

Fluxmeter Model 2130 Instruction Manual



Revision 3, 18-March-2013
Starting with Serial Number 41554

Manual Symbols and Messages

The following symbols and messages are used throughout this manual.



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.



The CAUTION Message indicates that a condition exists that may cause damage to the Model 2130.



The display symbol indicates the information displayed by the Model 2130 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 2130 Fluxmeter 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 100 kMaxwells to 100 MMaxwells (1 mWeber - 1 Weber) 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). Coil parameters such as number of turns, area, and resistance can be read from or written to the M2130, or manually entered using the menu system.

1.1.2 Key Features

- High Accuracy
- Low Drift with Automatic Drift Correction
- Measurement Ranges
- Single Button Zeroing and Calibration
- Measurement Functions (DC, AC, Peak)
- Modes of Operation (Normal, Dual Limit, and Relative)
- User-Defined Sampling Period from 10 ms to 2500 ms
- Readout in Maxwells, Maxwell Turns, Gauss, Tesla, Bdi (Gauss), or Bdi (Tesla)
- High Resolution ($4^{3/4}$ digit)
- 32-Character Display
- Compact Size (12.6" x 6.9" x 2.9")
- External Reset
- Factory-Set Default Mode
- Coil Parameters can be Stored and Read from Memory.
- Analog Output
- Dual Limit HI/GO/LO Outputs
- RS-232 Interface (Standard)
- IEEE-488 Interface (Option)
- Optional Rack Mount Kit (3.5" Single or Double Unit)
- Wide Selection of Search Coils and Helmholtz Coils Available

1.2 Front Panel Description

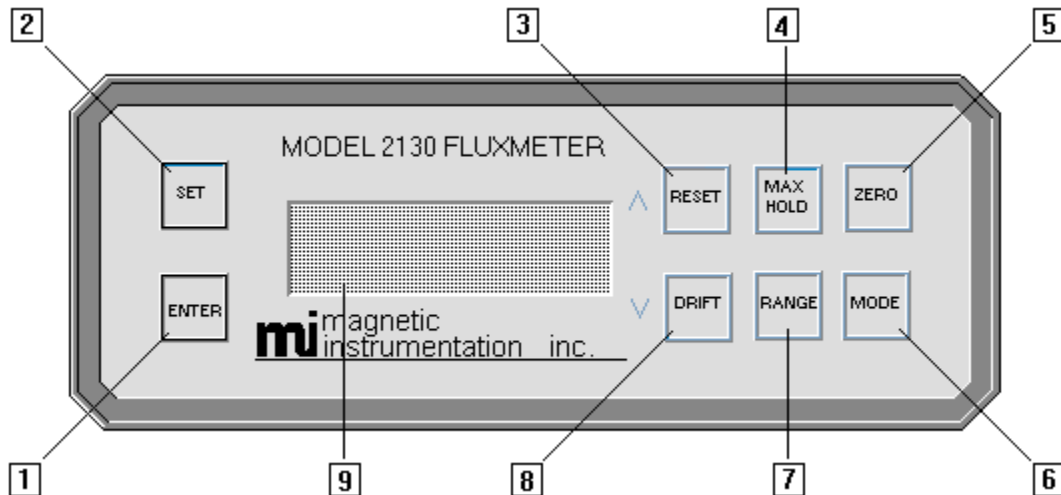


Figure 1.2.1 Model 2130 Front Panel

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, the RESET key resets the Model 2130's integrator. 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 and calibrate the Model 2130's integrator.
6	MODE Key	Switches between the NORMAL, DUAL LIMITS, and RELATIVE modes of operation.
7	RANGE Key	Selects the measurement range of the meter.
8	DRIFT Key	a) When the menu system is not enabled, the DRIFT key sets the drift compensation. "No" means the automatic drift compensation is disabled. "Lo", "Mi" and "Hi" are enabled states for the automatic drift compensation. b) When the menu system is enabled, the DRIFT key scrolls (decrements) through menu options and parameters.
9	Display	Conveys all measurement and configuration information to the user.

Table 1.2.1 Model 2130 Front Panel Items

1.3 Rear Panel Description

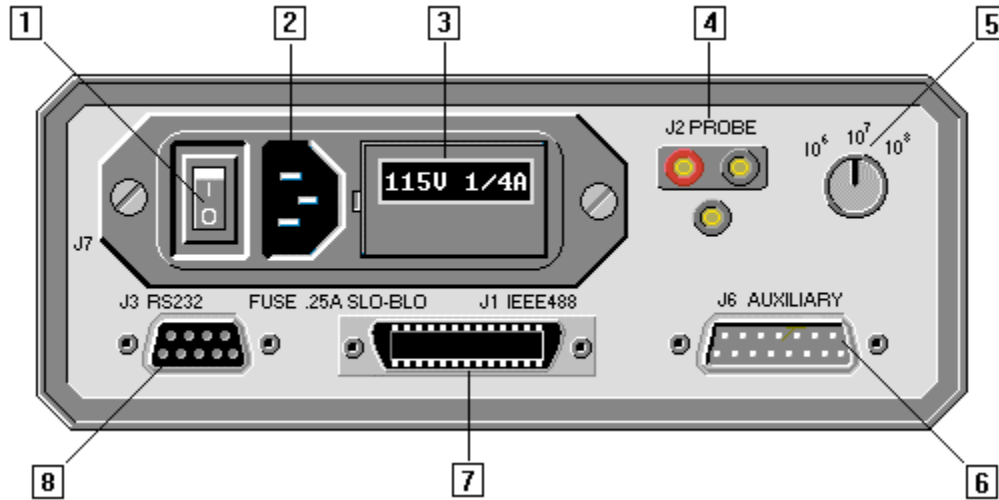


Figure 1.3.1 Model 2130 Rear Panel

Item	Name	Function
1	ON/OFF SWITCH	Connects or disconnects the Model 2130 from AC line voltage
2	POWER RECEPTACLE	Connects the power cord to the Model 2130.
3	FUSE HOLDER	Contains the line fuse for the 2130 meter. This fuse does not affect the operation of the meter from a ± 9 VDC power source.
4	PROBE CONNECTOR ¹	Connects a sense coil or Helmholtz coil to the Model 2130.
5	RANGE SWITCH	Coarse range selection (fine range selection is made via the front panel RANGE key).
6	J6 AUXILIARY CONNECTOR	Allows access to the analog output, limits outputs, ± 9 VDC input connections, and remote reset.
7	J1 GPIB CONNECTOR	Interfaces the Model 2130 to a GPIB controller.
8	J3 RS-232 CONNECTOR	Interfaces the Model 2130 to a PC serial port.

Table 1.3.1 Model 2130 Rear Panel Items

¹ The mating “dual miniature banana plug” (two pin plug) can be ordered as Magnetic Instrumentation part number 63012480. A “single miniature banana plug” (one pin plug) is available as part number 63012481.

1.4 Display Description

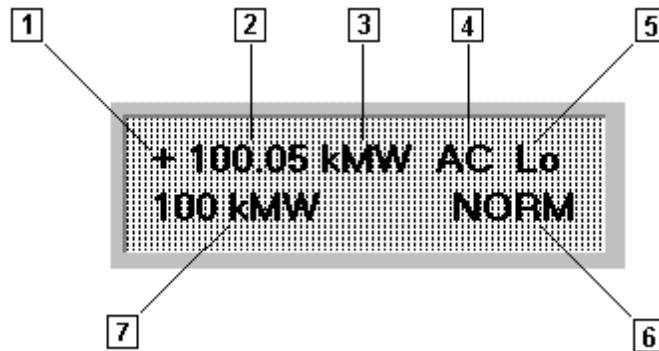


Figure 1.4.1 Model 2130 Display

Item	Name	Function
1	POLARITY	Indicates the polarity of the measured flux.
2	MEASUREMENT	Indicates the magnitude of flux being measured.
3	UNITS	Indicates the measurement units currently selected.
4	DC/AC	Indicates whether the Model 2130 is measuring a static or alternating flux. This space is blank when the meter is in DC mode. The letters AC are displayed when the meter is in AC mode.
5	DRIFT CORRECTION	Indicates the drift correction speed currently selected. When no dots appear before the drift correction speed, the reading is approximately within $\pm 0.5\%$ of the displayed range and the meter is continuously performing drift correction. When a single dot appears before the drift correction speed, the reading is between approximately $+0.5$ to $+1\%$ or -0.5 to -1% of the displayed range and the meter is continuously performing drift correction. When two dots appear before the drift correction speed, the reading is outside of the aforementioned percentages of the displayed range and no drift correction is being performed.
6	MODE	Indicates the measurement mode currently selected.
7	RANGE	Indicates the range currently selected.

Table 1.4.1 Model 2130 Display Items

1.5 Specifications

1.5.1 Accuracy Specifications

Function	Range	Typical (% of range)	Maximum (% of range)	Conditions
Normal (DC)	$10^5 - 10^8$	0.050	0.100	-
AC (RMS)	$10^5 - 10^8$	0.500	1.000	20 Hz - 30 Hz
AC (RMS)	$10^5 - 10^8$	0.300	0.700	30 Hz - 1 kHz
Max Hold (Peak)	$10^5 - 10^8$	0.300	0.800	≥ 1 ms Pulse width
Analog Output	$10^5 - 10^8$	0.150	0.400	Specification is for the deviation of the analog output compared to the Model 2130 display value.

Table 1.5.1 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, Output impedance 100Ω
Dual Limit Outputs	Low-power Schottky outputs (74LS37) DB-15 male connector <u>Source</u> $V_{OH} \geq 2.4$ V @ ≤ -1.2 mA <u>Sink</u> $V_{OL} \leq 0.4$ V @ ≤ 48 mA
Remote Reset	Low-power Schottky input (74LS37) DB-15 male connector <u>Input</u> (internal $10k\Omega$ pull up resistor) $V_{IH} \geq 2.0$ V $V_{IL} \leq 0.8$ V
Probe Input	Single ended with separate chassis ground Miniature banana jacks <u>input impedance</u> 10^6 range = $1k\Omega$ 10^7 range = $11k\Omega$ 10^8 range = $101k\Omega$

Table 1.5.2 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	7.5 lbs.
Power	115 or 220 VAC 50/60 Hz
Fuse	0.25A 250V type 3AG

Table 1.5.3 General Specifications

1.5.4 Radiated RF Immunity

When operated in a field of 3.0V/M at frequencies from 26 MHZ to 500 MHZ reading may change by as much as 40 KMT.

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 2130. No user serviceable parts are contained in this instrument. If repair or modifications are required, contact Magnetic Instrumentation, Inc. for assistance.

**CAUTION**

- e) Handling
The Model 2130 is a rugged, dependable instrument. As with any precision instrument, however, care should be taken when handling or storing this fluxmeter. Avoid dropping or jarring the Model 2130. Store the Model 2130 in a cool dry environment when it is not in use. Do not use solvents or abrasives to clean the exterior of this instrument.

2. INITIAL SETUP

2.1 Unpacking

- a) Before opening the Model 2130 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 2130 needs to be returned to Magnetic Instrumentation, Inc., the original shipping container will provide the best means of repackaging the fluxmeter 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 2130 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. Please report any damaged items to Magnetic Instrumentation, Inc. immediately.

2.2 Model 2130 Functional Check



CAUTION

Before attempting to apply power to the Model 2130, 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 2130 to line power using the supplied power cord.
- b) Connect a search coil, Helmholtz coil, or shorting bar to the rear terminal probe connector.
- c) Apply power to the Model 2130 by placing the power switch to the **ON** position. The display should momentarily display the following message:

**Magnetic
Instrumentation**
- d) Set the Range Switch on the rear panel to “107” position.
- e) 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
- f) Press the front panel UP (RESET) key or the DOWN (DRIFT) key until the menu system is set to the Default menu item.

SET
9. Default

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

**Set to Default
NO**

- h) Press the front panel UP (RESET) key or the DOWN (DRIFT) key to set the parameter to “All sets”.

**Set to Default
All sets**

- i) 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**

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

**00.000 MMT Mi
10 MMT NORM**

- k) The Model 2130 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	Maxwell Turns
3	Coil Parameter - Coil Resistance	0.0 Ohms
3	Coil Parameter - Coil Area	1.0 cm ²
3	Coil Parameter - Coil Turns	1 Turns
3	Coil Parameter - Helmholtz Constant	0.0143
4	Magnet Volume	1.0 cm ³
5	Calibration Coefficient	400000 MT/Vo
6	Dual Limits - Upper Limit	+0000001500 MT
6	Dual Limits - Lower Limit	+0000000500 MT
7	Relative Offset	+000001000 MT
8	Drift Rates	Lo, Mi and Hi enabled
9	Default	Set to Default - NO
10	GPIB Address	1
11	DC/AC Function	DC
12	Keypad Active	active
13	Setup #	1
-	Mode	Normal
-	Drift	No

Table 2.2.1 Default Configuration

3. USING THE MENU SYSTEM

Set the rear panel range switch to 10^7 for all examples shown in this section.

3.1 *General Menu Description*

The Model 2130 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 (DRIFT) 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. Change Unit).

The DOWN (DRIFT) 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 2130 Fluxmeter.

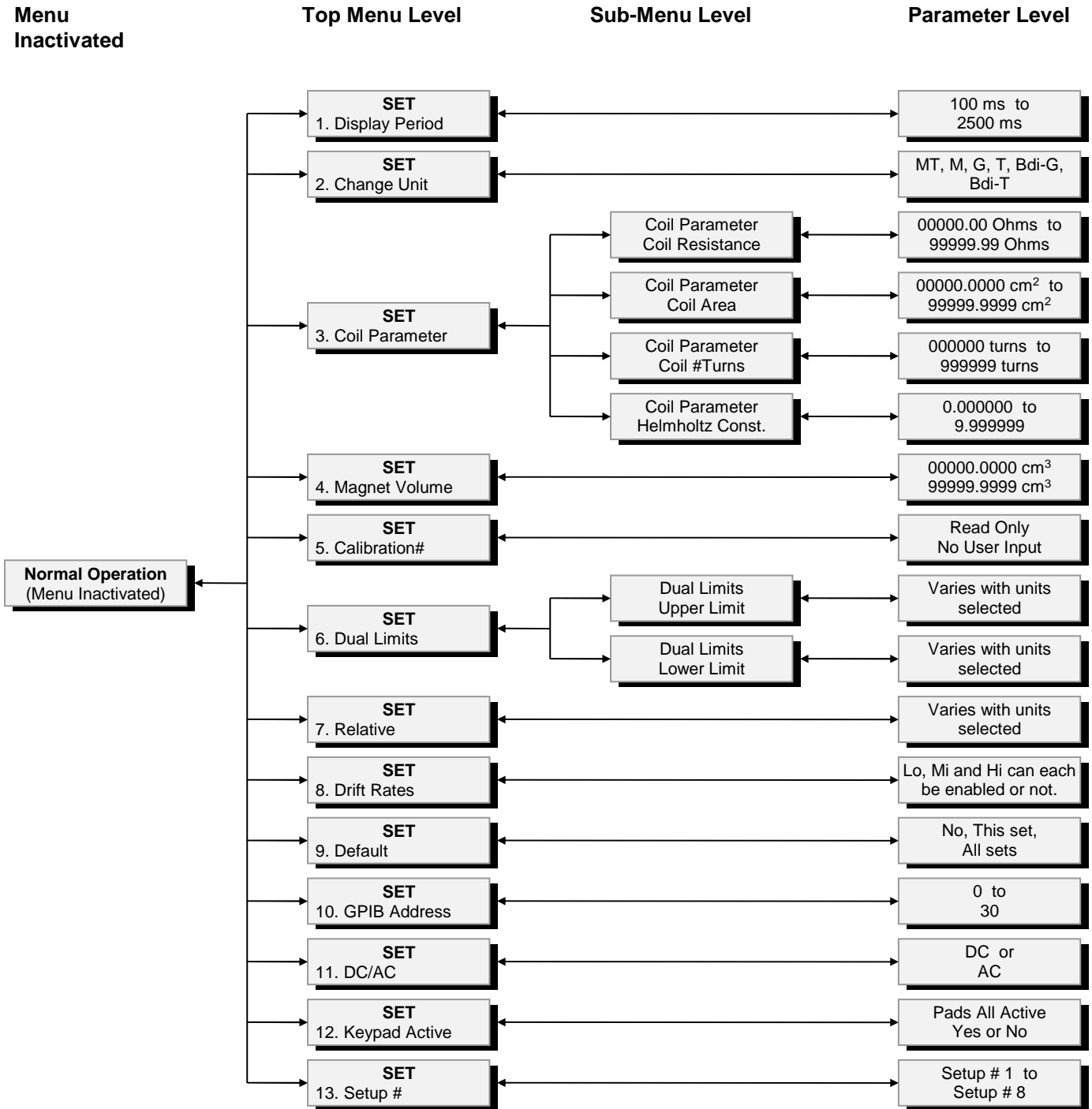


Figure 3.3.1 Model 2130 Menu System

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 fluxmeter to average fewer samples. Setting the display period to a higher value will cause the display to update less frequently, and will cause the fluxmeter to average a larger number of samples. The display period will also affect the speed with which the Model 2130 will respond to remote interface commands (RS-232C and IEEE-488). A longer interval leads to slower response.
2	Change Unit	Determines the measurement units displayed by the Model 2130.
3	Coil Parameters	Allows the user to enter information about the search coil or Helmholtz coil that is connected to the Model 2130. Some of the parameters will only be utilized when a particular measurement unit is selected. For instance, the Helmholtz constant is only used when either the Bdi (Gauss) or Bdi (Tesla) units are selected. Other parameters, such as coil resistance, are used by all measurement units. The fluxmeter ignores the parameters that are not necessary for a particular measurement unit.
4	Magnet Volume	Allows the user to enter the volume of a magnet specimen. This parameter is only used when the Bdi (Gauss) or Bdi (Tesla) measurement units are selected.
5	Calibration #	Allows the user to view the calibration correction coefficient for the Model 2130's integrator. This parameter cannot be modified by the user, but is updated by the fluxmeter after each zero/calibration cycle.
6	Dual Limits	Determines the lower and upper limits used by the Model 2130 while the Dual Limits mode is selected.
7	Relative	Determines the relative offset used by the Model 2130 while in the Relative mode of operation.
8	Drift Rates	Lo, Mi and Hi Drift Rates can each be either enabled or disabled.
9	Default	Allows the user to reset the meter to factory default settings for all parameters. Selecting the "This set" parameter will only set the current setup to default, while selecting the "All sets" parameter will set all eight setups to default. Note that resetting the Model 2130 to factory default will set the GPIB address to 1. If the GPIB remote interface is used to set the Model 2130 to factory default, communication may be lost if the fluxmeter GPIB address was previously set to any address other than 1.
10	GPIB Address	Determines the GPIB address used by the Model 2130.
11	DC/AC	Determines the measurement function used by the Model 2130.
12	Keypad Active	The user can set all keypads to be active or only the RESET, DRIFT 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.
13	Setup #	Determines the active setup number.

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.

SET 1. Display Period
--

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

SET 1. Display Period
--

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

Display Period 100 ms
--

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

Display Period 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.

SET 1. Display Period
--

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

000.01 kMT	Mi
100 kMT	NORM

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 (DRIFT) key until the menu system is set to the Change Unit menu item

SET 2. Change Unit

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

Change Unit Maxwell Turns
--

- d) Press the front panel UP (RESET) key or DOWN (DRIFT) key to change the parameter to the desired measurement units. In this example, the measurement unit is set to Gauss.

Change Unit Gauss

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

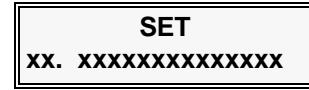
SET 2. Change Unit

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

000.01 kG	Mi
100 kG	NORM

3.6 Setting the Coil Resistance

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 (DRIFT) key until the menu system is set to the Coil Parameter 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 (DRIFT) key to select the Coil Resistance sub menu item.



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



f) Press the front panel DOWN (DRIFT) 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. In this example the coil resistance is set to 5 Ohms.



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



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



3.7 Setting the Coil Area

- 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.

<p style="text-align: center;">SET 1. Display Period</p>

- b) Press the front panel UP (RESET) key or the DOWN (DRIFT) key until the menu system is set to the Coil Parameter menu item.

<p style="text-align: center;">SET 3. Coil Parameters</p>
--

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

<p style="text-align: center;">Coil Parameter xxxxxxxx</p>

- d) Press the front panel UP (RESET) key or DOWN (DRIFT) key to select the Coil Area sub menu item.

<p style="text-align: center;">Coil Parameter Coil Area</p>
--

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

<p style="text-align: center;">Coil Area <u>00000</u>1.0000 cm²</p>

- f) Press the front panel DOWN (DRIFT) 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. In this example the coil area is set to 5 cm².

<p style="text-align: center;">Coil Area 00000<u>5</u>.0000 cm²</p>

- g) Press the front panel ENTER key to store the changes to the meter configuration. The system will return to the Coil Parameter sub menu item.

<p style="text-align: center;">Coil Parameter Coil Area</p>
--

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

<p style="text-align: center;">000.01 kMT Mi 100 kMT NORM</p>

3.8 Setting the Coil Turns

- 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.

<p style="text-align: center;">SET 1. Display Period</p>

- b) Press the front panel UP (RESET) key or the DOWN (DRIFT) key until the menu system is set to the Coil Parameter menu item.

<p style="text-align: center;">SET 3. Coil Parameter</p>

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

<p style="text-align: center;">Coil Parameter xxxxxxxx</p>

- d) Press the front panel UP (RESET) key or DOWN (DRIFT) key to select the Coil #Turns sub menu item.

<p style="text-align: center;">Coil Parameter Coil #Turns</p>
--

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

<p style="text-align: center;">Coil #Turns <u>0</u>00010 turns</p>

- f) Press the front panel DOWN (DRIFT) 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. In this example the coil area is set to 100 turns.

<p style="text-align: center;">Coil #Turns 000<u>1</u>00 turns</p>

- g) Press the front panel ENTER key to store the changes to the meter configuration. The menu system will return to the Coil Parameter sub menu item.

<p style="text-align: center;">Coil Parameter Coil #Turns</p>
--

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

<p style="text-align: center;">000.01 kMT Mi 100 kMT NORM</p>

3.9 Setting the Helmholtz Constant for use with Helmholtz Coils

- 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) Using the steps in Section 3.5 "Setting the Measurement Units," change the measurement unit to Bdi Gauss or Bdi Tesla.

- c) Press the front panel UP (RESET) key or the DOWN (DRIFT) key until the menu system is set to the Coil Parameter menu item.

```

SET
3. Coil Parameter
  
```

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

```

Coil Parameter
xxxxxxx
  
```

- e) Press the front panel UP (RESET) key or DOWN (DRIFT) key to select the Helmholtz Const. sub menu item.

```

Coil Parameter
Helmholtz Const.
  
```

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

```

Helmholtz Conts.
0.014300
  
```

- g) Press the front panel DOWN (DRIFT) 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. In this example the Helmholtz constant is set to 0.076.

```

Helmholtz Conts.
0.076000
  
```

- h) Press the front panel ENTER key to store the changes to the meter configuration. The menu system will return to the Coil Parameter sub menu item.

```

Coil Parameter
Helmholtz Const.
  
```

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

```

000.01 kBG      Mi
100 kBG         NORM
  
```


3.10 Setting the Magnet Volume

- 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 (DRIFT) key until the menu system is set to the Magnet Volume menu item.

```

SET
4. Magnet Volume
  
```

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

```

Magnet Volume
00001.0000 cm^3
  
```

- d) Press the front panel DOWN (DRIFT) 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. In this example the magnet volume is set to 2.5 cm³.

```

Magnet Volume
00002.5000 cm^3
  
```

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

```

SET
4. Magnet Volume
  
```

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

```

000.01 kMT      Mi
100 kMT         NORM
  
```

3.11 Viewing the Calibration Coefficient

- 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 (DRIFT) key until the menu system is set to the Calibration # menu item.

SET 5. Calibration#

- c) Press the front panel ENTER key to enter the menu parameter level. The display will show the calibration coefficient from the last calibration performed. This parameter can not be modified by the user, but is updated each time the fluxmeter is calibrated.

Calibration # 011253 MT / Vo

- d) Press the front panel SET key to return to the Calibration # menu item.

SET 5. Calibration #

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

000.01 kMT	Mi
100 kMT	NORM

3.12 Setting the Lower Limit

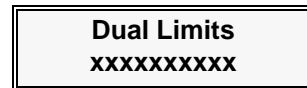
a) Press the front panel SET key until the menu system is active and is at the top menu level. This is indicated by the appearance of the “SET” message on the top row of the display.



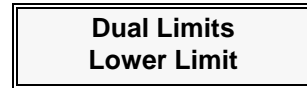
b) Press the front panel UP (RESET) key or the DOWN (DRIFT) key until the menu system is set to the Dual Limits menu item.



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



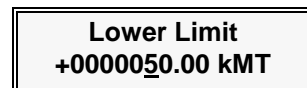
d) Press the front panel UP (RESET) key or DOWN (DRIFT) key to select the Lower Limit sub menu item.



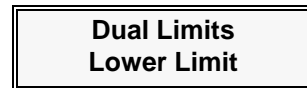
e) Press the front panel ENTER key to enter the menu parameter level.



f) Press the front panel DOWN (DRIFT) 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. In this example the lower limit is set to 50.0 kMT.



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



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



3.13 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 (DRIFT) 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
xxxxxxxxxx

d) Press the front panel UP (RESET) key or DOWN (DRIFT) 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.

Upper Limit
+000000.00 kMT

f) Press the front panel DOWN (DRIFT) 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. In this example the lower limit is set to 50.0 kMT.

Upper Limit
+000050.00 kMT

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

Dual Limits
Upper Limit

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

000.01 kMT Mi
100 kMT NORM

3.14 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.

<p>SET 1. Display Period</p>

- b) Press the front panel UP (RESET) key or the DOWN (DRIFT) key until the menu system is set to the Magnet Volume menu item.

<p>SET 7. Relative</p>

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

<p>Relative Offset ±0000000.00 kMT</p>
--

- d) Press the front panel DOWN (DRIFT) 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. In this example the relative offset is set to 1000 kMT.

<p>Relative Offset +000<u>1</u>000.00 kMT</p>

- 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.

<p>SET 7. Relative</p>

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

<p>000.01 kMT Mi 100 kMT NORM</p>

3.15 Enabling/Disabling the Drift Rates

- 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 (DRIFT) key until the menu system is set to the Drift Rates menu item.

```

SET
8. Drift Rates
  
```

- c) Press the front panel UP (RESET) key or the DOWN (DRIFT) key until the desired drift rate is displayed. Then, press the front panel ENTER key to enter the menu parameter level.

```

Drift Rate
Lo
  
```

- d) Press the front panel UP (RESET) key or the DOWN (DRIFT) key to enable or disable the particular drift rate. This selection applies to what drift rate(s) are available to the user when pressing the front panel DRIFT button with the normal data screen displayed. (RS-232 interface still pick any of the drift rates.)

```

Use Lo Drift
Yes
  
```

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

```

SET
8. Drift Rates
  
```

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

```

000.01 kMT      Mi
100 kMT         NORM
  
```

3.16 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.

SET 1. Display Period
--

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

SET 9. Default

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

Set to Default NO

- d) Press the front panel UP (RESET) key or the DOWN (DRIFT) key to set the parameter to “This set”, or “All sets”.

Set to Default This set
--

- e) 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

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

000.01 kMT Mi 100 kMT NORM

3.17 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.

SET 1. Display Period
--

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

SET 10. GPIB Address

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

GPIB Address 1

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

GPIB Address 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.

SET 10. GPIB Address

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

000.01 kMT	Mi
100 kMT	NORM

3.18 Setting the DC/AC 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.

SET 1. Display Period
--

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

SET 11. DC / AC

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

DC / AC DC

- d) Press the front panel UP (RESET) key or the DOWN (DRIFT) key to obtain the desired function. In this example, the function is set to AC.

DC / AC AC

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

SET 11. DC / AC

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

000.01 kMT	Mi
100 kMT	NORM

3.19 Setting the Keypad Active Function

- g) 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
--

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

SET 12. Keypad Active
--

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

Pads All Active Yes

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

Pads All Active No

- k) 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.

SET 12. Keypad Active
--

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

000.01 kMT Mi 100 kMT NORM

3.20 Selecting the active Setup

- 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 (DRIFT) key until the menu system is set to the Setup # menu item.

SET 13. Setup #

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

Setup # 1

- d) Press the front panel UP (RESET) key or the DOWN (DRIFT) key to select the desired setup number. In this example, the function is set to 2.

Setup # 2

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

SET 13. Setup #

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

000.01 kMT	Mi
100 kMT	NORM

4. MEASUREMENT CONSIDERATIONS

4.1 General Measurement Considerations

The Model 2130 allows the user to configure the fluxmeter for many different types of measurement situations. To realize the full potential of the Model 2130, the user must become familiar with some general guidelines for making measurements. This section will cover some of the basic configurations of the Model 2130 as well as the use of the auxiliary outputs (analog and dual limits).

This section assumes that the user is familiar with Model 2130 controls and the menu system as covered in Chapters 1, and 3 of this manual.

Since a magnetic flux in vacuum or air is referred to as a “magnetic field”, and a change in either magnetic field or flux can be readily measured by an integrating fluxmeter, the terms “flux” and “field” are sometimes used interchangeably. Keep in mind that magnetic flux is the more general term, and magnetic field is a magnetic flux in air or vacuum.

4.2 Selecting the Measurement Mode (DC, AC) and Max Hold function.

To make a relevant measurement, the user must know some characteristics of the magnetic flux to be measured. Magnetic flux may be Static (DC), Alternating (AC), pulsed, or any combination of the above in nature. These magnetic flux 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 2130 must also be properly configured to measure various types of magnetic flux. The DC and AC modes are accessed through the menu system. The peak reading mode is activated using the “Max Hold” button on the meter front panel.

4.2.1 DC Mode

The Model 2130, like all integrating fluxmeters, is only able to measure a change in magnetic flux. The term “DC” in this context refers to a flux quantity that undergoes a change, but does not change polarity. The change in flux may be due to a change in the magnetic field on the part being measured, or a change in the position of the coil being used to sense the magnetic flux.

While the DC mode is selected, the Model 2130 will indicate both the magnitude and polarity of the measured flux. The user should keep in mind that magnetic flux is a vector quantity. That is, the flux has both a magnitude and a direction. Search coils are sensitive to magnetic flux in one axis only. If the axis of the search coil is not aligned with the direction of the flux to be measured, an error will result. The proper orientation of the search coil to the magnetic flux is shown in the following figure. To quantify the error resulting from misalignment, refer to section 4.13, “Sources of Error”.

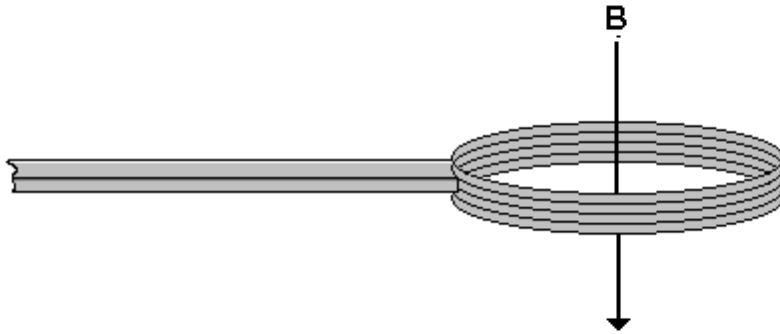


Figure 4.2.1 Search Coil Orientation

4.2.2 AC Mode

Alternating magnetic fields may be measured using the AC mode of the Model 2130. When set to this mode the Model 2130 will indicate the RMS value of the measured magnetic field but will not indicate the polarity (an alternating field, by definition, changes polarity). Note that the Model 2130 does not indicate RMS values in the true sense. In the AC mode, the output of the integrator is actually AC coupled to the RMS detector. This helps eliminate the problem of integrator drift causing the apparent measured AC field from drifting as well.

4.2.3 Max Hold Function

The Max Hold function only works when the meter is in DC mode. It allows the Model 2130 to capture the peak value of either an alternating or pulsed magnetic field or flux. The peak detection scheme used by the Model 2130 allows the fluxmeter to capture either the maximum positive or negative excursion of the measured flux. This value is then saved by the fluxmeter until either a larger value is detected, or a reset command is received (reset is initiated by the front panel RESET key, an RS232 or GPIB reset command, or a logic low on the remote reset pin of the auxiliary connector).

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

In addition to selecting the appropriate measurement mode (DC, AC or DC Peak), the user must also decide how the flux measurement will be displayed. The Model 2130 may be configured to provide a Normal, Dual Limits, or Relative readout.

4.3.1 Normal Mode

For most measurement situations, the Model 2130 will be used in the normal mode of operation. In this mode, the Model 2130 gives a direct indication of the magnetic flux that is measured.

4.3.2 Dual Limits Mode

The Dual Limits mode allows the user to compare the flux measurement against a user-defined upper and lower limit (refer to Sections 3.12 - 3.13 on setting the upper and lower limit). The Model 2130 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. (See Sections 4.1.1 and 8.3 for details.)

4.3.3 Relative Mode

Relative mode subtracts a user defined offset value from the measured flux before the measurement is displayed. This is useful, for example, if the user wishes to show the deviation of a measurement from a known value.

4.4 Selecting the Measurement Range

The Model 2130 allows the user to select from twelve measurement ranges. Each of these ranges is selected by using a combination of the rear panel range switch (coarse range select) and the front panel range key (fine range select). The actual range values will vary depending on the calibration coefficient for the fluxmeter's integrator, however the values shown in table 4.4.1 are typical.

Switch Position	Ranges Available			
10^6	100 kMT	200 kMT	500 kMT	1 MMT
10^7	1 MMT	2 MMT	5 MMT	10 MMT
10^8	10 MMT	20 MMT	50 MMT	100 MMT

Table 4.4.1 Typical Range Values

4.5 Selecting the Measurement Units

The Measurement units selected will depend on both user preference and the type of measurement to be performed. The Model 2130 allows the user to select from six measurement units.

4.5.1 Maxwell-Turns

Maxwell-Turns is the default measurement unit for the Model 2130. This measurement unit indicates the total flux crossing perpendicular to the search coil assuming that the search coil consists of a single turn. To indicate the true flux through the coil, the measurement must be divided by the number of turns in the coil.

4.5.2 Maxwells

The Maxwells unit is identical to Maxwell-Turns, with the exception that the measurement result is already divided by the number of turns entered in the Model 2130's coil parameter menu.

4.5.3 Gauss

The Gauss is the cgs unit for of flux density. It is defined as 1 Maxwell per cm^2 . To use this measurement unit, both the number of turns, and the coil area must be entered into the Model 2130's coil parameter menu. The shape and area of the sample must be very close to those of the search coil.

4.5.4 Tesla

The Tesla is the SI unit for flux density. It is defined as 1 Weber per m^2 (1 Weber = 10^8 Maxwells, 1 Tesla = 10^4 Gauss).

4.5.5 Bdi-Gauss

The Bdi-Gauss is a measure of the intrinsic remanent induction in a magnet sample. This unit should only be selected when the Model 2130 is used in conjunction with a Helmholtz coil. The Helmholtz constant for the coil and the volume of the magnet sample must be known, and entered into the coil parameter menu.

4.5.6 Bdi-Tesla

The Bdi-Tesla unit is similar to the Bdi-Gauss unit except that the unit for induction is in Tesla instead of Gauss.

4.6 Selecting a Search Coil

One of the real advantages of a fluxmeter is its ability to use almost any coil of wire as a sensor. However, the user should consider several parameters when deciding on the search coil for a particular application.

4.6.1 Number of Turns

The output voltage from a search coil for a given change in flux is directly proportional to the number of turns it contains. Since the Model 2130 readout is usually more stable as the range is increased, there is a definite advantage to having a large number of turns in the search coil when measuring a small change in flux, and a smaller number of turns when measuring a large change in flux.

4.6.2 Coil Resistance

Unfortunately, as the number of turns in a coil increases, so does its resistance. As the coil resistance increases, the signal strength seen by the Model 2130 decreases. As long as the coil resistance is known, the user may enter this value using the Model 2130's menu system. In this case, the fluxmeter will automatically compensate for the loss in sensitivity. As a general rule, though, the coil resistance should not exceed approximately 10% of the Model 2130's input impedance for a given range. This is due primarily to the temperature coefficient of the coil resistance. In other words, the Model 2130 can compensate for a large coil resistance, however if the resistance changes, the compensation the fluxmeter applies will no longer be correct. The following table indicates the Model 2130 input impedance for each range, and the maximum recommended coil resistance.

Range Switch Position	Input Impedance	Maximum Recommended Coil Resistance
10 ⁶	1000 Ω	$\approx 100 \Omega$
10 ⁷	11 k Ω	$\approx 1100 \Omega$
10 ⁸	101 k Ω	$\approx 10.1 \text{ k}\Omega$

Table 4.6.1 Model 2130 Input Impedance

4.6.3 Coil Area

When a search coil is used in an area of uniform flux density, the signal strength is directly proportional to the cross sectional area of the coil. Therefore using a search coil with a larger cross sectional area allows the Model 2130 to be set to a higher range. The size of the search coil will often be a compromise between the signal strength and the spatial resolution that is required. If the area of the coil is accurately known, flux density may be measured in addition to total flux.

4.7 Selecting a Helmholtz Coil

The Helmholtz coil is actually a pair of coaxial coils mounted such that the distance between the coils is equal to the radius of either coil. This arrangement allows the measurement of the B_{di} (intrinsic remanant induction) of a magnet sample in an open circuit condition. The Helmholtz coil arrangement is also fairly independent of the position of the sample within the coils. Several parameters should be considered when selecting a Helmholtz coil for a particular application.

4.7.1 Helmholtz Coil Diameter

A Helmholtz coil should be selected such that the largest dimension of the magnet sample is less than one third the diameter of the Helmholtz coil. Normally the diameter of the Helmholtz coil is a compromise between signal strength and the independence of the magnet sample position.

4.7.2 Helmholtz Coil Resistance

As with the search coil, the resistance of the Helmholtz coil should normally be less than 10% of the Model 2130 input impedance. Refer to section 4.6.2 "Coil Resistance" for more details.

4.7.3 Helmholtz Constant

In order to make an accurate measurement of the magnet sample B_{di}, the Helmholtz coil constant must be known, and entered into the Model 2130 coil parameter menu. Coils purchased from Magnetic Instrumentation, Inc. include this constant.

4.8 Using the Zero Key

The Zero Key allows the user to initiate a Zero/Self-Test process. During this process, the Model 2130 corrects for any offset at the input terminals of the meter, and then calibrates the integrator using a precision internal volt-second reference.

The Model 2130 will normally need to be zeroed after the search coil is changed, or if the rear panel range selector is set to a new position. The Model 2130 may also be zeroed if the drift rate appears to become too large for automatic drift correction to compensate for. It is important that the search coil is not moved during the calibration cycle. See 4.13.5.

4.9 Using the Drift Key

The Drift Key allows the user to select the rate at which the Model 2130 compensates for small changes in offset voltage which causes the display indication to drift. Every Miller-integrator-based fluxmeter (analog integration circuit, followed by some combination of analog and/or digital signal processing) has a tendency for the integrator output to move away from zero, either positive or negative. This "drift" has a variety of causes, the primary of which is that the integrating amplifier has input offset voltages and currents which vary as a function of time and temperature. Since the circuit is constantly creating the time-integral of any input voltage that is present, even very tiny error voltages quickly accumulate into a significant error signal which we term "drift."

In traditional fluxmeters the user can manually adjust a potentiometer to minimize the drift for a particular set of operating conditions. Typically the amount of drift present must be checked and corrected for periodically, since it changes in what appears to the user to be a random fashion.

In modern, microprocessor controlled fluxmeters like the Model 2130, the drift compensation adjustment is made under the control of the meter software. Instead of a user-adjustable potentiometer, a digital-to-analog converter is used to inject offsetting voltages into the integrator stage. The effectiveness of this automated drift adjustment depends on the resolution of the D/A converter and on the program used to control the D/A.

In the Model 2130 a "drift adjust cutoff window" of +/- 1% of range has been defined. Each time the user changes range, the extent of this window is also changed. Except in the NO mode (see below), the 2130 will constantly try to reduce the drift tendency to zero as long as the meter output is within the (+/- 1% of range) window. When the meter output is less than 0.5% of range no dots are shown on the display and automatic drift compensation takes place. For meter output >0.5% to 1% of range, one dot will appear on the right side of the display and automatic drift compensation still takes place. When meter output exceeds 1% of range, the meter stops trying to adjust drift and 2 dots appear on the display; the purpose is to prevent the meter from "correcting drift" against an actual, valid signal. For very low signal applications (when measuring at signal levels below 1% of range - not recommended!) the drift adjust can be set to NO to prevent the meter from tracking desired signal as though it were drift error.

Each press of the DRIFT button on the front panel of the 2130 cycles the meter to the next of the four possible drift adjustment modes. There is no "manual" drift adjustment.

No = No further drift adjustment. The meter will continue to operate with whatever drift compensation was in effect at the time "No" was selected.

Lo = Least aggressive mode for automatic drift adjustment. The meter nulls out the drift tendency of the output using very small steps. For most applications this mode may result in inadequate drift compensation.

Mi = Moderately aggressive mode for automatic drift adjustment. The meter uses larger steps to null out the drift tendency. This mode may result in inadequate drift compensation.

Hi = Most aggressive mode for automatic drift adjustment. The meter uses the largest of the available resolution steps to null out the drift tendency as quickly as possible. This is the preferred mode of operation for most applications.

NOTE: when adjusting drift, the Model 2130 does not try to create a zero display indication; it works to reduce the rate of change of the output to zero. The user must press RESET (or command RESET through one of the communication interfaces) to return the meter display to zero.

4.10 Using the Analog Output

The Analog Output allows the user to connect to an external means of measuring the output of the Model 2130's integrator. The analog output is always scaled such that on any given range, the output will be one volt for a full scale display indication.

Example: When the Model 2130 is set to the 100 kMT range, the analog output will be 1.00 volts for a reading of 100 kMT and 0.50 volts for a reading of 50 kMT.

Keep in mind that the analog output is a representation of the signal coming from the output of the Model 2130's integrator. Thus if the input signal is a sinusoid, the output will also be sinusoidal with a 90° phase shift. However, if the input signal is a square wave, the output will be a triangle wave (integrated square wave).

4.11 Using the Dual Limit Outputs

The Dual Limit outputs are Low-power Schottky signals that are accessible at the rear panel auxiliary connector. When the Model 2130 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. The limit outputs are normally logic high (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 state, and the Limits High Output and Limits Pass Output will be set to a logic high 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 kMT and the measured field is -1100 kMT, the Model 2130 will set the Limits High Output to a logic low state.

When the Model 2130 is not in the Dual Limit mode all the limit outputs are high. Refer to Section 3.12, "Setting the Lower Limit" and Section 3.13, "Setting the Upper Limit", to define the upper and lower limit parameters. Refer to Section 8.3, "Auxiliary Connector Pin Assignments" for the limit outputs pin designations.

4.12 Using the Remote Reset

The Remote Reset is a TTL/CMOS/NMOS compatible 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 2130 will respond as if the front panel RESET key were pressed. Refer to Section 8.3 "Auxiliary Connector Pin Assignments" for Remote Reset pin designation.

4.13 Sources of Error

When using a fluxmeter such as the Model 2130, several sources of error should be considered.

4.13.1 Coil Orientation

Search coils respond to magnetic flux in one axis only. If the axis of the search coil is not aligned with the direction of the flux or 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

$$\% \text{ Error} = (1 - \cos \phi) \times 100\%$$

where ϕ is the angular deviation as shown in Figure 4.13.1.

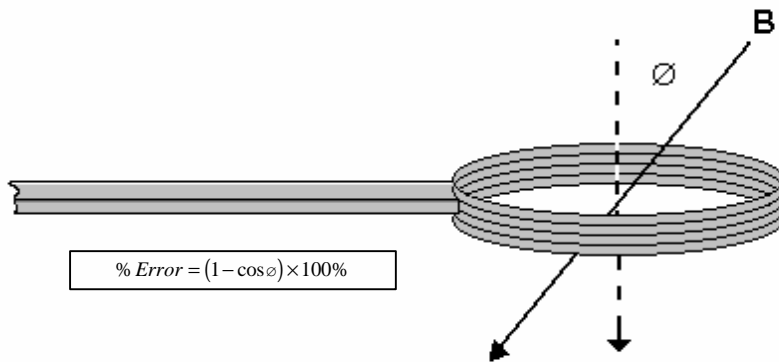


Figure 4.13.1 Search Coil Orientation Error

4.13.2 Coil Parameters

Depending on the type of measurement to be made, certain coil parameters must be known and properly programmed into the Model 2130 in order to make valid measurements. Any error in these parameters will directly affect the measurement accuracy. Most coil probes do not have a memory plug. If the probe coil does not have a memory plug, refer to Chapter 3, "USING THE MENU SYSTEM", for details on entering the coil parameters using the Model 2130's menu system. In the case of coils that contain a memory plug, the coil parameters are automatically loaded into memory each time the Model 2130 is powered on while the memory plug is attached. The following table lists the coil and other parameters that are used for each measurement unit.

<i>Unit</i>	<i>Resistance</i>	<i>Number of Turns</i>	<i>(Coil) Area¹</i>	<i>Helmholtz Constant</i>	<i>Magnet Volume</i>
Maxwell-Turns	X				
Maxwells	X	X			
Gauss	X	X	X		
Tesla	X	X	X		
BDI - Gauss	X			X	X
BDI - Tesla	X			X	X

Table 4.13.1 Required Coil Parameters

¹ Note: When using the Gauss and Tesla ranges, enter either: 1) One (1) turn and the total area of the coil, or 2) the actual number of turns on the coil being used and the average area of the coil. Entering the total area and the actual number of turns will result in an incorrect reading. See also Section 4.6.3.

4.13.3 Sample Volume

When a Helmholtz coil is used with the Model 2130, the volume of the magnet sample must be known and must be entered using the Model 2130's menu system. Any error in the magnet volume will directly affect the accuracy of the measurement. Refer to section 3.10 for details on entering the magnet volume and Section 4.7, "Selecting a Helmholtz Coil" for additional details on this type of measurement.

4.13.4 Instrument Specifications

The user should always refer to the instrument specifications to determine the suitability of the Model 2130 for any measurement application. Only by referring to these specifications can the user begin to identify the measurement uncertainty in any application.

4.13.5 Interference of coil signal with zero/self-test mode.

Before pressing the Zero button to initiate an automatic drift zero and self-test of the meter, be sure there is no signal being applied to the meter input terminals by the coil. The presence of a signal during this process will result in poor drift stability.

5. THEORY OF OPERATION

5.1 Measurement of Flux

The instantaneous voltage e induced in a coil having N turns that is cut by Φ lines of transverse flux during time t is given by:

$$1) \quad e = -N \frac{d\Phi}{dt}$$

where e is in volts, Φ is in Webers, and t is in seconds. If Φ is in Maxwells then the equation becomes:

$$2) \quad e = -N \frac{d\Phi}{dt} \times 10^{-8}$$

In this case e is directly proportional to both the number of turns and the rate of change in flux, and inversely proportional to the period in which the flux change occurs. In most cases of flux measurement, the desired measurement is the flux quantity independent of the rate of change. This is accomplished by integrating the emf produced by the coil over the time in which the change occurs. Integrating both sides of the equation 2 gives:

$$3) \quad \int_0^t e dt = -N\Phi_c \times 10^{-8}$$

where Φ_c is the total change in flux during the integration period t . Solving for Φ_c gives:

$$4) \quad \Phi_c = -\frac{1}{N} \int_0^t e dt \times 10^8$$

Applying equation 4 to a search coil with a known number of turns and a method of integration will therefore allow the total flux change to be measured.

5.2 Measurement of Flux Density

Flux density is defined as the quantity of flux per unit area

$$5) \quad B = \frac{\Phi}{a}$$

where B is in Gauss, Φ is in Maxwells, and a is in cm^2 . Substituting equation 4 for Φ gives:

$$6) \quad B = \frac{-\frac{1}{N} \int_0^t e dt \times 10^8}{a}$$

Applying equation 6 to a search coil with a known number of turns, a known cross sectional area, and a method of integration will therefore allow a change in flux density to be measured.

5.3 Method of Integration

In the preceding explanations, a method of integration was required to measure both total flux and flux density. Most electronic fluxmeters (the Model 2130 included) accomplish this function with a Miller integrator. The following figure is a simplified representation of the Model 2130's integrator.

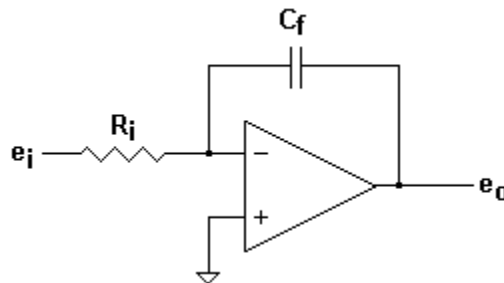


Figure 5.3.1 Miller Integrator

Suppose an emf e_i is present at the input of the integrator for time t . If the operational amplifier is considered to be ideal, the junction of R and C_f will remain at virtual ground. A current I will therefore flow through resistor R_i . The magnitude of this current will be:

$$7) \quad I = \frac{e_i}{R_i}$$

where I is in amps, e_i is in volts, and R_i is in ohms. Assuming that the operational amplifier has an infinite input impedance, the current that flows through R_i must also flow through C_f . The voltage v developed across a capacitor with value c when a current I flows through it for period t is given by:

$$8) \quad v = \frac{It}{c}$$

where v is in volts I is in amps t is in seconds and c is in farads. Substituting equation 7 for I and C_f for c gives:

$$9) \quad v = \frac{e_i}{R_i C_f} t$$

Since the junction of C_f and R_i is at virtual ground, the voltage developed across C_f is equal to the integrator output voltage e_o . This gives the transfer function for the integrator.

$$10) \quad e_o = \frac{e_i}{R_i C_f} t$$

The integrator output voltage is therefore directly proportional to the time integral of the input signal. If a search coil is connected to the input of the integrator and then experiences a change in magnetic flux $\Delta\phi$, the output of the integrator will be dependent upon the total flux crossing the coil, and independent of the speed with which the coil is withdrawn.

6. REMOTE OPERATION

6.1 General Communication Description

The Model 2130 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 fluxmeter. All information that is visible on the Model 2130 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 1 to 16. 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 2130 is divided into two categories; configuration commands, and query commands. The configuration commands are used to change meter settings such as range, mode, drift correction, 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 2130 which are not part of the command set are ignored.

When using the RS-232 interface, each character received by the Model 2130 is echoed to the host PC. Once a character is sent to the Model 2130, 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 2130 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. Coil Parameters" 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 +2000 kMT = +002000000 MT, the RESET (UP) and DRIFT (DOWN) commands may be used to change the value one digit at a time, or the user may send the characters "+002000000". 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>
```

COIL RESISTANCE QUERY

Character: "X"

Parameter: none

Returns: *coil resistance*

Description: Returns a string of characters indicating the *coil resistance* parameter.

Example: Sending the COIL RESISTANCE QUERY command will return a string similar to:

```
1.23<CR><LF>
```

DISPLAY QUERY

Character: "B"

Parameter: none

Returns: *display text*

Description: Returns the *display text* present on the Model 2130 LCD display.

Example: When the DISPLAY QUERY command is sent, the Model 2130 will return a string of characters similar to:

```
+000.09kMT Mi /100 kMT NORM <CR><LF>
```

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

When in Gauss mode, the lowest range is 10kG.

DRIFT (Down arrow)

Character: "Q"

Parameter: none

Returns: none

Description: Simulates the front panel DRIFT (Down arrow) key.

DRIFT DIRECT

Character: "q"

Parameter: *drift rate number*

Returns: none

Description: Sets the Model 2130 to the Drift Rate specified by *drift rate number*. The *drift rate number* is defined in the following table.

Example: Sending the command "q01" will set the Model 2130 to Lo Drift Rate adjustment.

Drift Rate	Drift rate number
No	"00"
Lo	"01"
Mi	"02"
Hi	"03"

Table 6.4.1 Drift Rate Numbers

DRIFT RATE QUERY

Character: "D"

Parameter: none

Returns: *drift rate*Description: Returns the current drift rate setting of the Model 2130. *Drift rate* can be "No", "Lo", "Mi" or "Hi".Example: Sending the DRIFT RATE QUERY command while the Model 2130 drift rate is set to *Lo* will return the following string.

Lo<CR><LF>

ENTER

Character: "E"

Parameter: none

Returns: none

Description: Simulates the front panel ENTER key.

GAIN QUERY

Character: "G"

Parameter: none

Returns: *gain*Description: Returns the current *gain* setting of the Model 2130. Value can be 1, 2, 4, or 8.

Example: Sending the GAIN QUERY command while the Model 2130 gain is set to 8 will return the following string.

8<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, DRIFT 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.

MAX HOLD DIRECT

Character: "h"

Parameter: *max hold number*

Returns: none

Description: Sets the Model 2130 to the Max Hold mode specified by *max hold number*. The *max hold number* is defined in the following table.

Example: Sending the command "h01" will set the Model 2130 in Max Hold mode.

Mode	Mode number
Normal	"00"
Max Hold	"01" through "99"

Table 6.4.2 Mode Numbers

MENU QUERY

Character: "A"

Parameter: none

Returns: *menu state*Description: Returns the *menu state* of the Model 2130. *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 6.4.3 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 2130 to the mode specified by *mode number*. *Mode number* is defined in the following table.

Example: Sending the command "m01" will set the Model 2130 to Dual Limits mode.

Mode	Mode number
Normal	"00"
Dual Limits	"01"
Relative	"02"

Table 6.4.4 Mode Numbers

MODE QUERY

Character: "K"

Parameter: none

Returns: *mode*

Description: Returns the current mode setting of the Model 2130.

Example: Sending the MODE QUERY command while the Model 2130 is set to the Normal mode will return the following string:

NORM<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 2130 to the range specified by *range number*. *Range number* is defined in the following table.

Example: Sending the command "n03" will set the Model 2130 range to the lowest range available. Note: the available ranges depend on the Coarse Range Switch setting, the Coil Resistance parameter and the Calibration Coefficient.

Range Number	Range	Gain
"03"	lowest	8
"02"	2 nd lowest	4
"01"	2 nd highest	2
"00"	highest	1

Table 6.4.2 Range Numbers

RANGE QUERY

Character: "J"

Parameter: none

Returns: *range*

Description: Returns a string of characters indicating the current range setting the Model 2130.

Example: Sending the RANGE QUERY command while the Model 2130 is set to the 100 kMT range will return the following string:

100 kMT <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:

10.000 kG <CR><LF>

SET

Character: "S"

Parameter: none

Returns: none

Description: Simulates the front panel SET key.

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 2130 will normally not require periodic service. No user serviceable parts are contained in the Model 2130.

7.2 Troubleshooting

If the Model 2130 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 3.16, "Setting Factory 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 2130. Some of these messages will appear each time power is supplied to the Model 2130 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 2130 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, flatblade 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 2130 still does not function after performing these steps, contact Magnetic Instrumentation, Inc. for assistance.

Message	Indication
“Magnetic Instrumentation”	This message is displayed each time power is applied to the Model 2130.
“Power Supply Error”	Indicates a failure in the Model 2130 $\pm 5V$ power supply. When the Model 2130 is being powered from an external $\pm 9VDC$ 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.
“ERROR: Flash Mem”	Indicates a failure in the Model 2130 flash memory. The Model 2130 will function normally, however, all configuration settings will be set to default. The unit should be returned to Magnetic Instrumentation, Inc. for repair.
“Checksum Error”	Indicates a check sum error in the Model 2130 program memory. The unit should be returned to Magnetic Instrumentation, Inc. for repair.

Table 7.2.1 Model 2130 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 Auxiliary Connector Pin Assignments



Figure 8.3.1 Auxiliary Connector

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

Table 8.3.1 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 [μ_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 [Φ]	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 [μ]	Henry/meter [H/m]	$10^7/4\pi$	Unitless
⁸ Permeability, relative [μ]	-	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]	$K = ^\circ C + 273.16$	degree Celsius [$^\circ C$]
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 $\text{dyn}/\text{cm}^2 \text{Oe}$.
3. Equal to N/Am .
4. Equal to permeability of space.
5. Equal to $\text{dyn cm}/\text{Oe}$.
6. Equal to Nm^2/A .
7. Equal to B/H .
8. Equal to $B/\mu_0 H$.
9. Inverse of reluctance.
10. Relative volume expressed as a percentage, equal to $J/\mu_0 H$.

Table 9.1.1 CGS-SI Units Conversion

10. DECLARATION OF CONFORMITY

We, Magnetic Instrumentation, declare under sole responsibility that the Model 2130 Fluxmeter 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
8431 Castlewood Drive
Indianapolis, Indiana 46250

Testing performed by:

Radiometrics Midwest Corporation
55 West 22nd Street
Lombard, Illinois 60148
Document #: RP-3083A
Test Completion Date: January 25, 1999

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