Magnetic Measurement and Control Catalog
3-year warranty and technical support

Lake Shore products are supported by a 3-year standard warranty, our confirmation of quality and commitment for the long term. Our scientists understand your applications and measurements and provide support throughout your decision making process and beyond the sale.
# Contents

- **Introduction**
- **Magnetic Device Selection Guide**
  - Calibration ......................................................... 9
  - Gaussmeter overview ........................................... 10
- **Field Measurement Technology**
  - Model 475 gaussmeter ........................................... 12
  - Model 425 gaussmeter ........................................... 19
  - 400 Series Hall probes ......................................... 24
  - Built-to-order 400 Series Hall probes ..................... 26
  - 400 Series Hall probe specifications ......................... 30
  - Accessories ...................................................... 40
  - InAs and GaAs Hall sensors .................................. 41
- **Flux Measurement Technology**
  - Model 480 ....................................................... 46
  - Search coils .................................................... 50
  - Helmholtz coils ................................................ 51
- **Other Magnetic Solutions and Accessories**
  - Modular characterization systems ......................... 54
  - EM-V Series electromagnets ................................ 55
  - Model 643 power supply ...................................... 57
  - Model 648 power supply ...................................... 60
  - Reference information ....................................... 63
Applications for Hall gaussmeters and probes

University and commercial research
Any lab application where researchers need magnetic measurement capabilities

Automotive manufacturing
In-process verification of motors, valves, and other vehicle components

Speaker manufacturing
Field verification of speaker assemblies

Magnetic shielding assembly
For testing enclosures designed to isolate electronics from magnetic fields

Machine and fabrication shops
To inspect parts for residual magnetic particles after machining

Magnet manufacturing
To assess magnet field strength, uniformity, and shape

Transportation, particularly overseas shipping containers
To inspect for magnetic field leakage in order to meet IATA regulations

Measuring magnetic fields is required in many research and development fields today. In the university lab, gaussmeters and Hall effect probes enable scientists to detect and compare the magnetic fields for various materials studied, and to explore magnetic phenomena. These experiments can lead to the development of improved magnetic materials and devices for the medical, geology, energy, and computing fields.

But the need to measure magnetic fields extends far beyond the university lab. Magnetics have become increasingly common in modern technical products, appliances, automotive, and industrial products and systems. Factors such as the continuing emphasis on energy efficiency and the drive to reduce cost and parts count have prompted a revived interest in using magnets.

What’s more, a number of products such as motors, speakers, interlock switches, and magnetic separators benefit from magnetic components due to their ability to transmit force across a space without physical connection. Then there’s the increasing use of rare earth materials. The use of rare earths has increased the efficiency of magnetic products by producing high magnetic fields, often in very compact spaces, such as in lightweight electronics, toys, and handheld telecommunications devices.

With this rise in the use of magnets, there’s a greater need for the right testing tools. Some of the instrumentation conventionally used in various phases of inspection may test magnets and magnetic assemblies indirectly, but this type of testing can often provide questionable results or disclose critical flaws too late in the process. Indirect testing might, for instance, fail to detect a faulty or under-performing magnet in a multiple-magnet assembly, or it might fail to identify a magnet that is only marginally defective before it is integrated into a product.

This is why direct testing of magnetic components using gaussmeters, probes, and other sophisticated testing instrumentation is often necessary. If your goal is to determine magnetic field strength at a point or in a gap, field uniformity, or field shape, then a Lake Shore gaussmeter is the instrument of choice.
Types of Hall testing for manufacturing QC

Use the results of magnetic field measurement for:

- Sorting sub-assemblies
- Confirming magnetic field characteristics vs. applied current
- Mapping magnetic field shape for a component
- Measuring fringe fields or residual fields
- Diagnosing detrimental effects of an external field
- Measuring operator exposure to magnetic fields

At various points in the manufacturing process, from incoming inspection to final assembly and performance testing, quality control engineers must ensure that magnetic components, and the products using them, meet specifications. This process often involves test and measurement activities that confirm the accuracy, location, shape, and stability of the magnetic fields that are generated.

Hall gaussmeters and probes offer real value to manufacturing QC. But, surprisingly, the instrumentation and methods used in these tests may be unfamiliar to the average product engineer or technician. And, until recently, magnetics knowledge and expertise were not high on the list of QC skill priorities. Furthermore, the relatively high level of technical knowledge required for thorough magnetic analysis and testing has also been a deterrent.

But this is all beginning to change. Lake Shore provides the technical guidance necessary for manufacturers to correctly apply magnetic measurement tools and processes. With minimal investment, design and quality control managers can accurately perform magnetic testing for modern products and equipment, avoiding costly assembly rework in later stages of production.

Failure to detect and correct design or production problems at an early stage can lead to later problems, including final inspection rejections and field failures that require costly revisions or rework. In the worst case, inability to quickly identify problems related to magnet performance can lead to product recalls and even raise safety concerns.

Quality control is key to a manufacturer’s customer satisfaction and profits. Lake Shore’s magnetic and measurement solutions help ensure your product will perform as the designer intended.
Choosing an InAs or GaAs Hall Probe: General Guidelines

Proper selection of a Hall probe is probably the most difficult and important decision to make after choosing a gaussmeter. Using the improper probe could lead to less than optimal accuracy or, even worse, costly damage.

The next few pages will help you make an informed probe choice. If you have additional questions, contact Lake Shore. Our experts can guide you through the selection process. Lake Shore can even custom design a Hall probe to meet your specific application requirements.

Use these guidelines to help choose a probe:

- Choose a probe to match the application. Do not buy more accuracy, field range, or thinness than is actually needed.

- The thinner a probe, the more fragile it is. Try to avoid selecting an easy-to-damage probe based on a possible, but not required, future application. For instance, avoid using an exposed-device probe such as a model HMFT-3E03-type for general field measurements. (Also, once you have a thin probe in use, be sure to use proper fixtures that hold it in a non-stressed manner and eliminate physical contact with measured items. Once a stem or sensor has been damaged, the probe is not repairable.)

- Metal-enclosed probes, such as the HMMT-6J04 and HMMA-2504 types, offer good protection to the Hall sensor. Brass stem transverse probes are even more rugged than the aluminum type probes and offer the greatest amount of protection.

- Be cautious about using aluminum-stemmed transverse probes, such as the HMMT-6J04-type, where AC magnetic fields are to be measured. Eddy currents in the stem material can affect reading accuracy. A superior choice for AC measurements would be the HMNT-4E04-type fiberglass-epoxy stem probes. Consult the probe’s frequency range specifications when selecting a suitable probe.

- Several stem lengths are offered for each probe type. User preference or test set-up dimensions usually determine the final selection. Longer stems are more susceptible to accidental bending (in many cases not catastrophic, but bothersome). Typically, stem length does not affect performance.

- Be aware of the differences in the probe “active areas” shown on the data sheet. A Hall effect probe will indicate the average field value sensed over that total active area. Thus, when measuring magnetic fields with a high gradient across the sensor width, choose the smallest active area practical. Keep in mind the fragility rule (see the second bullet above).

- Lake Shore gaussmeter probes exhibit different ranges of magnetic fields over which they will provide valid readings. Check the specification sheet and the tables at the right for these usable ranges.

- Be aware that when operating a high-sensitivity (HSE) probe below 100 G, the temperature coefficient of offset becomes more significant during low-field readings and that these changes can contribute to field error. So be sure to keep this in mind when evaluating sensitivity of a probe when ordering. For more information, please call us.

NOTE: If none of the probe configurations listed in this catalog fit your needs, Lake Shore can provide custom probes to meet your physical, temperature, and accuracy requirements. Please contact us with your special requirement details.
Magnitude

Typical Hall probes cover an operating range of 3 to 5 orders of magnitude. Operation beyond this field range requires some compromise in performance, often including higher noise or loss of resolution. Choosing the correct probe type ensures optimal performance in the desired measurement range.

High stability (HST-1, HST-2, HST-3, HST-4):

With a high field range of up to 350 kG (35 T), high stability probes are used when fields exceed the limit of other probe types. Their low field performance is slightly degraded with a minimum sensitivity of 50 mG (5 µT). HST probes are also inherently more temperature stable than other probes, and should be used when large temperature fluctuations are expected. They are offered in a variety of stem geometries.

High sensitivity (HSE and HSE-1):

High sensitivity probes are the most common for general-purpose field measurement. They operate effectively in fields up to 35 kG (3.5 T) with excellent sensitivity. At low fields, their sensitivity can be as low as 5 mG (0.5 µT). Convenient for many applications because of their relatively small active area, HSE probes are offered in the same geometries as HST probes.

Orientation

Getting to the field is part of the challenge in selecting a probe. Field orientation dictates the most basic probe geometry choice of transverse versus axial. Other variations are also available for less common, more challenging applications. Listed below are the standard configurations for HSE and HST probes.

Common geometries

Transverse:

Transverse probes, most often rectangular in shape, measure fields normal to their stem width. They are useful for most general-purpose field measurements and are essential for work in magnet gaps. Several stem lengths and thicknesses are available as standard probes. To identify the polarity of a transverse probe, the output will be positive when the direction of the flux density vector is into the Lake Shore logo (i.e., the logo is toward the north pole).

Flexible transverse:

Flexible probes have a flexible portion in the middle of their stem, while the active area at the tip remains rigid and somewhat exposed. This unique feature makes them significantly more fragile than other transverse probes. Flexible probes should only be selected for narrow-gap measurement applications.

Axial:

Axial probes, usually round, measure fields normal to their end. They can also be used for general-purpose measurements, but are most commonly used to measure fields produced by solenoids. Several stem lengths and diameters are available as standard probes. To identify the polarity of an axial probe: (except in rare, special cases) the output will be positive when the field vector is into the tip of the probe.

Radiation effects on Hall probes

The HST and HSE probes use a highly doped indium arsenide active material. The HST material is the more highly doped of the two and therefore will be less affected by radiation. Some general information relating to highly doped indium arsenide Hall sensors is as follows.

- Gamma radiation seems to have little effect on the Hall sensors
- Proton radiation up to 10 Mrad causes sensitivity changes less than 0.5%
- Neutron cumulative radiation (>0.1 MeV, $10^{15}$ per cm$^2$) can cause a 3% to 5% decrease in sensitivity

In all cases, the radiation effects seem to saturate and diminish with length of time exposed

---

1 350 kG with Models 475 and 455, 300 kG range with Models 460, 450, and 421
2 35 kG with Models 475 and 455, 30 kG range with Models 460, 450, and 421
Advanced geometries

**Tangential:**
Tangential probes are transverse probes designed to measure fields parallel to and near a surface. The active area is very close to the stem tip. They are intended for this specific application and should not be selected for general transverse measurements.

**Multi-axis:**
These probes measure two or three vectors of field simultaneously, important in directional applications such as field mapping.

**Cryogenic:**
Cryogenic Hall probes come in axial and transverse configurations and are specially designed to withstand extreme thermal contraction of probe materials while measuring at ultra-low temperatures. The probe construction helps prevent shifts in operating points when measuring fields in cryogenic applications. In addition, cryogenic probes are cold-cycled in liquid nitrogen during the manufacturing process to verify stable performance before shipment to the customer.

Frequency

Gaussmeters are equally well suited for measuring either static DC or periodic AC fields, but proper probe selection is required to achieve optimal performance.

**Metal stem:**
Metal stem probes are best for DC and low-frequency AC measurements. Non-ferrous metals are used for the stems because they provide the best protection for the delicate Hall sensor without altering the measured field. Aluminum is the most common stem material, but brass can also be used. Metal stems do have one drawback: eddy currents are generated in them when they’re placed in AC fields. These currents oppose the field and cause measurement error. The error magnitude is proportional to frequency and is most noticeable above 800 Hz.

**Non-metal stem:**
Non-metal stems are required for higher-frequency AC fields and for measuring pulse fields. Fiberglass/epoxy is a common non-metal material. Alternatively, the sensor can be left exposed on its ceramic substrate, which provides less protection for the sensor. Eddy currents do not limit the frequency range of these non-conductive materials, but other factors may.

NOTE: No gaussmeter probe type is suitable for direct exposure to high voltage.

**Gradient**

Probe selection would be easier if all fields were large and uniform, but most fields are limited in volume and contain gradients (changes in magnitude). Hall probes measure an average magnitude over their active area, so be sure to understand the relationship between active area and field gradients. Severe field gradients are always experienced as the active sense element moves away from a permanent magnet pole, making it important to know the distance between the active area and probe tip. The distance between probe tip and active area is specified for axial probes, but is less easily defined for transverse probes.

**Nominal active area:**
HSE and HST probes have a nominal active area on the order of 1 mm diameter, which is useful for all but the most stringent applications. The measured field is the average of the active area but without severe gradients. Therefore, the measured value accurately represents the true field. Field mapping with standard probes is also practical if a mapping resolution of 1 mm or greater is acceptable.

**Small active area:**
HSE and HST probes with a smaller active area are also available as custom products for measurements in severe gradients, or for high-resolution mapping applications.

**Other considerations**

Minor differences in probe position or angle can drastically change a reading; therefore you need to be precise when positioning it for some types of components. With magnet pole surface testing, for instance, be aware of the extreme falloff of the field strength near the surface. Only a few thousandths of an inch difference in distance between the sensor active area and the magnet surface can change the gaussmeter reading by more than the tolerance allowed by the test engineer. Similarly, another factor to consider is the change in reading with magnetic field vector angle. Be sure to ensure that the field is perpendicular to the probe sensor active area in order to achieve the most accurate reading. An even better option is to maximize the field reading by slightly rotating a transverse probe during test. Accurately aligning the longitudinal axis of an axial probe in a test fixture is also suggested.

**Pole field gradient**

**NOTE:** One of the greatest sources of repeatability errors is variable distance to the probe’s active area.
Calibration and NIST traceable standards

All Lake Shore probes and instruments ship to you factory calibrated for accuracy and interchangeability. Because the Hall probes feature a programmable read-only memory (PROM) in the probe connector, calibration data can be read automatically by the instrument. This way, you’re assured that the probe you receive is ready to use out of the box.

But our calibration capabilities don’t end there. Lake Shore also offers a full-service recalibration lab for probes, gaussmeters, and gaussmeter/probe combinations returned for calibration on a regular (typically annual) basis. This way, manufacturers and engineers who use our instruments for quality control can be sure of accurate measurements in product performance testing.

Point-by-point calibration on probes

Technicians at our on-site recalibration stations ensure that the instrument or probe you ship back to us is calibrated to the same performance specifications as our new products. With probes, this process involves performing a point-by-point calibration, placing the devices into a magnetic field with a preset reference standard. If required, we will perform a field sweep to create a curve that incorporates measurements taken. Typically, a Hall probe calibration involves 28 points, but can be more depending on the instrument type. Gaussmeters are adjusted electrically or electronically to ensure they meet published specifications.

And to ensure that you’re not without your Hall probe or gaussmeter for long, we offer quick turnaround. With most devices, we target between 7 and 10 business days.

Recalibrated to ISO 9001-2008 standards

With every recalibrated device returned to you, you get a certificate of calibration, indicating that the instrument and/or probe has been recalibrated to a standard that’s traceable to an original NIST standard. For our own certification, Lake Shore has an independent, accredited calibration company inspect and verify our recalibration systems and tools.

All Lake Shore probes and instruments are provided with certification indicating ISO 9001-2008 compliance, documentation required by many international manufacturers whose metrology instruments or labs play a key role in their overall quality management systems. If required, we can also provide traceability trees for specific models.

Pre- and post-calibration data available for many models

Depending on the instrument, we can also provide reports relating to pre- and post-calibration data, as well as technical data relating to measurement uncertainties, errors we encountered, and other metrology factors, as well as a list of every type of equipment used to perform the calibration.

This level of certification is required by many aerospace and government lab customers who require before and after data in order to meet standards of other national and international accrediting bodies. For details about our calibration data services, please contact us at service@lakeshore.com.
Gaussmeters

Gaussmeters come in various sizes and capabilities and are easy to use. You can use them to measure both AC and DC magnetic fields, but if you have a permanent magnet application, only DC magnetic field capability is required. All Lake Shore gaussmeters are supported by industry-leading experts in magnet measurement instrumentation, sensor, and Hall probe technology.

For most manufacturing operations, the affordable Model 425 benchtop instrument may be all that you need. For advanced research measurements using filtering with fast pulse applications, order the model 475. For questions about which model will work best for you, contact Lake Shore today.

Model 425 gaussmeter

Designed to meet the demanding needs of the permanent magnet industry, the Model 425 gaussmeter (featured on page 23) provides high-end functionality and performance in an affordable desktop instrument.

Model 475 DSP gaussmeter

Intended for use in demanding applications, the Model 475 features superior field-measurement performance and DSP technology. It is also offers field control and high-performance filtering with high-speed pulses. Please see page 12 for more information regarding the Model 475.

Need to measure flux? See our Model 480 fluxmeter

An advanced tool designed primarily for use in industrial and measurement systems settings, the Model 480 fluxmeter (featured on page 52) measures total flux from which B, flux density, and/or H, magnetic field strength, can be determined. It’s valuable for magnetizing, manual and automated magnet testing and sorting, and as the main component in BH loop or hysteresis measurement system applications. Use it, for instance, if you need to sort magnets in accordance with field strength and uniformity or test an assembly after the magnets have been installed. The Model 480 fluxmeter is compatible with most sensing coils and fixtures.
A comparison of Lake Shore gaussmeters
Field ranges and frequency ranges by model

Applications and product recommendations

<table>
<thead>
<tr>
<th>Primary task:</th>
<th>Model 425</th>
<th>Model 475</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetizing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnet sorting (manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnet sorting (automated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnet testing (manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnet testing (automated)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic sensing/switching</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Fringe field and safety</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hall electromagnet*</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hall superconducting</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B/H looper</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field mapping</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Magnetic levitation testing</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Testing shielding effectiveness</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Portable testing (manual)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Field control of magnet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Filtering with high-speed pulses</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*For measuring Hall electromagnetic flux, see our Model 480 fluxmeter.
Model 475 features

- Full-scale ranges from 35 mG to 350 kG
- DC measurement resolution to 0.02 mG
- Basic DC accuracy of ±0.05%
- DC to 50 kHz frequency range (probe-dependent)
- 15 band-pass and 3 low-pass AC filters
- Peak capture to 20 µs pulse widths
- Data buffer sampling rates to 1000 readings per s
- Computer interface sampling rates to 100 new readings per s
- Integrated electromagnet field control algorithm
- Specialized and custom probes available
- CE mark certification
For the most demanding DC and AC applications

Lake Shore combined the technical advantages of digital signal processing with over a decade of experience in precision magnetic field measurements to produce the first commercial digital signal processor (DSP) based Hall effect gaussmeter, the Model 475. DSP technology creates a solid foundation for accurate, stable, and repeatable field measurement while simultaneously enabling the gaussmeter to offer an unequalled set of useful measurement features. The Model 475 is intended for the most demanding DC and AC applications. In many cases, it provides the functionality of two or more instruments in a field measurement system.

The power of DSP technology is demonstrated in the superior performance of the Model 475 in DC, RMS, and Peak measurement modes.

Advanced features

The Model 475 combines hardware and firmware elements to create advanced features that facilitate automation and materials analysis.

Field control

A built-in PI control algorithm turns the Model 475 into an essential building block for magnetic field control in electromagnet systems. It, along with a voltage-programmable magnet power supply, is all that is needed to control stable magnetic fields in an electromagnet at the user-specified setpoint. One of the built-in analog voltage outputs drives the program input of the power supply for either bipolar or unipolar operation. See page 60 for more information.

High-speed data transfer

The IEEE-488 interface can be set to send readings in binary format rather than the more common ASCII format. This reduces interface overhead, enabling real-time reading rates up to 100 new readings per second. Temperature compensation is not available at the highest interface rate.

Data buffer

Internal memory provides storage for 1024 field readings in a data buffer. The buffer can be filled at high speed, up to 1000 readings per second, which is as much as ten times faster than the computer interface. Stored readings can then be retrieved over interface at slower speed and processed offline. A trigger input can be used to initiate the data log sequence. Slower sample rates can be programmed if desired.

Trigger in and trigger out

A TTL-level hardware trigger into the instrument can be used to initiate the data log sequence. A TTL-level hardware trigger out indicates when the instrument completes a reading, and can be used to synchronize other instruments in the system. An IEEE-488 software-based trigger can be used like the hardware trigger in.
DC measurement mode

Static or slowly changing fields are measured in DC mode, where the accuracy, resolution, and stability of the Model 475 are most evident. In this mode, the gaussmeter takes advantage of the internal auto zero function and probe linearity compensation to provide its best accuracy. Measurement resolution is enhanced by advanced signal processing capability, allowing users the choice of high reading rates to 100 readings per second or high resolution to 5¾ digits. The Model 475 also features front-end amplification specifically designed to complement DSP data acquisition, providing high stability and repeatability. That, along with probe temperature compensation, makes the Model 475 the most stable gaussmeter ever produced by Lake Shore, suiting it perfectly for demanding DC measurement applications such as field mapping and field control.

RMS measurement mode

Periodic, AC fields are measured in RMS mode, which highlights the uniquely flexible filter functions of the Model 475. An overall frequency range of 1 Hz to 50 kHz is offered by the gaussmeter. Selectable band-pass and low-pass filters allow users to reject unwanted signals and improve measurement performance. The exclusive Lake Shore DSP algorithms also free the Model 475 from the limitations of conventional RMS conversion hardware and provide better dynamic range, resolution, and frequency response than ever before. These improvements permit meaningful RMS field measurements with broad frequency content or in noisy environments.

Peak measurement mode

Pulsed fields are measured in Peak mode, which is a natural extension of the high-speed data acquisition necessary for DSP operation. Fast instrument sample rates permit capture of positive and negative field pulses as narrow as 20 µs in width, which can be held for an unlimited length of time with no sag. This is ideal for most magnetizers and other fast pulse applications. For more moderate field changes, the Model 475 can process the captured data to create other features. The gaussmeter can be configured to follow the peak of a periodic waveform for evaluation of crest factor. The Model 475 can also be used to sample field changes at 1000 readings per second that can later be read over the interface to illustrate the shape of pulses or other waveforms.

The probe connection

The Model 475 is only half of the magnetic field measurement equation. For the complete solution, Lake Shore offers a full complement of Hall effect probes in a variety of sizes and sensitivities. See the table on page 18 for our stock probes recommended for use with this gaussmeter. We also offer other probes beginning on page 30. If you don’t see the probe you need, give us a call.
Measurement features

The Model 475 offers a variety of features to enhance the usability and convenience of the gaussmeter.

Autorange: In addition to manual range selection, the instrument automatically chooses an appropriate range for the measured field. Autorange works in DC and AC measurement modes.

Auto probe zero: Allows the user to zero all ranges for the selected measurement mode with the push of a key.

Display units: Field magnitude can be displayed in units of G, T, Oe, and A/m.

Max/min hold: The instrument stores the fully processed maximum and minimum DC or RMS field value. This differs from the faster peak capture feature that operates on broadband, unprocessed field reading information.

Relative reading: Relative feature calculates the difference between a live reading and the relative setpoint to highlight deviation from a known field point. This feature can be used in DC, RMS, or Peak measurement mode.

Instrument calibration: Lake Shore recommends an annual recalibration schedule for all precision gaussmeters. Recalibrations are always available from Lake Shore, but the Model 475 allows users to field calibrate the instrument if necessary. Recalibration requires a computer interface and precision low resistance standards of known value.

Instrument probe features

The Model 475 has several capabilities that allow the best possible measurements with Lake Shore probes. These firmware-based features work in tandem with the probe’s calibration and programming to ensure accurate, repeatable measurements and ease of setup. Many of the features require probe characteristics that are stored in the probe connector’s non-volatile memory.

Probe field compensation: The Hall effect devices used in gaussmeter probes produce a near linear response in the presence of magnetic field. The small non-linearities present in each individual device can be measured and subtracted from the field reading. Model 475 probes are calibrated in this way to provide the most accurate DC readings.

Probe temperature compensation: Hall effect devices show a slight change in sensitivity and offset with temperature. Probe sensitivity temperature effects can be measured and subtracted out of field readings. A temperature sensor in the probe tip relays real time temperature to the gaussmeter, enabling compensation. Although temperature effects contribute only a small fraction of the overall probe measurement accuracy, temperature compensation will often improve measurement and control stability.

Probe temperature display: The gaussmeter can display the probe’s temperature in °C along with a field reading when using a probe that includes a temperature sensor.

Frequency display: When operating in RMS mode, the gaussmeter can display the frequency of the measured AC field along with a field reading (up to 20 kHz).

Probe information: The gaussmeter reads the probe information on power up or any time the probe is changed to allow hot swapping of probes. Critical probe information can be viewed on the front panel and read over the computer interface to ensure proper system configuration.

Extension cables: The complex nature of Hall effect measurements make it necessary to match extension cables to the probe when longer cables are needed. Keeping probes and their extensions from getting mixed up can become a problem when more than one probe is in use. The Model 475 alleviates most of the hassle by allowing users to match probes to extensions in the field. Stored information can be viewed on the front panel and read over the computer interface to ensure proper mating.

Hall effect sensors (magnetic field sensors): The Model 475 will operate with a discrete Hall effect sensor when a suitable probe is not available. Users can program nominal sensitivity and serial number into an optional HMCBL-6 blank connector to provide all gaussmeter functions except field and temperature compensation. If no sensitivity information is available, the Model 475 reverts to resistance measurement.

Model 475 rear panel

1. Line input assembly
2. Serial I/O interface
3. IEEE-488 interface
4. Auxiliary I/O
5. Probe input

Lake Shore Cryotronics, Inc. | t. 614.891.2244 | f. 614.818.1600 | e. info@lakeshore.com | www.lakeshore.com
Display and interface features

Display
The Model 475 has a 2-line by 20-character vacuum fluorescent display. During normal operation, the display is used to report field readings and give results of other features such as max/min or relative. The display can also be configured to show probe temperature or frequency. When setting instrument parameters, the display gives the operator meaningful prompts and feedback to simplify operation. The operator can also control display brightness.

Following are four examples of the various display configurations:

- **Normal reading**—the display configured to show the RMS field value and frequency, and the probe temperature
- **Max DC hold on**—the display configured to show both the Maximum and Minimum DC field values
- **Max peak hold on**—the display configured to show both the positive and negative Peak readings
- **Field control on**—the display configured to show the field control setpoint and current field value, when field control is active

Keypad
The instrument has a 22-position keypad with individual keys assigned to frequently used features. Menus are reserved for less frequently used setup operations. The keypad can be locked out to prevent unintended changes of instrument setup.

Alarm and relay
High and low alarms are included in the instrument. Alarm actuators include display annunciator, audible beeper, and two relays. The relays can also be controlled manually for other system needs.

Voltage output 1
The first voltage output gives access to amplified voltage signal directly from the probe. This voltage is corrected for the nominal sensitivity of the probe and provides the widest bandwidth of the three voltage outputs. In wide band AC mode, the signal can be viewed on an oscilloscope to observe the shape of AC fields. In Peak mode, the output can be used to view a pulse shape or other characteristic of a momentary signal. Output 1 serves only as a diagnostic tool in DC and narrow band AC modes because modulation of the probe signal prevents a clear view of the field response.

Voltage output 2
The second voltage output provides a voltage proportional to measured field with the benefits of some signal processing. The output is produced by the DSP through a fast D/A converter. The output signal is updated at 40 kHz, giving good response for low to mid frequency fields. Signal quality degrades at high frequency because of the sampling rate. This voltage can be corrected for probe offset and for the nominal sensitivity of the probe.

Voltage output 3
The third voltage output provides a voltage proportional to measured field with the most signal processing of the three outputs. All probe compensation available to the display readings, including temperature compensation, can be performed on this output. The output is produced by the microprocessor through a high-resolution, 16-bit, D/A converter updated at 30 readings per second. This output can also be used for field control.

Computer interface
Two computer interfaces are included with the Model 475, serial RS-232C and parallel IEEE-488. Both allow setup of all instrument parameters and read-back of measured values. The reading rate over the interface is nominally 30 readings per second but settings from 10 to 100 readings per second are available. LabVIEW™ drivers are provided to instrument users — consult Lake Shore for availability.

Model 475 specifications

**General measurement**
*(Does not include probe error, unless otherwise specified)*

**Input type:** Single Hall effect sensor

**Probe features:** Linearity Compensation, Temperature Compensation, Auto Probe Zero, and Hot Swap

**Measurement features:** Autorange, Max/Min Hold, Relative Mode, and Frequency

**Connector:** 15-pin D type

**DC measurement**

<table>
<thead>
<tr>
<th>Probe type</th>
<th>DC probes</th>
<th>DC resolution</th>
<th>DC resolution</th>
<th>DC resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>HST Probe</td>
<td>350 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
<td>0.1 µG</td>
</tr>
<tr>
<td></td>
<td>35 µG</td>
<td>0.0001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
<tr>
<td></td>
<td>3.5 µG</td>
<td>0.00001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
<tr>
<td></td>
<td>350 µG</td>
<td>0.0001 µG</td>
<td>0.01 µG</td>
<td>0.1 µG</td>
</tr>
<tr>
<td></td>
<td>35 G</td>
<td>0.0001 µG</td>
<td>0.01 µG</td>
<td>0.1 µG</td>
</tr>
<tr>
<td>HSE Probe</td>
<td>35 µG</td>
<td>0.0001 µG</td>
<td>0.01 µG</td>
<td>0.1 µG</td>
</tr>
<tr>
<td></td>
<td>3.5 µG</td>
<td>0.00001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
<tr>
<td></td>
<td>350 µG</td>
<td>0.0001 µG</td>
<td>0.01 µG</td>
<td>0.1 µG</td>
</tr>
<tr>
<td></td>
<td>35 G</td>
<td>0.0001 µG</td>
<td>0.01 µG</td>
<td>0.1 µG</td>
</tr>
<tr>
<td></td>
<td>3.5 G</td>
<td>0.00001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
<tr>
<td>UHS Probe</td>
<td>35 G</td>
<td>0.0001 µG</td>
<td>0.01 µG</td>
<td>0.1 µG</td>
</tr>
<tr>
<td></td>
<td>3.5 G</td>
<td>0.00001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
<tr>
<td></td>
<td>350 µG</td>
<td>0.00001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
<tr>
<td></td>
<td>35 G</td>
<td>0.00001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
<tr>
<td></td>
<td>3.5 G</td>
<td>0.00001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
<tr>
<td></td>
<td>350 µG</td>
<td>0.00001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
<tr>
<td></td>
<td>35 G</td>
<td>0.00001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
<tr>
<td></td>
<td>3.5 G</td>
<td>0.00001 µG</td>
<td>0.001 µG</td>
<td>0.01 µG</td>
</tr>
</tbody>
</table>

**Measurement resolution (RMS noise floor):** Indicated by value in above table for shorted input (probe effects not included); value measured as peak-to-peak divided by 6.6

**Display resolution:** Indicated by number of digits in above table

<table>
<thead>
<tr>
<th>Time constant:</th>
<th>Maximum reading rate:</th>
<th>5¾-digit resolution</th>
<th>4¾-digit resolution</th>
<th>3¾-digit resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 s</td>
<td>10 rdg/s</td>
<td>1 Hz</td>
<td>10 Hz</td>
<td>100 Hz</td>
</tr>
<tr>
<td>0.1 s</td>
<td>30 rdg/s</td>
<td>1 Hz</td>
<td>10 Hz</td>
<td>100 Hz</td>
</tr>
<tr>
<td>0.01 s</td>
<td>1000 rdg/s*</td>
<td>1 Hz</td>
<td>10 Hz</td>
<td>100 Hz</td>
</tr>
</tbody>
</table>

*Limited feature set, interface dependent

**DC accuracy:** ±0.05% of rdg ±0.005% of range

**DC temperature coefficient:** ±0.01% of rdg ±0.003% of range/°C
Introduction

AC RMS measurement

<table>
<thead>
<tr>
<th>Probe type</th>
<th>4¾-digit resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>HST Probe</td>
<td></td>
</tr>
<tr>
<td>350 kG</td>
<td>0.001 G</td>
</tr>
<tr>
<td>35 kG</td>
<td>0.0001 G</td>
</tr>
<tr>
<td>3.5 kG</td>
<td>0.00002 G</td>
</tr>
<tr>
<td>350 G</td>
<td>0.002 G</td>
</tr>
<tr>
<td>35 G</td>
<td>0.020 G</td>
</tr>
<tr>
<td>HSE Probe</td>
<td></td>
</tr>
<tr>
<td>35 kG</td>
<td>0.001 G</td>
</tr>
<tr>
<td>3.5 kG</td>
<td>0.0001 G</td>
</tr>
<tr>
<td>350 G</td>
<td>0.0002 G</td>
</tr>
<tr>
<td>35 G</td>
<td>0.002 G</td>
</tr>
<tr>
<td>3.5 G</td>
<td>0.0020 G</td>
</tr>
<tr>
<td>UHS Probe</td>
<td></td>
</tr>
<tr>
<td>(discontinued)</td>
<td></td>
</tr>
<tr>
<td>35 G</td>
<td>0.001 G</td>
</tr>
<tr>
<td>3.5 G</td>
<td>0.0005 G</td>
</tr>
<tr>
<td>350 mG</td>
<td>0.002 mG</td>
</tr>
<tr>
<td>35 mG</td>
<td>0.020 mG</td>
</tr>
</tbody>
</table>

Measurement resolution (RMS noise floor): Indicated by value in above table for shorted input
Display resolution: Indicated by number of digits in above table
Max reading rate: 30 rdg/s (100 to 1000 rdg/s; limited feature set, interface dependent)
AC accuracy: ±1% of reading ≥ 1% of full-scale range
AC frequency range: 1 Hz to 20 kHz, wide band mode; 100 Hz to 20 kHz, wide band mode
AC band limiting (filters): 18 user-selected frequencies of 3 low-pass or 15 band-pass

Peak measurement

<table>
<thead>
<tr>
<th>Probe type</th>
<th>4¾-digit resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>HST Probe</td>
<td></td>
</tr>
<tr>
<td>350 kG</td>
<td>0.001 G</td>
</tr>
<tr>
<td>35 kG</td>
<td>0.0001 G</td>
</tr>
<tr>
<td>3.5 kG</td>
<td>0.00002 G</td>
</tr>
<tr>
<td>350 G</td>
<td>0.002 G</td>
</tr>
<tr>
<td>35 G</td>
<td>0.020 G</td>
</tr>
<tr>
<td>HSE Probe</td>
<td></td>
</tr>
<tr>
<td>35 kG</td>
<td>0.001 G</td>
</tr>
<tr>
<td>3.5 kG</td>
<td>0.0001 G</td>
</tr>
<tr>
<td>350 G</td>
<td>0.0002 G</td>
</tr>
<tr>
<td>35 G</td>
<td>0.002 G</td>
</tr>
<tr>
<td>3.5 G</td>
<td>0.0020 G</td>
</tr>
<tr>
<td>UHS Probe</td>
<td></td>
</tr>
<tr>
<td>(discontinued)</td>
<td></td>
</tr>
<tr>
<td>35 G</td>
<td>0.001 G</td>
</tr>
<tr>
<td>3.5 G</td>
<td>0.0005 G</td>
</tr>
<tr>
<td>350 mG</td>
<td>0.002 mG</td>
</tr>
<tr>
<td>35 mG</td>
<td>0.020 mG</td>
</tr>
</tbody>
</table>

Measurement resolution (RMS noise floor): Indicated by value in above table for periodic mode and shorted input
Display resolution: Indicated by number of digits in above table
Max reading rate (periodic mode): 30 rdg/s (100 to 1000 rdg/s; limited feature set, interface dependent)
# Gaussmeters — Model 475

**Stock probes** 🏷️RoHS

The most commonly ordered probes for this gaussmeter. Others available starting on page 30.

<table>
<thead>
<tr>
<th>Model</th>
<th>Orientation</th>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem length (in)</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>475</td>
<td>Axial</td>
<td>DC to 400 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>HMMA-2504-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 800 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass</td>
<td>4</td>
<td>HMMA-1904-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 10 kHz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>HMMA-2504-VR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 20 kHz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass</td>
<td>4</td>
<td>HMNA-1904-VR</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>DC to 400 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>HMNT-6J04-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 800 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass</td>
<td>4</td>
<td>HMNT-4E04-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 20 kHz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>HMNT-6J04-VR</td>
</tr>
</tbody>
</table>

## Ordering Information

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>475</td>
<td>Model 475 DSP gaussmeter</td>
</tr>
</tbody>
</table>

Please indicate your power/cord configuration:

- **1**: 100 V—U.S. cord (NEMA 5-15)
- **2**: 120 V—U.S. cord (NEMA 5-15)
- **3**: 220 V—Euro cord (CEE 717)
- **4**: 240 V—Euro cord (CEE 717)
- **5**: 240 V—U.K. cord (BS 1363)
- **6**: 240 V—Swiss cord (SEV 1011)
- **7**: 220 V—China cord (GB 1002)

### Accessories included

- **106-253**: I/O mating connector
- **106-264**: I/O mating connector shell
- **4060**: Small zero gauss chamber
- **119-036**: Model 475 user manual

### Accessories available

- **4005**: 1 m (3.3 ft) long IEEE-488 (GPIB) computer interface cable assembly—includes extender required for simultaneous use of IEEE cable and auxiliary I/O connector
- **4065**: Large zero gauss chamber
- **HMCSL-6**: User programmable cable with EEPROM (1.8 m [6 ft])
- **HMCSL-20**: User programmable cable with EEPROM (6.1 m [20 ft])
- **HMPCEC-10**: Probe extension cable with EEPROM (3 m [10 ft], calibrated
- **HMPCEC-10-U**: Probe extension cable with EEPROM (3 m [10 ft], uncalibrated
- **HMPCEC-25**: Probe extension cable with EEPROM (7.6 m [25 ft], calibrated
- **HMPCEC-25-U**: Probe extension cable with EEPROM (7.6 m [25 ft], uncalibrated
- **HMPCEC-50**: Probe extension cable with EEPROM (15 m [50 ft], calibrated
- **HMPCEC-50-U**: Probe extension cable with EEPROM (15 m [50 ft], uncalibrated
- **HMPCEC-100**: Probe extension cable with EEPROM (30 m [100 ft], calibrated
- **HMPCEC-100-U**: Probe extension cable with EEPROM (30 m [100 ft], uncalibrated
- **RM-1/2**: Rack mount kit for one ½-rack gaussmeter in 483 mm (19 in) rack
- **RM-2**: Rack mount kit for two ½-rack gaussmeters in 483 mm (19 in) rack

### Calibration services

- **CAL-NEW-DATA**: New instrument calibration with certificate and data
- **CAL-475-CERT**: Instrument recalibration with certificate
- **CAL-475-DATA**: Instrument recalibration with certificate and data

All specifications are subject to change without notice.
Other probes available — see page 30.
Model 425 Gaussmeter — RoHS

Model 425 features
- Field ranges from 350 mG to 350 kG
- DC measurement resolution to 4¾ digits (1 part of ±35,000)
- Basic DC accuracy of ±0.20%
- DC to 10 kHz AC frequency
- USB interface
- Large liquid crystal display
- Sort function (displays pass/fail message)
- Alarm with relay
- Standard and custom probes available
- CE mark certification
Introduction

Designed to meet the demanding needs of the permanent magnet industry, the Lake Shore Model 425 gaussmeter provides high-end functionality and performance in an affordable desktop instrument. Magnet testing and sorting have never been easier. When used in combination with the built-in relay and audible alarm features, the Model 425 takes the guesswork out of pass/fail criteria. Additional features including DC to 10 kHz AC frequency response, max hold and relative measurement make the Model 425 the ideal tool for your manufacturing, quality control and R&D flux density measurement applications. For added functionality and value, the Model 425 also includes a standard Lake Shore Hall probe. Put the Model 425 gaussmeter to use with confidence knowing it’s supported by industry leading experts in magnet measurement instrument, sensor, and Hall probe technology.

Throughput

Throughput involves much more than just the update rate of an instrument. An intuitive menu navigation and keypad, along with overall ease of use are equally important. The Model 425 is designed with these qualities in mind. The operation is straightforward, with user display prompts to aid set-up. We understand that time is money! In addition to being user friendly, the automated magnet testing and sorting features of the Model 425 streamline sorting and testing operations. In addition, hot swapping of Hall probes allows you to switch probe types without powering the instrument off and back on. These features support increased productivity, allowing you to spend less time setting up your instrument and more time working on the task at hand.

DC measurement mode

Static or slowly changing fields are measured in DC mode. In this mode, the Model 425 uses probe field compensation to correct for probe nonlinearity, resulting in a DC accuracy to ±0.20%. Measurement resolution is enhanced with internal filtering, allowing resolution to 4¾ digits with reading rates to 30 readings per second over the USB interface.

AC measurement mode

In addition to the DC measurement mode, the Model 425 offers an AC measurement mode for measuring periodic AC fields. The instrument provides an overall frequency range of 10 Hz to 10 kHz and is equipped with both narrow and wide band frequency modes. While in narrow band mode, frequencies above 400 Hz are filtered out for improved measurement performance.

Measurement features

The Model 425 offers a variety of features to enhance the usability and convenience of the gaussmeter.

Autorange: In addition to manual range selection, the instrument automatically chooses an appropriate range for the measured field. Autorange works in DC and AC measurement modes.

Probe zero: Allows you to zero all ranges while in DC mode with the simple push of a key.

Display units: Field magnitude can be displayed in units of G, T, Oe, and A/m with resistance in Ω.

Max hold: The instrument stores and displays the captured maximum DC or AC field reading.

Relative reading: The relative mode calculates the difference between a live reading and the relative setpoint to highlight deviation from a known field point. This feature can be used in DC or AC measurement modes.

Instrument calibration: Lake Shore recommends an annual recalibration schedule for all precision gaussmeters. Recalibrations are always available from Lake Shore, but the Model 425 allows you to field calibrate the instrument if necessary. Recalibration requires a computer interface and precision low resistance standards of known value.
Instrument probe features

The Model 425 offers the best measurement performance when used along with Lake Shore Hall probes. Firmware-based features work in tandem with the probe’s calibration and programming to ensure accurate, repeatable measurements and ease of setup. Many of the features require probe characteristics that are stored in the probe connector’s non-volatile memory.

Probe field compensation: The Hall effect devices used in gaussmeter probes produce a near linear response in the presence of a magnetic field. The small nonlinearities present in each individual device can be measured and subtracted from the field reading. Model 425 probes are calibrated in a way to provide the most accurate DC readings.

Probe information: The gaussmeter reads the probe information on power up or any time the probe is changed to allow hot swapping of probes. Critical probe information can be viewed on the front panel and read over the computer interface to ensure proper system configuration.

Extension cable: The complex nature of Hall effect measurements makes it necessary to match extension cables to the probe when longer cables are needed. Keeping probes and their extensions from getting mixed up can become a problem when more than one probe is used. The Model 425 alleviates most of the hassle by allowing you to match probes to extension cables in the field. Stored information can be viewed on the front panel and read over the computer interface to ensure proper mating.

Hall effect sensors (magnetic field sensors): The Model 425 will operate with a discrete Lake Shore Hall effect sensor when a suitable probe is not available. You can program the nominal sensitivity and serial number into an optional HMCBL blank connector to provide all gaussmeter functions except field compensation. If no sensitivity information is available, the Model 425 reverts to resistance measurement.

Display and interface features

Keypad

The instrument keypad has 14 keys with individual keys assigned to frequently used features. Menus are reserved for less frequently used setup operations. The keypad can be locked out to prevent unintended changes of instrument setup.

Alarm, relay and sort

High and low alarm functions and one relay are included with the instrument, and can be used to automate repetitive magnet testing and sorting operations. Alarm actuators include display annunciator, audible beeper, and a relay. The alarm can be configured to display a pass or fail message and the relay can be configured to activate a mechanism to separate parts that meet pre-set fail criteria. The relay can also be controlled manually for other system needs.

Monitor output

The monitor output provides an analog representation of the reading that is corrected for probe offset and nominal sensitivity. This feature makes it possible to view the analog signal, which has not been digitally processed. The monitor output can be connected to an oscilloscope or data acquisition system.

Computer interface

The Model 425 is equipped with a universal serial bus (USB) interface. It emulates an RS-232C serial port at a fixed baud rate of 57,600, but with the physical connections of a USB. In addition to gathering data, nearly every function of the instrument can be controlled through the USB interface. The reading rate over the interface is nominally 30 readings per second. A LabVIEW™ driver is available from the downloads section of the Lake Shore website at www.lakeshore.com.

The Model 425 has a 2-line by 20-character liquid crystal display. During normal operation, the display is used to report field readings and give results of other features such as max or relative. When setting the instrument parameters, the display gives you meaningful prompts and feedback to simplify operation.

Display configuration examples

Normal reading—the default mode with the display of the live DC field reading.

Max DC hold on—the maximum value is shown in the lower display while the upper display contains the live DC field reading.

Alarm on—the alarm gives an audible and visual indication of when the field value is selectively outside or inside a user specified range. The relay can be associated with the alarm.

Sort on—the live reading is shown in the upper display while the lower display contains the pass/fail (repetitive sorting or testing) message. The relay facilitates pass/fail operation.
Model 425 specifications (Does not include probe error, unless otherwise specified)

General measurement

Input type: Single Hall effect sensor
Maximum update rate: 30 rdg/s
Probe features: Linearity compensation, probe zero, and hot swap
Measurement features: Autorange, max hold, relative mode, and filter
Probe connector: 15-pin D-sub

DC measurement

<table>
<thead>
<tr>
<th>Probe type ranges</th>
<th>Filter on 4¾-digit resolution</th>
<th>Filter off 3¾-digit resolution</th>
</tr>
</thead>
<tbody>
<tr>
<td>HST probe</td>
<td>350 kG 0.001 kG</td>
<td>0.001 kG</td>
</tr>
<tr>
<td></td>
<td>35 kG 0.001 kG</td>
<td>0.001 kG</td>
</tr>
<tr>
<td></td>
<td>3.5 kG 0.0001 kG</td>
<td>0.001 kG</td>
</tr>
<tr>
<td></td>
<td>350 G 0.0002 G</td>
<td>0.001 G</td>
</tr>
<tr>
<td>HSE probe</td>
<td>35 kG 0.001 kG</td>
<td>0.001 kG</td>
</tr>
<tr>
<td></td>
<td>3.5 kG 0.0001 kG</td>
<td>0.001 kG</td>
</tr>
<tr>
<td></td>
<td>350 G 0.001 G</td>
<td>0.001 G</td>
</tr>
<tr>
<td>UHS probe (discontinued)</td>
<td>35 G 0.0001 G</td>
<td>0.001 G</td>
</tr>
<tr>
<td></td>
<td>3.5 G 0.0001 G</td>
<td>0.001 G</td>
</tr>
<tr>
<td></td>
<td>350 mG 0.0002 G</td>
<td>0.001 mG</td>
</tr>
</tbody>
</table>

Measurement resolution (RMS noise floor): Indicated by value in above table, measured at mid-scale range

<table>
<thead>
<tr>
<th>AC accuracy</th>
<th>Narrow band mode</th>
<th>Wide band mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>±2% of rdg,</td>
<td>±0.05% of mg (20 to 100 Hz);</td>
<td>±2% of rdg,</td>
</tr>
<tr>
<td>±0.05% of mg</td>
<td>±2.5% of rdg,</td>
<td>±0.05% of mg</td>
</tr>
<tr>
<td>(10 to 400 Hz)</td>
<td>±0.05% of mg</td>
<td>(50 Hz to 10 kHz)</td>
</tr>
</tbody>
</table>

AC specifications based on sine wave inputs or signals with crest factors <4.
AC temperature coefficient: ±0.01% of reading ±0.006% of range/°C

AC measurement

Display resolution: 4¾-digit
Response: 10 Hz to 400 Hz
Minimum input signal: >1% of mg, except >2% of mg on lowest mg

Interfaces

USB: Emulates a standard RS-232 serial port
Function: B-type USB connector
Baud rate: 57,600
Connector: Shared 25-pin D-sub
Software support: LabVIEW™ driver (consult Lake Shore for availability)

Relays

Number: 1
Contacts: Normally open (NO), normally closed (NC), and common (C)
Contact rating: 30 VDC at 2 A
Operation: Follows alarm or operated manually
Connector: Shared 25-pin D-sub

Monitor output

Configuration: Real time analog voltage output proportional to measured field
Range: ±3.5 V
Scale: ±3.5 V = full scale on selected range
Frequency response: DC to 10 kHz
Accuracy: Offset and single point gain corrected to ±0.5% of reading ±0.1% of range, linearity is probe dependent
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: Shared 25-pin D-sub

General

The Model 425 is the replacement for the Model 421 with a new software command set.
Ambient temperature: 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C with reduced accuracy
Power requirement: 100 VAC to 240 VAC, 50 Hz to 60 Hz, 40 VA
Size: 216 mm W × 89 mm H × 318 mm D (8.5 in × 3.5 in × 12.5 in), half rack
Weight: 2.1 kg (4.6 lb)
Approvals: CE mark, RoHS

Probes and extensions

Probe compatibility: Full line of probes available—see page 27 for recommended stock probes available.
Hall sensor compatibility: Front panel programmable sensitivity and serial number for user supplied Hall sensor using HMCBL cable
Extension cable compatibility: Calibrated or uncalibrated probe extension cables with an EEPROM are available from 10 ft to 100 ft

Model 425 rear panel

1. Line input assembly
2. USB
3. Auxiliary I/O
4. Probe input

Lake Shore Cryotronics, Inc. | t. 614.891.2244 | f. 614.818.1600 | e. info@lakeshore.com | www.lakeshore.com
## Gaussmeters — Model 425

### Stock probes ✓RoHS

The most commonly ordered probes for this gaussmeter. Others available starting on page 30.

<table>
<thead>
<tr>
<th>Model 425</th>
<th>Orientation</th>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem length (in)</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Axial</td>
<td>DC to 400 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>HMMA-2504-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 800 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass</td>
<td>4</td>
<td>HMNA-1904-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 10 kHz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>HMMA-2504-VR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 20 kHz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass</td>
<td>4</td>
<td>HMNA-1904-VR</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>DC to 400 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>HMMT-6J04-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 800 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass</td>
<td>4</td>
<td>HMNT-4E04-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 20 kHz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>HMMT-6J04-VR</td>
</tr>
</tbody>
</table>

### Ordering information

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>425</td>
<td>Model 425 gaussmeter</td>
</tr>
</tbody>
</table>

Please indicate your power/cord configuration:

1. 100 V—U.S. cord (NEMA 5-15)
2. 120 V—U.S. cord (NEMA 5-15)
3. 220 V—Euro cord (CEE 717)
4. 240 V—Euro cord (CEE 717)
5. 240 V—U.K. cord (BS 1363)
6. 240 V—Swiss cord (SEV 1011)
7. 220 V—China cord (GB 1002)

### Accessories included

- G-106-253 I/O mating connector
- G-106-264 I/O mating connector shell
- 4060 Small zero gauss chamber
- 119-053 Model 425 user manual

### Accessories available

- 4065 Large zero gauss chamber
- HMCBL-6 User programmable cable with EEPROM (6 ft)
- HMCBL-20 User programmable cable with EEPROM (20 ft)
- HMPEC-10-U Probe extension cable with EEPROM (10 ft), uncalibrated
- HMPEC-25-U Probe extension cable with EEPROM (25 ft), uncalibrated
- HMPEC-50-U Probe extension cable with EEPROM (50 ft), uncalibrated
- HMPEC-100-U Probe extension cable with EEPROM (100 ft), uncalibrated
- RM-1/2 Rack mount kit for one ½-rack gaussmeter in 483 mm (19 in) rack
- RM-2 Rack mount kit for two ½-rack gaussmeter in 483 mm (19 in) rack
- CAL-NEW-DATA New instrument calibration with certificate and data
- CAL-425-CERT Instrument recalibration with certificate
- CAL-425-DATA Instrument recalibration with certificate and data

All specifications are subject to change without notice.
Other probes available — see page 30.
400 Series Hall Probes

Hall probe features
- Axial, transverse, multi-axis, and tangential Hall probes for measuring magnetic flux density
- Choose from a wide range of lengths and thicknesses
- Probes also available for cryogenic applications
Stock Probes — Ordering Information

Shown in the tables below are our recommended in-stock Hall probes for use with your gaussmeter. They are the ones most commonly ordered by our customers and require no special configuration. Because they are in stock, they offer shorter lead time when ordered.

For other probes, including versions for tangential, multi-axis, and cryogenic applications, see the specialized probes beginning on the next page. Also, for technical specifications and illustrations related to the probes listed (as well as others in this catalog), see the end of the Hall probes section.

Don’t see the probe you need in this catalog? Please contact us. We also offer custom configured Hall probes.

### Table 1: Models 425, 455, and 475

<table>
<thead>
<tr>
<th>Model</th>
<th>Orientation</th>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem length (in)</th>
<th>RoHS</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models 425, 455 and 475</td>
<td>Axial</td>
<td>DC to 400 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>Yes</td>
<td>HMMA-2504-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 800 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass</td>
<td></td>
<td></td>
<td>HMMA-1904-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 10 kHz</td>
<td>HSE-3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td></td>
<td></td>
<td>HMMA-2504-VR</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 20 kHz</td>
<td>HSE-3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass</td>
<td></td>
<td></td>
<td>HMMA-1904-VR</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>DC to 400 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>Yes</td>
<td>HMMT-6J04-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 800 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass</td>
<td></td>
<td></td>
<td>HMMT-4E04-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 20 kHz</td>
<td>HSE-3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td></td>
<td></td>
<td>HMMT-6J04-VR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Fiberglass</td>
<td></td>
<td></td>
<td>HMMT-4E04-VR</td>
</tr>
</tbody>
</table>

**NOTE:** The Model 455 is a legacy gaussmeter no longer available from Lake Shore.

### Table 2: Models 421, 450, and 460

<table>
<thead>
<tr>
<th>Model</th>
<th>Orientation</th>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem length (in)</th>
<th>RoHS</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Models 421, 450 and 460</td>
<td>Axial</td>
<td>DC and 10 Hz to 400 Hz</td>
<td>HST-2: 300 G, 3 kG, 30 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>No</td>
<td>MMA-2504-VG</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Fiberglass</td>
<td></td>
<td></td>
<td>MMA-2504-VH</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>DC and 10 Hz to 100 Hz</td>
<td>HST-2: 300 G, 3 kG, 30 kG</td>
<td>Aluminum</td>
<td>4</td>
<td>No</td>
<td>MMZ-6J04-VG</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC and 10 Hz to 400 Hz</td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Aluminum</td>
<td></td>
<td></td>
<td>MMZ-6J04-VR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>460 only</td>
<td>3-axis</td>
<td>DC and 10 Hz to 400 Hz</td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Aluminum</td>
<td>8</td>
<td></td>
<td>MMZ-2508-UH</td>
</tr>
</tbody>
</table>

**NOTE:** The Model 421, 450, and 460 are legacy gaussmeters no longer available from Lake Shore.

### Table 3: Model 410

<table>
<thead>
<tr>
<th>Model</th>
<th>Orientation</th>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem length (in)</th>
<th>RoHS</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 410</td>
<td>Axial</td>
<td>DC</td>
<td>200 G, 2 kG, 20 kG</td>
<td>Brass</td>
<td>2</td>
<td>No</td>
<td>MSA-2202-410</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DC to 10 kHz</td>
<td>200 G, 2 kG, 20 kG</td>
<td>Brass</td>
<td>4</td>
<td></td>
<td>MSA-2204-410</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Flexible plastic tubing</td>
<td>2.6</td>
<td></td>
<td>MSA-410</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>DC</td>
<td>200 G, 2 kG, 20 kG</td>
<td>Brass</td>
<td>2</td>
<td>No</td>
<td>MST-9P02-410</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>200 G, 2 kG, 20 kG</td>
<td>Brass</td>
<td>4</td>
<td></td>
<td>MST-9P04-410</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Flexible plastic tubing</td>
<td>2.6</td>
<td></td>
<td>MST-410</td>
</tr>
</tbody>
</table>

For the specifications of each probe, please see the individual probe product spec sheets, starting on page 37.
Follow these steps to order the probe you need from the tables on the following pages:

### Step 1:
Look for the table header identifying your Lake Shore gaussmeter model and your desired field orientation (axial, transverse) or specialized application (tangential, cryogenic, or multi-axis).

### Step 2:
Within the table, choose the probe frequency range and field range.

### Step 3:
Choose your stem material and diameter/thickness.

### Step 4:
Specify stem length by filling in the “XX.” This gives you the probe part number.

### Step 5 (optional):
By default, most probes come with a 2 m cable. However, other cable lengths are available. For 6 m, 10 m, and 30 m probe cable lengths, add -06, -10, or -30 to end of the probe part number.
### Built-to-Order Probes

**Axial probes for Model 475, 455, and 425 gaussmeters**

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem thickness (in)</th>
<th>Stem lengths (in)</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>0.08</td>
<td>02, 04, 08</td>
<td>HMMA-08XX-UH</td>
</tr>
<tr>
<td></td>
<td>HST-3: 35 G, 350 G, 3.5 kG, 35 kG, 350 G</td>
<td>Aluminum</td>
<td>0.25</td>
<td>04, 36</td>
<td>HMMA-25XX-WL</td>
</tr>
<tr>
<td>DC to 400 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>0.06</td>
<td>02, 04, 08, 18</td>
<td>HMMA-06XX-TH</td>
</tr>
<tr>
<td></td>
<td>HST-3: 35 G, 350 G, 3.5 kG, 35 kG, 350 G</td>
<td>Aluminum</td>
<td>0.18</td>
<td>02, 04, 08, 18</td>
<td>HMMA-18XX-VF</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>02, 04, 08, 12</td>
<td>HMMA-25XX-VF</td>
</tr>
<tr>
<td>DC to 800 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass epoxy</td>
<td>0.187</td>
<td>02, 04, 08</td>
<td>HMMA-19XX-VF</td>
</tr>
<tr>
<td>DC to 10 kHz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>0.18</td>
<td>02, 04, 08, 18</td>
<td>HMMA-18XX-VR</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>02, 04, 08, 12</td>
<td>HMMA-25XX-VR</td>
</tr>
<tr>
<td>DC to 20 kHz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass epoxy</td>
<td>0.187</td>
<td>02, 04, 08</td>
<td>HMMA-19XX-VR</td>
</tr>
<tr>
<td>DC to 50 kHz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass epoxy</td>
<td>0.25</td>
<td>18</td>
<td>HMMA-25XX-VR-HF</td>
</tr>
</tbody>
</table>

* Cable length can be changed. See below.

**Transverse probes for Model 475, 455, and 425 gaussmeters**

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem thickness (in)</th>
<th>Stem lengths (in)</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Brass</td>
<td>0.061</td>
<td>02, 04, 08</td>
<td>HMMTB-6JXX-VF</td>
</tr>
<tr>
<td></td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Brass</td>
<td>0.061</td>
<td>02, 04, 08</td>
<td>HMMTB-6JXX-VR</td>
</tr>
<tr>
<td>DC to 400 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>0.061</td>
<td>02, 04, 08, 12, 18</td>
<td>HMMT-6JXX-VF</td>
</tr>
<tr>
<td></td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Aluminum</td>
<td>0.061</td>
<td>02, 04, 08, 12, 18</td>
<td>HMMT-6JXX-VR</td>
</tr>
<tr>
<td>DC to 800 Hz</td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass epoxy</td>
<td>0.045</td>
<td>02, 04</td>
<td>HMNT-4EXX-VF</td>
</tr>
<tr>
<td></td>
<td>HST-4: 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Flexible plastic tubing</td>
<td>0.02</td>
<td>03</td>
<td>HMFT-29XX-VH</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.025</td>
<td>03</td>
<td>HMFT-3EXX-VF</td>
</tr>
<tr>
<td>DC to 20 kHz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Fiberglass epoxy</td>
<td>0.045</td>
<td>02, 04</td>
<td>HMNT-4EXX-VR</td>
</tr>
<tr>
<td></td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Flexible plastic tubing</td>
<td>0.02</td>
<td>03</td>
<td>HMFT-29XX-VJ</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>0.025</td>
<td>03</td>
<td>HMFT-3EXX-VR</td>
</tr>
</tbody>
</table>

* Indicates probe characteristic and length that is offered as a stock probe. This item would not need to be “built-to-order.” See page 31 for our stock probes.

* By default, most probes have a 2 m long cable. Also available: 6 m, 10 m, and 30 m lengths. To specify a length other than default length, add -06, -10, or -30 to end of the probe part number.

For the specifications of each probe, please see the individual probe product spec sheets, starting on page 37.
# Built-to-Order Probes

Axial probes for Model 460, 450, and 421 gaussmeters

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem diameter (in)</th>
<th>Stem lengths (in)</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC</td>
<td>HST-2: 300 G, 3 kG, 30 kG</td>
<td>Aluminum</td>
<td>0.08</td>
<td>02, 04, 08</td>
<td>MMA-08XX-UH</td>
</tr>
<tr>
<td></td>
<td>HST-1: 300 G, 3 kG, 30 kG, 300 kG</td>
<td>Aluminum</td>
<td>0.25</td>
<td>04, 36</td>
<td>MMA-25XX-WL</td>
</tr>
<tr>
<td>DC and 10 Hz to 400 Hz</td>
<td>HST-2: 300 G, 3 kG, 30 kG</td>
<td>Aluminum</td>
<td>0.06</td>
<td>02, 04, 08, 18</td>
<td>MMA-06XX-TH</td>
</tr>
<tr>
<td></td>
<td>HST-1: 300 G, 3 kG, 30 kG, 300 kG</td>
<td>Aluminum</td>
<td>0.18</td>
<td>02, 04, 18</td>
<td>MMA-18XX-VG</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fiberglass epoxy</td>
<td>0.25</td>
<td>02, 04, 08, 12</td>
<td>MMA-25XX-VG</td>
</tr>
<tr>
<td></td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Aluminum</td>
<td>0.18</td>
<td>04, 08</td>
<td>MMA-18XX-WL</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Fiberglass epoxy</td>
<td>0.25</td>
<td>02, 04, 08, 12</td>
<td>MMA-25XX-VH</td>
</tr>
</tbody>
</table>

* Cable length can be changed. See below.

**Transverse probes for Model 460, 450, and 421 gaussmeters**

<table>
<thead>
<tr>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem thickness (in)</th>
<th>Stem lengths (in)</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC</td>
<td>HST-2: 300 G, 3 kG, 30 kG</td>
<td>Aluminum</td>
<td>0.061</td>
<td>02, 04, 08, 12, 18</td>
<td>MMT-6JXX-VG</td>
</tr>
<tr>
<td></td>
<td>HST-2: 300 G, 3 kG, 30 kG</td>
<td>Brass</td>
<td>0.061</td>
<td>02, 04, 08</td>
<td>MMTB-6JXX-VG</td>
</tr>
<tr>
<td></td>
<td>HST-2: 300 G, 3 kG, 30 kG</td>
<td>Brass</td>
<td>0.061</td>
<td>02, 04, 08</td>
<td>MMTB-6JXX-VH</td>
</tr>
<tr>
<td>DC and 10 Hz to 100 Hz</td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Aluminum</td>
<td>0.061</td>
<td>02, 04, 08, 12, 18</td>
<td>MNT-4EXX-VG</td>
</tr>
<tr>
<td></td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Fiberglass epoxy</td>
<td>0.025</td>
<td>02, 04</td>
<td>MFT-29XX-VH</td>
</tr>
<tr>
<td></td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Flexible plastic tubing</td>
<td>0.025</td>
<td>02, 04</td>
<td>MFT-33XX-VG</td>
</tr>
<tr>
<td>DC and 10 Hz to 400 Hz</td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Fiberglass epoxy</td>
<td>0.025</td>
<td>02, 04</td>
<td>MFT-29XX-VJ</td>
</tr>
<tr>
<td></td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Flexible plastic tubing</td>
<td>0.025</td>
<td>02, 04</td>
<td>MFT-33XX-VH</td>
</tr>
</tbody>
</table>

* Cable length can be changed. See below.

**Transverse and axial probes for Model 410 gaussmeters**

<table>
<thead>
<tr>
<th>Orientation</th>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem lengths (in)</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>Axial</td>
<td>DC</td>
<td>200 G, 2 kG, 20 kG</td>
<td>Brass</td>
<td>02, 04</td>
<td>MSA-22XX-410</td>
</tr>
<tr>
<td></td>
<td>DC to 10 kHz</td>
<td>200 G, 2 kG, 20 kG</td>
<td>Flexible plastic tubing</td>
<td>2.6</td>
<td>MSA-410</td>
</tr>
<tr>
<td>Transverse</td>
<td>DC</td>
<td>200 G, 2 kG, 20 kG</td>
<td>Brass</td>
<td>02, 04</td>
<td>MST-9PX-410</td>
</tr>
<tr>
<td></td>
<td>DC to 10 kHz</td>
<td>200 G, 2 kG, 20 kG</td>
<td>Flexible plastic tubing</td>
<td>2.6</td>
<td>MST-410</td>
</tr>
</tbody>
</table>

* Indicates probe characteristic and length that is offered as a stock probe. This item would not need to be “built-to-order.” See page 31 for our stock probes.

* By default, most probes have a 2 m long cable. Also available: 6 m, 10 m, and 30 m lengths. To specify a length other than default length, add -06, -10, or -30 to end of the probe part number. (NA for 410 probes)

For the specifications of each probe, please see the individual probe product spec sheets, starting on page 37.
## Specialized Probes—Built-to-Order

Tangential probes for Model 475, 455, 425, 460, 450, and 421 gaussmeters
Probes to measure tangential fields, which are fields parallel to and near a surface

<table>
<thead>
<tr>
<th>Model</th>
<th>Orientation</th>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem thickness (in)</th>
<th>Stem length (in)</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>475, 455, 425</td>
<td>N/A</td>
<td>DC to 400 Hz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>Plastic</td>
<td>0.11</td>
<td>1.5</td>
<td>HMNTAN-DQ02-TH</td>
</tr>
<tr>
<td>460, 450, 421</td>
<td>N/A</td>
<td>DC and 10 Hz to 400 Hz</td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Plastic</td>
<td>0.11</td>
<td>1.5</td>
<td>MNTAN-D002-TH</td>
</tr>
</tbody>
</table>

Cryogenic probes for Model 475, 455, 425, 460, 450, and 421 gaussmeters
Probes designed to withstand thermal contraction of probe materials while measuring at ultra-low temperatures

<table>
<thead>
<tr>
<th>Model</th>
<th>Orientation</th>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem diameter (in)</th>
<th>Stem length (in)</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>475, 455, 425</td>
<td>Axial</td>
<td>DC</td>
<td>HST-3: 35 G, 350 G, 3.5 kG, 35 kG, 350 kG</td>
<td>Stainless steel</td>
<td>0.25</td>
<td>60</td>
<td>HMCA-2560-WN</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>DC to 800 Hz</td>
<td>HST-3: 35 G, 350 G, 3.5 kG, 35 kG, 350 kG</td>
<td>Stainless steel</td>
<td>0.25</td>
<td>61</td>
<td>HMCT-3160-WN</td>
</tr>
<tr>
<td>460, 450, 421</td>
<td>Axial</td>
<td>DC</td>
<td>HST-1: 300 G, 3 kG, 30 kG, 300 kG</td>
<td>Stainless steel</td>
<td>0.25</td>
<td>60</td>
<td>MCA-2560-WN</td>
</tr>
<tr>
<td></td>
<td>Transverse</td>
<td>DC and 10 Hz to 400 Hz</td>
<td>HST-1: 300 G, 3 kG, 30 kG, 300 kG</td>
<td>Stainless steel</td>
<td>0.25</td>
<td>61</td>
<td>MCT-3160-WN</td>
</tr>
</tbody>
</table>

Multi-axis probes for Model 460 gaussmeter
Multi-sensor probes designed to measure three vectors of magnetic field simultaneously

<table>
<thead>
<tr>
<th>Model</th>
<th>Orientation</th>
<th>Frequency range</th>
<th>Full-scale field ranges</th>
<th>Stem material</th>
<th>Stem diameter (in)</th>
<th>Approximate Stem lengths (in)</th>
<th>Probe part number</th>
</tr>
</thead>
<tbody>
<tr>
<td>460</td>
<td>3-Axis</td>
<td>DC and 10 Hz to 400 Hz</td>
<td>HSE-1: 30 G, 300 G, 3 kG, 30 kG</td>
<td>Aluminum</td>
<td>0.25</td>
<td>02, 04, 08, 12, 18, 36, 60</td>
<td>MMZ-25XX-UH</td>
</tr>
</tbody>
</table>

* Indicates probe characteristic and length that is offered as a stock probe. This item would not need to be “built-to-order.” See page 31 for our stock probes.

By default, most probes have a 2 m long cable. Also available: 6 m, 10 m, and 30 m lengths. To specify a length other than default length, add -06, -10, or -30 to end of the probe part number.

30 m length not available for 3-axis probes.

For the specifications of each probe, please see the individual probe product spec sheets, starting on page 37.
Hall Probe Specifications
## Specifications

### Axial Probes

<table>
<thead>
<tr>
<th>L mm (in)</th>
<th>D mm (in)</th>
<th>A mm (in)</th>
<th>Active area mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Corrected accuracy (% rdg at 25 °C)</th>
<th>Temp coefficient (max) of sensitivity</th>
<th>Temp coefficient (max) zero</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>400 Series Hall Probes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Models 475, 455, and 425</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **HMMA-0602-TN** No 50.8 ±3.2 (2 ±0.125)
  - 1.52 dia +0.03/-0.08 (0.080 dia +0.011/-0.003) 0.13 ±0.08 (0.005 ±0.003) Approx 0.51 dia (0.020 dia) Aluminum DC to 400 Hz HST-4 35 G, 350 G, 35 kG ±0.25% to 10 kG ±0.13 G°C ±0.01%/°C No

<table>
<thead>
<tr>
<th>L mm (in)</th>
<th>D mm (in)</th>
<th>A mm (in)</th>
<th>Active area mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Corrected accuracy (% rdg at 25 °C)</th>
<th>Temp coefficient (max) of sensitivity</th>
<th>Temp coefficient (max) zero</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>400 Series Hall Probes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Models 475, 455, and 425</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **HMMA-0604-TN** No 101.6 ±3.2 (4 ±0.125)
  - 2.03 dia ±0.13 (0.080 dia ±0.005) 0.25 ±0.13 (0.010 ±0.005) DC Fiberglass epoxy DC to 20 kHz HSE 3.5 G, 35 G, 35 kG ±0.25% to 20 kG ±0.09 G°C ±0.01%/°C 455/475: ±0.015%/°C 425: -0.04%/°C

<table>
<thead>
<tr>
<th>L mm (in)</th>
<th>D mm (in)</th>
<th>A mm (in)</th>
<th>Active area mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Corrected accuracy (% rdg at 25 °C)</th>
<th>Temp coefficient (max) of sensitivity</th>
<th>Temp coefficient (max) zero</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>400 Series Hall Probes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Models 475, 455, and 425</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

- **HMMA-0606-TN** No 203.2 ±3.2 (8 ±0.125)
  - 6.35 dia ±0.15 (0.25 dia ±0.008) Approx 0.76 dia (0.030 dia) Aluminum DC to 1 kHz HST-4 35 G, 350 G, 35 kG ±0.20% to 30 kG ±0.10% to 30 to 35 kG ±0.09 G°C ±0.01%/°C

### Operating Temperature Range

- 0 °C to +75 °C

**Note:** 15 in flexible probes are no longer available. Please contact your local sales representative to discuss alternatives if you require a similar product for your application.
### 400 Series Hall Probes — Specifications

**Axial probes**

<table>
<thead>
<tr>
<th>L mm (in)</th>
<th>D mm (in)</th>
<th>A mm (in)</th>
<th>Active area mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Corrected accuracy (% rdg at 25 °C)</th>
<th>Operating temp range (°C)</th>
<th>Temp coefficient (max) zero</th>
<th>Temp coefficient (max) of sensitivity</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>for Models 460, 450, and 421</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| MMA-0602-TH | 50.8 ±3.2 (2 ±0.125) | 1.52 dia +0.03/-0.08 (0.060 dia +0.001/-0.003) | 0.13 ±0.08 (0.005 ±0.003) | Aluminum | DC and 10 Hz to 400 Hz | ±0.25% to 10 kG | ±0.13 G/°C | ±0.01%/°C | No |
| MMA-0604-TH | 101.6 ±3.2 (4 ±0.125) | 2.03 dia ±0.13 (0.080 dia ±0.005) | 0.25 ±0.13 (0.010 ±0.005) | Fiberglass epoxy | HST-2 300 G, 3 kG, 30 kG | ±0.25% to 20 kG | ±0.09 G/°C | ±0.01%/°C | Yes |
| MMA-0618-TH | 457 ±6.4 (18 ±0.25) | 1.03 dia +0.05/-0.08 (0.040 dia +0.003/-0.004) | 0.38 ±0.13 (0.015 ±0.005) | Aluminum | HSE-1 30 G, 300 G, 3 kG, 30 kG | ±0.25% to 30 kG | ±0.15% to 30 kG | 0 °C to +75 °C | |
| MMA-1802-VH | 50.8 ±1.6 (2 ±0.063) | 4.75 dia +0.13 (0.187 dia ±0.005) | 0.13 ±0.08 (0.005 ±0.003) | Fiberglass epoxy | DC and 10 Hz to 400 Hz | ±0.15% to 30 kG | ±0.13 G/°C | ±0.005%/°C | No |
| MMA-1804-VH | 101.6 ±3.2 (4 ±0.125) | 4.57 dia +0.05/-0.10 (0.180 dia ±0.002/-0.004) | 0.38 ±0.13 (0.015 ±0.005) | Aluminum | HST-2 300 G, 3 kG, 30 kG | ±0.25% to 10 kG | ±0.13 G/°C | ±0.01%/°C | No |
| MMA-1808-VH | 203.2 ±3.2 (8 ±0.125) | 305 ±6.4 (12 ±0.25) | 6.35 dia ±0.15 (0.25 dia ±0.006) | 0.13 ±0.08 (0.005 ±0.003) | Approx 0.76 dia (0.030 dia) | ±0.25% to 20 kG | ±0.13 G/°C | ±0.01%/°C | No |
| MMA-1818-VH | 457 ±6.4 (18 ±0.25) | 101.6 ±3.2 (4 ±0.125) | 4.75 dia +0.13 (0.187 dia ±0.005) | Fiberglass epoxy | DC and 10 Hz to 400 Hz | ±0.15% to 30 kG | ±0.13 G/°C | ±0.005%/°C | No |
| MMA-2502-VH | 50.8 ±1.6 (2 ±0.063) | 4.57 dia +0.05/-0.10 (0.180 dia ±0.002/-0.004) | 0.38 ±0.13 (0.015 ±0.005) | Aluminum | HST-2 300 G, 3 kG, 30 kG | ±0.25% to 10 kG | ±0.13 G/°C | ±0.005%/°C | No |
| MMA-2504-VH | 101.6 ±3.2 (4 ±0.125) | 4.57 dia +0.05/-0.10 (0.180 dia ±0.002/-0.004) | 0.38 ±0.13 (0.015 ±0.005) | Aluminum | HST-2 300 G, 3 kG, 30 kG | ±0.25% to 10 kG | ±0.13 G/°C | ±0.005%/°C | No |
| MMA-2508-VH | 203.2 ±3.2 (8 ±0.125) | 305 ±6.4 (12 ±0.25) | 6.35 dia ±0.15 (0.25 dia ±0.006) | 0.13 ±0.08 (0.005 ±0.003) | Approx 0.76 dia (0.030 dia) | ±0.25% to 20 kG | ±0.13 G/°C | ±0.01%/°C | No |
| MMA-2512-VH | 457 ±6.4 (18 ±0.25) | 101.6 ±3.2 (4 ±0.125) | 4.75 dia +0.13 (0.187 dia ±0.005) | Fiberglass epoxy | DC and 10 Hz to 400 Hz | ±0.15% to 30 kG | ±0.13 G/°C | ±0.005%/°C | No |
| MMA-2504-VG | 50.8 ±1.6 (2 ±0.063) | 4.57 dia +0.05/-0.10 (0.180 dia ±0.002/-0.004) | 0.38 ±0.13 (0.015 ±0.005) | Aluminum | HST-2 300 G, 3 kG, 30 kG | ±0.25% to 10 kG | ±0.13 G/°C | ±0.005%/°C | No |
| MMA-2508-VG | 203.2 ±3.2 (8 ±0.125) | 305 ±6.4 (12 ±0.25) | 6.35 dia ±0.15 (0.25 dia ±0.006) | 0.13 ±0.08 (0.005 ±0.003) | Approx 0.76 dia (0.030 dia) | ±0.25% to 20 kG | ±0.13 G/°C | ±0.01%/°C | No |
| MMA-2512-VG | 457 ±6.4 (18 ±0.25) | 101.6 ±3.2 (4 ±0.125) | 4.75 dia +0.13 (0.187 dia ±0.005) | Fiberglass epoxy | DC and 10 Hz to 400 Hz | ±0.15% to 30 kG | ±0.13 G/°C | ±0.005%/°C | No |
| MMA-1804-WL | 101.6 ±3.2 (4 ±0.125) | 4.57 dia +0.05/-0.10 (0.180 dia ±0.002/-0.004) | 0.38 ±0.13 (0.015 ±0.005) | Aluminum | HST-2 300 G, 3 kG, 30 kG | ±0.25% to 10 kG | ±0.13 G/°C | ±0.005%/°C | No |
| MMA-1808-WL | 203.2 ±3.2 (8 ±0.125) | 305 ±6.4 (12 ±0.25) | 6.35 dia ±0.15 (0.25 dia ±0.006) | 0.13 ±0.08 (0.005 ±0.003) | Approx 0.76 dia (0.030 dia) | ±0.25% to 20 kG | ±0.13 G/°C | ±0.01%/°C | No |
| MMA-2504-WL | 101.6 ±3.2 (4 ±0.125) | 4.57 dia +0.05/-0.10 (0.180 dia ±0.002/-0.004) | 0.38 ±0.13 (0.015 ±0.005) | Aluminum | HST-2 300 G, 3 kG, 30 kG | ±0.25% to 10 kG | ±0.13 G/°C | ±0.005%/°C | No |
| MMA-2508-WL | 203.2 ±3.2 (8 ±0.125) | 305 ±6.4 (12 ±0.25) | 6.35 dia ±0.15 (0.25 dia ±0.006) | 0.13 ±0.08 (0.005 ±0.003) | Approx 0.76 dia (0.030 dia) | ±0.25% to 20 kG | ±0.13 G/°C | ±0.01%/°C | No |

Note: 15 in flexible probes are no longer available. Please contact your local sales representative to discuss alternatives if you require a similar product for your application.
### Transverse probes

**Specifications**

<table>
<thead>
<tr>
<th>Model</th>
<th>L mm (in)</th>
<th>T mm (in)</th>
<th>W mm (in)</th>
<th>A mm (in)</th>
<th>Active area mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Corrected accuracy (% rdg at 25 °C)</th>
<th>Temp coefficient (max) zero</th>
<th>Temp coefficient (max) of sensitivity</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMNT-6J02-VR</td>
<td>No</td>
<td>50.8 ±3.2 (2 ±0.125)</td>
<td>1.55 (0.061) max</td>
<td>4.57 ±0.13 (0.180 ±0.005)</td>
<td>Approx 1.02 dia (0.040 dia)</td>
<td>Aluminum</td>
<td>DC to 800 Hz</td>
<td>HSE-3 3 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>±0.20% to 30 kG; ±0.25% to 35 kG</td>
<td>±0.09 G/°C</td>
<td>450/475: ±0.015%/°C; 425: -0.4%/°C</td>
<td>Yes</td>
</tr>
<tr>
<td>HMNT-6J04-VR</td>
<td>Yes</td>
<td>101.6 ±3.2 (4 ±0.125)</td>
<td>1.55 (0.061) max</td>
<td>4.57 ±0.13 (0.180 ±0.005)</td>
<td>Approx 1.02 dia (0.040 dia)</td>
<td>Aluminum</td>
<td>DC to 400 Hz</td>
<td>HST-5 3 G, 350 G, 3 kG, 35 kG</td>
<td>±0.10% to 30 kG; ±0.15% to 35 kG</td>
<td>±0.13 G/°C</td>
<td>-0.005%/°C</td>
<td>No</td>
</tr>
<tr>
<td>HMNT-6J08-VR</td>
<td>No</td>
<td>203.2 ±3.2 (8 ±0.125)</td>
<td>1.55 (0.061) max</td>
<td>4.57 ±0.13 (0.180 ±0.005)</td>
<td>Approx 1.02 dia (0.040 dia)</td>
<td>Aluminum</td>
<td>DC to 800 Hz</td>
<td>HST-6 3 G, 350 G, 3 kG, 35 kG</td>
<td>±0.10% to 30 kG; ±0.15% to 35 kG</td>
<td>±0.13 G/°C</td>
<td>-0.005%/°C</td>
<td>No</td>
</tr>
<tr>
<td>HMNT-6J12-VR</td>
<td>No</td>
<td>305 ±6.4 (12 ±0.25)</td>
<td>1.55 (0.061) max</td>
<td>4.57 ±0.13 (0.180 ±0.005)</td>
<td>Approx 1.02 dia (0.040 dia)</td>
<td>Aluminum</td>
<td>DC to 10 Hz to 100 Hz</td>
<td>HSE-1 3 G, 300 G, 3 kG, 30 kG</td>
<td>±0.25% to 30 kG</td>
<td>±0.09 G/°C</td>
<td>450/460: ±0.015%/°C; 421: -0.04%/°C</td>
<td>Yes</td>
</tr>
<tr>
<td>HMNT-6J18-VR</td>
<td>No</td>
<td>457 ±6.4 (18 ±0.25)</td>
<td>1.55 (0.061) max</td>
<td>4.57 ±0.13 (0.180 ±0.005)</td>
<td>Approx 1.02 dia (0.040 dia)</td>
<td>Aluminum</td>
<td>DC to 400 Hz</td>
<td>HST-2 3 G, 300 G, 3 kG, 30 kG</td>
<td>±0.15% to 30 kG</td>
<td>±0.13 G/°C</td>
<td>-0.005%/°C</td>
<td>No</td>
</tr>
</tbody>
</table>

Operating temperature range: 0 °C to +75 °C
# Brass stem transverse probes (short)

Operating temperature range: 0 °C to +75 °C

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Model</th>
<th>L (mm)</th>
<th>T (mm)</th>
<th>Width (mm)</th>
<th>A (mm)</th>
<th>Active Area (mm)</th>
<th>Stem Material</th>
<th>Frequency Range</th>
<th>Usable Full-Scale Ranges</th>
<th>Corrected Accuracy (% rdg at 25 °C)</th>
<th>Temp Coefficient (max) of Sensitivity</th>
<th>Contains Temp Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 475, 455, and 425</td>
<td>HMMTB-6J02-VR</td>
<td>No</td>
<td>50.8 ±3.2 (2 ±0.125)</td>
<td>1.78 (0.070) max</td>
<td>5.59 (0.22)</td>
<td>3.81 ±1.27 (0.150 ±0.050)</td>
<td>Brass</td>
<td>DC</td>
<td>HST-4 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>±0.20% to 30 kG and ±0.25% to 35 kG</td>
<td>±0.09 G/°C</td>
<td>455/475: ±0.015%/°C, 425: ±0.04%/°C</td>
</tr>
<tr>
<td>Model 460, 450, and 421</td>
<td>MMTB-6J02-VH</td>
<td>No</td>
<td>50.8 ±3.2 (2 ±0.125)</td>
<td>1.78 (0.070) max</td>
<td>5.59 (0.22)</td>
<td>3.81 ±1.27 (0.150 ±0.050)</td>
<td>Brass</td>
<td>DC</td>
<td>HST-2 300 G, 3 kG, 30 kG</td>
<td>±0.15% to 30 kG</td>
<td>±0.13 G/°C</td>
<td>-0.005%/°C</td>
</tr>
</tbody>
</table>

# Brass stem transverse probes (long)

Operating temperature range: 0 °C to +75 °C

<table>
<thead>
<tr>
<th>Specifications</th>
<th>Model</th>
<th>L (mm)</th>
<th>T (mm)</th>
<th>Width (mm)</th>
<th>A (mm)</th>
<th>Active Area (mm)</th>
<th>Stem Material</th>
<th>Frequency Range</th>
<th>Usable Full-Scale Ranges</th>
<th>Corrected Accuracy (% rdg at 25 °C)</th>
<th>Temp Coefficient (max) of Sensitivity</th>
<th>Contains Temp Sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Model 475, 455, and 425</td>
<td>MMTB-6J04-VR</td>
<td>No</td>
<td>101.8 ±3.2 (4 ±0.125)</td>
<td>1.78 (0.070) max</td>
<td>5.58 (0.22)</td>
<td>3.81 ±1.27 (0.150 ±0.050)</td>
<td>Brass</td>
<td>DC</td>
<td>HSE-1 30 G, 300 G, 3 kG, 30 kG</td>
<td>±0.25% to 30 kG</td>
<td>±0.09 G/°C</td>
<td>450/460: ±0.015%/°C, 421: ±0.04%/°C</td>
</tr>
<tr>
<td>Model 460, 450, and 421</td>
<td>MMTB-6J08-VR</td>
<td>No</td>
<td>203.2 ±3.2 (8 ±0.125)</td>
<td>1.78 (0.070) max</td>
<td>5.58 (0.22)</td>
<td>3.81 ±1.27 (0.150 ±0.050)</td>
<td>Brass</td>
<td>DC</td>
<td>HST-2 300 G, 3 kG, 30 kG</td>
<td>±0.15% to 30 kG</td>
<td>±0.13 G/°C</td>
<td>-0.005%/°C</td>
</tr>
</tbody>
</table>
**Flexible transverse probes**

Operating temperature range: 0 °C to +75 °C

<table>
<thead>
<tr>
<th>RoHS</th>
<th>L mm (in)</th>
<th>W mm (in)</th>
<th>T mm (in)</th>
<th>A mm (in)</th>
<th>S mm (in)</th>
<th>Active area mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Corrected accuracy (% rdg at 25 °C)</th>
<th>Temp coefficient (max) zero</th>
<th>Temp coefficient (max) of sensitivity</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>for Models 475, 455, and 425</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMFT-3E03-VR</td>
<td>76.2 +12.7/-3.18 (3 +0.5/-0.125)</td>
<td>3.42 (0.135) max</td>
<td>0.64 (0.025) max</td>
<td>3.18 ±0.13 (0.125 ±0.005)</td>
<td>9.52 (0.375)</td>
<td>Approx 1.02 dia (0.040 dia)</td>
<td>Flexible plastic tubing</td>
<td>DC to 20 kHz</td>
<td>3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>±0.20% to 30 kG, ±0.25% to 30 to 35 kG</td>
<td>±0.09 G/°C</td>
<td>±0.015%/°C</td>
<td>Yes</td>
</tr>
<tr>
<td>HMFT-3E03-VF</td>
<td>76.2 +12.7/-3.18 (3 +0.5/-0.125)</td>
<td>2.16 (0.085) max</td>
<td>0.51 (0.020) max</td>
<td>1.65 ±0.13 (0.065 ±0.003)</td>
<td>Approx 0.76 dia (0.030 dia)</td>
<td>Flexible plastic tubing</td>
<td>DC to 800 Hz</td>
<td>35 G, 350 G, 3.5 kG, 35 kG</td>
<td>±0.20% to 30 kG, ±0.25% to 30 to 35 kG</td>
<td>±0.13 G/°C</td>
<td>±0.005%/°C</td>
<td>Yes</td>
<td></td>
</tr>
<tr>
<td>HMFT-2903-VJ</td>
<td>76.2 +12.7/-3.18 (3 +0.5/-0.125)</td>
<td>3.2 mm (0.125 in) diam max</td>
<td>9.1 ± 0.76 mm (0.36 ±0.030 in) diam</td>
<td>64 mm (2.5 in)</td>
<td>3.2 mm (0.125 in) diam max</td>
<td>Approx 1.02 dia (0.040 dia)</td>
<td>Flexible plastic tubing</td>
<td>DC to 20 kHz</td>
<td>3.5 G, 35 G, 350 G, 3.5 kG, 35 kG</td>
<td>±0.25% to 30 kG</td>
<td>±0.09 G/°C</td>
<td>±0.015%/°C</td>
<td>Yes</td>
</tr>
<tr>
<td>HMFT-2903-VH</td>
<td>76.2 +12.7/-3.18 (3 +0.5/-0.125)</td>
<td>2.16 (0.085) max</td>
<td>0.51 (0.020) max</td>
<td>1.65 ±0.13 (0.065 ±0.003)</td>
<td>Approx 0.76 dia (0.030 dia)</td>
<td>Flexible plastic tubing</td>
<td>DC to 800 Hz</td>
<td>35 G, 350 G, 3.5 kG, 35 kG</td>
<td>±0.25% to 30 kG</td>
<td>±0.09 G/°C</td>
<td>±0.015%/°C</td>
<td>No</td>
<td></td>
</tr>
</tbody>
</table>

| **for Models 460, 450, and 421** |
| MFT-3E03-VH | No | 76.2 +12.7/-3.18 (3 +0.5/-0.125) | 3.42 (0.135) max | 0.64 (0.025) max | 3.18 ±0.13 (0.125 ±0.005) | 9.52 (0.375) | Approx 1.02 dia (0.040 dia) | Flexible plastic tubing | DC and 10 Hz to 400 Hz | 30 G, 300 G, 3 kG, 30 kG | ±0.25% to 30 kG | ±0.09 G/°C | 450/460; ±0.015%/°C 421: -0.04%/°C | Yes |
| MFT-3E03-VG | No | 76.2 +12.7/-3.18 (3 +0.5/-0.125) | 3.42 (0.135) max | 0.64 (0.025) max | 3.18 ±0.13 (0.125 ±0.005) | 9.52 (0.375) | Approx 1.02 dia (0.040 dia) | Flexible plastic tubing | DC and 10 Hz to 400 Hz | 30 G, 300 G, 3 kG, 30 kG | ±0.25% to 30 kG | ±0.09 G/°C | 450/460; ±0.015%/°C 421: -0.04%/°C | Yes |
| MFT-2903-VJ | No | 76.2 +12.7/-3.18 (3 +0.5/-0.125) | 3.42 (0.135) max | 0.64 (0.025) max | 3.18 ±0.13 (0.125 ±0.005) | 9.52 (0.375) | Approx 1.02 dia (0.040 dia) | Flexible plastic tubing | DC and 10 Hz to 400 Hz | 30 G, 300 G, 3 kG, 30 kG | ±0.25% to 30 kG | ±0.09 G/°C | 450/460; ±0.015%/°C 421: -0.04%/°C | Yes |
| MFT-2903-VH | No | 76.2 +12.7/-3.18 (3 +0.5/-0.125) | 2.16 (0.085) max | 0.51 (0.020) max | 1.65 ±0.13 (0.065 ±0.003) | Approx 0.76 dia (0.030 dia) | Flexible plastic tubing | DC and 10 Hz to 400 Hz | 30 G, 300 G, 3 kG, 30 kG | ±0.25% to 30 kG | ±0.09 G/°C | ±0.015%/°C | No |

Note: 15 in flexible probes are no longer available. Please contact your local sales representative to discuss alternatives if you require a similar product for your application.
## Tangential probes

- **Cable length**: 2 m (6.5 ft)
- **Stem**: 76 mm (3 in)
- **Diameter**: 9.1 ± 0.8 mm (0.36 ± 0.030 in)

### Specifications

<table>
<thead>
<tr>
<th>Model</th>
<th>L mm (in)</th>
<th>T mm (in)</th>
<th>W mm (in)</th>
<th>A mm (in)</th>
<th>Active area mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Corrected accuracy (% rdg at 25 °C)</th>
<th>Operating temp range</th>
<th>Temp coefficient (max) of sensitivity</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMNTAN-D002-TH</td>
<td>No</td>
<td>38.1 ± 0.52 (1.5 ± 0.060)</td>
<td>2.8 (0.11)</td>
<td>6.6 (0.26) max</td>
<td>0.76 ± 0.18 (0.030 ± 0.005)</td>
<td>Plastic</td>
<td>DC to 400 Hz</td>
<td>HSE: 3.5 G, 35 G, 350 G, 3.5 kG</td>
<td>0.25% to 20 kG</td>
<td>0 °C to 75 °C</td>
<td>±0.1 G/°C</td>
<td>Yes</td>
</tr>
<tr>
<td>MNTAN-D002-TH</td>
<td>No</td>
<td>38.1 ± 0.52 (1.5 ± 0.060)</td>
<td>2.8 (0.11)</td>
<td>6.6 (0.26) max</td>
<td>0.76 ± 0.18 (0.030 ± 0.005)</td>
<td>Plastic</td>
<td>DC and 10 Hz to 400 Hz</td>
<td>HSE-1: 30 G, 300 G, 3 kG</td>
<td>0.25% to 20 kG</td>
<td>0 °C to 75 °C</td>
<td>±0.1 G/°C</td>
<td>No</td>
</tr>
</tbody>
</table>

### 3-axis probes

- **Cable length**: 2 m (6.5 ft)
- **Stem**: 83 mm (3.25 in)
- **Diameter**: 12.7 mm (0.5 in)

### Specifications

<table>
<thead>
<tr>
<th>L mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Corrected accuracy (% rdg at 25 °C)</th>
<th>Operating temp range</th>
<th>Temp coefficient (max) of sensitivity</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MMZ-2502-UH</td>
<td>54±3.2 (2.125±0.125)</td>
<td>Aluminum</td>
<td>DC and 10 Hz to 400 Hz</td>
<td>HSE-1: 30 G, 300 G, 3 kG</td>
<td>0.25% to 20 kG; 0.5% from 20 kG to 30 kG</td>
<td>10 °C to 40 °C</td>
<td>±0.09 G/°C</td>
</tr>
<tr>
<td>MMZ-2504-UH</td>
<td>104.8±3.2 (4.125±0.125)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMZ-2508-UH</td>
<td>206.4±3.2 (8.125±0.125)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMZ-2512-UH</td>
<td>308±3.2 (12.125±0.125)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMZ-2518-UH</td>
<td>460±6.4 (18.125±0.25)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMZ-2536-UH</td>
<td>918±6.4 (36.125±0.25)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MMZ-2560-UH</td>
<td>1534±6.4 (60.375±0.5)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** The sensors at the ends of the multi-axis probes are quite fragile and susceptible to damage. Lake Shore offers an assortment of brass covers for probe protection during use with DC fields. For more information, contact Lake Shore.
### Axial probes for cryogenic applications

<table>
<thead>
<tr>
<th>Model</th>
<th>RoHS</th>
<th>L (mm)</th>
<th>D (mm)</th>
<th>A (mm)</th>
<th>Active area (mm²)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Corrected accuracy (% rdg at 25 °C)</th>
<th>Operating temp range</th>
<th>Temp error (approx) calibration</th>
<th>Temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>for Models 475, 455, and 425</td>
<td></td>
<td>9.1 ± 0.76 mm (0.36 ± 0.030 in) diam</td>
<td>64 mm (2.5 in)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMCA-2560-WN</td>
<td>No</td>
<td>1524 ±12.7 (60 ± 0.50)</td>
<td>6.35 dia ±0.15 (0.25 dia ±0.006)</td>
<td>0.64 ±0.13 (0.025 dia ±0.005)</td>
<td>Approx 0.76 dia (0.030 dia)</td>
<td>Stainless steel</td>
<td>DC</td>
<td>HST-3</td>
<td>±2% to 100 kG</td>
<td>1.5 K to 350 K</td>
<td>±0.13 G/°C</td>
<td>No</td>
</tr>
<tr>
<td>MCA-2560-WN</td>
<td>No</td>
<td>1524 ±12.7 (60 ± 0.50)</td>
<td>6.35 dia ±0.15 (0.25 dia ±0.006)</td>
<td>0.64 ±0.13 (0.025 dia ±0.005)</td>
<td>Approx 0.76 dia (0.030 dia)</td>
<td>Stainless steel</td>
<td>DC</td>
<td>HST-1</td>
<td>±2% to 100 kG</td>
<td>1.5 K to 350 K</td>
<td>±0.13 G/°C</td>
<td>No</td>
</tr>
</tbody>
</table>

### Transverse probes for cryogenic applications

<table>
<thead>
<tr>
<th>Model</th>
<th>RoHS</th>
<th>L (mm)</th>
<th>D (mm)</th>
<th>A (mm)</th>
<th>Active area (mm²)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Corrected accuracy (% rdg at 25 °C)</th>
<th>Operating temp range</th>
<th>Temp error (approx) calibration</th>
<th>Temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>for Models 475, 455, and 425</td>
<td></td>
<td>9.1 ± 0.76 mm (0.36 ± 0.030 in) diam</td>
<td>64 mm (2.5 in)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>HMCT-3160-WN</td>
<td>No</td>
<td>1549 ±25.4 (61 ± 1)</td>
<td>6.35 dia ±0.25 (0.25 dia ±0.010)</td>
<td>5.33 ±1.27 (0.210 ±0.050)</td>
<td>Approx 1 dia (0.040 dia)</td>
<td>Stainless steel</td>
<td>DC to 800 Hz</td>
<td>HST-3</td>
<td>±2% to 100 kG</td>
<td>1.5 K to 350 K</td>
<td>±0.13 G/°C</td>
<td>No</td>
</tr>
<tr>
<td>MCT-3160-WN</td>
<td>No</td>
<td>1549 ±25.4 (61 ± 1)</td>
<td>6.35 dia ±0.25 (0.25 dia ±0.010)</td>
<td>5.33 ±1.27 (0.210 ±0.050)</td>
<td>Approx 1 dia (0.040 dia)</td>
<td>Stainless steel</td>
<td>DC and 10 Hz to 400 Hz</td>
<td>HST-1</td>
<td>±2% to 100 kG</td>
<td>1.5 K to 350 K</td>
<td>±0.13 G/°C</td>
<td>No</td>
</tr>
</tbody>
</table>
### Transverse probes for Model 410 gaussmeter

![Diagram of transverse probes for Model 410 gaussmeter]

<table>
<thead>
<tr>
<th>L mm (in)</th>
<th>Active area mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Accuracy (% rdg at 25 °C)</th>
<th>Temp coefficient (max) zero</th>
<th>Temp coefficient (max) calibration</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MST-410</td>
<td>66 ±6.4 (2.6 ±0.25)</td>
<td>Flexible plastic tubing</td>
<td>DC to 10 kHz</td>
<td>200 G, 2 kG, 20 kG</td>
<td>2%</td>
<td>-10 °C to +75 °C</td>
<td>0.1 G/°C</td>
<td>-0.06%/°C</td>
</tr>
</tbody>
</table>

### Brass stem transverse probes for Model 410 gaussmeter

![Diagram of brass stem transverse probes for Model 410 gaussmeter]

<table>
<thead>
<tr>
<th>L mm (in)</th>
<th>Active area mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Accuracy (% rdg at 25 °C)</th>
<th>Temp coefficient (max) zero</th>
<th>Temp coefficient (max) calibration</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MST-9P02-410</td>
<td>50.8 ±3.2 (2 ±0.125)</td>
<td>Brass</td>
<td>DC</td>
<td>200 G, 2 kG, 20 kG</td>
<td>2%</td>
<td>-10 °C to +75 °C</td>
<td>0.1 G/°C</td>
<td>-0.06%/°C</td>
</tr>
<tr>
<td>MST-9P04-410</td>
<td>101.6 ±3.2 (4 ±0.125)</td>
<td>Flexible plastic tubing</td>
<td>DC to 10 kHz</td>
<td>200 G, 2 kG, 20 kG</td>
<td>2%</td>
<td>-10 °C to +75 °C</td>
<td>0.1 G/°C</td>
<td>-0.06%/°C</td>
</tr>
</tbody>
</table>

### Axial probes for Model 410 gaussmeter

![Diagram of axial probes for Model 410 gaussmeter]

<table>
<thead>
<tr>
<th>L mm (in)</th>
<th>Active area mm (in)</th>
<th>Stem material</th>
<th>Frequency range</th>
<th>Usable full-scale ranges</th>
<th>Accuracy (% rdg at 25 °C)</th>
<th>Operating temp range</th>
<th>Temp coefficient (max) zero</th>
<th>Temp coefficient (max) calibration</th>
<th>Contains temp sensor</th>
</tr>
</thead>
<tbody>
<tr>
<td>MST-2202-410</td>
<td>50.8 ±3.2 (2 ±0.125)</td>
<td>Flexible plastic tubing</td>
<td>DC</td>
<td>200 G, 2 kG, 20 kG</td>
<td>2%</td>
<td>-10 °C to +75 °C</td>
<td>0.1 G/°C</td>
<td>-0.06%/°C</td>
<td>No</td>
</tr>
<tr>
<td>MST-2204-410</td>
<td>101.6 ±3.2 (4 ±0.125)</td>
<td>Flexible plastic tubing</td>
<td>DC to 10 kHz</td>
<td>200 G, 2 kG, 20 kG</td>
<td>2%</td>
<td>-10 °C to +75 °C</td>
<td>0.1 G/°C</td>
<td>-0.06%/°C</td>
<td>No</td>
</tr>
</tbody>
</table>
Magnetics accessories

Reference magnets

High quality reference magnets are available in transverse (flat) and axial (round) configurations—also see Helmholtz coil low field references on page 57.

Zero gauss chambers

To obtain a null field reference, a zero gauss chamber must be used to shield the probe sensing area from external field.

### Zero gauss chambers

<table>
<thead>
<tr>
<th>Size</th>
<th>Bore</th>
</tr>
</thead>
<tbody>
<tr>
<td>4060 – Standard</td>
<td>33 mm × 33 mm × 61 mm (1.3 in × 1.3 in × 2.4 in)</td>
</tr>
<tr>
<td>4065 – Large</td>
<td>58 mm × 53 mm × 305 mm (2.3 in × 2.1 in × 12 in)</td>
</tr>
</tbody>
</table>
Introduction

Magnetic Field Technology

Lake Shore Cryotronics, Inc.  |  t. 614.891.2244  |  f. 614.818.1600  |  e. info@lakeshore.com  |  www.lakeshore.com

Extension cables

To maintain probe accuracy, probes and extension cables for Models 460, 450, and 421 must be calibrated together at Lake Shore. When ordering an extension cable and more than one probe, it is necessary to specify with which probe the cable will be used. It should be noted that probes will exhibit their full accuracy specifications when used without an extension cable. Model 460 2- and 3-axis probes require 2- and 3-extension cables, respectively. Extension cables for Models 475 and 455 are field programmable, but can be ordered factory-calibrated.

Hall probe stands

These moveable probe stands consist of a 30 mm (1.2 in) square post mounted on a 180 mm × 130 mm × 22.5 mm (7.1 × 5.1 × 0.9 in) thick base plate. A probe holder is integrated into the stand. The holder can be moved up or down and fixed at any angle and location along the post. Two standard models are available. Consult Lake Shore for other post heights.

Extension cables

To maintain probe accuracy, probes and extension cables for Models 460, 450, and 421 must be calibrated together at Lake Shore. When ordering an extension cable and more than one probe, it is necessary to specify with which probe the cable will be used. It should be noted that probes will exhibit their full accuracy specifications when used without an extension cable. Model 460 2- and 3-axis probes require 2- and 3-extension cables, respectively. Extension cables for Models 475 and 455 are field programmable, but can be ordered factory-calibrated.

Probe extension cables for Model 460, 450, and 421 gaussmeters

<table>
<thead>
<tr>
<th>Length</th>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 m (10 ft)</td>
<td>MPEC-10</td>
<td>475/455 probe extension cable with EEPROM</td>
</tr>
<tr>
<td>7.6 m (25 ft)</td>
<td>MPEC-25</td>
<td>475/455 probe extension cable with EEPROM</td>
</tr>
<tr>
<td>15 m (50 ft)</td>
<td>MPEC-50</td>
<td>475/455 probe extension cable with EEPROM</td>
</tr>
<tr>
<td>30 m (100 ft)</td>
<td>MPEC-100</td>
<td>475/455 probe extension cable with EEPROM</td>
</tr>
</tbody>
</table>

Probe extension cables for Model 475 and 455 gaussmeters

<table>
<thead>
<tr>
<th>Length</th>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>3 m (10 ft)</td>
<td>HMPEC-10</td>
<td>475/455 probe extension cable with EEPROM</td>
</tr>
<tr>
<td>7.6 m (25 ft)</td>
<td>HMPEC-25</td>
<td>475/455 probe extension cable with EEPROM</td>
</tr>
<tr>
<td>15 m (50 ft)</td>
<td>HMPEC-50</td>
<td>475/455 probe extension cable with EEPROM</td>
</tr>
<tr>
<td>30 m (100 ft)</td>
<td>HMPEC-100</td>
<td>475/455 probe extension cable with EEPROM</td>
</tr>
</tbody>
</table>

All specifications are subject to change without notice.

Ordering information

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4030-12</td>
<td>Hall probe stand, 12 in post, accepts 3/8 in dia. Hall probe handle</td>
</tr>
<tr>
<td>4030-24</td>
<td>Hall probe stand, 24 in post, accepts 3/8 in dia. Hall probe handle</td>
</tr>
<tr>
<td>4060</td>
<td>Small zero gauss chamber</td>
</tr>
<tr>
<td>4065</td>
<td>Large zero gauss chamber</td>
</tr>
<tr>
<td>MRA-312-100</td>
<td>Axial reference magnet: 0.312 in inside diameter, 100 G, 1%</td>
</tr>
<tr>
<td>MRA-312-200</td>
<td>Axial reference magnet: 0.312 in inside diameter, 200 G, 1%</td>
</tr>
<tr>
<td>MRA-312-300</td>
<td>Axial reference magnet: 0.312 in inside diameter, 300 G, 1%</td>
</tr>
<tr>
<td>MRA-312-500</td>
<td>Axial reference magnet: 0.312 in inside diameter, 500 G, 1%</td>
</tr>
<tr>
<td>MRA-312-1K</td>
<td>Axial reference magnet: 0.312 in inside diameter, 1 kG, 1%</td>
</tr>
<tr>
<td>MRA-312-2K</td>
<td>Axial reference magnet: 0.312 in inside diameter, 2 kG, 1%</td>
</tr>
<tr>
<td>MRT-062-200</td>
<td>Transverse reference magnet: 0.062 in gap, 200 G, 1%</td>
</tr>
<tr>
<td>MRT-062-500</td>
<td>Transverse reference magnet: 0.062 in gap, 500 G, 1%</td>
</tr>
<tr>
<td>MRT-062-1K</td>
<td>Transverse reference magnet: 0.062 in gap, 1 kG, 0.5%</td>
</tr>
<tr>
<td>MRT-062-2K</td>
<td>Transverse reference magnet: 0.062 in gap, 2 kG, 0.5%</td>
</tr>
<tr>
<td>MRT-062-5K</td>
<td>Transverse reference magnet: 0.062 in gap, 5 kG, 0.5%</td>
</tr>
<tr>
<td>MRT-062-10K</td>
<td>Transverse reference magnet: 0.062 in gap, 10 kG, 0.5%</td>
</tr>
<tr>
<td>MRT-343-50</td>
<td>Transverse reference magnet: 0.343 in gap, 50 G, 1%</td>
</tr>
<tr>
<td>MRT-343-100</td>
<td>Transverse reference magnet: 0.343 in gap, 100 G, 1%</td>
</tr>
<tr>
<td>MRT-343-200</td>
<td>Transverse reference magnet: 0.343 in gap, 200 G, 1%</td>
</tr>
<tr>
<td>MRT-343-1K</td>
<td>Transverse reference magnet: 0.343 in gap, 1 kG, 1%</td>
</tr>
<tr>
<td>MRT-343-2K</td>
<td>Transverse reference magnet: 0.343 in gap, 2 kG, 1%</td>
</tr>
</tbody>
</table>

All specifications are subject to change without notice.
InAs and GaAs Hall Sensors

Hall sensor theory

A Hall sensor is a solid state sensor which provides an output voltage proportional to magnetic flux density. As implied by its name, this device relies on the Hall effect. The Hall effect is the development of a voltage across a sheet of conductor when current is flowing and the conductor is placed in a magnetic field.

Electrons (the majority carrier most often used in practice) “drift” in the conductor when under the influence of an externally produced electric field. These moving electrons experience a force proportional and perpendicular to the product of their velocity and the magnetic field vector. This force causes the charging of the edges of the conductor, one side positive with respect to the other, resulting in an internally generated transverse electric field which exerts a force on the moving electrons equal and opposite to that caused by the magnetic-field-related Lorentz force. The resultant voltage potential across the width of the conductor is called the Hall voltage and can be measured by attaching two electrical contacts to the sides of the conductor.

The Hall voltage can be given by the expression:

\[ V_H = Y_B B \sin \theta \]

where

- \( V_H \) = Hall voltage (mV)
- \( Y_B \) = Magnetic sensitivity (mV per kG, at a fixed current)
- \( B \) = Magnetic field flux density (kG)
- \( \theta \) = Angle between magnetic flux vector and the plane of Hall sensor

As can be seen from the above formula, the Hall voltage varies with the angle of the sensed magnetic field, reaching a maximum when the field is perpendicular to the plane of the Hall sensor.

Active area

The Hall sensor assembly contains the sheet of semiconductor material to which the four contacts are made. This entity is normally called a “Hall plate.” The Hall plate is, in its simplest form, a rectangular shape of fixed length, width and thickness. Due to the shorting effect of the current supply contacts, most of the sensitivity to magnetic fields is contained in an area approximated by a circle, centered in the Hall plate, whose diameter is equal to the plate width. Thus, when the active area is given, the circle as described above is the common estimation.
Using a Hall sensor

A Hall sensor is a 4-lead device. The control current \( I_c \) leads are normally attached to a current source such as the Lake Shore Model 121. The Model 121 provides several fixed current values compatible with various Hall sensors.

**Caution:** Do not exceed the maximum continuous control current given in the specifications.

The Hall voltage leads may be connected directly to a readout instrument, such as a high impedance voltmeter, or can be attached to electronic circuitry for amplification or conditioning. Device signal levels will be in the range of microvolts to hundreds of millivolts.

The Hall sensor input is not isolated from its output. In fact, impedance levels on the order of the input resistance are all that generally exist between the two ports. To prevent erroneous current paths, which can cause large error voltages, the current supply must be isolated from the output display or the downstream electronics.

**Attaching discrete Hall sensors to Lake Shore gaussmeters**

Lake Shore provides cable assemblies containing the electronic memory (EEPROM) to interface a Hall sensor to a gaussmeter. This allows users to assemble a Hall sensor into a difficult to access area prior to gaussmeter attachment. The figure below shows the general cable configuration. While convenient, this method provides less than optimum performance. Because of the intricacies involved with proper calibration, the user is responsible for the measurement accuracy. A probe fully calibrated by Lake Shore is always suggested. Special probe mechanical configurations are also available.

Certain Hall sensor sensitivity constraints are applicable:

- Sensitivities between 5.5 and 10.5 mV/kG at 100 mA control current.
- Sensitivities between 0.55 and 1.05 mV/kG at 100 mA control current.

**For the Model 475, 455, and 425 gaussmeters**

2 m (6 ft) and 6.1 m (20 ft) cables are available.

The 475, 455, and 425 gaussmeters offer the convenience of front panel programming. No external computer is required.

The Hall sensor serial number and single-point sensitivity are directly entered using the keypad.

**For the Model 460, 450, and 421 gaussmeters**

Connection of discrete Hall sensors to these instruments is no longer supported. Contact Service for ongoing support of these instruments.

---

**Ordering information**

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HMCBL-6</td>
<td>1.8 m (6 ft) long cable for Model 475 and 455</td>
</tr>
<tr>
<td>HMCBL-20</td>
<td>6.1 m (20 ft) long cable for Model 475 and 455</td>
</tr>
</tbody>
</table>

All specifications are subject to change without notice.
Axial Hall sensors

**Lead colors:**
- Red: +I<sub>C</sub>
- Green: -I<sub>C</sub>
- Blue: +V<sub>H</sub>
- Clear: -V<sub>H</sub>

### HGA-2010**
- Description: General purpose axial; high sensitivity
- Active area (approx): 0.127 × 0.127 mm (0.005 in × 0.005 in) square
- Input resistance (approx): 450 Ω to 900 Ω
- Output resistance (approx): 550 Ω to 1350 Ω
- Nominal control current (I<sub>CN</sub>): 1 mA
- Maximum continuous current (non-heat sinked, 25 °C): 10 mA
- Magnetic sensitivity (I<sub>C</sub> = nominal control current): 11 mV/kG to 28 mV/kG
- Maximum linearity error (sensitivity vs. field, % rdg): ±1 (-10 kG to +10 kG)
- Zero field offset voltage (I<sub>C</sub> = nominal control current): ±2.8 mV (max)

### HGA-2302
- Description: General purpose axial; 3.30 mm (0.13 in) diameter
- Active area (approx): 0.51 × 0.020 mm (0.020 × 0.040 in) rectangle
- Input resistance (approx): 2 Ω
- Output resistance (approx): 2 Ω
- Nominal control current (I<sub>CN</sub>): 100 mA
- Maximum continuous current (non-heat sinked, 25 °C): 150 mA
- Magnetic sensitivity (I<sub>C</sub> = nominal control current): 5.5 mV/kG to 11.0 mV/kG
- Maximum linearity error (sensitivity vs. field, % rdg): ±1 (-10 kG to +10 kG)
- Zero field offset voltage (I<sub>C</sub> = nominal control current): ±100 µV (max)

### HGA-2303
- Description: General purpose axial; 4.95 mm (0.195 in) diameter
- Active area (approx): 0.51 × 0.020 mm (0.020 × 0.040 in) rectangle
- Input resistance (approx): 2 Ω
- Output resistance (approx): 2 Ω
- Nominal control current (I<sub>CN</sub>): 200 mA
- Maximum continuous current (non-heat sinked, 25 °C): 200 mA
- Magnetic sensitivity (I<sub>C</sub> = nominal control current): 5.5 mV/kG to 11.0 mV/kG
- Maximum linearity error (sensitivity vs. field, % rdg): ±1 (-30 kG to +30 kG)
- Zero field offset voltage (I<sub>C</sub> = nominal control current): ±50 µV (max)

### HGA-3010**, HGA-3030**
- Description: Instrumentation quality axial; phenolic package
- Active area (approx): 0.76 mm (0.030 in) diameter
- Input resistance (approx): 2 Ω
- Output resistance (approx): 2 Ω
- Nominal control current (I<sub>CN</sub>): 1 Ω
- Maximum continuous current (non-heat sinked, 25 °C): 300 mA
- Magnetic sensitivity (I<sub>C</sub> = nominal control current): 1.05 mV/kG
- Maximum linearity error (sensitivity vs. field, % rdg): ±1.25 (-30 kG to +30 kG)
- Zero field offset voltage (I<sub>C</sub> = nominal control current): ±75 µV (max)

### Ordering information

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGA-2010</td>
<td>General purpose axial Hall sensor; plastic package</td>
</tr>
<tr>
<td>HGA-2302</td>
<td>General purpose axial Hall sensor; phenolic shoulder</td>
</tr>
<tr>
<td>HGA-2303</td>
<td>General purpose axial Hall sensor; phenolic shoulder</td>
</tr>
<tr>
<td>HGA-3010</td>
<td>Instrumentation quality axial Hall sensor; phenolic package</td>
</tr>
<tr>
<td>HGA-3030</td>
<td>Instrumentation quality axial Hall sensor; phenolic package</td>
</tr>
</tbody>
</table>

### Accessories available

- CAL-1X-DATA 1-axis Hall sensor recalibration with certificate and data

All specifications are subject to change without notice.

Lake Shore Cryotronics, Inc. | t. 614.891.2244 | f. 614.818.1600 | e. info@lakeshore.com | www.lakeshore.com
### Specifications

#### InAs and GaAs Hall Sensors

**HGT-1020**
- **Description**: General purpose transverse; flat mount
- **Active area (approx)**: 1.02 mm (0.040 in) diameter circle
- **Input resistance (approx)**: 2 Ω
- **Nominal control current (IC)**: 250 mA
- **Magnetic sensitivity (IC = nominal control current)**: 7.5 mV/kg to 12.5 mV/kg
- **Maximum continuous current (non-heat sunked, 25 °C)**: 250 mA
- **Operating temperature range**: -40 °C to +100 °C
- **Temperature coefficient of magnetic sensitivity (IC = nominal control current)**: -0.08%/°C (max)
- **Temperature coefficient of offset (IC = nominal control current)**: ±1 μV/°C (approx)
- **Temperature coefficient of resistance (IC = nominal control current)**: +0.18%/°C (approx)
- **Leads**: 34 AWG copper with poly-nylon insulation
- **Data**: Single sensitivity value at IC = 100 mA

**HGT-1050**
- **Description**: Low field for magnetic circuit applications
- **Active area (approx)**: 0.76 mm (0.030 in) diameter circle
- **Input resistance (approx)**: 4 Ω (max)
- **Nominal control current (IC)**: 200 mA
- **Magnetic sensitivity (IC = nominal control current)**: 8 mV at 100 Oe (min)
- **Maximum continuous current (non-heat sunked, 25 °C)**: 250 mA
- **Operating temperature range**: -65 °C to +100 °C
- **Temperature coefficient of magnetic sensitivity (IC = nominal control current)**: -0.15%/°C (max)
- **Temperature coefficient of offset (IC = nominal control current)**: ±3 μV/°C (approx)
- **Temperature coefficient of resistance (IC = nominal control current)**: +0.15%/°C (approx)
- **Leads**: 36 AWG copper with poly-nylon insulation
- **Data**: Single sensitivity value at H = 100 Oe

**HGT-1070**
- **Description**: High sensitivity
- **Active area (approx)**: 1.52 × 2.03 mm (0.06 × 0.08 in)
- **Input resistance (approx)**: 2 Ω
- **Nominal control current (IC)**: 50 mA
- **Magnetic sensitivity (IC = nominal control current)**: ±2.0 mV/kG (approx)
- **Maximum continuous current (non-heat sunked, 25 °C)**: 50 mA
- **Operating temperature range**: -40 °C to +100 °C
- **Temperature coefficient of magnetic sensitivity (IC = nominal control current)**: -0.06%/°C (max)
- **Temperature coefficient of offset (IC = nominal control current)**: ±0.005%/°C (max)
- **Temperature coefficient of resistance (IC = nominal control current)**: ±0.04%/°C (max)
- **Leads**: 34 AWG copper with poly-nylon insulation
- **Data**: Single sensitivity value at IC = 100 mA

**HGT-2010**
- **Description**: Instrumentation quality transverse; low temp coefficient; ceramic package
- **Active area (approx)**: 0.127 mm (0.005 in) diameter circle
- **Input resistance (approx)**: 450 Ω to 900 Ω
- **Nominal control current (IC)**: 1 mA
- **Magnetic sensitivity (IC = nominal control current)**: 11 mV/kg to 28 mV/kg
- **Maximum continuous current (non-heat sunked, 25 °C)**: 100 mA
- **Operating temperature range**: -125 °C to -100 °C
- **Temperature coefficient of magnetic sensitivity (IC = nominal control current)**: ±0.30%/°C (approx)
- **Temperature coefficient of offset (IC = nominal control current)**: ±0.01%/°C (approx)
- **Temperature coefficient of resistance (IC = nominal control current)**: ±0.3%/°C (approx)
- **Leads**: 34 AWG copper with poly-nylon insulation
- **Data**: Uncalibrated

**HGT-3010, HGT-3030**
- **Description**: Instrumentation quality transverse ceramic package
- **Active area (approx)**: 1.02 mm (0.040 in) diameter circle
- **Input resistance (approx)**: 1 Ω
- **Nominal control current (IC)**: 100 mA
- **Magnetic sensitivity (IC = nominal control current)**: ±2% rdg (-10 to 10 kG)
- **Maximum continuous current (non-heat sunked, 25 °C)**: 100 mA
- **Operating temperature range**: -40 °C to +100 °C
- **Temperature coefficient of magnetic sensitivity (IC = nominal control current)**: ±1.5%/°C (approx)
- **Temperature coefficient of offset (IC = nominal control current)**: ±0.06%/°C (max)
- **Temperature coefficient of resistance (IC = nominal control current)**: ±0.05%/°C (max)
- **Leads**: 34 AWG copper with poly-nylon insulation
- **Data**: Room temperature, 30 kG data supplied

---

**Notes:**
- Not compatible with Lake Shore gaussmeters
- Data Single sensitivity value at IC = 100 mA
- Single sensitivity value at H = 100 Oe
- Uncalibrated

---

Lake Shore Cryotronics, Inc. | t. 614.891.2244 | f. 614.818.1600 | e. info@lakeshore.com | www.lakeshore.com
Temperature error table

The magnetic sensitivity generally increases as the temperature drops below 300 K. However, this trend reverses between 200 K and 100 K, and the sensitivity decreases at an increasing rate as the temperature cools. The sensitivity increase versus room temperature is as follows:

<table>
<thead>
<tr>
<th>Temperature (K)</th>
<th>Change in magnetic sensitivity (approx)</th>
</tr>
</thead>
<tbody>
<tr>
<td>200 K</td>
<td>+0.05%</td>
</tr>
<tr>
<td>100 K</td>
<td>−0.04%</td>
</tr>
<tr>
<td>80 K</td>
<td>−0.09%</td>
</tr>
<tr>
<td>20 K</td>
<td>−0.4%</td>
</tr>
<tr>
<td>4 K</td>
<td>−0.7%</td>
</tr>
<tr>
<td>1.5 K</td>
<td>−1.05%</td>
</tr>
</tbody>
</table>

HGCA-3020

Lead Colors:
- Red: +Ic
- Black: −Ic
- Blue: +VH
- Yellow: −VH

HGCT-3020

Ordering information

Axial Hall sensors

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGA-2010</td>
<td>General purpose axial Hall sensor; plastic package</td>
</tr>
<tr>
<td>HGA-2302</td>
<td>General purpose axial Hall sensor; phenolic shoulder</td>
</tr>
<tr>
<td>HGA-2303</td>
<td>General purpose axial Hall sensor; phenolic shoulder</td>
</tr>
<tr>
<td>HGA-3010</td>
<td>Instrumentation quality axial Hall sensor; phenolic package</td>
</tr>
<tr>
<td>HGA-3030</td>
<td>Instrumentation quality axial Hall sensor; phenolic package</td>
</tr>
</tbody>
</table>

Transverse Hall sensors

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGT-1010</td>
<td>General purpose transverse Hall sensor</td>
</tr>
<tr>
<td>HGT-1020</td>
<td>General purpose transverse Hall sensor</td>
</tr>
<tr>
<td>HGT-1050</td>
<td>General purpose transverse Hall sensor; flat mount</td>
</tr>
<tr>
<td>HGT-1070</td>
<td>Ferrite embedded transverse Hall sensor</td>
</tr>
<tr>
<td>HGT-2010</td>
<td>General purpose transverse Hall sensor</td>
</tr>
<tr>
<td>HGT-2101</td>
<td>Surface mount transverse Hall sensor</td>
</tr>
<tr>
<td>HGT-3010</td>
<td>Instrumentation quality transverse Hall sensor; ceramic package</td>
</tr>
<tr>
<td>HGT-3030</td>
<td>Instrumentation quality transverse Hall sensor; ceramic package</td>
</tr>
</tbody>
</table>

Cryogenic Hall sensors

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGCA-3020</td>
<td>Cryogenic axial Hall sensor; phenolic package</td>
</tr>
<tr>
<td>HGCT-3020</td>
<td>Cryogenic transverse Hall sensor; ceramic package</td>
</tr>
</tbody>
</table>

Accessories available

| CAL-1X-DATA | 1-axis Hall sensor recalibration with certificate and data |

All specifications are subject to change without notice.
Model 480 Fluxmeter

**Model 480 features**

- 5½-digit DC resolution (1 part out of ±300,000)
- Automatic drift compensation
- Very fast peak capture
- AC frequency response to 50 kHz
- IEEE-488 and serial interfaces
- Storage of parameters for up to 10 existing coils
- CE mark certification
Product description
An advanced tool designed primarily for use in industrial and measurement systems settings, the Model 480 fluxmeter measures total flux from which B, flux density, and H, magnetic field strength, can be determined. The Model 480 is valuable for magnetizing, manual and automated magnet testing and sorting, and as the main component in BH loop or hysteresis measurement system applications. The Model 480 is compatible with most sensing coils and fixtures.

Manual magnet testing
A bright display and fast update rate make the Model 480 ideal for manual magnet sorting and testing. The instrument’s low drift improves productivity with fewer adjustments. Remote terminals allow for foot pedal reading reset to keep hands on the work, not the instrument. Configurable alarms give an audible signal or relay closure to signify pass/fail.

Automated magnet testing
In automated testing, time is money. The Model 480 has many features to enhance throughput. The instrument has a fast update rate and fast settling time. It recovers quickly from reading reset to start a new reading cycle. The IEEE-488 and serial interfaces included with the Model 480 can be used to control most instrument functions. Relays and analog outputs can be used for automation without a computer interface.

Magnetizing
The magnetizing process places unique demands on all associated electronics. The Model 480 responds with a very fast peak capture that can keep up with the fastest magnetizing pulses. Both a positive and negative peak can be captured from the same pulse. The input of the Model 480 is protected against the high voltages present during magnetizing.

Materials analysis
High resolution and low drift define a fluxmeter’s role in analytical measurement. The high resolution of the Model 480 is reinforced by a low noise floor. A configurable filter helps keep the readings quiet. Automatic and manual drift adjustment modes help optimize the integrators’ low drift characteristics. The IEEE-488 and serial computer interfaces included with the Model 480 allow automated data taking.

AC magnetic fields
Sensing coils are sensitive to AC magnetic fields but many conventional integrating fluxmeters can not measure AC fields. The Model 480 has an AC mode that enables it to measure fields over a wide frequency range using simple sensing coils. Applications are limited to field volumes as large as or larger than the coil, but for some it is an inexpensive way to make low drift AC field measurements.

Drift adjustment
Adjusting or nulling the drift of an analog integrator wastes time—it can be the only unpleasant part of using an integrating fluxmeter. Lake Shore innovation brings some relief. The Model 480 has a built-in drift algorithm that continually adjusts drift when the instrument and coil are idle. It is ready when you are to make precision low-drift measurements. The adjustment algorithm has no effect during flux integration. Manual drift adjustment is also available.

Display
The Model 480 has a 2-line by 20-character vacuum fluorescent display. During normal operation, the display is used to report field readings and give results of other features such as max/min or relative. When setting instrument parameters, the display gives the operator meaningful prompts and feedback to simplify operation. The operator can also control display brightness.

Following are three examples of the various display configurations:

- **Alarm on**—the alarm gives an audible and visual indication of when the flux value is selectively outside or inside a user-specified range.
FH-series Helmholtz coils

Lake Shore coils can be used with the Model 480 fluxmeter as well as with other fluxmeters. When used with a Model 480 fluxmeter, calibration and setup data are automatically loaded into the instrument. These probes and coils are accurately calibrated, using field standards maintained at Lake Shore. Most standards are traceable to physical standards such as a coil or probe of carefully controlled dimensions, or in some cases, to proton resonance. The coil constants are measured on the basis of the field generated by a current through the coil.

See pages 56, 57, and 58 for more information about available Helmholtz and search coils.

Helmholtz and search coils

Coils and probes wound by the user or from other manufacturers can be easily used with the Model 480. The Model 480 allows the user to save parameters for up to 10 existing coils/probes and quickly switch between them. Lake Shore also offers several sensing coils and probe assemblies for use with the Model 480 that have several conveniences. They are factory calibrated for accuracy and interchangeability. Calibration data is loaded into memory in the probe connector so it does not have to be entered by the user. Special coil assemblies are also available and can be designed to meet customer specifications.

Model 480 rear panel

1. Line input assembly
2. Serial I/O interface
3. IEEE-488 interface
4. Terminal block (for relays and analog signals)*
5. Coil input for user coils
6. Probe input for Lake Shore probes

* The Model 480 terminal block has connections for external reset. With this feature, a foot pedal or programmable logic controller (PLC) can be used to start a new measurement cycle. The external reset is TTL-compatible and a logic low will activate a reset. The signal is internally pulled up to allow operation with a simple switch closure between pins 12 and 13.
Model 480 specifications

Measurement

**Number of inputs:** 1

**Input type:** 2-lead, ground referenced

**Input resistance:** 100 kΩ or 10 kΩ

**Maximum operating input voltage:** 60 V

| Absolute maximum input voltage: 100 V — **WARNING**—voltages between 60 V and 100 V will not damage the instrument but could result in personal injury or damage to other instruments |
| Update rate: 5 rdg/s; display, 30 rdg/s IEEE-488; 30 rdg/s serial |

**DC**

**DC resolution:** To 5½ digits

**DC integrator capacitance:** 1 µF nominal

<table>
<thead>
<tr>
<th>DC input resistance</th>
<th>100 kΩ</th>
<th>100 kΩ</th>
<th>10 kΩ</th>
<th>10 kΩ</th>
</tr>
</thead>
<tbody>
<tr>
<td>DC ranges</td>
<td>300 mVs</td>
<td>30 mVs</td>
<td>30 mVs</td>
<td>3 mVs</td>
</tr>
<tr>
<td>DC resolution</td>
<td>0.001 mVs</td>
<td>0.0005 mVs</td>
<td>0.0005 mVs</td>
<td>0.0005 mVs</td>
</tr>
<tr>
<td>DC accuracy</td>
<td>±10 µV</td>
<td>±DC integrator drift; gain: ±0.25% of reading (&lt;10 V/s maximum rate of change)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC minimum dΦ/dt</td>
<td>20 µVs/min</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC maximum dΦ/dt</td>
<td>60 V/s</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DC integrator drift</td>
<td>±1 µV/min, 0.0004% full scale/min on 300 mVs range (100 kΩ input resistance constant temperature environment)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**AC**

**AC resolution:** 4½ digits

**AC integrator capacitance:** 1 µF nominal

<table>
<thead>
<tr>
<th>AC input resistance</th>
<th>100 kΩ</th>
<th>100 kΩ</th>
<th>10 kΩ</th>
<th>10 kΩ</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC ranges</td>
<td>30 mVs</td>
<td>3 mVs</td>
<td>300 µVs</td>
<td>30 µVs</td>
</tr>
<tr>
<td>AC resolution</td>
<td>0.001 mVs</td>
<td>0.0001 mVs</td>
<td>0.01 µVs</td>
<td>0.01 µVs</td>
</tr>
<tr>
<td>AC minimum reading</td>
<td>3.000 mVs</td>
<td>0.3000 mVs</td>
<td>30.00 µVs</td>
<td>3.00 µVs</td>
</tr>
<tr>
<td>AC frequency response: 2 Hz to 50 kHz</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>AC accuracy</td>
<td>±1% rdg</td>
<td>±10 µVs (10 Hz to 10 kHz sinusoidal); ±5% rdg</td>
<td>±10 µVs (2 Hz to 50 kHz sinusoidal)</td>
<td></td>
</tr>
<tr>
<td>AC integrator drift</td>
<td>NA</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Relays**

**Number:** 3

**Contacts:** Normally open (NO), normally closed (NC), and common (C)

**Contact rating:** 30 VDC at 2 A

**Operation:** Follow high, low alarms with third relay indicating no alarm state—can be operated manually

**Connector:** Detachable terminal block

**Monitor analog output**

**Scale:** ±3 V = full scale on Vs range

**Accuracy:** ±1% of reading ±10 mV, (DC to 10 kHz); ±5% of reading ±10 mV, (10 kHz to 50 kHz)

**Minimum load resistance:** 1 kΩ

**Connector:** Detachable terminal block

**Corrected analog output**

**Scale:** User selected

**Range:** ±10 V

**Resolution:** 0.3 mV

**Accuracy:** ±2.5 mV

**Minimum load resistance:** 1 kΩ

**Connector:** Detachable terminal block

**General**

**Ambient temperature:** 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C with reduced accuracy

**Power requirement:** 100, 120, 220, 240 VAC, ±5% -10%, 50 or 60 Hz; 20 VA

**Size:** 216 mm W × 89 mm H × 318 mm D (8.5 in × 3.5 in × 12.5 in), half rack

**Weight:** 5 kg (6.6 lb)

**Approval:** CE mark, RoHS

**Accessories included**

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>119-028</td>
<td>240 V—U.S. cord (NEMA 5-15)</td>
</tr>
<tr>
<td>240 V—Euro cord (CEE 717)</td>
<td></td>
</tr>
<tr>
<td>240 V—Euro cord (CEE 717)</td>
<td></td>
</tr>
<tr>
<td>240 V—U.K. cord (BS 1363)</td>
<td></td>
</tr>
<tr>
<td>240 V—Swiss cord (SEV 1011)</td>
<td></td>
</tr>
<tr>
<td>720 V—China cord (GB 1002)</td>
<td></td>
</tr>
</tbody>
</table>

**Accessories available**

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>4005</td>
<td>1 m (3.3 ft) long IEEE-488 (GPIB) computer interface cable assembly—including extender required for simultaneous use of IEEE cable and auxiliary terminal block</td>
</tr>
<tr>
<td>CAL-480-CERT</td>
<td>Instrument recalibration with certificate</td>
</tr>
<tr>
<td>CAL-480-DATA</td>
<td>Instrument recalibration with certificate and data</td>
</tr>
<tr>
<td>CAL-NEW-DATA</td>
<td>Calibration data for a new instrument</td>
</tr>
<tr>
<td>RM-1/2</td>
<td>Rack mount kit for mounting one Model 480 in 483 mm (19 in) rack</td>
</tr>
<tr>
<td>RM-2</td>
<td>Rack mount kit for mounting two Model 480s in 483 mm (19 in) rack</td>
</tr>
</tbody>
</table>

| Coils—see pages 56, 57, and 58 for more information |
| FNT-6R04-100 | 100 cm² search coil |
| FNT-6R04-30  | 30 cm² search coil |
| FH-2.5       | Helmholtz coil, 64 mm (2.5 in) ID |
| FH-6         | Helmholtz coil, 152 mm (6 in) ID |
| FH-12        | Helmholtz coil, 305 mm (12 in) ID |
| FCBL-6       | User programmable cable with PROM, 1.5 m (5 ft) long |

All specifications are subject to change without notice
Search coils
(for use with the Model 480 fluxmeter only)

The 100 cm² field probe is the most commonly used search coil, while the 30 cm² field probe is useful for measurements in narrow gaps or where field gradients dictate the use of a smaller coil diameter.

<table>
<thead>
<tr>
<th>Specifications</th>
<th>FNT-6R04-100</th>
<th>FNT-5P04-30</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration accuracy</td>
<td>0.25%</td>
<td>0.35%</td>
</tr>
<tr>
<td>Area-turns (approx)</td>
<td>100 cm²</td>
<td>30 cm²</td>
</tr>
<tr>
<td>Coil resistance (approx)</td>
<td>6.5 Ω</td>
<td>110 Ω</td>
</tr>
<tr>
<td>Average coil diameter</td>
<td>10.4 mm</td>
<td>3.9 mm</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>0 °C to 60 °C</td>
<td></td>
</tr>
<tr>
<td>RoHS</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Input resistance (fluxmeter)</td>
<td>10 kΩ</td>
<td>100 kΩ</td>
</tr>
<tr>
<td>DC ranges</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Φ</td>
<td>30 mV·s</td>
<td>300 mT</td>
</tr>
<tr>
<td></td>
<td>3 mV·s</td>
<td>3 T</td>
</tr>
<tr>
<td>B</td>
<td>30 T</td>
<td>300 mT</td>
</tr>
<tr>
<td></td>
<td>3 mT</td>
<td>300 μT</td>
</tr>
<tr>
<td></td>
<td>30 μV·s</td>
<td>10 mT</td>
</tr>
<tr>
<td>Additional AC ranges</td>
<td></td>
<td></td>
</tr>
<tr>
<td>300 μV·s</td>
<td>3 mV·s</td>
<td>30 mT</td>
</tr>
<tr>
<td>30 μV·s</td>
<td>3 mT</td>
<td>300 μT</td>
</tr>
<tr>
<td>3 μV·s</td>
<td>3 mT</td>
<td>300 μV·s</td>
</tr>
</tbody>
</table>

**FNT-6R04-100**

- 1.5 m (5 ft) dia (max)
- 19.1 mm (0.75 in) dia (approx)
- 102 mm (4 in) dia (approx)
- 102 ±3.18 mm (±0.125 in)
- 6.9 mm (0.35 in)
- 17.8 mm (0.7 in)
- 1.57 mm (0.062 in)

**FNT-5P04-30**

- 1.5 m (5 ft) dia (max)
- 9.1 mm (0.36 in) dia (approx)
- 76 mm (3 in) dia (approx)
- 102 ±3.18 mm (±0.125 in)
- 5.84 mm (0.23 in)
- 8.13 mm (0.32 in)

**NOTE:** Φ is designated as that flux passing through the coil, into the side with the Lake Shore logo on the probe handle.

**Ordering information**

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FNT-5P04-30</td>
<td>Field probe: 30 cm²</td>
</tr>
<tr>
<td>FNT-6R04-100</td>
<td>Field probe: 100 cm²</td>
</tr>
</tbody>
</table>

All specifications are subject to change without notice.
Helmholtz Coils

Field standards
- Field accuracy of 0.75%
- Field uniformity of 0.5%*
- Standard field coil (field generation)
- Maximum field strengths from ≈26 G to ≈60 G
- Single axis configuration with 2.5 in, 6 in, and 12 in diameter coils

Magnet moment measurement
- Calibration accuracy of 0.5%
- Use with Model 480 fluxmeter only
- Inspection and research of magnets (measure moment)
- Single and 2-axis configurations with 2.5 in, 6 in and 12 in diameter coils

*Model dependent, see technical specifications
Magnet moment measurement for use with the Model 480 fluxmeter only

We offer 3 Helmholtz coils for fluxmeter moment measurements: 64 mm (2.5 in), 152 mm (6 in), and 305 mm (12 in) diameter.

<table>
<thead>
<tr>
<th></th>
<th>FH-2.5</th>
<th>FH-6</th>
<th>FH-12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration accuracy</td>
<td>0.75%</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Inside diameter</td>
<td>64 mm (2.5 in)</td>
<td>152 mm (6 in)</td>
<td>305 mm (12 in)</td>
</tr>
<tr>
<td>Coil resistance (approx)</td>
<td>35 Ω</td>
<td>110 Ω</td>
<td>140 Ω</td>
</tr>
<tr>
<td>Operating temperature range</td>
<td>0 °C to 60 °C</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Coil constant (approx)</td>
<td>0.013 Wb-cm/V·s</td>
<td>0.016 Wb-cm/V·s</td>
<td>0.047 Wb-cm/V·s</td>
</tr>
<tr>
<td>Input resistance (fluxmeter)</td>
<td>10 kΩ</td>
<td>100 kΩ</td>
<td>100 kΩ</td>
</tr>
<tr>
<td>Range (approx)</td>
<td>390 µWb-cm</td>
<td>3.9 mWb-cm</td>
<td>480 µWb-cm</td>
</tr>
<tr>
<td></td>
<td>39 µWb-cm</td>
<td>390 µWb-cm</td>
<td>48 µWb-cm</td>
</tr>
</tbody>
</table>

**Ordering information**

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>FH-2.5</td>
<td>64 mm (2.5 in) Helmholtz coil</td>
</tr>
<tr>
<td>FH-6</td>
<td>152 mm (6 in) Helmholtz coil</td>
</tr>
<tr>
<td>FH-12</td>
<td>305 mm (12 in) Helmholtz coil</td>
</tr>
</tbody>
</table>

All specifications are subject to change without notice

**NOTE:** The FH Series coils are for use with the Lake Shore Model 480 fluxmeter only. They cannot be used with the Model 475, 455, 460, 450, or 421 gaussmeters.
Field standards
for use with current source or power supply only

We offer 4 Helmholtz coils for field standards: 64 mm (2.5 in), 152 mm (6 in), and 305 mm (12 in) diameter single-axis, and the MX-2X-10 double-axis.

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
<th>MH-2.5</th>
<th>MH-6</th>
<th>MH-12</th>
<th>MH-2X-10</th>
</tr>
</thead>
<tbody>
<tr>
<td>MH-2.5</td>
<td>64 mm (2.5 in) inside diameter, maximum field approximately 60 G</td>
<td>0.75%</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MH-6</td>
<td>152 mm (6 in) inside diameter, maximum field approximately 50 G</td>
<td>0.75%</td>
<td>0.5%</td>
<td>0.5%</td>
<td></td>
</tr>
<tr>
<td>MH-12</td>
<td>305 mm (12 in) inside diameter, maximum field approximately 26 G</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
</tr>
<tr>
<td>MH-2X-10</td>
<td>305 mm (12 in) inside diameter (x-axis), 248 mm (9.75 in) inside diameter (y-axis), maximum field approximately 30 G</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
<td>0.5%</td>
</tr>
</tbody>
</table>

NOTE: The MH Series coils are for use as low field standards. They cannot be used with the Model 480 fluxmeter.

All specifications are subject to change without notice.
MCS Series Modular Characterization Systems

Research platforms that quickly adapt to a wide range of material characterization applications, now and into the future.

MCS-EMP
Electromagnet platform

Key features
- Variable magnetic fields to over 3 T
- Low-noise 4-quadrant power supply
- Integrated teslameter for closed loop field control
- MeasureLINK™-MCS control software license and script library

Measurement options
- Fully-integrated measurement modules, e.g., Hall effect
- Measurement instrumentation
- Variable temperature
- Sample holders
- Ferromagnetic resonance (FMR)*

Typical applications
- Electronic/electro-transport measurements
- Magnetic/magneto-transport measurements
- Specialized, customer-built measurements

MCS-CPS
Cryogenic probe station

Key features
- Automated temperature control
- Automated field control

* CPW, Helmholtz coils, cables, and FMR instrument from NanOsc Instruments AB required

See the full MCS Modular Characterization Systems catalog for more details
EM-V Series Electromagnets

Introduction

The Lake Shore EM-4V and EM-7V electromagnets (EM-V Series) produce magnetic fields with a variety of indexed air gap and pole cap configurations. The EM-V Series are ideally suited for integration into customer-designed magnetic test platforms for applications including magneto-optical studies, magnetic hysteresis studies, in-line annealing, Hall effect studies, susceptibility measurements, spin magnetic resonance demonstrations, and biological studies.

The EM-V Series magnet coupled with a Lake Shore magnet power supply (MPS) and teslameter form a versatile laboratory electromagnet capable of producing magnetic fields up to 3.22 T and supporting very fast ramp rates of up to 1 T/s. This system, with true bipolar MPS power output, provides rapid uniform magnetic field ramping and field reversal to avoid discontinuities that occur during zero crossover when using unipolar power supplies.

ExactGAP™ indexed gap settings

The EM-V Series electromagnets feature ExactGAP™ indexed pole settings. The ExactGAP™ pole gap indexing makes it fast and easy to reconfigure the magnet gap for the required sample or option size without having to re-calibrate the magnet after changing the gap.

Choose from 6 repeatable gap widths by unbolting the top plate and clicking the selector into place. The EM-V Series incorporate water-cooled coils and precision yokes made of magnetically soft, ultra-pure steel, assuring precise pole cap alignment as well as excellent field homogeneity and stability.

EM-4V, EM-7V features

- Indexed pole gap settings (ExactGAP™) allow repeatable air gap changes without having to re-calibrate between changes
- Exceptional field intensities achieved with cylindrical or tapered pole caps
- Water-cooled coils provide excellent field stability and uniformity
- Removable pole caps facilitate variable pole face configurations and easy pole cap exchange
- Accurate pole alignment by precise construction of the air gap adjustment mechanism
- The EM-4V/EM-7V yoke designed for optimum air gap accessibility for both top and bottom of the magnet
- Compact size of the EM-4V permits convenient bench-top mounting
- Optional optical access pole caps available
- Optional shim kit is available
EM-4V

EM-7V

See the full EM-V Series Electromagnets catalog for more details
Model 643 Electromagnet Power Supply

Model 643 features
- Low noise
- Compact design
- CE mark certification
- ±70 A/±35 V, 2450 W
- Built-in fault protection
- Analog programming and IEEE-488 and USB interfaces
- Bipolar, linear, true 4-quadrant output
- 0.1 mA of programmed current resolution
- Can be modulated to frequencies up to 0.17 Hz at ±70 A
**Introduction**

The Model 643 electromagnet power supply is a linear, bipolar current source providing true 4-quadrant output, eliminating the need for external switching or operator intervention to reverse current polarity. The Model 643 is capable of supplying ±70 A/±35 V to a nominal 0.5Ω, 0.5 H load, and the output can be modulated from an external source to frequencies up to 0.17 Hz at ±70 A. Internally programmed output provides 20-bit resolution, while externally programmed output provides unlimited resolution.

The compact, low noise design of the Model 643 makes it the ideal supply for use in laboratory settings. When combined with a Lake Shore EM4 4-inch electromagnet and Model 475 DSP gaussmeter, the Model 643 provides a versatile field control system ideal for a wide range of user defined applications. These include but are not limited to magneto-optical, magnetic hysteresis and susceptibility, and Hall effect measurements, as well as in-line annealing.

**Output architecture**

The Model 643 output architecture relies on low noise linear input and output stages. The linear circuitry of the Model 643 permits operation with less electrical noise than switch-mode electromagnet power supplies. The clean field background allows greater resolution and finer detail in results drawn from data taken during high sensitivity experiments. One key benefit of this architecture is CE compliance to the electromagnetic compatibility (EMC) directive, including the radiated emissions requirement.

The true 4-quadrant output capability of the Model 643 is ideal for sweeping through both positive and negative fields. Tightly integrated analog control of the 4-quadrant output provides smooth current change with very low overshoot. This eliminates the need for external switching or operator intervention to reverse the polarity, significantly simplifying system design. The transition through zero current is smooth and continuous, allowing the user to readily control the magnetic field as polarity changes. This is achieved without reversal contactors or relays, which would produce unintended field spikes and other discontinuities. As a result, field hysteresis and other biases are avoided in the experimental data.

**Output programming**

The Model 643 output current is programmed internally via the keypad or the computer interface, externally by analog programming input, or by the sum of the external and internal settings. For internal programming, the Model 643 incorporates a proprietary 20-bit digital-to-analog converter (DAC) that is monotonic over the entire output range and provides resolution of 0.1 mA. External programming provides unlimited resolution.

The Model 643 generates extremely smooth and continuous ramps with virtually no overshoot. The digitally generated constant current ramp rate is variable between 0.1 mA/s and 50 A/s. To ensure smooth ramp rate, the power supply updates the high-resolution DAC 23.7 times per second. A low-pass filter on the output DAC smooths the transitions at step changes during ramping.

**Output reading**

The Model 643 provides high-resolution output readings. The output current reading reflects the actual current in the magnet, and has a resolution of 0.1 mA. The output voltage reading reports the voltage at the output terminals with a resolution of 0.1 mV. All output readings can be prominently displayed on the front panel and read over the computer interface.

**Protection**

The Model 643 provides built-in protection against short circuit, open circuit, line loss, low line voltage, high line voltage, output over voltage, output over current, over temperature, and abrupt change of the external programming input. In the event of water flow failure, flow sensors provide feedback to the Model 643 and output current is set to 0 A. Internal heat sink, cold plate, and transformer temperatures are also monitored. Warnings are displayed before temperature limits are exceeded and current is set to 0 A. If temperatures continue to increase over safety limits, the Model 643 turns off.

A proprietary circuit limits the power dissipated in the water-cooled cold plate should low resistance and high line conditions exist. The Model 643 protects itself if operated into resistances outside of nominal limits. By limiting current output, the power supply will safely operate into a shorted load, and it operates safely into high resistance loads by limiting voltage output. The Model 643 is also protected against power loss under full operation and nominal magnet load. Both low and high power line conditions are reported on the front panel display.

**Interfaces**

The Model 643 includes both parallel IEEE-488 and universal serial bus (USB) computer interfaces that provide access to operating data, stored parameters, and remote control of all front panel operating functions. The USB interface emulates an RS-232C serial port at a fixed 57,600 baud rate, but with the physical connections of a USB. This allows you to download firmware upgrades, ensuring your power supply is using the most current firmware version with no need for any physical changes. The Model 643 also provides two analog monitors for output current and voltage. Each monitor is a buffered, differential, analog voltage representation of the signal being monitored. The current monitor has a sensitivity of 7 V/70 A output, while the voltage monitor has a sensitivity of 3.5 V/35 V output.

**Display and keypad**

The Model 643 incorporates a large 8-line by 40-character vacuum fluorescent display. Output current and output voltage readings are displayed simultaneously. Five front panel LEDs provide quick verification of instrument status, including ramping, compliance, fault, power limit, and computer interface mode. Error conditions are indicated on the main display along with an audible beeper. Extended error descriptions are available under the status key.

The keypad is arranged logically to separate the different functions of the power supply. The most common functions of the power supply are accessed using a single button press. The keypad can be locked in order to secure either all changes or just the instrument setup parameters allowing the supply output to be changed.
Model 643 specifications

Output
Type: Bipolar, 4-quadrant, DC current source
Current generation: Fully linear regulation with digital setting and analog control
Current range: ±70 A
Compliance voltage (DC): ±35 V nominal
Power: 2450 W nominal
Nominal load: 0.5 Ω, 0.5 H
Maximum load resistance: 0.6 Ω for ±70 A DC operation at +10% to -5% line voltage
Minimum load resistance: 0.4 Ω for ±70 A DC operation at +5% to -10% line voltage
Load inductance range: 0 H to 1 H
Current ripple: 5 mA RMS (0.007%) at 70 A into nominal load
Current ripple frequency: Dominated by the line frequency and its harmonics
Temperature coefficient: ±15 ppm of full scale/°C
Line regulation: ±50 ppm of full scale/10% line change
Stability (1 h): ±1 mA/mA (after warm-up)
Stability (24 h): ±35 V nominal
Operation: Keypad, computer interface
Keypad type: 26 full-travel keys
Keypad functions: Direct access to common operations, menu-driven setup
Power: Power flush on and red extended OFF push buttons

Output programming
Internal current setting
Resolution: 0.1 mA (20-bit)
Settling time: 0.0001 A to 50.0000 A (compliance limited)
Update rate: 23.7 increments/s
Ramp segments: 5
Operation: Keypad, computer interface
Protection: Programmable ramp rate limit

External current programming
Sensitivity: 10 V/70 A
Resolution: Analog
Accuracy: ±10 mA ±0.5% of setting
Input resistance: 20 kΩ
Operation: Voltage program through rear panel, can be summed with internal current setting
Limits: Internally clamped at ±10.1 V and bandwidth limited at 40 Hz to protect output
Connector: Shared 15-pin D-sub
Readings
Current output
Resolution: 0.1 mA
Accuracy: ±10 mA ±0.05% of rdg
Update rate: 2.5 rdg/s display, 5 rdg/s interface

Output voltage (at supply terminals)
Resolution: 1 mV
Accuracy: ±5 mV ±0.05% of rdg
Update rate: 2.5 rdg/s display, 5 rdg/s interface
Front panel
Display type: 8-line by 40-character graphic vacuum fluorescent display module
Display readings: Output current, output voltage, and internal water temperature
Display settings: Output current and ramp rate
Display annunciators: Status and errors
Keypad type: 26 full-travel keys
Keypad functions: Direct access to common operations, menu-driven setup
Power: Power flush on and red extended OFF push buttons
Interface
IEEE-488.2 interface
Features: SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT0, C0, E1
Reading rate: To 10 rdg/s
Software support: National Instruments LabVIEW™ driver (consult Lake Shore for availability)
USB interface
Function: Emulates a standard RS-232 serial port
Baud rate: 57,600
Reading rate: To 10 rdg/s
Connector: B-type USB connector
Software support: National Instruments LabVIEW™ driver (consult Lake Shore for availability)
Output current monitor
Sensitivity: 7 V/70 A
Accuracy: ±1.5% of full scale
Noise: 1 mV RMS
Source impedance: 20 Ω
Connector: Shared 15-pin D-sub

Output voltage monitor
Sensitivity: 3.5 V/30 V
Accuracy: 1% of full scale
Noise: 1 mV RMS
Source impedance: 20 Ω
Connector: Shared 15-pin D-sub

Power supply cooling water
Remote enable input: TTL low or contact closure to enable output; jumper required if unused
Valve power output: 24 VAC at 1 A maximum, automatic or manual control
Connector: Shared 4-pin detachable terminal block; Flow switch and water valve optional
Magnet cooling water
Remote enable input: TTL low or contact closure to enable output; jumper required if unused
Valve power output: 24 VAC at 1 A maximum, automatic or manual control
Connector: Shared 4-pin detachable terminal block; Flow, temperature switch, and water valve not included
Auxiliary
Emergency stop: Requires 1 A, 24 VAC normally closed (NC) contact to enable power-up, jumper required if unused
Fault output: Relay with normally open (NO) or normally closed (NC) contact, 30 VDC at 1 A
Remote enable input: TTL low or contact closure to enable output; jumper required if unused
Connector: Shared 8-pin detachable terminal block
Emergency stop and inhibit switches not included

General
Line power
Power: 5500 VA max
Voltage and current: 200/208 VAC ±10%, 13 A/phase; 220/230 VAC ±10%, 12 A/phase; 380/415 VAC ±10%, 7 A/phase; 400/415 VAC ±10%, 6.5 A/phase
Protection: 3-phase thermal relay with adjustable current setting; two class CC 0.25 A fuses; over-voltage lockout circuit
Frequency: 50 Hz or 60 Hz
Configuration: 3-phase delta
Connector: 4-pin terminal block
Features: Soft start circuit, rear panel voltage selection indicator
Line voltage must be specified at time of order but is field reconfigurable; cable from power supply to facility power not included

Cooling water
Flow rate: 5.7 l/min (1.5 gal)/min minimum
Pressure range: 34 kPa (5 psi) to 552 kPa (80 psi)
Pressure drop: 10 kPa (1 psi) at 5.7 L (1.5 gal)/min minimum for power supply only
Temperature: 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C at reduced accuracy

Humidity: Non-condensing
Warm-up: 30 min at output current setting
Approvals: CE mark—low voltage compliance to EN61010-3, EMC compliance to EN55022-1

Ordering information
Part # | Description
--- | ---
643 | Model 643 ±70 A ±35 V ±2.5 kW—specify 204/208 VAC, 220/230 VAC, 380 VAC, or 400/415 VAC

Accessories included
6031 | Two front handles
6032 | Two rear handles
6051 | Terminal block, 4-pin
6052 | Terminal block, 8-pin
6252 | 15-pin D-sub mating connector, analog I/O
6261 | 3 m (10 ft) magnet cable kit, AWG 4
6262 | 6 m (20 ft) magnet cable kit, AWG 4
6420 | Cal-643-CERT Instrument recalibration w/ certificate
6421 | CAL-643-CERT Instrument recalibration w/ certificate & data
6041 | Water flow switch
6042 | Water valve

All specifications are subject to change without notice
Model 648 Bipolar Magnet Power Supply

**Model 648 features**
- Low noise
- CE mark certification
- ±135 A/±75 V, 9.1 kW
- Built-in fault protection
- Bipolar, linear, 4-quadrant output
- 1 mA of programmed current resolution
- Analog programming and IEEE-488 and USB interfaces
**Introduction**

The Model 648 electromagnet power supply is a robust, fault-tolerant 9 kW supply optimized for powering large 7 or 10 in research electromagnets. It is specifically designed for high precision laboratory use requiring extremely low electrical noise. The linear design removes undesirable higher frequency noise typical of switch mode power supplies. Eliminating the need for external switching or operator intervention to reverse current polarity, the Model 648 uses convenient bipolar, 4-quadrant operation. It is capable of supplying ±135 A/±75 V to a nominal 0.5 Ω, 0.5 H load. The Model 648 is built to last with a rugged design, integrated fault protection, and a simple, clean interior electronic design.

This robust power supply is developed to minimize downtime. It uses worry-free water cooling for quiet efficient operation compared to air-cooled power supplies. The seamless water lines only have external junctions, eliminating internal water leaks. In addition, safety interlocks ensure that cooling water is always flowing to the supply while operating. Magnet water can also be interlocked into the power supply if desired. Internal software controls manage water usage intelligently.

**Output architecture**

The low electrical noise design of the Model 648 makes it the ideal power supply for use with large electromagnets in high precision laboratory settings, ensuring greater resolution and finer detail in data taken during highly sensitive measurements. Because low noise is critical to measurement systems, the Model 648 implements both a linear design and bipolar architecture. Linear magnet power supplies have several advantages over switch mode power supplies, primarily smooth field generation that is nearly free from offending electromagnetic signatures. The bipolar, 4-quadrant operation required to safely operate an inductive load provides clean transitions through zero without discontinuities.

**Output programming**

The Model 648 output current is programmed internally via the keypad or the computer interface, externally by analog programming input, or by the sum of the external and internal settings. External programming via analog input signal provides analog resolution. The Model 648 generates extremely smooth and continuous ramps — the digitally generated constant current ramp rate is variable between 0.1 mA/s and 50.000 A/s. To ensure a smooth ramp rate, the power supply updates the high-resolution DAC 12.3 times per second.

**Output reading**

The Model 648 provides high-resolution output current readings that reflect the actual current in the magnet, and have a resolution of 1 mA. The output voltage reading reports the voltage at the output terminals with a resolution of 1 mV. All output readings can be prominently displayed on the front panel and read over the computer interface.

**Protection**

The Model 648 provides built-in protection against short circuit, open circuit, line loss, low line voltage, high line voltage, output over voltage, output over current, over temperature, and abrupt change of the external programming input. A proprietary circuit limits the power dissipated in the water-cooled cold plate should low resistance and high line conditions exist. The Model 648 protects itself if operated into resistances outside of nominal limits. By limiting current output, it will safely operate into a shorted load, and operate safely into high resistance loads by limiting voltage output. The Model 648 is also protected against power loss under full operation and nominal magnet load. Both low and high power line conditions are reported on the front panel display.
### Specifications

#### Output

**Type:** Bipolar, 4-quadrant, DC voltage/current source  
**Current generation:** Fully linear regulation with digital setting and analog control  
**Current range:** ±135 A nominal  
**Compliance voltage (DC):** ±25 V  
**Power:** 9.1 kW nominal  
**Nominal load:** 0.5 Ω, 0.5 H  
**Maximum load resistance:** 0.55 Ω for ±135 A DC operation at ±10% to -5% line voltage  
**Minimum load resistance:** 0.41 Ω for ±135 A DC operation at +5% to -10% line voltage  
**Load inductance range:** 0 H to 1 H  
**Current ripple:** 10 mA RMS (0.007%) at 135 A into nominal load  
**Current ripple frequency:** Dominated by the line frequency and its harmonics  
**Temperature coefficient:** ±50 ppm of full scale/°C  
**Line regulation:** ±75 ppm of full scale/10% line change  
**Stability (1 h):** 2 mA/hr (after warm-up, internal setting)  
**Stability (24 h):** 10 mA/24 h (typical, internal setting, dominated by temperature coefficient and line regulation)  
**Isolation:** Differential output is optically isolated from chassis to prevent ground loops  
**Slew rate:** 50 A/s into nominal load (dominated by magnet characteristics), 100 A/s maximum into a resistive load  
**Settling time:** <1 s for 10% step to within 1 mA of output into nominal load  
**Harmonic distortion:** <0.1 Hz at ±135 A sine wave into resistive load, <0.02% THD; <10 Hz at ±10 A sine wave into resistive load, <0.30% THD  
**Attenuation:** -0.5 dB at 10 Hz (external programming input)  
**Protection:** Short circuit, line loss, low line voltage, high line voltage, output over voltage, output over current, and over temperature  
**Connector:** Two lugs with 8.64 mm (0.34 in) holes for M8 or M16 in bolts  

#### Output programming

**Internal current setting**
- **Resolution:** 1.0 mA (20-bit)  
- **Settling time:** 600 ms for 1% step to within 1 mA of output into nominal load  
- **Accuracy:** ±20 mA ±0.05% of setting  
- **Operation:** Keypad, computer interface  
- **Protection:** Programmable current setting limit  

**Internal current ramp**
- **Ramp rate:** 0.1 mA/s to 50,000 A/s (compliance limited)  
- **Update rate:** 12.3 increments/s  
- **Ramp segments:** 5  
- **Operation:** Keypad, computer interface  
- **Protection:** Programmable ramp limit rate  

**External current programming**
- **Sensitivity:** 10 V/135 A  
- **Resolution:** Analog  
- **Accuracy:** ±20 mA ±1% of setting  
- **Input resistance:** 20 kΩ differential, 50 kΩ common-mode  
- **Operation:** Voltage program through rear panel, can be summed with internal current setting  
- **Limits:** Internally clamped at ±10.1 V and bandwidth limited -3 dB at 40 Hz (2 pole, low pass filter)  
- **Connector:** Shared 15-pin D-sub

#### Readings

**Output current**
- **Resolution:** 1.0 mA  
- **Accuracy:** ±20 mA ±0.05% of rdg  
- **Update rate:** 2.5 rdg/s display, 10 rdg/s interface  
- **Output voltage (at supply terminals)**
  - **Resolution:** 1.0 mV  
  - **Accuracy:** ±10 mV ±0.05% of rdg  
  - **Update rate:** 2.5 rdg/s display, 5 rdg/s interface  

**Front panel**
- **Display type:** 8-line by 40-character graphic vacuum fluorescent display module  
- **Display readings:** Output current, output voltage, and internal water temperature  
- **Display settings:** Output current and ramp rate  
- **Display annunciators:** Status and errors  
- **LED annunciators:** Fault, Compliance, Power Limit, Ramp, Remote  
- **Audible annunciator:** Errors and faults  
- **Keypad type:** 20 full-travel keys  
- **Keypad functions:** Direct access to common operations, menu-driven setup  
- **Power:** Green flush ON and red extended OFF push buttons  

**Interface**
- **IEEE-488.2 interface**
  - **Features:** SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT0, C0, E1  
  - **Error types:** Reading rate, To 10 rdg/s  
  - **Software support:** National Instruments LabVIEW™ driver (consult Lake Shore for availability)  

**USB interface**
- **Function:** Emulates a standard RS-232 serial port  
- **Baud rate:** 57,600  
- **Reading rate:** To 10 rdg/s  
- **Connector:** Type B USB connector  
- **Software support:** National Instruments LabVIEW™ driver (consult Lake Shore for availability)  

**Output current monitor**
- **Sensitivity:** 7 V/135 A  
- **Accuracy:** ±1.5% of full scale  
- **Noise:** 5 mV RMS  
- **Source impedance:** 20 Ω  
- **Connector:** Shared 15-pin D-sub  

**Output voltage monitor**
- **Sensitivity:** 7 V/70 V  
- **Accuracy:** 1% of full scale  
- **Noise:** 2 mV RMS  
- **Source impedance:** 20 Ω  
- **Connector:** Shared 15-pin D-sub  

**Power supply cooling water**
- **Remote enable input:** TTL low or contact closure to enable output; used for mandatory 1 gal/min flow switch (included)  
- **Connector:** 2-pin detachable terminal block connector  
- **Valve power output:** 24 VAC at 1.5 A maximum, automatic or manual control  
- **Connector:** 2-pin detachable terminal block connector  
- **Water valve optional**

**Magnet cooling water**
- **Remote enable input:** TTL low or contact closure to enable output; jumper required if unused  
- **Valve power output:** 24 VAC at 1.5 A maximum, automatic or manual control  

**Connector:** Shared 4-pin detachable terminal block  
**Flow, temperature switch, and water valve not included**

**Auxiliary**
- **Emergency stop:** Requires 1 A, 24 VAC normally closed (NO) contact to enable power up; jumper required if unused  
- **Fault output:** Relay with normally open (NO) or normally closed (NC) contact, 30 VDC at 1 A  
- **Remote enable input:** TTL low or contact closure to enable output; jumper required if unused  
- **Connector:** Shared 8-pin detachable terminal block; Emergency stop and inhibit switches not included

#### General

**Line power**
- **Power:** 15.5 kVA max  
- **Voltage and current:** 200 VAC ±5%, 41 A/phase; 208 VAC ±5%, 40 A/phase; 220 VAC ±5%, 38 A/phase; 230 VAC ±5%, 37 A/phase; 380 VAC ±5%, 23 A/phase; 400 VAC ±5%, 21 A/phase; 415 VAC ±5%, 21 A/phase  
- **Protection:** 3-phase thermal relay with adjustable current setting; two class CC 2 A fuses; over-voltage lockout circuit  
- **Frequency:** 50 Hz or 60 Hz  

**Configuration:** 3-phase delta  
**Connector:** 4-pin terminal block; Line voltage must be specified at time of order but is field reconfigurable; cable from power supply to facility power not included

**Cooling water**
- **Flow rate:** 7.6 L (2.0 gal)/min minimum  
- **Maximum pressure:** 552 kPa (80 psi)  
- **Pressure drop:** 159 kPa (23 psi) at 7.6 L (2.0 gal)/min minimum for power supply and mandatory flow switch  
- **Temperature:** 15 °C to 30 °C (non-condensing)  
- **Connection:** Two 12.7 mm (0.5 in) hose barbs  
- **CAUTION:** Internal condensation can cause damage to the power supply  

**Enclosure type:** Custom 19 in rack cabinet  
- **Size:** 559 mm W × 673 mm D × 1054 mm H  
- **Weight:** 225 kg (495 lb)  
- **Shipping size:** 208 VAC, 220 VAC, 230 VAC, 380 VAC, 400 VAC, 415 VAC

**Shipping weight:** 281 kg (620 lb)  
**Ambient temperature:** 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C at reduced accuracy  
**Humidity:** Non-condensing  
**Warm-up:** 30 min at output current setting  
**Approvals:** CE mark—low voltage compliance to EN61010-1, EMC compliance to EN61326-1

---

Lake Shore Cryotronics, Inc.  |  t. 614.891.2244  |  f. 614.818.1600  |  e. info@lakeshore.com  |  www.lakeshore.com

---

### Ordering information

<table>
<thead>
<tr>
<th>Part number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>648</td>
<td>Model 648—specify 200 VAC, 208 VAC, 220 VAC, 230 VAC, 380 VAC, 400 VAC, or 415 VAC</td>
</tr>
</tbody>
</table>

All specifications are subject to change without notice.
# Units for magnetic measurement

<table>
<thead>
<tr>
<th>Symbol</th>
<th>Gaussian &amp; cgs emu*</th>
<th>Conversion Factor, C°</th>
<th>SI &amp; rationalized mks°</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic flux density, magnetic induction</td>
<td>B</td>
<td>gauss (G)d</td>
<td>$10^{-4}$</td>
</tr>
<tr>
<td>Magnetic flux</td>
<td>Φ</td>
<td>maxwell (Mx), G·cm²</td>
<td>$10^{-8}$</td>
</tr>
<tr>
<td>Magnetic potential difference, magnetomotive force</td>
<td>U, F</td>
<td>gilbert (Gb)</td>
<td>$10/4\pi$</td>
</tr>
<tr>
<td>Magnetic field strength, magnetizing force</td>
<td>H</td>
<td>oersted (Oe), Gb/cm</td>
<td>$10^3/4\pi$</td>
</tr>
<tr>
<td>(Volume) magnetization</td>
<td>M</td>
<td>emu/cm³</td>
<td>$10^3$</td>
</tr>
<tr>
<td>(Volume) magnetization</td>
<td>4πM</td>
<td>G</td>
<td>$10^3/4\pi$</td>
</tr>
<tr>
<td>Magnetic polarization, intensity of magnetization</td>
<td>J, I</td>
<td>emu/cm³</td>
<td>$4\pi \times 10^{-4}$</td>
</tr>
<tr>
<td>(Mass) magnetization</td>
<td>σ, M</td>
<td>emu/g</td>
<td>$1/4\pi \times 10^{-7}$</td>
</tr>
<tr>
<td>Magnetic moment</td>
<td>m</td>
<td>emu, erg/G</td>
<td>$10^{-3}$</td>
</tr>
<tr>
<td>Magnetic dipole moment</td>
<td>j</td>
<td>emu, erg/G</td>
<td>$4\pi \times 10^{-10}$</td>
</tr>
<tr>
<td>(Volume) susceptibility</td>
<td>χ, κ</td>
<td>dimensionless, emu/cm³</td>
<td>$4\pi (4\pi)^2 \times 10^{-7}$</td>
</tr>
<tr>
<td>(Mass) susceptibility</td>
<td>χ₀, κ₀</td>
<td>cm³/g, emu/g</td>
<td>$4\pi \times 10^{-3}$ (4π)² × 10⁻¹⁰</td>
</tr>
<tr>
<td>(Molar) susceptibility</td>
<td>χₘ₀, κₘ₀</td>
<td>cm³/mol, emu/mol</td>
<td>$4\pi \times 10^{-4}$ (4π)² × 10⁻¹³</td>
</tr>
<tr>
<td>Permeability</td>
<td>μ</td>
<td>dimensionless</td>
<td>$4\pi \times 10^{-2}$</td>
</tr>
<tr>
<td>Relative permeability</td>
<td>μr</td>
<td>not defined</td>
<td>—</td>
</tr>
<tr>
<td>(Volume) energy density, energy product</td>
<td>W</td>
<td>erg/cm³</td>
<td>$10^{-1}$</td>
</tr>
<tr>
<td>Demagnetization factor</td>
<td>D, N</td>
<td>dimensionless</td>
<td>$1/4\pi$</td>
</tr>
</tbody>
</table>

---

a. Gaussian units and cgs emu are the same for magnetic properties. The defining relation is $B = H + 4\pi M$.
b. Multiply a number in Gaussian units by C to convert it to SI (e.g., $1 \text{ G} \times 10^{-4} \text{T/G} = 10^{-4} \text{T}$).
c. SI (Système International d'Unités) has been adopted by the National Bureau of Standards. Where two conversion factors are given, the upper one is recognized under, or consistent with, SI and is based on the definition $B = \mu_0 (H + M)$, where $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$. The lower one is not recognized under SI and is based on the definition $B = \mu_0 H + J$, where the symbol I is often used in place of J.
d. $1 \text{ gauss} = 10^5 \text{ gamma (γ)}$.
e. Both oersted and gauss are expressed as cm⁻¹·g⁻½·s⁻¹ in terms of base units.
f. A/m was often expressed as “ampere-turn per meter” when used for magnetic field strength.
g. Magnetic moment per unit volume
h. The designation “emu” is not a unit.
i. Recognized under SI, even though based on the definition $B = \mu_0 H + J$. See footnote c.
j. $\mu_r = \mu/\mu_0 = 1 + \chi$, all in SI. μr is equal to Gaussian μ.
k. B · H and $\mu r M · H$ have SI units J/m²; M · H and B · H/4π have Gaussian units erg/cm².

---

Gaussmeters, Hall Probes, and Accessories

Gaussmeters

400 Series Hall Probes

InAs and GaAs Hall Sensors

Fluxmeters

Search Coils

Helmholtz Coils

Electromagnets

Power Supplies