MODEL 1700
LIQUID LEVEL INSTRUMENT

(LIQUID NITROGEN VERSION)

INSTALLATION, OPERATION, AND MAINTENANCE INSTRUCTIONS
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Foreword

Purpose and Scope

This manual contains the operation and maintenance instructions for the American Magnetics, Inc. Model 1700 Liquid Level Control Instrument and outlines applications for various system configurations. Since it is not possible to cover all equipment combinations for all magnet systems, only the most common configurations are discussed. The user is encouraged to contact an authorized AMI Technical Support Representative for information regarding specific configurations not explicitly covered in this manual. This manual refers to the instrument as configured for liquid nitrogen operation.

Contents of this Manual

Introduction describes the functions, specifications, and characteristics of the Model 1700 Instrument. It provides illustrations of the front and rear panel layouts as well as documenting the performance specifications. Additional information is provided in the form of system block diagrams.

Installation describes how the Model 1700 Instrument is unpacked and installed in conjunction with ancillary equipment in typical systems. Block-level diagrams document the interconnects for various system configurations.

Operation describes how the Model 1700 Instrument is used to monitor and automatically control liquid nitrogen levels.

Calibration describes the various calibration techniques for liquid nitrogen level sensors.

Remote Interface Reference documents all remote commands and queries available through the Model 1700 Instrument RS-232 and Ethernet interfaces. A quick-reference summary of commands is provided as well as a detailed description of each.

The Appendix and Glossary sections support the information in the sections listed above. See the Appendix section when referenced from other sections. See the Glossary for any words or acronyms presented in the above sections, requiring a more complete understanding.
Cryogen Safety

The two most common cryogenic liquids used in superconducting magnet systems are nitrogen and helium. Both of these cryogens are extremely cold at atmospheric pressure (−321°F and −452°F, respectively). The following paragraphs outline safe handling precautions for these liquids.

Personnel handling cryogenic liquids should be thoroughly instructed and trained as to the nature of the liquids. Training is essential to minimize accidental spilling. Due to the low temperature of these materials, a cryogen spilled on many objects or surfaces may damage the surface or cause the object to shatter, often in an explosive manner.

Inert gases released into a confined or inadequately ventilated space can displace sufficient oxygen to make the local atmosphere incapable of sustaining life. liquefied gases are potentially extreme suffocation hazards since a small amount of liquid will vaporize and yield a very large volume of oxygen-displacing gas. Always ensure the location where the cryogen is used is well ventilated. Breathing air with insufficient oxygen content may cause unconsciousness without warning. If a space is suspect, purge the space completely with air and test before entry. If this is not possible, wear a forced-air respirator and enter only with a co-worker standing by wearing a forced-air respirator.

Cryogenic liquids, due to their extremely low temperatures, will also burn the skin in a similar manner as would hot liquids. Never permit cryogenic liquids to come into contact with the skin or allow liquid nitrogen to soak clothing. Serious burns may result from careless handling. Never touch uninsulated pipes or vessels containing cryogenic liquids. Flesh will stick to extremely cold materials. Even nonmetallic materials are dangerous to touch at low temperatures. The vapors expelled during the venting process are sufficiently cold to burn flesh or freeze optic tissues. Insulated gloves should be used to prevent frost-bite when operating valves on cryogenic tanks. Be cautious with valves on cryogenic systems; the temperature extremes they are typically subjected to cause seals to fail frequently.

In the event a person is burned by a cryogen or material cooled to cryogenic temperatures, the following first aid treatment should be given pending the arrival and treatment of a physician or other medical care worker:

1. If any cryogenic liquid contacts the skin or eyes, immediately flush the affected area gently with tepid water (102°F – 105°F, 38.9°C – 40.5°C) and then apply cold compresses.
2. Do not apply heat. Loosen any clothing that may restrict circulation. Apply a sterile protective dressing to the affected area.

3. If the skin is blistered or there is any chance that the eyes have been affected, get the patient immediately to a physician for treatment.

Containers of cryogenic liquids are self pressurizing (as the liquid boils off, vapor pressure increases). Hoses or lines used to transfer these liquids should never be sealed at both ends (i.e. by closing valves at both ends).

When pouring cryogenic liquids from one container to another, the receiving container should be cooled gradually to prevent damage by thermal shock. The liquid should be poured slowly to avoid spattering due to rapid boil off. The receiving vessel should be vented during the transfer.

Introduction of a substance at or near room temperature into a cryogenic liquid should be done with great caution. There may be a violent gas boil-off and a considerable amount of splashing as a result of this rapid boiling. There is also a chance that the material may crack or catastrophically fail due to forces caused by large differences in thermal contraction of different regions of the material. Personnel engaged in this type of activity should be instructed concerning this hazard and should always wear a full face shield and protective clothing. If severe spraying or splashing could occur, safety glasses or chemical goggles along with body length protective aprons will provide additional protection.

The properties of many materials at extremely low temperatures may be quite different from the properties that these same materials exhibit at room temperatures. Exercise extreme care when handling materials cooled to cryogenic temperatures until the properties of these materials under these conditions are known.

Metals to be used for use in cryogenic equipment application must posses sufficient physical properties at these low temperatures. Since ordinary carbon steels, and to somewhat a lesser extent, alloy steels, lose much of their ductility at low temperatures, they are considered unsatisfactory and sometimes unsafe for these applications. The austenitic Ni-Cr alloys exhibit good ductility at these low temperatures and the most widely used is 18-8 stainless steel. Copper, Monel®, brass and aluminum are also considered satisfactory materials for cryogenic service.

Cryogen Safety Summary

Cryogenic systems are complex systems with the potential to seriously injure personnel or equipment if not operated according to procedures. The
use of safety mechanisms (pressure relief valves, rupture disks, etc.) in cryogenic systems is usually necessary.

**Recommended Safety Equipment**

The use of proper safety equipment is necessary. Such equipment may include, but not limited to, the following items:

- First Aid kit
- Fire extinguisher rated for class C fires
- Cryogenic gloves
- Face shield
- Signs to indicate that there are potentially dangerous cryogens in use in the area.

**Safety Legend**

- Instruction manual symbol: the product is marked with this symbol when it is necessary for you to refer to the instruction manual in order to protect against damage to the product or personal injury.
- Hazardous voltage symbol.
- Alternating Current (Refer to IEC 417, No. 5032).
- Off (Supply) (Refer to IEC 417, No. 5008).
- On (Supply) (Refer to IEC 417, No. 5007).

**Warning**

The Warning sign denotes a hazard. It calls attention to a procedure or practice, which if not correctly adhered to, could result in personal injury. Do not proceed beyond a Warning sign until the indicated conditions are fully understood and met.

**Caution**

The Caution sign denotes a hazard. It calls attention to an operating procedure or practice, which if not adhered to, could cause damage or destruction of a part or all of the product. Do not proceed beyond a Caution sign until the indicated conditions are fully understood and met.
Equipment Warnings

Before energizing the equipment, the earth ground of the power receptacle must be verified to be at earth potential and able to carry the rated current of the power circuit. Using extension cords should be avoided. However, if an extension cord must be used, insure the ground conductor is intact and the cord is capable of carrying the rated current without excessive voltage drop.

In the event that the ground path becomes less than sufficient to carry the rated current of the power circuit, the equipment should be disconnected from power, labeled as unsafe, and removed from place of operation.

Do not operate this equipment in the presence of flammable gases. Doing so could result in a life-threatening explosion.

Do not modify this equipment in any way. If component replacement is required, return the equipment to AMI facilities as described in the troubleshooting section of this manual.

If used in a manner not specified in this manual, the protection provided by the design, manufacture and documentation of the Model 1700 Instrument may be impaired.

Other Manual Conventions

This manual refers to measuring liquid nitrogen (LN₂) when referring to capacitance-based level measurement since nitrogen is by far the most common cryogenic fluid used by this sort of instrument. This instrument can be used to measure most any cryogenic liquid.

Instrument Configuration

The Model 1700 Instrument is configured at time of purchase as a capacitance-based (typically liquid nitrogen) level instrument/controller.

Every configuration may be further customized by the following options:

- Table top, single rack mounting, dual rack mounting.
- Line cord: North American, European Schuko, Australia/NZ, China, UK, pigtailed ends.

The instrument part number, shown on the serialization label located on the underside of the instrument, as well as in a field in the instrument Menu, identifies the configuration according to the following key:

1700-A-B-C-D-E where
A indicates the mounting method:

Tbl = tabletop
SR19L = single rack mounted, 19” wide rack standard, instrument on left side
SR19R = single rack mounted, 19” wide rack standard, instrument on right side
SR10L = single rack mounted, 10” wide rack standard, instrument on left side
SR10R = single rack mounted, 10” wide rack standard, instrument on right side
DRL = dual rack mount, 19” wide rack standard, instrument on left side
DRR = dual rack mount, 19” wide rack standard, instrument on right side

B indicates the line cord shipped with the instrument:

N = North American
E = European, Schuko
A = Australian/New Zealand
C = Chinese
U = United Kingdom
P = India/pigtailed

C indicates the capacitance-based level configuration:

CAP = capacitance-based (typically nitrogen)
N = not configured

The sensor active length and length units are appended to the configuration code, ie ...CAP-10.4CM-...

D indicates the helium level configuration:

N = not configured

E is used to denote any instrument customization:

S = standard (no customization)
C = instrument modified.
1 Introduction

1.1 Model 1700 Instrument

The AMI Model 1700 Liquid Level Instrument is a sophisticated measurement and control instrument which provides monitoring liquid helium and/or capacitance-based level sensors as inputs and provides for automatic level control based on user set parameters.

At time of purchase, the Model 1700 will be configured as:

- A capacitance-based (typically liquid nitrogen) level instrument/controller.

1.1.1 Cryogenic (Capacitance-Based) Liquid Level Sensors

The Model 1700 Instrument will be used with a capacitance-based sensor for all cryogenic liquids except for helium. Special insulated capacitance sensors are required for liquids with electrical conductivity, i.e. water.

The Model 1700 Instrument must use an oscillator device to measure cryogenic liquid levels. This instrument has an internal oscillator if the distance between the sensor and the instrument is less than or equal to 15 feet (457 cm) so no external oscillator is necessary. If the distance between the sensor and the instrument is greater than 15 feet, an external oscillator/transmitter unit is necessary. The instrument will automatically

---

1. The instrument can be used to measure/control any cryogenic liquid but the most common is nitrogen.
configure itself to use the internal oscillator unless the external oscillator/transmitter is connected to the BNC connector on the rear panel.

Figure 1-1. Model 1700 Instrument using internal oscillator/transmitter
Introduction
Model 1700 Liquid Level Instrument

1.1.2 Digitally-Controlled
The Model 1700 contains a microcomputer which controls analog data conversion, display/keypad functions, communications I/O, dry contact closures, generation of analog output signals and relay control of a mains power outlet for solenoid valve autofill applications.

1.1.3 System Flexibility
The Model 1700 instrument incorporates data converters to translate signals between the analog and digital domains. Precision instrumentation techniques and potentiometer-free designs are employed throughout the Model 1700 Instrument to ensure long term stability and accurate signal translation for a wide range of conditions.

1.1.4 Display
The Model 1700 Instrument has a 4.3” diagonal measure TFT (Thin Film Transistor) color liquid crystal display of 480 x 272 pixels. The display has a 4-wire resistive touch overlay for easy operator input.
1.1.5 Intuitive Human-Interface Design
The Model 1700 instrument is designed to simplify the touch-screen based user interface. All functions were analyzed and subsequently programmed so that the most commonly used functions are addressed with the least number of keystrokes. The menus are presented in a logical fashion so that the operation of the Model 1700 is intuitive to the user.

1.1.6 Measurement Flexibility
Set points can be assigned to control two dry-contact relay outputs. The make or break function of each relay can be set independently. A solid-state relay allows mains power to be switched according to set points to operate a solenoid-operated valve or other load.

1.1.7 Real Time Clock
The Model 1700 Instrument incorporates a real time clock with automatic daylight savings time adjustment (if desired).

1.1.8 Valve Control Output
The Model 1700 Instrument has a switched 2 ampere at mains voltage output for energizing a solenoid operated flow valve or other loads. This output is controlled by a zero-crossing solid state relay.

The fill start is triggered by a level reading. The fill is stopped by reaching a user-set level, or exceeding a maximum fill time.

1.1.9 Analog Outputs
The Model 1700 Instrument has two analog outputs, a 0-10 V<sub>DC</sub> voltage output and a 4-20 mA<sub>DC</sub> current loop output. The 4-20 mA<sub>DC</sub> loop output has 1500 V<sub>PK</sub> circuit isolation. The outputs can be used simultaneously.

1.1.10 Signal Relays
The Model 1700 Instrument has two signal relays that change state based on a measured input. The set points of these relays are user-selectable as is their function, alarm on level above or below set point.

1.1.11 Connectivity
The Model 1700 Instrument has a 10Base-T Ethernet connection as well as a 115,200 baud RS-232 port for connecting to other equipment. The instrument communicates with a SCPI-based command set. The command set is 100% backward compatible with the AMI Model 135, 136, 185, and 186 instruments when configured as a single channel instrument. When configured as a dual channel instrument, additional commands are incorporated into the command set.
Introduction
Model 1700 Liquid Level Instrument

The Model 1700 Instrument allows for remote operation with an external browser via TCP/IP connection. All commands that are available by touching the local screen are available via the web browser.

![Image of Model 1700 nitrogen instrument via web browser]

**Figure 1-3. Model 1700 Nitrogen Instrument Via Web Browser**

**Note**

Using a web browser to connect to the instrument allows different browser sessions to display different information. For instance, one browser window can display helium level only and a second browser window can display nitrogen level only. The instrument can be configured independently as well since it’s display is also a browser. Refer to “Configure the instrument to display nitrogen level” on page 26.
Introduction
Model 1700 Front Panel

1.2 Model 1700 Front Panel Layout

![Model 1700 Front View; Dual Channel Instrument Shown](image)

Figure 1-4. Model 1700 Front View; Dual Channel Instrument Shown

1.3 Model 1700 Rear Panel Layout

![Model 1700 Rear Panel Description](image)

Table 1-1. Model 1700 Rear Panel Description

<table>
<thead>
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<th>Description</th>
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<tr>
<td>1</td>
<td>Computer Network Connector</td>
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<tr>
<td>2</td>
<td>Aux I/O Connector</td>
</tr>
<tr>
<td>3</td>
<td>RS-232 Serial Connector</td>
</tr>
<tr>
<td>4</td>
<td>Switched Valve Outlet Socket</td>
</tr>
<tr>
<td>5</td>
<td>Capacitive Sensor Input Connector</td>
</tr>
<tr>
<td>6</td>
<td>Mains Power Entry Connector</td>
</tr>
<tr>
<td>7</td>
<td>LHe Level Sensor Connector</td>
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<table>
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</tr>
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</tr>
<tr>
<td>Maximum length readout:</td>
<td>Capacitance-based liquid level - 999 in</td>
</tr>
<tr>
<td>System operating firmware storage:</td>
<td>Flash memory</td>
</tr>
<tr>
<td>System clock:</td>
<td>Real time clock with automatic DST adjustment</td>
</tr>
<tr>
<td>Display measurement units:</td>
<td>liquid level in cm, in or percent</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Level Measurement</th>
</tr>
</thead>
<tbody>
<tr>
<td>Resolution:</td>
</tr>
<tr>
<td>Accuracy:</td>
</tr>
<tr>
<td>Linearity:</td>
</tr>
<tr>
<td>Capacitance Sensor Excitation Voltage:</td>
</tr>
<tr>
<td>Capacitance Transmitter Measurement Resolution:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Operating Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alarm Set points:</td>
</tr>
<tr>
<td>Controller Output:</td>
</tr>
<tr>
<td>Sample and Hold Period:</td>
</tr>
<tr>
<td>Audible alarm:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Analog Outputs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output Types:</td>
</tr>
<tr>
<td>4-20 mA Current Loop Power Supply Voltage:</td>
</tr>
<tr>
<td>0-10 V&lt;sub&gt;DC&lt;/sub&gt; Recorder Output Output Load:</td>
</tr>
<tr>
<td>Converter Resolution:</td>
</tr>
<tr>
<td>Integral Non-linearity:</td>
</tr>
<tr>
<td>Differential Non-linearity&lt;sup&gt;2&lt;/sup&gt;:</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Relays</th>
</tr>
</thead>
<tbody>
<tr>
<td>№1 and/or №2</td>
</tr>
<tr>
<td>(W171DIP-7, or equivalent):</td>
</tr>
<tr>
<td>Maximum Switched Power: 0.29 W</td>
</tr>
<tr>
<td>Maximum Switched Current: 3 A</td>
</tr>
<tr>
<td>Switching Voltage: 60 V&lt;sub&gt;AC&lt;/sub&gt; / 100 V&lt;sub&gt;DC&lt;/sub&gt;</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Auto Fill</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controller output socket:</td>
</tr>
</tbody>
</table>
## Introduction

### Model 1700 System Specifications

<table>
<thead>
<tr>
<th>Specification</th>
<th>Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>Controller output power</td>
<td>2 A&lt;sub&gt;AC&lt;/sub&gt; at line voltage</td>
</tr>
<tr>
<td>Autofill start/stop triggering</td>
<td>Level-based; 0% to 100%, adjustable</td>
</tr>
<tr>
<td>Fill Timeout Period</td>
<td>1 minute to 99 hours, 59 minutes</td>
</tr>
<tr>
<td>Fill error alarm</td>
<td>Fill time out</td>
</tr>
</tbody>
</table>

### Communication Protocol

| Host computer network protocol | 10Base-T TCP/IP and RS-232 115,200 baud                                                                                                     |
| IP Addressing                 | DHCP or static, IPv4                                                                                                                       |
| Network connectivity          | Link and Activity LEDs on instrument rear panel                                                                                             |
| RS-232 connector specifications| 9-pin D-sub female connector to connect standard DTE 9-pin D-sub male connector using a standard straight cable  |
| Communication command set     | SCPI-based. 100% backward compatible with the Model 184, 185, 186 instruments.                                                             |

### Power Requirements

<table>
<thead>
<tr>
<th>Source</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Primary</td>
<td>100-240 ±10% V&lt;sub&gt;AC&lt;/sub&gt;, 50-60 Hz, 2.2 A maximum (200 VA plus sum of controller output)</td>
</tr>
<tr>
<td>Backup battery for RTC</td>
<td>CR2032</td>
</tr>
</tbody>
</table>

### Physical

| Dimensions<sup>b</sup>        | Table top configuration: 3.8" H x 8.4" W x 11.4" D  |
|                               | Single rack mount configuration: 3.5" H x 19.0" W x 11.4" D  |
|                               | Weight: table-top configuration: 3.3 lbm [1.5 kG]; single rack-mount configuration: 4.0 lbm [1.8 kG] |

### Environmental Limits

| Ambient Temperature           | Operating: 0°C to 40°C [-32°F to 104°F]; Non-operating: -20°C to 60°C [-4°F to 140°F] |
| Relative Humidity             | 0 to 95%; non-condensing                                                                                      |
| Maximum Instrument Background Field |                                     |
| Field                        | Gauss (TBD)                                                                                                  |

### Standards

<table>
<thead>
<tr>
<th>Test Standards</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Testing of Equipment for Measurement, Control, and Laboratory Use (IEC 61326-1:2012, EN 61326-1)</td>
<td></td>
</tr>
<tr>
<td>Electrostatic Discharge (ESD)</td>
<td>EN 61000-4-2</td>
</tr>
<tr>
<td>Radiated Immunity</td>
<td>EN 61000-4-3</td>
</tr>
<tr>
<td>Fast Transient Burst</td>
<td>EN 61000-4-4</td>
</tr>
<tr>
<td>Surges</td>
<td>EN 61000-4-5</td>
</tr>
<tr>
<td>Conducted Immunity</td>
<td>EN 61000-4-6</td>
</tr>
</tbody>
</table>
**Introduction**  
Model 1800 System Specifications

- Power Frequency Magnetic Field  
  (EN 61000-4-8)
- Voltage Dips and Interrupts  
  (EN 61000-4-11)
- Harmonics (EN 61000-3-2)
- Flicker (EN 6100-3-3)
- Conducted Emissions (EN 55011/IEC/CISPR 11)
- Radiated Emissions (EN 55011/IEC/CISPR 11)
- Safety Requirements for Electrical Equipment for Measurement, Control, and Laboratory Use (IEC 61010-1)

- a. Guaranteed monotonic over operating temperature range
- b. H = height; W = width; D = depth
2 Installation

Warning

Equipment warnings apply to all system installation configurations. Refer to “Equipment Warnings” on page xv, in the Forward to be familiar with the safety requirements for a system installation.

2.1 Unpacking and Inspecting the Instrument

Carefully remove the equipment, interconnecting cabling, and documentation CD (and/or printed material) from the shipping carton, and remove all packaging material.

Note

If there is any shipping damage, save all packing material and contact the shipping company representative to file a damage claim. Do not return to AMI unless prior authorization has been received.

2.2 Mounting the Model 1700 Instrument

If the Model 1700 Instrument is to be used as a table top model, place the equipment on a flat, secure surface.

If the Model 1700 Instrument is to be rack mounted, install it in a 19" wide instrument rack using the mounting hardware supplied by the rack cabinet manufacturer. The feet on the bottom of the instrument may be removed to facilitate rack mounting. Secure the front panel to the rack rail in each of the four corners.

2.3 Installing Capacitance-Based Liquid Level Sensors

Refer to the installation instructions provided with the level sensor(s). The following steps are general installation notes and should be used to supplement the installation instructions provided with the sensor.

Exercise care when installing the capacitance sensor since dents, crimps, bends or other physical distortions in the cylindrical capacitor will change electrical characteristics, possibly causing calibration errors and/or disruption of proper instrument operation. Before installing the sensor, review “Calibration” on page 37 to determine what, if any, calibration procedures may be necessary prior to operation.
Note
The coaxial interconnecting cables and the transmitter should be mounted in such a manner as to avoid large temperature changes such as those encountered in the path of dewar vents.

1. Carefully remove the sensor from the shipping container and remove all packaging material.

Note
If there is any shipping damage, save all packing material and contact the shipping representative to file a damage claim. Do not return the instrument to AMI unless prior authorization has been received.

2. Install the sensor in the vessel using the specified fitting of the sensor.

Caution
- Ensure the sensor is mounted with the top vent hole located inside of the cryostat.

- Avoid installing in a location where icing may occur. Ice formations or moisture buildup on the BNC connector may cause the sensor to short out indicating a higher liquid level than actually exists.

- Moisture or contaminants in any of the BNC coaxial connectors can short out the sensor and cause measurement errors. A pack of non-conductive electrical connection lubricant (ECL or “Dielectric Tune-up Grease”) has been included with the liquid level sensor packaging to reduce the possibility of this occurring. If desired, apply a small amount of ECL to any of the BNC connectors that may be exposed to moisture. Mate the ECL-coated connectors then remove any excess ECL from the outside of the connector. Added protection can be achieved by covering the ECL-coated connections with a short section of heat-shrink tubing.

- MSDS sheets for the ECL are available upon request.

- Exercise care when installing the sensor since dents, crimps, bends or other physical distortions in the thin wall capacitor will change electrical characteristics possibly causing calibration errors and/or disruption of proper instrument operation.

2.4 Connecting the Sensor to the Instrument
2.4.1 Connecting a Capacitance Sensor

The sensor may be connected directly to the BNC connector on the instrument rear panel if the length of the coaxial cable is 15 feet or less. If the sensor is greater than 15 feet from the instrument, an external oscillator/transmitter unit must be used. Refer to figures “Model 1700 Instrument using internal oscillator/transmitter” on page 2 and “Model 1700 Instrument using external oscillator/transmitter” on page 3 as appropriate.

If the transmitter is connected to the sensor with a length of coaxial cable, the a 15 ft standard length cable, with part number of EH2362, is available from AMI. Contact the factory for details. Speak to an AMI Sales Engineer before using cables longer than 15 feet.

---

**Note**

Regarding the coaxial cable is used to connect the capacitance level sensor to the instrument or oscillator/transmitter, in order to maintain system performance and accuracy, the cable must be Trompeter TCC-75-2 and should not be longer than 15 feet [4.57 m]. If a longer length section of coaxial cable is necessary, please discuss with an Authorized AMI Technical Representative.

---

**Note**

If an oscillator/transmitter is used, the length of coaxial cable between the oscillator/transmitter and the instrument may be up to 500 feet in length.

---

**Caution**

Moisture or contaminants in any of the BNC coaxial connectors can short out the sensor and cause an erroneous readings or transmitter failure. A pack of non-conductive electrical connection lubricant (ECL or “Dielectric Tune-up Grease”) has been included with the liquid level sensor packaging to reduce the possibility of this occurring.

---

To connect the coaxial cable to the BNC connector on the capacitance level sensor:

1. Apply a small amount of ECL to any of the BNC connectors that may be exposed to moisture.

2. Mate the ECL-coated connectors then remove any excess ECL from the outside of the connector.

3. Cover the ECL-coated connections with a short section of heat-shrink tubing, also included, for added moisture protection.
2.5 Setting Up an Autofill System

Autofill systems are useful in applications where liquid level in a dewar must be maintained without operator intervention.

To create an autofill system, a cryogenic liquid source must be attached to the target or level controlled dewar via a solenoid-controlled valve. The valve will be controlled by the Model 1700 Instrument.

2.5.1 Autofill System Description

For autofill, the system consists of a Model 1700 Instrument with a liquid level sensor, and a solenoid-operated flow valve. The instrument makes continuous level measurements and based on level, energizes the valve to
begin liquid transfer. The transfer is stopped when the measured level reaches a user-determined point.

Table 2-1. Standard Autofill Setup Description

<table>
<thead>
<tr>
<th>Number</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Model 1700 Liquid Level Instrument (Level Controller)</td>
</tr>
<tr>
<td>2</td>
<td>IEC60320 C13 socket labeled VALVE CONTROL</td>
</tr>
<tr>
<td>3</td>
<td>BNC connector labeled O/T</td>
</tr>
<tr>
<td>4</td>
<td>Solenoid-operated flow control valve line cord with IEC60320 C14 plug</td>
</tr>
<tr>
<td>5</td>
<td>Instrument IEC60329 C14 Power cord socket</td>
</tr>
</tbody>
</table>
### 2.5.2 Autofill System Setup

**Caution**

A relief valve must be used in autofill systems to ensure no cryogenic liquid can be trapped in a transfer line volume where expansion can cause damaging pressure. This can occur if the solenoid operated fill valve and the supply dewar isolation valve are closed, trapping a cryogenic liquid in a confined volume. All AMI transfer line systems include a relief valve to preclude this sort of event.

1. Mount the level sensor (8) in the target dewar.

2. Connect the transfer line (11) and fill solenoid valve (12) or supply manifold to the source dewar.

3. Connect the other end of the transfer line to the fill port (10) on the valve/manifold of the target dewar.

4. Connect the sensor to the instrument.
   a. For distances of 6 feet and less, connect the coaxial cable (6) between the BNC connector on the liquid level sensor and the BNC connector on the back of the instrument labeled O/T (3).
   b. For distances greater than 6 feet, connect the coaxial cable (9) between the BNC connector on the liquid level sensor and the BNC connector on the oscillator / transmitter (7). Use a second length of coaxial cable (6) to connect between the oscillator / transmitter (7) and the BNC connector on the back of the instrument labeled O/T (3).

---

<table>
<thead>
<tr>
<th>Number</th>
<th>Item</th>
</tr>
</thead>
<tbody>
<tr>
<td>6</td>
<td>Coaxial cable connecting the oscillator / transmitter and the instrument</td>
</tr>
<tr>
<td>7</td>
<td>Oscillator / Transmitter (optional; refer to section 2.4.1 on page 13)</td>
</tr>
<tr>
<td>8</td>
<td>Level Sensor for level controlled or target dewar</td>
</tr>
<tr>
<td>9</td>
<td>Coaxial cable connecting the Oscillator / Transmitter and the liquid level sensor (optional; refer to section 2.4.1 on page 13)</td>
</tr>
<tr>
<td>10</td>
<td>Fill port on target dewar</td>
</tr>
<tr>
<td>11</td>
<td>Transfer line attached to the target dewar and the fill solenoid valve on the source dewar</td>
</tr>
<tr>
<td>12</td>
<td>Solenoid-operated fill valve</td>
</tr>
<tr>
<td>13</td>
<td>Supply dewar relief valve</td>
</tr>
<tr>
<td>14</td>
<td>Supply dewar</td>
</tr>
</tbody>
</table>

---

**Table 2-1. Standard Autofill Setup Description**
5. Connect the solenoid valve (12) to the IEC60320 C13 valve socket\(^1\) on the Model 1700 Instrument rear panel labeled VALVE CONTROL (2).

Connect the IEC320 C14 inlet connector and instrument power cord (5) to an appropriate power source (see below).

**Note**

*Should the nitrogen level sensor become disconnected from the instrument, a LOSS OF SENSOR message will be displayed and the autofill valve will be shut (M-CLOSED). When the sensor connection has been restored, the instrument will display the level but the autofill state will have to be manually changed back to AUTOFILL.*

2.6 Power Requirements

⚠️ **Warning**

*The Model 1700 Instrument operates on 50-60 Hz power and may be powered from 100-240 Vac. Insure that the input ground terminal is connected securely to an external earth ground.*

*Insure the detachable mains supply cord is of suitable rating, i.e. 10 A (min) at 125 Vac for North America.*

Insure the power switch is in the OFF (O) position. Plug the Model 1700 Instrument line cord into the power entry module on the instrument rear panel and into the appropriate power receptacle.

---

1. The valve socket must be IEC60320 C13 type.
Installation
Power Requirements
3 Operation

This section describes the operation of the Model 1700 Instrument.

3.1 Energizing the Model 1700 Instrument

1. Turn the power switch on the front panel of the instrument to the On (1) position. The display will briefly show the AMI logo and then boot information.

The boot process takes approximately 30 seconds. This time can be longer (approximately 2 minutes) if the instrument has been configured for a network connection and then is booted without the network present.

**Note**

*If the instrument was purchased with a level sensor, the instrument will be configured and calibrated at the factory.*

2. When the boot process is complete, the instrument will display the home (level) screen.

   a. The display will look similar to the following:

   b. If the instrument requires calibration\(^1\), refer to the following chapter to calibrate the instrument with an AMI level sensor.

3.2 Screen Navigation

3.2.1 Home Screen Footer

Every screen has a footer. The level home screen (refer to Figure 3.2.1 as an example) displays both level information and buttons in the footer to navigate to other screens.

\(^1\) If the instrument was purchased with level sensor(s), the instrument will be shipped set up and calibrated.
Operation
Using the Model 1700 Menus

The home screen footer appears as follows:

![Figure 3-2. Home Screen Footer]

Table 3-1. Model 1700 Instrument Home Screen Footer

<table>
<thead>
<tr>
<th>No.</th>
<th>Name</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>MENU</td>
<td>Takes the user to the menu screen</td>
</tr>
<tr>
<td>2</td>
<td>ALARM</td>
<td>When illuminated, displays an alarm condition</td>
</tr>
<tr>
<td>3</td>
<td>AUTOFILL</td>
<td>Indicates the condition of the autofill function</td>
</tr>
</tbody>
</table>

3.3 Navigating the Instrument Menus

The menu system is invoked by pressing the Menu button in the lower left corner of the instrument level display screen.

When invoked, the MENU screen will be displayed:

![Figure 3-3. MENU button on HOME screen]

Pressing the Home icon in the lower left corner of the screen will display the Home screen.

![Figure 3-4. MENU Selection Screen]

Once a MENU has been chosen, a back button will be presented to the right of the Home icon. This button will return the user to the previously displayed screen.

3.3.1 Menu Overview

The Model 1700 Instrument displays menus on the graphic display to the left of the keypad. Press MENU on the menu keypad to display options on the graphic display. Menu options are listed in the following Table.
## Note

The following table shows all menu choices, some of which will not be shown based on the instrument configuration.

### Table 3-2. Model 1700 Nitrogen Instrument Menu Structure

<table>
<thead>
<tr>
<th>Menu Label</th>
<th>Function</th>
<th>Field Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUTS</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>ALARM RELAY No.1 SOURCE:</td>
<td>Toggles between:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DISABLED, NITROGEN</td>
</tr>
<tr>
<td></td>
<td>(ALARM RELAY No. 1) SETPOINT:</td>
<td>Data entry &lt;value&gt; %</td>
</tr>
<tr>
<td></td>
<td>(ALARM RELAY No. 1) ALARM WHEN LEVEL &lt;state&gt;</td>
<td>Toggles between: ≤, ≥ SETPOINT</td>
</tr>
<tr>
<td></td>
<td>ALARM RELAY No.2 SOURCE:</td>
<td>Toggles between:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DISABLED, NITROGEN</td>
</tr>
<tr>
<td></td>
<td>(ALARM RELAY No. 2) SETPOINT:</td>
<td>Data entry &lt;value&gt; %</td>
</tr>
<tr>
<td></td>
<td>(ALARM RELAY No. 2) ALARM WHEN LEVEL &lt;state&gt;</td>
<td>Toggles between: ≤, ≥ SETPOINT</td>
</tr>
<tr>
<td></td>
<td>AUTOFILL SOURCE:</td>
<td>Toggles between:</td>
</tr>
<tr>
<td></td>
<td></td>
<td>DISABLED, NITROGEN</td>
</tr>
<tr>
<td></td>
<td>AUTOFILL CONTROL: START:</td>
<td>Data entry &lt;value&gt; %</td>
</tr>
<tr>
<td></td>
<td>AUTOFILL CONTROL: STOP:</td>
<td>Data entry &lt;value&gt; %</td>
</tr>
<tr>
<td></td>
<td>FILL TIMEOUT (N2 ONLY):</td>
<td>Data entry &lt;value&gt; MINUTES</td>
</tr>
</tbody>
</table>
Table 3-2. Model 1700 Nitrogen Instrument Menu Structure

<table>
<thead>
<tr>
<th>Menu Label</th>
<th>Function</th>
<th>Field Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>OUTPUTS, continued</td>
<td>0-10 Vdc SOURCE:</td>
<td>Toggles between: DISABLED, NITROGEN</td>
</tr>
<tr>
<td></td>
<td>4-20 mA SOURCE:</td>
<td>Toggles between: DISABLED, NITROGEN</td>
</tr>
<tr>
<td>NETWORK</td>
<td>ADDRESS: &lt;value&gt;</td>
<td>Data entry or Information</td>
</tr>
<tr>
<td></td>
<td>NETMASK: &lt;value&gt;</td>
<td>Data entry or Information</td>
</tr>
<tr>
<td></td>
<td>GATEWAY: &lt;value&gt;</td>
<td>Data entry or Information</td>
</tr>
<tr>
<td></td>
<td>ADDRESSING:</td>
<td>Toggles between: DISABLED, STATIC, DYNAMIC</td>
</tr>
<tr>
<td></td>
<td>MAC ADDRESS:</td>
<td>Information: &lt;value&gt;</td>
</tr>
<tr>
<td>SYSTEM (page 1)</td>
<td>NITROGEN SENSOR NAME:</td>
<td>Data entry: &lt;value&gt;</td>
</tr>
<tr>
<td></td>
<td>SYSTEM DATE &amp; TIME:</td>
<td>Information: &lt;value&gt;</td>
</tr>
<tr>
<td></td>
<td>(SYSTEM DATE &amp; TIME) SET</td>
<td>Transfer to another screen</td>
</tr>
<tr>
<td></td>
<td>(SYSTEM SETTINGS) PAGE 2</td>
<td>Transfer to another screen</td>
</tr>
<tr>
<td>SYSTEM: DATE &amp; TIME (page 4)</td>
<td>SYSTEM DATE AND TIME: YEAR</td>
<td>Data entry</td>
</tr>
<tr>
<td></td>
<td>SYSTEM DATE AND TIME: MONTH</td>
<td>Data entry</td>
</tr>
<tr>
<td></td>
<td>SYSTEM DATE AND TIME: DAY</td>
<td>Data entry</td>
</tr>
<tr>
<td></td>
<td>SYSTEM DATE AND TIME: HOUR</td>
<td>Data entry</td>
</tr>
<tr>
<td></td>
<td>SYSTEM DATE AND TIME: MIN</td>
<td>Data entry</td>
</tr>
</tbody>
</table>
### Table 3-2. Model 1700 Nitrogen Instrument Menu Structure

<table>
<thead>
<tr>
<th>Menu Label</th>
<th>Function</th>
<th>Field Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM (page 2)</td>
<td>SERIAL NUMBER:</td>
<td>Information: &lt;value&gt;</td>
</tr>
<tr>
<td></td>
<td>HARDWARE VERSION:</td>
<td>Information: &lt;value&gt;</td>
</tr>
<tr>
<td></td>
<td>DATE OF MANUFACTURE:</td>
<td>Information: &lt;value&gt;</td>
</tr>
<tr>
<td></td>
<td>FIRMWARE VERSION:</td>
<td>Information: &lt;value&gt;</td>
</tr>
<tr>
<td></td>
<td>HELIUM POWER SUPPLY:</td>
<td>Information: NONE</td>
</tr>
<tr>
<td></td>
<td>RESET INSTRUMENT TO FACTORY DEFAULTS</td>
<td>Transfer to another screen</td>
</tr>
</tbody>
</table>
### Table 3-2. Model 1700 Nitrogen Instrument Menu Structure

<table>
<thead>
<tr>
<th>Menu Label</th>
<th>Function</th>
<th>Field Type</th>
</tr>
</thead>
<tbody>
<tr>
<td>SYSTEM (page 3)</td>
<td>RESET INSTRUMENT</td>
<td>Performs a function</td>
</tr>
<tr>
<td>CALIBRATE TOUCH SCREEN</td>
<td>Assists user in performing the instrument touch screen calibration</td>
<td>Transfer to another screen</td>
</tr>
<tr>
<td>SHUT DOWN SYSTEM</td>
<td>Shuts down the instrument in an orderly fashion which reduces boot time for the next power on.</td>
<td>Transfer to another screen</td>
</tr>
<tr>
<td>SENSORS: CALIBRATE NITROGEN</td>
<td>OSCILLATOR PERIOD:</td>
<td>Information: &lt;value&gt; μs</td>
</tr>
<tr>
<td></td>
<td>SENSOR ACTIVE LENGTH:</td>
<td>Data entry: &lt;value&gt; cm</td>
</tr>
<tr>
<td></td>
<td>PERFORM MAX CAL</td>
<td>Transfer to another screen and Information: &lt;value&gt; μs</td>
</tr>
<tr>
<td></td>
<td>PERFORM MIN CAL</td>
<td>Transfer to another screen and Information: &lt;value&gt; μs</td>
</tr>
<tr>
<td></td>
<td>NO SENSOR CAL</td>
<td>Transfer to another screen and Information: &lt;value&gt; μs</td>
</tr>
<tr>
<td></td>
<td>APPROX CAL. VALUE:</td>
<td>Data entry: &lt;value&gt;</td>
</tr>
<tr>
<td></td>
<td>(APPROX CAL. VALUE:) APPLY</td>
<td>Performs a function</td>
</tr>
</tbody>
</table>

#### 3.3.2 Editing a Field

Once a field on a screen has been selected for editing, the footer changes to appear as follows:

![Figure 3-7. Field Editing Footer](image-url)
### Table 3-3. Model 1700 Instrument Footer during editing a field

<table>
<thead>
<tr>
<th>Button No.</th>
<th>Name</th>
<th>Function</th>
<th>Reference Paragraph</th>
</tr>
</thead>
<tbody>
<tr>
<td>❶</td>
<td>SAVE</td>
<td>Saves the entries made on the screen. The footer changes to the footer shown in Table 3-1, above.</td>
<td></td>
</tr>
<tr>
<td>❷</td>
<td>CANCEL</td>
<td>Exits out of the screen, not saving entries. The footer changes to the footer shown in Table 3-1, above.</td>
<td></td>
</tr>
<tr>
<td>❸</td>
<td>ALARM Status</td>
<td></td>
<td>Refer to Table 3-1, above.</td>
</tr>
<tr>
<td>❹</td>
<td>AUTOFILL Status</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
3.3.3 Menu Navigation

![Model 1700 Menu Structure](image)

Figure 3-8. Model 1700 Menu Structure

3.4 Capacitance (Liquid Nitrogen) Level

3.4.1 Configure the instrument to display nitrogen level

**Note**

*If the instrument was purchased with a capacitance-based level sensor, Steps 1 through 5, below have already been performed.*

1. From the main screen, choose the following: **MENU > SENSORS.**
2. The instrument has a built-in sensor oscillator which will be used if the level sensor is connected to the BNC connector on the rear panel of the instrument with a maximum of 6 foot of RG59/U coaxial cable (refer to Figure 1-1 on page 2). Ensure the “NITROGEN OSCILLATOR:” field displays “INTERNAL”.

3. If the sensor is greater than 15 feet from the instrument, an external oscillator/transmitter will have to be used and the “NITROGEN OSCILLATOR:” will display “EXTERNAL” (refer to Figure 1-2 on page 3).

4. Ensure that N2 LEVEL ON HOME SCREEN? is set to YES.

5. Press the Home icon at the bottom of the screen.

3.5 Alarms and Relays

3.5.1 Overview

The Model 1700 Instrument has two types of alarms, level-based and time-based alarms.

3.5.1.1 Level-Based Alarms

The Model 1700 Instrument has two user-configurable level alarms. Each alarm can be triggered by either level measurement (for dual level configured instruments). Each alarm can be configured to be active above or below a user-defined setpoint.
When an alarm condition occurs, an audible alert will sound and visual indication on the front panel.

Alarm №1 and №2 have relays associated with them. These relays have Normally Open (NO) contacts. The alarm/relays can be assigned to either the helium or nitrogen channel and the alarm/relay can each be configured to have the alarm active when the reading is either ≤ or ≥ the setpoint. As an example of this setup flexibility, a level channel can be configured to have an alarm condition when the level is outside a normal operating band.

3.5.1.2 Time-Based Fill Alarm

The Model 1700 Instrument has an alarm to indicate that there is a problem with the LN₂ autofill function. If enabled, the instrument will start a timer when an autofill condition is initiated, and if the level has not reached the fill stop level within the user-set period of time, an Autofill Timeout alarm will occur.

This alarm will cause three things to occur:

1. the de-energizing of the fill valve socket on the instrument rear panel,
2. an audible alarm will sound,
3. a visual indication in the footer of the instrument front panel which shows repeatedly ALARM > NITROGEN > TIMEOUT > MUTE?¹ > ALARM > etc.
4. The blue AUTOFILL text in the right side of the screen footer will turn to red T-CLOSED indicating that the fill timeout has automatically closed the fill valve by deenergizing the power socket on the instrument rear panel.

This Autofill Timeout function can be disabled by setting the interval to 0 minutes.

3.5.1.3 Multiple alarms

More than one alarm condition can occur at the same time. The footer will display the cause(s) of the alarm condition(s).

¹ The MUTE? function is not applicable to the screen on a remote browser since audible alarms are not supported remotely.
3.5.2 Configuring Alarm Setpoints

1. From the MENU choice, select OUTPUTS and the first page of the Output Configuration screen will be displayed.

2. Ensure the Alarm Relay Source fields are set to NITROGEN (or DISABLED).

3. Set the levels at which the alarm will be triggered in the Setpoint fields.

4. Use the ≤ or ≥ button to toggle between the two states of alarm, either alarm when the indicated level is less than or equal to the setpoint or alarm when the indicated level is greater than or equal to the alarm setpoint.

3.5.3 Acknowledging an Alarm

Note

The alarms are not “latched” so if the alarm condition clears itself, the instrument will remove the alarm condition.
1. When an alarm is initiated, several things will occur:

   a. The bar-graph level display that is causing the alarm condition as well as the sensor name will flash red.

   b. The ALARM button in the footer will indicate what the alarm condition is, either by showing LO LEVEL, HI LEVEL, or TIMEOUT.

   c. An audible alarm will be energized.

2. For example, a helium low level alarm will flash the following three displays in a repeating fashion:

3.5.4 Muting an Alarm

The audible alarm can be muted by pressing the ALARM button in the footer. As long as the alarm condition occurs with muting enabled, the ALARM button in the footer will alternate between the alarm conditions (Figure 3-17) and MUTED.

3.5.5 Resetting the Autofill Timeout Alarm

1. Press the red T-CLOSED text in the right side of the footer twice until M-CLOSED is displayed.

2. Press SAVE.

3. To restart the autofill process, Press the M-CLOSED annunciator once and the AUTOFILL annunciator will be displayed. Press SAVE and the autofill sequence will be enabled.
3.6 Configure the Autofill Function

3.6.1 Autofill overview

There are several variables that must be addressed to set up an autofill system. These include the level indication that will be used to control autofill, the Fill Start level (A), the Fill Stop Level (B), and the fill timeout interval.

3.6.2 Setting the autofill parameters

1. From the Menu screen, choose OUTPUTS and then choose PAGE 2.

2. Toggle the AUTOFILL CONTROL button until NITROGEN is displayed.

3. Enter the Fill START and STOP levels.

4. Enter the FILL TIMEOUT (N2 ONLY) interval. Refer to section 3.6.2 on page 31 for a description of the Autofill timeout function.

5. Press HOME in the footer to return back to the level display.

3.6.3 Enable the Autofill function

The autofill function must be enabled from the front panel of the instrument. After the autofill control loop has been configured (steps in section 3.6) the instrument will be left in the valve manually-closed state.
To enable the autofill function:

1. Press on the **M-CLOSED** icon in the display footer until it reads **AUTOFILL**.

2. Press **SAVE** to enable the autofill function.

The **AUTOFILL** button has three states:

<table>
<thead>
<tr>
<th>Function</th>
<th>Operation</th>
<th>Overrides</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUTOFILL</td>
<td>Maintains level between fill START and STOP setpoints.</td>
<td>Autofill will alarm and cease if fill valve stays open for ≥ the FILL TIMEOUT setting (nitrogen AUTOFILL CONTROL only).</td>
</tr>
<tr>
<td>M-OPEN(^a)</td>
<td>Energizes the valve control socket on the rear panel.</td>
<td>None</td>
</tr>
<tr>
<td>M-CLOSED(^b)</td>
<td>De-energizes the valve control socket on the rear panel.</td>
<td>None</td>
</tr>
</tbody>
</table>

\(^a\) Manual Open  
\(^b\) Manual Closed

### 3.7 Select the appropriate units on the display

Touch the units on the display to change the units. The available units are percent (\%), inches (in), and centimeters (cm).

![Figure 3-22. LN₂ Home Screen](image)

### 3.8 Analog output signals

#### 3.8.1 Connecting to the Aux Connector

Refer to “Aux I/O Connector” on page 85 of the Appendix for a connector pin-out.
3.8.2 Configuring the Analog Outputs

1. From the **MENU** screen, choose **OUTPUTS**, then **Page 2**.

2. If necessary, choose the source for the 0-10 VDC output and 4-20 mA output.

3. Press the **SAVE** button to save the choice (or **CANCEL** to quit without making a change).

4. Press the home icon to go back to the home screen.

3.9 Ethernet Connectivity

3.9.1 IP Addressing Scheme

1. From the **MENU** screen, choose **NETWORK**. The current settings will be displayed.

2. To change the settings, choose **EDIT**.

3. In the **ADDRESSING** button, choose **STATIC**, **DYNAMIC**, or **DISABLED** as appropriate.

4. If **STATIC** is chosen for the addressing scheme, enter **IP ADDRESS**, **NETMASK**, and **GATEWAY** addresses that are appropriate for the connected device.
network. Once an address field is touched, the pop-up keyboard will be presented for data entry. Press SAVE when done.

5. If the DYNAMIC addressing scheme is chosen, the IP ADDRESS, NETMASK, and GATEWAY addresses will automatically be assigned from a network DHCP server. Press SAVE when done.

6. If changes are made, select the SAVE button and then the instrument will reboot and reconfigure itself with the chosen settings.

**Note**

*Until the instrument is rebooted, the IP Addressing changes will not be applied.*

![Figure 3-27. Saving Network Settings](image)

### 3.10 Abnormal Operation

#### 3.10.1 Capacitance Sensor Contamination

To ensure proper instrument calibration and operation, care must be taken to ensure the sensor is kept free of contaminants and not subjected to any force which would physically distort the sensor. Water or other electrically conducting substances in the sensor will disturb the measured capacitance and the instrument’s response. Physically distorting the sensor in any way will also cause abnormal instrument operation by introducing variations in the sensor capacitance not due to liquid level. The absolute calibration of the instrument can be inaccurate if care is not taken to ensure the sensor is in the proper environment.

Cold sensors exposed to humidified air can show erroneous high level readings because the air contains moisture that can condense between the cold sensing tubes. A minute film of water can cause a shorted or partially shorted condition, which results in false level readings. As the sensor warms, the moisture may evaporate and the sensor will again read correctly. This is a physical phenomenon and does not indicate any problem with your AMI level equipment. Limit or eliminate exposure of cold sensors to humidified air to avoid this condition.

If a sensor should require cleaning and the sensor is for use with liquids other than liquid oxygen, flushing with pure alcohol is recommended. The
sensor cannot be used again until all the alcohol has been evaporated. Under no circumstances should the sensor be disassembled.

For sensors to be used with liquid oxygen (LOX), although measures are taken to minimize oils and greases during manufacture, no special cleaning required for LOX service is provided by AMI. Certified LOX cleaning is the responsibility of the customer.

3.10.2 Resetting the Instrument to Factory Defaults

1. Press **MENU**, then **SYSTEM**, then **PAGE 2**.

2. Press **RESET INSTRUMENT TO FACTORY DEFAULTS**.

3. Press **RESET** and the instrument will be reset to factory defaults.
3.11 Shutting the Instrument Down

1. The instrument should be shut down by using the menu function **SHUT DOWN SYSTEM**.

   **Note**
   
   The Model 1700 Instrument is a Linux-based computer system and in order to ensure the file system is properly unmounted, the **SHUT DOWN SYSTEM** function should be invoked. If it is not, i.e. the instrument is shut down by removing power via the front panel power switch, the next time the instrument boots up, it will have to scan its memory system to ensure everything is in order.

2. Choose **YES** to confirm shutdown.

3. When prompted, turn off the front panel power switch.
Model 1700 instrument is calibrated at the factory for a specific length sensor(s) for use in a specific liquid(s). The calibration length(s) and calibration liquid(s) are listed on the calibration sticker on the bottom of the instrument. For capacitance sensors, if the factory calibration method utilized was approximate, the calibration length will be noted as an approximate value.

4.1 Setting the System Date and Time

1. From the home screen, choose **MENU**.

2. From the **MENU** screen, choose **SYSTEM**.

3. From the **SYSTEM CONFIGURATION, PAGE 1** screen, choose **SET**.
4. Edit the YEAR, MONTH, DAY, HOUR, and MIN fields as necessary. Touching in a field will launch the keyboard on the screen. Edit the information in the field as necessary and choose Enter to enter the data in the field and close the pop up keyboard.

**Note**

The clock is set to GMT at the factory and is battery backed. There is no provision in the instrument for automatic Daylight Savings Time correction.

5. Choose SAVE in the footer after all the fields have been edited as necessary.

### 4.2 Capacitance-based Level Calibration

#### 4.2.1 Understanding the Sensor Active Length

American Magnetics, Inc. fabricates the liquid level sensor with two vent holes; a lower vent hole in the side wall near the bottom which is typically the minimum liquid level calibration point and the upper vent hole in the sensor side typically near the top of the sensor. The liquid level location approximately 2.5 cm (1 in) below the upper vent hole is typically the 100% calibration point.

The Model 1700 Instrument requires the user to enter the calibrated, or active length, (physical distance between the Min and Max calibration locations on the sensor) in order for the absolute units function (inches, cm) to be displayed if desired.

**Note**

Without an active length entered, the instrument will not be able to read out in units other than percent.
The user must enter the sensor length in centimeters. Use the Active Length value noted on the level sensor documentation or measure the distance between the lower vent hole on the sensor and 1.0 inch (2.5 cm) below the upper vent hole on the sensor.
4.2.2 Relationship between Calibration and Sensor Length

The capacitance-based method of measuring the liquid level operates by measuring the frequency of an oscillator, which is contained in the oscillator/transmitter unit. As the liquid level varies, the value of the capacitance varies proportionally. Since the dielectric properties of liquids vary and the component tolerances for the sensor and oscillator introduce variations, a calibration is required to assure maximum accuracy for a specific sensor immersed in the target liquid. The calibration minimum and maximum settings correspond to the maximum and minimum oscillation frequencies, respectively, for a given sensor and target liquid configuration.

The length setting of the instrument is only provided as a means of scaling the 0% (minimum calibration) to 100% (maximum calibration) range of the measurement to meaningful units of length. During the calibration it is important to accurately measure the distance between the physical locations on the sensor corresponding to the maximum and minimum calibration points. The measured value for the length will be used in configuring the instrument for operation.

4.2.3 Variations in the Dielectric with Changing Density

For cryogenic liquids, the dielectric of the liquid will change with a change in density. The amount of change is dependent on the properties of the specific liquid. Figure 4-6 illustrates the variations in dielectric for nitrogen vs. pressure under saturated conditions. Since the instrument uses a capacitance-based method for determining liquid level, such a change in the dielectric of the liquid will result in a shift in the level reading of the instrument. The calibration procedures described herein are most accurate when applied in situations where the operating conditions of the cryo-vessel are relatively constant, i.e. the operating pressure and temperature of the cryo-vessel are relatively constant.

To minimize the effects of shifts in the dielectric of the target liquid, perform a closed dewar calibration (see page 53) at the expected operating condition of the cryo-vessel. If this is not feasible, then calibrate the sensor at atmospheric pressure and use the approximate calibration method to compensate for the shift of the dielectric when the cryogenic liquid is under pressure. For this type of approximate calibration, the reference liquid will be the target liquid at atmospheric pressure — see page 49 for a detailed discussion of the approximate calibration method. If any questions exist in regard to calibration issues, contact AMI for assistance in determining the optimal calibration strategy.

1. Data obtained from NIST Standard Reference Database 12.
Calibration

Calibration methods

Note

All references to “dielectric constant” herein refer to the unitless relative dielectric to $\varepsilon_0$ ($\varepsilon_0$ is the dielectric constant of a vacuum).

4.2.4 Capacitance-based Sensor Calibration Methods

The most straightforward calibration method is the Open Dewar Calibration which requires the customer to have access to a filled dewar where the full active length of the sensor can be dipped. The Closed Dewar Calibration method can be performed in situations where it is not feasible for the customer to dip the sensor into an open dewar, such as situations where the target liquid is under pressure. The closed dewar calibration is more complex and may require initial preparations to insure success.

Occasionally customers ask AMI to calibrate an instrument and sensor for a liquid which is not available at AMI for calibration purposes and/or for a sensor which is too long to be calibrated at our facilities.

For the case of the target liquid being unavailable, AMI uses liquid nitrogen as the reference liquid and an Approximate Calibration is performed using mathematical manipulation of the ratio of the dielectric constants between liquid nitrogen and the desired liquid. This procedure is outlined in the Approximate Calibration section beginning on page 49. The technique is intended to provide the instrument with an approximate

Figure 4-6. Dielectric vs. pressure for nitrogen under saturated conditions.
Open dewar calibration so that it can be used immediately by the customer. However, the customer is still expected to perform a more accurate calibration where feasible, such as the open dewar or closed dewar calibration, with the target liquid.

For the case where a sensor is too long to be calibrated in AMI facilities, AMI will perform a partial length open dewar calibration in liquid nitrogen, and then calculate the MAX calibration point. A dielectric ratio may also be subsequently utilized to adjust for a target liquid other than liquid nitrogen. The customer is expected to perform a more accurate open dewar or closed dewar calibration if feasible.

As a quick guide for selection of the best calibration method available, a calibration selection diagram is presented below. If the instrument and sensor are purchased as a unit from AMI, then the factory calibration will be adequate in most cases. However, for the exceptions noted in the previous paragraphs (which are approximate calibrations), the customer should perform a more accurate open dewar or closed dewar calibration. A customer performed calibration is also required for sensors that are purchased as a separate item from the instrument, since the instrument and sensor were not both available for calibration at AMI facilities.

Each Model 1700 Instrument must be calibrated with a sensor before use. If the instrument was purchased with a sensor to be used in liquid nitrogen, the instrument has been calibrated at the factory.

4.2.4.1 Selection of Capacitance Sensor Calibration Methods

As a quick guide for selection of the best calibration method available, a calibration selection diagram is presented in 4-7. If the instrument and sensor are purchased as a unit from AMI, then the factory calibration, including sensor serial number and sensor physical parameter information entered at the factory, will be adequate in most cases. However, for the exceptions noted in the following paragraphs (which are approximate calibrations), the customer should perform a more accurate open dewar or closed dewar calibration if at all possible. A customer-performed calibration is also required for sensors that are purchased as a separate item from the instrument, since the instrument and sensor were not both available for calibration at AMI facilities.

The most straightforward calibration method is the Open Dewar Calibration which requires the customer to have access to a filled dewar where the full active length of the sensor can be dipped. The Closed Dewar Calibration method can be performed in situations where it is not feasible for the customer to dip the sensor into an open dewar, such as situations where the target liquid is under pressure. The closed dewar calibration is more complex and requires initial preparations to insure success.
Occasionally customers ask AMI to calibrate an instrument and Sensor Transmitter for a liquid which is not available at AMI for calibration purposes and/or for a sensor which is too long to be calibrated at our facilities. For the case of the target liquid being unavailable, AMI uses liquid nitrogen as the reference liquid and an Approximate Calibration is performed using mathematical manipulation of the ratio of the dielectric constants between liquid nitrogen and the desired liquid. The technique is intended to provide the instrument with an approximate calibration so that it can be used immediately by the customer. However, the customer is
still expected to perform a more accurate calibration where feasible, such as the open dewar or closed dewar calibration, with the target liquid.

For the case where a sensor is too long to be calibrated in AMI facilities, AMI performs a partial length open dewar calibration in liquid nitrogen, and then calculates the maximum calibration point. A dielectric ratio (i.e. approximate calibration factor) may also be subsequently used to adjust for a target liquid other than liquid nitrogen. The customer is expected to perform a more accurate open dewar or closed dewar calibration if feasible.

4.2.5  Pre-Calibration Procedure

4.2.5.1  Enter Capacitance Sensor Information

1. Press the MENU button in the lower left corner of the display screen.

2. Choose the SENSORS selection from the MENU screen.

3. If the capacitance sensor will be longer than 15 feet from the instrument, ensure an Oscillator/Transmitter is used between the instrument and the sensor.

4. Verify that the oscillator source selection is correct, either INTERNAL or EXTERNAL. Note that this setting is auto-detected by the instrument,

![MENU Selection Button](image1)

![SENSORS Selection Button](image2)

![NITROGEN OSCILLATOR Selection](image3)
5. Press the **CALIBRATE NITROGEN** button

6. Touch in the **SENSOR ACTIVE LENGTH** field and using the numerical keypad, enter the sensor active length in cm. Press **Enter** and then **SAVE** at the bottom of the screen when finished.

7. Press the back button in the screen footer twice to revert back to the **MENU** screen.

8. Press the **SYSTEM** button.
9. Touch in the **NITROGEN SENSOR NAME**: field. The keyboard will be displayed. Edit the displayed name and press **ENTER** at the bottom of the screen.

![Figure 4-15. PERFORM MAX CAL. Selection Button](image)

10. Press the home icon button in the screen footer to return to the level display screen.

**4.2.5.2 Performing Loss of Sensor Calibration**

The Model 1700 will detect when the liquid level sensor has been disconnected from the instrument and display a notification on the front panel. If the instrument has been configured for autofill, the fill valve will be shut, requiring operator intervention to resume autofill operation. This loss of sensor threshold must be calibrated as follows:

1. For a system where the internal oscillator is used, connect the coaxial cable to the BNC connector on the instrument rear panel but leave the cable disconnected from the sensor BNC connector. For a system where an external oscillator is used, connect the coaxial cable between the instrument and the oscillator/transmitter unit. Connect the second (6') coaxial cable to the input of the oscillator/transmitter unit but leave the cable disconnected from the sensor BNC connector.

2. Press the **MENU** button in the lower left corner of the display screen.

![Figure 4-16. Home Selection Button](image)

![Figure 4-17. MENU Selection Button](image)
3. Choose the **SENSORS** selection from the **MENU** screen.

4. From the **SENSORS** Menu, choose **CALIBRATE NITROGEN**.

5. Select the **NO SENSOR CAL** button.

6. When the calibration procedure is completed, choose **SAVE** in the footer of the screen.

7. Press on the home icon to return to the home screen.

8. Connect the BNC cable to the liquid level sensor.
4.2.6 Performing an Open Dewar Calibration

1. Press the **MENU** button in the lower left corner of the display screen.

2. Choose the **SENSORS** selection from the **MENU** screen.

3. Press the **CALIBRATE NITROGEN** button

4. Position the capacitance sensor in the target liquid at the 100% level. Hold the sensor at this location and press the **PERFORM MAX CAL** button.
5. The instrument will display the following screen as it takes data for several seconds. Once the calibration measurement is completed, press the SAVE button.

6. Position the capacitance sensor in the target liquid at the 0% level. Hold the sensor at this level and press the PERFORM MIN CAL button.

7. After several seconds of displaying “CALIBRATING...”, the instrument will complete the calibration process. Press the SAVE button to save the new calibration set point.

---

**Note**

Note that the frequencies listed to the right of the PERFORM MAX and MIN CAL buttons are updated as well as the date and time stamps of the calibration points.

---

**Note**

The Minimum and Maximum calibration can be performed in either order. Also, either the Minimum or Maximum calibration point can be updated without altering the other calibration point.

### 4.2.7 Approximate Calibration

This procedure is the least accurate form of calibration and should be used only when the aforementioned calibration procedures are not viable. The approximate calibration method can be used in cases where the sensor cannot be dipped into the target liquid, the full active length of the sensor cannot be dipped into an open dewar, or both. Approximate calibration may also be useful for situations where the sensor cannot be dipped into the target liquid under the expected operating pressure.

If the target liquid is not available for dipping, a substitute non-conducting reference liquid can be used. If the full length of the
sensor cannot be dipped, then a partial length dip can be performed. If both situations are encountered, then a partial length dip can be performed in a substitute reference liquid.

1. Press the **MENU** button in the lower left corner of the display screen.

2. Choose the **SENSORS** selection from the **MENU** screen.

3. Press the **CALIBRATE NITROGEN** button

4. Position the capacitance sensor in the target liquid at the 100% level. Hold the sensor at this location and press the **PERFORM MAX CAL** button.
Calibration
Capacitance-Based Level Calibration: Approximate Calibration Procedure

5. The instrument will display the following screen as it takes data for several seconds. Once the calibration measurement is completed, press the SAVE button.

6. Position the capacitance sensor in the target liquid at the 0% level. Hold the sensor at this level and press the PERFORM MIN CAL button.

7. After several seconds of displaying "CALIBRATING...", the instrument will complete the calibration process. Press the SAVE button to save the new calibration set point.

**Note**

Note that the frequencies listed to the right of the PERFORM MAX and MIN CAL buttons are updated as well as the date and time stamps of the calibration points.

**Note**

The Minimum and Maximum calibration can be performed in either order. Also, either the Minimum or Maximum calibration point can be updated without altering the other calibration point.

8. Measure the distance between the bottom hole of the sensor and the location of the liquid level dipped for max calibration. This measured length is $L_{dipped}$.

9. The dielectric constant for the reference liquid, $e_1$, and the target liquid, $e_2$, must be known to complete the approximate calibration. These values must be placed in the equation:

$$\text{Approximate Calibration Factor} = \left[ \frac{e_2 - 1}{e_1 - 1} \times 100 \right] \frac{L_{active}}{L_{dipped}}$$
where \( L_{\text{dipped}} \) is the length of the sensor dipped in the reference liquid and \( L_{\text{active}} \) is the active sensor length.

**Note**

*If the target liquid is available for dipping (i.e., the reference liquid and target liquid are the same), then the dielectric ratio, \((e_2 - 1)/(e_1 - 1)\), becomes 1. If the full active length of the sensor can be dipped, then the length ratio, \( L_{\text{active}} / L_{\text{dipped}} \), becomes 1.*

Note that \( e_1 = 1.454 \) for liquid nitrogen at -203°C at atmospheric pressure. Dielectric constants for several liquids are provided in the Appendix. The dielectric constant varies with temperature and pressure, therefore for best accuracy use the dielectric constant for the target liquid at the temperature and pressure maintained in the containing vessel.

10. Touch the **APPROX. CAL. VALUE** field and using the numerical keypad that pops up, enter the Approx Cal Value to be applied.

11. Press the **APPLY** button and note that the Approximate Calibration value will be used to scale the **MAX** Calibration frequency displayed adjacent to the **PERFORM MAX CAL** button and the value entered into the **APPROX. CAL. VALUE** field will vanish.

**Note**

The last approximate calibration factor is not retained in the instrument memory, therefore the effects of repeated approximate calibrations are cumulative.

Example: Purchased a 100" active length sensor for operation in liquid argon at atmospheric pressure, however only liquid nitrogen is available for calibration at a maximum depth of 30":

First, the sensor is dipped as far as possible into the liquid nitrogen and cooled. The minimum point is then set as outlined
in step 2. The maximum point is set as outlined in step 3 while the sensor is submerged 30" in liquid nitrogen. The dielectric constant for liquid nitrogen is 1.454 and for liquid argon is 1.53. Substituting all values into the approximate calibration factor equation yields:

\[
\text{Approximate Calibration Factor} = \left[ \frac{1.53 - 1}{1.454 - 1} \times 100 \right] \frac{100}{30} = 389.1
\]

A value of 389.1 would be entered as the approximate calibration factor as outlined in steps 6 and 7. The sensor is now approximately calibrated for 100" active length operation in liquid argon.

12. The sensor can now be installed in the dewar containing the target liquid. The approximate calibration can be used until an open dewar or closed dewar calibration can be performed with the target liquid.

4.2.8 Closed Dewar Calibration

A calibration can be performed in a closed dewar system by monitoring the liquid level while transferring the target liquid to an initially empty (or near empty) dewar at a constant rate. In order to insure success with the closed dewar technique, it is necessary to prepare the instrument by presetting the calibration minimum and maximum calibration points outside the estimated level range. If the instrument is not prepared in this manner before the calibration procedure, it is possible to reach the maximum calibration point of the instrument before the target vessel is at the desired maximum level point. If minimum and maximum liquid level indication is available via some other means (e.g. flow calculation, visual determination, point sensors, etc.), then the presetting of the instrument is not necessary.

4.2.8.1 Presetting the maximum and minimum calibration points

The following procedure should be performed before installation of the sensor in the target cryo-vessel.

1. Connect the sensor coaxial cable to the BNC connector on the rear panel of the instrument (Refer to “Connecting the Sensor to the Instrument” on page 12). Do not connect the sensor. Energize the instrument.
2. Press the **MENU** button in the lower left corner of the display screen.

3. Choose the **SENSORS** selection from the **MENU** screen.

4. Press the **CALIBRATE NITROGEN** button.

5. Press the **PERFORM MIN CAL** button.

6. After several seconds of displaying “**CALIBRATING...**”, the instrument will complete the calibration process. Press the **SAVE** button to save the new calibration set point.

**Note**

*Note that the frequency listed to the right of the **PERFORM MIN CAL** button is updated as well as the date and time stamp of the calibration point.*
7. Connect the sensor to the oscillator coaxial cable that is connected to the instrument.

8. Perform the maximum level calibration by invoking the maximum calibration function by pressing **MENU > SENSORS > CALIBRATE NITROGEN > PERFORM MAX CAL**.

9. Save the calibration value.

10. Calculate the factor $C_{adj}$ using the following equation:

    \[
    C_{adj} = 120 \left[ 1 + \frac{2.1(L_{active})}{5.2(L_{total})} \right] e - 0.454
    \]

    where $L_{total}$ is the total sensor length in inches, $L_{active}$ is the active sensor length in inches, and $e$ is the dielectric constant of the target liquid.

11. Enter $C_{adj}$ into the instrument by touching the **APPROX CAL VALUE**: field.

12. Using the pop up numeric keypad, enter the $C_{adj}$ value and press the **APPLY** button.

13. With the sensor connected, again press the **PERFORM MIN CAL** button. The presetting procedure is complete. Proceed to the remainder of the closed dewar calibration procedure as presented below.

4.2.8.2 Completing the closed dewar calibration procedure

1. Install the sensor in the dewar and energize the instrument with the sensor connected to the instrument via the oscillator (if required) and extension cable(s) (see the system diagram on page 2).

2. Connect a strip chart recorder or graphical data logging application to the recorder output terminals on the rear panel of the instrument. If the recorder output is not available, the 4-20 mA current loop output may be used if installed, or an installed...
communications option can be used to query the instrument for the liquid level at regular time intervals during the calibration procedure. If no remote monitoring or communication option is installed, the level display must be manually plotted vs. time during the procedure.

3. Refer to “Analog output signals” on page 32 to configure the recorder output or current loop output.

4. Commence filling the dewar. While the sensor is cooling down, there may be a slow drift in the displayed liquid level. However, when the liquid actually touches the bottom of the sensor, contact with the liquid surface may become apparent by virtue of more random and frequent fluctuations in the displayed liquid level. The liquid level trace will also start to show an increasing profile with positive slope.

Once the indications of the contact between the sensor and liquid become readily apparent, use the PERFORM MIN CAL procedure below to reset the new minimum calibration point. This point is the 0% level of the sensor when the PERFORM MIN CAL procedure is finished and saved becomes the 0% level.

**Note**

*If the sensor is installed in the dewar with some small amount of liquid already in contact with the sensor, then the final minimum calibration point can be set before filling begins but after any thermally induced fluctuations in the observed output have diminished. However, note that the measured span of the liquid level is reduced by the initial level of liquid in contact with the sensor.*

5. Perform the minimum level calibration by invoking the minimum calibration function by pressing **MENU > SENSORS > CALIBRATE NITROGEN > PERFORM MIN CAL.**

6. After several seconds of displaying “CALIBRATING...”, the instrument will complete the calibration process. Press the **SAVE** button to save the new calibration set point.
Calibration
Capacitance-Based Level Calibration : Closed Dewar Calibration Procedure

**Note**

Note that the frequency listed to the right of the \textit{PERFORM MIN CAL} button is updated as well as the date and time stamp of the calibration point.

7. Continue the transfer while observing the liquid level trace on the strip chart recorder or computer display, whose slope is proportional to the transfer rate. The slope of the liquid level trace should decrease significantly when the liquid reaches the hole in the top of the sensor.

When the break in the slope of the level trace occurs (i.e. the slope of the level trace becomes 0 or horizontal), perform a \textit{PERFORM MAX CAL} procedure below. The level on the sensor when the \textit{PERFORM MAX CAL} procedure is finished and saved becomes the 100% level.

**Note**

If the instrument displayed a 100% reading before a break is observed in the slope of the level trace, then the maximum calibration point set prior to the current procedure has interfered. If this occurs, the customer has two options: 1) stop the procedure, repeatedly enter a value of 120 for $C_{adj}$ (see steps 4 and 5 of the presetting procedure) until the current liquid level display falls below 100%, and then continue the procedure; or 2) continue the liquid transfer until the liquid level is determined to be 100% by means other than feedback from the instrument and then performing the maximum calibration procedure.

8. Perform the maximum level calibration by invoking the maximum calibration function by pressing \textbf{MENU > SENSORS > CALIBRATE NITROGEN > PERFORM MAX CAL}.

\begin{figure}
\centering
\includegraphics[width=0.5\textwidth]{figure4-42.png}
\caption{PERFORM MAX CAL. Selection Button}
\end{figure}
9. The instrument will display the following screen as it takes data for several seconds. Once the calibration measurement is completed, press the SAVE button.

**Note**

*Note that the frequency listed to the right of the PERFORM MAX CAL button is updated as well as the date and time stamp of the calibration point.*

10. To achieve a standard calibration of the sensor with the active region located from the lower hole to one inch below the upper hole, use the level data from the instrument to recalibrate the maximum point when the percent level corresponds to one inch below the upper hole. Use the following equation to determine the percent level at which to reset the maximum calibration point:

\[
MAX_{\text{percent}} = 100 - 100 \left( \frac{1}{L_{\text{active}}} \right)
\]

where \(L_{\text{active}}\) is the active length of the sensor in inches. This technique can be used assuming the sensor was built as a standard sensor. If the sensor was made in a custom configuration, refer to the sensor documentation and/or drawing or contact AMI.

**Example: 20” active length sensor:**

When the sensor is calibrated by the closed dewar procedure, the actual length of calibration will be 21” (distance between the bottom and top holes in the sensor). When the liquid is 1” below the upper hole, the display will show 95.2% [e.g. 100% – (1”/21” x 100%)] . When the liquid level reaches this point during usage, perform the **PERFORM MAX CAL** operation. The instrument and sensor are now calibrated with a standard active region of 20”. The length setting of the sensor in the instrument should also be configured for 50.8 cm (20”).

Proceed to the **Operation** section for directions for configuring the instrument.
Calibration
Capacitance-Based Level Calibration : Closed Dewar Calibration Procedure
Calibration
Capacitance-Based Level Calibration: Closed Dewar Calibration Procedure
The Model 1700 Instrument provides both serial (RS-232) and Ethernet interfaces as standard features. The serial and Ethernet interfaces can be operated simultaneously. Separate output buffers are also provided for the serial and Ethernet return data. However, for optimal performance and simplicity of programming, AMI recommends limiting normal operation to one interface. An exception to this recommendation would be using the serial port as a debugging aid during programming of the Ethernet port, or vice-versa, which can prove to be a useful resource.

The Model 1700 also allows a browser connection via TCP/IP. The instrument’s IP address can be ascertained by referring to the section titled “IP Addressing Scheme” on page 33. By using a browser to connect to the instrument, all functionality of the Model 1700 can be controlled via the browser.

5.1 SCPI Command Summary

The following manual conventions are used for SCPI (Standard Commands for Programmable Instruments) syntax for the remote interface commands:

- Braces {} enclose valid parameter choices.
- A vertical bar | separates multiple choices for each parameter.

For example, the command `CONFigure:TIME:DST {0|1}` indicates that the command `CONFigure:TIME:DST` has two parameter options: 0 or 1.

The following section is a reference list of SCPI commands. Refer to the detailed description of each command for information regarding specific parameter choices and their meanings. Capitalized portions of the commands indicate acceptable abbreviations. Default settings are shown in bold.

5.2 SCPI Ethernet Communication

The Ethernet port via an RJ-45 connector on the rear of the instrument allows a computer to communicate with the instrument using the SCPI commands described in “Command Set Reference” on page 63. The host computer must run a Telnet program, such as PuTTY\(^1\), and connect to port 7180.

\(^1\) http://www.chiark.greenend.org.uk/~sgtatham/putty/
5.3 SCPI Serial (RS-232) Communication

An RS-232 serial communication port is available as a 9-pin D-type connector on the rear panel of the instrument for serial communication function.

5.3.1 Serial port connector and cabling

An PC-compatible computer’s serial port can be directly connected to the Model 1700 via a standard cable. Refer to the computer’s documentation to determine which serial ports are available on a computer and the required connector type.

The Model 1700 uses three wires of the rear-panel DB25 connector: pin 2 (transmit), pin 3 (receive), and pin 7 (common). There is no software or hardware handshaking. The Model 1700 is classified as a DCE (Data Communication Equipment) device since it transmits data on pin 3 and receives data on pin 2. The instrument to which the Model 1700 is attached must do the opposite, i.e., transmit on pin 2 and receive on pin 3 (the requirements for a DTE, or Data Terminal Equipment device). If a serial-to-parallel converter is used, it must be capable of receiving data on pin 3 or the cable connected to the Model 1700 must interchange the wires between pins 2 and 3.

5.4 Command/return termination characters

All commands are transmitted and received as ASCII values and are case insensitive. The Model 1700 always transmits <CR><LF> (i.e. a carriage return followed by a linefeed) at the end of an serial transmission. The Model 1700 can accept <CR>, <LF>, <CR><LF>, or <LF><CR> as termination characters from an external computer.

The simplest method for communicating with the Model 1700 via RS-232 is by using the interactive mode of a commercially available terminal emulation program. The Model 1700 transmits and receives information at a baud rate of 115,200 and uses 8 data bits, no parity, and 1 stop bit. When the Model 1700 receives a terminated ASCII string, it always sends back a reply as soon as the string is processed. When sending commands to the Model 1700, you must wait for the reply from the Model 1700 before sending another command even if the reply consists of only termination characters. Otherwise, the shared input/output command buffer of the Model 1700 may become corrupted.

The host device can be a standard dot matrix printer connected via a serial-to-parallel converter, or connected directly with a printer capable of receiving serial data. Presumably, any serial-to-parallel converter which can be properly configured is acceptable. AMI has tested the Model 1700
with a standard, low cost converter configured as a DTE device, 115,200 baud, 8 data bits, no parity, and 1 stop bit. In order to communicate with the host device, it is necessary to set the terminal program to the identical baud rate of the host device.

5.5 Command Set Reference

All commands sent to the Model 1700 are processed and the Model 1700 responds with a return value (if applicable) and termination. If the command is invalid, the Model 1700 will respond with an error code (see the Error Codes section). All return values including error codes are terminated with <CR><LF> (i.e. a carriage return followed by a linefeed). For those commands that do not return a value, the Model 1700 will return the <CR><LF> termination only.

The remote units settings are saved in non-volatile memory and are restored at power-up.

The Model 1700 instrument may be configured for reading liquid nitrogen, liquid helium, or both. Some commands will not be applicable if the instrument is not configured for certain level measurement.

5.5.1 Commands for determining the instrument configuration

Command: N2?
Function: Returns a 0 if the instrument is not configured to read liquid nitrogen level, a 1 if it is with the internal oscillator, and a 2 if it is with an external oscillator/transmitter.
Returns: 0, 1 or 2<CR><LF>
Default: N/A

Command: HE?
Function: Returns a 0 if the instrument is not configured to read liquid helium level, a 1 if instrument is configured to read 4.2K liquid helium level for sensors of active length ≤ 40 inches, 2 if instrument is configured to read 4.2K liquid helium level for sensors of active length ≤ 80 inches, a 3 if the instrument is configured to read 2K liquid helium level for sensors of active length ≤ 40 inches, 5 if instrument is configured to read 2K liquid helium level for sensors of active length ≤ 80 inches.
Returns: 0, 1, 2, 3, 4 or 5<CR><LF>
Default: N/A
Remote Interface Reference
Command Set Reference: Instrument Configuration Queries

**Command:** DISPLAY:N2?
**Function:** Returns a 0 if the instrument is not configured to display liquid nitrogen level on the home screen and a 1 if it is.
**Returns:** 0 or 1<CR><LF>
**Default:** N/A

**Command:** DISPLAY:HE?
**Function:** Returns a 0 if the instrument is not configured to display liquid helium level on the home screen and a 1 if it is.
**Returns:** 0 or 1<CR><LF>
**Default:** N/A

**Command:** UNIT
**Function:** Returns the current liquid level units in use.
**Returns:** C, I, or %<CR><LF>
**Default:** %

**Command:** N2:UNIT?
**Function:** Returns the current liquid nitrogen level units in use.
**Returns:** C, I, or P<CR><LF>
**Default:** P

**Command:** RELAY1:CHANNEL?
**Function:** Returns a 0 if relay №1 is disabled, a 1 if the relay is assigned to the nitrogen channel, and a 2 if the relay is assigned to the helium channel.
**Returns:** 0, 1, or 2<CR><LF>
**Default:** 0

**Command:** RELAY2:CHANNEL?
**Function:** Returns a 0 if relay №2 is disabled, a 1 if the relay is assigned to the nitrogen channel, and a 2 if the relay is assigned to the helium channel.
**Returns:** 0, 1, or 2<CR><LF>
**Default:** 0

**Command:** FILL:CHANNEL?
**Function:** Returns a 0 if the auto fill relay is disabled, a 1 if the relay is assigned to the nitrogen channel, and a 2 if the relay is assigned to the helium channel.
**Returns:** 0, 1, or 2<CR><LF>
**Default:** 0
Remote Interface Reference
Command Set Reference: Instrument Configuration Queries

Command: RELAY1:OPeration?
Function: Returns a 0 if relay №1 closes (alarms) when the level is above the setpoint and a 1 if the relay closes (alarms) when the relay is below the setpoint. By default, relay №1 is configured as the high level relay with alarm condition when level is greater than the setpoint.
Returns: 0 or 1<CR><LF>
Default: 0

Command: RELAY2:OPeration?
Function: Returns a 0 if relay №2 closes (alarms) when the level is below the setpoint and a 1 if the relay closes (alarms) when the relay is above the setpoint. By default, relay №2 is configured as the low level relay with alarm condition when level is less than the setpoint.
Returns: 0 or 1<CR><LF>
Default: 0

Command: HI
Function: Returns the HI setpoint limit (default: relay №1) in the current units.
Returns: <value><CR><LF>
Default: 90%

Command: LO
Function: Returns the LO setpoint limit (default: relay №2) in the current units.
Returns: <value><CR><LF>
Default: 10%

Command: RELAY1:SETpoint?
Function: Returns the Relay №1 setpoint in the current units
Returns: <value><CR><LF>
Default: 90%

Command: RELAY2:SETpoint?
Function: Returns the Relay №2 setpoint in the current units
Returns: <value><CR><LF>
Default: 10%
Remote Interface Reference
Command Set Reference: Instrument Configuration Queries

Command: A
Function: Returns the A setpoint limit (auto fill stop level) in the current units
Returns: <value><CR><LF>
Default: 80%

Command: B
Function: Returns the A setpoint limit (auto fill start level) in the current units
Returns: <value><CR><LF>
Default: 20%

Command: INTERVAL
Function: Returns the fill timer setting in minutes if the instrument is configured for the nitrogen channel. Returns the sampling interval in minutes if the instrument is configured for the helium channel.
Returns: <value><CR><LF>
Default: 15

Command: N2:INTERVAL?
Function: Returns the fill timer setting in minutes if the instrument is configured for the nitrogen channel.
Returns: <value><CR><LF>
Default: 15

Command: LENGTH
Function: Returns the sensor active length in the current units.
Returns: <value><CR><LF>
Default: N/A

Command: SOURCE:REC_OUT?
Function: Returns a 0 if the 0-10 VDC Recorder Output is disabled, a 1 if it is configured for the nitrogen channel, and a 2 if it is configured for the helium channel.
Returns: 0, 1, or 2<CR><LF>
Default: 0
Remote Interface Reference
Command Set Reference: Instrument Configuration Queries

Command: SOURCE:CURRent_LOOP?
Function: Returns a 0 if the 4-20 mA Current Loop Output is disabled, a 1 if it is configured for the nitrogen channel, and a 2 if it is configured for the helium channel.
Returns: 0, 1, or 2
Default: 0

Command: NAME:SENSor:N2?
Function: Returns the name of the nitrogen level sensor.
Returns: <string>
Default: Nitrogen Level

Command: SERial_NUMber?
Function: Returns the serial number of the instrument.
Returns: <string>
Default: N/A

Command: HardWare_VERsion?
Function: Returns the hardware version of the instrument.
Returns: <string>
Default: N/A

Command: DATE_MANUFacture?
Function: Returns the date of manufacture of the instrument.
Returns: <string>
Default: N/A

Command: FirmWare_VERsion?
Function: Returns the firmware version of the instrument.
Returns: <string>
Default: N/A

Command: HElium_PowerSupply?
Function: Returns the helium power supply configuration of the instrument where 0 is not installed, 1 is standard, and 2 is XL version.
Returns: 0, 1, or 2
Default: N/A
5.5.2 Commands for setting the units of measurement

Command: CM
Function: Sets the liquid level units of measurement to centimeters.
Returns: <CR><LF>
Default: N/A

Command: INCH
Function: Sets the liquid level units of measurement to inches.
Returns: <CR><LF>
Default: N/A

Command: PERCENT
Function: Sets the liquid level units of measurement to percent of active sensor length.
Returns: <CR><LF>
Default: N/A

Command: CONFigure:N2:UNIT <value>
Function: Sets the liquid nitrogen level units of measurement to percent (0, or PERCENT), centimeters (1, or CM), or inches (2, or INCH)
Returns: <CR><LF>
Default: N/A
5.5.3 Commands for configuring setpoints

Command: CONFigure:RELAY1:CHannel <value>
Function: Assigns relay 1 to either no channel (disabled) (0), nitrogen (1), or helium (2).
Returns: <CR><LF>
Default: 0

Command: CONFigure:RELAY2:CHannel <value>
Function: Assigns relay 1 to either no channel (disabled) (0), nitrogen (1), or helium (2).
Returns: <CR><LF>
Default: 0

Command: CONFigure:RELAY1:OPeration <value>
Function: Configures relay №1 such that it closes (alarms) when the level is ≤ the setpoint (0) or ≥ the setpoint (1).
Returns: <CR><LF>
Default: 1

Command: CONFigure:RELAY2:OPeration <value>
Function: Configures relay №2 such that it closes (alarms) when the level is ≤ the setpoint (0) or ≥ the setpoint (1).
Returns: <CR><LF>
Default: 0

Command: CONFigure:FILL:CHannel <value>
Function: Assigns the auto fill control relay to either no channel (disabled) (0), nitrogen (1), or helium (2).
Returns: <CR><LF>
Default: 0
Note: If the relay is not assigned to a channel, the units are assumed to be percent.

Command: CONFigure:RELAY1:SETpoint <value>
Function: Configures the relay №1 trip setpoint in the current channel’s units.
Returns: <CR><LF>
Default: 20
Note: If the relay is not assigned to a channel, the units are assumed to be percent.
Command: CONFigure:RELAY2:SETpoint <value>
Function: Configures the relay №2 trip setpoint in the current channel’s units.
Returns: <CR><LF>
Default: 80

Command: HI=<value>
Function: Sets the HI setpoint in the current units (Relay №1).
Returns: <CR><LF>
Default: 80

Command: LO=<value>
Function: Sets the LO setpoint in the current units (Relay №2).
Returns: <CR><LF>
Default: 20

Command: A=<value>
Function: Sets the A setpoint (control band upper limit).
Returns: <CR><LF>
Default: 60
Note: The A setpoint (autofill stop) must be greater than the B setpoint (fill start) and must also be between 0 and 100%.

Command: B=<value> or CONFigure:FILL:B <value>
Function: Sets the B setpoint (control band lower limit).
Returns: <CR><LF>
Default: 40
Note: The B setpoint (autofill start) must be less than the A setpoint (fill stop) and must also be between 0 and 100%.

Command: INTERVAL=<value>
Function: Sets the liquid nitrogen fill time out value in minutes.
Returns: <CR><LF>
Default: 15
Note: Setting the value of INTERVAL to 0 disables the fill timer function. The maximum value allowable is 600 minutes.

Command: CONFigure:INTerval:FILL <value>
Function: Sets the fill timer in minutes.
Returns: <CR><LF>
Default: 15
Note: Setting the value of FILL to 0 disables the fill timer function.
Remote Interface Reference
Command Set Reference: Configuring Setpoints

Command: CONFigure:SOURCE:REC_OUT <value>
Function: Configures the 0-10 Vdc Recorder Output’s source to disabled (0), assigned to the nitrogen channel (1), or the helium channel (2).
Returns: <CR><LF>
Default: 0

Command: CONFigure:SOURCE:CURRENT_LOOP <value>
Function: Configures the 4-20 mA Current Loop’s output source to disabled (0), assigned to the nitrogen channel (1), or the helium channel (2).
Returns: <CR><LF>
Default: 0

Command: SAVE
Function: None. Allows Model 18x and Model 13x backwards compatibility.
Returns: <CR><LF>
Default: N/A
5.5.4 Commands for setting the channel identifiers

Command:  CONFigure:NAME:SENSOR:N2=<“string”>
Function:  Sets the name of the nitrogen level sensor.
Returns:   <CR><LF>
Default:   Nitrogen Level
5.5.5 Commands for making liquid level measurements

**Command:** LEVEL
**Function:** Returns the liquid nitrogen or helium level in the current units.
**Returns:** `<value><CR><LF>`
**Default:** N/A

**Command:** MEASure:N2:LEVel?
**Function:** Returns the liquid nitrogen level in the current units.
**Returns:** `<value><CR><LF>`
**Default:** N/A

**Command:** MEASure:N2:PERIod?
**Function:** Returns the liquid nitrogen level measurement period in microseconds.
**Returns:** `<value><CR><LF>`
**Default:** N/A
5.5.6 Commands for calibrating level sensors

**Command:** MINCAL
**Function:** Performs a minimum calibration point calibration.
**Returns:** <CR><LF>
**Default:** N/A

**Command:** MAXCAL
**Function:** Performs a maximum calibration point calibration.
**Returns:** <CR><LF>
**Default:** N/A

**Command:** CONFigure:N2:LENGTH=<value>
**Function:** Configures the liquid nitrogen sensor active length in current units.
**Returns:** <CR><LF>
**Default:** N/A
**Note:** Returns -5 if the current units are percent.

**Command:** LENGTH=<value>
**Function:** Configures the liquid nitrogen liquid level sensor active length in current units.
**Returns:** <CR><LF>
**Default:** N/A

**Command:** NOSENSCAL
**Function:** Calibrates the loss of sensor point for the LN₂ measurement function.
**Returns:** <CR><LF>
**Default:** N/A
5.5.7 System Commands

Command: SYStem:BEEPer:IMMediate,<time>
Function: The receipt of this command causes an audible tone to be generated by the instrument. Note that this command generates an event and therefore it has no associated SYS:REBOOT state or query form. The duration time parameter is specified in seconds.
Returns: <CR><LF>
Default: N/A

Command: SYStem:BEEPer:STATe <Boolean>
Function: Enables/disables the beeper. When STATe 0 is selected, no instrument condition, except the :SYStem:BEEPer:IMMediate command, shall cause an audible beep to be emitted. At SYS:REBOOT, this value is reset to 1.
Returns: <CR><LF>
Default: 1

Command: SYStem:DATE <year>,<month>,<day>
Function: <year> as a four-digit number; <month> Range is 1 to 12 inclusive; <day> Number of days in the month.
Returns: <CR><LF>
Default: N/A

Command: SYStem:DATE?
Function: Returns the system date.
Returns: <year>,<month>,<day><CR><LF>
Default: N/A

Command: SYStem:KLOCk<Boolean>
Function: This command locks the local controls of an instrument. This includes any front panel, keyboard, or other local interfaces. This value cannot be reset to OFF, unless SYStem:SECurity:STATe is OFF. If SYStem:SECurity:STATe is OFF, the KLOCk value is set to OFF at SYS:REBOOT. If SYStem:SECurity:STATe is ON, SYS:REBOOT has no effect.
Returns: <CR><LF>
Default: OFF

Command: SYStem:TIME <hour>,<minute>,<second>
Function: This command is used to set the instrument’s clock:
<hour> Range is 0 to 23 inclusive.
<minute> Range is 0 to 59 inclusive.
Remote Interface Reference
Command Set Reference : Calibration Functions

<second> Range is 0 to 60.
The query response message shall consist of three fields
separated by commas: <hour>,<minute>,<second>

**Returns:** <CR><LF>
**Default:** N/A

**Command:** SYStem:TIME?
**Function:** This command reads the instrument’s clock.
**Returns:** <hour>,<minute>,<second><CR><LF>
**Default:** N/A

**Command:** SYStem:REBOOT
**Function:** This command reboots the instrument.
**Returns:** <CR><LF>
**Default:** N/A

**Command:** SYStem:RESTORE
**Function:** This command reboots the instrument and sets all
parameters back to factory defaults.
**Returns:** <CR><LF>
**Default:** N/A

### 5.6 Error Codes

The Model 1700 returns specific error codes for invalid commands and/or
arguments. If an error condition is returned, the command is not processed
and the configuration of the instrument is not modified. The table below
provides a list of error codes, their meaning, and any associated limits.

<table>
<thead>
<tr>
<th>Error Code</th>
<th>Meaning</th>
<th>Valid Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>-1</td>
<td>LO (or relay №2a) setpoint out of range</td>
<td>0 ≤ LO (or relay №2a) ≤ LENGTH</td>
</tr>
<tr>
<td>-2</td>
<td>Fill B setpoint (fill start) out of range</td>
<td>0 ≤ B &lt; A</td>
</tr>
<tr>
<td>-3</td>
<td>Fill A setpoint (fill stop) out of range</td>
<td>B &lt; A ≤ LENGTH</td>
</tr>
<tr>
<td>-4</td>
<td>HI (or relay №1a) setpoint out of range</td>
<td>0 ≤ HI (or relay №1a) ≤ LENGTH</td>
</tr>
<tr>
<td>-5</td>
<td>Attempted to set or query for LENGTH in PERCENT units mode</td>
<td></td>
</tr>
<tr>
<td>Error Code</td>
<td>Meaning</td>
<td>Valid Range</td>
</tr>
<tr>
<td>------------</td>
<td>------------------------------------------------------</td>
<td>----------------------------------</td>
</tr>
<tr>
<td>-6</td>
<td>Invalid argument, value out of maximum calibration range</td>
<td>1 cm ≤ value ≤ 650 cm</td>
</tr>
<tr>
<td>-7</td>
<td>INTERVAL setting out of range</td>
<td>0 ≤ INTERVAL ≤ 600 min</td>
</tr>
<tr>
<td>-8</td>
<td>Unrecognized command</td>
<td></td>
</tr>
<tr>
<td>-9</td>
<td>Invalid argument, value was negative or non-numeric</td>
<td></td>
</tr>
<tr>
<td>-10</td>
<td>Approximate calibration factor out of range</td>
<td>0.1 ≤ factor ≤ 999.9</td>
</tr>
<tr>
<td>-11</td>
<td>Command exceeds SCPI input buffer limit</td>
<td>256 characters, including spaces, etc.</td>
</tr>
</tbody>
</table>

- Applies to dual instrument configuration
6 Service and Repair

6.1 Cleaning

To prevent electrical shock, disconnect the instrument from AC mains power and disconnect all connected wiring before cleaning. Clean the outside of the instrument using a soft, lint-free, cloth slightly dampened with water.

Do not use detergent or solvents.

Do not attempt internal cleaning.

6.2 User Replaceable Parts

Replacement parts for the instrument are listed in the table below.

<table>
<thead>
<tr>
<th>AMI Part Number</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>HG0128</td>
<td>Instrument foot</td>
</tr>
<tr>
<td>SA 1045</td>
<td>Single Rack Mount Kit</td>
</tr>
<tr>
<td>SA 1046</td>
<td>Dual Rack Mount Kit</td>
</tr>
<tr>
<td>EF1700</td>
<td>Fuse, 3 A, 250 Vac, 5x20 mm, fast acting, UL/CSA recognized.</td>
</tr>
<tr>
<td>HG0005</td>
<td>Battery, 3V lithium, 20mm x 3.2 mm coin cell; CR2032.</td>
</tr>
</tbody>
</table>
6.3 Battery Replacement

This section describes the procedure for replacing the battery on the instrument's main circuit board.

**Warning**

*This procedure should only be performed by a technician who is familiar with electronic instrumentation and trained in electrical safety and ESD precautions. Always disconnect the power cord and any external wiring before removing the instrument cover.*

Always disconnect all inputs, cords, and cables before disassembling the instrument.

6.3.1 Tools Required

- Torx Plus (T.M.) size 10 driver (Wera 028034 or equivalent)
- Torx Plus (T.M.) size 15 driver (Wera 028035 or equivalent)
- Small, flat-blade screw driver (for prying)

6.3.2 Procedure

1. Unplug the instrument from the AC power source.

2. Using the T-15 driver, remove the four 8-32 machine screws on the sides of the instrument cover. Set these screws aside as they will be re-used.

3. Using the T-10 driver, remove the four 6-32 machine screws on the rear of the instrument cover. Set these screws aside as they will be re-used.

4. Lift the instrument cover off of the instrument chassis and set aside.

5. Using the small, flat-blade screwdriver, carefully pry the battery from the holder BH1.

6. Install the new battery into the battery holder BH1.

7. Replace the top cover and secure using the eight machine screws which were removed previously.
6.4 Fuse Replacement

This section describes the procedure for replacing the two fuses on the instrument's main circuit board.

**Warning**

*This procedure should only be performed by a technician who is familiar with electronic instrumentation and trained in electrical safety and ESD precautions. Always disconnect the power cord and any external wiring before removing the instrument cover.*

Always disconnect all inputs, cords, and cables before disassembling the instrument.

6.4.1 Tools Required

- Torx Plus (T.M.) size 10 driver (Wera 028034 or equivalent)
- Torx Plus (T.M.) size 15 driver (Wera 028035 or equivalent)
- Small, flat-blade screwdriver (for prying)

6.4.2 Procedure

1. Unplug the instrument from the AC power source.

2. Using the T-15 driver, remove the four 8-32 machine screws on the sides of the instrument cover. Set these screws aside as they will be re-used.

3. Using the T-10 driver, remove the four 6-32 machine screws on the rear of the instrument cover. Set these screws aside as they will be re-used.

4. Lift the instrument cover off of the instrument chassis and set aside.

5. Using the small, flat-blade screwdriver, carefully pry the fuse(s) from the fuse holders F1 and/or F2.

6. Install the new fuse(s) into the fuse holder(s) F1 and/or F2.

7. Replace the top cover and secure using the eight machine screws which were removed previously.
A.1 Connector Wiring

The following sections document the connector pin outs and pin definitions.

A.1.1 Serial (RS-232) Connector

The RS-232 connector is a 9-pin D-sub female connector to connect standard DTE 9-pin D-sub male connector using a standard straight (not NULL) cable.

<table>
<thead>
<tr>
<th>Pin</th>
<th>Mnemonic</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>N/C</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>TXD</td>
<td>Transmit Data</td>
</tr>
<tr>
<td>3</td>
<td>RXD</td>
<td>Receive Data</td>
</tr>
<tr>
<td>4</td>
<td>N/C</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>GND</td>
<td>Signal Ground</td>
</tr>
<tr>
<td>6</td>
<td>N/C</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>CTS</td>
<td>Clear to Send</td>
</tr>
<tr>
<td>8</td>
<td>RTS</td>
<td>Request to Send</td>
</tr>
<tr>
<td>9</td>
<td>N/C</td>
<td></td>
</tr>
</tbody>
</table>

Figure A-1 Serial (RS-232) Pin Out

Table A-1 Serial (RS-232) Pin Definitions
A.1.2 Ethernet Connector

Figure A-2 Ethernet Connector Socket Pin out

Table A-2 Ethernet RJ-45 Connector Pin Definitions

<table>
<thead>
<tr>
<th>Pin</th>
<th>Mnemonic</th>
<th>Function</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>TXD+</td>
<td>Transmit differential output +</td>
</tr>
<tr>
<td>2</td>
<td>TXD-</td>
<td>Transmit differential output -</td>
</tr>
<tr>
<td>3</td>
<td>RXD+</td>
<td>Transmit differential input +</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>not used</td>
</tr>
<tr>
<td>5</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>RXD</td>
<td>Transmit differential input -</td>
</tr>
<tr>
<td>7</td>
<td></td>
<td>not used</td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### A.1.3 Aux I/O Connector

*Figure A-3 Aux I/O Connector*

Table A-3 Aux I/O Pin Definitions

<table>
<thead>
<tr>
<th>Pin</th>
<th>Function</th>
<th>Polarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>4-20 mA Current Loop</td>
<td>+</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>3</td>
<td>0-10 VDC Output</td>
<td>+</td>
</tr>
<tr>
<td>4</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>5</td>
<td>Relay № 2 Dry Contact</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td></td>
<td>N/A</td>
</tr>
<tr>
<td>7</td>
<td>Relay № 1 Dry Contact</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>External Reset</td>
<td></td>
</tr>
</tbody>
</table>
Appendix
Troubleshooting

A.2 Troubleshooting

The following paragraphs serve as an aid to assist the user in troubleshooting a potential problem with the Model 1700 Instrument. If the user is not comfortable in troubleshooting the system, contact an AMI Technical Support.

If the cause of the problem cannot be located, contact an AMI Technical Support Representative at +1 (865) 482-1056 for assistance. The AMI technical support group may also be reached by internet e-mail at:

support@americanmagnetics.com

A.3 Firmware Licenses

The Model 1700 firmware is based on a distribution of Debian Linux, with modifications to the Linux kernel by Technologic Systems and AMI, and additional user interface components by AMI. Some components of this firmware are licensed under agreements that require AMI to make source code available to interested parties. Other components require explicit acknowledgment of the authorship/ownership of the firmware and/or the terms under which it is licensed. In particular:

The Linux kernel version 2.6.34 is licensed under the GNU Public License, version 2. Source code for the version of the Linux kernel used in the Model 1700 is available from the Technologic Systems github repository at https://github.com/embeddedarm/linux-2.6.34-ts471x.git

AMI's modifications to that Linux kernel sources are available from: http://firmware.americanmagnetics.com/1700/kernel-patches.tar

The Model 1700 uses the “lighttpd” web server, available in source code form from https://www.lighttpd.net. It is made available under the following license:

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* @author Vincent Rijmen <vincent.rijmen@esat.kuleuven.ac.be>
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The source code to tslib was obtained by AMI from github.com using the
command:

`git clone https://github.com/kergoth/tslib`

The Model 1700's touchscreen browser was linked against the Qt libraries
for The X Window System that were available from the Debian package
repository. The source code for those libraries, as well as the compilers
and other tools required to recompile those libraries and the browser, are
available from the Debian repository using the normal Debian package
manipulation commands, e.g. pkg-add or symantic. The source code for
the browser is brief enough to be included here:

```c++
---begin file browser.cpp---
#include <QtGui>
#include <QtWebKit>
int main(int argc, char** argv) {
  QApplication app(argc, argv);
  QWebView view;
  view.setWindowFlags (Qt::FramelessWindowHint);
  view.showFullScreen ();
  view.setUrl(QUrl(argv[1]));
```
The Model 1700 firmware uses the Jansson library for encoding and decoding messages in the JSON (JavaScript Object Notation) format. The Jansson library is subject to the following license:

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## Abbreviations and Acronyms Used in This Manual

<table>
<thead>
<tr>
<th>Term</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>AC; ac</td>
<td>Alternating Current; strictly, electrical current that periodically reverses direction. Typically used also to describe an electrical power source in terms of the voltage. For example, 240 Vac.</td>
</tr>
<tr>
<td>ASCII</td>
<td>American Standard Code for Information Interchange; numerical representation of characters such as 'a' or '@' or an action (such as line-feed); 'plain' raw text with no formatting such as tabs, bold or underscoring</td>
</tr>
<tr>
<td>BNC connector</td>
<td>A miniature quick connect/disconnect RF connector used for coaxial cable, featuring two bayonet lugs on the female connector.</td>
</tr>
<tr>
<td>CR</td>
<td>Text Carriage-Return character</td>
</tr>
<tr>
<td>Cryogen</td>
<td>A substance for obtaining low temperatures. In the case of use with the Model 1700 instrument, a cryogen is a liquefied gas such as liquid nitrogen or liquid helium.</td>
</tr>
<tr>
<td>D-Sub</td>
<td>Term referring to the family of connectors containing an odd number of pins in two parallel rows with a 1-pin difference in pins-per-row (DB9, DB15, and DB25 are most common)</td>
</tr>
<tr>
<td>DB9</td>
<td>Type of electrical connector containing 9 pins arranged in two parallel rows of 4 pins and 5 pins each</td>
</tr>
<tr>
<td>DCE</td>
<td>Data Circuit-terminating Equipment - a device that sits between the Data Terminal Equipment (DTE) and a data transmission circuit.</td>
</tr>
<tr>
<td>DHCP</td>
<td>Dynamic Host Configuration Protocol; a computer networking protocol which dynamically distributes the IP address to networked devices</td>
</tr>
<tr>
<td>dt</td>
<td>Rate of change</td>
</tr>
<tr>
<td>DTE</td>
<td>Data Terminal Equipment - an end instrument that converts user information into signals or reconverts received signals. A DTE device communicates with the Data Circuit-terminating Equipment (DCE).</td>
</tr>
<tr>
<td>ECL</td>
<td>Electrical Connection Lubricant - also known as Dielectric Tune-up Grease, a protective lubricant that prevents corrosion.</td>
</tr>
<tr>
<td>E₀</td>
<td>Power supply output voltage</td>
</tr>
<tr>
<td>i, I</td>
<td>Electrical current flow</td>
</tr>
<tr>
<td>I₀</td>
<td>Power supply output current</td>
</tr>
<tr>
<td>IEC</td>
<td>International Electrotechnical Commission</td>
</tr>
</tbody>
</table>
## Glossary

<table>
<thead>
<tr>
<th>Term</th>
<th>Meaning</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEE</td>
<td>Institute of Electrical and Electronics Engineers</td>
</tr>
<tr>
<td>I/O</td>
<td>Input/Output; The hardware and associated protocol that implement communication between information processing systems and/or devices. Inputs are the signals or data received by the system or device, and outputs are the signals or data sent from it.</td>
</tr>
<tr>
<td>IP</td>
<td>Internet Protocol; when used with “address”, refers to a numerical Internet address</td>
</tr>
<tr>
<td>kG</td>
<td>kilogauss: a magnetic field unit of measurement</td>
</tr>
<tr>
<td>LED</td>
<td>Light-Emitting Diode; a semiconductor device that emits light when energized - used for visual status indication</td>
</tr>
<tr>
<td>LHe</td>
<td>Liquid Helium</td>
</tr>
<tr>
<td>Max</td>
<td>Maximum</td>
</tr>
<tr>
<td>Min</td>
<td>Minimum</td>
</tr>
<tr>
<td>MSDS</td>
<td>Material Safety Data Sheet - provides workers and emergency personnel with procedures for handling or working with a specific substance in a safe manner and includes information such as physical data, toxicity, health effects, first aid, reactivity, storage, disposal, protective equipment, and spill-handling procedures.</td>
</tr>
<tr>
<td>RG-59/U</td>
<td>A specific type of coaxial cable, often used for low-power video and RF signal connections, with a characteristic impedance of 75 ohms.</td>
</tr>
<tr>
<td>R&lt;sub&gt;lead&lt;/sub&gt;</td>
<td>Electrical circuit lead or wiring resistance</td>
</tr>
<tr>
<td>RS-232</td>
<td>RS-232 is a long-established standard and protocol for relatively low speed serial data communication between computers and related devices; originally established for teletypewriter communication.</td>
</tr>
<tr>
<td>SCPI</td>
<td>Standard Commands for Programmable Instruments</td>
</tr>
<tr>
<td>V</td>
<td>Volts</td>
</tr>
<tr>
<td>VA</td>
<td>Volt-amperes (V x I); a unit of electrical reactive power</td>
</tr>
<tr>
<td>V&lt;sub&gt;lead&lt;/sub&gt;</td>
<td>Voltage (I x R) developed across circuit lead or wiring resistance due to current flow</td>
</tr>
<tr>
<td>V&lt;sub&gt;m&lt;/sub&gt;</td>
<td>Magnet voltage</td>
</tr>
<tr>
<td>V&lt;sub&gt;s&lt;/sub&gt;</td>
<td>Power supply voltage</td>
</tr>
</tbody>
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