



Measurements International

Metrology is Our Science, Accuracy is Our Business™

ACCUBRIDGE® 6010D

Automated Primary Resistance/Thermometry Bridge



Featuring

- ▶ Resistance and Temperature Applications
- ▶ Range 0.001 Ω to 100 k Ω
- ▶ Accuracy < 30 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

Feature	Benefit
DCCT based.	Provides excellent stability and range linearity.
Fast reversal rates.	Reversal rates as fast as 4 seconds without affecting bridge accuracy.
Extremely low uncertainty.	Allows sub-ppm high current measurements.
Includes automation software.	6010DSW allows complete control of all resistance measurements and parameters.
National and primary lab continuity.	Used by all DOD, DOE, NMI's and space organizations.
Up to 10,000 Amps!	Can be expanded for shunt calibrations and DCCT's.
Dual use operation.	Use for resistor maintenance or measuring SPRT's.



ACCUBRIDGE® 6010D

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 an effective resolution of 25-bit. It provides ratio measurements with an accuracy of better than 30 ppb. It covers a ratio range of from 14:1, with 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 6010 SW 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. The 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 the Laboratory of Metrology and Quality, Faculty of Electrical Engineering, University of Ljubljana (UL-FE/LMK). All measured data is available in 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 a broader range of measurements but with larger uncertainties. There are three different bridge designs that 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.

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.

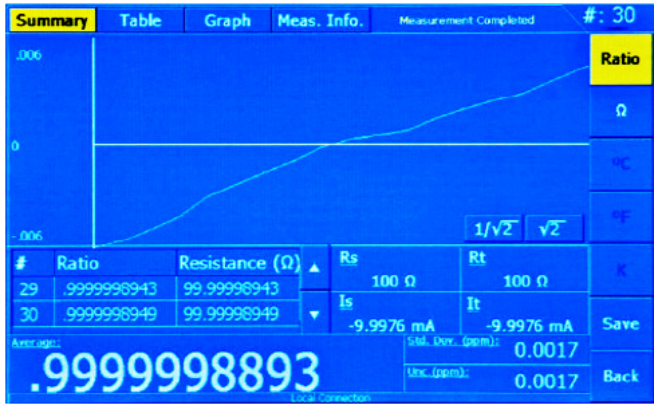
Windows®-Based Operating Software

Measurements International's AccuBridge® 6010 SW 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



ACCUBRIDGE® 6010D

Standard Resistor Oil Bath or 9300A Air Bath, you can automatically perform alpha and beta calculations on resistors under test.



The Summary screen displays data for both ratio or resistance



The Measurement Info screen displays the measurement parameters

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, IEEE-488 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 6010 SW 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 been overwritten. The 6010 SW software provides the ultimate in programmability and control for all your resistors and temperature calibrations.

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 6011/150 A, and 6011/300 A 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 ensure 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 1 — 6010/300 A system with front 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



Figure 2 — 6010/3000 A system with side connections



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AccuBridge® 6010 SW Windows® Based Operating Software

System & Rack Settings

6010
Expanded Unc. (95%) 0.1 ppm
Unc. Degrees of Freedom Infnx
Serial Number 1040624
GPIB Address 15

GPIB Mode Demo Display

Settings File Sample
Load File Save File

Scanners | Extenders & Power Supplies | Thermometers

Scanner #1
In System
Type 4210A
Serial Number
GPIB Address 2
4220-1R Used
Serial Number

Scanner #2
In System
Type 4210A
Serial Number
GPIB Address 3
4220-1R Used
Serial Number

System & Rack Menu

UUT & Standard Resistor ID Listings

Designator Channel None Coeff. Temp.
Clear All Clear Type Resistor
Measurand Resistors Value Serial # Alpha 0
ID File Sample ID # Beta 0
Load File Save File Expanded Unc. (95%) ppm Max. I (A)
Unc. Degr. of Freedom Infnx Mfg./Model
Create Resistor Chub Auto Update None Calibrator None

Standard	Measurand	Value (Ohms)	Exp. Unc. (95%)	D. of Freedom	Scanner Ch.	Chub Ch.	Calibrator	Serial #	ID #
mR1		1.00000000	0.0000	Infinite	None	None	None	A1	0
mR2		10.00000000	0.0000	Infinite	None	None	None	A2	0
mR3		100.00000000	0.0000	Infinite	None	None	None	A3	0
mR4		1000.00000000	0.0000	Infinite	None	None	None	A4	0
mR5									
mR6									
mR7									
mR8									
mR9									
mR10									
mR11									
mR12									
mR13									

Resistor ID Menu

Program Selection and Creation

Program File Sample Load File Save File Active Program P1

Elements

Resistors
Standard Measurand

Value (Ohms)	Serial #	Type	Scanner Ch.
mR1	A1	Resistor	None
mR2	A2	Resistor	None
mR3	A3	Resistor	None
mR4	A4	Resistor	None
mR5			
mR6			
mR7			
mR8			
mR9			
mR10			

Wait State Attributes
Wait For Wait Until Time
Create Wait State 00:00

Wait States Clear Wait

Type	Time
W1	
W2	
W3	
W4	
W5	
W6	

Measurement Attributes
Ix (A) Rs Reversal Rate 4
Rx Measurements 30
Rx As Standard Statistics 25
Create Measurement Filter 0.3s

Measurements Clear Mmnt

Resistors	Ix	Rev Rate	# Mmts	# Stats	
M1	mR1 mR2 s	0.005	4	5	3
M2	mR2 mR3 s	0.005	4	5	3
M3	mR3 mR4 s	0.005	4	5	3
M4					
M5					

Program ID Menu

Main Menu

Start Measurement System & Rack Settings UUT & Standard Resistor ID Listings Program Selection Measurement Options File & Directory Setup History Information Diagnostic Check

Resistance Measurements

PPM
Print Graph
R mean: 10.00000007 Ratio_uncert. (95%) [ppm]: 0.2767 R_max [ppm]: 0.223 R_min [ppm]: -0.299

Ratio	Resistance
1	10.00000210
2	9.99999905
3	9.99999708
4	10.00000230
5	9.99999882

Resistor Information Operation Information Measurement Information

Rs mR1 Standard Rx mR2

Type Resistor Absolute Value 1.000000000
Type Resistor Value 9.99999974
Max. I (A) Serial # 0.1 A1
Max. I (A) Serial # 0.1 A2
Ix (A) Px (W) 0.0500 2.50e-3
Ix (A) Px (W) 5.00e-3 0.250e-3

Task 1 of 1 Element 1 of 1
T1 M1
Ratio Mean Rate Expanded Uncertainty (95%)
9.99999974 0.7196 ppm 0.7196 ppm

Measurement Menu

History Information

Resistor History (ppm) HF98532

YScale 1.0
Print Graph

Origin 1997-04-03 (ppm)

Date	Resistance	R Std Dev	R Uncert	Temperature	T Uncert
1	1997-04-03	1.00000036	0.0363	0.0373	
2	1997-07-01	1.000000076	0.0136	0.0293	
3	1998-01-05	1.000000099	0.0273	0.0375	
4	1998-03-02	1.000000904	0.0433	0.0498	
5	1998-07-01	1.000000916	0.0913	0.1813	
6	1998-11-02	1.000000925	0.0343	0.0489	
7	1999-04-02	1.000000935	0.0294	0.0533	
8	1999-07-03	1.000000948	0.0134	0.0434	
9	2000-03-04	1.000000955	0.0408	0.0609	
10	2000-07-01	1.000000960	0.0395	0.0573	

Projection Value 1.000001187

Load History File
Open Saved History File in WordPad

History Menu

Measurement Options

Save Options

Save Measurements
File Name
Save Resistor Summary to History
Save Data To Database

Set Manual Readings

Temperature °C
Pressure kPa
Humidity %RH

Bath Temperatures

Standard Bath °C
Variable Bath °C

Laboratory Personnel

Measurement Options



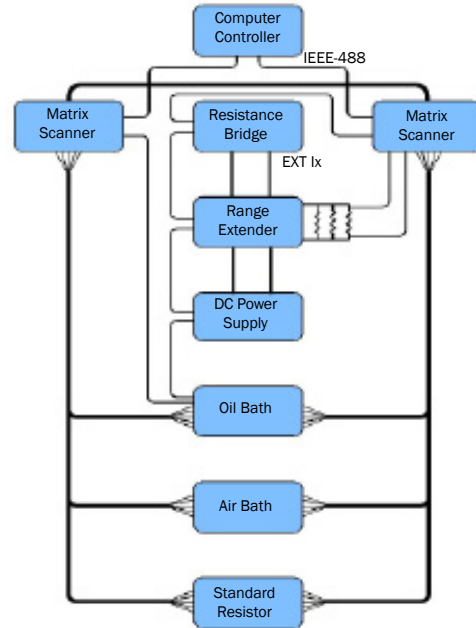
ACCUBRIDGE® 6010D

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
6150A	150 A Linear DC Power Supply
6250A	300 A Linear DC Power Supply
9300	Air Bath
9300A	Air Bath with IEEE-488
9400	Oil Bath with IEEE-488
9210A/1	Oil Resistor 1 Ω Resistor
9210A/0R1	Oil Resistor 0.1 Ω Resistor
9210B/xx	Oil Resistor 10 Ω to 100 kΩ
9331R/xx	Air Resistor 0.1 Ω to 100 MΩ
9331/xx	Air Resistor 0.001 Ω to 100 MΩ
9332/xx	1 A to 3000 A Shunt
9332/CAL	17025 Calibration
6011D/150	150 A Range Extender
6011D/300	300 A Range Extender
6013M	400 A Range Extender
6014M	3000 A Range Extender
6027	2000 A Automated Reversing Switch

[Refer to the High Precision DCC Shunt Measurement System Brochure](#)

System Information



Accessories

- System Controller
- System Rack
- System Rack Shielded
- NI IEEE USB Card
- 4 - Conductor, 18 Awg Teflon Cable
- 2 - Conductor, 18 Awg Teflon Cable
- 2 - Conductor, 22 Awg Solid Copper



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Specifications: Rev 8

	Range	Accuracy	With Range Extender	
Self-calibration ratio bridge where the ratio accuracies can be verified at anytime using the interchange technique method for 1:1 ratio measurements with the following equation $r_e = (R_a - 1/R_b)/2$.	10 $\mu\Omega$ to 100 $\mu\Omega$	N/A	< 0.5×10^{-6}	
	100 $\mu\Omega$ to 1 m Ω	N/A	< 0.4×10^{-6}	
	1 m Ω to 10 m Ω	< 5.0×10^{-6}	< 0.3×10^{-6}	
	10 m Ω to 100 m Ω	< 0.5×10^{-6}	< 0.2×10^{-6}	
	100 m Ω to 1 Ω	< 0.03×10^{-6}	< 0.2×10^{-6}	
	1:1 Ratio	Accuracy	10:1 Ratio	Accuracy
Uncertainties follow GUM at 2 sigma level (95 %) along with degrees of freedom.	0.1 Ω to 0.1 Ω	< 0.1×10^{-6}	0.1 Ω to 1 Ω	< 0.03×10^{-6}
	1 Ω to 1 Ω	< 0.03×10^{-6}	1 Ω to 10 Ω	< 0.03×10^{-6}
	10 Ω to 10 Ω	< 0.03×10^{-6}	10 Ω to 25 Ω	< 0.03×10^{-6}
	25 Ω to 25 Ω	< 0.03×10^{-6}	10 Ω to 100 Ω	< 0.03×10^{-6}
	100 Ω to 100 Ω	< 0.03×10^{-6}	100 Ω to 1 k Ω	< 0.03×10^{-6}
	1 k Ω to 1 k Ω	< 0.03×10^{-6}	1 k Ω to 10 k Ω	< 0.03×10^{-6}
	10 k Ω to 10 k Ω	< 0.1×10^{-6}	10 k Ω to 100 k Ω	< 0.1×10^{-6}

General Specifications

Measurement Mode	4-wire
Linearity	< 0.005 ppm
Temperature Coefficient	< 0.01 ppm/°C
Test Current Range	10 μ A to 200 mA (Internal) with 24.9 V compliance
Test Current Accuracy	100 ppm +10 μ A (full range)
Test Current Resolution	1 μ A
Automatic Current Reversal	4 to 1000 seconds
Interface	IEEE-488
Operating Line Voltage	100 V, 120 V, 220 V, 240 V _{ac} \pm 10 % 1-phase
Display	Touch-screen display (no external keyboard), resolution 0.001 ppm
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.
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.
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.
Free Running	The bridge is capable of free running in order to trim potentiometers, decade boxes and other resistive adjustments.
Terminals	Tellurium-copper binding posts.
USB	USB features data storage and software upgrades.
Operating Temperature	23 \pm 5 °C.

Note 1: Linearity of the bridge can be verified at any time using the built-in calibration function

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