

MODEL 6010D



Automated Primary Resistance/ Thermometry Bridge

- **Resistance & Temperature Applications**
- **Range 0.001 Ω to 100 K Ω**
- **Accuracy < 40 x 10⁻⁹**
- **Linearity < 5 x 10⁻⁹**
- **Featuring true ratio self calibration**
- **Manual and Automatic Operation**
- **Full system solutions and full system integration with 4200 series of Matrix Scanners and 6011 Range Extenders**

The Model 6010D is a fully automated resistance ratio bridge based on the Direct-Current-Comparator (DCC) principle. Using innovative technology, the 6010's speed and measurement accuracy accounts for its preferred status as the primary resistance measurement system in most national laboratories throughout the world. It is designed for flexibility and ease of use and is perfectly suited for stand-alone use or with Measurements International's Windows based Software with real time uncertainty analysis, history logging, graphing and regression analysis.

Only after many years of research and development is it possible to elaborate on this remarkable instrument. Recognized as the worlds leading Automated Resistance/Thermometry Bridge, the 6010D is ideal for both resistance and temperature measurements. Automatic current reversal insures that dc offsets and thermals are cancelled out during the measurement.

The Model 6010D has two inputs, Rx and Rs. The number of inputs can be expanded to 40 when the 6010D is used in conjunction with the 4200 Series Low Thermal Four Terminal Matrix Scanners. Measurements and values can be performed automatically with Measurements International's 6010SW, delayed or scheduled measurements can all be performed at any time.

Self-calibration of the DCC can be carried out at any time. The instrument determines resistance by measuring the ratio of

the unknown resistance to a known resistance standard.

Overview:

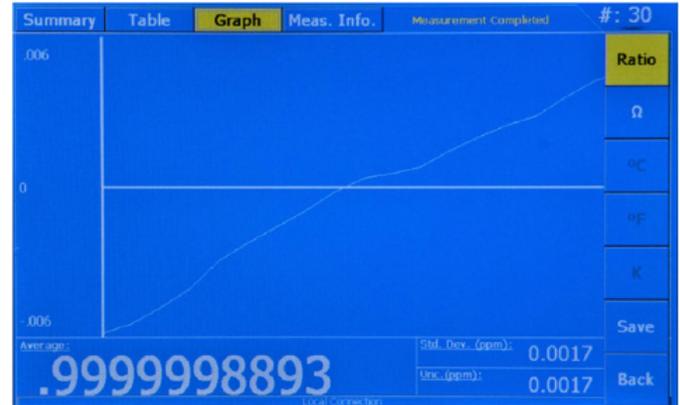
As a stand-alone device, the 6010D will measure both ratio and absolute values. Menu driven functions are selectable using the menu displayed on the large touch screen display. For absolute measurements the value and related uncertainty for Rs are entered in from the keypad displayed on the touch screen display. Measurement functions such as current through the unknown resistor and settle time, number of measurements and number of statistics are all also entered using the keypad on the touch screen.

Calibration of the 6010D is performed by first calibrating the linearity of the DC Current Comparator. The accuracy of the 6010D can be verified by performing an interchange measurement at any ratio. Previously the interchange method was only used to verify 1:1 ratios. With the increased ampere turns for ratios below 1, the interchange method works at all ratios from 13:1 down to 0.0769.

The large Touch Screen display chosen for its low noise characteristics is interactive with the measurements. The user has the choice to display data (several measurements at a time), a combination of data and a graph of the measurements or just the graph. When the reading is complete the average value and uncertainty based on the number for statistics are displayed. All uncertainty calculations are 2 sigma calculations.



For Resistance Measurements the Summary tab screen displays measurement data as well as graphical information for current measurement and can be viewed in ratio or Ohms at any time.



reversal rate and value of the standard resistor being used. The graph screen displays a graphical representation of the individual measurement data plots.

#	Ratio	Resistance (Ω)	Ratio
22	.9999998902	99.99998902	Ratio
23	.9999998909	99.99998909	Ω
24	.9999998915	99.99998915	Ω
25	.999999892	99.9999892	Ω
26	.9999998924	99.99998924	Ω
27	.9999998932	99.99998932	Ω
28	.9999998939	99.99998939	Ω
29	.9999998943	99.99998943	Ω
30	.9999998949	99.99998949	Ω

Average: **.9999998893**
 Std. Dev. (ppm): 0.0017
 Unc. (ppm): 0.0017

The Table screen list is a chronological list of measurement results for ratio and resistance.

Windows Operating Software

Measurements International's 6010SW Software features report generation, historical analysis and tracks and corrects for resistor drift rates. Combined with a Measurements International 9400 Standard Resistor Oil Bath or 9300A Air Bath, alpha and beta calculations can be performed automatically on resistors under test. All data can be exported 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. rack. Resistor baths (oil or air), instrument controllers, printers, system software, IEEE interface, installation and training are all available for complete system packages.

R _S		R _T		Ratio
Type	Resistor	Type	Resistor	
Absolute Value	100	Absolute Value	100	Ω
I _S (mA)	-9.9976 mA	I _T (mA)	10	Ω
		Serial #	0000	Ω
Settle Time (s):	8	# Meas. :	30	Ω
Sample Time (s):		# Statistics :	20	Ω
Save File Name:	Data Not Saved	Filter:	10	Save

Average: **.9999998893**
 Std. Dev. (ppm): 0.0017
 Unc. (ppm): 0.0017

The Measurement Info screen displays measurement parameters such as applied current, number of measurements,

Measurements International's software was developed by metrologists for metrologists. The software features real time uncertainty analysis, graphing, history logging, and data storage with export to Excel and regression analysis. The 6010SW provides ultimate programmability and control for all your resistors and temperature calibrations, now and in the future.

The range of the Model 6010D can be extended, when used in conjunction with the 6011D series of Range Extenders and 6100 series of Power Supplies. These include the 6010/100A, 6010/150A and the 6010/300A modules. The range can be extended further to 1μΩ with the Model 6013M 400 Amp Range Extender (Model 6010D/400), or with the Model 6012M 2000 Amp Range Extender (Model 6010D/2000) and or with the Model 6014M 3000 Amp Range Extender (Model 6010D/3000).



6010SW – Windows Operating Software

System & Rack Settings

6010

Expanded Unc. (95%) 0.1 ppm

Unc. Degrees of Freedom Infinite

Serial Number SN

GPIB Address 15

GPIB Mode Demo

Settings File Sample

Load File Save File

Scanners

Scanner #1

Type 4210A

Serial Number

GPIB Address 2

4220-1R Used

Serial Number

Scanner #2

Type 4210A

Serial Number

GPIB 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		1.010000150	1.0100	Infinite	None	None	123456	0	Yes
mR4		1.3259257550	1.3601	Infinite	None	None	34599899	0	Yes
mR5		0.0100002748	0.1612	Infinite	None	None	34599899	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	Rev. Rate	# of Minits	# 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						
P13						
P14						
P15						

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%) 0.1598 R_max [ppm]: 0.487 R_min [ppm]: -0.488

Ratio	Resistance
23 9.99994206	10.00000413
24 9.99994270	10.00000477
25 9.99993502	9.99997709
26 9.99992983	10.00000090
27 9.99994212	10.00000419
28 9.99992447	9.99998654
29 9.99994290	10.00000497
30 9.99993639	9.99999846
31 9.99993848	10.00000553

Resistor Information

Rs sR6 Standard Rx mR2

Type Resistor Absolute Value 1.00000307

Max I (A) 0.15 Serial # 1008306

Is (A) 0.0500 Ps (W) 2.500E-3

Expanded Uncertainty (95%)

Ratio Mean 9.99993804

Ratio 0.1598

Resistance 0.1628 ppm

Measurement Menu

History Information

Resistor History (ppm)

HF98532

YScale 0.2

Print Graph

Origin 1997-04-03 (open)

Date	Resistance	Std. Dev.	Uncert.
1 1997-04-03	1.000000836	0.0063	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	0.0813	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

Projection Value 1.00001024

Load History File

Open Saved History File in WordPad

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



6010D Accessories

6010D Input Channels

The Number of input channels on the 6010D can be increased to almost any number from 10 to 80, using combinations of up to 4 scanners. These include the 4210A, 4210B with ten input channels and two output channels, 4216A, 4216B with sixteen input channels and two output channels and the 4220A and 4220B with twenty input channels and two output channels. The A series of scanners have tellurium copper terminals on both the input and output while the B series have four-wire Teflon cable for both the input and output.



4220A



4220B

Matrix Scanner 20 Channels

See the 4200 Data Sheet for a complete range of Matrix Scanners.

Temperature and Power Coefficients

Model 9300A Air Bath 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. Two internal fans are used to achieve temperature stability. 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 6010SW software for automated measurements and calculations of alpha, beta coefficients and resistor values. A Hi, Lo temperature protection circuit is built in.



See the 9300A Data Sheet for a complete range of Air Baths

Model 9400 Oil Bath with IEEE 488

The Model 9400 oil bath was designed after compiling years of customer feedback on existing resistor oil baths. Control is provided through a touch screen interface. The result is a stable, quiet oil bath that can be used with the CCC and QHR due to its low electrical noise. The bath also features the capability of changing speed on the stirrer motors depending on the quantity of resistors in the bath. IEEE Drivers for this bath are built into the 6010SW software for automated measurements and calculations of alpha and beta coefficients and resistor values.



See the 9400 Data Sheet for a complete spec

STANDARD AIR RESISTORS

MODEL 9331 SERIES OF AIR RESISTORS

These high accuracy working standards are used for precision, on-site, resistance calibrations for values from 1 mΩ to 100 MΩ. They are small, light and rugged resistance standards that do not require a temperature controlled oil or air bath for the specifications shown. Stability and temperature coefficients of the 9331 make this resistor ideal for easy transport and for operation in any working environment within the range of 18 °C to 28 °C.



Connections to the Model 9331 are made using tellurium copper binding posts for values to 100 MΩ. A separate ground terminal is included for guarding and the case is hermetically sealed to keep moisture out. The Model 9331G (shown), based on the NIST design, ranges from 100 MΩ to 100 TΩ.

See the 9331, 9331G and 9331R Data Sheet for a complete range of Air Resistors

MODEL 9210 STANDARD OIL RESISTORS

Oil resistors provide better stability and temperature coefficients over air resistors and will give you the highest precision and stability in resistance measurements. The standard oil resistors manufactured by MI include the 9210A Primary 1 Ω, the 9210A Primary 0.1 Ω and the 9210B series of oil resistors from 1 Ω to 100 kΩ. The 9210A 1 Ω and 9210A 0.1 Ω have a negligible pressure coefficient.



See the 9210A and 9210B Data Sheets for a complete range of Oil Resistors.

LOW RESISTANCE MEASUREMENTS

6011 SERIES OF RANGE EXTENDERS

Measurements International's (MI) series of Low Resistance Shunt Measurement Systems offers the best accuracy, lowest uncertainty and ease of use of any commercial system available on the market today. The Range Extenders are fully automated and expand the measuring capabilities of the MI Model 6010D to measure lower resistance values at higher currents.

A typical measurement system from MI consists of the 6010D Resistance Bridge, a 6011 Range Extender and the 6100A Power supply. All cables are supplied with the system.

See the 6011 Data Sheet for a complete range of Current Range Extenders.

STANDARD SYSTEM MODELS INCLUDE THE

- | | |
|---------------|----------------|
| 6010/6511/5 A | 6010/400 |
| 6010/100 | 6010/2000 |
| 6010/150 | 6010/3000 |
| 6010/300 | 6010/6011/xxxx |



Specifications:

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

General Specifications:

1(a) Measurement Mode	4 Wire
1(b) Linearity	± 0.005 ppm
1(c) Operating Temperature Range	23°C ± 5
1(d) Test Current Range	10 μA to 200mA (Internal) with 24.9V 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 with Standard Code Programmable Interchange (SCPI) Instructions.
1(i) Operating Line Voltage	100, 120, 220, 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 $\sqrt{2}$ and dividing of power by $1/\sqrt{2}$. These functions are both manual and automated modes.
1(l) Measurement Setup	Measurement Setup Parameters include internal current outputs to 200 mA extended current outputs to 150 Amps or higher. Measurement setups are identical for manual as well as software operation.
1(m) Display Operation	The display of the bridge is a 7" touch screen display for entering the measurement setup parameters and displaying the data in real time graphically or statistically or both. Touch Screen is able to save all data to front panel USB which can save the data and be independently of each other requirement.
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 5 way binding posts. Accept male banana plugs, Spade lugs or bare wire.
1(p)	Data Storage Unit features data storage

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

* 10:1 Accuracy specifications are valid for ratios up to 13:1.

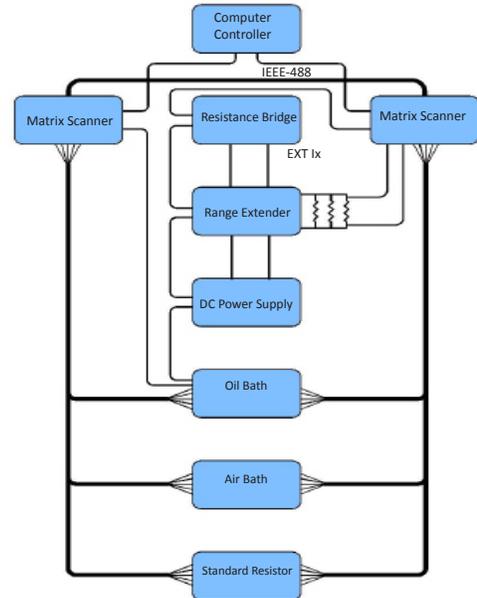
ORDERING INFORMATION

Model	Description
6010D	Resistance Bridge with Software
6010D/Cal	17025 Calibration Report
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 Amp DC Power Supply
6150A	150 Amp DC Power Supply
9300A	Air Bath
9400	Oil Bath
9210A/1	1 Ω Resistor
9210A/OR1	0.1 Ω Resistor
9332/100	100 A Shunt
9332/CAL	17025 Calibration
6011D/100	100 Amp Range Extender
6011D/150	150 Amp Range Extender
6011D/300	300 A Range Extender
6012M	2000 A Range Extender
6013M	400 A Range Extender
6014M	3000 A Range Extender

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
 17025 Calibration Report

SYSTEM INFORMATION



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DELTA STRUMENTI S.r.l
 Via Mattei 6 - 21036 GEMONIO (VA)
 Tel 0332 604.667 - Fax 0332 610.511
 info@deltastrumenti.it - www.deltastrumenti.it

