magnetic instrumentation inc.

KJS ASSOCIATES

Gaussmeter/Teslameter
Model 2100
Instruction Manual

Revision 2, 25-March-2013
Starting with Serial Number 41554

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Manual Symbols and Messages

The following symbols and messages are used throughout this manual.

WARNING

The WARNING Message indicates that a condition exists that may be hazardous to the user, such as high voltage etc. Please pay especially close attention to these messages.

CAUTION

The CAUTION Message indicates that a condition exists that may cause damage to the Model 2100.

1.21 G	**DC**
Auto	**NORM**

The display symbol indicates the information displayed by the Model 2100 **after** a preceding step is executed.

EXAMPLE: The EXAMPLE message indicates that an example follows.

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1. INTRODUCTION

1.1 Overall Description

1.1.1 Overview

The Magnetic Instrumentation, Inc. Model 2100 Gaussmeter is a compact, precision, microprocessor-controlled instrument capable of measuring static, alternating, or pulsed magnetic fields. Twelve measurement ranges allow the user to configure the meter for maximum resolution and accuracy from 300mG to 300kG (30 uT - 30 T) full scale. The meter configuration is completely accessible using either the front panel keypad and menu system, or the RS-232 interface (IEEE-488 optional). The user may choose from a wide selection of Hall effect probes

1.1.2 Key Features

- High Accuracy
- Autoranging
- 10 Measurement Ranges
- 3 Measurement Functions (DC, AC, Peak)
- 4 Modes of operation (Normal, Dual Limit, Relative, and Temperature)
- Wide Bandwidth
- User-defined sampling period from 10 ms to 2.5 seconds
- 8 Selectable Hall Probe Excitation Currents
- Measurement Readout in Gauss or Tesla
- 32-Character Display
- Compact Size (12.6" x 6.9" x 2.9")
- External “Peak” Reset
- Zero Gauss Chamber Included
- Factory Set Default Mode
- Analog Output
- Dual Limit HI/GO/LO Outputs
- RS-232 Interface (Standard)
- IEEE-488 Interface (Option)
- Wide Selection of Probes Available

1.2 Front Panel Description

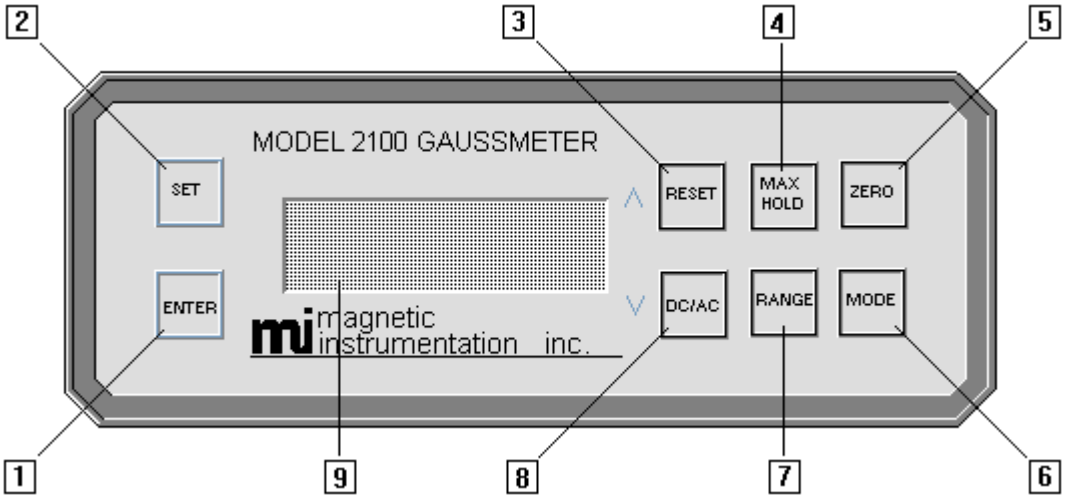


Figure 1.2.1 Model 2100 Front Panel

Item	Name	Function
1	ENTER Key	Selects menu options. A selection will be stored in the meter's configuration only if the ENTER key is pressed.
2	SET Key	Toggles the menu system on or off. This key also allows navigation through the various levels of the menu system.
3	RESET Key	a) When the menu system is **not** activated and the meter is being used in the MAX mode of operation, the RESET key will reset the meter's peak indication. b) When the menu system **is** enabled, the RESET key scrolls (increments) through menu options and parameters.
4	MAX HOLD Key	Switches between NORMAL and MAX HOLD modes of operation.
5	ZERO Key	Allows the user to zero the meter.
6	MODE Key	Switches between the NORMAL, DUAL LIMITS, RELATIVE and TEMPERATURE modes of operation.
7	RANGE Key	Selects the measurement range of the meter or the auto range function.
8	DC/AC	a) When the menu system is **not** enabled, the DC/AC key allows the user to toggle between static (DC) and alternating (AC) modes of operation. b) When the menu system **is** enabled, the DC/AC key scrolls (decrements) through menu options and parameters.
9	Display	Conveys all measurement and configuration information to the user.

Table 1.2.1 Model 2100 Front Panel Items

1.3 Rear Panel Description

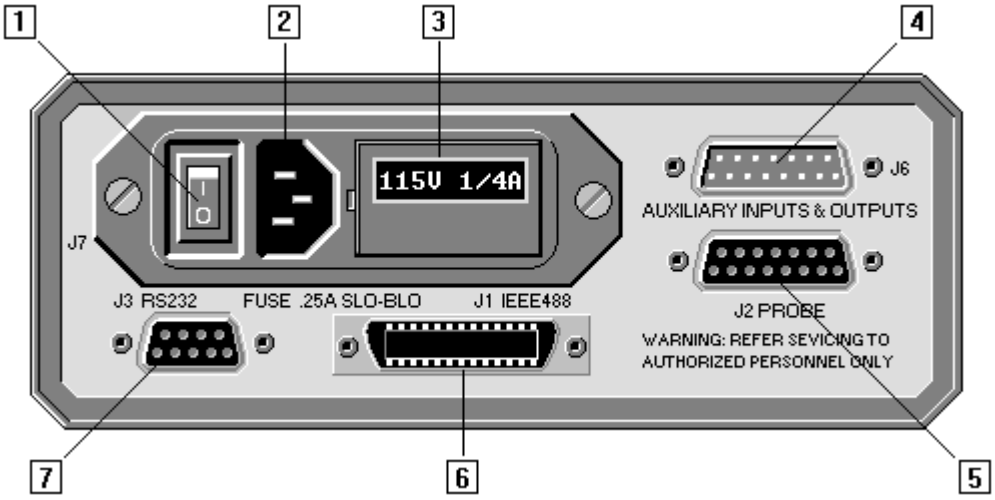


Figure 1.3.1 Model 2100 Rear Panel

Item	Name	Function
1	ON/OFF SWITCH	Connects or disconnects the Model 2100 from AC line voltage.
2	POWER RECEPTACLE	Connects the power cord to the Model 2100.
3	FUSE HOLDER	Contains the line fuse for the 2100 meter. This fuse does not affect the operation of the meter from a ±9 VDC power source.
4	J6 AUXILIARY CONNECTOR	Allows access to the analog output, limits outputs, ±9 VDC input connections, and remote reset.
5	J2 PROBE CONNECTOR	Used to connect the Hall effect probe to the Model 2100.
6	J1 GPIB CONNECTOR	Interfaces the Model 2100 to a GPIB controller.
7	J3 RS-232 CONNECTOR	Interfaces the Model 2100 to a PC serial port.

Table 1.3.1 Model 2100 Rear Panel Items

1.4 Display Description

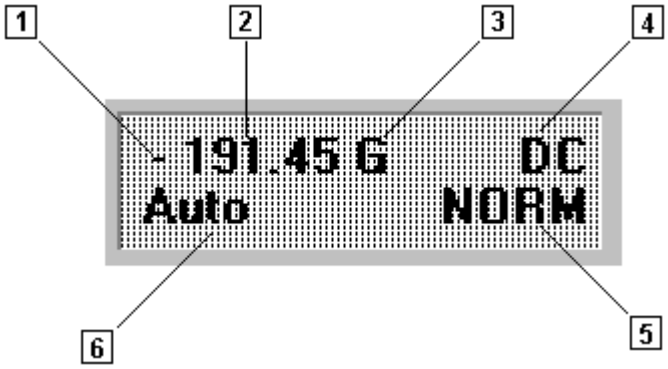


Figure 1.4.1 Model 2100 Display

Item	Name	Function
1	POLARITY	Indicates the polarity of the measured field.
2	MEASUREMENT	Indicates the magnitude of field being measured.
3	UNITS	Indicates the measurement units currently selected.
4	DC/AC	Indicates whether the Model 2100 is measuring a static or alternating field.
5	MODE	Indicates the measurement mode currently selected.
6	RANGE	Indicates the range currently selected.

Table 1.4.1 Model 2100 Display Items

1.5 Specifications

1.5.1 Accuracy Specifications

DC Accuracy ±(% of reading + % of range)

Range	Typical	Maximum
≥ 30 KG	0.050 + 0.020	0.100 + 0.050
≥ 3 KG	0.050 + 0.020	0.110 + 0.050
≥ 300 G	0.060 + 0.020	0.150 + 0.050
≥ 30 G	0.080 + 0.020	0.200 + 0.050

Table 1.5.1 DC Accuracy Specifications

Probe Current Accuracy ±(% of value)

Value	Typical	Maximum
100 mA	0.050	0.080
50 mA	0.060	0.090
25 mA	0.070	0.100
12.5 mA	0.080	0.110
-100 mA	0.100	0.130
-50 mA	0.110	0.140
-25 mA	0.120	0.150
-12.5 mA	0.130	0.160

Table 1.5.2 Probe Current Accuracy Specifications

AC (RMS) Accuracy ±(% of reading + % of range)

Range	10 – 20 Hz	20 – 100 Hz	100 – 1000 Hz	1 – 7 KHz	7 – 15 KHz	15 – 20 KHz
≥ 30 KG	1.400 + 0.800	0.700 + 0.800	0.700 + 0.800	0.800 + 0.800	1.200 + 0.800	2.600 + 0.800
≥ 3 KG	1.400 + 0.800	0.700 + 0.800	0.700 + 0.800	0.900 + 0.800	3.200 + 0.800	~
≥ 300 G	1.600 + 0.800	0.900 + 0.800	0.900 + 0.800	~	~	~
≥ 30 G	2.000 + 0.800	1.300 + 0.800	~	~	~	~

Table 1.5.3 AC (RMS) Accuracy Specifications

Peak Mode Accuracy ±(% of reading + % of range)

Range	Pulse Width (square wave)		
	>1000 us	200 – 1000 us	100 – 200 us
≥ 30 KG	0.700 + 0.200	0.800 + 0.200	0.900 + 0.200
≥ 3 KG	0.700 + 0.200	0.900 + 0.200	1.000 + 0.200
≥ 300 G	0.900 + 0.300	1.000 + 0.300	1.800 + 0.300
≥ 30 G	1.500 + 1.200	~	~

Table 1.5.4 Peak Mode Accuracy Specifications

~ indicates no accuracy claim at this point

Other Accuracy Specifications

Function	Specification
Analog Output	± (2% of reading + 10mV + accuracy of selected function)
Temperature	± 1.0°C

Table 1.5.5 Other Accuracy Specifications

1.5.2 I/O Specifications

Interface	Specification
Serial	RS-232C 9600 baud rate, 8 data bits, no parity, 1 stop bit, no handshaking DB-9 female connector
GPIB (optional)	Complies with IEEE-488-1978
Analog Output	±1 Volt full scale.
Dual Limit Outputs	Low-power Schottky outputs (74LS37) DB-15 male connector Source $V_{OH} \geq 2.4$ V @ ≤ -1.2 mA Sink $V_{OL} \leq 0.4$ V @ ≤ 48 mA
Remote Reset	Low-power Schottky input (74LS37) DB-15 male connector Input (internal 10kΩ pull up resistor) $V_{IH} \geq 2.0$ V $V_{IL} \leq 0.8$ V

Table 1.5.6 I/O Specifications

1.5.3 General Specifications

Property	Specification
Size	12.6" x 6.9" x 2.9" (L x W x H)
Weight	4.75 lbs.
Power	115 or 220 VAC 50/60 Hz
Fuse	0.25A 250V type 3AG

Table 1.5.7 General Specifications

1.5.4 Radiated RF Immunity

≥ 70 dB isolation when operated in a field of ≤ 3.0V/M at frequencies from 26 to 500 MHz.

Safety Precautions

The following safety precautions must be observed at all times during operation or service of this product. Magnetic Instrumentation, Inc. assumes no liability for failure to comply with these requirements.

WARNING

a) Fuse
Use only 0.25A 250V 3AG SLO-BLO type fuses in this instrument. In the event of a malfunction, the use of any other fuse may increase the likelihood of an electrical fire. Replacement fuses may be ordered as Magnetic Instrumentation part number 57600600.

b) Power Cord
Use only a three conductor power cord as supplied with this instrument. Ensure the power receptacle to which the power cord is connected is properly wired, and that the safety ground is connected to earth ground. If these precautions are not followed, electrical shock could result.

c) Wet Environment
Do not operate this equipment in standing water or damp areas. Failure to follow this precaution could result in electrical shock.

d) Repair or Modification
Do not attempt to open, modify or repair this equipment. Potentially lethal voltages are present in the Model 2100. No user serviceable parts are contained in this instrument. If repair or modifications are required, contact Magnetic Instrumentation, Inc. for assistance.

CAUTION

e) The Model 2100 is a rugged, dependable instrument. As with any precision instrument, however, care should be taken when handling or storing this Gaussmeter. Avoid dropping or jarring the Model 2100. Store the Model 2100 in a cool dry environment when it is not in use. Do not use solvents or abrasives to clean the exterior of this instrument.

f) Hall probes are, by nature, delicate devices. Handle them with care.

2. INITIAL SETUP

2.1 Unpacking

a) Before opening the Model 2100 shipping container, inspect for any obvious shipping damage such as crushed, punctured, or torn packaging, water damage, etc. If such damage is present, contact the shipping agent as soon as possible to submit a damage claim.

b) If possible, keep the original shipping container. In the event that the Model 2100 needs to be returned to Magnetic Instrumentation, Inc., the original shipping container will provide the best means of repackaging the Gaussmeter and accessories.

c) Open the shipping container, and inventory the contents to ensure that the order is complete. Please report any missing items to Magnetic Instrumentation, Inc. immediately.

d) Inspect the Model 2100 for any obvious shipping damage such as cracked or scratched display or keypads; bent or cracked rear panel connectors, or dented case. Inspect all accessories for damage. Hall probes are inherently fragile, so pay particularly close attention when inspecting them. Please report any damaged items to Magnetic Instrumentation, Inc. immediately.

2.2 Model 2100 Functional Check

Before attempting to apply power to the Model 2100, ensure that the meter is configured for the line voltage that will be used. To determine the line voltage for which the meter is configured, refer to the rear panel of the instrument.

a) Connect the Model 2100 to line power using the supplied power cord.

b) Connect a Hall effect probe to the rear panel probe connector.

c) Apply power to the Model 2100 by placing the power switch to the **ON** position. The display should momentarily display the following messages:

Magnetic Instrumentation

Standard Probe

OR

Probe Memory Detected

If the display does not display these messages or displays an error message, please contact Magnetic Instrumentation Inc. for assisstance.

d) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the “SET” message on the top row of the display.

SET **1. Display Period**

e) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Default menu item.

SET **9. Default**

f) Press the front panel ENTER key to enter the menu parameter level.

Set to Default **NO**

g) Press the front panel UP (RESET) key or the DOWN (DC/AC) key to set the parameter to “Yes”.

Set to Default **Yes**

h) Press the front panel ENTER key to set the meter configuration to factory default. The menu system will return to the Default menu item.

SET **9. Default**

i) Press the front panel SET key to disable the menu system and return to normal operation.

1.21 G **DC** **Auto** **NORM**

j) The Model 2100 is now set to factory default configuration. The following table indicates the default configuration settings which are now enabled.

Menu Number	Parameter	Default Value
1	Display Period	300 ms
2	Units	Gauss
3	Probe Current	+100 mA
4	Max/Min Range	*100kG / 70G
5	Calibration #	*100000 G/V @100mA
6	Dual Limits - Upper Limit	+1500 G
6	Dual Limits - Lower Limit	+500 G
7	Relative Offset	+1000 G
8	Keypad Active	Yes
9	Defaults	Yes
10	GPIB Address	01
11	Use Probe Equation	Yes
12	Adjust for Temperature - Temp. Correction	*NO
12	Adjust for Temperature - Nominal Temp.	*24.0 °C
12	Adjust for Temperature - Temp. Coefficient	*0.000% / °C
12	Adjust for Temperature - Temp. Offset Coefficient	*000.0 µV / °C
13	MAX Polarity	+ & -
-	Range	Auto
-	Mode	Normal
-	Function	DC

** When probe memory is used, these default values are replaced by the values stored in probe memory on power up.*

Table 2.2.1 Default Configuration

3. USING THE MENU SYSTEM

3.1 General Menu Description

The Model 2100 menu system is composed of a three-level hierarchical arrangement of optional settings and configuration information. The top level of the menu system allows access to the major groups of menu options and configuration. Some of these major groups are divided into sub-menus. These sub-menus make up the second level of the menu system. The third level of the menu system contains the actual parameters that can be selected or modified.

3.2 Menu System Navigation

The front panel SET key, ENTER key, UP (RESET) key, and DOWN (DC/AC) key are used to navigate through the levels of the menu system, and to select and modify parameters.

Pressing the SET key when the menu system is inactive will activate the menu system. Conversely, if the menu system is activated and set to the top level, pressing the SET key will deactivate the menu system. If the menu system is active, and is set to either the sub-menu, or parameter levels, pressing the SET key will place the menu system at the top level.

Pressing the ENTER key while the menu is set to either a top level menu item or a sub-menu item causes the menu system to move down one level. Once the menu system is at the parameter level, pressing the ENTER key stores any selected or modified parameter to the meter's configuration. Keep in mind that any selections or modifications made at the parameter level will be saved only when the ENTER key is pressed. If a parameter is mistakenly selected or modified, pressing the SET key will cause the parameter to revert to its previous value.

The UP (RESET) key is used to scroll (increment) through the menu items on any menu level. For example, pressing the UP key while the menu is set to the first item on the top menu (1. Display Period) will cause the menu system to advance to the second menu item (2. Gauss/Tesla).

The DOWN (DC/AC) key has a function similar to that of the UP key except that the menu item will be decremented instead of incremented. There is one exception to this function of the DOWN key. When the menu system is set to the parameter level, and the parameter requires a numeric input (such as the Limits parameter), pressing the DOWN key causes the cursor to advance one position to the right. This action allows the user to select the digit to be modified.

3.3 Menu Item Descriptions

The top level of the menu system is composed of thirteen menu items. Following is a description of each item and the effect that selecting or modifying its parameters will have on the operation of the Model 2100 Gaussmeter.

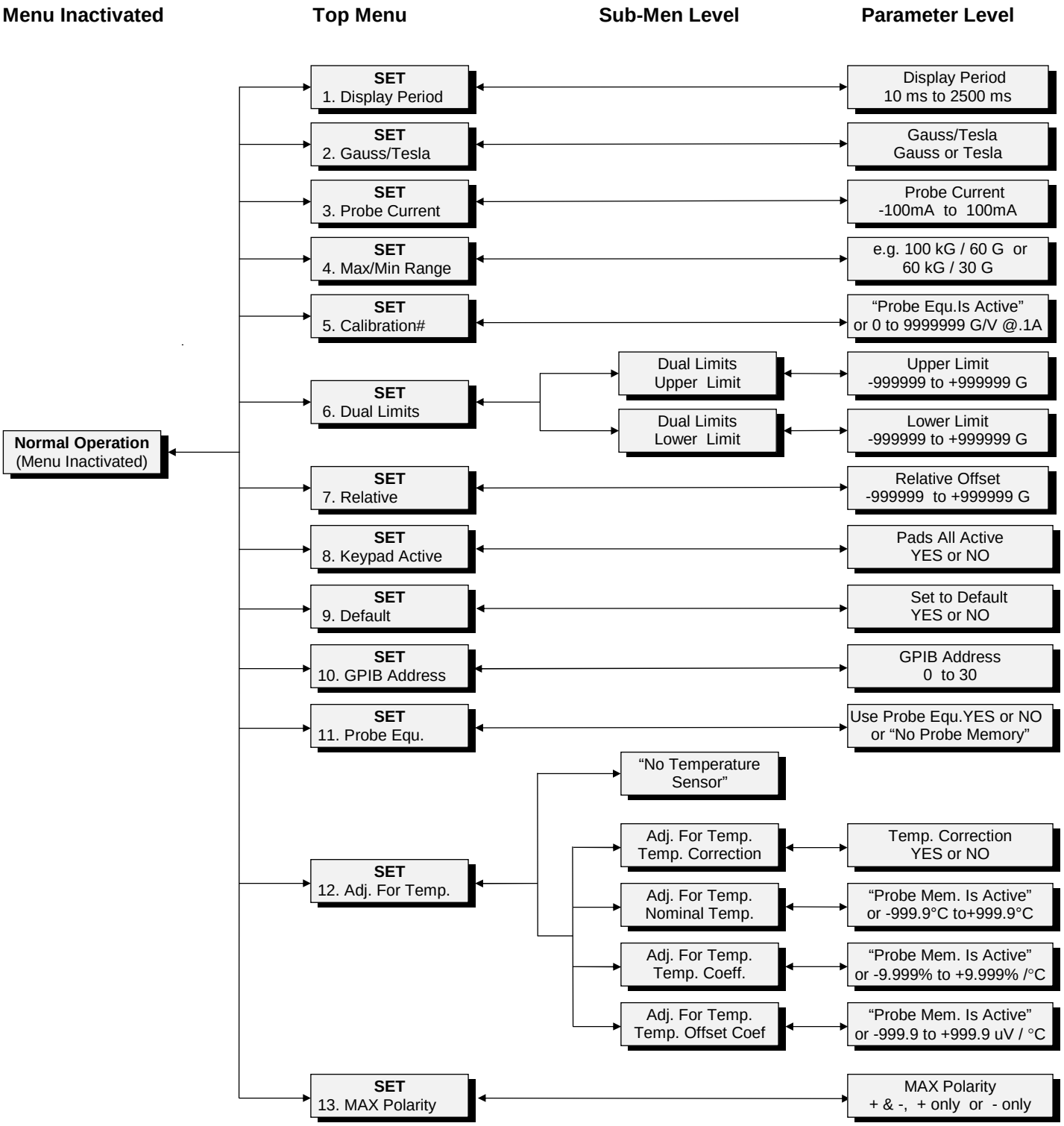


Figure 3.3.1 Model 2100 Menu System

Item #	Name	Description
1	Display Period	Determines the time interval between display information updates. This interval may be set to 10 ms for fast update, and from 100 ms to 2500 ms in 100 ms intervals. Setting the display period to a low value will cause the display to update more frequently, and will cause the Gaussmeter to average fewer samples. Setting the display period to a higher value will cause the display to update less frequently, and will cause the Gaussmeter to average a larger number of samples. The display period will also affect the speed with which the Model 2100 will respond to remote interface commands (RS-232C and IEEE-488). A longer interval leads to slower response.
2	Gauss/Tesla	The Gauss/Tesla menu allows the user to select the measurement units displayed by the Model 2100. Changing this parameter will only affect displayed readings, and readings transferred using the remote interface. Changing the Gauss/Tesla parameter will not effect other parameter level menu items that require a numeric input. For example, the Dual Limits parameter will always be in Gauss regardless of the units that are selected.
3	Probe Current	The probe current menu allows the user to select the Hall probe excitation current. Normally, best performance is achieved with a +100 mA current; however, if a non-standard probe is used, the user may select from eight excitation currents to best match the characteristics of the Hall element. The available excitation currents are 100, 50, 25, 12.5, -12.5, -25, -50, and -100 mA. For more information about the effects of changing the Hall element excitation current and for general information on Hall effect sensors, refer to Section 5.1 “Hall Element Theory of Operation”.
4	Max/Min Range	The Max/Min Range menu item allows the user to select between two groups of five ranges. The actual ranges available will depend on the Hall probe that is being used.
5	Calibration #	The Calibration # menu item allows the user to manually set the Hall probe sensitivity. The parameter can be set from 0 G/V to 9999999 G/V at 100 mA probe current. Hall probes sold by Magnetic Instrumentation, Inc. that do not contain a correction EEPROM will have this parameter listed on the probe connector. When adapting other probes for use with the Model 2100, refer to Section 4.9 “Determining the Hall Probe Calibration Number”.
6	Dual Limits	The Dual Limits menu item allows the user to set the lower and upper limits used by the Model 2100 when it is placed in the limits mode of operation (Section 4.7). Both the Lower Limit and Upper Limit sub-menu parameters can range from -999999G to +999999G.
7	Relative	The Relative menu item allows the user to set the relative measurement parameter. When the Model 2100 is used in the relative mode, the parameter will be subtracted from the actual measurement. The range of the relative parameter is from -999999G to +999999G.
8	Keypad Active	The user can set all keypads to be active or only the RESET and ZERO keys to be active. The latter selection requires a password, which is MH, RA, MH, RA, RA, MH, RA, where MH stands for the MAX HOLD button and RA the RANGE button.
9	Default	The Default menu item allows the user to reset the meter to factory default settings for all parameters. Selecting the YES parameter will enable default settings while selecting the NO parameter will not change the settings. Note that resetting the Model 2100 to factory default will set the GPIB address to 1. If the GPIB remote interface is used to set the Model 2100 to factory default, communication may be lost in cases where the gaussmeter GPIB address was previously set to any address other than 1.
10	GPIB Address	The GPIB address menu item allows the user to change the remote interface address of the Model 2100. The GPIB address parameter can be set from 0 to 30.

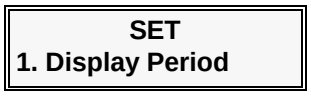
11	Probe Equation	The Probe Equation menu item allows the user to enable or disable the use of probe memory. This feature may only be used with probes containing a correction EEPROM. Selecting the YES parameter enables the use of probe memory. Selecting the NO parameter disables use of probe memory, and allows the user to calibrate the Hall probe using the Calibration # menu item.
12	Adj. for Temp.	The Adj. for Temp. menu item allows the user to enable or disable Hall probe temperature correction. The menu item also allows the user to set the nominal temperature, temperature coefficient, and temperature offset coefficient values for the Hall element. Setting the Temp. Correction sub-menu parameter to YES enables temperature correction, while setting the parameter to NO disables temperature correction. The Nominal Temp. sub-menu allows the user to set the nominal temperature at which the Hall element was calibrated. The parameter range is 0°C to 100°C. The Temp. Coeff. sub-menu allows the user to set the temperature coefficient of the Hall element. The temperature coefficient is the change in Hall element sensitivity per change in temperature. The range of this parameter is 0 °C to 100 °C. The Temp. Offset Coef sub menu allows the user to set the temperature offset coefficient for the Hall element. The temperature offset coefficient is the change in the Hall element offset voltage per change in temperature. The range of this parameter is -999.9 uV/°C to +999.9 uV/°C.
13	MAX Polarity	Options for the MAX Mode are “+ & -“, “+ only” or “- only”. Choose “+ & -“ to use both polarities of the signal when finding the maximum value of the signal received. Choose “+ only” to use only positive levels of the signal. Choose “- only” to use only negative levels of the signal.

Table 3.3.1 Menu Items

3.4 Setting the Display Period

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

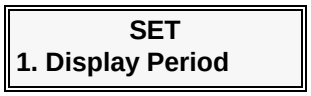
b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Display Period menu item.



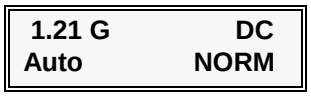
c) Press the front panel ENTER key to enter the menu parameter level.

d) Press the front panel UP (RESET) key or DOWN (DC/AC) key to change the parameter to the desired display period. In this example, the Display Period has been set to 500 ms.

e) Press the front panel ENTER key to store the changes to the meter configuration. The menu system will return to the Display Period menu item.



f) Press the front panel SET key to disable the menu system and return to normal operation.



3.5 Setting the Measurement Units

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display

SET
1. Display Period

b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Gauss/Tesla menu item

SET
2. Gauss/Tesla

c) Press the front panel ENTER key to enter the menu parameter level.

Gauss/Tesla
Gauss

d) Press the front panel UP (RESET) key or DOWN (DC/AC) key to change the parameter to the desired measurement units. In this example, the measurement unit is set to Tesla.

Change Unit
Tesla

e) Press the front panel ENTER key to store the changes to the meter configuration. The system will return to the Gauss/Tesla menu item.

SET
2. Gauss/Tesla

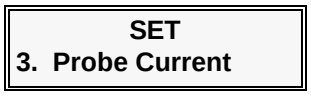
f) Press the front panel SET key to disable the menu system and return to normal operation.

1.21 G	DC
Auto	NORM

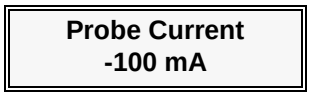
3.6 Setting the Probe Current

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display

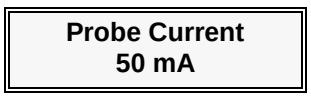
b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Probe Current menu item.



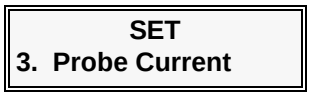
c) Press the front panel ENTER key to enter the menu parameter level.



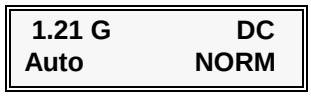
d) Press the front panel UP (RESET) key or DOWN (DC/AC) key to change the parameter to the desired probe current. In this example, the probe current has been set to 50 mA.



e) Press the front panel ENTER key to store the changes to the meter configuration. The menu system will return to the Probe Current menu item.



f) Press the front panel SET key to disable the menu system and return to normal operation.



3.7 Setting the Max/Min Range

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

SET
1. Display Period

b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Max/Min Range menu item.

SET
4. Max/Min Range

c) Press the front panel ENTER key to enter the parameter level.

Man/Min Range
200kG / 200G

d) Press the front panel UP (RESET) key or DOWN (DC/AC) key to change the parameter to the desired max/min range setting. In this example, the max/min range has been set to 30 kG / 30 G.

Man/Min Range
30kG / 30G

e) Press the front panel ENTER key to store the changes to the meter configuration. The menu system will return to the Max/Min Range menu item.

SET
4. Max/Min Range

f) Press the front panel SET key to disable the menu system and return to normal operation.

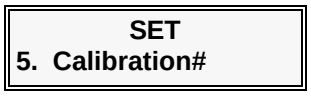
1.21 G	DC
Auto	NORM

3.8 Setting the Hall Probe Calibration Number

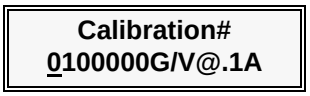
Note: This section only applies if (a) the Hall probe does not contain a correction EEPROM or (b) the probe memory function is disabled

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

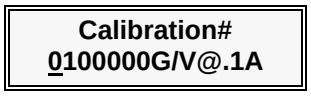
b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Calibration# menu item.



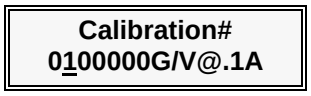
c) Press the front panel ENTER key to enter the parameter level.



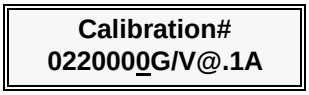
d) Press the front panel UP (RESET) key to set the first digit of the calibration number to the desired value.



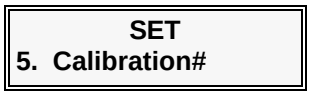
e) Press the front panel DOWN (DC/AC) key to move the display cursor to the right until it is under the next digit to be modified. Press front panel UP (RESET) key to increment the digit to the desired value.



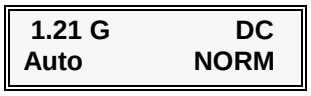
f) Repeat step e for other digits as needed. In this example, the calibration number has been set to 220000G/V.



g) Press the front panel ENTER key to store the changes to the meter configuration. The menu system will return to the Calibration# menu item.



h) Press the front panel SET key to disable the menu system and return to normal operation.

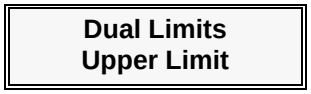


3.9 Setting the Lower Limit

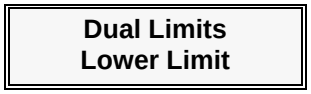
a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Dual Limits menu item.

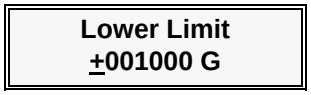
c) Press the front panel ENTER key to enter the sub menu level.



d) Press the front panel UP (RESET) key or DOWN (DC/AC) key to select the Lower Limit sub menu item.



e) Press the front panel ENTER key to enter the menu parameter level. Press the UP (RESET) key to change the desired polarity.



f) Press the front panel DOWN (DC/AC) key to move the display cursor under the digit to be modified, then press front panel UP (RESET) key to increment the digit to the desired value. Repeat as needed to modify other digits. In this example the lower limit is set to +1500 G.

g) Press the front panel ENTER key to store the changes to the meter configuration. Press the front panel SET key. The menu system will return to the Dual Limits menu item.

h) Press the front panel SET key to disable the menu system and return to normal operation.

3.10 Setting the Upper Limit

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

SET
1. Display Period

b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Dual Limits menu item.

SET
6. Dual Limits

c) Press the front panel ENTER key to enter the sub menu level.

Dual Limits
Lower Limit

d) Press the front panel UP (RESET) key or DOWN (DC/AC) key to select the Upper Limit sub menu item.

Dual Limits
Upper Limit

e) Press the front panel ENTER key to enter the menu parameter level. Press the UP (RESET) key to change the desired polarity.

Upper Limit
±001000 G

f) Press the front panel DOWN (DC/AC) key to move the display cursor under the digit to be modified, then press front panel UP (RESET) key to increment the digit to the desired value. Repeat as needed to modify other digits. In this example the upper limit is set to +10000 G.

Upper Limit
+010000 G

g) Press the front panel ENTER key to store the changes to the meter configuration. Press the front panel SET key. The menu system will return to the Dual Limits menu item.

SET
6. Dual Limits

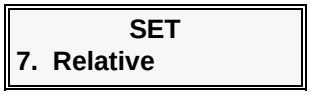
h) Press the front panel SET key to disable the menu system and return to normal operation.

1.21 G	DC
Auto	NORM

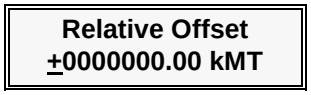
3.11 Setting the Relative Offset

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

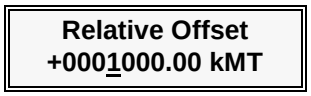
b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Relative menu item.



c) Press the front panel ENTER key to enter the menu parameter level.

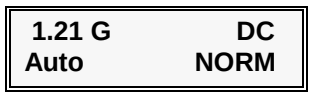


d) Press the front panel DOWN (DC/AC) key to move the display cursor under the digit to be modified, then press front panel UP (RESET) key to increment the digit to the desired value. Repeat as needed for other digits. In this example the relative offset is set to 1000 kMT.



e) Press the front panel ENTER key to store the changes to the meter configuration. The menu system will return to the Relative menu item.

f) Press the front panel SET key to disable the menu system and return to normal operation.



3.12 Setting the Keypad Active Function

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

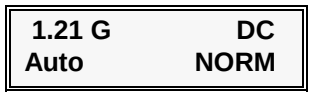
b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Keypad Active menu item.

c) Press the front panel ENTER key to enter the menu parameter level.

d) Press the front panel UP (RESET) key or the DOWN (DC/AC) key to obtain the desired selection. If No is selected, only the RESET and ZERO buttons will be active.

e) Press the front panel ENTER key to store the changes to the meter configuration. If *No* had been selected, the meter asks for a password, which is MH, RA, MH, RA, RA, MH, RA, where MH stands for the MAX HOLD button and RA the RANGE button.

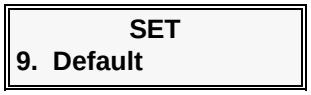
f) Press the front panel SET key to disable the menu system and return to normal operation.



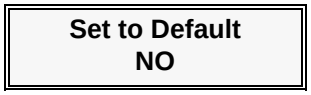
3.13 Setting Factory Default Configuration

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

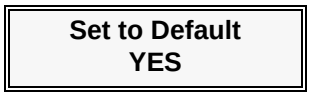
b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Default menu item.



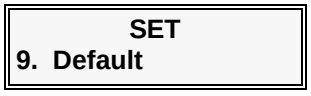
c) Press the front panel ENTER key to enter the menu parameter level.



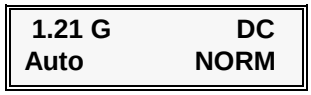
d) Press the front panel UP (RESET) key or the DOWN (DC/AC) key to set the parameter.



e) Press the front panel ENTER key. If *YES* had been selected, the meter configuration will be set to the factory default. The menu system will return to the Default menu item.



f) Press the front panel SET key to disable the menu system and return to normal operation.

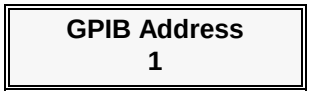


3.14 Setting the GPIB Address

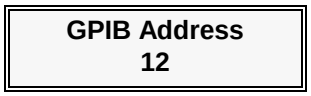
a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the GPIB Address menu item.

c) Press the front panel ENTER key to enter the menu parameter level.

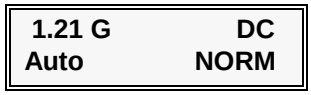


d) Press the front panel UP (RESET) key or the DOWN (DC/AC) key to set the address to the desired value. In this example the GPIB address is set to 12.



e) Press the front panel ENTER key to store the changes to the meter configuration. The menu system will return to the GPIB Address menu item.

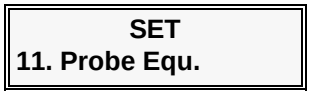
f) Press the front panel SET key to disable the menu system and return to normal operation.



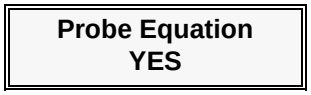
3.15 Enabling/Disabling Probe Memory

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

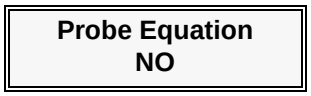
b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Probe Equ. menu item.



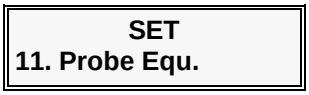
c) Press the front panel ENTER key to enter the menu parameter level.



d) Press the front panel UP (RESET) key or the DOWN (DC/AC) key to obtain the desired parameter. Selecting YES will enable the use of probe memory, while selecting NO will disable the use of probe memory.



e) Press the front panel ENTER key to store the changes to the meter configuration. The menu system will return to the Probe Equ. menu item.



f) Press the front panel SET key to disable the menu system and return to normal operation.

3.16 Enabling/Disabling Probe Temperature Correction

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

SET 1. Display Period

b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Adj. for Temp. menu item.

SET 12. Adj. for Temp.

c) Press the front panel ENTER key to enter the sub-menu level.

Adj. for Temp. Temp. Correction

d) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Temp. Correction sub-menu item.

Adj. for Temp. Temp. Correction

e) Press the ENTER key to enter the menu parameter level.

Temp. Correction NO

f) Press the front panel UP (RESET) key or the DOWN (DC/AC) key to enable or disable temperature correction.

Temp. Correction YES

g) Press the front panel ENTER key to store the changes to the meter configuration.

Adj. for Temp. Temp. Correction

h) Press the front panel SET key to return to the Adj. for Temp. menu item.

SET 12. Adj. for Temp.

i) Press the front panel SET key to disable the menu system and return to normal operation.

1.21 G DC Auto NORM

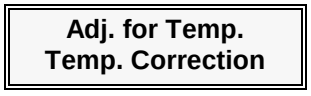
3.17 Setting the Nominal Probe Temperature

Note: This section only applies if (a) the Hall probe does not contain a correction EEPROM or (b) the probe memory function is disabled

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

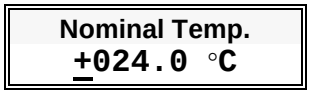
b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Adj. for Temp. menu item.

c) Press the front panel ENTER key to enter the sub-menu level.

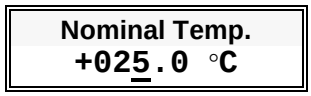


d) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Nominal Temp. sub-menu item.

e) Press the ENTER key to enter the menu parameter level. If necessary, press the UP (RESET) key to change the desired polarity.



f) As needed, press the front panel DOWN (DC/AC) key to move the cursor to the right. Press the front panel UP (RESET) key to change the digit. Repeat for other digits as desired. In this example the nominal temperature has been set to +25.0 °C.



g) Press the front panel ENTER key to store the changes to the meter configuration.

h) Press the front panel SET key to return to the Adj. for Temp. menu item.

i) Press the front panel SET key to disable the menu system and return to normal operation.

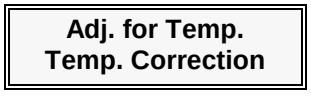
3.18 Setting the Probe Temperature Coefficient

Note: This section only applies if (a) the Hall probe does not contain a correction EEPROM or (b) the probe memory function is disabled

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

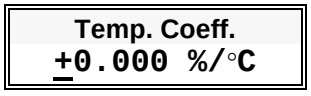
b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Adj. for Temp. menu item.

c) Press the front panel ENTER key to enter the sub-menu level.

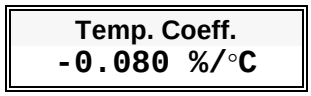


d) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Temp. Coeff. sub-menu item.

e) Press the ENTER key to enter the menu parameter level. If necessary, press the UP (RESET) key to change the desired polarity.



f) As needed, press the front panel DOWN (DC/AC) key to move the cursor to the right. Press the front panel UP (RESET) key to change the digit. Repeat for other digits as desired. In this example the temperature coefficient has been set to -0.080 %/°C.



g) Press the front panel ENTER key to store the changes to the meter configuration.

h) Press the front panel SET key to return to the Adj. for Temp. menu item.

i) Press the front panel SET key to disable the menu system and return to normal operation.

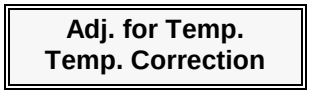
3.19 Setting the Probe Temperature Offset Coefficient

Note: This section only applies if (a) the Hall probe does not contain a correction EEPROM or (b) the probe memory function is disabled

a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

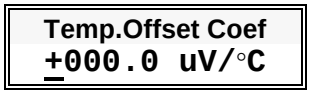
b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Adj. for Temp. menu item.

c) Press the front panel ENTER key to enter the sub-menu level.

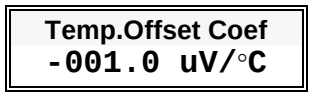


d) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the Temp.Offset Coef sub-menu item.

e) Press the ENTER key to enter the menu parameter level. If necessary, press the UP (RESET) key to change the desired polarity.



f) As needed, press the front panel DOWN (DC/AC) key to move the cursor to the right. Press the front panel UP (RESET) key to change the digit. Repeat for other digits as desired. In this example the temperature offset coefficient has been set to -1.0 uV/°C.



g) Press the front panel ENTER key to store the changes to the meter configuration.

h) Press the front panel SET key to return to the Adj. for Temp. menu item.

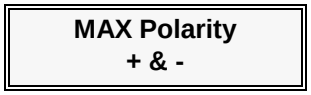
i) Press the front panel SET key to disable the menu system and return to normal operation.

3.20 Selecting the MAX Polarity

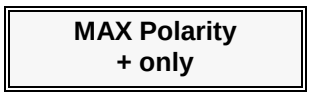
a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the "SET" message on the top row of the display.

b) Press the front panel UP (RESET) key or the DOWN (DC/AC) key until the menu system is set to the MAX Polarity menu item.

c) Press the front panel ENTER key to enter the menu parameter level.

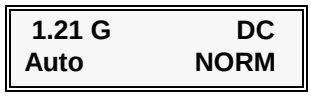


d) Press the front panel UP (RESET) key or the DOWN (DC/AC) key to select the desired MAX polarity mode. Select "+ & -" to use both polarities when determinig the largest peak signal. Select "+ only" or "- only" when desiring only a certain polarity in peak signal detection.



e) Press the front panel ENTER key to store the changes to the meter configuration. The menu system will return to the MAX Polarity menu item.

f) Press the front panel SET key to disable the menu system and return to normal operation.



4. MEASUREMENT CONSIDERATIONS

4.1 General Measurement Considerations

The Model 2100 allows the user to configure the gaussmeter for many different types of measurement situations. To realize the full potential of the Model 2100, the user must become familiar with some general guidelines for making measurements. This section will cover some of the basic configurations of the Model 2100 as well as the use of the auxiliary outputs (analog and dual limits).

4.2 Selecting the Measurement Mode (DC, AC, or Peak)

To make a relevant measurement, the user must know some characteristics of the magnetic field to be measured. Magnetic fields may be Static (DC), Alternating (AC), pulsed, or any combination of the above in nature. These magnetic field types can be likened to DC, AC, or Peak voltage, respectively. Just as a voltmeter must be configured to measure DC, AC, or Peak voltage, the Model 2100 must also be properly configured to measure various types of magnetic fields.

4.2.1 DC Mode

Static (DC) fields or the Static component of a field will normally be measured using the DC function of the Model 2100. To select DC operation, the Model 2100 should be set to either Norm, Relative, or Dual Limits mode by pressing the front panel MODE key until the desired mode is selected (proper mode selection will be described in 4.3). Press the DC/AC key until the display DC/AC indicator is set to “DC”.

While the DC function is selected, the Model 2100 will indicate both the magnitude and polarity of the measured field. The user should keep in mind that flux density is a vector quantity. That is, the magnetic field has both a magnitude and a direction. Hall elements are sensitive to magnetic fields in one axis only. If the sensitive axis of the Hall probe is not aligned with the direction of the field to be measured, an error will result. The proper orientation of the Hall probe to the magnetic field is shown in figure 4.2.1. To quantify the error resulting from misalignment, refer to section 4.10, “Sources of Error”.

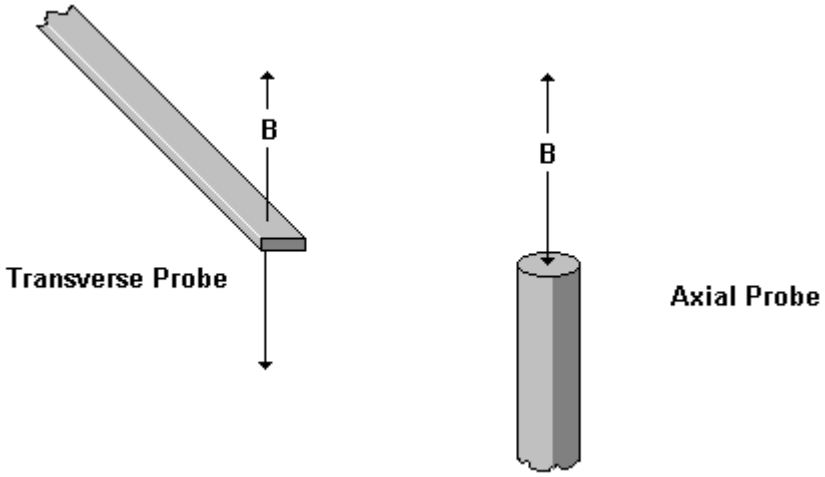


Figure 4.2.1 Hall Probe Orientation

4.2.2 AC Mode

Alternating magnetic fields may be measured using the AC mode of the Model 2100. When set to this mode, the Model 2100 will indicate the RMS value of the measured magnetic field but will not indicate the polarity (an alternating field, by definition, changes polarity).

Continuously alternating fields will normally be measured using the AC function of the Model 2100. To select AC operation, press the DC/AC key until the display DC/AC indicator is set to "AC". When the Model 2100 is configured for AC measurement, it will indicate the RMS value of the measured field. Keep in mind that the RMS measurement includes the alternating portion of the field as well as any static field that is present.

Probe orientation for alternating field measurements is identical to that for static field measurements.

4.2.3 Max Hold Function

To measure the peak or maximum value of either a static, alternating, or pulsed field, the Max Hold function of the Model 2100 should be used. To select the Max Hold function, press the front panel MAX/HOLD key until the display mode indicator is set to "MAX".

In Set menu item MAX Polarity, choose between "+ & -", "+ only" or "- only". Select "+ & -" to have the Model 2100 use both polarities of the signal when determining the maximum signal. Select "+ only" to use only the positive part of the signal when determining the maximum signal. Select "- only" to use only the negative part of the signal when determining the maximum signal.

When the Model 2100 is configured for peak measurement, the display indicates the peak magnetic field. To obtain a valid peak measurement, the pulse width of the measured field must be at least 100us. As the Model 2100 gain is increased, that is, as the lower ranges are selected, the pulse width may need to be greater than 100us to obtain an accurate measurement. Refer to the Model 2100 specifications for more specific instrument capabilities.

When making peak field measurements, the Hall probe orientation requirements are identical to those necessary for both static and alternating fields.

4.3 Selecting the Measurement Mode (Normal, Dual Limits, Relative or Temperature)

In addition to the type of field being measured, the user must also decide how the measurements will be displayed. The Model 2100 may be configured to provide a direct, relative, dual limits, or maximum readout. The Model 2100 can also indicate the temperature of the Hall probe.

Although the Model 2100 provides an indication of the Hall probe temperature, this temperature is meant to allow the instrument to compensate for Hall element sensitivity variations due to changes in temperature only. The Hall probe is not a thermometer. To prevent damage, avoid subjecting the Hall probe to extremes of temperature.

4.3.1 Normal Mode

For most measurement situations, the Model 2100 will be used in the normal mode of operation. In this mode, the Model 2100 gives a direct indication of the magnetic field that is measured. To select the normal mode of operation, press the front panel MODE key until the display mode indicator is set to “NORM”.

4.3.2 Dual Limits Mode

The Dual Limits mode allows the user to compare the field measurement against a user-defined upper and lower limit (section 3.9). The Model 2100 display will indicate if the measurement is between the upper and lower limits, less than the lower limit, or above the upper limit. In addition to the front panel indication, the Pass, High, and Low signals on the auxiliary output connector are active during this mode of operation. To select the Dual Limits mode, press the front panel MODE key until the display mode indicator is set to “DUAL”.

4.3.3 Relative Mode

Relative mode subtracts a user defined offset value from the measured field before the measurement is displayed. To select the relative mode of operation, press the front panel MODE key until the display mode indicator is set to “REL”. While in relative mode, pressing the ENTER key will store the current reading as the relative offset.

4.3.4 Temperature Mode

The temperature mode of operation allows the user to view the temperature of the Hall probe. This value is used to correct for Hall element sensitivity changes due to changes in temperature. To select the temperature mode, press the front panel MODE key until the display mode indicator is set to “TEMP”.

4.4 Selecting the Measurement Range

The Model 2100 allows the user to select from 10 different ranges (2 groups of 5 ranges). Whenever possible, the user should select a range such that the measured value will be at least one half the maximum value for the selected range. This will allow the maximum resolution of the Model 2100 to be realized.

Example: If the field to be measured is approximately 140 G, then the 200 G range would be a much better choice than the 2 kG range.

Alternatively, the user may use the Auto range function. In this case, the Model 2100 will automatically select the range giving the best resolution.

The Min/Max menu item allows the user to select between two groups of range values with each group containing 5 ranges.

Note: The actual range values available will depend on the Hall probe that is used.

4.5 Selecting the Display Period

The display period parameter determines the time interval between display information updates. This interval may be set to 10 ms or from 100 ms to 2500 ms, in 100 ms steps.

Setting the display period to a low value will cause the display to update more frequently, and will cause the gaussmeter to average fewer samples. Setting the display period to a higher value will cause the display to update less frequently and will cause the gaussmeter to average a larger number of samples. The display period will also affect the speed with which the Model 2100 will respond to remote interface commands (RS-232C and IEEE-488).

The selection of the display period is typically a compromise between the speed with which the user wants to see the display updated, and the amount of stability in the measurement indication. When the measured field is particularly “noisy”, a longer display period may be desirable.

To set the Model 2100 display period to the desired value, refer to Section 3.4 “Setting the Display Rate”.

4.6 Using the Analog Output

The analog output allows the user to view the wave shape of the field measured by the Model 2100. The analog output is scaled such that on any given range the full scale value will be one volt.

Example: If the Model 2100 is set to the 200 kG range, and a 20 kG field is being measured, the analog output will be approximately 0.10 volts.

When measuring an alternating or pulsed magnetic field, the signal present at the analog output will have a similar characteristic. That is, if an alternating field is being measured, then the signal at the analog output will also be alternating.

Refer to Appendix A.4 “Auxiliary Connector Pin Assignments”, for the analog output pin designations.

4.7 Using the Dual Limit Outputs

The Dual Limit outputs are accessible at the rear panel auxiliary connector. When the Model 2100 is configured for Dual Limits Mode, the limit outputs indicate the current state of the measured signal as compared to the user-defined upper and lower limits (Section 3.9). The limit outputs utilize inverse logic levels (active low).

Example: If the measured signal is less than the user-defined lower limit, then the Limits Low Output signal will be set to a logic low ($\leq$ 0.4 V) state, and the Limits High Output and Limits Pass Output will be set to a logic high ($\geq$ 2.4V) state.

When setting the upper and lower limits, the user should keep in mind that both the magnitude and polarity of the measured signal are compared against these limits.

Example: If the lower limit is set to 1000 kG and the measured field is -1100 kG, the Model 2100 will set the Limits High Output to a logic low state.

When the Model 2100 is not in the Dual Limit mode all the limit outputs are high. Refer to Section 3.9 “Setting the Upper and Lower Limit Values”, to define the upper and lower limit parameters. Refer to Appendix A.4 “Auxiliary Connector Pin Assignments”, for the limit outputs pin designations.

4.8 Using the Remote Reset

The Remote Reset is an input which allows the user to simulate the front panel RESET key without the use of the RS-232 or IEEE-488 interfaces. If a logic low (< 0.8 V) is placed on the Remote Reset pin, the Model 2100 will respond as if the front panel RESET key had been pressed. Refer to Appendix A.4 “Auxiliary Connector Pin Assignments”, for the Remote Reset pin designation.

4.9 Determining the Hall Probe Calibration Number

Hall probes supplied by Magnetic Instrumentation, Inc. for use with the Model 2100 will normally contain a correction EEPROM. In this case, the user will not be requried to enter the Hall probe calibration number.

If the user wishes to adapt an older Magnetic Instrumentation, Inc. probe for use with the Model 2100, the appropriate adapter must be obtained from Magnetic Instrumentation, Inc. In addition, the calibration number from the older probe must be converted to a calibration number that may be used by the Model 2100. Table 4.9.1 lists the conversions that must be performed for several older Magnetic Instrumentation, Inc. probe types.

Probe Model	Conversion
7300-***	(Old Number / 0.4) X 100000 = New Number
915-***	(Old Number / 0.4) X 100000 = New Number
912-***	(Old Number / 0.67) X 100000 = New Number
904-***	(Old Number / 38) X 100000 = New Number

Table 4.9.1 Calibration Number Conversion

4.10 Sources of Error

When using a Hall effect gaussmeter such as the Model 2100, several sources of error should be considered.

4.10.1 Probe Orientation

Hall elements are sensitive to magnetic fields in one axis only. If the sensitive axis of the Hall probe is not aligned with the direction of the field that is to be measured, an error will result. The magnitude of this error will depend on the degree of misalignment, and is defined by

$$\%Error = (1 - \cos\varnothing) \times 100\%$$

where ∅ is the angular deviation shown in Figure 4.10.1 below

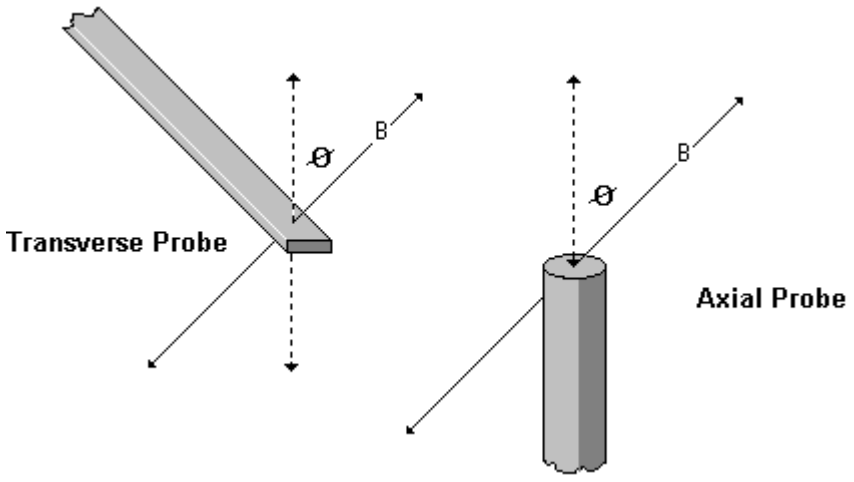


Figure 4.10.1 Hall Probe Orientation Error

4.10.2 Field Uniformity

Non-uniform fields may be a source of error if the magnetic field varies appreciably over the active area of the Hall element. The Hall element tends to average the magnetic field present within its active measurement area, therefore the measured value may not be a true representation of the peak value of the measured field. This error may become significant when measuring small magnets or assemblies. Magnetic Instrumentation, Inc. probe specifications include the active Hall element area to assist the user in selecting the appropriate probe for a specific application.

4.10.3 Instrument Specifications

The user should always refer to instrument specifications to determine the suitability of the Model 2100 for any measurement application. Only by referring to these specifications can the user begin to identify the measurement uncertainty in any application.

5. THEORY OF OPERATION

This section provides a brief overview of the Hall effect and general gaussmeter theory of operation.

5.1 [1] Hall Element Theory of Operation

When a magnetic field is applied to a conducting material carrying an electric current, there is a transverse Lorentz force on the charge carriers given by

$$F = \mu_0 e v \times H$$

The expression here is for the force on a single charge ***e*** with velocity ***v*** in a field of strength ***H.*** Because the force on a charge ***e*** can be expressed as

$$F = eE$$

where ***E*** is the electric field, we consider that the force is due to an equivalent electric field $\boldsymbol{E}_{\text{Hall}}$, known as the Hall field.

$$E_{Hall} = \mu_0 v \times H$$

and hence to a Hall e.m.f. $\boldsymbol{V}_{\text{Hall}}$, which is in the direction perpendicular to the plane containing ***i*** and ***H.*** The Hall e.m.f., therefore, depends linearly on the magnetic field ***H*** if the current is kept constant. This provides a very convenient measure of magnetic field ***H***, as the following analysis shows.

Referring to Figure 5.1.1, if the electric current passes in the **x** direction, and the magnetic field passes in the **y** direction of a slab of semiconductor of dimensions $\mathbf{l_x}$, $\mathbf{l_y}$, $\mathbf{l_z}$, the Hall e.m.f. will be along the **z**-axis.

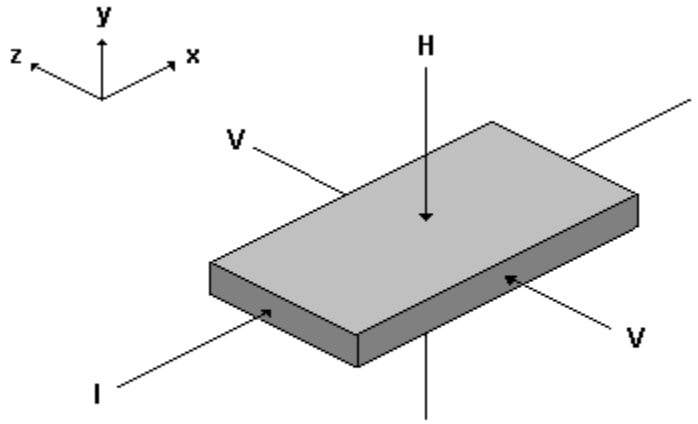


Figure 5.1.1 Hall Element

Hall effect elements can be fabricated with very small active areas. This allows the device to be used in situations where high spatial resolution is required. Another important factor is that unlike coils, which measure the flux linkage and must be scaled appropriately for their cross-sectional area in order to determine the magnetic induction, Hall elements measure the field strength directly.

The only difficulties with Hall elements arise from linearity errors at higher fields and from the temperature dependence of the response. In the case of Model 2100 Hall probes, both of these sources of error are compensated for by the use of a correction EEPROM included in the connector of the probe.

[1] Jiles, D. (1991) *Magnetism and Magnetic Materials,* Chapman and Hall, London.

5.2 General Gaussmeter Theory of Operation

To take advantage of the Hall effect, a gaussmeter needs to provide both a constant current source, and a method for measuring the Hall voltage. Along with these two basic requirements, there must normally be several stages of gain to amplify the Hall voltage to a suitable level, and a method for detecting alternating or pulse wave forms. Additionally, depending on the complexity of the instrument, a microprocessor may be required to interface with the instrument either directly (key pad) or indirectly (RS-232 or GPIB).

The following diagram and definitions give a simplified description of the Model 2100 Gaussmeter.

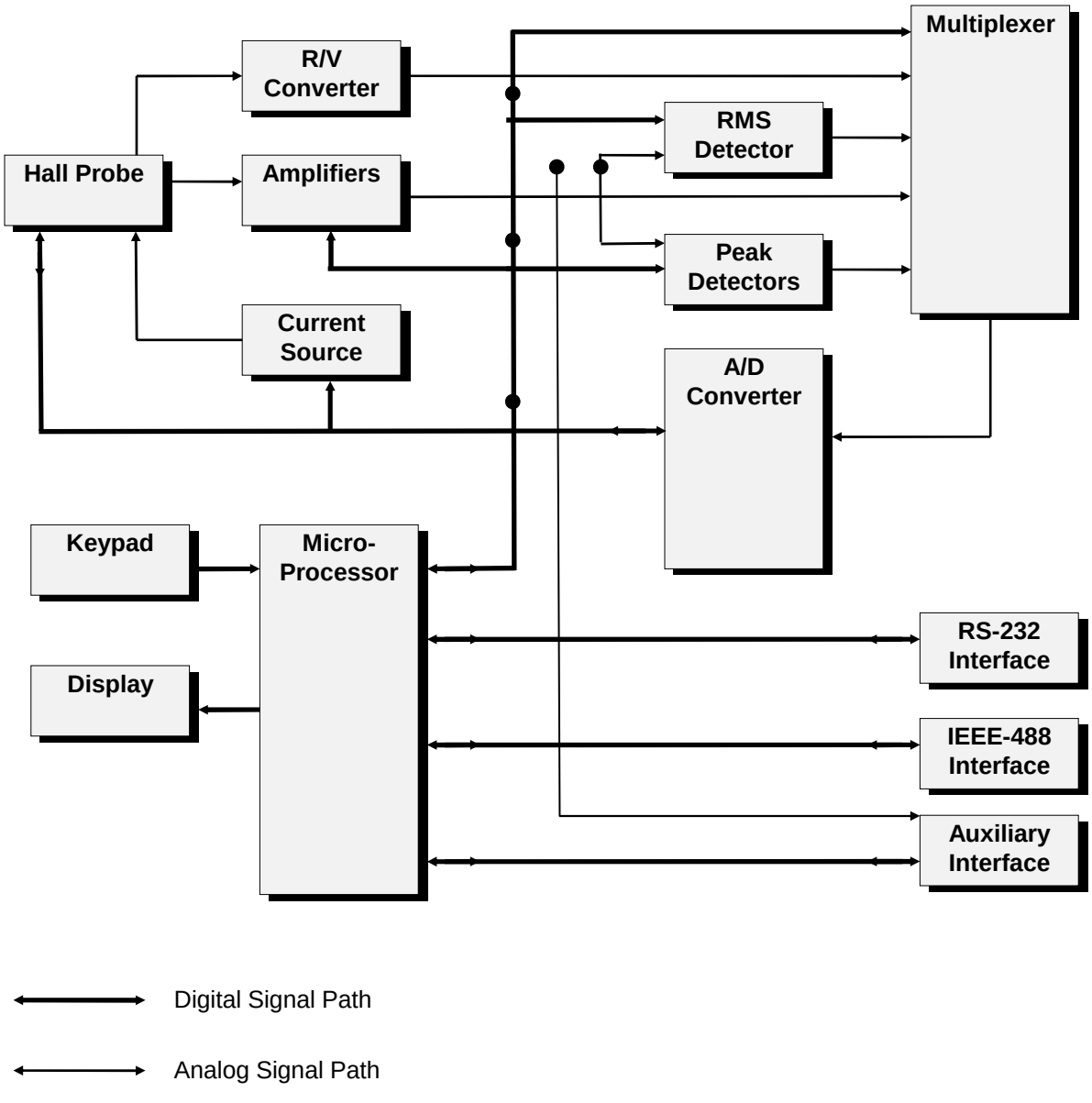


Figure 5.2.1 Model 2100 Block Diagram

Hall Probe
The Hall probe is composed of the Hall element, temperature sensor, and the correction EEPROM. The element converts the magnetic field to a voltage (see Section 5.1 “Hall Element Theory of Operation”). The temperature sensor converts the probe temperature to a resistance. This temperature is used to correct for Hall element sensitivity variations due to changes in temperature. The correction EEPROM contains sensitivity, temperature, and linearization correction data used by the Model 2100.

R/V converter
The resistance to voltage converter is used to convert the temperature sensor resistance into a voltage which can be measured by the A/D converter.

Amplifiers
The amplifiers amplify and scale the Hall voltage to a level that can be measured by the A/D converter.

Current Source
The current source supplies the excitation current for the Hall element.

RMS Detector
When the Model 2100 is placed in the AC function, the RMS detector is used to convert an alternating wave form to a direct voltage which can be measured by the A/D converter.

Peak Detectors
When the Model 2100 is placed in the Max Hold function, the peak detectors allow the peak amplitude of a wave form to be captured and stored until the A/D converter is able to measure the value.

Multiplexer
The multiplexer allows several different analog signals to be routed to the A/D converter.

A/D Converter
The A/D converter is used to convert the analog signals from various sources within the Model 2100 to digitized values that the microprocessor is able to use.

Keypad
The keypad acts as the interface between the user and the Model 2100. The keypad allows the user to select and edit the Model 2100 configuration.

Display
The Display conveys measurement and configuration information to the user.

Microprocessor
The microprocessor controls all meter functions, user interface and data processing for the Model 2100.

RS-232 Interface
The RS-232 interface converts RS-232 level signals to digital level, and digital level signals to RS-232 levels.

IEEE-488(GPIB) Interface
The IEEE-488 interface allows the microprocessor to communicate with an IEEE-488.1 compliant controller.

Auxiliary Interface
The Auxiliary interface provides an analog output, limits outputs, ±9V battery input and remote reset input at the Model 2100 rear panel auxiliary connector.

6. REMOTE OPERATION

6.1 General Communication Description

The Model 2100 may be controlled remotely using either the standard RS-232 serial interface, or the optional IEEE-488 (GPIB) interface. Either of these interfaces may be used to perform any operation that the user can accomplish from the front panel of the Gaussmeter. All information that is visible on the Model 2100 display is also accessible using the remote interfaces.

Unless otherwise specified, all remote operation descriptions given in this section apply to both the RS-232 and the IEEE-488 interface.

6.2 Communication Settings

6.2.1 RS-232 Settings

The RS-232 interface settings are factory-set and cannot be modified. These settings are shown in the following table.

Parameter	Setting
Baud Rate	9600
Word Length	8 bits
Parity	None
Stop Bits	1
Hand Shaking	None

Table 6.2.1 RS-232 Settings

6.2.2 IEEE-488 Settings

The IEEE-488 (GPIB) address may be set by the user and can range from 0 to 30. Refer to Section 3.16 “Setting the GPIB Address” for details on setting the address.The user application must read at least 36 characters to assure that the entire contents of the meter display are recognized.

6.3 Using the Remote Interface

The command set for the Model 2100 is divided into two categories; configuration commands, and query commands. The configuration commands are used to change meter settings such as range, mode, AC/DC, etc., while query commands are used to read meter settings.

Each command is composed of a single ASCII character. No termination characters (such as an ASCII #10, (carriage return)) are required after the command. Alpha characters received by the Model 2100 which are not part of the command set are ignored.

When using the RS-232 interface, each character received by the Model 2100 is echoed to the host PC. Once a character is sent to the Model 2100, no further characters should be sent until the echoed character is received. When the IEEE488 interface is used, characters are not echoed.

Some configuration commands require a parameter to specify the desired setting. In this case the parameter must directly follow the command. In other words no characters may be transmitted between the command and the parameter. The parameter must always contain two ASCII numeric characters.

While the Model 2100 menu system is enabled, the user may scroll through the menu options and parameters by simulating front panel key presses, or by sending numeric characters corresponding to the menu option or parameter.

Example: Suppose the menu system is active and is set to the top menu item “1. Display Rate”. If the user wishes to select the 3rd menu item “3. Probe Current” the RESET (UP) command may be sent two times, or the user may simply send the characters “03”.

Example: Suppose the “Upper Limit” parameter level menu is active. If the user wants to set the limit to +002000G, the RESET (UP) and DC/AC (DOWN) commands may be used to change the value one digit at a time, or the user may send the characters “+002000”. Both methods will have the same result.

6.4 Command Reference

A/D QUERY
Character: "V"
Parameter: none
Returns: *counts*
Description: Returns the current analog-to-digital converter *counts.* The value of counts will range from -32768 to 32767.
Example: Sending the A/D QUERY command will return a string similar to:

23534<CR><LF>

DC/AC (Down arrow)
Character: "Q"
Parameter: none
Returns: none
Description: Simulates the front panel DC/AC (Down arrow) key.

DIGITAL OFFSET QUERY
Character: "d"
Parameter: none
Returns: *digital offset*
Description: Returns the current *digital offset* value in bits. (Note, *digital offset* is determined during ZEROing. In DC mode, *digital offset* is used. In AC mode, it is not.)
Example: Sending the DIGITAL OFFSET QUERY command will return a string similar to:

+3<CR><LF>

DISPLAY QUERY
Character: "B"
Parameter: none
Returns: *display text*
Description: Returns the *display text* present on the Model 2100 display.
Example: When the DISPLAY QUERY command is sent, the Model 2100 will return a string of characters similar to:

-0.74G DC<CR><LF>
300 G NORM<CR><LF>

Note: Read 50 characters to assure that the entire buffer contents are read.

ENTER
Character: "E"
Parameter: none
Returns: none
Description: Simulates the front panel ENTER key.

EQUATION POSITIVE PARAMETERS QUERY
Character: "h"
Parameter: none
Returns: *positive equation parameters*
Description: Returns *positive equation parameters* separated by commas being used by the Model 2100.
Example: Sending the EQUATION POSITIVE PARAMETERS QUERY command will return a string such as the following:

-4.717050e-01, +9.381420e+00, -4.446620e-04, -8.940714e-09, +5.529150e-10, -2.347253e-13<CR><LF>

EQUATION NEGATIVE PARAMETERS QUERY
Character: "j"
Parameter: none
Returns: *negative equation parameters*
Description: Returns *negative equation parameters* separated by commas being used by the Model 2100.
Example: Sending the EQUATION NEGATIVE PARAMETERS QUERY command will return a string such as the following:

-4.717050e-01, +9.381420e+00, -4.446620e-04, -8.940714e-09, +5.529150e-10, -2.347253e-13<CR><LF>

GAIN QUERY
Character: "G"
Parameter: none
Returns: *gain*
Description: Returns the current *gain* setting of the Model 2100.
Example: Sending the GAIN QUERY command while the Model 2100 gain is set to 200 will return the following string.

200<CR><LF>

LOCK KEYPAD
Character: "Ok" (uppercase O, lower case k)
Parameter: none
Returns: none
Description: Disables input from the front panel keypad except for the RESET and ZERO buttons.

UNLOCK KEYPAD
Character: "OK" (uppercase O, upper case K)
Parameter: none
Returns: none
Description: Enables input from the front panel keypad.

MAX HOLD
Character: "H"
Parameter: none
Returns: none
Description: Simulates the front panel MAX HOLD key.

MENU QUERY
Character: "A"
Parameter: none
Returns: *menu state*
Description: Returns the *menu state* of the Model 2100. *Menu state* is defined below.

Menu	Menu state
Enabled	"S" when meter is in a SET menu or submenu.
Disabled	"T" when meter is not in a SET menu or submenu.

Table 6.4.1 Menu State

MODE
Character: "M"
Parameter: none
Returns: none
Description: Simulates the front panel MODE key.

MODE DIRECT
Character: "m"
Parameter: *mode number*
Returns: none
Description: Sets the Model 2100 to the mode specified by *mode number*. *Mode number* is defined in the following table.
Example: Sending the command "m01" will set the Model 2100 to Dual Limits mode.

Mode	Mode number
Normal	"00"
Dual Limits	"01"
Relative	"02"
Temp.	"03"

Table 6.4.2 Mode Numbers

MODE QUERY
Character: "K"
Parameter: none
Returns: *mode*
Description: Returns the current mode setting of the Model 2100.
Example: Sending the MODE QUERY command while the Model 2100 is set to the Normal mode will return the following string:

NORM<CR><LF>

NUMBER OF POSITIVE EQUATION PARAMETERS QUERY
Character: "g"
Parameter: none
Returns: *number of positive equation parameters*
Description: Returns the *number of positive equation parameters* setting of the Model 2100. This number will be greater than or equal to 2. If a probe with memory for correction parameters is connected to the Model 2100, this number can be as high as 7.
Example: Sending the NUMBER OF POSITIVE EQUATION PARAMETERS QUERY command will return a string such as the following:

6<CR><LF>

NUMBER OF NEGATIVE EQUATION PARAMETERS QUERY
Character: "i"
Parameter: none
Returns: *number of negative equation parameters*
Description: Returns the *number of negative equation parameters* setting of the Model 2100. This number will be greater than or equal to 2. If a probe with memory for correction parameters is connected to the Model 2100, this number can be as high as 7.
Example: Sending the NUMBER OF NEGATIVE EQUATION PARAMETERS QUERY command will return a string such as the following:

6<CR><LF>

PROBE CURRENT FACTOR QUERY
Character: "c"
Parameter: none
Returns: *Probe Current Factor*
Description: Returns the *Probe Current Factor* of the Model 2100. *Probe Current Factor* is defined below.

Probe Current	Probe Current Factor
12.5 mA or -12.5 mA	8
25 mA or -25 mA	4
50 mA or -50 mA	2
100 mA or -100 mA	1

Table 6.4.3 Probe Current Factor

Example: Sending the PROBE CURRENT FACTOR QUERY command while the Model 2100's *Probe Current* is set to 100 mA will return the following string:

1<CR><LF>

PROBE CURRENT SIGN QUERY
Character: "s"
Parameter: none
Returns: *probe current sign*
Description: Returns 1 if the Model 2100's *Probe Current* setting is positive. Returns 0 if it is negative.
Example: Sending the PROBE CURRENT SIGN QUERY command while the Model 2100's *Probe Current* is set to 100 mA will return the following string:

1<CR><LF>

PROBE MEMORY PRESENT FLAG QUERY
Character: "f"
Parameter: none
Returns: *probe memory flag*
Description: Returns 1 if the Model 2100 has a probe attached to it that has memory for correction parameters. Returns 0 if it does not.
Example: Sending the PROBE MEMORY PRESENT FLAG QUERY command while the Model 2100 has a probe attached to it that has memory will return the following string:

1<CR><LF>

RANGE
Character: "N"
Parameter: none
Returns: none
Description: Simulates the front panel RANGE key.

RANGE DIRECT
Character: "n"
Parameter: *range number*
Returns: none
Description: Sets the Model 2100 to the range specified by *range number*. *Range number* is defined in the following table.
Example: Sending the command "n04" will set the Model 2100 to the lowest range.
Note: the actual ranges will depend on the sensitivity of the Hall probe that is used.

Range Number	Range
"00"	Auto
"01"	Highest Range
"02"	2nd highest
"03"	Upper middle
"04"	Lower middle
"05"	2nd lowest
"06"	Lowest Range

Table 6.4.4 Range Numbers

RANGE QUERY
Character: "J"
Parameter: none
Returns: *range*
Description: Returns a string of characters indicating the current range setting the Model 2100.
Example: Sending the RANGE QUERY command while the Model 2100 is set to the 300kG range will return the following string:

300 kG<CR><LF>

RESET (Up arrow)
Character: "R"
Parameter: none
Returns: none
Description: Simulates the front panel RESET (Up arrow) key.

RESULT QUERY
Character: "I"
Parameter: none
Returns: *result*
Description: Returns a string of characters indicating the current measurement *result*.
Example: Sending the RESULT QUERY command will return a string similar to:

1001.7 G <CR><LF>

SET
Character: "S"
Parameter: none
Returns: none
Description: Simulates the front panel SET key.

TEMPERATURE COEFFICIENT FACTOR QUERY
Character: "a"
Parameter: none
Returns: *Temperature Coefficient Factor*
Description: Returns the current *Temperature Coefficient Factor* setting of the Model 2100. If probe memory exists, this factor is read from there; otherwise, it is entered in Set Menu Item 12.
Example: Sending the TEMPERATURE COEFFICIENT FACTOR QUERY command will return a string similar to:

+1.023456<CR><LF>

TEMPERATURE OFFSET COEFFICIENT FACTOR QUERY
Character: "b"
Parameter: none
Returns: *Temperature Offset Coefficient Factor*
Description: Returns the current *Temperature Offset Coefficient Factor* setting of the Model 2100. If probe memory exists, this factor is read from there; otherwise, it is entered in Set Menu Item 12.
Example: Sending the TEMPERATURE OFFSET COEFFICIENT FACTOR QUERY command will return a string similar to:

+0.012345<CR><LF>

VALUE PER BIT QUERY
Character: "v"
Parameter: none
Returns: *value per bit*
Description: Returns the current value of *value per bit*, which depends on various settings/parameters including what *Range* has been selected. The units for *value per bit* are Gauss/bit.
Example: Sending the VALUE PER BIT QUERY command will return a string similar to:

+1.234567<CR><LF>

ZERO
Character: "Z"
Parameter: none
Returns: none
Description: Simulates the front panel ZERO key.

7. SERVICE

7.1 General

Except for routine calibration, the Model 2100 will normally not require periodic service. No user serviceable parts are contained in the Model 2100.

7.2 Troubleshooting

If the Model 2100 gives readings which appear incorrect or erratic, the user should return the meter to factory default settings. This will eliminate the possibility that the problem is simply one of incorrect meter configuration. Refer to section 3.13, ”Setting Default Configuration” for instructions on resetting the meter configuration to factory default.

Table 7.2.1 is a listing of messages that may be displayed by the Model 2100. Some of these messages will appear each time power is supplied to the Model 2100 while other messages will only appear in the event of an error. Refer to Table 7.2.1 to identify possible problems and corrective action.

If the Model 2100 does not power up, first ensure that the instrument is connected to the proper power source. Next, inspect the fuse. To remove or replace the fuse, follow the steps below.

a) Set the Power Switch to the OFF position.

b) Remove the Power Cord.

c) Insert a small, flat-blade screwdriver into the slot located on the fuse holder door. Gently pry the door open.

d) Using an Ohmmeter, determine if the fuse is blown. Replace if necessary.

e) Insert the fuse into the fuse compartment and replace the fuse holder door.

f) Reconnect the Power Cord and place the Power Switch to the ON position.

g) If the Model 2100 still does not function after performing these steps, contact Magnetic Instrumentation, Inc. for assistance.

Message	Indication
"Standard Probe"	Indicates that the Model 2100 did not detect an EEPROM in the Hall probe handle. This is normal for probes that do not contain a correction EEPROM. If the probe does contain a correction EEPROM, this message may indicate a damaged probe.
"Probe Memory Detected"	Indicates that the Model 2100 has detected an EEPROM in the Hall probe handle. This is normal for probes that contain a correction EEPROM.
"No Temperature Sensor"	Indicates that the Model 2100 did not detect a temperature sensor in the Hall probe. This is normal for probes that do not contain a temperature sensor. If the probe does contain a temperature sensor, this message may indicate a damaged probe.
"NO PROBE"	Indicates that the Model 2100 did not detect a Hall probe. A damaged Hall probe may also cause this message to be displayed.
"Power Supply Error"	Indicates a failure in the Model 2100 ±5V power supply. When the Model 2100 is being powered from an external ±9VDC source, this error will result if the external source voltage is too low. If this message is displayed while powering the unit from an AC source, check to be certain the correct line voltage is being used. If this message persists, the unit should be returned to Magnetic Instrumentation, Inc. for repair.
"CheckSum Error"	Indicates a check sum error in the Model 2100 program memory. The unit should be returned to Magnetic Instrumentation, Inc. for repair.

Table 7.2.1 Model 2100 Display Messages

8. CONNECTOR PIN ASSIGNMENTS

8.1 GPIB Connector Pin Assignments

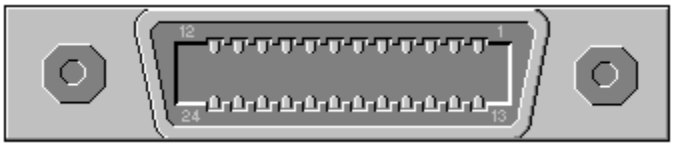


Figure 8.1.1 GPIB Connector

PIN	NAME	DESCRIPTION
1	DIO 1	Data Input / Output 1
2	DIO 2	Data Input / Output 2
3	DIO 3	Data Input / Output 3
4	DIO 4	Data Input / Output 4
5	EOI	End or Identify
6	DAV	Data Valid
7	NRFD	Not Ready For Data
8	NDAC	Not Data Accepted
9	IFC	Interface Clear
10	SRQ	Service Request
11	ATN	Attention
12	SHIELD	Cable Shield
13	DIO 5	Data Input / Output 5
14	DIO 6	Data Input / Output 6
15	DIO 7	Data Input / Output 7
16	DIO 8	Data Input / Output 8
17	REN	Remote Enable
18	GND	Ground Wire (twisted pair DAV)
19	GND	Ground Wire (twisted pair NRFD)
20	GND	Ground Wire (twisted pair NDAC)
21	GND	Ground Wire (twisted pair IFC)
22	GND	Ground Wire (twisted pair SRQ)
23	GND	Ground Wire (twisted pair ATN)
24	GND	Digital Ground

Table 8.1.1 GPIB Connector Pin Assignments

8.2 RS-232 Connector Pin Assignments

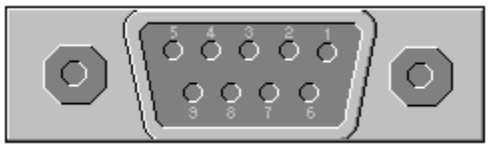


Figure 8.2.1 RS-232 Connector

PIN	NAME	DESCRIPTION
1		pins 1, 4, and 6 internally shorted
2	TXD	Transmit Data
3	RXD	Receive Data
4		pins 1, 4, and 6 internally shorted
5	GND	Ground
6		pins 1, 4, and 6 internally shorted
7		pins 7 and 8 internally shorted
8		pins 7 and 8 internally shorted
9		Not Connected

Table 8.2.1 RS-232 Connector Pin Assignments

8.3 Probe Connector Pin Assignments

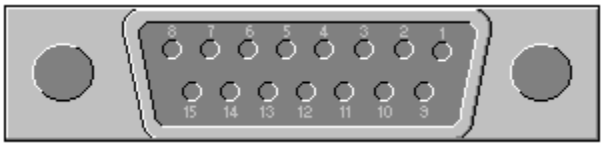


Figure 8.3.1 Probe Connector

PIN	NAME	DESCRIPTION
1	-I	Probe Current Return
2	+I	Probe Current High
3	+V	Hall Voltage High
4	-V	Hall Voltage Low
5	Temp1	Probe Thermistor
6	Temp2	Probe Thermistor
7	GND_T	Probe Thermistor Shield
8	GND_p	Probe Shield
9	GND_I	Probe Current Shield
10	GND_V	Hall Voltage Shield
11	PP	EEPROM Program Protect
12	SCL	EEPROM Serial Clock
13	SDA	EEPROM Data
14	GND_E	EEPROM Vss
15	Vcc	EEPROM Vcc

Table 8.3.1 Probe Connector Pin Assignments

8.4 Auxiliary Connector Pin Assignments

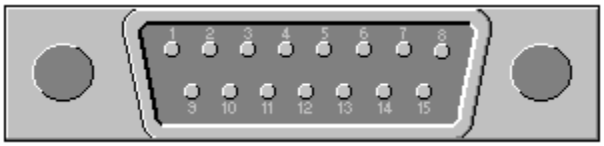


Figure 8.4.1 Auxiliary Connector

PIN	NAME	DESCRIPTION
1	GND	Ground
2	LH	Limits High Output (active low)
3	LL	Limits Low Output (active low)
4	GND	Ground (Limits Common)
5	LP	Limits Pass Output (active low)
6	RS	Remote Reset (active low)
7		Not Connected
8		Not Connected
9	+Batt	+9V Battery Connection
10	-Batt	-9V Battery Connection
11	GND	Ground (Battery Common)
12		Not Connected
13		Not Connected
14	AO	Analog Output
15	GND	Ground (Analog Output Common)

Table 8.4.1 Auxiliary Connector Pin Assignments

9. UNITS CONVERSION

9.1 CGS - SI Conversion

SI Units multiplied by Conversion equals CGS Units.

Quantity	SI Units	Conversion SI/CGS	CGS Units
Electric Current [I]	Ampere [A]	10^{-1}	abampere
Flux Density [B]	[1] Tesla [T]	10^4	Gauss [G]
Force	Newton [N]	10^5	dyne [dyn]
Intensity of Magnetization [J]	[3] Tesla [T]	$10^4/ 4\pi$	[2] e.m.u.
Length [l]	meter [m]	10^2	centimeter [cm]
[4] Magnetic constant [u_0]	Henry/meter [H/m]	$10^7/4\pi$	[unity]
Magnetic dipole moment [j]	[6] Weber meter [Wb m]	$10^{10}/4\pi$	[5] e.m.u.
Magnetic field strength [H]	Ampere/meter [A/m]	79.6	Oersted [Oe]
Magnetic flux [Æ]	Weber [W]	10^8	Maxwell [Mx]
Magnetic pole strength [p]	Weber [W]	$10^8/4\pi$	e.m.u.
Magnemotive force [F]	Ampere [A]		Gilbert [Gb]
Mass	kilogram [kg]	10^3	gram [g]
[7] Permeability, absolute [u]	Henry/meter [H/m]	$10^7/ 4\pi$	Unitless
[8] Permeability, relative [u]	-	1	-
[9] Permeance	Henry [H]	$4\pi/10^9$	Maxwell/gilbert
Power [P]	watt [W]	10^7	erg/second
Reluctance [Rm]	1/Henry [H^{-1}]	$4\pi/10^9$	Gilbert/Maxwell
[10] Susceptibility	ratio	$1/4\pi$	e.m.u
Temperature [T]	Kelvin [K]	K= °C + 273.16	degree Celsius [°C]
Time [t]	second [s]	1	second [s]
Work or energy	joule [J]	10^7	erg

Notes

1. *Equal to Webers per square meter.*
2. *Equal to $G/4\pi$ or dyn/cm^2Oe.*
3. *Equal to N/Am.*
4. *Equal to permeability of space.*
5. *Equal to dyn cm/Oe.*
6. *Equal to Nm^2/A.*
7. *Equal to B/H.*
8. *Equal to B/u_0H.*
9. *Inverse of reluctance.*
10. *Relative volume expressed as a percentage, equal to J/u_0H.*

Table 9.1.1 CGS-SI Units Conversion

10. DECLARATION OF CONFORMITY

We, Magnetic Instrumentation, Inc. declare under sole responsibility that the Model 2100 Gaussmeter to which this declaration relates is in conformity with emissions requirements CENELEC document EN5022 and for class B ITE and immunity requirements of CENELEC document EN50082-1, Part 1: Residential, Commercial, Light Industry (sections covered: Environmental Phenomena, RF Electromagnetic Field, Electrodischarge Air, Fast Transient, and Electrostatic Discharge Contact.)

The Technical Construction File is maintained at:

Magnetic Instrumentation, Inc.
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Testing performed by:

Radiometrics Midwest Corporation
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