Measurements International

Metrology is Our Science, Accuracy is Our Business™

SELF-CALIBRATION QUANTUM HALL RATIO/RESISTANCE BRIDGE

ACCUBRIDGE® MODEL 6020Q

- Quantum Hall Applications Including Gallium Arsenide and Graphene Sample Measurements
- V_{cr}, Vxx, and Vxy Measurements
- Self-Calibration of the Binary Wound Current Comparator (25-Bit) Plus Nanovolt Detector Reading
- Current Range from 1 µA to 200 mA
- Ratio 0 to 14:1
- Resistance Range 0.1 Ω to 100 kΩ
- 7” Touch Screen with USB
- Best Accuracy < 15 ppb

ACCUBRIDGE® MODEL 6020Q QUANTUM HALL RATIO/RESISTANCE BRIDGE

Since 1994, Measurements International’s (MI) 6010B, and 6010C technology has set the standard for DC Current Comparator (DCC) Resistance Bridge performance in calibration laboratories globally. The time has now come to advance this best-in-class series, taking advantage of twenty-first-century AccuBridge® technology.

Measurements International’s major technological advantage in resistance measurements is the development of the first commercially available portable Quantum Hall System, 6800, (figure 1) which uses AccuBridge® technology as the measurement system operated at ambient temperatures. The current range is from 1 µA to 200 mA for use as a Quantum Hall Bridge and a Resistance Bridge. The 6020Q features increased ampere-turn (AT) sensitivity with more turns on both the master and slave windings and a new voltage feedback circuit to improve on the linearity error of the nanovolt amplifier.

Figure 1 – 6800 System

Measurements International has world class expertise in both DC Resistance Metrology at NMI’s and ISO 17025 Accreditation throughout industry. As your accreditation partner and global support partner, MIL offers leading product knowledge and applications expertise through coaching, system design, implementation, calibration services, and ongoing expert support ensuring your competitive advantage.

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.

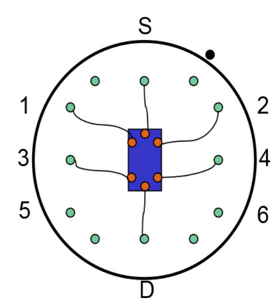

Figure 2 – 6800 Sample

The AccuBridge® 6020Q (furthermore 6020Q) room temperature Quantum Hall Resistance Bridge can be used to characterize both GaAs/AlGaAs (Figure 2) or graphene samples by measuring and plotting the field sweep, the contact resistance (V_{cr}), the longitudinal resistance and dissipation of the I = 2 plateau (Vxx), and transferring the Hall Resistance (Vxy) to a 1 kΩ or 10 kΩ standard resistors.

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Enhancements using AccuBridge® technology include a higher ampere-turn sensitivity covering a wider range of resistance ratio, a current and voltage feedback circuit for increased linearity performance and a new calibration technique with increased resolution in obtaining even tighter specifications. In addition to the updated technology, it has the 6010's dependability, simplified calibration, ease-of-use, automation, the speed of measurement and worldwide support making the 6020Q the best and only resistance bridge that offers uncertainty specifications that rival anything available today.

The 6020Q is a fully automated bridge. Its speed, precision and measurement accuracy accounts for its preferred status as the primary resistance bridge in most NMIs throughout the world. It is designed for flexibility and ease of use and is perfectly suited for stand-alone resistor calibrations.

The 6020Q has two inputs: R_X and R_S. The number of inputs can be expanded to 40 when used in conjunction with the 4200 series Low Thermal Four-Terminal Matrix Scanners, see figure 3. It is recommended that the model 4210A 10-Channel Matrix Scanner be ordered for use in the Quantum Hall System. Measurements can then be performed automatically with the software. Delayed or scheduled measurements can be performed at any time. Automatic current reversal ensures that DC offsets and thermals are cancelled out the measurement.

Figure 3 – 4210A Matrix Scanner

See the 4200 data sheet for a complete range of Matrix Scanners.

Overview

As a stand-alone device, the 6020Q is capable of performing the sweep check, contact resistance, longitudinal potential difference (dissipation) and hall resistance measurements on the Quantum Hall Resistance (QHR) sample. You can select menu driven functions using the front panel display or over IEEE-488. Also, you can use the 6020Q as a high accuracy DC resistance ratio bridge for calibrating resistors using either a 1 Ω or 10 kΩ standard resistor. For laboratories without a QHR system, the 6020Q can be used to build up from the 1 Ω or down from the 10 kΩ.

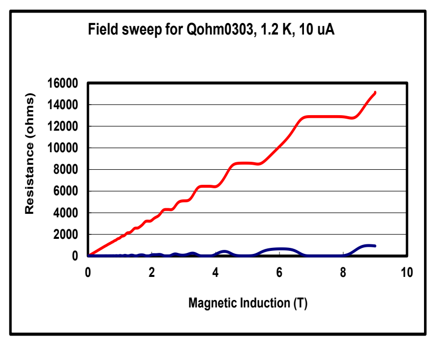

Figure 4 – Sweep Check Measurement

The 6020Q performs the field sweep check measurement (see figure 4) by feeding a current, into the source and drain of the sample, and then reversing it. This enables measurement of potential differences between various points on the sample. These potential differences can be measured at Hall resistances Vxy (1-2) or Vxy (3-4) and the longitudinal resistance Vxx (1-3) and Vxx (2-4) on the sample. Vxy (1-2) and Vxy (3-4) should be in close agreement with each other, as should Vxx (1-3) and Vxx (2-4).

The 6020Q's microvolt detector makes contact resistance measurements. It is important to measure the contact resistance each time the QHR device is cycled to room temperature and re-cooled as large contact resistances can lead to errors in the QHR measurement. The 6020Q uses a three-probe measurement on each of the contacts in turn to measure the contact resistance. The contact resistance is equal to V_{cr}/I = resistance of wire + resistance of contact + resistance of 2-DEG.

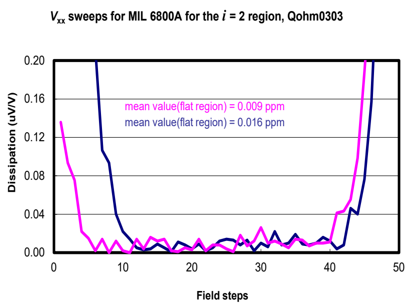

Figure 5 — Dissipation Measurement

For an accurate transfer of the QHR value, the longitudinal potential difference must be measured. You can do this by measuring between Vxx (1-3) and Vxx (2-4) using the 6020Q's Vxx nanovolt mode. Take this measurement to verify that there is no dissipation (see figure 5) in the 2-DEG. When the 2-DEG is quantized, Vxx should go to 0 and should be $< 2 \times 10^{-8}$ of Vxy.

For traceable measurements, use the keypad on the touch screen to enter the QHR value and related uncertainty in the resistor ID standards file and the 1000 Ω transfer resistor into the measurand (unknown) ID file. Enter standard resistors such as the 1 Ω or 10 kΩ into the standards file after they have been calibrated. Enter resistors to be calibrated into the measurand (R_x) or unknown file. Using the keypad, enter measurement functions such as current through the unknown resistor, settle time, number of measurements, and number of statistics into the Programs file.

Example (for stated specifications)

Maximum Current Reversal Rate = 12 seconds

Maximum Measurement Setting = 50 Measurements

Maximum Statistical Settings = 40 Measurements

The 6020Q is compatible with both the 6800A and 6800B software, as well as both the 4220 and 4210 Matrix Scanners.

When performing resistance measurements, the 6020Q's low-noise, touch screen display is interactive with the measurements. You can display data (several measurements at a time), a combination of data and a graph of the measurements, or just the graph. When a reading is complete, the average value and uncertainty (based on the number for statistics) are displayed. All uncertainty calculations are 2σ level. For resistance measurements, the Summary screen displays measurement data as well as graphical information for current measurements, which can be viewed anytime in ratio or ohms.

Windows® Based Operating Software

Measurements International's software features an MI report generation, historical analysis and tracks and corrects for resistor drift rates. Combined with a 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 creating various test patterns or mainframe applications. Resistor baths (oil or air), instrument controllers, printers, system software, IEEE interface, installation, and training are all available from MI.

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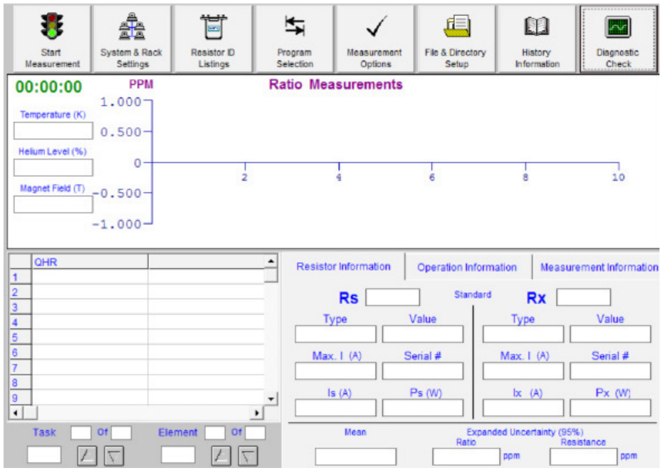
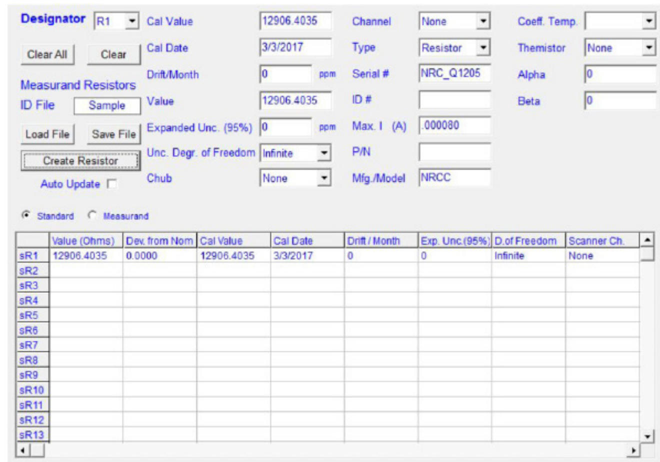
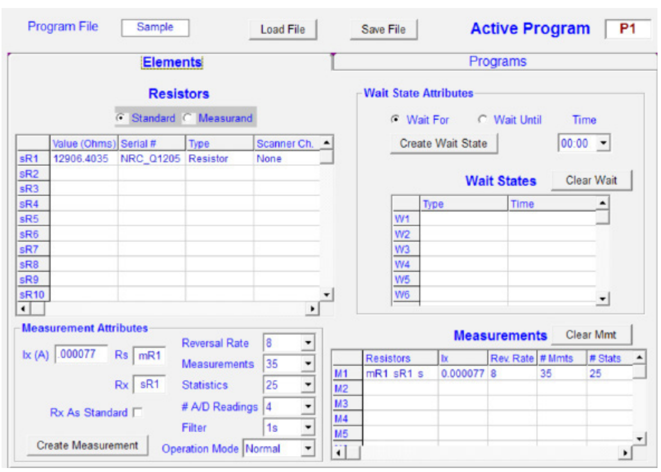


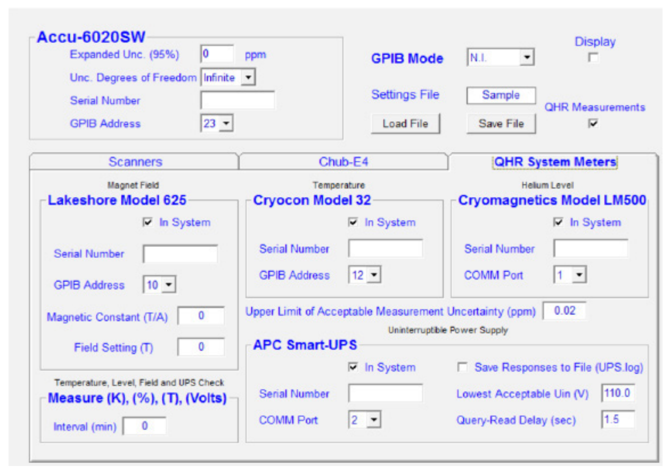
Main Manual Screen



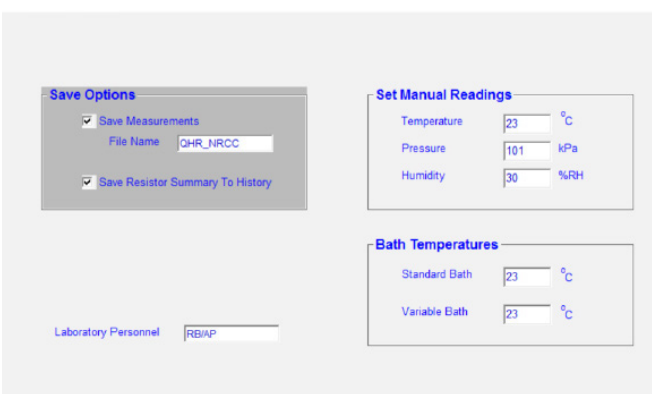
Resistor ID Listing



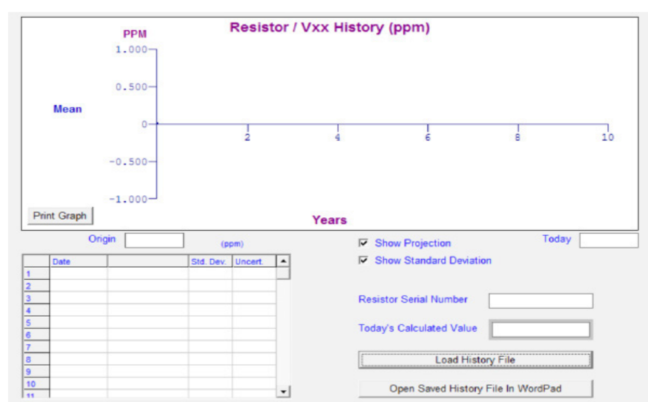
Program Selection & Creation



Rack & Rack Settings



Measurement Options



History Information

AccuBridge® 6020Q 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 40. 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 6020Q 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 bath can be supplied without IEEE and with IEEE. 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 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 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 0.001 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.

ORDERING INFORMATION	
6020Q	Resistance Bridge with 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
9300A	Air Bath
9400	Oil Bath
9210A/	Evanohm Resistor (1 Ω and 0.1 Ω)
9210B/	Oil Resistors 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ
9331R/	Air Resistors 1 Ω, 10 Ω, 100 Ω, 1 kΩ, 10 kΩ, 100 kΩ
J005-Spec 30/100	4-Conductor Teflon Cable, 30 m or 100 m

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Specifications: Rev 5

Note:
Either R_s or R_x can be selected as the standard. 6020Q uncertainties in the bridge and software are specified at the 2σ level (95 %) this includes all secondary specifications such as linearity and noise with a ± 2 °C temperature variance.

0.1 Ω to 100 kΩ			
R_x	Ratio & Accuracy (ppm)*		
--	1:1	10:1	14:1
0.1 Ω	< 0.02	--	--
1 Ω	< 0.015	< 0.015	< 0.015
10 Ω	< 0.015	< 0.015	< 0.015
100 Ω	< 0.015	< 0.015	< 0.015
1 kΩ	< 0.015	< 0.015	< 0.015
10 kΩ	< 0.02	< 0.015	--
100 kΩ	--	< 0.05	--

*As a ratio device the accuracy specifications can be improved upon based on your standards and environmental conditions.

Measurement Mode	4-wire
Linearity	< 0.005 ppm of full-scale
Operating Conditions	10 °C to 35 °C, 10 % to 90 % RH non-condensing
Test Current Range	1 µA to 200 mA
Test Current Resolution	18-bit
Interface	IEEE-488
Display	Touch Screen Display (no external keyboard), Resolution 0.001 ppm

Dimensions (W × D × H):
438 × 406 × 267 (mm)

Weight:
19 kg

Shipping Weight:
23 kg

Main Power:
100 V, 120 V, 220 V, 240 V_{ac} – 50/60 Hz
200 VA maximum

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