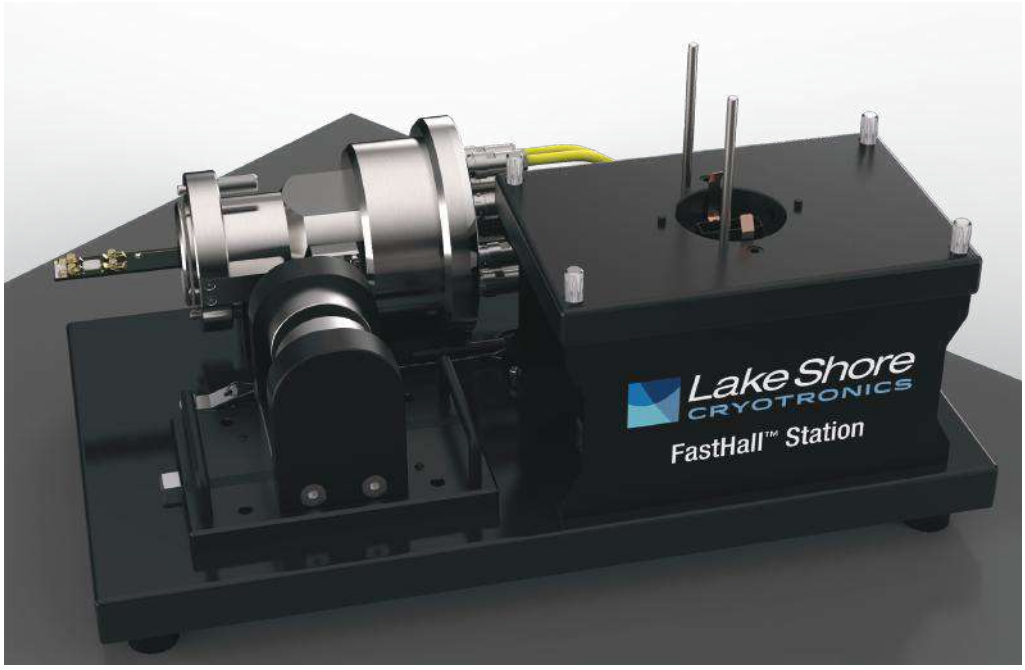
MeasureReady™ FastHall™ Station

The highest performance tabletop system for van der Pauw and Hall bar samples

Lake Shore CRYOTRONICS

MeasureReady™ FastHall Station

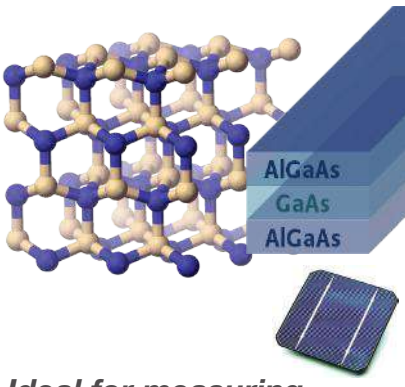
FastHall measurement capability contained in a complete characterization platform

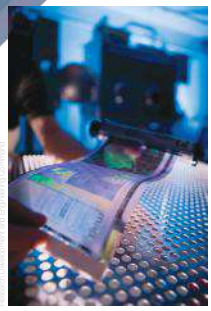


The MeasureReady M91 FastHall™ measurement controller is a revolutionary, all-in-one Hall analysis instrument that delivers significantly higher levels of precision, speed, and convenience to researchers involved in the study of electronic materials.

And now this novel capability is available as part of the FastHall Station, an integrated, high-precision tabletop measurement system for simplified Hall measurements and less experimental setup.

The FastHall Station includes a Windows® 10 PC, 1 T permanent magnet, high precision sample holder, and all the necessary software and cabling to provide a range of measurement capabilities including sample resistances up to 1 GΩ and mobility measurements down to 0.01 cm^2/V s —making it a great choice for labs studying low-mobility materials.





Ideal for measuring low mobility materials

Widest measurement range

- Proprietary FastHall™ technology enables low-mobility measurements without field reversal in seconds
- Mobility measurements down to 0.01 cm^2/V s for van der Pauw samples with resistances from 10 mΩ to 1 GΩ
- Completely guarded triaxial cabling to fully shielded, insertable, light-tight sample chamber plus an LN_2 option

Completely integrated mini-system solution

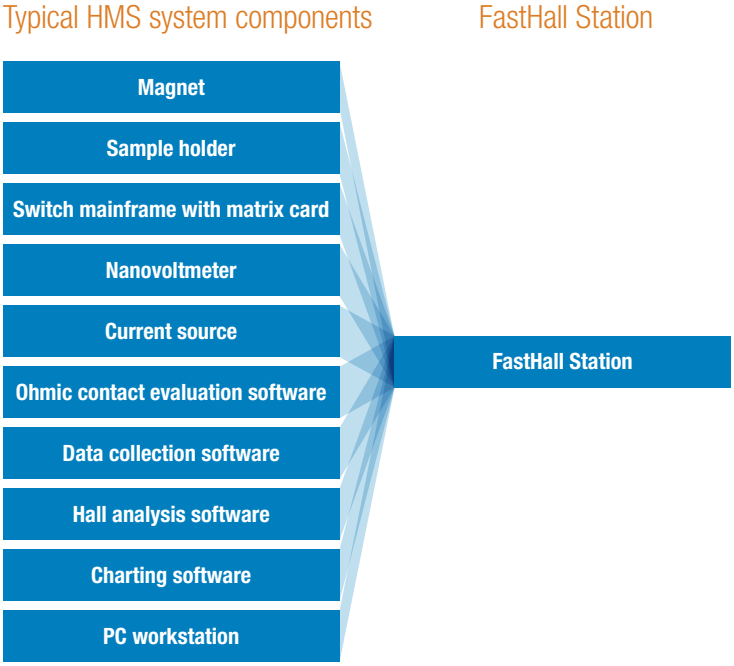
- MeasureLINK™-MCS software provides standard sequences, charts, exportable reports and user customizable test scripts
- M91 FastHall™ instrument with high resistance option integrates all signal source, measure, and switching functions
- Easy to use spring pin and solder sample holder cards accommodate up to 10 mm × 10 mm van der Pauw and Hall bar type samples

Increased productivity and flexibility

- Measurement times greatly reduced through patented FastHall™ method and fully integrated system solution
- Available gate bias instrument option and ability to easily integrate third-party sources and instruments
- Simple, repeatable, and reversible permanent magnet with nominal fields of 1 T and optional 0.75 T for LN_2 chamber

In order to build your own Hall effect measurement system (HMS), you would need to specify the appropriate electrical measurement instrumentation, a suitable field strength and uniformity magnet, and a signal switching unit to automatically measure sample resistivity and Hall voltages, plus develop and validate some level of custom software to correctly acquire measurements and perform the proper pre- and post-measurement calculations. But in such a customized setup, you would not take advantage of the unique capabilities of the M91 measurement controller, which offers a level of speed, precision, and convenience not currently available with commercially off-the-shelf source, measure, and switching instrumentation.

The FastHall Station combines all of the necessary van der Pauw measurement functions into a single tabletop system that not only includes our revolutionary measurement controller, but all the rest of the instrumentation and software specifically designed for automating, charting, and analyzing the measurement. It is truly a turnkey solution for researchers who are looking to derive key parameters of materials—and do so more quickly—without any complicated equipment setup.



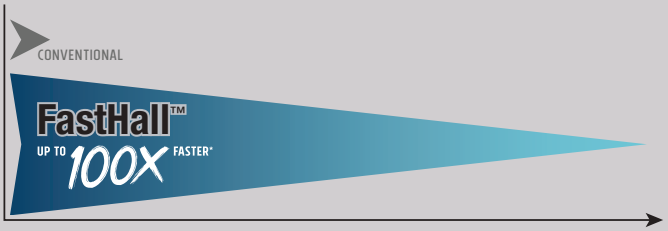
Patented technology for faster, better measurements

The FastHall™ Station contains all the sourcing, measurement, and switching instrumentation plus software needed to execute a complete measurement sequence—quickly and conveniently.

Key to its speed is the included M91 measurement controller. Using Lake Shore's patented* FastHall™ technology, the instrument automatically executes measurement steps and provides better measurements faster, especially when working with low-mobility materials—up to 100× faster in many cases. Most commonly measured materials can be analyzed in a few seconds.

For more about the M91 controller, visit **lakeshore.com/M91**.

FastHall vs. conventional Hall measurement speed of an IGZO sample



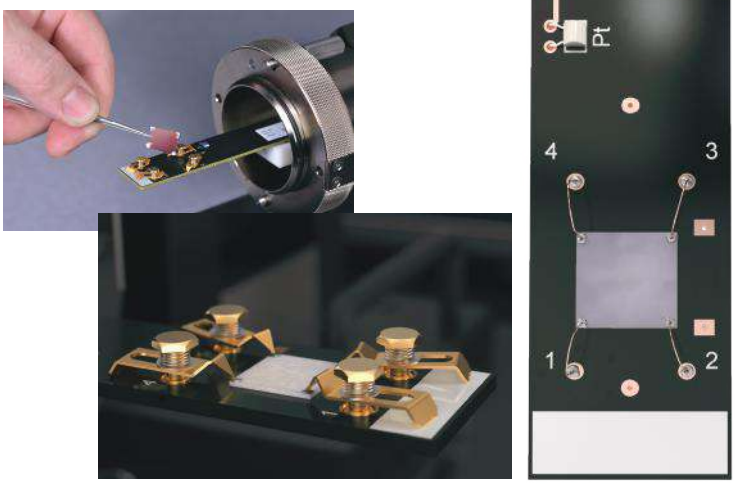
*1.4 s FastHall measurement vs 114 s for conventional measurement

*Protected by US patent numbers 9797965 and 10073151. Other patents pending.

A fully enclosed, shielded measurement environment

A durable, light-tight system, the FastHall Station features an electronically shielded, low-noise sample space with guarded contacts, resulting in far superior measurements as compared to most similar solutions—whether you want to derive carrier type, carrier concentration, mobility, or Hall coefficient properties of the sample.

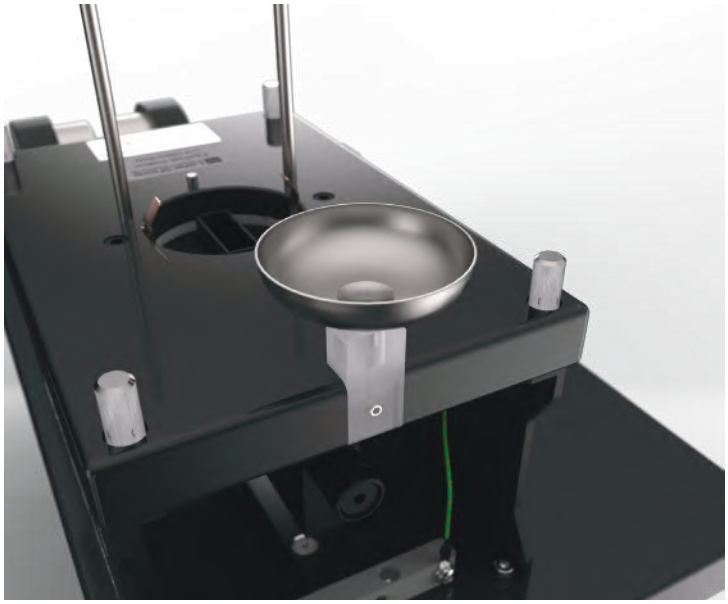
The sample card starter kit includes both solder and prober pin style sample cards. The prober pin style cards allow you to mount your samples without requiring contact pad soldering. Simply load your sample and begin running van der Pauw measurements using the included PC loaded with MeasureLINK-MCS application software.



Both probing and solder sample cards are included

Options for optimizing your FastHall Station

LN_2 option



The LN_2 option includes a sample platform with a reservoir and funnel for measurements in a LN_2 bath.

The LN_2 option includes all the components needed to convert the standard room temperature FastHall Station into a cryogenically cooled (LN_2) sample space. This way, Hall analysis measurements can be easily performed while the sample is in a flooded LN_2 bath. The standard sample holder and sample cards are used in this configuration. Hold time is approximately 10 min.

Included in the kit for the option are:

- LN_2 sample platform with LN_2 option reservoir
- 0.75 T wide-gap magnet
- Parking garage for room temperature components to be stored during LN_2 use
- Funnel for pour-fill operation

Gate bias option

This option, which includes a MeasureReady™ 155 DC precision current and voltage source instrument (155-DC), provides a low-noise voltage source for conducting Hall measurements with a gate bias applied.

The voltage is applied through the triaxial connectors on top of the sample holder which also implements a safety interlock that disables the bias voltage when the sample is removed. Measurement scripts are provided for a gate bias sweep to make Hall measurements for a range of discrete gate bias settings.

Comparing the FastHall Station with other available solutions (see at right) shows that even though it has a compact size, it provides nearly the same measurement performance as premium Hall measurement systems.

Key parameter comparison vs. other solutions

	Typical tabletop Hall system	Our FastHall Station	Our premium electromagnet HMS
Lowest mobility ($cm^2/V\ s$)	1	0.01	0.001
Sample resistance	10 MΩ	1 GΩ	200 GΩ
Gate bias option	✗	✓	✓
Parameter optimization	✗	✓	✓
Full electrical sample shielding	✗	✓	✓
Driven guarding (triaxial)	✗	✓	✓
Purged sample space	✗	✓	✓
Light-tight sample space	✗	✓	✓

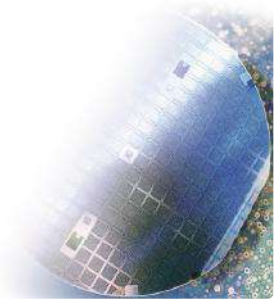
Ideal for characterizing and analyzing a wide range of electronic materials

Why it's optimized for low-mobility materials

Traditional DC field Hall effect measurement is relatively straightforward and reliable for simpler materials with higher mobilities. Measurement difficulty increases and precision decreases as carrier mobilities decrease. This is often the case in promising new semiconductor materials such as photovoltaics, thermoelectrics, and organics.

AC field techniques using advanced lock-in amplifiers and longer measurement windows can extract smaller Hall voltage signals and are commonly used today to explore low mobility materials. Extended measurement intervals can also add error from thermal drift effects and results take longer to get—sometimes many hours.

The FastHall technique eliminates both of these issues — it precisiely measures even extremely low–mobility materials in seconds.



Materials

Solar cells

OPVs, a:Si, µc-Si, CdTe, CuInGaSe (CIGS)

Organic electronics

OTFTs, Pentacene, Chalcogenides, OLEDs

Transparent conducting oxides

InSnO (ITO), ZnO, GaZnO, InGaZnO (IGZO)

III-V semiconductors

InP, InSb, InAs, GaN, GaP, GaSb, AlN based devices, high electron mobility transistors (HEMTs) and heterojunction bipolar transistors

II-VI semiconductors

CdS, CdSe, ZnS, ZnSe, ZnTe, HgCdTe

Elemental semiconductors

Ge, Si on insulator devices (SOI), SiC, doped diamond
SiGe based devices: HBTs and FETs

Dilute magnetic semiconductors

GaMnAs, MnZnO

Half -Heusler compounds

TiNiSn, ZrNiSn, GdPtBi

Topological semi-metals

TaAs, WTe_2, $MoTe_2$

Topological insulators

Bi_2Te_3, Bi_2Se_3, Sb_2Te_3

Transition-metal Di-chalcogenides (TMDC)

WS_2, WSe_2, MoS_2, HfS_2

Other 2D materials

BN, graphene structures

Other conducting materials

Metal oxides
Organic and inorganic conductors

High temperature superconductors

The Lake Shore factor: unparalleled application expertise and support

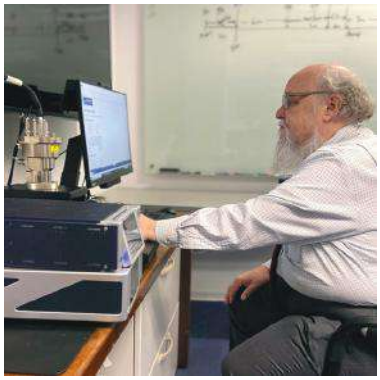
At Lake Shore, we understand your applications and measurement needs. This is because we have served the scientific community for more than 50 years and have provided high performance Hall measurement systems to researchers in academia, national labs, and industry.

Plus, we're there for you on every step of your journey, from choosing the best system to meet your unique requirements, to getting you started in your lab and helping with measurements. Our on-staff application scientists—published and active material researchers in their own right—provide an unparalleled level of application support.
In addition to conducting application training, they work closely with you to help you and your staff better understand and interpret the results obtained by your Hall system, particularly when working with novel materials.

We can even work with you to customize your system's MeasureLINK™-MCS software for your specific research application requirements and for faster results.

In addition, our technical customer service representatives are on-call to ensure that you are benefiting from the full range of capabilities offered on our products, ready to provide real-time assistance and, if necessary, set up test scenarios to isolate performance issues.

If you have any questions, we have the expertise to help you work toward a resolution. Together, we can transform the research of today into the technology of tomorrow.



Dr. Jeffrey Lindemuth, widely recognized as an expert in Hall measurement instrumentation and methods, is one of several application scientists on staff to aid you with FastHall Station measurements.

The FastHall Station offers the ultimate in Hall measurement system speed, convenience, and precision

Measurement applications

The FastHall Station is capable of running a wide array of Hall analysis functions including:

Hall voltage

- Resolution = 1 µV
- Noise = 0.1 µV (RMS), averaged over 1 power line cycle

Resistance/resistivity (four-contact in-line probe and van der Pauw)

- Calculated by instrument
- Resistance range: 10 mΩ to 1 GΩ

Magnetoresistance

- System provides field control to measure resistance as a function of magnetic field

Hall coefficient

- Calculated by instrument
- Derived from Hall voltage, magnetic field, and current

Hall mobility

- Calculated by instrument
- 10^{-2} to 10^{6} $cm^2/V\ s$

Anomalous Hall effect (AHE)

- System provides field control to measure Hall voltage as a function of magnetic field

Carrier type/concentration/density

- Sheet or volume carrier concentration calculated
- Typical sheet carrier density ≤10^{17} cm^{-2} (carrier density depends on measurement parameters)

More science, less time

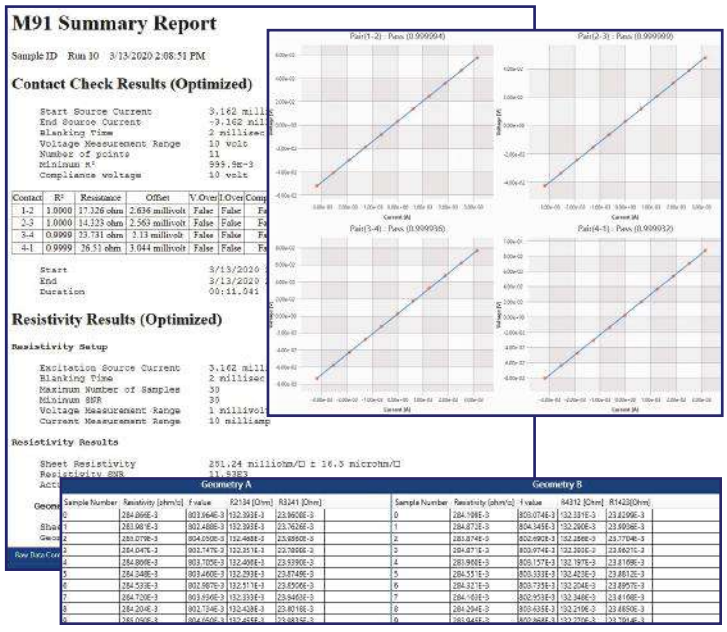
Owing to the M91 measurement controller included in the system, the FastHall Station is extremely fast, reducing analysis time in some cases by 100× when compared with various other HMS solutions. Most commonly measured materials can be analyzed in a few seconds. Even extreme high resistance (up to 1 GΩ) or low mobility (~0.01 $cm^2/V\ s$) samples can generally be analyzed in under 2 min. With other HMS techniques, this could take hours to complete.

The FastHall Station encourages rapid initial assessments of materials to determine if further study or greater precision is warranted. Spend less time waiting and more time doing real science.

Get all the data

Analysis of low mobility or high resistance materials faces challenges due to very low signal-to-noise ratios. Inaccurate measurements are likely unless sophisticated techniques and/or larger measurement samples are used. Also, with some HMS solutions, the researcher often has little chance to double check the intermediate results of the analysis, and can therefore be easily misled as to the validity of the reported results.

The FastHall Station collects all the data. In addition to performing the complete Hall analysis and outputting the usual measured and derived mobility values, the system can also generate detailed reports including all of the supporting intermediate data, so the researcher can readily confirm the integrity of the final results.



Specifications

Hall measurement
FastHall™ method (no physical field reversal) — van der Pauw samples
Traditional DC method — Hall bar and van der Pauw samples

Derived parameters
Hall coefficient, Hall mobility, resistivity, carrier concentration

Maximum sample size
Solder card: 10 mm × 10 mm × 3 mm
Pin card: 10 mm × 10 mm × 2 mm

DC magnetic field intensities
Room temperature: 1 T
With LN_2 option: 0.75 T

Resistance range
10 mΩ to 1 GΩ

Resistivity
1×10^{-5} Ω cm to 10^5 Ω cm (typical)

Hall mobility range
0.01 to 10^6 cm^2/V s

Carrier concentration
$800/cm^3$ to $8 \times 10^{23}/cm^3$ (typical)

Measurement speed
<10 s (typical)

Programmable limits
I out: compliance voltage; **V out:** current limit
Positive output: ±5% of setting (when setting is >10% of its full-scale range)
Negative output: ±5% of setting (when setting is >10% of its full-scale range)
Programming resolution current limit: 0.1% of full-scale current range (auto selected)
Programming resolution voltage limit: 10 mV

Instrument analog input
Analog input raw signal accuracy: ±300 mV of reading
Raw analog input voltage range: ±11 V
Safe input voltage range: ±15 V
Compliance voltage (typical): ≤10 V
Current limit (typical): ≤0.1 A

Instrument analog output
Analog output raw signal accuracy: ±300 mV of setting
Raw analog output voltage range: ±11 V rails, ±15 V maximum during overload

Instrument digital input
Number of independent inputs: 4
Input isolation: Optical
Maximum low-level input voltage: 1 V
Minimum high-level input voltage: 4 V
Safe input voltage range: -5 V to 32 V

Instrument digital output
Number of independent outputs: 4
Relay type: Solid state
Digital output relay maximum current: 1.5 A
Digital output relay maximum voltage: 32 V

Instrument rear panel test connectors
Sample connections: 6 individual 3-lug socket triaxial connectors
Analog input BNC
Analog output BNC
10-pin Phoenix connector for digital output
10-pin Phoenix connector for digital input
2-pin Phoenix connector for signal return

Instrument front panel
Display: 5 in capacitive touch, color TFT-LCD WVGA (800 × 480) with LED backlight

Instrument interface
USB host

Type	USB 3.0, mass storage class (MSC) device
Function	Firmware updates, flash drive support
Location	Rear panel
Connector	USB Type-C™

USB device

Type	USB 2.0
Function	Emulates a standard RS-232 serial port
Protocol	Standard commands for programmable instruments (SCPI)
Baud rate	921,600
Connector	USB Type-B
Software support	LabVIEW™ and IVI.NET drivers (see www.lakeshore.com)

Ethernet

Function	TCP/IP command and control, mobile app
Application layer protocol	Standard commands for programmable instruments (SCPI)
Connector	RJ-45
Speed	1 Gb/s
Software support	LabVIEW™ and IVI.NET drivers (see www.lakeshore.com)

General

Operating conditions: 23 °C ±5 °C at rated accuracy; 10 °C to 35 °C at reduced accuracy, <70% RH non-condensing

M91 FastHall measurement controller

Warm-up time:	30 min
Maximum field exposure:	Operational limit <10 mT DC, 1 mT RMS; Guaranteed performance <2 mT RMS
Power requirement:	100 V to 240 V (universal input), 50 to 60 Hz, 30 VA
Power consumption:	35 W maximum
Size:	216 mm W × 87 mm H × 369 mm D (8.5 in × 3.4 in × 14.5 in), half rack
Weight:	3.2 kg (7 lb)

Measurement platform with magnet and insert

Size:	254 mm W × 330.2 mm H × 457.2 mm D (10 in × 13 in × 18 in)
Weight:	9.1 kg (20 lb)

LN_2 option with 0.75 T magnet and insert

Size:	140 mm W × 235 mm H × 209.6 mm D (5.5 in × 9.25 in × 8.25 in)
Weight:	5.4 kg (12 lb)

Gate bias option (Model 155 precision I/V source)

Size:	216 mm W × 87 mm H × 369 mm D (8.5 in × 3.4 in × 14.5 in), half rack
Weight:	3.2 kg (7 lb)

Approval: CE mark

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Questions? Answers?

Visit http://forums.lakeshore.com/ and become part of the conversation!

Ordering information

HMS-TT-MAN	FastHall Station with room temperature sample holder, pump/purge fitting, sample card starter kit, 1.0 T permanent magnet, M91-HR FastHall measurement controller, and Windows PC with MeasureLINK-MCS software
HMS-TT-ADD-LN$_2$	LN_2 option for FastHall™ Station—includes LN_2 sample platform with LN_2 reservoir, 0.75 T wide-gap magnet, parking garage for room temperature components to be stored during LN_2 use, and funnel for pour-fill operation
HMS-TT-ADD-GATEBIAS	Gate bias option for FastHall™ Station—includes MeasureReady™ 155 DC precision current and voltage source (155-DC), calibration certificate, and accessory kit (quick start guide, USB-A to USB-C adapter, two 6-pin IO connectors, power cord, and one 2-pin interlock)
RM-1/2	Kit for mounting one 1/2-rack M91 instrument in a 483 mm (19 in) rack
RM-2	Kit for mounting one 1/2-rack M91 instrument and another 1/2-rack instrument in a 483 mm (19 in) rack
843-076	Low noise triaxial cable, 3-slot, 1 m (3 ft)