MAG|RS

MAGNETIC RESEARCH SYSTEM

DISCOVERY
STARTS HERE

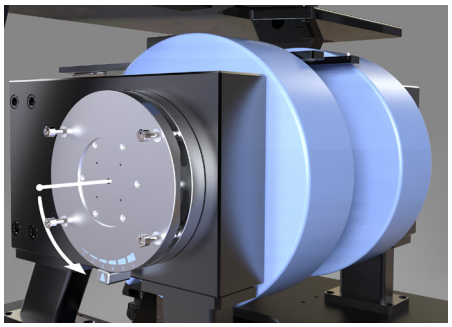
Lake Shore
CRYOTRONICS

MAG|RS
MAGNETIC RESEARCH SYSTEM

Configure your base system

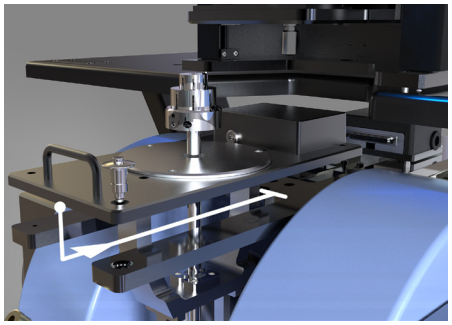
The MagRS base system comes with either a 4 or 7 in magnet, with additional options to customize the system for your experimental needs. Choose to add VSM capability, temperature option accessories, or optical access. MagRS comes with ExactGAP magnet pole gap indexing and GlideLOCK precision sample positioning.

Magnet features



ExactGAP™

ExactGAP magnet pole gap indexing makes it fast and easy to reconfigure the gap for the required sample or option size without having to recalibrate the magnet after a change.



GlideLOCK™

Slide in and out of the magnet on the precision-aligned GlideLOCK tray, and click into place to ensure repeatable positioning of the enclosed sample within the magnet poles.

Choose the exact configuration you need

Includes electromagnet with standard pole caps and electromagnet system controller with magnet power supply

MRS-EM*WX-Y-Z*

Specify AC power and CE mark in configurator

W = **Magnet size**

4 = 4 in (102 mm)
7 = 7 in (178 mm)

X = **Field options**

T = F71 (standard)
7 = 737 (required for magnetometer applications)

Y = **Temperature option accessories**

(required if temperature options will be used)
N = None (standard)
V = Variable temperature kit installed (includes 336 temperature controller, GlideLOCK™ option mount, and cabling)
G = GlideLOCK™ option for physical mount only (no cabling supplied)

Z = **Optical access**

= None (standard)
O = 0.25 in access (only includes pole caps with optical hole; solid pole caps should be ordered separately)

For example, an MRS-EM7-T-V-O is the base platform with a 7 in (102 mm) magnet, an F71 teslameter, variable temperature kit installed, and optical access added.

Applied field strength with standard 2 in pole face (±1%)

ExactGAP™ setting	Air gap	4 in magnet maximum field	7 in magnet maximum field
Index 1	7.5 mm	2.61 T	3.05 T
Index 2	12 mm	2.37 T	2.83 T
Index 3	20 mm	1.96 T	2.47 T
Index 4	25 mm	1.69 T	2.28 T
Index 5	28 mm	1.54 T	2.17 T
Index 6	50 mm	0.91 T	1.54 T

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Add the measurement options *you* need

The MagRS can be equipped to provide the functionality you need on your path to discovery. Choose one or many options, or add options on as you need them. The possibilities are endless.

Add on options for additional capabilities

HALL EFFECT MEASUREMENTS

2× noise improvement over previous 8400 system

ACField option

with optional high-resistance to 200 GΩ

MRS-8400-ACFIELD-MO

or

FastHall option

MRS-FASTHALL-MO

ELECTRON TRANSPORT MEASUREMENTS

ETransport option

coming soon

MRS-ETRANSPORT-MO

FERROMAGNETIC RESONANCE MEASUREMENTS

FMR option

MRS-FMR-1-MO

VIBRATING SAMPLE MAGNETOMETER MEASUREMENTS

VSM option

MRS-8600-VSM-MO

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HALL EFFECT MEASUREMENTS

ACField and FastHall™ options

If you make Hall effect measurements, there are two different options available.

The ACField option combines the best of both DC and AC field measurement capabilities, with the convenience of a wide mobility range. The unique AC field measurement technique extends your mobility measurements down to 0.001 cm^2/Vs.

The FastHall option uses our patented FastHall measurement technique, which eliminates the need to switch the polarity of the applied magnetic field during the measurement. This makes DC field measurements extremely fast, reducing analysis time in some cases by 100×. Most commonly measured materials can be analyzed in a few seconds. Even extreme high resistance (up to 200 GΩ) or low mobility (~0.001 cm^2/Vs) samples can generally be analyzed in under 2 min.

M81-SSM synchronous source measure system

integrated into the **ACField** option

The M81-SSM synchronous source measure system implements a unique instrument architecture optimized to provide synchronous DC, AC, mixed DC+AC source and lock-in capabilities for low-level measurements.

- MeasureSync™ technology for simultaneous source module update and measure module sampling timing across all channels
- Optimized for fundamental, harmonic, and phase AC plus DC biased measurements

M91 FastHall™ controller

integrated into the **FastHall** option

The M91 FastHall measurement controller integrates all the required source measure and signal switching capabilities to provide a complete start-to-finish Hall analysis. Cut your measurement time up to one-half with the M91. Measurements are so fast that time-dependent misalignment errors are eliminated using the patented FastHall™ measurement technique.

- No need to reverse the magnetic field with FastHall
- Up to 100× faster for low mobility materials
- Improves accuracy by minimizing thermal drift

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HALL EFFECT MEASUREMENTS

ACField and FastHall™ options

Hall option specifications	ACField option MRS-8400-ACFIELD-MO 2× noise improvement over previous 8400 system	FastHall option MRS-FASTHALL-MO
Temperature options	**Standard** room temperature **Low temp** 10 K to 350 K (optical CCR), 400 K (CCR) **High temp** room temperature to 1273 K (oven)	
Sample type	van der Pauw, Hall bar	
Maximum sample size	10 mm × 10 mm × 3 mm	
Software	MeasureLINK™ software included to execute Hall measurements	
Gate bias option	Up to 100 V	
Legacy conversion	Full legacy 8400 replacement	Partial legacy 8400 replacement
Resistance range options	**Low-resistance** Coming soon **Standard resistance** 0.5 mΩ to 10 MΩ **High-resistance** 10 MΩ to 200 GΩ	**Standard resistance** 10 mΩ to 10 MΩ **High-resistance** 10 MΩ to 200 GΩ
Measurement type	DC field Hall measurement AC field Hall measurement	DC field Hall measurement FastHall measurement (AC electrical, DC field)
Measurement-specific instrumentation	**Base** 776B and M81-SSM-6 + BCS-10 **Standard resistance** BCS-10, VM-10 **High-resistance** VM-10, VS-10, CM-10	**Standard resistance** M91 **High-resistance** M91-HR
DC field options (nominal)	**4-inch magnet** 1.69 T room temp and 0.91 T variable temp **7-inch magnet** 2.28 T room temp and 1.54 T variable temp	
AC field range options (fixed field, nominal)	Frequency: 50 mHz or 100 mHz **4-inch magnet** 1.18 T (RMS) room temp and 0.63 T (RMS) variable temp **7-inch magnet** 1.20 T (RMS) room temp and 0.69 T (RMS) variable temp	None
Resistivity	10^{-5} to 10^{5} Ω·cm	10^{-3} to 10^{5} Ω·cm
Carrier concentration density	8×10^{2} to 8×10^{23} cm^{-3}	8×10^{2} to 8×10^{23} cm^{-3}
Mobility range	1×10^{6} (DC field) and 10^{-3} to 10^{6} (AC field) $cm^2/V\ s$	10^{-3} to 10^{6} $cm^2/V\ s$
Multi-carrier analysis	QMSA-compatible (DC field only)	QMSA-compatible

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ELECTRON TRANSPORT MEASUREMENTS

ETransport option *coming soon*

Using the M81-SSM, the ETransport option allows AC and DC field transport measurements with the lowest possible source/measure noise. The system uses a central instrument with remote source and measure modules for the shortest possible signal path to the DUT, separating sensitive analog circuits from digital circuits and unwanted sources of interference typical of traditional instrument designs.

Typical applications

- Spin orbit torque
- Differential conductance
- 3-terminal FET
- High-resistance
- Low-resistance

M81-SSM capabilities

- Source modes: DC, sine, triangle, square
- Source ranges: 1 pA to 100 mA
- Source frequency: 100 µHz to 100 kHz (square <5 kHz)
- Measurement limits: 10 V max
- Input impedance: ≥10 GΩ (differential)

ETransport option specifications

MRS-ETRANSPORT-MO

Temperature options	**Standard** room temperature **Low temp** 10 K to 350 K (optical CCR), 400 K (CCR) **High temp** room temperature to 1273 K (oven)
Max sample size	10 mm × 10 mm × 3 mm
Software	MeasureLINK™ software included to calculate field control, temperature control, measurement sequencing, and integration functions
Field type	AC and DC field
Measurement-specific instrumentation	M81-SSM-6 and application-specific module combinations

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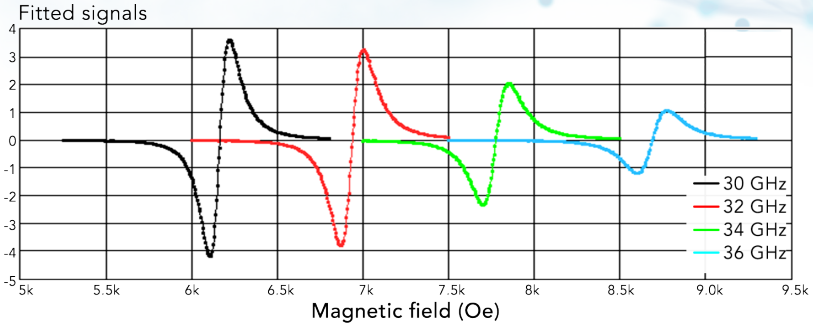
FERROMAGNETIC RESISTANCE MEASUREMENTS

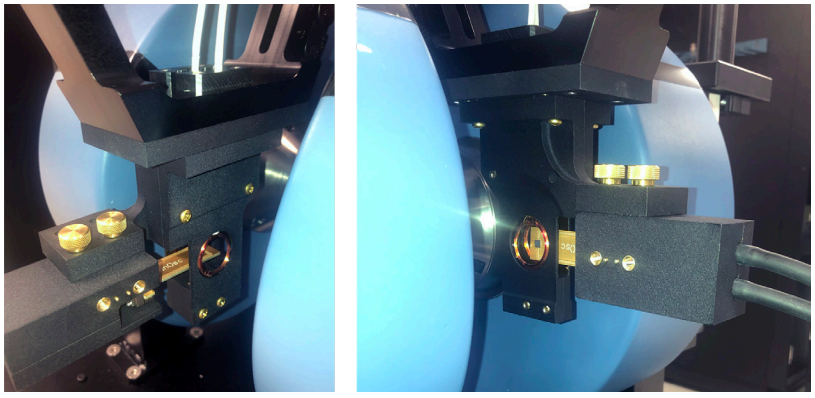
FMR option

The MagRS FMR measurement option enables you to easily use a NanOsc Instruments PhaseFMR or PhaseFMR-40 spectrometer with the 4 in or 7 in MagRS magnet systems for ferromagnetic resonance (FMR) measurements. It provides hardware and software integration of NanOsc instruments and u-type CPW sample holder products in a room temperature application.* With it installed, broadband 2 to 18 GHz (PhaseFMR) or 2 to 40 GHz (PhaseFMR-40) measurements in variable DC magnetic fields are possible. Maximum fields depend on the system and whether in-plane (IP) or out-of-plane (OOP) orientation is used.

**Does not include NanOsc CPW, Helmholtz coils, cables, and FMR instruments. These NanOsc room temperature FMR products are available from Quantum Design, our preferred source of NanOsc products*



Measured and fitted data for $Ni_{80}Fe_{20}$ (10 nm)/Ta (5 nm) thin film as a function of IP field to 0.94 T at frequencies of 30, 32, 34, and 36 GHz (typical results)



CPW sample holder for NanOsc spectrometer integration

FMR option specifications

MRS-FMR-N

Temperature options	**Standard** room temperature
Max sample size	10 mm × 10 mm
Software	MeasureLINK™ software included to calculate field control, temperature control, measurement sequencing, and integration functions
Measurement-specific instrumentation	NanOsc PhaseFMR-40 (sold separately)
Field range (nominal)	**4-inch magnet** up to 1.69 T in-plane, up to 2.41 T out-of-plane **7-inch magnet** up to 2.34 T in-plane, up to 2.91 T out-of-plane

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VIBRATING SAMPLE MAGNETOMETER MEASUREMENTS

VSM option

The MagRS VSM option brings cutting-edge levels of measurement performance to magnetic characterization. The system features ultra-high sensitivity (down to 15 nemu), wide dynamic range, faster field ramping (10,000 Oe/s) and rapid data acquisition (up to 10 ms/pt). A complete -2 T to +2 T hysteresis loop with 3,000 measurement points can be completed in about 30 s. Field setting resolution of 1 mOe is available across the entire measurement range, and especially helpful in regions where moment gradient ΔM is high. This fine resolution, combined with high sensitivity and fast measurement speed, makes the MagRS VSM ideal for first order reversal curve (FORC) measurements, which inherently involve very large data sets.

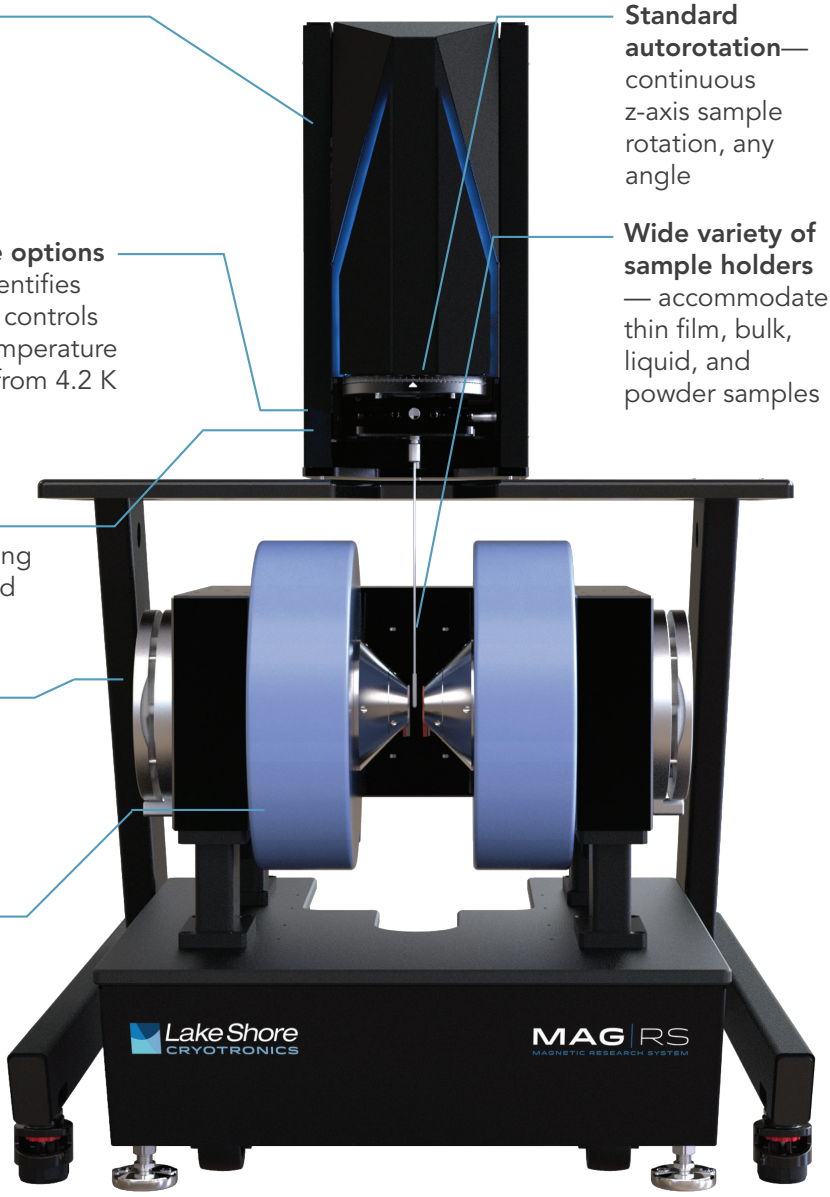
Very easy sample exchange — motorized head movement for sample extraction, allows for one-handed exchange of the QuickLIGN™ sample rods

Easy-to-install temperature options — software automatically identifies and displays option-specific controls for installed GlideLOCK™ temperature options to quickly measure from 4.2 K to 1,273 K

Unattended single-stage control — automatic switching between cryogenic to heated operations

Repeatable gap settings — six indexed ExactGAP™ magnet positions each have their own saved calibration

Two electromagnet configurations — choose from the 4 in or 7 in magnets for field requirements up to 3.22 T



Standard autorotation— continuous z-axis sample rotation, any angle

Wide variety of sample holders — accommodate thin film, bulk, liquid, and powder samples

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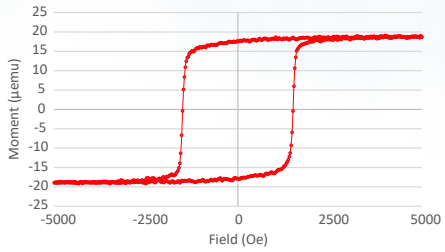
VIBRATING SAMPLE MAGNETOMETER MEASUREMENTS

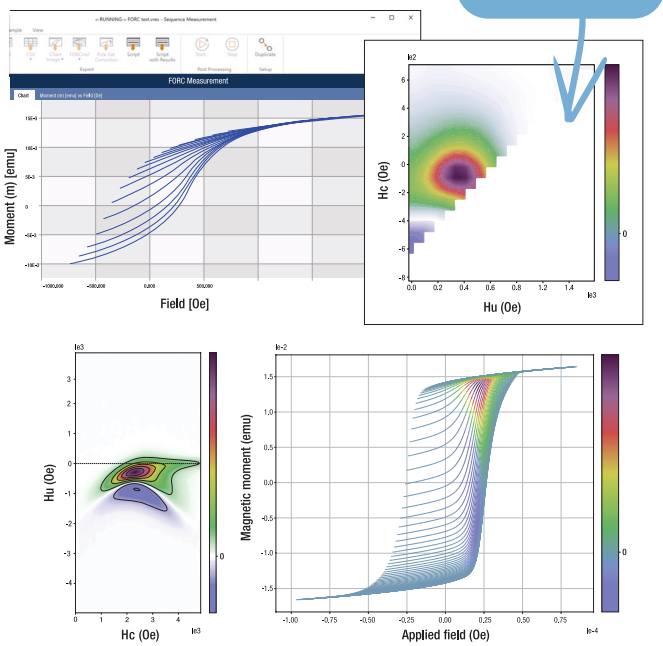
VSM option

The standard for FORC measurements with integrated RTForc™ software

The MagRS VSM option was created with first-order reversal curve (FORC) measurement as a primary objective. FORC analysis is greatly enhanced by the high sensitivity of the vibrating sample magnetometer. FORC also benefits from increased data point density, and the VSM flies through complex FORC data collection sequences in a fraction of the time required on previous systems. In addition, the system includes Real-Time FORC (RTForc™) software, which enables fully automated FORC data acquisition using the 8600 software.



Existing 8600 customers can upgrade to all MagRS measurements



8600 software

- Standard suite of magnetic measurements
- Real-time FORC
- Colorized FORC
- Custom measurements (scripting)

VSM option specifications

MRS-8600-VSM-MO

Temperature options	**Standard** room temperature **Low temp** 4.2 K to 420 K (CCR) **High temp** room temperature to 1273 K (oven) **Variable temp** 77 K to 950 K (SSVT)
Max sample mass	10 g
Software	8600 VSM software
Noise floor	15 nemu at 10 s/pt (room temperature)
Closed-loop field control stability	100 nT (1 mOe)
Field range (nominal)	**4-inch magnet** up to 2.67 T **7-inch magnet** up to 3.22 T

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MeasureLINK™ software

MeasureLINK-MCS software is the key component of each MagRS system. It facilitates field control, temperature control, measurement sequencing, and integration functions.

This flexible software allows real-time system performance monitoring and to construction of measurement sequences from a set of predefined controls. The menu-driven graphical user interface (GUI) provides the ability to control field and temperature to a specific setpoint or to loop these parameters through a range of settings with a specified step value. The sequences can be saved and recalled for use in repeated measurements.

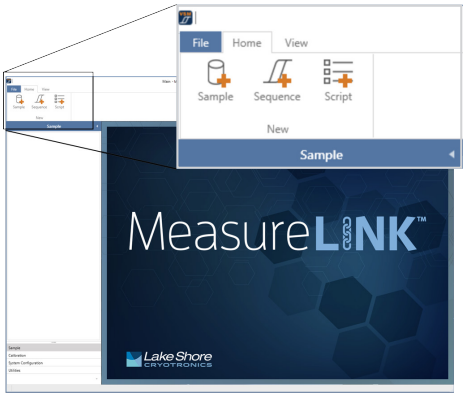
MeasureLINK™ software features

- Temperature and field control
- Measurement sequences
- Integrate Lake Shore or third-party instruments
- Integration with other lab software
- Custom measurements with scripting

Home screen

Three main functions:

- Sample setup
- Sequencing
- Scripting

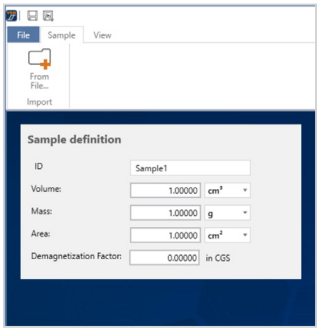


Sample setup screen

Associate sample information with a measurement sequence

Enter new sample information directly

Import existing sample information from a previously-saved file



Sequence screen

Build a sequence of steps that define the desired measurement protocol

Choose from:

Measurement functions

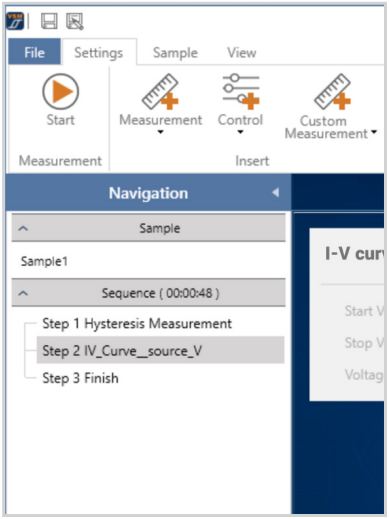
- Built-in functions

Control functions

- Go to field or temperature
- Loop field or temperature

Custom measurements

- Modified or specialized routines, previously defined by scripts



Script screen

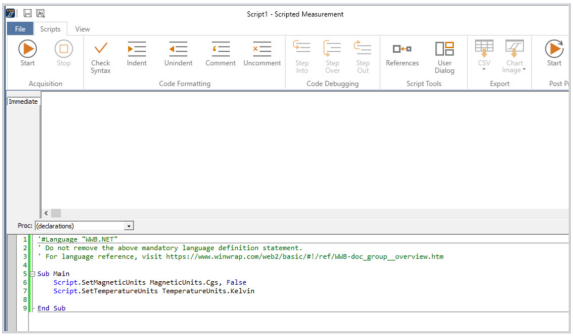
Create custom scripts

- Implement nearly any measurement
- Integrate third-party instruments

Modify existing scripts

Import other scripts

Simpler and faster than writing code



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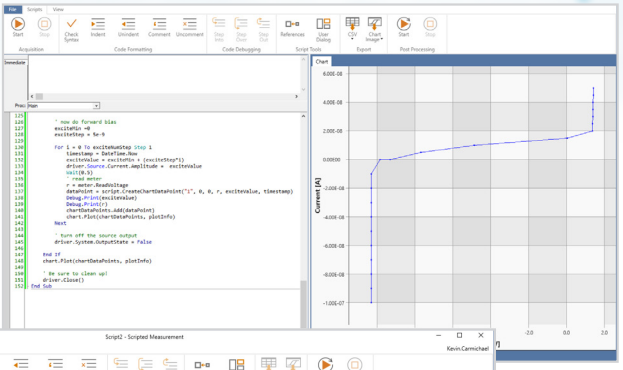
MeasureLINK™ software

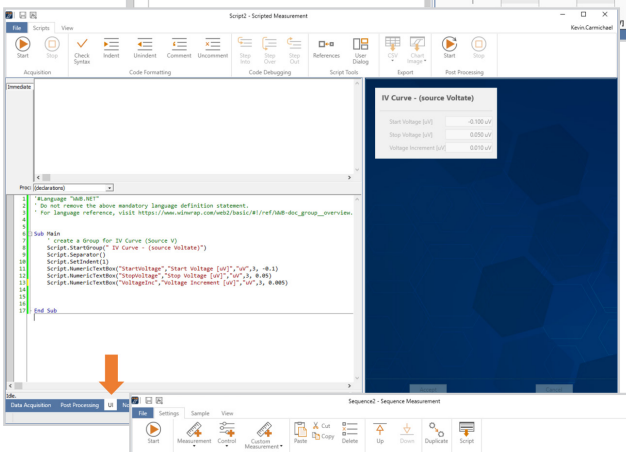
Scripting example

I-V measurement



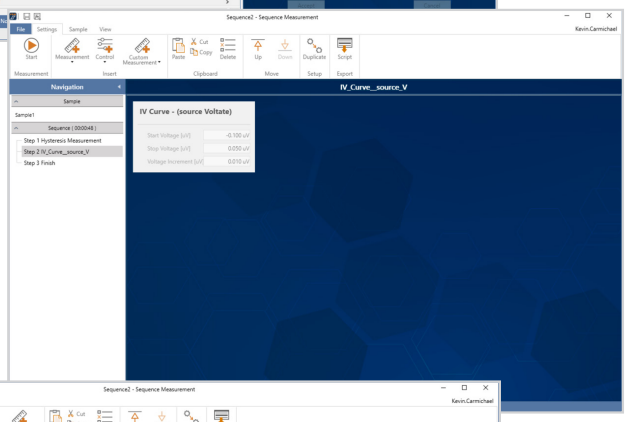
Loop through 20 voltage steps

- Set V
- Measure I



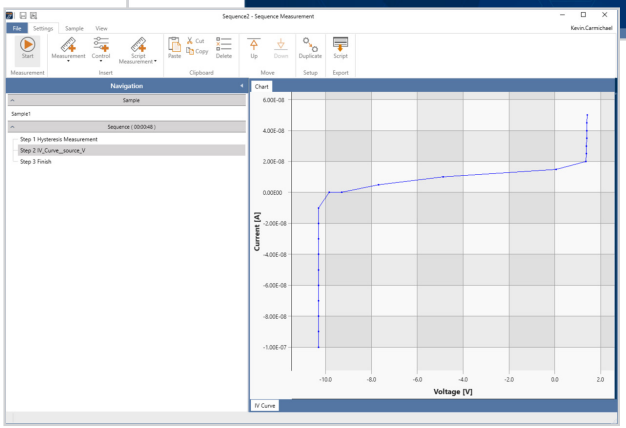
Scripting tool enables presentation of a simple user interface

- Start voltage
- Finish voltage
- Number of steps



Once script is ready

- Add to Custom Measurement list
- Select and add the custom script to the sequence steps from the drop-down list
- Appears exactly like built-in functions



Customized measurement sequence

- Executes sequential steps as defined
- Presents UI steps such as data entry windows
- Custom scripts execute like other steps
- Data collection and graphing can be included

Start discovering with MAG|RS MAGNETIC RESEARCH SYSTEM

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