Measurements International

Metrology is Our Science, Accuracy is Our Business™

6600A DUAL SOURCE HIGH RESISTANCE BRIDGE

Developed & designed by metrologists for metrologists & calibration technicians

6600A-10 kV System shown with optional 10 kV extender and 10-channel scanner

Featuring

- Based on proven NMI Design
- Range: 10 kΩ to 10 PΩ
- Voltages: 1 V to 1000 V (10 000 V Optional)
- Automatic and Manual Operation
- Not Affected by Temperature Change
- 10 and 20-Channel Coaxial Matrix Scanners (Optional)
- Environmental & Pressure Monitoring (Optional)
- Ratio 1:1, 10:1, 100:1, 1000:1
- Multiple Modes of Operation

Overview

Measurements International (MI), in keeping with "Metrology is our Science, Accuracy is our Business™", has introduced the first commercially available Automated Dual Source High Resistance Bridge. This principle has become the primary measurement technique of all National Measurement Laboratories (NMIs) worldwide due to its unprecedented accuracy and stability over various other methods. Multiple modes of operation in the 6600A allow users to make resistance measurements differently.

Feature	Benefit
Only true ratio bridge mode for direct comparison of high resistance standards.	Customers get the very best in commercially available technology.
Offers only high resistance bridge with any voltage between 0 V and 1000 V.	Customers are no longer limited to selected voltage through resistors.
Offers any ratio up to 1000:1.	Users can fully use any ratio up to 1000:1 and are not limited in ratio.
Voltages can be extended to 10 000 V.	Allows users to extend voltage range beyond 1000 V up to 10 000 V.
Based on NMI chosen technology.	Gives users the ability to use leading edge highest precision measurement technology.

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Bridge Mode

Using the Bridge mode, the UUT is measured live against a standard reference resistor where the ratio of the sources is equal to the ratio of resistances ($E_1/E_2 = R_1/R_2$). This is the most accurate and reliable type of measurement for high resistance. Lead set N-type to N-type cables are supplied.

Direct Mode and Insulation Resistance Mode

The Direct and Insulation Resistance modes which are made on the R1 (shown in Figure 1) channel allow users to perform teraohmmeter type measurements without the need to connect a reference standard resistor where R = E1/I1. These modes are useful to determine the resistor's nominal value, its settle time, leakage resistance, etc. N-type to N-type lead and N-type to alligator lead are supplied.

All modes of operation offer users the flexibility to choose UUT test voltages from 1 V to 1000 V with six digits of resolution. Other commercially available units are limited within this range and do not allow the full freedom that the MI 6600A can offer.

Metrologists in any laboratory now have the ability to achieve measurable results and uncertainties that were previously only achievable in the highest NMI laboratories for measurements above 100 MΩ. This is due to the advanced technology of the Dual Source Bridge. While other commercially available "meters" are limited to only measuring one artifact at a time, the 6600A offers an actual "true bridge" measurement mode to complete this process where a known standard is measured against an unknown resistor in "true bridge" technology form. Ratios of 1:1, 10:1, 100:1, or even 1000:1 can be made with the best uncertainties being measured at ratio 1:1 or 10:1 at any voltage.

Ratio Measurement Principal (Figure 1)

The bridge architecture in the 6600A is formed by substituting two of the resistive arms of a Wheatstone bridge circuit with low-impedance digitally programmable voltage sources.

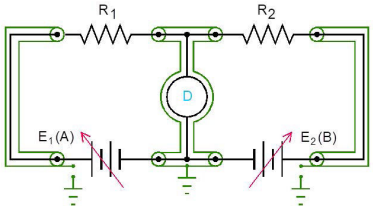
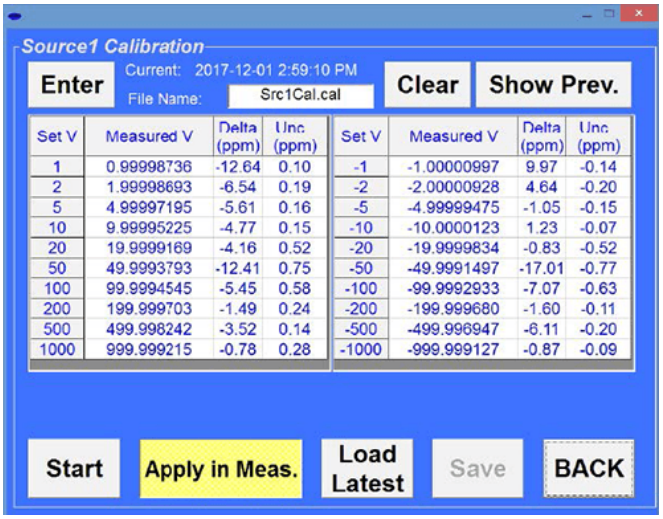


Figure 1 - Bridge Block Diagram

Voltage Sources

The 1000 V DC sources in the 6600A offer voltage ratios of 1:1, 10:1, 100:1, or any ratio in between. The voltage settings can be observed on the front panel display. The model 6600A is the only commercially available high-resistance bridge that offers any selectable voltage between 1 V to 1000 V. Other manufacturers are limited to specific voltages within the set range of 1 V to 1000 V. The 6600A is housed in a shielded chamber to limit the effect of the outside environment due to air movement and static electricity caused by people passing by or technicians working in the area.



Set V	Measured V	Delta (ppm)	Unc (ppm)	Set V	Measured V	Delta (ppm)	Unc (ppm)
1	0.99998736	-12.64	0.10	-1	-1.00000997	9.97	-0.14
2	1.99998693	-6.54	0.19	-2	-2.00000928	4.64	-0.20
5	4.99997195	-5.61	0.16	-5	-4.99999475	-1.05	-0.15
10	9.99995225	-4.77	0.15	-10	-10.0000123	1.23	-0.07
20	19.9999169	-4.16	0.52	-20	-19.9999834	-0.83	-0.52
50	49.9993793	-12.41	0.75	-50	-49.9991497	-17.01	-0.77
100	99.9994545	-5.45	0.58	-100	-99.9992933	-7.07	-0.63
200	199.999703	-1.49	0.24	-200	-199.999680	-1.60	-0.11
500	499.998242	-3.52	0.14	-500	-499.996947	-6.11	-0.20
1000	999.999215	-0.78	0.28	-1000	-999.999127	-0.87	-0.09

Figure 2 - Source Calibration Example

6600A Calibration

Calibration of the 6600A is achieved by calibrating the sources and the electrometer. A Diagnostic menu included in the software allows the user to run diagnostics on all the units in the system. A built-in calibration routine that controls an external calibrated 3458A DMM calibrates the sources one at a time. Source voltages are measured and stored automatically in the source table as Source 1 and Source 2 as offsets from nominal. Figure 2 shows an example of Source 1 calibration. These offsets (Delta) are applied to the voltages selected during measurement. As an alternative with better accuracy, the MI model 8000B system can be used to calibrate the sources.

Electrometer calibration is achieved by using a calibrated source and calibrated resistor to determine the absolute current readings on the electrometer (Figure 3 shows the electrometer calibration example). The effect of the uncertainty on the electrometer is reduced greatly when the 6600A is operated in bridge mode as the electrometer is used over a very small window reducing the type-B uncertainty to effectively zero leaving only the type-A uncertainty. In the direct mode, the type-B uncertainty combined with the type-A uncertainty is used.

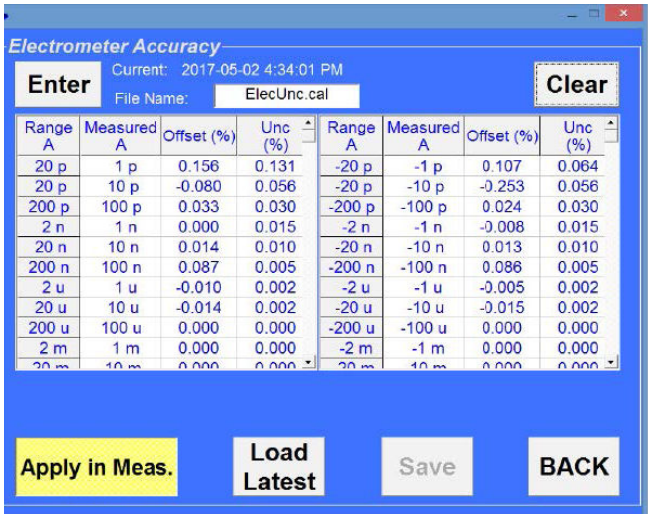


Figure 3 - Electrometer Calibration

Leakage Paths

In the 6600A, the resistors are measured with the case grounded, so that a leakage resistance path between the high terminal of the resistor and case is effectively in parallel with the voltage source A, and does not contribute to any measurement errors. Terminal leakage resistance at the low resistor terminal is effectively in parallel with the detector where a very small voltage is present to drive this leakage.

Connections and Thermal Voltages

The resistors are connected to R_1 and R_2. Either can be designated as the standard. The reversal method is used to eliminate thermal voltage signals and to allow the capacitance effect of the leads and the resistor time constant to settle.

Software

Making a measurement on the 6600A is simple, the software allows the user to define the measurement and test parameters utilizing the same proven software used on the MI 6010 and 6000 series of DC Bridges that our customers have become accustomed to. Features include resistor protection, settle time to verify time constants of resistors, number of measurements, statistics, voltage, temperature coefficients, and graphing.

The program's menu allows users to create and combine several program tasks such as intercomparing standards to standards, standards to measurands, and measurands to measurands. Selectable parameters include measurement time delays (wait times), reversal rate, number of measurements, number of stats, applied voltage, standards used, current threshold, and standard resistor uncertainty. All measurement parameters including statistical data are displayed during measurement.

Measurement Analysis

The 6600A software allows the user to fully analyze all measurements. In the measurements screen, the measurement data includes the ratio, absolute value, and measurement graph. Voltage and power graphing allows the user to observe a measurement trend for the current measurement or after the measurement is complete. All the measurement data can be exported to Excel using the supplied Excel Macro. There, further analysis can be performed with the ability to crop out sample sets or remove outliers.

Resistor data can be stored in the history file based on the serial number which is updated every time the resistor is measured. In the Resistor History file menu, the resistor data can be recalled and graphed including the standard deviation of each measurement. A trend line based on linear, logarithmic, or polynomial wave-shapes can be displayed. Regression analysis can also be used to determine projected values over time and the Y-axis can be scaled to fit the graph.

Voltage Extension

An optional model 66001 Voltage Extender is available to increase the E_1 output of the 6600A to 10 kV for direct mode measurements. This is useful for the calibration of high-voltage standard resistors used to verify hipot or insulation breakdown testers or surface and volume resistivity measurements.

Related Products

Available for use with the 6600A is the MI Matrix Scanner. The MI model 4610A is a 10-Channel Coaxial Matrix Scanner designed specifically for use in high-resistance measurements. Using a proprietary (completely) coaxial design, leakage paths are minimized allowing measurements up to 1 TΩ with zero added uncertainty. N-type high and low connections are utilized for their superior isolation properties and labeled high and low on the rear panel. Additional cables are available for connection to various other types of High Resistance terminals such as BPO and Triax.

The MI model 9331G has become the primary standard in high resistance measurements in many laboratories. It is available in standard values from 100 MΩ to 100 TΩ and custom values are available at any resistance therein. The high stability and supplied alpha and beta temperature coefficients of the 9331G make them ideal for easy transport and operation in any working environment within the range of 18 °C to 28 °C. The resistance standards require no controlled oil or air bath to meet specifications, however, for improved performance, they can be placed in an air bath such as the model 9300A.

The model 9300A Laboratory Air Bath is designed as a convenient way to maintain the temperature of standard resistors. Heating and cooling are provided by Peltier modules for low-noise operation. The air baths can be set for a wide range of temperatures to establish temperature coefficients. The model 9300A is a shielded bath and is controllable via GPIB.

Optional Accessories	
4610A	10-Channel High Resistance Coaxial
9300A	Ultra High Stability Programmable Air Bath
66001	Voltage Range Extender
6600A-Cal	Accredited Calibration
6600A-SW	Control and Data Acquisiton Software (Included)
9331G-XXX	100 MΩ, 1 GΩ, 10 GΩ, 100 GΩ, 1 TΩ, 10 TΩ, 100 TΩ Standard Resistors
9331G-01	Lead Set, N-Type to GR
9331G-02	Lead Set, N-Type to N-Type
9331G-03	Lead Set, N-Type to BNC
9331G-XX	Lead Set, N-Type to Special
HF556	HygroFlex Humidity Temperature Transmitter

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Specifications: Rev 5

6600A Specifications[1,4]				
Resistance Measurement		Live Ratio Mode Uncertainty[2] (ppm)		Direct Measurement[3]
Range	Applied Voltage	1:1 & 10:1 Ratios	100:1 Ratio	
100 kΩ to 1 MΩ	1 V to 100 V	< 7	< 20	100
1 MΩ to 10 MΩ	1 V to 100 V	< 7	< 20	50
10 MΩ to 100 MΩ	10 V to 1000 V	< 7	< 20	50
100 MΩ to 1 GΩ	10 V to 1000 V	< 7	< 20	50
1 GΩ to 10 GΩ	10 V to 1000 V	< 7	< 20	100
10 GΩ to 100 GΩ	100 V to 1000 V	< 12	< 40	100
100 GΩ to 1 TΩ	100 V to 1000 V	< 20	< 50	500
1 TΩ to 10 TΩ	100 V to 1000 V	< 100	< 250	1,000
10 TΩ to 100 TΩ	100 V to 1000 V	< 500	< 1,000	1,500
100 TΩ to PΩ	1000 V	< 1,000	< 10,000	10,000
1 PΩ to 10 PΩ	1000 V	< 15,000	< 50,000	100,000

1. Uncertainty Confidence Level: 95 %
2. Ratio mode uncertainty does not include uncertainty of reference resistor (Results of calibration with model 8000B).
3. 12 month uncertainties relative to calibration standards used.
4. Specifications do not include settle time, dielectric or voltage coefficient etc. for the resistor being measured.

Additional Capabilities

Voltage Generation				Current Measurement			
Range	Resolution	24 Hour ppm	1 Year ppm	Amps Range	Resolution	Accuracy ±,%,rdg 18 °C - 28 °C, 1 Year	Temperature Coefficient ±,%,rdg/°C
2 - 20.2 V	10 µV	2	10	20 pA	100 aA	1	0.1
0 - 202 V	100 µV	2	10	200 pA	1 fA	1	0.1
200 - 1025 V	1 mV	2	10	2 nA	10 fA	0.2	0.1
				20 nA	100 fA	0.2	0.03
				200 nA	1 pA	0.2	0.03
				200 µA	1000 pA	0.1	0.005

General Specifications

Resistance Mode	Current Mode	Power	Temperature	Relative Humidity	Warm-Up	Connection
10^5 to 10^{15} Ω	20 pA to 20 mA	450 W	Operating 23°C ± 5°C Storage - 5 °C to + 60 °C	< 80 % to 30 °C < 70 % to 40 °C < 40 % to 50 °C	10 minutes	N-Type Connectors

Dimensions (L × W × H):
737 x 813 x 1016 (mm)

Weight:
250 kg

Shipping Weight:
270 kg

Mains Power:
100, 120, 220, 240 V_{ac}, 50/60 Hz

Corporate Headquarters
Measurements International
PO Box 2359, 118 Commerce Drive
Prescott, Ontario, Canada K0E 1T0

Phone: 613-925-5934
Fax: 613-925-1195
Email: sales@mintl.com

Toll Free: 1-800-324-4988

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