Model 455 Gaussmeter

Model 455 features

- Field ranges from 3.5 G to 350 kG
- DC measurement resolution to 0.02 mG
- Basic DC accuracy of ±0.075%
- DC to 20 kHz AC frequency range
- AC narrow and wide band modes
- Standard probe included
- Specialized and custom probes also available
- CE mark certification

Introduction

The Model 455 digital signal processing (DSP) gaussmeter combines the technical advantages of DSP technology with many advanced features at a moderate price. DSP technology creates a solid foundation for accurate, stable, and repeatable field measurements. Advanced features including DC to 20 kHz AC frequency range, peak field detection to 50 µs pulse widths, DC accuracy of 0.075%, and up to 5¾ digits of display resolution make the Model 455 ideal for both industrial and research applications. For added functionality and value, the Model 455 includes a standard Lake Shore Hall probe.

DC measurement mode

Static or slowly changing fields are measured in DC mode. In this mode, the Model 455 takes advantage of the internal auto zero function and probe linearity compensation to provide a basic DC accuracy of ±0.075%. Measurement resolution is enhanced by advanced signal processing capability, allowing users the choice of reading rates to 30 readings per second or high resolution to 5¾ digits. Front-end amplification specifically designed to complement DSP data acquisition provides high stability and repeatability. That, along with probe temperature compensation, provides superior stability ideally suited for demanding DC measurement applications such as field mapping.

RMS peak mode

Periodic AC fields are measured in RMS mode. The Model 455 provides an overall RMS frequency range of 10 Hz to 20 kHz and is equipped with both narrow and wide band frequency modes. While in narrow band mode, frequencies above 1 kHz are filtered out for improved measurement performance. The exclusive DSP algorithms free the Model 455 from the limitations of conventional RMS conversion hardware and provide for an excellent dynamic range, resolution, and frequency response.

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 transient fields as narrow as 50 µs pulse widths. The peak reading can be held for an unlimited length of time with no sag. This is ideal for most magnetizers and other fast pulse applications. The Model 455 can also be configured to follow the peak of a periodic waveform for evaluation of crest factor.

The probe connection

The Model 455 is only half of the magnetic measurement equation. For the complete solution, Lake Shore offers a full complement of standard and custom Hall effect probes in a variety of sizes and sensitivities. See the table on page 25 for our stock probes recommended for use with this gaussmeter. We also offer other probes beginning on page 37. If you don't see the probe you need, give us a call.

Measurement features

The Model 455 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 455 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 455 has 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 magnetic field. The small nonlinearities present in each individual device can be measured and subtracted from the field reading. Model 455 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 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.

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 455 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 generators (magnetic field sensors): The Model 455 will operate with a discrete Hall effect generator when a suitable probe is not available. Users can program nominal sensitivity and serial number into an optional MCBL-6 blank connector to provide all gaussmeter functions except field and temperature compensation. If no sensitivity information is available, the Model 455 reverts to resistance measurement.

Display and interface features

Display

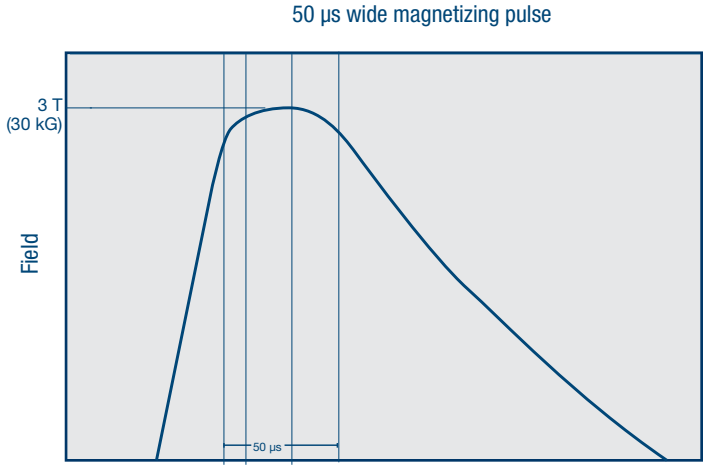
The Model 455 has a 2-line by 20-character vacuum fluorescent display. During normal operation, the display is used to report field readings and give results of other features such as max/min or relative. The display can also be configured to show probe temperature or frequency. When setting instrument parameters, the display gives the operator meaningful prompts and feedback to simplify operation. The operator can also control display brightness.

Following are three examples of the various display configurations:

The display configured to show the RMS field value and frequency and the probe temperature

The display configured to show both the maximum and minimum DC field values

The display configured to simultaneously show the positive and negative Peak readings



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.

Alarms and relays

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 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 16-bit D/A converter updated at 30 readings per second.

Computer interface

Two computer interfaces are included with the Model 455: 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. LabVIEW™ drivers are provided to instrument users—consult Lake Shore for availability.

Model 455 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			
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

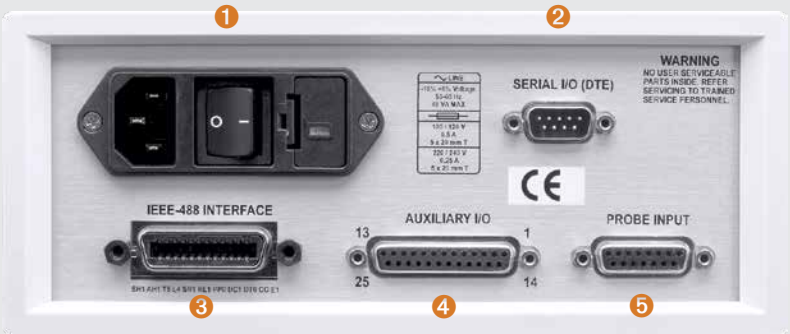
Measurement resolution (RMS noise floor): Indicated by value in above table for shorted input (probe effects not included); value measured as peak-to-peak divided by 6.6
Display resolution: Indicated by digit number in above table

	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
Max reading rate	10 rdg/s	30 rdg/s	30 rdg/s

DC accuracy: ±0.075% of reading ±0.005% of range
DC temperature coefficient: ±0.01% of reading ±0.003% of range per °C

Model 455 rear panel

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



AC RMS measurement

Probe type ranges	4¾-digit esolution
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	
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 digit number in above table
Max reading rate: 30 rdg/s
AC accuracy: ±1% of reading ≥1% of full scale range, 10 Hz to 20 kHz
AC frequency range: 10 Hz to 1 kHz, narrow band mode; 135 Hz to 20 kHz, wide band mode

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	
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 digit number in above table
Max reading rate (periodic mode): 30 rdg/s
Peak accuracy (5 Hz to 20 kHz): ±2% of reading ≥1% of full scale range (50 µs or longer pulse width)
Peak frequency range (periodic mode): 50 Hz to 5 kHz
Peak frequency range (pulse mode): 5 Hz to 20 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

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
Software support: LabVIEW™ driver
Alarm
Settings: High/low setpoint, inside/outside, and audible
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: Shared 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: 10 Hz to 20 kHz (wide band AC)
Accuracy: Probe dependent
Noise: ±1.0 mV RMS
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: Shared 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 RMS
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: Shared 25-pin I/O connector

Voltage output 3

Configuration: Voltage output of compensated DC or RMS field value, generated by DAC
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 RMS
Minimum load resistance: 1 kΩ (short circuit protected)
Connector: Shared 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

Probes and extensions

Probe compatibility: Full line of probes available—see page 25 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 455 probe.
The uncalibrated version requires the operator to load the matching probe data file into the cable PROM directly from the Model 455 front panel. Additional errors caused by the uncalibrated extension cables are ±0.02% of field reading error and 1 °C temperature reading error.

Technically speaking:
Model 455 theory of operation

The Model 455 gaussmeter uses digital signal processing (DSP), as opposed to analog signal processing, for filtering. In analog processing, the components used have different values from component to component and are temperature dependent. Using DSP gives better measurement repeatability and increases the temperature stability of the instrument.

How the Model 455 handles sampling

Digital signals are different from continuous analog signals in the fact that they are sampled in time and quantized in amplitude. Both of these properties limit the ability of the digital representation to match the original analog signal. An ADC will sample a signal at fixed intervals of time. Quantization results from the fact that an ADC has a limited amount of resolution. When both the sampling frequency and resolution are properly chosen however, the digital signal is an accurate representation of the original analog signal.

The sampling frequency of the Model 455 allows an accurate RMS measurement to be made on signals of up to 20 kHz. The sampling and filtering in the Model 455 can allow realizable resolutions of 20 bits, which is in the noise floor of the instrument.

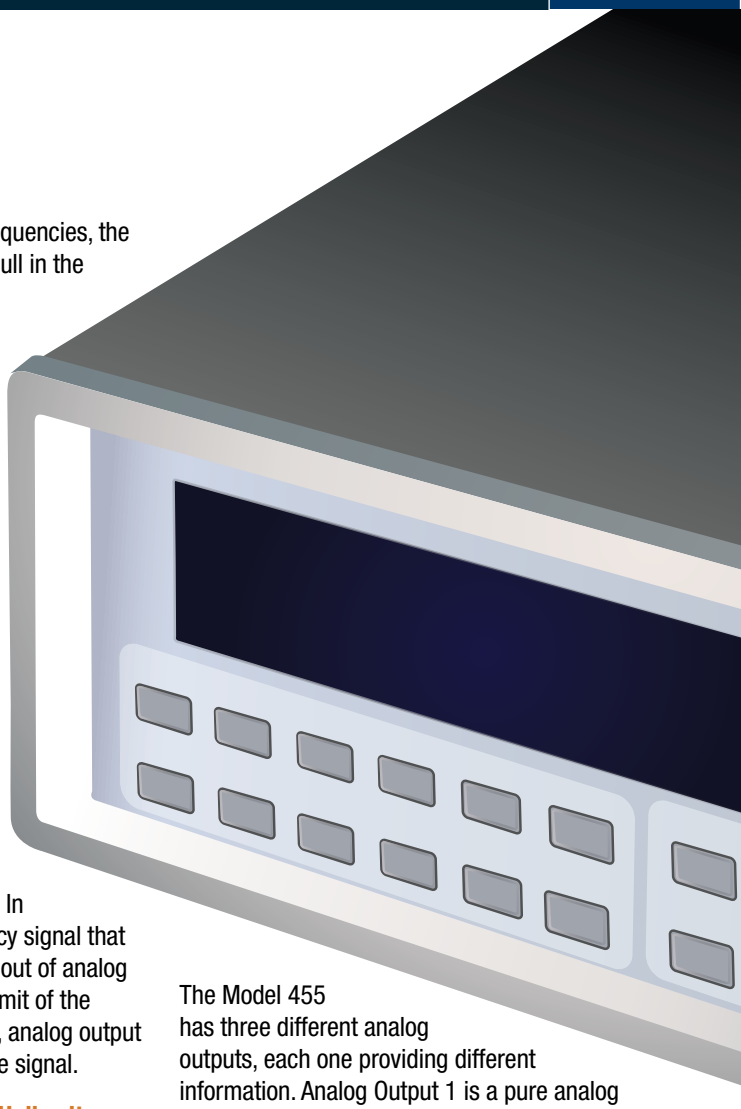
Sampled data systems do have their limitations because a continuous analog signal is being sampled and digitized. This inherently limits the frequency of the signal that can be read as well as the resolution at which it can be read. Typically, the resolution is high enough and enough averaging is done that it does not present a problem. But the frequency limitation can in certain situations cause unique problems. There are notches in the frequency response as the input signal approaches one-half the sampling rate and its harmonics. As the measured signal approaches these harmonic frequencies, the reading will fall off due to the null in the filter.

Also, the rate at which an analog signal must be sampled depends on the frequency content of the signal. A signal is said to be properly sampled if the original signal can be exactly reconstructed from the digital information. It turns out that a signal can only be properly reconstructed if the signal does not contain frequencies above one-half of the sampling rate. This is referred to as the Nyquist frequency. In the case of the Model 455, the ADC is sampled at 40 kHz in wide-band AC mode. In this mode, the highest frequency signal that can be accurately represented out of analog output 2 is 20 kHz due to the limit of the Nyquist frequency. In this case, analog output 1 should be used to monitor the signal.

How the Model 455 handles Hall voltage

The Model 455 uses a 100 mA, 5 kHz square wave excitation to drive the Hall sensor in DC mode and narrow band AC mode. In wide band AC mode, it uses a 100 mA, DC excitation to drive the sensor. The Hall voltage produced by the sensor is fed back into the instrument and sent through a programmable gain stage. The signal is then AC coupled into the A/D where it is read at up to 50 kHz.

Those signals are then sent to the digital signal processing (DSP) circuitry where the signal processing is done and the readings are filtered. The data is then transferred to the microprocessor where the readings can be sent to the display or out to the computer interface.



The Model 455 has three different analog outputs, each one providing different information. Analog Output 1 is a pure analog output being taken just before the A/D and is corrected for nominal probe sensitivity. In wide-band AC mode, this represents the actual signal being generated by the Hall sensor. It is not as useful in narrow-band AC and DC modes where the output is going to contain the 5 kHz excitation frequency. Analog Output 2 is generated from a high speed D/A converter controlled by the DSP. This output is generated from the data after the product detector and is a representation of the actual field being measured. A measured DC field will appear as a DC signal and an AC field will appear as an AC signal. Analog Output 2 is corrected for nominal probe sensitivity and probe zero offset.

Stock probes

The most commonly ordered probes for this gaussmeter. Others available starting on page 39.

Model	Orientation	Frequency range	Full-scale field ranges	Stem material	Stem length (in)	Probe part number
Model 455	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
455	Model 455 DSP gaussmeter
455-HMXX-XXXX-XX	Model 455 DSP gaussmeter with standard probe choice—specify probe number for HMXX-XXXX-XX from list above

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	Zero gauss chamber
119-040	Model 455 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 for gamma probe
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-N7-DATA	New instrument calibration for Model 455/475 with certificate and data
CAL-455-CERT	Instrument recalibration with certificate
CAL-455-DATA	Instrument recalibration with certificate and data

All specifications are subject to change without notice

Other probes available — see page 39