Resistance Measurements Using the Agilent B2900A Series

Technical Overview

Agilent B2900A Series Precision Source/Measure Unit

Agilent B2901A Precision SMU, 1ch, 100fA resolution, 210V, 3A DC/10.5A pulse
Agilent B2902A Precision SMU, 2ch, 100fA resolution, 210V, 3A DC/10.5A pulse
Agilent B2911A Precision SMU, 1ch, 10fA resolution, 210V, 3A DC/10.5A pulse
Agilent B2912A Precision SMU, 2ch, 10fA resolution, 210V, 3A DC/10.5A pulse

Introduction

The Agilent B2900A Series of Precision Source/Measure Units are compact and cost-effective bench-top Source/Measure Units (SMUs) with the capability to output and measure both voltage and current. They cover currents from 10 fA to 10.5 A and voltages from 100 nV to 210 V, which enables you to make a wide range of current versus voltage (IV) measurements more accurately and quickly than ever before. The B2900A Series also supports a resistance measurement function that facilitates both low and high resistance measurements. These features make the B2900A Series the best solution for accurate characterization of resistors and other devices.

Making accurate resistance measurements is actually one of the more challenging areas of measurement science. Many factors can affect the accuracy of a resistance measurement, including residual test lead resistance, thermal electromotive force and leakage currents in the measurement path. The B2900A Series possesses a variety of features to address these measurement issues, including a remote sense function (4-wire connection), offset compensation, and a guard function. All of these will be described in greater detail in this technical overview.

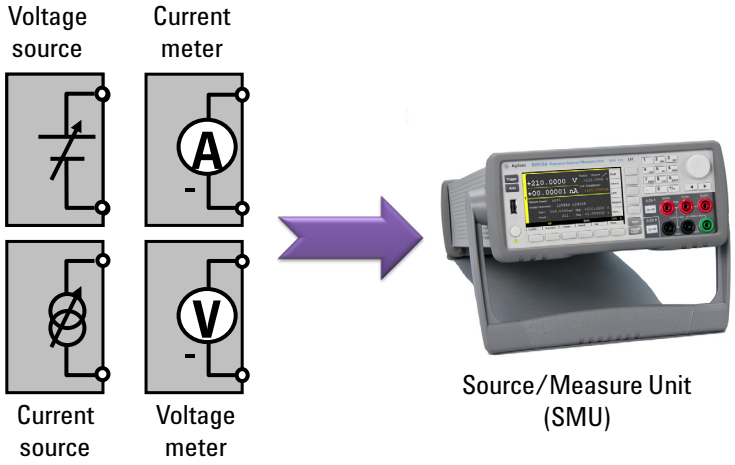


Figure 1. The B2900A Series Precision SMU combines four measurement functions into a single instrument

What is the B2900A Series SMU?

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 (please see Figure 1). 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 B2900A Series members 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 units also have the ability to perform pulsed measurements in order to prevent device self-heating from distorting the measurement results. Finally, the B2900A Series also has a built-in resistance measurement function.

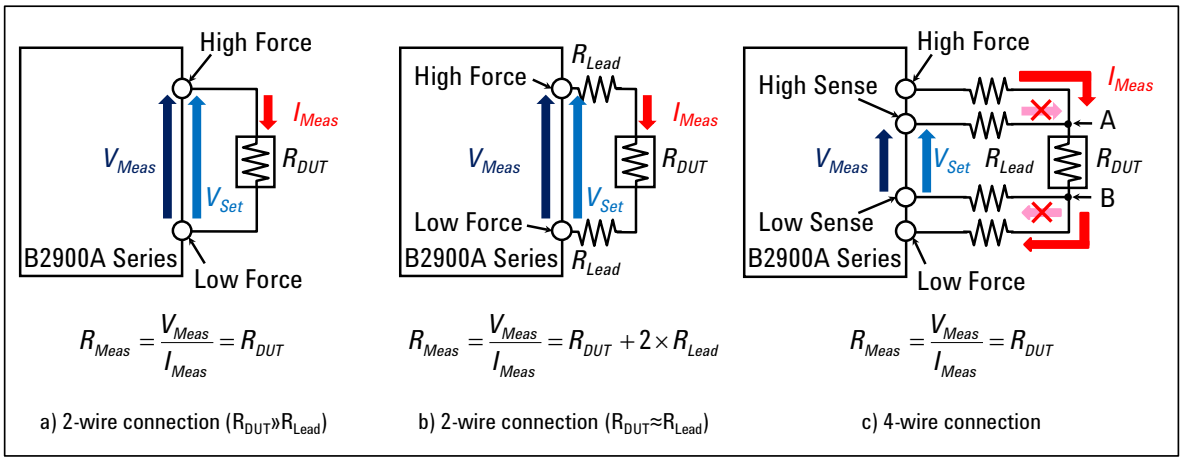
Best resistance measurement solution

The B2900A Series is the best solution for making accurate resistance measurements due to its intrinsic voltage/current sourcing and measurement capabilities. In addition, the B2900A Series has some special built-in functions specifically designed to improve resistance measurement. The following sections describe these features in detail.

Eliminating residual resistance effects

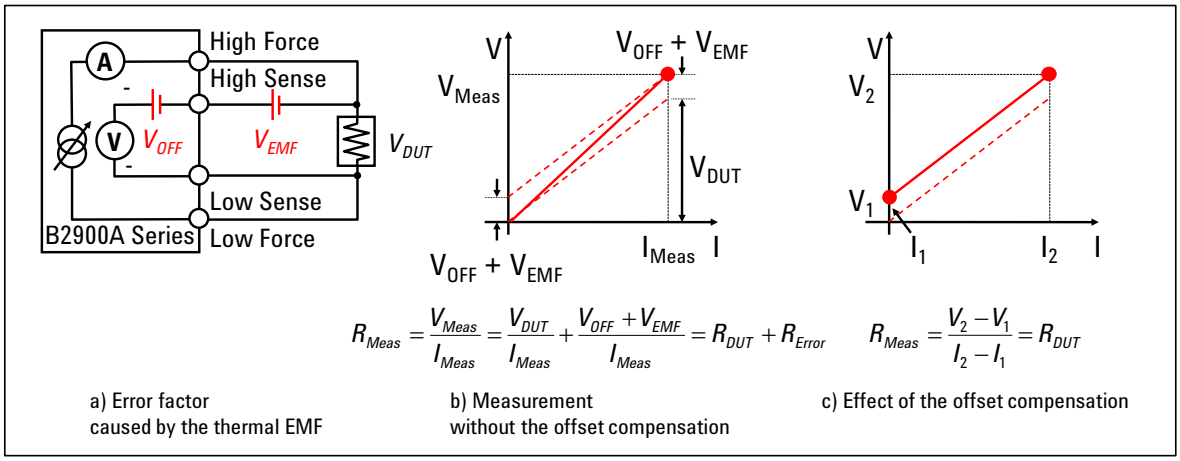
A basic 2-wire connection is the most common scheme used for resistance measurements. In this configuration (shown in Figure 2a) the same pair of test leads is used to both force current and measure voltage. This arrangement is suitable for resistance measurements as long as the residual lead resistance is negligible compared to the resistance of the device under test (DUT).

However, for very low resistance measurements where the residual lead resistance is comparable to the DUT resistance, the 2-wire measurement will give erroneous measurement results (please see Figure 2b). In this case a 4-wire connection scheme (remote sensing) can be used to eliminate this error. 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 2c). In addition, the B2900A Series' 4-wire measurement scheme keeps the voltage between the sense points (A and B in Figure 2b) at exactly the specified voltage V_{set}, thereby ensuring that your device is characterized exactly under the measurement conditions you specify. The B2900A Series supports both connection schemes and it is easy to switch between them.



a) 2-wire connection ($R_{DUT} \gg R_{Lead}$) b) 2-wire connection ($R_{DUT} \approx R_{Lead}$) c) 4-wire connection

Figure 2. A 4-wire connection eliminates the measurement error caused by residual lead resistance



a) Error factor caused by the thermal EMF b) Measurement without the offset compensation c) Effect of the offset compensation

Figure 3. The B2900A Series has a compensation feature that can automatically eliminate the effects of offset voltages and thermal electromotive force

Offset compensation

When measuring small resistances, both the offset voltages inherent in the instrumentation and the thermal electromotive force (EMF) generated when the mechanical reed relays in the SMU output path close can create measurement inaccuracies. An equivalent circuit model of these effects is shown in Figure 3a. Since the voltage drop across the DUT is small when measuring low resistances, the effects of the offset and EMF voltages are not negligible (please see Figure 3b). However, using the B2900A Series' resistance compensation function the instrument will automatically make a two point measurement and calculate the true value of the resistance using the following equation.

$$R_{comp} = \frac{V_2 - V_1}{I_2 - I_1}$$

Where:V_1 is the measured voltage when the source is set to 0 volts (voltage force mode) or 0 amps (current force mode).
V_2 is the measured voltage when the source is set to V_f (voltage force mode) or I_f (current force mode).
I_1 is the measured current when the source is set to 0 volts (voltage force mode) or 0 amps (current force mode).
I_2 is the measured current when the source is set to V_f (voltage force mode) or I_f (current force mode).

By using its built-in 2 point measurement function, the B2900A Series allows you to easily eliminate the influence of offset voltages on a resistance measurement (please see Figure 3c).

Leakage current prevention

Leakage currents in the cables and test fixturing can cause significant measurement errors, especially when measuring large resistances where the measurement current is small (less than a nanoamp). In this case, the B2900A Series' guard function can be used by employing banana-to-triaxial adaptors and triaxial cables. The SMU circuitry maintains the guard terminal at same voltage potential as the high force line, which prevents current from leaking into the cable and the surrounding measurement path (please see Figure 4).

Powerful GUI and convenient PC control options

The B2900A Series' wide QVGA LCD display supports an easy-to-use GUI that provides easy instrument control from the front panel. This makes it simple to perform both spot resistance measurements using constant voltage or current and sweep measurements to obtain an IV curve. 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 (please see Figure 5).

For the remote control, both Standard Commands for Programmable Instruments (SCPI) and IVI-COM drivers are available for the B2900A Series. The Agilent B2900A Quick I/V Measurement Software is available for download from the Agilent Web site for free. The Agilent B2900A Graphical Web Interface is also available, and it provides functionality to allow access to the B2900A Series over a LAN connection. The B2900A Series is fully compliant with the LXI class C specification, making it easy to take measurements using a standard web browser by just connecting the B2900A Series to a PC using a LAN cable.

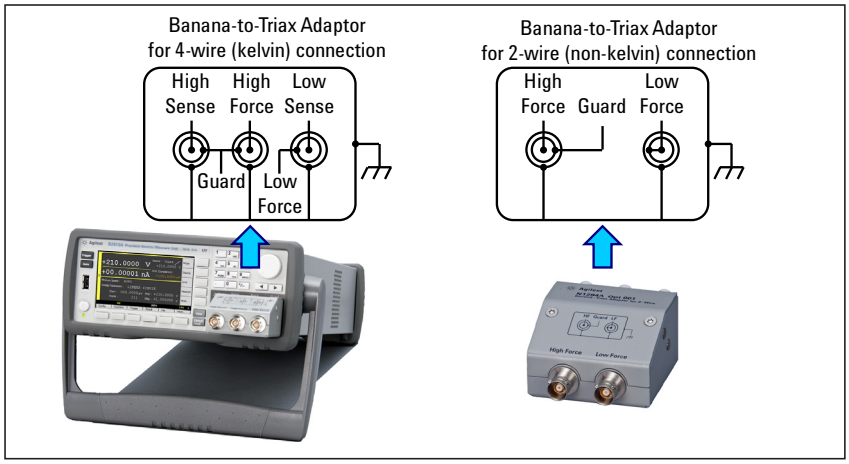


Figure 4. The B2900A Series' active guard eliminates leakage currents when used with the proper triaxial connectors and cabling

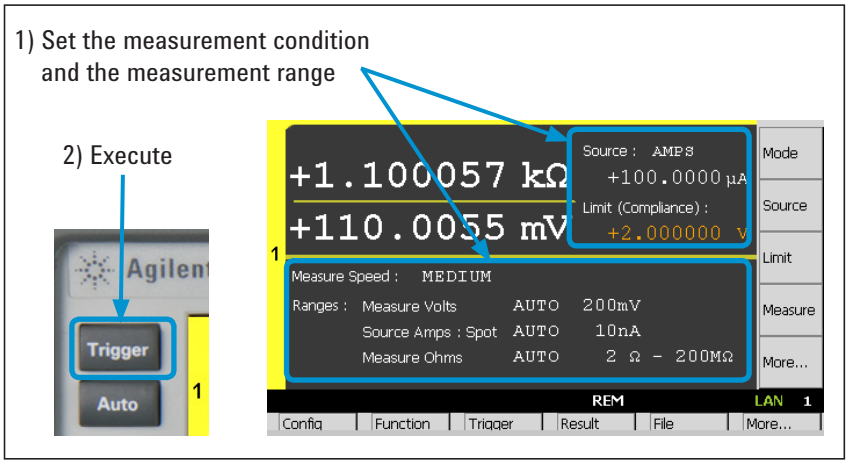


Figure 5. B2900A Series' GUI makes it easy to take a quick measurement

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Summary

The Agilent B2900A Series of Precision Source/Measure Units is the best solution for IV characterization of resistors and a variety of other devices. The B2900A Series has many built-in functions that make it easy to take accurate resistance measurements, including support for a 4-wire connection (remote sense function), voltage offset compensation and an active guard function. The B2900A Series' easy-to-use GUI provides fast and convenient front panel operation, and for PC-based programming there are a variety of options to control the SMU over GPIB, USB and LAN.

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

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

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