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.
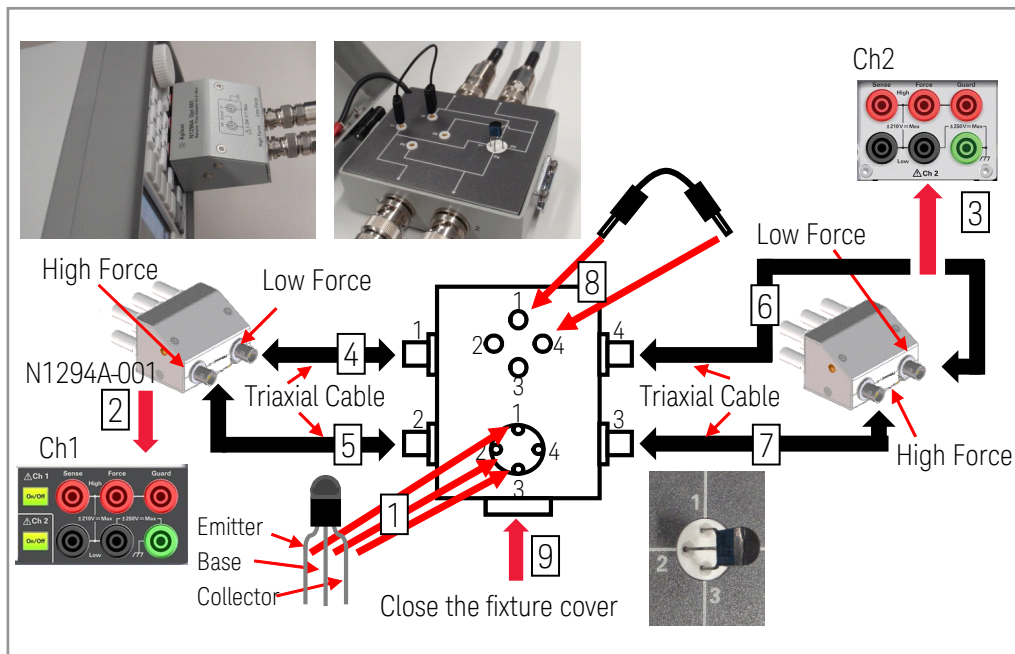
Make sure that the connection between the output terminals and the N1294A-001 Banana to Triax Adaptor is secure, because a loose connection can affect the measurement results.

There is no space between the adaptor and the output terminals

OK
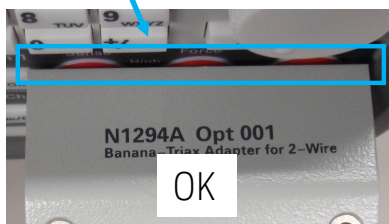
Proper connection

There is some space between the adaptor and the output terminals

Loose

Improper connection

LAB: Make Bipolar Transistor Characterization using SMU
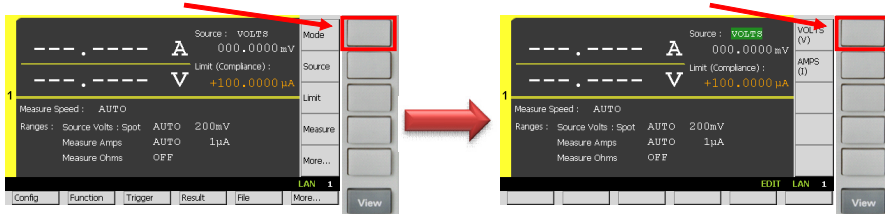
Demonstration

1. Change the View mode to the Channel 1 Single View

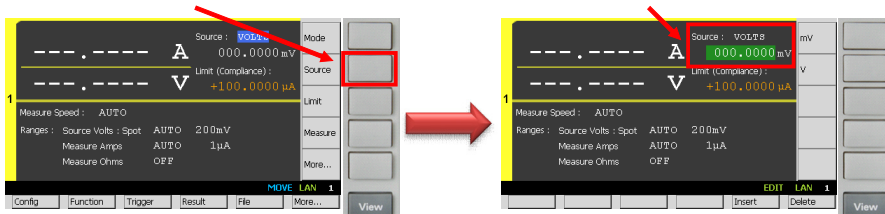1) Press **View** repeatedly until the Channel 1 **Single View** is displayed.

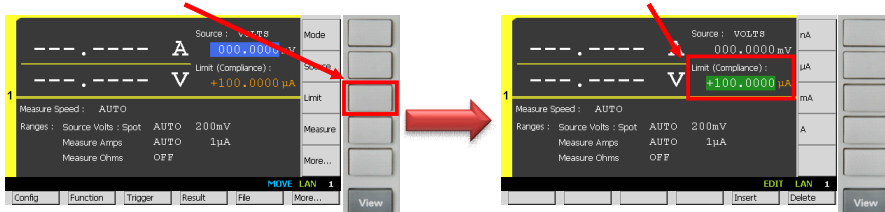### 2. Configure the Channel 1 condition to source and measure

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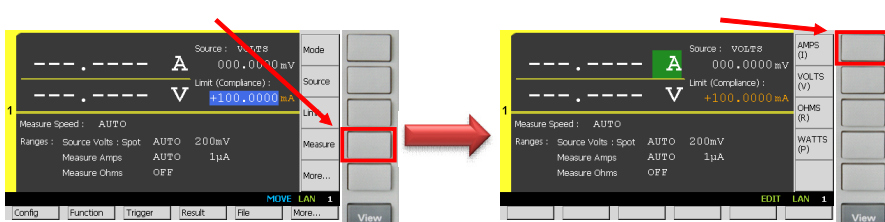

2) Press **Source** to edit the **Source value** then enter **0 V** to set the **Source value** to **0 V**.

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

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


Objective

This demo explains how to make a voltage sweep measurement simultaneously using 2 channels to make a bipolar 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
8. View the list of measurement results
9. Store the measurement data to a USB flash memory device
10. Copy the Graph View screen dump to a USB flash memory device.

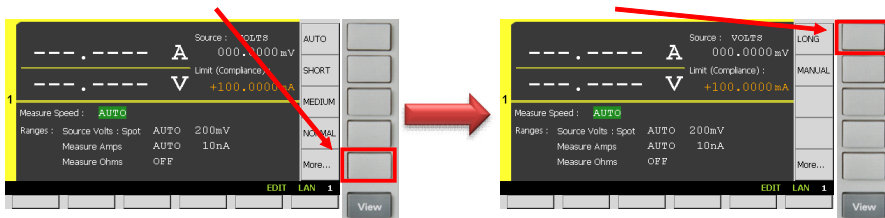5) Rotate ⬤ to select the **Current minimum measurement range** and press ⬤ to edit it.
Then press [10nA] to set the **Current minimum measurement range** to **10 nA**.
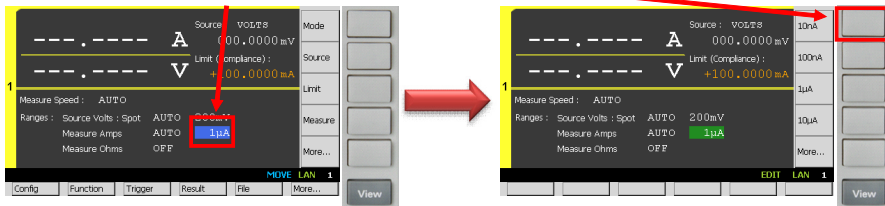
6) Press [More...] to change the keys shown in Assist keys then press [Speed] to set the
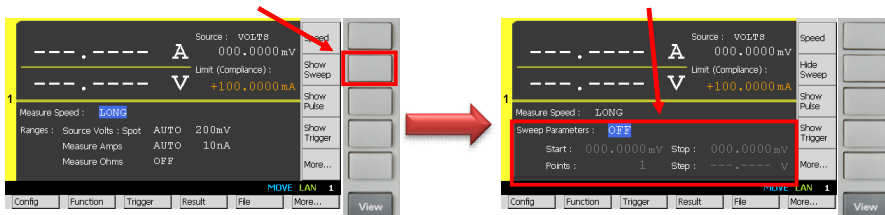**Measurement Speed Parameter.**
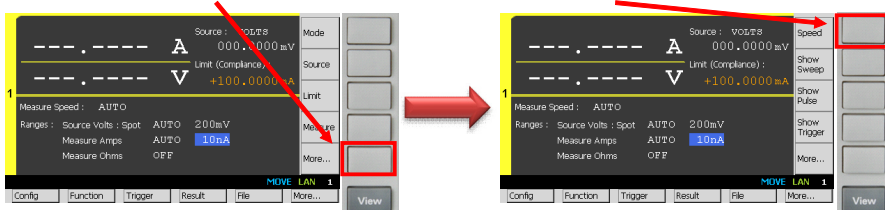
7) Press [More...] then press [LONG] to set the **Measurement Speed** to **LONG (10 PLC)**.

If you do not want to make the sub-nA current measurement, "AUTO" Measure Speed
should be selected. It makes the measurement much faster.

8) Press [Show Sweep] to show **Sweep Sub-Panel**.

9) Press ⬤, then press [LINEAR SINGLE] to turn on the **Single Linear Sweep Mode**. After turning on
the **Single Linear Sweep Mode**, you can see the **Source Shape** which shows the single
linear sweep mode.
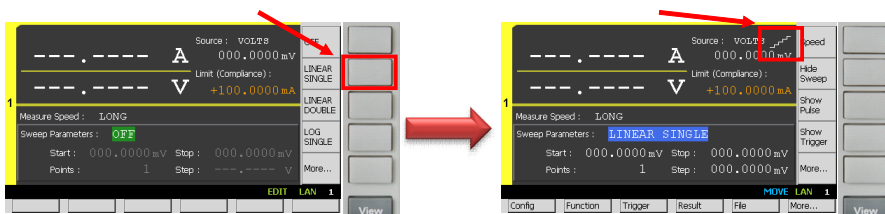
10) Rotate to select the Channel 1 Sweep Parameters and set them up as below.
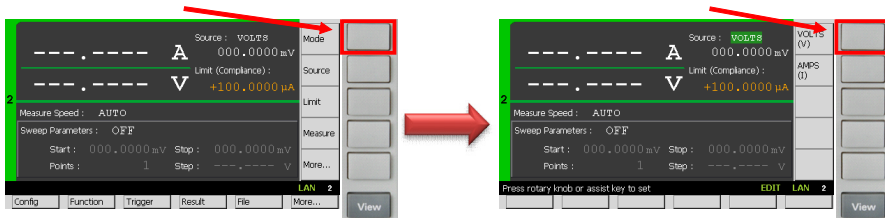(Start: 0 V, Stop: 0.85 V, Points: 86, Step: 10 mV)
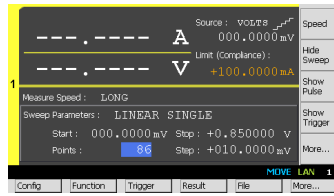
3. Change the View mode to the Channel 2 Single View

1) Press **View** 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** then enter **0 V** to set the **Source value to 0 V**.
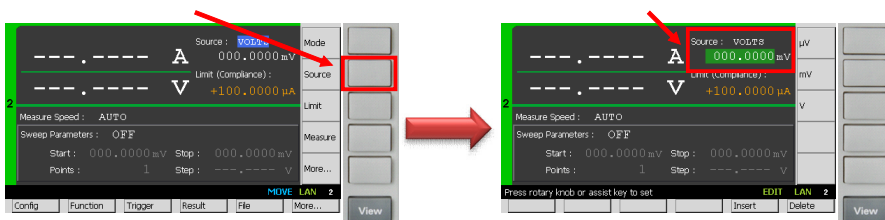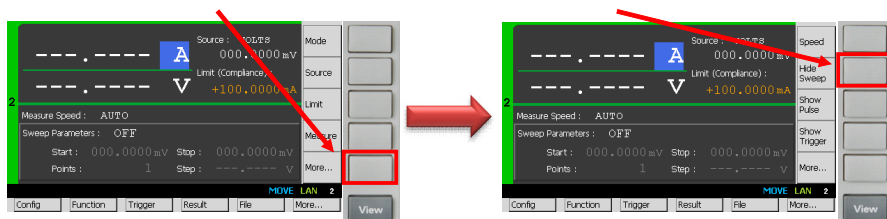

3) Press **Limit** to edit the **Limit value** then enter **100 mA** to set the **Limit value** to **100 mA**.
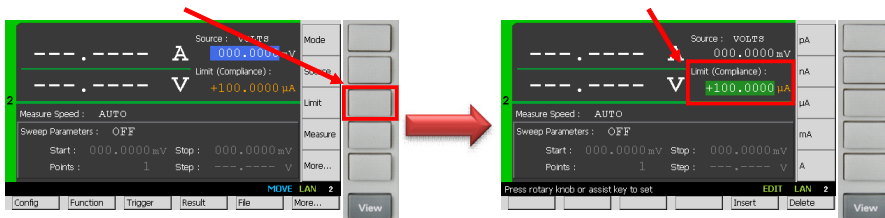
4) Press [Measure] to configure the **Measurement parameter** then select [AMPS (I)] to set the
Measurement parameter to **Current**.
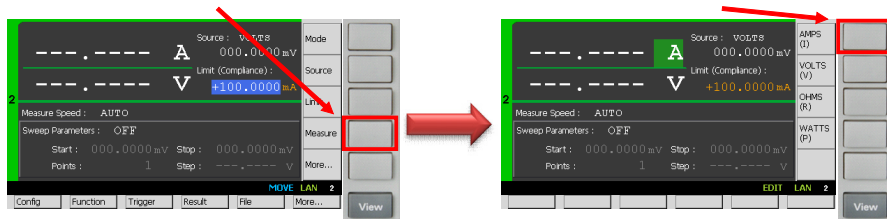
5) Press [More...] to change the keys shown in Assist keys then press [Hide Sweep] to show
Range Sub-Panel.

6) Rotate ⦾ to select the **Current minimum measurement range** and press ⦾ to

edit it. Then press [10nA] to set the **Current minimum measurement range** to **10 nA**.
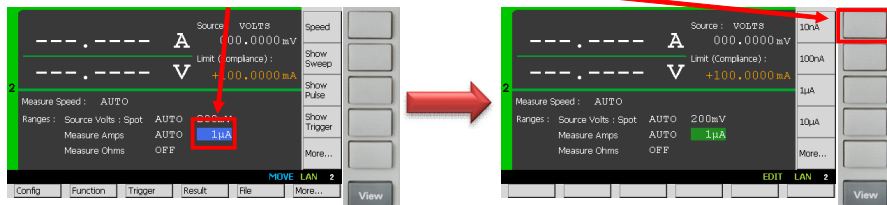
7) Press [Speed] to set the Measurement Speed Parameter.
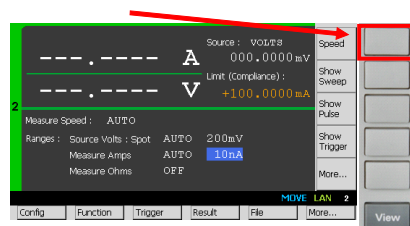
If you do not want to make the sub-nA current measurement, "AUTO" Measure Speed
should be selected. It makes the measurement much faster.

8) Press [More...] then press [LONG] to set the **Measurement Speed to LONG (10 PLC)**.

9) Press [Show Sweep] to show **Sweep Sub-Panel**.
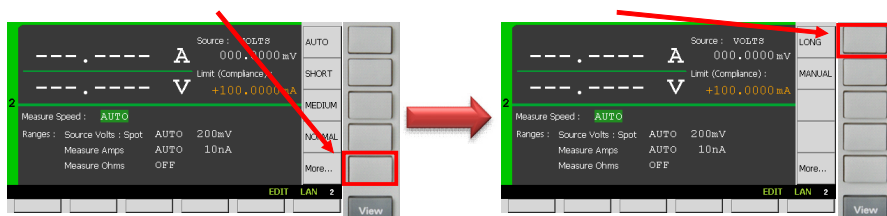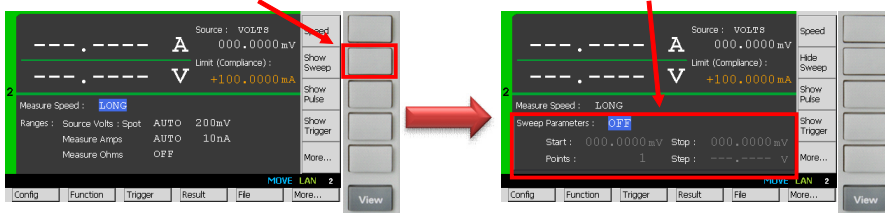

10) Press ⬤, then press [LINEAR SINGLE] to turn on the **Single Linear Sweep Mode**. After turning on the **Single Linear Sweep Mode**, you can see the **Source Shape** which shows the single linear sweep mode.
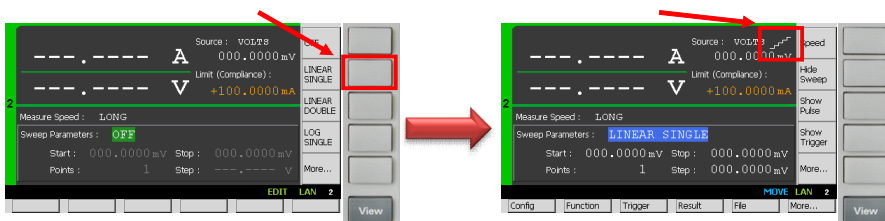
11) Rotate ⬤ to select the Channel 2 Sweep Parameters and set them up as below. (Start: 0 V, Stop: 0.85 V, Points: 86, Step: 10 mV)
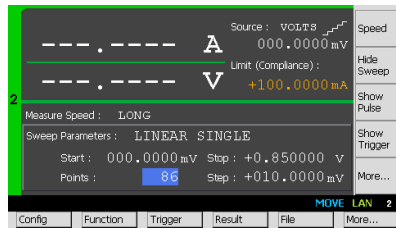
5. Change the View mode to Graph View

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

6. Perform the measurement

1) Press Ch1 and Ch2 [On/Off] to turn on both Channel Output relays.

2) Press [Trigger] to perform a sweep measurement.
(The status information will show **ARM** during the measurement.)
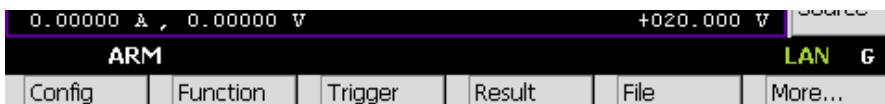
7. View the measurement result graph

1) Press ⬛[Auto Scale] 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.
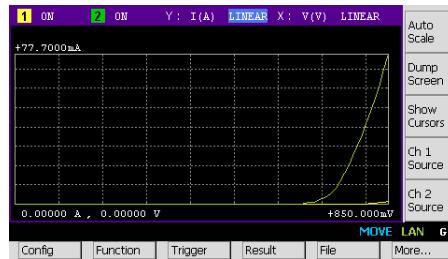
2) To change the **Graph scaling of the Y-axis** from LINEAR to **LOG**, rotate and press ⬤ to select the **Y-axis scaling**.
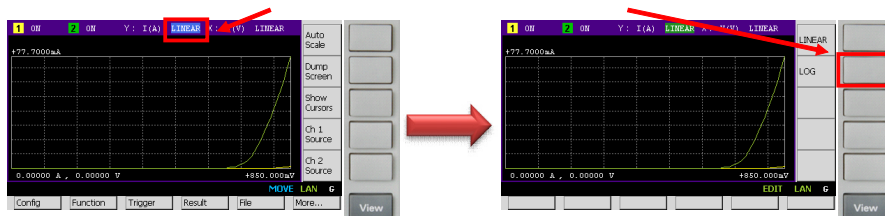
3) To change the **Graph scale value of the Y-axis**, rotate and press ⬤ to modify the **Y-axis scale value**.
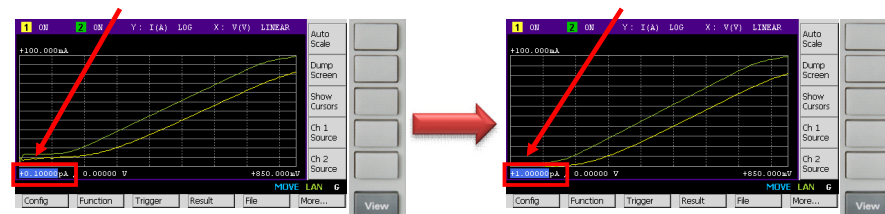
8. View the list of measurement results

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

1) If you are not at the top of the Function menu, press ⬛[Cancel Local] repeatedly to return to the top level.

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

(1) Press **Result**
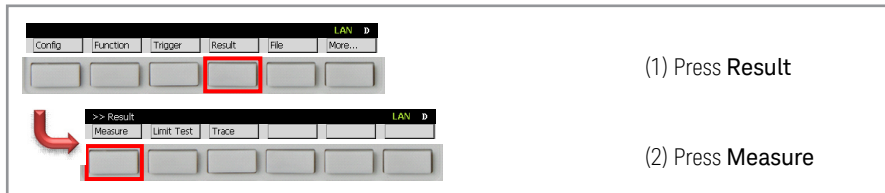
(2) Press **Measure**

3) Rotate and press ⬤ to select the **Data field**. Then rotate ⬤ to scroll the **Data list**.
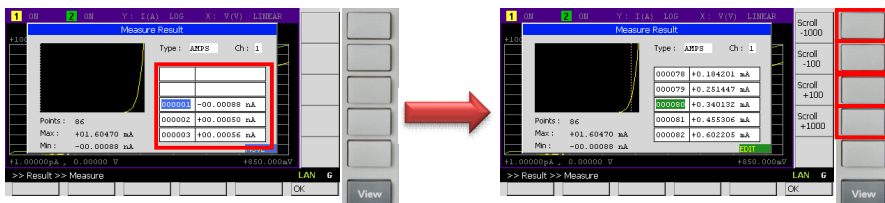
9. Store the measurement data to a USB flash memory device

Attach a USB flash memory device to the USB port on the front panel of the B2900A SMU.

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

At the top level of the Function menu

No tree structure can be seen

In the middle level of the Function menu

Some tree structure can be seen
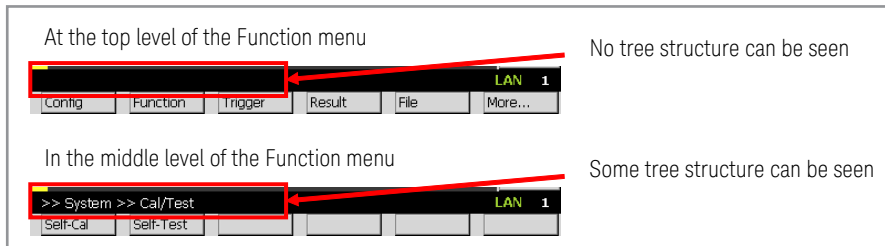
2) Press `File`, `Save` then press `Measure` to open **File Selection dialogue**.

(1) Press **File**

(2) Press **Save**

(3) Press **Measure**
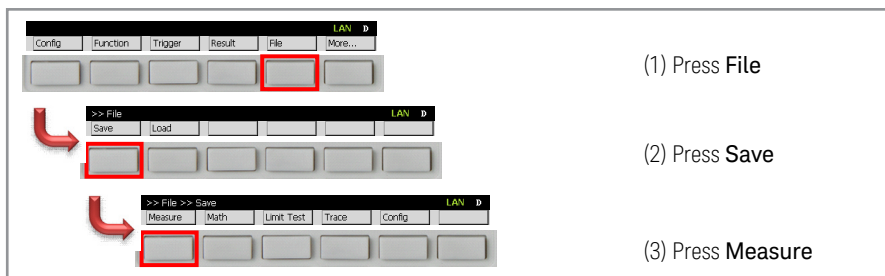
3) Select the folder on USB flash memory device to which the data file should be saved. For example, select DeviceB folder.

(1) Press and rotate ⬤ to select DeviceB folder

(2) Press OPEN to open DeviceB folder

(3) Press [Cancel/Local] to fix the folder
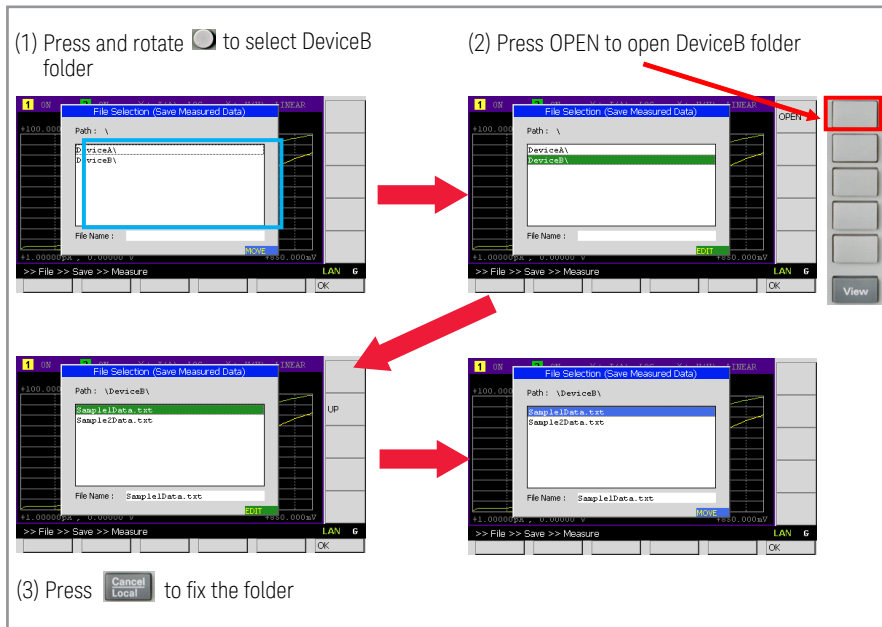
4) Specify the saved data file name.

(1) Rotate and press ⬤ to select File Name field

Alphabet input mode
Numeric input mode

(2) Enter the file name such as "DATA"

(2-1) Press "3(D)"
(2-2) Press "2(A)"
(2-3) Press "8(T)"
(2-4) Press "2(A)"

Insert or Delete

Current input mode

(4) Press OK to save the data

(3) Press ⬤ to fix the file name
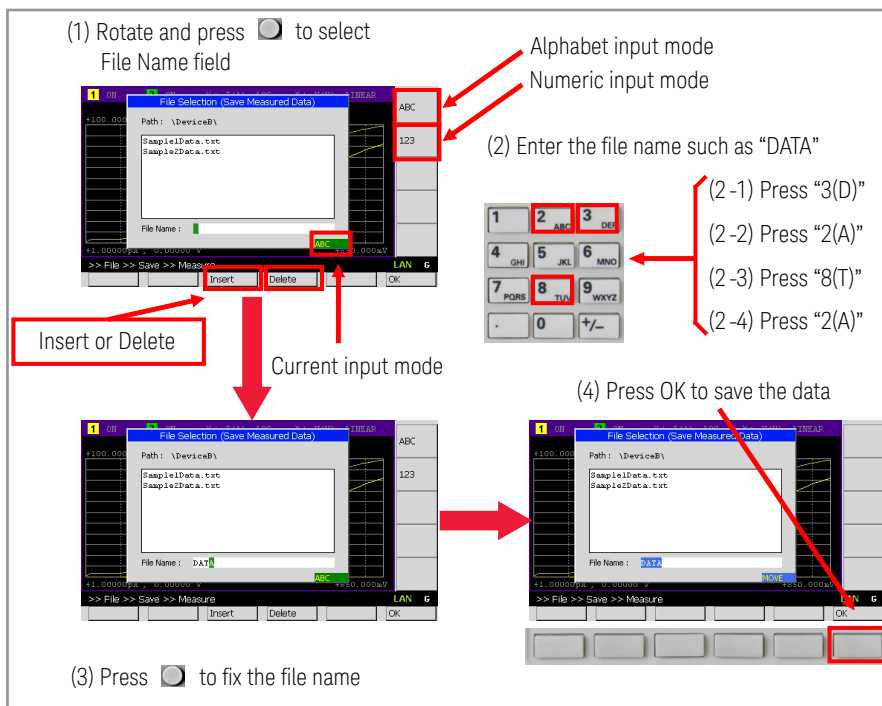
10. Copy the Graph View screen dump to a USB flash memory device

1) If you connect any USB flash memory device to the B2900A SMU, you can copy the Graph View screen dump to the USB flash memory device as a JPEG file. ".jpg" is added to the file name automatically.

(1) Press Dump Screen

(2) Rotate and press ⬤ to select File Name field

(3) Enter the file name such as "BJT" and Press ⬤ to fix the file name

(4) Press OK to save the data
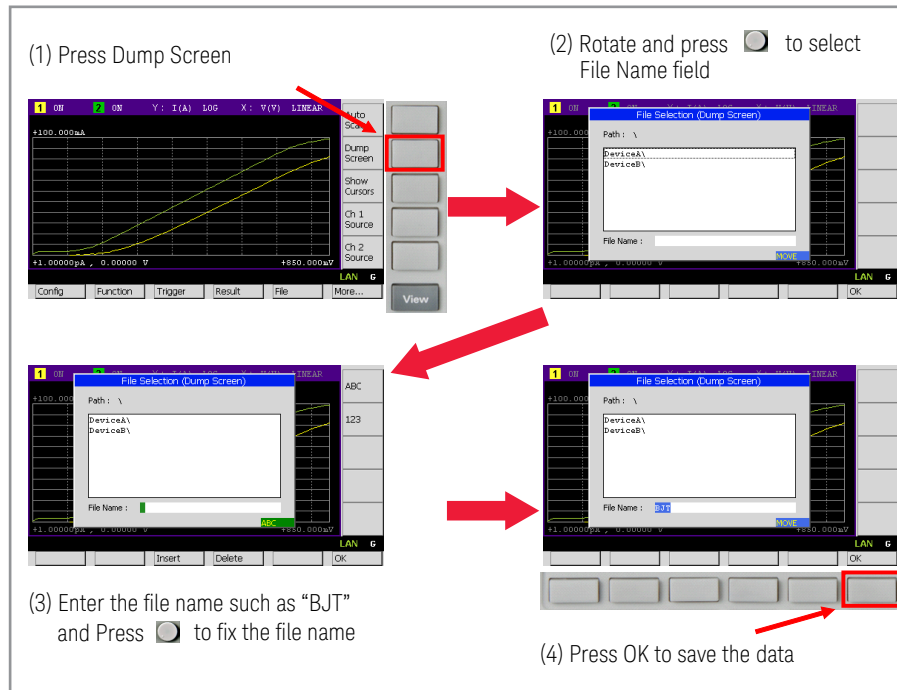
Conclusion

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, bipolar transistor (BJT) 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 BJTs.

B2900 Precision Instrument Family

The B2900 family contains products that perform both precision sourcing and precision measurement.

www.Keysight.com/find/b2900a

Evolving

Our unique combination of hardware, software, support, and people can help you reach your next breakthrough. We are unlocking the future of technology.

From Hewlett-Packard to Agilent to Keysight

myKeysight

myKeysight
www.keysight.com/find/mykeysight
A personalized view into the information most relevant to you.

Keysight Infoline

Keysight Infoline
www.keysight.com/find/Infoline
Keysight's insight to best in class information management. Free access to your Keysight equipment company reports and e-library.

KEYSIGHT SERVICES

Keysight Services
www.keysight.com/find/service
Our deep offering in design, test, and measurement services deploys an industry-leading array of people, processes, and tools. The result? We help you implement new technologies and engineer improved processes that lower costs.

Three-Year Warranty
www.keysight.com/find/ThreeYearWarranty
Keysight's committed to superior product quality and lower total cost of ownership. Keysight is the only test and measurement company with three-year warranty standard on all instruments, worldwide. And, we provide a one-year warranty on many accessories, calibration devices, systems and custom products.

Keysight Assurance Plans
www.keysight.com/find/AssurancePlans
Up to ten years of protection and no budgetary surprises to ensure your instruments are operating to specification, so you can rely on accurate measurements.

Keysight Channel Partners
www.keysight.com/find/channelpartners
Get the best of both worlds: Keysight's measurement expertise and product breadth, combined with channel partner convenience.

For more information on Keysight Technologies' products, applications or services, please contact your local Keysight office. The complete list is available at:
www.keysight.com/find/contactus

Americas
Canada	(877) 894 4414
Brazil	55 11 3351 7010
Mexico	001 800 254 2440
United States	(800) 829 4444

Asia Pacific
Australia	1 800 629 485
China	800 810 0189
Hong Kong	800 938 693
India	1 800 11 2626
Japan	0120 (421) 345
Korea	080 769 0800
Malaysia	1 800 888 848
Singapore	1 800 375 8100
Taiwan	0800 047 866
Other AP Countries	(65) 6375 8100

Europe & Middle East
Austria	0800 001122
Belgium	0800 58580
Finland	0800 523252
France	0805 980333
Germany	0800 6270999
Ireland	1800 832700
Israel	1 809 343051
Italy	800 599100
Luxembourg	+32 800 58580
Netherlands	0800 0233200
Russia	8800 5009286
Spain	800 000154
Sweden	0200 882255
Switzerland	0800 805353
	Opt. 1 (DE)
	Opt. 2 (FR)
	Opt. 3 (IT)
United Kingdom	0800 0260637

For other unlisted countries:
www.keysight.com/find/contactus
(BP-06-08-16)

DEKRA Certified
ISO9001 Quality Management System

www.keysight.com/go/quality
Keysight Technologies, Inc.
DEKRA Certified ISO 9001:2015
Quality Management System

KEYSIGHT TECHNOLOGIES

Unlocking Measurement Insights