

8000 SERIES GAUSS / TESLA METER

Instruction Manual



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8000 Series
GAUSS / TESLA METER

Instruction Manual

Manual UN-01-270

Rev. 4
July, 2012
Applicable System Firmware Release 1.2.1
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This symbol appears on the instrument and probe. It refers the operator to additional information contained in this instruction manual, also identified by the same symbol.

NOTICE:

See Pages 4-1, 4-2, and 4-3
for SAFETY
instructions prior to first use !

See Page 2-4
for EMC Notes concerning I/O Cables and I/O
Filter Adapters

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Section 1

Introduction

OVERVIEW

The F.W. BELL 8000 Series Gauss/Tesla meters incorporate the latest developments in magnetic flux density measurement technology with a modern user interface. It features a large display for easy viewing, a comprehensive keypad for control of common functions, and an easy-to-use menu system. The 8010 model features single channel while the 8030 model provides three input channels. Both models provide high accuracy suitable for use in the laboratory and enough features to be versatile in a manufacturing environment.

Table 1-1 on the following page provides a list of features. Detailed descriptions of the 8000 Series Meter functions and features are provided in the remaining sections.

Note: Some of the listed 8000 Gaussmeter features are currently under development and are not supported with the supplied system firmware. Visit the FW Bell web site at www.fwbell.com or contact customer support for the latest updates.

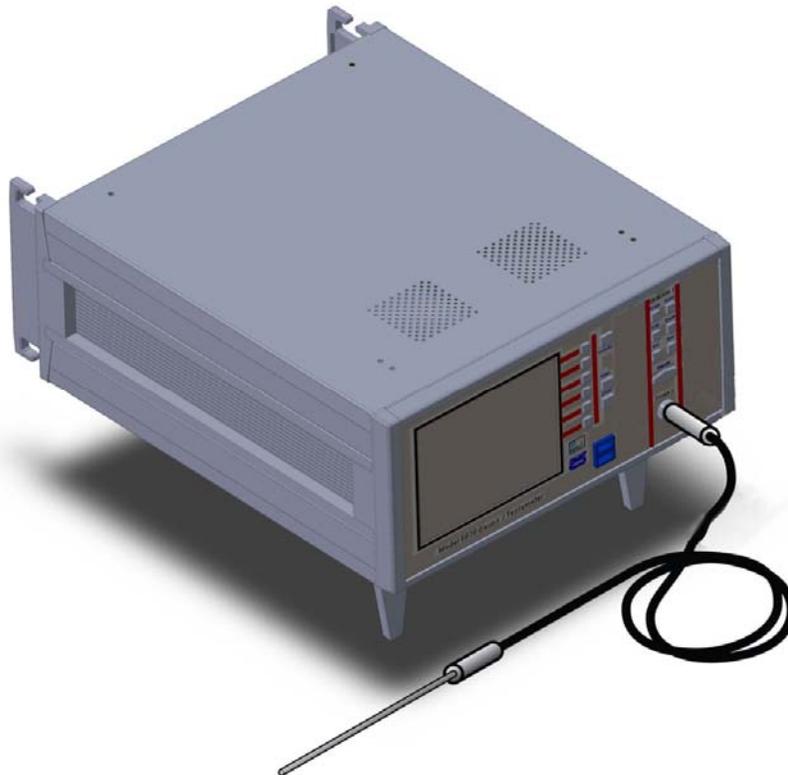


Table 1-1 Model 8010 Gauss/Tesla meter List of Features	
Flux Density Measurement	Auto Range and Zeroing Capability
	DC and AC Field Measurement up to 50 kHz
	Automatic Calibration
	Units in gauss (G), tesla (T), amp/meter (A/m), or Oersted (Oe)
	Temperature Compensated Hall Probes Available
User Interface	Large TFT color LCD Display with backlighting
	Common Functions are Activated Quickly Through the Front Panel Keypad
	Other Functions are Accessible Through Graphical Menu System
	Mouse / Keyboard Supported (future expansion via USB ports)
Support Functions	Analog and Digital Filtering
	Relative Feature Allows Small Fluctuations to be Observed Within a Larger Field
	Hold Feature Includes Arithmetic Min/Max Readings Calculated by the Instrument and Signal Peaks/Valleys of Rapid Changing Pulses
	Field Classifier With Pass/Fail Outputs (not currently supported)
Remote Operation and Communications	RS-232C Standard 9-pin female "D" connector
	Protocol: SCPI-1999
	Protocol: IEEE-488-1987.2 w/ External Adapter (not currently supported)
	Protocol: IEEE-802.3u Data Link Layer & TCP / IP Transport & Network Layer
	Ethernet Standard RJ-45 Interface (10/100 MHz Ethernet Port)
	Dual USB 2.0 Compliant Ports – Firmware Update via USB drive
Signal Outputs	Corrected and Uncorrected Analog Outputs
	+/- 3V and +/- 10V Selectable Ranges
	Either Wave Form or RMS Signals
	Vector Summation Output (8030 Model Only)
	Spare Analog Outputs (not currently supported)
Probe Styles	Transverse and Axial
	Temperature Compensated
	Low, Medium, and High Field
	Standard and Heavy Duty
Software	On-Site Firmware Updates
	HTML User Remote Interface (not currently supported)
	LabView Drivers (under development)



GENERAL DESCRIPTION

The Model 8000 Series Gauss/Tesla meters utilizes Hall effect probes to measure magnetic flux density in units of gauss (G), tesla (T), amp/meter (A/m), or oersted (Oe). Either steady-state (dc) or alternating (ac) fields may be measured. Fields as low as 10 μ Gauss (0.001 μ T) or as high as 300k gauss (30 tesla), at frequencies up to 50 kHz, can be measured with extreme accuracy and 5-3/4 digit resolution. Each channel is calibrated and linearized independently from data stored within the probes and meters. With a temperature compensated Hall probe, the instrument can also compensate for errors due to variations in probe temperature.

User Interface

The meters feature a WVGA, 600x480 pixel, TFT Color LCD Display with backlighting. The display format may be customized by the operator and the meter automatically adjusts text sizes for the most convenient view of the information displayed.

Common functions are activated quickly through the front panel keypad, with each channel having its own identical set of keys. In addition each key has a back-light that is illuminated to indicate that it is active.

Less commonly used functions are easily accessible through the menu system.

Note: Each channel operates independently and each has the following features

Auto Range

Four measurement ranges may be selected manually or the instrument can automatically select the best range based on the present flux density level being measured.

Zero

The “zero” function allows the user to remove undesirable readings from nearby magnetic fields (including earth’s) as well as to remove initial electrical offsets in the probe and instrument. A “zero flux chamber” is included as an accessory which shields the probe from external magnetic fields during this operation.

**GENERAL
DESCRIPTION
(Continued)**

Hold

When the hold function is enabled the instrument will “hold” and display the highest and/or lowest flux density readings that have been measured. Hold features include capturing peaks and valleys of rapidly changing pulses as well as arithmetically calculated max and min of slow changing signals.

Relative

Another feature, called “relative mode”, allows large flux readings to be suppressed so that small variations within the larger field can be observed directly.

Update Interval

The update interval of the reading may be adjusted. Shorter update intervals allow rapid fluctuations in flux density levels to be observed. Longer update intervals provide higher resolution and stability in the flux density reading.

Analog Outputs

Each channel provides a Corrected and Uncorrected analog output voltage signal available from standard BNC connectors. The uncorrected output signal is representative of the magnetic flux density measured by the Hall probe. The corrected output signal is compensated for influences of temperature and frequency variations, as well as non-linearities inherent in the Hall probe and instrument.

Both the Corrected and Uncorrected analog outputs offer the selection of either raw wave form or RMS output data, and come with standard full scale output ranges of 3V and 10V full scale. An adjustable full scale output up to 9.9V in increments of 0.1V is also available (adjustable scale not currently supported).

Separate BNC outputs, not associated with the probe input channels, provide analog outputs for the Vector Summation (8030 Only) and Spare Analog outputs (spare analog outputs not currently supported).

These outputs may be connected to a voltmeter, oscilloscope, recorder, or external analog-to-digital converter.

**GENERAL
DESCRIPTION
(Continued)**

Analog Filters

Several analog filter modes are available in AC mode to help reject undesired frequency content from AC field level signals. These filters affect both the displayed reading and the analog outputs.

Field Classifiers

The “Classifier” function allows the user to define a lower and upper limit of flux density that can be used to quickly determine the status of a magnetic field. The instrument will indicate visually whether the field is below, within, or above the pre-defined limits. The same information is provided in the form of general purpose switch closures available at a standard 15 pin “D” type female connector. (this function is currently not supported and will be available in a future firmware revision)

Remote Operation

Remote operation is supported through either a standard 9-pin “D” RS232 serial port connector or standard RJ-45 Ethernet connector (10/100 MHz Ethernet Port). The 8000 meters can be remotely operated and flux density readings and other information can be acquired by a remote computer or PLC. The commands follow widely accepted protocols established by the SCPI-1999 standards.

Accessories

The instrument is shipped with a “zero flux chamber” used for shielding the probe from unwanted fields during zeroing. In addition a sturdy carrying case is provided for the zero flux chamber, probes, and other accessories or tools.

GENERAL DESCRIPTION (Continued)

Front Panel

The front panel consists of the TFT Color LCD display, Keypad, USB Ports, and Probe Connector(s).

TABLE 1-2 FRONT PANEL DESCRIPTION	
(1) Display	WVGA, 600 x 480 pixels, TFT Color LCD Display with Backlighting
(2) Standby Key	Standby Power Indicator
(3) Menu Key	Menu System Navigation
(4) Enter Key	Menu System Navigation
(5) Range Key	Selects Fixed Ranges or Auto Range
(6) Mode Key	Selects ac or dc Field Measurement
(7) Reset Key	Resets the Min/Max and Peak/Valley Detectors Used with the Hold Feature
(8) Zero Key	Starts the Zeroing Process
(9) Relative Key	Activates / De-activates the Relative Function
(10) Manual Key	Numeric Entry / Menu Navigation
(11) Probe Connector	12 Pin Non-Magnetic Female Connector for Hall Effect Probes
(12) Hold Key	Activates / Deactivates the Hold Feature
(13) USB Ports	Dual USB 2.0 Compliant Ports
(14) Menu Hot Keys	Menu Navigation and Function Selection

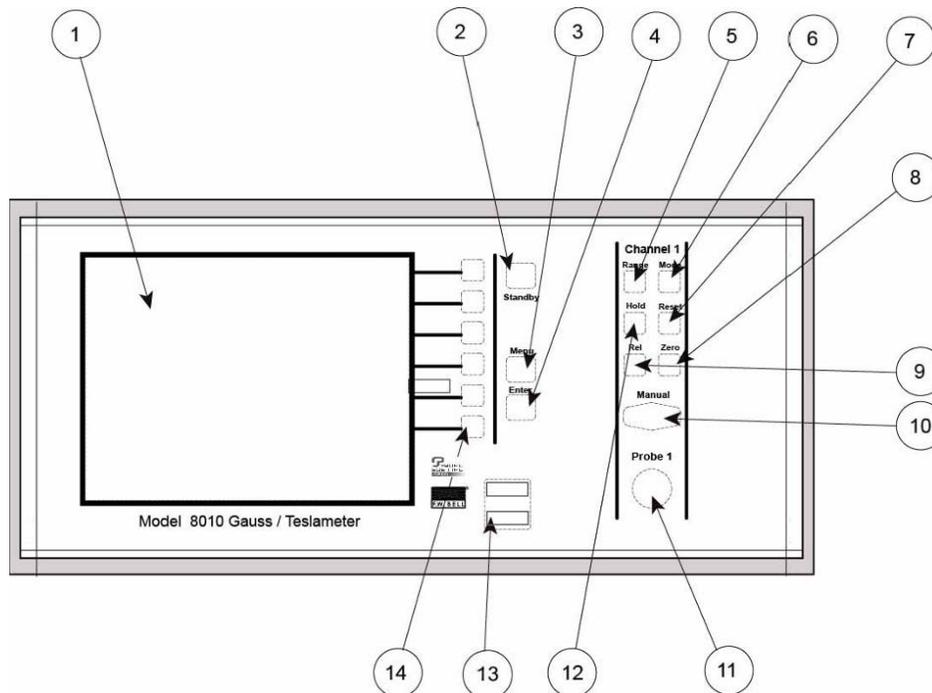


Figure 1-1 Front Panel (8010 Model Shown)

GENERAL DESCRIPTION (Continued)

Rear Panel

The rear panel consists of the Power Inlet / Fuse Holder, Analog Signal Outputs, Communication Ports, and the Cooling Fan Vent.

TABLE 1-3 REAR PANEL DESCRIPTION	
(1) Corrected Analog Output	Compensated Analog Output Voltage Signal, Standard BNC Connector.
(2) Uncorrected Analog Output	Uncompensated Analog Output Voltage Signal, Standard BNC Connector.
(3) Fuse Chart	Specifies the Proper Fuse Rating
(4) Ethernet Port	Standard RJ-45 Connector (10/100 MHz Ethernet Port)
(5) Power Receptacle	Accepts an International Instrumentation Power Line Cord
(6) Cooling Vent	Vents for Cooling Fan (Should Remain Clear)
(7) RS-232 Port	RS-232 Serial Communication Port. Standard 9 Pin "D" Type Female Connector.
(8) Digital I/O	Standard 15 Pin "D" Type Female Connector, Provides Switch Closure Points for Classifier Operation
(9) Auxiliary Output	Auxiliary Analog Voltage Output. Standard BNC Connector

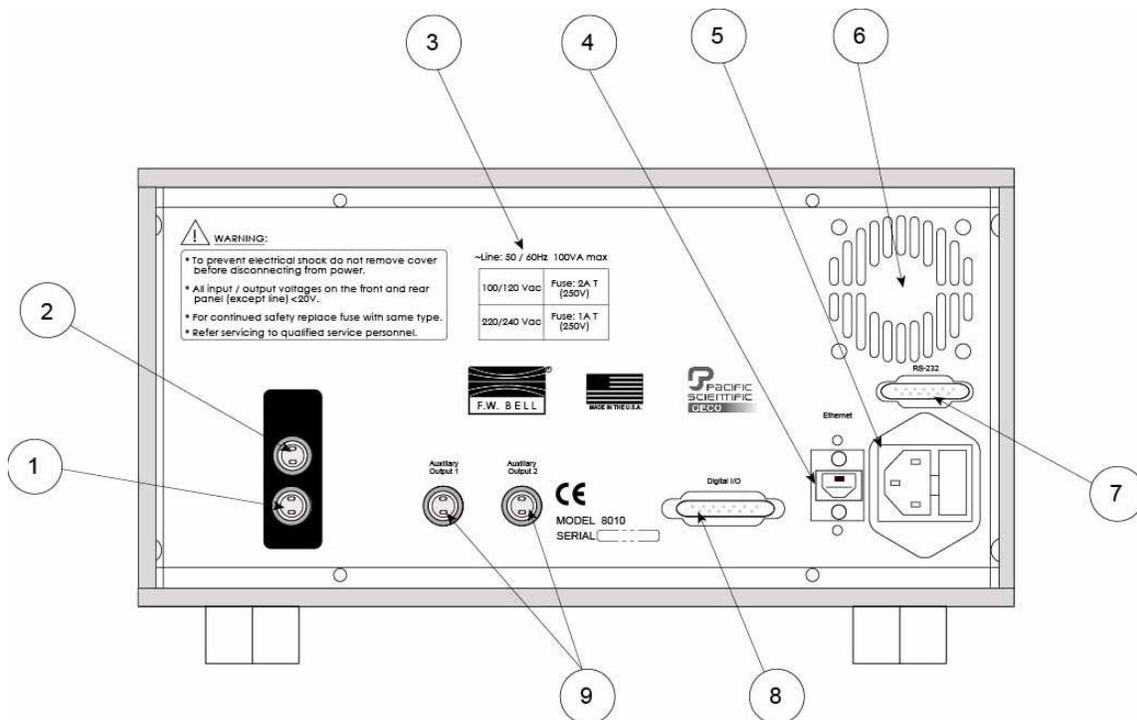


Figure 1-2 Rear Panel (8010 Model Shown)

**GENERAL
DESCRIPTION
(Continued)**

Cabinet

The cabinet is equipped with a side handle and two feet underneath the unit which serve to adjust the tilt angle of the instrument. **Figure 1-3** shows the instrument in various positions.

A rack mount option is available for the 8000 Series Meters that allows the meter to be mounted in a 19" equipment rack. Consult your FW Bell sales representative for more information.

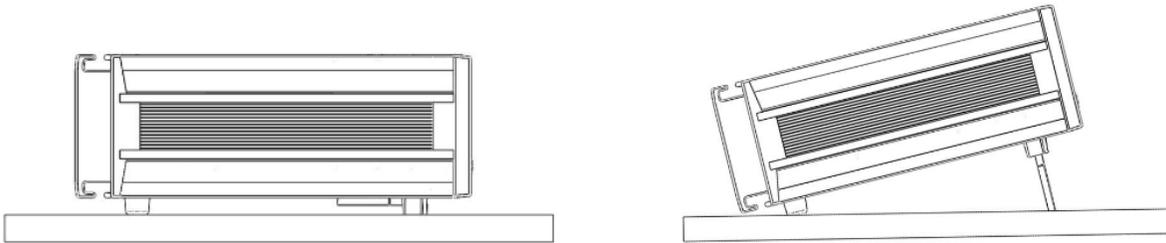


Figure 1-3 Various Positions of Instrument

APPLICATIONS

- Sorting or performing incoming inspection on permanent magnets, particularly multi-pole magnets.
- Testing audio speaker magnet assemblies, electric motor armatures and stators, transformer lamination stacks, cut toroidal cores, coils and solenoids.
- Determining the location of stray fields around medical diagnostic equipment.
- Determining sources of electromagnetic interference.
- Locating flaws in welded joints.
- Inspection of ferrous materials.
- 3-dimensional field mapping.
- Inspection of magnetic recording heads.
- Designing new magnetic assemblies.

Section 2

Specifications

METER SPECIFICATIONS

Full-scale ranges are shown in the **Tables 2-1a through 2-1c** below, listed by probe type. In all cases, the resolution is 1 part in 300,000.

Table 2-1a: Ranges for Low Field Probe:			
gauss (G)	tesla (T)	oersted (Oe)	ampere-turn/meter (A/m)
300.000 mG	30.0000 μ T	300.000 mOe	23.8732 A/m
3.00000 G	300.000 μ T	3.00000 Oe	238.732 A/m

Note: Low Field probe cannot be used for measurements above 2 Gauss.

Table 2-1b: Ranges for Mid Field Probe:			
gauss (G)	tesla (T)	oersted (Oe)	ampere-turn/meter (A/m)
30.0000 G	3.00000 mT	30.0000 Oe	2.38732 kA/m
300.000 G	30.0000 mT	300.000 Oe	23.8732 kA/m
3.00000 kG	300.000 mT	3.00000 kOe	238.732 kA/m
30.0000 kG	3.00000 T	30.0000 kOe	2.38732 MA/m

Table 2-1c: Ranges for High Field Probe:			
gauss (G)	tesla (T)	oersted (Oe)	ampere-turn/meter (A/m)
300.000 G	30.0000 mT	300.000 Oe	23.8732 kA/m
3.00000 kG	300.000 mT	3.00000 kOe	238.732 kA/m
30.0000 kG	3.00000 T	30.0000 kOe	2.38732 MA/m
300.000 kG	30.0000 T	300.000 kOe	23.8732 MA/m

Table 2-2 Accuracies at 23°C ±2°C (Instrument Only *)			
	Display and Digital Outputs (min speed)	Corrected Analog Output and Digital Outputs (max speed)	Uncorrected Analog Output
DC Accuracy	±0.05% of reading and ±0.01% of range	±0.15% of 3V or 10V ranges	3V range: 0.25% of reading ±40mV 10V range: 0.25% of reading±120mV
AC Accuracy In DC Mode	N/A	2% of range dc to 100 hz	2% of range dc to 100Hz
AC accuracy in AC mode	2.0% of reading ± 0.15% of range (20 Hz to 50 kHz)	2.0% of 3V or 10V ranges (ac 20 to 500 Hz) (ac rms (dc) 20Hz-50kHz)	See Figure 2-1 for Graph (Typical) ac and ac rms (dc) output
ac peak accuracy	5.00% of Reading	N/A	N/A

***Probes Errors Not Included**

REFERENCE

Min / Max Hold Acquisition Time:

dc Mode: 200mS
ac Mode: 200mS

Peak / Valley Hold Acquisition Time:

dc Mode: 2ms
ac Mode: 200 μ s

Temperature Coefficient:

0.02% of reading
 ± 1 count/degree Celsius

Update Rate:

Display: 5/s (max)
Ethernet and
RS-232 Output: 100/s (max)

Corrected Analog Output Noise (3V output range with 500 Hz filter):

All ranges:
2mVrms (35mV p-p)

Un-Corrected Analog Output Noise (3V output range with 500 Hz filter):

300G, 3kG, 30kG ranges:
50 μ Vrms (10mV p-p)
30G range:
2mVrms (20mV p-p)

Temperature Range:

Operating: 0 to 70 degrees Celsius
Storage: -20 to 60 degrees Celsius

Humidity Range:

0 to 35°C, to 80% RH at 35°C

Analog Output Impedance:

<100 Ohms

Analog Output Connector:

Standard female BNC

Analog Output Scaling:

dc Mode: 3V or 10V standard
 $\pm 0.1V$ to $\pm 9.9V$ adjustable,
with increments of 0.1 V
ac Mode: 3Vrms or 10Vrms standard
 $\pm 0.1Vrms$ to $\pm 9.9Vrms$ adjustable,
with increments of 0.1Vrms

Front Panel Display:

WVGA, 600 x 480 pixels, TFT Color LCD Display
with Backlighting.
Dimensions: 4.7 W x 3.5 H inches
119 W x 89 H millimeters

Power:

Volts: 100/120 220/240
Frequency: 50-60 Hz or 50-60 Hz
Current: 1.0 A (max) 0.5 A (max)

Size:

11.5 W x 5.2 H x 14.5 D inches (5.85H with feet)
292 W x 132 H x 368 D millimeters (148.6H with feet)

Weight:

Net: 11.5 lbs. / 5.3 kg
Shipping: 17.7 lbs. / 8.1 kg

Warm-up Time to Rated Accuracy:

60 Minutes

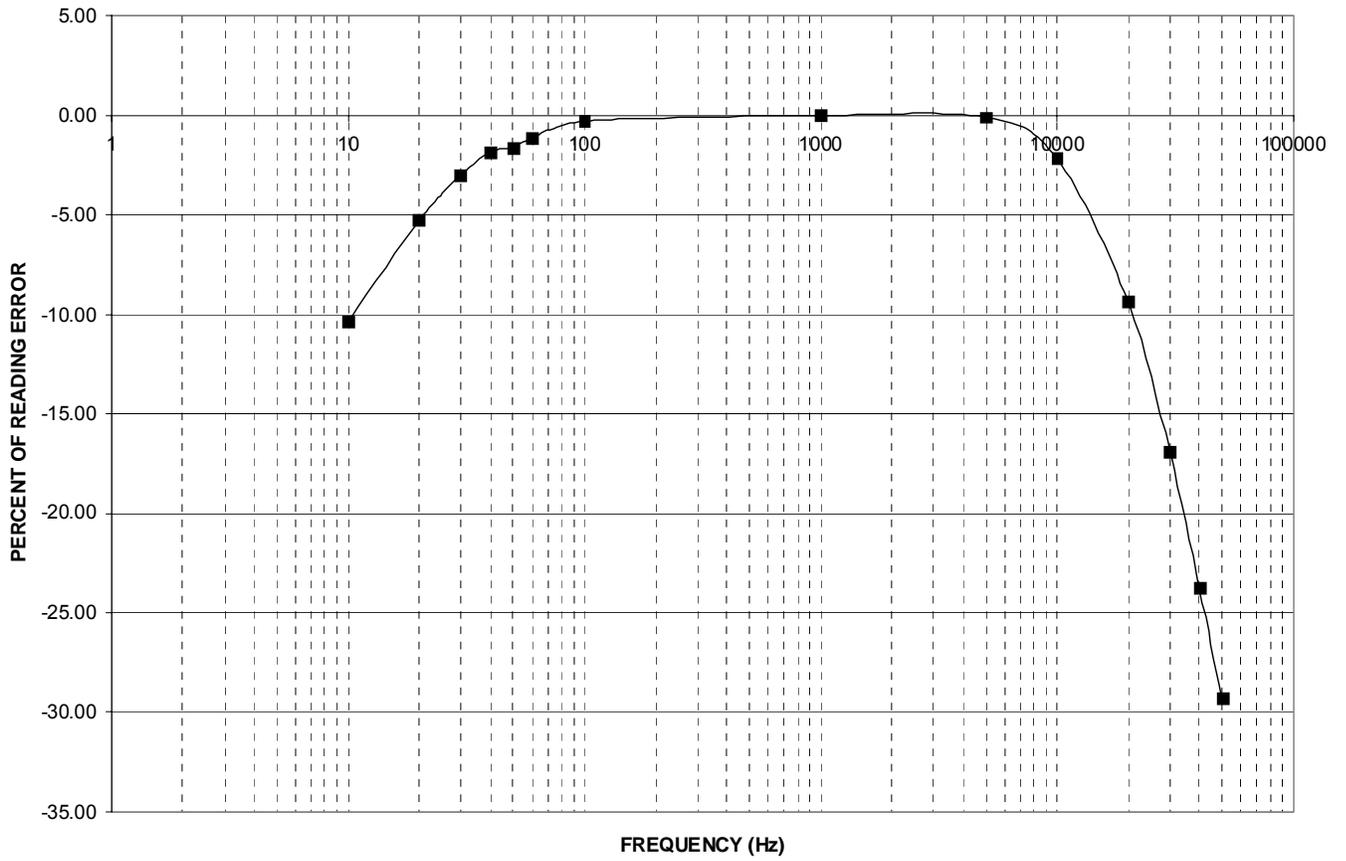


Figure 2-1 Frequency Response of Uncorrected Analog Output (Typical)
No Probe (Instrument Only)

Communications

EMC Application Note:

Use only high quality, double shielded cables for the RS-232 and Digital I/O connections. Keep the length of the cables less than 3 meters. Cables greater than 3 meters with insufficient EMI shielding can cause excessive emissions or may be susceptible to external interference.

Serial Port:

Format:	RS-232C
Connector type:	9-pin "D" female
Cable length:	3 m (9.8 ft.) maximum
Receive input resistance:	3 k Ω minimum
Receive voltage limit:	\pm 30 V maximum
Transmit output voltage:	\pm 5 V min, \pm 8 V typical
Baud rate:	9600
Stop bits:	1, 2
Character length:	7,8
Parity:	None
Handshaking	None
Standards supported:	SCPI-1999

Digital I/O (available with future firmware revision)

Signal Type:	Solid State Relay Closure
Connector:	15-Pin "D" Female
Switching Voltage:	30 V Dc or AC Peak MAX
Switching Current:	0.100 A DC or AC Peak MAX
On-State Resistance:	25 Ω MAX
Operating Time, Including Bounce:	3 mS MAX

Classifier Connection

Low	3,11
High	4,12
GND	8
+3.3Vdc	7
+5Vdc	15

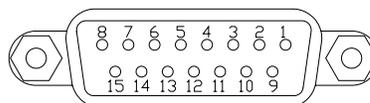


Figure 2-2 Digital I/O Connector
15 pin "D"

Note: The 3.3 and 5Vdc pins are limited to 100mA maximum and intended for Classifier logic use only.

Regulatory Information:

Compliance was demonstrated to the following specifications as listed in the official Journal of the European Communities:

EN 61326-1:2006	Immunity
IEC 61000-4-2:2008	Electrostatic Discharge (ESD) Immunity
IEC 61000-4-3:2010	Radiated Electromagnetic Field (RF) Immunity
IEC 61000-4-4:2004	Electrical Fast Transient/Burst (EFT) Immunity (A1:2010)
IEC 61000-4-6:2008	Conducted Immunity
IEC 61000-4-8:2009	Magnetic Field Immunity
IEC 61000-4-11:2004	Voltage Interruptions
IEC 61000-4-11:2004	Voltage Dips

EN 61326-1:2006 Class A	Emissions
CISPR 11:2009 (A1:2010)	Radiated and Conducted Emissions

CALIBRATION SERVICE

The instrument is calibrated at the factory prior to shipment. To maintain rated accuracy, it is recommended that the instrument be re-calibrated every 12 months.

Answers to any questions concerning the calibration of this instrument may be obtained by contacting Pacific Scientific OECO at the address below:

Pacific Scientific OECO
4607 SE International Way
Milwaukie, OR 97222

Phone: 503-659-5999

ZERO FLUX CHAMBER

Model Number:
YA-111

Cavity Dimensions:
Length: 50.8 mm (2")
Diameter: 8.7 mm (0.343")

Attenuation:
80 dB to 30 mT (300 G)

Purpose:
To shield the probe from external magnetic fields during the ZERO or RELATIVE operations.

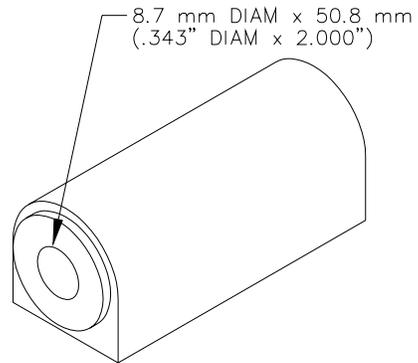


Figure 2- 3
Zero Flux Chamber

Section 3

Probes

OVERVIEW

F.W. Bell's 8000 series gauss/tesla meter probes are designed to meet the electrical and mechanical requirements of virtually any application. Models are available for transverse, axial, and very low field measurements. The probe style is dependent upon the measurement environment. The standard polypropylene stem is generally adequate for laboratory or light handling environments, while the heavy duty aluminum stem is recommended for harsher environments. The probe's length, outside diameter (axial probes) or thickness and width (transverse probes) are important if there are physical constraints where the probe will be used.

In "transverse" probes the Hall generator is mounted in a thin, flat stem whereas in "axial" probes the Hall generator is mounted in a cylindrical stem. The primary difference is the axis of measurement, as shown by "+B" in **Figure 3-2**. Generally transverse probes are used to make measurements between two magnetic poles such as those in audio speakers, electric motors and imaging machines. Axial probes are often used to measure the magnetic field along the axis of a coil or solenoid. Either probe can be used where there are few physical space limitations, such as in geomagnetic or electromagnetic interference surveys.

The low field probe is designed for high sensitivity, volumetric measurement such as mapping variations in the earth's magnetic field or detecting the presence of ferrous objects.



Handle Hall probes with care. Do not bend the stem or apply pressure to the probe tip as damage may result.

PROBE VARIATIONS

A wide variety of probes are available for use with the 8010 gauss/tesla meters. The types include heavy-duty transverse and axial, standard transverse and axial, standard transverse with exposed element, flexible transverse and axial with exposed element and low field probes. All of these probes are available with or without temperature compensation. All standard probes have a 10 foot (3.04m) cable length and most are available with various stem lengths. **Table 3-1** lists the maximum field measurement capabilities and resolutions.

Table 3-1 Probe Maximum Field Levels and Resolutions		
Probe Type	Maximum Field	Resolution
Low Field	2 G (200 μ T)	1 μ G (0.1 nT)
Medium Field	30 kG (3 T)	0.1 mG (0.01 μ T)
High Field	300 kG (30 T)	1 mG (0.1 μ T)

Figure 3-1 serves as an ordering guide for F.W. BELL 8000 series probes. Full electrical and mechanical specifications of all probes are available on request.

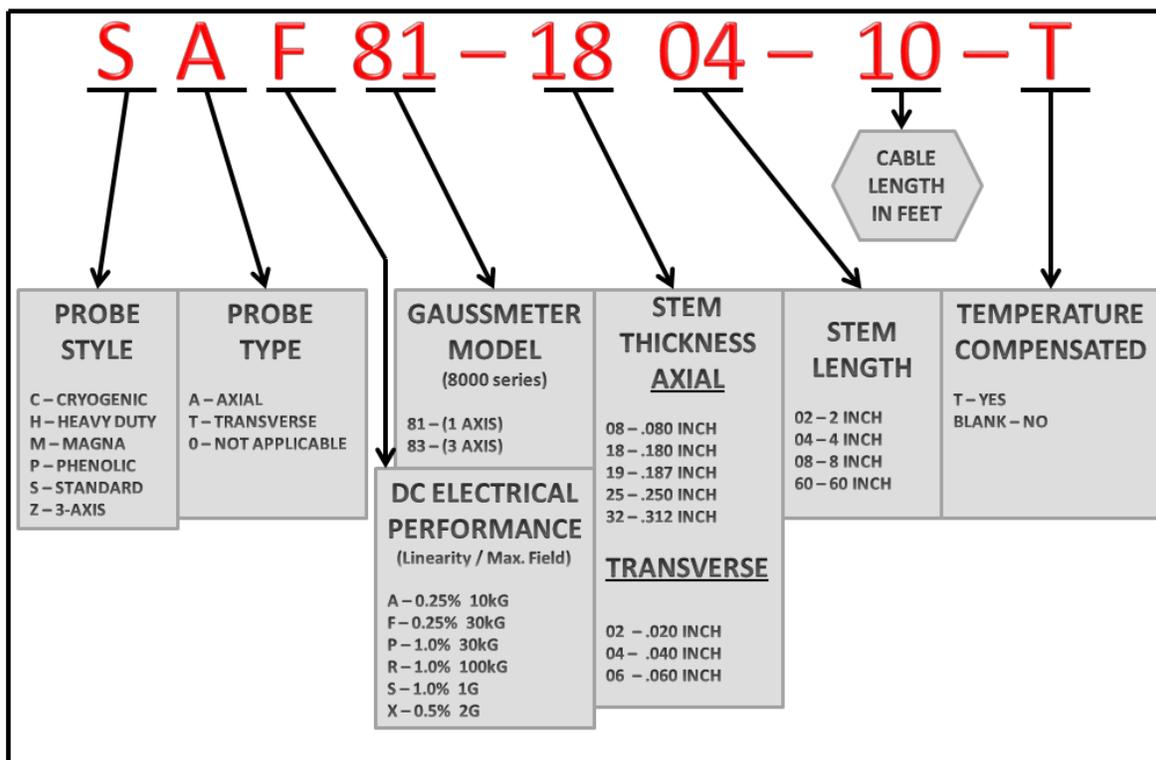


Figure 3-1 8000 Series Probe Ordering Guide

Note: Probes are not available in all part number combinations.



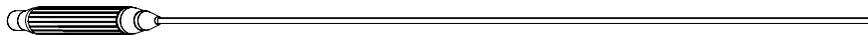
PROBE MEMORY

The connector of each probe contains a memory device which stores registration information (model number, serial number, date calibrated, etc.) as well as performance information for Hall generator sensitivity, linearity, frequency response and temperature response. Each probe is physically identified with model number, serial number and a maximum voltage rating of “30VRMS / 60Vdc MAX” on a durable polyester label wrapped around the cable jacket.



PROBE STEM

All probes except the low field probe are supplied with a rigid stem cover to protect the probe when not in use. It is strongly recommended to use the stem protector when storing the probe or when the probe will not be used for any length of time. If a probe stem becomes damaged it can not be repaired.



TEMPERATURE EFFECTS

All Hall probes have an initial electrical offset that will affect the accuracy of static (dc) field measurements. This offset should be canceled using the instrument’s “zero” function. However, the probe’s offset and sensitivity will change with temperature. Using temperature-compensated probes will minimize these effects.

There can be substantial errors in uncompensated probes. A typical probe’s dc offset can change by $\pm 0.1 \text{ G} / ^\circ\text{C}$ ($\pm 10 \text{ } \mu\text{T} / ^\circ\text{C}$). It is best to allow the probe’s temperature to stabilize before performing a “zeroing” operation. Zeroing is discussed in **Section 6 – Flux Density Measurement**. The probe’s sensitivity will decrease as temperature increases. Probes are calibrated at ambient temperature ($\sim 23 \text{ } ^\circ\text{C}$). A typical probe may change by $-0.05\% / ^\circ\text{C}$. For instance a reading of 200 mT at 23°C may drop to 197 mT at 50°C .



FIXTURING

In some applications it may be necessary to install a probe into a holding fixture to maintain a constant probe position. If this becomes necessary, do not clamp onto the probe stem as this will most likely damage the probe. Rather, clamp onto the aluminum probe body.

8000 series probes

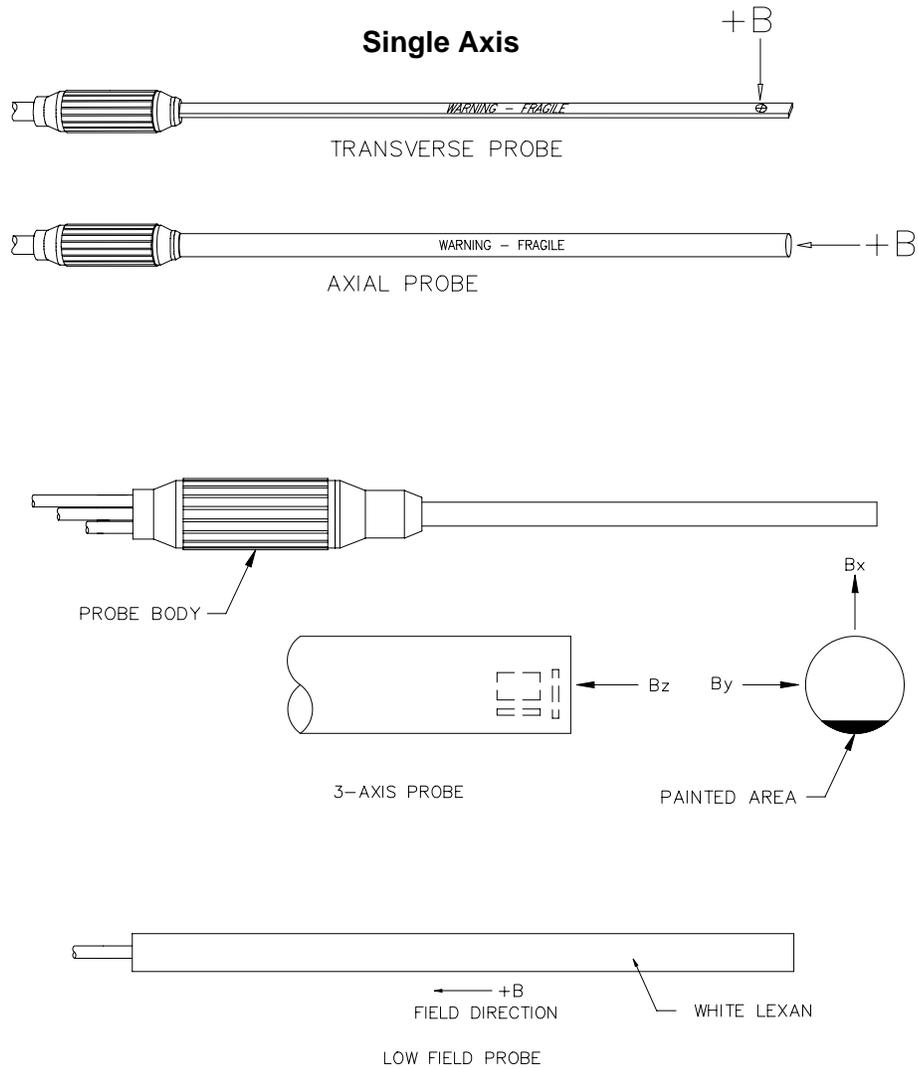


Figure 3-2 Hall Probe Configurations

Section 4

Setup

SAFETY INSTRUCTIONS

 **GENERAL:**

For safe and correct use of this instrument it is necessary that both operating and servicing personnel follow generally accepted safety procedures plus the safety cautions and warnings specified.

If it is determined that safety protection has been impaired, the instrument must be made inoperative and be secured against any unintended operation. For example, safety may be impaired if the instrument fails to perform or shows visible damage.

 **CAUTION:**

All input and output voltages, except line (mains), are less than 20V.

  **WARNING:**

The opening of covers or removal of parts might expose live parts and accessible terminals which can be dangerous.

  **WARNING:**

Any interruption of protective earth conductors or disconnection of the protective earth terminals inside or outside of the instrument can create a dangerous condition.

 **CAUTION:**

For continued protection replace the fuse with the same type (IEC 127 type T).

**SAFETY
INSTRUCTIONS
(Continued)**



WARNING:

The Hall probe is a non-contact measuring device. The probe is not to contact a surface which exceeds a voltage of 30Vrms (42.4V peak) or 60V dc.

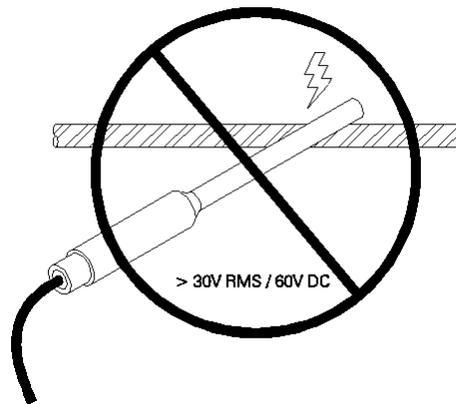


Figure 4-1 Probe Electrical Warning



CAUTION:

This instrument may contain ferrous components which will exhibit attraction to a magnetic field. Care should be utilized when operating the instrument near large magnetic fields, as pull-in may occur.



WARNING! READ THIS CAREFULLY

The 8000 Series gauss/tesla meters incorporate a universal power supply which operates from 90 to 260Vac. There are no switches or jumpers to select line voltage, but proper fuse selection is required.



LINE VOLTAGE SETTINGS / FUSE PANEL

Follow these instructions to replace a fuse or change to match the line voltage.

- 1) **See figure 4-2a.** This is the power cord receptacle. It is designed to accept an international instrumentation power cord. This receptacle also contains the fuse. Remove the power cord. On the right side of the receptacle is a slot. Insert a narrow screwdriver and gently release the access door (the door will not open unless power cord is removed). The door will swing out toward the right.
- 2) **See figure 4-2b.** Remove the fuse by pulling straight out. On the back side of the meter there is a fuse chart which specifies which fuse to use depending on your operating voltage 100/120 Vac or 220/240 Vac. There is a fuse kit which comes with the meter which includes the second fuse if needed for proper operation.

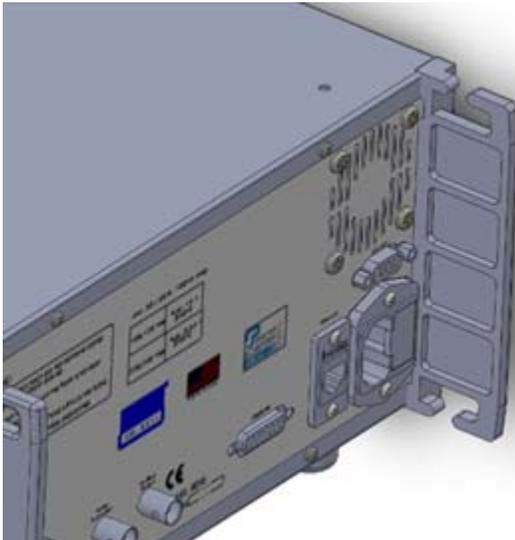


Figure 4-2a

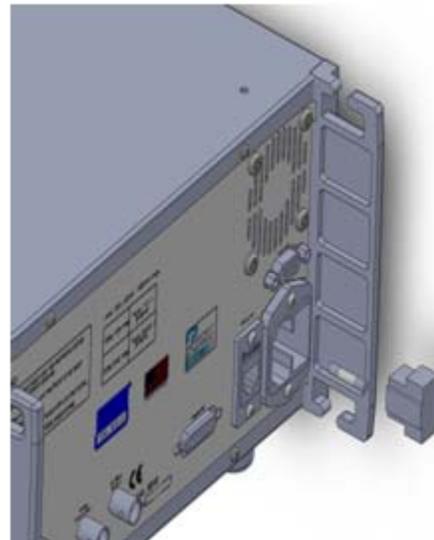


Figure 4-2b



ADJUSTING THE HANDLE

See Figure 4-3

The handle on the side of the meter can easily be grasped whenever the meter needs to be carried. The meter has two feet on the bottom as shown below which can easily be extended or collapsed to adjust the viewing angle of the front panel as preferred.

CAUTION: The feet lock into place and must be pulled away from the case before folding toward the rear to prevent breaking the feet.

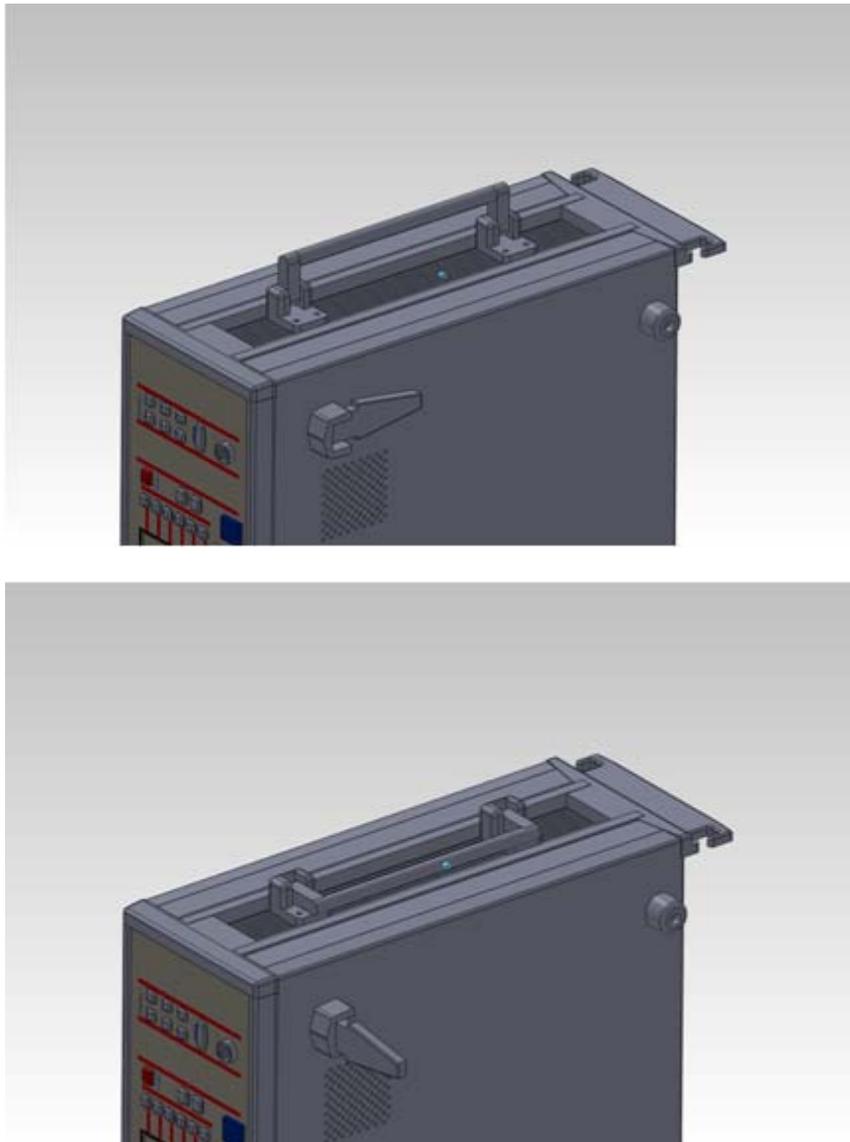


Figure 4-3 Adjusting the Handle and Feet



PROBE INSTALLATION / REMOVAL

See Figure 4-4

Install the probe connector so that the molded key in the connector body lines up with a similar key-way at the lower edge of the receptacle on the front panel. Push the connector in until it will travel no further. The connector will lock into place. There is no twist lock so it is not necessary to rotate any part of the connector.

To remove the connector, grab at the collar and slide back. The probe connector cannot be removed by pulling only on the rear of the connector body.

Note: You may install or remove a probe at any time, although it is not recommended to do so during the zeroing operation.

For more information on probes, see **Section 3 – Probes.**

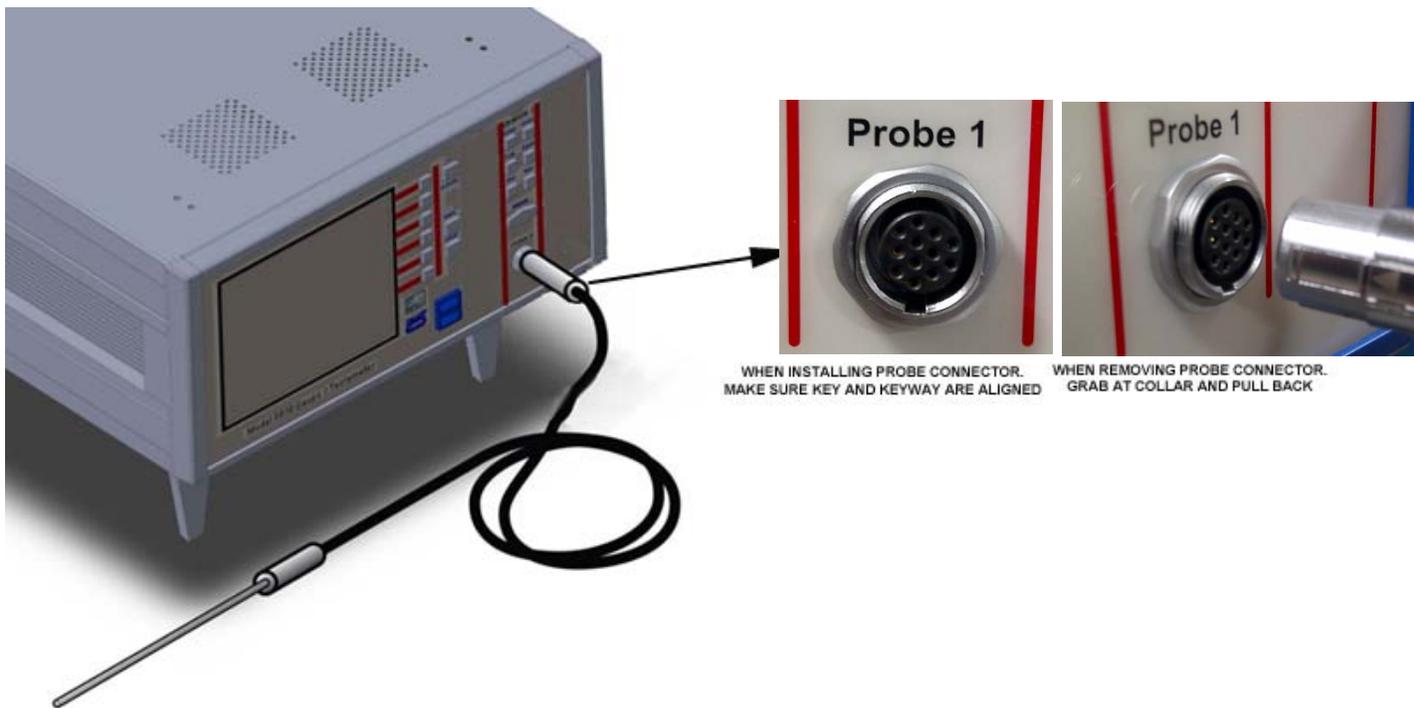


Figure 4-4 Installing and Removing Probes



POWER - UP

Locate the **Standby** button on the front panel, see **Figure 4-5**. After application of power to the input line cord, the standby button back light LED will slowly strobe red to indicate that the meter is in standby mode and power is applied. To turn ON the meter, press the button and release. The switch color will change to blue and the boot up procedure will begin.

To shut the instrument off, press the **Standby** button and release. After a few seconds the unit will shut off and the **Standby** button will return to the red strobe.

Note: Allow at least 3 seconds for the instrument to be off before turning it back on again to ensure a proper boot up..

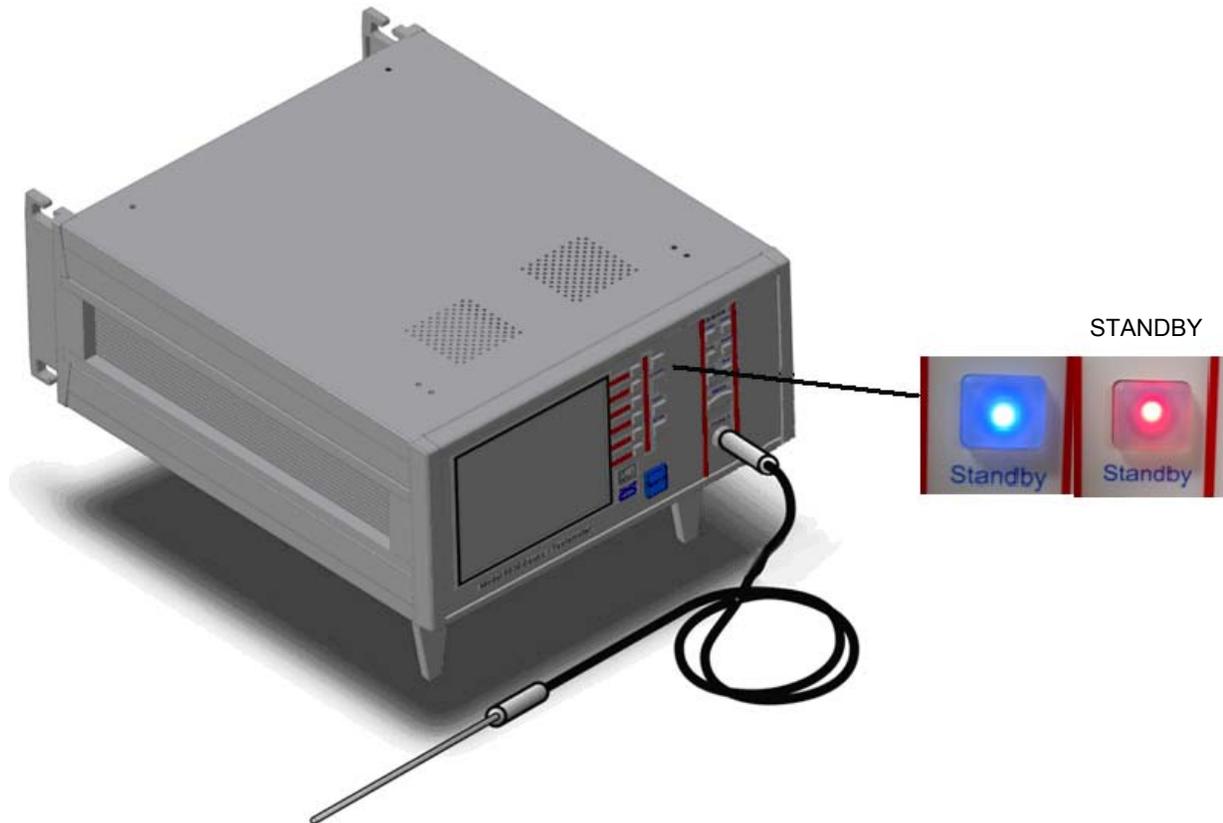


Figure 4-5 Standby Button Location

POWER – UP (Continued)

Firmware Initialization

During boot up, the OE logo will appear and a status bar indicates boot up progress. See **Figure 4-6**. Internal diagnostics are performed first, followed by the initial formatting of the display.



Figure 4-6 Boot Up Screen

Calibration data from all channels and their probes are retrieved next. The message “**Configuring Probe**” may be displayed during this process. If no probe is connected to a channel, the message “**No Probe Connected**” will be displayed.

If any of the internal diagnostic tests fail, an error message will appear and the instrument will halt the power-up procedure.

Upon successful completion of the diagnostics and initial calibration, the instrument will be ready to use. Active keys on the front panel are illuminated and present flux density readings and status are displayed.

Other parameters, such as range settings, AC/DC, hold, etc. will be initialized to the same condition they were in when the instrument was last turned off. More information on saving configuration settings is presented in **SECTION 5 – User Interface**.

Note: It is recommended that the instrument warm-up for at least sixty (60) minutes to achieve rated accuracy

Section 5

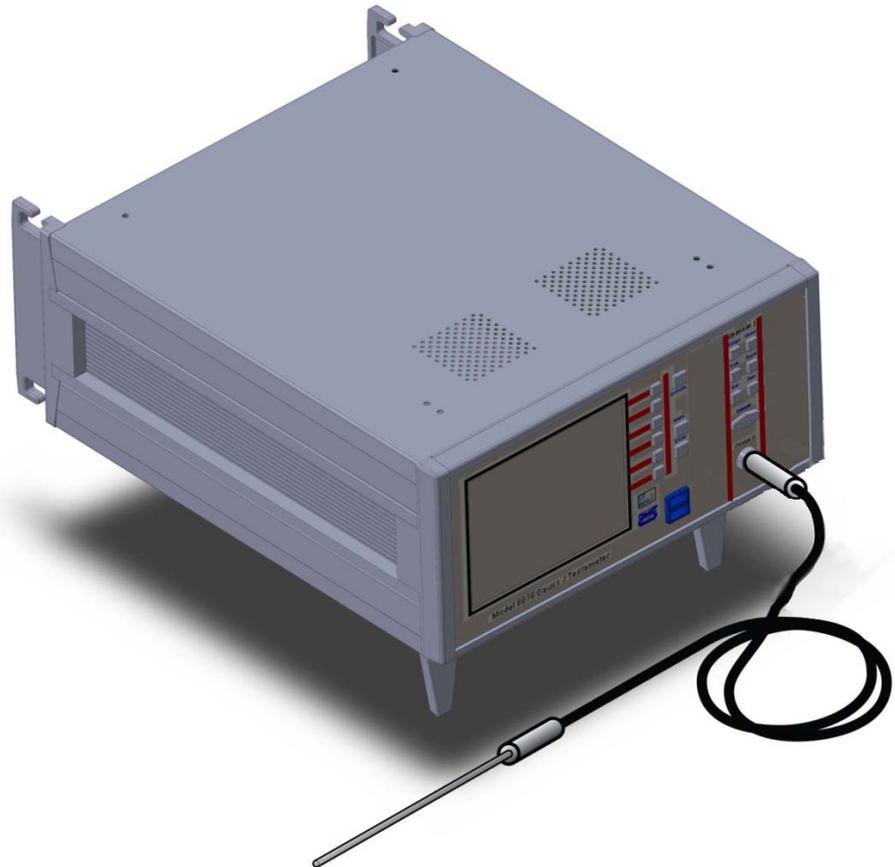
User Interface

OVERVIEW

Most of the features and functions of the 8000 Series Gaussmeters are activated directly from the front panel keypad. Each probe input channel has its own dedicated set of keys that control commonly used functions and the remaining functions are accessed through the menu system.

This section of the manual describes how the user interface to 8000 Series Gaussmeters is organized, including keypad layout and menu organization.

Operation and general considerations relating to flux density measurements and function operations are discussed in **Section 6 – Flux Density Measurement**.





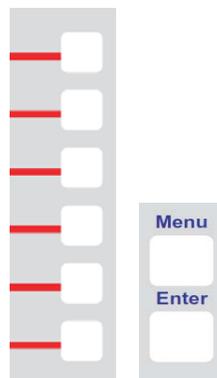
FRONT PANEL KEYPAD

There are several sets of keys on the 8000 Series Gaussmeter.

One set is associated with the menu system and these keys include; 'Menu', 'Enter' and the row of Menu Hot Keys that are aligned beside the display window as shown in Figure 5-1(a)

In addition, for each available probe input channel there is a set of keys associated with that channel. This set includes: 'Range', 'Mode', 'Hold', 'Reset', 'Rel', 'Zero', and the 'Manual' adjust keys as shown in Figure 5-1(b)

Refer to Figure 1-1 on page 1-7 for a complete diagram of the front panel keypad layout.



5-1(a) Menu keys



5-1(b) Channel Keys

Figure 5-1 Front Panel Key Sets

Each key features a back-light that will illuminate indicating that it is active or available for user access. In some instances, certain keys will flash indicating that a particular function is enabled and or that some condition requires attention.



MENU SYSTEM

The menu system for the 8000 Series Gaussmeter is very intuitive to use. It features the use of “Hot Keys” which are linked to menu selections or functions on the display. Note the corresponding red line that link the six Menu Hot Keys to menu selections on the right-hand side of the display as shown in Figure 5-2. The current menu or sub menu is identified in the bottom block highlighted in blue.

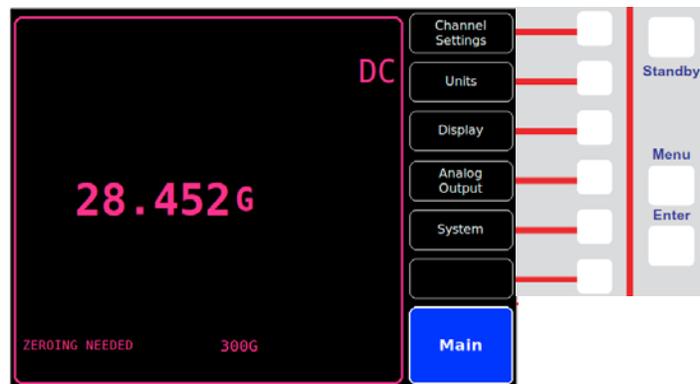


Figure 5-2 8000 Main Menu Example

To navigate the menu system, simply press the menu hot key that corresponds to the menu selection or function desired. To return to the previously accessed menu, press the ‘Menu’ button. Pressing the ‘Menu’ button multiple times will return the display to the ‘Main’ menu.

Table 5-1
Menu Key Operation Descriptions

Key	Operation
Hot Keys	Select Menu or Feature
Menu	Revert One Menu Level
Enter	User Acceptance or Selection Verification

MENU SYSTEM (Continued)

As the menu system is accessed each selection opens the selected menu or provides access to a list of settings for the desired function. At the point where function options are selected, the option selected will be highlighted in yellow as shown with the 30G range in the following example depicted in Figure 5-3.

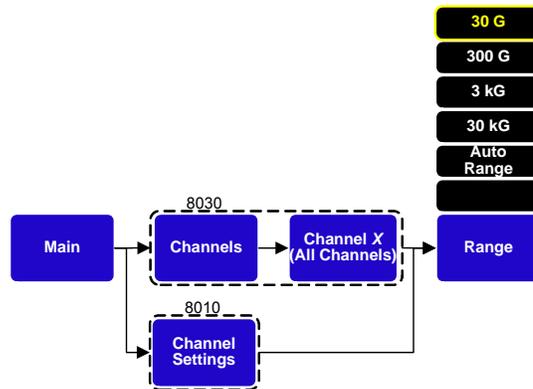


Figure 5-3 Menu Selections Example

Note: Some menu selections differ based on the specific model number. Menu selections or paths for different models are indicated by dashed boxes.

Special Menu Screens

Some menu selections have special menu screens that can be accessed. For example the Main⇒System⇒Firmware Update and the Main⇒System⇒Network Configuration menus bring up the following screens as shown in Figure 5-4.

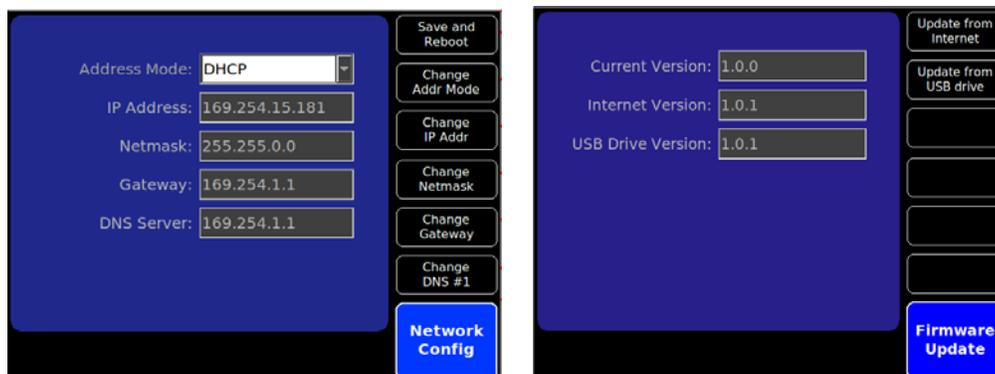


Figure 5-4 Special Menu Screens

**MENU SYSTEM
(Continued)**

The complete 8000 Series Gaussmeter menu system map is shown in Figure 5-5.

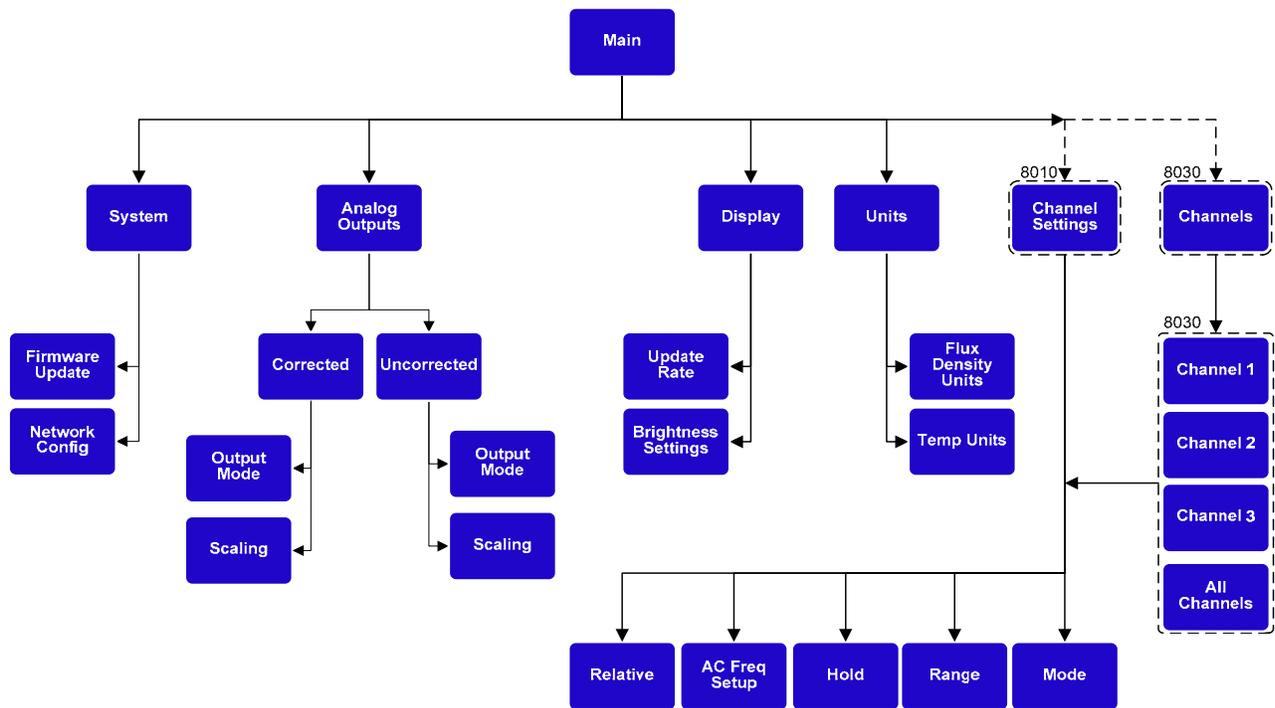


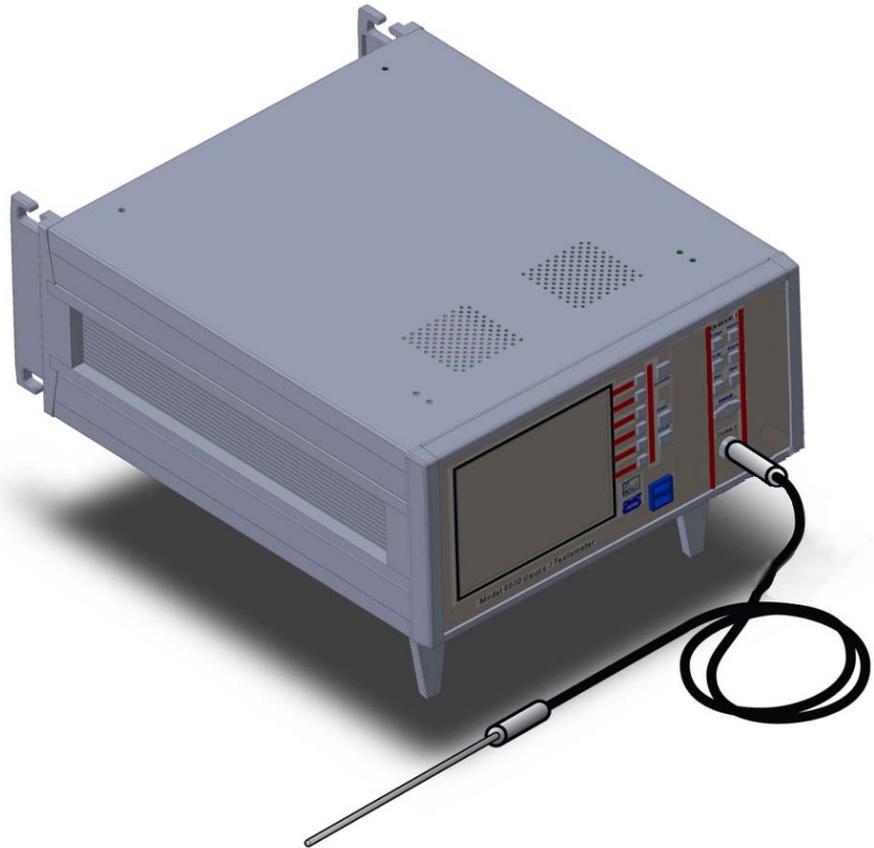
Figure 5-5 8000 Gaussmeter Menu Map

Section 6 Flux Density Measurement

OVERVIEW

This section describes field measurement operations for the 8000 Series gauss/tesla meters. Each of the meter's functions and features relating to field measurement is described in detail. This includes general considerations, technical information, and instructions on how to use each feature or function.

For a general discussion concerning the user interface, see **Section 5 – User Interface**.





MEASUREMENT UNITS

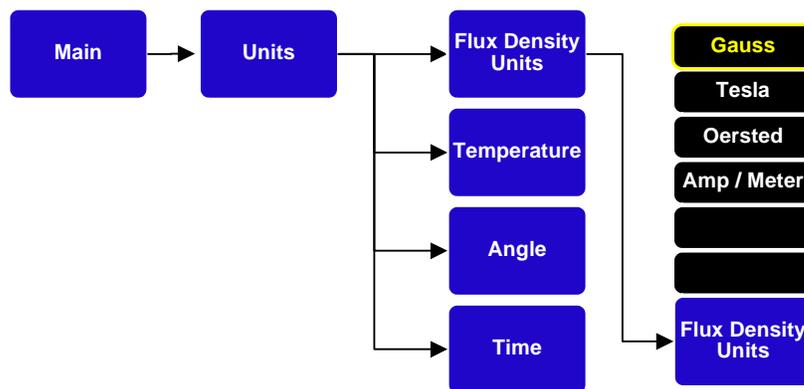
Units of measurement are set for the entire meter, i.e. it is not possible for one channel to have different units than another. The measurement units selected are displayed as part of the measurement when selected. **Table 6-1** lists the available units for each parameter.

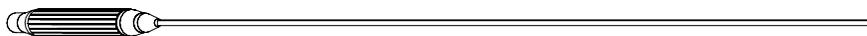
Table 6-1 Available Units	
Quantity	Units
Flux Density	Gauss (G)
	Tesla (T)
	Oersted (Oe)
	Ampere / meter (A / m)
Temperature	Fahrenheit (°F)
	Celsius (°C)
	Kelvin (°K)
Angle	Degrees (deg)
	Radians (rad)
Time (Frequency / Period)	Hertz (Hz)
	seconds (Sec)

Setting the Units

To change the units:

- 1) From the main menu, choose UNITS.
- 2) For each quantity, press the hot key next to the desired setting.
- 3) Press Menu to back out.



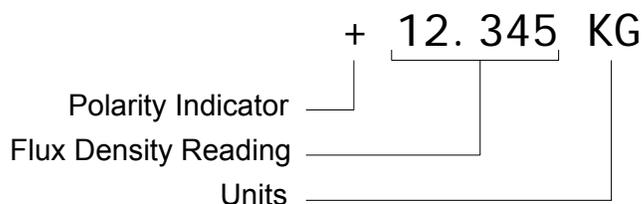


FLUX DENSITY READING

The flux density reading contains five or six digits of information, a decimal point, polarity identifier, and the units of measurement; see **Figure 6-1**. In the dc mode of operation, the polarity is indicated with a “+” or a “-”. The polarity information is absent when in ac mode, unless relative mode is enabled. Relative mode operation is discussed later in this section.

Note: The reading displayed in ac mode will represent the true RMS value of the field waveform.

Figure 6-1 Present Flux Density Reading

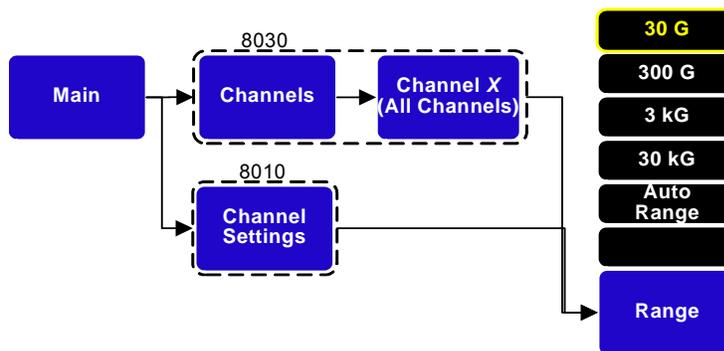


MEASUREMENT RANGE SELECTION

The instrument is capable of providing flux density measurements on one of four fixed ranges, or it can be programmed to automatically select the best range for the present flux density being measured. The available ranges are listed in **Section 2 – Specifications**. The ranges advance in decade steps and the magnitudes available depend on the probe type. The lowest range offers the best resolution while the highest range allows higher flux density levels to be measured.

Setting the Range

- 1) Using the Channel Keys, pressing the ‘RANGE’ key will advance the range setting. The four ranges are followed by the Auto range selection.
- 2) Navigate the menu, selecting the channel and range desired.



**MEASUREMENT
RANGE
SELECTION
(Continued)**

Auto Range

In the Auto Range mode, the range is advanced if the reading reaches 90% full scale of the present range. The range is lowered if the present reading falls below 8% full scale of the present range.

NOTE: When the word "Auto" does not appear on the Measurement Range indicator line, the channel is in manual ranging mode.

Over Range Condition

An over range condition will occur when the following is true:

The instrument is in manual range mode or is in auto range mode at the highest range; and the measured flux density is 110% of the present full scale range.

When an over range condition occurs the instrument will display the message "Overrange" in place of the flux density reading. The next highest range should be selected. If already on the highest range, then the flux density is too great to be measured with this instrument and its probe.

Note: For dc mode operation, the polarity of the flux density that caused the over range condition will be displayed to the left of the "OverRange" message.



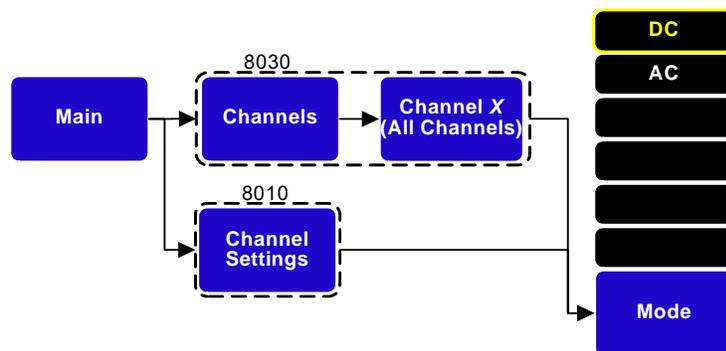
MEASUREMENT MODE SELECTION

The 8000 Series Gaussmeter is capable of measuring either static (DC) or alternating (AC) magnetic fields. To measure DC fields the meter must be set to operate in DC mode and conversely to measure AC fields the meter must be set to AC mode.

The active measurement mode is displayed in the upper right-hand corner of the display and indicates that the meter is in either DC or AC measurement modes.

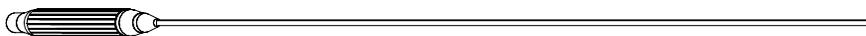
To change the measurement mode:

- 1) Using the channel keys, press the 'Mode' button for the channel you want to change.
- 2) Navigate the menu system and select the channel and mode desired.



DC MODE OPERATION

In the DC mode, the presence of an AC component can lead to unstable readings. If the peak value of the combined AC and DC component reaches the electrical limits of the meter, even though the average DC level is within the limits, an over range condition will appear on the display. This situation can also lead to erratic behavior if the automatic ranging feature is being used. The presence of an AC signal can be verified by observing the analog output signal or by using the AC mode to determine the magnitude of the AC component. Analog outputs are discussed later in this section.



**AC MODE
OPERATION**

It is possible for the flux density signal to contain both a DC component and an AC component. In the AC mode the value displayed is the true RMS value of the waveform with its DC component removed.

Frequency Measurement

When used in the AC mode, the meter will display the frequency or period of an AC field on the frequency indicator line, see **Figure 6-3**.

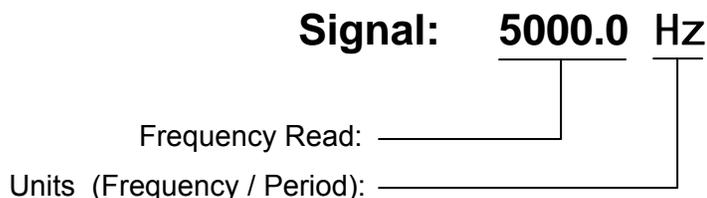


Figure 6-3 Frequency / Period Indicator Line

Note: Depending on the selection in the UNITS menu, frequency or period may be displayed.

Frequency Compensation in AC Mode

To obtain accurate ac measurements using frequency compensation, the ac field must have a frequency greater than 5 Hz, and depending on the selected range, a minimum magnitude according to **Table 6-2**.

Table 6-2 Minimum Magnitudes for Rated ac Accuracy			
Range			Minimum Magnitude
Low Field Probe	Mid Field Probe	High Field Probe	
300.000 mG (30.0000 μ T)	30.0000 G (3.00000 mT)	300.000 G (30.0000 mT)	20% Full Scale
3.00000 G (300.000 μ T)	300.000 G (30.0000 mT)	3.00000 kG (300.000 mT)	6% Full Scale
N/A	3.00000 kG (300.000 mT)	30.0000 kG (3.00000 T)	4% Full Scale
N/A	30.0000 kG (3.00000 T)	300.000 kG (30.0000 T)	2% Full Scale

If the measured magnetic field is less than the “minimum magnitude” shown on **Table 6-2**, fourth column; the frequency of the magnetic field may not be measured accurately resulting in magnitude errors that do not meet the specified rated accuracy.

**AC MODE
OPERATION
(Continued)**

AC Mode Analog Filtering

While operating in AC mode one of four analog filters must be selected as shown in Table 6-3. These filters affect the displayed reading and analog outputs.

As shown in Table 6-3 the High Frequency filter selection represents the full bandwidth of the 8000 Series Gaussmeter. The other filter selections can be used to narrow or focus the bandwidth of the meters analog amplifiers to minimize influence from noise or other unintentional signals.

Internally the meter also uses these filter selections to determine the best data sampling and averaging rates to generate the most accurate RMS calculations and readings.

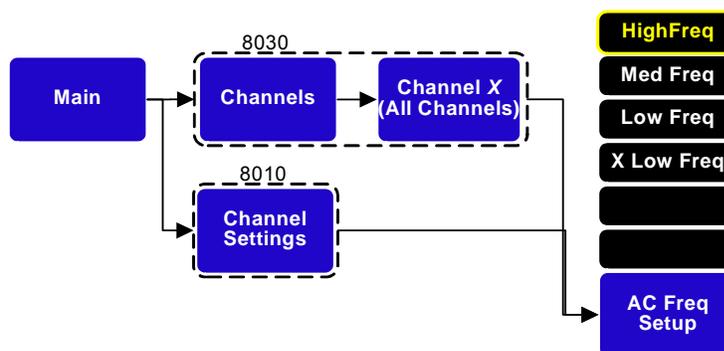
To avoid additional reading errors care should be taken to avoid using any particular filter with input frequencies close to the filter limits. Driving the input with signal frequencies at or near these frequencies limits the effectiveness of internal correction factors.

Table 6-3 AC Mode Analog Filter Selections	
Filter Selection	Bandwidth
High Frequency	20 Hz to 50 kHz
Medium Frequency	20 Hz to 10 kHz
Low Frequency	20 Hz to 500 Hz
X Low Frequency	1 Hz to 500 Hz

Setting the Analog Filters

To select the analog filter:

- 1) Navigate the menu system to select the desired channel, then choose AC Freq Setup and select the appropriate filter.



ZEROING

Overview

“Zeroing” the probe and instrument is one of the most important steps to obtaining accurate flux density measurements. An ideal Hall effect sensor produces zero output in the absence of a magnetic field, but actual devices are subject to variations in materials, construction and temperature. Therefore, most Hall effect sensors produce some output even in a zero field. This will be interpreted by the instrument as a magnetic field signal.

Also, the circuits within the instrument can produce a signal even when there is no signal present at the input. This will also be interpreted as a magnetic field by the instrument. Lastly, magnetic sources close to the actual field being measured, such as those from electric motors, permanent magnets and the earth’s magnetic field (roughly 0.5 gauss or 50 μ T), can introduce errors in the final reading.

The zero operation is performed for both AC and DC modes of operation. While in DC mode, the zero point can be adjusted manually. When the zeroing process is initiated, the instrument performs separate zeroing sequences for AC and DC mode operation. Both sequences occur regardless of whether a channel is in AC or DC mode, and each has its own considerations.

NOTE: The process of zeroing also affects other functions such as corrected analog output signals, the hold and relative, and the field classifiers. Uncorrected analog outputs are not affected.

NOTE: The manual zero user entry is not currently supported.

Zeroing

For most situations it is preferable to shield the probe from all external magnetic fields prior to zeroing. Provided with the instrument is a “zero flux chamber” which is capable of shielding against fields as high as 30 mT (300 G or 23.88 kA/m). The probe is simply inserted into the chamber before the zeroing process begins. **Initiating Zeroing**

To initiate zeroing on one channel

- 1) Prepare the probe for zeroing.
- 2) Press the ZERO key for the appropriate channel.

To initiate zeroing on all channels

- 1) Prepare all probes for zeroing.
- 2) Press and hold the ENTER key, then press the Channel 1 ZERO key .

The channel(s) will display the message “Zeroing” and a countdown indicates the approximate duration of the zeroing process. Once zeroing begins it must be allowed to complete. During this time, all controls are disabled except for the power switch. When only one channel is zeroed, the remaining channels will suspend operation during the zeroing process but will

not lose their present zero point information. The zeroing process is approximately 60 seconds when basic ac mode zeroing is enabled and is approximately 2 minutes for advanced ac mode zeroing



Handle the Hall probe with care. Do not bend the stem or apply pressure to the probe tip as damage may result.

In other situations the user may want the probe to be exposed to a specific magnetic field during the zeroing process. As an example, consider zeroing the probe when it is exposed to the earth's magnetic field. This will cancel the effect of the earth's magnetic field for all future readings. If a range is exceeded by the level of field while zeroing, the lower range cannot be entered by the instrument.

ZEROING (Continued)

Zero Prompt

The meter will inform the user to zero a channel by flashing the appropriate ZERO key on the front panel. The following conditions will cause the meter to prompt the user to zero a channel:

- The meter was just turned on.
- A probe was just inserted into the meter.
- Fifteen (15) minutes has elapsed since a probe has been inserted.
- Sixty (60) minutes has elapsed since the meter was turned on.
- The meter's internal temperature has drifted by at least 5°C since the last zero operation (only applied after 60 minute warm up period is complete).

Initiating Zeroing

To initiate zeroing on one channel

- 3) Prepare the probe for zeroing.
- 4) Press the ZERO key for the appropriate channel.

To initiate zeroing on all channels (8030 only)

- 3) Prepare all probes for zeroing.
- 4) Navigate the menu system select 'All Channels' and press the 'Zero' menu button.

The channel(s) will display the message 'Zeroing in Progress' and a progress bar will indicate the status of the zero operation selected. Once zeroing begins it must be allowed to complete. The zeroing process is approximately 2 minutes.

Manual Zero (not currently supported)

This feature also allows the user to manually set the zero point to a value other than zero or to make a fine adjustment to the zero point after performing a zeroing operation.

To manually adjust the zero point:

- 1) Position the probe for zeroing.
- 2) Navigate the system menu for the desired channel select manual zero.

This value will be added to (or subtracted from) all future readings.

NOTE: Making a manual adjustment to the zero point only affects the current range. Adjustment may need to be repeated for other ranges.

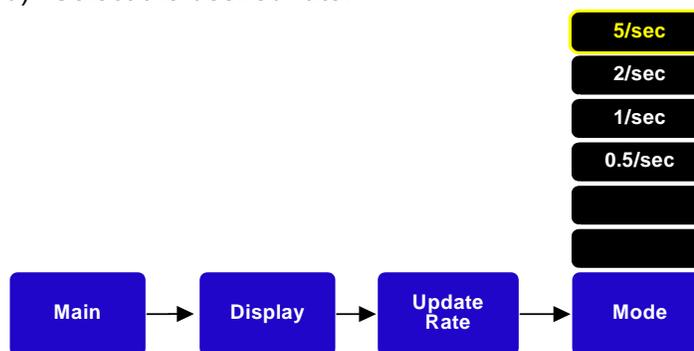
**DISPLAY
UPDATE
INTERVAL**

The update interval of the reading may be adjusted. Larger update intervals allow rapid fluctuations in flux density levels to be observed. Smaller update intervals provide higher resolution, accuracy, and stability in the flux density reading. The Update Intervals are shown in **Table 6-4**.

Table 6-4 Update Interval Setting
5 Readings per Second
2 Readings per Second
1 Readings per Second
0.5 Readings per Second

Configuring the Update Interval

- 1) From the main menu, choose DISPLAY.
- 2) Select Update Rate
- 3) Select the desired rate.





HOLD FUNCTION

In some applications it may be desirable to “hold” a reading that is either greater than (MAX hold) or less than (MIN hold) all previous readings. Also, it may be necessary to capture the high (PEAK Hold) and low (VALLEY Hold) extremes of rapidly changing pulses. The hold functions will hold their readings until reset by the user.

MIN and MAX HOLD General Description

The MIN and MAX hold functions are useful in determining the maximum or minimum value of magnetic readings that occur over a period of time. The MIN and MAX use readings that are arithmetically averaged by the meter for slow changing signals.

The MAX hold function holds any reading that is arithmetically greater than all previous readings. For instance, a reading of +125.0 is greater than +99.0 or -150.0.

The MIN hold function holds any reading that is arithmetically less than all previous readings. For instance, a reading of -125.0 is less than -99.0 or +150.0.

PEAK and VALLEY HOLD General Description

PEAK and VALLEY hold modes are used to track rapid events such as magnetizing pulses. Unlike MIN and MAX, PEAK and VALLEY are not arithmetically averaged by the meter. They represent the extremes of a flux density waveform as they have been captured within the bandwidth of the meter.

In AC mode the analog filter selection will also affect the peak and valley hold operation such that lowering the bandwidth and by extension the sampling rate, will limit the meters ability to capture rapidly changing signals.

Numerically, The PEAK hold function holds it's reading the same as the MAX hold function. The PEAK hold function holds the reading greater than all previous readings, within the response time of the instrument. For instance, a reading of +125.0 is greater than +99.0 or -150.0.

Numerically, The VALLEY hold function holds it's reading the same as the MIN hold function. The VALLEY hold function holds the reading that is lower than all previous readings, within the response time of the instrument. For instance, a reading of -125.0 is less than -99.0 or +150.0.

Note: Peak and Valley Hold functions are not available for the Vector Sum display. (8030 Only)

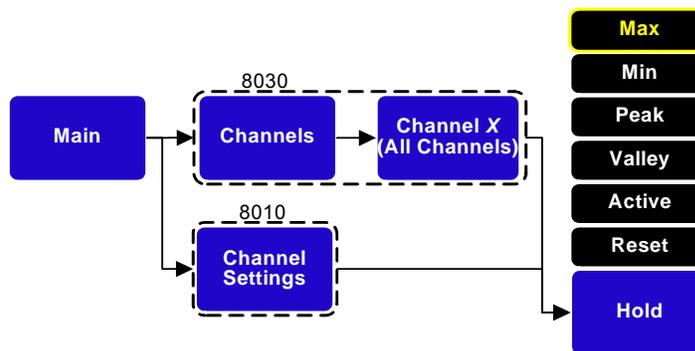
HOLD FUNCTION (Continued)

Hold Mode Configuration

The hold functions are setup for use from each channels hold menu, but can also be activated and reset from the front panel using the channel keys. Any combination of the various hold functions may be enabled for display.

To enable / disable the display of the hold function(s):

- 1) From the main menu navigate to Channel Settings (8010) or Channels (8030)
- 2) Select the desired channel or all channels (8030 only)
- 3) Select Hold
- 4) Enable the desired Hold function(s).



Hold functions that are enabled in the HOLD menu will be highlighted yellow.

Using the HOLD Function

To activate / de-activate the hold function(s):

- 1) Using the channel keys press the HOLD key.
- 2) Use the channel(s) Hold menu system to active.

Note: Using the Hold menu is the only way to activate the Vector Sum Hold functions (8030 only).

The HOLD and RESET keys will illuminate indicating that the hold function is active. Pressing the HOLD key again will de-activate the hold function.

To reset the hold function:

- 1) With the hold function active, press the RESET key.
- 2) Use the Hold Menu RESET menu key.

Note: The hold functions are reset automatically when they are activated (i.e. the "hold" readings are not saved when the hold functions are de-activated).



RELATIVE MODE

The relative mode allows a specific flux density value to be subtracted from all future readings. Thus all future readings will be “relative” to that value. For instance if the relative value is +100.0 gauss, and the present flux density is +112.0 gauss, the actual displayed value will be +12.0 gauss. If the flux density drops to +77.0 gauss, the actual displayed value will be -23.0. Thus the relative mode allows for the direct readout of variations around a given field, whether static (dc) or alternating (ac).

There are two ways to generate a relative value. When the ‘REL’ channel key on the front panel is pressed the meter turns on the Auto Relative feature and the meter uses the present flux density reading from the probe as the relative value. Alternatively, you may specify a pre-determined value from each channels relative menu to activate and set the meters Manual Relative feature. (*note: the Manual Relative feature is not currently supported*)

There may be situations when the user may prefer to shield the probe from all external magnetic fields prior to performing a relative operation. Provided with the instrument is a “zero flux chamber” which is capable of shielding against fields as high as 30 mT (300 G or 23.88 kA/m). The probe is simply inserted into the chamber before the relative operation begins.



Handle the Hall probe with care. Do not bend the stem or apply pressure to the probe tip as damage may result.

Relative and AC Mode Operation

In normal operation, AC readings do not indicate a polarity as they represent the true RMS magnitude of the flux density reading. With the relative mode however, the polarity indicates whether the magnitude of the measured AC field is greater or less than the relative value. For example, if the relative value is 100.000 gauss AC and the measured flux density is 90.000 gauss AC, the displayed reading will be -10.000G.

Note: The relative value in ac mode is always positive; the relative reading may be positive or negative.

Note: The relative mode is cancelled if the probe is disconnected, if the instrument is turned off and back on again, or if the instrument is switched between AC and DC modes.

**RELATIVE MODE
(Continued)**

Auto Relative Mode – Front Panel

In the automatic mode, the present flux density as seen by the probe is used as the relative value.

To use the present flux density as the relative value:

- 1) Select AC or DC mode.
- 2) Press the 'REL' channel key.

The 'REL' key for that channel will illuminate to indicate that the relative function is enabled. The "Relative Value Indicator" displays a value that was the present flux density reading before the relative key was pressed see **Figure 6-5**. The present flux density reading should then display a value of zero. All readings from this point forward are "relative" and not absolute. The relative value is subtracted from all future readings. In the relative mode, a reading of zero indicates that the actual flux density being measured is equal to the relative value.

Rel : 1. 23456G

Figure 6- 5 Relative Value Indicator

To de-activate the relative mode:

- 1) Press the 'REL' channel key.

The RELATIVE key back light will go off and the relative value indicator will disappear. All readings from this point forward are now absolute.

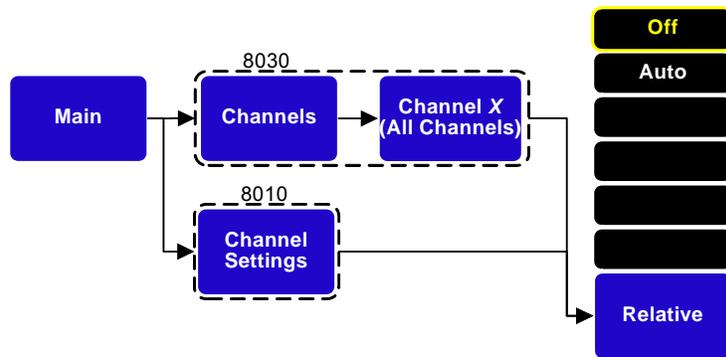
**RELATIVE MODE
(Continued)**

Auto / Manual Relative Mode – Menu System (*manual mode not currently supported*)

In some cases you may wish to set a pre-determined relative value. The relative value can be set precisely from the menu system.

To set a pre-determined relative value from the menu system:

- 1) Select AC or DC mode.
- 2) From the main menu navigate to Channel Settings (8010) or Channels (8030)
- 3) Select Relative
- 4) Select Manual or Auto



Adjusting the Relative Value from the Measurement Screen

Once the relative value is set, either from the front panel or from the RELATIVE menu, its value may be adjusted by using the MANUAL ADJUST keys. The right MANUAL ADJUST key will add to the relative value, and the left MANUAL ADJUST key will subtract from the relative value.

**VECTOR
SUMMATION
(8030 ONLY)**

In addition to the three standard channels, the vector summation is dedicated to vector measurements. The resultant magnitude of the three channels vector sum and relative vector angles are calculated, displayed, and a corrected analog output is also provided. Analog outputs are described later in this section. Vector summation also supports the hold (MIN and MAX only) and relative features, which were described previously.

Using 8000 Series 3-Axis Probes

A three axis probe is shown in **Figure 6-6a**. The orientation of the probe and location of the “X” hall effect element is specified with a painted mark. The straight side of the painted mark is parallel with the Y axis. **Figure 6-6b** is an inside view that shows the locations of the X, Y, and Z hall effect elements. The planes of the three Hall elements are orthogonal with one another. A positive magnetic field entering the hall elements along the X, Y, and Z axes as shown in **Figures 6-6a** and **6-6b** will produce positive readings.

The meter will detect the presence of an 8000 series 3-axis probe and will automatically recognize X, Y, and Z regardless of how their cables are connected to channels 1, 2, and 3. The axis for each channel will be shown on the display using the Probe Axis Indicator.

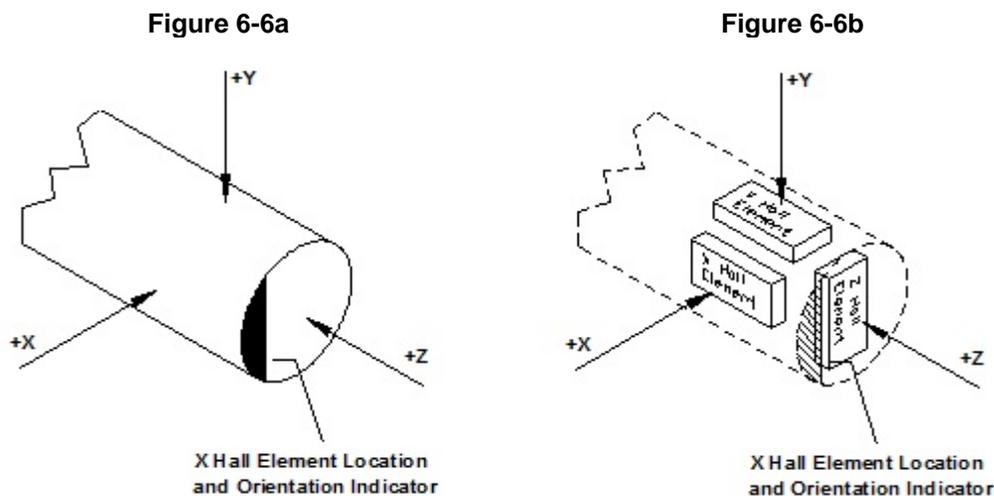


Figure 6-6 8000 Series 3-Axis Probe Orientation

**VECTOR
SUMMATION
(8030 ONLY)
(Continued)**

Vector Magnitude

The vector magnitude is calculated using the Pythagorean Theorem for an Orthogonal Cartesian co-ordinate system, mathematically:

$$R = \sqrt{X^2 + Y^2 + Z^2}$$

Where X, Y, and Z, are the axis readings from channels 1, 2, or 3 and R is the resultant vector magnitude.

Vector Angle

Vector Angles are specified as the angles between the resultant vector and X, Y, and Z axes. The angles are calculated using the following equations.

$$\theta_x = \cos^{-1} (X/R), \quad \theta_y = \cos^{-1} (Y/R), \quad \theta_z = \cos^{-1} (Z/R)$$

Where θ_x , θ_y , and θ_z are the angles between R and the X, Y, and Z axes. On the display, vector angles are indicated as X, Y, and Z corresponding to θ_x , θ_y , and θ_z , respectively.

Vector Summation and Relative Mode Operation

If the relative mode is enabled for individual channels, the meter will use those readings when calculating the vector summation. When all three channels are in relative mode, a vector difference is calculated using the following equation:

$$R_{rel} = \sqrt{(X - X_{rel})^2 + (Y - Y_{rel})^2 + (Z - Z_{rel})^2}$$

Where X, Y, and Z are the present readings in relative mode and X_{rel} , Y_{rel} , and Z_{rel} are the relative settings. R_{rel} is the magnitude of the difference vector.

Similarly, the angles are computed using the following equations:

$$\theta_x = \cos^{-1} ([X-X_{rel}]/R_{rel}), \quad \theta_y = \cos^{-1} ([Y-Y_{rel}]/R_{rel}), \quad \theta_z = \cos^{-1} ([Z-Z_{rel}]/R_{rel})$$

Where R is the vector magnitude calculated using the relative readings.

**VECTOR
SUMMATION
(8030 ONLY)
(Continued)**

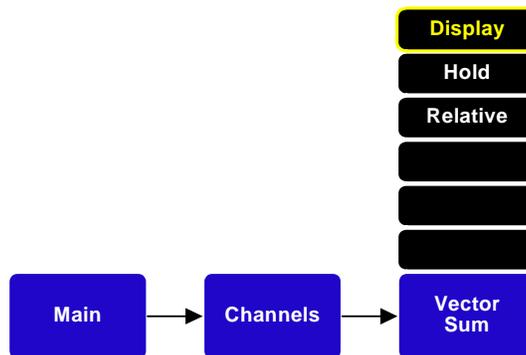
Activating and Configuring the Vector Summation

The Vector Summation functions are configured and activated / de-activated through the menu system.

To configure or activate vector summation functions:

- 1) From the main menu, choose 'Channels'.
- 2) From the channels menu choose 'Vector Sum'.
- 3) Choose and set up the functions needed.
- 4) Select 'Display' to enable the vector sum display.

Note: The Vector sum display can also be enabled by using the 'Display' menu as previously shown.





ANALOG OUTPUTS

Each channel provides a corrected and uncorrected analog output voltage signals that are available from standard BNC connectors located on the back panel. The uncorrected output signal is representative of the magnetic flux density as measured by the Hall probe and is simply the amplified, scaled analog probe signal. The corrected output signal is compensated for influences of temperature, frequency, and non-linearity's inherent in the Hall probe and meter. As such the corrected output is specified with higher output accuracy than the uncorrected output.

Two additional BNC connectors on the back panel provide spare analog outputs for the 8010 models and one spare and the Vector Sum analog output for the 8030 models.

All of these outputs may be connected to a voltmeter, oscilloscope, recorder, or external analog-to-digital converter.

Modes of Operation

Both the corrected and uncorrected analog outputs offer two modes of operation.

Setting the analog output to RMS mode for both DC and AC measurement modes sets the analog output to generate a scaled DC analog voltage that corresponds to the displayed measurements. The only difference between corrected and uncorrected outputs being the temperature, frequency, and linearity compensation as previously described.

Setting the analog output to Waveform mode sets the analog output to generate a scaled analog voltage that produces replicas of the magnetic flux density waveforms being measured. This mode of operation will be most useful with AC measurement modes where the probe signal is reproduced. In DC measurement mode the waveform output produces a signal that is representative of the probe excitation current and the synchronous modulation techniques used to accurately measure DC fields. Generally this information is not very useful to most users but it may give some indications of other AC components included or added to the DC field of interest.

Output Scaling

Standard full scale output ranges of 3V, 10V and an adjustable full scale range up to 9.9V, in increments of 0.1V are available for all analog outputs. (*Note: adjustable full scale range not currently supported*).

**ANALOG
OUTPUTS
(Continued)**

Flux Density Range and Output Voltage Range

Full scale of the present flux density range always corresponds to the full scale setting for the analog output voltage range. For example, if the full scale flux density range is 30 gauss and the full scale analog output voltage range is 3 volts; then a reading of 30 gauss will produce a voltage of 3 volts at the output. A reading of -20 gauss will produce a voltage of -2 volts at the output.

Using Analog Outputs with Auto Range

When using auto range and the analog output features together, the following situation can occur. Suppose the present range is 3 kG and the present reading is +2.8 kG. The analog output will be +2.8 VDC. The signal then increases to +3.2 kG, which would force an automatic change to the 30 kG range setting. The analog output will now be +0.32 VDC because of the range change. This can lead to problems if the analog signal is being used to make decisions, because there is no indication that a range change has occurred. In these situations it is best to select a fixed range that covers the expected flux density span.

Using the Vector Summation Analog Output

Full scale for the vector summation output will correspond to the full scale range of the channel with the highest range setting. For example, if the range for channels 1 and 2 are set to 30 gauss, and channel 3 is set to 300 gauss; the vector summation will associate 300 gauss with its full scale output voltage setting.

Vector summation also allows the output voltage to exceed the full scale value. This allows the possible range of vector magnitudes to be fully represented at the analog outputs. As an example, consider all three channels set for the 300 gauss range and each channel measuring a flux density of 300 gauss. In this situation the vector magnitude would be calculated as follows:

$$V_{SUM} = \sqrt{(300G)^2 + (300G)^2 + (300G)^2} = 519.6G$$

With a full scale analog output voltage setting of 3 volts, the output voltage would be approximately 5.2 volts.

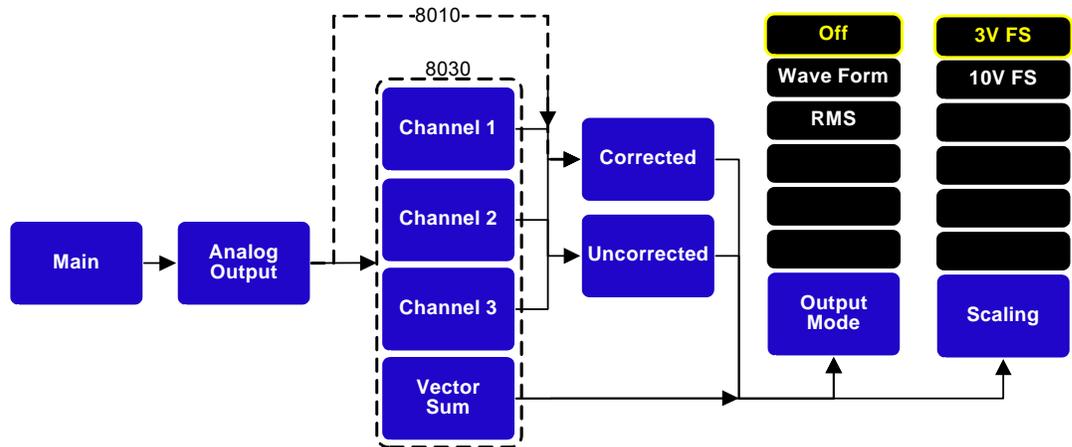
Note: In all cases the maximum output voltage is limited to 10 V.



ANALOG OUTPUTS (Continued)

Configuring the Analog Outputs

- 1) From the main menu choose, 'ANALOG OUTPUT'.
- 2) Select the channel or vector sum (8030 only).
- 3) Select corrected or uncorrected.
- 4) Set the analog output mode and scaling.





CLASSIFIERS
(not currently supported)

The classifier function allows a lower and upper limit of flux density to be defined that can be quickly used to determine the status of a magnetic field. The meter will indicate visually whether the field is above, within, or below these limits. The same information is presented in the form of general purpose switch closures available at standard 15 pin “D” type female connector. The connector is located at the rear of the instrument.

The pin assignments for the classifier connector (digital I/O) are indicated in **Section 2 – Specifications**.

Configuring the Classifier Settings

Two flux density values are set. One value sets the upper limit and the other sets the lower limit. It does not matter which value is chosen to be the upper or lower limit, the instrument will automatically make this determination. For DC mode operation, polarity information needs to be specified. With AC mode, only positive values may be set. The instrument will retain Dc polarity information when switching between AC and DC modes.

Example Circuit for Classifier Outputs

Figure 6-6 shows an example circuit for using the classifier outputs. These outputs are in the form of general purpose switch closures available from the 15 pin “D” type connector located on the rear panel of the instrument.

If the measured field is within the pre-defined classifier settings, both relays are open and neither LED is illuminated. If the measured field is above the defined limits, the classifier high relay is closed causing the “High” LED to illuminate. If the measured field is below the defined limits, the classifier low relay is closed causing the “Low” LED to illuminate.

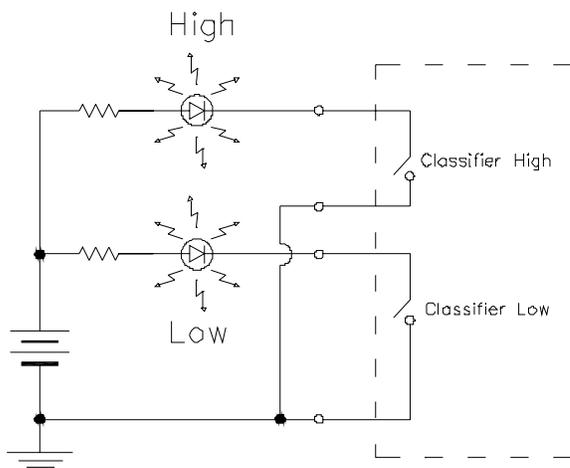
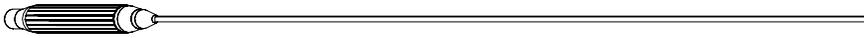


Figure 6-6 Example Circuit for Classifier Outputs



SOURCES OF MEASUREMENT ERROR

When making flux density measurements there are several conditions that can introduce errors:

- 1) Failure to zero the error signals from the meter, probe, and nearby sources of magnetic interference.
- 2) Subjecting the probe to physical abuse.
- 3) One of the most common sources of error is the angular position of the probe with respect to the field being measured. A Hall Effect sensor is not only sensitive to the number of flux lines passing through it but also the **angle** at which they pass through it. The Hall Effect sensor produces the greatest signal when the flux lines are perpendicular to the sensor as shown in **Figure 6-7**.

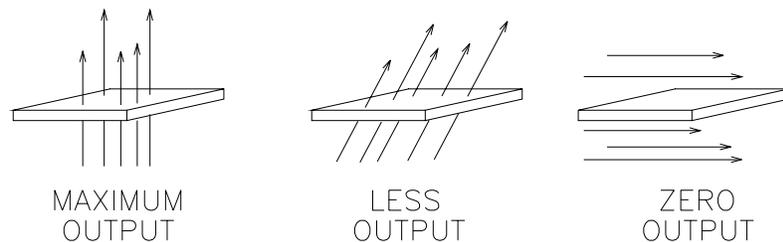


Figure 6-7 Probe Output versus Flux Angle

Note: The probe is calibrated and specified with flux lines passing perpendicularly through the Hall effect sensor.

- 4) As shown in **Figure 6-8** as the distance between the magnetic source and the Hall probe increases fewer flux lines will pass through the probe, causing the probe's output to decrease.

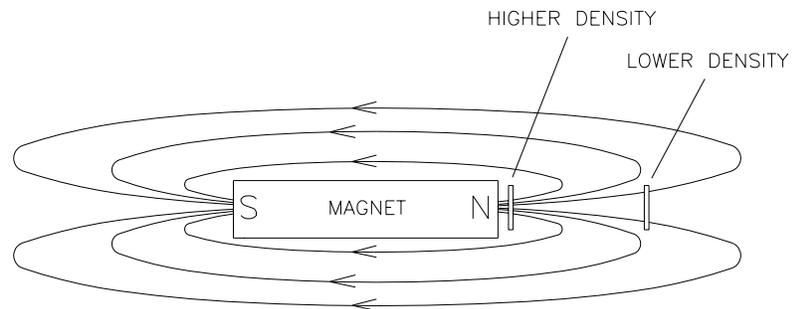


Figure 6-8 Probe Output versus Distance

SOURCES OF MEASUREMENT ERROR
(Continued)

- 5) Flux density can vary considerably across the pole face of a permanent magnet. This can be caused by internal physical flaws such as hairline cracks or bubbles, or an inconsistent mix of materials. Generally the sensitive area of a Hall Effect sensor is much smaller than the surface area of the magnet, so the flux density variations are very apparent. **Figure 6-9** illustrates this situation.

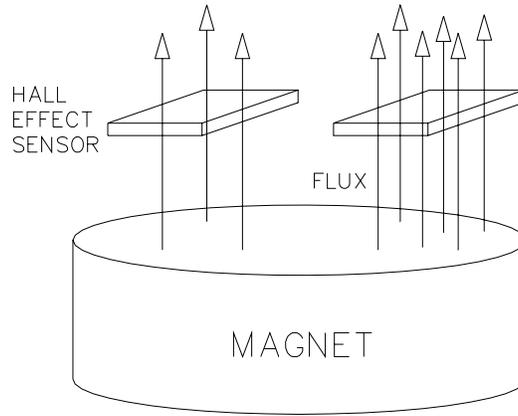


Figure 6-9 Flux Density Variations in a Magnet

- 6) The accuracy of the instrument and probe are affected by temperature variations. See **Section 2 – Specifications**. Temperature variations are greatest during the initial warm up phase after power-up (15 minutes). Allow the meter and probe to stabilize for approximately 60 minutes for best accuracy.

Section 7

Remote Operation

INTRODUCTION

In 1975 the IEEE-488 standard defined the electrical and mechanical aspect for cables and connectors, as well as the handshaking, addressing and general protocol for transmitting individual bytes of information between instruments and computers. The standard was later updated and is now called IEEE 488.1-1987.

Although the standard solved the problem of how to communicate it did not specify the meaning of the bytes. Instrument manufacturers freely invented new commands as they developed new instruments. For instance a command to program a range on one manufacturer's voltmeter may not have worked with another's. Eventually some manufacturers began offering models that recognized other manufacturer's command sets so that customers could easily switch over without making extensive changes to their programs.

The IEEE 488.2-1987 standard was a step toward creating a universal way to communicate with any instrument, regardless of the manufacturer or the type of instrument used. It defined a set of "common" commands that all instruments should respond to in a predictable manner. Yet it did not specify which features or commands should be implemented for a particular instrument.

Later the SCPI-1999 standard (Software Commands for Programmable Instruments) defined specific commands and responses that covered a broad range of applications. For a given measurement function such as frequency or voltage, SCPI defines a specific command set that is available for that function. The command sets are easy to learn and read. Manufacturers can still create new commands unique to their own instruments while conforming to the structure and spirit set forth by SCPI.

The 8000 Series Gauss / Tesla Meters utilize many of the IEEE-488-1987.2 "common" commands in addition to a subset of the SCPI-1999.0 commands. Due to the uniqueness of the gauss/tesla meter, there are some commands that are not specified by SCPI but conform to the rules indicated by the standard.



COMMUNICATION PORTS

RS-232 PORT FUNCTIONAL DESCRIPTION

The instrument has been designed to interface directly to the 9-pin “D” serial connector on most personal computers using a straight-through cable. This means Pin-1 on the meter is connected to Pin-1 on the computer, Pin-2 to Pin-2, etc. Figure 7-1 shows the pin out for the 8000 Series Meter RS-232 communications port.

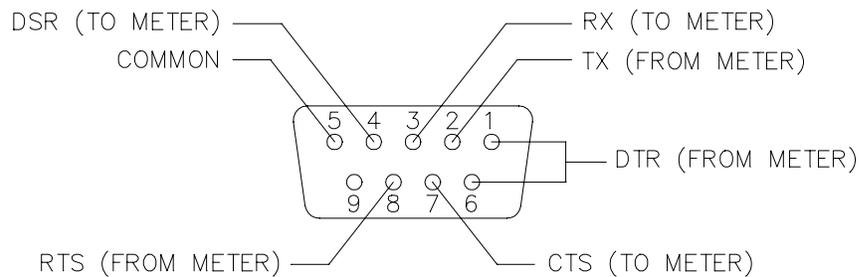


Figure 7-1 RS-232 Connector

RS-232 PORT COMMUNICATIONS SETUP

The serial transmission characteristics such as baud rate, parity setting, etc. are defined in the table 7-1. These settings must be duplicated on the host computer.

Table 7-1 RS-232 Port Settings	
Parameter	Setting
Baud Rate	9600
Data Bits	8
Stop Bits	1
Parity	None
Handshaking	None

ETHERNET PORT FUNCTIONAL DESCRIPTION

The 8000 Series Gaussmeters are equipped with a standard 10/100MHz Ethernet port via a RJ-45 connector on the back panel. This port supports TCP/IP communications and provides the user access to the system's internal web based application interface. It is designed to connect directly to computer networks using a standard patch cable (T568B) as shown in Figure 7-2. Direct connection to computers using a crossover cable is not supported.

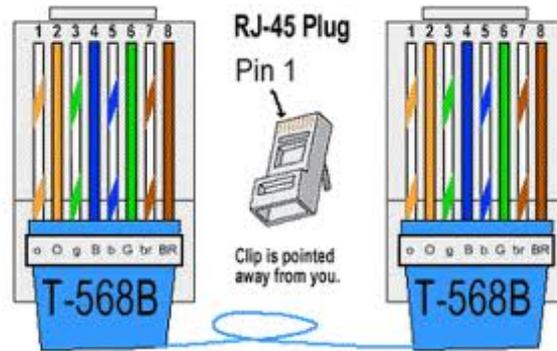


Figure 7-2 Ethernet Connector Pin Out

ETHERNET PORT COMMUNICATIONS SETUP

Navigating the system menu from [Main] to [System ⇒ Network Configuration] will bring up the Ethernet port network configuration screen as shown in Figure 7-3.

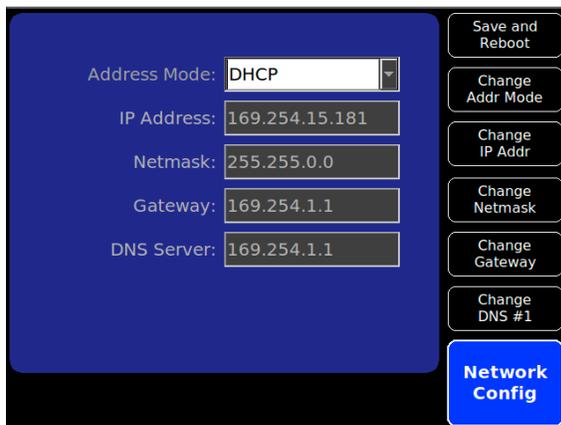


Figure 7-3 Network Configuration Screen

The meter offers two network address setup options which the user can select by pressing the [Change Addr Mode] button.

The default selection is DHCP (Dynamic Host Configuration Protocol), which sets the meter to automatically obtain an IP address from the network.

Pressing the [Change Addr Mode] button will change the system network configuration to Manual, and will bring up additional menu selections that will allow the user to specify a static IP, Netmask, Gateway, and DNS Server addresses.

ETHERNET PORT COMMUNICATIONS SETUP (Continued)

After making changes to the network configuration pressing the [Save and Reboot] menu button will save the settings and reboot the system.

Note: While in DHCP mode the network connection must be installed prior to system boot up in order for the meter to obtain your network configuration settings from the network. If no network is detected the system will assign internal default address information.

ETHERNET PORT ACCESSING THE INTERNAL WEB APPLICATION

With the meter connected to a computer network navigate to the [Network Config] menu and determine the meter's current IP address.

On a network computer, open a web browser application like Windows Internet Explore and enter the meter's current IP address. For example *http://10.60.43.105/*

The 8000 Series Gaussmeters Web Application will open as shown below in Figure 7-4.

Note: Currently the web application is under development, check with FW Bell field applications support for future firmware updates.

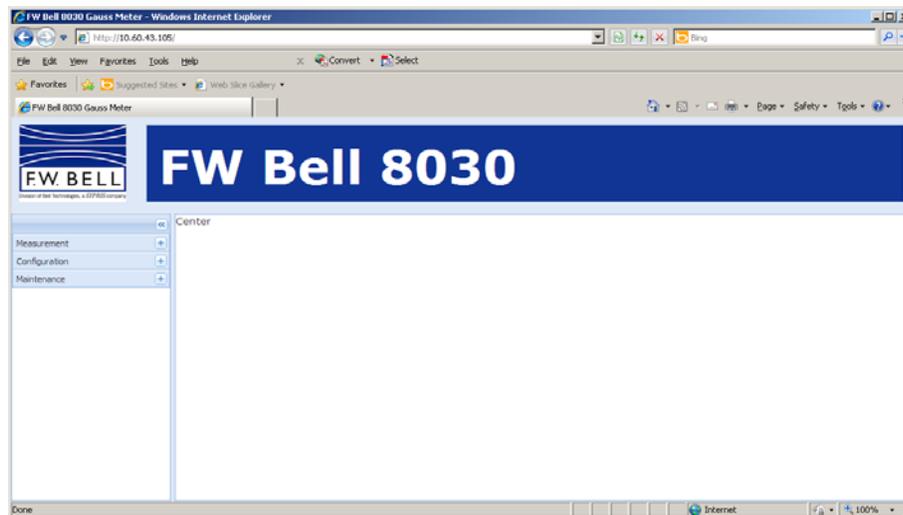


Figure 7-4 8030 Gaussmeter Web Application Screen

ETHERNET PORT ACCESSING THE SYSTEM WITH TELNET CLIENT

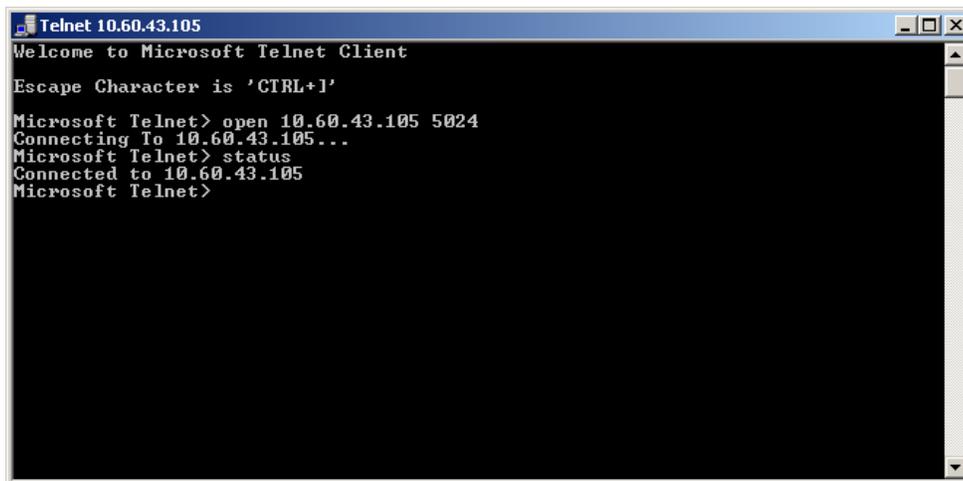
The meter can also be remotely accessed using a Telnet Client such as Windows Telnet Client.

Note: The following example utilizes the windows system32 telnet.exe client as part of WindowsXP. Applications may vary based on operating system installed, please consult your application's help files for more detailed descriptions and operating instructions.

Open the Telnet Client and at the command prompt use the open port command "open *hostname* [*port*]" where the *hostname* is your meters network IP address and the [*port*] is 5024. See Figure 7-5.

Note: Port 5024 is a registered transport protocol port number for SCPI-TELNET.

Once connected you may use the escape character to return to the command prompt and enter "status" to verify connection. Hitting "Enter" will return you to the entry prompt where you can enter SCPI commands.



```
Telnet 10.60.43.105
Welcome to Microsoft Telnet Client
Escape Character is 'CTRL+I'
Microsoft Telnet> open 10.60.43.105 5024
Connecting To 10.60.43.105...
Microsoft Telnet> status
Connected to 10.60.43.105
Microsoft Telnet>
```

Figure 7-5 Windows Telnet Example



REMOTE COMMANDS

IEEE-488.2 “COMMON” COMMAND SYNTAX

The “common” commands are recognized and acted upon in a similar manner by all IEEE-488.2 instruments, whether a DVM, scope, frequency meter, tesla meter, etc. These are the syntax rules:

- 1) A common command always begins with an asterisk character (*) followed by a three or four character acronym and possibly one other parameter. For instance a command to reset the instrument is *RST.
- 2) The commands are not case sensitive. For instance the *RST, *rst and *rSt commands are valid.
- 3) If there is a fourth character in the acronym it will always be a question mark (?) and indicates that information is being requested from the instrument. For instance a command to read the model number and manufacturer of the instrument is *IDN?.
- 4) If a parameter follows a command it must be separated from the acronym by at least one space. The parameter is the ASCII representation of a decimal integer. For instance if the parameter to be sent is binary 1100, the actual parameter sent would be the two ASCII characters 12, since binary 1100 = decimal 12. If you were to send the four ASCII characters 1100 it would be interpreted as decimal 1100 (eleven hundred).
- 5) A number returned from the instrument is an ASCII representation of a decimal integer. For instance if the instrument returns the ASCII string 345 the number is decimal 345 (three hundred forty five), which translates to 159 hex.

IEEE-488.2 “COMMON” COMMANDS

Table 7-2 Common Command Summary		
ACRONYM	NAME	BRIEF DESCRIPTION
*IDN?	Identification query	Return manufacturer, model number, software version number.

IEEE-488.2 “COMMON” COMMANDS

***IDN? - IDENTIFICATION QUERY**

Returns the following string: F.W.BELL,80m0 GAUSS-TESLAMETER,x.x.x.
Where m is the 8000 model (i.e. 8010 or 8030) and x.x.x is the firmware revision level.

**SCPI
COMMAND
SYNTAX**

The SCPI commands provide a language protocol and define a standard set of commands to program every aspect of the instrument. These are the syntax rules:

- 1) The first character of any command string is a colon (:).
- 2) The commands are not case sensitive. For instance the: MEASURE, :measure and :MEASure commands are valid.
- 3) A question mark (?) in a command means that the command is requesting information from the instrument. This is called a “query” command.
- 4) For any command there is a short and long spelling of the command. Use the following rules for the short version:
 - a) If the length of the command is four letters or less, there is no short version.
 - b) If the command has more than four letters and the fourth letter is a vowel, drop it and all letters that follow it. For instance the command :INPUT can be shortened to :INP.
 - c) If the command has more than four letters and the fourth letter is a consonant, drop all letters that follow it. For instance the command :MEASURE can be shortened to :MEAS
 - d) If the command contains a question mark (?) or a non-optional parameter it must be included after the short form version. For instance a query command of :MEASURE:TEMPERATURE? can be shortened to :MEAS:TEMP?
 - e) If the command contains a number as the last character of the command follow the above rules but also include the digit. For instance the command :COUPLING2 would be shortened to :COUP2.
 - f) The use of anything other than the short or long version of a command is invalid. For instance both the :MEASURE and :MEAS commands are valid, but :MEASU is not.
- 5) If a parameter follows a command it must be separated from the command by at least one space.

**SCPI
COMMANDS
GENERAL**

In the following discussion the commands are written such that the short form of the command is written in UPPER CASE letters and the remainder of the command is written in lower case letters. Either form can be used.

If parameters are required they will appear within <> brackets. A parameter indicates a Boolean function, either “0” or “OFF”, or “1” or “ON”. A <n> parameter is a single ASCII digit. <NRf> is usually a multiple digit number and means Numeric Representation format.

Many commands are channel specific, so the “#” character in these commands should be replaced with the channel number 1, 2, or 3 for multi-channel instruments such as the 8030 model. If the channel number is omitted then Channel-1 is assumed.

The gauss / tesla meter supports a subset of the available SCPI commands. However, there are some functions that are not supported with standard SCPI commands. In these cases these special commands are patterned after other SCPI commands that are similar in function.

Table 7-3a SCPI Range Commands	
COMMAND	DESCRIPTION
:SENSe#:FLUX:DC	Set the instrument for dc flux density measurements
:SENSe#:FLUX:AC	Set the instrument for ac flux density measurements
:SENSe#:FLUX:RANGe:AUTO 	Enable/disable auto range in dc mode
:SENSe#:FLUX:DC:RANGe:AUTO 	Enable/disable auto range in dc mode
:SENSe#:FLUX:AC:RANGe:AUTO 	Enable/disable auto range in ac mode
:SENSe#:FLUX:RANGe:FIXed <n>	Define a fixed range in dc mode
:SENSe#:FLUX:DC:RANGe:FIXed <n>	Define a fixed range in dc mode
:SENSe#:FLUX:AC:RANGe:FIXed <n>	Define a fixed range in ac mode
:SENSe#:FLUX:RANGe?	Query range and ac/dc setting

Table 7-4b SCPI Measurement Commands	
COMMAND	DESCRIPTION
:MEASure#:FLUX?	Measure flux density

Table 7-4c SCPI Filter Commands	
COMMAND	DESCRIPTION
:INPut#:FILTer:BPASs <n>	Selects the band pass filter for AC mode operation.

Table 7-4d SCPI Zeroing Commands	
COMMAND	DESCRIPTION
:CALibration#:ZERo:HSENSor:INITiate	Zero the Hall probe and instrument for single channel.
:CALibration:ALL:ZERo:HSENSor:INITiate?	Zero the Hall probe and instrument for all channels.

COMMAND	DESCRIPTION
:OUTPut#:UNCorrected:MODE <n>	Set the output mode of the uncorrected analog output.
:OUTPut#:UNCorrected:MODE?	Query the output mode of the uncorrected analog output.
:OUTPut#:UNCorrected:SCALing <n>	Set the scaling of the uncorrected analog output.
:OUTPut#:UNCorrected:SCALing?	Query the scaling of the uncorrected analog output.
:OUTPut#:CORRected:MODE <n>	Set the output mode of the corrected analog output.
:OUTPut#:CORRected:MODE?	Query the output mode of the corrected analog output.
:OUTPut#:CORRected:SCALing <n>	Set the scaling of the corrected analog output.
:OUTPut#:CORRected:SCALing?	Query the scaling of the corrected analog output.

**SCPI
RANGE
COMMANDS**

These commands select either a fixed range or AUTO range, and specify if the measured flux density will be static (dc) or alternating (ac).

:SENSe#:FLUX:AC
:SENSe#:FLUX:DC

These commands do not alter the present range setting.

:SENSe#:FLUX:RANGe:FIXed <n>
:SENSe#:FLUX:DC:RANGe:FIXed <n>
:SENSe#:FLUX:AC:RANGe:FIXed <n>

Specifies that the measured flux density will be static (dc) or alternating (ac) while also specifying one of four fixed operating ranges for the instrument, as defined in table 7-5 shown below.

<n>	Maximum Flux Density Using Low Field Probe	Maximum Flux Density Using Mid Field (1x) Probe	Maximum Flux Density Using High Field (10x) Probe
0	300 mG (30 μT)	30 G (3 mT)	300 G (30 mT)
1	3 G (300 μT)	300 G (30 mT)	3 kG (300 mT)
2	30 G (3 mT)	3 kG (300 mT)	30 kG (3 T)
3	300 G (30 mT)	30 kG (3 T)	300 kG (30 T)

**SCPI
RANGE
COMMANDS
(Continued)**

**:SENSe#:FLUX:RANGe:AUTO
:SENSe#:FLUX:DC:RANGe:AUTO
:SENSe#:FLUX:AC:RANGe:AUTO **

Specifies that the measured flux density will be static (dc) or alternating (ac) and AUTO ranging is turned off when is "0" or on when is "1". When AUTO range is turned on the instrument determines the range that will offer the best resolution. When AUTO range is turned off the range will be fixed to the last range that was in use when the command was issued.

:SENSe:FLUX:RANGe?

Places an ASCII string in the output queue representing the present ac/dc setting, the present range and the state of the AUTO range feature.

The string will start with the phrase "AC" or "DC, followed by a comma(.). The next single digit will be the range setting, as shown in Table 7-5, and will be in the range of 0 to 3, followed by a comma(.). Next will be the phrase "OFF" or "ON, indicating the state of the AUTO range feature.

For example the string DC,2,OFF indicates that the channel is in dc mode on a fixed range setting of 2.

**SCPI
MEASUREMENT
COMMANDS**

:MEASure#:FLUX?

The latest flux density reading is placed in the output queue and will be between 0.0000000000 and ± 299999999 . The meaning of this value depends upon the currently selected unit of measure (gauss, tesla, etc.). For instance the value 1.0203 could mean 1.0203 G or 1.0203 T. The rate at which flux density readings are updated is controlled by the display update rate. Issuing the MEASure:FLUX? command at a rate that is faster than this update rate will return the same reading multiple times. For instance, if the meter updates the reading once per second, and the MEASure:FLUX? command is issued 10 times per second, the same reading will be returned 10 times.

The rate at which new flux density readings can be acquired is also dependant on the speed of the communications port. Currently the RS-232 port is limited to a baud rate of 9600, if faster communication is needed use the Ethernet port.

**SCPI
FILTER
COMMANDS**

These commands control the hardware band-pass filters while in AC mode.

:INPut#:FILTer:BPASs <n>

Selects the analog band-pass filter frequency response when in AC mode where:

- n = 0 >> High Frequency 16Hz to 50kHz
- n = 1 >> Medium Frequency 16Hz to 10kHz
- n = 2 >> Low Frequency 16Hz to 500Hz
- n = 3 >> XLow Frequency 0.5Hz to 500Hz

**SCPI
ZEROING
COMMANDS**

These commands control zeroing of the Hall probe and the instrument.

:CALibration#:ZERo:HSEnSor:INITiate

This command initiates the same zeroing process as the front-panel ZERO push button for the specified channel. The Hall probe should be placed in a stable, low-flux environment such as a zero flux chamber prior to issuing this command.

:CALibration:ALL:ZERo:HSEnSor:INITiate

Same as the “:CALibration#:ZERo:HSEnSor:INITiate” command, but ALL channels are zero simultaneously.

**SCPI
ANALOG
OUTPUT
COMMANDS**

The instrument provides a corrected and uncorrected analog output for each channel. These commands specify the output configuration by setting the output mode and scaling options.

:OUTPut#:UNCorrected:MODE <n>
:OUTPut#:CORRected:MODE <n>

Sets the mode of operation for the selected uncorrected or corrected analog output where:

n = 0 >> Output Off
 n = 1 >> Output is in Waveform Output Mode
 n = 2 >> Output is in RMS Output Mode

:OUTPut#:UNCorrected:MODE?
:OUTPut#:CORRected:MODE?

Queries the mode of operation for the selected uncorrected or corrected analog output where the return value represents the following:

0 = Output Off
 1 = Output is in Waveform Output Mode
 2 = Output is in RMS Output Mode

:OUTPut#:UNCorrected:SCALing <NRF>
:OUTPut#:CORRected:SCALing <NRF>

Sets the scale value for the selected uncorrected or corrected analog output where <NRF> is the scale value from 0.0 to 10.0 in 0.1 volt increments. Setting the value to 0.0 sets the analog output mode to off.

Normally a full-scale level of 3.0 volts is used because it directly corresponds to the full-scale ranges of the instrument. For instance, if on the 300 mT range, a reading of -189.3 mT will result in an analog output of -1.893 volts. If on the 3 kG range, a reading of +2.6 kG will result in an analog output of +2.6 volts. Some data acquisition systems may require different analog input ranges. For example, assume such a system cannot accept signals greater than ± 2.0 volts. In this case you can specify 2.0V as the full-scale range of the analog output (<NRF> = 2.0).

The relationship between the output voltage and the flux density reading is:
 Full scale output voltage / full scale flux density range

For example, assume the full scale output voltage has been set to 2.0 volts and the present range setting is 300 mT. The relationship will be:

$$2.0 \text{ volts} / 300 \text{ mT} = 0.0067 \text{ volts} / \text{mT}$$

Thus, when the flux density reaches the maximum for the present range, the analog output voltage will reach a maximum of ± 2.0 volts.

**SCPI
ANALOG
OUTPUT
COMMANDS
(Continued)**

**:OUTPut#:UNCorrected:SCALing?
:OUTPut#:CORRected:SCALing?**

Queries the scaling value for the selected uncorrected or corrected analog output where the return value represents the current scaling factor in volts.



**SCPI
MESSAGE
TERMINATORS**

When transmitting a string to the instrument the message must be “terminated” properly to notify the instrument that the message is complete. One way is to append an ASCII line feed (LF) character as the final character in the string, which is a 0A hex or 00001010 binary. Note that 0A hex is equivalent to 10 decimal, but sending the two ASCII characters “10” will not work. It must be the single byte representation of the LF control character.

When using the RS-232 or the Ethernet port the instrument will always send the LF (line feed) and CR (carriage return) characters every time it transmits a message to the system controller.

Carriage Return >> ASCII code 13
Line Feed >> ASCII code 10

Section 8

Firmware Update

OVERVIEW

FW Bell is dedicated to continuously provide our customers with the latest features and accessories available for the 8000 Series Gaussmeters. This section describes the procedures for updating the internal firmware of the 8000 Series Gaussmeter via either the Internet or USB flash memory device.

FIRMWARE UPDATE PROCEDURE

From the [Main] system menu, navigating to [System ⇒ Firmware Update] will open the Firmware Update screen as shown in Figure 8-1.

When this screen is accessed the meter will display the current firmware version installed and the most recent firmware versions available via the internet and / or attached USB memory device.

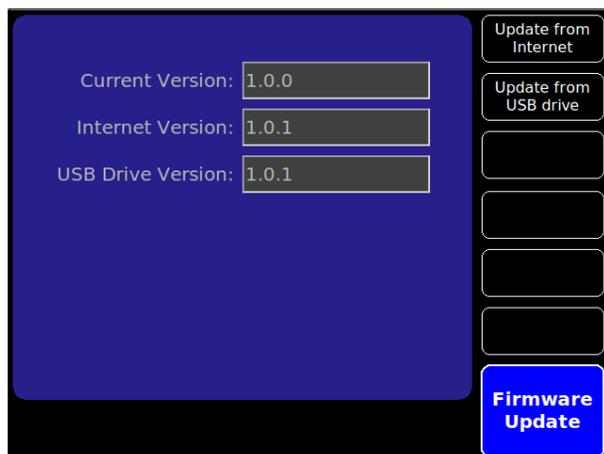


Figure 8-1 Firmware Update Screen

The user can then choose to update firmware from the USB drive or over the internet by pressing the appropriate menu button.

When one of the [Update from...] buttons are pressed the meter will confirm the operation by asking the user to press the Enter button. When the [Enter] button is pressed the meter will begin the update process and re-boot from the new firmware.

Note: If either the network or USB drive is not present before entering this menu the meter will display a message warning the user.

Note: If the network is present but the internet is unavailable the Internet version will be N/A without any other indication.

Note: Some network firewalls or network security policies block unrestricted access to the internet; please contact your network administrator for access policies.

PREPARING THE USB DRIVE FOR UPDATE

To prepare the USB memory device for a firmware update: Download the latest firmware release from www.fwbell.com or call your technical support representative, then save it to a USB memory device.

The file name will be fwb8000-x.x.x.bin, where the x.x.x represents the revision of the firmware.

Note: The meter will search the device for firmware files and will select the most recent version on the drive based on file name. It is best to copy the desired firmware to the root directory and remove all previous versions in order to ensure the correct version is selected.

Appendix A Understanding Flux Density

Magnetic fields surrounding permanent magnets or electrical conductors can be visualized as a collection of magnetic *flux* lines; lines of force existing in the material that is being subjected to a magnetizing influence. Unlike light, which travels away from its source indefinitely, magnetic flux lines must eventually return to the source. Thus all magnetic sources are said to have two *poles*. Flux lines are said to emanate from the “north” pole and return to the “south” pole, as depicted in **Figure A-1**.

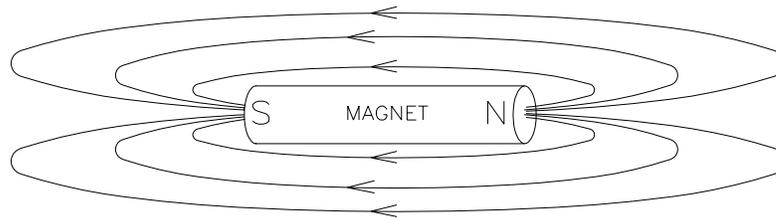


Figure A-1 Flux Lines of a Permanent Magnet

One line of flux in the cgs measurement system is called a *maxwell* (Mx), but the *weber* (Wb), which is 10^8 lines, is more commonly used.

Flux density, also called magnetic induction, is the number of flux lines passing through a given area. It is commonly assigned the symbol “*B*” in scientific documents. In the cgs system a *gauss* (G) is one line of flux passing through a 1 cm^2 area. The more commonly used term is the *tesla* (T), which is 10,000 lines per cm^2 . Thus

$$\begin{aligned} 1 \text{ tesla} &= 10,000 \text{ gauss} \\ 1 \text{ gauss} &= 0.0001 \text{ tesla} \end{aligned}$$

Magnetic field strength is a measure of force produced by an electric current or a permanent magnet. It is the ability to induce a magnetic field “*B*”. It is commonly assigned the symbol “*H*” in scientific documents. The unit of “*H*” in the cgs system is an *oersted* (Oe), but the *ampere/meter* (A/m) is more commonly used. The relationship is

$$\begin{aligned} 1 \text{ oersted} &= 79.6 \text{ ampere/meter} \\ 1 \text{ ampere/meter} &= 0.01256 \text{ oersted} \end{aligned}$$

It is important to know that magnetic field strength and magnetic flux density are not the same. The only time the two are considered equal is in free space. Only in free space is the following relationship true:

$$1 \text{ G} = 1 \text{ Oe} = 0.0001 \text{ T} = 79.6 \text{ A/m}$$

MEASUREMENT OF FLUX DENSITY:

A device commonly used to measure flux density is the *Hall Effect sensor*. A Hall Effect sensor is a thin slice of a semiconductor material to which four leads are attached at the midpoint of each edge, as shown in **Figure A-2**.

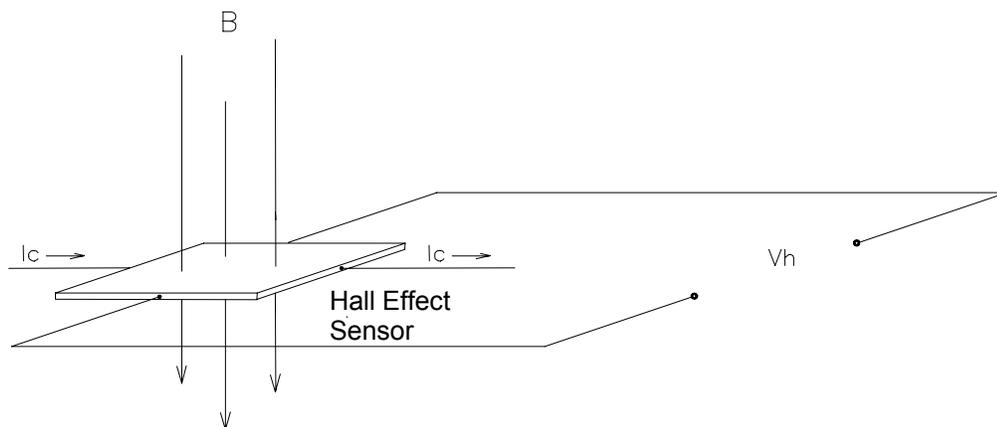


Figure A-2 Hall Effect Sensor

A constant current (I_c) is forced through the material. In a zero magnetic field there is no voltage difference between the other two edges. When flux lines pass through the material the path of the current bends closer to one edge, creating a voltage difference known as the Hall voltage (V_h). In an ideal Hall generator there is a linear relationship between the number of flux lines passing through the material (flux density) and the Hall voltage.

The Hall voltage is also a function of the *direction* in which the flux lines pass through the material, producing a positive voltage in one direction and a negative voltage in the other. If the same number of flux lines passes through the material in either direction, the net result is zero volts. This sensitivity to flux direction makes it possible to measure both static (dc) and alternating (ac) magnetic fields.

The Hall voltage is also a function of the *angle* at which the flux lines pass through the material. The greatest Hall voltage occurs when the flux lines pass perpendicularly through the material. Otherwise the output is related to the cosine of the difference between 90° and the actual angle.

The sensitive area of the Hall Effect sensor is generally defined as the largest circular area within the actual slice of the material. This *active area* can range in size from 0.2 mm (0.008") to 19 mm (0.75") in diameter. Often the Hall Effect sensor assembly is too fragile to use by itself so it is often mounted in a protective tube and terminated with a flexible cable and a connector. This assembly is known as a *Hall probe*. For more information on Hall Probes see **Section 3 – Probes**.

Appendix B Vector Summation Tutorial

The Model 8030 gauss/tesla meter is an extremely useful tool for acquiring simultaneous magnetic field measurements from two or three individual probes or from a 3-axis probe. The instrument presents vector summation results directly to the user, eliminating the need to perform manual calculations.

The classical approach to defining the location of a point in a two-dimensional plane involves the use of the Cartesian coordinate system, shown in **Figure B-1**. In this system a point can be defined by its combined horizontal (x) and vertical (y) distance from the origin of the graph (the point where the x-axis and y-axis intersect). In the example shown, the point has coordinates of $x = +3$ and $y = +5$. To calculate the actual distance from the origin to the point r , use Pythagorean's theorem:

$$r = \sqrt{x^2 + y^2} = \sqrt{3^2 + 5^2} = 5.83$$

This distance is the vector sum of the individual x and y vectors.

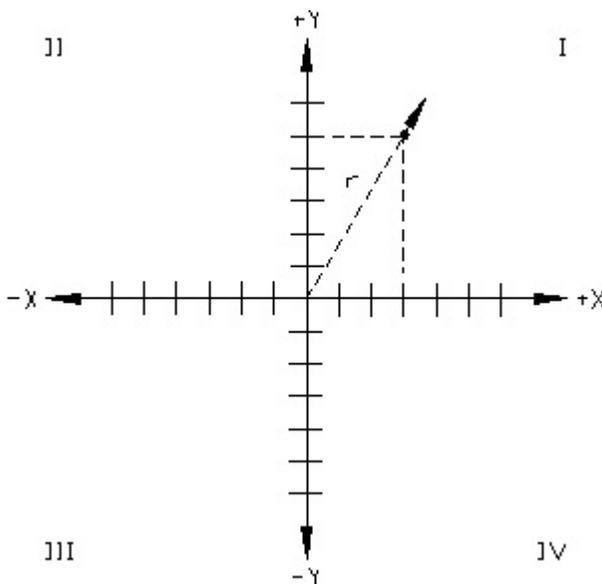


Figure B-1 Two-Dimensional Co-Ordinate System

In some cases it is useful to know the rotational angle, α , between one axis and the vector sum. **Figure B-2** depicts this. The classical representation defines the angle between the x-axis and the vector sum, rotating counterclockwise. Quadrant-I covers angles between 0 to 90 degrees. Quadrant-II from 90 to 180 degrees, Q-III from 180 to 270 degrees and Q-IV from 270 to 360 degrees.

The angle α can be calculated as follows:

$$\alpha = \cos^{-1} (x / r) = \cos^{-1} (3 / 5.83) = 59.0 \text{ degrees}$$

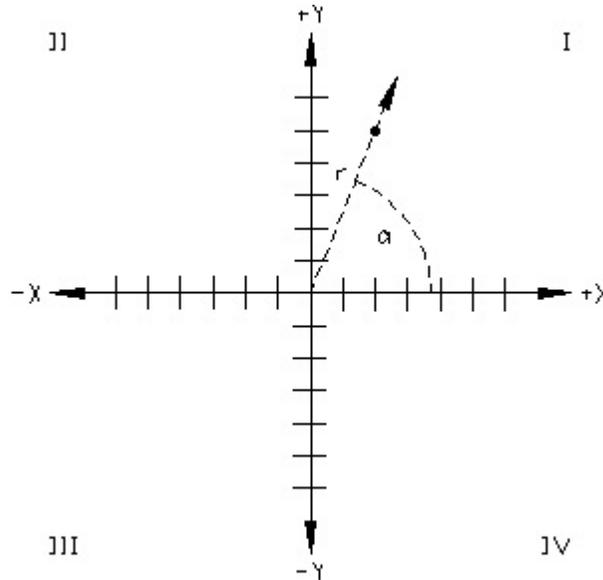


Figure B-2 Vector Angle in a Two Dimensional System

A similar system can be used to define a point in three-dimensional space, as visualized in **Figure B-3**. In this system a point can be defined by its combined horizontal (x), vertical (y) and depth (z) distance from the origin of the graph. In the example shown, if the point has coordinates of $x=+12$, $y=+6$ and $z=+5$, calculate the distance from the origin to the point as follows:

$$r = \sqrt{x^2 + y^2 + z^2} = \sqrt{12^2 + 6^2 + 5^2} = 14.32$$

This distance is the vector sum of the individual x, y and z vectors.

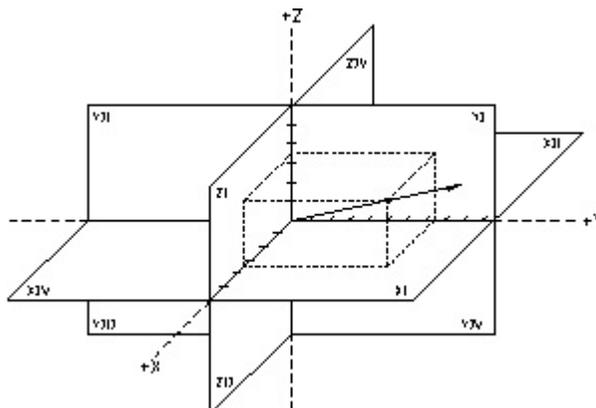


Figure B-3 Three-Dimensional Co-Ordinate System

As in the two-dimensional system, it is often important to determine the angles between each axis and the summation vector in a three dimensional system, as shown in **Figure B-4**.

The angles can be calculated as follows:

$$\alpha = \cos^{-1} (x / r) = \cos^{-1} (12 / 14.32) = 33.0 \text{ degrees.}$$

$$\beta = \cos^{-1} (y / r) = \cos^{-1} (6 / 14.32) = 65.2 \text{ degrees}$$

$$\gamma = \cos^{-1} (z / r) = \cos^{-1} (5 / 14.32) = 69.6 \text{ degrees.}$$

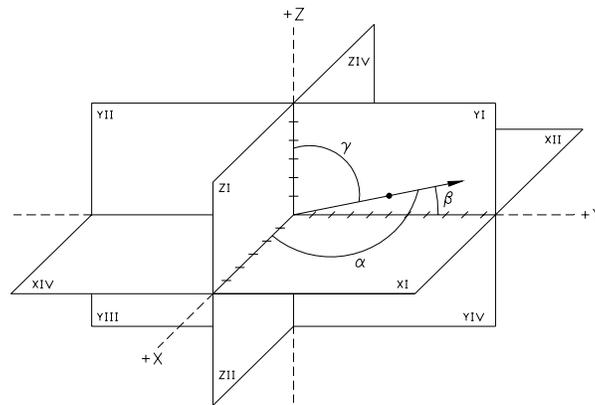


Figure B-4 Vector Angles in a Three-Dimensional System

WARRANTY

This instrument is warranted to be free of defects in material and workmanship. Pacific Scientific OECO's obligation under this warranty is limited to servicing or adjusting any instrument returned to the factory for that purpose, and to replace any defective parts thereof. This warranty covers instruments which, within one year after delivery to the original purchaser, shall be returned with transportation charges prepaid by the original purchaser, and which upon examination shall disclose to Pacific Scientific OECO's satisfaction to be defective. If it is determined that the defect has been caused by misuse or abnormal conditions of operation, repairs will be billed at cost after submitting an estimate to the purchaser.

Pacific Scientific OECO reserves the right to make changes in design at any time without incurring any obligation to install same on units previously purchased.

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