Model 475 DSP Gaussmeter RoHS

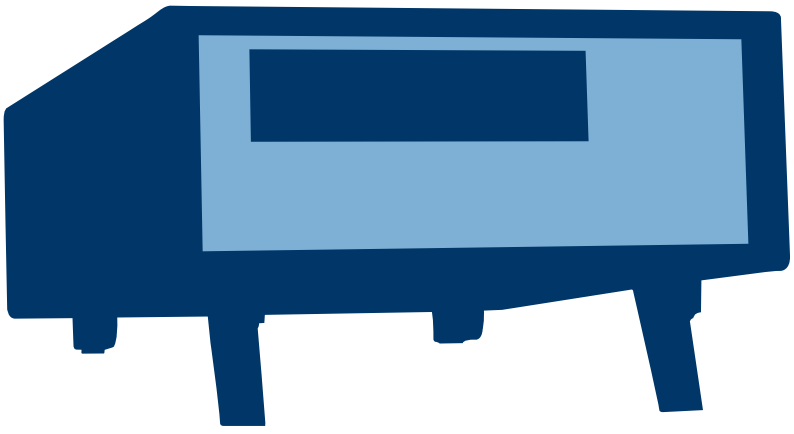
Model 475 features

- Full-scale ranges from 3.5 G 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 unequaled 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.

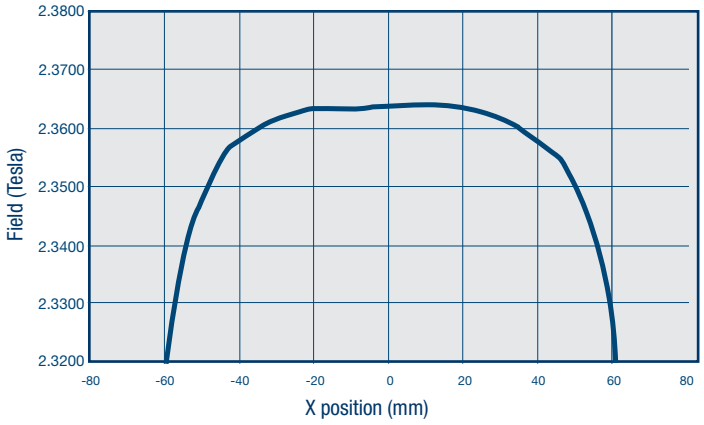
Trigger in and trigger out

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.

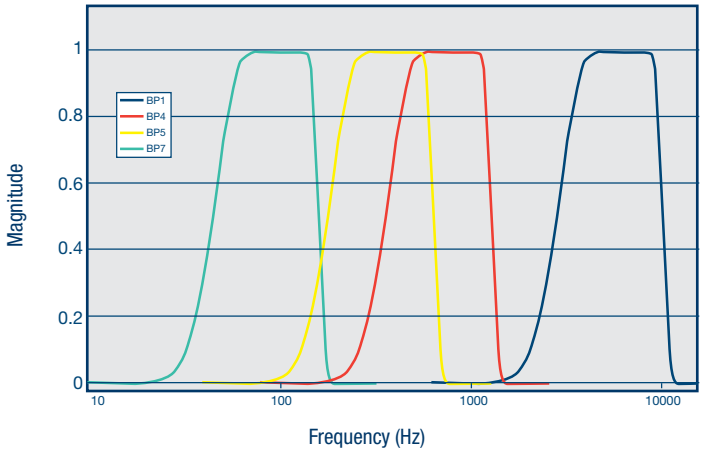
Field uniformity plot across an electromagnet pole face



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.

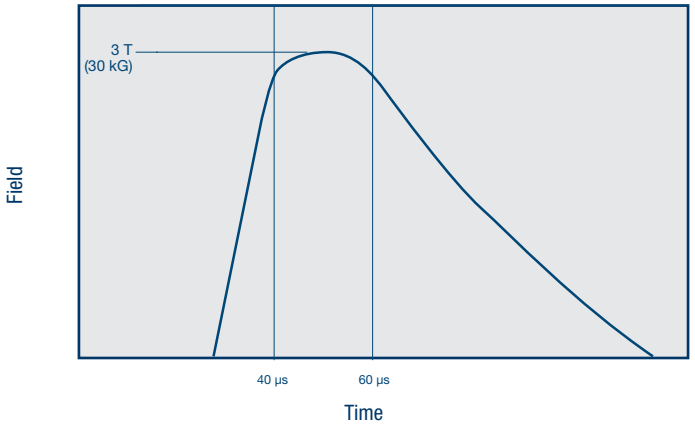
Selective bandpass filters (4 of a possible 15)



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.

Selective bandpass filters (4 of a possible 15)



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).

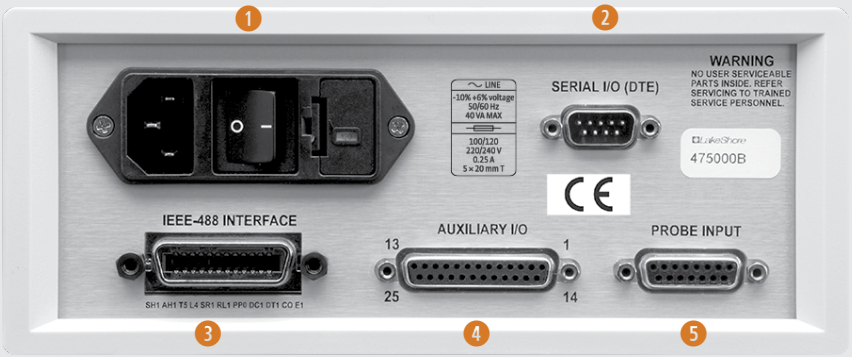
Probe information: The gaussmeter reads the probe information on power up or any time the probe is changed to allow hot swapping of probes. Critical probe information can be viewed on the front panel and read over the computer interface to ensure proper system configuration.

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. Auxillary I/O
5. Probe input



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 both show 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 style

DC measurement

Probe type ranges	5¾-digit resolution	4¾-digit resolution	3¾-digit resolution
HST Probe			
350 kG	000.001 kG	000.01 kG	000.1 kG
35 kG	00.0001 kG	00.001 kG	00.01 kG
3.5 kG	0.00001 kG	0.0001 kG	0.001 kG
350 G	000.003 G	000.02 G	000.1 G
35 G	00.0030 G	00.015 G	00.04 G
HSE Probe			
35 kG	00.0001 kG	00.001 kG	00.01 kG
3.5 kG	0.00001 kG	0.0001 kG	0.001 kG
350 G	000.001 G	000.01 G	000.1 G
35 G	00.0003 G	00.002 G	00.01 G
3.5 G	0.00030 G	0.0015 G	0.004 G
UHS Probe (discontinued)			
35 G	00.0001 G	00.001 G	00.01 G
3.5 G	0.00001 G	0.0001 G	0.001 G
350 mG	000.003 mG	000.02 mG	000.1 mG
35 mG	00.0030 mG	00.015 mG	00.04 mG

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

	5¾-digit resolution	4¾-digit resolution	3¾-digit resolution
3 dB bandwidth:	1 Hz	10 Hz	100 Hz
Time constant:	1 s	0.1 s	0.01 s
Maximum reading rate:	10 rdg/s	30 rdg/s	100 to 1000 rdg/s*

*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

AC RMS measurement

Probe type ranges	4¾-digit resolution
HST Probe	
350 kG	000.01 kG
35 kG	00.001 kG
3.5 kG	0.0002 kG
350 G	000.02 G
35 G	00.020 G
HSE Probe	
35 kG	00.001 kG
3.5 kG	0.0001 kG
350 G	000.02 G
35 G	00.002 G
3.5 G	0.0020 G
UHS Probe (discontinued)	
35 G	00.001 G
3.5 G	0.0002 G
350 mG	000.02 mG
35 mG	00.020 mG

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 1 kHz, narrow 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

Probe type ranges	4¾-digit resolution
HST Probe	
350 kG	000.01 kG
35 kG	00.001 kG
3.5 kG	0.0002 kG
350 G	000.02 G
35 G	00.020 G
HSE Probe	
35 kG	00.001 kG
3.5 kG	0.0001 kG
350 G	000.02 G
35 G	00.002 G
3.5 G	0.0020 G
UHS Probe (discontinued)	
35 G	00.001 G
3.5 G	0.0002 G
350 mG	000.02 mG
35 mG	00.020 mG

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)
Peak accuracy (5 Hz to 20 kHz): ±2% of rdg ≥ 1% of full-scale range (20 µs or longer pulse width)
Peak accuracy (20 kHz to 50 kHz): ±5% of rdg ≥ 1% of full-scale range (20 µs or longer pulse width)
Peak frequency range (periodic mode): 50 Hz to 5 kHz
Peak frequency range (pulse mode): 5 Hz to 50 kHz

Temperature measurement

Temperature range: Probe dependent (typically 0 °C to 75 °C)
Measurement resolution: 0.01 °C
Temperature display resolution: 0.01 °C
Electronic accuracy: ±0.7 °C

Front panel

Display type: 2-line × 20-character, vacuum fluorescent with 9 mm high characters
Display resolution: To ±5¾ digits
Display update rate: 5 rdg/s
Display units: gauss (G), tesla (T), oersted (Oe), and ampere per meter (A/m)
Units multipliers: µ, m, k, M
Display annunciators:
DC – DC measurement mode
RMS – AC RMS measurement mode
PK – Peak measurement mode
MX – Max hold value
MN – Min hold value
SP – Relative setpoint value
CSP – Field control setpoint value
LED annunciators:
Relative reading mode
Alarm active
Remote IEEE-488 operation
Keypad: 22 full-travel keys
Front panel features: Display prompts, front panel lockout, and brightness control Interfaces

RS-232C

Baud: 9600, 19200, 38400, and 57600
Update rate: 30 rdg/s (ASCII)
Software support: LabVIEW™ driver
Connector: 9-pin D-style, DTE configuration

IEEE-488.2

Capabilities: SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT1, C0, and E1
Update rate: 30 rdg/s (ASCII), to 100 rdg/s (binary, no temperature compensation)
Software support: LabVIEW™ driver

Data buffer

Capacity: 1024 field readings
Reading rate: 1 to 1000 rdg/s
Data transfer: Through computer interface after data is logged
Trigger: Hardware trigger to begin data log sequence

Alarm

Settings: High/low setpoint, Inside/outside, Audible, and Sort
Actuators: LED annunciator, beeper, and relays

Relays

Number: 2
Contacts: Normally open (NO), normally closed (NC), and common (C)
Contact rating: 30 VDC at 2 A
Operation: Follows alarm or operated manually
Connector: In 25-pin I/O connector

Voltage output 1

Configuration: Real-time analog voltage output of wide-band AC signal
Range: ±3.5 V
Scale: ±3.5 V = ±full scale on selected range
Frequency response: 1 Hz to 40 kHz (wide-band AC)
Accuracy: Probe-dependent
Noise: ±1.0 mV
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: In 25-pin I/O connector

Voltage output 2

Configuration: Voltage output of field value, generated by DAC
Range: ±5 V
Scale: ±3.5 V = ±full scale on selected range
Resolution: 16-bit, 0.15 mV
Update rate: 40,000 updates/s
Accuracy: ±10 mV
Noise: ±0.3 mV
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: In 25-pin I/O connector

Voltage output 3

Configuration: Voltage output of compensated DC or RMS field value, generated by DAC (also used for field control)
Range: ±10 V
Scale: User-specified (defaults same as Voltage Output 2)
Resolution: 16-bit, 0.3 mV
Update rate: 30 updates/s
Accuracy: ±2.5 mV
Noise: ±0.3 mV
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: In 25-pin I/O connector

General

Ambient temperature: 15 °C to 35 °C at rated accuracy, 5 °C to 40 °C with reduced accuracy
Power requirement: 100, 120, 220, and 240 VAC (+6%, -10%), 50 Hz 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: 3 kg (6.6 lb)
Approval: CE mark, RoHS

Probes and extensions

Probe compatibility: Full line of probes available—see page 18 for recommended stock probes available.
Hall sensor compatibility: Front panel programmable sensitivity and serial number for user-supplied Hall sensor.
Extension cable compatibility: Calibrated or uncalibrated probe extension cables with an EEPROM are available from 10 ft to 100 ft.

Lake Shore calibrated extension cables maintain the same accuracy as the Model 475 probe.

The uncalibrated version requires the operator to load the matching probe data file into the cable PROM directly from the Model 475 front panel. Additional errors caused by the uncalibrated extension cables are ±0.02% of field reading error and 1 °C temperature reading error.

Stock probes RoHS

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

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

Ordering information

Part number	Description
475	Model 475 DSP gaussmeter

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
HMCBL-6	User programmable cable with EEPROM (1.8 m [6 ft])
HMCBL-20	User programmable cable with EEPROM (6.1 m [20 ft])
HMPEC-10	Probe extension cable with EEPROM (3 m [10 ft]), calibrated
HMPEC-10-U	Probe extension cable with EEPROM (3 m [10 ft]), uncalibrated
HMPEC-25	Probe extension cable with EEPROM (7.6 m [25 ft]), calibrated
HMPEC-25-U	Probe extension cable with EEPROM (7.6 m [25 ft]), uncalibrated
HMPEC-50	Probe extension cable with EEPROM (15 m [50 ft]), calibrated
HMPEC-50-U	Probe extension cable with EEPROM (15 m [50 ft]), uncalibrated
HMPEC-100	Probe extension cable with EEPROM (30 m [100 ft]), calibrated
HMPEC-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