



User's Manual

Model 420

Gaussmeter



Lake Shore Cryotronics, Inc.
575 McCorkle Blvd.
Westerville, Ohio 43082-8888 USA

Internet Addresses:
sales@lakeshore.com
service@lakeshore.com

Fax: (614) 891-1392
Telephone: (614) 891-2243

Methods and apparatus disclosed and described herein have been developed solely on company funds of Lake Shore Cryotronics, Inc. No government or other contractual support or relationship whatsoever has existed which in any way affects or mitigates proprietary rights of Lake Shore Cryotronics, Inc. in these developments. Methods and apparatus disclosed herein may be subject to U.S. Patents existing or applied for. Lake Shore Cryotronics, Inc. reserves the right to add, improve, modify, or withdraw functions, design modifications, or products at any time without notice. Lake Shore shall not be liable for errors contained herein or for incidental or consequential damages in connection with furnishing, performance, or use of this material.

LIMITED WARRANTY

Lake Shore Cryotronics, Inc. (henceforth Lake Shore), the manufacturer, warrants this product to be free from defects in material or workmanship for a period of twelve (12) months from the date of shipment. During the warranty period, under authorized return of instruments or component parts to Lake Shore freight prepaid, the company will repair, or at its option replace, any part found to be defective in material or workmanship, without charge to the owner for parts, service labor or associated customary return shipping cost. Replacement or repaired parts will be warranted for only the unexpired portion of the original warranty or 90 days (whichever is greater).

All products are thoroughly tested and calibrated to published specifications prior to shipment. Calibration Certifications are offered for six month periods only. Where such documentation must be updated, a re-certification service is offered by Lake Shore at a reasonable cost.

LIMITATION OF WARRANTY

This warranty does not apply to defects resulting from improper installation, product modifications made by others without Lake Shore's express written consent, or from misuse of any product or part. This warranty also does not apply to fuses, software, non-rechargeable batteries, or problems arising from normal wear or failure to follow instructions.

This warranty is in lieu of any other warranties, expressed or implied, including merchantability, or fitness for a particular purpose, which are expressly excluded. The owner agrees that Lake Shore's liability with respect to this product shall be set forth in this warranty, and incidental or consequential damages are expressly excluded.

CERTIFICATION

Lake Shore certifies that this product has been inspected and tested in accordance with its published specifications and that this product met its published specifications at the time of shipment. The accuracy and calibration of this product at the time of shipment are traceable to the United States National Institute of Standards and Technology (NIST); formerly known as the National Bureau of Standards (NBS).

TRADEMARK ACKNOWLEDGMENT

Many manufacturers and sellers claim designations used to distinguish their products as trademarks. Where those designations appear in this manual and Lake Shore was aware of a trademark claim, they appear with initial capital letters and the TM or [®] symbol.

ASYST[®] is a trademark of MacMillian Software Co.

Duco[®] is a trademark of E.I. DuPont de Nemours

Hercules is a trademark of Hercules, Inc.

MS-DOS[®] is a trademark of MicroSoft Corporation

NI-488.2TM is a trademark of National Instruments

PC, XT, AT, and PS-2 are trademarks of IBM

Scotch[®] is a trademark of 3M

TACKIWAX[®] is a trademark of CSC Scientific Co., Inc.

Apiezon[®] is a trademark of Biddle Instruments.

FormvarTM is a trademark of Monsanto Chemical Company.

IDEAS[®] is a trademark of Unisys Corporation and is licensed for use with Lake Shore software drivers.

CalCurveTM, Carbon-GlassTM, CernoxTM, Duo-TwistTM, Quad-LeadTM, Quad-TwistTM, and SoftCalTM

are trademarks of Lake Shore Cryotronics, Inc.

Stycast[®] is a trademark of Emerson & Cuming.

Teflon[®] is a trademark of DuPont De Nemours.

Copyright © 1993 – 1997 by Lake Shore Cryotronics, Inc. All rights reserved. No portion of this manual may be reproduced, stored in a retrieval system, or transmitted, in any form or by any means, electronic, mechanical, photocopying, recording, or otherwise, without the express written permission of Lake Shore.

TABLE OF CONTENTS

<i>Chapter/Paragraph</i>	<i>Title</i>	<i>Page</i>
1	INTRODUCTION	1-1
1.0	General.....	1-1
1.1	Model 420 Gaussmeter System Description.....	1-2
1.2	Electrostatic Discharge.....	1-4
1.2.1	Identification of Electrostatic Discharge Sensitive Components.....	1-4
1.2.2	Handling of Electrostatic Discharge Sensitive Components.....	1-5
1.3	Safety Summary.....	1-5
1.3	Safety Symbols.....	1-6
2	INSTALLATION.....	2-1
2.0	General.....	2-1
2.1	Inspection and Unpacking.....	2-1
2.2	Repackaging For Shipment.....	2-1
2.3	Definition of Rear Panel Connections.....	2-2
2.4	Initial Setup and System Checkout Procedure.....	2-3
3	OPERATION.....	3-1
3.0	General.....	3-1
3.1	Definitions of Front Panel Controls.....	3-1
3.1.1	Front Panel Keypad.....	3-1
3.1.2	Front Panel Display.....	3-2
3.2	Max Hold and Max Reset.....	3-2
3.3	Zero Probe.....	3-2
3.4	Range.....	3-3
3.5	AC/DC.....	3-3
3.6	Gauss/Tesla.....	3-4
3.7	Interface.....	3-4
3.8	Relative.....	3-4
3.9	Analog Out.....	3-4
3.10	Locking and Unlocking the Keypad.....	3-5
3.11	Factory Default Settings.....	3-5
3.12	Probe Considerations.....	3-5
3.12.1	Changing Probes.....	3-5
3.12.2	Probe Handling.....	3-5
3.12.3	Probe Operation.....	3-6
3.12.4	Probe Accuracy Considerations.....	3-6
4	REMOTE OPERATION.....	4-1
4.0	General.....	4-1
4.1	Serial I/O Interface.....	4-1
4.1.1	Serial Interface Hardware Configuration.....	4-2
4.1.2	Serial Interface Settings.....	4-2
4.1.3	Sample BASIC Serial Interface Program.....	4-2
4.2	Serial Interface Command Summary.....	4-4
4.2.1	Command List Structure.....	4-4
4.2.2	Interface Commands.....	4-4
4.2.3	Device Specific Commands.....	4-5

TABLE OF CONTENTS (Continued)

<i>Chapter/Paragraph</i>	<i>Title</i>	<i>Page</i>
5	SERVICE	5-1
5.0	General	5-1
5.1	General Troubleshooting	5-1
5.2	Changing Power Setting and Fuse Rating.....	5-1
5.3	Rear Panel Connector Definitions	5-2
5.4	Serial Interface Cable and Adapters.....	5-4
5.5	Operating Software EPROM Replacement	5-5
6	ACCESSORIES AND PROBES	6-1
6.0	General	6-1
6.1	Accessories.....	6-1
6.2	Probe Selection Criteria	6-6
APPENDIX A – UNITS FOR MAGNETIC PROPERTIES.....		A-1
APPENDIX B – HALL GENERATORS		B-1
B1.0	General	B-1
B2.0	Theory of Operation	B-1
B2.1	Active Area	B-1
B2.2	Orientation	B-2
B2.3	Handling.....	B-2
B2.4	Polarity	B-2
B2.5	Lead Configurations.....	B-2
B3.0	Hall Generator Generic Hookup	B-2
B4.0	Using a Hall Generator with the Model 420.....	B-3
B5.0	Specifications.....	B-4
B6.0	HALLCAL.EXE Program	B-8

LIST OF ILLUSTRATIONS

Figure No.	Title	Page
2-1	Model 420 Rear Panel.....	2-2
3-1	Model 420 Front Panel.....	3-1
3-2	Front Panel Display Definition.....	3-2
3-3	Maximum Flexible Probe Bend Radius.....	3-6
3-4	Probe Orientation For Positive Measurement.....	3-6
3-5	Effect Of Angle On Measurements.....	3-7
4-1	Serial Interface Adapters.....	4-1
5-1	Power Fuse Access.....	5-1
5-2	DA-15 PROBE INPUT Connector Details.....	5-2
5-3	Corrected and Monitor ANALOG OUTPUTS Connector Details.....	5-2
5-4	SERIAL I/O RJ-11 Connector Details.....	5-2
5-5	Model 4001 RJ-11 Cable Assembly Wiring Details.....	5-3
5-6	Model 4002 RJ-11 to DB-25 Adapter Wiring Details.....	5-3
5-7	Model 4003 RJ-11 to DE-9 Adapter Wiring Details.....	5-3
5-8	Location Of Operating Software EPROM.....	5-4
6-1	Model 4001 RJ-11 Cable Assembly.....	6-2
6-2	Model 4002 RJ-11 to DB-25 Adapter.....	6-2
6-3	Model 4003 RJ-11 to DE-9 Adapter.....	6-2
6-4	Model 4022 Rack-Mount Kit.....	6-3
6-5	Model 4026 Dual Rack-Mount Shelf.....	6-3
6-6	Model 4060 Standard Zero Gauss Chamber.....	6-4
6-7	Model 4065 Large Zero Gauss Chamber.....	6-4
6-8	Definition of Lake Shore Transverse Probes.....	6-6
6-9	Definition of Lake Shore Axial Probes.....	6-7
6-10	Definition of Lake Shore Flexible Transverse Probes.....	6-8
6-11	Definition of Lake Shore Gamma Probes.....	6-8
B-1	Hall Generator Theory.....	B-1
B-2	Axial and Transverse Configurations.....	B-2
B-3	Typical Hall Generator Hookup.....	B-3
B-4	Hall Generator Input Impedance.....	B-3
B-5	Axial Hall Generator HGA-3010, HGA-3030, & HGCA-3010 Dimensions.....	B-4
B-6	Transverse Hall Generator HGT-3010, HGT-3030, & HGCT-3020 Dimensions.....	B-4
B-7	Axial Hall Generator HGA-2010 Dimensions.....	B-5
B-8	Transverse Hall Generator HGT-1010 Dimensions.....	B-6
B-9	Transverse Hall Generator HGT-2010 Dimensions.....	B-6
B-10	Transverse Hall Generator HGT-2100 Dimensions.....	B-6

LIST OF TABLES

Table No.	Title	Page
1-1	Model 420 Specifications.....	1-2
4-1	Serial Interface Specifications.....	4-2
4-2	Sample BASIC Serial Interface Program.....	4-3
B-1	Cryogenic Hall Generator Specifications.....	B-4
B-2	Axial Hall Generator Specifications.....	B-5
B-3	Transverse Hall Generator Specifications.....	B-7

This Page Intentionally Left Blank

CHAPTER 1

INTRODUCTION

1.0 GENERAL

Lake Shore Cryotronics, Inc. designed and manufactures the Model 420 in the United States of America. It is highly accurate and ideally suited for field work. It features:

- **Field Measurement:**
 - DC Accuracy: $\pm 0.45\%$ of Reading $\pm 0.05\%$ of Range.
 - Auto Range.
 - DC or AC Field Measurement.
 - Individual Linearization of Hall Probes.
- **Alphanumeric Display:**
 - 4-character, 1 Part In 3,000 Resolution On All Ranges.
 - 2 Line by 16 Character Backlighted Liquid Crystal Display.
- **Other Operating Functions:**
 - Gauss or Tesla Units.
 - Max Hold.
 - Relative Reading.
- **Interface:**
 - Serial Interface (RS-232C Electrical Format).
 - Corrected and Monitor Analog Outputs.
- **Probe Compatibility:**
 - High Stability Probes (HST) – 300 G to 300 kG Full-Scale Ranges.
 - High Sensitivity Probes (HSE) – 30 G to 30 kG Full-Scale Ranges.
 - Ultra High Sensitivity Probes (UHS) – 300 mG to 30 G Full-Scale Ranges.

We welcome comments concerning this manual. Although we make every effort to keep it error-free, some may occur. When reporting a specific problem, describe it briefly and include the appropriate paragraph, figure, table, and page number. Send comments to Lake Shore Cryotronics, Attn: Technical Publications, 575 McCorkle Blvd., Westerville, Ohio 43082-8888. This manual is subject to change without notice.

1.1 MODEL 420 GAUSSMETER SYSTEM DESCRIPTION

The Model 420 has an easy-to-use front panel that includes an alphanumeric Liquid Crystal Display (LCD) for message-based front panel operation. Perform and monitor most operations through the front panel keypad and message display. The display has a resolution of 4-characters.

The Model 420 measures fields from 3 mG (0.3 μ T) to 300 kG (30 T), in either gauss or tesla. Set field ranges either manually or with auto ranging. The **Range** key displays the full scale value and cycles through allowable ranges for the probe installed. The Auto Range function automatically selects the range with the best resolution for the measured field.

The gaussmeter measures both DC and AC field values. In DC operation, it displays the field at the probe with the sign (orientation), followed by appropriate field units. In AC operation, it displays a RMS value for the field at the probe. The DC and AC values are available over the Serial I/O Computer Interfaces and also the Corrected Analog Output. The Monitor Analog Output displays actual magnetic field waveform.

The Max Hold function captures and displays the largest field magnitude since the last Max Reset. After pressing **Max Hold**, the maximum value appears in the lower display while the upper display contains the live field reading. In AC RMS, the Max Hold feature displays the maximum RMS value of the waveform.

The relative function displays small variations in larger fields. The **Relative Set** key captures or defines a relative setpoint which becomes the zero point of the relative reading and appears on the lower line of the display. The relative reading appears in the top display with a **▲** symbol. The relative reading maintains the same resolution and units as the setpoint.

Accept new settings in two ways: 1) Wait a few seconds until the built in timeout returns you to the normal display, or 2) Press any key other than the function currently addressed. For example, after changing the range, press any key other than Range.

Table 1-1 Model 420 Specifications

Measurement:

Number of Inputs: One
 Update Rate: Three Per Second
 Autorange: Yes
 Field Ranges/Resolutions:

High Stability Probe				High Sensitivity Probe				Ultra-High Sensitivity Probe			
Gauss		tesla		Gauss		tesla		Gauss		tesla	
Range	Res.	Range	Res.	Range	Res.	Range	Res.	Range	Res.	Range	Res.
±300 kG	±0.1 kG	±30 T	±0.01 T	±30 kG	±0.01 kG	±3 T	±0.001 T	±3 G	±0.001 G	±300 μT	±0.1 μT
±30 kG	±0.01 kG	±3 T	±0.001 T	±3 kG	±0.001 kG	±300 mT	±0.1 mT	±300 mG	±0.1 mG	±30 μT	±0.01 μT
±3 kG	±0.001 kG	±300 mT	±0.1 mT	±300 G	±0.1 G	±30 mT	±0.01 mT				
±300 G	±0.1 G	±30 mT	±0.01 mT	±30 G	±0.01 G	±3 mT	±0.001 mT				

Electronic DC Accuracy: ±0.45% of reading ±0.05% of range
 Drift of DC Electronics: 0.05% of reading + 1 count per degree Celsius
 RMS Frequency Range: 10 to 400 Hertz
 AC RMS Accuracy: ±5% or better

Front Panel:

Display Type: 2 line by 16 characters, backlighted LCD
 Display Resolution: 4-character (see field ranges above)
 Display Units: Gauss or tesla
 Keypad: Eight function

Interfaces:

Corrected Analog Output: ±3 volt range
 Uncorrected Analog Output: ±3 volts for full scale range; accuracy is probe dependent
 Serial communication with RS-232C electrical format; 300, 1200, or 9600 BAUD; RJ-11 connector

Instrument General:

Ambient Temperature Range: 15 °C to 35 °C (59 °F to 95 °F)
 Power Requirement: 100, 120, 220, 240 VAC (+5% -10%), 50 or 60 Hz, 25 watts
 Size: 216 mm wide x 90 mm high x 317 mm deep, (8.54 x 3.5 x 12.5 inches); half-rack package
 Weight: 3 kilograms (6.61 pounds)

1.2 ELECTROSTATIC DISCHARGE

Electrostatic Discharge (ESD) may damage electronic parts, assemblies, and equipment. ESD is a transfer of electrostatic charge between bodies at different electrostatic potentials caused by direct contact or induced by an electrostatic field. The low-energy source that most commonly destroys Electrostatic Discharge Sensitive (ESDS) devices is the human body, which generates and retains static electricity. Simply walking across a carpet in low humidity may generate up to 35,000 volts of static electricity.

Current technology trends toward greater complexity, increased packaging density, and thinner dielectrics between active elements, which results in electronic devices with even more ESD sensitivity. Some electronic parts are more ESDS than others. ESD levels of only a few hundred volts may damage electronic components such as semiconductors, thick and thin film resistors, and piezoelectric crystals during testing, handling, repair, or assembly. Discharge voltages below 4000 volts cannot be seen, felt, or heard.

1.2.1 Identification of Electrostatic Discharge Sensitive Components

Below are various industry symbols used to label components as ESDS:



1.2.2 Handling Electrostatic Discharge Sensitive Components

Observe all precautions necessary to prevent damage to ESDS components before attempting installation. Bring the device and everything that contacts it to ground potential by providing a conductive surface and discharge paths. As a minimum, observe these precautions:

1. Deenergize or disconnect all power and signal sources and loads used with unit.
2. Place unit on a grounded conductive work surface.
3. Ground technician through a conductive wrist strap (or other device) using 1 M Ω series resistor to protect operator.
4. Ground any tools, such as soldering equipment, that will contact unit. Contact with operator's hands provides a sufficient ground for tools that are otherwise electrically isolated.
5. Place ESDS devices and assemblies removed from a unit on a conductive work surface or in a conductive container. An operator inserting or removing a device or assembly from a container must maintain contact with a conductive portion of the container. Use only plastic bags approved for storage of ESD material.
6. Do not handle ESDS devices unnecessarily or remove from the packages until actually used or tested.

1.3 SAFETY SUMMARY

Observe these general safety precautions during all phases of instrument operation, service, and repair. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended instrument use. Lake Shore Cryotronics, Inc. assumes no liability for Customer failure to comply with these requirements.

The Model 420 protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature, and spread of fire from the instrument. Environmental conditions outside of the conditions below may pose a hazard to the operator and surrounding area.

- Temperature: 5° to 40° C.
- Maximum relative humidity: 80% for temperature up to 31° C decreasing linearly to 50% at 40° C.
- Power supply voltage fluctuations not to exceed $\pm 10\%$ of the nominal voltage.

Ground The Instrument

To minimize shock hazard, connect the instrument chassis and cabinet an electrical ground. The instrument is equipped with a three-conductor AC power cable. Plug the power cable into an approved three-contact electrical outlet or use a three-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Do Not Operate In An Explosive Atmosphere

Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.














Keep Away From Live Circuits

Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.

Do Not Substitute Parts Or Modify Instrument

Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized Lake Shore Cryotronics, Inc. representative for service and repair to ensure that safety features are maintained.

1.4 SAFETY SYMBOLS

	Direct current (power line).		Equipment protected throughout by double insulation or reinforced insulation (equivalent to Class II of IEC 536 - see Annex H).
	Alternating current (power line).		Caution: High voltages; danger of electric shock. Background color: Yellow; Symbol and outline: Black.
	Alternating or direct current (power line).		Caution or Warning - See instrument documentation. Background color: Yellow; Symbol and outline: Black.
	Three-phase alternating current (power line).		Fuse.
	Earth (ground) terminal.		
	Protective conductor terminal.		
	Frame or chassis terminal.		
	On (supply).		
	Off (supply).		

CHAPTER 2

INSTALLATION

2.0 GENERAL

This chapter covers general Model 420 installation instructions: Inspection and Unpacking (Paragraph 2.1), Repackaging for Shipment (Paragraph 2.2), Definition of Rear Panel Connections (Paragraph 2.3), and Initial Setup and System Checkout Procedure (Paragraph 2.4).

2.1 INSPECTION AND UNPACKING

Inspect shipping containers for external damage. Make all claims for damage (apparent or concealed) or partial loss of shipment in writing to Lake Shore within five (5) days from receipt of goods. If damage or loss is apparent, please notify the shipping agent immediately.

Open the shipping containers. Use the packing list included with the system to verify receipt of the instrument, sensor, accessories, and manual. Inspect for damage. Inventory all components supplied before discarding any shipping materials. If there is freight damage to the instrument, file proper claims promptly with the carrier and insurance company and notify Lake Shore. Notify Lake Shore immediately of any missing parts. Lake Shore cannot be responsible for any missing parts unless notified within 60 days of shipment. See the standard Lake Shore Warranty on the A Page (immediately behind the title page).

2.2 REPACKAGING FOR SHIPMENT

To return the Model 420, sensor, or accessories for repair or replacement, obtain a Return Goods Authorization (RGA) number from Technical Service in the United States, or from the authorized sales/service representative from which the product was purchased. Instruments may not be accepted without a RGA number. When returning an instrument for service, Lake Shore must have the following information before attempting any repair.

1. Instrument model and serial number.
2. User name, company, address, and phone number.
3. Malfunction symptoms.
4. Description of system.
5. Returned Goods Authorization (RGA) number.

Wrap instrument in a protective bag and use original spacers to protect controls. Repack the system in the LSCI shipping carton (if available) and seal it with strong paper or nylon tape. Affix shipping labels and FRAGILE warnings. Write the RGA number on the outside of the shipping container or on the packing slip.

Because of their fragility, Lake Shore probes ship in special cardboard and foam boxes. Retain these boxes to store probes when not in use, or return probes to Lake Shore for re-calibration or repair.

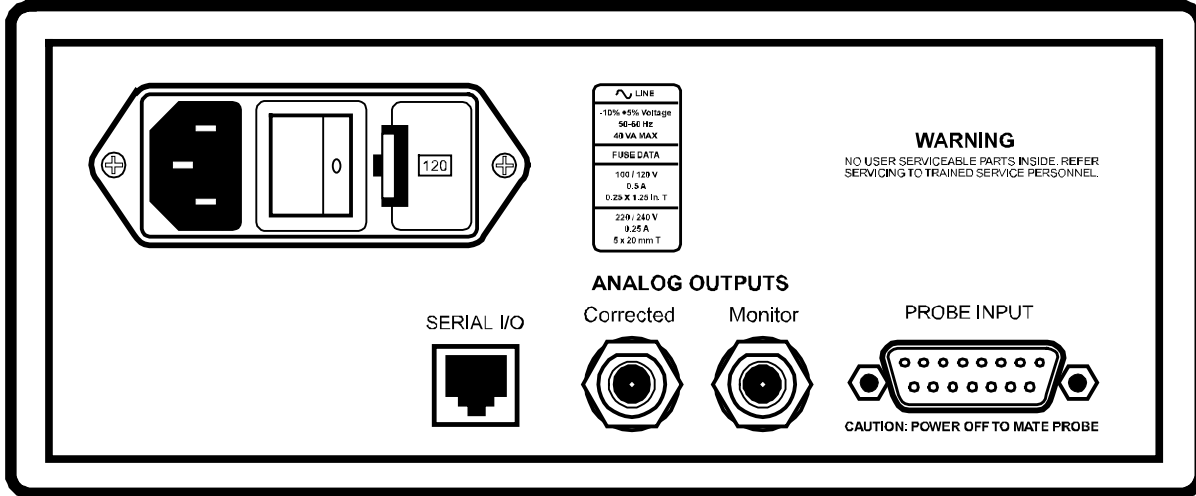


Figure 2-1 Model 420 Rear Panel

2.3 DEFINITION OF REAR PANEL CONNECTIONS

The Model 420 rear panel consists of the power and fuse assembly, Serial I/O Connector, Corrected and Monitor Analog Output BNCs, and a DA-15 Probe Input Connector. See Chapter 5 for rear panel connector pin-out details.

Power and Fuse Assembly. The power and fuse assembly is the primary entry and control point for AC power to the unit. The assembly consists of three parts: power line jack, power on/off switch, and the fuse drawer. The line cord connects to the power line jack. The on/off switch controls power to the unit. The “I” symbol shows when power is on and the “O” shows when power is off. The fuse drawer has a dual purpose: housing the fuse and setting unit input power.

Serial I/O Connector. The Serial I/O (Input/Output) Connector accepts the standard RJ-11 telephone connector. Lake Shore offers RJ-11 to DE-9 or DB25 Adapters that permit connection to a computer. See Paragraph 4.1 and 5.4.

Corrected and Monitor Analog Outputs. Analog outputs are available on two Bayonet Nut Connectors (BNCs). The signal is on the center conductor while the outer casing is for ground. Both outputs may be used simultaneously. The corrected output is not a real-time signal, but updates at the same rate as the display. The default range of the corrected output is ± 3 volts equals \pm full scale for the range. The monitor output is a live analog signal proportional to the magnetic flux density waveform. See Paragraph 3.12 for further operational information.

Probe Input Connector. The probe plugs into the DA-15 connector. Always turn off the instrument before connecting the probe. Align the probe connector with the rear panel connector and push straight in to avoid bent pins. For best results, secure the connector to the rear panel using the two thumbscrews. A tight connector keeps the cable secure and prevents interference. See Paragraph 3.12 for additional probe considerations.

2.4 INITIAL SETUP AND SYSTEM CHECKOUT PROCEDURE

This procedure verifies basic unit operation before initial use for measurements.

CAUTION: Check power source for proper voltage before connecting line cord. Check power setting on fuse drawer window. Damage may occur if connected to improper voltage.

1. Check power source for proper voltage. The Model 420 operates with 100, 120, 220, or 240 (+5%, -10%) AC input voltage.
2. Check fuse drawer window for proper voltage setting. If incorrect, see Paragraph 5.2.
3. Ensure power switch is off (O).

CAUTION: The probe must be connected to the rear of the unit before applying power to the gaussmeter. Damage to the probe may occur if connected with power on.

4. Plug in the DA-15 probe connector to PROBE INPUT. Use thumbscrews to tighten connector to unit.
5. Connect and check all other rear panel connections (SERIAL I/O, or ANALOG OUTPUTS) before applying power to the unit.
6. Plug line cord into receptacle.

Lake Shore 420
Field Monitor

7. Turn power switch on (I). The front panel display turns on and briefly displays the message to the right.

8. The normal gaussmeter display appears, similar to the one to the right.

+ 0.00 kG DC

NOTE: For best results, warm up instrument and probe for at least 5 minutes before zeroing probe, and at least 30 minutes for rated accuracy. The probe and the zero gauss chamber should be at the same temperature.

Some Lake Shore probes come with a clear plastic sleeve to protect the probe tip when not in use. The sleeve slides up and down the probe cable. To place the probe in the zero gauss chamber, slide the protective sleeve back, exposing the probe tip, before placing the tip in the chamber.

9. Place the probe in the zero gauss chamber and press the front panel **Zero Probe** key. The display to the right appears.

Press Again With
Probe At Zero

10. Press **Zero Probe** again. The *CALIBRATING* message briefly displays, followed by the normal display. Do not move the probe while the *CALIBRATING* message displays.

NOTE: If the unit performs well to this point, the unit is functioning properly. If there is a reference magnet available, continue the test using the magnet to verify the Model 420 accuracy.

11. If continuing the procedure with a reference magnet, verify the probe accommodates the magnet range. Use the **Range Select** key to select the proper range (or press **Auto Range**). Set the display for DC. Finally, since probe orientation is very selective, press **Max Hold** to capture the highest reading.

CAUTION: Take care when handling the probe; its tip is very fragile. Excess force may break it.

NOTE: Probe readings depend on the angle of the tip in relation to the magnetic field. The greater the angle, the higher the percentage of error. For example, a 5° angle causes a 0.4% error, a 10° angle induces a 1.5% error, etc. See Paragraph 3.15.

12. Carefully place probe in contact with the magnet and hunt a bit for the maximum reading. For this example, we used a 999 ±1% Gauss probe reference magnet.

+0.972 kG DC
0.995 kG MAX

The top line displays the current reading. The bottom line displays the maximum reading captured, which is within the tolerance of our reference magnet. The top line continually changes as the probe moves, but the bottom remains fixed on the highest reading. To capture a new maximum value, press **Max Reset**.

After successfully completing this checkout procedure, the unit is ready for normal operation.

This Page Intentionally Left Blank

CHAPTER 3

OPERATION

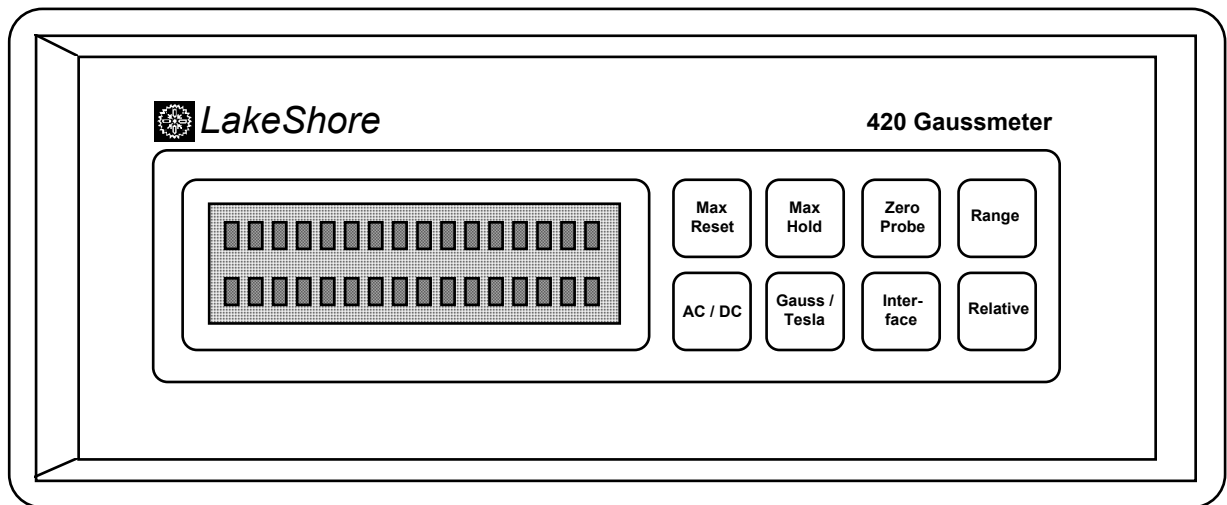
3.0 GENERAL

This chapter covers aspects of Model 420 operation: Front Panel Controls (Paragraph 3.1), Front Panel Functions (Paragraphs 3.2 thru 3.10), Default Settings (Paragraph 3.11), and Probe Handling Considerations (Paragraph 3.12). See Chapter 4 for remote serial interface operation.

3.1 DEFINITION OF FRONT PANEL CONTROLS

The front panel consists of two major sections: 8 front panel keys (Paragraph 3.1.1), and a 2 row by 16 character Liquid Crystal Display (LCD, Paragraph 3.1.2).

3.1.1 Front Panel Keypad Definitions



C-420-U-1-1

Figure 3-1 Model 420 Front Panel

Max Reset: Works with Max Hold function. Returns Max reading to normal field reading. See Paragraph 3.2.

Max Hold: Turns Max Hold feature ON and OFF. Captures and displays the highest field reading. Use Max Reset key to clear reading. See Paragraph 3.2.

Zero Probe: Zeros or nulls effects of ambient low level fields from the probe. To use, place tip of probe into Zero Gauss Chamber and press **Zero Probe**. Display returns to normal readings in about 5 seconds. See Paragraph 3.3.

Range: Selects manual field measurement range or Autorange. Available ranges depend on which probe is installed. There is a slight delay until the unit settles on the proper range. See Paragraph 3.4.

AC/DC: Selects periodic (AC) or static (DC) magnetic fields. The AC selection provides RMS readings. See Paragraph 3.5.

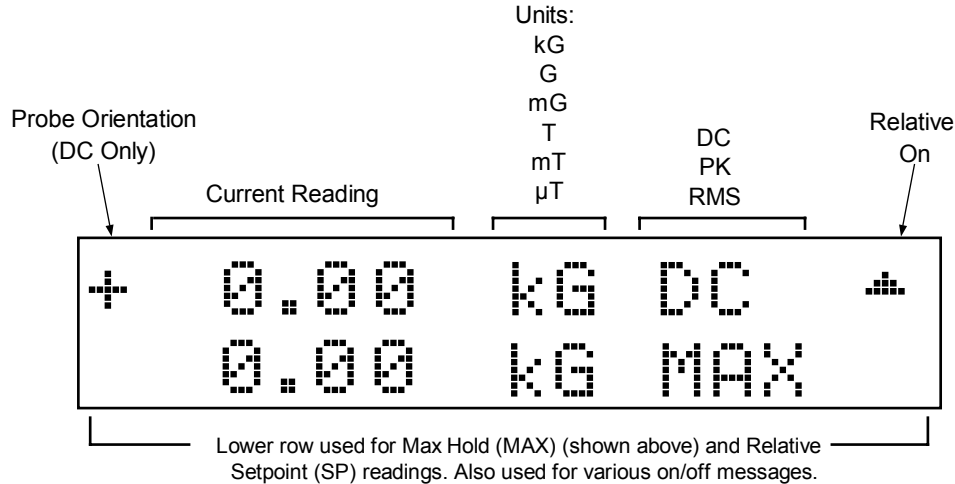
Gauss/Tesla: Changes display units from gauss to tesla. Gauss (G) is used in the cgs system, where $1\text{ G} = 10^{-4}\text{ T}$. Tesla (T) is used in the SI system, where $1\text{ T} = 10^4\text{ G}$. See Paragraph 3.6.

Interface: Adjusts the baud rate to 300, 1200, or 9600 during serial interface. See Paragraph 3.7.

Relative: Displays the positive or negative deviation from setpoint in the lower line of the display. Often used to offset large magnetic fields. May also be used with Max Hold and Alarm. See Paragraph 3.8.

3.1.2 Front Panel Display

In normal operation, the two row by sixteen character LCD provides magnetic readings on the top row and special information or readings on the bottom row. Other information displays when using the various keypad functions. Each character is comprised of a 5 by 7 dot matrix. See Figure 3-2.



C-420-U-3-2

Figure 3-2 Front Panel Display Definition

3.2 MAX HOLD AND MAX RESET

Max Hold displays the largest field magnitude measured since the last **Max Reset**. Press **Max Hold** to view the maximum value in the lower line of the display and the field reading in the upper line. **Max Hold** may also be used in conjunction with the Relative display (see Paragraph 3.8).



Max Reset clears the **Max Hold** value. The **Max Hold** value also resets upon power up or when changing from AC or DC.

Max Hold functions differently with AC and DC fields. In DC operation, **Max Hold** captures the largest magnitude field reading. This monitors slowly changing signals. A field change not visible on the display can not be recorded in DC Max Hold. The display shows only the magnitude of the maximum reading.

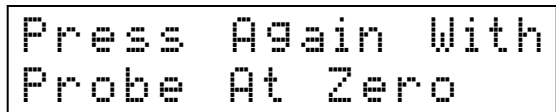
In AC RMS operation, **Max Hold** captures the maximum RMS value.

3.3 ZERO PROBE

The zero probe function cancels out the zero offset of the probe or small magnetic fields. It is normally used in conjunction with the zero gauss chamber, but may also be used with an unshielded probe (registering the local earth magnetic field). To cancel large magnetic fields, use the Relative function.

NOTE: For best results, allow the instrument and probe to warm up for at least 5 minutes before zeroing the probe, and at least 30 minutes for rated accuracy. The probe and the zero gauss chamber should be at the same temperature.

To zero the probe in the zero gauss chamber, first allow the temperature of the probe and chamber to equalize. (A large temperature discrepancy affects the quality of the calibration.) Carefully place the probe tip into the chamber.



Probe orientation is not critical. Once inserted, press **Zero Probe** to display the screen to the right.

Press **Zero Probe** again to display the *CALIBRATING* message, followed by the normal display. Do not move the probe while calibrating. The probe is now zeroed. For best results, periodically zero the probe.

3.4 SELECT RANGE AND AUTO RANGE

The Model 420 reads each Lake Shore probe type: High Stability, High Sensitivity, or Ultra-High Sensitivity. These probes sense fields as low as 0.2 mG and as high as 300 kG. The tables below list full scale ranges for each probe sensitivity, along with fixed display resolution.

High Stability Probe				High Sensitivity Probe				Ultra-High Sensitivity Probe			
Gauss		tesla		Gauss		tesla		Gauss		tesla	
Range	Res.	Range	Res.	Range	Res.	Range	Res.	Range	Res.	Range	Res.
±300 kG	±0.1 kG	±30 T	±0.01 T	±30 kG	±0.01 kG	±3 T	±0.001 T	±3 G	±0.001 G	±300 µT	±0.1 µT
±30 kG	±0.01 kG	±3 T	±0.001 T	±3 kG	±0.001 kG	±300 mT	±0.1 mT	±300 mG	±0.1 mG	±30 µT	±0.01 µT
±3 kG	±0.001 kG	±300 mT	±0.1 mT	±300 G	±0.1 G	±30 mT	±0.01 mT				
±300 G	±0.1 G	±30 mT	±0.01 mT	±30 G	±0.01 G	±3 mT	±0.001 mT				

For manual ranging, press **Range** and select one of the full scale ranges displayed. The display to the right appears.



Press **Range** to cycle through allowable full scale ranges for the installed probe. To accept the new range either wait about 6 seconds until the display disappears automatically, or press any key other than **Range**.

In Auto Range mode, the Model 420 selects the range with the best resolution for the measured field. It can take up to 2 seconds for Auto Range to work, so manual ranging may be better sometimes. Press **Range** until the screen to the right displays. To accept the new range either wait about 6 seconds until the display disappears automatically, or press any key other than **Range**.



Do not use Auto Ranging with **Max Hold** operation or during small field measurement in a large background field, such as measuring a small DC field in presence of a large AC field, or vice versa.

3.5 AC/DC

The **AC/DC** key toggles between AC and DC measurements. The annunciator immediately changes from "DC" to "RMS" as applicable. One update cycle is required for a new display value.

In DC operation, the display shows the DC field at the probe with sign (orientation) followed by the appropriate field units, and the letters "DC". The DC value is available over the Serial Interface and both Analog Outputs.

In AC operation, the RMS readings meet specified accuracy from 10 to 400 Hz. The AC RMS reading is defined as the square root of the average of the square of the field function taken through one period.

The AC value is available over the Serial Interface. The Corrected Analog Output yields a DC voltage representation of the Peak or RMS reading, while the Monitor Analog Output yields a true analog waveform. (In fact, the Monitor Analog Output is not affected by the selection of AC or DC.)

When changing to AC or DC, the unit maintains previously established Relative and Alarm setpoints, but Max Hold operation changes (see Paragraph 3.2).

3.6 GAUSS / TESLA

The Model 420 displays magnetic field values in gauss (G) or tesla (T). Press **Gauss/Tesla** to toggle the display between the two units. The relation between gauss and tesla is 1 G = 0.0001 T, or 1 T = 10,000 G. When field units are changed, relative and alarm setpoints convert to the new units with no interruption in operation. The Corrected and Monitor Analog Outputs are not affected by a change in units.

When tesla is selected, the Model 420 displays AC or DC field values followed by T for tesla, mT for millitesla, or uT for microtesla and formats field values over the Serial Interface accordingly.

When gauss is selected, the Model 420 displays AC or DC field values followed by kG for kilogauss, G for gauss, or mG for milligauss and formats field values over the Serial Interface accordingly.

3.7 INTERFACE

To use the Serial Interface, set the Baud rate. Press **Interface** to display the screen to the right. Press **Interface** again to cycle through the choices of 300, 1200, or 9600 Baud. To accept the new rate, either wait about 6 seconds until the display disappears automatically, or press any key other than **Interface**.

```
Press Interface
Baud  +3  12  96
```

3.8 RELATIVE

The relative function lets the user see small variations in larger fields. To set the setpoint (or center) of the relative reading, press **Relative**. This captures the field reading, nulling the present field.

```
+1.420  kG DC
Relative On
```

After pressing Relative, the "Relative On" message briefly appears on the lower line of the display, followed by the selected setpoint (SP). The plus or minus deviation from that setpoint displays on the upper line. A small delta (±) signifies the relative display.

```
+0.037  kG DC ±
+1.420  kG SP
```

The relative feature also interacts with other features. When Relative and Max Hold functions are used at the same time, the relative reading still displays on the top line with proper annunciators, but the bottom line shows the relative maximum instead of the relative setpoint.

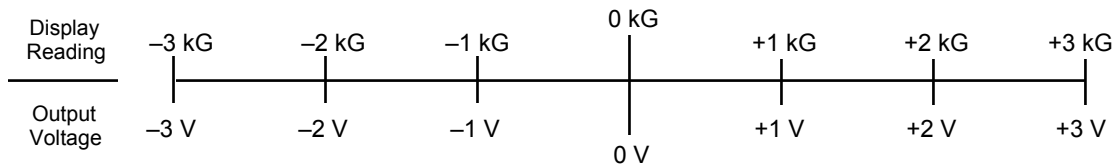
```
+0.037  kG DC ±
+0.054  kG MAX
```

Press **Max Hold** again to turn OFF the maximum hold function, returning the relative reading to the display. Press **Relative On/Off** to turn OFF the relative function. The "Relative Off" message briefly displays.

3.9 ANALOG OUT

There are two rear panel analog outputs on the Model 420 called the Corrected and Monitor Analog Outputs. Both use BNC connectors with the center conductor carrying the signal and the outer portion the ground.

The Corrected Analog Output is a DC value proportional to the displayed field. The displayed field reading may be corrected for probe nonlinearity and zero offset. This output is not a real time signal, but updates at the same rate as the display. The Corrected output range is ±3 volts equals ± full scale for the selected range. The example below shows the 3 kG range.



The Monitor Analog Output is a real-time analog signal proportional to the magnetic field and scaled to ±3 volts for full scale of selected range. It is not as accurate as the Corrected Monitor Output, but it has the full 400 Hz bandwidth of the AC measurement.

3.10 LOCKING AND UNLOCKING THE KEYPAD

The Model 420 front panel keypad may be locked, preventing unauthorized changes to the settings. To lock the keypad, press and hold **Max Hold** (about 10 seconds) until the display to the right appears.



Lock Keypad

To unlock the keypad, press and hold **Max Hold** (about 10 seconds) until the display to the right appears. The keypad unlocks and the display reverts to the normal display.



Unlock Keypad

3.11 FACTORY DEFAULT SETTINGS

To return the instrument to factory default settings, press and hold **Max Reset** for about 20 seconds:

Max Hold: Off	Auto Range: Off	Relative: Off	Interface: 300
Range: Highest range for probe	AC/DC: DC	Gauss/Tesla: Gauss	Keypad: Unlocked

Other gaussmeter calibration information and probe data are not affected by this reset. Zero the probe after completing this operation.

3.12 PROBE CONSIDERATIONS

This section covers several probe concerns to avoid damage and yield the best results: Changing Probes (Paragraph 3.15.1), Probe Handling (Paragraph 3.15.2), Probe Operation (Paragraph 3.15.3), and Accuracy Considerations (Paragraph 3.15.4). For details of available Lake Shore Probes, see Paragraph 6.2.

3.12.1 Changing Probes

CAUTION: Connect the probe to the unit rear before applying power to the gaussmeter. Probe memory may be erased if connected with power on.

Each probe includes a 512-byte Electrically Erasable Programmable Read Only Memory (EEPROM). The EEPROM stores specific information the gaussmeter requires for operation. The information includes serial number and probe sensitivity, and may also include field and temperature compensation data.

Upon power up, probe memory downloads to the gaussmeter. Probe memory includes available ranges and which error correction to apply. To change probes, first turn power off, remove existing probe, then plug in the new probe. When power is restored, the new probe characteristics download to the gaussmeter and normal operation may continue. If the unit powers up with no probe attached, the message to the right displays.



* * NO PROBE * *
Power off, attach

3.12.2 Probe Handling

CAUTION: Take care when handling the probe; the tip is very fragile. Stressing the Hall sensor can alter its calibration. Any excess force can easily break the sensor. Broken sensors are irreparable.

Although probes are designed as sturdily as possible, they are still fragile. This is especially true for the exposed ceramic tip of transverse probes. Take care to place no pressure on the ceramic tip during measurements. Secure the probe in place only at the handle. Never apply force to the probe stem. Any strain on the ceramic substrate may alter the probe calibration, and excessive force may destroy the Hall sensor.

Avoid repeated flexing of the sensor mounted at the end of a flexible stem. As a rule, do not bend the stem more than 45° from the base (see Figure 3-3). Never apply force to the tip of the probe. On all probes, do not pinch or allow cables to be struck by heavy or sharp objects. Although Lake Shore repairs damaged or severed cables that are returned, probes are not always repairable.

When probes are installed on the gaussmeter but not in use, place the protective tube provided with many probes over the probe handle and stem to protect the tip. When the gaussmeter is not in use, store probes separately in some type of rigid container, preferably the cardboard and foam container in which Lake Shore probes ship. For details on available accessories and probes, see Chapter 6.

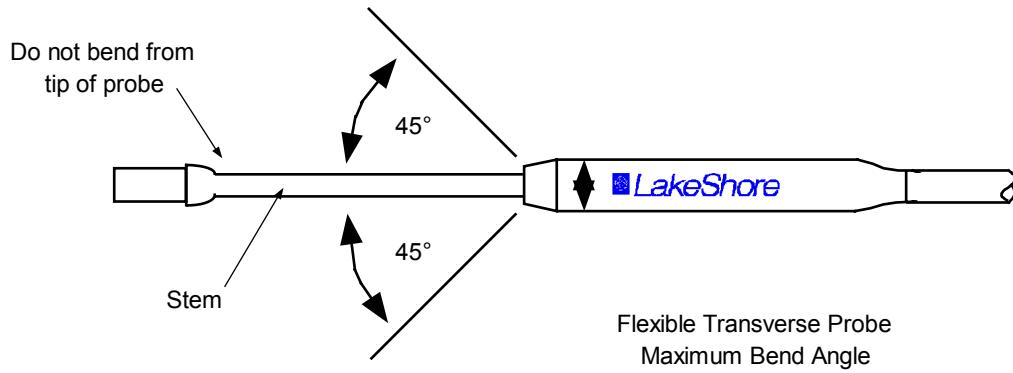


Figure 3-3 Maximum Flexible Probe Bend Radius

3.12.3 Probe Operation

NOTE: For best results, allow the instrument and probe to warm up for at least 5 minutes before zeroing the probe, and at least 30 minutes for rated accuracy. The probe and the zero gauss chamber should be at the same temperature.

In the DC mode of operation, probe orientation affects the polarity reading of the gaussmeter. On a transverse probe, the Lake Shore name printed on the handle indicates the side for positive (+) flux entry. On an axial probe, positive (+) flux entry is always from the front of the probe. See Figure 3-4.

If the magnetic field orientation is unknown, determine it by turning on **Max Hold** and slowly adjusting the probe. As the probe turns and the measured field rises and falls, its maximum value is held on the display. Note probe orientation at the maximum reading to identify the field orientation.

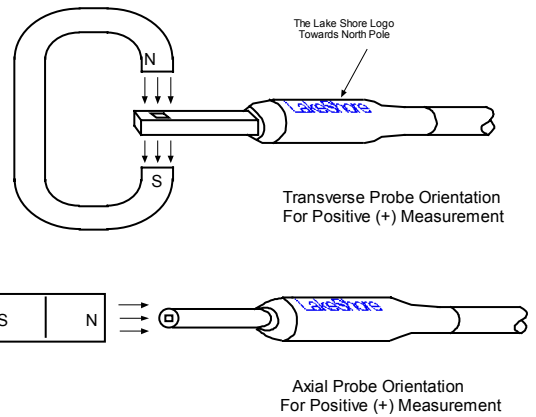


Figure 3-4 Probe Orientation for Positive Measurement

3.12.4 Probe Accuracy Considerations

NOTE: For best results, allow the instrument and probe to warm up for at least 5 minutes before zeroing the probe, and at least 30 minutes for rated accuracy. The probe and the zero gauss chamber should be at the same temperature.

Several element impact probe accuracy. Zero the probe before making critical measurements. The zero probe function cancels out the zero offset of the probe or small magnetic fields. It is normally used with the zero gauss chamber, but may be used with a non-shielded probe (registering the local earth magnetic field). To cancel out large magnetic fields, use the Relative function (see Paragraph 3.8).

Probe temperature can also affect readings. Read the probe specification sheets to determine possible temperature effects. To help offset the effects of temperature on the Hall sensor, a thermistor may be included in the Lake Shore High Sensitivity and Ultra-High Sensitivity Probes. The High Stability Probe requires no temperature correction due to inherent thermal stability of materials used in its construction.

Probe readings depend on the angle of the sensor (Hall sensor) in relation to the magnetic field. Maximum output occurs when the flux vector is perpendicular to the plane of the sensor. This is the condition that exists during factory calibration. The greater the deviation from right angles in either of three axes, the larger the reading error. For example, a 5° variance on any one axis causes a 0.4% error, a 10° variance induces a 1.5% error, etc. See Figure 3-5.

Consider gaussmeter, probe, and magnet tolerances before making critical measurements. The accuracy of the gaussmeter reading is better than $\pm 0.1\%$ of reading and $\pm 0.005\%$ of range. An absolute accuracy reading for gaussmeters and Hall probes is a difficult to specify, because measurement variables are difficult to reproduce. For example, a 1° error in alignment to the magnetic field causes a 0.015% reading error. The best probes have an accuracy of $\pm 0.1\%$. This implies that the absolute accuracy measurement of a magnetic field can be no better than $\pm 0.15\%$ under the best of circumstances, and more likely 0.20% to 0.25% .

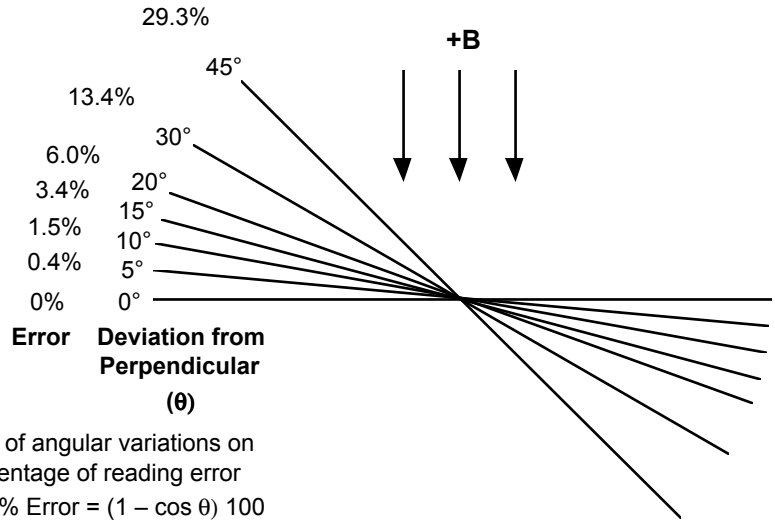


Figure 3-5 Effect Of Angle On Measurements

This Page Intentionally Left Blank

CHAPTER 4

REMOTE OPERATION

4.0 GENERAL

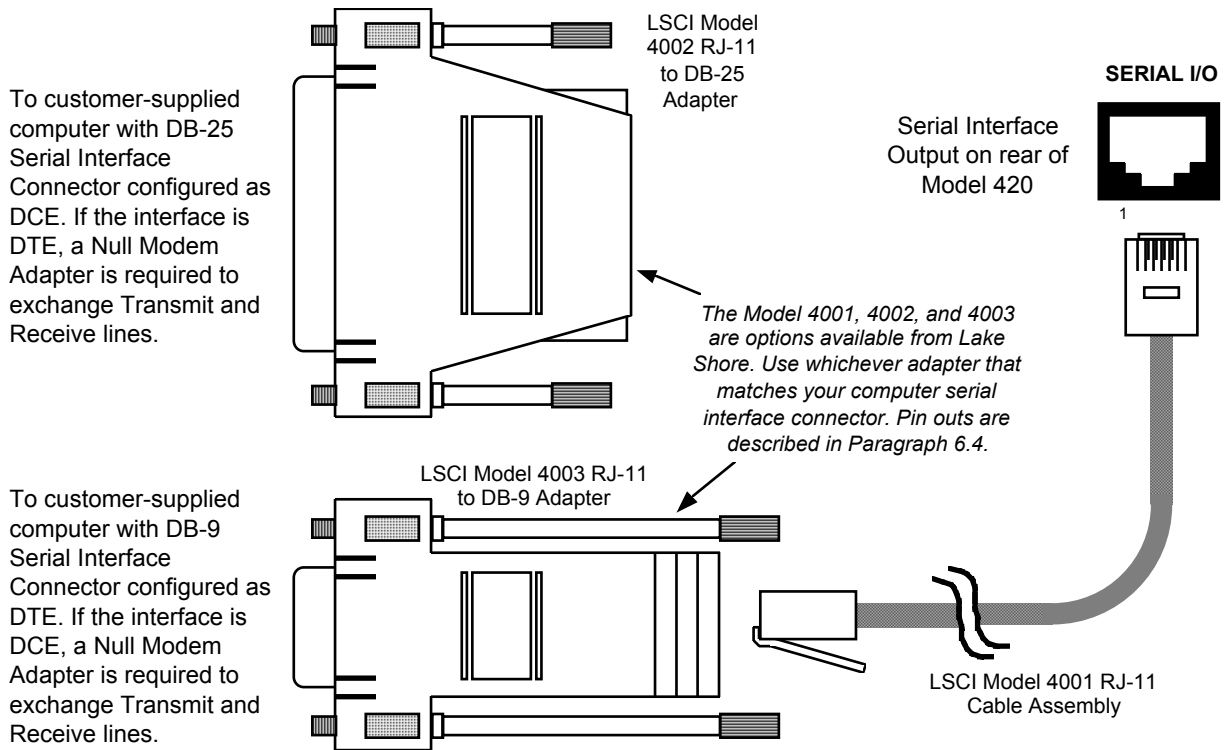
This chapter covers the Serial Interface hardware and software (Paragraph 4.1), and the interface command summary (Paragraph 4.2).

4.1 SERIAL I/O INTERFACE

RS-232C is a standard of the Electronics Industries Association (EIA) and one of the most common interfaces between a computer and electronic equipment. The Customer supplied computer must have a Serial Interface port. The Model 420 Serial Interface complies with the electrical format of the RS-232C Interface Standard. A Serial Interface between the computer and the Model 420 permits remote monitoring and control of Model 420 control functions, which in turn controls Model 420 operation. See Figure 4-2.

The Serial Interface can both transmit and receive information. In transmit (Tx) mode, the instrument converts parallel information to serial and sends it over a cable up to 50 feet long (or longer with proper shielding). In receive (Rx) mode, the instrument converts serial information back to parallel for processing.

See Paragraph 4.1.1 for Serial Interface hardware configuration and adapters, Paragraph 4.1.2 for Serial Interface settings, and Paragraph 4.1.3 for a sample BASIC program to establish communications between the computer and the Model 420.



C-420-U-4-2

Figure 4-1 Serial Interface Adapters

4.1.1 Serial Interface Hardware Configuration

Below is a technical description of the Serial Interface. Table 4-1 lists communication parameters. Terminators are fixed to Carriage Return (CR) and Line Feed (LF).

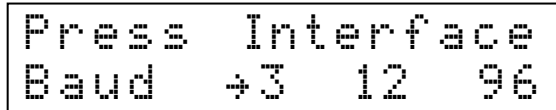
The connector used for the serial interface is a standard 6-wire RJ-11 (telephone) jack. Lake Shore offers the Model 4001 10-foot Cable Assembly, Model 4002 RJ-11 to DB-25 Adapter, and the Model 4003 RJ-11 to DE-9 Adapter. See Chapter 5 for Serial I/O connector and adapter pin out details, and Chapter 6 for adapter dimensional data.

Table 4-1 Serial Interface Specifications

Transmission	Three-Wire
Connector	RJ-11 Modular Socket
Timing Format	Asynchronous, RS-232C Electrical Format
Transmission Mode	Half Duplex
Baud Rate	300, 1200, or 9600
Bits per Character	1 Start, 7 Data, 1 Parity, and 1 Stop
Parity Type	Odd
Data Interface Levels	Transmits and Receives Using EIA Voltage Levels
Fixed Terminator	CR (0DH) LF (0AH)

4.1.2 Serial Interface Settings

To use the Serial Interface, set the Baud rate. Press **Interface** to display the screen to the right. Press **Interface** again to cycle through the choices of 300, 1200, or 9600 Baud. To accept the new rate, either wait about 6 seconds until the display disappears automatically, or press any key other than **Interface**.



4.1.3 Sample BASIC Serial Interface Program

The program in Table 4-2 is a sample interactive serial poll routine for the Model 420 Serial Interface written in QuickBASIC V4.0. The following are typical examples using this BASIC program. Input provided by the user is shown in **bold type**.

```

ENTER COMMAND? FIELD?           Field Reading Query. Unit returns field reading in the form ±XXX.XX.
                                   Decimal point placement appropriate to range.

+000.12
ENTER COMMAND? RANGE?           Range Query. Unit returns appropriate range: 0 = highest range
                                   through 3 = lowest range.

0
ENTER COMMAND? UNITS?           Units Query. Unit returns appropriate units: G = gauss, T = tesla.

G
ENTER COMMAND? ACDC?           AC or DC Query. Unit returns appropriate setting: 0 = DC, 1 = AC.

0

ENTER COMMAND?
    
```


4.1.4 Notes On Using The Serial Interface

- To chain commands together, insert a semi-colon (;) between them. Multiple queries cannot be chained.
- Queries generally use the same syntax as the associated setting command followed by a question mark. They usually return the same information that is sent.
- Add a query to the end of a command string to confirm command execution. For example, **UNIT G;UNIT?** commands the Model 420 to set units to gauss then requests the Model 420 return the units to confirm the change.
- A correctly spelled query without a "?", returns nothing. Misspelled commands and queries are ignored
- The term **free field** indicates a decimal point floats and can be placed at any appropriate place in the string of digits.
- Leading zeros and zeros following a decimal point are unneeded in a command string, but they are sent in response to a query. A leading "+" is not required, but a leading "-" is required.
- **[term]** indicates where the user places terminating characters or where they appear on a returning character string from the Model 420.
- The following commands are available only over the computer interface; there are no front panel equivalent commands: **CODE**, **BRIGT**, **FAST**, and **SNUM**.
- To change number inputs to the field reading resolution, first set them to zero.

Table 4-2 Sample BASIC Serial Interface Program

```

SEREXAM.BAS      EXAMPLE PROGRAM FOR SERIAL INTERFACE
'
' This program works with QuickBasic 4.0/4.5 or Qbasic on an IBM PC or compatible
' with a serial interface. It uses the COM1 communication port at 9600 BAUD. Enter
' an instrument command or query at the prompt. The command transmits to the
' instrument which displays any query response. Type "EXIT" to exit the program.
' NOTE: The INPUT instruction in this example accepts no commas as part of an input
' string. If a comma appears in an instrument command, replace it with a space.
'
CLS                                'Clear screen
PRINT " SERIAL COMMUNICATION PROGRAM"
PRINT
TIMEOUT = 2000                      'Read timeout (may need more)
BAUD$ = "9600"

TERM$ = CHR$(13) + CHR$(10)        'Terminators are <CR><LF>

OPEN "COM1:" + BAUD$ + ",N,8,1,RS" FOR RANDOM AS #1 LEN = 256

LOOP1: INPUT "ENTER COMMAND (or EXIT):"; CMD$ 'Get command from keyboard
CMD$ = UCASE$(CMD$)                'Change input to upper case
IF CMD$ = "EXIT" THEN CLOSE #1: END 'Get out on Exit
CMD$ = CMD$ + TERM$
PRINT #1, CMD$;                    'Send command to instrument

IF INSTR(CMD$, "?") <> 0 THEN      'Test for query
RS$ = ""                            'If query, read response
N = 0                                'Clr return string and count

WHILE (N < TIMEOUT) AND (INSTR(RS$, TERM$) = 0) 'Wait for response
IN$ = INPUT$(LOC(1), #1)           'Get one character at a time
IF IN$ = "" THEN N = N + 1 ELSE N = 0 'Add 1 to timeout if no chr
RS$ = RS$ + IN$                    'Add next chr to string
WEND                                'Get chrs until terminators

IF RS$ <> "" THEN                  'See if return string is empty
RS$ = MID$(RS$, 1, (INSTR(RS$, TERM$) - 1)) 'Strip off terminators
PRINT "RESPONSE:"; RS$            'Print response to query
ELSE
PRINT "NO RESPONSE"              'No response to query
END IF
END IF                              'Get next command
GOTO LOOP1

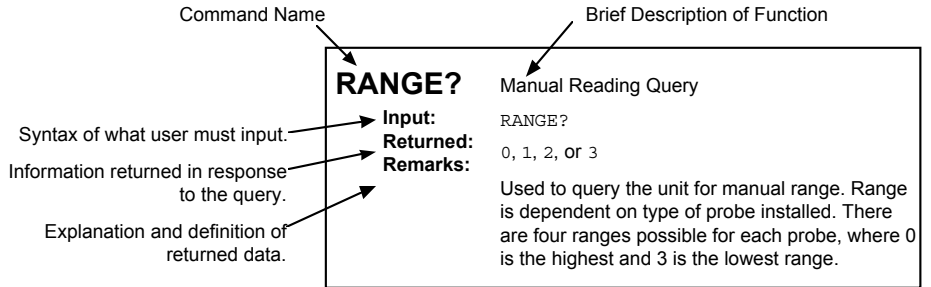
```

4.2 SERIAL INTERFACE COMMAND SUMMARY

There are two command groups: Interface Commands (Paragraph 4.2.2) and Device Specific Commands (Paragraph 4.2.3).

Command	Function	Page	Command	Function	Page
Interface Commands			MAXC	Initiate Max Clear (Reset).....	4-6
*IDN?	Query Identification	4-4	MAXR?	Max Reading Query	4-6
*RST	Reset Instrument.....	4-4	MULT?	Reading Units Multiplier Query.....	4-6
BAUD	Set Serial Interface Baud Rate.....	4-4	RANGE	Set Manual Range Status	4-6
BAUD?	Serial Interface Baud Rate Query.....	4-4	RANGE:	Manual Range Query	4-6
Device Specific Commands			REL	Set Relative Mode Status.....	4-6
ACDC	Set AC/DC Field Reading Status.....	4-5	REL?	Relative Mode Query.....	4-6
ACDC?	AC/DC Field Reading Query	4-5	RELR?	Relative Mode Reading Query	4-6
AUTO	Set Autorange Status On/Off.....	4-5	RELS	Set Relative Mode Setpoint.....	4-6
AUTO?	Autorange On/Off Query	4-5	RELS?	Relative Mode Setpoint Query.....	4-7
FIELD?	Present Field Reading Query	4-5	SNUM?	Probe Serial Number Query	4-7
LOCK	Set Keypad Lock Status.....	4-5	TYPE?	Probe Type Query	4-7
LOCK?	Keypad Lock Query.....	4-5	UNIT	Set Gauss or Tesla Units	4-7
MAX	Set Max Hold Status	4-5	UNIT?	Gauss or Tesla Units Query	4-7
MAX?	Max Hold Query	4-5	ZCAL	Initiate Zero Probe Command	4-7

4.2.1 Command List Structure



4.2.2 Interface Commands

***IDN?** Query Identification
Input: *IDN?
Returned: <manufacturer>, <model number>, <serial number>, <firmware date>
 Format: **LSCI,MODEL340,aaaaa,nnnnnn[term]**
Remarks: Identifies the instrument model and software level.

***RST** Reset Instrument
Input: *RST
Returned: Nothing
Remarks: Sets controller parameters to power-up settings.

BAUD Set Serial Interface Baud Rate.
Input: BAUD 0, BAUD 1, or BAUD 2
[type]: The 3 settings are: 0 = 300 Baud, 1 = 1200 Baud, 2 = 9600 Baud.
Returned: Nothing
Remarks: Sets the Serial Interface Baud rate.

BAUD? Serial Interface Baud Rate Query.
Input: BAUD?
Returned: Returns current Serial Baud rate, where: 0 = 300 Baud, 1 = 1200 Baud, and 2 = 9600 Baud

4.2.3 Device Specific Commands

ACDC	Set AC or DC Magnetic Field Reading Status.
Input:	ACDC 0 or ACDC 1
Returned:	Nothing
Remarks:	Configures the unit for AC or DC measurements: 0 = DC, 1 = AC.

ACDC?	AC or DC Magnetic Field Reading Query.
Input:	ACDC?
Returned:	0 or 1
Remarks:	Queries current AC or DC measurement status: 0 = DC, 1 = AC.

AUTO	Set Auto Range Status.
Input:	AUTO 0 or AUTO 1
Returned:	Nothing
Remarks:	Sets the Auto Range status: 0 = Auto Range Off, 1 = Auto Range On.

AUTO?	Auto Range Query.
Input:	AUTO?
Returned:	0 or 1
Remarks:	Queries Auto Range status: 0 = Off, 1 = On.

FIELD?	Present Magnetic Field Reading.
Input:	FIELD?
Returned:	±XXX.XX
Remarks:	Returns sign, five numbers, and decimal point. Places decimal appropriate to range. Requires MULT? and UNIT? commands to fully define the reading.

LOCK	Set Front Panel Keypad Lock Status.
Input:	LOCK 0 or LOCK 1
Returned:	Nothing
Remarks:	Sets front panel keypad lock status: 0 = Unlocked, 1 = Locked.

LOCK?	Front Panel Keypad Lock Query.
Input:	LOCK?
Returned:	0 or 1
Remarks:	Queries front panel keypad lock status: 0 = Unlocked, 1 = Locked.

MAX	Set Max Hold Status.
Input:	MAX 0 or MAX 1
Returned:	Nothing
Remarks:	Sets the Max Hold feature: 0 = Off, 1 = On. Works with the MAXR and MAXC commands.

MAX?	Max Hold Query.
Input:	MAX?
Returned:	0 or 1
Remarks:	Queries Max Hold status: 0 = Off, 1 = On. Works with the MAXR and MAXC commands.

MAXC Initiate Max Clear (Reset).
Input: MAXC
Returned: Nothing
Remarks: Initiate a Max Clear (or reset). Upon entry, Max Hold zeros out and captures a new peak.

MAXR? Max Reading Query.
Input: MAXR?
Returned: ±XXX.XX
Remarks: Queries Max Hold reading. Returns sign, five digits, and decimal point. Places decimal appropriate to range.

MULT? Probe Multiplier Query.
Input: MULT?
Returned: m, k, or _
Remarks: Queries probe multiplier: **m** = milli (x 1/1,000), **k** = kilo (x 1,000), and **_** (Blank) = unity (x 1).

RANGE Set Manual Range Status.
Input: RANGE X
Returned: Nothing
Remarks: Range depends on type of probe installed. There are four ranges possible for each probe: **0** = highest through **3** = lowest. See Paragraph 3.4.

RANGE? Manual Range Query.
Input: RANGE?
Returned: 0, 1, 2, or 3
Remarks: Queries manual range. Range depends on type of probe installed. There are four ranges possible for each probe: **0** = highest through **3** = lowest. See Paragraph 3.4.

REL Set Relative Mode Status.
Input: REL 0 or REL 1
Returned: Nothing
Remarks: Sets Relative Mode Status: **0** = Off, **1** = On.

REL? Relative Mode Query.
Input: REL?
Returned: 0 or 1
Remarks: Queries Relative Mode status: **0** = Off, **1** = On.

RELR? Relative Mode Reading Query.
Input: RELR?
Returned: ±XXX.XX
Remarks: Returns sign, up to 5 digits, and decimal point. Places decimal appropriate to range.

RELS Set Relative Mode Setpoint.
Input: RELS ±XXX.XX
Returned: Nothing
Remarks: Enter sign, up to 5 digits, and decimal point. Place decimal appropriate to range.

RELS? Relative Mode Setpoint Query.
Input: RELS?
Returned: ±XXX.XX
Remarks: Returns sign, up to 5 digits, and decimal point. Places decimal appropriate to range.

SNUM? Probe Serial Number Query.
Input: SNUM?
Returned: XXXXXXXXXXXX
Remarks: Queries probe serial number. The latest probe serial number format is HXXXXXX, though there is room for up to a ten-character response.

TYPE? Probe Type Query.
Input: TYPE?
Returned: 0, 1, or 2
Remarks: Queries probe type: **0** = high sensitivity, **1** = high stability, **2** = ultra-high sensitivity.

UNIT Set Gauss or Tesla Unit Status.
Input: UNIT G or UNIT T
Returned: Nothing
Remarks: Sets unit status: **G** = gauss, **T** = tesla.

UNIT? Gauss or Tesla Unit Query.
Input: UNIT?
Returned: G or T
Remarks: Queries unit status: **G** = gauss, **T** = tesla.

ZCAL Initiate Zero Probe Command.
Input: ZCAL
Returned: Nothing
Remarks: Initiates zero probe function. Place probe in the Zero Gauss Chamber first and then enter the ZCAL command.

This Page Intentionally Left Blank

CHAPTER 5

SERVICE

5.0 GENERAL

This chapter covers: General Troubleshooting (Paragraph 5.1), Changing Power Settings and Fuse Ratings (Paragraph 5.2) Rear panel Connector Definitions (Paragraph 5.3), Serial Interface Cables and Adapters (Paragraph 5.4), and Operating Software EPROM Replacement (Paragraph 5.5).

5.1 GENERAL TROUBLESHOOTING

If the keyboard locks up, hold **Escape** for about 20 seconds to reset the Model 420 to factory defaults. The gaussmeter then requires the user to re-enter setpoints and zero the probe.

If there is no power, check the outlet and the connection at both ends of the power cord. Next check the fuse. Remove line cord then place a small slotted screwdriver in the slot of the small door at the rear of the unit to access the fuse (see Figure 5-1). For 100/120 V operation, the fuse rating is 0.5 A and the fuse type is 3AG Slow Blow. For 220/240 V operation, the fuse rating is 0.25 A and the fuse type is 5x20 mm T. Test fuse with ohmmeter. Do not rely on visual inspection of fuse.

5.2 Changing power SETTING and fuse RATING

There are two basic power configurations: domestic and foreign. Domestic has a single fuse on the hot. Foreign has a double fuse for the hot and neutral. Units with power requirements specified at purchase are factory pre-configured for the proper power setting. If power settings are incorrect for your application, use the procedure below to change power settings.

1. Turn Off unit.
2. Unplug line cord from rear of unit.
3. Use small screwdriver to open fuse drawer.
4. Pull out the fuse holder, rotate until the proper voltage setting displays through the fuse drawer window. Place fuse holder back in fuse drawer.
5. Remove existing fuse(s). Replace with proper fuse ratings as follows: 0.5 A for 100/120 VAC; or 0.25 A for 220/240 VAC.
6. Slide fuse drawer back into unit.
7. Plug line cord into rear of unit.
8. Perform initial setup and system checkout procedure in Paragraph 2.4.

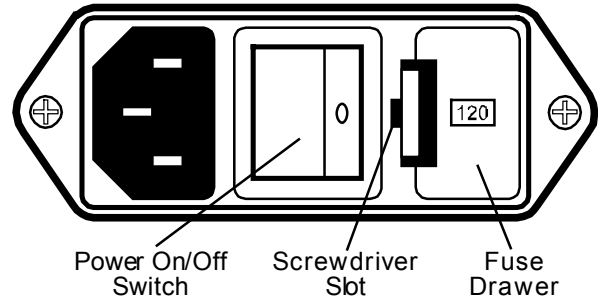
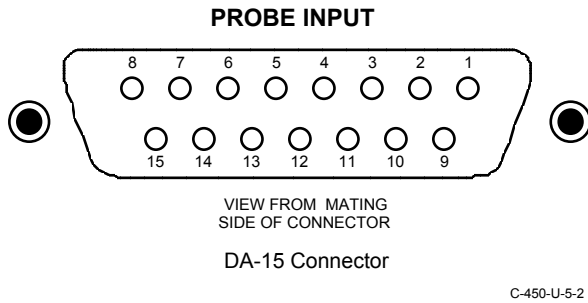


Figure 5-1 Power Fuse Access

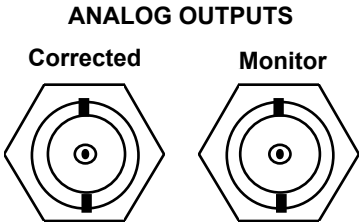
5.3 REAR PANEL CONNECTOR DEFINITIONS



C-450-U-5-2

PIN	DESCRIPTION
1	Input +
2	NC
3	NC
4	ITEMP +
5	ITEMP -
6	NC
7	NC
8	I _c +
9	INPUT -
10	NC
11	GND 1
12	V _{cc}
13	A/D CLK
14	EE-DATA
15	I _c -

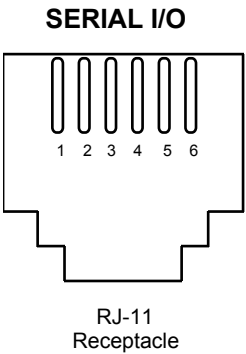
Figure 5-2 DA-15 PROBE INPUT Connector Details



C-450-U-5-3

PIN	DESCRIPTION
1	Analog Output - Center Conductor
2	Ground - Connector Shell

Figure 5-3 Corrected and Monitor ANALOG OUTPUTS Connector Details



C-450-U-5-4

PIN	DESCRIPTION
1	Serial In (RxD)
2	Serial In (RxD)
3	Serial Ground
4	Serial Ground
5	Serial Out (TxD)
6	Serial Out (TxD)

Figure 5-4 SERIAL I/O RJ-11 Connector Details

5.4 SERIAL INTERFACE CABLE AND ADAPTERS

To aid in Serial Interface troubleshooting, Figures 5-6 through 5-8 show wiring information for the cable assembly and the two mating adapters.

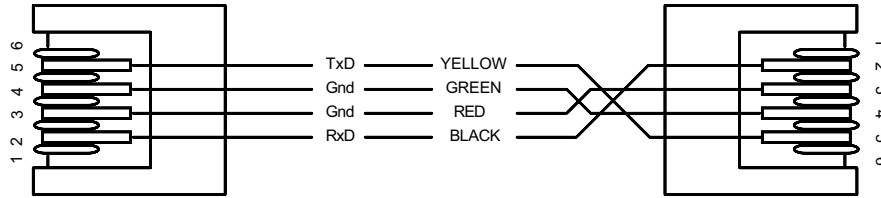


Figure 5-6 Model 2001 RJ-11 Cable Assembly Wiring Details

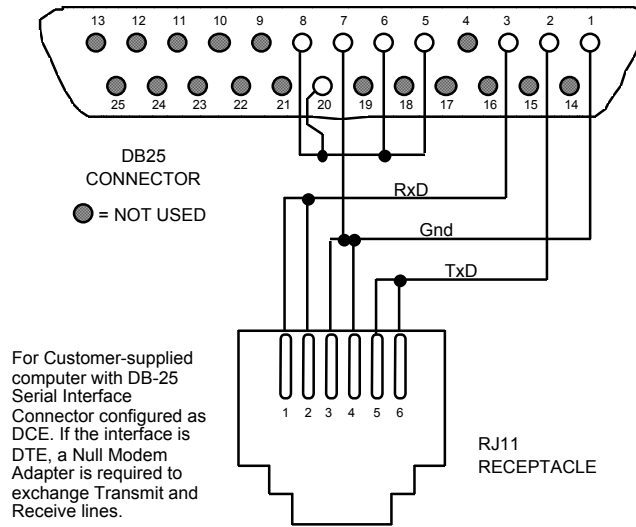


Figure 5-7 Model 2002 RJ-11 to DB-25 Adapter Wiring Details

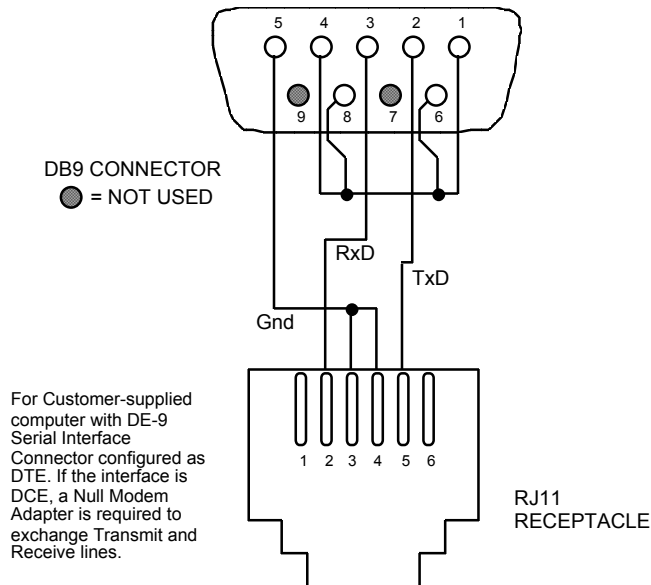


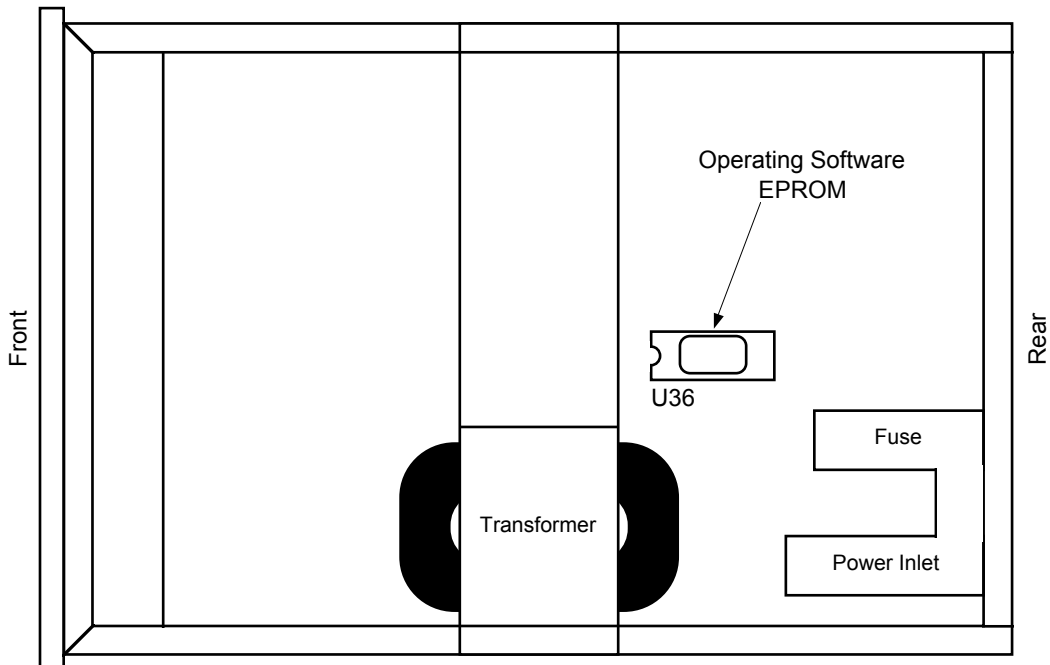
Figure 5-8 Model 2003 RJ-11 to DE-9 Adapter Wiring Details

5.5 OPERATING SOFTWARE EPROM REPLACEMENT

The operating software for the Model 420 is contained on one Erasable Programmable Read Only Memory (EPROM) Integrated Circuit (IC). The EPROM is numbered U36 and located just behind the microprocessor IC (U31). The EPROM also has a label on top identifying the software version and date (see Figure 5-9). Use the procedure below to replace the operating software EPROM.

WARNING: To avoid potentially lethal shocks, turn off the instrument and disconnect it from the AC power line before performing this procedure.

1. Set power switch to Off and disconnect power cord from rear of unit.
2. Use 5/64 hex key to remove four screws attaching top panel to unit.
3. Use 5/64 hex key to loosen two screws attaching bottom panel to unit.
4. Carefully remove back bezel.
5. Slide top panel back and remove from unit.
6. Locate software EPROM U36 on main circuit board. Note its orientation (circular notch on front of IC). See Figure 5-9.
7. Use IC puller to remove existing EPROM from socket.
8. Use IC insertion tool to place new EPROM into socket, noting its orientation.
9. Replace top of enclosure and secure with four screws.
10. Replace back bezel and use 5/64 hex key to tighten two screws attaching bottom panel to unit.
11. Reconnect power cord to rear of unit and set power switch to On.
12. Perform the initial setup and system checkout (see Paragraph 2.6). When replacing the operating software EPROM, all operating parameters reset to factory defaults specified in Paragraph 3.14.



C-450-U-5-9

Figure 5-9 Location Of Operating Software EPROM

CHAPTER 6

ACCESSORIES AND PROBES

6.0 GENERAL

This chapter lists Model 420 Gaussmeter Accessories (Paragraph 6.1) and Probes (Paragraph 6.2).

6.1 ACCESSORIES

Accessories are devices that perform a secondary duty as an aid or refinement to the primary unit.

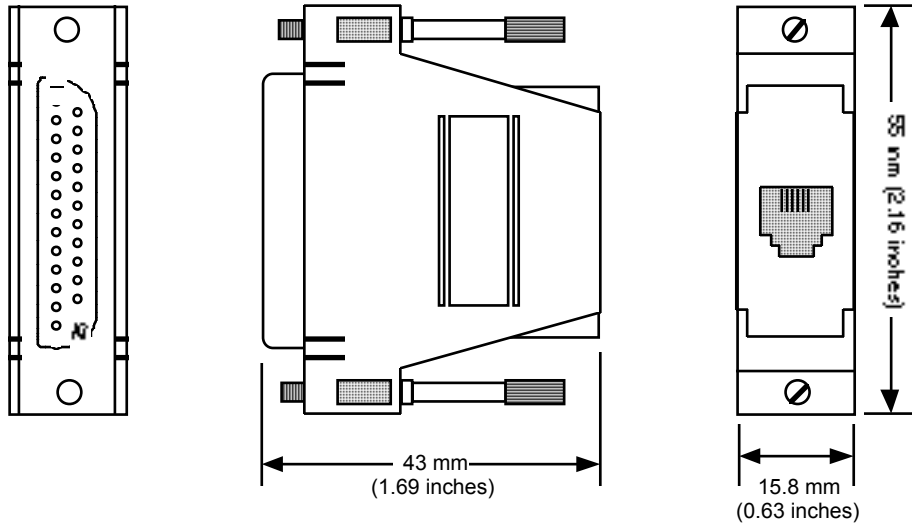
MODEL NUMBER	DESCRIPTION								
4001	RJ-11 Cable Assembly. Four-Wire Cable Assembly with RJ-11 plugs on each end. Used with RS-232C Interface. Cable is 4.3 meters (14 feet) long. See Figure 6-1.								
4002	RJ-11 to DB-25 Adapter. Adapts RJ-11 receptacle to female DB-25 connector. Connects Model 420 to RS-232C Serial Port on rear of Customer's computer. See Figure 6-2.								
4003	RJ-11 to DE-9 Adapter. Adapts RJ-11 receptacle to female DE-9 connector. Connects Model 420 to RS-232C Serial Port on rear of Customer's computer. See Figure 6-3.								
4004	IEEE-488 Interface Cable. Connects Model 420 to customer-supplied computer with IEEE-488 Interface. Cable is 1 meter (3.3 feet) long.								
4022	Half-Rack Mounting Kit for One 1/2 Rack Gaussmeter. Half-length mounting panel and mounting ears to attach one Model 420 Gaussmeter to a 482.6 mm (19-inch) rack mount space. See Figure 6-4.								
4026	Dual Mounting Shelf for Two 1/2 Rack Gaussmeters. Mounting panel and mounting ears to attach two Model 420 Gaussmeters to a 482.6 mm (19-inch) rack mount space. See Figure 6-5.								
4040	Handle Carrying Kit with Feet. Contains side-mounting handle and feet.								
4060	Standard Zero Gauss Chamber. Calibrates standard probes. Size: 32.2 x 32.2 x 61 mm (1.27 x 1.27 x 2.4 in.). Bore: 12.2 mm dia. x 50.8 mm deep (0.48 x 2 in.). See Figure 6-6.								
4065	Large Zero Gauss Chamber. Calibrates Gamma probes™. Size: 57.1 x 53.3 x 304.8 mm (2.25 x 2.06 x 12 in.). Bore: 19.1 mm dia. x 279.4 mm deep (0.75 x 11 in.). See Figure 6-7.								
4502	Model 420 Gaussmeter User's Manual.								
MCBL-6	Hall Generator Cable Assembly. The MCBL-6 Cable Assembly connects a discrete Hall generator to the Model 420 Gaussmeter. Cable is 2 meters (79 inches) long. The cable ships with the HALLCAL.EXE program on a 3.5 inch diskette which permits cable PROM programming through an IBM PC or compatible computer serial port. Because of the many calibration intricacies, the user is responsible for measurement accuracy. See Appendix C.								
MPEC-XXX	<p>Probe Extension Cables. Contains a EEPROM for calibration data. Probe and extension cable must be calibrated together. Available part numbers and cables lengths are:</p> <table style="margin-left: 40px;"> <tr> <td>MPEC-10</td> <td>Probe Extension Cable – 3 meters (10 feet)</td> </tr> <tr> <td>MPEC-25</td> <td>Probe Extension Cable – 7.6 meters (25 feet)</td> </tr> <tr> <td>MPEC-50</td> <td>Probe Extension Cable – 15.2 meters (50 feet)</td> </tr> <tr> <td>MPEC-100</td> <td>Probe Extension Cable – 30.5 meters (100 feet)</td> </tr> </table>	MPEC-10	Probe Extension Cable – 3 meters (10 feet)	MPEC-25	Probe Extension Cable – 7.6 meters (25 feet)	MPEC-50	Probe Extension Cable – 15.2 meters (50 feet)	MPEC-100	Probe Extension Cable – 30.5 meters (100 feet)
MPEC-10	Probe Extension Cable – 3 meters (10 feet)								
MPEC-25	Probe Extension Cable – 7.6 meters (25 feet)								
MPEC-50	Probe Extension Cable – 15.2 meters (50 feet)								
MPEC-100	Probe Extension Cable – 30.5 meters (100 feet)								



Cable Length: 4.3 meters (14 feet)

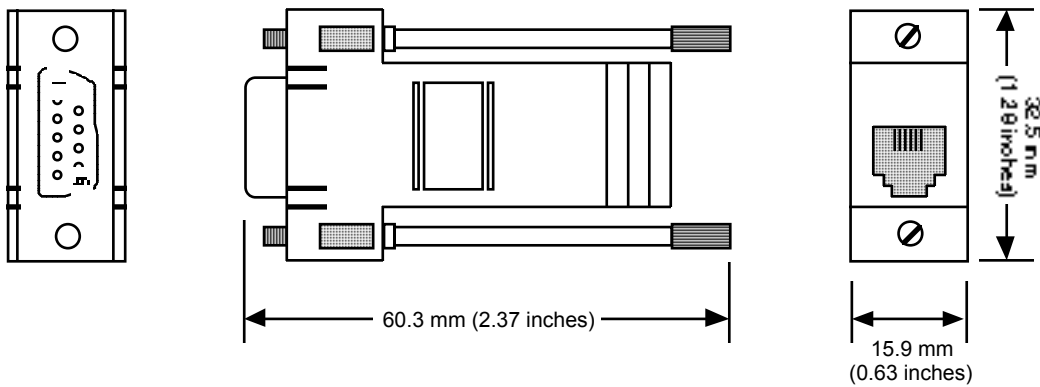
C-450-U-6-1

Figure 6-1 Model 4001 RJ-11 Cable Assembly



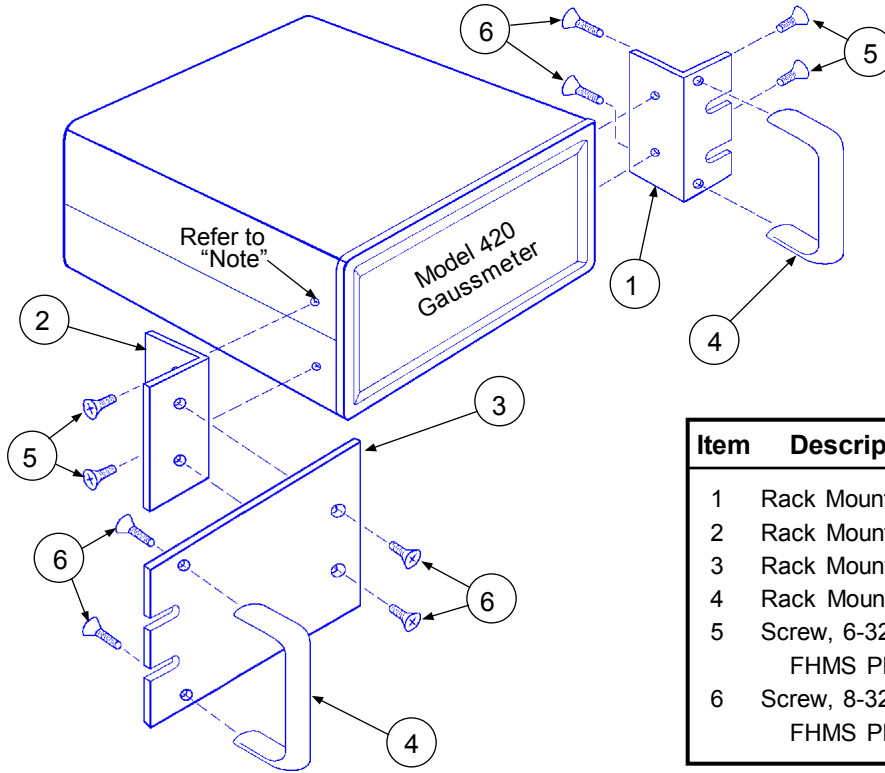
C-450-U-6-2

Figure 6-2 Model 4002 RJ-11 to DB-25 Adapter



C-450-U-6-3

Figure 6-3 Model 4003 RJ-11 to DE-9 Adapter

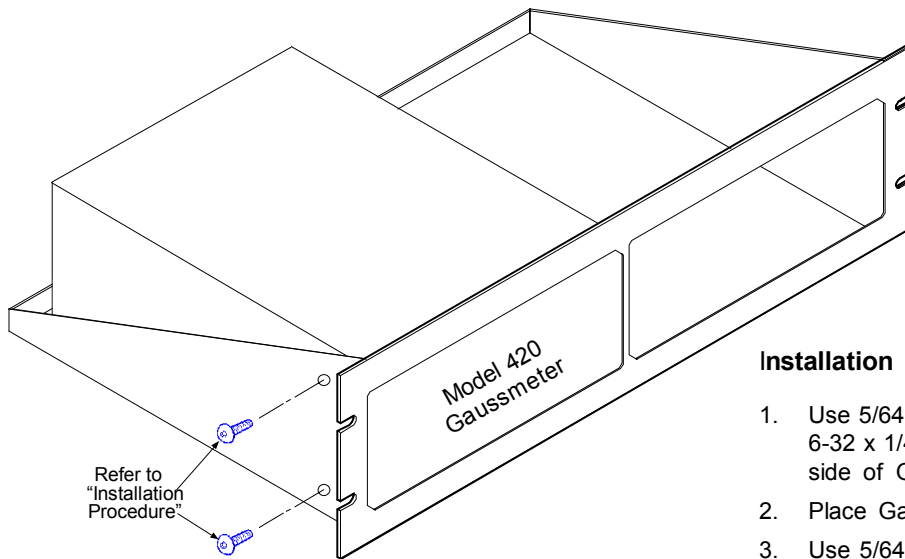


NOTE: Remove four Model 450 side screws with 5/64" (2 mm) hex key.
Drawing shows right side mounting. Left side mounting also possible.

Item	Description	P/N	Qty
1	Rack Mount Ear	107-430	1
2	Rack Mount Support	107-431	1
3	Rack Mount Panel	107-432	1
4	Rack Mount Handle	107-433	2
5	Screw, 6-32 x 1/2 Inch FHMS Phillips	0-035	4
6	Screw, 8-32 x 3/8 Inch FHMS Phillips	0-081	6

Figure 6-4 Model 4022 Rack-Mount Kit

C-450-U-6-4



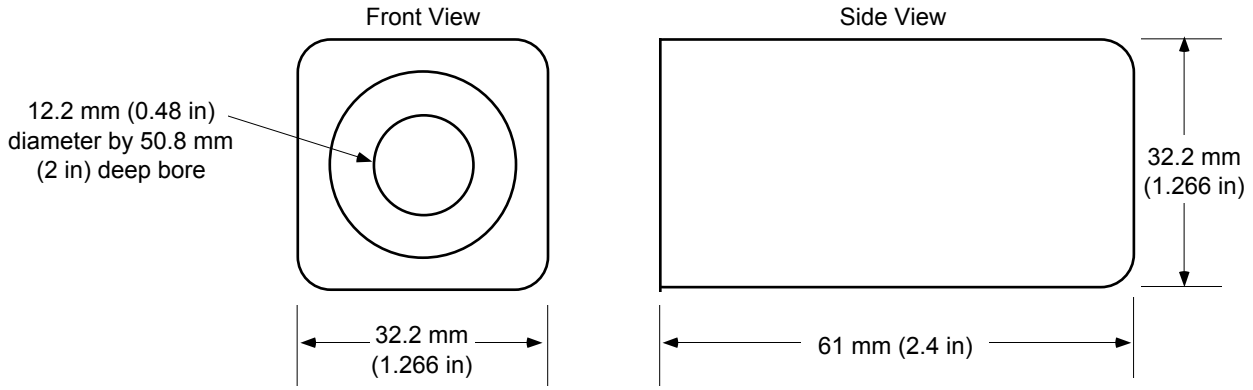
Installation Procedure

1. Use 5/64 inch (2 mm) hex key to remove two 6-32 x 1/4 black button head screws from side of Gaussmeter.
2. Place Gaussmeter on shelf.
3. Use 5/64 inch (2 mm) hex key to reinstall two 6-32 x 1/4 black button head screws through side of rack into corresponding holes in the side of the Gaussmeter.

Figure 6-5 Model 4026 Dual Rack-Mount Shelf

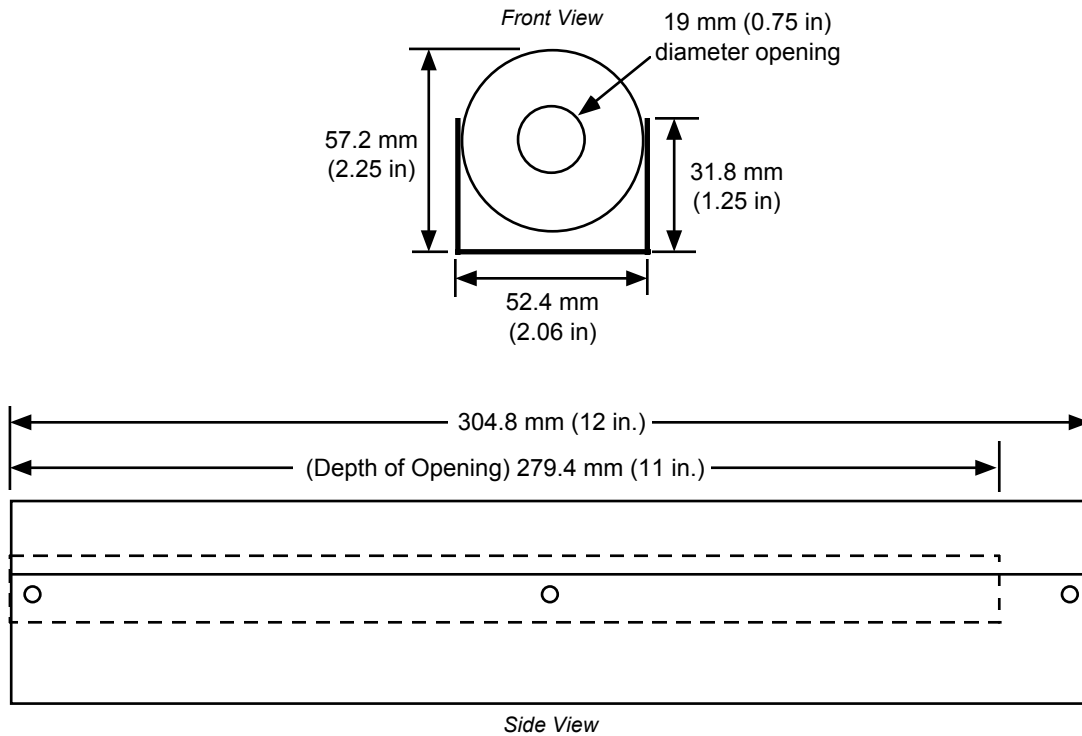
C-450-U-6-5

NOTE: Periodically de-magnetize (degauss) the chamber. Using a magnetized chamber to zero a probe can lead to erroneous field readings. If no professional degausser is available, use a bulk tape degausser (Radio Shack P/N 44-232 or equivalent).



C-450-U-6-6

Figure 6-6 Model 4060 Standard Zero Gauss Chamber



C-450-U-6-7

Figure 6-7 Model 4065 Large Zero Gauss Chamber

6.2 PROBES

There are four types of Model 420 probes available: Transverse (Figure 6-8), Axial (Figure 6-9), Flexible Transverse (Figure 6-10), and Gamma (Figure 6-11) - each named by its Hall sensor orientation. Because the Model 420 covers such a wide magnetic field range (0.01 mG to 300 kG), three probe ranges are available: High Stability (HST), High Sensitivity (HSE), and Ultra-High Sensitivity (UHS). Consult the factory for availability of probe types not detailed in these figures.

Selecting the right probe can be difficult. Below are simple guidelines to help in the selection process.

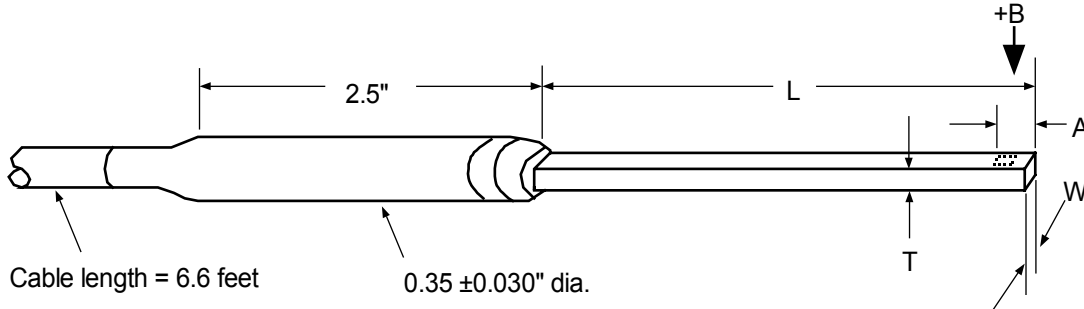
1. Match the probe to the application. Do not buy more accuracy, field range, or fragility than necessary.
2. The thinner a probe, the more fragile it is. Avoid selecting an easily damaged probe based on a possible, but not probable, future application. For instance, avoid using an exposed-device probe such as a Model MFT-3E03 type for general field measurements. *A damaged probe stem or sensor is irreparable.*
3. Metal enclosed probes, such as the Model MMT-6J08 and MMA-2508, offer the greatest Hall sensor protection and are the most rugged.
4. Be cautious about aluminum stemmed, transverse probes like the Model MMT-6J08 types, if measuring AC magnetic fields. Eddy currents in the aluminum can affect accuracy. A superior choice for AC measurements is the Model MNT-4E04 type fiberglass-epoxy stem probes.
5. Each probe type has several stem lengths. User preferences or test set-up dimensions usually determine final selection. Longer stems are more susceptible to accidental bending (mostly bothersome, not catastrophic). Stem length does not affect performance.
6. Be aware of the differences in the probe "active areas" shown on the data sheet. A Hall effect probe indicates the average field value sensed over that total active area. Thus, when measuring magnetic fields with a high gradient across the sensor width, choose the smallest active area practical, remembering guideline #2 above.
7. Lake Shore gaussmeter probes provide valid readings over different ranges of magnetic fields. Check the specification sheet for these usable ranges. Use High Stability probes, (i.e. -VG models) on 300 gauss (30 millitesla) to 30 kilogauss (3 tesla) full scale ranges. Use High Sensitivity probes (i.e., -VH models) on 30 G (3 mT) to 30 kG (3 T) full scale ranges. Use specially calibrated High Field probes for fields above 30 kG (3 T). Use the Gamma probe™ on the 300 mG (30 μ T) and 3 G (300 μ T) ranges.
8. If no standard probe configuration fits your needs, Lake Shore offers custom probes to meet physical, temperature, and accuracy requirements. Contact Lake Shore for details.

Probe Table Definitions:

- A** = Distance from tip of probe to center line of active area.
- +B** = Magnetic flux density vector (positive Gaussmeter reading).
- HST** = High Stability Probe.
- HSE** = High Sensitivity Probe.
- UHS** = Ultra-High Sensitivity Probe.

Usable Full-Scale Ranges vs Probe Type

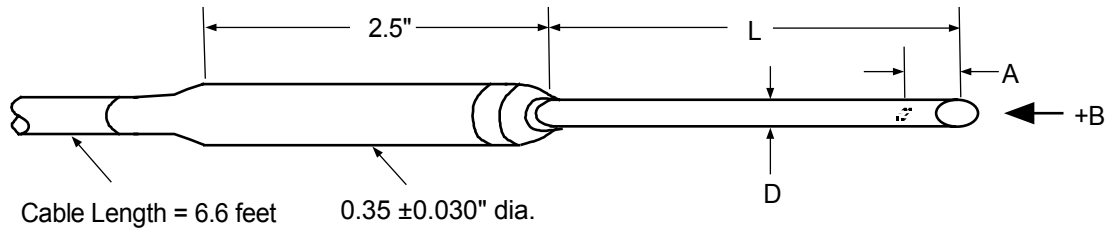
Type	HST-1	HST-2	HSE-1	UHS-1
Usable on Ranges	300 G	300 G	30 G	300 mG
	3 kG	3 kG	300 G	3 G
	30 kG	30 kG	3 kG	30 G
	300 kG	—	30 kG	—



Model Number	L	T	W	A	Active Area	Stem Material	Freq. Range	Type	Corrected Accuracy (% of rdg)	Op. Temp. Range	Temperature Coefficient (Max)							
											Zero	Calibration						
MMT-6J02-VH	2"	0.061" max.	0.180 ±0.005"	0.150 ± 0.050"	0.040" dia. approx.	Alum.	DC	HSE-1	±0.25% to 30 kG	0 °C to +75 °C	±0.09 Gauss per °C	-0.015% per °C						
MMT-6J04-VH	4"																	
MMT-6J08-VH	8"																	
MMT-6J18-VH	18"																	
MNT-4E02-VH	2"	0.045" max.	0.140 ±0.005"			0.150 ± 0.050"	0.040" dia. approx.	Rigid Glass Epoxy	DC, 10 to 400 Hz	HSE-1	±0.25% to 30 kG	0 °C to +75 °C	±0.09 Gauss per °C	-0.015% per °C				
MNT-4E04-VH	4"																	
MMT-6J02-VG	2"	0.061" max.	0.180 ±0.005"					0.150 ± 0.050"	0.040" dia. approx.	Alum.	DC	HST-2	±0.15% to 30 kG	0 °C to +75 °C	±0.13 Gauss per °C	-0.005% per °C		
MMT-6J04-VG	4"																	
MMT-6J08-VG	8"																	
MMT-6J18-VG	18"																	
MNT-4E02-VG	2"	0.045" max.	0.140 ±0.005"							0.150 ± 0.050"	0.040" dia. approx.	Rigid Glass Epoxy	DC, 10 to 400 Hz	HST-1	±2% to 100 kG	1.5 K to 350 K	-0.010% per °C	-0.010% per °C
MNT-4E04-VG	4"																	
MCT-3160-WN	60"	0.312" dia. max.	0.210" ±0.050"	0.150 ± 0.050"	0.040" dia. approx.							Stainless Steel	DC, 10 to 400 Hz	HST-1	±2% to 100 kG	1.5 K to 350 K	-0.010% per °C	-0.010% per °C

C-450-U-6-8

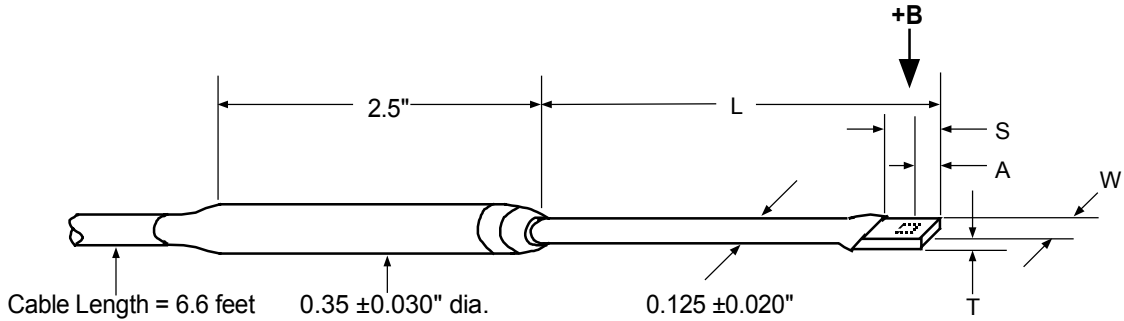
Figure 6-8 Definition of Lake Shore Transverse Probes



Model Number	L	D	A	Active Area	Stem Material	Freq. Range	Type	Corrected Accuracy (% of Reading)	Op. Temp. Range	Temp. Coefficient (Maximum)	
										Zero	Calibration
MMA-0602-TH	2 ± 0.125"	0.060 dia. +0.001 -0.003"	0.010 ± 0.005"	0.020" dia. approx.	Alum	DC, 10 to 400 Hz	HST-2	±0.25% to 10 kG	0 °C to 75 °C	±0.13 G per °C	±0.010%/°C
MMA-0604-TH	4 ± 0.125"										
MMA-0608-TH	8 ± 0.125"										
MMA-0618-TH	18 ± 0.125"										
MMA-1302-UH	2 ± 0.125"	0.125 dia. ±0.005"			Stainless Steel			±0.25% to 20 kG			
MMA-1304-UH	4 ± 0.125"										
MMA-1308-UH	8 ± 0.125"										
MNA-1902-VH	2 ± 0.125"	0.187 dia. ±0.005"		Fiber-glass Epoxy	±0.25% to 30 kG		HSE-1	±0.09 G per °C		-0.015 %/°C	
MNA-1904-VH	4 ± 0.125"										
MNA-1908-VH	8 ± 0.125"										
MMA-2502-VH	2 ± 0.063"	0.25 ± 0.006"		Alum	±0.15% to 30 kG		HST-2	±0.13 G per °C		±0.005%/°C	
MMA-2508-VH	8 ± 0.125"										
MNA-1902-VG	2 ± 0.125"	0.187 dia. ±0.005"	0.030" dia. approx.	Fiber-glass Epoxy	HST-2	±0.13 G per °C	±0.005%/°C				
MNA-1904-VG	4 ± 0.125"										
MNA-1908-VG	8 ± 0.125"										
MMA-2502-VG	2 ± 0.063"	0.25 ± 0.006"	Alum	±1% to 100 kG	HST-1	±0.13 G per °C	±0.010%/°C				
MMA-2508-VG	8 ± 0.125"										
MMA-2536-WL	36 ± 0.25"										
MCA-2560-WN	60 ± 0.50"		0.025 ± 0.005"		Stainless Steel	DC	HST-1	±2% to 100 kG	1.5 K to 350 K		

C-450-U-6-9

Figure 6-9 Definition of Lake Shore Axial Probes



This table is for L = 3 inches and S = 0.375 inch

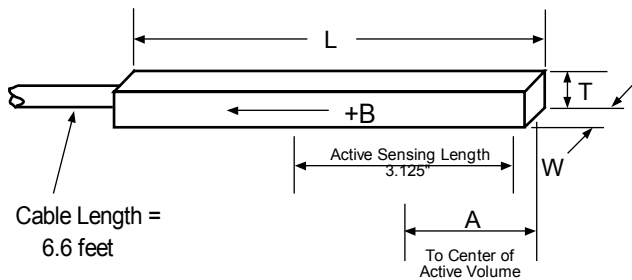
Model Number	W	T	A	Active Area	Stem Material	Frequency Range	Type	Corrected Accuracy (% of Reading)	Operating Temperature Range	Temperature Coefficient (maximum)	
										Zero	Calibration
MFT-3E03-VH	0.135" max	0.025" max	0.125" ±0.005"	0.040" dia. approx.	Flexible Tubing	DC, 10 to 400 Hz	HSE-1	±0.25% to 30 kG	0 °C to 75 °C	±0.09 G/°C	-0.015%/°C
MFT-3E03-VG							HST-1			±0.15% to 30 kG	±0.13 G/°C
MFT-2903-VJ	0.085" max	0.020" max	0.065" ±0.005"	HSE-1			±0.50% to 30 kG			±0.09 G/°C	-0.015%/°C
MFT-2903-VH				HST-2			±0.25% to 30 kG			±0.13 G/°C	±0.005%/°C

This table is for L = 15 inches and S = 0.75 inch

Model Number	W	T	A	Active Area	Stem Material	Frequency Range	Type	Corrected Accuracy (% of Reading)	Operating Temperature Range	Temperature Coefficient (maximum)	
										Zero	Calibration
MFT-4F15-VH	0.150" max	0.025" max	0.150" ±0.005"	0.040" dia. approx.	Flexible Tubing & Epoxy Fiberglass	DC, 10 to 400 Hz	HSE-1	±0.25% to 30 kG	0 °C to 75 °C	±0.09 G/°C	-0.015%/°C
MFT-4F15-VG							HST-2			±0.15% to 30 kG	±0.13 G/°C

C-450-U-6-10

Figure 6-10 Definition of Lake Shore Flexible Transverse Probes



Around large solenoids, measure small variations or low values of large volume magnetic fields such as that of the earth, or fringe fields with ultra-high sensitivity probes. Resolutions of several gammas (10^{-5} gauss) to tens of gammas are available depending on the mating gaussmeter.

Optimum application for homogeneous fields over lengths >1 foot. The active sensing length of the gamma probe is about 3.125 inches.

Model Number	W	T	A	L	Frequency Range	Type	Corrected Accuracy (% of Reading)	Operating Temperature Range	Temperature Coefficient (maximum)	
									Zero	Calibration
MLA-5006-HJ	0.25"	0.5"	2.2"	5.7"	DC, 10 to 400 Hz	UHS-1	±0.5% to 2 G	0 °C to 75 °C	1 mG/°C	-0.02%/°C
MLA-5009-HJ			4.5"	9.0"						

C-450-U-6-11

Figure 6-11 Definition of Lake Shore Gamma Probes™

APPENDIX A

UNITS FOR MAGNETIC PROPERTIES

Conversion from CGS to SI Units				
Quantity	Symbol	Gaussian & CGS emu ^a	Conversion Factor, C ^b	SI & Rationalized mks ^c
Magnetic flux density, Magnetic induction	B	gauss (G) ^d	10 ⁻⁴	tesla (T), Wb/m ²
Magnetic Flux	Φ	maxwell (Mx), G•cm ²	10 ⁻⁸	weber (Wb), volt second (V•s)
Magnetic potential difference, magnetomotive force	U, F	gilbert (Gb)	10/4π	ampere (A)
Magnetic field strength, magnetizing force	H	oersted (Oe), ^e Gb/cm	10 ³ /4π	A/m ^f
(Volume) magnetization ^g	M	emu/cm ^{3h}	10 ³	A/m
(Volume) magnetization	4πM	G	10 ³ /4π	A/m
Magnetic polarization, intensity of magnetization	J, I	emu/cm ³	4π x 10 ⁻⁴	T, Wb/m ²ⁱ
(Mass) magnetization	σ, M	emu/g	$\frac{1}{4\pi \times 10^{-7}}$	A•m ² /kg Wb•m/kg
Magnetic moment	m	emu, erg/G	10 ⁻³	A•m ² , joule per tesla (J/T)
Magnetic dipole moment	j	emu, erg/G	4π x 10 ⁻¹⁰	Wb•m ¹
(Volume) susceptibility	χ, κ	dimensionless emu/cm ³	(4π) ² x 10 ⁻⁷	Henry per meter (H/m), Wb/(A•m)
(Mass) susceptibility	χ _p , κ _p	cm ³ /g, emu/g	$\frac{4\pi \times 10^{-3}}{(4\pi)^2 \times 10^{-10}}$	m ³ /kg H•m ² /kg
(Molar) susceptibility	χ _{mol} , κ _{mol}	cm ³ /mol, emu/mol	$\frac{4\pi \times 10^{-6}}{(4\pi)^2 \times 10^{-13}}$	m ³ /mol H•m ² /mol
Permeability	μ	dimensionless	4π x 10 ⁻⁷	H/m, Wb/(A•m)
Relative permeability ^j	μ _r	not defined	-	dimensionless
(Volume) energy density, energy product ^k	W	erg/cm ³	10 ⁻¹	J/m ³
Demagnetization factor	D, N	dimensionless	1/4π	dimensionless

NOTES:

- Gaussian units and cgs emu are the same for magnetic properties. The defining relation is $B = H + 4\pi M$.
- Multiply a number in Gaussian units by C to convert it to SI (e.g. $1 \text{ G} \times 10^{-4} \text{ T/G} = 10^{-4} \text{ T}$).
- SI (Système International d'Unités) has been adopted by the National Bureau of Standards. Where two conversion factors are given, the upper one is recognized under, or consistent with, SI and is based on the definition $B = \mu_0(H + M)$, where $\mu_0 = 4\pi \times 10^{-7} \text{ H/m}$. The lower one is not recognized under SI and is based on the definition $B = \mu_0 H + J$, where the symbol I is often used in place of J.
- 1 gauss = 10⁵ gamma (γ).
- Both oersted and gauss are expressed as $\text{cm}^{-1/2} \cdot \text{g}^{1/2} \cdot \text{s}^{-1}$ in terms of base units.
- A/m was often expressed as "ampere-turn per meter" when used for magnetic field strength.
- Magnetic moment per unit volume.
- The designation "emu" is not a unit.
- Recognized under SI, even though based on the definition $B = \mu_0 H + J$. See footnote c.
- $\mu_r = \mu/\mu_0 = 1 + \chi$, all in SI. μ_r is equal to Gaussian μ .
- $B \cdot H$ and $\mu_0 M \cdot H$ have SI units J/m³, M • H and $B \cdot H/4\pi$ have Gaussian units erg/cm³.

R.B. Goldfarb and F.R. Fickett, U.S. Department of Commerce, National Bureau of Standards, Boulder, Colorado 80303, March 1985, NBS Special Publication 696. For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

This Page Intentionally Left Blank

APPENDIX B

HALL GENERATORS

B1.0 GENERAL

This chapter covers useful information about Hall Generators including: Theory of Operation (Paragraph B2.0), Generic Hall Generator Hookup (Paragraph B3.0), Hookup to a Model 420 Gaussmeter (Paragraph B4.0), Specifications (Paragraph B5.0), and the HALLCAL.EXE Program (Paragraph B6.0). Obtain additional installation and calibration information in Lake Shore Document Number C2S001.

B2.0 THEORY OF OPERATION

E. H. Hall discovered the Hall effect in 1879. For nearly 70 years it remained a laboratory curiosity. Finally, development of semiconductor and ceramic material brought Hall generators into the realm of the practical.

A Hall generator is a solid state sensor which provides an output voltage proportional to magnetic flux density. The device relies on the Hall effect which is the development of a voltage across a sheet of conductor placed in a magnetic field with current flowing. See Figure B-1.

Electrons (the majority carrier most often used in practice) “drift” in the conductor when under the influence of an external driving electric field. When exposed to a magnetic field, these moving charged particles experience a force perpendicular to both the velocity and magnetic field vectors. This force charges the conductor edges, one side positive with respect to the other. This edge charging sets up an electric field which exerts a force on the moving electrons equal and opposite to that caused by the magnetic-field-related Lorentz force. The voltage potential across the width of the conductor is called the Hall voltage. This Hall voltage can be utilized by attaching two electrical contacts to the sides of the conductor.

The Hall voltage can be given by the expression: $V_H = \gamma_B B \sin \theta$

where: V_H = Hall voltage (mV)

γ_B = Magnetic sensitivity (mV/kG) (at a fixed current)

B = Magnetic field flux density (kilogauss)

θ = Angle between magnetic flux vector and the plane of Hall generator.

The Hall voltage varies with the angle of the sensed magnetic field, reaching a maximum with the field perpendicular to the plane of the Hall generator.

B2.1 ACTIVE AREA

The Hall generator assembly contains the sheet of semiconductor material, normally called a “Hall plate”, to which the four contacts are made. In its simplest form, the Hall plate is a rectangle of fixed length, width, and thickness. Due to the shorting effect of the current supply contacts, most magnetic field sensitivity is contained in an area approximated by a circle, centered in the Hall plate, with a diameter equal to the plate width. Thus, when the active area is given, the circle as described above is the common estimation.

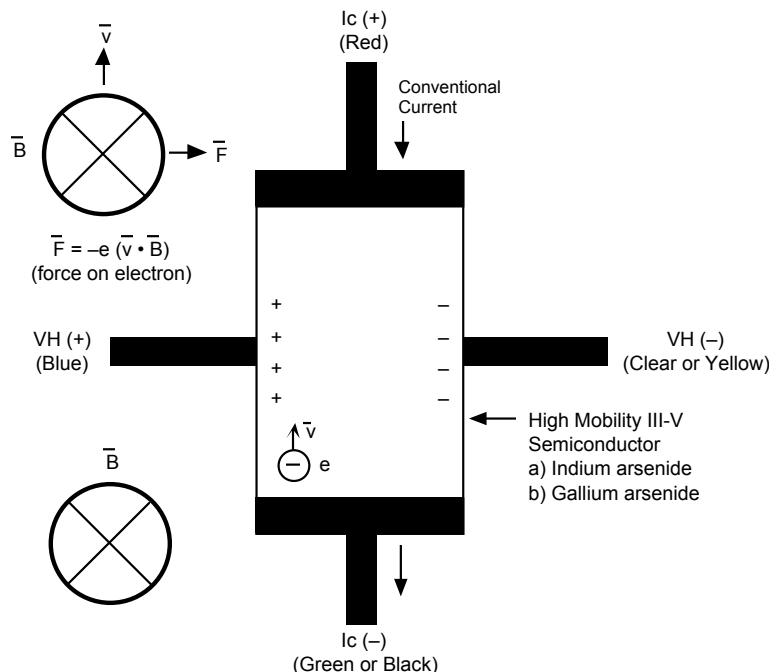


Figure B-1 Hall Generator Theory

B2.2 ORIENTATION

Hall generators come in two main configurations, axial and transverse. Transverse devices are generally thin and rectangular. They are applied successfully in magnetic circuit gaps, surface measurements, and general open field measurements. Axial sensors are mostly cylindrical. Their applications include ring magnet center bore measurements, solenoids, surface field detection, and general field sensing.

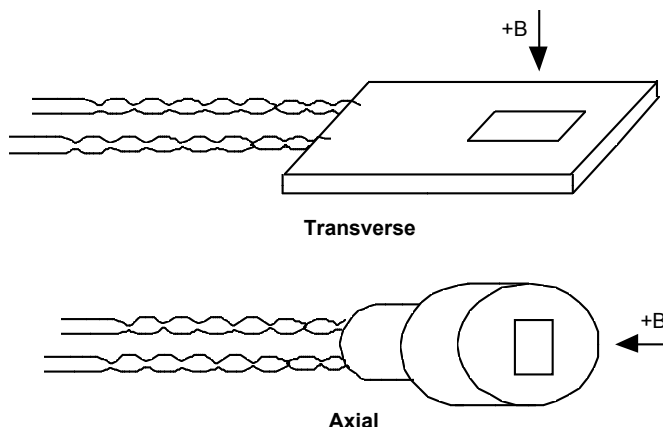


Figure B-2 Axial and Transverse Configurations

B2.3 HANDLING

CAUTION: Take care when handling the Hall generator; it is very fragile. Stressing it can alter its output, and any excess force can easily break it. Broken Hall generators are irreparable.

Hall Generators are very fragile and require delicate handling. The ceramic substrate used to produce the Hall Generator is very brittle. Use the leads to move the Hall generator. Do not handle the substrate. The strength of the lead-to-substrate bond is about 7 ounces, so avoid tension on the leads and especially avoid bending them close to the substrate. The Hall Generator is also susceptible to bending and thermal stresses.

B2.4 POLARITY

If the control current enters the red lead (with $+I_C$ connected to the positive terminal of the current supply), and the magnetic field direction is as shown in Figure B-2, a positive Hall voltage generates at the blue lead ($+V_H$). Reversing either the current or the magnetic field reverses the output voltage.

B2.5 LEAD CONFIGURATIONS

All Hall generators (except Models HGCA-3020 and HGCT-3020) have 34 AWG solid copper with poly-nylon insulation and have the lead configuration below:

Red = $+I_C$; Green = $-I_C$: Input (Control Current) Blue = $+V_H$; Clear = $-V_H$: Output (Hall Voltage)

The Model HGCA-3020 and HGCT-3020 Hall generators have 34 AWG stranded copper with Teflon[®] insulation and have the lead configuration below:

Red = $+I_C$; Black = $-I_C$: Input (Control Current) Blue = $+V_H$; Yellow = $-V_H$: Output (Hall Voltage)

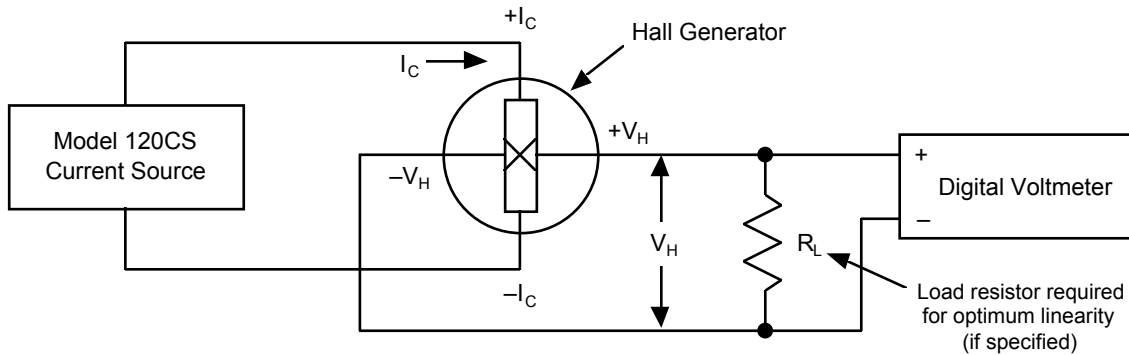
B3.0 HALL GENERATOR GENERIC HOOKUP

The Hall voltage leads may connect directly to a readout instrument, such as a high impedance voltmeter, or to electronic circuitry for amplification or conditioning. Device signal levels are in the range of microvolts to hundreds of millivolts. In this case, a separate precision current source (Lake Shore Model 120CS or equivalent) is necessary. See Figure B-3.

CAUTION

- The four Hall generator leads connect to four points on a semiconductor sheet with different potentials. No two leads can connect together without adversely affecting operation. The current source and the output indicator cannot connect, but must be isolated from each other. One or the other, but not both, may be grounded.
- Do not exceed the maximum continuous control current given in the specifications.

The Hall generator input is not isolated from its output. In fact, impedance levels on the order of the input resistance are all that generally exist between the two ports. To prevent erroneous current paths which can cause large error voltages, isolate the current supply from the output display or the down stream electronics.



C-450-U-C-3

Figure B-3 Typical Hall Generator Hookup

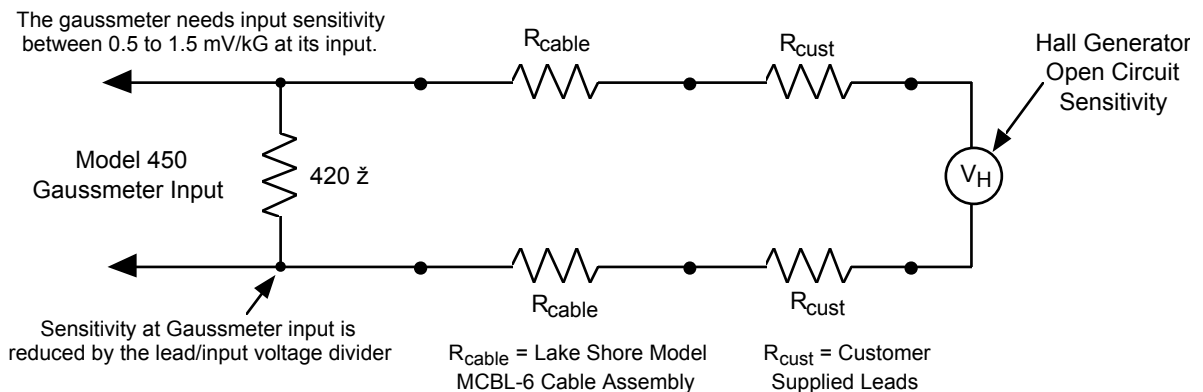
B4.0 USING A HALL GENERATOR WITH THE MODEL 420

To hookup a Hall generator to the Model 420 Gaussmeter, use a Lake Shore Model MCBL-6 Cable Assembly. The cable is 200 cm (79 inches) long with a DA-15 connector on one end and four leads on the other. The Hall generator is a four lead device. The four leads are labeled +I_c (Red), -I_c (Black), +V_H (Blue), and -V_H (Yellow), corresponding to the four leads on all Hall generators except for cryogenic models (see Paragraph B2.5).

The Model 420 has an input impedance of 420 Ω. Therefore, the actual sensitivity at the gaussmeter input is less than the value given with the Hall generator due to drop in the leads and cable. This is important because a sensitivity value is supposed to load into the cable PROM to set calibration. We recommend the customer always check accuracy against a reference field rather than use the sensitivity value sent with the bare Hall generator. Because Lake Shore has no control of conditions beyond the cable, the customer must accept responsibility for accuracy and compatibility.

Finally, Maganin wire is not usually acceptable for cryogenic installations because its resistance is often too high. In cryogenic applications, Hall generators normally connect with twisted pairs of copper wire such as 34 gauge, Teflon insulated. There are two reasons for this:

1. The gaussmeter current source is normally limited in compliance voltage. The Model 420 should not drive a load (Hall generator, Wires in cryostat, and probe cable) greater than 50 Ω. For best performance, use a load less than 30 Ω.
2. Because the Model 420 input impedance is 420 Ω, there is a voltage drop due to lead resistance in series with the gaussmeter input. The Lake Shore Hall generator sensitivity given on the data sheet includes no lead resistance. See Figure B-4.



C-450-U-C-4

Figure B-4 Hall Generator Input Impedance

B5.0 SPECIFICATIONS

This section covers three types of Hall generators available from Lake Shore: HGCA & HGCT Series Cryogenic Hall generators (Figures B-5 and B-6) with specifications (Table B-1), HGA Series Axial Hall generators (Figures B-5 and B-7) with specifications (Table B-2), and HGT Series Transverse Hall generators (Figures B-8 thru B-10) with specifications (Table B-3).

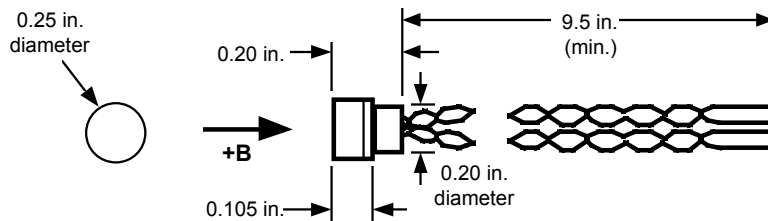


Figure B-5 Axial Hall Generator HGA-3010, HGA-3030, and HGCA-3010 Dimensions

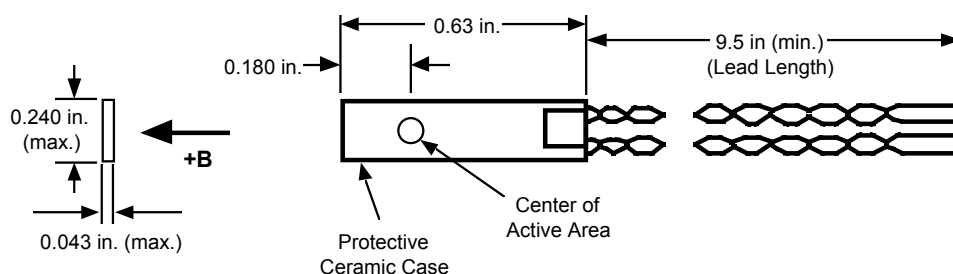


Figure B-6 Transverse Hall Generator HGT-3010, HGT-3030, and HGCT-3020 Dimensions

Table B-1 Cryogenic Hall Generator Specifications

Cryogenic	HGCA-3020	HGCT-3020
Description	Cryogenic axial; phenolic package	Cryogenic transverse; ceramic package
Active area	0.030 inch diameter circle	0.040 inch diameter circle
Input resistance	1 ohm	1 ohm
Output resistance	1 ohm	1 ohm
Nominal control current (I_{CN})	100 mA	100 mA
Maximum continuous current (non-heat sunked)	300 mA	300 mA
Magnetic sensitivity (I_C = nominal control current)	0.56 to 1.04 mV/kG	0.56 to 1.04 mV/kG
Maximum linearity error (sensitivity vs field)	$\pm 1.0\%$ RDG (-30 to +30 kG) $\pm 2.0\%$ RDG (-150 to +150 kG)	$\pm 1.0\%$ RDG (-30 to +30 kG) $\pm 2.0\%$ RDG (-150 to +150 kG)
Zero field offset voltage (I_C = nominal control current)	$\pm 200 \mu\text{V}$ (max.)	$\pm 200 \mu\text{V}$ (max.)
Operating temperature range	4.2 K to 375 K	4.2 K to 375 K
Mean temperature coefficient of magnetic sensitivity	$\pm 0.01\%/K$ (approx.)	$\pm 0.01\%/K$ (approx.)
Mean temperature coefficient of offset (I_C = nominal control current)	$\pm 0.4 \mu\text{V}/K$ (max.)	$\pm 0.4 \mu\text{V}/K$ (max.)
Mean temperature coefficient of resistance	$\pm 0.6\%/K$ (max.)	$\pm 0.6\%/K$ (max.)
Leads	34 AWG copper w/Teflon insulation	34 AWG copper w/Teflon insulation

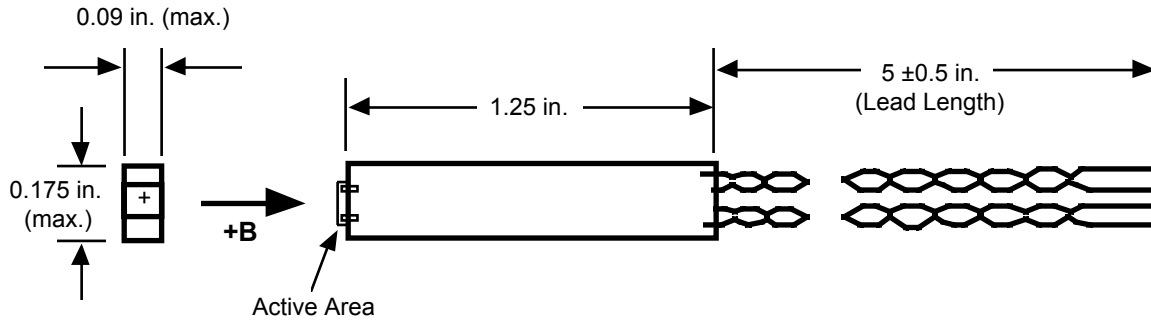


Figure B-7 Axial Hall Generator HGA-2010 Dimensions

Table B-2 Axial Hall Generator Specifications

Axial	HGA-2010	HGA-3010	HGA-3030
Description	General purpose axial; high sensitivity	Instrumentation quality axial; low temperature coefficient; phenolic package	Instrumentation quality axial; phenolic package
Active area	0.005 x 0.005 inch square	0.030 inch diameter circle	0.030 inch diameter circle
Input resistance	450 to 900 ohms	1 ohm	2 ohms
Output resistance	550 to 1350 ohms	1 ohm	2 ohms
Nominal control current (I_{CN})	1 mA	100 mA	100 mA
Maximum continuous current (non-heat sunked)	10 mA	300 mA	300 mA
Magnetic sensitivity ($I_C =$ nominal control current)	11 to 28 mV/kG	0.56 to 1.04 mV/kG	6.0 to 10.0 mV/kG
Maximum linearity error (sensitivity versus field)	±1% RDG (-10 to +10 kG) ±2% RDG (-20 to +20 kG)	±1% RDG (-20 to +20 kG) ±1.5% RDG (-100 to +100 kG)	±0.25% RDG (-10 to +10 kG) ±1.00% RDG (-30 to +30 kG)
Zero field offset voltage ($I_C =$ nominal control current)	±2.8 mV (max.)	±50 μ V (max.)	±75 μ V (max.)
Operating temperature range	-20 to 75 °C	-40 to +100 °C	-40 to +100 °C
Mean temperature coefficient of magnetic sensitivity	-0.06%/°C (max.)	±0.005%/°C (max.)	-0.04%/°C (max.)
Mean temperature coefficient of offset ($I_C =$ nominal control current)	±1 μ V/°C (max.)	±0.4 μ V/°C (max.)	±0.3 μ V/°C (max.)
Mean temperature coefficient of resistance	+0.15%/°C (approx.)	±0.15%/°C (approx.)	+0.18%/°C (approx.)
Leads	34 AWG copper with poly-nylon insulation	34 AWG copper with poly-nylon insulation	34 AWG copper with poly-nylon insulation

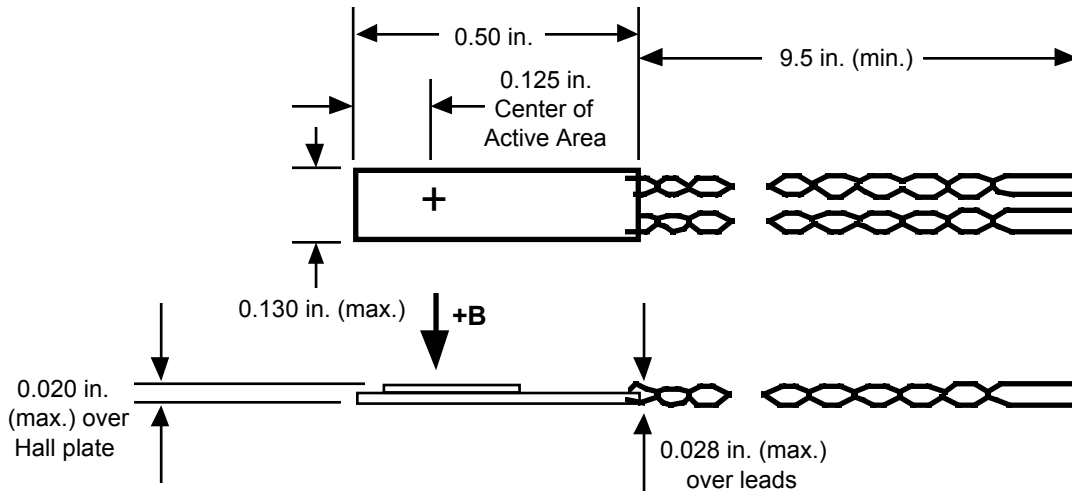


Figure B-8 Transverse Hall Generator HGT-1010 Dimensions

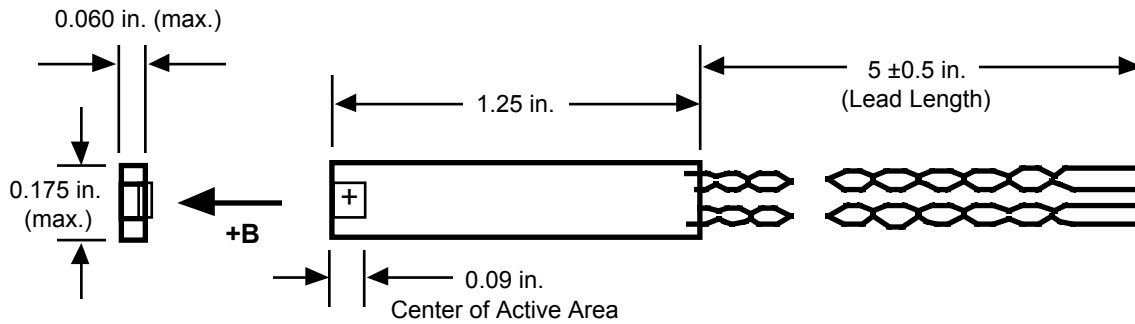


Figure B-9 Transverse Hall Generator HGT-2010 Dimensions

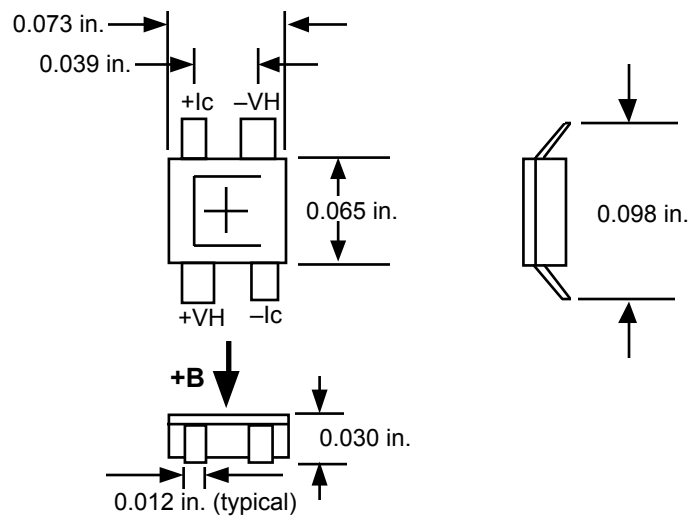


Figure B-10 Transverse Hall Generator HGT-2100 Dimensions

Table B-3 Transverse Hall Generator Specifications

Transverse	HGT-1010	HGT-2010	HGT-2100	HGT-3010	HGT-3030
Description	General purpose transverse; 0.020 inch thick	General purpose transverse; high sensitivity	Low cost; high sensitivity; surface mount	Instrumentation quality transverse; low temperature coefficient; ceramic package	Instrumentation quality transverse ceramic package
Active area	0.040 inch diameter circle	0.005 x 0.005 inch square	0.005 x 0.005 inch square	0.040 inch diameter circle	0.040 inch diameter circle
Input resistance	2 ohms	450 to 900 ohms	450 to 900 ohms	1 ohm	2 ohms
Output resistance	2 ohms	550 to 1350 ohms	550 to 1350 ohms	1 ohm	2 ohms
Nominal control current (I_{CN})	100 mA	1 mA	5 mA	100 mA	100 mA
Maximum continuous current (non-heat sinked)	300 mA	10 mA	10 mA	300 mA	300 mA
Magnetic sensitivity (I_C = nominal control current)	7.7 to 12.5 mV/kG	11 to 28 mV/kG	55 to 140 mV/kG	0.56 to 1.04 mV/kG	6.0 to 10.0 mV/kG
Maximum linearity error (sensitivity versus field)	±1.0% RDG (-10 to 10 kG)	±1% RDG (-10 to 10 kG) ±2% RDG (-20 to 20 kG)	±1% RDG (-10 to 10 kG) ±2% RDG (-20 to 20 kG)	±1% RDG (-20 to 20 kG) ±1.5% RDG (-100 to 100 kG)	±0.25% RDG (-10 to 10 kG) ±1.00% RDG (-30 to 30 kG)
Zero field offset voltage (I_C = nominal control current)	±100 μ V max.	±2.8 mV max.	±14 mV max.	±50 μ V max.	±75 μ V max.
Operating temperature range	-40 to +100 °C	-20 to +75 °C	-55 to +125 °C	-40 to +100 °C	-40 to +100 °C
Mean temperature coefficient of magnetic sensitivity	-0.08%/°C max.	-0.06%/°C max.	-0.06%/°C max.	±0.005%/°C max.	-0.04%/°C max.
Mean temperature coefficient of offset (I_C = nominal control current)	±1 μ V/°C max.)	±1 μ V/°C max.	±5 μ V/°C max.	±0.4 μ V/°C max.	±0.3 μ V/°C
Mean temperature coefficient of resistance	±0.18%/°C approx.	+0.15%/°C approx.	+0.15%/°C approx.	±0.15%/°C approx.	+0.18%/°C approx.
Leads	34 AWG copper with poly-nylon insulation.	34 AWG copper with poly-nylon insulation	Not applicable	34 AWG copper with poly-nylon insulation	34 AWG copper with poly-nylon insulation

B6.0 HALLCAL.EXE PROGRAM

The HALLCAL.EXE program interfaces customer attached Hall generators to the Model 420 Gaussmeter. (See the Software License Agreement behind the title page of this manual.) Because of the many intricacies of proper calibration, the Customer must accept responsibility for measurement accuracy.

Requirements:

- Lake Shore Model 420 Gaussmeter (connected via RS-232 to the computer's COM1 port).
- Lake Shore Model MCBL-6 Cable Assembly.
- IBM or compatible CPU.
- Hall generator meeting the sensitivity ranges given below.
- Hall generator calibration or sensitivity constant and serial number.

1. Set the Lake Shore Model 420 Gaussmeter to 300 Baud (see Paragraph 3.11).
2. Insert the 5.25-inch disk and type the default drive (**A:** or **B:**).
3. Type **HALLCAL** to execute the HALLCAL.EXE program.
4. The program prompts for the Probe serial number. Type any combination of 6 letters or numbers. Press **Enter** when done.
5. The program prompts for the probe type. Enter "**0**" for Hall generators with sensitivities between 5.6 and 10.4 mV/kG (@ 100 mA current). Enter "**1**" for Hall generators with sensitivities between 0.56 and 1.04 mV/kG (@ 100 mA current).
6. The program prompts for the Calibration Constant. Enter the magnetic sensitivity in mV/kG at a control current of 100 mA. Remember to account for the Gaussmeter 420 Ω input impedance when calculating the proper load resistor to install.
7. The program displays all values entered along with designated F keys:
F1: Probe Serial Number - ABC123 **F10:** Program Probe
F2: Probe Type - 0 **Esc:** Exit Program
F3: Calibration Constant - X.XXX

To change any parameter, press the appropriate F key and type in the new value. When everything appears correct, press F10 to program the probe.

8. It takes about 20 seconds to program the probe. After the probe is programmed, press **Esc** to exit the program.