

# 8000 SERIES GAUSS / TESLA METER

## Instruction Manual



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*8000 Series*  
*GAUSS / TESLA METER*

# Instruction Manual

Manual UN-01-270

Rev. 8  
August, 2013  
Applicable System Firmware Release 1.5.0  
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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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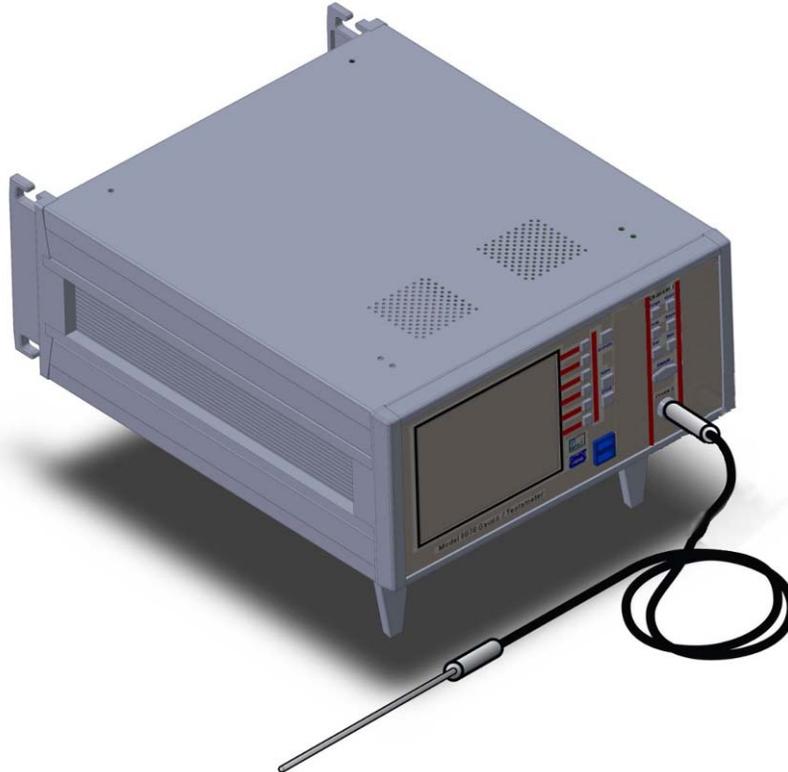
## SECTION 1 Introduction

### 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 features shown in this manual may be under development or are not supported with the supplied system firmware. Visit the FW Bell web site at [www.fwbell.com](http://www.fwbell.com) or contact customer support for the latest updates.*



**Table 1-1 8000 Series Gauss/Tesla Meter List of Features**

|  |  |
|--|--|
| <b>Flux Density Measurement</b>            | 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)  |
| <b>Display and User Interface</b>          | Large TFT color LCD Display with backlighting  |
|  | AC Waveform Graphical Display Mode   |
|  | Common Functions are Activated Quickly Through the Front Panel Keypad  |
|  | Other Functions are Accessible Through Graphical Menu System   |
|  | 10 User Configuration Setups May be Stored   |
| <b>Support Functions</b>                   | 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  |
| <b>Remote Operation and Communications</b> | RS-232C Standard 9-pin female "D" connector  |
|  | Protocol: SCPI-1999  |
|  | Protocol: IEEE-488-1987.2 w/ External Prologix Adapter   |
|  | 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   |
| <b>Signal Outputs</b>                      | Corrected and Uncorrected Analog Outputs   |
|  | +/- 3V and +/- 10V Selectable Ranges   |
|  | Either Waveform or RMS Signals   |
|  | Vector Summation Output (Model 8030 Only)  |
|  | Spare Analog Output(s) (not supported)   |
| <b>Probe Styles</b>                        | Transverse and Axial   |
|  | Temperature Compensation Available   |
|  | Low, Medium, and High Field Options  |
|  | Standard and Heavy Duty  |
| <b>Software &amp; Data Logging</b>         | On-Site Firmware Updates   |
|  | HTML User Remote Interface with Data Logging   |
|  | Automatic Data Logging on USB Drive or Internal Memory   |
|  | Screen Capture Utility   |

## 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  $\mu$ Gauss (0.001  $\mu$ 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.

### 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.

### 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.

**General  
Description  
(Continued)**

**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-linearity inherent in the Hall probe and instrument.

Both the Corrected and Uncorrected analog outputs offer the selection of either raw waveform 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 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 supported).

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

**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.

**General  
Description  
(Continued)**

**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.

In addition the 8000 Series Gaussmeters are supplied with an internal HTML based remote monitoring and data logging application, that when connected to a computer network can be accessed with standard web browser applications.

**AC Waveform Display Mode**

The graphical AC Waveform Display mode allows users to look at AC measurements without the use of an external oscilloscope or other analog graphing device. It provides operation and custom settings that will trigger on user parameters and display the measurement on a familiar oscilloscope type display.

**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.

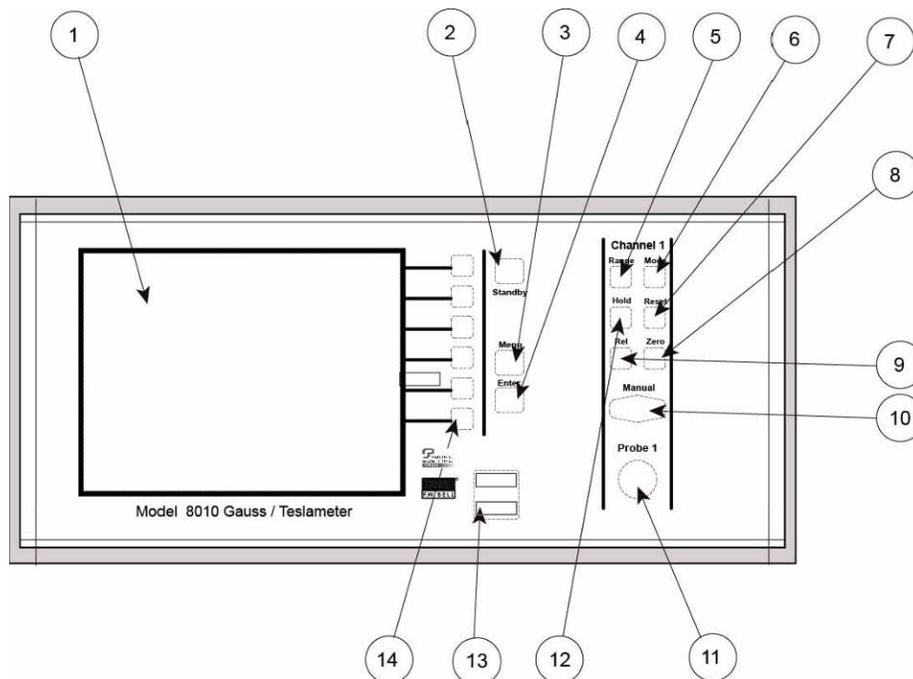
**General Description (Continued)**

**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)**

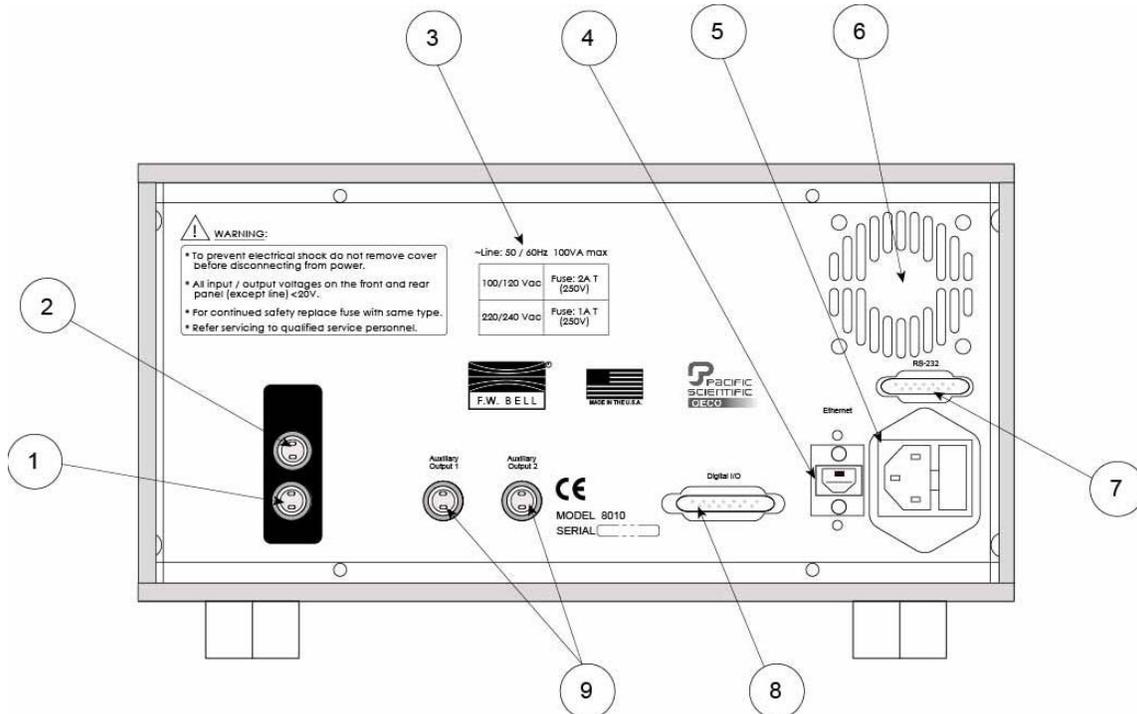
**General Description (Continued)**

**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  |



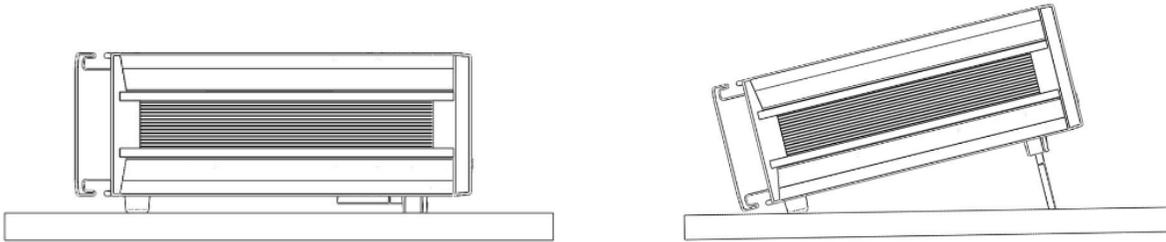
**Figure 1-2 Rear Panel (8010 Model Shown)**

**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 Meter**

**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 2-1 through 2-3 below, listed by probe type. In all cases, the resolution is 1 part in 300,000.

**Table 2-1 Ranges for Low Field Probes**

| gauss (G)  | tesla (T)       | oersted (Oe) | ampere-turn/meter (A/m) |
|------------|-----------------|--------------|-------------------------|
| 300.000 mG | 30.0000 $\mu$ T | 300.000 mOe  | 23.8732 A/m             |
| 3.00000 G  | 300.000 $\mu$ T | 3.00000 Oe   | 238.732 A/m             |

*Note: Low Field MOX probes have an upper calibrated range of  $\pm 2G$  but will respond to  $\pm 3G$  with increased error, MOS probes have a measurement limit of  $\pm 1G$ .*

**Table 2-2 Ranges for Mid Field Probes**

| 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 2-3 Ranges for High Field Probes**

| 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            |

**Min / Max Hold Acquisition Time:**

dc Mode: 200mS  
ac Mode: 200mS

**Peak / Valley Hold Acquisition Time:**

dc Mode: 2ms  
ac Mode: 200 $\mu$ s

**Temperature Coefficient:**

0.02% of reading  
 $\pm 1$  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 $\mu$  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     | or | 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

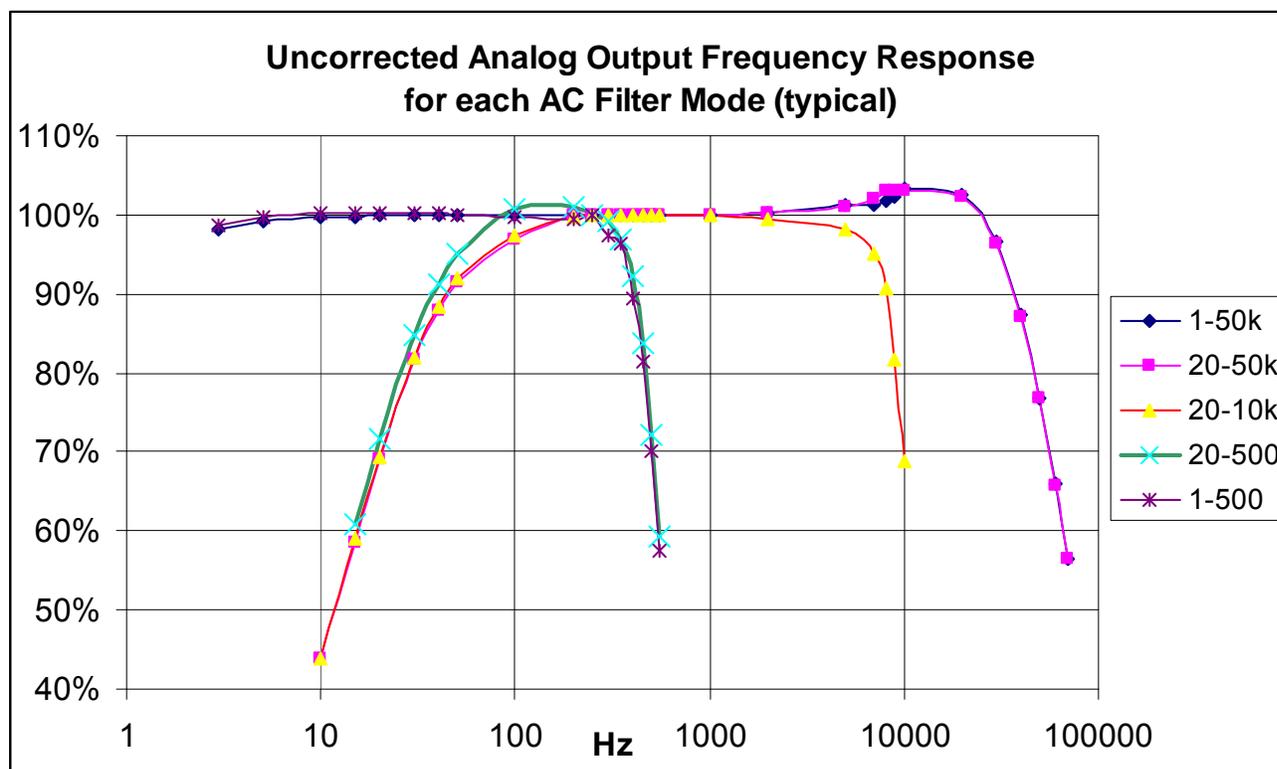
**Warm-up Time to Rated Accuracy:**

60 Minutes

**Table 2-4 Accuracies at 23°C ±2C° (Meter Only)**

|                               | Display and Digital Outputs (min speed)            | Corrected Analog Output and Digital Outputs (max speed)                | Uncorrected Analog Output  |
|-------------------------------|--|--|--|
| <b>DC Accuracy</b>            | ±0.05% of reading and ±0.01% of range              | ±0.15% of 3V or 10V ranges   | 3V range: 0.25% of Reading ±40mV<br>10V range: 0.25% of Reading ±120mV |
| <b>AC Accuracy in DC Mode</b> | N/A  | 2% of range DC to 100 Hz   | 2% of range DC to 100Hz  |
| <b>AC accuracy in AC mode</b> | 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)<br>(AC RMS (DC) 20Hz-50kHz) | See Figure 2-1 for Graph (Typical)<br>AC and AC RMS (DC) output        |
| <b>AC peak Accuracy</b>       | 5.00% of Reading                                   | N/A  | N/A  |

*\*Probes Errors Not Included*



**Figure 2-1 Frequency Response of Uncorrected Analog Output NO Probe (Meter 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:

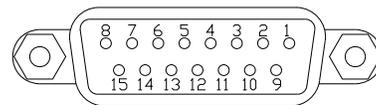
|                           |                                  |
|---------------------------|----------------------------------|
| Format:                   | RS-232C                          |
| Connector type:           | 9-pin "D" female                 |
| Cable length:             | 3 m (9.8 ft.) maximum            |
| Receive input resistance: | 3 k $\Omega$ 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                        |

#### Classifier Digital Outputs:

|                                   |                           |
|-----------------------------------|---------------------------|
| 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 $\Omega$ MAX           |
| Operating Time, Including Bounce: | 3 mS MAX                  |

**Table 2-5 Classifier Connections**

| Channel 1 Pins |      |
|----------------|------|
| Low            | 1,9  |
| High           | 2,10 |
| Channel 2 Pins |      |
| Low            | 3,11 |
| High           | 4,12 |
| Channel 3 Pins |      |
| Low            | 5,13 |
| High           | 6,14 |
| Common Pins    |      |
| GND            | 8    |
| +3.3Vdc        | 7    |
| +5Vdc          | 15   |



**Figure 2-2 Digital I/O Connector  
15 Pin "D" Type**

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

*Note: The 8010 model uses Channel 2 Pins for classifier operation. Channels 1 & 3 are used on the 8030 only.*

## Regulatory Information

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

| <b>EN 61326-1:2006</b>         | <b>Immunity</b>  |
|--------------------------------|--|
| 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   |
| <br>                           |  |
| <b>EN 61326-1:2006 Class A</b> | <b>Emissions</b>   |
| 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 Chambers

### Purpose:

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

### 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)

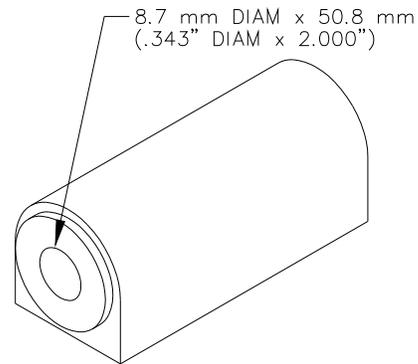


Figure 2-3 YA-111 Zero Flux Chamber

### Model Number:

YA-112

### Cavity Dimensions:

Length: 280 mm (11")  
Diameter: 12.7 mm (0.75")

### Attenuation:

60 dB to 30 mT (300 G)

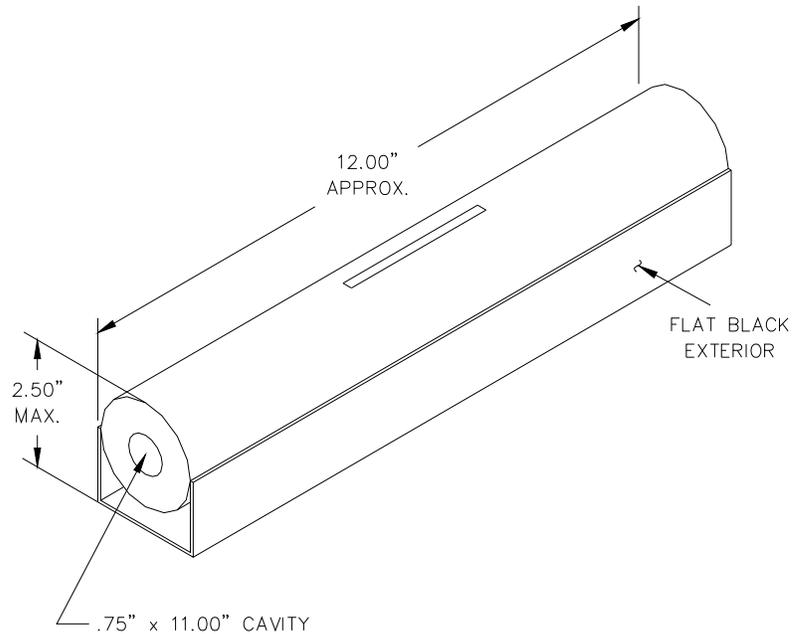


Figure 2-4 YA-112 Zero Flux Chamber

## 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.

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.



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

## Probe Variations

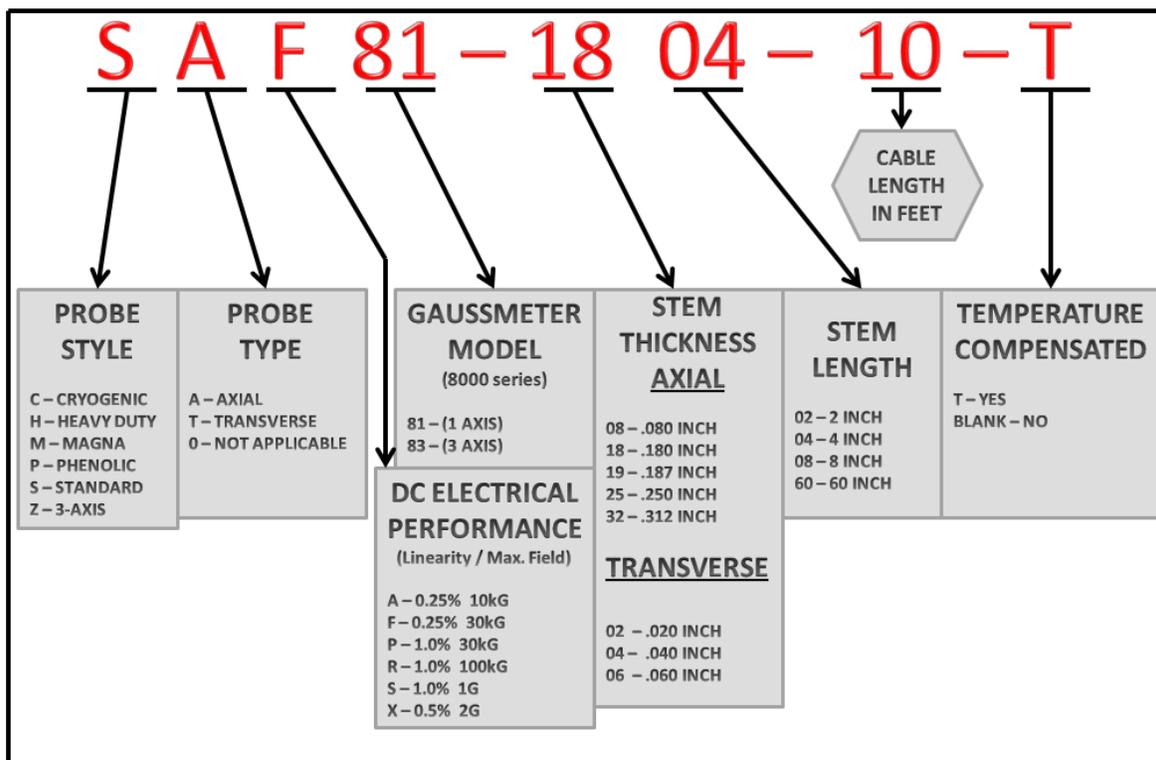
A wide variety of probes are available for use with the 8010 gauss/tesla meters. The types include heavy-duty transverse and axial, standard transverse and axial, standard transverse with exposed element, flexible transverse and axial with exposed element and low field probes. All of these probes are 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*   | 3 G (200 $\mu$ T) | 1 $\mu$ G (0.1 nT)    |
| Medium Field | 30 kG (3 T)       | 0.1 mG (0.01 $\mu$ T) |
| High Field   | 300 kG (30 T)     | 1 mG (0.1 $\mu$ T)    |

*\*Note: Low Field MOX probes have an upper calibrated range of  $\pm 2G$  but will respond to  $\pm 3G$  with increased error, MOS probes have a measurement limit of  $\pm 1G$ .*

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.

## 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 ( $\sim 23^\circ\text{C}$ ). A typical probe may change by  $-0.05\% / ^\circ\text{C}$ . For instance a reading of 200 mT at  $23^\circ\text{C}$  may drop to 197 mT at  $50^\circ\text{C}$ .

## 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

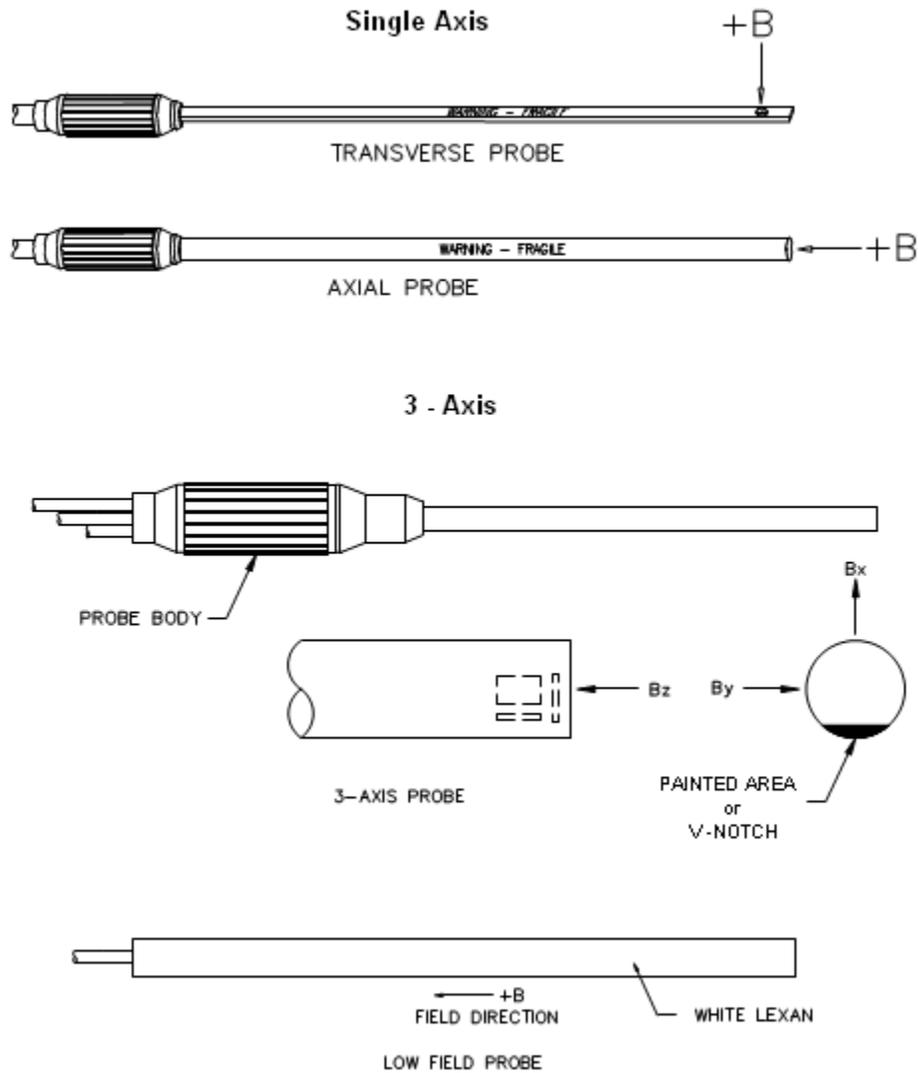


Figure 3-2 Hall Probe Configurations

## 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:

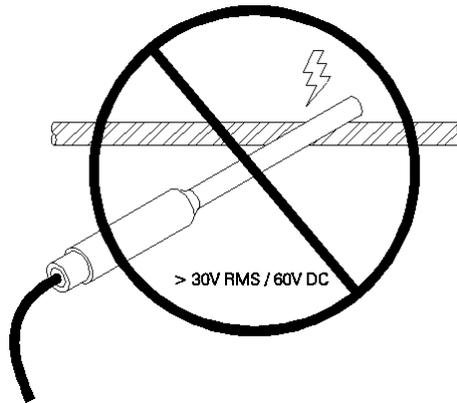
For continued protection replace the fuse with the same type (IEC 127 type T).

**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.



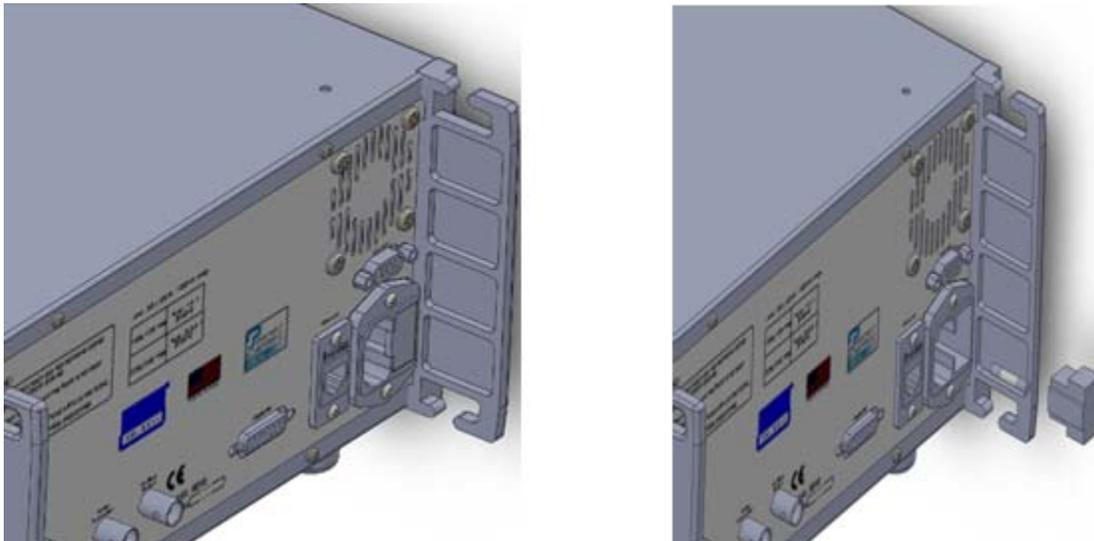
**WARNING! READ THIS CAREFULLY**

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 the fuse to match the line voltage.

- 1) **See figure 4-2.** 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 4-2.** 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 4-2 Fuse Replacement**

## Adjusting the Handle & Feet

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.

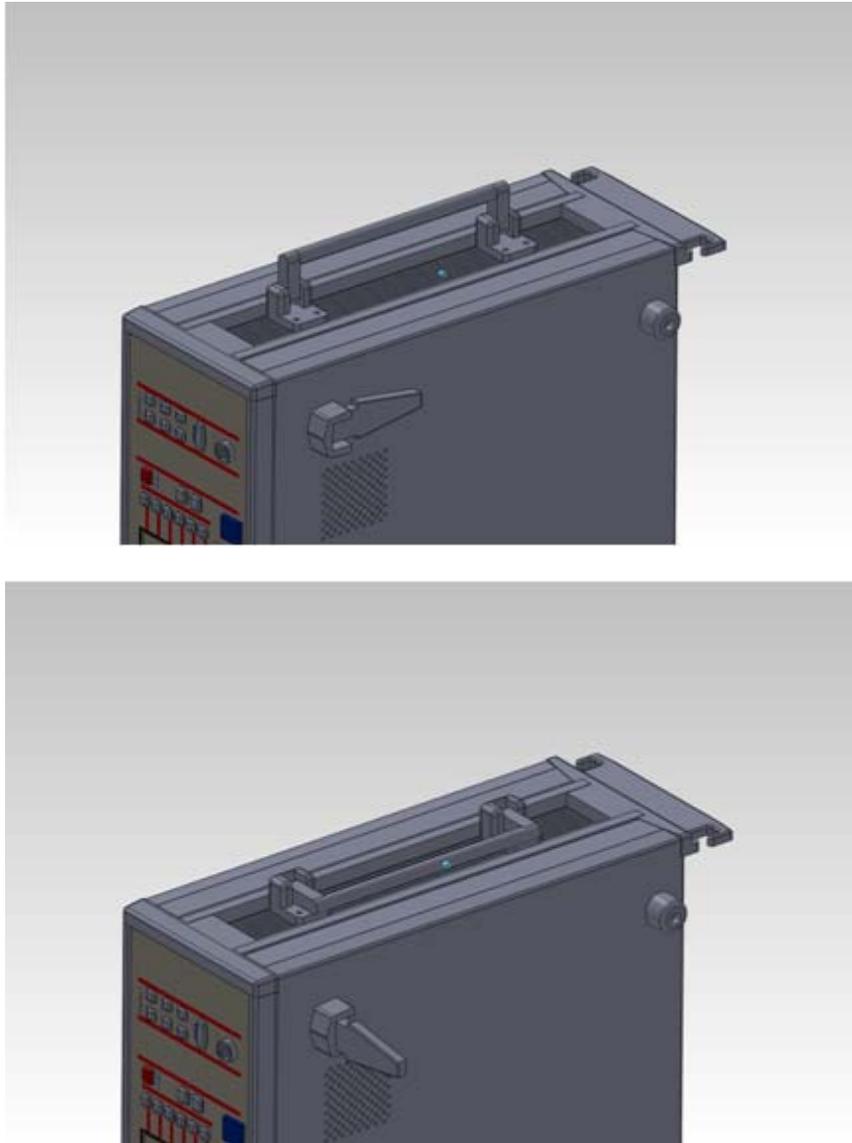


Figure 4-3 Adjusting the Handle and Feet

## 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 below. 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..*

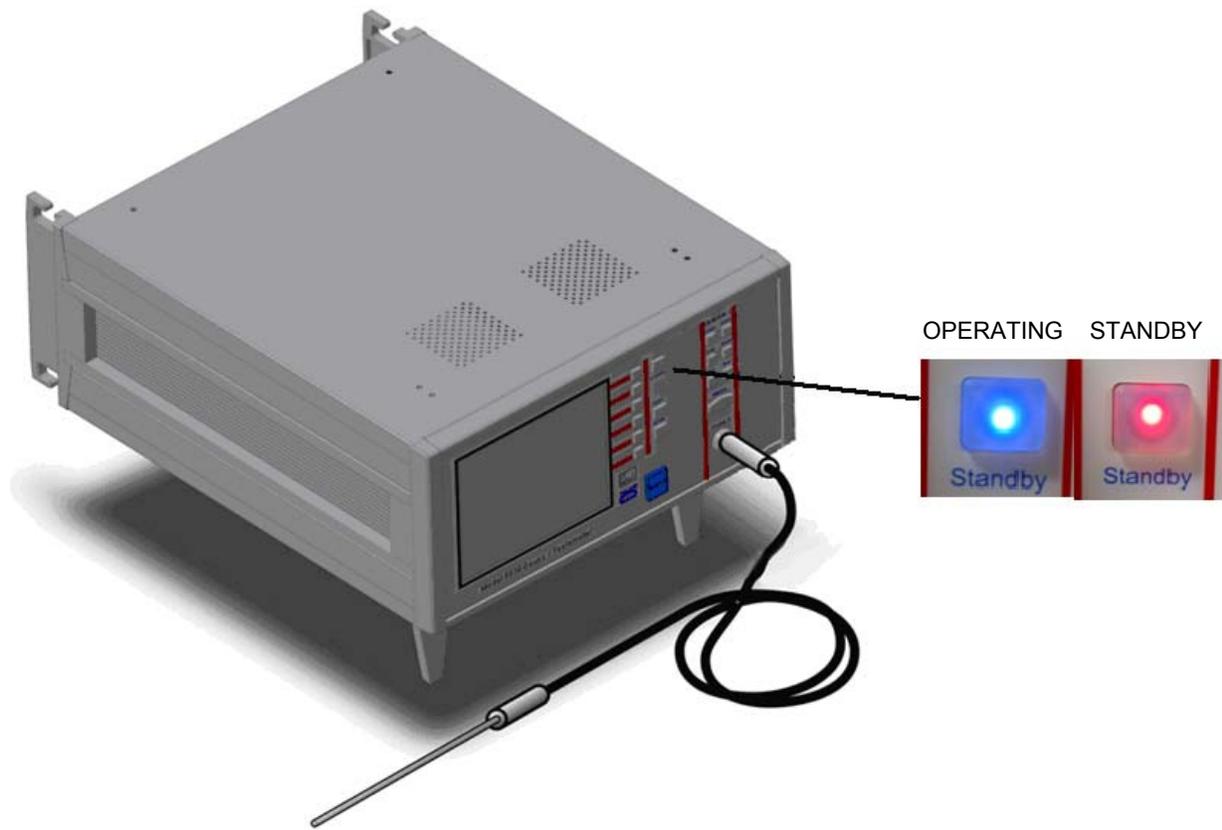
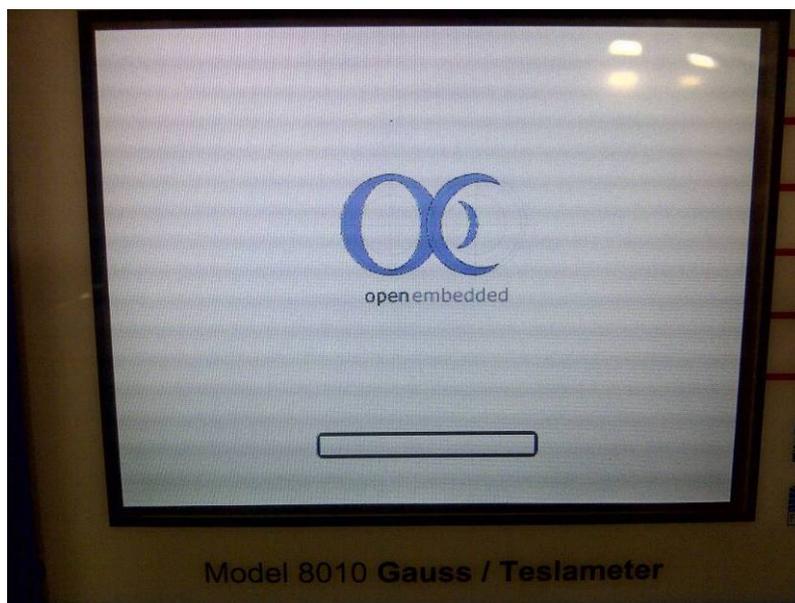


Figure 4-5 Standby Button Location

**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***

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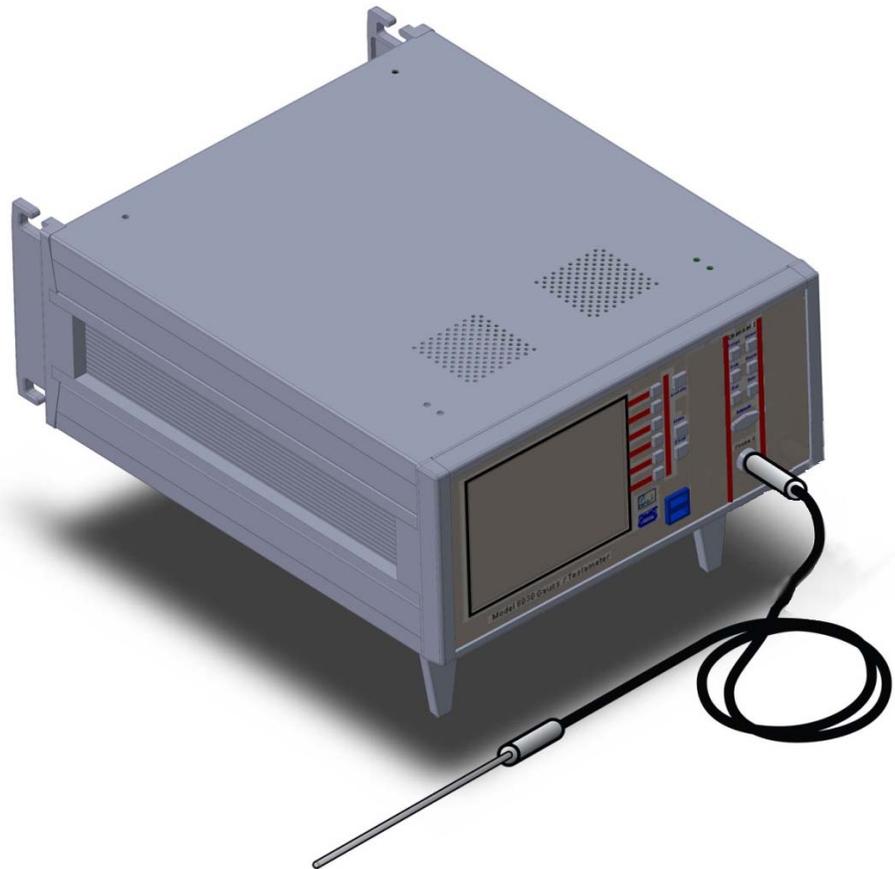
## SECTION 5 User Interface

### 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.



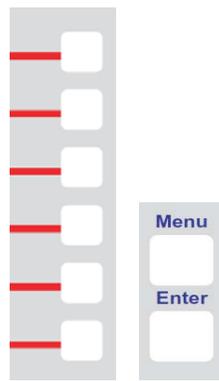
## Front Panel Keypad

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 lines 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 selected menu or sub menu is identified in the bottom block highlighted in blue.

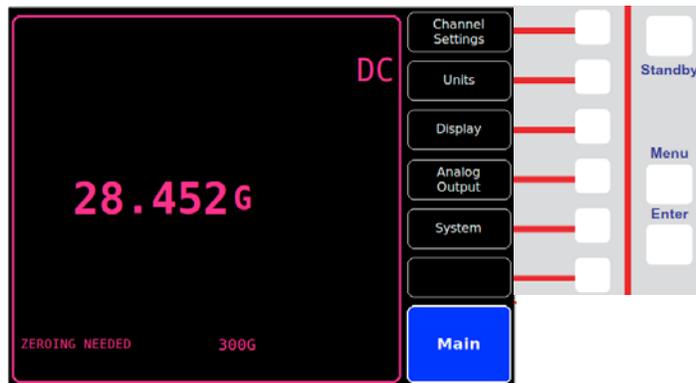


Figure 5-2 Main Menu Example

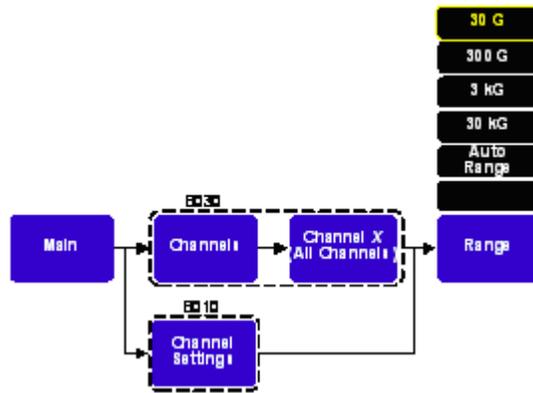
To navigate the menu system, simply press the menu hot key that corresponds to the menu selection or function desired. To return to the previously accessed menu, press the [Menu] button. Pressing the [Menu] button multiple times will return the display to the ‘Main’ menu.

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.

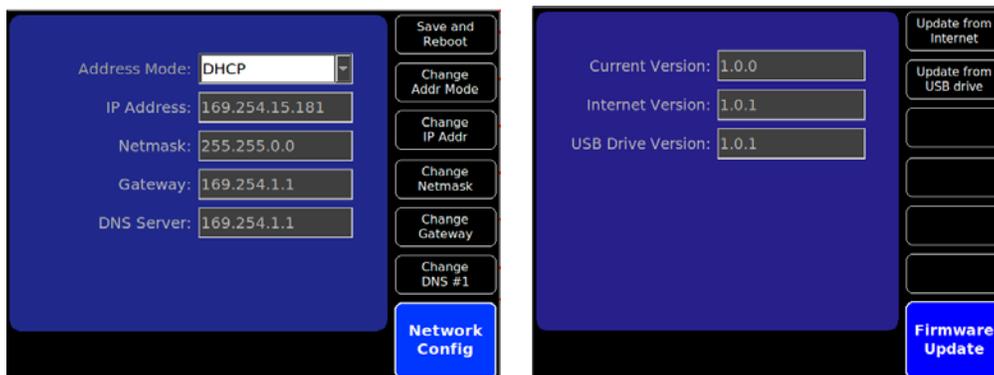


**Figure 5-3 Menu Selections Example**

*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**

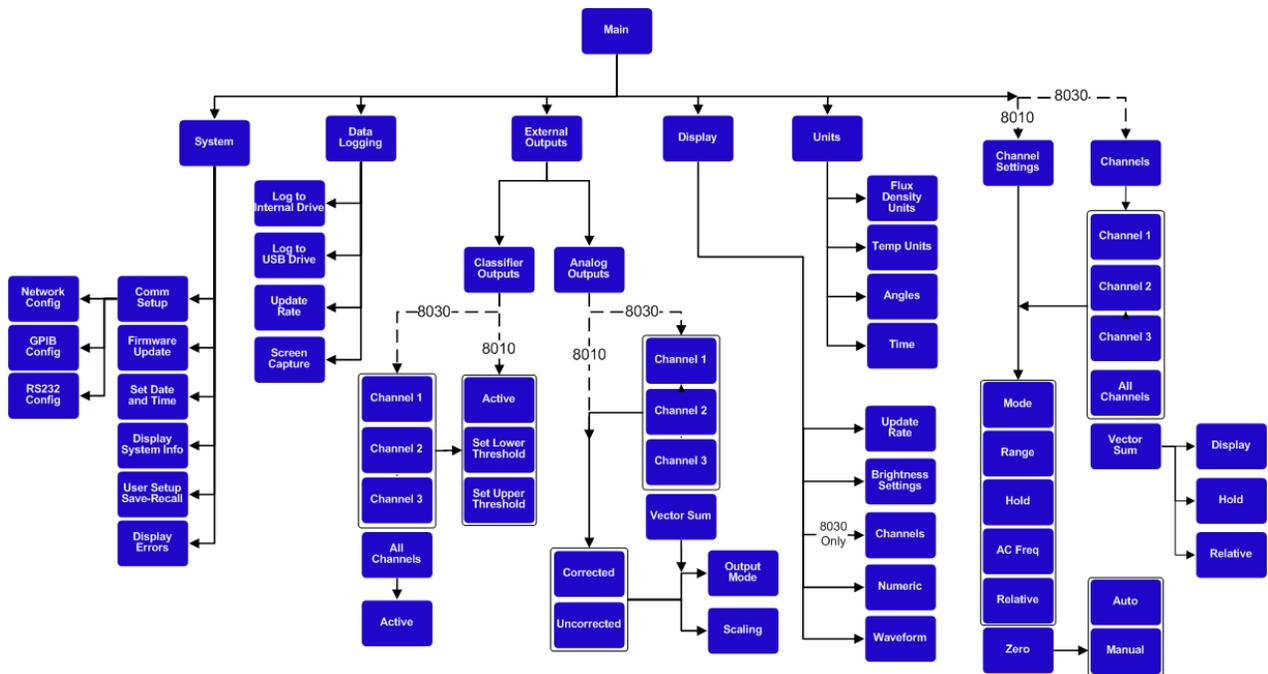
Some menus selections have special menu screens that can be accessed. For example the Main⇒System⇒Firmware Update and the Main⇒System⇒Network Configuration menus bring up the following screens as shown in Figure 5-4.



**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**

## **Display System Information**

Information about the meter and probes connected to the meter including the firmware revisions, model numbers, serial numbers, calibration dates and other miscellaneous data can be viewed using this menu selection.

### **To View System Information:**

- 1) From the MAIN menu, navigate to the SYSTEM menu and select the “Display System Info” hot key button.
- 2) Press the menu button to exit this screen.

## **User Setup Save and Recall**

Up to 10 user setup configurations may be saved in the meter’s internal flash memory. These setups are saved in non-volatile memory and may be recalled at anytime, including after a power on/off cycle. The settings from all menus are saved including those enabled remotely or from the front panel.

### **To Save or Recall a Configuration Setup:**

- 1) From the MAIN menu, navigate to the SYSTEM menu and select “User Setup Save-Recall”.
- 2) Use the number entry hot keys to enter the desired setup profile (1 to 10).
- 3) Select either “Save” to save the current setup to memory or “Recall” to load a setup from memory.
- 4) Press the MENU button to exit the User Setup Save and Recall menu.

### **To Load Default Settings:**

- 1) From the main menu, navigate to the SYSTEM menu and select “User Setup Save-Recall”.
- 2) Press the “Default” hot key button to load the default system settings as shown in Table 5-2.

**Table 5-2 Default Configuration Settings**

| Function   | Item                    | Setting        | Scope                             |
|------------|-------------------------|----------------|-----------------------------------|
| UNITS      | Flux Density            | tesla (T)      | All Channels and Vector Summation |
|            | Temperature             | Celsius (°C)   | All Channels                      |
|            | Angle                   | Radians (rad)  | Vector Summation                  |
|            | Time                    | Frequency (Hz) | All Channels                      |
| HOLD       | Maximum                 | Disabled       | All Channels and Vector Summation |
|            | Minimum                 | Disabled       | All Channels and Vector Summation |
|            | Peak                    | Disabled       | All Channels                      |
|            | Valley                  | Disabled       | All Channels                      |
|            | Active                  | Disabled       | All Channels and Vector Summation |
|            | Reset                   | Reset to Zero  | All Channels and Vector Summation |
| FILTER     | Analog Filter           | High Freq      | All Channels                      |
| DISPLAY    | Update Rate             | 1/sec          |                                   |
|            | Channel 1               | Enabled        |                                   |
|            | Channel 2 (8030 only)   | Enabled        |                                   |
|            | Channel 3 (8030 only)   | Enabled        |                                   |
|            | Vector Sum              | Disabled       |                                   |
|            | Brightness Settings     | Mid Level      | Display and Buttons               |
|            | Numeric                 | Enabled        |                                   |
|            | Waveform                | Disabled       |                                   |
| RELATIVE   | Active                  | Disabled       | All Channels and Vector Summation |
|            | Value                   | +0.00000 T     | All Channels and Vector Summation |
|            | RS232 Baud Rate         | 9600           |                                   |
|            | RS232 Parity            | None           |                                   |
|            | RS232 Data Bits         | 8              |                                   |
|            | RS232 Stop Bits         | 1              |                                   |
|            | RS232 Flow Control      | Disabled       |                                   |
|            | IEEE 488 (GPIB) Address | 1              |                                   |
|            | Network                 | DHCP           |                                   |
| ANALOG OUT | Active                  | Disabled       | All Channels and Vector Summation |
|            | Scale                   | 3 V            | All Channels and Vector Summation |
| CLASSIFIER | Active                  | Disabled       | All Channels                      |
|            | High Value              | +0.00000 G     | All Channels                      |
|            | Low Value               | +0.00000 G     | All Channels                      |

## Setting the Date and Time

The meter's internal clock is used to generate time stamps for data logging of measurements.

The time is set and stored in 24-hour format; refer to Table 5-3 for conversions between 12-hour and 24-hour formats.

### To Set the Date and Time:

- 1) From the MAIN menu, navigate to the SYSTEM menu and select "Set Date and Time".
- 2) To set the Year, Month, Day, Hour, or Minute, select the desired hot key button and edit the number as desired.
- 3) After all the fields have been edited pressing the "Set Date and Time" hot key will set the date and time and the meter will display a message that the Date and Time Have Been Set.

**Table 5-3 12-hour to 24-hour Conversion Chart**

| <b>12-Hour Format</b> | <b>24- Hour Format</b> | <b>12- Hour Format</b> | <b>24- Hour Format</b> |
|-----------------------|------------------------|------------------------|------------------------|
| 12 am                 | 00 hours               | 12 pm                  | 12 hours               |
| 1 am                  | 01 hours               | 1 pm                   | 13 hours               |
| 2 am                  | 02 hours               | 2 pm                   | 14 hours               |
| 3 am                  | 03 hours               | 3 pm                   | 15 hours               |
| 4 am                  | 04 hours               | 4 pm                   | 16 hours               |
| 5 am                  | 05 hours               | 5 pm                   | 17 hours               |
| 6 am                  | 06 hours               | 6 pm                   | 18 hours               |
| 7 am                  | 07 hours               | 7 pm                   | 19 hours               |
| 8 am                  | 08 hours               | 8 pm                   | 20 hours               |
| 9 am                  | 09 hours               | 9 pm                   | 21 hours               |
| 10 am                 | 10 hours               | 10 pm                  | 22 hours               |
| 11 am                 | 11 hours               | 11 pm                  | 23 hours               |

## Display Errors

The meter has an internal error log that will store up to 25 error messages generated during operation. Refer to the sections of this manual covering status and error queue for more information regarding the error log, and Appendix C for a list of error messages.

### To View the Error Log on the Display:

- 1) From the MAIN menu, navigate to the SYSTEM menu and select the “More” and “Display Errors” hot key buttons. The error log will be displayed with the oldest errors at the beginning of the list.
- 2) Press the menu button to exit this screen.

### To Refresh or Clear the System Error Log:

Pressing the “Refresh” hot key will refresh the display to capture any errors that may have occurred while viewing the log.

Pressing the “Clear Oldest” hot key will delete the oldest error message from the log and refresh the display.

Pressing the “Clear All” hot key will delete all entries from the error log and refresh the display.

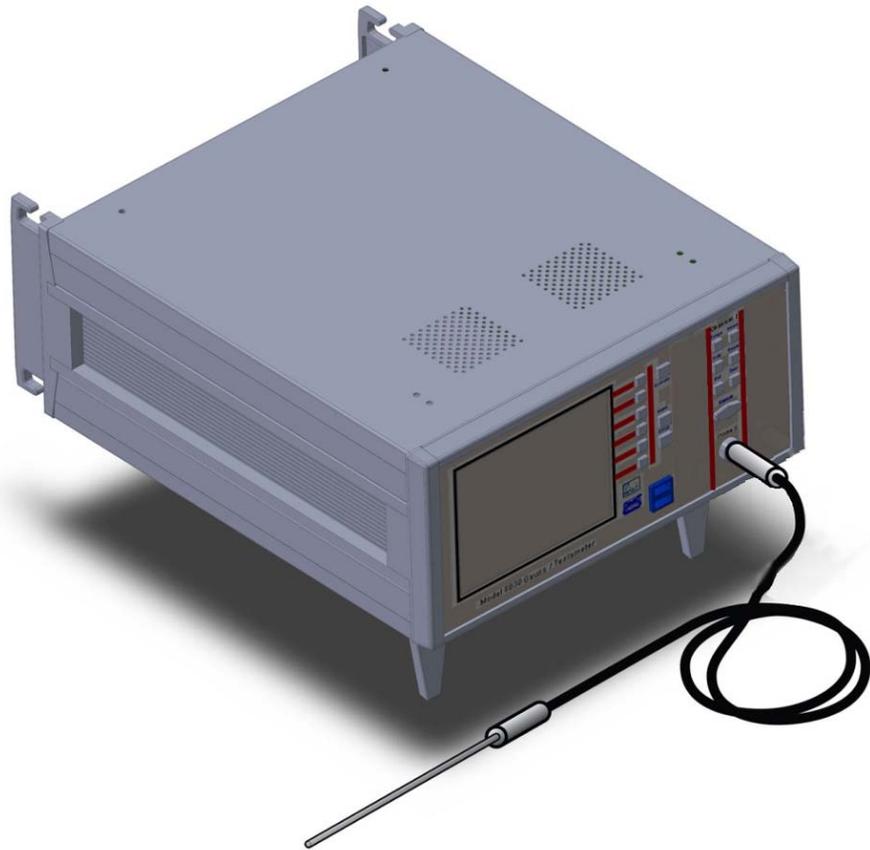
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## SECTION 6 Flux Density Measurement

### 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.

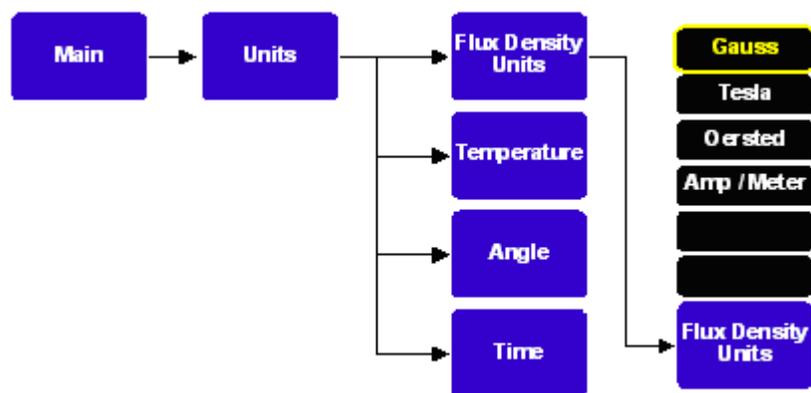
**Table 6-1 Available Units**

| 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.

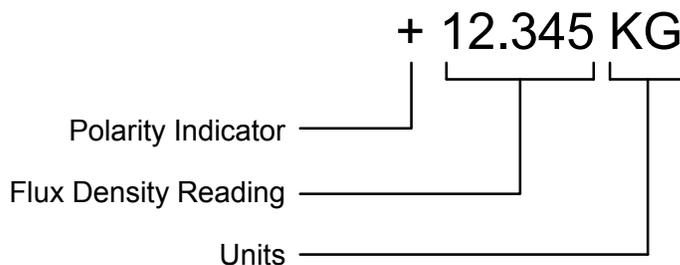


**Figure 6-1 Setting the Units**

## 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 6-2. 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.*



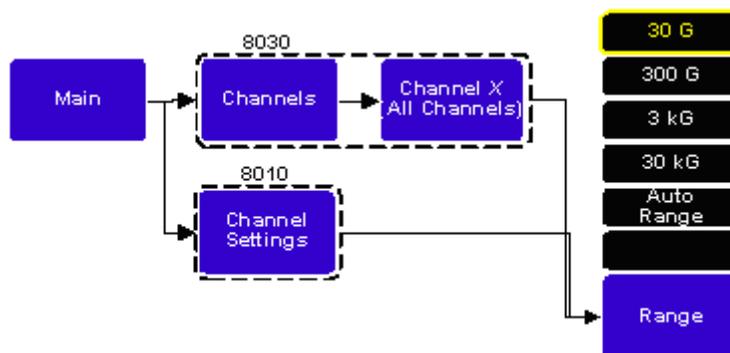
**Figure 6-2 Flux Density Reading**

## Measurement Range Selection

The meter 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.



**Figure 6-3 Range Settings**

## Measurement Range Selection

### 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.*

*Note: Using Auto Range with high crest factor signals or pulses may cause toggling of the range setting if the peak is considerably higher than the average or rms value of the signal and exceeds the full scale value. For this type of signal, it is best to use a fixed range setting.*

## Measurement Mode Selections

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.

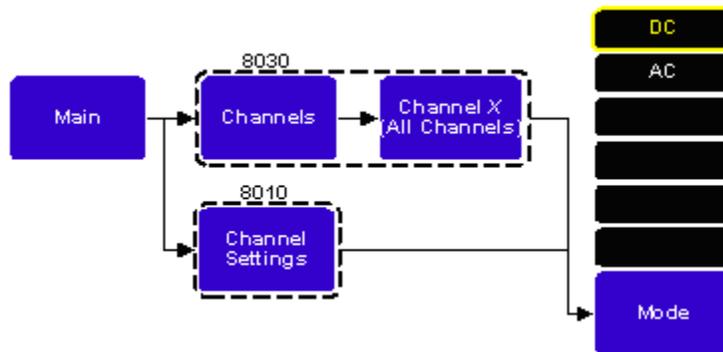


Figure 6-4 Measurement Mode Selection

### 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 6-5.

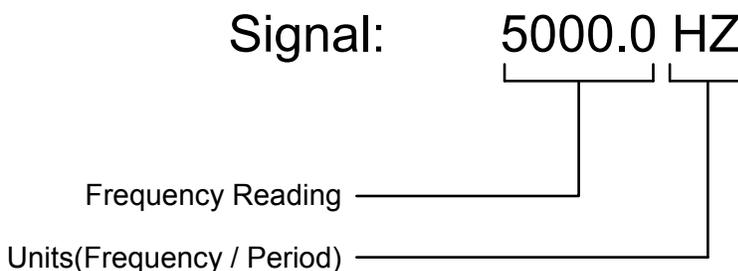


Figure 6-5 Frequency / Period Indicator

*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 $\mu$ T) | 30.0000 G (3.00000 mT)  | 300.000 G (30.0000 mT)  | 20% Full Scale    |
| 3.00000 G (300.000 $\mu$ 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

### AC Mode Analog Filtering

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

As shown in Table 6-3 the Full Bandwidth 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.

A selection called No Corrections is also available. This filter mode sets the meter to its full bandwidth but does not apply AC frequency correction factors. This setting can be useful if measuring signals that do not have stable frequency content or if trying to capture transient events.

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.

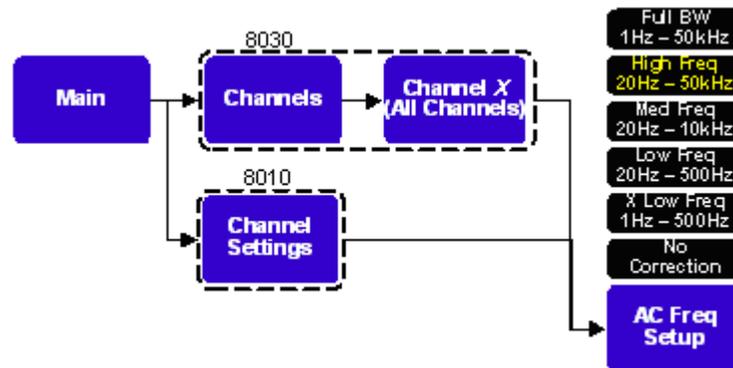
**Table 6-3 AC Mode Analog Filter Selections**

| Filter Selection | Bandwidth       |
|------------------|-----------------|
| Full Bandwidth   | 1 Hz to 50 kHz  |
| 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  |
| No Corrections   | 1Hz to 50 kHz   |

### 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.



**Figure 6-6 Analog Filter Selection**

## Zeroing

### Overview

“Zeroing” the probe and meter 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 the actual devices are subject to variations in materials, construction and temperature. Therefore, most Hall effect sensors produce some output even in a zero field and this will be interpreted as a magnetic field signal by the meter.

In addition, the circuits within the meter can produce a signal even when there is no signal present at the input. This also 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  $\mu\text{T}$ ), can introduce errors in the final reading.

For most situations it is preferable to shield the probe from all external magnetic fields prior to zeroing. For this reason the 8000 Series Meters are provided with a “zero flux chamber” which is capable of shielding against fields as high as 30mT (300G). The probe is simply inserted into the chamber before the zeroing process is initiated.



***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.

*NOTE: If a range is exceeded by the level of field while zeroing, that range cannot be entered by the meter.*

## Zeroing

### Automatic Zeroing

The meter's automatic zero can be setup to zero in either DC Only, Basic, or Advanced zeroing modes.

DC Only zeroing provides the shortest zeroing process delay and as the name suggests only measures and applies zeroing factors for DC Mode measurements.

Basic zeroing provides both DC and AC mode zeroing, but the AC zeroing process has a reduced process delay that provides slightly less accurate results. For most purposes the basic AC zeroing is sufficient to provide results within the rated accuracy for RMS averaged measurements.

Advanced zeroing provides both DC and AC mode zeroing with the best AC zeroing accuracy. This mode requires a substantially longer zeroing period but offers the best performance for all AC measurement modes.

The estimated zeroing times for each of these modes is shown in Table 6.4.

**Table 6-4 Estimated Zeroing Times**

| Zeroing Mode                | Estimated Zeroing Time |
|-----------------------------|------------------------|
| DC Only                     | 30 seconds             |
| Basic (DC & Basic AC)       | 60 seconds             |
| Advanced (DC & Advanced AC) | 90 seconds             |

*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*

### Initiating an Automatic Zero

To initiate zeroing on one channel

- 1) Set the channel's Auto Zero Menu to the desired zero mode.
- 2) Prepare the probe for zeroing.
- 3) Press the [Auto Zero] menu button or the zero key for the appropriate channel.

To initiate zeroing on all channels. (8030 Only)

- 1) Set the All Channels Auto Zero Menu to the desired zero mode.
- 2) Prepare all probes for zeroing.
- 3) Press the All Channels, [Auto Zero] menu button.

Each channel will display a message that indicates the selected zeroing mode and a progress status bar that approximates the duration of the zeroing process. Once zeroing begins it must be allowed to complete.

## Zeroing

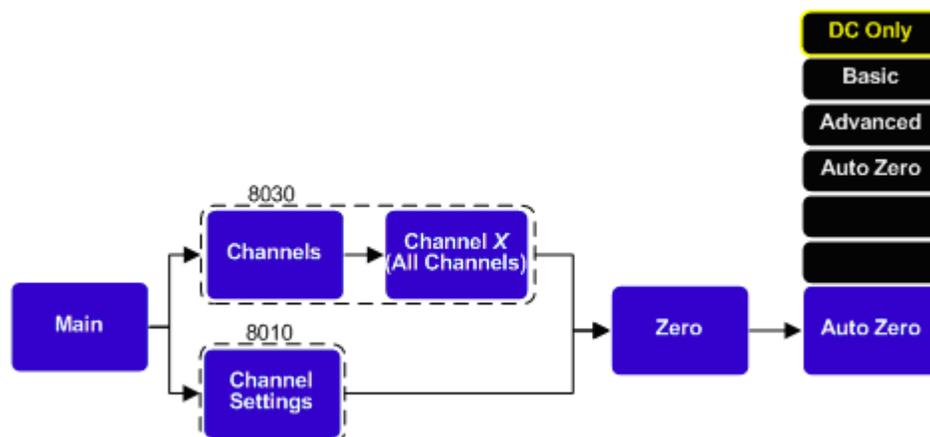


Figure 6-7 Auto Zero Menu Path

### Zero Prompt

The meter will inform the user that a channel needs to be zeroed 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).
- The meter was zeroed in DC Only mode and the measurement mode is changed to AC.

### Manual Zero

In addition to the automatic zeroing features the meter 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 and select Manual Zero.

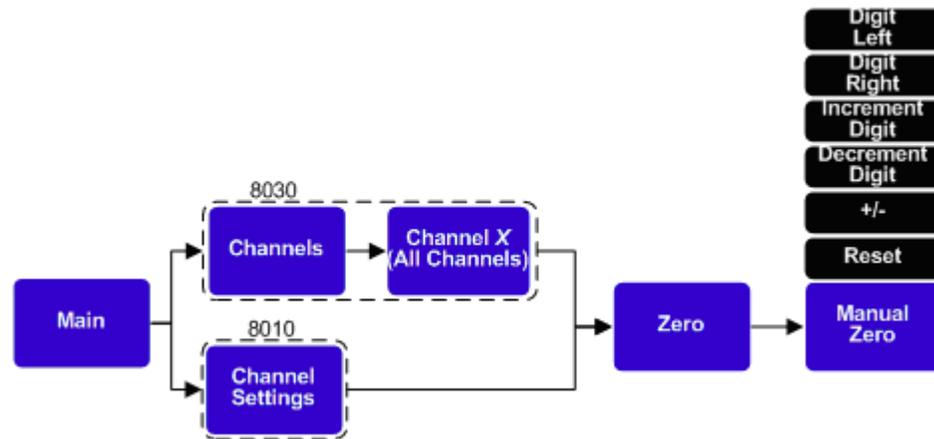
**Zeroing Manual Zero (continued)**

The display will change to show the manual zero input value (MZERO) and using the menu buttons the user can enter a value by selecting the appropriate digit and either incrementing or decrementing the digit. Incrementing or decrementing any of the digits can be done by pressing the left or right side of the [Manual] button or by pressing the corresponding menu hot key button. Pressing the [Reset] button resets the manual zero value to zero and backing out of the menu with the value at zero turns off the manual zero feature.

While manual zero is active this value will be added to (or subtracted from) all future readings.

*NOTE: Attempting to enter manual zero values larger than the selected range is not allowed, the meter will beep and ignore the requested value change.*

*NOTE: Making a manual adjustment to the zero point only affects the selected range. Changing the range also resets the manual zero value to zero and turns off manual zero mode.*



**Figure 6-8 Manual Zero Menu Path**

## Display Update Interval

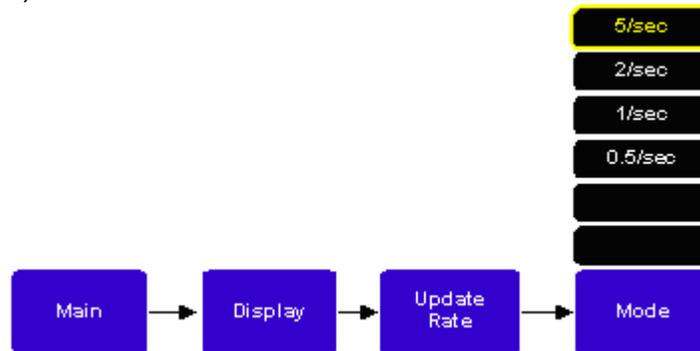
The update interval of the displayed readings and the data log rate may be adjusted using the Update Rate menu. Shorter update intervals allow rapid fluctuations in flux density levels to be observed. Longer update intervals provide higher resolution, accuracy, and stability in the flux density reading by averaging more samples to obtain a reading. The Update Intervals are shown in Table 6-4.

**Table 6-5 Update Interval Settings**

|                         |
|-------------------------|
| 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.



**Figure 6-9 Update Interval Setting**

## 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 its 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 its 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

### Hold Mode Configuration

The hold functions are setup for use from each channel's 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).

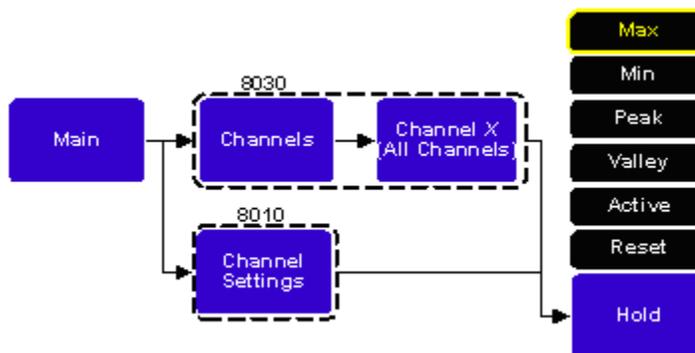


Figure 6-10 Hold Features Settings

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 Hold menu system to activate.

*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 channel’s relative menu to activate and set the meter’s Manual Relative feature. *(note: the Manual Relative feature is not 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 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

### 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 6-9. 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 6-11 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      Auto / Manual Relative Mode – Menu System

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

To set a 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

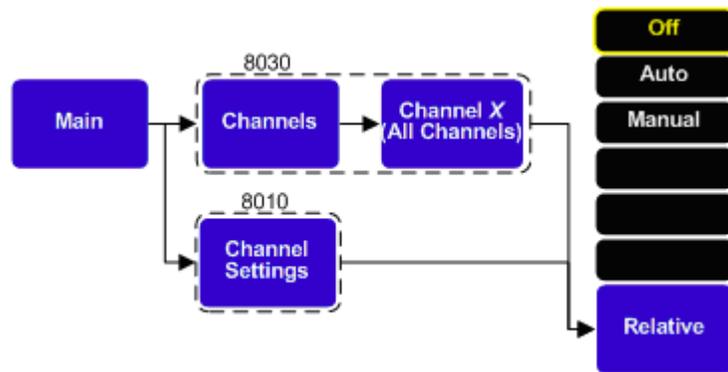


Figure 6-12 Relative Settings Menu Path

### Adjusting the Relative Value from the Measurement Screen

Once the relative value is set, either from the front panel or from the auto relative menu button, its value may be adjusted manually. To manually adjust the relative value enter manual relative mode by pressing the manual relative menu button. The menu will change to show the manual relative input controls and using the menu buttons the user can enter a value by selecting the appropriate digit and either incrementing or decrementing the digit. Incrementing or decrementing any of the digits can be done by pressing the left or right side of the [Manual] button or by pressing the corresponding menu hot key button. Pressing the reset button resets the manual relative value to zero.

## 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 channel's 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 6-11a. The orientation of the probe and location of the "X" hall effect element is specified with a "painted" mark or V-notch. The straight side of the painted mark is parallel with the Y axis. Figure 6-11b 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 6-11a and 6-11b 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.

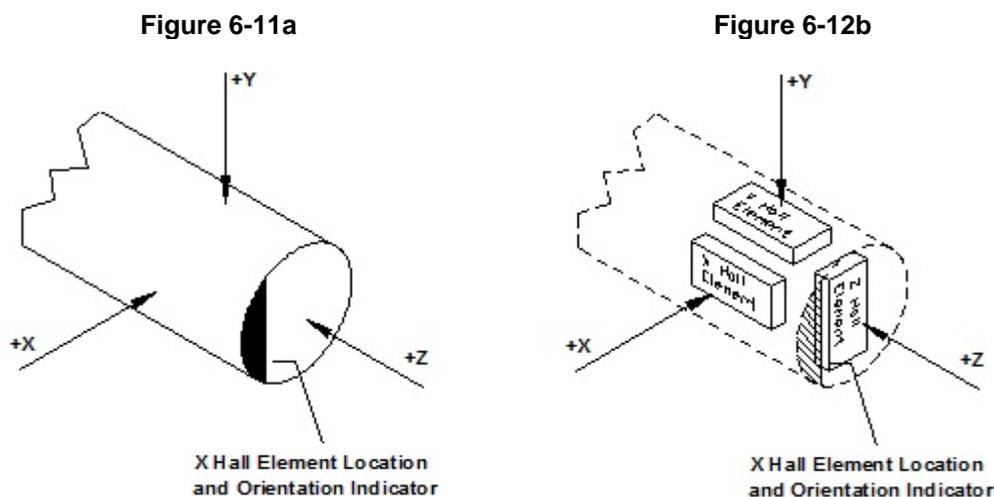


Figure 6-13 8000 Series 3-Axis Probe Orientation

**Vector  
Summation  
(8030 ONLY)**

**Vector Magnitude**

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

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

**Figure 6-14 Vector Sum Equation**

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  $\theta_x$ ,  $\theta_y$ , and  $\theta_z$  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  $\theta_x$ ,  $\theta_y$ , and  $\theta_z$ , 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:

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

**Figure 6-15 Vector Sum Relative Equation**

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)

### 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.*

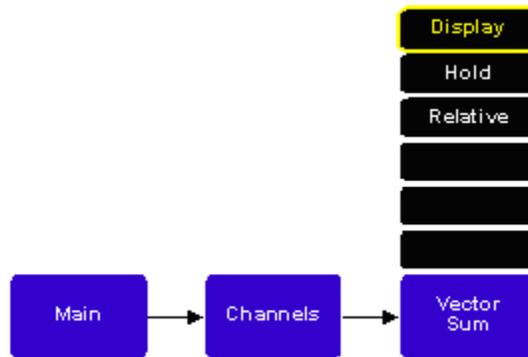


Figure 6-16 Vector Sum Settings

## Analog Outputs

Each channel provides 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 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.

*Note: Auxiliary (spare) outputs are not assigned any functionality, and are reserved for future development.*

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.

**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.

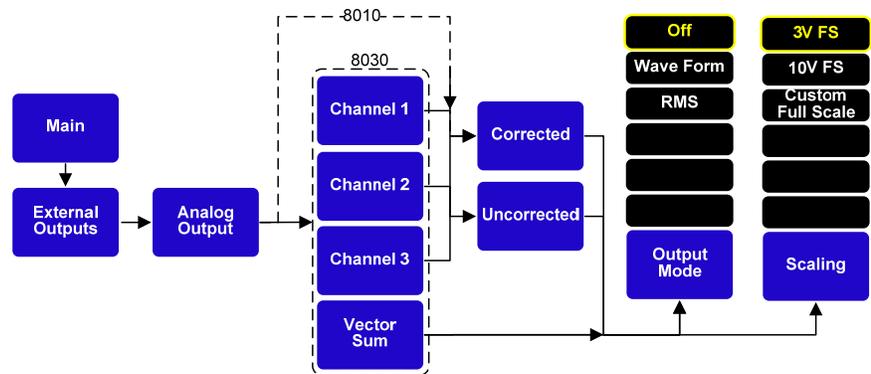


Figure 6-17 Analog Output Settings

## Classifier Outputs

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 a 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. For DC mode operation, polarity information needs to be specified. With AC mode, only magnitude values may be set. The meter will retain DC polarity information when switching between AC and DC modes.

### Example Circuit for Classifier Outputs

Figure 6-16 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.

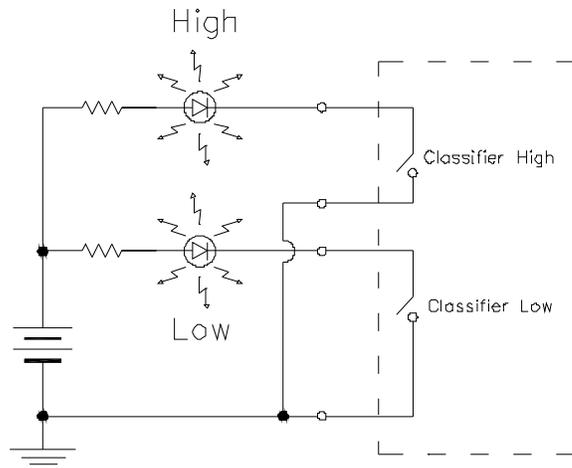
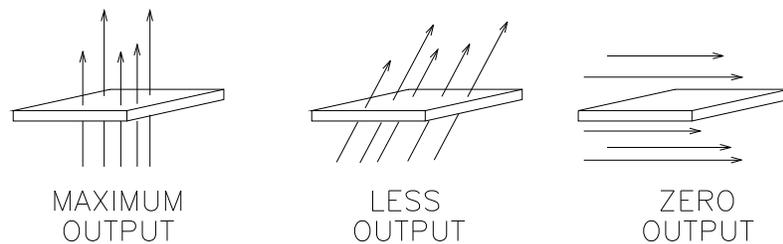


Figure 6-18 Example Circuit for Classifier Outputs

## Sources of Measurement Error

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

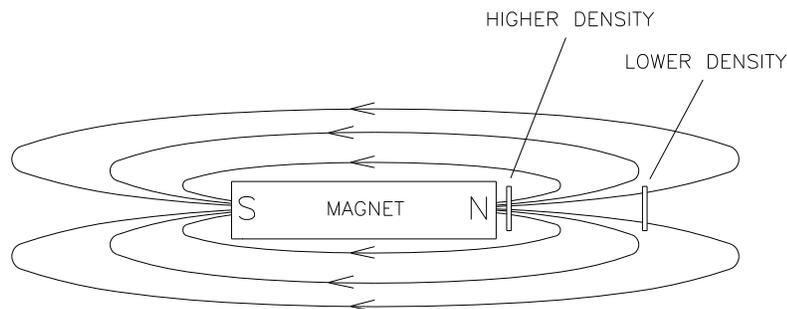
- 1) Failure to zero the error signals from the meter, probe, and nearby sources of magnetic interference.
- 2) Subjecting the probe to physical abuse.
- 3) One of the most common sources of error is the angular position of the probe with respect to the field being measured. A Hall Effect sensor is not 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 below.



**Figure 6-19 Probe Output versus Flux Angle**

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

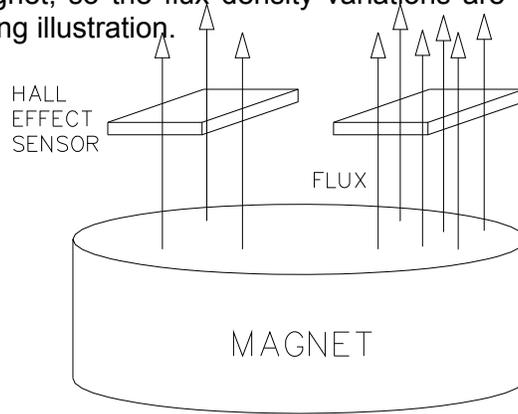
- 4) As shown below, the distance between the magnetic source and the Hall probe increases fewer flux lines will pass through the probe, causing the probe's output to decrease.



**Figure 6-20 Probe Output versus Distance**

## Sources of Measurement Error

- 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 as shown in following illustration.



**Figure 6-21 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 AC Waveform Display

### Introduction

The 8000 Series Gauss / Tesla meter is the first meter in its class to offer a graphical, color, waveform display for AC mode measurements without the use of an external oscilloscope or other analog graphing device.

The 8000 Series AC Waveform Display operates very much like a modern oscilloscope, but is simple enough that even novice users will be able to set up and capture AC mode measurements easily.

Inside the AC Waveform Display menus users can adjust the time and vertical measurement scales, chose several different trigger modes, and enter customizable trigger levels and slopes that make it possible to capture repetitive and transient measurement events.

### AC Waveform Display Graphical Layout

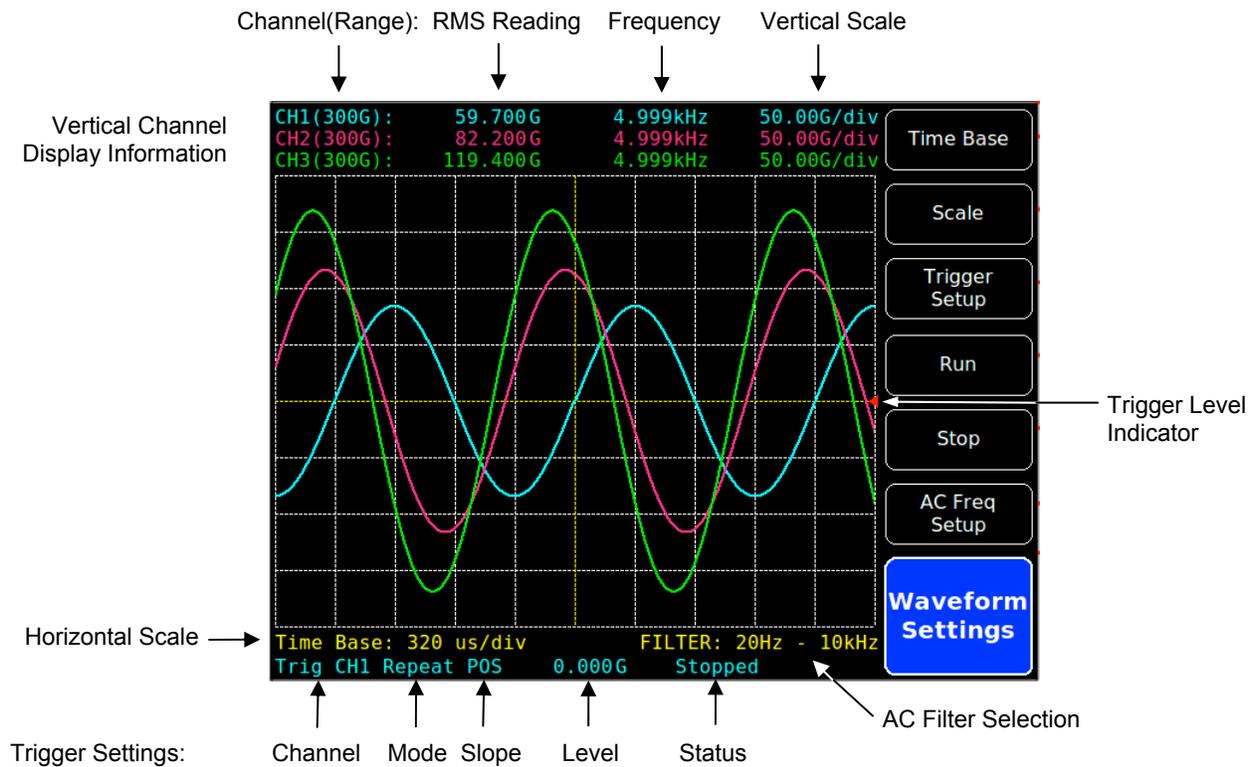


Figure 7-1 AC Waveform Display Layout

## Accessing the AC Waveform Display

To enter the AC Waveform Display, navigate the menu system as shown in Figure 7-2. Pressing the Waveform hot key will enable the waveform display with the layout as seen in Figure 7-1.

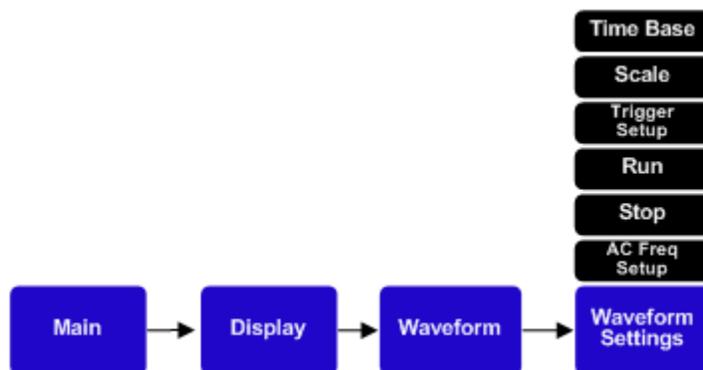


Figure 7-2 Waveform Display Menu

To return back to the numeric display press the [Menu] button as many times as necessary to back through the menu system to the Display menu and select Numeric.

*Note: Accessing other menus and changing settings associated with the numeric display will also return the display to the numeric format. For example changing the display channels, vector sum on the 8030, or zeroing the meter.*

*Note: To display an AC waveform the meter must have a probe present and be in AC Mode. This will be indicated in the vertical channel display information.*

## Setting the Time Base

From the Waveform Settings menu, accessing the Time Base menu brings up a row of hot keys that set the time per division for the horizontal time scale of the waveform display.

The time base horizontal scale selection range is associated with the AC Freq Setup menu selection, such that one of six values are available that will scale the display within the bandwidth of the selected AC Frequency Filter.

For example, with the AC Frequency Filter set to the High Freq (20Hz – 50kHz) bandwidth filter, six selections ranging from 8 $\mu$ S per division to 6.4mS per division are available. For the Med Freq (20Hz – 10kHz) filter, six selections ranging from 16 $\mu$ S to 6.4mS are available.

## Setting the Time Base

Selecting the appropriate AC bandwidth filter for the signal of interest will allow the user to display the desired time resolution for the signal being examined. Table 7-1 shows the time base settings for each of the AC Frequency Filters.

For convenience the AC Freq Setup menu is duplicated in the Waveform Setting menu. Refer to the AC Mode Operation section in this manual for more description of the AC Frequency Filter Selections.

The selected time base setting is indicated in the lower left corner of the display as seen in Figure 7-1.

**Table 7-1 Time Base Selections for AC Filter Settings**

| High Freq<br>(20Hz -50kHz) | Med Freq<br>(20Hz -10kHz) | Low Freq<br>(20Hz -500Hz) | X Low Freq<br>(1Hz -500Hz) | Full BW &<br>No Correction |
|----------------------------|---------------------------|---------------------------|----------------------------|----------------------------|
| 8 $\mu$ s                  | 16 $\mu$ s                | 320 $\mu$ s               | 320 $\mu$ s                | 8 $\mu$ s                  |
| 24 $\mu$ s                 | 48 $\mu$ s                | 640 $\mu$ s               | 640 $\mu$ s                | 24 $\mu$ s                 |
| 64 $\mu$ s                 | 128 $\mu$ s               | 1.28ms                    | 1.28ms                     | 64 $\mu$ s                 |
| 400 $\mu$ s                | 320 $\mu$ s               | 1.92ms                    | 3.20ms                     | 400 $\mu$ s                |
| 1.60ms                     | 1.60ms                    | 3.20ms                    | 6.40ms                     | 2.00ms                     |
| 6.40ms                     | 6.40ms                    | 6.4ms                     | 128ms                      | 16.0ms                     |

## Setting the Vertical Scale

From the Waveform Settings menu, accessing the Scale menu brings up a row of hot keys that set the units per division measurement for the vertical value of the waveform display.

The vertical scale selection range is associated with each channel's input range, such that one of six values are available to scale the display within that channel's selected range.

For example, with the range set to 30kG six selections ranging from 0.50kG to 20.00kG per division are available. For a range selection of 3mT there are six selections ranging from 0.03mT to 2.00mT per division.

Selecting the appropriate measurement range for the signal of interest will allow the user to display the desired vertical scale for the signal being examined. Refer to section 6-3 of this manual for more information regarding measurement range selection.

The present measurement range and waveform scale per division settings are indicated on the top of the waveform display as seen in Figure 7-1.

*Note: In waveform mode the range buttons for each channel are active and can be used to change the range without using the menu system.*

## Trigger Operation

Navigating from the Waveform Setting menu and selecting the [Trigger Setup] button will open the Trigger Setup menu as seen below in Figure 7-3.

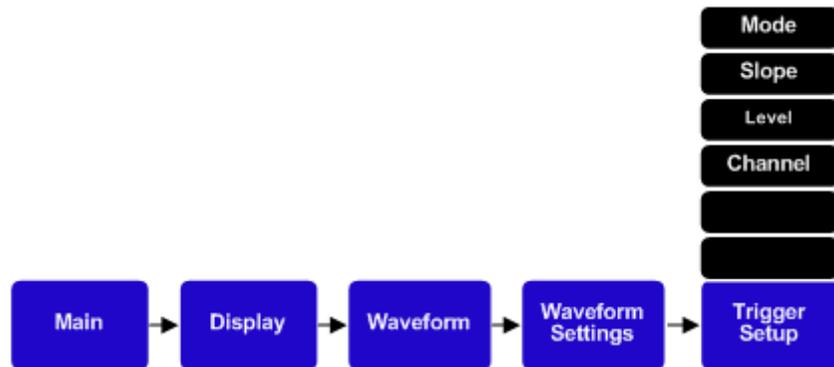


Figure 7-3 Trigger Setup Menu

Much like an oscilloscope the 8000 Series Waveform Display uses a trigger to synchronize the measurement display data.

Several different modes of operation are possible including ones that allow the setting of custom trigger levels and slopes.

To start a waveform display, set up the desired AC Frequency Filter, time base, vertical range and scale, trigger mode, slope, trigger level, and trigger channel (8030 only) settings and press the [Run] button.

Depending on various settings the meter's trigger status line will display Waiting, Running, or Stopped.

**Waiting:** Indicates that the meter is looking for or waiting for a valid trigger event.

**Running:** Indicates that a trigger has been identified and that the display is being updated repeatedly.

**Stop:** Indicates that the display is frozen with the last triggered event.

On the display, the trigger event is always displayed at the center time graticule and at any time in the trigger process the user can press the [Stop] button and the present display will be frozen.

## Trigger Operation (Continued)

### Trigger Channel Selection

The trigger channel selection is only available on 8030 models and allows the user to select the trigger channel.

The selected trigger channel and trigger settings are displayed on the bottom line of the waveform display as shown in Figure 7-1.

*Note: Only channels that have probes present and are in AC mode are displayed or can be selected as the active trigger channel. By default the meter will select the first possible trigger channel.*

### Trigger Modes

#### Free Run

Selecting the Free Run trigger mode will set the waveform display to show measurement data without using a trigger level. The capture event is still triggered it is just not based on any level setting. For this reason the display may jump around showing various phase shifts and appear unstable. This is intentional and can be helpful to identify signals that may be outside of the trigger level while still displaying a waveform.

#### Auto

In Auto trigger mode the meter continuously and automatically calculates an appropriate trigger level based on the data being sampled by the meter. This trigger level, combined with a positive going slope, initiates a trigger event and causes the meter to display data associated with that trigger.

#### Repeat

Repeat mode is similar to auto mode except the meter uses the custom user settings for the level and slope to generate the capture event. After a trigger is detected the data associated with that trigger is displayed and the meter will automatically look for the next trigger event.

#### Single

Single trigger mode is exactly the same as repeat mode except that only one trigger event is captured and displayed. After an event is displayed the trigger is put into the stopped state. In order to capture another event the user must press the [Run] button.

Single trigger mode may be useful to capture single pulses commonly found when magnetizing material, or ones which are followed by secondary pulses which may cause an unwanted re-trigger which would overwrite the desired wave shape with Repeat mode triggering.

## Trigger Slope

The trigger slope setting is used in combination with the trigger level setting to determine the desired trigger point for capturing events in Repeat and Single trigger modes. It can be set to either Positive or Negative slope.

For a positive slope, the signal being analyzed must be increasing in value while passing the trigger level to initiate a trigger. Likewise for a negative slope the signal must be decreasing in value while passing the trigger level. In either setting trigger levels with a slope opposite of the setting will be ignored.

Refer to Figure 7-1 for the location of the slope indicator on the waveform display.

## Trigger Level

The trigger level can be set manually by entering the trigger level menu and using the hot keys to move the active digit to the left or right, increment or decrement the active digit, change the polarity of the level entry, or reset the level to zero.

The input trigger level is used in combination with the slope setting to create a trigger point level in Repeat and Single trigger modes. Settings to the trigger level can still be made while operating in Free Run or Auto modes but they will not be used.

A trigger level indicator is displayed on the right hand graticule to indicate that it is active and where the trigger level is relative to the selected vertical scale. If the trigger level is outside of the selected scale the arrow will point up or down off scale. Refer to Figure 7-1 for the location of the trigger level on the waveform display.

## SECTION 8 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 many more commands that are not specified by SCPI but conform to the rules indicated by the standard.

## Communications 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. The serial transmission characteristics such as baud rate, parity setting, etc. are defined in the SYSTEM⇒COMM SETUP⇒RS232 CONFIGURATION menu. These settings must match those of the computer.

A set of controls lines are used to indicate the overall status of the instrument and computer. The instrument asserts the Data-Terminal-Ready (DTR) to inform the computer that it is powered up, initialized and ready for communications. Likewise the computer asserts Data-Set-Ready (DSR) to indicate that it is ready for communications.

Data is transmitted to the instrument on the Receive (RX) line. Data is transmitted to the computer on the Transmit (TX) line. In most cases these are the only signals needed for communications.

However, there may be a need to control the flow of data between the instrument and the computer. For example, if the computer is receiving data from the instrument but is interrupted by another task, it may want to halt the instrument’s transmission until it has completed that task. This can be accomplished in one of two ways.

#### Hardware Handshaking

Two lines called Clear-To-Send (CTS) and Request-To-Send (RTS) are used to control the flow of data. This is often referred to as “hardware handshaking”. The instrument will not transmit data until the computer asserts the CTS line. Likewise the computer should not transmit data until the instrument asserts the RTS line.

Hardware handshaking can be enabled or disabled from the RS232 setup menu. It must also be enabled or disabled on the computer accordingly.

#### Software Handshaking

Another way to control the flow of data is called “software handshaking”. In this method two special characters are used to halt or resume the flow of data. The XOFF character is decimal 19 (hex 13). If the instrument receives the XOFF character at any time it will halt transmission until it receives the XON character, which is decimal 17 (hex 11). Likewise if the instrument transmits an XOFF character to the computer the computer should halt transmission until it receives the XON character.

Software handshaking can be enabled or disabled from the RS232 setup

menu. It must also be enabled or disabled on the computer accordingly. If disabled the instrument will treat the XON and XOFF characters as any other character.

Shown below is the pin out for the 8000 Series Meter RS-232 communications port.

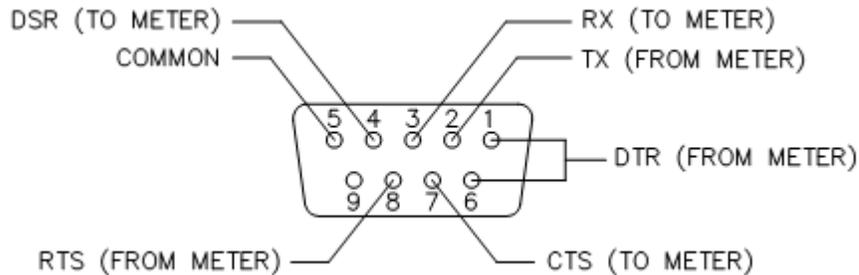
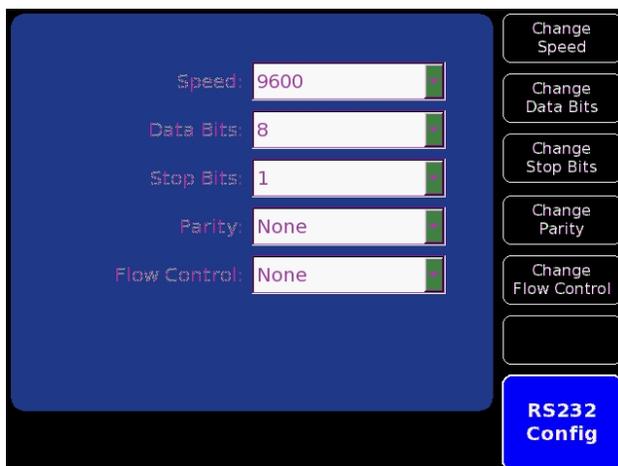


Figure 8-1 RS-232 Connector

**Configuration**

To setup the RS-232 communications port, navigate from the MAIN menu to [SYSTEM⇒COMM SETUP⇒RS232 CONFIGURATION]. This will open the RS-232 setup screen where the serial transmission characteristics such as baud rate, parity setting, etc. can be modified.



The lists of possible selections are defined in the following table. These settings must be duplicated on the host computer.

Figure 8-2 RS-232 Setup Screen

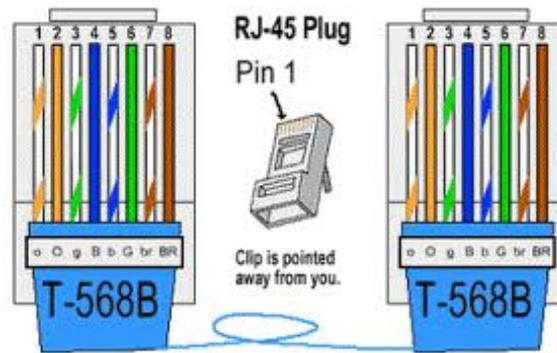
**Table 8-1 RS-232 Port Settings**

| Parameter   | Setting                                       |
|-------------|---|
| Baud Rate   | 2400, 4800, 9600, 19200, 38400, 57600, 115200 |
| Data Bits   | 7, 8  |
| Stop Bits   | 1, 2  |
| Parity      | None, Even, Odd                               |
| Handshaking | None, Software, Hardware                      |

## 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 below. Direct connection to computers using a crossover cable is not supported.



**Figure 8-3 Ethernet Connector Pin Out**

### Configuration

Navigating the system menu from MAIN menu to [SYSTEM ⇒ COMM SETUP ⇒ NETWORK CONFIGURATION] will bring up the Ethernet port network configuration screen as shown below.

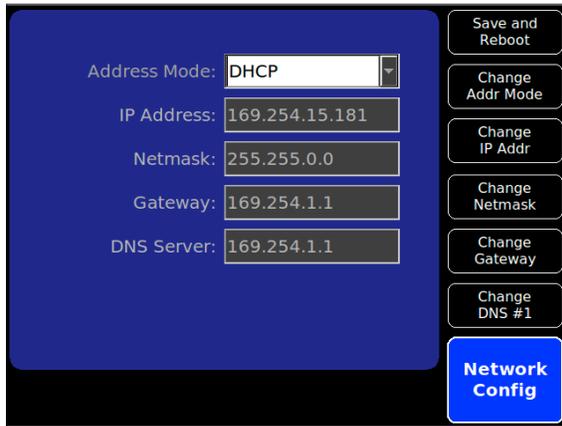


Figure 8-4 Network Configuration Screen

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.

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.*

**Accessing the System with TELENET 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 meter's network IP address and the [*port*] is 5024. See below.

*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.

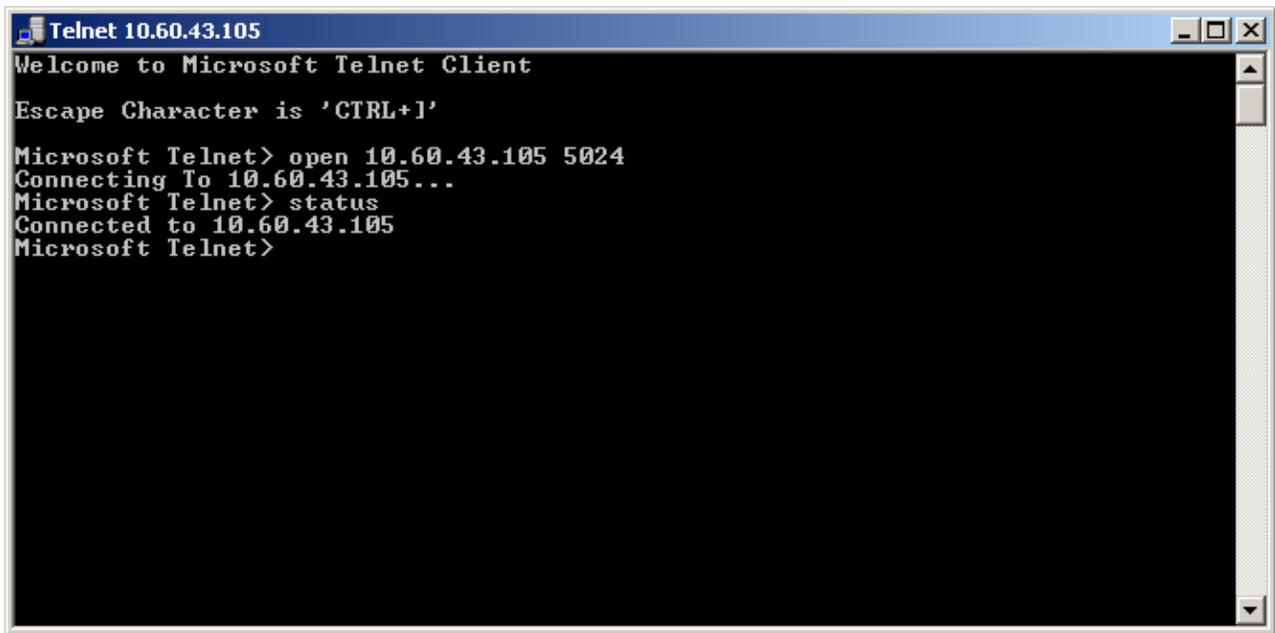


Figure 8-5 Windows TELENET Example

## Internal Web Application

The 8000 Series Gaussmeters offer an internal web application that is accessible over computer networks using standard web browser programs.

The application provides remote access to view measurements, change meter settings, log data, and access the meter's internal data storage for transfer to a host computer.

## Accessing the Internal Web Application

With the meter connected to a computer network, navigate from the MAIN menu to [SYSTEM ⇒ COMM SETUP ⇒ NETWORK CONFIGURATION] menu and determine the meter's IP address, or the use manual address mode to set an IP address.

**Note:** In DHCP mode the network connection must be installed and active during meter boot up, this is the only time the network card assigns an IP address in DHCP mode.

Open a web browser application (Windows Internet Explorer or equivalent) and enter the meter's IP address. For example <http://10.60.44.83/>

The 8000 Series Gaussmeter's Web Application will open as shown below and begin to display meter information and readings.

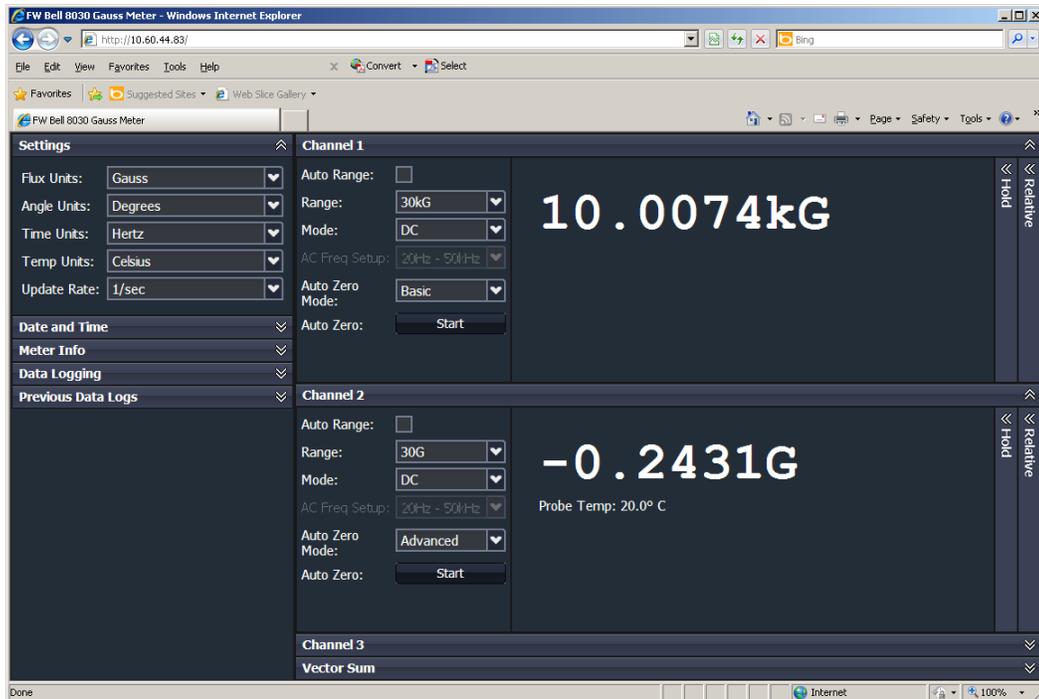


Figure 8-6 8030 Gaussmeter Web Application Screen

**Functional Description**

This remote display is separated into a series of different windows that display meter information including common controls, the flux density, frequency, and temperature measurements, data logging, and file utilities for the internal flash drive.

Each window can be collapsed or expanded to display the information of interest. This is done by clicking the double arrow symbols in each window's header.

**Settings**

The Settings window, allows the remote user to set the meter's Flux Units, Angle Units, Time Units, Temperature Units, and the Display Update Rate.

*NOTE: The update rate is the meters display update rate and is also used as the data log rate. It is NOT the update rate for this application, the update rate of this application is limited to twice per second and may vary based on network speed and or available bandwidth. In either event this will not affect the meters display or data log update rates.*

**Date and Time**

The Date and Time window, allows the remote user to manually enter and set the meter's date and time, or use the time from the remote computer to set the meter's date and time.

**Meter Info**

The Meter Info window shows the meter's model number and installed firmware versions.

**Data Logging**

The Data Logging window can start, stop, or cancel a data logging session to the meters internal flash drive.

Pressing <Start> will start the data log and show the number of rows captured, note that the rate at which the rows are captured is set by the Update Rate setting.

Pressing <Stop> will terminate the open log session, save the file on the internal flash drive, and open a pop up window that allows the user to open or save (download) the log file to the remote computer.

Pressing <Cancel> will terminate the log session and discard the log file.

**Previous Data Logs**

The Previous Data Logs window shows a list of all the log files stored on the internal flash drive.

Right clicking a particular log file will give the user a choice to Download or Delete the log file.

*NOTE: Only one file at a time may be downloaded or saved to the remote computer.*

Multiple files can be selected for deletion by <Ctrl> left clicking each file and then right clicking over one of the selected files.

**Channels and Vector Sum**

Each Channel window (only one for the 8010 model) and the Vector Sum window (8030 only) has controls that give the remote user the ability to set the following:

- Enable Auto Range
- Set the Range
- Set the Mode
- Set the AC Frequency Filter (AC mode only)
- Set the Zero mode
- Initiate channel Zeroing
- Activate and Display the Hold functions
- Activate and set the Auto and Manual Relative functions

In addition, for each channel the flux density measurement, AC frequency, and probe temperature if available are displayed in real time.

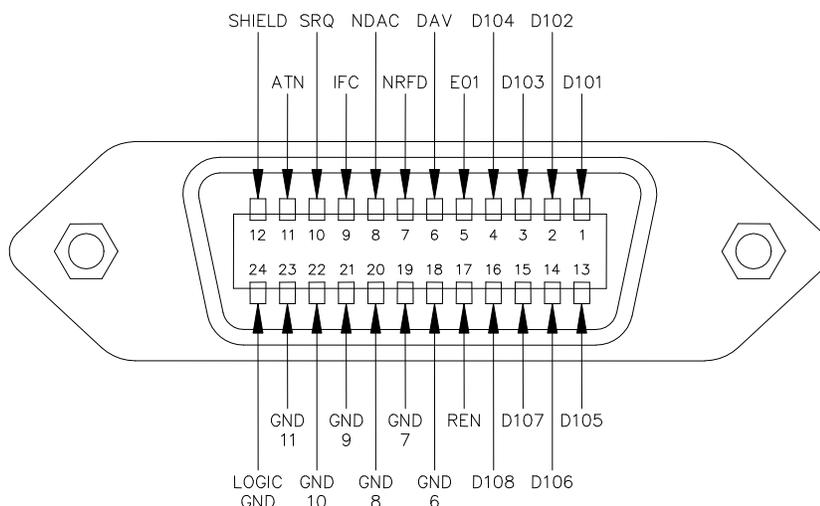
## IEEE-488 (GPIB) BUS

### Functional Description

The IEEE-488 (GPIB) instrumentation bus allows up to 15 instruments to be connected together in a "daisy chain" fashion.

Any device connected to the bus is capable of acting in any of three basic roles: controller, talker and listener. As a controller, the device dictates which devices act as talkers and listeners. There is only one controller at any given time, called the "system controller." This is normally the computer in an automated data acquisition system. As a talker, the device sends device-dependent data across the bus, but only when commanded to do so by the controller. As a listener, the device receives device-dependent data from a talker, and there can be many listeners at any given time.

The bus is implemented on a standard 24-pin connector, as shown below.



**Figure 8-7 IEEE-488 (GPIB) Connector**

- |                              |  |
|------------------------------|--|
| Pin-1,2,3,4,13,14,15,16:     | These are the eight data lines DIO1 through DIO8 respectively.   |
| Pin-5: End or Identify (EIO) | The line is normally asserted by a talker to indicate the end of a multiple byte data transfer. When EOI is asserted along with ATN (Attention), it indicates that the controller is conducting a parallel poll. |
| Pin-6: Data Available (DAV)  | This line is asserted when a talker puts a data byte on the bus.   |

|  |   |
|--|---|
| Pin-7: Not Ready for Data (NRF)            | This line is asserted by a listener until it is ready to accept a data byte.  |
| Pin-8: Not Data Accepted (NDAC)            | This line is asserted by a listener until it has accepted a data byte.  |
| Pin-9: Interface Clear (IFC)               | Asserted by the system controller to force all other devices to go idle.  |
| Pin-10: Service Request (SRQ)              | This line can be asserted by any device requiring service.  |
| Pin-11: Attention (ATN)                    | Asserted by the controller to indicate that the byte on the data bus is an interface command.   |
| Pin-12: Not Connected                      |   |
| Pin-17: Remote Enable (REN)                | Asserted by the system controller to tell the systems receiving data that they can actually use the data, and that their front panel controls are locked out. |
| Pin-18,19, 20, 21, 22, 23, 24 Ground (GND) | These are the common return lines for all other signals except earth ground (Pin-12).   |

## Implementation

The 8000 Series Gaussmeters implement GPIB communications using an externally connected Prologix GPIB-USB Controller through the meter's front panel USB port.

The Prologix GPIB-USB controller is not included with the meter and can be purchased through distribution or directly from Prologix, visit [www.prologix.biz](http://www.prologix.biz) for more information.

The GPIB-USB controller converts any computer based USB port into a GPIB controller or device. For GPIB implementation on the 8000 Series Gaussmeters the controller is automatically set up as a device which allows the meter to be a talker and listener on the GPIB bus. Meaning that the meter will listen for valid commands to its GPIB address and respond accordingly to those messages immediately. There is no output message queue available in this configuration and the GPIB interface works very similarly to the serial communication ports.

No customer configuration of the Prologix GPIB-USB Controller is required. The meter will automatically configure the device. Refer to the Prologix GPIB-USB Controller User Manual for additional information.

**Configuration**

The only gaussmeter setting that may be configured for the GPIB communications is the instrument address. This may be any value between 0 and 30.

Navigating the system menu from [Main] to [System ⇒ Comm Setup ⇒ GPIB Configuration] will bring up the GPIB configuration screen as shown below.

Use the hot keys to set the desired address.



**Figure 8-8 GPIB Configuration Screen**

*Note: The Prologix GPIB-USB Controller will be set by the meter to this address.*

## Status Registers and Error Queue

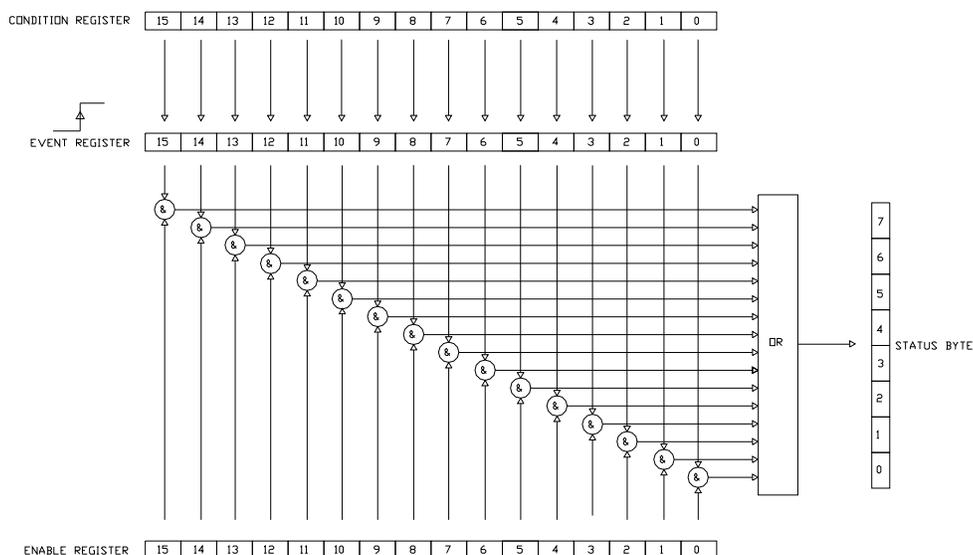
### Status Registers

There are four register sets that indicate the status of the instrument, such as errors or the present state of the machine. These are 16-bit registers, but in many cases not all of the bits are used. The four register sets are called:

|                   |                    |
|-------------------|--------------------|
| MEASUREMENT EVENT | OPERATION EVENT    |
| STANDARD EVENT    | QUESTIONABLE EVENT |

There is also an 8-bit register that provides a 1-bit summary for each of the four register sets. This is called the STATUS BYTE.

Each register set consists of three individual registers, as shown below.



**Figure 8-9 Condition, Event, and Enable Registers**

The CONDITION register is a real time, read-only register that is constantly updated to reflect current operating conditions.

The EVENT register is fed by the CONDITION register, but operates as a latch. Whenever any bit in the CONDITION register goes to “1”, a corresponding “1” is latched into the EVENT register and remains that way until cleared by a specific command.

The ENABLE register is a mask register that is used to generate the single status bit in the STATUS BYTE. Setting any bit in the ENABLE register to “1” will allow a corresponding “1” in the EVENT register to set the summary bit in the STATUS BYTE.

An example of their usage appears at the end of this section.

### Status Byte and Service Request (SRQ)

The IEEE-488 bus is a common bus linking a master controller (your computer) to one or more instruments. If an instrument requires action from the controller it must somehow get the controller's attention. A hardware line on the bus called SRQ (service request) is used to signal the controller that one or more instruments on the bus require attention. A bit in the STATUS BYTE called RQS (request for service) also sets. The master then reads the STATUS BYTE from each instrument to determine which instrument(s) require service.

On the RS-232 port there is no hardware method of signaling a service request, so the STATUS BYTE must be inspected ("polled") to determine if service is required.

The RQS bit can set if any of the summary bits from the MEASUREMENT EVENT, OPERATION EVENT, STANDARD EVENT or QUESTIONABLE EVENT registers are set, or if an error or output message is ready to be transmitted to the master. The SRQ ENABLE register is a mask register that is used to allow any of these conditions to set the RQS bit, and thus the SRQ line. Setting any bit in the SRQ ENABLE register to "1" will allow a corresponding "1" in the STATUS BYTE register to set the RQS bit.

These registers are depicted below. An example of their usage appears at the end of this section.

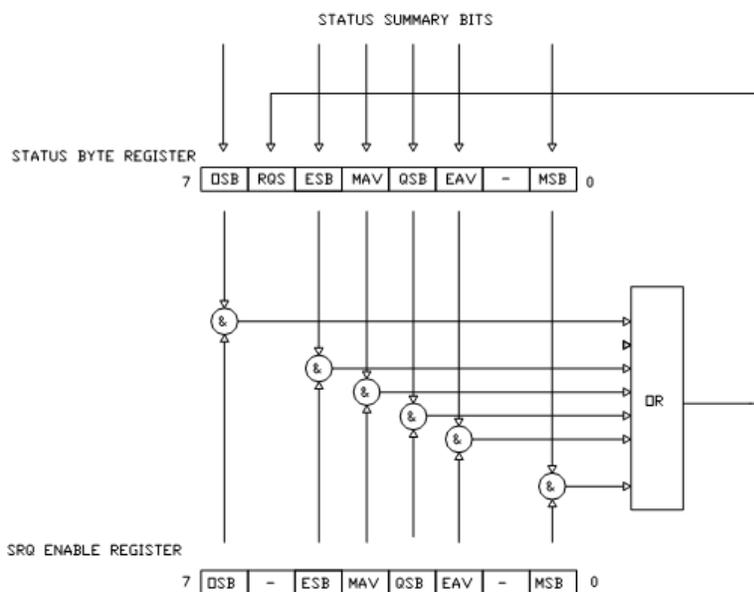


Figure 8-10 Status Byte and SRQ Enable Register

**Status Byte  
and Service  
Request (SRQ)  
(continued)**

**OSB - Operation Summary Bit:**

If any of the bits in the OPERATION EVENT register set, and their respective enable bits are set, the Operation Summary Bit (OSB) will set.

**ESB - Event Summary Bit:**

If any of the bits in the STANDARD EVENT register set, and their respective enable bits are set, the Event Summary Bit (ESB) will set.

**QSB - Questionable Summary Bit:**

If any of the bits in the QUESTIONABLE EVENT register set, and their respective enable bits are set, the Questionable Summary Bit (QSB) will set.

**MSB - Measurement Summary Bit:**

If any of the bits in the MEASUREMENT EVENT register set, and their respective enable bits are set, the Measurement Summary Bit (MSB) will set.

**MAV - Message Available:**

This bit is always set. Because the GPIB to USB controller only has an output message queue of one, each time the serial interface gets a command that requires a response that is sent immediately with out using an output queue.

**EAV - Error Available:**

This bit sets any time there is an error message available in the error queue.

**RSQ - Request For Service:**

If any of the other bits in the STATUS BYTE are set, and their respective enable bits are set in the SRQ ENABLE register, the Request For Service (RQS) will set, causing the SRQ interface line to be asserted if using the IEEE-488 bus.

**Error Queue**

Errors can be generated from a variety of sources, such as hardware errors, system diagnostic errors, probe configuration errors, or errors in the SCPI command syntax. As these errors occur they are stored in an internal error queue that will hold the latest 25 errors.

These errors can be read out and delete using specific SCPI commands discussed later in the next sections.

**Standard Event Register** If any of these bits set, and their respective enable bits are set, the Event Summary Bit (ESB) will set in the STATUS BYTE.

|    |    |    |    |    |    |   |   |     |   |     |     |     |     |   |     |
|----|----|----|----|----|----|---|---|-----|---|-----|-----|-----|-----|---|-----|
| 15 | 14 | 13 | 12 | 11 | 10 | 9 | 8 | 7   | 6 | 5   | 4   | 3   | 2   | 1 | 0   |
| -  | -  | -  | -  | -  | -  | - | - | PON | - | CME | EXE | DDE | QYE | - | OPC |

**Figure 8-11 Standard Event Register**

**PON - Power On:**

Indicates that the instrument was turned off and on since the last communication.

**CME - Command Error:**

Indicates that there was a syntax or spelling error in the command, or the command received is not supported.

**EXE – Execution Error:**

Indicates that the instrument detected an error while attempting to execute a command.

**DDE - Device Dependent Error:**

Indicates that the instrument did not operate properly due to some internal error.

**QYE – Query Error:**

Indicates that an attempt was made to read an empty output queue.

**OPC - Operation Complete:**

Indicates that all requested operations have been completed.

**Measurement Event Register** If any of these bits set, and their respective enable bits are set, the Measurement Summary Bit (MSB) will set in the STATUS BYTE.

|     |     |      |     |     |      |   |   |   |   |      |      |      |     |     |      |
|-----|-----|------|-----|-----|------|---|---|---|---|------|------|------|-----|-----|------|
| 15  | 14  | 13   | 12  | 11  | 10   | 9 | 8 | 7 | 6 | 5    | 4    | 3    | 2   | 1   | 0    |
| HL3 | LL3 | ROF3 | HL2 | LL2 | ROF2 | - | - | - | - | RAV3 | RAV2 | RAV1 | HL1 | LL1 | ROF1 |

**Figure 8-12 Measurement Event Register**

**HL1, HL2, HL3 - High Limit Exceeded:**

When the classifier function is enabled these bits indicate that the present reading is higher than the upper limit set for Channel-1, 2, and/or 3.

**LL1, LL2, LL3 - Low Limit Exceeded:**

When the classifier function is enabled these bits indicate that the present reading is below the lower limit set for Channel-1, 2, and/or 3.

**ROF1, ROF2, ROF3 - Reading Overflow:**

Indicates that the present reading exceeds the measurement range for Channel-1, 2, and/or 3.

**RAV1, RAV2, RAV3 - Reading Available:**

Indicates a reading is available and processed for Channel-1, 2, and/or 3.

**Operation Event Register**

If any of these bits set, and their respective enable bits are set, the Operation Summary Bit (OSB) will set in the STATUS BYTE.

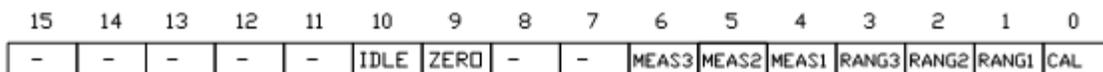


Figure 8-13 Operation Event Register

**IDLE:**

Indicates the instrument is idle. This condition indicates that there are no probes installed or all channels have been turned off.

**ZERO:**

The instrument is presently performing a zeroing operation.

**MEAS1, MEAS2, MEAS3:**

Indicates the instrument is performing a measurement on channel 1, 2, or 3 respectively.

**RANG1, RANG2, RANG3:**

The instrument is presently ranging on channel 1, 2, or 3, respectively.

**CAL:**

The instrument is presently performing an internal calibration.

**Questionable Event Register**

If any of these bits set, and their respective enable bits are set, the Questionable Summary Bit (QSB) will set in the STATUS BYTE.

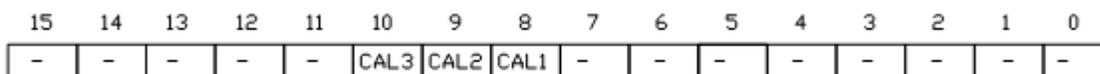


Figure 8-14 Questionable Event Register

**CAL1, CAL2, CAL3:**

Indicates that an invalid calibration factor was detected during power up or when one of the probes was installed. The instrument will instead use default parameters. These bits will clear once all active channels and probes have been successfully calibrated.

## Remote SCPI 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” Command Descriptions

Table 8-2 Common Command Summary

| ACRONYM    | NAME                        | BRIEF DESCRIPTION  |
|------------|-----------------------------|--|
| *CLS       | Clear status                | Clear all event registers and error queue.   |
| *ESE <NRf> | Program event enable        | Program standard event enable register.  |
| *ESE?      | Event enable query          | Read standard event enable register.   |
| *ESR?      | Event status query          | Read standard event register and clear it.   |
| *IDN?      | Identification query        | Return manufacturer, model number, software version number.  |
| *OPC       | Set operation complete      | Set the Operation Complete bit in the standard event register after all pending commands have been executed. |
| *OPC?      | Operation complete query    | Places an ASCII “1” in the output queue after all pending commands have been executed.                       |
| *OPT?      | Option identification query | Returns information about each probe.  |
| *RST       | Reset                       | Returns the instrument to a default operating condition.   |
| *SRE <NRf> | Program SRQ enable          | Program SRQ enable register.   |
| *SRE?      | SRQ enable query            | Read SRQ enable register.  |
| *STB?      | Status byte query           | Read status byte register.   |
| *REN       | Remote enable               | Disable front panel controls   |
| *GTL       | Go to local                 | Enable front panel controls  |
| *SAV <n>   | Save Setup                  | Save the existing meter setup in one of ten non-volatile memory locations.                                   |
| *RCL <n>   | Recall Setup                | Replaces the existing meter setup with one of ten stored in non-volatile memory.                             |

NOTE: The parameter <NRf> means Numeric Representation format and is required.

### \*CLS - CLEAR STATUS

Clears the MEASUREMENT EVENT, OPERATION EVENT, STANDARD EVENT and QUESTIONABLE EVENT status registers, but not their enable registers. It also clears any messages in the error queue.

### \*ESE <NRf> - PROGRAM STANDARD EVENT ENABLE REGISTER

A set bit in the STANDARD EVENT ENABLE register allows its corresponding event to set the ESB (event summary bit) in the STATUS BYTE register. <NRf> is an ASCII string representing an integer mask. For instance a value of 45 decimal is the same as binary 00101101, thus setting bits 5, 3, 2 and 0 in the enable register.

### \*ESE? - STANDARD EVENT ENABLE REGISTER QUERY

Read the contents of the STANDARD EVENT ENABLE register. The results are placed in the output queue of the instrument.

### \*ESR? - STANDARD EVENT REGISTER QUERY

Read the contents of the STANDARD EVENT register. The results are placed in the output queue of the instrument.

NOTE: The STANDARD EVENT register is cleared after an \*ESR? Command.

**\*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.

**\*OPC - SET OPERATION COMPLETE**

Causes the OPC (operation complete) bit to set in the STANDARD EVENT register when all commands have been executed.

**\*OPC? - OPERATION COMPLETE QUERY**

Places an ASCII "1" in the output queue once all commands have been executed. This is particularly useful when using the RS-232 Port.

**\*OPT? - OPTION IDENTIFICATION QUERY**

Indicates the existence and identity of all attached Hall probes.

Two numbers will be returned for Channel-1's probe, separated by a comma (,). The first number is the model number of the probe and can be up to 12 characters in length, such as STF71060815T. If the probe is missing, a "0" will be returned. The second number is the probe's serial number and can be up to 10 characters in length, such as 9923009. If the probe is missing, a "0" will be returned.

This sequence is repeated for Channel-2 and -3. All strings are separated by commas (,). For instance, if only Channel-2's probe is attached, the returned string will be:

```
0,0,STF81060815T,9923009,0,0
```

**\*RCL <n> - RECALL SETUP**

The present state of the instrument, called the setup, can be saved in non-volatile memory and later recalled with this command to instantly return the instrument to that state. Up to four different setups can be saved. <n> should be a single ASCII character from "1" to "4" to specify the memory location. If <n> is omitted then "1" is assumed.

For more information see the discussion about the SYSTEM menu.

**\*RST - RESET**

Cancels any pending commands and any response to any previously received \*OPC or \*OPC? commands.

**\*SRE <NRf> - PROGRAM SRQ ENABLE REGISTER**

A set bit in the SRQ ENABLE register allows its corresponding event to set the RQS (request for service) in the STATUS BYTE register and activate the SRQ (service request) bus line. <NRf> is an ASCII string representing an integer mask. For instance a value of 45 decimal is the same as binary 00101101, thus setting bits 5, 3, 2 and 0 in the enable register.

**\*SRE? - SRQ ENABLE REGISTER QUERY**

Read the contents of the SRQ ENABLE register. The results are placed in the output queue of the instrument.

**\*STB? - STATUS BYTE QUERY**

Read the contents of the STATUS BYTE register. The results are placed in the output queue of the instrument.

*NOTE: The STATUS BYTE register is not cleared after an \*STB? Command. Other registers and queues must be cleared for the bits in the STATUS BYTE register to be cleared.*

**\*REN - REMOTE ENABLE**

All front panel controls are disabled except for the power switch. This command was primarily intended for use with the RS-232 port, but can be used on the GPIB bus.

**\*GTL - GO TO LOCAL**

This command cancels remote mode and restores front panel operation. This command was primarily intended for use with the RS-232 port, but can be used on the GPIB bus.

**\*SAV <n> - SAVE SETUP**

The present state of the instrument, called the setup, can be saved in non-volatile memory. Up to ten different setups can be saved. <n> must be ASCII characters from "1" to "10" to specify the memory location. If <n> is omitted then "1" is assumed.

**\*RCL <n> - RECALL SETUP**

The present state of the instrument, called the setup, can be recalled from non-volatile memory to instantly return the instrument to that state. Up to ten different setups can be recalled. <n> must be ASCII characters from "1" to "10" to specify the memory location. If <n> is omitted then "1" is assumed.

## 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 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

## SCPI Meter Specific Commands

In the following tables and descriptions 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 <b> 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 8-3 SCPI Error Queue Commands**

| COMMAND             | DESCRIPTION   |
|---------------------|---|
| :SYSTem:ERRor?      | Retrieve the most recent error message in the queue |
| :SYSTem:ERRor:NEXT? | Retrieve and remove the oldest message in the queue |

**Table 8-4 SCPI System Information and Configuration Commands**

| COMMAND                        | DESCRIPTION  |
|--------------------------------|--|
| :SYSTem:VERsion?               | Query the SCPI standard version number               |
| :SYSTem:TIMe <NRf>,<NRf>,<NRf> | Set the system clock in HH,MM,SS format              |
| :SYSTem:TIMe?                  | Query the system clock, returns HH,MM,SS format      |
| :SYSTem:DATE <NRf>,<NRf>,<NRf> | Set the system date in YYYY,MM,DD format             |
| :SYSTem:DATE?                  | Query the system calendar, returns YYYY,MM,DD format |
| :SYSTem:NETWork:ADDReSS?       | Query the system network IP address                  |
| :SYSTem:LOGGing:DATA:REMOve    | Remove all data logs from internal memory            |

**Table 8-5 SCPI Status Register Commands**

| COMMAND                           | DESCRIPTION                                  |
|-----------------------------------|--|
| :STATus:MEASurement:EVENT?        | Query the Measurement Event register         |
| :STATus:OPERation:EVENT?          | Query the Operation Event register           |
| :STATus:QUESTionable:EVENT?       | Query the Questionable Event register        |
| :STATus:MEASurement:ENABle <NRf>  | Set the Measurement Event Enable register    |
| :STATus:OPERation:ENABle <NRf>    | Set the Operation Event Enable register      |
| :STATus:QUESTionable:ENABle <NRf> | Set the Questionable Event Enable register   |
| :STATus:MEASurement:ENABle?       | Query the Measurement Event Enable register  |
| :STATus:OPERation:ENABle?         | Query the Operation Event Enable register    |
| :STATus:QUESTionable:ENABle?      | Query the Questionable Event Enable register |
| :STATus:MEASurement:CONDition?    | Query the Measurement Condition register     |
| :STATus:OPERation:CONDition?      | Query the Operation Condition register       |
| :STATus:QUESTionable:CONDition?   | Query the Questionable Condition register    |
| :STATus:PRESet                    | Clear all event enable registers             |

**Table 8-6 SCPI Unit Commands**

| COMMAND                            | DESCRIPTION                               |
|------------------------------------|---|
| :UNIT:ANGLE DEG RAD                | Define the vector summation angular units |
| :UNIT:ANGLE?                       | Query the vector summation angular units  |
| :UNIT:TEMPerature C CEL F FAR K    | Define the temperature units              |
| :UNIT:TEMPerature?                 | Query the temperature units               |
| :UNIT:FLUX GAUSSs TESLa AM OERSted | Define the flux density units             |
| :UNIT:FLUX?                        | Query the flux density units              |
| :UNIT:TIME SEC HZ                  | Define the time-based measurement units   |
| :UNIT:TIME?                        | Query the time-based measurement units    |

**Table 8-7 SCPI Range and Mode 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 <b> | Enable/disable auto range in dc mode                |

|                                 |                                      |
|---------------------------------|--------------------------------------|
| :SENSe#:FLUX:DC:RANGe:AUTo <b>  | Enable/disable auto range in dc mode |
| :SENSe#:FLUX:AC:RANGe:AUTo <b>  | 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 8-8 SCPI Display Update Rate Command**

| COMMAND           | DESCRIPTION                           |
|-------------------|---------------------------------------|
| :DISPlay:RATE <n> | Set the reading display update rate   |
| :DISPlay:RATE?    | Query the reading display update rate |

**Table 8-9 SCPI Classifier (Limit) Commands**

| COMMAND                            | DESCRIPTION                                |
|------------------------------------|--|
| :CALCulate#:LIMit:LOWer:DATA <NRf> | Program the lower classifier setting       |
| :CALCulate#:LIMit:LOWer:DATA?      | Query the lower classifier setting         |
| :CALCulate#:LIMit:UPPer:DATA <NRf> | Program the upper classifier setting       |
| :CALCulate#:LIMit:UPPer:DATA?      | Query the upper classifier setting         |
| :CALCulate#:LIMit:STATe <b>        | Enable or disable the classifier operation |
| :CALCulate#:LIMit:STATe?           | Query classifier operation setting         |
| :CALCulate#:LIMit:FAIL?            | Query classifier pass / fail status        |

**Table 8-10 SCPI Measurement Commands**

| COMMAND                       | DESCRIPTION   |
|-------------------------------|---|
| :MEASure#:FLUX?               | Query flux density measurement  |
| :MEASure#:FLUX:STReaming? <n> | Query and stream flux measurement readings over communications port at display update rate for specified period of time |
| :MEASure#:FREQuency?          | Query frequency of selected signal  |
| :MEASure#:TIME?               | Query period of selected signal   |
| :MEASure#:TEMPerature?        | Query probe temperature   |
| :MEASure:FLUX:ALL?            | Query and return flux density measurement of all three channels and vector sum (8030 only)                              |

**Table 8-11 SCPI Filter Commands**

| COMMAND                  | DESCRIPTION  |
|--------------------------|--|
| :INPut#:FILTer:BPASs <n> | Selects the band pass filter for AC mode operation |

**Table 8-12 SCPI Zeroing Commands**

| COMMAND                                 | DESCRIPTION   |
|---|---|
| :CALibration#:ZERO:HSEnSor:INITiate     | Zero the Hall probe and instrument for single channel |
| :CALibration#:ZERO:HSEnSor:MODE <n>     | Set the auto zero mode                                |
| :CALibration#:ZERO:HSEnSor:MODE?        | Query the auto zero mode                              |
| :CALibration#:ALL:ZERO:HSEnSor:INITiate | Zero the Hall probe and instrument for all channels   |
| :CALibration#:ALL:ZERO:HSEnSor:MODE <n> | Set the auto zero mode for all channels               |

**Table 8-13 SCPI Relative Offset Commands**

| COMMAND                       | DESCRIPTION                                 |
|-------------------------------|---|
| :INPut#:OFFSet <NRf>          | Set relative offset value                   |
| :INPut#:OFFSet?               | Query relative offset value                 |
| :INPut#:OFFSet:STATe <b> ONCe | Enable/disable the relative offset function |
| :INPut#:OFFSet:STATe?         | Query state of relative offset function     |

**Table 8-14 SCPI Analog Output Commands**

| 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       |
| :OUTPut:VECTorsum:MODE <n>       | Set the output mode of the vector sum analog output    |
| :OUTPut:VECTorsum:MODE?          | Query the output mode of the vector sum analog output  |
| :OUTPut:VECTorsum:SCALing <n>    | Set the scaling of the vector sum analog output        |
| :OUTPut:VECTorsum:SCALing?       | Query the scaling of the vector sum analog output      |

**Table 8-15 SCPI Vector Summation Command**

| COMMAND                | DESCRIPTION  |
|------------------------|--|
| :CALCulate:VSUMmation? | Query vector summation result and angles (8030 only) |

**Table 8-16 SCPI Hold Commands**

| COMMAND                            | DESCRIPTION   |
|------------------------------------|---|
| :CALCulate#:HOLD:MINimum:STATe <b> | Enable/disable the MIN HOLD function                    |
| :CALCulate#:HOLD:MINimum:STATe?    | Query the state of the MIN HOLD function                |
| :CALCulate#:HOLD:MINimum:CLEar     | Resets the value being held by the MIN HOLD function    |
| :CALCulate#:HOLD:MINimum?          | Query the value being held by the MIN HOLD function     |
| :CALCulate#:HOLD:MAXimum:STATe <b> | Enable/disable the MAX HOLD function                    |
| :CALCulate#:HOLD:MAXimum:STATe?    | Query the state of the MAX HOLD function                |
| :CALCulate#:HOLD:MAXimum:CLEar     | Resets the value being held by the MAX HOLD function    |
| :CALCulate#:HOLD:MAXimum?          | Query the value being held by the MAX HOLD function     |
| :CALCulate#:HOLD:PEAK:STATe <b>    | Enable/disable the PEAK HOLD function                   |
| :CALCulate#:HOLD:PEAK:STATe?       | Query the state of the PEAK HOLD function               |
| :CALCulate#:HOLD:PEAK:CLEar        | Resets the value being held by the PEAK HOLD function   |
| :CALCulate#:HOLD:PEAK?             | Query the value being held by the PEAK HOLD function    |
| :CALCulate#:HOLD:VALley:STATe <b>  | Enable/disable the VALLEY HOLD function                 |
| :CALCulate#:HOLD:VALley:STATe?     | Query the state of the VALLEY HOLD function             |
| :CALCulate#:HOLD:VALley:CLEar      | Resets the value being held by the VALLEY HOLD function |
| :CALCulate#:HOLD:VALley?           | Query the value being held by the VALLEY HOLD function  |

## SCPI Command Descriptions

### Error Queue Commands

As error messages occur, they are placed in the error queue. Each message will contain a number, a comma (,) and a brief description of the error. Negative (-) numbers are used for SCPI defined messages while positive (+) numbers relate specifically to the instrument.

The error queue can hold up to 25 messages. Each time the queue is read an error message is reported, if no errors exist the message "0, No error" will be returned. If the queue is full the message "-350, Queue Overflow" will occupy the most recent queue location. It is an indication that at least one, perhaps more error message(s) were lost.

There are certain error status bits that will set in the STANDARD EVENT register. These bits provide general error indications. The error queue will provide more detailed information about the errors.

#### **:SYSTem:ERRor?**

This command responds with the most recent error message in the error queue.

#### **:SYSTem:ERRor:NEXT?**

This command responds with the oldest error message in the error queue and removes it from the error queue.

### System Information and Configuration Commands

#### **:SYSTem:VERSion?**

This command responds with the version number of the SCPI standard that is supported by this instrument. The version number is in the format of "YYYY.V", where "YYYY" is the year version of the standard and "V" is the approved revision number, such as "1999.0".

#### **:SYSTem:TIME <NRf>, <NRf>,<NRf>**

This command sets the instrument's real time clock. The clock can be set from the SYSTEM menu or with this command using the following format:

:SYSTem:TIME <hour>, <minute>, <second>

where:           <hour> is in the range of 0 – 23 (24-hour format)  
                   <minute> is in the range of 1 – 59  
                   <second> is in the range of 1 – 59

The clock supports 24-hour format and can only be set using the 24-hour format. See Table 5-3 for 12-hour to 24-hour conversions.

**:SYSTem:TIME?**

The contents of the instrument's real time clock will be returned in using the following format:

<hour>, <minute>, <second>

where: <hour> is in the range of 0 – 23 (24-hour format)  
<minute> is in the range of 1 – 59  
<second> is in the range of 1 – 59

**:SYSTem:DATE <NRf>, <NRf>,<NRf>**

The instrument's real time calendar can be set from the SYSTEM menu or with this command using the following format:

:SYSTem:DATE <year>, <month>, <day>

where: <year> is in the range of 2000 – 9999  
<month> is in the range of 1–12 (1=January, 2=February, etc)  
<day> is in the range of 1 – 31 (day of the month)

A <year> less than 2000 will not be accepted because the instrument did not exist prior to the year 2000. The instrument does not check the validity of the day of the month. For instance, a date of February 31 will not generate an error.

**:SYSTem:DATE?**

The contents of the instrument's real time calendar will be returned using the following format:

<year>, <month>, <day>

where: <year> is in the range of 2000 – 9999  
<month> is in the range of 1 – 12 (1 = January, 2 = February, etc)  
<day> is in the range of 1 – 31 (day of the month)

**:SYSTem:NETWork:ADDRess?**

This command returns the instrument's network IP address.

**:SYSTem:LOGGing:DATa:REMOve**

This command deletes all previously stored data log files from the instrument's internal memory.

**Status Register  
Commnads**

The Status Register Commands control and query the MEASUREMENT EVENT, OPERATION EVENT and QUESTIONABLE EVENT registers as well as the error queue.

**:STATus:MEASurement:EVENT?**

**:STATus:OPERation:EVENT?**

**:STATus:QUEStionable:EVENT?**

These commands return the contents of the specified EVENT register and then clear that event register contents.

**:STATus:MEASurement:ENABLE <NRf>**

**:STATus:OPERation:ENABLE <NRf>**

**:STATus:QUEStionable:ENABLE <NRf>**

These commands program the specified EVENT ENABLE register with the value <NRf>. <NRf> is an ASCII string representing an integer mask. For instance a value of 45 decimal is the same as binary 00101101, thus setting bits 5, 3, 2 and 0 in the enable register.

**:STATus:MEASurement:ENABLE?**

**:STATus:OPERation:ENABLE?**

**:STATus:QUEStionable:ENABLE?**

These commands return the contents of the specified EVENT ENABLE register.

**:STATus:MEASurement:CONDition?**

**:STATus:OPERation:CONDition?**

**:STATus:QUEStionable:CONDition?**

These commands return the contents of the specified EVENT CONDITION register. The EVENT CONDITION register is a real-time register reflecting the state of the instrument at the time of the read. Some conditions could happen very quickly and could be missed by this query. It is often better to rely on the contents of the EVENT register since it latches the event until cleared by a specific command.

**:STATus:PRESet**

This command clears the MEASUREMENT EVENT ENABLE, OPERATION EVENT ENABLE and QUESTIONABLE EVENT ENABLE registers.

**Unit Commands**

These commands select the measurement units for temperature, vector angle, flux density and time-based measurements.

**:UNIT:ANGLE DEG|RAD**

Specifies that the vector summation angle units are to be in degrees (DEG) or radians (RAD).

**:UNIT:ANGLE?**

Returns an ASCII string representing the vector summation angle units. The ASCII string will be DEG for degrees or RAD for radians.

**:UNIT:TEMPerature C|CEL|F|FAR|K**

Specifies that the temperature units are to be in Celsius (C or CEL), Fahrenheit (F or FAR) or Kelvin (K).

**:UNIT:TEMPerature?**

Returns an ASCII string representing the temperature units. The ASCII string will be CEL for Celsius, FAR for Fahrenheit or K for Kelvin.

**:UNIT:FLUX GAUSS|TESLa|AM|OERSted**

Specifies that the flux density units are to be in gauss (GAUSS), tesla (TESLa), amps per meter (AM) or oersted (OERSted).

**:UNIT:FLUX?**

Returns an ASCII string representing the flux density units. The ASCII string will be GAUSS, TESLA, AM or OERSTED.

**:UNIT:TIME SEC|HZ**

Specifies that the time-based measurement units are to be period measurements in seconds (SEC) or frequency measurements in hertz (HZ).

**:UNIT:TIME?**

Returns an ASCII string representing the time-based measurement units. The ASCII string will be SEC for period measurements or HZ for frequency measurements.

**Range and Mode Commands**

These commands control each channels mode and range settings.

**:SENSe#:FLUX:AC**

**:SENSe#:FLUX:DC**

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

**Table 8-17 Operating Ranges with Various Probes**

| <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 $\mu$ T)                        | 30 G (3 mT)                                     | 300 G (30 mT)                                     |
| 1   | 3 G (300 $\mu$ T)                          | 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)                                     |

**Range and Mode Commands**

**:SENSe#:FLUX:RANGe:AUTO <b>**  
**:SENSe#:FLUX:DC:RANGe:AUTO <b>**  
**:SENSe#:FLUX:AC:RANGe:AUTO <b>**

Specifies that the measured flux density will be static (DC) or alternating (AC) and that AUTO ranging is turned OFF when <b> is "0" or ON when <b> 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?**

Returns an ASCII string representing the most present or most recent AC/DC mode 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 8-18, 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 or 30G for a Low Field Probe, 3kG for a 1x probe etc.

**Display Update Command**

This command controls the display update rate as well as the software averaging used by the instrument.

**:DISPlay:RATE <n>**

where <n>            0 = 2 second update rate  
                           1 = 1 second update rate  
                           2 = 0.5 second update rate  
                           3 = 0.2 second update rate

**:DISPlay:RATE?**

where <n>            0 = 2 second update rate  
                           1 = 1 second update rate  
                           2 = 0.5 second update rate  
                           3 = 0.2 second update rate

**Classifier (Limit) Commands**

These commands control the CLASSIFIER, or limit checking function. Two individual flux density limits can be specified. If the present flux density reading becomes arithmetically less than the lower limit, or arithmetically greater than the upper limit, the situation is considered to be a "failure".

Since these commands are channel-specific the "#" in each command should be replaced with the channel number 1,2 or 3. If the channel number is omitted then Channel-1 is assumed.

**:CALCulate#:LIMit:LOWer:DATA <NRf>**

**:CALCulate#:LIMit:UPPer:DATA <NRf>**

Specifies the upper and lower classifier limit value. <NRf> is a signed decimal number that sets the lower and upper classifier limits. <NRf> must be between 0.0000000000 and  $\pm 29999999$ . The meaning of the limit depends upon the selected unit of measure (gauss, tesla, etc.). For instance the value 1.0203 could mean 1.0203 G or 1.0203 T.

If a lower limit is specified that is arithmetically larger than the upper limit, an error will be generated and the entry will be ignored. The sign of the limit has no meaning in the AC measurement mode.

**:CALCulate#:LIMit:LOWer:DATA?**

**:CALCulate#:LIMit:UPPer:DATA?**

Returns the classifier limit. The limit will be between 0.0000000000 and  $\pm 29999999$ . The meaning of the limit depends upon the selected unit of measure (gauss, tesla, etc.). For instance the value 1.0203 could mean 1.0203 G or 1.0203 T.

**:CALCulate#:LIMit:STATe <b>**

Specifies that the classifier function is turned ON when <b> is "1" or "ON", or turned OFF when <b> is "0" or "OFF".

**:CALCulate#:LIMit:STATe?**

Returns the state of the classifier function state "OFF" or "ON".

**:CALCulate#:LIMit:FAIL?**

Returns the pass/fail status of the classifier test. A "0" indicates that the measured value falls between the lower and upper limit and is considered a "pass" situation. A "1" indicates that the measured value either falls below the lower limit or above the higher limit.

## Measurement Commands

Since these commands are channel-specific the "#" in each command should be replaced with the channel number 1,2 or 3. If the channel number is omitted then Channel-1 is assumed.

**:MEASure#:FLUX?**

Returns the latest flux density reading, the value will be between 0.0000000000 and  $\pm 29999999$ . The meaning of this value depends upon the 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.

**:MEASure#:FLUX:STReaming? <n>**

Returns a stream of the latest flux density readings at the rate set by the display update rate for a period of time <n> in seconds.

**:MEASure#:FREQUency?**

Returns the latest frequency measurement of the flux density signal.

**:MEASure#:TIME?**

Returns the latest period measurement of the flux density signal.

**:MEASure#:TEMPerature?**

Returns the latest temperature reading from a temperature-compensated Hall probe. The meaning of this value depends upon the selected unit of measure (Celsius, Kelvin or Fahrenheit). For instance the value 45.3 could mean 45.3 °F or 45.3 °C.

**Filter Command**

This command controls 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 20Hz - 50kHz
- n = 1 >> Medium Frequency 20Hz - 10kHz
- n = 2 >> Low Frequency 20Hz - 500Hz
- n = 3 >> XLow Frequency 1Hz - 500Hz
- n = 4 >> Full Bandwidth 1Hz - 50kHz
- n = 5 >> FBWNC 1Hz - 50kHz w/ No Correction

**Zeroing  
Commands**

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

Since these commands are channel-specific the “#” in each command should be replaced with the channel number 1, 2, or 3. If the channel number is omitted then Channel-1 is assumed.

**: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.

**:CALibration#:ZERo:HSEnSor:MODE <n>**

Specifies the auto zero mode of operation.

- where <n>
- 0 = DC Only
  - 1 = Basic
  - 2 = Advanced

**:CALibration:ALL:ZERo:HSEnSor:MODE <n>**

Specifies the auto zero mode of operation for all channels.

where <n>            0 = DC Only  
                         1 = Basic  
                         2 = Advanced

**:CALibration#:ZERo:HSEnSor:MODE?**

Returns the state or the auto zero mode for the selected channel.

where <n>            0 = DC Only  
                         1 = Basic  
                         2 = Advanced

**Relative Offset  
Commands**

These commands control the RELATIVE function. The RELATIVE function subtracts a fixed flux density value from all measured values. The user can define the offset or it can be generated using the present value of flux density as measured by the Hall probe.

Since these commands are channel-specific the “#” in each command should be replaced with the channel number 1, 2, or 3. If the channel number is omitted then Channel-1 is assumed. A channel number (#) of “4” affects the relative functions for vector summation.

**:INPut#:OFFSet <NRf>**

This command defines a fixed relative offset value, which will be subtracted from all measured values. The relative offset value will only be used when the RELATIVE function is enabled. See the “:INPut#:OFFSet:STATe” command for details.

<NRf> is a signed decimal number between 0.0000000000 and ± 299999999. The meaning of the offset depends upon the selected unit of measure (gauss, tesla, etc.). For instance the value 1.0203 could mean 1.0203 G or 1.0203 T.

**:INPut#:OFFSet?**

Returns the relative offset value, it will be between 0.0000000000 and ± 299999999. The meaning of the offset depends upon the selected unit of measure (gauss, tesla, etc.). For instance the value 1.0203 could mean 1.0203 G or 1.0203 T.

**:INPut#:OFFSet:STATe <b>|ONCe**

When <b> is “0” or “OFF” the RELATIVE function is turned off. The present flux density readings will not be altered.

When <b> is “1” or “ON” the RELATIVE function will be enabled. A fixed relative offset value will be subtracted from all flux density readings. This value could have been previously defined using the “:INPut#:OFFSet <NRf>” command, manually entered using the RELATIVE menu, or generated automatically using the probe as the input source.

When <b> is “ONCe” the automatic RELATIVE operation is started. This command initiates the same process as the front-panel RELATIVE push button. The Hall probe should be placed in a stable environment prior to issuing this command. The value presently measured by the probe will become the new relative offset value. This will overwrite any value previously defined using the “:INPut#:OFFSet <NRf>” command or entered manually from the RELATIVE menu. When the automatic RELATIVE operation is complete the RELATIVE function will be enabled.

**:INPut#:OFFSet:STATe?**

Returns the state of the RELATIVE function “OFF” or “ON”.

**Analog Output  
Commands**

The instrument provides a corrected and uncorrected analog output for each channel. The 8030 models also provide an analog output for the vector summation. These commands specify the output configuration by setting the output mode and scaling options.

*Note: The Vector Sum output does not have a waveform output mode, and can only be turned on and off. Selecting waveform or RMS modes will turn it on.*

Since these commands are channel-specific the “#” in each command should be replaced with the channel number 1, 2, or 3. If the channel number is omitted then Channel-1 is assumed or controls the vector summation output.

**: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?**

Returns 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:VECTorsum:MODE <n>**

Sets the mode of operation for the vector sum analog output where:

n = 0 >> Output Off

n = 1 >> Output On

**:OUTPut:VECTorsum:MODE?**

Returns the mode of operation for the vector sum analog output where the return value represents the following:

0 = Output Off

1 = Output On

**:OUTPut#:UNCorrected:SCALing <NRf>**

**:OUTPut#:CORReCted:SCALing <NRf>**

**:OUTPut:VECTorsum:SCALing <NRf>**

Sets the scale value for the selected uncorrected, corrected, or vector sum 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  $\pm 2.0$  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:

$$\text{Full Scale Output Voltage} / \text{Full Scale Flux Density Range}$$

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  $\pm 2.0$  volts.

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

**:OUTPut#:CORReCted:SCALing?**

**:OUTPut:VECTorsum:SCALing?**

Returns the scaling value for the selected uncorrected, corrected, or vector sum analog output where the return value represents the scaling factor in volts.

**Vector Summation Command**      **:CALCulate:VSUMmation?**

Returns the latest vector summation value and angle results from the flux density readings of all three channels.

The value will be between 0.0000000000 and  $\pm$  299999999. The meaning of this value depends upon the selected unit of measure (gauss, tesla, etc.). For instance the value 1.0203 could mean 1.0203 G or 1.0203 T. This value is followed by a comma(,).

The vector angles for Channel 1, 2, and 3, respectively, separated by commas(,). The meaning of this values depends upon the selected unit of measure (degrees or radians).

For example, a response of 123.366, 49.2,18.1,112.7 might mean that the vector summation is 123.366 mT and the vector angles for Channel-1, 2 and 3 are 49.2 degrees, 18.1 degrees and 112.7 degrees, respectively.

**Hold Commands**      These commands set and query the state of the instrument's hold features.

Since these commands are channel-specific the “#” in each command should be replaced with the channel number 1, 2, or 3. If the channel number is omitted then Channel-1 is assumed. A channel number (#) of “4” affects the hold functions for vector summation.

*Note: The Vector Sum hold functions do no include Peak or Valley detection. The use of # = 4 in these commands is not supported.*

**:CALCulate#:HOLD:MINimum:STATe <b>**

The MIN HOLD function is turned on when <b> is “1” or “ON”, or turned off when <b> is “0” or “OFF”.

**:CALCulate#:HOLD:MINimum:STATe?**

Returns the state of the MIN HOLD function “OFF” or “ON”.

**:CALCulate#:HOLD:MINimum:CLEar**

The value being held by the MIN HOLD function is reset to 0.

**:CALCulate#:HOLD:MINimum?**

Returns the value being held by the MIN HOLD function, the value and will be between 0.0000000000 and  $\pm$  299999999. The meaning of this value depends upon the selected unit of measure (gauss, tesla, etc.). For instance the value 1.0203 could mean 1.0203 G or 1.0203 T.

**:CALCulate#:HOLD:MAXimum:STATe <b>**

The MAX HOLD function is turned on when <b> is “1” or “ON”, or turned off when <b> is “0” or “OFF”.

**:CALCulate#:HOLD:MAXimum:STATe?**

Returns the state of the MAX HOLD function “OFF” or “ON”.

**:CALCulate#:HOLD:MAXimum:CLEar**

The value being held by the MAX HOLD function is reset to 0.

**:CALCulate#:HOLD:MAXimum?**

Returns the value being held by the MAX HOLD function. The value will be between 0.0000000000 and  $\pm 29999999$ . The meaning of this value depends upon the selected unit of measure (gauss, tesla, etc.). For instance the value 1.0203 could mean 1.0203 G or 1.0203 T.

**:CALCulate#:HOLD:PEAK:STATe <b>**

The PEAK HOLD function is turned on when <b> is “1” or “ON”, or turned off when <b> is “0” or “OFF”.

**:CALCulate#:HOLD:PEAK:STATe?**

Returns the state of the PEAK HOLD function “OFF” or “ON”.

**:CALCulate#:HOLD:PEAK:CLEar**

The value being held by the PEAK HOLD function is reset to 0.

**:CALCulate#:HOLD:PEAK?**

Returns the value being held by the PEAK HOLD function. The value will be between 0.0000000000 and  $\pm 29999999$ . The meaning of this value depends upon the selected unit of measure (gauss, tesla, etc.). For instance the value 1.0203 could mean 1.0203 G or 1.0203 T.

**:CALCulate#:HOLD:VALley:STATe <b>**

The VALLEY HOLD function is turned on when <b> is “1” or “ON”, or turned off when <b> is “0” or “OFF”.

**:CALCulate#:HOLD:VALley:STATe?**

Returns the state of the VALLEY HOLD function “OFF” or “ON”.

**:CALCulate#:HOLD:VALley:CLEar**

The value being held by the VALLEY HOLD function is reset to 0.

**:CALCulate#:HOLD:VALley?**

Returns the value being held by the VALLEY HOLD function. The value will be between 0.0000000000 and  $\pm 29999999$ . The meaning of this value depends upon the selected unit of measure (gauss, tesla, etc.). For instance the value -1.0203 could mean -1.0203 G or -1.0203 T.

## SECTION 9 Data Logging Utilities

### Overview

In addition to the remote communications capabilities where customers can create their own data logging utilities, the 8000 Series Gaussmeters include several features to accommodate data storage in the form of log files that can be recorded and saved to either a USB memory device or internal flash memory. The user may also capture and store screen shots of the display to a USB memory drive.

Data log files stored to either the USB drive or Internal Drive are stored and saved as Comma-Separated Values files (.csv). These plain text files can be manipulated by several different data utility programs but most commonly are imported into Microsoft Excel or other similar spread sheet software tools.

*NOTE: Each CSV file is limited to 1 million rows. After this limit is reached the log file will be closed and data logging will stop.*

When data is logged to a USB drive the files are stored in file path named :\\fwb8000\data. If this file path is not already stored on the drive the meter will create it.

Data is logged at the same rate as the Display Update Rate, and varies from a log entry every 2 seconds to 5 entries per second. Each log row is time stamped and contains all information that is available for any active channels. This includes the flux density reading, frequency in AC mode, and probe temperature if available. An example is shown below.

**Table 9-1 Sample Data Log**

| Timestamp   | CH1 Flux<br>G AC | CH1<br>Freq Hz | CH2 Flux<br>G AC | CH2<br>Freq Hz | CH2<br>Temp C |
|-------------|------------------|----------------|------------------|----------------|---------------|
| 12:40:35 PM | 118              | 0              | 0.2299           | 0              | 20            |
| 12:40:36 PM | 116.9            | 0              | 0.2307           | 0              | 20            |
| 12:40:37 PM | 116.4            | 0              | 0.2305           | 0              | 20            |
| 12:40:38 PM | 117              | 0              | 0.2303           | 0              | 20            |
| 12:40:39 PM | 116.4            | 0              | 0.2301           | 0              | 20            |

## Logging Data

Navigating from the MAIN menu to the DATA LOGGING menu as shown below, opens the data logging options to “Log to the USB Drive” or “Log to the Internal Drive”

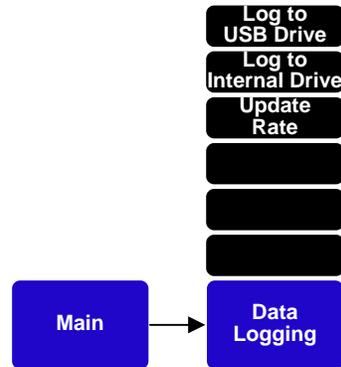


Figure 9-1 Data Logging Menu Path

*NOTE: The “Update Rate” button is a duplicate of the display update rate menu described in previous sections of this manual, and is provided here for convenience.*

## Logging to USB Drive

Pressing the “Log to USB Drive” hot key button and the “Start Data Logging” button initiates data logging to the USB Drive and changes the menu hot key to “Stop Data Logging”

Pressing the “Stop Data Logging” button will end the data logging session and a dialog box will identify the data path and the name of the data file. Press enter to remove the dialog box and continue.

If a USB memory drive is not detected a pop up screen will alert the user to install the drive and press the <Enter> button to continue.

## Logging to Internal Drive

Similarly pressing the “Log to Internal Drive” hot key button and the “Start Data Logging” button initiates data logging to the Internal Flash Drive and changes the menu hot key to “Stop Data Logging”

Pressing the “Stop Data Logging” button will end the data logging session and a dialog box will identify the data path and the name of the data file. Press enter to remove the dialog box and continue.

*NOTE: Internal Flash Memory space is limited to 1.5GB. After this space is full the oldest data files are automatically erased to make room for the new data.*

To download the stored data file please refer to the section of this manual that describes the internal web application.

***NOTE: The data stored on the internal flash drive is only available to download via the web interface. DO NOT store data to the internal flash drive unless you have access to the internal web application via a network connection.***

## Screen Capture

The screen capture feature on the 8000 Series Gaussmeters allows the user to save a JPEG picture of the display that will be stored on a USB memory drive attached to the meter's front panel USB port.

The captured image files are stored in the file path :\\fwb8000\\screens. If this file path is not already stored on the drive the meter will create it.

To use the screen capture feature navigate from the MAIN menu to the SYSTEM menu.

Pressing the <Screen Capture> button will arm the screen capture feature and illuminate the <Enter> button.

Pressing the <Enter> button after arming the screen capture feature will write the image (.jpg) to the USB drive and will open a dialog box that shows the path and name of the file. Press <Enter> again to continue.

Before pressing the <Enter> button but after arming the screen capture feature, the user may navigate to different menus and or modes of operation to capture the desired image.

For example, if the user wanted to capture an image in Waveform mode:

- Navigate back to the system menu.
- Press the <Screen Capture> button.
- Navigate to waveform mode.
- Set the time base and vertical scales as desired.
- Press enter to capture the image.

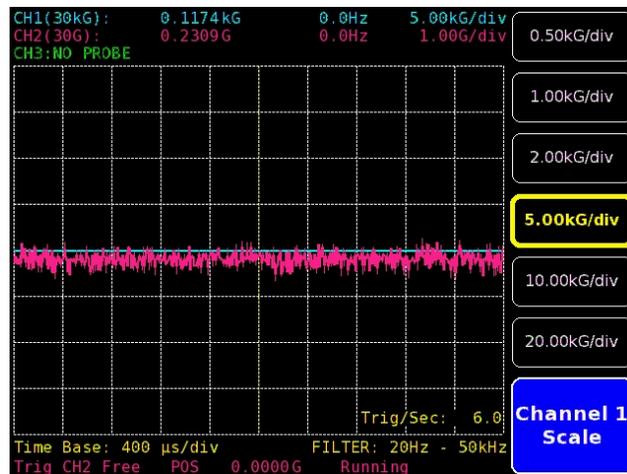


Figure 9-2 Example of Waveform Mode Screen Capture

*Note: If a USB memory drive is not detected, a dialog box will alert the user to install the drive and press the <Enter> button to continue.*

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## SECTION 10 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 below.

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

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

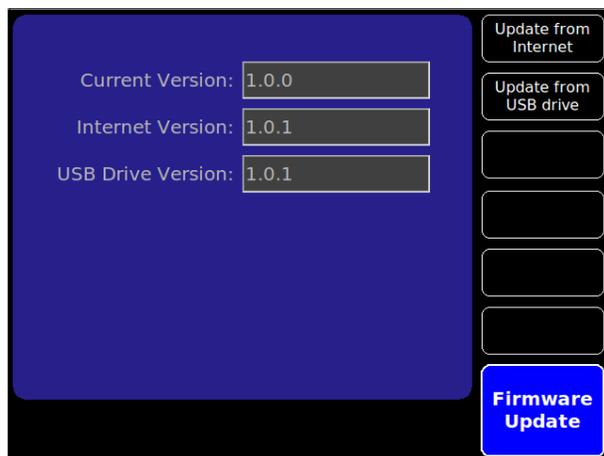


Figure 10-1 Firmware Update Screen

When one of the [Update from...] buttons is pressed the meter will request confirmation for 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

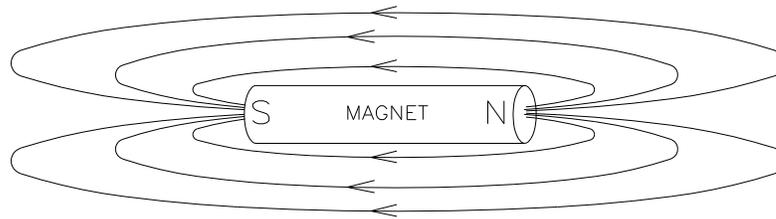
To prepare the USB memory device for a firmware update: Download the latest firmware release from [www.fwbell.com](http://www.fwbell.com) or call your technical support representative, then save it to a USB memory device.

The file name will be fw8000-x.x.x.bin, where the x.x.x represents the revision of the firmware.

*Note: The meter will search the USB 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 of the USB device 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  $1 \text{ cm}^2$  area. The more commonly used term is the *tesla* (T), which is 10,000 lines per  $\text{cm}^2$ . 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

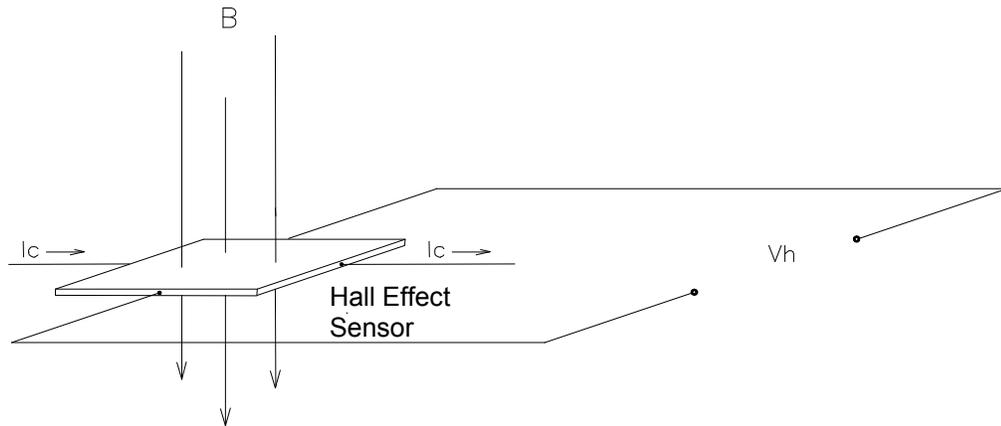
$$\begin{aligned} 1 \text{ oersted} &= 79.5775 \text{ ampere/meter} \\ 1 \text{ ampere/meter} &= 0.0125664 \text{ oersted} \end{aligned}$$

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:

$$1 \text{ G} = 1 \text{ Oe} = 0.0001 \text{ T} = 79.5775 \text{ A/m}$$

## 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  $90^\circ$  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.

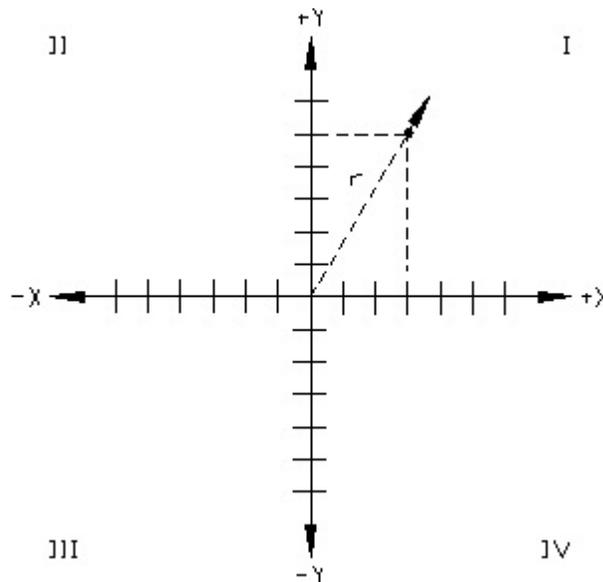
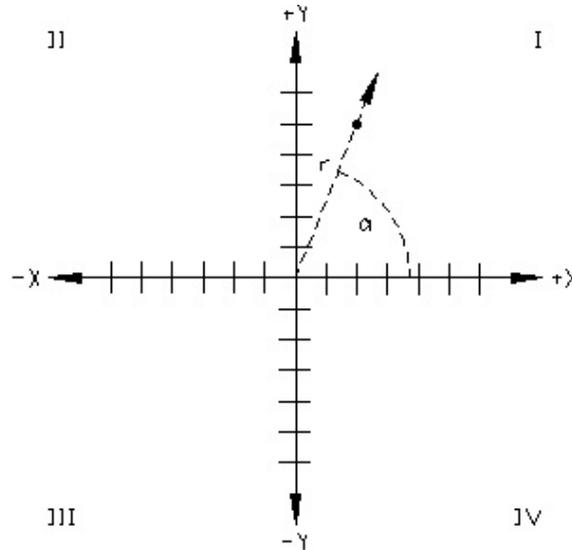


Figure B-1 Two Dimensional Coordinate System

In some cases it is useful to know the rotational angle,  $\alpha$ , 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  $\alpha$  can be calculated as follows:

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

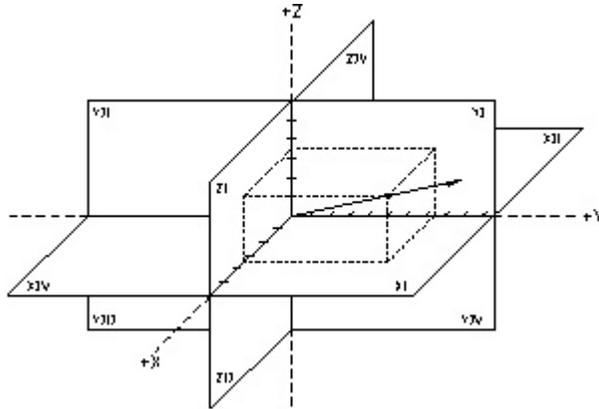


**Figure B-2 Vector Angle in a Two Dimensional System**

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 Coordinate System**

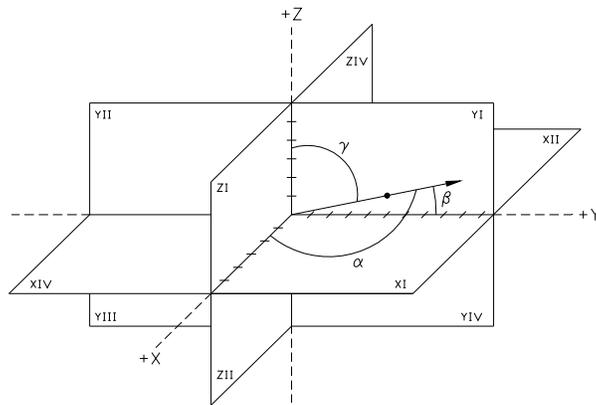
As in the two-dimensional system, it is often important to determine the angles between each axis and the summation vector in a three dimensional system, as shown in Figure B-4.

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**

## APPENDIX C Error Codes

| <b>Meter Specific Errors</b> |  |                                   |
|------------------------------|--|-----------------------------------|
| <b>Error Code</b>            | <b>Display Text</b>  | <b>SCPI Text</b>                  |
| 0                            | No Error   | No Error                          |
| 1                            | The calibration data stored in the probe is not valid. Default values will be used.                      | Invalid probe cal data            |
| 2                            | The calibration data stored in the meter is not valid. Default values will be used.                      |                                   |
| 3                            | The analog card is not present or not functioning.   | Analog card not present           |
| 4                            | The temperature correction data stored on the probe is not valid. Probe temp comp will not be used.      | Invalid probe temp comp data      |
| 5                            | The probe excitation current is not within tolerance.  | Probe current out of range        |
| 6                            | There is no calibration data stored in the probe. Default values will be used                            | Missing probe cal data            |
| 7                            | This is a 7000 series probe. It will function but the readings will not be as accurate.                  | 7000 series probe attached        |
| 8                            | This is an unknown probe type. It cannot be used with this meter.  | Unknown probe type                |
| 9                            | This probe has not been programmed. Default values will be used.   | Missing probe cal data            |
| 10                           | This probe has not been programmed with temperature compensation data. Probe temp comp will not be used. | Missing probe temp comp data      |
| 11                           | The requested range cannot be used while relative offset is greater than its full scale value.           | Invalid range requested.          |
| 12                           | The upper threshold must be greater than or equal to the lower threshold.                                | Invalid upper threshold requested |
|                              |  |                                   |
|                              |  |                                   |
| <b>SCPI Specific Errors</b>  |  |                                   |
| <b>Error Code</b>            | <b>Description</b>   | <b>SCPI Text</b>                  |
| -100                         | SCPI command error   | Command error                     |
| -200                         | SCPI execution error   | Execution error                   |
| -300                         | SCPI device specific error   | Device specific error             |
| -350                         | SCPI error queue overflow  | Error queue overflow              |
| -400                         | SCPI query error   | Query error                       |
| -500                         | SCPI power on event  | Power on event                    |
|                              |  |                                   |

## **APPENDIX D    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.

**THE ABOVE WARRANTY IS EXPRESSLY IN LIEU OF ALL OTHER WARRANTIES EXPRESSED OR IMPLIED AND ALL OTHER OBLIGATIONS AND LIABILITIES ON THE PART OF PACIFIC SCIENTIFIC OECO, AND NO PERSON INCLUDING ANY DISTRIBUTOR, AGENT OR REPRESENTATIVE OF PACIFIC SCIENTIFIC OECO IS AUTHORIZED TO ASSUME FOR PACIFIC SCIENTIFIC OECO ANY LIABILITY ON ITS BEHALF OR ITS NAME, EXCEPT TO REFER THE PURCHASER TO THIS WARRANTY. THE ABOVE EXPRESS WARRANTY IS THE ONLY WARRANTY MADE BY PACIFIC SCIENTIFIC OECO. PACIFIC SCIENTIFIC OECO DOES NOT MAKE AND EXPRESSLY DISCLAIMS ANY OTHER WARRANTIES, EITHER EXPRESSED OR IMPLIED, INCLUDING WITHOUT LIMITING THE FOREGOING, WARRANTIES OF MERCHANTABILITY OR FITNESS FOR A PARTICULAR PURPOSE OR ARISING BY STATUE OR OTHERWISE IN LAW OR FROM A COURSE OF DEALING OR USAGE OR TRADE. THE EXPRESS WARRANTY STATED ABOVE IS MADE IN LIEU OF ALL LIABILITIES FOR DAMAGES, INCLUDING BUT NOT LIMITED TO CONSEQUENTIAL DAMAGES, LOST PROFITS OR THE LIKE ARISING OUT OF OR IN CONNECTION WITH THE SALE, DELIVERY, USE OR PERFORMANCE OF THE GOODS. IN NO EVENT WILL PACIFIC SCIENTIFIC OECO BE LIABLE FOR SPECIAL, INDIRECT OR CONSEQUENTIAL DAMAGES EVEN IF PACIFIC SCIENTIFIC OECO HAS BEEN ADVISED OF THE POSSIBILITY OF SUCH DAMAGES.**

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