6645Q Quantum Hall System

Complete Turn-Key Quantum Hall Resistance system

Introducing the World's Most Advanced Turn-Key QHR System!

FEATURES

- Complete Turn Key System – Fully Integrated and Ready To use!
- Featuring NEW Patented 6640Q-QHR Bridge!
- Best Accuracy: ± 0.015 ppm of Reading at QHR Currents of 30 µA - 100 µA with Interchange!
- Fasted Measurement Speed of 2 Seconds!
- Built in Nano-Voltmeter for Hall Resistances and Longitudinal Resistances!
- Pre-Cool with Nitrogen For Cost Savings!
- 4 to 6 Day Uninterrupted QHR Operation!
- Option for Magnetic Field Strength Up To 14 Tesla!
- Premium QHR Sample Included, Built by NMI with 20 Years' Experience
- Change All Key Parameters "On-the-Fly" While the Measurement is Running!
- BridgeWorks™ Data Acquisition Software!

Guildline's 6645Q Quantum Hall System has been designed and developed to meet the needs of Standards Laboratories around the world for an improved level of accuracy in the calibration and maintenance of primary resistance standards.

The 6645Q System is based on over 60 years of Guildline expertise in precise resistance measurements and on over 50 years of design and manufacturing expertise with Direct Current Comparator (DCC) Resistance Bridges.

THE 6645Q SYSTEM PROVIDES THE BEST IN INNOVATIONS, CUTTING EDGE TECHNOLOGY, AND MOST IMPORTANTLY, THE BEST MEASUREMENT PERFORMANCE OF ANY QHR SYSTEM WITH A DCC BRIDGE MANUFACTURED TODAY!

Guildline has being working closely with Oxford Instruments, a company that also has over 50 years of experience, to supply the cryogenic and superconducting magnet systems; and with a leading National Metrology Institute (NMI) that has over 20 years of experience developing semiconductor Quantum Hall Effect (QHE) sensors. Guildline has fully integrated all required system components to provide customers with an advanced, easy-to-use, fully automatic QHR System!

The 6645Q System provides an absolute value of resistance related to the von Klitzing constant of 25812.807 Ω. To provide this reference, a Quantum Hall semiconducting device is maintained at 1.5 Kelvin with a He-4 refrigerator within a high magnetic field.

A superconducting magnet is used to generate a background field of up to 12 Tesla. Under these conditions the Quantum Hall plateaus of resistance are easily obtained. This system has the ability to make Turn-Key measurements of resistance devices at any point within the measurement range of 10 mΩ to 100 kΩ.

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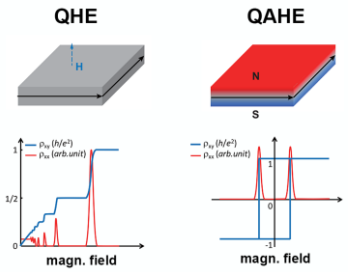
GUILDLINE INSTRUMENTS 6640Q QUANTUM HALL RESISTANCE (QHR) BRIDGE has been completely redesigned to provide better uncertainties and more operational capability. The 6640Q Quantum Hall Resistance Bridge incorporates many patented new design and measurement technologies to provide a Precision Resistance Bridge operating at room temperature that will scale from the Quantum Hall resistance value of 12906.4035 Ω to nominal resistance values of 0.1Ω to 100 kΩ.

The 6640Q Bridge, utilizing an internal calibrated Nano-Voltmeter as the Null Detector, is used to measure Hall Resistances (R_{xy}), Longitudinal (R_{xx}) Resistances and Contact Resistance of a Quantum Hall Device. The 6640Q is capable of making the measurements necessary to ensure the accuracy of the QHR Resistance Standard. It is a room temperature Direct Current Comparator (DCC) Resistance Bridge that has been designed to provide better uncertainties and more operational capability when used with Quantum Hall Resistance Systems (i.e. QHRs).

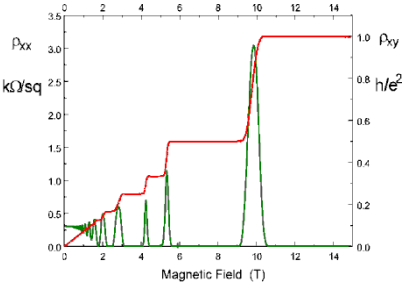
The 6640Q incorporates a new patented toroid design, new Nano-Voltmeter (i.e. null detector), two new faster processors, new internal communications structure, and new firmware. The new touch screen interface and associated embedded Windows 10 Computer makes the 6640Q easy to use while providing complete functionality for measurements and addressing the requirements for 17025 Accreditation of resistance measurements

6640Q – The Absolute Best in Engineering Design and Innovation

For quality in measurements, you must have quality design and quality manufacturing in your standard. If you examine the internal layout of the new 6640Q Bridge you will find this quality throughout. Special attention has been paid to: isolation and use of shielding to reduce noise, better grounding, the latest in modern components to reduce affects due to temperature and power dissipation, increased resolution, better stability in excitation current, increased reliability, and faster measurement cycles. Add to this the new patented designs and a carefully thought out and designed internal and external layout; and you will find a completely redesigned Bridge that meets customer requirements today, as well as years into the future.



Every effort has been taken in the 6640Q design to reduce noise and error. **Thermal EMF effects are eliminated** by automatic current reversal. The **unique architecture** of the bridge and its **control algorithm** further removes gain and offset errors in the **Nano-Voltmeter balance detector** and the **new precision toroid**. The end results are shown by **long term accuracy and linearity** without the need for routine, frequent verification tests or calibrations.



6640Q Operators Interface

NEW 10-inch VGA capacitive touch screen with full color graphical user interface. The most visible feature on the new 6640Q Bridge is the 10 Inch display running the latest Windows software. This display not only has low noise characteristics but is designed to provide maximum protection from Electromagnetic Interface (EMI) with respect to the internal measurement circuitry. The embedded Intel processor running the latest Windows operating system provides a modern user interface that is completely independent from the high-speed processor used to make the measurements, thus providing faster response times and lowering the measurement noise.

Unique New Design Incorporates Dual Processors

Older Guildline DCC Bridges had, and **current competitive models** only have, a single old processer for all functions. This older processor controlled the measurement circuitry, data collection, display, user interface, IEEE and communications, and much more. This work load puts a heavy burden on the capability of this single older-generation processer. The competition appears to make their instruments more modern by simply adding a larger screen, however all the functionality and control is still based on an older design with a very old processer. The use of a single processor, especially an older generation processor, makes it very difficult to improve performance and speed of a DCC Bridge, and makes it impossible to provide a modern user interface. Guildline solved these issues by using a complete new design for the 6640Q, including using two modern, very fast processors.

System Controller and Interface Processor (Processor #1)

The 6640Q QHR Bridge contains an Intel based Computer which is dedicated to running the user interface and has a Windows 10 Operating System installed. This embedded Intel Computer also does all of the data analysis, display graphics, and controls the embedded 10-inch capacitive, multi-touch screen. This architecture allows the 6640Q to become the center of a larger measurement system via many different interfaces commonly available to a modern Windows 10 Professional computer such as GPIB, TCP/IP, RS-232, and USB. This computer processor, through Guildline's unique architecture, can also be placed into a slave mode allowing the 6640Q to be remotely controlled with the same flexibility as any remotely controlled Windows Computer. This allows the 6640Q to run in an already established larger system with any external PC and custom or off-the-shelf software. Finally, third party analysis software, such as Excel, can be installed right on the 6040Q Bridge thus providing enhanced capabilities.

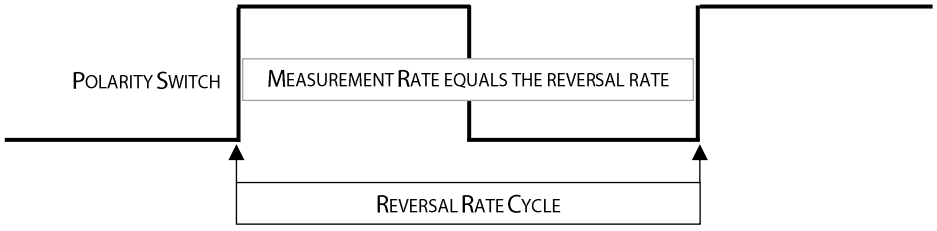
Measurement Processor (Processor #2)

The real heart of the 6640Q is its modern embedded high-speed measurement processor. This is one of the latest real-time processors dedicated to the control of only the measurement circuitry hardware. The real-time processor ensures fast measurements and reliable control of the hardware such that the reported data is consistent and fail-safe. The embedded processor is dedicated to this function and is complete isolated and EMI shielded from the sensitive measurement circuitry.

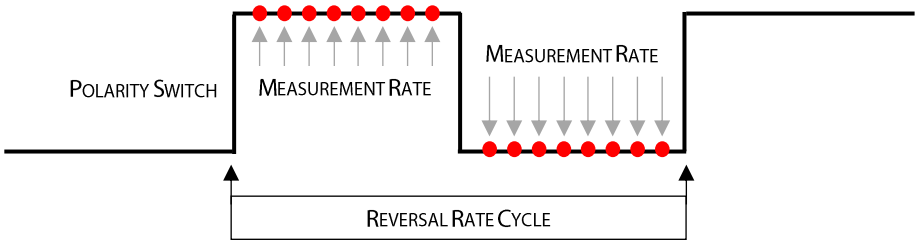
With the two processors working together in the 6640Q, Guildline provides the best of both worlds. A real-time processor ensuring consistent reliable fast measurements; and the flexibility of an Intel computer running the Windows 10 operating system. This allows advanced control and analysis though Guildline's flexible software architecture as well as a limitless set of options provided by the Windows 10 Professional platform.

New Design Incorporates Decoupling of Measurement Rate from Reversal Rate

Old DCC Bridge technology, **used by competitors,** requires that a measurement be based on the polarity reversal. This can be represented by the figure shown to the right. While having statements such as reversal rates as low as 2 seconds; to meet published specifications the reversal rates are typically 20 seconds or more with a reading every 20 to 40 seconds.

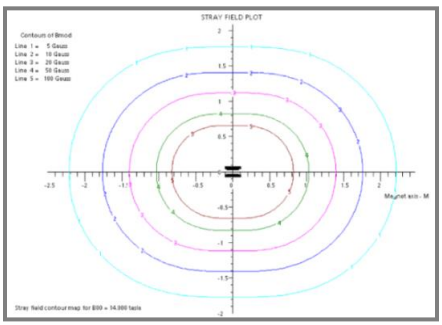


Guildline's 6640Q QHR Bridge decouples the polarity reversal rate from the measurement rate allowing measurements to be made much faster than competitive DCC bridges. As shown in the below figure, you can independently specify a measurement rate and a reversal rate. With the 6640Q's dedicated measurement processor, many measurements can be made while on a single polarity. This allows a vastly increased number of measurements to be made on a single reversal rate cycle. Add to this our many other patented design features and you will find that Guildline's 6640Q QHR Bridge is truly the latest in innovations and technology. Guildline's new 6640Q QHR Bridge provides best performance across the entire resistance operating range. Imagine what you could now analyse and see with complete data available from the entire measurement cycle.



OXFORD Cyrogenics

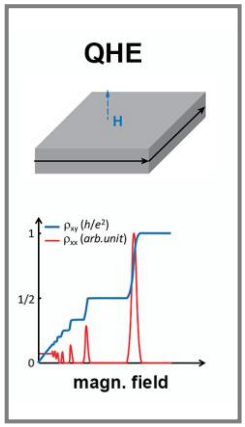
The **cryogenics cooling Dewar**, **Superconducting Magnet**, **associated power supply**, and the **QHR device insert** are provided in cooperation with **Oxford Instruments**. The superconducting magnet system is equipped with a low loss Dewar that can contain up to **70 litres of liquid helium**. It is capable of producing DC magnetic fields up to **12 Tesla** in normal operation and **14 Tesla** with using an optional lambda point refrigerator. The Dewar can maintain the liquid helium level for routine **QHR operation for 4 to 6 days** with the setting of the magnet and the QHR device inserted into the Dewar. The power supply offers bi-polar DC current to support the magnet persistent mode switch feature. For the consideration of safety, the **magnet quench detection** and protection are designed and built into the System. The magnet will be de-energised automatically **without quenching** when the helium level falls below the pre-set limit. A **safety valve** is also built-in to ensure the pressure inside the Dewar is under the pre-set limit.



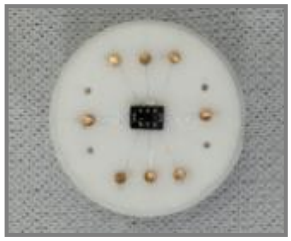
The magnet and Dewar both have liquid helium level and temperature sensors and there is a temperature sensor set up close to the QHR sample.

The **QHR device insert** has a **TO-8 socket for mounting the QHR device**. The interface for the user to link the measurement system to the QHR sample is located on top of the insert. The insert can be easily inserted into the Dewar and **pulled out through the O-ring seal**. Optionally a **Split Hinged Insert** can be provided to allow sample insertions in room with ceiling heights **below 3.2 m**.

NMI QHR Sample



The QHR Sample is designed and manufactured by a **NMI** with over **20 years of experience developing QHR devices**. It can be operated on the **plateau of i =2 or i =4** under the operating current **lower than 100 µA.** Sample can be supplied with the magnet field strength of either higher than 9 Tesla or lower than 9 Tesla at the centre of plateau i =2. The longitudinal potential difference of the sample is **less than 20 nV** at nominal operating current. The contact resistance of the sample is less than **1 Ω at nominal operating current**. The sample can be mounted on a **TO-8 socket** which is part of the QHR device insert. As an option, the 6645Q System can be **calibrated by a NMI** prior to delivery to a customer.



The cooling system includes the variable temperature insert (VTI), the needle, and the pump. The needle and the pump can control the temperature of the environment where the sample is located to reduce the nominal operating temperature of the sample to **1.5 Kelvin**. A temperature sensor is designed to be close to the needle on the bottom of the VTI.

Supporting all **standard cryogenic sensors** (ruthenium oxide, cernox, silicon diodes, platinum, thermocouple and RhFe), the system measures and controls temperatures to **1.5 K with a precision of 0.1 mK** (24 bit A to D resolution).

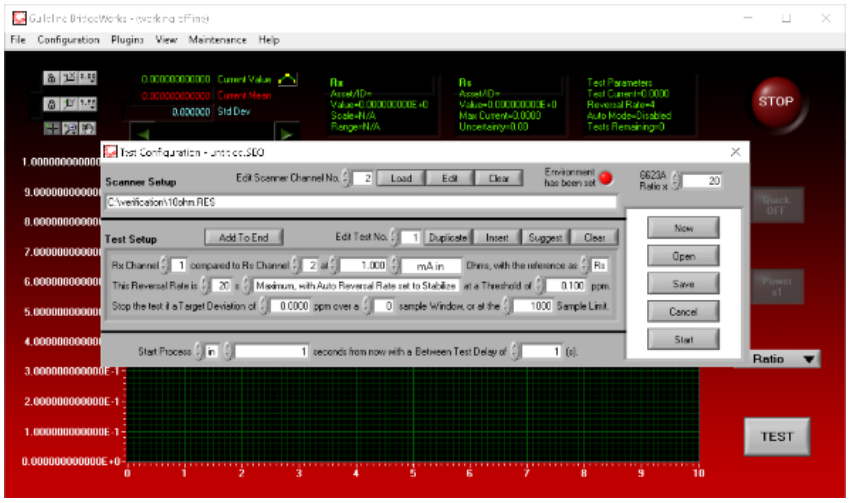
The use of the room temperature **6640Q-QHR DCC Resistance Bridge** and low loss Dewar greatly reduces the operation complexity and the consumption of liquid helium, thus **reducing the operating cost** of the 6645Q System.

6645 QHR Software

Not only does Guildline provide unique DCC Bridge and QHR System hardware, but we offer complete new solutions for software as well. Note that all QHR and Bridge measurements, including automated measurements, can be controlled and results displayed by using the embedded Windows 10 computer that exists inside the 6640Q Bridge.

Alternatively, a customer can use Guildline's proven **BridgeWorks** software running on either the internal 6640Q computer or an external computer. BridgeWorks Software is provided at no charge with the 6640Q QHR Bridge. **Optional BridgeWorks plug-ins** are available to expand BridgeWorks functionality including control of the superconducting magnet and the rest of the QHR system.

The QHR plug-in has routines to: check the remote connection of the instruments connected to the entire QHR System; display and change all system variables; and to modify control parameters and variables in order to optimize the QHR System to improve measurement uncertainty and speed. The software comes with all of the useful and convenient features commonly found in **Windows based** commercial software programs and is designed to work with a touch screen. **On-line context help** is available to provide added assistance in understanding the functions of the software. The 6645Q QHR System software and 6640Q Bridge software was **developed in LabVIEW©** offering direct compatibility to all National Instruments GPIB interfaces. These interfaces come in a wide variety of connection options to your PC such as **USB, FireWire, Ethernet, PCI, PCMCIA, IEEE 488.2 RS232/485** and more. All user **definable test variables**, such as excitation current, measurement speed, reversal rate etc. can be **programmed on a per test basis**, giving the **users full control and flexibility** in conducting well designed measurements. No other manufacturer allows bridge measurement parameters to be changed while taking a measurement. Competitors require that the measurement be stopped, parameters reset, and the measurement restarted. As a result, measurement data is lost. Additionally, internal utilities reside within the BridgeWorks software to enhance and **simplify the calibration of the 6640Q** QHR Bridge by using the Guildline 6634A Series of Temperature Stabilized Resistance Standards.



For a **complete, Automated Resistance Measuring System**, a 6640Q Bridge can be provided with Guildline's 6664C Low Thermal Scanners and Guildline's 6634A Temperature Stabilized Resistance Standards. This System is integrated, verified and tested in a rack a little more than 36" high (i.e. less than 1 meter). When the Bridge is used with a Guildline low **thermal matrix scanner,** the software can turn the bridge into a **multiple-channel** calibration and measurement system. Timed, sequenced single or multiple tests can be initiated while the bridge is unattended. **Complete turnkey solutions**!

OXFORD MF120LLD Integra System Specifications

Cryostat type: LLD1-FRP LN2 Liquid nitrogen-shielded low loss Dewar & FRP neck

- Central neck diameter (nominal): 140 mm
- Top plate surface to magnet field centre position: 1352 mm
- Usable liquid helium volume (nominal) excluding tail and without insert fitted: 70 litres
- Liquid helium consumption: Dewar fitted with VTI or HELVL insert: <= 325 cc/h
- Liquid nitrogen volume (nominal): 66 litres
- Liquid nitrogen consumption: <= 250 cc/h
- Dewar height from ground level to top flange: approximately 1652 mm
- Dewar top plate diameter: approximately 622 mm

NOTE: Liquid helium consumption is specified for stated configuration(s) only. The figures specified are in static mode (magnet at zero or persistent 4.2 K field zero flow through insert)

Magnet type: S12/14/52/13 Vertical field solenoid superconducting magnet

- Central field at 4.2 K: 12 Tesla at 4.2 K, 14 Tesla at 2.2 K
- Ramp rate (nominal): 1.0 T/min at 4.2 K, 0.5 T/min at 2.2 K
- Operating current (nominal): = 120 A
- Magnetic field homogeneity: = 0.1 % total variation over a 10 mm diameter sphere (dsv)
- Magnetic field stability in persistent mode: <= 1.0 x 10E-4 relative/h measured at 12 T
- Clear bore diameter (nominal): 52 mm

NOTE: Ferrous materials in the environment: The offer assumes that NO static/structural steel is within 1.2 m, or moving steel is within 1.8 m the distance from magnetic field centre.

Magnet Power Supply: MERC-IPS-120-L magnet power supply with cryogen level meter

- Output current: ± 120 A nominal, ± 125 A maximum.
- Output voltage: ± 10 V
- Current output stability (typical): < ± 2.8 mA
- Current output drift (typical): < 0.14 mA/h/°C
- Current setting resolution: 0.1 mA
- Operating voltage: Single Phase 100-240 VAC 47-63 Hz (800W) per unit (2 required for 120 A)
- 426 x 480 x 131 mm (W x D x H) per unit (2 required for 120 A)

Controller: MERC-ITC-3-AUX temperature controller and needle valve gas flow control

- Temperature Sensor Inputs/PID Control Loops: 3
- Heater output: 80 W per channel
- Operating voltage: Single Phase 100-240 VAC 50-60 Hz (650 W)
- 426 x 272 x 131 mm (W x D x H)

NMI QHR Sample

- Operational Plateau: i =2 or i =4
- Operational Current Range: < 100 µA
- i=2 plateau magnet field strength: sample can be supplied with either lower than 9 Tesla or higher than 9 Tesla specifications
- Longitudinal Potential Difference: < 20 nV (at nominal operating current)
- Contact resistance: < 1 Ω (at nominal operating current)
- Socket Mounting: TO-8 socket

6640Q QHR Bridge Specifications

6640Q QHR	Range 0.1 Ω to 100 kΩ. Specifications are relative and 1 year (except Interchange @ 24 hours), 2 Sigma Level (95 %) and within ±2 °C Temperature. Includes all secondary specifications including noise and linearity.

Rs / Rx (Either can be Selected as Standard)	**Ratio / Ratio Uncertainties (± ppm)**				
	Interchange[1] (1:1)	0.1 : 1 [2]	1 : 1	10 : 1	13.4 : 1
1 Ω	0.015	0.05	0.02	0.02	0.02
10 Ω	0.015	0.02	0.02	0.02	0.02
100 Ω	0.015	0.02	0.02	0.02	0.02
1 kΩ	0.015	0.02	0.02	0.02	0.02
10 kΩ	0.02	0.02	0.03	0.05	0.05

1 - Interchange specification is a 24 hour specification (i.e. sometimes referred to as a self-calibration).
2- Ratio Uncertainties of 0.02 ppm are based on reversing Rs and Rx (i.e. Rx / Rs) connections.
3 - Specifications are based on standard practice use of 30 µA - 100 µA of current in the QHR.

General Specifications			
Linearity		± 0.005 ppm (1:1 to 13.4:1 Ratios)	
Display resolution (ppm)		Selectable (Programmable) from 0.0001 ppm to 10 ppm	
Temperature Coefficient		0.01 ppm/°C of reading (Outside Operating Temperature)	
Automatic current reversal rate (in seconds)		4 to 1637 programmable, increment of 1 second	
Fastest Measurement Sample Rate		2 seconds	
Communication		USB, IEEE 488.2, SCPI Based Language Instructions	
Test current (for measurements to 100 kΩ)	Range (±30Vdc compliance)	10 µA to 150 mA	
	Resolution (µA)	1 µA	
	Accuracy [error(ppm) + offset(A)]	±100 ppm ± 10 µA	
Bridge Operating Temperature to Full Specifications		21 °C to 25 °C	69.8 °F to 77 °F
Bridge Maximum Operating Range (<50 % RH)		+18 °C to +28 °C	+65 °F to +82 °F
Bridge Temperature Storage Range		-20 °C to +60 °C	-4 °F to +140 °F
Power Requirements	Vac: 100 V, 120 V, 220 V, 230 V and 240 V; All ± 10 % 50 or 60 Hz ±5 %, Or 45 Hz – 65 Hz		

Dimensions (Width x Height x Depth)		Weight	
440 mm x 200 mm x 465 mm	17.3" x 7.8" x 18.3"	27 kg	59.5 lbs

Ordering Information	
6645Q	QHR System
	Includes Calibration Certificate, Operator and Software manual, and one set of Rs/Rx Low Thermal Leads
/RC	Report of Calibration Available at Nominal Charge
/RT	Specifies Rear Terminals versus Front Terminals (Default)

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