

AccuBridge® Model 6010D



Automated Primary Resistance/ Thermometry Bridge

- *Resistance and temperature applications*
- *Range 0.001 Ω to 100 k Ω*
- *Accuracy < 40 ppb*
- *Ratio self-calibration*
- *System integration with Measurements International (MI) Matrix Scanners and High-Current Range Extenders*
- *Make MI your partner in ISO 17025 accreditation through coaching, system design, implementation, calibration services, documentation support and ongoing expert support*

MODEL INFORMATION

The AccuBridge® 6010D Resistance Bridge (Furthermore 6010D) is the metrologist's choice for primary lab level resistance measurements. Recognized as the world's leading Automated Resistance/Thermometry Bridge, the 6010D is ideal for resistance measurements in both resistance metrology and temperature thermometer applications. With its innovative technology, the 6010D's speed, measurement accuracy, and data handling capabilities, make it the preferred primary resistance measurement system in National Measurement Institutes (NMIs) and other primary labs worldwide. The 6010D is designed for flexibility and ease of use.

Ratio Range and Accuracy

The AccuBridge® Direct Current Comparator (DCC) with its binary wound current comparator technology balances current with effective resolution of 25 bits. It provides ratio measurements with an accuracy to better than 40 ppb. It covers a ratio range of from 14:1 to 1:14, with a linearity of better than 5 ppb. The 6010D can perform ratio measurements with resistances valued from 0.001 Ω to 100 k Ω . A line of optional high current range extenders permits measurements down to 1 $\mu\Omega$ for shunt resistance measurement applications.

Automated Resistance Operation

The 6010D Bridge itself can ratio a standard resistor to another resistor being tested. Optional 10—, 16— or 20— channel scanners can be used individually or together to connect to up to 80 channels of ratio measurement for up to 40 different test resistors to be calibrated.

The 6010D is perfectly suited for front panel operation or you can team it with MI's 6010SW Windows®-based Operating Software for fully automated measurements, history logging, graphing, and regression analysis. Stand-alone operation with the touch sensitive display panel provides full bridge capabilities to the operator. Ratio or direct resistance measurements can be made. Multiple measurements over time can be numerically displayed or graphically displayed to best fit your needs.

Automated Temperature Operation

Measurements International's Accu-T-Cal™SW is a software package for the automation of measurements and calibration of platinum resistance thermometers using the 6010D as the measurement device. Accu-T-Cal™ SW is based on over 15 years of experience and research of metrologists from Laboratory of Metrology and Quality, Faculty of Electrical Engineering, University of Ljubljana (UL-FE/LMK). All measured data is available as graphical and tabular format and is automatically saved for detailed analysis and calibration report generation.

AccuBridge® Family of Bridges

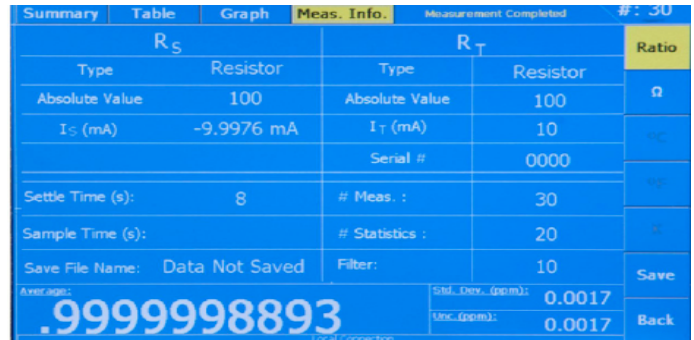
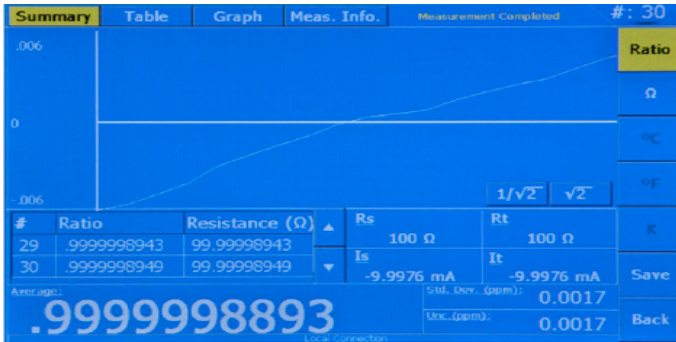
The 6010D is a high performance model MI Bridge. One of a family of bridges where there are various bridges optimized for different tasks, from measuring Quantum Hall Resistance (QHR) standards over a smaller range of resistance but with excellent uncertainties, to others which are a better fit for other labs with broader range of measurements but with larger uncertainties. There are three different bridge designs which use different measurement methods to measure over 21 orders of magnitude of resistance, from 1 $\mu\Omega$ to 10 P Ω . The AccuBridge® family offers the best line of bridges available for measuring the widest range of resistance.

Overview

The 6010D measures both ratio and absolute values. You select functions using the menu on the large touch screen display. For absolute measurements, you enter the value and related uncertainty of the standard resistor using the display's keypad. You enter the measurement functions such as current through the unknown resistor, settle time, number of measurements, and number of statistics the same way.

You can verify the calibration accuracy by performing an interchange measurement at any ratio. The interchange technique works at all ratios from 14:1 down to 1:14.

The 6010D's low-noise, touch screen display is interactive with the measurements, as shown in the screen images below. When a reading is complete, the average value and uncertainty (based on the number for statistics) are displayed. All uncertainty calculations are 2 sigma level.



The Summary screen displays data for both ratio or resistance

The Measurement Info screen displays the measurement parameters

Windows® Based Operating Software

Measurements International's AccuBridge® 6010SW Windows®-based software features measurement automation, report generation, historical analysis, and tracking and correcting for resistor drift rates. When you combine the 6010D with an MI IEEE-controlled 9400 Standard Resistor Oil Bath or 9300A Air Bath, you can automatically perform alpha and beta calculations on resistors under test.

You can export all data directly to Excel® for various test patterns or mainframe applications. External atmospheric pressure, humidity, and temperature indicators are optional and the entire system can be enclosed in a 4 or 5 ft (1224 to 1530 mm) rack. Resistor baths (oil or air), instrument controllers, printers, system software, IEEE488 interface, installation, and training are available for complete system packages.

At MI, it's not only about the equipment and science, it's about what you can do and the ease with which you can do it.

The 6010SW features both a standards ID file (R_s) and an unknown resistor ID (R_x) file for storing the resistor information and data to help protect the standard resistor data from being overwritten. The 6010SW software provides the ultimate in programmability and control for all your resistors and temperature calibrations.



Figure 1— 6010/300 A System with Front Connections

The range of the 6010D can be extended with our 6011D series of Range Extenders and 6100 series of Power Supplies. Our Range Extenders include the 6011/150A, and 6011/300A modules, see Figure 1, where connections are made on the front of the rack using cables or braided cables. The 6011D/150 A range can be extended further to 1 μΩ with our Model 6013M 400 A Range Extender, Model 6012M 1000 A Range Extender, Model 6012M 2000 A Range Extender, or Model 6014M 3000 A Range Extender, see Figure 2. For these shunt systems the connections are made on the side of the rack using copper plates. Copper plates insure no losses in the cables. Copper extender plates are available for connecting the shunts directly to the system. Controllers may also be added directly into the system.



Figure 2—6010/3000 A System with side connections

For more information, see our High Precision DCC Shunt Measurement System data sheet and High Precision DCC Shunt Measurement System Brochure for system information

AccuBridge® 6010SW Windows® Based Operating Software

System & Rack Settings

6010

Expanded Unc. (95%) 0.1 ppm

Unc. Degrees of Freedom Infinite

Serial Number SN

GPB Address 15

GPB Mode Demo

Settings File Sample

Load File Save File

Scanners

Scanner #1

Type 4210A

Serial Number

GPB Address 2

4220-1R Used

Serial Number

Scanner #2

Type 4210A

Serial Number

GPB Address 3

4220-1R Used

Serial Number

System & Rack Menu

Resistor ID Listings

Designator R3

Channel None

Coeff. Temp. 25 C

Type Resistor

Thermistor None

Value 100.00000150

Serial # 123456

Alpha 0

Expanded Unc. (95%) 0.0100 ppm

ID # 0

Beta 0

Unc. Degr. of Freedom Infinite

Max. I (A) 0.01

Chub None

Mfg. Model MIL

Auto Update

Standard	Measured	Value (Ohms)	Exp. Unc. (95%)	D. of Freedom	Scanner Ch.	Chub Ch.	Serial #	ID #	Auto Update
mR1		10.00000000	5.000	Infinite	None	None		0	No
mR2		10.00000000	3.000	Infinite	None	None		0	No
mR3		100.00000150	1.0100	Infinite	None	None	123456	0	Yes
mR4		1.0250267550	1.9601	Infinite	None	None	34509899	0	Yes
mR5		0.0100002748	0.1612	Infinite	None	None	34509899	0	Yes
mR6		12.00000000	0.0000	Infinite	None	None		0	No
mR7		14.00000000	0.0000	Infinite	None	None		0	No
mR8									
mR9									
mR10									
mR11									
mR12									
mR13									
mR14									

Resistor ID Menu

Program Selection & Creation

Program File Sample

Load File Save File

Active Program P1

Elements

Resistors	z	Rsr. Rate	# of Minis	# for Stab.	
M1	mR1 mR2	0.01	5	9	5
M2	mR6 mR2	0.005	4	30	25
M3					
M4					
M5					

Programs

Program	1	2	3	4	5	6
P1	T1					
P2	T2					
P3						
P4						
P5						
P6						
P7						
P8						
P9						
P10						
P11						
P12						

Tasks

Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T1	M1														
T2	M2														
T3															
T4															
T5															

Program ID Menu

Main Menu

Start Measurement

System & Rack Settings

Resistor ID Listings

Program Selection

Measurement Options

File & Directory Setup

History Information

Diagnostic Check

Resistance Measurements

PPM

Print Graph

R. mean: 10.0000010 Ratio uncert. (95%) [ppm]: 0.1598 R. max [ppm]: 0.467 R. min [ppm]: 0.488

Ratio	Resistance
22	9.99994206
23	9.99994270
24	9.99993502
25	9.99993883
26	9.99994212
27	9.99993447
28	9.99994280
29	9.99992639
30	9.99993848
31	

Resistor Information

Type sR6

Absolute Value 1.000006207

Max. I (A) 0.15

Serial # 1008306

I_s (A) 0.0500

P_s (W) 2.500E-3

Operation Information

Standard

Measurement Information

Type Rx

Absolute Value 10.00000010

Max. I (A) 0.1

Serial #

I_s (A) 5.000E-3

P_s (W) 0.250E-3

Expanded Uncertainty (95%)

Ratio Mean 9.99993804

Ratio 0.1598

Resistance 0.1628

Measurement Menu

History Information

Resistor History (ppm)

HF98532

YScale 0.2

Print Graph

Origin 1997-04-03

Years

Show Standard Deviation

Show Trend Line Linear

Show Projection 12942005

Projection Value 1.00001024

Load History File

Open Saved History File in WordPad

Date	Resistance	Std. Dev.	Uncert.	
1	1997-04-03	1.000000836	0.0363	0.0373
2	1997-07-01	1.000000876	0.0136	0.0263
3	1998-01-05	1.000000899	0.0273	0.0376
4	1998-03-02	1.000000904	0.0430	0.0496
5	1998-07-01	1.000000916	0.0513	0.1813
6	1998-11-02	1.000000925	0.0343	0.0489
7	1999-04-02	1.000000935	0.0284	0.0533
8	1999-07-03	1.000000948	0.0134	0.0434
9	2000-03-04	1.000000955	0.0490	0.0659
10	2000-07-01	1.000000968	0.0395	0.0573

History Menu

Measurement Options

Save Options

Save Measurements

File Name MIL0010

Save Resistor Summary To History

Save Data To Database

Set Manual Readings

Temperature 23.4 °C

Pressure 101.123 kPa

Humidity 38.2 %RH

Bath Temperatures

Standard Bath 25 °C

Variable Bath 20 °C

Laboratory Personnel MB

Measurement Options



>163.65546 676 10.1 22287 577
 >198.65546 656 12.23 2829 955
 >152.698016 688 18.28 2399 92356
 >198.643636 786 17.73 2289 783
 >124.634546 78672 23 7779 683
 >458.11142 83417.78 2397 876 56
 >145.523286 64486.22 2889 986 56
 >140.77060 32814 07 7060 328 56-20

AccuBridge® 6010D Accessories

Channel Extension

By using combinations of up to four matrix scanners, you can increase the number of input channels to almost any number from 10 to 80. Our Automated Low Thermal Matrix Scanners include the 4210A and 4210B with ten input and two output channels; 4216A, 4216B with 16 input and two output channels; and 4220A and 4220B with 20 input and two output channels. Our A-series of matrix scanners have tellurium copper terminals on their inputs and outputs while our B-series units have four-wire Teflon cable on their inputs and outputs. **For more information, see our 4200 Series Model 4210, 4216 and 4220 Automated Low Thermal Matrix Scanners data sheet**



Model 9300 Air Bath

The Model 9300 Series Air Baths are designed as a convenient and inexpensive way to maintain the temperature of air resistors in your calibration laboratory. It is large enough to house several standard air resistors and features an adjustable shelf to permit easy access to the standards. The shelves are easily removable in order to place a single ESI type SR104 standard in the bath. The bath is small and rugged and may be moved about easily. **For our complete range of Air Baths, see the 9300 Data Sheet**



Model 9300A Temperature Controlled Chamber with IEEE 488

The 6010D is also ideal for verifying the temperature and power coefficient of resistors or shunts using the MI 9300A Air Bath. Up to four SR104's or combination thereof can be installed in the bath, two shelves are provided. The IEEE Drivers for this bath are built into the software for automated measurements and calculations of alpha, beta coefficients and resistor values. A Hi/Lo temperature protection circuit is built into the bath to protect your resistors. **For our complete range of Air Baths, see the 9300A Data Sheet**



Model 9400 Oil Bath with IEEE 488

We designed our Model 9400 Standard Resistor Oil Bath based on years of customer feedback on existing resistor oil baths. You control this bath through a touch screen interface. Due to its low electrical noise, the quiet 9400 can be used with the Cryogenic Current Comparator (CCC) and Quantum Hall Resistance (QHR) Standard. Depending on the quantity of resistors in the bath, the stirrer motor speed can be changed. The IEEE drivers for this bath are built into the 6010SW software for automated measurements and calculations of alpha and beta coefficients and resistor values. **For more information, see our 9400 Series Model 9400 Standard Resistor Oil Bath data sheet.**



Model 9331 & 9331R Series Air Resistors

Our high-accuracy working standard air resistors are used for precision on-site resistance calibrations for values from 1 mΩ to 100 MΩ. Our 9331's are small, light, and rugged resistance standards that do not require a temperature-controlled oil or air bath for their specification range. The stability and temperature coefficients of the 9331's make them ideal for easy transport and for operation in any working environment within the range of 18 °C to 28 °C.

Connections to the Model 9331R are made with tellurium copper 5-way binding posts for values to 10 MΩ. A separate ground terminal is included for guarding and the case is hermetically sealed to keep moisture out. The Model 9331 ranges from 0.00 1 Ω to 10 MΩ. **For more information, see our Model 9331R Reference Series Standard Air Resistors and Model 9331 Standard Air Resistor data sheets**



Model 9210 Series Standard Oil Resistors

Oil resistors provide better stability and temperature coefficients over air resistors and provide the highest precision and stability in resistance measurements. Our standard oil resistors include the 9210A Primary 1 Ω, 9210A Primary 0.1 Ω, and 9210B series from 10 Ω to 100 kΩ. The 9210A 1 Ω and 9210A 0.1 Ω resistors have a negligible pressure coefficient. **For more information, see our Model 9210A MI-Type Standard and Model 9210B Reference Series Standard Oil Resistors data sheets**



6011 Series Range Extenders

Our 6011 Series of Low Resistance Shunt Measurement Systems offer the best accuracy, lowest uncertainty, and are the best ease of use of any commercial systems available. Our range extenders are fully automated, expanding the measuring capabilities of the 6010D or 6242D to measure lower resistance values at higher currents. A typical MI measurement system consists of the AccuBridge® 6010D or 6242 Automated Resistance Bridge, a 6011 Range Extender, and the 6100A Power supply. All required cables are supplied with the system. **For more information, see the Model 6011D Automated Range Extender and Power Supplies data sheet and the 6010 /6242 Precision Shunt Measurement System data sheet**



Specifications:

	Range	Accuracy	With Range Extender	
Self-calibration ratio	10 $\mu\Omega$ to 100 $\mu\Omega$	N/A	<0.5 x 10 ⁻⁶	
bridge where the Ratio	100 $\mu\Omega$ to 1 m Ω	N/A	<0.4 x 10 ⁻⁶	
accuracies can be verified	1 m Ω to 10 m Ω	<5.0 x 10 ⁻⁶	<0.3 x 10 ⁻⁶	
at anytime using the	10 m Ω to 100 m Ω	<0.5 x 10 ⁻⁶	<0.2 x 10 ⁻⁶	
interchange technique	100 m Ω to 1 Ω	<0.04 x 10 ⁻⁶	<0.2 x 10 ⁻⁶	
method for 1:1 ratio,	1:1 Ratio	Accuracy	10:1 Ratio	Accuracy
10:1 ratio and 1:10 ratio	0.1 Ω to 0.1 Ω	<0.1 x 10 ⁻⁶	0.1 Ω to 1 Ω	<0.04 x 10 ⁻⁶
measurements with the	1 Ω to 1 Ω	<0.04 x 10 ⁻⁶	1 Ω to 10 Ω	<0.04 x 10 ⁻⁶
following equation	10 Ω to 10 Ω	<0.04 x 10 ⁻⁶	10 Ω to 25 Ω	<0.04 x 10 ⁻⁶
$r_e = (R_a - 1/R_b)/2$.	25 Ω to 25 Ω	<0.04 x 10 ⁻⁶	10 Ω to 100 Ω	<0.04 x 10 ⁻⁶
	100 Ω to 100 Ω	<0.04 x 10 ⁻⁶	100 Ω to 1 k Ω	<0.04 x 10 ⁻⁶
Uncertainties follow GUM	1 k Ω to 1 k Ω	<0.04 x 10 ⁻⁶	1 k Ω to 10 k Ω	<0.04 x 10 ⁻⁶
at 2 sigma level (95%) along	10 k Ω to 10 k Ω	<0.1 x 10 ⁻⁶	10 k Ω to 100 k Ω	<0.1 x 10 ⁻⁶
with degrees of freedom.				

General Specifications:

1(a) Measurement Mode	4-wire
1(b) Linearity	<0.005 ppm
1(c) Temperature Coefficient	<0.01 ppm/°C
1(d) Test Current Range	10 μA to 200 mA (Internal) with 24.9 V compliance
1(e) Test Current Accuracy	100 ppm +10 μA (Full Range)
1(f) Test Current resolution	1 μA
1(g) Automatic Current reversal	4 to 1000 seconds
1(h) Interface	IEEE488.2
1(i) Operating Line Voltage	100 V, 120 V, 220 V, 240 Vac \pm 10% 1-Phase
1(j) Display	Touch screen display (no external keyboard), resolution 0.001 ppm
1(k) Touch Screen Menu Operation	The touch screen menu operations are the same as the software and provide key measurement functions such as display resolution; filtering; display of ohms or ratio, or both; viewing of data graphical or statistical, or both; doubling of power by $\sqrt{2}$, or dividing of power by $1/\sqrt{2}$. These functions are both manual and automated.
1(l) Measurement Setup	Measurement setup parameters include internal current outputs to 200 mA extended current outputs to 150 A or higher. Measurement setups are identical for manual as well as software operation.
1(m) Display Operation	The display is a 7"-touch screen display for entering the measurement setup parameters and displaying the data in real time graphically, or statistically, or both. The touch screen can be used to save all data to front panel USB.
1(n) Free Running	The bridge is capable of free running in order to trim potentiometers, decade boxes and other resistive adjustments.
1(o) Terminals	Tellurium-copper gold plated binding posts. Accepts male banana plugs, spade lugs, or bare wire.
1(p) USB	USB features data storage and software upgrades.

Note1: Accuracy of the bridge can be verified using the interchange technique for 1 : 1 and 10 : 1 ratios.

Note2: Linearity of the bridge can be verified at any time using the built in Calibration function

ORDERING INFORMATION

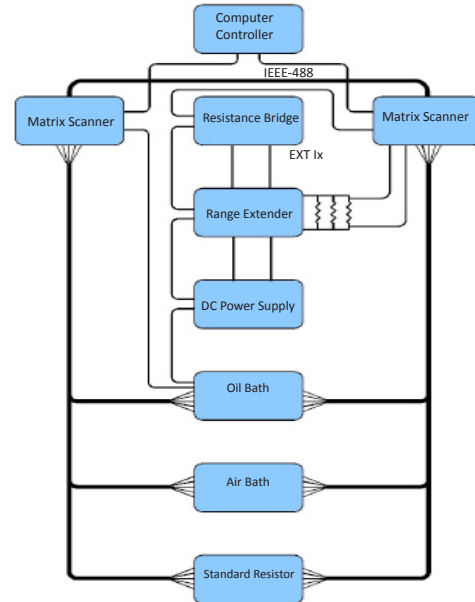
Model	Description
6010D	Resistance Bridge with Software
6010D/Cal	17025 Calibration Report
6010D/ACC	17025 Accreditation Package
Accu-T-Cal	Temperature Software
4210A	10-Channel Matrix Scanner, terminal inputs
4210B	10-Channel Matrix Scanner, wire inputs
4216A	16-Channel Matrix Scanner, terminal inputs
4216B	16-Channel Matrix Scanner, wire inputs
4220A	20-Channel Matrix Scanner, terminal inputs
4220B	20-Channel Matrix Scanner, wire inputs
6100A	100 A Linear DC Power Supply
6150A	150 A Linear DC Power Supply
6250A	300 A Linear DC Power Supply
9300	Air Bath
9300A	Air Bath
9300A	Air Bath with IEEE488
9400	Oil Bath with IEEE488
9210A/1	Oil Resistor 1 Ω Resistor
9210A/OR1	Oil Resistor 0.1 Ω Resistor
9210B/xx	Oil Resistor 0.1 Ω to 100 kΩ
9331R/xx	Air Resistor 0.1 Ω to 10 MΩ
9331/xx	Air Resistor 0.001 Ω to 100 MΩ
9332/100	100 A Shunt
9332/CAL	17025 Calibration
6011D/100	100 A Range Extender
6011D/150	150 A Range Extender
6011D/300	300 A Range Extender
6012M	2000 A Range Extender
6013M	400 A Range Extender
6014M	3000 A Range Extender

Refer to the High Precision DCC Shunt Measurement System Brochure

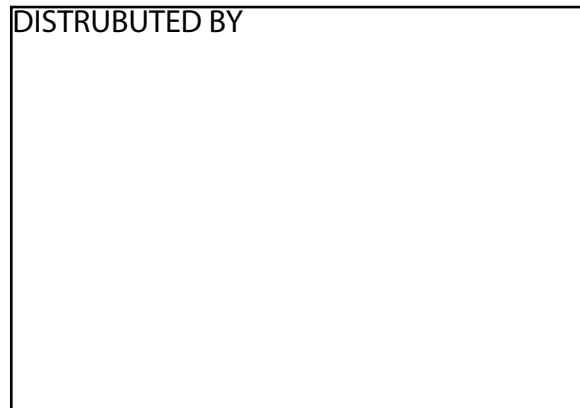
Accessories

- System Controller
- System Rack
- System Rack Shielded
- NI IEEE USB Card
- 4—Conductor, 18 Awg Teflon Cable
- 2—Conductor, 18 Awg Teflon Cable

SYSTEM INFORMATION



DISTRUBUTED BY



Form MI 66, Rev. 8, Dated 2012-03-28 (QAP19, App. "N")

Data Subject to Change - Rev. A

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