

>185.65546 65612.23 2829 955 56
 >198.65546 65612.23 2829 955 56
 >198.65546 65612.23 2829 955 56
 >152.698016 68818.28 2399 92356
 >198.643636 78617.73 2289 783 56
 >124.634546 78672.23 7779 683 56
 >458.11142 83417.78 2397 876 56
 >145.523286 64486.22 2889 986 56
 >140.77060 32814.07 7060 328 56

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**

MODEL INFORMATION

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.



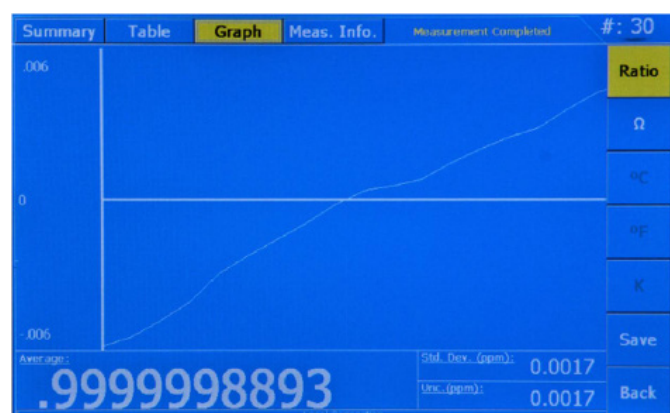
For Resistance Measurements the Summary tab screen displays measurement data as well as graphical information for current measurement and can be viewed in ratio or Ohms at any time.

Summary	Table	Graph	Meas. Info.	Measurement Completed	#: 30
#	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	Save Back

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

Summary	Table	Graph	Meas. Info.	Measurement Completed	#: 30
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	Ω	
Average: .9999998893			Std. Dev. (ppm): 0.0017	Unc. (ppm): 0.0017	Save Back

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



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

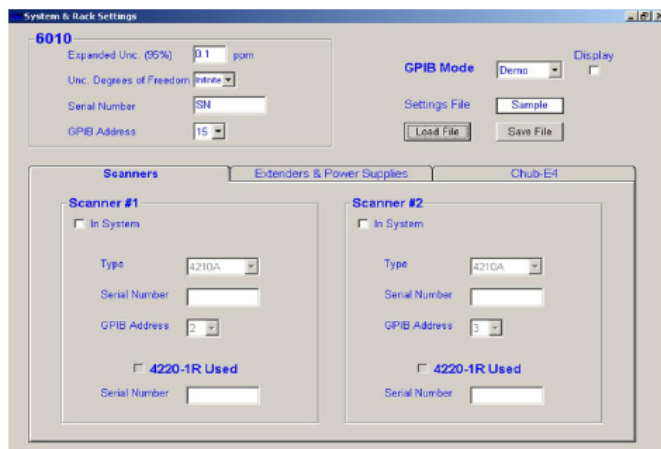
Windows Operating Software

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.

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 ☐ Display ☐

Settings File Sample

Scanners **Extenders & Power Supplies** **Chub-E4**

Scanner #1

☐ In System

Type 4210A
 Serial Number
 GPIB Address 2

☐ 4220-1R Used
 Serial Number

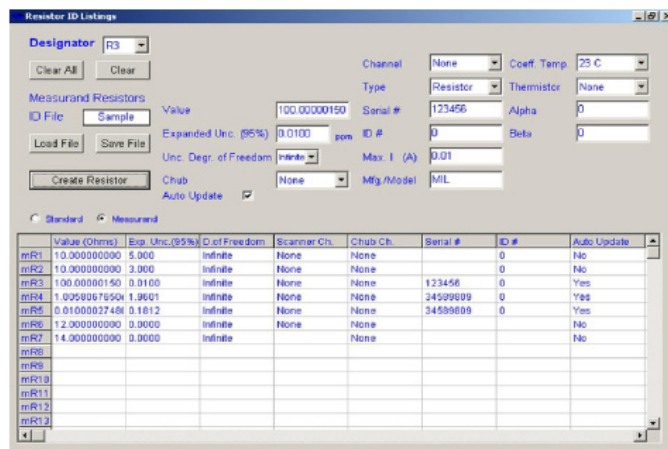
Scanner #2

☐ In System

Type 4210A
 Serial Number
 GPIB Address 3

☐ 4220-1R Used
 Serial Number

System & Rack Menu



Resistor ID Listings

Designator R3

Channel None **Coeff. Temp** 25 C
Type Resistor **Thermistor** None

Measurand Resistors

ID File Sample

Value 100.00000150
Expanded Unc. (95%) 0.0100 ppm
Unc. Degr. of Freedom Infinite
Chub None **Mfg./Model** MIL

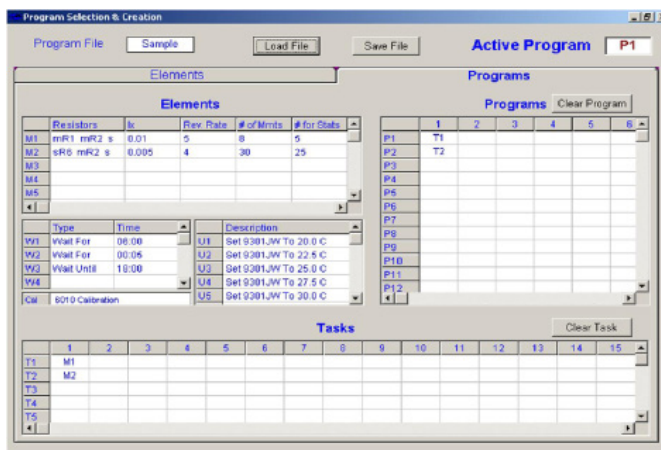
Serial # 123456 **ID #** 0
Alpha 0 **Beta** 0

Max I (A) 0.01

☐ Standard ☒ Measurand

Value (Ohms)	Exp. Unc. (95%)	Dof Freedom	Scanner Ch.	Chub Ch.	Serial #	ID #	Auto Update
mR1	10.000000000	5.000	Infinite	None	None	0	No
mR2	10.000000000	3.000	Infinite	None	None	0	No
mR3	100.00000150	0.0100	Infinite	None	None	123456	Yes
mR4	1.0259267550	1.9601	Infinite	None	None	34599699	Yes
mR5	0.0100002748	0.1612	Infinite	None	None	34599699	Yes
mR6	12.000000000	0.0000	Infinite	None	None	0	No
mR7	14.000000000	0.0000	Infinite	None	None	0	No
mR8							
mR9							
mR10							
mR11							
mR12							
mR13							

Resistor ID Menu



Program Selection & Creation

Program File Sample **Active Program** P1

Elements

Resistors	In	Rev. Rate	# of Minis	# for Stds
M1	mR1 mR2	0.01	5	5
M2	sR6 mR2	0.005	4	30
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

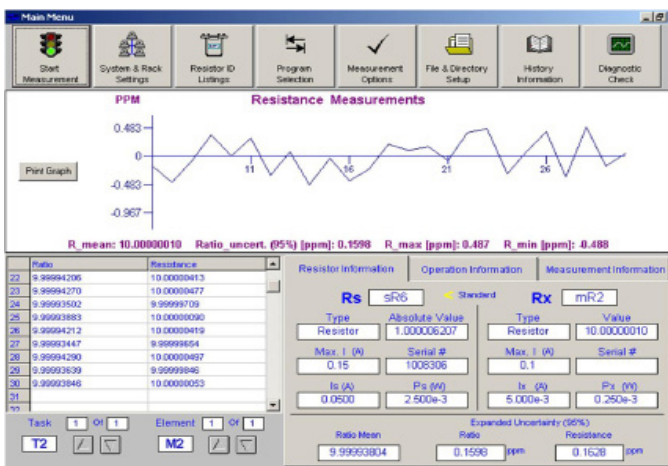
Task	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
T1	M1														
T2	M2														
T3															
T4															
T5															

Tasks

Type	Time	Description
V1	Wait For 08:00	U1 Set 9.9813W To 20.0 C
V2	Wait For 00:05	U2 Set 9.9813W To 22.5 C
V3	Wait Until 18:00	U3 Set 9.9813W To 25.0 C
V4		U4 Set 9.9813W To 27.5 C
V5		U5 Set 9.9813W To 20.0 C

Clear Task

Program ID Menu



Main Menu

Resistance Measurements

PPM

Print Graph

R_mean: 10.00000010 Ratio uncert. (95%) [ppm]: 0.1598 R_max [ppm]: 0.487 R_min [ppm]: 0.488

Ratio	Resistance
23	9.99994206
24	9.99994270
25	9.99993502
26	9.99992883
27	9.99994212
28	9.99993447
29	9.99994290
30	9.99993639
31	9.99993848

Resistor Information

Rs sR6 **Standard** **Rx** mR2

Type Absolute Value **Type** Value

Resistor 1.000006207 **Resistor** 10.00000010

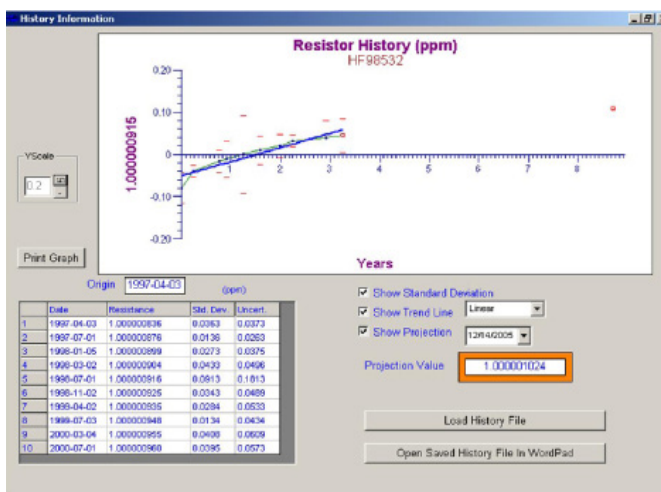
Max I (A) 0.15 **Serial #** 1005306 **Max I (A)** 0.1 **Serial #**

Is (A) 0.0500 **Ps (W)** 2.500e-3 **Ix (A)** 5.000e-3 **Px (W)** 0.250e-3

Task T2 **Element** M2

Ratio Mean 9.99993804 **Ratio** 0.1598 **Expanded Uncertainty (95%)** 0.1628 ppm

Measurement Menu



History Information

Resistor History (ppm) HF96532

YScale 0.2 **Print Graph**

Origin 1997-04-03 (ppm)

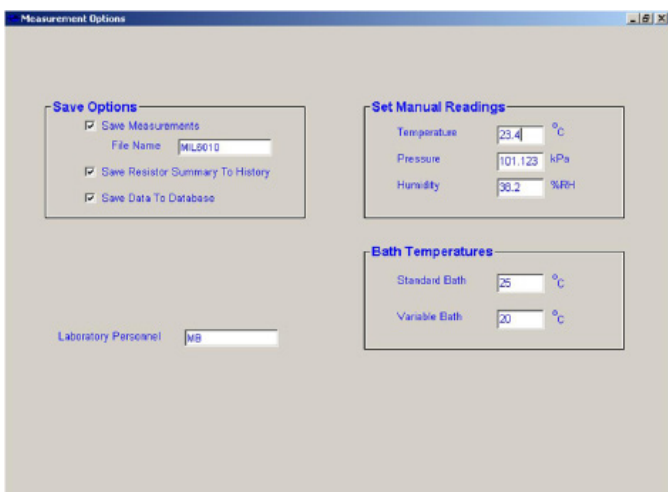
Years

☐ Show Standard Deviation ☐ Show Trend Line ☐ Show Projection

Projection Value 1.00001024

Date	Resistance	Std. Dev.	Uncert.
1	1997-04-03	1.000000836	0.0263 0.0373
2	1997-07-01	1.000000876	0.0136 0.0263
3	1998-01-05	1.000000899	0.0273 0.0375
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	0.0294 0.0533
8	1999-07-03	1.000000948	0.0134 0.0434
9	2000-03-04	1.000000955	0.0430 0.0659
10	2000-07-01	1.000000969	0.0395 0.0573

History Menu



Measurement Options

Save Options

☒ Save Measurements MIL6010

☒ 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

>185.65546 67816.122187 5771 56
 >198.65546 65612.232829 955 56
 >198.65546 65612.232829 95556
 >152.698016 68818.282399 92356
 >198.643636 78617.732289 783 56
 >124.634546 78672.237779 683 56
 >458.11142 83417.782397 876 56
 >145.523286 64486.222889 986 56
 >140.77060 32814.077060 328 56

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:

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

Uncertainties follow GUM
at 2 sigma level (95%) along
with degrees off freedom.

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 μ A to 200mA (Internal) with 24.9V compliance
1(e) Test Current Accuracy	100 ppm +10 μ A (Full Range)
1(f) Test Current resolution	1 μ A
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 ±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.

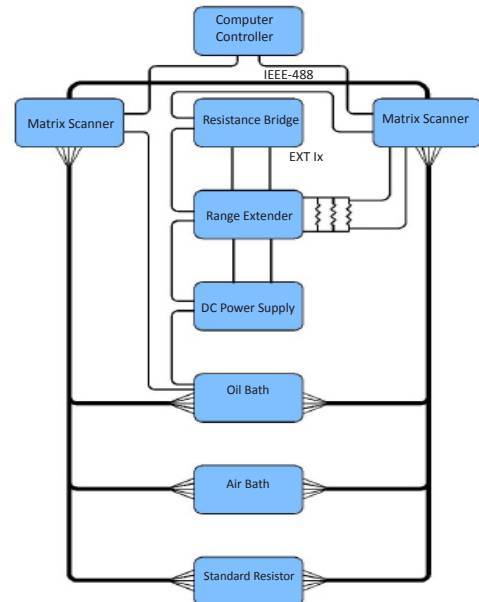
ORDERING INFORMATION

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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