USER'S MANUAL

Model 9300

Cryogenic
Vibrating Sample Magnetometer (VSM)
Hardware – Volume 1

Also Refer To Volume 2 – VSM System Software Manual

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NICKEL SAMPLE

Serial Number: _____

This nickel sample was fabricated from 99.995% purity nickel. The moment was verified with two independent measurement techniques. Corrections for demagnetization effects were not made. The estimated accuracy of each determination is ± 2%. We recommend averaging the two measurements.

Method 1 involved a mass determination and the use of the magnetization values for nickel as stated in the ASTM Standard A 894-89. The density of nickel was taken as 8.908 gm/cm^3. The table to the right summarizes the magnetization values at 293 K.

Magnetic Field (kOe)	M_v (±2 emu/cm^3)	M_m (±0.2 emu/gm)
5	487	54.7
6	488	54.8
7	489	54.9
8	490	55.0
9	491	55.1
10	492	55.2

Method 2 was a direct experimental comparison with a NIST SRM 772 Nickel Sphere using a vibrating sample magnetometer.

Method 1

Mass: _____ gm

Magnetic Moment: _____ emu calculated at _____ kOe

Method 2

Test Magnetic Field:_____kOe

Magnetic Moment: _____emu

Magnet Specifications

Magnet #: _____ Rated Current:

Manufacturer: _____ Field to Current Ratio:

Model #: _____ Measured Inductance:

Rated Central Field @ 4.2 k: _____ Charging Voltage (used in test):

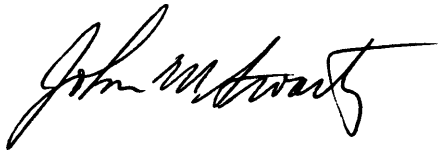
Declaration of Conformity

We:

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

hereby declare that the equipment specified conforms to the following Directives and Standards:

Application of Council directives:	**73/23/EEC** **89/336/EEC**
Standard to which Conformity is declared:	**EN55022** **EN50082-1** **EN61010-1**
Type of Equipment:	**VSM System**
Model Number:	**9300**



Signature

May 12, 1997

Date

John M. Swartz
Printed Name

President
Position

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CHAPTER 1

INTRODUCTION

1.1 GENERAL

Lake Shore Cryotronics, Inc. manufactures the Model 9300 Cryogenic Vibrating Sample Magnetometer (VSM) to be one of the most versatile computer-controlled systems to characterize magnetic properties of matter. State of the art design augmented with a comprehensive applications software package allows greater adaptability to specific application requirements. Broad measurement capability, high sensitivity, fast measurement speed, and easy operation make the system equally attractive for either research and development or manufacturing.

1.2 MODEL 9300 SPECIFICATIONS

1.2.1 Measurements

The Model 9300 either directly measures the parameters below or derives them:

- Hysteresis Loops
  - Saturation Magnetization (M_{SAT})
  - Retentivity or Remanent Magnetization (M_{REM})
  - Coercivity (Hc)
  - Slope at H_c, value of dM/dH, or Differential Susceptibility at H_c
  - Switching Field Distribution
  - Flatness
  - Squareness Ratio
  - Hysteresis Loss, Ws
- Minor Hysteresis Loops
- Initial Magnetization Curve
- AC Remanence
- DC Remanence
- Vector Measurements (m_x, m_y)
- Magnetization as a function of time
- Magnetization as a function of temperature for transition temperature and Curie point determinations. (4.2 K to 1273 K with optional cryostat and/or oven).

1.2.2 Sample Materials

The Model 9300 measures the magnetic moment of any magnetic material in any form except gases. The only constraint is sample size; it must fit into the sample holder.

1.2.3 Computer Requirements

1. **Minimum:** 486 PC-compatible, 16 MB RAM, VGA-compatible color monitor, 10 MB disk space.
   Recommended: Pentium PC-compatible, 32 MB RAM, SVGA-compatible color monitor, 10 MB disk space.
2. National Instruments GPIB-PCII/PCIIA IEEE-488.2 or AT-GPIB\TNT Legacy interface card.

1.2.4 System Elements

The VSM includes **IDEAS™ VSM Software**, a Windows™ menu-driven, enhanced color graphic software for system operation, data acquisition, and analysis. It includes individual instrument drivers for complete front panel control of the magnet power supply and VSM control unit. Display real-time feedback of processed magnetic moment measurement data in either graphical or tabular format. Standard measurements such as hysteresis loops, moment/time and moment/temperature are built into the control software. See the VSM Software manual for minimum hardware and software requirements.

Standard Model 9300 Superconducting Magnet VSM system

- Model 735 VSM Control Electronics
- Model 340 Temperature Controller
- Model 704 Motion Controller
- Model 620/622 Magnet Power Supply
- Model 241 Liquid Helium Level Monitor
- Superconducting Magnet Dewar
- VSM Drive Assembly and Mounting Structure
- Cryostat VSM Insert with Sample Rod
- Edwards 2-Stage ½ HP Pump
- Cryostat with 1, 5, 9, or 12 T parallel field, or 7 T transverse field superconducting magnet

1.2.5 System Options (See Chapter 6)

- **High-temperature ovens** allow measurements from 25 °C to 700 °C.
- The **Vector/Torque Magnetometer** option simultaneously measures 2-axis magnetic moment vectors to investigate anisotropic and low dimensional magnetic materials.
- The **Auto-Rotation** option automatically rotates a sample over a full 360° with angular resolution of better than 1°. Use it with the Vector/Torque option to produce torque curves as a function of rotation angle.
- The **Auto-Positioning** option automatically positions the sample within the VSM sensing coils to significantly simplify operation and enhance measurement accuracy.

1.2.6 General Superconducting Magnet VSM Specifications

SPECIFICATION	MODEL 9305	MODEL 9309	MODEL 9307T
EMU Dynamic Range	5 x10^{-6} to 1000 emu		50 x10^{-6} to 1000 emu
EMU Noise	5 x10^{-6} emu		50 x10^{-6} emu
EMU Time Constants	0.1 s, 0.3 s, 1.0 s, 3.0 s, 10.0 s		
EMU Stability	< ±0.05% of full scale per day, constant H and T		
EMU Absolute Accuracy	2% of reading, ±0.2% of full scale		
EMU Reproducibility	< ±1% or ±0.15% of full scale whichever is greater		
Field Noise	0.5 gauss		1.0 gauss
Field Accuracy	1% of reading ±0.05% full scale		
Field Stability			
Field Strength	±50 kG	±90 kG	±70 kG
Temperature Range	2.0 K to 400 K		
Temperature Accuracy	±0.2 K or ±0.5% of T whichever is greater at 0 field		
Temperature Stability	±0.1 K		
Temperature Uniformity	< ±(0.1 K + 0.5% of T)		
Temperature Precision	10 mK		
Helium Usage	0.27 liters/hr, 4-5 liters/day		
Helium Storage	40 liters		45 liters

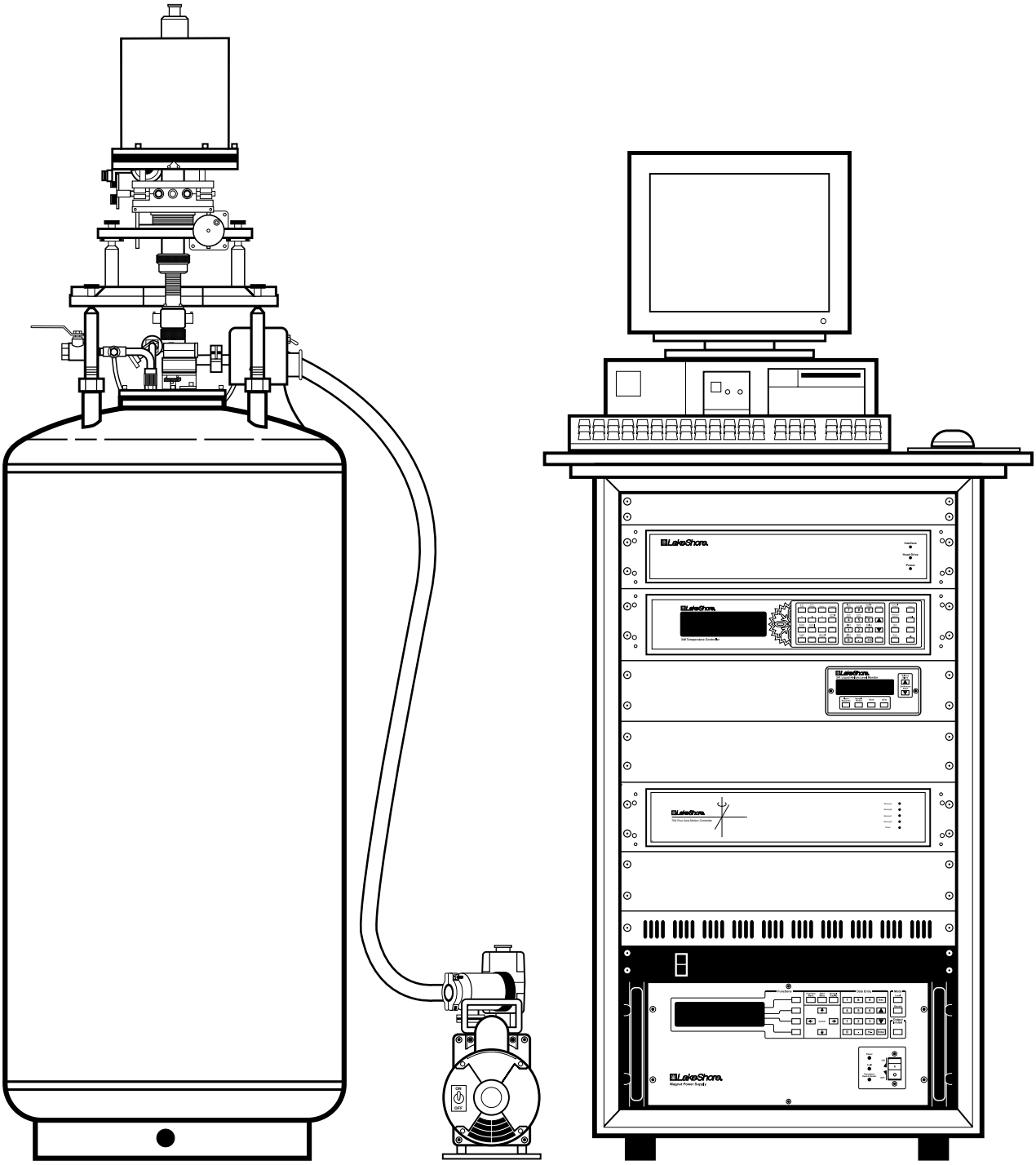

Figure 1-1. Typical Superconducting Magnet VSM System

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CHAPTER 2

PRE-INSTALLATION

2.1 GENERAL

The 9300 System was electrically and mechanically inspected and operationally tested prior to shipment. It should be free from mechanical damage and in perfect working order upon receipt. Study the 9300 User's Manual before attempting to run the system.

2.1.1 Inspecting and Unpacking the Model 9300

Set pallets on level surface. 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, notify shipping agent immediately.

Carton Shockwatch® and Tip-n-Tell indicators aid in judging the condition of received goods (see Figure 2-1). A Shockwatch® sticker is also on the pallet under the units. Please accept shipment even if Shockwatch® is red. Note it on the bill of lading and inspect for damage immediately. Two Tip-n-Tell indicators are placed on the Instrument Console pallet. Blue beads above the line indicate the container was tipped or mishandled.

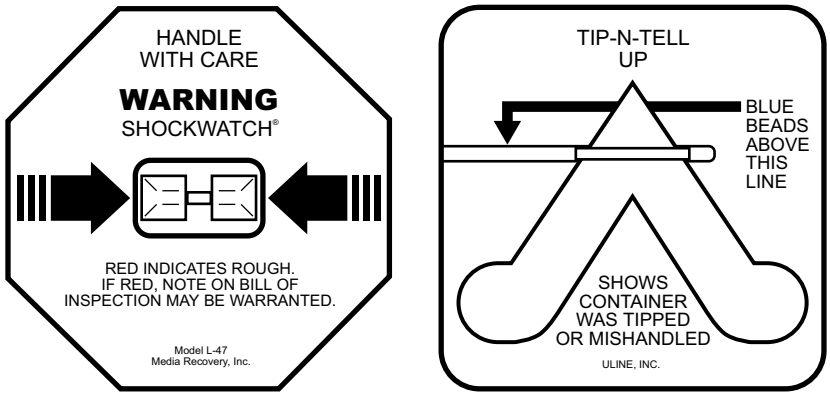

Figure 2-1 Shockwatch and Tip-n-Tell Indicators

Cut off strapping, lift off lid, and locate the packing list included with the system. Use it to check receipt of all components, cables, accessories, and manuals as the system is unpacked. Inspect for damage. Inventory all components supplied before discarding any shipping materials.

Remove the box from the top of the Instrument Console. Use four people to lift the Instrument Console from the pallet. Do not lift the console at the top: always lift from the bottom.

Note how the console was supported on the pallet for future reference. Foam blocks between the instruments support their weight during shipment; remove them, or simply leave them in place. To transport the unit, first insert the foam blocks.

The second pallet contains the system dewar. Three other boxes contain the system computer, cryostat with VSM insert and sample rod, and the drive. Verify receipt of all manuals. If any manuals are missing, contact Lake Shore immediately. **Be sure to fill out and send instrument warranty cards.**

If there is instrument freight damage, file claims promptly with the carrier and insurance company, and advise Lake Shore Cryotronics of such filings. Advise Lake Shore immediately of missing parts. Lake Shore cannot be responsible for any missing parts unless notified within 60 days of shipment. The standard Lake Shore Cryotronics, Inc. Warranty appears on the A Page (immediately behind the title page) of this manual.

2.1.2 Removing Packing Material from the Magnetometer Drive

Inside the magnetometer drive, there are several pieces of protective material to remove before operation. The drive normally ships on a wood base.

1. Remove the three stainless steel rim screws (NOT the black anodized screws) and lift off the cover.
2. The mechanism under the cover is protected by a plastic bag, and sometimes, a piece of foam rubber outside the bag. Remove the foam rubber, if present, and the bag.
3. Remove the shock bumper which goes completely around the disk at the top of the assembly.
4. Remove the two rubber shock mounts at the top of the disk.
5. Before reinstalling cover, lightly grasp the copper weights to verify they have not worked loose in shipment. Do not use excessive torque. If they are loose (very unlikely), contact the factory.
6. Inspect wiring for breakage (also unlikely).
7. Replace the cover and rethread the rim screws.
8. When ready to install the drive assembly, remove it from the wooden block by removing the lag bolts in each corner.

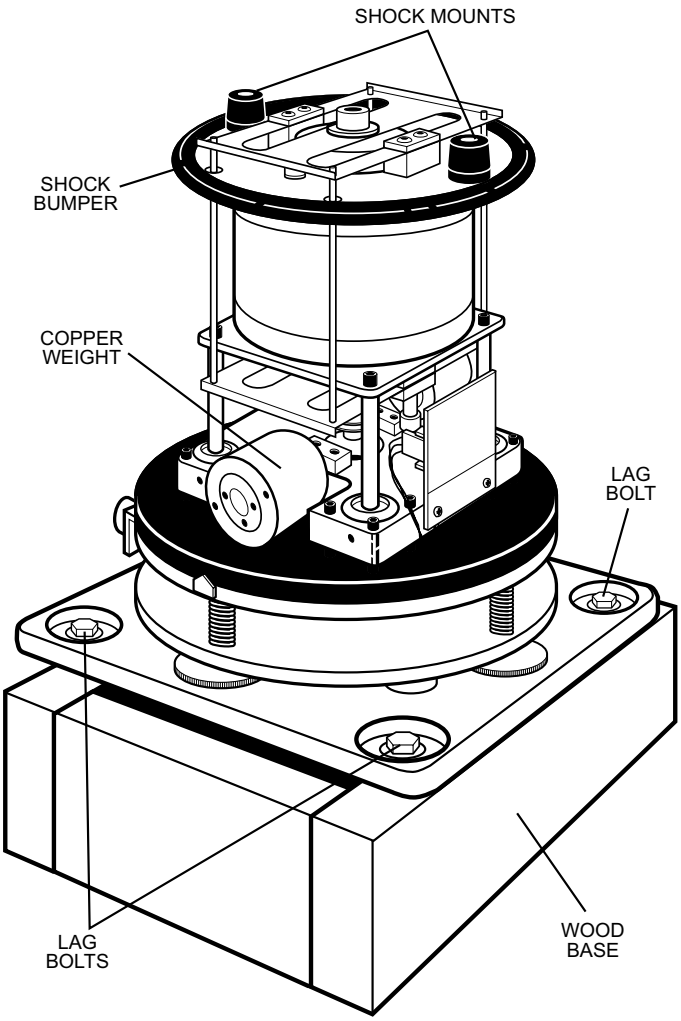

Figure 2-2. Drive with Cover Removed

2.1.3 Site Requirements

The Customer is responsible for site preparation. Plan the site before the 9300 System arrives. Research physical location, environment, cryogenic storage and access, power, ventilation, safety, and local building, electrical, and safety codes before system installation. See Figure 2-2 for physical dimensions of a suggested site. After initial screening, evaluate sites according to space, location, power, and structural integrity.

1. **Space:** Adequate for system installation, operation, potential expansion, service, and storage of supplies. Space and layout requirements depend on the system selected. The ceiling must be high enough to allow the sample rod assembly insertion and removal. Minimum clearance, measured from the center of the magnet pole pieces to the ceiling is 85 inches (215.9 cm).
2. **Location:** Convenient for equipment and supply delivery, and handy to related work areas for efficient operation. Especially important is sufficient access for a lift to move and place an electromagnet. Place the magnet in an area free from major vibration from motors, pumps, forklifts, etc.; it may interfere with VSM System Operation. Place the magnet dewar as far away as possible from equipment containing large AC magnetic fields, including the magnet power supply; they can induce signals large enough to overload the magnetometer input amplifiers. If necessary, shim the magnet dewar to level it. Perform a complete check of the magnet and magnet power supply before proceeding with installation.
3. **Power:** Adequate for system requirements, potential expansion, and wiring for maximum efficiency and economy of operation.
4. **Structural Integrity:** Level floor strong enough to support anticipated loads and free from extraneous vibrations or magnetic fields. Vibrations transmitted to consoles may degrade system performance.

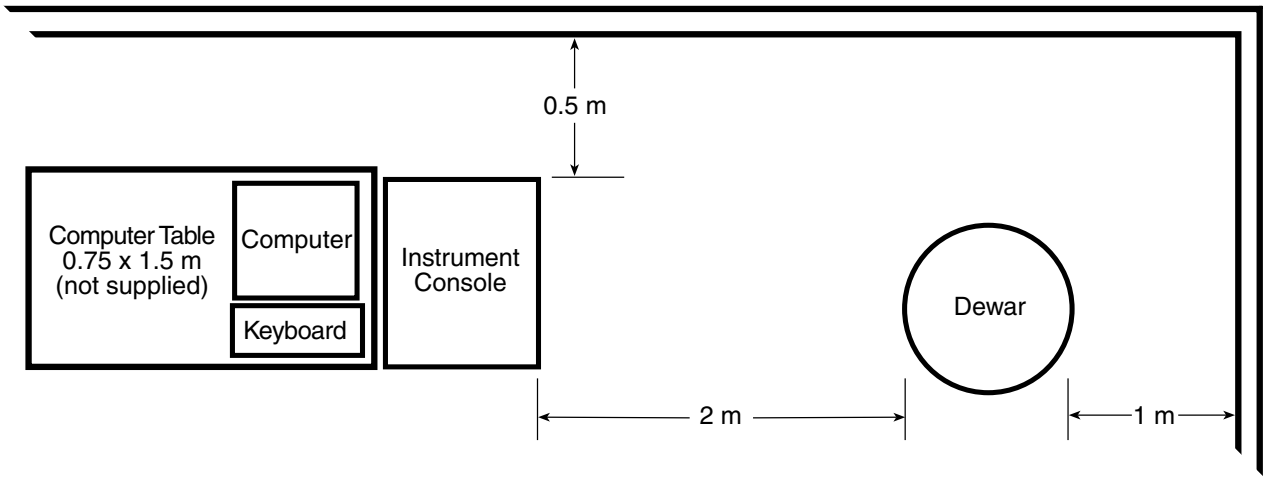

Figure 2-3. 9300 VSM System Sample Floor Plan and Clearances

2.1.4 System Power And Ground Requirements

The AC power source for the Model 9300 System must be frequency and voltage regulated and isolated from sources that may generate Electromagnetic Interference (EMI). The equipment in the 9300 requires single-phase 3-wire AC power. Do not use two-wire (without ground) AC power. Ground Fault Interrupter (GFI) and Transient Surge Protection circuitry at the AC source are also strongly recommended.

In areas where AC voltage is variable, consider a constant voltage transformer. If power outages are a problem, consider an Uninterruptable Power Supply (UPS).

CAUTION: Do not attempt to apply electrical power to the system until all instruments have been checked for proper input power settings and fuse/circuit breaker ratings.

The factory presets Model 9300 electrical component power requirements for proper operation upon receipt. Set the input voltage for each instrument in the system on the rear panel. Before applying power to the main input power cable, verify input power settings for each instrument are correct for the power source voltage.

Ground instrument panels and cabinets. The safety ground provides a true ground path for electrical circuitry and, in the event of internal electrical faults such as shorts, carries the entire fault current to ground to protect users from electrical shock. The Power Strip in the Instrument Console has a three-conductor power input connector which grounds equipment in the Instrument Console when plugged into a 3-wire receptacle.

When the earth ground connection is likely impaired, render the Model 9300 inoperative and secure it against any unintended operation. The connection is likely impaired if the instrument:

1. Shows visible damage.
2. Fails to perform the intended measurement.
3. Is subjected to prolonged storage under unfavorable conditions.
4. Is subjected to severe transport stresses.

Do not use such apparatus until qualified service personnel verifies its safety.

Electromagnetic interference (EMI) is both a natural and man-made phenomena which, either directly or indirectly, may degrade electronic system performance. Natural EMI includes thunderstorms, solar disturbances, cosmic rays, etc. Man-made EMI includes fixed and mobile transmitters, high voltage power lines, power tools and appliances, florescent lights, and other equipment containing motors, heaters, etc. Protect the AC source from EMI. Consider transient surge protectors for lightning protection.

2.1.5 Environmental Requirements

To meet and maintain specifications, operate the system at an ambient temperature range of 18 to 28 °C (64.4 to 82.4 °F). Operate it within the range of 15 to 35 °C (59 to 95 °F) with less accuracy. The system is intended for laboratory use. Although no specific humidity or altitude specifications exist, relative humidity of 20% to 80% (no condensation) and altitudes from sea level to 2.4 km (8,000 feet) are generally acceptable.

Adequately ventilate the work area to prevent build up of potentially life-threatening concentrations of nitrogen gas (see Paragraph 2.2.1). Oxygen content monitor/alarms should be installed near the work site to warn against low oxygen levels if liquid cryogens are used. The air-conditioning system should filter dust and other particulates to reasonable levels. Consult an air-conditioning expert about special filtering if salt air, corrosive gases, or other air pollutants exist.

2.2 SAFETY

Train personnel in proper emergency measures such as electrical power shut off, fire department notification, fire extinguishing, and personnel and records evacuation. Here is a list of suggested personnel safety considerations:

- Ground Fault Interrupter (GFI) AC circuits (Paragraph 2.2.1).
- Cryogenic Safety Gloves, Apron, Goggles/Faceshield, and Apparel (Paragraph 2.2.1).
- Fire Extinguisher.
- Oxygen Concentration Monitor/Alarm (Paragraph 2.2.1).
- Magnetic Field Warning Signs.
- Fireproof Safe for Data, Original Software and Documentation Storage.
- Emergency Lighting.

Locate in the immediate vicinity fire extinguisher(s) that extinguish all three classes of fires: A, B, and C. Class A is ordinary combustibles like wood, paper, rubber, many plastics, and other common materials that burn easily. Class B is flammable liquids like gasoline, oil, and grease. Class C is energized electrical equipment including wiring fuse boxes, circuit breakers, machinery, and appliances. Do not use chemical extinguishers even though they are less expensive and cover all classes of fires. They may damage electronic equipment. Use a Carbon Dioxide or Halon fire extinguisher.

During the planning stage, consult local experts, building authorities, and insurance underwriters on locating and installing sprinkler heads, fire and smoke sensing devices, and other fire extinguishing equipment.

Locate an oxygen concentration monitor and alarm in the system work area near the system. Locate another in the dewar storage area. LHe and LN_2 can rapidly replace the breathing atmosphere in an enclosed area with no warning. Oxygen concentration monitor and alarms are the best way to reduce this potential hazard.

A superconducting magnet can generate large magnetic fields. Post signs at each entrance to the work area that state: "Warning: High Field Magnets – Fringe fields may be hazardous to pacemakers and other medical devices. Keep magnetic materials clear of area." Paint a yellow magnetic field warning line on the floor 1 meter (3 feet) from the sides of the electromagnets.

Locate a fireproof safe at or near the work site for temporary storage of data and copies of original system software and documentation. Store duplicate copies of vital data well away from the system area, also in a fireproof storage vault or safe.

Even where not required by code, install some type of automatic, battery-operated emergency lighting in case of power failure or fire.

2.2.1 Handling Liquid Helium and Liquid Nitrogen

Helium and Nitrogen are colorless, odorless, and tasteless gases. When properly cooled, the gases liquify. Liquid Helium (LHe) and liquid nitrogen (LN_2) may be used in conjunction with the Model 9300. Although not explosive, there are certain safety considerations in the handling of LHe and LN_2.

Operate all cryogenic containers (dewars) in accordance with manufacturer instructions. Safety instructions are normally posted on the side of each dewar. Keep cryogenic dewars in a well-ventilated place, protected from the weather, and away from heat sources. Figure 2-4 shows a typical cryogenic dewar.

Transfer LHe and LN_2 and operate storage dewar controls in accordance with manufacturer/supplier instructions. During transfer, follow all safety precautions written on the storage dewar and recommended by the manufacturer.

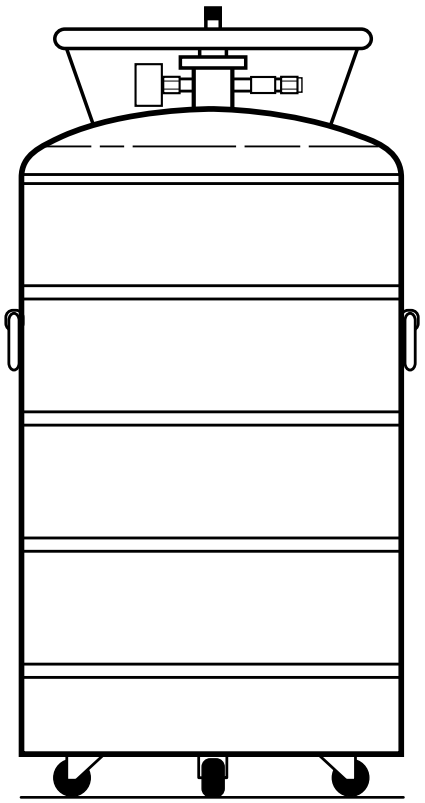

Figure 2-4. Cryogenic Storage Dewar

WARNING

- **Liquid helium and liquid nitrogen are potential asphyxiants and can cause rapid suffocation without warning. Store and use in an adequately ventilated area. DO NOT vent the container in confined spaces. DO NOT enter confined spaces where gas may be present unless area is well-ventilated. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.**
- **Liquid helium and liquid nitrogen can cause severe frostbite to exposed body parts. DO NOT touch frosted pipes or valves. For frostbite, consult a physician immediately. If a physician is unavailable, warm the affected parts with water that is near body temperature.**

Two essential safety aspects of handling LHe are adequate ventilation and eye and skin protection. Although helium and nitrogen gases are non-toxic, they are dangerous because they replace air in a normal breathing atmosphere. Liquid helium is an even greater threat because a small amount of liquid evaporates to create a large amount of gas. Store and operate cryogenic dewars in open, well-ventilated areas.

When transferring LHe and LN_2, protect eyes and skin from accidental contact with liquid or the cold gas issuing from it. Protect eyes with full face shield or chemical splash goggles; safety glasses (even with side shields) are inadequate. Always wear special cryogenic gloves (Tempshield Cryo-Gloves® or equivalent) when handling anything that is, or may have been, in contact with the liquid or cold gas, or with cold pipes or equipment. Wear long sleeve shirts and cuffless trousers long enough to prevent liquid from entering shoes.

2.2.1.1 Recommended First Aid for LHe or LN_2 Exposure

Post an appropriate Material Safety Data Sheet (MSDS) obtained from the manufacturer/distributor at every site that stores and uses LHe and LN_2. The MSDS specifies symptoms of overexposure and first aid.

If a person exhibits symptoms of asphyxia such as headache, drowsiness, dizziness, excitation, excessive salivation, vomiting, or unconsciousness, remove to fresh air. If breathing is difficult, give oxygen. If breathing stops, give artificial respiration. Call a physician immediately.

If exposure to cryogenic liquids or cold gases occurs, restore tissue to normal body temperature (98.6 °F) by bathing it in warm water not exceeding 105 °F (40 °C). DO NOT rub the frozen part, either before or after rewarming. Protect the injured tissue from further damage and infection and call a physician immediately. Flush exposed eyes thoroughly with warm water for at least 15 minutes. In case of massive exposure, remove clothing while showering with warm water. The patient should not drink alcohol or smoke. Keep warm and rest. Call a physician immediately.

2.2.2 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 4,000 volts cannot be seen, felt, or heard.

2.2.2.1 Identification of Electrostatic Discharge Sensitive Components

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

2.2.2.2 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. De-energize 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 MΩ 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.

2.2.3 Instrument Safety

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 assumes no liability for Customer failure to comply with these requirements.

Lake Shore instrumentation 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.

- Indoor use.
- Temperature: 5 °C to 40 °C.
- Maximum relative humidity: 80% for temperature up to 31 °C decreasing linearly to 50% at 40 °C.
- Altitude up to 2,000 meters.
- Power supply voltage fluctuations not to exceed ±10% of the nominal voltage.
- Transient overvoltages according to OVERVOLTAGE CATETORIES I, II, and III (IEC 1010). For mains supply the minimum and normal category is II.
- Pollution Degree 2 in accordance with ICE 664.

Ground Instruments

To minimize shock hazard, connect instrument chassis and cabinet to an electrical ground. Most Lake Shore instruments come with a three-conductor AC power cable. Plug the power cable into an approved 3-contact electrical outlet or use a 3-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 instruments 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 instruments. Return the system to authorized Lake Shore representative for service and repair to ensure that safety features are maintained.

2.2.4 Safety Symbols

Direct current (power line).

Alternating current (power line).

Alternating or direct current (power line).

Three-phase alternating current (power line).

Earth (ground) terminal.

Protective conductor terminal.

Frame or chassis terminal.

On (supply)

Off (supply)

Equipment protected throughout by double insulation or reinforced insulation (equivalent to Class II of IEC 536 - see Annex H).

Caution: High voltages; danger of electric shock. Background color: Yellow; Symbol and outline: Black.

Caution or Warning - See instrument documentation. Background color: Yellow; Symbol and outline: Black.

2.2.5 Cleaning

WARNING: Disconnect all sources of power to the system before attempting any cleaning.

No cleaning schedule is needed for normal use. If you wish to clean any of the equipment, use a damp cloth to clean the outside of the instruments. Use a vacuum to clean out the vents.

2.3 LINE INPUT ASSEMBLY

On the rear of most Lake Shore instruments is the line input assembly (Figure 2-5). It contains the line voltage selector, line fuse holder, and power cord connector. Verify appropriate line voltage setting and correct line fuse for all system instruments before initial power up. A table similar to Table 2-1 appears on the rear of most Lake Shore instruments. The factory configures line input if the final destination of the instruments is known when it ships. Verify this configuration; it is not unusual for instruments to change hands before reaching the user. All line voltages discussed are single phase.

Table 2-1. Sample AC Line Input List

Indicator	Line Voltage Range	Fuse (slow blow)
100	90-105 VAC	# A* 50/60 Hz.
120	108-126 VAC	# A* 50/60 Hz.
220	198-231 VAC	# A* 50/60 Hz.
240	216-252 VAC	# A* 50/60 Hz.

*** See Power Requirement label outside Instrument Console for system power requirements.**

2.3.1 Line Voltage and Fuse Verification

To verify the proper line voltage selection look at the indicator in the window of the line input assembly. The voltage table on the rear of the instrument lists the line voltage range for each indicator. If the range does not match your line voltage, change the line voltage selector (see Paragraph 2.3.2), and remove the fuse to verify its value (see Paragraph 2.3.3 for fuse replacement instructions). Use slow blow fuses of the value specified on the instrument rear panel.

WARNING: To avoid potentially lethal shocks, turn off instruments and disconnect from AC power before performing these procedures. Only qualified personnel should perform these procedures.

CAUTION: For continued protection against fire hazard, replace only with the same fuse type and rating specified for the line voltage selected.

2.3.2 Line Voltage Selection

Below is the procedure to change the instrument line voltage selector. Verify the fuse value whenever line voltage is changed. See Figure 2.5.

1. Locate the line input assembly on the instrument rear panel.
2. Turn the line power switch OFF.
3. Remove the instrument power cord.
4. With a small screwdriver, release the drawer holding the line voltage selector and fuse.
5. Slide out the removable plastic fuse holder from the drawer.
6. Rotate the fuse holder until the proper voltage indicator shows through the window.
7. Verify the proper fuse value.
8. Re-assemble the line input assembly in the reverse order.
9. Verify the voltage indicator in the window of the line input assembly.
10. Connect the instrument power cord.
11. Turn the line power switch ON.

2.3.3 Fuse Replacement

To replace a line fuse, use slow blow fuses with the proper value shown in the table on the rear of the instrument. To change line input from the factory setting, use the appropriate fuse in the connector kit shipped with the instrument.

1. Locate line input assembly on the instrument rear panel.
2. Turn the power switch OFF.
3. Remove the instrument power cord.
4. With a small screwdriver, release the drawer holding the line voltage selector and fuse.
5. Remove fuse and replace it with appropriate slow blow fuse.
6. Re-assemble the line input assembly in reverse order.
7. Verify voltage indicator in line input assembly window.
8. Connect the instrument power cord.
9. Turn the power switch ON.

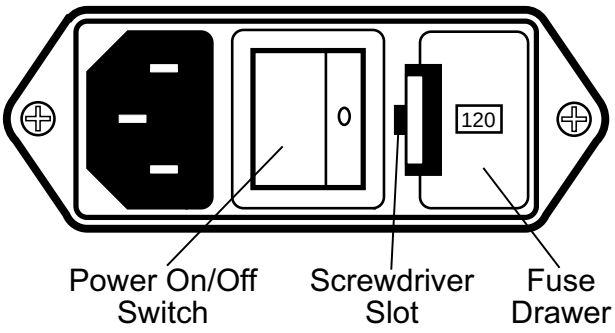

Figure 2-5. Line Input Assembly

2.3.4 Power Cord

Lake Shore instrumentation includes a 3-conductor power cord. Line voltage travels across the outer two conductors. The center conductor is a safety ground and connects to the instrument metal chassis when the power cord attaches to the power connector. For safety, plug the cord into an appropriate *grounded* receptacle.

2.3.5 Power Switch

The power switch turns instruments ON and OFF and is located in the line input assembly on the instrument rear. When **1** is raised on the switch, the instrument is ON; when **0** is raised, the instrument is OFF. A graphic above the switch illustrates the on and off positions. Do not remove instrument covers without first disconnecting the power cord, even if the instrument power switch is off.

CHAPTER 3

INSTALLATION

3.1 MODEL 9300 SYSTEM INSTALLATION

Required Tools: **1.** 9/64-inch Allen Wrench **2.** Level **3.** Open-End Wrench, 1 1/8 inch

Read chapter 2 carefully before installing the system. Remove the system from the shipping crates. Place the magnet dewar, system console, and computer in their planned locations (see Figure 2-2). Place the magnet dewar at least 6 feet from the computer. The high magnetic fields generated by the superconducting magnet may effect computer performance if it is closer than 6 feet. Level the dewar.

3.1.1 INITIAL COMPUTER/CONSOLE CONNECTIONS

The computer connects the same way regardless of the system configuration (see Figure 3-1).

1. Plug the mouse into the rear computer port with a mouse icon beneath it.
2. Plug the keyboard into the rear computer port with a keyboard icon beneath it.
3. Plug the Monitor into the rear computer port with a monitor icon beneath it.
4. Plug the monitor power cord into the back of the monitor. Plug the other end into the console power strip.
5. Plug the computer power cord into the back of the computer. Plug the other end into the console power strip.
6. Connect a IEEE-488 cable from the computer IEEE port to the Model 735 IEEE port. Connect a IEEE-488 cable from the Model 735 IEEE port to the Model 340 IEEE port. Connect a IEEE-488 cable from the Model 340 IEEE port to the Model 620 IEEE port.
7. Plug the power cords of the Model 735, 340, and 620 into their respective instruments. Plug the other ends into the console power strip.
8. Turn on the computer and each instrument to verify they work. Turn off the Model 620, but leave the computer and the other instruments on.
9. If it is not already loaded, load the IDEAS VSM software onto the computer hard drive. See the IDEAS VSM Software User's Manual.

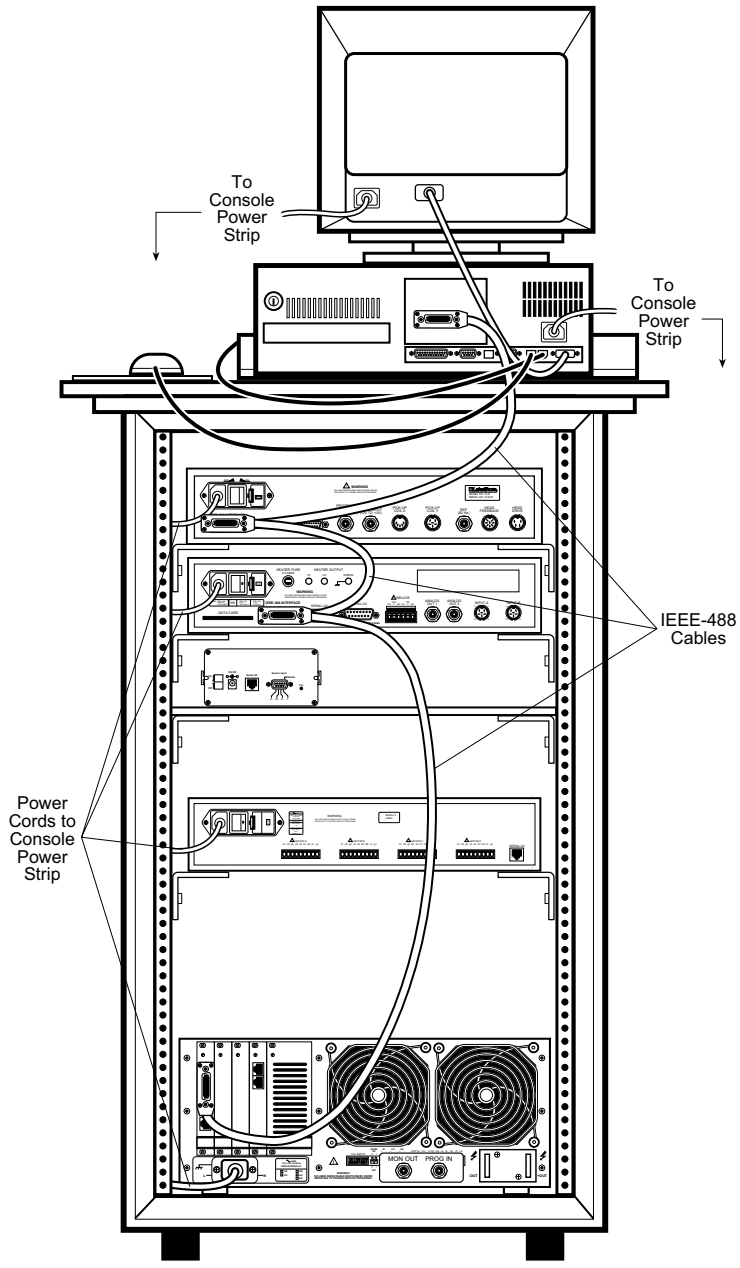

Figure 3-1 Initial Computer/Console Connections

3.1.2 Preparing the Dewar

1. Remove the vacuum pump from its shipping box. If not already installed, clamp the Foreline Trap to the pump with a 25 mm clamp. Clamp the pump hose to the Foreline Trap with a 25 mm clamp. (Figure 3-2).
2. Remove the dewar from its shipping crate, place it in its planned location, and level it. Thread the locking nuts onto each of the four adjustment rods, then thread the rods into the dewar. Lock the rods so that approximately 6.5" of the rod protrudes from the top of the locking nut. (Figure 3-3).

   The dewar comes with O-rings taped to its top. Inspect one of the O-rings for cracks, then seat it properly in the top of the dewar (Figure 3-3).
3. Fit the VSM Mounting Structure onto the four adjusting rods. With the $1^1/_8$ inch Open-End Wrench, turn the adjustment rods until the mounting structure is level. After leveling, remove the Mounting Structure and set it aside (Figure 3-3).
4. Remove the cryostat from its shipping crate and carefully lay it on its side, or place it in a probe stand (recommended). Clamp the pump Solenoid Valve Assembly to the cryostat Flush Pipe with a 16 mm clamp. (Figure 3-4).

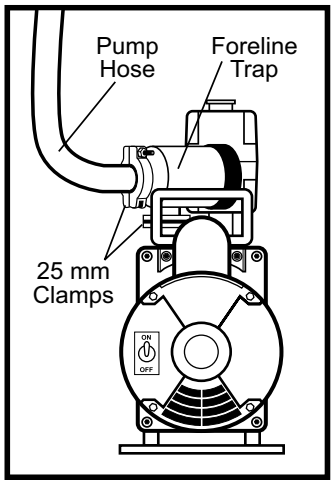

Figure 3-2 Pump Assembly

5. Push the end of the Solenoid Valve Assembly Flush Line onto the ribbed inlet of the Vent Pipe. Temporarily coil up the solenoid Relay Cable so it is out of the way. (Figure 3-4). **Optional:** To pre-cool the dewar, pour 5 liters of liquid nitrogen into it. Liquid nitrogen is considerably less expensive than liquid helium.
6. Open the cryostat Vent Valve (Figure 3-4). With two people, lift the cryostat by grasping the Flush Pipe and the Vent Pipe, and carefully slide it into the dewar. If pre-cooling, the liquid nitrogen will boil vigorously upon cryostat insertion.

   TRANSVERSE FIELD MAGNETS ONLY: Unlike parallel field magnets, the magnet resides in the dewar instead of at the end of the cryostat. Two metal rods emerge from inside the dewar; these are the magnet terminals. Each of the baffles on the cryostat has two holes into which the terminal rods insert. As the cryostat slowly slides into the dewar, guide the terminal rods through the holes in each of the baffles. Finally, guide the terminal rods through the top of the cryostat so that approximately ½ inch protrudes from the top of the terminal posts. Tighten the terminal post compression fittings to secure the terminal rods in place.

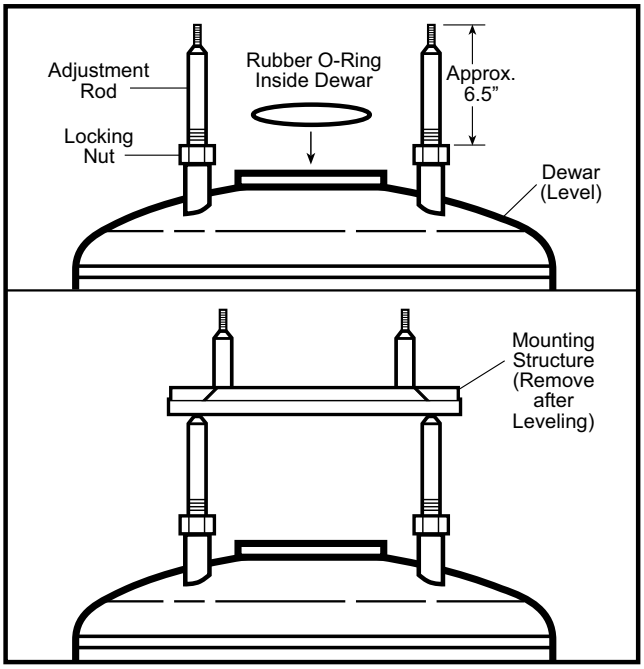

Figure 3-3 Dewar: Adjustment Rods, O-Ring, and Leveling the Mounting Structure.

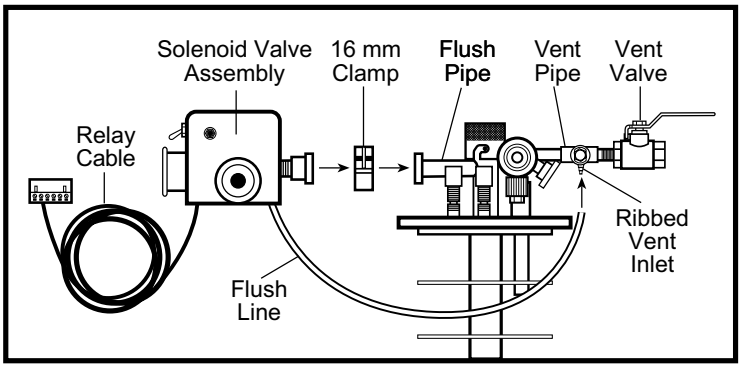

Figure 3-4 Attaching Solenoid Valve Assembly to Cryostat

7. Tighten the eight cryostat flange bolts with the $^{9}/_{64}$-inch Allen Wrench. Complete steps 7-11, then tighten them again. (Figure 3-5).

   NOTE: The weight of the cryostat makes it unnecessary to thread all eight flange bolts for a good seal. If desired, a single bolt in the front and back suffices to seal the dewar.

8. Clamp pump hose to Solenoid Valve Assembly with 25 mm clamp (Figure 3-5). Plug in pump and turn it **On**.

9. Plug Relay Cable (Figure 3-4) into the Model 340 Relay port (Figure 3-6).

10. Plug the Solenoid Transformer into Solenoid Valve Assembly. Under the transformer is a voltage switch. Set it to the voltage appropriate to your supply: 115 V or 230 V. (Figure 3-7).

11. Plug the solenoid power cord into the Solenoid Transformer. Plug the other end into the console power strip or other power supply. (Figure 3-7).

12. Plug in the pump and turn it on.

13. Open the IDEAS 340 software driver and click the Relay Switch button (Figure 3-8). The Solenoid Valve Assembly clicks and the pump evacuates air from the sample space. Pump out the sample space for about 10 minutes.

    CAUTION: Evacuate the sample space as soon as possible to avoid water freezing in the sample space.

14. If pre-cooling with liquid nitrogen, wait until after the boil-off dies down, then shut Vent Valve, unseat Needle Valve and pull it out from the dewar approximately 6 inches. Pump out the valve tube for about 10 minutes, then reseat the Needle Valve (Figure 3-9). If not pre-cooling, skip this step.

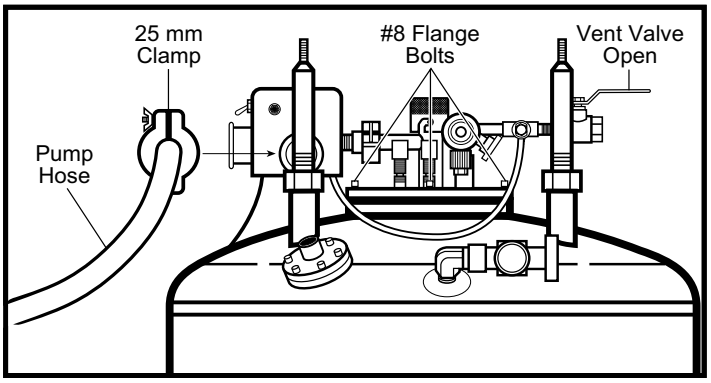

Figure 3-5 Inserting Cryostat and Attaching Pump Hose

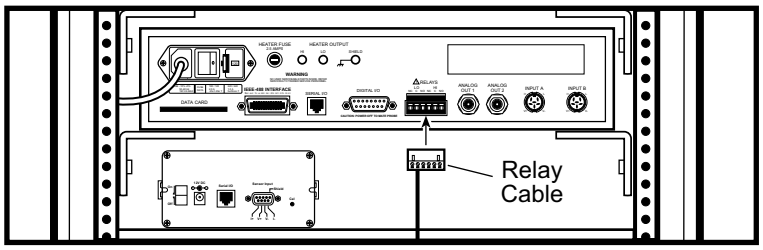

Figure 3-6 Connecting Relay Cable to Model 340

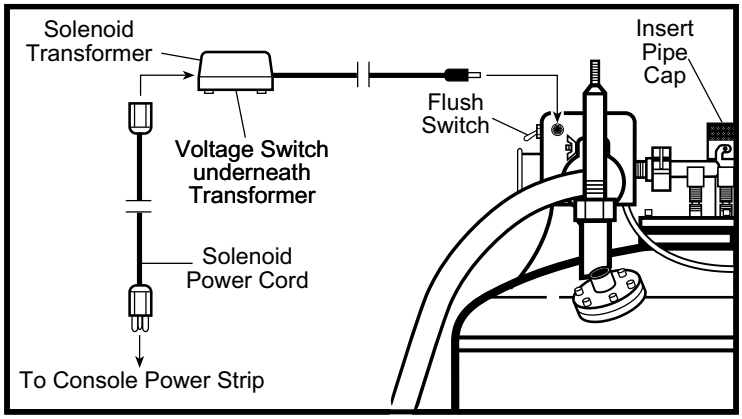

Figure 3-7 Connecting Solenoid Valve Assembly to Power

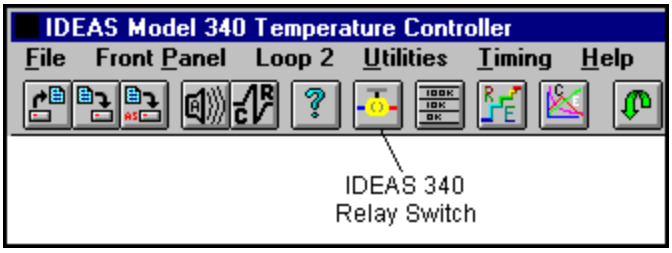

Figure 3-8 IDEAS 340 Relay Switch Button

15. Click the IDEAS 340 Relay Switch off (Figure 3-8). Push Solenoid Valve Assembly Flush Switch toward **FLUSH** and remove Insert Pipe Cap. Slide the VSM Insert into the Insert Pipe. Align VSM Insert Cap Slot with Insert Pipe Locking Nub and turn the VSM Insert clockwise to lock in place (Figure 3-9).

16. Plug top of Insert with the supplied rubber stopper and push the Flush Switch away from **FLUSH** (Figure 3-9). Click the IDEAS 340 Relay Switch on (Figure 3-8).

17. Plug the Secondary Heater Cable (Cable 655-450) from the Model 340 Analog Out 2 port into the 4-pin VSM Insert Input. (Figure 3-10)

18. The Model 340 tri-cable consists of Cable A, Cable B, and the Primary Heater Cable merging into a 10-pin connector. Plug Cable A into Input A and Cable B into Input B (Figure 3-10).

The Primary Heater Cable ends in a single and dual banana plug. The dual connector plugs into the HI and LO outputs. The single connector plugs into the Shield input (Figure 3-10).

Plug the 10-pin connector into the 10-pin VSM Insert input (Figure 3-10).

The Model 340 should now display temperature.

19. If not pre-cooling, shut Vent Valve, unseat Needle Valve and pull it out from the dewar approximately 6 inches, and pump out the valve tube for about 10 minutes. Securely reseat Needle Valve after pumping (Figure 3-9). Follow instructions in Paragraph 3.2 to transfer liquid helium from the storage dewar to the magnet dewar.

NOTE: Helium transfer takes several hours to complete.

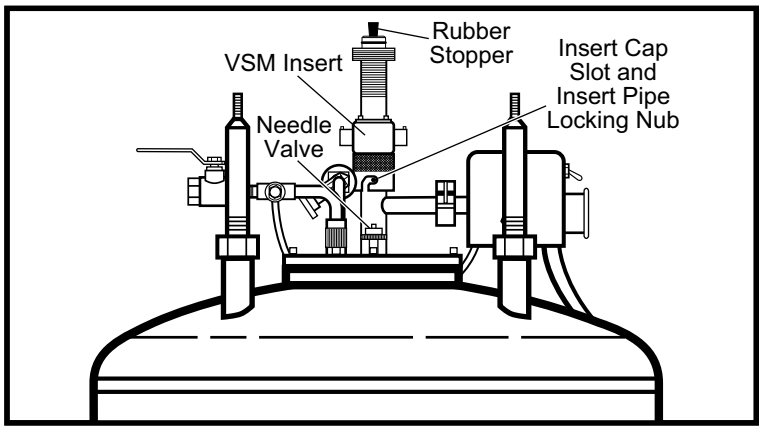

Figure 3-9 Installing the VSM Insert

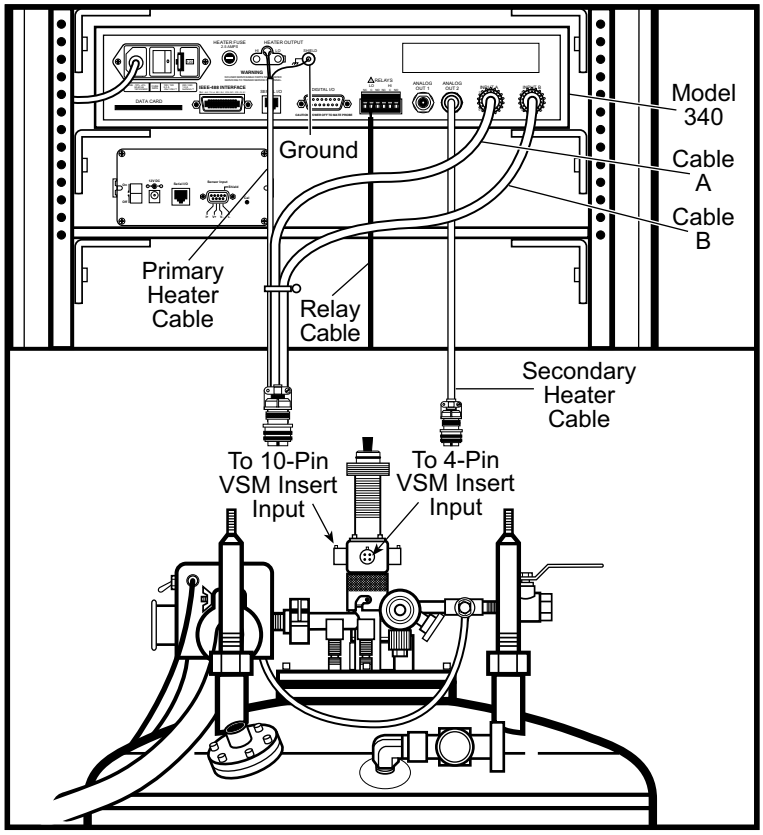

Figure 3-10 Connecting Model 340 to VSM Insert

20. Connect the Magnet Power Supply (MPS) Terminal Cables to the MPS terminals. Red = positive, Black = negative. Connect the other ends to the magnet terminals on top of the cryostat (Figure 3-11). Just to the left of the MON OUT port are two small switches labeled V and I (voltage and current). Set V to INT and I to EXT. Turn on the MPS.

21. Verify the Needle Valve is securely tightened, then install the Sample Inlet Valve Stepper Motor. Viewing the magnet dewar from the front, the Stepper Motor Mounting Bracket installs behind and to the right of the Needle Valve. The teeth of the Stepper Motor Gear engage the front of the Needle Valve Gear (Figure 3-12).

On the Cryostat Flange there is a mounting hole to the front right of the Needle Valve. After engaging gear teeth, align this hole with the hole in the Stepper Motor Mounting Bracket, and secure with a #8 machine bolt.

Plug the Stepper Motor Cable into the Motor B output of the Model 704.

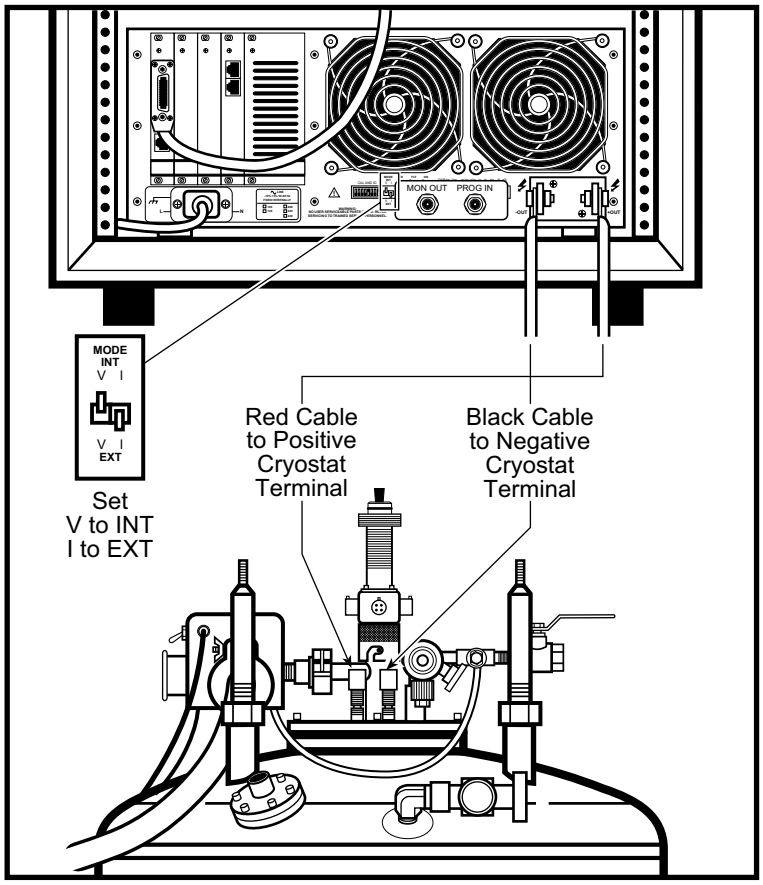

Figure 3-11 Connecting MPS to Superconducting Magnet Terminals

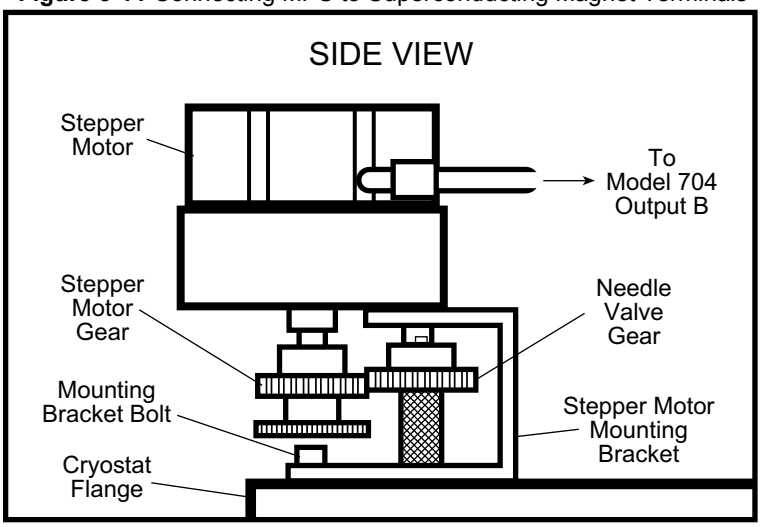

Figure 3-12 Installing the Sample Inlet Valve Stepper Motor

22. Connect a BNC cable from the Model 735 Program Out port to the Model 620 MPS Program Input port. Connect a BNC cable from the Model 735 Field Input port to the Model 620 MPS Monitor Output (Figure 3-13).

23. Plug Cable 653-142 into the Model 735 Pick-Up Coil X port and Cable 653-143 (optional) into the Model 735 Pick-Up Coil Y port. Connect the other end of this cable(s) to Cable 655-452. Connect the other end of Cable 655-452 to the 8-pin connector on the VSM Insert (Figure 3-14).

TRANSVERSE FIELD MAGNETS ONLY: Connect other end of Cable 655-452 to the 8-pin connector on the Dewar (Figure 3-14).

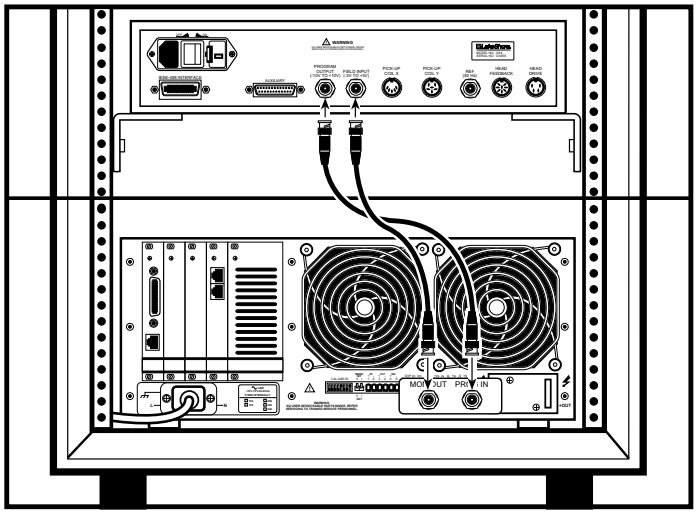

Figure 3-13 Connecting the Model 735 to the MPS

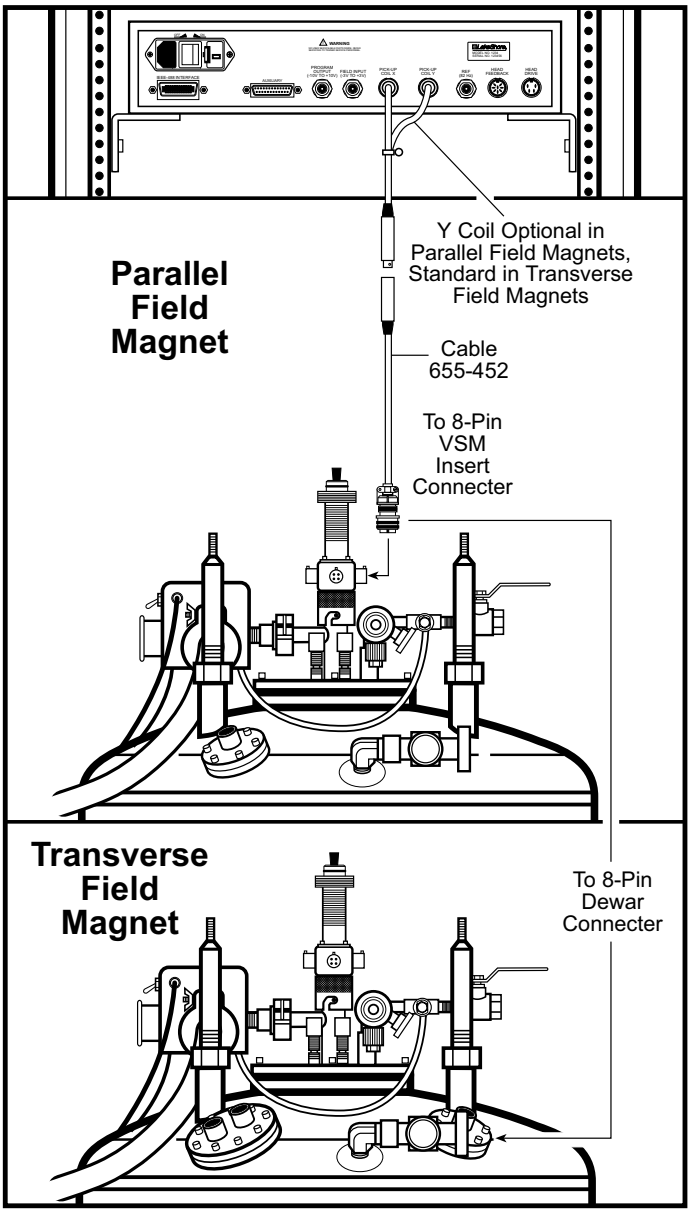

Figure 3-14 Connecting the Model 735 to the VSM Insert

24. Fit the Mounting Structure onto the Adjustment rods and secure it with thumb nuts. The Mounting Structure consists of a Bottom Plate and a Top Plate. The Bottom Plate mounts to the Adjustment Rods, while the Top Plate slides forward and backward and laterally on the Bottom Plate.

The Forward Stop Adjustment Screw limits how far the Top Plate slides forward. Loosen the Lateral Movement Screws to move the Top Plate laterally. Tighten them to lock the Top plate in place (Figure 3-15).

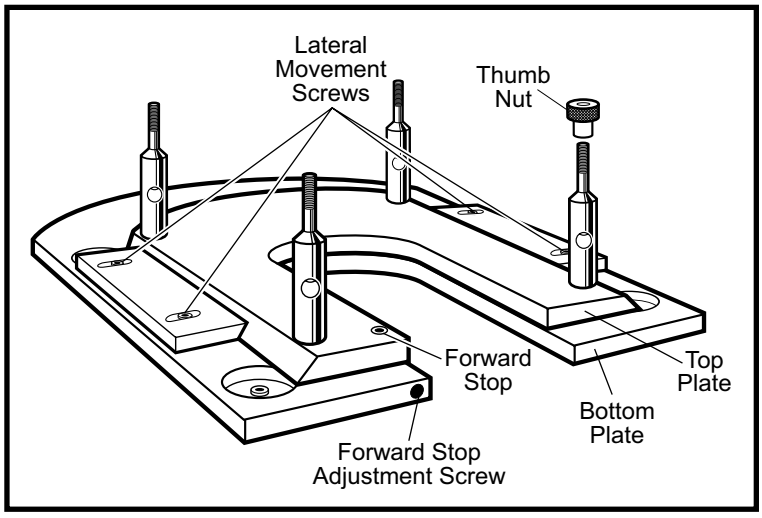

Figure 3-15 Mounting Structure

25. Slide back the Mounting Structure Top Plate and fit the drive onto the Top Plate rods (Figure 3-16). Be sure to remove any packing materials from the inside of the drive (see Paragraph 2.1.2). Secure the drive with thumb nuts and level it.

26. Connect Cable 653-145 from the Model 735 Head Feedback port to the 5-Pin Drive Connector. Connect Cable 653-144 from the Model 735 Head Drive port to the 3-Pin Drive Connector (Figure 3-16).

27. Connect the Z Motor Cable from the Model 704 Motor C port to the Z Motor Drive Connector (Figure 3-16). Connect a serial cable from the Model 704 serial port to the computer Serial A port.

28. Click the IDEAS 340 Relay Switch button off (Figure 3-8). Push the Flush Switch toward Flush and remove the rubber stopper from the top of the VSM Insert (Figure 3-9).

29. Slide forward the Mounting Structure Top Plate and securely thread the drive coupling onto the top of the VSM Insert. Remove the Stopper on top of the drive, insert the Sample Rod, then replace the Stopper (Figure 3-16).

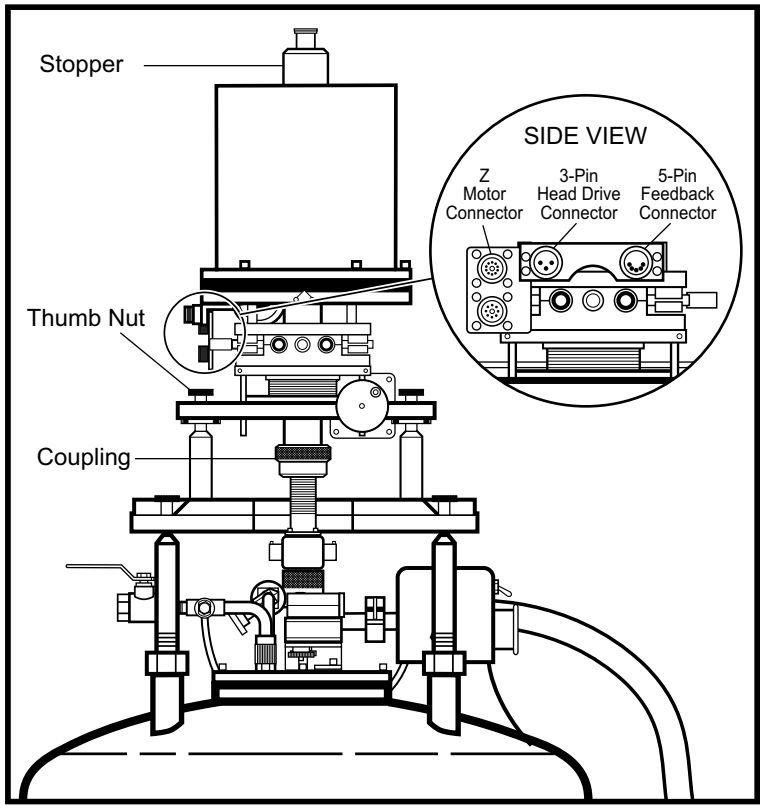

Figure 3-16 Installing the VSM Drive, Connecting the Model 735 and Model 704 to the Drive

30. Turn the Flush Switch off, click the IDEAS 340 Relay Switch on, and pump out the sample space for about 10 minutes. The system is ready to perform a measurment.

3.2 HELIUM TRANSFER

WARNING

- **Liquid helium and liquid nitrogen are potential asphyxiants and can cause rapid suffocation without warning. Store and use in an adequately ventilated area. DO NOT vent the container in confined spaces. DO NOT enter confined spaces where gas may be present unless area is well-ventilated. If inhaled, remove to fresh air. If not breathing, give artificial respiration. If breathing is difficult, give oxygen. Get medical attention.**
- **Liquid helium and liquid nitrogen can cause severe frostbite to exposed body parts. DO NOT touch frosted pipes or valves. For frostbite, consult a physician immediately. If a physician is unavailable, warm the affected parts with water that is near body temperature.**
- **See Paragraph 2.2.1 for further safety information before proceeding.**

The economical transfer of liquid helium depends upon technique. Too rapid a transfer results in excessive "blow-off" or waste of liquid. It is much more economical to pre-cool the dewar first with liquid nitrogen then cold helium vapor, than to simply vaporize liquid helium. For an efficient transfer, follow one of the two transfer procedures: Warm Transfer (Paragraph 3.2.2) or Cold Transfer (Paragraph 3.2.3) after connecting the Model 241 Liquid Helium Level Meter to the system (Paragraph 3.2.1).

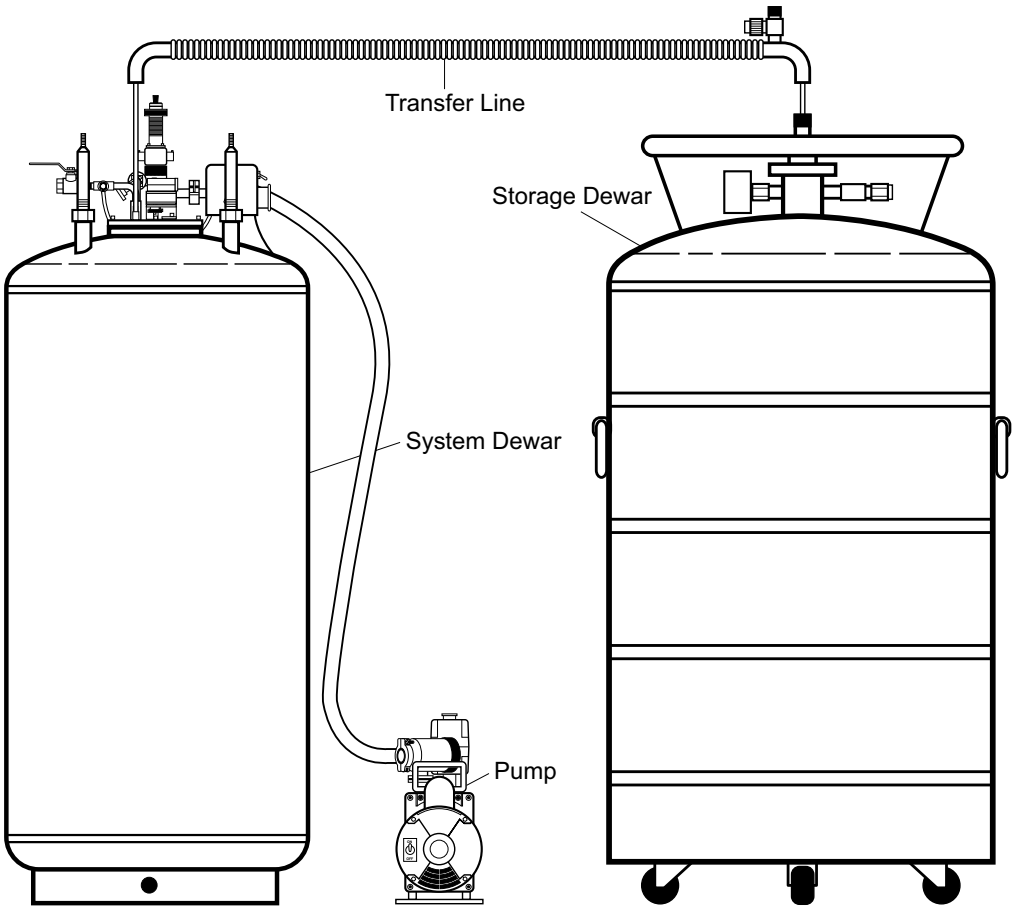

Figure 3-17 Typical Liquid Helium Transfer

3.2.1 Connecting the Model 241

1. Plug the Model 241 cable with the DB-9 connector on one end into the Model 241 DB-9 port. Plug the other end into the Dewar 4-Pin Output.

   TRANSVERSE FIELD MAGNETS ONLY: The dewar has a flange with two 4-Pin Outputs. This redundancy is for the sake of reliability. Plug the other end of the DB-9 Cable into either one of the Dewar 4-Pin Outputs.
2. Plug a serial cable from the Model 241 serial port to computer Serial B port.
3. Plug the Model 241 power transformer into the Model 241 power port. Plug the transformer into the power supply. Turn on the Model 241.

NOTE: For parallel field magnets, calibrate the Model 241 liquid helium level monitor for an 11-inch probe. For transverse field magnets, calibrate for a 23" probe. See the Model 241 User's Manual for details.

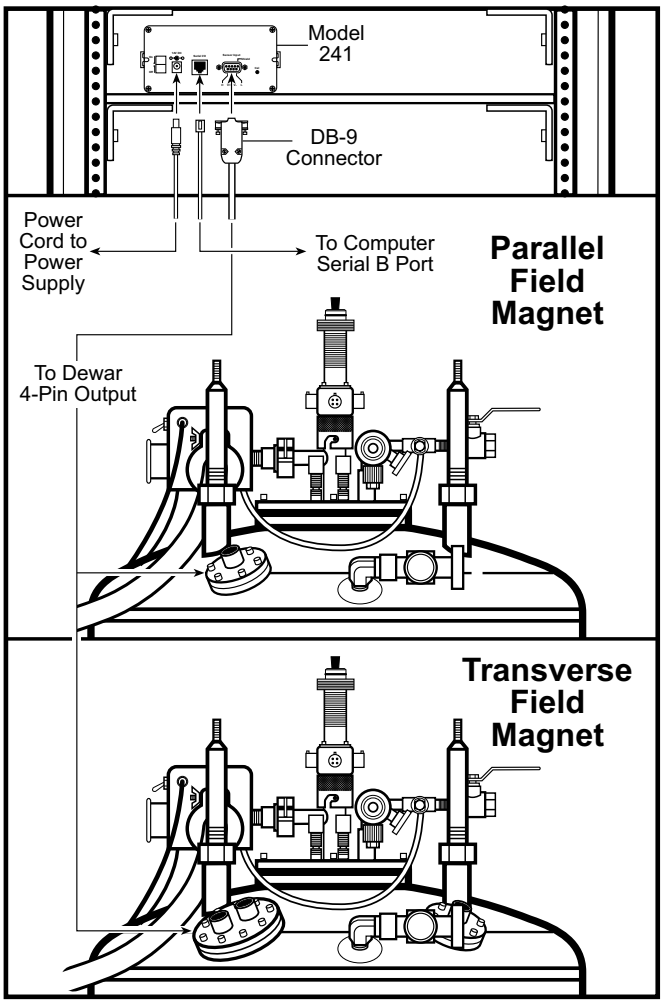

Figure 3-18 Connecting the Model 241

3.2.2 Warm Transfer

If the dewar is at room temperature or contains *no* liquid helium, perform the warm transfer procedure below. Read all the steps before performing the procedure.

NOTE: Pre-cooling the dewar with liquid nitrogen is strongly recommended.

1. Open the Vent Valve to release any helium pressure in the system dewar during transfer.
2. Insert one end of transfer line into liquid helium storage dewar. See Figure 3-17. Position end of transfer line a few inches above the dewar bottom.

CAUTION: To prevent rapid pressure build-up, open Vent Valve and insert transfer line slowly into dewar. Venting excessive gas is usually necessary during initial transfer line insertion.

3. Remove cryostat transfer port plug and insert other end of transfer line into cryostat transfer port (Figure 3-19). Position end of transfer line a few inches above the magnet dewar bottom. Total length is 54 inches.
4. Transfer slowly. Simply sealing/closing storage dewar and allowing transfer to proceed under ambient pressure is often sufficient for initial phase.
5. After the transfer starts, allow about 15 minutes for helium gas to totally flush the dewar. Then open the Solenoid Assembly Valve and crack open the needle valve a bit.

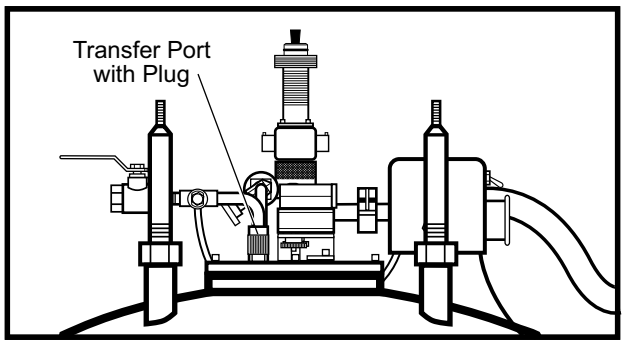

Figure 3-19 Helium Transfer Port with Plug

6. It takes about 2 to 3 hours to bring system temperature from room temperature to under 40 K. (Allow 4 to 6 hours for 9 tesla systems.) Since the Model 241 Level Monitor uses a superconductive probe, it makes no level readings until dewar temperature is <10 K. When temperature nears 4.2 K (or as needed), apply pressure to storage dewar to force liquid helium over. Typically, 1 to 5 psi (7 to 35 kPa) pressure is enough to transfer helium. Monitor helium level indicator and fill to desired level. The standard helium capacity is about 40 liters at a depth of 11 inches. This stage requires about 15 to 30 minutes.

NOTE: Helium transfer efficiency depends on the combined properties of the storage dewar, transfer line, and receiving dewar. Each user determines the optimum transfer characteristics for their type of storage dewar and transfer line as they relate to the 9300 System. In an efficient transfer, a 40 liter dewar requires about 75 liters for initial filling from room temperature.

7. Remove both ends of transfer line. Wear cryo-gloves when performing this operation.

CAUTION: After a lengthy transfer, ice build-up may prevent removal of the transfer line or immediate replacement of the transfer port plug. Use a gentle hot air gun to warm the transfer port and melt the ice. Do *not* over-heat.

8. Firmly plug transfer port and close Vent Valve to ensure proper gas flow through leads and prevent air condensation inside dewar.

3.2.3 Cold Transfer

If the system already has liquid helium in the dewar, follow the procedure below to perform a cold transfer. Read all steps before performing the procedure.

1. Open the Vent Valve to release any helium pressure in the dewar during transfer.

2. Insert one end of transfer line into liquid helium storage dewar. See Figure 3-18. Position the end of the transfer line a few inches above the dewar bottom.

3. Remove the system dewar transfer port plug (see Figure 3-19). Apply pressure (if required) to storage dewar while watching exposed end of transfer line. When a sputtering sound is heard and a vapor cloud forms at end of transfer line, insert it into the transfer port of the system dewar. The transfer line must be long enough to reach the "belly" of dewar (30 inches; 76 cm), but should not extend below the existing helium level.

CAUTION: To prevent pressure build-up, open Vent Valve when inserting transfer line into dewar. Warm transfer line insertion causes existing liquid helium to boil off.

4. Transfer and fill dewar to desired level by pressurizing storage dewar. A cold transfer takes 15 to 30 minutes to fill the dewar. The Model 241 Level Monitor uses a super-conductive probe; dewar temperature >10 K interrupts level readings.

5. Remove both ends of transfer line. Wear cryo-gloves when performing this operation.

CAUTION: After a lengthy transfer, ice build-up may prevent removal of the transfer line or immediate replacement of the transfer port plug. Use a gentle hot air gun to warm the transfer port and melt the ice. Do *not* over-heat.

6. Firmly plug transfer port and close Vent Valve to ensure proper gas flow through leads and prevent air condensation inside system dewar.

CHAPTER 4

CALIBRATION

4.1 INTRODUCTION

When a sample material is placed in a uniform magnetic field, a dipole moment proportional to the product of the sample susceptibility times the applied field is induced in the sample. A sample undergoing sinusoidal motion as well induces an electrical signal in suitably located stationary pick-up coils. This signal, which is at the vibration frequency, is proportional to the magnetic moment, vibration amplitude, and vibration frequency.

The material under study is contained in a sample holder, which is centered in the region between the pole pieces of a laboratory magnet (see Figure 2-1). A slender vertical sample rod connects the sample holder with a transducer assembly located above the magnet, which supports the transducer assembly with sturdy, adjustable support rods.

The transducer converts a sinusoidal AC drive signal, provided by a circuit located in the console, into a sinusoidal vertical vibration of the sample rod, and the sample is thus made to undergo a sinusoidal motion in a uniform magnetic field. Coils mounted on the pole pieces of the magnet pick up the signal resulting from the sample motion.

This AC signal at the vibration frequency is proportional to the magnitude of the moment induced in the sample. However, it is also proportional to the vibration amplitude and frequency. A servo system maintains constancy in the drive amplitude and frequency so that the output accurately tracks the moment level without degradation due to variations in the amplitude and frequency of vibration.

This technique depends on being able to use a vibrating capacitor located beneath the transducer to generate an AC control signal that varies solely with the vibration amplitude and frequency. The signal, which is at the vibration frequency, is fed back to the Oscillator where it is compared with the drive signal so as to maintain constant drive output. It is also phase adjusted and routed to the signal demodulator where it functions as the reference drive signal.

The signal from the sample is developed in the pickup coils, then buffered, amplified, and applied to the demodulator. There it is synchronously demodulated with respect to the reference signal derived from the moving capacitor assembly. The resulting DC output is an analog of the moment magnitude alone, uninfluenced by vibration amplitude changes and frequency drift.

4.2 MOMENT CALIBRATION

The moment calibration of Vibrating Sample Magnetometers is traditionally performed with a nickel standard at an applied field above the saturation field of nickel, nominally 5000 Oe. Lake Shore supplies a nickel cylinder of 99.99% purity, an aspect ratio of nearly 1:1 and a mass of approximately 0.02 grams. These samples are etched and weighed prior to measuring their saturation magnetization. The saturation magnetization of the nickel samples are measured with a VSM calibrated with a NIST (NBS) nickel standard. Typical magnetization data is recorded between 5000 Oe and 10000 Oe.

The Model 735 VSM Controller must pass a range linearity test. It must meet the range to range and full range linearity specifications. Therefore, calibration on a single range insures the overall calibration of the electronics.

Lake Shore performs moment offset calibrations. Additional moment offset adjustments should not be required, but Lake Shore allows for software offset corrections to the moment readings.

The Model 735 operates the Model 620/622 Magnet Power Supply to accurately measure the applied magnetic field at the sample and to control the magnetic field. Lake Shore calibrates both the gain and the offset of the measurement\control loop to specification accuracy during final assembly and testing.

4.2.1 Moment Calibration for the Model 735

The Model 735 moment calibration is a software calibration. After positioning the nickel sample in a saturating field (H > 3500 Oe), the user initiates the software calibration procedure via the IDEASVSM menu item. The IDEASVSM Software Manual details how the software calibration functions and how to perform this procedure.

4.2.2 Moment Offset Calibration for the Model 735

Electronic and embedded software adjustments in the VSM controller eliminate 99.9% of the Model 735 moment offset calibrations. For the Model 735, Lake Shore moment offset adjustments are made on a per range basis resulting in a final offset typically less than 0.01% of the full scale of the range. Lake Shore included additional software adjustments for moment offset calibration; however, there is no significant advantage to this adjustment in a VSM system operating under normal conditions. The user initiates the software calibration procedure via the IDEASVSM menu item. The IDEASVSM Software Manual details how the software calibration functions and how to perform this procedure.

4.3 FIELD CALIBRATION

The Lake Shore Cryotronics, Inc. Cryogenic VSM is configured with a Model 735 VSM Controller and Model 620/622 Magnet Power Supply. The Model 735 reads and controls the Model 620/622 which supplies the current for the superconducting magnet (see Figure 4-1).

In a superconducting magnet, the relationship between input current and field produced by the magnet is linear and defined by the magnet constant Field/Current in gauss/amp. The Model 735 Program Output DAC controls the Model 620/622 output current. This Model 735 Program Output is set by the system software when a user enters a "go to field" command. All of the control parameters are linear; thus, the Lake Shore Cryogenic VSM is configured for open loop or Current mode with feedback and PI parameters eliminated from the magnetic field control configuration.

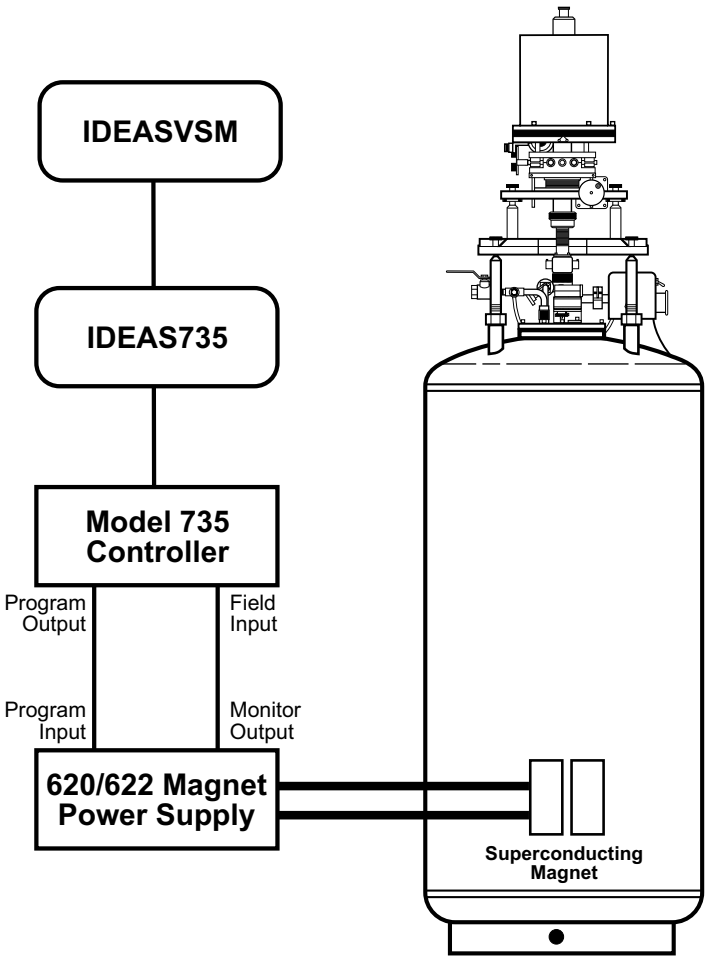

Figure 4.1. Block Diagram of VSM Field Measurement\Control Loop

4.3.1 Field Setting

Control flow for SETTING the magnetic field is:

- User inputs FIELD (software) >
- Model 735 Program Output ramps VOLTAGE >
- Model 620/622 Remote Program Input in VOLTAGE >
- Model 620/622 sets CURRENT in superconducting magnet.

4.3.2 Field Reading

To READ the applied field, the Model 735 implements a ADC and reads the current through a shunt in the Model 620/622 via the Monitor Output. The signal flow for READING magnetic field is:

- Current in superconducting magnet and shunt (CURRENT) >
- Model 620/622 Monitor Output (VOLTAGE) >
- Model 735 Field Input ADC (VOLTAGE) >
- Software converts Model 735 DAC readings to FIELD

The IDEASVSM software implements field control configuration using the calibrated values of the constants listed above. In addition, there are instrumentation offsets which are calibrated out of the system. The non-linear term, remenant field of the superconducting magnet, is not accounted for in the configuration.

The ramp rate of a superconducting magnet is limited by the maximum charging voltage, a design parameter tested during magnet manufacturing. The maximum ramp rate-charging voltage relationship is shown in the equation below:

maximum charging voltage = ir drop in the leads + (magnet inductance x maximum ramping rate)

If the magnet leads are large gauge copper-brass, ir drop can be ignored. The maximum ramp rate is the maximum charging voltage/magnet inductance in amps/second.

The superconducting magnet field control, including ramp rate, is configured using the magnet constants and calibrated measure/control instrumentation electronics. Instrumentation offsets must be calibrated in situ, and remenant fields are not accounted for in the field readings.

4.4 HARDWARE CONFIGURATION

The Model 9300 hardware configuration including a wiring diagram appears in Section 3.1.2. Specifications and Constants for the superconducting magnet, Model 735 and Model 620/622 appear in Table 2.1.

4.4.1 Model 620/622 Magnet Power Supply Configuration

Model 620/622 configuration is vital to prevent damage to the superconducting magnet. The current design of the Cryogenic VSM does not implement digital communication between IDEASVSM and the Model 620/622, but future design enhancements will. However, the user should know exactly how to configure the Model 620/622 for the superconducting magnet.

1. Set INT/EXT switches on back panel to V = INT, I = EXT, see Figure 2.1

NOTE 1: The Model 620/622 adds the Remote Program Input voltage to the front panel settings during operation. For example, if 1 V is at the Remote Program Input the output current is 10 amps. If the user then programs 10 amps output from the front panel the total output of the power supply will be 20 amps.

2. Use the Function Menu key and Instr. Setup menu item to configure the power supply:

FLDENABLE: ON
IMAX: (magnet maximum current)
BUNITS: kG
COMPLIANCE: (magnet maximum ramping voltage)
kG/A: (magnet constant)

Input all information from the magnet data sheet into the Model 620/622 memory. When properly configured, the Model 620/622 can be used to set fields from the front panel (see Note 1 above).

Additional parameters complete the field control configuration of the Cryogenic VSM. The Model 620/622 must be integrated to be used with the Model 735 VSM Controller. Tables 2.1 and 2.2 list a number of constants which must be configured for IDEASVSM to properly Set/Read the magnetic field.

Table 4-1 Constants for Field Programming (Set)

Superconducting Magnet Constant (G/A)	variable, see magnet data sheet
Model 620/622 Remote Program Constant (V/A)	0.1 V/A
Model 735 Program Output Constant (V/G)	Max. Output / Superconducting Magnet Max. Field
Model 735 Maximum Output (V)	10 V * (Superconducting Magnet Max. Current / 100 A)
Superconducting Magnet Maximum Field (G)	variable, see magnet data sheet
Superconducting Magnet Maximum Current (A)	variable, see magnet data sheet
Superconducting Magnet Ramp Voltage Limit (V)	variable, see magnet data sheet
Superconducting Magnet Ramp Rate Limit (G/minute)	variable, calculated from magnet data sheet

Two variables require calculation for the field control setup. The Model 735 Maximum Output must be set properly in order to limit Model 735 Program Output voltage which sets the output current of Model 620/622. The Model 735 Maximum Output is a ratio of Model 735 Program Output, 10 V, to Model 620/622 reference current, 100 A, scaled by the maximum current of the magnet.

The second variable to be calculated is the Ramp Rate Limit. The Ramp Rate Limit is determined by the allowable ramping voltage of the magnet which is supplied with the magnet data sheet.

Maximum Voltage = ir drop in leads + (magnet inductance * ramp rate limit).

Maximum Voltage = I(A) * R(ohms) + L(H) * RR(A/s).

assume ir drop in leads negligible

RRL(G/minute) = RR(A/s)* 60 s/minute * Magnet Constant(G/A)

NOTE 2: For IDEASVSM, the Ramp Rate Limit is in G/minute.

Table 4-2 Constants for Field Monitor (Read)

Superconducting Magnet Constant (G/A)	variable, see magnet data sheet
Model 620/622 Monitor Output Constant (V/A)	0.01 V/A
Model 735 Field Input Gain Constant (none)	Inverse Magnet Constant * 620/622 Monitor Constant * (Field Input Scale Factor = 10^5)
Model 735 Field Input Scale Factor (G/V)	Maximum Gaussmeter Range/ Maximum Voltage Input: 300000 G / 3 V (Range=0)
Offset in Read Circuit	Model 620/622 Monitor Out offset + Model 735 Field Input offset

The Field Input Scale Factor parameter is influenced by the electromagnet VSM design. Note the 300000 G/3V; this is the Maximum Field Range of the Model 450 Gaussmeter used in the electromagnet systems with a gaussmeter probe type TYPE_450= 0 (HST), and the Model 735 set to use Range=0 or Domain 1.

Offset in the Read Circuit is measured once the magnet has been cooled and the power supply and VSM controller are operating.

4.5 SOFTWARE CONFIGURATION

IDEASVSM, configured for a Model 735 VSM Controller, uses four configuration files located in the c:\windows directory. These four files are **ideacfg.ini**, **m735init.ini**, **m735zone.ini**, and **probedat.ini**.

Data in **m735init.ini** configures Model 735 Program Output. Data in **m735init.ini** and **probedat.ini** configures Model 735 Field Input. Data in **m735init.ini** and **m735zone.ini** controls superconducting magnet ramping.

Table 4-3 IDEASVSM Software configuration file entry points for Field Control

Model 735 Maximum Output (V)	m735init.ini: Maximum output =
Superconducting Magnet Maximum Field (G)	m735init.ini: Maximum field =
Ramp Rate Limit (G/minute)	m735init.ini: Ramp rate limit =
Magnet type, always '0'	m735init.ini: Magnet = 0
Model 735 Program Output Full Scale, always 10 V	m735init.ini: Output jumper = 10
Field Range, always '0'	m735init.ini: Field range = 0
Model 735 Field Input Gain Constant (none)	probedat.ini: in [Probe Description] Field Sensitivity = 1.0 and in [Calibration Data] 0= offset, gain
Field Compensation, always 'off'	m735init.ini: Field Compensation = 0
Offset in Read Circuit	probedat.ini: in [Calibration Data] 0 = offset, gain
Magnet Ramping Maximum Field*	m735zone.ini: in [Zone 1] MAXIMUM GAUSS =
Magnet Ramping Rate*	m735zone.ini: in [Zone 1] RAMP RATE =
Field Input Scale Factor (G/V)	probedat.ini: in [Probe Description] TYPE_450 = 0 always
Magnet Control Mode#	m735init.ini: Control mode=

* Setup IDEAS735 Domains using "Rates" button.
# Lake Shore has not tested in Field Control Mode, 3/98.

4.6 EXAMPLE

The field control of a Lake Shore Cryogenic VSM with a 9 Tesla magnet, configure the Model 620 MPS and Model 735 VSM Controller with the following information from the magnet data sheet:

1. Magnet Serial # = A001
2. Field/Current = 2000 G/A
3. Maximum Field = 90000 G
4. Maximum Current = 45 A
5. Maximum (Compliance) Voltage = 2 V
6. Magnet Inductance = 30 H

Maximum Output and Ramp Rate Limit calculations:

Maximum Output = 10 V * (45 A/100 A).

Ramp rate limit:

compliance voltage = ir drop in leads + (magnet inductance * ramp rate limit).

2 V = I(A) * R(ohms) + L(H) * RR(A/s).

assume ir drop in leads negligible

RR(G/minute) = RR(A/s) * 60 s/minute * Magnet Constant(G/A)

RR(G/minute) = (2/30) * 60 * 2000 = 8000

Table 4-4 m735init.ini configuration file using magnet A001

Maximum output=	4.5	V
Maximum field=	90000	G
Ramp rate limit=	8000	G/minute
Magnet= 0	0 always	use 735 Field Input
Field Compensation= 0	0 always	off
Output jumper= 10	10 always	V
Field range= 0	0 always	Domain 1
Control mode=	0	Current

Model 735 Field Input Gain Calculation:

gain = Field Sensitivity * inverse Magnet Constant * Model 620/622 Monitor Output Constant * Model 735 Field Input Scale Factor

gain = 1.0 * (1/2000) (A/G) * (0.01) (V/A) * (300000/3) (G/V) = 0.5

Table 4-5 probedat.ini configuration file using magnet A001

[Probe Description] TYPE_450=	0 always
[Probe Description] Field Sensitivity=	1.0 always
[Calibration Data] 0= ..., gain	gain = 0.5
[Calibration Data] 0= offset, ...	offset = variable

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CHAPTER 5

MODEL 735 CONTROLLER REMOTE OPERATION

5.0 GENERAL

This chapter covers the Model 735 IEEE-488 Interface (Paragraph 5.1) and Command Set (Paragraph 5.2).

5.1 IEEE-488 INTERFACE

The IEEE-488 Interface is an instrumentation bus with hardware and programming standards that simplify instrument interfacing. The Model 735 IEEE-488 Interface complies with most of the IEEE-488.2-1987 standard and incorporates its functional, electrical, and mechanical specifications unless otherwise specified.

5.1.1 Interface Capabilities

- **SH1:** Source handshake capability
- **RL1:** Complete remote/local capability
- **DC1:** Full device clear capability
- **DT0:** No device trigger capability
- **C0:** No system controller capability
- **SR0:** Service request capability
- **AH1:** Acceptor handshake capability
- **PP0:** No parallel poll capability
- **E1:** Open collector electronics.
- **T5:** Basic TALKER, serial poll capability, talk only, unaddressed to talk if addressed to listen
- **L4:** Basic LISTENER, unaddressed to listen if addressed to talk

5.1.2 Common Commands

Common Commands are addressed commands which create commonalty between instruments on the bus. All instruments that comply with the IEEE-488 1987 standard share these commands and their format. Common commands all begin with an asterisk. Common query commands end with a question mark (?). The only common command supported by the Model 735 is *IDN?.

5.1.3 Interface Settings

The IEEE-488 interface on the model 735 is somewhat limited in flexibility because it is intended for use as part of a larger system. It is recommended to use the default interface settings below whenever possible.

735 Default Interface Settings

Address	9
Terminators	CrLf
EOI	On
Mode	Remote

To operate two Model 735 Controllers on the bus at one time, change the address of one with the ADDR command. Record the new address; the instrument will not respond at the default address after a change. The new address will be kept when instrument power is turned off. Local operation of the instrument is not possible so the mode is defined as remote.

5.1.4 Interface LED

There is and Interface LED on the Model 735 front panel. Its normal state is off, but it turns on momentarily each time an interface command is sent to the instrument. If the instrument performs a long task such as calibration, the LED remains on until the task is complete. The interface should not be used during this time except for the BUSY? Query that informs the user when the task is complete.

5.1.5 Example IEEE Setup and Program

NOTE: The following is intended for servicing the Model 735 stand alone. The setup and configuration are not appropriate for use in a larger system. Below is an example of how to setup and run a simple program using the Model 735 IEEE-488 Interface. The example uses a National Instruments GPIB - PCII/IIA card and QuickBasic 4.0 or 4.5 on a PC compatible.

5.1.5.1 GPIB Board Installation

1. Install GPIB-PCII/IIA card using National Instruments instructions.
2. Install NI - 488.2 software (for DOS). Version 2.1.1 was used for the example.
3. Verify that config.sys contains the command: device = \gpib-pc\gpib.com
4. Reboot the computer.
5. Run IBTEST to test software configuration. Do not install the instrument before running IBTEST.
6. Run IBCONF to configure the GPIB - PCII/IIA board and dev 9. Set the EOS byte to 0AH. IBCONF modifies gpib.com.
7. Connect the instrument to the interface board and power up the instrument. Verify address as 9 and terminators as CR LF.

5.1.5.2 Running The Example QuickBasic Program

1. Copy c:\gpib-pc\Qbasic\qbib.obj to the QuickBasic directory (QB4).
2. Change to the QuickBasic directory and type: **link /q qbib.obj,,,bqlb4x.lib;** where x = **0** for QB4.0 and **5** for QB4.5 This one-time only command produces the library file qbib.qlb. The procedure is found in the National Instruments QuickBasic readme file Readme.qb.
3. Start QuickBasic. Type: **qb /l qbib.qlb**. Start QuickBasic in this way each time the IEEE interface is used to link in the library file.
4. Create the IEEE example interface program in QuickBasic. See Table 5-1. Name the file "ieeeexam.bas" and save.
5. Run the program.

5.1.6 Notes On Using the IEEE Interface

- To chain commands or queries together, insert a semi-colon (;) between them. Multiple queries cannot be chained. The Model 735 responds to the last query entered when addressed as a talker.
- Queries generally use the same syntax as an associated setting command followed by a question mark. They most often return the same information that is sent. Some queries have no command form.
- Add a query to the end of a command string to confirm command execution. For example, **HEAD 1;HEAD?** commands the Model 735 to set the head on then return the head setting to confirm the change.
- 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 735.

Some numbers are stored in 4 byte binary floating point. The numbers are sent over the interface with an eight digit hex representation of the binary number. The first bit represents the sign of the mantissa. The remaining 7 bits in the first byte are the two's complement binary exponent. The last three bytes are the mantissa where 000000 = 0 and FFFFFF = 1. Example: 81800000 = - 2^{1} x .5 = -1.

Table 5-1 Sample BASIC IEEE-488 Interface Program

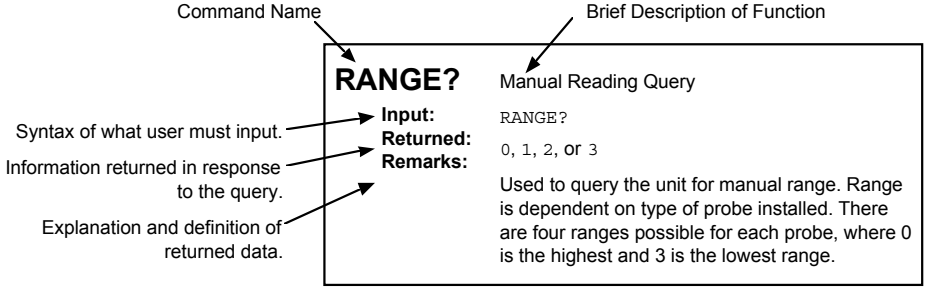
```
'     IEEEEXAM.BAS    EXAMPLE PROGRAM FOR IEEE-488 INTERFACE
'
'     This program works with QuickBasic 4.0/4.5 on an IBM PC or compatible.
'
'     The example requires a properly configured National Instruments GPIB-PC2 card. The REM
'     $INCLUDE statement is necessary along with a correct path to the file QBDECL.BAS. CONFIG.SYS
'     must call GPIB.COM created by IBCONF.EXE prior to running Basic. There must be QBIB.QBL
'     library in the QuickBasic Directory and QuickBasic must start with a link to it. All
'     instrument settings are assumed to be defaults: Address 12, Terminators <CR> <LF> and EOI
'     active.
'
'     To use, type an instrument command or query at the prompt. The command transmits to the
'     instrument and the MPS receives and displays the response. If no query is sent, the
'     instrument responds to the last query received. Type "EXIT" to exit the program. NOTE: The
'     INPUT instruction accepts no commas as part of an input string. If a comma appears in an
'     instrument command, replace it with a space.
'
       REM $INCLUDE: 'c:\gpib-pc\qbasic\qbdecl.bas'        'Link to IEEE calls
       CLS                                                 'Clear screen
       PRINT "IEEE-488 COMMUNICATION PROGRAM"
       PRINT

       CALL IBFIND("dev12", DEV12%)                        'Open communication at address 12
       TERM$ = CHR$(13) + CHR$(10)                         'Terminators are <CR><LF>

LOOP2: IN$ = SPACE$(2000)                                  'Clear for return string

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


       CALL IBWRT(DEV12%, CMD$)                            'Send command to instrument


       CALL IBRD(DEV12%, IN$)                              'Get data back each time


       ENDTEST = INSTR(IN$, CHR$(13))                      'Test for returned string
          IF ENDTEST > 0 THEN                              'String is present if <CR> is seen
             IN$ = MID$(IN$, 1, ENDTEST - 1)               'Strip off terminators
             PRINT "RESPONSE:", IN$                        'Print return string
          ELSE
             PRINT "NO RESPONSE"                           'No string present if timeout
          END IF
       GOTO LOOP2                                          'Get next command
```

5.2 IEEE-488 COMMAND SUMMARY

There are several types of commands: Common (Paragraph 5.2.2), Interface (Paragraph 5.2.3) Reading Setup and Reading (Paragraph 5.2.4), Field Setting (Paragraph 5.2.5), Auxiliary (Paragraph 5.2.6), Miscellaneous (Paragraph 5.2.7), and Calibration (Paragraph 5.2.8)

Command	Function	Page
Common Commands		
*IDN?	Query Identification	5-5
Interface Commands		
ADDR	Set Address	5-5
ADDR?	Address Query	5-5
END	EOI	5-5
END?	EOI Query	5-5
TERM	Terminator	5-5
TERM?	Terminator Query	5-5
Reading Setup and Reading Commands		
ALLR?	Query all available reading data	5-6
EMUR	Set Range	5-6
EMUR?	Query Range	5-6
EMUTC	Set Filter Time Constant	5-6
EMUTC?	Query Filter Time Constant	5-6
HEAD	Set Head Drive Status	5-7
HEAD?	Query Head Drive Status	5-7
NEWR?	Query Data from Newest to Oldest	5-7
OLDR?	Query Data from Oldest to Newest	5-7
QUAD	Set Channel Y Quadrature Status	5-7
QUAD?	Query Channel Y Quadrature Status	5-7
READ?	Query Newest Reading Data	5-8
READC	Clear Data from Buffer	5-8
READP	Set Sample Period for Read Buffer	5-8
READP?	Query Read Buffer Sample Period	5-8
READS?	Query Reading Status for Inputs	5-8
Reading Setup and Reading Commands		
CMODE	Set Field Setting Mode	5-9
CMODE?	Query Field Setting Mode	5-9
CONLIM	Set Field-Controlled Output Change Limit	5-9
CONLIM?	Query Output Change Limit	5-9
CONPI	Set Field-Controlled P & I Parameters	5-9
CONPI?	Query Field-Controlled P & I Parameters	5-9
CONRT	Set Field Controlled Ramp Rate	5-9
CONRT?	Query Field Controlled Ramp Rate	5-10
CONSP?	Query Field-Controlled Ramp Setpoint	5-10
CONST?	Query Field-Controlled Ramp Status	5-10
CONTO	Set Field-Controlled Ramp Value	5-10
CONTO?	Query Field-Controlled Ramp Value	5-10
COUT	Set Field Output	5-10
COUT?	Query Field Output	5-10
RAMP?	Query Ramp Status	5-11
RMPRT	Set Ramp Rate	5-11
RMPRT?	Query Ramp Rate	5-11
RMPTO	Set Current Ramp Value	5-11
RMPTO?	Query Current Ramp Value	5-11
Auxiliary Commands		
AUXAD?	Query Auxiliary Readings	5-12
AUXDA	Set Auxiliary Output	5-12
AUXDA?	Query Auxiliary Output	5-12
AUXDI?	Query Auxiliary Input State	5-12
AUXDO	Set All Five Auxiliary Outputs	5-12
AUXDO?	Query All Five Auxiliary Outputs	5-13
RELAY	Set Auxiliary Relay State	5-13
RELAY?	Query Auxiliary Relay State	5-13
Miscellaneous Commands		
BEEP	Set Beeper Status	5-14
BEEP?	Query Beeper Status	5-14
IDSW?	Query Main Board ID Switches	5-14
POKE	Set Value of EEPROM Location	5-14
POKE?	Query Value of EEPROM Location	5-14
PON?	Query Instrument Power Status	5-14
XMEM	Set Value of External Memory Location	5-14
XMEM?	Set Value of External Memory Location	5-14
Calibration Commands		
ADFILT	Set Filter Pole of A/D Converters	5-15
ADFILT?	Query Filter Pole of A/D Converters	5-15
APCAL	Initiate Auto Phase Calibration	5-15
BUSY?	Inform User of Calibration Completion	5-15
CALCLEAR	Clear Instrument Calibration Memory	5-15
CALSAVE	Save Calibration	5-15
PCAL	Set Instrument Phase Calibration	5-15
PCAL?	Query Instrument Phase Calibration	5-15
SNUM	Set Instrument Serial Number	5-16
SNUM?	Query Instrument Serial Number	5-16
ZCAL	Zero Calibrates X & Y Inputs	5-16

5.2.1 Command List Structure



5.2.2 Common Commands

***IDN?** Identification query.

Sent: ***IDN?**
Returned: LSCI,MODEL 735,XXXXXX,MMDDYY[term]
Remarks: Returns manufacturer, model number, six-digit instrument serial number, and firmware date.

5.2.3 Interface Commands

ADDR Set instrument IEEE-488 address.

Sent: **ADDR XX[term]**
Returned: Nothing. Address return requires **ADDR?**.
Remarks: Two ASCII digits (**XX**) set the IEEE-488 address between **01** and **31**. Default **09**.

ADDR? Query instrument IEEE-488 address.

Sent: **ADDR?[term]**
Returned: XX[term]
Remarks: Returns two ASCII digits (**XX**) of the IEEE-488 address between **01** and **31**. Default **09**.

END Set instrument IEEE-488 EOI status.

Sent: **END X[term]**
Returned: Nothing. END return requires **END?**.
Remarks: One ASCII digit (**X**) sets IEEE-488 EOI status: **0** = EOI enabled (EOI set with last data byte in transmission), **1** = EOI disabled (No EOI is set with last data byte in transmission). Default **0**.

END? Query instrument IEEE-488 EOI setting.

Sent: **END?[term]**
Returned: X[term]
Remarks: Returns one ASCII digit (**X**) indicating IEEE-488 EOI setting: **0** = EOI enabled (EOI set with last data byte in transmission), **1** = EOI disabled (No EOI is set with last data byte in transmission). Default **0**.

TERM Set instrument IEEE-488 terminators.

Sent: **TERM X[term]**
Returned: Nothing. Terminator setting return requires **TERM?**.
Remarks: One ASCII digit (**X**) sets instrument terminators: **0** = <CR> <LF>, **1** = <LF> <CR>, **2** = <LF>, and **3** = None. EOI must be set active with the END command. Default **0**.

TERM? Query instrument IEEE-488 terminator setting.

Sent: **TERM?[term]**
Returned: X[term]
Remarks: Returns one ASCII digit (**X**) IEEE-488 terminator setting: **0** = <CR> <LF>, **1** = <LF> <CR>, **2** = <LF>, and **3** = None. Default **0**.

5.2.4 Reading Setup and Reading Commands

ALLR? Query all available reading data in the 100 point data buffer.

Sent: **ALLR?[term]**
Returned: NNN,XXXXXXXX,YYYYYYYY,FFFFFFFF,TTTTTTTT….[term].
Remarks: **NNN** = three ASCII digits of an integer number of readings that follow. The X, Y and F fields are three eight-character ASCII representations of a binary floating point number: **X field** = voltage present at Channel X input, **Y field** = voltage present at Channel Y input, **F field** = voltage present at Field input. The T field is an eight digit decimal integer representing time in 10ms increments from initial instrument power up until the reading was taken.

All NNN readings are sent at the same time in order of oldest to newest. Data is taken and time stamped every period specified in the READP command from 100 ms to 1000mS. If NNN is 100, assume some readings were lost.

EMUR Set range for either X or Y EMU input.

Sent: **EMUR *X, YY*[term]**
Returned: Nothing. Range setting return requires **EMUR?**.
Remarks: One ASCII digit (**X**) sets desired channel: **0** = Channel X, **1** = Channel Y. Two ASCII digits, (**YY**) set the range from 00 to 3F hex (Default **00**): 00 = 2 V
01 = 200 mV
02 = 20 mV
03 = 2 mV
07 = 200 uV
0B = 20 uV
1B = 2 uV
2B = 200 nV

EMUR? Query range setting for either X or Y EMU input.

Sent: **EMUR?*X*[term]**
Returned: *YY*[term].
Remarks: One ASCII digit (**X**) indicates desired channel: **0** = Channel X, **1** = Channel Y. Returns two ASCII digits (**YY**) indicating range from 00 to 3F hex (Default 00): 00 = 2 V
01 = 200 mV
02 = 20 mV
03 = 2 mV
07 = 200 uV
0B = 20 uV
1B = 2 uV
2B = 200 nV

EMUTC Set filter time constant for both X and Y EMU inputs.

Sent: **EMUTC X[term]**
Returned: Nothing. Time constant return requires **EMUTC?**.
Remarks: One ASCII digit (**X**) sets filter time constant: **0** = 10 s, **1** = 3 s, **2** = 1 s, **3** = 300 ms, **4** = 100 ms. Default **0**.

EMUTC? Query filter time constant setting for X and Y EMU inputs.

Sent: **EMUTC?[term]**
Returned: X[term].
Remarks: Returns one ASCII digit (**X**) indicating filter time constant: **0** = 10 s, **1** = 3 s, **2** = 1 s, **3** = 300 ms, **4** = 100 ms. Default **0**.

HEAD Set head drive on or off.

Sent: **HEAD X[term]**
Returned: Nothing. Head setting return requires **HEAD?**.
Remarks: One ASCII digit (**X**) sets head drive on or off: **0** = OFF, **1** = ON. Default **0**.

HEAD? Query head drive setting.

Sent: **HEAD?[term]**
Returned: X[term].
Remarks: Returns one ASCII digit (**X**) indicating head drive status: **0** = OFF, **1** = ON. Default **0**.

NEWR? Query the newest reading data in the 100 point data buffer.

Sent: **NEWR?###[term]**
Returned: NNN,XXXXXXXX,YYYYYYYY,FFFFFFFF,TTTTTTTT….[term].
Remarks: **###** = number of data sets to be sent between 1 and 100. **NNN** = three ASCII digits of an integer number of readings that follow. The X, Y and F fields are three eight-character ASCII representations of a binary floating point number: **X field** = voltage present at Channel X input, **Y field** = voltage present at Channel Y input, **F field** = voltage present at Field input. The T field is an eight digit decimal integer representing time in 10ms increments from initial instrument power up until the reading was taken.

The newest ### readings are sent at the same time in order of oldest to newest. If fewer new readings are available, only valid readings are sent. All older readings are lost. Data is taken and time stamped every period specified in the READP command from 100 ms to 1000mS.

OLDR? Query the oldest reading data in the 100 point data buffer.

Sent: **OLDR?###[term]**
Returned: NNN,XXXXXXXX,YYYYYYYY,FFFFFFFF,TTTTTTTT….[term].
Remarks: **###** = number of data sets to be sent between 1 and 100. **NNN** = three ASCII digits of an integer number of readings that follow. The X, Y and F fields are three eight-character ASCII representations of a binary floating point number: **X field** = voltage present at Channel X input, **Y field** = voltage present at Channel Y input, **F field** = voltage present at Field input. The T field is an eight digit decimal integer representing time in 10ms increments from initial instrument power up until the reading was taken.

The oldest ### readings are sent at the same time in order of oldest to newest. If fewer readings are available, only valid readings are sent. Newer readings are preserved for future retrieval. Data is taken and time stamped every period specified in the READP command from 100 ms to 1000mS.

QUAD Set channel Y quadrature on or off.

Sent: **QUAD X[term]**
Returned: Nothing. Return requires **QUAD?**.
Remarks: One ASCII digit (**X**) sets channel Y quadrature on or off: **0** = OFF (Channel Y in phase with channel X), **1** = ON (Channel Y in quadrature with channel X). Default **0**.

QUAD? Query channel Y quadrature setting.

Sent: **QUAD?[term]**
Returned: X[term].
Remarks: Returns one ASCII digit (**X**) indicating channel Y quadrature: **0** = OFF (Channel Y in phase with channel X), **1** = ON (Channel Y in quadrature with channel X). Default **0**.

READ? Query newest reading data.

Sent: **READ?[term]**
Returned: XXXXXXXX,YYYYYYYY,FFFFFFFF,TTTTTTTT[term].
Remarks: Returns three eight-character ASCII representations of a binary floating point number indicated by the X, Y and F fields: **X field** = voltage present at Channel X input, **Y field** = voltage present at Channel Y input, **F field** = voltage present at Field input. The T field is an eight digit decimal integer representing time in 10 ms increments from initial instrument power up until the reading was taken. New data taken every 100mS.

READC Clears data from the reading buffer.

Sent: **READC[term]**
Returned: Nothing.
Remarks: Data in the reading buffer is lost. Stores data taken after the READC command; return data using the **ALLR?** query.

READP Set sample period for read buffer.

Sent: **READP XX[term]**
Returned: Nothing. READP setting return requires READP?.
Remarks: Two ASCII digits (**XX**) set sample period in 0.1 second increments. Setting range is **1** (0.1 second) to **10** (1 second). Default **1**.

READP? Query read buffer sample period.

Sent: **READP?[term]**
Returned: X[term].
Remarks: Two ASCII digits (**XX**) indicate sample period in 0.1 second increments. Range is **1** (0.1 second) to **10** (1 second). Default **1**.

READS? Query reading status for the X EMU, Y EMU, Field, and AUX inputs.

Sent: **READS?[term]**
Returned: XX[term].
Remarks: Two ASCII digits (**XX**) indicate overload on the input channels. Each digit represents a nibble (**0**-**F**) of an eight bit status byte. **0** = no error, **1** = error present. Bit weighting is as follows:

Bit	Weight	Use
0	01	EMUX A/D overload
1	02	EMUX PSDMON overload
2	04	EMUX PREMON overload
3	08	EMUY A/D overload
4	10	EMUY PSDMON overload
5	20	EMUY PREMON overload
6	40	Field A/D overload
7	80	Auxiliary A/D overload

Hex addition of the bit weights gives the complete status byte.

5.2.5 Field Setting Commands

CMODE Set field setting mode.

Sent: **CMODE X[term]**
Returned: Nothing. Return requires **CMODE?**.
Remarks: One ASCII digit (**X**) sets field setting mode: **0** = Manual setting mode (uses **COUT**), **1** = Current ramp mode (uses **RMPTO**, **RMPRT**), **2** = Field controlled ramp mode (uses **CONTO**, **CONRT**, **CONPI**, **CONLIM**). Default **0**.

CMODE? Query field setting mode.

Sent: **CMODE?[term]**
Returned: X[term].
Remarks: One ASCII digit (**X**) indicates field setting mode: **0** = Manual setting mode (uses **COUT**), **1** = Current ramp mode (uses **RMPTO**, **RMPRT**), **2** = Field controlled ramp mode (uses **CONTO**, **CONRT**, **CONPI**, **CONLIM**). Default **0**.

CONLIM Set field output change limit for field controlled ramp.

Sent: **CONLIM XXXXXXXX[term]**
Returned: Nothing. Return requires **CONSCALE?**.
Remarks: The X field is an eight ASCII character representation of a binary floating point number set in percent of full scale field output per minute. When **CMODE** = **2**, the instrument will not change the field output faster than **CONLIM**. Default **00000000** (0 %/min).

CONLIM? Query field output change limit for a field controlled ramp.

Sent: **CONLIM?[term]**
Returned: XXXXXXXX[term].
Remarks: The X field is an eight ASCII character representation of a binary floating point number set in percent of full scale field output per minute. Default **00000000** (0 %/min).

CONPI Set field controlled ramp P (proportional) and I (integral) parameters.

Sent: **CONPI XXXXXXXX,YYYYYYYY[term]**
Returned: Nothing. Return requires **CONPI?**.
Remarks: The X field is an eight ASCII character representation of a binary floating point **P** (no units). The Y field is an eight ASCII character representation of a binary floating point **I** in seconds. When **CMODE** = **2**, the instrument uses **the P** and **I** values in a PI control algorithm. Default **00000000,00000000** (0,0).

CONPI? Query field controlled ramp P (proportional) and I (integral) parameters.

Sent: **CONPI?[term]**
Returned: XXXXXXXX,YYYYYYYY[term]
Remarks: The X field is an eight ASCII character representation of a binary floating point **P** (no units). The Y field is an eight ASCII character representation of a binary floating point **I** in seconds. Default **00000000,00000000** (0,0).

CONRT Set field controlled ramp rate.

Sent: **CONRT XXXXXXXX[term]**
Returned: Nothing. Return requires **CONRT?**.
Remarks: The X field is an eight ASCII character representation of a binary floating point number set in field input volts per minute. When **CMODE** = **2**, the instrument uses **CONRT** to approach the **CONTO** value. Default **00000000** (0 V/min).

CONRT? Query the field controlled ramp rate.

Sent: **CONRT?[term]**
Returned: XXXXXXXX[term].
Remarks: The X field is an eight ASCII character representation of a binary floating point number set in field input volts per minute. Default **00000000** (0 V/min).

CONSP? Query current field controlled ramp setpoint.

Sent: **CONSP?[term]**
Returned: XXXXXXXX[term].
Remarks: The X field is an eight ASCII character representation of the current field controlled ramp setpoint in volts per minute. Default **00000000** (0V).

CONST? Query field controlled ramp status.

Sent: **CONST?[term]**
Returned: X[term].
Remarks: One ASCII digit (**X**) indicates ramp status: **0** = no field controlled ramp active, **1** = Field controlled ramp active; **CONSP** approaching **CONTO**, **2** = **CONSP** reached **CONTO** and controlling to final value. Default **0**.

CONTO Set ramp-to value for field controlled ramp of field output and initiate a ramp.

Sent: **CONTO XXXXXXXX[term]**
Returned: Nothing. Return requires **CONTO?**.
Remarks: The X field is an eight ASCII character representation of a binary floating point number in voltage corresponding to the field input. Range and resolution are 5.00000 to +5.00000 V. Default **00000000** (0V).

NOTE: CONTO initiates only if **CONRT** $\neq$ 0 and **CMODE** = 2.

CONTO? Query ramp-to setting for field controlled ramp.

Sent: **CONTO?[term]**
Returned: XXXXXXXX[term].
Remarks: The X field is an eight ASCII character representation of the control destination. Range and resolution are 5.00000 to +5.00000 V. Default **00000000** (0V).

NOTE: CONTO? returns the ramp destination. Use **CONSP?** to obtain current field setpoint.

COUT Manually set field output.

Sent: **COUT XXXXXXXX[term]**
Returned: Nothing. Return requires **COUT?**.
Remarks: The X field is an eight character ASCII representation of a binary floating point number in percent of full scale field output. Use **COUT** when **CMODE** = **0**. The range and resolution are -100.000 to +100.000%. Default **00000000** (0%).

NOTE: COUT ends an active ramp and forces field output to the **COUT** setting value. **COUT?** is always active and will not stop a ramp.

COUT? Query field output setting.

Sent: **COUT?[term]**
Returned: XXXXXXXX[term].
Remarks: The X field is an eight character ASCII representation of a binary floating point number in percent of full scale field output. The range and resolution are -100.000 to +100.000%. Default **00000000** (0%).

NOTE: COUT? always returns the field output even if **COUT** is not used to set it.

RAMP? Query ramp status.

Sent: **RAMP?[term]**
Returned: X[term].
Remarks: One ASCII digit (**X**) indicates ramp status: **1** = ramp active, **0** = no ramp active. Use **RAMP?** when **CMODE** = **1**. Default **0**.

RMPRT Set ramp rate in percent of full scale field output /min.

Sent: **RMPRT XXXXXXXX[term]**
Returned: Nothing. Return requires **RMPRT?**.
Remarks: The X field is an eight ASCII character representation of a binary floating point number in percent of full scale field output per minute. Range and resolution are 0.00 to +100.00%/min. Default **00000000** (0%/min). Use **RAMPRT** when **CMODE** = **1**.

NOTE: A ramp initiates only if a non-zero ramp rate is set.

RMPRT? Query the ramp rate setting.

Sent: **RMPRT?[term]**
Returned: XXXXXXXX[term].
Remarks: The X field is an eight ASCII character representation of a binary floating point number in percent of full scale field output per minute. Range and resolution are 0.00 to +100.00%/min. Default **00000000** (0%/min).

RMPTO Set ramp-to value for current ramp of field output and initiate a ramp.

Sent: **RMPTO XXXXXXXX[term]**
Returned: Nothing. Return requires **RMPTO?**.
Remarks: The X field is an eight ASCII character representation of a binary floating point number in percent of full scale field output. Range and resolution are -100.000 to +100.000%. Default **00000000** (0%). **RAMPTO** works for **CMODE** = **1** or **2**.

NOTE: A ramp initiates only if a non-zero ramp rate is set.

RMPTO? Query ramp-to setting for current ramp.

Sent: **RMPTO?[term]**
Returned: XXXXXXXX[term].
Remarks: The X field is an eight ASCII character representation of a binary floating point number in percent of full scale field output. Range/resolution = -100.000 to +100.000%. Default **00000000** (0%).

NOTE: RMPTO? returns the ramp destination. Use **COUT?** to obtain current field output.

5.2.6 Auxiliary Commands

AUXAD? Query one of seven auxiliary A/D readings.

Sent: **AUXAD?X[term]**
Returned: YYYYYYYY[term].
Remarks: One ASCII digit (**X**) indicates the A/D input from 1 to 7. The Y field is an eight ASCII character representation of a binary floating point number which is the voltage at the A/D input. Range: -5 V to +5 V. Resolution: 18 bits or greater.

NOTE: One A/D updates every 100 ms; 700 ms to update all seven.

AUXDA Set output of auxiliary output D/A 1 or 2.

Sent: **AUXDA X, YYYYYYYY[term]**
Returned: Nothing. Output setting return requires **AUXDA?**.
Remarks: One ASCII digit (**X**) indicates output: **1** = Auxiliary output D/A 1, **2** = Auxiliary output D/A 2. The Y field is an eight ASCII character representation of a binary floating point number in percent of full scale for the output. Range/resolution = -100.00 to +100.00%. Default **00000000** (0%).

AUXDA? Query output setting for auxiliary output D/A 1 or 2.

Sent: **AUXDA?X[term]**
Returned: YYYYYYYY[term].
Remarks: One ASCII digit (**X**) indicates output: **1** = Auxiliary output D/A 1, **2** = Auxiliary output D/A 2. The Y field is an eight ASCII character representation of the output setting. Range and resolution are -100.00 to +100.00%. Default **00000000** (0%).

AUXDI? Query auxiliary digital input states.

Sent: **AUXDI?[term]**
Returned: XX[term].
Remarks: Two ASCII digits (**XX**) represent the digital inputs as a hex number from 00 to 1F. Each input is represented by an individual bit. **0** = logic low; **1** = logic high. Returns the hex sum of the bit weights. Bit weighting is as follows:

Bit	Weight	Use
0	01	Digital output 1
1	02	Digital output 2
2	04	Digital output 3
3	08	Digital output 4
4	10	Digital output 5

Hex addition of the bit weights gives all input states. Default **00**. **NOTE:** Digital outputs and inputs share pins on the auxiliary connector. To use a digital line as an input, set it to output = 1.

AUXDO Set all five auxiliary digital outputs.

Sent: **AUXDO XX[term]**
Returned: Nothing. Output return requires **AUXDO?**.
Remarks: Two ASCII digits (**XX**) represent the five digital outputs. Each output is represented by an individual bit. **0** = logic low; **1** = logic high. The hex sum of the bit weights create a setting value from 00 to 1F hex. Bit weighting is as follows:

Bit	Weight	Use
0	01	Digital output 1
1	02	Digital output 2
2	04	Digital output 3
3	08	Digital output 4
4	10	Digital output 5

Hex addition of the bit weights gives all input states. Default **00**. **NOTE:** Digital outputs and inputs share pins on the auxiliary connector. To use a digital line as an input, set it to output = 1.

AUXDO?

Query auxiliary digital output setting.

Sent: **AUXDO?[term]**

Returned: XX[term].

Remarks: Two ASCII digits (**XX**) represent the five digital outputs. Each output is represented by an individual bit. **0** = logic low; **1** = logic high. The hex sum of the bit weights create a setting value from 00 to 1F hex. Bit weighting is as follows:

Bit	Weight	Use
0	01	Digital output 1
1	02	Digital output 2
2	04	Digital output 3
3	08	Digital output 4
4	10	Digital output 5

Hex addition of the bit weights gives all output states. Default **00**.

RELAY

Set state of one of four auxiliary relays.

Sent: **RELAY X, Y[term]**

Returned: Nothing. Relay state return requires **RELAY?**.

Remarks: One ASCII digit (**X**) indicates desired relay: **1** = Auxiliary Relay 1, **2** = Auxiliary Relay 2, **3** = Auxiliary Relay 3, **4** = Auxiliary Relay 4.
One ASCII digit (**Y**) is the relay state: **0** = Normal, **1** = Active. Default **0**.

RELAY?

Query the state setting of an auxiliary relay.

Sent: **RELAY?X[term]**

Returned: Y[term].

Remarks: One ASCII digit (**X**) indicates desired relay: **1** = Auxiliary relay 1, **2** = Auxiliary relay 2, **3** = Auxiliary relay 3, **4** = Auxiliary relay 4. Returns one ASCII digit (**Y**) which is the relay state: **0** = Normal, **1** = Active. Default **0**.

5.2.7 Miscellaneous Commands

BEEP Sets main board beeper on or off.

Sent: **BEEP X[term]**
Returned: Nothing. Beeper setting return requires **BEEP?**.
Remarks: One ASCII digit (**X**) specifies beeper setting: **0** = OFF, **1** = ON. Default **0**.

BEEP? Query beeper setting.

Sent: **BEEP?[term]**
Returned: X[term].
Remarks: One ASCII digit (**X**) indicates beeper setting: **0** = OFF, **1** = ON. Default **0**.

IDSW? Query the four ID switches on the instrument main board.

Sent: **IDSW?[term]**
Returned: X[term].
Remarks: Returns one ASCII digit (**X**) which represents the switch states as a hex number from 0 to 1F. An individual bit represents each of the four switches. **0** i= closed; **1** = open. Returns the hex sum of the bit weights. Bit weighting is as follows:

Bit	Weight	Use
0	01	Switch 1
1	02	Switch 2
2	04	Switch 3
3	08	Switch 4

NOTE: Hex addition of bit weights gives all switch states.

POKE Sets the value of any location in EEPROM memory.

Sent: **POKE XXX,YY[term]**
Returned: Nothing. Return requires **POKE?**.
Remarks: Three ASCII digits (**XXX**) represent the decimal memory address from 0 to 511. Two ASCII digits (**YY**) represent the 8 bit data byte in hex. No default.

POKE? Query the value in any location in EEPROM memory.

Sent: **POKE?XXX[term]**
Returned: YY[term].
Remarks: Three ASCII digits (**XXX**) represent the decimal memory address from 0 to 511. Returns two ASCII digits (**YY**) which represent the 8 bit data byte in hex. No default.

PON? Query instrument power on status.

Sent: **PON?[term]**
Returned: X[term].
Remarks: One ASCII digit (**X**) represents the instrument power on status: **1** = instrument powered off then on again since last **PON?** query; **0** = instrument not powered off since last **PON?** query.

XMEM Sets the value of any location in external memory.

Sent: **XMEM XXXX,YY[term]**
Returned: Nothing. Return requires **XMEM?**.
Remarks: Four ASCII digits (**XXXX**) represent the 16 bit hex memory address. Two ASCII digits (**YY**) represent the 8 bit data byte in hex. No default.

XMEM? Query the value in any location in external memory.

Sent: **XMEM?XXXX[term]**
Returned: YY[term].
Remarks: Four ASCII digits (**XXXX**) represent the 16 bit hex memory address. Returns two ASCII digits (**YY**) which represent the 8 bit data byte in hex. No default.

5.2.8 Calibration Commands (NOTE: CALSAVE must be sent to save calibrations)

ADFILT Sets filter pole of A/D converters.

Sent: **ADFILT XXX[term]**
Returned: Nothing. Return requires **ADFILT?**.
Remarks: Three ASCII digits (**XXX**) indicate the hex value of the A/D pole setting. The pole is computed in decimal as f pole = 10MHz/(512*setting). The converter sample rate is 1/f pole. Convert the pole setting to hex before sending. Default **188** (50Hz).

ADFILT? Queries filter pole setting of A/D converters.

Sent: **ADFILT?[term]**
Returned: XXX[term].
Remarks: Returns three ASCII digits (**XXX**) which indicate the hex value of the A/D pole setting. Default **188** (50Hz).

APCAL Initiates instrument auto phase calibration.

Sent: **APCAL [term]**
Returned: Nothing. Return requires **PCAL?**.
Remarks: A large in-phase signal should reside in the instrument EMUX input before sending this command. It takes at least 10 seconds to complete, and **BUSY?** = 1 during the task. Send **CALSAVE** to permanently store the calibration.

BUSY? Informs user when a long calibration is complete.

Sent: **BUSY?[term]**
Returned: X[term]
Remarks: Returns one ASCII digit (**X**). If **X** = **1**, the instrument is calibrating. If **X** = **0** the instrument is performing normal operation.

CALCLEAR Clears instrument calibration memory.

Sent: **CALCLEAR [term]**
Returned: Nothing.
Remarks: The instrument writes default calibration data to EEPROM where it is read on power up. All software calibrations are lost including serial number. It takes at least two seconds to complete, and **BUSY?** = 1 during the task.

CALSAVE Saves a calibration.

Sent: **CALSAVE [term]**
Returned: Nothing.
Remarks: The instrument writes calibration data to EEPROM where it is read on power up. A software calibration done without **CALSAVE** is lost when the instrument is turned off. It takes at least two seconds to complete, and **BUSY?** = 1 during the task.

PCAL Sets instrument phase calibration.

Sent: **PCAL XXXX[term]**
Returned: Nothing. Return requires **PCAL?**.
Remarks: Four ASCII digits of serial number specify phase calibration. Default **0000**.

PCAL? Instrument phase calibration setting query.

Sent: **PCAL?[term]**
Returned: XXXX[term].
Remarks: Returns four ASCII digits which indicate phase calibration setting. Default **0000**.

SNUM Sets instrument serial number.

Sent: **SNUM XXXXXX[term]**
Returned: Nothing. Setting return requires **SNUM?**.
Remarks: Six ASCII digits specifies serial number. Default ######.

SNUM? Query instrument serial number.

Sent: **SNUM?[term]**
Returned: XXXXXX[term].
Remarks: Returns six ASCII digits which indicate instrument serial number. Default ######.

ZCAL Auto zero calibrates both X and Y inputs on all ranges.

Sent: **ZCAL X [term]**
Returned: Nothing.
Remarks: One digit (**X**) indicates the channel: **0** = X, **1** = Y. The instrument should have no signal into the EMUX or EMUY input before sending this command. It takes at least ten seconds to complete, and **BUSY?** = 1 during the task. Send **CALSAVE** to permanently store the calibration.

CHAPTER 6

MODEL 704 REMOTE MOTION CONTROL

6.1 GENERAL

This chapter covers Model 704 Remote Motion Control Hardware (Paragraph 6.2), RS-232 Commands (Paragraph 6.3) and Automatic Valve Control (Paragraph 6.4).

6.2 HARDWARE

The enclosure and input configuration of this instrument is similar to other Lake Shore instruments used in the Model 9300 VSM System. It is shipped mounted in the instrument console and with the proper fuse installed for the local voltage requirement. Please refer to the label on instrument console for the exact power settings. Follow all the safety instruction in Chapter 2 for operate this instrument.

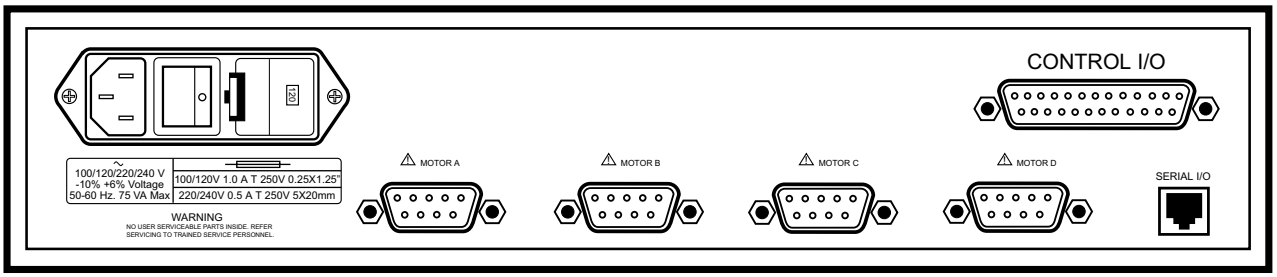
6.2.1 Fuse Requirement

Use a 1.0 A fuse for 100/120 V 50/60 Hz. operation and a 0.5 A fuse for 220/240 V 50/60 Hz operation.

CAUTION: Always disconnect the power cord from the source before changing the fuse.

6.2.2 Output and Wiring information

There are four DB-9 connectors on the back panel of the instrument to connect up to four stepping motors. (See Figure 6-1.) However only one motor can be energized at any one time. Pins 5 and 9, and 3 and 8 provide power to the motor winding pairs. Maximum power output to the windings are 2.5 A at 26 V.

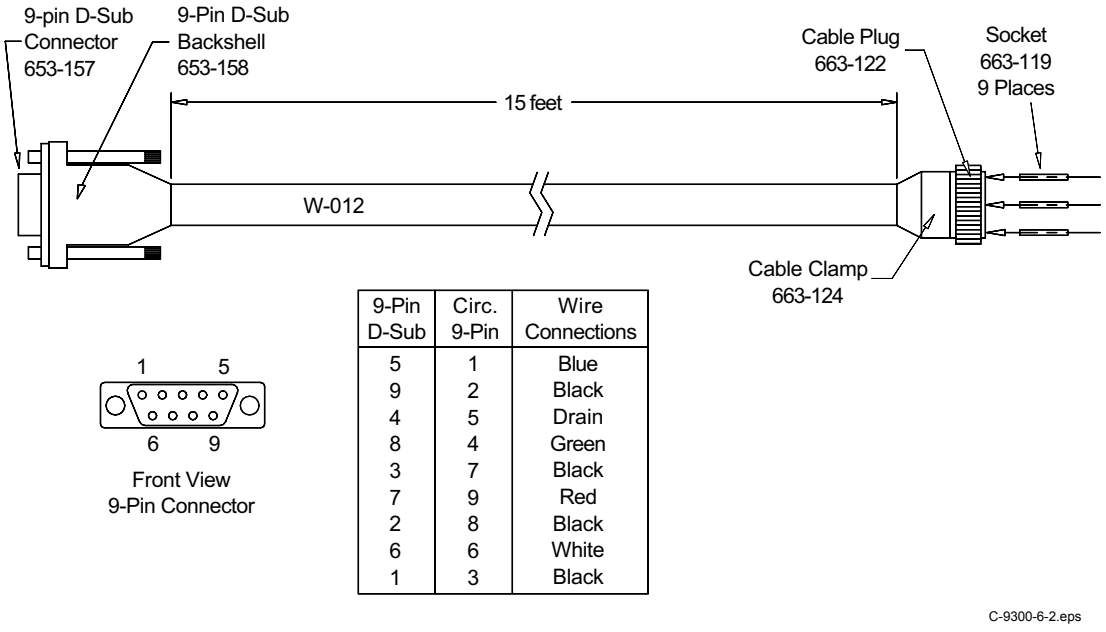


F-9300-6-1.eps

Figure 6-1. Model 704 Rear Panel

Table 6-1. Model 704 Wiring Information

Motor		Limit Switch					
663-121 (X or Y)	653-414 (Z or Rotation)	Mechanical	Optical	Cable (W-017)	9-Pin Circle Connector	Cable-4 pr. (W-012)	DB-9
green/orange	white				1	blue	5
white/brown	green				2	black	9
drain (shield)	drain				5	drain	4
yellow/black	black				4	green	8
red/blue	red				7	black	3
		high	high	black	9	red	7
	(short blue/yellow)	low	low	white	8	black	2
		—	+5 V	black	6	white	6
	(short orange/brown)	ground	G1	red	3	black	1



9-Pin D-Sub	Circ. 9-Pin	Wire Connections
5	1	Blue
9	2	Black
4	5	Drain
8	4	Green
3	7	Black
7	9	Red
2	8	Black
6	6	White
1	3	Black

Figure 6-2. Model 704 Cable Assembly

6.3 MODEL 704 MOTION CONTROLLER RS-232 COMMANDS

6.3.1 Communication Via RS-232 and Hyperterminal

To open a connection with the Model 704 directly, click **Start > Programs > Accessories > Hyperterminal** on the Windows 95 Taskbar. Then double click the Model 704 icon. After the terminal window appears, press the spacebar twice to receive a # sign response. Terminal settings are Com Port 1, 9600 baud, 8 bits, 1 stop bit, no parity.

Command List	
ESC	**Abort/Terminate**
@	**Soft Stop**
Ann	**Motor Selection:** **A0** = Motor A **A16** = Motor B **A8** = Motor C **A24** = Motor D
A129	**Read Input/Output Status:** Response = the sum of the following: **DATA:** **CAUSE:** 1 High input on Port 1 2 High input on Port 2 4 High input on Port 3 8 Output 1 ON 16 Output 2 ON 32 High if moving 64 Trip Point passed 128 Direction Level: High if "-"
Enn	**Motor On/Off:** **E0** = motor phases off **E12** = motor phases on, limit switches enabled
Innnn	**Initial Velocity** (steps/second)
Knnnn	**Ramp Slope** (**0** = no ramp, larger numbers mean slower ramps)
M	**Move** at constant speed
Onnnn	**Set Origin:** Set current position to nn, **O0** sets current position = 0
S	**Store** parameters as defaults
T	**Trip Point** (not used)
+nnnn	**Positive Step:** move nnnn steps in the positive direction
-nnnn	**Negative Step:** move nnnn steps in the negative direction
Vnnnn	**Slew Velocity** (steps/second)
Wnnnn	**Wait** nnnn milliseconds
X	**Examine Parameters** (format: K=kk, I=ii, V=vv, T=tt)
Z	**Display Position**

6.3.2 Normal Initial Setup

To restore the Model 704 to its correct initial state before running the IDEAS 4-Axis software, power-up the controller, start the Model 704 Hyperterminal session, then type the following commands (terminate lines with carriage returns, *italics indicates response*):

<spacebar>	#
E0	
A16	
V100	
I400	
K8	
O0	
E12	
X	*K=8, I=400, V=100, T=0*
Z	*0*
+10	*Motor moves 10 steps in positive direction*
Z	*10*
-10	*Motor moves 10 steps in negative direction*
Z	*0*

6.3.3 Sample of Typical Operation

E0		*turn motor phases off*
A0		*switch to channel A*
E12		*turn motor phases on*
O0		*set current location to 0*
V1000		*set velocity to 1000(for channel A)*
K8		*set ramp to 8*
+1000		*move 1000 steps in the positive direction*
A129		*check limits*
	3	*indicates Channel A selection and both limit inputs are high, or inactive (0 + 2 + 1 = 3)*
Z		*request current position*
	1000	*response*
E0		*turn motor phases off*
A16		*change to channel B*
E12		*turn motor phases on*
O0		*set current location to 0*
V400		*set velocity to 400*
K4		*set ramp to 4 (a faster acceleration than K = 8)*
-550		*move 550 steps in the negative direction*
A129		*check limits*
	18	*indicates channel B selection and low limit activation (16 + 2 + 0 = 18)*
Z		*request current position*
	-327	*response (current position = -327, indicates where limit switch tripped)*
W2000		*wait 2 seconds*
E0		*turn motor phases off*
A0		*switch to channel A*
E12		*turn motor phases on*
O1000		*set current position to 1000 (= position of channel A)*
V1000		*set velocity to 1000 (= velocity for channel A)*
K8		*set ramp to 8 (= ramp for channel A)*
+500		*move 500 steps in the positive direction*
A129		*check limits*
	3	*indicates Channel A selection and both limit inputs are high, or inactive (0 + 2 + 1 = 3)*
Z		*request position*
	1500	*response*

Notes:

1. Always turn off motor phases before switching channels to avoid damaging motor windings and switching relays.
2. Keep track of the position of each channel and reset the position (along with velocity, acceleration, initial velocity, etc.) each time you change channels.
3. Activate limit switches for channel X by bringing inputs X1 or X2 to ground (g1). Limits are active only for the currently selected channel. A +5V output is provided so that optical or other logic-based limit detectors can be used as well as a simple switch. Input X1 is the negative limit for channel X, while input X2 is the positive. If a limit input is brought low, the motor stops moving and holds at the current position. Check status of limit switches with the A129 command. If the limit inputs are both high, then the least significant bits of the response to A129 will be ones. (i.e., 3, 7, 19, etc., depending on the status of the more significant bits.) If the low limit is activated, then the one's bit = 0 (i.e., 2, 6, 18, etc.) If the high limit is activated, then the two's bit = 0 (i.e., 1, 5, 17, etc.). These are easy to check from a programming standpoint with bit arithmetic.

6.4 AUTOMATIC VALVE CONTROL

The Model 9300 flow cryostat is equipped with automatic valve control for both the flow control (needle) valve and the sample space evacuation (solenoid) valves. Communication codes are described in Paragraph 6.3.

6.4.1 Flow Control Valve

Proper operation of the flow control valve depends on correctly initializing the valve controller. The following procedure explains how to initialize the flow control valve.

1. Power up the system and start the Virtual Temperature Control software. (This can be started directly or by starting the IDEAS VSM experiment.)
2. Click the **FourAxis** button on the Windows task bar to bring up the Motion Controller software.
3. Select the **Front Panel** menu.
4. Be sure that Motor 2 is active. Click the **Motor Off** radio button.
5. Manually tighten the needle valve as far as possible. The valve stem turns clockwise to tighten, but the motor shaft turns counter-clockwise.
6. Click the **Motor On** radio button.
7. Click inside the **Move To** edit box and type -20. Then click on the **Move** button.
8. Click the **Set Origin** button. The current position should read **0**.
9. Close the front panel and minimize, but do not exit, the FourAxis software.

NOTE: The Model 704 motion controller remembers its current position as long as it remains powered up. It should not be necessary to repeat this procedure unless the power is switched off. Upon power-up, the Model 704 starts up with its current position set to 0. Simply returning the flow control valve to 0 before powering down preserves the current setting.

Set the flow control valve position directly through either the FourAxis or the Virtual 340 front panel. In the latter case, type the desired setting into the **Flow Valve** edit box, followed by the **Tab** key. Valve settings are given in steps; there are 400 steps per valve stem rotation.

The Virtual 340 software uses the **Domains** settings for automatic control over the flow control valve settings. Each temperature domain has two fields for entering flow control valve positions: **During Ramp** and **After Ramp**. The **During Ramp** setting controls the valve position while the temperature setpoint is changing during a temperature ramp and until the first wait time has elapsed. The **After Ramp** setting controls the valve setting after the first wait time has elapsed. Access temperature domains using the **Utilities > Enter Domain Information** menu item in the Virtual 340 software.

NOTE: Temperature domains are either ascending or descending. The starting temperature of a descending domain is higher than its ending temperature, and *vice versa* for an ascending domain. It is common in a descending domain to open the flow control valve wide during the ramp, and then open it only slightly after the ramp. It is also common to open the solenoid valve during a descending ramp and close it afterward. This allows rapid cool-down followed by temperature control with minimal power and helium consumption.

6.4.2 Sample Space Evacuation Valve

The sample space needs to be evacuated to facilitate rapid cool-down and to reach temperatures below 4.2 K. The space is evacuated by opening a relay-controlled solenoid valve using either the IDEAS340 or Virtual 340 software.

IDEAS 340: To toggle the position of the solenoid valve from the IDEAS340 software, click the valve button on the toolbar. Also access the two Model 340 relays through the **Utilities->Relay Settings** menu item. The **Low Relay** controls the solenoid; the **High Relay** is unassigned.

VIRTUAL 340: Control the solenoid valve from the Virtual 340 front panel by clicking the **Sample Space Valve** radio buttons: **Open**, **Closed**, and **Auto**. The **Auto** setting allows the valve to be controlled automatically through the temperature domains. As with the flow control valve, the sample space valve has two settings for each domain, one for during and after a ramp.

CHAPTER 7

OPTIONS

7.1 VECTOR OPTION

In reference to the Vector Option pick-up coil set, the x-axis measures the magnetic moment parallel to the applied magnet field and the y-axis measures the magnetic moment perpendicular to to the applied magnet field. The 735 VSM Controller can obtain both x- and y-axis magnetic moment measurements simultaneously. For cryogenic systems, the Vector option is available only for transverse field magnets.

7.1.1 Calibration

Y-axis coils calibration uses X-axis coils calibration as a reference. Calibrate Y-axis coils with a permanent magnet at an applied field of zero gauss. First, measure the magnetic moment of a permanent magnet with the X-axis coils. Rotate the permanent magnet 90° to produce a positive moment in the Y-axis coils (see VSM Reference Frame, Figure 7-1). Adjust the Y-axis coil moment reading to equal the X-axis coil moment reading.

NOTE: The magnetization axis of the permanent magnet rotates **–90°** according to the rotation index on the VSM drive head. Proper calibration requires the sample saddled after rotation. For the Y-axis coils, the minimum and maximum emu outputs required to saddle the sample interchange. The x-direction saddle is now a maximum emu output and the y-direction saddle is a minimum emu output.

After obtaining the new saddle point, allow the software to measure the Y-axis emu value and determine a calibration constant. This calibration constant is stored until a new calibration is performed.

7.2 ROTATION OPTION

The Rotation Option varies sample orientation relative to the direction of applied magnetic field. The angle of rotation is within a single plane defined by the direction of applied magnetic field, called the x-axis, and perpendicular to the direction of vibration, called the z-axis (see Figure 7-1). A stepping motor on the VSM drive head controls the motion. Two limit switches determine HOME and END positions of rotation. All stepping motor controller communication is through the RS-232 serial interface to the PC.

Find more information about the stepping motor, its drive, and the interface software in the VSM Software User's Manual.

7.2.1 Installation (see Figure 7-1)

1. Remove mechanical drive from its box and set it on the bench with its electrical connectors to your left.

   CAUTION: The gear that runs around the bottom of the VSM head has a small 1/16 inch diameter pin protruding from the bottom of it. This pin signals the limit switch that it has reached its limit of travel. Handle the VSM head carefully to avoid damaging this pin.

2. If the large gear is not already installed on the mechanical drive cover, remove the cover and replace the decorative black ring with the gear. Position the gear so its mounting holes line up with the holes in the cover and the pin points downward. The gear should fit tight against the cover. Draw the gear onto the cover with the long mounting screws. After the gear seats, replace the mounting screws with the proper cap screws. Thread the screws gradually and evenly. Re-install the cover. The pin should be on the right side with the drive positioned at zero degrees.
3. Install the limit switch to the right side of the cover base with two #4-40 screws. Install the switch with the cable exiting at the bottom.
4. Install the stepper motor bracket to the bottom of the mechanical drive with the two hex bolts. Visually line up the two gears. Adjust the gear on the motor shaft so the teeth are at the same level as the larger gear. Tighten the set screws at the gear.
5. Install the timing belt over the pulleys. Rotate the cover 90 degrees to seat the belt in the gear teeth. Move motor bracket outward with one hand while tightening mounting screws. Use hand force only.
6. Install metal belt shroud.
7. The cables to the both the limit switch and the stepper motor merge into a single connector. Plug it into the Model 704 Motor D output.

If the Rotation Option shipped with the VSM System, the correct software is already installed in the computer and automatically detects the presence of the stepping motor drive when the program starts.

If the Rotation Option shipped after receipt of the VSM System, install the proper PC operation software before using the option. Follow the instructions included with the software to install the program.

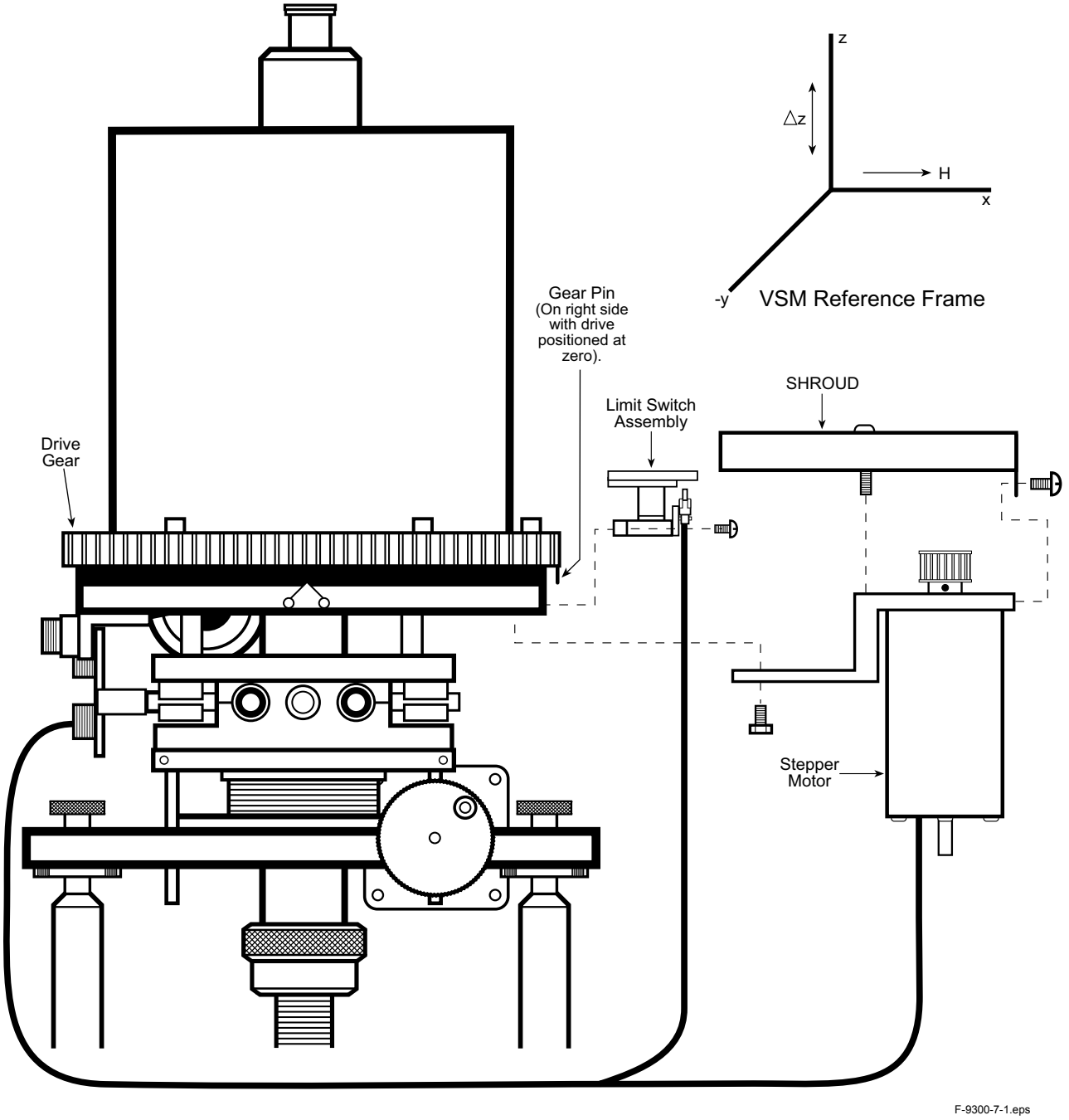


Figure 7-1. Rotation Option Installation

7.3 HIGH TEMPERATURE VSM INSERT OPTION

The High Temperature insert option allows the Model 9300 to investigate magnetic properties of materials over a temperature range from near absolute zero to 700 °C.

This convenient, high-efficiency accessory made of non-magnetic materials; similar to a standard VSM insert. The sample-zone temperature range extends to 700 °C and it requires only 61 watts to maintain this temperature. Even at the highest operating temperature, outer case temperature is maintained <130 °C at the hottest spot. The inner sample-zone chamber is lined with stainless steel for easy cleaning. The sample holder consists of a quartz tube extension attached to a boron-nitride sample cup.

The High Temperature insert installs in the 9300 similarly to a standard insert. However, a vacuum pump-out port replaces the standard 10-pin connector for the Model 340.

To exclude atmospheric oxygen which may react with the sample, either evacuate the sample zone or fill it with an inert gas. Magnetically observe oxidation/reduction reactions by back-filling with appropriate gas mixtures. A chromel-alumel thermocouple facilitates temperature measurement and control.

The High Temperature insert is perfect for measuring Curie temperatures of materials up to 700 °C. The inherent sensitivity of the 9300 Magnetometer determines Curie temperature at relatively low field intensities. The steeper change in magnetic moment significantly increases accuracy.

7.3.1 Specifications

FUNCTION: Extends Model 9300 VSM temperature range. Obtains controlled sample-zone temperatures to 700 °C.

INSTALLATION: Replaces standard VSM insert. No Model 9300 modification necessary.

HEATER: Integral 20 Ω (±20%) heater coil.

POWER REQUIREMENTS: 0 to 2.0 A (max) of well-filtered DC. Sustain maximum rated temperature with nominal 61 watts. Never exceed 80 watts maximum power.

TEMPERATURE MEASUREMENT AND CONTROL: Internal chromel-alumel thermocouple senses heater temperature. Thermocouple output cables to Model 340 for convenient automatic temperature monitoring.

SAMPLE ENVIRONMENT: Evacuate the sample zone or fill it with gas appropriate to the experiment.

7.3.2 Storage

Store the insert in any position, but preferably in an upright position supported by an insert holder.

7.3.3 Sample Holder Cleaning

To assure measurement accuracy, keep sample-holder parts free of contamination. High temperatures produced by the High Temperature insert tend to compound contamination. Fortunately, boron-nitride is a relatively inert material. Use a strong cleaning solution without fear of damage to sample holder parts. In most instances, a solution of 50% concentrated hydrochloric acid and 50% concentrated nitric acid suffices.

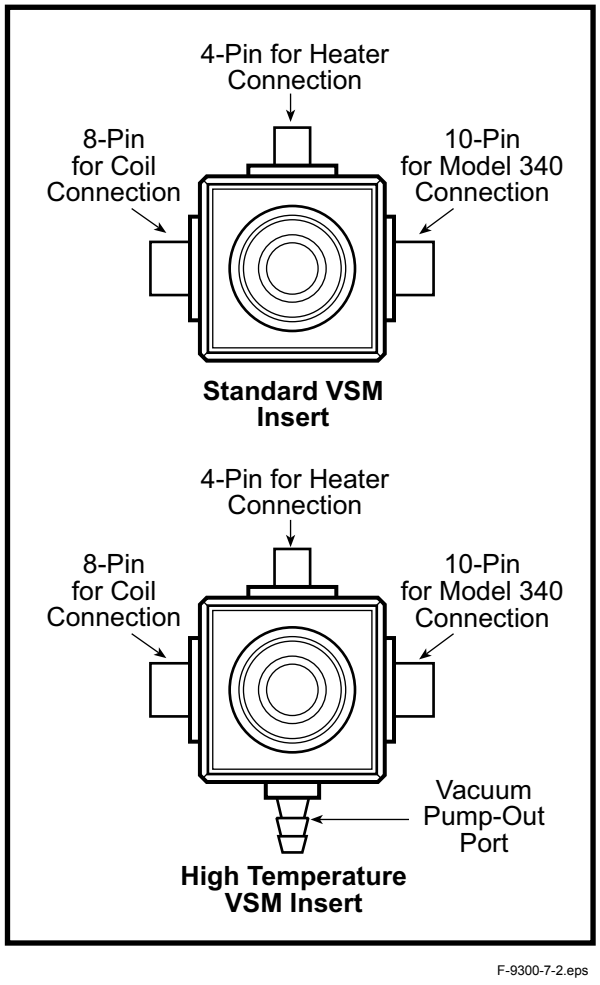


Figure 7-2. Top View of Standard and High Temperature VSM Inserts

APPENDIX A

EMU TO CGS TRANSLATION

Though the EMU is the output unit of the VSM, many areas of study rely on units of measurement other than EMU. The world is slowly adopting the International System of Units (SI), but most existing literature uses the Gaussian System of Units (CGS). To avoid unnecessary complications, this section uses CGS almost exclusively. Refer to a general physics reference text for CGS to SI translation. This section details how to translate EMU to CGS in regard to two general areas: Ferromagnetic Materials, and Paramagnetic and Diamagnetic Materials.

A.1 FERROMAGNETIC MATERIALS

Ferromagnetism is a property of materials with an abnormally high magnetic permeability, a definite saturation point, appreciable residual magnetism, and hysteresis. Properties characteristic of ferromagnets include magnetization and induction, permeability, coercivity, and Curie point. The latter three are not directly related to the EMU, but may be determined with a VSM.

The VSM measures the total magnetic moment, m, of a sample in emu. Using the definition of the emu, this result relates to sample magnetization:

$$1 \text{ emu} = 1 \text{ Gauss} \bullet \text{cm}^3 \quad (1)$$

To determine magnetization, M, divide the sample moment, m, by the sample volume, V:

$$M(\text{Gauss}) = m(\text{emu} = \text{Gauss} \bullet \text{cm}^3) \div V(\text{cm}^3) \quad (2)$$

Also express magnetization in terms of the magnetic moment per gram, denoted σ. To calculate σ, divide the sample moment, m, by the sample mass:

$$\sigma(\text{emu/g}) = m(\text{emu}) \div \text{mass(g)} \quad (3)$$

M and σ are related by the sample density, ρ:

$$M(\text{Gauss}) = \sigma(\text{emu/g}) \bullet \rho(\text{g/cm}^3) \quad (4)$$

The magnetic moment per gram is normally handier to use than the magnetization, since it is easier to weigh a sample than to measure its volume. When converting to magnetization via Equation 4, remember that density is generally temperature dependent.

The magnetic induction, B, is defined in terms of the applied field, H, and the magnetization, M:

$$B(\text{Gauss}) = H(\text{Oersted}) + 4^1M(\text{Gauss}) \quad (5)$$

where 1 Gauss = 1 Oersted in vacuum. The quantity (B-H) is known as the intrinsic induction, and this quantity reaches a maximum value, called the saturation induction, B_s, as the field H increases.

$$\lim_{H\rightarrow}(B\text{-}H) = B_s(\text{Gauss}) \quad (6)$$

Likewise, magnetization M reaches a limiting value, the saturation magnetization, M_s, as the field increases; since B, H, and M are related by Equation 5, then using Equation 6:

$$B_s = 4^1M_s(\text{Gauss}) \quad (7)$$

The magnetic moment per gram, σ, also reaches a saturation value as the field increases:

$$\sigma_s(\text{emu/g}) = M_s(\text{Gauss}) \div \rho(\text{g/cm}^3) \quad (8)$$

EXAMPLE 1: Nickel exhibits the properties below at 20 °C.

Density: 8.90 g/cm^3
Saturation Magnetization M: 484.1 Gauss

The VSM comes with a nickel sample that weighs about 0.09 gm. What reading on the VSM would this sample give when saturated?

First, using Equation 8,

σ_s = (484.1/8.9) = 54.4(emu/g)

Then, using Equation 3,

m = (54.4 • 0.09) = 4.9 emu

EXAMPLE 2: A thin film of ferromagnetic material on a circular aluminum substrate is determined to have a saturation moment of 2.56 • 10^{-2} (see Figure 1-2). The sample size is 1/4-inch diameter by 0.05 mil thick. What is the saturation magnetization, M_s, and saturation induction, B_s? (neglect the magnetic properties of the aluminum—see Example 4).

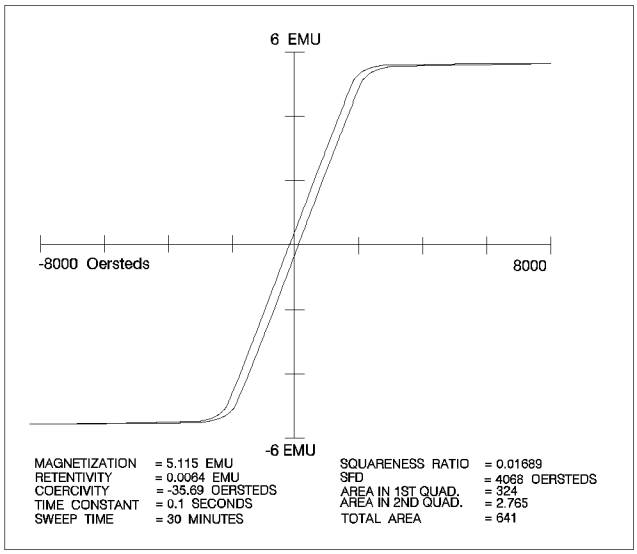


Figure A-1 **Saturation Behavior of Nickel**

First, convert the dimensions to cgs units: 1/4 in. = 0.635 cm; 0.05 mil = 1.27 • 10^{-4} cm.

Then calculate the sample volume: V = $^1d^2t/4$ = 4.0 • 10^{-5} cm^3

Equation 2 give the magnetization: M_s = m/V = (2.56 • 10^{-2})/(4.0 • 10^{-5}) emu/cm^3 = 640 Gauss,

and Equation 7 gives the induction: $B_S = 4^1M_S = 4^1640$ = 8040 Gauss

The translation between Bohr magnetons, ß, per atom to emu and vice versa involves more steps, but it is a straightforward calculation involving keeping track of units. The units for ß are (erg/Gauss), but:

$$1 \text{ (erg/Gauss)} = 1 \text{ emu} \quad (9)$$

and:

$$1 \text{ ß} = 0.9274 \cdot 10^{-20} \text{ erg/Gauss} = 0.9274 \cdot 10^{-20} \text{ emu} \quad (10)$$

The sensitivity of the VSM is quoted as 5 • 10^{-5} emu; it may also be quoted in terms of the Bohr magneton:

$$5 \cdot 10^{-5} \text{ emu} = 5.4 \cdot 10^{15} \text{ ß} \quad (11)$$

EXAMPLE 3: The ferromagnetic material γ-Fe_2O_3 has a reported saturation magnetization of 1.25 ß/Fe atom. What is the saturation moment of a piece of tape 1/4 inch square with a 0.05 mil coat of Fe_2O_3?

γ-Fe_2O_3 has the following physical properties:

Molecular Weight: 159.7(g/mole)
Density: 3.7(g/cm^3)

First, convert the dimensions to cgs units:

1/4 in. = 0.635 cm
0.05 mil = $1.27 \cdot 10^{-4}$ cm

Then, calculate the volume of the sample:

$V = 1^2t = 5.12 \cdot 10^{-5}$ cm^3

Next, determine the mass:

mass = $\rho v = (4.7)\ (5.12 \cdot 10^{-5})$ g = $2.4 \cdot 10^{-4}$ g

Calculate the number of Fe atoms. There are two atoms per molecule and Avogadro's number is $6.02 \cdot 10^{23}$ $mole^{-1}$.

$2.4 \cdot 10^{-4}$ g = $1.8 \cdot 10^{18}$ Fe atoms

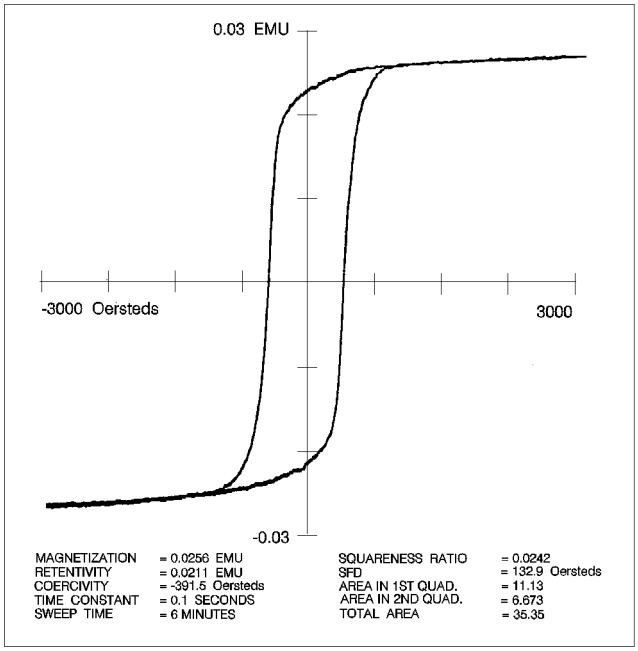


Figure A-2 Thin-Film Saturation Behavior

Finally, calculate the moment:

$(1.8 \cdot 10^{18}$ Fe atoms$)(1.25$ ß/Fe atom$) \cdot (0.927 \cdot 10^{-20}$ emu/ß$) = 2.1 \cdot 10^{-2}$ emu

Thus the sample will have a saturation moment of 0.021 emu, well within the sensitivity of the VSM.

Two other quantities often seen in the literature are M_O and σ_O. These are the values of M_S and σ_S at 0 K. They may be manipulated using the same relationships that are used for M and σ. Permeability, μ, is the ratio of the induction, B to the field H:

$$\mu = B/H \qquad (12)$$

The coercivity is the field strength required to reduce the magnetization, or induction, to zero once the sample is saturated. In Figure 1-2, the coercivity as shown on the moment vs. field (m vs H) plot is -390 Oersted. The Curie (or Ne'el) point is the temperature at which a material ceases to be ferromagnetic (or anti-ferromagnetic) and becomes paramagnetic.

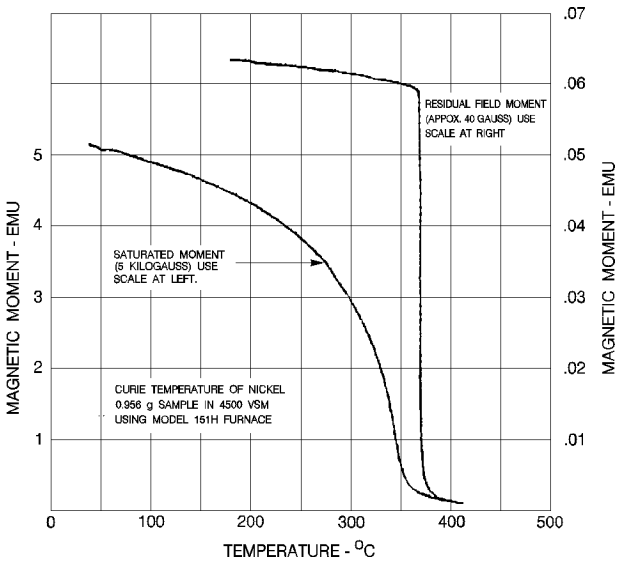


Figure A-3 Curie Point of Nickel

A.2 PARAMAGNETISM AND DIAMAGNETISM

Paramagnetic material is slightly more permeable than a vacuum and has a moment parallel to and proportional to the magnitude of the applied magnetic field. Diamagnetic material is slightly less permeable than a vacuum. The parameter most often encountered in paramagnetism and diamagnetism is susceptibility. However, since there are several types of susceptibility, it is easy to become confused unless the particular type is specified.

The VSM reports the total magnetic moment, m, of a sample in emu. This moment can be converted to susceptibility units through the equation 1 emu = 1 Gauss • cm^3. The susceptibility of a sample has units of volume and is defined for paramagnetic material by the equation:

$$\chi(cm^3) = m(emu = Gauss \cdot cm^3) \div H(Oersted) \qquad (13)$$

VSM sensitivity is $5 \cdot 10^{-5}$ emu. For a field of 50 kOe, this corresponds to a susceptibility change of:

$$\Delta\chi = \Delta m/H = 5 \cdot 10^{-5} \text{ emu} \div 5 \cdot 10^{-4} \text{ Gauss } \Delta\chi = 1 \cdot 10^{-9} \text{ cm}^3 \qquad (14)$$

Other types of susceptibility include gram (specific), molar (atomic), and volume:

Gram (Specific) Susceptibility: $\chi g = \chi/\text{mass}$ (15)
(Units: cm^3/gram)

Molar (Atomic) Susceptibility: $\chi m = (\chi g) \cdot (\text{Mol wt})$ (16)
(Units: cm^3/gram)

Volume susceptibility: $\chi^v = (\chi/V)$ (17)
(Units: dimensionless)

EXAMPLE 4: The aluminum substrate in example 2 was 2 mm thick and the sample weighed 0.21 g. If the saturation moment of the sample, $2.56 \cdot 10^{-2}$ emu, was measured at 10 kOe, what was the contribution of the Aluminum?

The listed specific susceptibility of Al at 20 °C is:

$\chi g = 0.65 \cdot 10^{-6}$ cm^3/g
(Aluminum is paramagnetic; see Figure 1-4)

The moment then is:

$m = (0.65 \cdot 10^{-6} \text{ cm}^3/\text{g} \cdot (2.1 \cdot 10^{-1})\text{g} \cdot (10^4 \text{ Oe}) = 1.4 \cdot 10^{-3}$ emu,

or about 5% of the sample moment including the film.

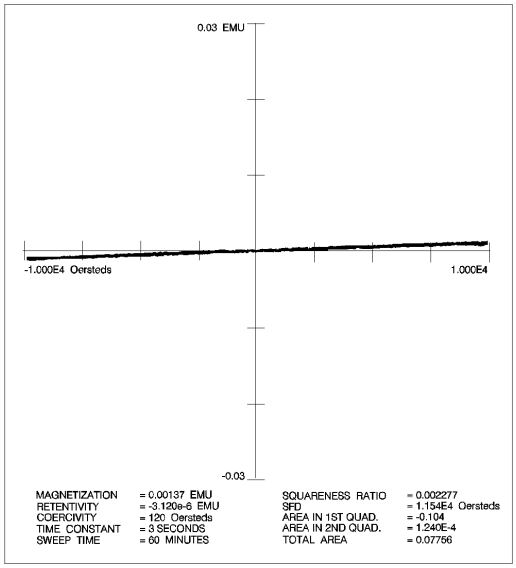


Figure A-4
Moment vs Field Plot of Aluminum

Table A-1 Ferromagnetic Terms and Relations

1 emu = 1 Gauss • cm^3 = 1 erg/Gauss

Magnetization: M(Gauss) = moment m(emu) ÷ volume V (cm^3)

Magnetic moment per gram: σ = moment(emu)/mass(g)

Induction: B(Gauss) = Field H + 4^1M

Saturation Induction: $(B\text{-}H) = B_s(\text{Gauss})$ as $H \rightarrow$

Saturation Magnetization: $M_s = B_s/4^1$(Gauss)

$\mathbf{M_O}$ = saturation magnetization at 0 K

$\boldsymbol{\sigma_O}$ = saturation magnetic moment per gram at 0 K

1 Bohr magneton = $0.9274 \cdot 10^{-20}$ emu

Notes: 1. VSM measures m = sample total magnetic moment.
2. VSM output is in emu.

APPENDIX B

SAMPLE HOLDERS

B.1 GENERAL

This section describes thin film (Paragraph B.2) and capsule (Paragraph B.3) sample holders.

B.2 THIN FILM SAMPLE HOLDERS

Three each of two different thin film sample holders come with the Model 9300:

1. Side-Mount Thin Film Sample Holder.
2. Bottom-Mount Thin Film Sample Holder.

The side-mount sample holder mounts the sample perpendicular to the field. The bottom-mount mounts the sample parallel to the field. Suggested adhesives to mount sample films to the holders include:

1. TACKIWAX® by CSC Scientific Co., Inc.
2. Beeswax.
3. Duco® Cement by E.I. DuPont de Nemours.
4. Double-coated Scotch® tape by 3M.

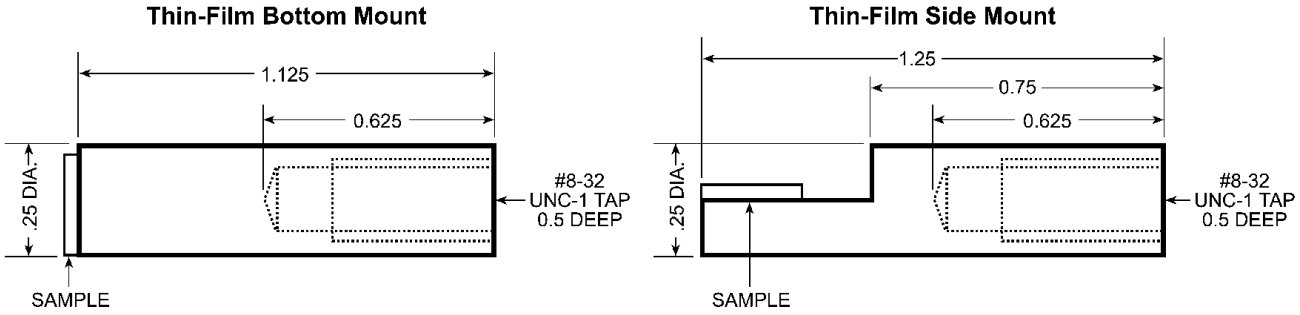


Figure B-1 Thin-Film Sample Holders

B.3 POSITIONING A SAMPLE WITH BOTTOM MOUNT SAMPLE CUPS

When measuring samples parallel to the magnetic field, it is advantageous to use bottom mount cups, because sample orientation is not critical. When measuring samples with weak signals (<.005 emu) bottom mount cups allow positioning before the sample is inserted. **NOTE:** For samples with larger signals (>.005 emu), use the normal method to position the sample.

1. Turn on the VSM hardware and software using the standard procedure.
2. Place an empty bottom mount cup onto the extension piece and mount it between the pick-up coils. Visually center the cup in the x and y direction.
3. Set a large field (6000 Oe) in the magnet with the **Set Field** function in the software.
4. Open the IDEAS735 Momentmeter. Turn the head drive ON and monitor the emu signal.
5. Adjust the z-axis until the moment signal reads zero.
6. Remove the sample cup and mount the sample.
7. Re-install the cup and re-adjust the z-axis upwards a distance of half of the sample thickness.
8. Remove the magnetic field.
9. Follow the normal steps for taking a measurement with the software.

For further assistance please contact the Systems Service department at Lake Shore Cryotronics, Inc. Phone: (614) 891-2243 • Fax: (614) 891-1392

B.3 CAPSULE SAMPLE HOLDERS

Two different capsule sample holders come with the Model 9300. They are:

1. Holder for #3 Capsule
2. Holder for #4 Capsule

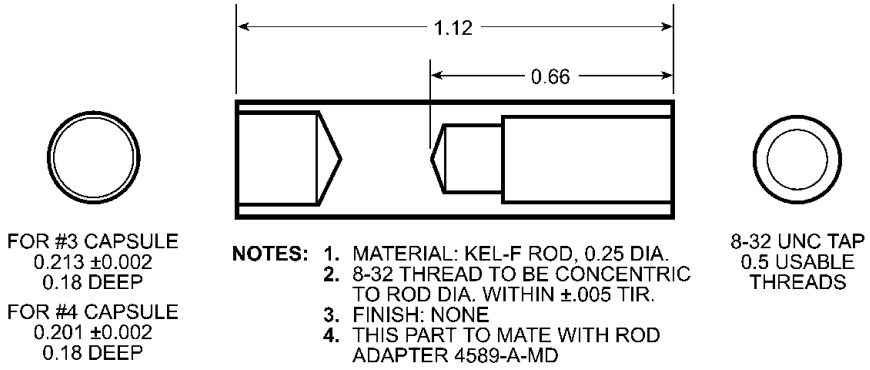


Figure B-2 Capsule Sample Holders

APPENDIX C

WIRING TABLES

Table C-1 Standard VSM Insert Pinouts

ITEM	LEADS	10-PIN CONNECTOR	8-PIN CONNECTOR	4-PIN CONNECTOR	FLAT CABLE TERMINAL
Coils	TB (red)		D		1
	TE, BE (blue, green)		C		2, 3
	BB (clear)		B		4
Heater (A)	50 Ω (+) 32 AWG	D			
	50 Ω (-) 32 AWG	E			
Heater (B)	100 Ω (+) 40 AWG			A	5
	100 Ω (-) 40 AWG			B	6
Temperature Sensor (B)	V- (red)	A			7
	V+ (green)	B			8
	I+ (blue)	J			9
	I- (clear)	C			10
Control Sensor (A)	V- (red)	G			
	V+ (green)	H			
	I+ (blue)	K			
	I- (clear)	F			

Table C-2 Transverse VSM Signal Cable Pinouts (X & Y)

8-PIN CONNECTOR	COLOR	5-PIN CONNECTOR	COIL
B	Black	2	X
C	Shield	3	
D	White w/Black	4	
E	Black	2	Y
F	Shield	3	
G	White w/Black	4	

Table C-3 Model 241 Cable Pinouts

4-PIN CONNECTOR	SIGNAL	9-PIN CONNECTOR
A	I+	9
B	I-	6
C	V-	7
D	V+	8

Table C-4 Solenoid Valve Cable Pinouts

FUNCTION	COLOR	6-PIN CONNECTOR
0	Black	C
24 VAC	Red	NO

Table C-5 Flow Cryostat Needle Valve Stepper Motor Cable Pinouts

FUNCTION	COLOR	9-PIN CONNECTOR
Coil 1	White	d1
Coil 2	Black (2)	d2
Coil 3	Red	d3
Coil 4	Black (1)	d4
Shield		g2

Table C-6 MPS External Programming Adaptor Pinouts

BNC	FUNCTION	COLOR	18-PIN CONNECTOR
Center	Program	Red	15
Shield	IN	Black	11
Shield	Monitor	Black	11
Center	OUT	Red	9

Table C-7 Model 735 Drive Cable Pinouts

SIGNAL	PIN	COLOR
Ground	1	Brown
Drive Ret	2	White w/Black
Drive Out	3	Black
Shield	4	Shield

Table C-8 Model 735 Feedback Cable Pinouts

SIGNAL	PIN	COLOR
Ground	1	Brown
+15 V	2	Black
-15 V	3	White w/Black
Shield	4	Shield

APPENDIX D

ASCII CHARACTER CODES

Table C-1 Control Character Alternate Code Names

CHARACTER	MEANING
NUL	NULL, CTRL SHIFT P, TAPE LEADER
SOH	START OF HEADER, SOM
STX	START OF TEXT, EOA
ETX	ENX OF TEXT, EOM
EOT	END OF TRANSMISSION, END
ENQ	ENQUIRY, WRU, WHO ARE YOU
ACK	ACKNOWLEDGE, RU, ARE YOU
BEL	BELL
BS	BACKSPACE, FE0
HT	HORIZONTAL TAB, TAB
LF	LINE FEED, NEW LINE, NL
VT	VERTICAL TAB, VTAB
FF	FORM FEED, FORM, PAGE
CR	CARRIAGE RETURN, EOL
SO	SHIFT OUT, RED SHIFT
SI	SHIFT IN, BLACK SHIFT
DLE	DATA LINK ESCAPE, DC0
DC1	XON, READER ON
DC2	TAPE, PUNCH ON
DC3	XOFF, READER OFF
DC4	TAPE, PUNCH OFF
NAK	NEGATIVE ACKNOWLEDGE, ERR
SYN	SYNCHRONOUS IDLE, SYNC
ETB	END OF TEXT BUFFER, LEM
CAN	CANCEL, CANCL
EM	END OF MEDIUM
SUB	SUBSTITUTE
ESC	ESCAPE, PREFIX
FS	FILE SEPARATOR
GS	GROUP SEPARATOR
RS	RECORD SEPARATOR
US	UNIT SEPARATOR

BINARY	DEC	HEX	CHAR	TYPE
0000000	0	00	NULL	CONTROL @
0000001	1	01	SOH	CONTROL A
0000010	2	02	STX	CONTROL B
0000011	3	03	ETX	CONTROL C
0000100	4	04	EOT	CONTROL D
0000101	5	05	ENQ	CONTROL E
0000110	6	06	ACK	CONTROL F
0000111	7	07	BEL	CONTROL G
0001000	8	08	BS	CONTROL H
0001001	9	09	HT	CONTROL I
0001010	10	0A	LF	CONTROL J
0001011	11	0B	VT	CONTROL K
0001100	12	0C	FF	CONTROL L
0001101	13	0D	CR	CTRL M/RET
0001110	14	0E	SO	CONTROL N
0001111	15	0F	SI	CONTROL O
0010000	16	10	DLE	CONTROL P
0010001	17	11	DC1	CONTROL Q
0010010	18	12	DC2	CONTROL R
0010011	19	13	DC3	CONTROL S
0010100	20	14	DC4	CONTROL T
0010101	21	15	NAK	CONTROL U
0010110	22	16	SYN	CONTROL V
0010111	23	17	ETB	CONTROL W
0011000	24	18	CAN	CONTROL X
0011001	25	19	EM	CONTROL Y
0011010	26	1A	SUB	CONTROL Z
0011011	27	1B	ESC	ESC
0011100	28	1C	FS	CONTROL \
0011101	29	1D	GS	CONTROL]
0011110	30	1E	RS	CONTROL ^
0011111	31	1F	US	CONTROL _
0100000	32	20	SPACE	SPACE
0100001	33	21	!	!
0100010	34	22	"	"
0100011	35	23	#	#
0100100	36	24	$	$
0100101	37	25	%	%
0100110	38	26	&	&
0100111	39	27	'	'
0101000	40	28	(	(
0101001	41	29	)	)
0101010	42	2A	*	*
0101011	43	2B	+	+
0101100	44	2C	,	,
0101101	45	2D	-	-
0101110	46	2E	.	.
0101111	47	2F	/	/
0110000	48	30	0	0
0110001	49	31	1	1
0110010	50	32	2	2
0110011	51	33	3	3
0110100	52	34	4	4
0110101	53	35	5	5
0110110	54	36	6	6
0110111	55	37	7	7
0111000	56	38	8	8
0111001	57	39	9	9
0111010	58	3A	:	:
0111011	59	3B	;	;
0111100	60	3C	<	<
0111101	61	3D	=	=
0111110	62	3E	>	>
0111111	63	3F	?	?

BINARY	DEC	HEX	CHAR	TYPE
1000000	64	40	@	@
1000001	65	41	A	A
1000010	66	42	B	B
1000011	67	43	C	C
1000100	68	44	D	D
1000101	69	45	E	E
1000110	70	46	F	F
1000111	71	47	G	G
1001000	72	48	H	H
1001001	73	49	I	I
1001010	74	4A	J	J
1001011	75	4B	K	K
1001100	76	4C	L	L
1001101	77	4D	M	M
1001110	78	4E	N	N
1001111	79	4F	O	O
1010000	80	50	P	P
1010001	81	51	Q	Q
1010010	82	52	R	R
1010011	83	53	S	S
1010100	84	54	T	T
1010101	85	55	U	U
1010110	86	56	V	V
1010111	87	57	W	W
1011000	88	58	X	X
1011001	89	59	Y	Y
1011010	90	5A	Z	Z
1011011	91	5B	[	[
1011100	92	5C	\	\
1011101	93	5D	]	]
1011110	94	5E	^	^
1011111	95	5F	_	_
1100000	96	60	`	`
1100001	97	61	a	a
1100010	98	62	b	b
1100011	99	63	c	c
1100100	100	64	d	d
1100101	101	65	e	e
1100110	102	66	f	f
1100111	103	67	g	g
1101000	104	68	h	h
1101001	105	69	i	i
1101010	106	6A	j	j
1101011	107	6B	k	k
1101100	108	6C	l	l
1101101	109	6D	m	m
1101110	110	6E	n	n
1101111	111	6F	o	o
1110000	112	70	p	p
1110001	113	71	q	q
1110010	114	72	r	r
1110011	115	73	s	s
1110100	116	74	t	t
1110101	117	75	u	u
1110110	118	76	v	v
1110111	119	77	w	w
1111000	120	78	x	x
1111001	121	79	y	y
1111010	122	7A	z	z
1111011	123	7B	{	{
1111100	124	7C	|	|
1111101	125	7D	}	}
1111110	126	7E	~	~
1111111	127	7F	RUBOUT	

APPENDIX E

PARAMETER DEFAULT VALUES

PARAMETER	NORMAL INITIALIZATION	COMPLETE INITIALIZATION
EMU Range	10^3	10^3
OER Range	*	10^3
Time	*	5
Peak Field	*	10^3
Max Temp	*	100^3
Min Temp	0	0
Initial Temp	MIN	MIN
Offset	OFF	OFF
Expand	1	1
Sweep Mode	Current	Current
Sample Drive	*	OFF
Time Constant	*	100 ms
GPIB address (F1)	*	9
Max Gauss Range (F2)	*	10^3
Curve Length (F3)	*	1000
Degauss Parameters (F4)	*	.5, .01, 1.2
Fast Mode (F5)	*	0
RS-232 Baud Rate (F6)	*	!9600
RS-232 Stop Bits (F7)	*	!1
RS-232 Echo (F8)	*	!0 (OFF)
RS-232 Parity On/Off (F9)	*	! 0
RS-232 Parity Even/Odd (F10)	*	! 1 (ODD)
RS-232 Word Size 7/8 (F11)	*	! 8
GPIB Test Echo (F12)	*	!0 (OFF)
Terminator CR/CRLF (F13)	*	! 13 (CR)
Step Mode (F14)	*	0, 1, 2, (OFF)
Playback Mode (F15)	*	0
Delimiter	*	! 44 (COMMA)
Service Request Mask	*	!0

* Means that the parameter retains the value in effect at last power down.

! Means that the parameter is not affected by GPIB DEVICE CLEAR or DCL command.

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