

# Keysight Technologies

## IV Characterizations of Solar Cells Using the B2900A Series of SMUs

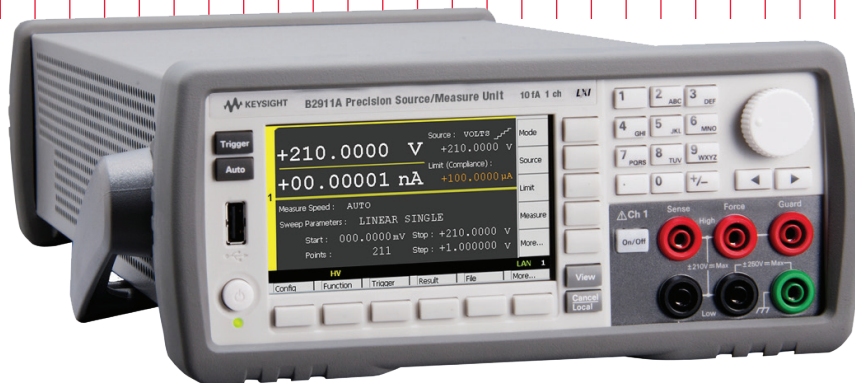
Keysight B2901A Precision SMU, 1ch, 100fA resolution, 210V, 3A DC/10.5A pulse

Keysight B2902A Precision SMU, 2ch, 100fA resolution, 210V, 3A DC/10.5A pulse

Keysight B2911A Precision SMU, 1ch, 10fA resolution, 210V, 3A DC/10.5A pulse

Keysight B2912A Precision SMU, 2ch, 10fA resolution, 210V, 3A DC/10.5A pulse

### Application Note



## Introduction

The Keysight Technologies, Inc. B2901/02/11/12A Precision Source/Measure Unit is a compact and cost-effective bench-top Source/Measure Unit (SMU) with the capability to output and measure both voltage and current. The B2900A Series of SMUs enables you to make a wide range of current versus voltage (IV) measurements more accurately and quickly than ever before. In addition, the B2900A Series of SMUs comes with an intuitive graphical user interface (GUI) and multiple free software control options that make it easy for you to begin making productive measurements immediately, allowing you to choose the solution that best fits your particular application. These features make the B2900A Series of SMUs the best solution for accurate characterization of photovoltaic cells and other devices.



## What is the B2900A Series of SMUs?

An SMU combines the capabilities of a current source, a voltage source, a current meter and a voltage meter along with the capability to switch easily between these various functions into a single instrument. This gives it the ability to evaluate the IV characteristics of devices across all four measurement quadrants without the need for any additional equipment. Besides being able to output and measure voltage or current very accurately, SMUs also possess a compliance feature that allows a limit to be placed on the voltage or current output to prevent device damage. The members of the B2900A Series of SMUs are single or dual channel SMU units that offer a wide range of IV measurement capability for a variety of two-terminal and three-terminal devices. They cover currents from 10 fA to 10.5 A and voltages from 100 nV to 210 V. In addition to their DC operation mode, the B2900A Series of SMUs also has the ability to perform pulsed measurements in order to prevent device self-heating from distorting the measurement results.

Figure 1 illustrates photovoltaic cell measurement using a member of B2900A Series of SMUs. The B2900A Series of SMUs supports 4-wire measurements (remote sensing) to eliminate the voltage error caused by test lead residual resistance. Measurements made through a 2-wire connection can contain significant error when the resistance being measured is comparable to that of the test leads (please see Figure 1a). However, a 4-wire measurement uses one pair of leads to force current and the other pair of leads to monitor voltage. This eliminates cable resistance effects so that only the voltage drop across the DUT is measured (please see Figure 1b). In addition, the 4-wire measurement scheme of the B2900A Series of SMUs keeps the voltage between the sense points (A and B in Figure 1b) at exactly the specified voltage  $V_{\text{set}}$ , thereby ensuring that your device is characterized exactly under the measurement conditions you specify. The B2900A Series of SMUs allows you to accurately and easily measure the IV parameters and characteristics of photovoltaic cells, including short circuit current, open circuit voltage, and maximum power point.

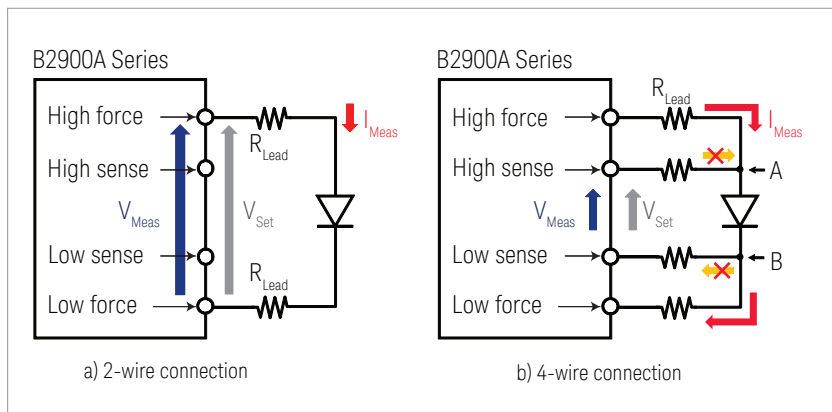


Figure 1. A 4-wire connection eliminates the measurement error caused by residual lead resistance

## Quick and easy IV characterization

During routine device evaluation it is often desirable to make a quick measurement from the instrument's front panel without having to go through the time and trouble of writing a test program. To meet this need, all members of the B2900A Series of SMUs have a resident GUI that makes it easy to perform a variety of tests and save measurement data without having to write any code.

The wide QVGA LCD display of the B2900A Series of SMUs supports an easy-to-use GUI that provides easy instrument control from the front panel (please see Figure 2). The GUI of the B2900A Series of SMUs has the following multiple viewing modes: Single View, Dual View, Graph View and Roll View (for viewing time domain measurements). Single View mode allows you to easily set up not only constant voltage and current measurements but also swept voltage and current measurements. Dual View can perform similar functions for both channels simultaneously (for B2902A and B2912A). The GUI also supports the list sweep mode, which permits the creation of sweeps consisting of arbitrary voltage or current steps. One big advantage of the list sweep mode is that it allows you to specify widely-spaced steps in regions where the device characteristics are stable, and closely-spaced steps in regions of special interest such as the maximum power point of a photovoltaic cell (please see figure 3). After measurement completion you can use the front panel GUI to graphically view measurement results such as IV curves using Graph View, and display a list of the measurement data using the Measure Result dialog window.

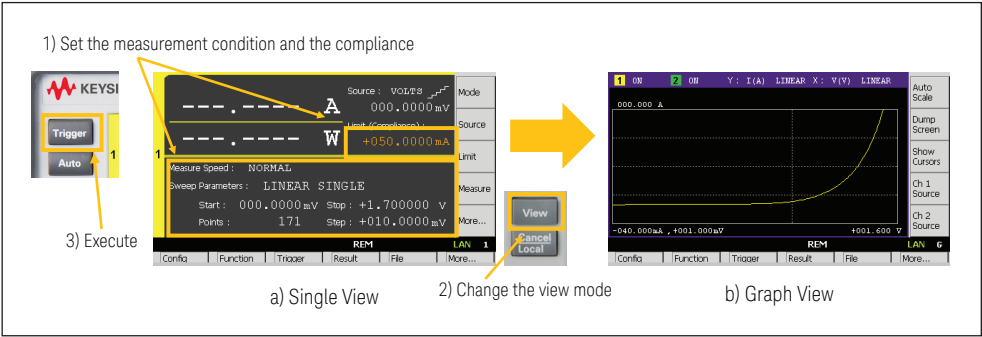


Figure 2. The GUI of the B2900A Series of SMUs makes it easy to take a quick measurement and display the results

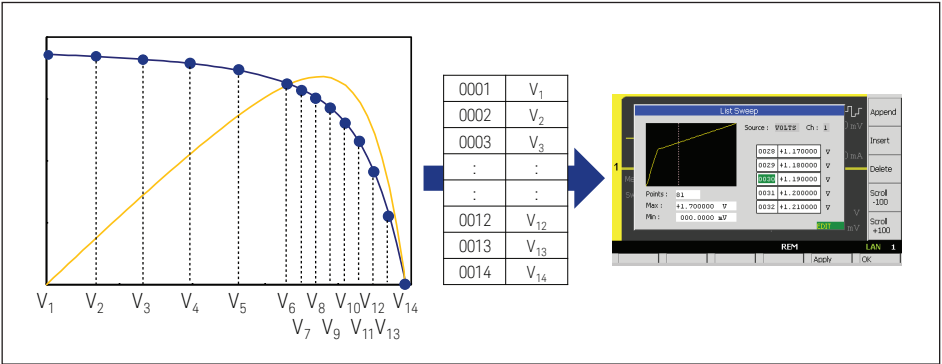


Figure 3. The list sweep mode of the B2900A Series of SMUs makes it easy to characterize photovoltaic cells in the region of interest

The B2900A Series of SMUs has a USB interface on the front panel so that a USB flash memory device can be used with the B2900A Series of SMUs to save and load measurement setups as well as to save measurement results. For example, you can create the complicated voltage/current steps for a list sweep on a PC using the software of your choice and then transfer the setup file to the B2900A Series of SMUs via USB flash memory. In addition, Graph View supports a Screen Dump function that enables you to save screen images (such as IV curves) to any attached USB flash memory device as JPEG files, making it easy to include graphical results in reports and presentations (please see Figure 4).

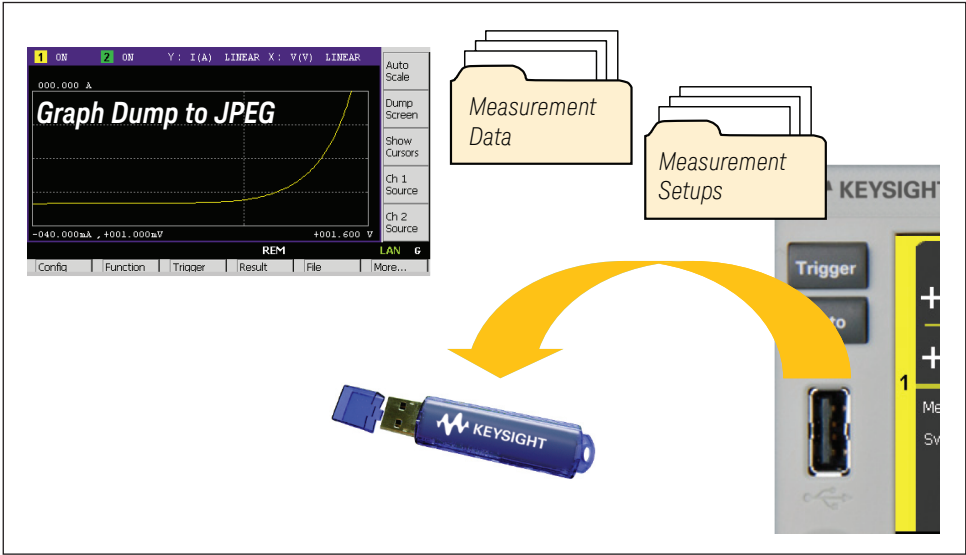


Figure 4. Measurement setups and results can be transferred and saved using any USB flash memory device

## A Range of Free Software Control Options

In addition to its powerful and easy-to-use GUI, if you prefer PC-based instrument control, then the B2900A Series of SMUs comes with a range of free software control options to facilitate program development, allowing you to choose the solution that best fits your particular application.

### BenchVue

The Keysight BenchVue software for the PC reinvents your bench testing by making it simple to connect and record results with your instruments without the need for programming. You can quickly and easily obtain results by viewing, logging and exporting measurement data and screen images with just a few mouse clicks. BenchVue provides a wide array of capabilities, depending on the chosen instrument application. These capabilities will vary according to the functionality of the instrument types and models, including the B2900A Series of SMUs, that are connected to the PC that is running the BenchVue software.

See <http://www.keysight.com/find/benchvue> for more details.

### Graphical Web Interface

The Keysight B2900A Graphical Web Interface provides functionality to allow access to the B2900A Series of SMUs over a LAN connection. The B2900A Series of SMUs is fully compliant with the LXI class C specification and contains a web server that provides a webpage with an interface to support the basic measurement functions of the B2900A. You can quickly and easily make measurements using a standard web browser by simply connecting the B2900A Series of SMUs to a PC using a LAN cable.

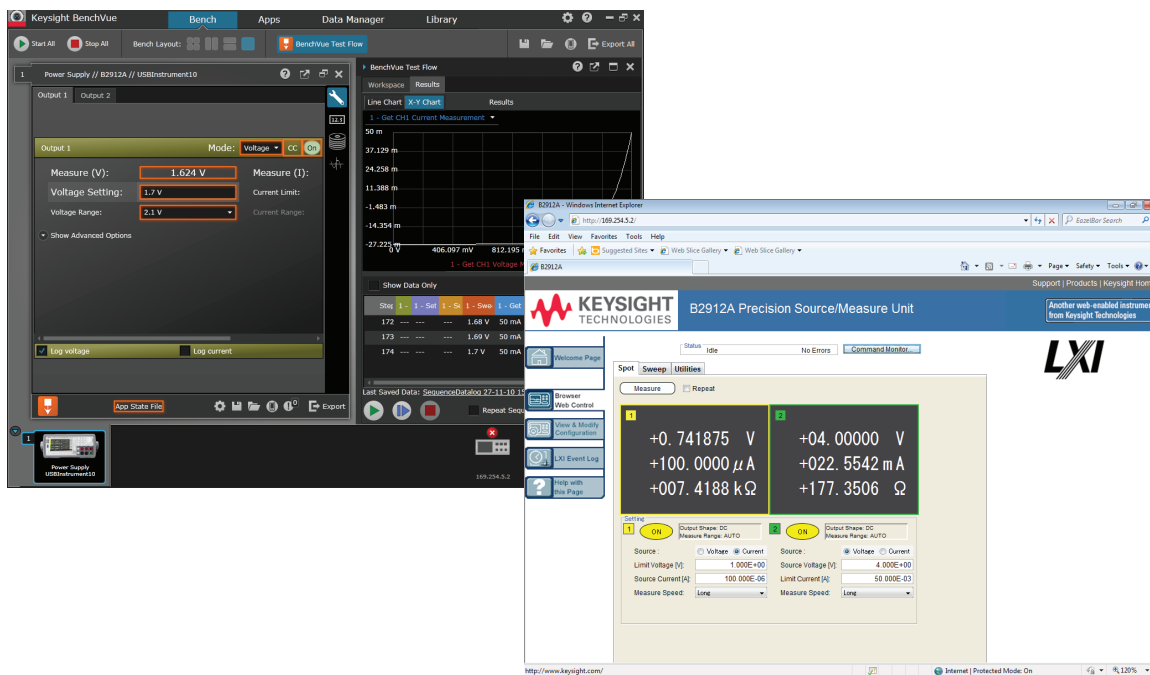


Figure 5. BenchVue and Graphical Web Interface

## Quick I/V Measurement Software

The Keysight B2900A Quick I/V Measurement Software is a common software solution for the entire B2900 precision instrument family. It has powerful measurement capabilities to control the B2900A Series of SMUs over GPIB, USB or LAN connections (see Figure 6). You can download this PC-based software for free from <http://www.keysight.com/find/quickiv>. The Keysight B2900A Quick I/V Measurement Software also supports a variety of functions such as a sweep measurement, a sampling measurement, basic math functions, graphical display functions and the ability to save test results as CSV files.

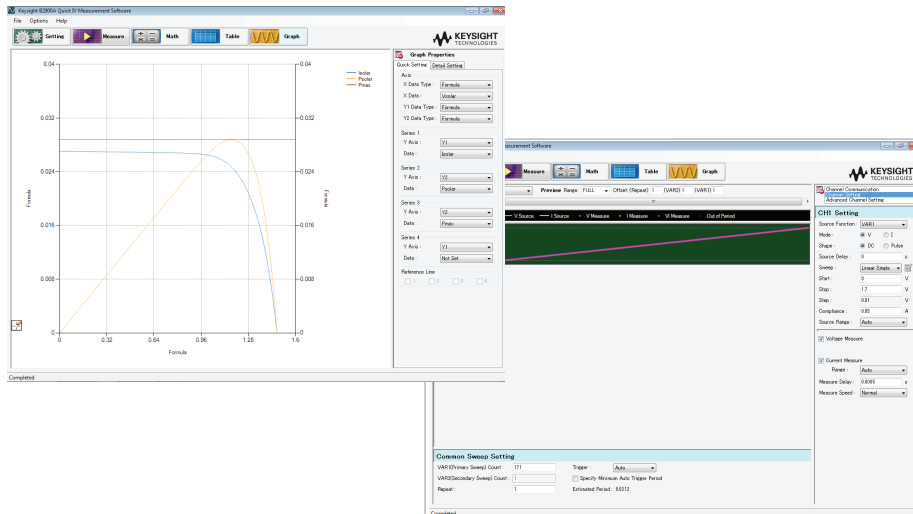


Figure 6. It is easy to make a quick measurement on a PC using the Keysight B2900A Quick I/V Measurement Software

## EasyEXPERT group+

The EasyEXPERT group+ software is the more powerful solution for detailed characterization and analysis of devices, circuits and materials. It supports efficient and repeatable characterization across the entire characterization process from measurement setup and execution to analysis and data management. EasyEXPERT group+ makes it easy to perform complex characterization with ready-to-use furnished measurements (application tests), and gives you the option of automatically storing every test condition and piece of measurement data in a unique built-in database (workspace), ensuring that valuable information is not lost and that measurements can be repeated at a later date.

See <http://www.keysight.com/find/easyexpert> for more details.

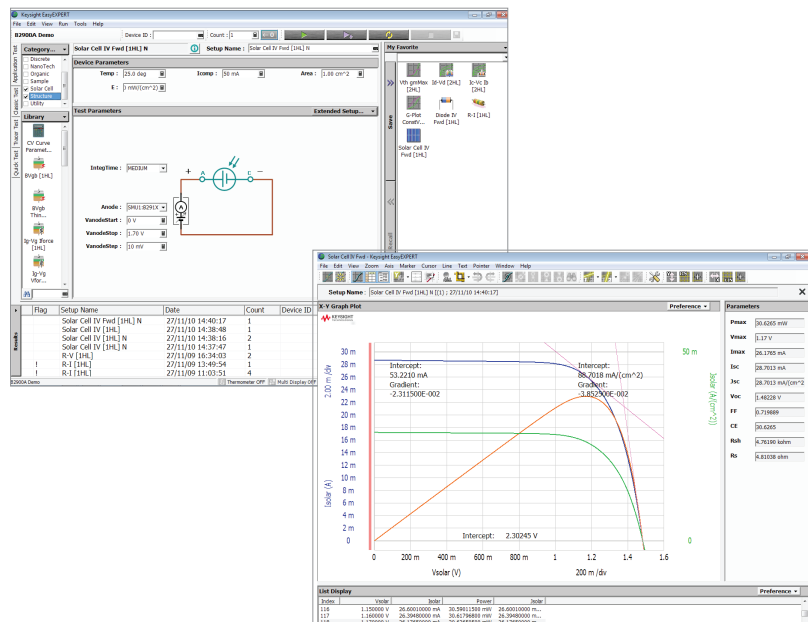


Figure 7. EasyEXPERT group+ is a powerful solution for detailed characterization and analysis of devices, circuits and materials



## Easy Custom Program Support

If you have specialized programming needs, then both Standard Commands for Programmable Instruments (SCPI) and IVI-COM drivers are available for the B2900A Series of SMUs. SCPI is an industry-standard command set for basic instruments, and it has a uniform structure that supports a common set of commands. The SCPI command set for the B2900A Series of SMUs not only supports its advanced features but also general-purpose SMU commands (such as those used by the Keithley 2400) to simplify test program migration. In addition to SCPI, the IVI-COM drivers for the B2900A Series of SMUs work in a variety of programming environments and languages so that you can develop programs without having to use low-level commands.

## Summary

The Keysight B2901/02/11/12A Precision Source/Measure Unit is the best solution for IV characterization of photovoltaic cells and a variety of other devices. Its wide current and voltage measurement ranges (from 10 fA/100 nV to 10.5 A/210 V) provide superior measurement performance and allow you to characterize devices more accurately and easily than ever before.

The easy-to-use GUI of the B2900A Series of SMUs has a variety of capabilities and features that make it easy to take measurements quickly and to save both the measurement setup conditions and data to USB-based flash memory devices.

In addition to being able to control the B2900A Series of SMUs remotely over GPIB, USB and LAN interfaces, Keysight offers multiple free software control options to facilitate program development if you prefer PC-based instrument control, allowing you to choose the solution that best fits your particular application.

For more detailed information on the various models of the B2900A Series of SMUs, please refer to the data sheet of the B2900A Series of SMUs (5990-7009EN)

The B2900A Series of SMUs enables you to quickly debug and accurately characterize a wide variety of devices using only a single bench-top SMU.

### Keysight Precision Current-Voltage Analyzer Series and Power Device Analyzer Series

Keysight also offers a variety of analyzers which ensure accurate and efficient current-voltage measurements that give a clear insight into IV characteristics across a wide range of applications. [www.keysight.com/find/analyzer](http://www.keysight.com/find/analyzer)





## Unlocking Measurement Insights