MODEL 1700
LIQUID LEVEL INSTRUMENT

(DUAL HELIUM & 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 both liquid nitrogen and liquid helium 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 level and/or monitor liquid helium level.

Calibration describes the various calibration techniques for liquid helium and 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.

GENERAL PRECAUTIONS

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 austinetic 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 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).

o Off (Supply) (Refer to IEC 417, No. 5008).

I 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 (LN_2) when referring to capacitance-based level measurement since nitrogen is by far the most common cryogenic liquid measured by a capacitance-based sensor. The capacitance sensor technology can be used to measure most any

cryogenic liquid, with the exception of liquid helium (LHe) which requires a superconductor-based sensor.

INSTRUMENT CONFIGURATION

The Model 1700 Instrument is configured at time of purchase in several ways:

- As a capacitance-based (typically liquid nitrogen) level instrument/controller.
- As a helium level instrument for level sensors with active length up to 80 inches (203 cm) for either 4.2K or 2K LHe.
- As a combination nitrogen and helium instrument/controller. Note that there is only one control channel even though the instrument can simultaneously display both liquid levels.

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, pig-tailed 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:

He2K = 2K helium for sensors

He4K = 4.2K helium for sensors

N = not configured

The sensor active length and length units are appended to the configuration code, ie ...He2K-40IN-...

E is used to denote any instrument customization:

S = standard (no customization)

C = instrument modified.

INTRODUCTION

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:

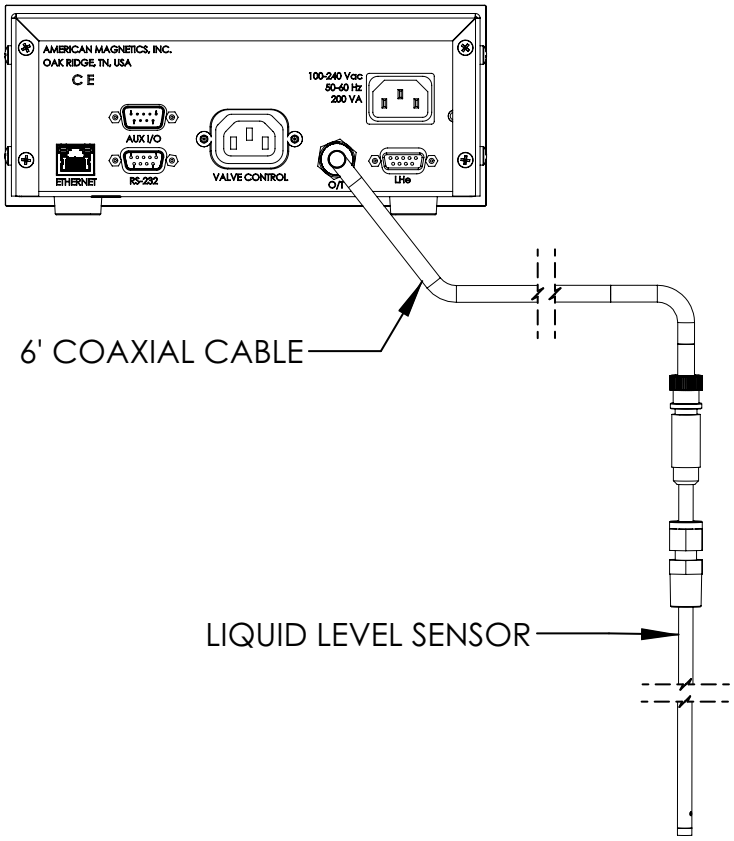
- A combination capacitance-based and helium level instrument/controller. Note that there is only one valve control channel (typically used for nitrogen auto fill systems) but both liquid levels can be displayed simultaneously.

The Model 1700 instrument will measure liquid helium level using a superconducting level sensor. The instrument will be factory configured for either 4.2K or 2K liquid helium level sensors at time of purchase.

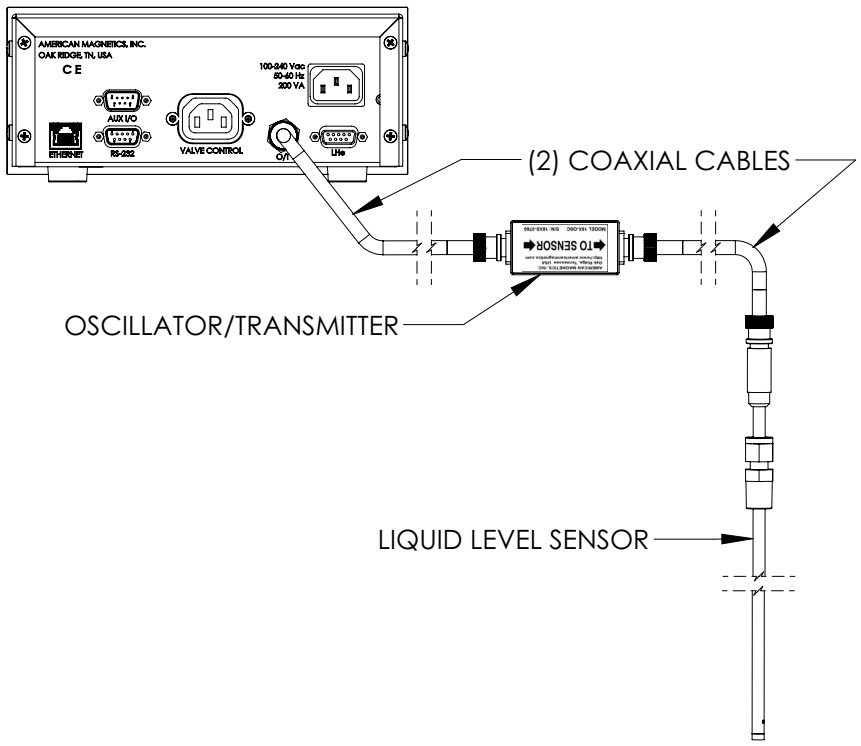
CRYOGENIC (CAPACITANCE-BASED) LIQUID LEVEL SENSORS

The Model 1700 Instrument will be used with a capacitance-based sensor for all cryogenic liquids except for helium. Specially insulated capacitance sensors are required for liquids with electrical conductivity, e.g. 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 configure itself at boot time to use the internal oscillator unless the external oscillator/transmitter is connected to the BNC connector on the rear panel.



Model 1700 Instrument using internal oscillator/transmitter



Model 1700 Instrument using external oscillator/transmitter

SUPERCONDUCTING LEVEL SENSORS

The instrument can be used with a superconducting level sensor to measure liquid helium levels. The instrument will be configured at the factory to measure liquid helium levels. The instrument is configured for level sensors of active lengths of 1 to 80 inches. The instrument can be used with either 4.2K or 2K level sensor types but must be configured and calibrated at time of purchase for the LHe level sensor type.

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.

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.

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.

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. Context-sensitive Help screens are also provided.

MEASUREMENT FLEXIBILITY

Depending on the instrument version purchased, the Model 1700 can be configured to monitor and display one capacitance-based liquid level sensor (LN_2 version) or one liquid helium level sensor (LHe version) or both simultaneously. 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.

REAL TIME CLOCK

The Model 1700 Instrument incorporates a real time clock, which can be manually set or synchronized via NTP, with support for worldwide timezones including automatic DST adjustment.

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.

ANALOG OUTPUTS

The Model 1700 Instrument has two analog outputs, a 0-10 V_{DC} voltage output and a 4-20 mA_{DC} current loop output. The 4-20 mA_{DC} loop output has 1500 V_{PK} circuit isolation. The outputs can be used simultaneously. The sources for either of the analog outputs can be either one of the two configured sensors. Both outputs can be driven from the same source, if desired.

SIGNAL RELAYS

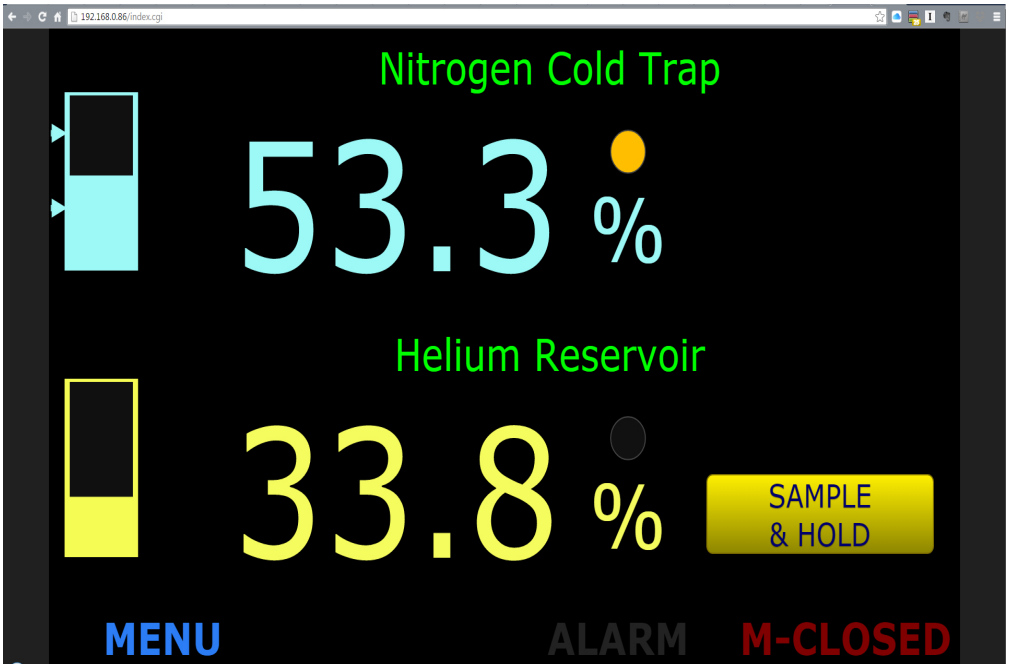
The Model 1700 Instrument has two signal relays that change state based on a measured input. The set points of these relays are user-selectable as is their function, alarm on level above or below set point.

For the dual channel instrument, both relays can be assigned to either channel. For the single channel instrument, both relays are assigned to the only channel.

CONNECTIVITY

The Model 1700 Instrument has a 10Base-T Ethernet connection as well as an 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.

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



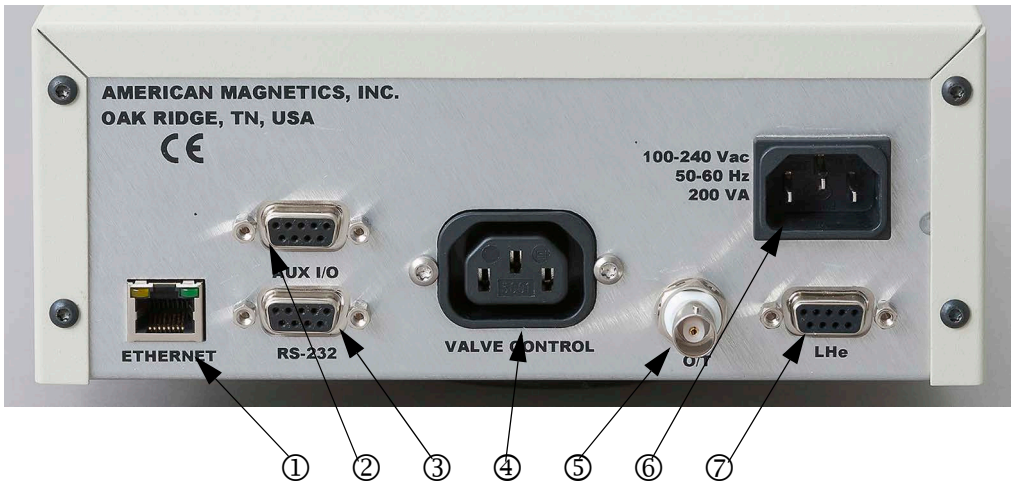
Model 1700 (Dual Display) Via Web Browser

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 33. Refer to "Configure the instrument to display helium level" on page 34.**

MODEL 1700 FRONT PANEL LAYOUT

Model 1700 Front View; Dual Channel Instrument Shown

MODEL 1700 REAR PANEL LAYOUT



Model 1700 Rear Panel Description

1	Computer Network Connector
2	Aux I/O Connector
3	RS-232 Serial Connector
4	Switched Valve Outlet Socket (IEC 60320 C13)
5	Capacitive Sensor Input Connector
6	Mains Power Entry Connector (IEC 60320 C14)
7	LHe Level Sensor Connector

MODEL 1700 SPECIFICATIONS @ 25°C

System Architecture

Display:	4.3” 24-bit color TFT display, 480x272 pixel with resistive touch screen
Sensor Types:	Capacitance-based liquid level Superconductivity-based liquid level
Maximum Length Readout:	Capacitance-based liquid level up to 999 in Superconductivity-based liquid level (LHe) up to 80 in
Superconducting (LHe) Sensor Excitation:	Continuous reading or Sample and Hold mode
System Operating Firmware Storage:	microSD card
System Clock:	Real time clock with timezone support, automatic DST adjustment, and NTP synchronization
Display Measurement Units:	Liquid level in cm, in or percent

Level Measurement

Resolution:	0.1%, 0.1 cm, 0.1 in
Accuracy:	±0.5% of active sensor length
Linearity:	±0.1% or 1 mm (whichever is greater)
Capacitance Sensor Excitation Voltage:	5 V_{DC}
Capacitance Transmitter Measurement Resolution:	0.7 pF
Extension Cable Limits with External Oscillator:	6-500 ft
Superconducting LHe Sensor Current:	4.2K LHe Temperature: 75 mA_{DC} nominal
	2K LHe Temperature: 57 mA_{DC} nominal
Dirty Sensor Mode:	Approximately twice normal current for 1 second prior to normal measurement excitation
Superconducting LHe Sensor Voltage:	4.2K Sensor: approximately 0.87 V_{DC} per inch of sensor active length @ 10K
	2K Sensor: approximately 0.66 V_{DC} per inch of sensor active length @ 10K
Maximum Open Circuit Voltage:	96 V_{DC}, galvanically isolated

Operating Parameters

Alarm Set Points:	0% to 100%, adjustable; Alarm condition settable to above or below set point; Assignable to any channel as high or low alarm for dual instrument
Controller Output:	Line voltage @ 2 A_{AC} (maximum)
Sample and Hold Period:	1 second to 86,400 seconds (24 hrs)
Audible alarm:	3500 ± 500 Hz, 73 to 86 dB(A)

Analog Outputs

Output Types:	0-10 V_{DC} and simultaneous 4 - 20 mA_{DC}; Each assignable to either level channel for dual instrument
4-20 mA Current Loop Power Supply Voltage:	12-32 V_{DC}
0-10 V_{DC} Recorder Output Load:	50k ohms or greater
0-10 V_{DC} Recorder Output 0% Max Offset:	+20 mV
0-10 V_{DC} Recorder Output 100% Max Error:	± 80 mV
Voltage and Current Output Converter Resolution:	12 bits
Integral Non-linearity:	±1LSB
Differential Non-linearity[a]:	±1LSB

Relays

№1 and/or №2 (W171DIP-7, or equivalent):	Contact Form: 1 Form A (SPST-NO) Maximum Switched Current: 3 A Switching Voltage: 60 V_{AC} / 100 V_{DC}
Level Control (Solid State):	Rated Load Voltage: 2 A at 100 to 240 V_{AC} Load Voltage Range: 75 to 264 V_{AC} (Line Dependent) Load Current: 0.1 to 2 A Surge Current: 30 A (60 Hz, 1 cycle)

Auto Fill

Controller Output Socket:	IEC 60320-13 socket on rear panel
Controller Output Power:	2 A_{AC} at line voltage
Autofill Start/Stop Triggering:	Level-based; 0% to 100%, adjustable; Assignable to either nitrogen or helium channel
Fill Timeout Period:	1 minute to 99 hours, 59 minutes
Fill Error Alarm:	Fill time out

Communication Protocol

Host Computer Network Protocol:	Ehternet 10Base-T TCP/IP and RS-232
IP Addressing:	DHCP or static, IPv4
Network Connectivity and Traffic Indication:	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.

Power Requirements

Primary:	100-240 ±10% V_{AC}, 50-60 Hz, 2.2 A maximum (200 VA plus sum of controller output)
Backup Battery for RTC:	CR2032

Physical

Dimensions[b]:	Table top configuration: 3.8” H x 8.4” W x 11.4” D [97 mm H x 213 mm W x 290 mm D] Single rack mount configuration: 3.5” H x 19.0” W x 11.4” D [89 mm H x 483 mm W x 290 mm 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:	Gauss (TBD)

Standards

Test Standards	Testing of Equipment for Measurement, Control, and Laboratory Use (IEC 61326-1:2012, EN 61326-1)
	Electrostatic Discharge (ESD) (EN 61000-4-2)
	Radiated Immunity (EN 61000-4-3)
	Fast Transient Burst (EN 61000-4-4)
	Surges (EN 61000-4-5)
	Conducted Immunity (EN 61000-4-6)
	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

INSTALLATION

WARNING **Equipment warnings apply to all system installation configurations. Refer to "Equipment Warnings" on page xi, in the Foreword to be familiar with the safety requirements for a system installation.**

UNPACKING AND INSPECTING THE INSTRUMENT

Carefully remove the equipment, interconnecting cabling, and documentation 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.**

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 by using a prying device to remove the glossy black cap from the center of the foot and then prying the rubber foot itself from the chassis. Secure the front panel to the rack rail in each of the four corners.

CAPACITANCE-BASED LIQUID LEVEL SENSOR INSTALLATION

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 53 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.**

CAUTION **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.**

CAUTION **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.

CAUTION **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.**

CONNECTING THE CAPACITANCE SENSOR

The capacitance 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 **In order to maintain system performance and accuracy, the coaxial cable used to connect the capacitance level sensor to the instrument or oscillator/transmitter must be Trompeter TCC-75-2 or equivalent 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.

NOTE **MSDS sheets for the ECL are available upon request.**

LIQUID HELIUM LEVEL SENSOR INSTALLATION

1. The sensor must be mounted with the electrical leads at the top.
2. For minimum losses, mount the liquid helium sensor so that warm helium gas rising from the sensor can pass directly out of the dewar without contacting surfaces at 4.2K.
3. Do not mount the sensor in restricted areas (tubes, etc.) where the liquid level around the sensor might be depressed by pressure differences in the gas. Do not cover the holes in the sensor.
4. The sensor may be mounted by taping or clipping it to an appropriate support structure. Do not exert excess pressure on the sensor with the mounting device to avoid crushing the tube. Avoid constraining both ends of the sensor and allow for contraction of the sensor during cooldown.

CAUTION **Do not operate the sensor in a vacuum. Operating the sensor in a vacuum may cause thermal damage and/or destruction of the superconducting filament sensor. Do not inadvertently turn the instrument on with the sensor in an evacuated chamber. Operation in pumped liquid helium environments is acceptable to 1K as long as liquid helium is present.**

5. Avoid installing in a location where icing (frozen water or gas) may occur since ice formations may cause erratic operation. Ice formation on the NbTi filament may stop the propagation of the normal (resistive) zone before it actually reaches the liquid/gas interface. This will give an indication of a higher helium level than actually exists.

6. Connect the sensor to the Model 1700 LHe Level Sensor connector on the instrument rear panel (refer to “Liquid Helium Connector J1 Wiring” on page 111). The liquid helium level sensor leads are color coded:

LHe Level Sensor Wire Identification

Wire Function	Teflon Insulation Color	Formvar Insulation Color	Instrument Connector Pin
I+	Red	Red	1
V+	Blue	Green	8
V-	Yellow	Natural	6
I-	Black	Blue	7

CONNECTING THE LIQUID HELIUM LEVEL SENSOR

The instrument is connected to the liquid helium level sensor with a 4-conductor cable which has a 9-pin D-sub male connector on one end that mates with the connector used at the instrumentation feed through connector on the cryostat. This connector is typically a multi-pin circular type connector.

Prepare the sensor to be connected to the instrument by soldering the sensor leads to a male 9-pin D-Sub connector which will connect to the female 9-pin D-Sub connector on the transmitter. Refer to the table on page 15 and the *Appendix* of this manual as well as the AMI sensor manual for the proper pin out and wire color connections. Connect the sensor to the **LHe** connector on the rear panel.

WARNING

Although the sensor connector terminals are isolated from earth ground and therefore touching one terminal is not hazardous, the voltage between terminals is at a hazardous potential. The sensor connector is for use with an AMI LHe sensor and the wiring for the sensor is to have no live parts which are accessible. Conductors connected to its terminals must be insulated from user contact by basic insulation rated for 150 V_{AC} (Category I).

The lead wire for the sensor may be sized by the following equation:

$$R = 420 - 5.21(L_A)$$

where R is the maximum allowable resistance (in ohms) for each lead wire from the instrument to the sensor, and L_A is the *active length* of the

connected helium level sensor in inches. Values for active sensor length vs. lead wire distance are provided in the table below.

Minimum recommended wire gauge for copper lead wire

<table>
<tr><td rowspan="2">Distance</td><td>R=367</td><td>R=315</td><td>R=263</td><td>R=211</td><td>R=107</td><td>R=3.2</td></tr>
<tr><td>L_A=10”</td><td>L_A=20”</td><td>L_A=30”</td><td>L_A=40”</td><td>L_A=60”</td><td>L_A=80”</td></tr>
<tr><td>10 ft.</td><td colspan="4" rowspan="8">36 AWG</td><td rowspan="7">36 AWG</td><td>34 AWG</td></tr>
<tr><td>20 ft.</td><td rowspan="3">30 AWG</td></tr>
<tr><td>30 ft.</td></tr>
<tr><td>40 ft.</td><td>28 AWG</td></tr>
<tr><td>50 ft.</td><td>27 AWG</td></tr>
<tr><td>100 ft.</td><td>24 AWG</td></tr>
<tr><td>200 ft.</td><td>22 AWG</td></tr>
<tr><td>500 ft.</td><td>32 AWG</td><td>16 AWG</td></tr>
</table>

NOTE **If the system is an Autofill system, proceed to section “Configuring an Autofill System” on page 17. If the installed capacitance or liquid helium level sensor(s) are used for indication only (not autofill), proceed to “Energizing the Model 1700 Instrument” on page 23.**

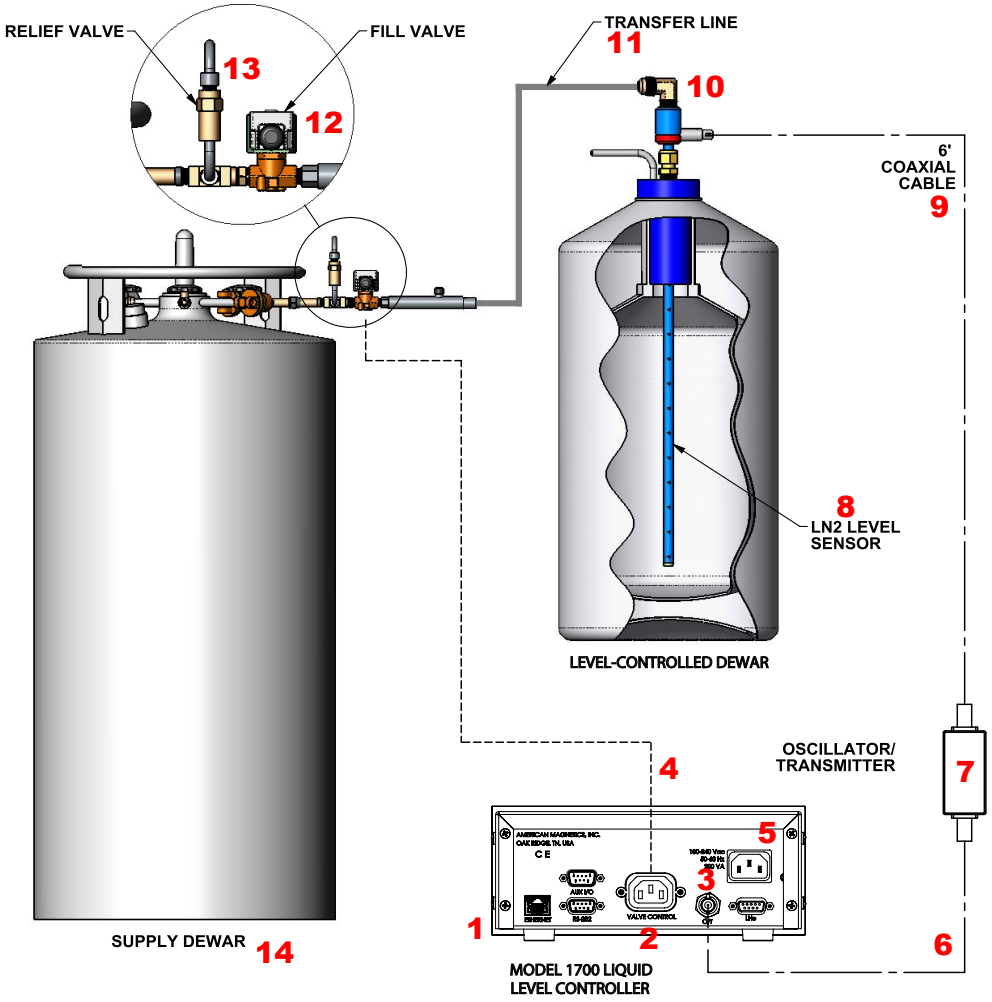
CONFIGURING AN AUTOFILL SYSTEM

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, or customized valving system for LHe application. The valve should be controlled by the Model 1700 Instrument.

LN2 AUTOFILL SYSTEM DESCRIPTION

For LN2 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.



Typical LN2 Autofill Setup

Standard Autofill Setup Description

Number	Item
1	Model 1700 Liquid Level Instrument (Level Controller)
2	IEC60320 C13 socket labeled **VALVE CONTROL**
3	BNC connector labeled **O/T**
4	Solenoid-operated flow control valve line cord with IEC60320 C14 plug
5	Instrument IEC60329 C14 Power cord inlet
6	Coaxial cable connecting the oscillator / transmitter and the instrument
7	**Oscillator / Transmitter** (optional; refer to the figure on page 13)
8	Level Sensor for level controlled or target dewar
9	Coaxial cable connecting the Oscillator / Transmitter and the liquid level sensor (optional; refer to the figure on page 13)
10	Fill port on target dewar
11	Transfer line attached to the target dewar and the fill solenoid valve on the source dewar
12	Solenoid-operated fill valve
13	Supply dewar relief valve
14	Supply dewar

LN2 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 LN2 transfer line systems include a relief valve to preclude this sort of event.**

CAUTION **The switched valve outlet socket switches the line voltage to which the instrument mains power is connected. Ensure any connected valve is rated to support the local VAC line voltage.**

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 capacitance sensor to the instrument.

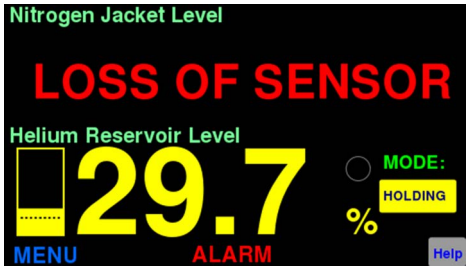
   a. For distances of 15 feet and less, connect the coaxial cable (**6**) between the BNC connector on the liquid level sensor and the BNC connector on the back of the instrument labeled **O/T** (**3**).

   b. For distances greater than 15 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**).

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 or an interconnecting cable fails, a LOSS OF SENSOR message will be displayed (as shown at right) 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.**



LHE AUTOFILL SYSTEM SETUP

An autofill system for LHe application is a more complex issue than simply selecting a solenoid-controlled valve that can be used for other cryogens such as LN2. The valving control must be highly-insulated to avoid vaporizing the transferred LHe. Contact an AMI Technical Support Representative to inquire about available LHe autofill solutions as this is a continually changing marketplace.

1. The valve socket must be IEC60320 C13 type.

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.**

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

Ensure 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.

CONNECTING THE ANALOG OUTPUTS

The Model 1700 instrument provides 0-10 V_{DC} and 4-20 mA_{DC} outputs as standard. These outputs may be optionally connected to external equipment per the instructions below.

NOTE **Both analog outputs can be connected to the same or different level measurement source as desired, and both will operate simultaneously.**

0-10 V_{DC} RECORDER OUTPUT

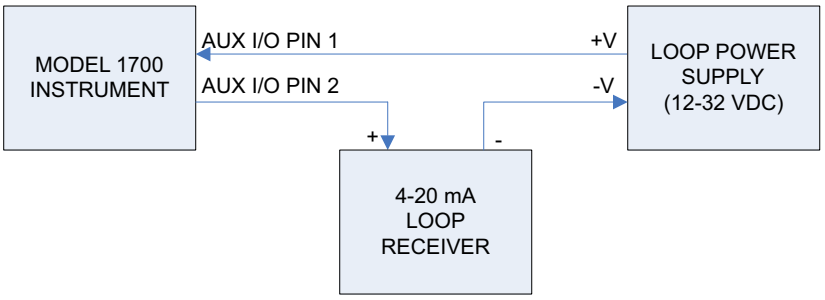
The Model 1700 instrument provides a 0-10 V_{DC} output on the AUX I/O connector (refer to “Aux I/O Pin Definitions” on page 112) corresponding to 0-100% of liquid level. This output can be assigned to either level measurement channel (refer to “Analog output signals” on page 47). Connect the voltage output on the AUX I/O connector to a suitable receiver being careful not to exceed the impedance restrictions (refer to “Model 1700 Specifications @ 25°C” on page 8).

4-20 MA CURRENT LOOP OUTPUT

The Model 1700 instrument provides a 4-20 mA_{DC} output on the AUX I/O connector (refer to “Aux I/O Pin Definitions” on page 112) corresponding to 0-100% of liquid level. This output can be assigned to either level measurement channel (refer to “Analog output signals” on page 47).

The instrument requires an external power supply for current loop operation. Connect a suitable power supply as shown below.

CAUTION **It is extremely important to observe all polarities and to not exceed +32VDC for the loop power supply in order to prevent damage to the 4-20mA driver circuit.**



OPERATION

This section describes the operation of the Model 1700 Instrument.

ENERGIZING THE MODEL 1700 INSTRUMENT

1. Turn the power switch on the front panel of the instrument to the On (**I**) position. The display will briefly show a boot image and then display the home screen showing level(s).
2. The boot process takes approximately 30 seconds. Boot 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.
3. When the boot process is complete, the instrument will display the home (level) screen.

SCREEN NAVIGATION

HOME SCREEN

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

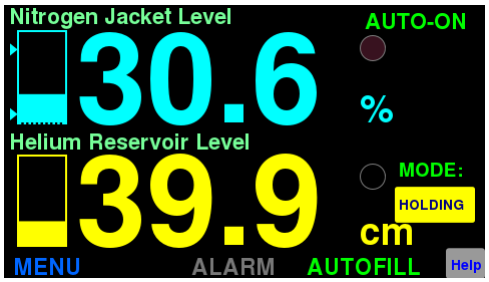
If the instrument is configured for only liquid nitrogen level, the display will look similar to the image shown at right:

Nitrogen Home Screen

If the instrument is configured for only liquid helium level, the display will look similar to the image shown at right:

LHe Home Screen

If the instrument is configured for both liquid nitrogen *and* liquid helium levels, the display will look similar to the image shown at right:



Dual LN_2 and LHe Home Screen

If the instrument requires calibration[1], refer to the following chapter to calibrate the instrument with an AMI level sensor.

HOME SCREEN FOOTER

Every screen has a footer. The level home screen displays both status information and buttons in the footer to navigate to other screens.

The home screen footer appears as shown at right:

Home Screen Footer

Model 1700 Instrument Home Screen Footer

No.	Name	Function
①	MENU	Takes the user to the main menu screen.
②	ALARM	When illuminated, indicates an active alarm condition. Touch to enter the ALARM STATUS screen.
③	AUTOFILL	When illuminated, indicates the AUTOFILL function is enabled. Touch to enter the AUTOFILL configuration screen.
④	HELP	Takes the user to a Help screen where available.

1. If the instrument was purchased with level sensor(s), the instrument will be shipped set up and calibrated.

EDITING A FIELD

Once a field or multi-choice button on a screen has been edited, the footer changes to appear as follows:

Field Editing Footer

Model 1700 Instrument Footer during editing a field

No.	Name	Function
①	SAVE	Saves the entries made on the screen. The footer then reverts to the default footer as shown in the previous section.
②	CANCEL	Cancels a change while *not saving entries*. The footer then reverts to the default footer as shown in the previous section.

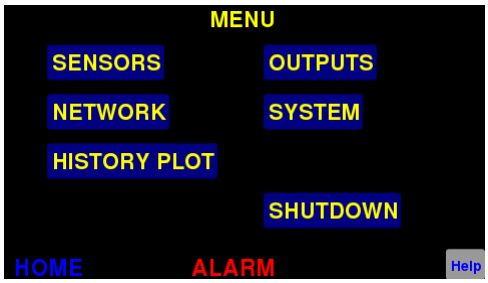
The functions of the **ALARM**, **AUTOFILL**, and **Help** footer items are as described in the previous section.

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.

MENU button on HOME screen

When invoked, the **MENU** screen will be displayed:



MENU Selection Screen

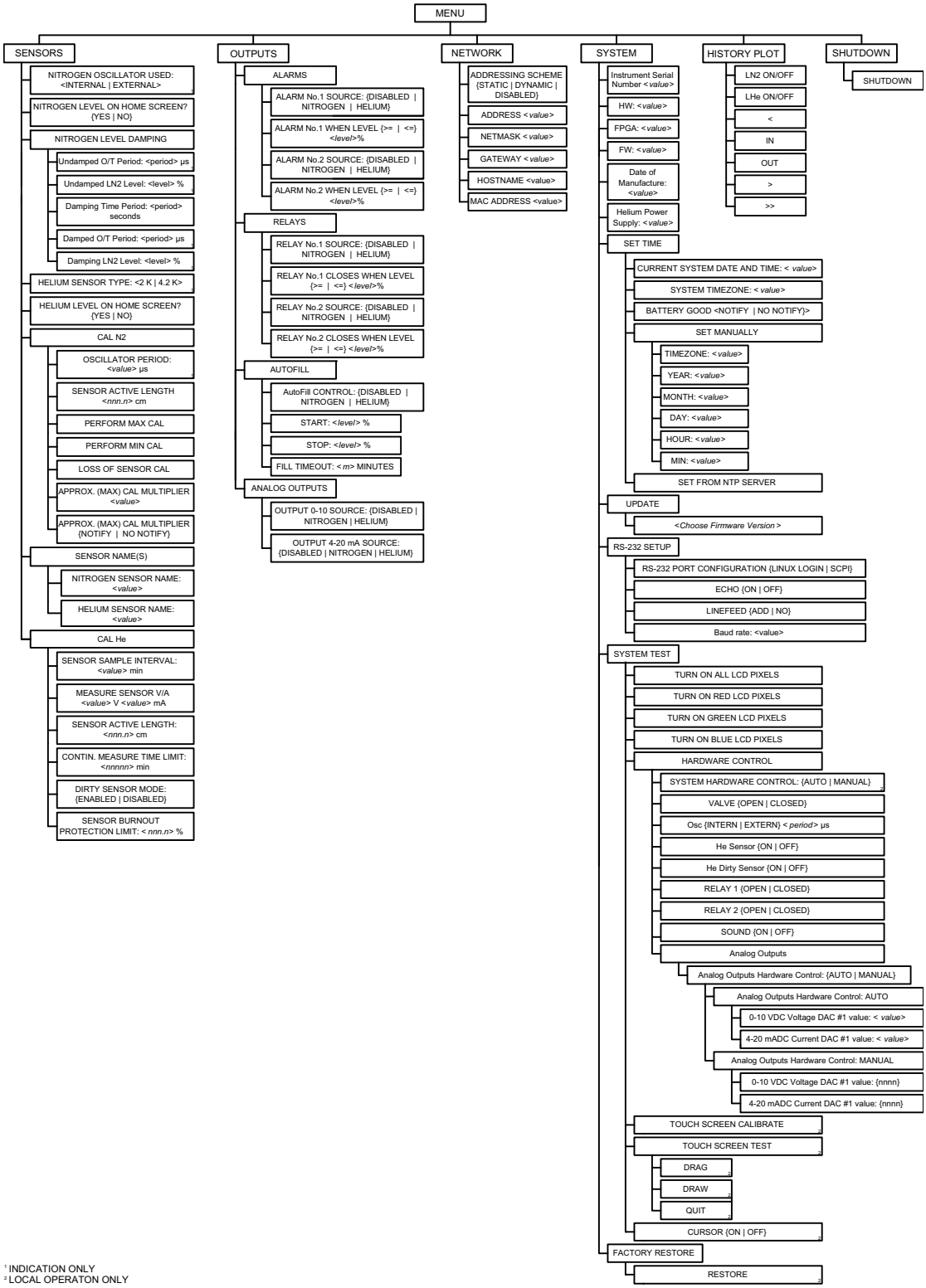
Pressing **HOME** in the lower left corner of the screen will display the level display screen.

HOME button on MENU screen

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

BACK button

MENU STRUCTURE



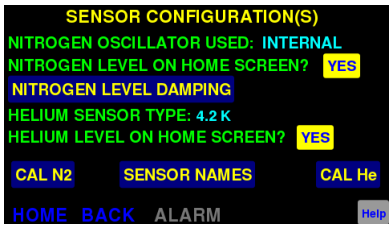
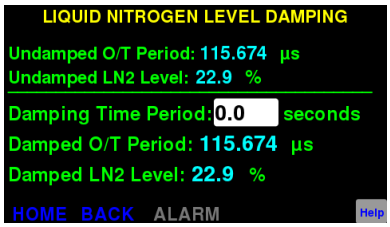
[1] INDICATION ONLY
[2] LOCAL OPERATON ONLY

Model 1700 Menu Structure

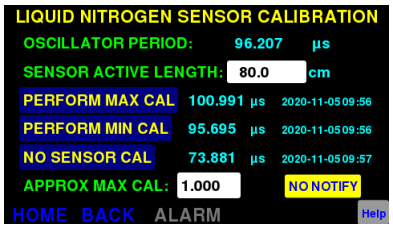
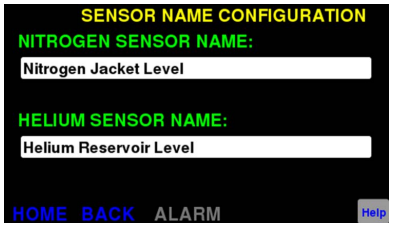
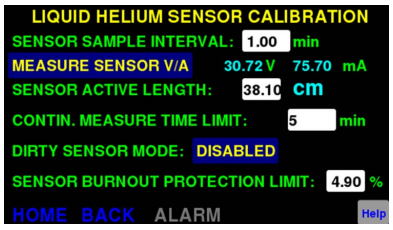
SCREEN DESCRIPTIONS

The Model 1700 Instrument displays various screens on the graphic display when a MENU item is chosen. The items for each screen are described in the following table.

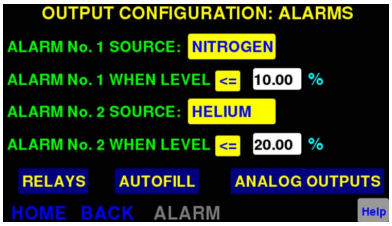
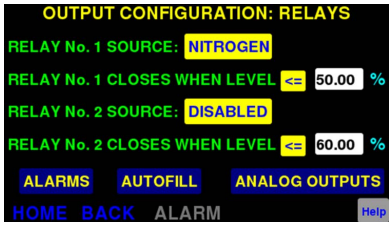
Model 1700 Dual Level Instrument Screen Descriptions

Screen[a]	Item Label	Field Type or Function
SENSOR CONFIGURATION(S)  MENU > SENSORS	NITROGEN OSCILLATOR USED:	Information: INTERNAL, EXTERNAL[b]
	NITROGEN LEVEL ON HOME SCREEN?	Toggles between: YES, NO
	NITROGEN LEVEL DAMPING	Move to another screen
	HELIUM SENSOR TYPE:	Information: 2K, 4.2K[b]
	HELIUM LEVEL ON HOME SCREEN?	Toggles between: YES, NO
	CAL N2	Move to another screen
	SENSOR NAME(S)	Move to another screen
	CAL He	Move to another screen
LIQUID NITROGEN LEVEL DAMPING  MENU > SENSORS > NITROGEN LEVEL DAMPING	Undamped O/T Period:	Information: <value>[b] µs (present value)
	Undamped LN2 Level:	Information: <value>[b] % (present value)
	Damping Time Period:	Data entry: <value> seconds
	Damped O/T Period:	Information: <value>[b] µs (present value)
	Damped LN2 Level:	Information: <value>[b] % (present value)

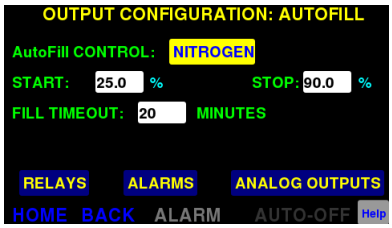
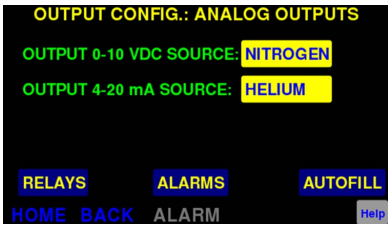
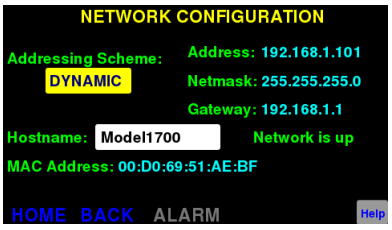
Model 1700 Dual Level Instrument Screen Descriptions

Screen[a]	Item Label	Field Type or Function
LIQUID NITROGEN SENSOR CALIBRATION  MENU > SENSORS > CAL N2	OSCILLATOR PERIOD:	Information: <value>[b] µs (present value)
	SENSOR ACTIVE LENGTH:	Data entry: <value> cm *or* in (tap units to change)
	PERFORM MAX CAL	Move to another screen and Information: <value>[b] in µs followed by the date/time of last entry
	PERFORM MIN CAL	Move to another screen and Information: <value>[b] in µs followed by the date/time of last entry
	NO SENSOR CAL	Move to another screen and Information: <value>[b] in µs followed by the date/time of last entry
	APPROX MAX CAL:	Data entry: <value> followed by a button that toggles between: NO NOTIFY, NOTIFY[c]
SENSOR NAME CONFIGURATION  MENU > SENSORS > SENSOR NAME(S)	NITROGEN SENSOR NAME:	Data entry: <value>
	HELIUM SENSOR NAME:	Data entry: <value>
LIQUID HELIUM SENSOR CALIBRATION  MENU > SENSORS > CAL He	SENSOR SAMPLE INTERVAL:	Data entry: <value> min
	MEASURE SENSOR V/A	Performs a function: <values> V mA[b]
	SENSOR ACTIVE LENGTH:	Data entry: <value> cm *or* in (tap units to change)
	CONTIN. MEASURE TIME LIMIT:	Data entry: <value> min
	DIRTY SENSOR MODE:	Toggles between: DISABLED, ENABLED
	SENSOR BURNOUT PROTECTION LIMIT:	Data entry: <value> %

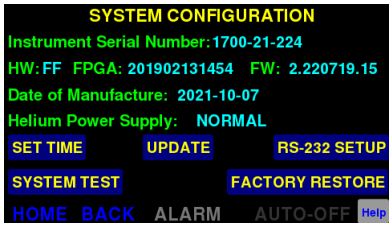
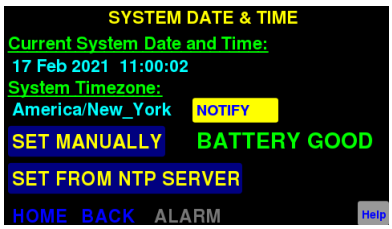
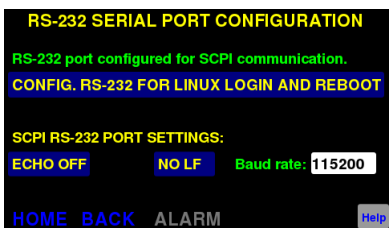
Model 1700 Dual Level Instrument Screen Descriptions

Screen[a]	Item Label	Field Type or Function
OUTPUT CONFIGURATION: ALARMS  MENU > OUTPUTS > ALARMS	ALARM No. 1 SOURCE:	Toggles between: DISABLED, NITROGEN, HELIUM
	ALARM No. 1 SETPOINT:	Data entry <value> %, in, *or* cm (tap units to change)
	ALARM No. 1 WHEN LEVEL <state>	Toggles between: ≤, ≥
	ALARM No. 2 SOURCE:	Toggles between: DISABLED, NITROGEN, HELIUM
	ALARM No. 2 SETPOINT:	Data entry <value> %, in, *or* cm (tap units to change)
	ALARM No. 2 WHEN LEVEL <state>	Toggles between: ≤, ≥
	RELAYS	Move to another screen
	AUTOFILL	Move to another screen
	ANALOG OUTPUTS	Move to another screen
OUTPUT CONFIGURATION: RELAYS  MENU > OUTPUTS > RELAYS	RELAY No. 1 SOURCE:	Toggles between: DISABLED, NITROGEN, HELIUM
	RELAY No. 1 SETPONT:	Data entry <value> %, in, *or* cm (tap units to change)
	RELAY No. 1 CLOSES WHEN LEVEL <state>	Toggles between: ≤, ≥
	RELAY No. 2 SOURCE:	Toggles between: DISABLED, NITROGEN, HELIUM
	RELAY No. 2 SETPOINT:	Data entry <value> %, in, *or* cm (tap units to change)
	RELAY No. 2 CLOSES WHEN LEVEL <state>	Toggles between: ≤, ≥
	ALARMS	Move to another screen
	AUTOFILL	Move to another screen
	ANALOG OUTPUTS	Move to another screen

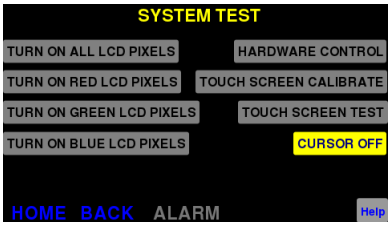
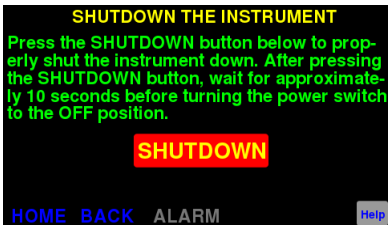
Model 1700 Dual Level Instrument Screen Descriptions

Screen[a]	Item Label	Field Type or Function
OUTPUT CONFIGURATION: AUTOFILL  MENU > OUTPUTS > AUTOFILL	AutoFILL CONTROL:	Toggles between: DISABLED, NITROGEN, HELIUM
	START:	Data entry <value> %, in, *or* cm (tap units to change)
	STOP:	Data entry <value> %, in, *or* cm (tap units to change)
	FILL TIMEOUT:	Data entry <value> MINUTES
	RELAYS	Move to another screen
	ALARMS	Move to another screen
	ANALOG OUTPUTS	Move to another screen
OUTPUT CONFIG.: ANALOG OUTPUTS  MENU > OUTPUTS > ANALOG OUTPUTS	OUTPUT 0-10 VDC SOURCE:	Toggles between: DISABLED, NITROGEN, HELIUM
	OUTPUT 4-20 mA SOURCE:	Toggles between: DISABLED, NITROGEN, HELIUM
	RELAYS	Move to another screen
	ALARMS	Move to another screen
	AUTOFILL	Move to another screen
NETWORK CONFIGURATION  MENU > NETWORK	Addressing Scheme:	Toggles between: DYNAMIC, DISABLED, STATIC
	Address:	Information: <value>[d] (DYNAMIC) Data entry: <value> (STATIC)
	Netmask:	Data entry: <value>[b]
	Gateway:	Data entry: <value>[b]
	Hostname:	Data entry: <value>
	MAC Address:	Information: <value>[b]

Model 1700 Dual Level Instrument Screen Descriptions

Screen[a]	Item Label	Field Type or Function
SYSTEM CONFIGURATION  MENU > SYSTEM	Instrument Serial Number:	Information: <value>[b]
	HW: FPGA: FW:	Information: <values>[b]
	Date of Manufacture:	Information: <value>[b]
	Helium Power Supply:	Information: <value>[b]
	SET TIME	Move to another screen
	UPDATE	Move to another screen
	RS-232 SETUP	Move to another screen
	SYSTEM TEST	Move to another screen
	FACTORY RESTORE	Move to another screen
SYSTEM DATE/TIME  MENU > SYSTEM > SET TIME	Current System Date and Time:	Information[b]
	System Timezone:	Information[b]
	SET MANUALLY	Move to another screen
	SET FROM NTP SERVER	Action with status screen
FIRMWARE UPDATE INSTALL  MENU > SYSTEM > UPDATE	Select Firmware Version:	Selection list: <values> and then moves to INSTALL verification on selection
RS-232 SERIAL PORT CONFIGURATION  MENU > SYSTEM > RS-232 SETUP	Current Configuration:	Information[b]
	Configuration Choice:	Choose alternate function by touching
	Echo Setting:	Choose ECHO OFF or ECHO ON
	Line Ending:	Choose NO LF or ADD LF
	Baud rate:	Choose desired baud rate

Model 1700 Dual Level Instrument Screen Descriptions

Screen[a]	Item Label	Field Type or Function
SYSTEM TEST  MENU > SYSTEM > SYSTST	TURN ON ALL LCD PIXELS	Move to multi-color test screen
	TURN ON RED LCD PIXELS	Move to red test screen
	TURN ON GREEN LCD PIXELS	Move to green test screen
	TURN ON BLUE LCD PIXELS	Move to blue test screen
	HARDWARE CONTROL	Move to hardware test screen
	TOUCH SCREEN ALIBRATE	Move to touch calibration screen
	TOUCH SCREEN TEST	Move to touch test screen
	CURSOR ON/CURSOR OFF	Toggles visibility of cursor
HISTORY  MENU > HISTORY	LN2	Enables/disables nitrogen trace
	LHe	Enables/disables helium trace
	<	Move graph back in time
	IN	Zoom in (less time per division)
	OUT	Zoom out (more time per division)
	>	Move graph forward in time
	>>	Shift graph to most recent levels
SHUTDOWN  MENU > SHUTDOWN	SHUTDOWN	Shuts down the instrument in an orderly fashion which reduces boot time for the next power on.

a. The path below each illustration indicates the necessary actions in the menu structure required to display the indicated screen.

b. Displays the state or value (display only).

c. If the NOTIFY state is selected and the Approx. Cal factor is not equal to 1.00, a brief message will be displayed indicating an approximate calibration is in effect when the instrument boots.

d. Value displayed is chosen by the DHCP server for the network in DYNAMIC mode.

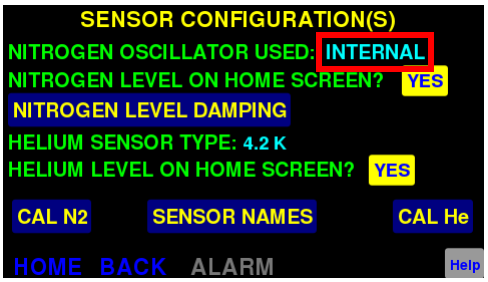
CAPACITANCE (LIQUID NITROGEN) LEVEL

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 15 feet of RG59/U coaxial cable (refer to the figure on page 2). Ensure the **NITROGEN OSCILLATOR USED** field displays **INTERNAL**.

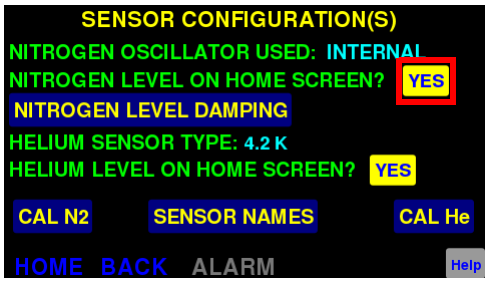


INTERNAL Oscillator Indicated

   a. If the sensor is greater than 15 feet from the instrument, an external oscillator/transmitter is required and the **NITROGEN OSCILLATOR USED** will display **EXTERNAL** (refer to the figure on page 3).

3. Ensure that **NITROGEN LEVEL ON HOME SCREEN?** is set to **YES**.

4. Press the **HOME** icon at the bottom of the screen.



Nitrogen Level Chosen for Display on Home Screen

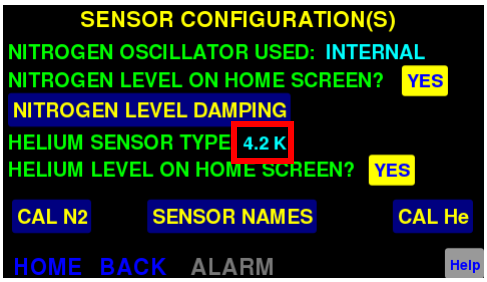
SUPERCONDUCTING (LIQUID HELIUM) LEVEL

CONFIGURE THE INSTRUMENT TO DISPLAY HELIUM LEVEL

NOTE **If the instrument was purchased with an AMI LHe level sensor, Steps 1 through 6, below have already been performed.**

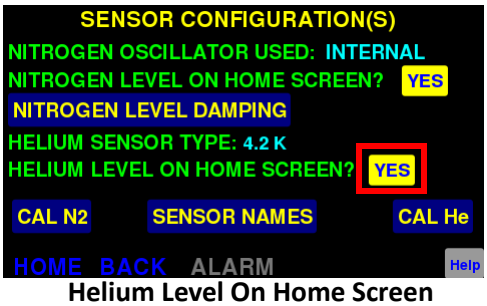
1. From the main screen, choose the following: **MENU** > **SENSORS**.

2. The instrument will display the instrument configuration vis-à-vis the LHe level sensor, 4.2K or 2K. Note that this configuration is set at time of manufacture and is not alterable by the user.



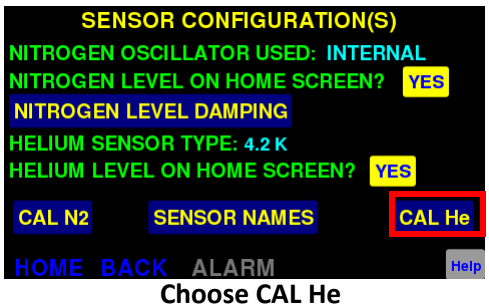
Type of LHe Level Sensor

3. Ensure that **HELIUM LEVEL ON HOME SCREEN?** is set to **YES**.



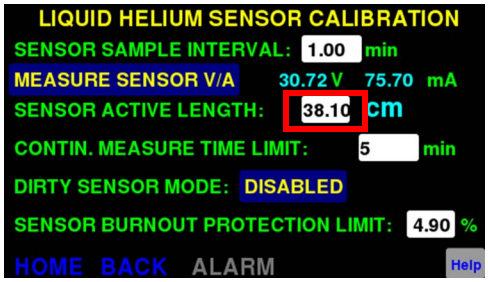
Helium Level On Home Screen

4. Press the **CAL He** button.



Choose CAL He

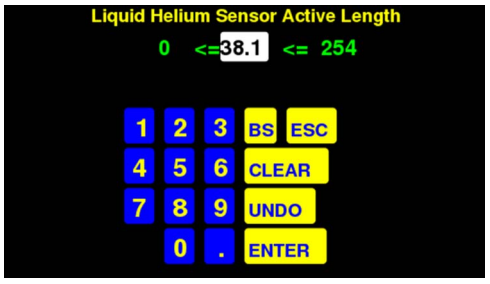
5. Press the **SENSOR ACTIVE LENGTH** field.



Calibrate Helium Screen

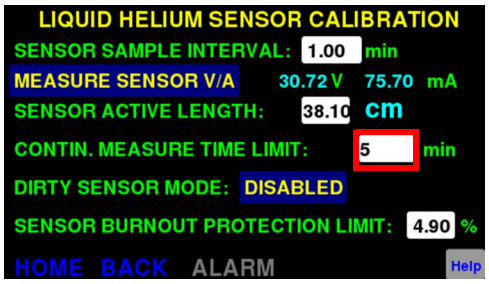
NOTE **The entered sensor active length *must* match the actual active length of the connected LHe sensor for accurate results.**

6. In the numeric pop-up keypad, enter the sensor active length in centimeters. Press **ENTER** when finished.



Numeric Keypad

7. Touch in the **CONTIN. MEASURE TIME LIMIT** field.

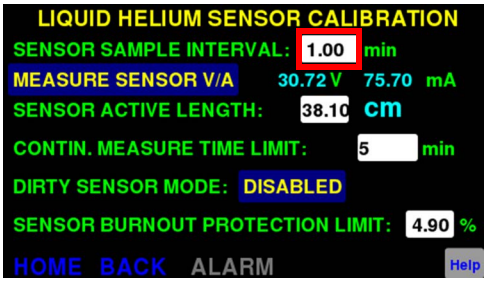


Calibrate Helium Screen

8. Using the pop-up numeric keypad, enter the maximum amount of time that the sensor should remain energized in the **UPDATING** mode before automatically changing to the **HOLDING** mode. This limit prevents inadvertent sensor energization for long periods of time which will cause excessive liquid helium boil off. When the sensor is energized (**UPDATING**) a timer is started and after the **CONTIN. MEASURE TIME LIMIT** is reached, the sensor is de-energized (switches back to **HOLDING** mode).

NOTE **Setting the CONTIN. MEASURE TIME LIMIT to 0 (zero) disables the timeout function and the sensor will remain energized indefinitely until the operator proactively exits to HOLDING mode.**

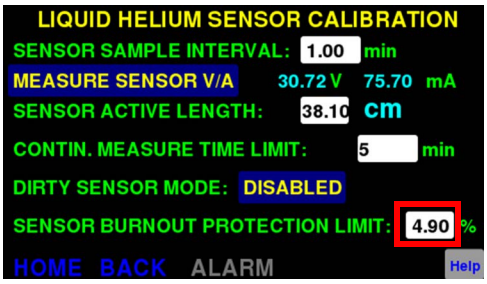
9. Set the **SENSOR SAMPLE INTERVAL** to an appropriate value. This value is used by the **HOLDING** timer to determine how often the sensor is sampled and the display is updated. The timer is started when the instrument is powered up, when this value is changed, or when entering the **HOLDING** (sampled) mode.



Setting the Sample Interval

NOTE **Setting the SAMPLE INTERVAL to 0 (zero) disables the sampling function and the sensor is energized at all times.**

10. The **SENSOR BURNOUT PROTECTION LIMIT** is typically set at approximately 5%. This limit specifies the amount of excess sensed resistance that is allowed before the Model 1700 engages the burnout protection feature (see the next section) primarily intended to protect the sensor filament in a *vacuum* environment. If you wish to allow a higher excess resistance limit in a warm, gas-filled cryostat, increase the value by 2% increments until the burnout protection is disengaged.



Setting the Burnout Protection Limit

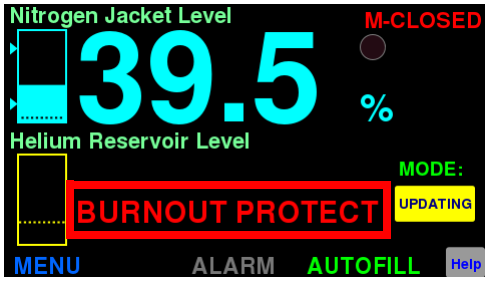
11. Press **HOME** in the footer to return to the home screen.

SENSOR BURNOUT PROTECTION

Operating the sensor in a *vacuum* without contact with liquid helium can cause thermal damage and/or destruction of the superconducting filament. The Model 1700 is equipped with circuitry that automatically prevents this type of damage from occurring (the sensor active length setting must be correctly configured). If excessive sensor resistance is detected, the Model 1700 display will indicate burnout protection is in effect and the sensor current will be turned off for a minimum of six seconds after which time the instrument will attempt to resume normal operation. When the sensor resistance has returned to within the expected range, normal operation will be restored. No relay or alarm states are affected.

Helium Level Sensor Protection Mode

If an attached sensor is installed in a *warm, gas-filled* cryostat (not in a vacuum), the sensor burnout protection may activate as soon as the Model 1700 is energized and a liquid helium level measurement is attempted. This is normal until the cryostat and sensor are cooled in the helium environment. However, you may adjust the **SENSOR BURNOUT PROTECTION LIMIT** setting in the **MENU** > **SENSORS** > **CAL He** screen (see page 36) to allow the sensing function to operate in the warm, gas-filled cryostat if desired.



Helium Level Sensor Protection Mode in a Dual Display

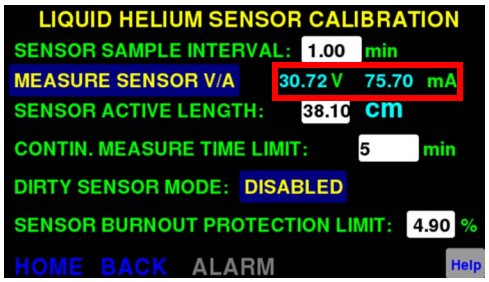
SAMPLED OR CONTINUOUS MEASUREMENTS

While viewing the home screen, toggle between **HOLDING** (sampled) and **UPDATING** (continuous measurement) modes by pressing the button.

Helium Level Measurement Mode

OTHER LIQUID HELIUM FUNCTIONS

In the **MENU** > **SENSORS** > **CAL He** screen, the instrument displays the LHe level sensor voltage. If the voltage is shown in light blue, it is the actual (real-time) voltage as the instrument is in **UPDATING** mode. If it is displayed in gray, it is the voltage measured the last time the sensor was energized (**HOLDING** mode). To update the reading, press the **MEASURE SENSOR V/A** button and the level reading will be updated as will the measured sensor voltage and excitation current.



Helium Sensor Voltage

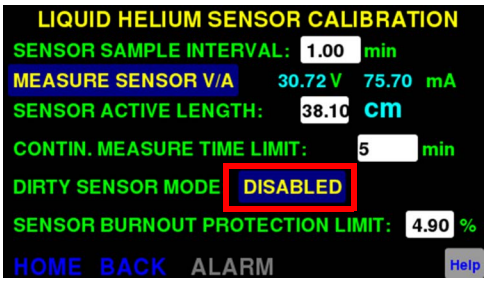
NOTE **Nominal LHe sensor excitation current is 75 mA for 4K sensors, and 57 mA for 2K sensors.**

AMI expects the helium level sensor to be reasonably clean and free from oil, water, ice, etc. for proper operation. However, it is recognized that some experiments might result in some material being deposited on the sensor wire. Ice formation at some point on the sensor is a typical occurrence. Therefore, the Model 1700 has the capability of increasing the current for a short period of time at the beginning of the measurement cycle (in the **HOLDING** mode only) to try and drive the resistive zone of the sensor wire past the dirty region. This is termed **DIRTY SENSOR MODE**. This operation may or may not be successful depending on the degree of sensor contamination. This mode should be viewed as a stopgap measure only. If correct readings cannot be reestablished, the only choice is to warm the sensor or remove for cleaning or replacement.

NOTE **Operation in the dirty sensor mode increases liquid helium losses. Consequently, operation in this mode should not be used unless the sensor is known or anticipated to become dirty or the helium level measurement is in question due to unclean operation.**

To enable the **DIRTY SENSOR MODE**, Press the **DISABLED** button until **ENABLED** appears and press **SAVE**.

Press the home icon in the footer to return to the home screen.



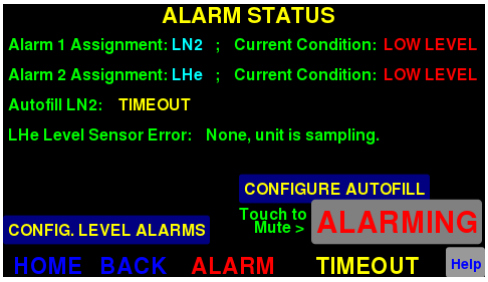
Dirty Sensor Mode

ALARMS AND RELAYS

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

ALARM STATUS SCREEN

Prior revisions of the Model 1700 have attempted to indicate the alarm conditions in the main screen footer region, including cycling through multiple alarm texts in the footer. This has been replaced by an Alarm Status screen that summarizes all alarm states and provides a button for muting.



Alarm Status Screen

The Alarm Status screen can be accessed at any time by tapping on the **ALARM** text in the footer. All alarms are summarized in the Alarm Status screen. If the Alarm Status screen shows the “ALARMING” button (as illustrated above), then touching the button will mute the alarm(s). This mute function will remain in effect until a new alarm is activated, or the status of any active alarm changes. Shortcuts may also be provided on the Alarm Status screen to enter the Level Alarms and Autofill configuration screens.

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 will appear on the front panel.

Two relays can also be configured with independent setpoints to actuate independently of the alarm states. These relays have Normally Open (NO) contacts. The relays can be assigned to either the helium or nitrogen channel and each relay can be configured to close 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, or in a dual level configuration, each channel can have a low level alarm. The *relay actions* can be set to act identically, or configured for other conditions, per the user-defined application.

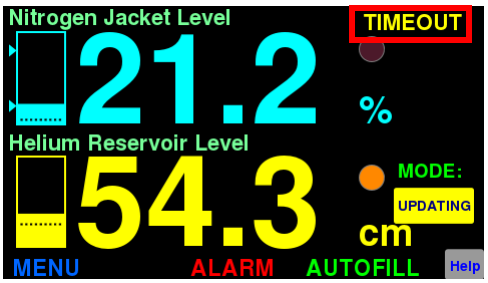
TIME-BASED FILL ALARM

The Model 1700 Instrument has an alarm to indicate that there is a problem with the 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 **TIMEOUT** visual indication on the Home screen (as shown at right) or in the footer of the instrument front panel.

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



Fill Timeout Alarm Indicators

MULTIPLE ALARMS

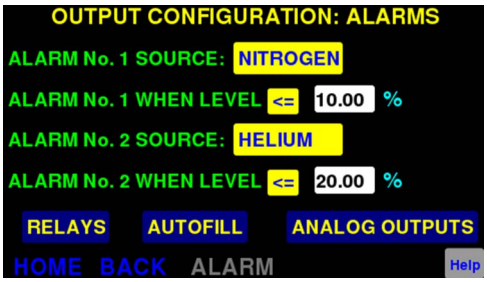
More than one alarm condition can occur at the same time. If that is the case, the Alarm Status screen summarizes all the alarm states. Access the Alarm Status screen by touching the **ALARM** text in the footer.

NOTE **Prior versions of the instrument flashed a series of alarms in the screen footer. This has been superseded by the Alarm Status screen.**

CONFIGURING ALARM SETPOINTS

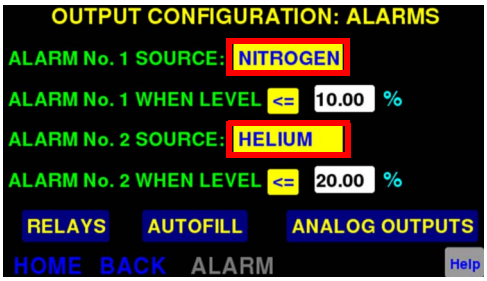
1. From the **MENU** screen, select **OUTPUTS** and the **OUTPUT CONFIGURATION: ALARMS** screen will be displayed.

   (If already in another **OUTPUT CONFIGURATION** screen, choose the **ALARMS** button.)



Output ALARMS Configuration Screen

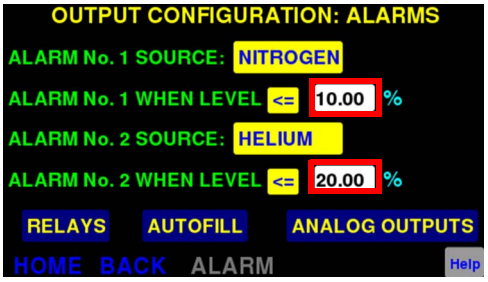
2. If the instrument is configured to display both nitrogen and helium, toggle the Alarm Source fields to choose the appropriate level source. If the instrument is configured for either nitrogen or helium, the source will automatically be assigned to the configured level.



ALARMS Source Configuration

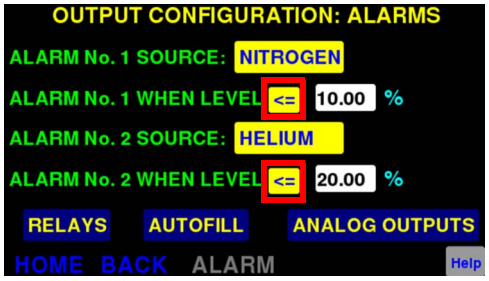
3. Set the levels at which the alarm will be triggered in the Setpoint fields highlighted in red in the image at right.

NOTE **Tapping the units symbol (%, in, or cm) allows selection of the available unit selections for the selected source liquid.**



ALARMS Setpoints

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.



Alarm Condition Above or Below Setpoints

ACKNOWLEDGING AN ALARM

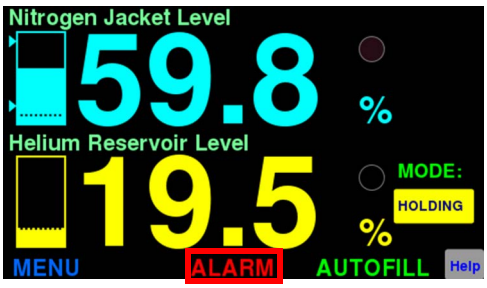
NOTE **The alarms are not "latched" so if the alarm condition clears itself, the instrument will remove the alarm condition.**

1. When an alarm is initiated, several things will occur:

a. The **ALARM** text in the footer will illuminate in bold, red text.

b. An audible alarm will be energized.

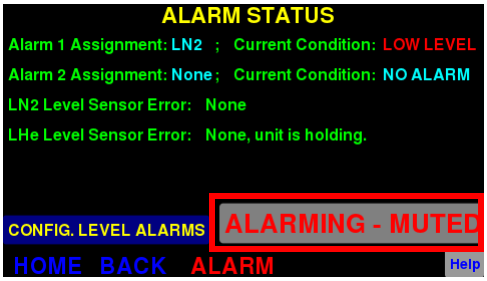
c. The Alarm Status screen, accessible by touching the **ALARM** text in the footer, will display a summary of all alarms.



Alarm Annunciator

MUTING AN ALARM

To mute the audible alarm, first touch the **ALARM** text in the footer. The Alarm Status screen will appear with the "ALARMING" status shown. Tap the "ALARMING" button to mute all active alarms. A change in any alarm state will also re-enable the audible alarm for any remaining active alarms. There is no permanent mute.

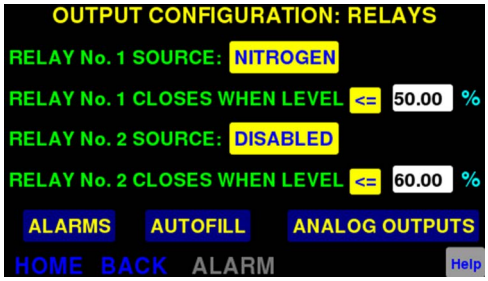


Muted Alarm Condition

CONFIGURING RELAY SETPOINTS

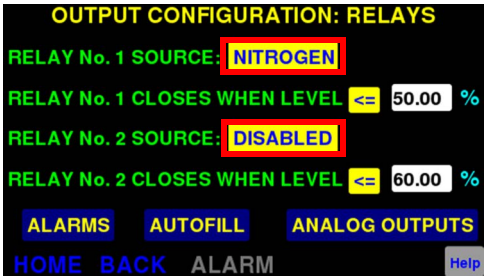
The relay outputs are available via the AUX I/O connector on the rear panel of the instrument per the pinout provided on page 112.

1. From the **MENU** screen, select **OUTPUTS** and then choose **RELAYS**.



OUTPUT CONFIGURATION: RELAYS Screen

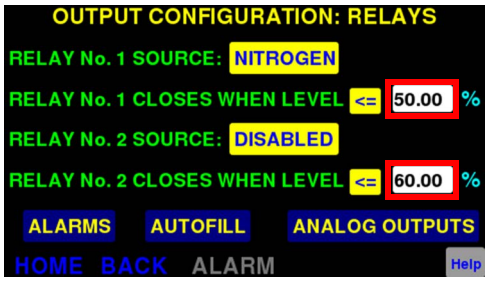
2. If the instrument is configured to display both nitrogen and helium, toggle the Relay Source fields to choose the appropriate level source. If the instrument is configured for either nitrogen or helium, the source will automatically be assigned to the configured level.



RELAYS Source Configuration

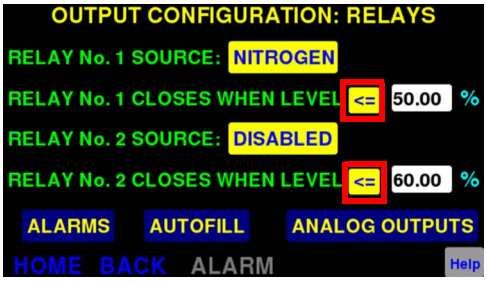
3. Set the levels at which the relay will be closed in the Setpoint fields.

NOTE **Tapping the units symbol (%, in, or cm) allows selection of the available unit selections for the selected source liquid.**



RELAYS Setpoints

4. Use the ≤ or ≥ button to toggle between the two states of actuation. Either the relay will close when the indicated level is less than or equal to the setpoint, or when the indicated level is greater than or equal to the setpoint.



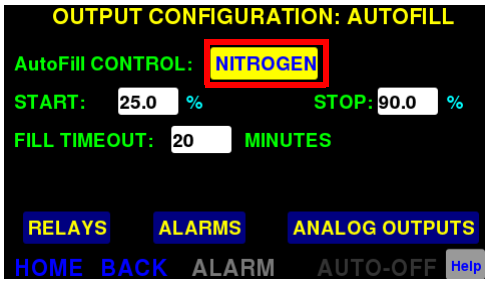
Relay Closed Above or Below Setpoints

CONFIGURE THE AUTOFILL FUNCTION

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.

SETTING THE AUTOFILL PARAMETERS

1. From the **MENU** screen, choose **OUTPUTS** and then choose **AUTOFILL**.
2. Toggle the **AutoFILL CONTROL** button until **NITROGEN or HELIUM** is displayed.

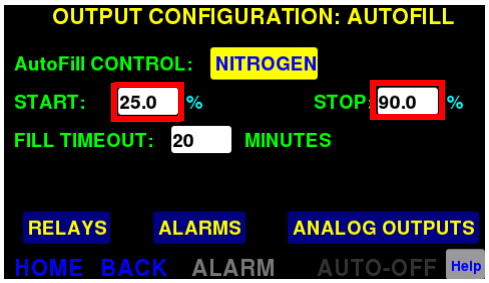


AUTOFILL Level Control Selection

3. Enter the Fill **START** and **STOP** levels.

NOTE If the START value is set to 0.0% the autofill function will be effectively disabled.

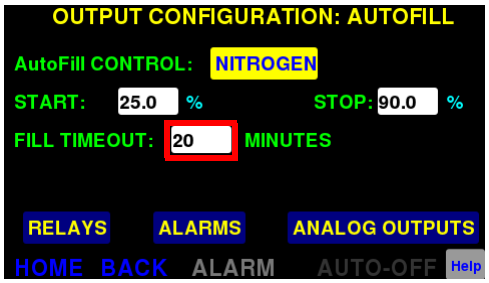
NOTE Tapping the units symbol (%, in, or cm) allows selection of the available unit selections for the selected source liquid.



AUTOFILL Level Start Setting

4. Enter the **FILL TIMEOUT** interval. Refer to page 45 for a description of the Autofill timeout function.

NOTE If the FILL TIMEOUT value is set to 0 minutes, the timeout function is disabled.



AUTOFILL Timeout Setting

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

ENABLE THE AUTOFILL FUNCTION

The autofill function must first be enabled. After the autofill control loop has been configured (the parameters in the prior section) the instrument will enter the **AUTO-OFF** state.

To enable the autonomous autofill function:

1. Touch the **AUTO-OFF** text in the display footer until it reads **AUTO-ON**.
2. Touch **SAVE** to enable the autonomous autofill function.

The AUTOFILL function has four manually-selectable states by touching the fill state indicator either in the **HOME** screen or in the footer when not in the **HOME** screen:

AUTOFILL States

Function	Operation	Overrides
AUTO-ON	Automatically maintains level between fill START and STOP set-point (i.e. autonomous mode).	Autofill will alarm and cease if fill valve stays open for ≥ the FILL TIMEOUT setting .
M-OPEN	Manual Open: Energizes the valve control socket on the rear panel.	Any active ALARM with >= setpoint defined for the fill liquid will close valve.
M-CLOSED	Manual Close: De-energizes the valve control socket on the rear panel.	None
AUTO-OFF	Disables the AUTOFILL function.	None

CLEARING THE AUTOFILL TIMEOUT ALARM

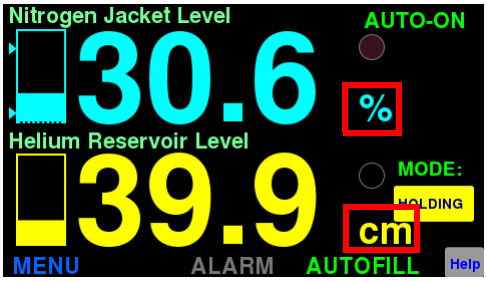
NOTE **A Loss of Sensor error condition (see page 19) on the nitrogen channel will also halt an active autofill in addition to the autofill timeout feature.**

1. Touch the **TIMEOUT** text in the **HOME** screen or in the footer until **AUTO-ON** is displayed.
2. Touch **SAVE** in the footer. This will restart the autonomous autofill function.
3. To clear the **TIMEOUT** *without restarting* the autofill function, choose the **M-CLOSED** state and then choose **SAVE** in the footer.

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**).

NOTE **Tapping the units symbol (%, in, or cm) in a configuration screen also allows selection of the available unit selections for given liquid. The units selection is then used for all indication and configuration values for that liquid.**



Dual Liquid Home Screen

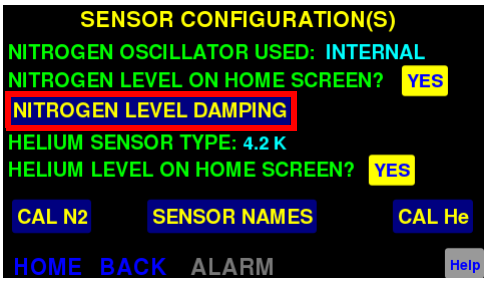
DAMPING CONFIGURATION

The level measurement function offers a damping feature which can be used to dampen fluctuations in the nitrogen level reading that arise from sloshing liquids or other surface disruptions.

To set the damping for the nitrogen measurement:

1. From the main screen, choose the following: **MENU** > **SENSORS**. Ensure the nitrogen level measurement is enabled and displayed on the **HOME** screen.

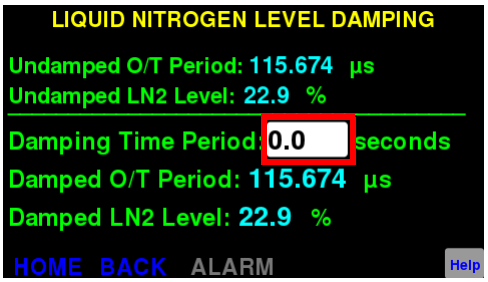
2. Touch the **NITROGEN LEVEL DAMPING** button to enter the damping configuration screen.



Choose Nitrogen Level Damping

3. In the **LEVEL DAMPING** screen, enter the desired damping time in seconds. The damping is a first-order low-pass filter function where the damping period is equal to *five times the filter time constant* (99% of final reading).

   A damping period of 0.0 seconds means the damping function is disabled.



Damping Configuration

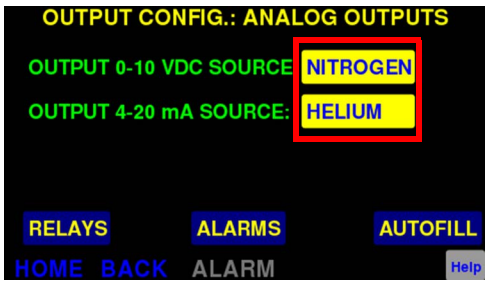
NOTE **If the damping period is set to a non-zero value, the damping function will then be applied to the level measurement used for *all* indication and control functions for the liquid nitrogen level. This includes analog output and fill cycle functions.**

ANALOG OUTPUT SIGNALS

Refer to page 112 of the Appendix for the AUX connector pin-out.

CONFIGURING THE ANALOG OUTPUTS

1. From the **MENU** screen, choose **OUTPUTS**, then **ANALOG OUTPUTS**.
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).



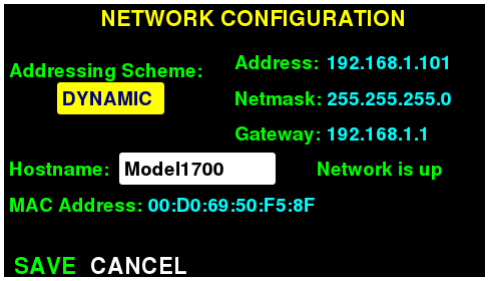
ANALOG OUTPUTS Source Selection

4. Press **HOME** to go back to the home screen.

ETHERNET CONNECTIVITY

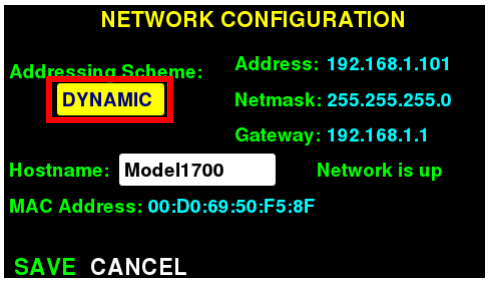
IP ADDRESSING SCHEME

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



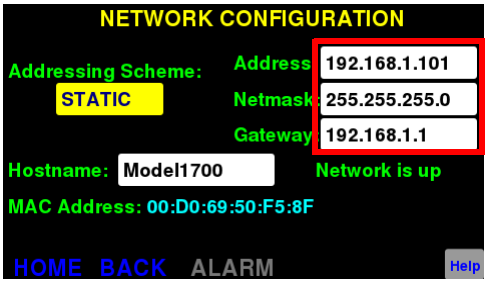
Network Configuration Screen

2. Touch the addressing scheme button, to choose **STATIC**, **DYNAMIC**, or **DISABLED** as appropriate.



Editing the Networking Mode

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



Editing Static Network Parameters

4. Set the **HOSTNAME** field as desired.

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.

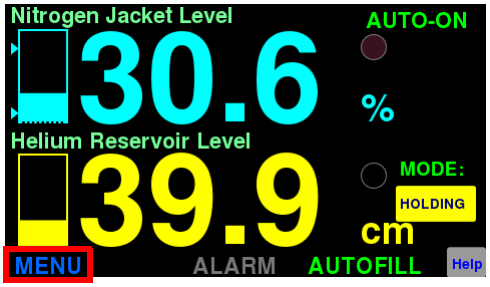
6. If changes are made, select the **SAVE** button and then the instrument will reconfigure itself with the chosen network settings.

SERIAL CONNECTIVITY

The serial (RS-232) connectivity can be customized per the following instructions.

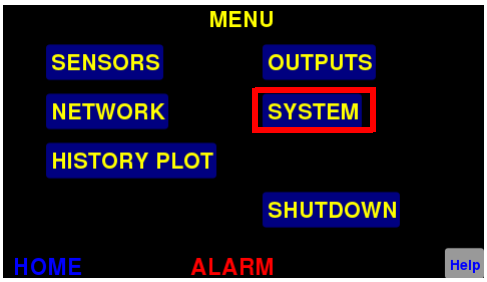
CONFIGURING THE RS-232 SETTINGS

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



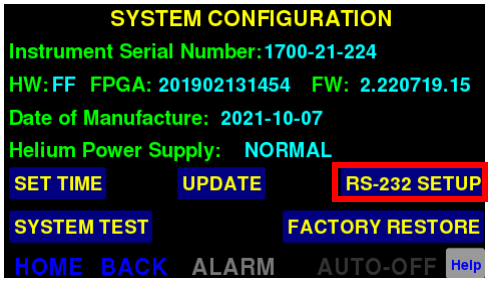
Menu Selection From Home Screen

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



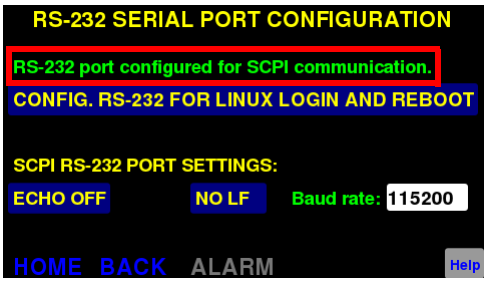
MENU Selection Screen

3. From the **SYSTEM CONFIGURATION** screen choose **RS232 SETUP**.



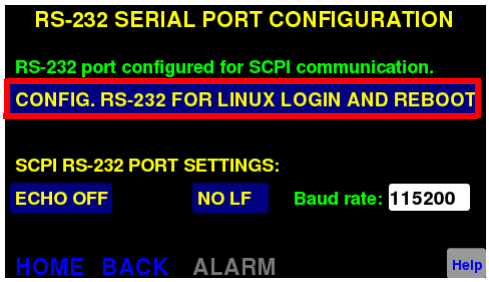
SYSTEM CONFIGURATION Screen

4. The RS-232 Configuration screen shows the current function for the serial connection.



RS-232 SERIAL PORT CONFIGURATION Screen

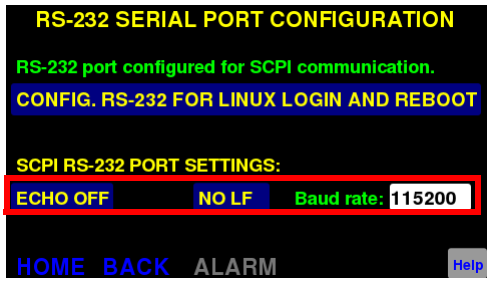
5. Choose the alternate function for the serial connection if desired.



RS-232 SERIAL PORT CONFIGURATION Screen

6. Choose to customize the port behavior for character echo, line ending, and baud rate.

7. If changes are made, select the **SAVE** button in the footer.



RS-232 SERIAL PORT CONFIGURATION Screen

ABNORMAL OPERATION

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.

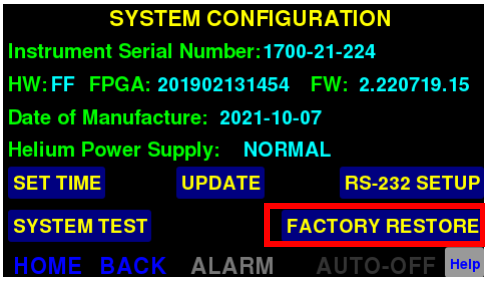
For sensors to be used with liquid oxygen (LOX), although measures are taken to minimize oils and greases during manufacture, no special cleaning required for LOX service is provided by AMI. Certified LOX cleaning is the responsibility of the customer.

DIRTY HELIUM SENSOR OPERATIONAL MODE

Refer to “Other Liquid Helium Functions” on page 37.

RESETTING THE INSTRUMENT TO FACTORY DEFAULTS

1. Press **MENU**, then **SYSTEM**, then **FACTORY RESET**.



System Configuration Screen

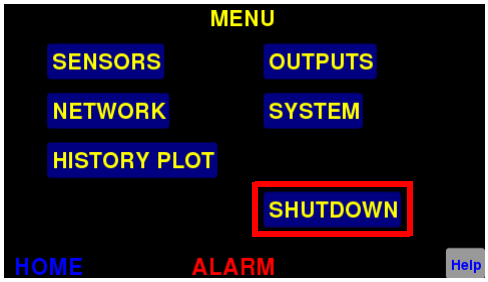
2. Press **RESTORE**.
3. The instrument will be reset to factory defaults.

Resetting Instrument to Factory Defaults

SHUTTING THE INSTRUMENT DOWN

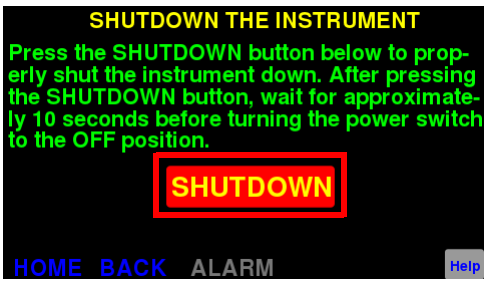
NOTE **The Model 1700 Instrument is a Linux-based computer system and in order to ensure the file system is properly unmounted, the SHUTDOWN function should be invoked. If it is not, i.e. the instrument is shut down by removing power via the front panel power switch, the next time the instrument boots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

1. The instrument should be shut down by using the menu function **SHUTDOWN**.



Invoking Instrument Shut Down

2. Choose **SHUTDOWN** again to confirm.
3. When prompted, turn off the front panel power switch.



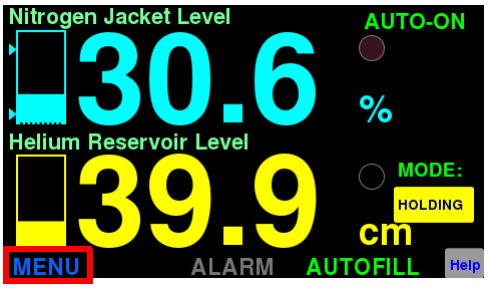
Confirming Instrument Shutdown

CALIBRATION

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.

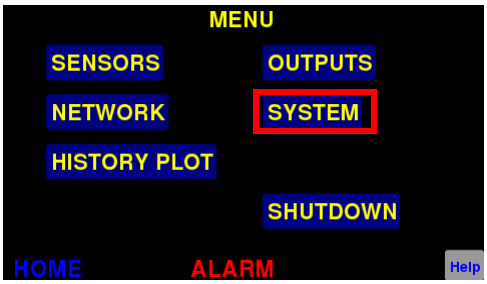
SETTING THE SYSTEM DATE AND TIME

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



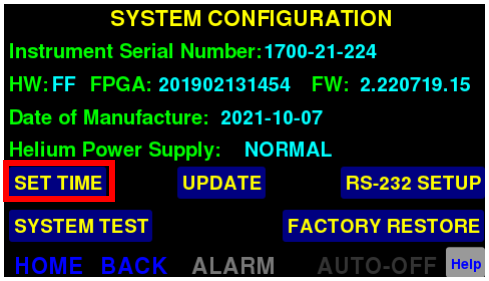
MENU Selection From Home Screen

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



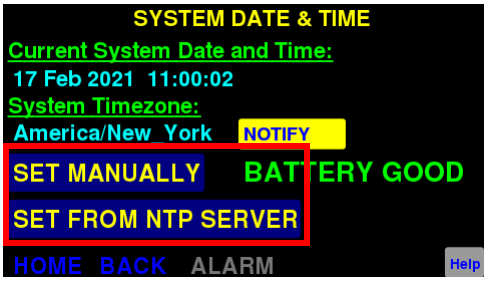
MENU Selection Screen

3. From the **SYSTEM CONFIGURATION** screen, choose **SET TIME**.



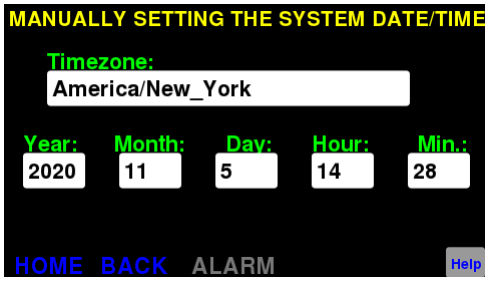
SYSTEM CONFIGURATION Screen

4. In the **SYSTEM DATE/TIME** screen, choose to either set the date and time *manually*, or set it automatically from an NTP server if the instrument has Internet access.



SYSTEM DATE/TIME Screen

5. For the **SET MANUALLY** selection, edit the **TIMEZONE**, **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.



SYSTEM DATE/TIME Manual Entry

NOTE **The clock is set to GMT at the factory and is battery backed. The TIMEZONE field must be set to a value from the TZ database.[1] The list of TIMEZONE values can be found at:**

https://en.wikipedia.org/wiki/List_of_tz_database_time_zones

The TIMEZONE entry must exactly match the entire field as listed in the above URL in the *TZ database name* column and it is case sensitive. An instrument reboot may be required for the TIMEZONE to take effect. If the entered TIMEZONE supports Daylight Savings Time (DST), then the local time will be automatically adjusted to DST.

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

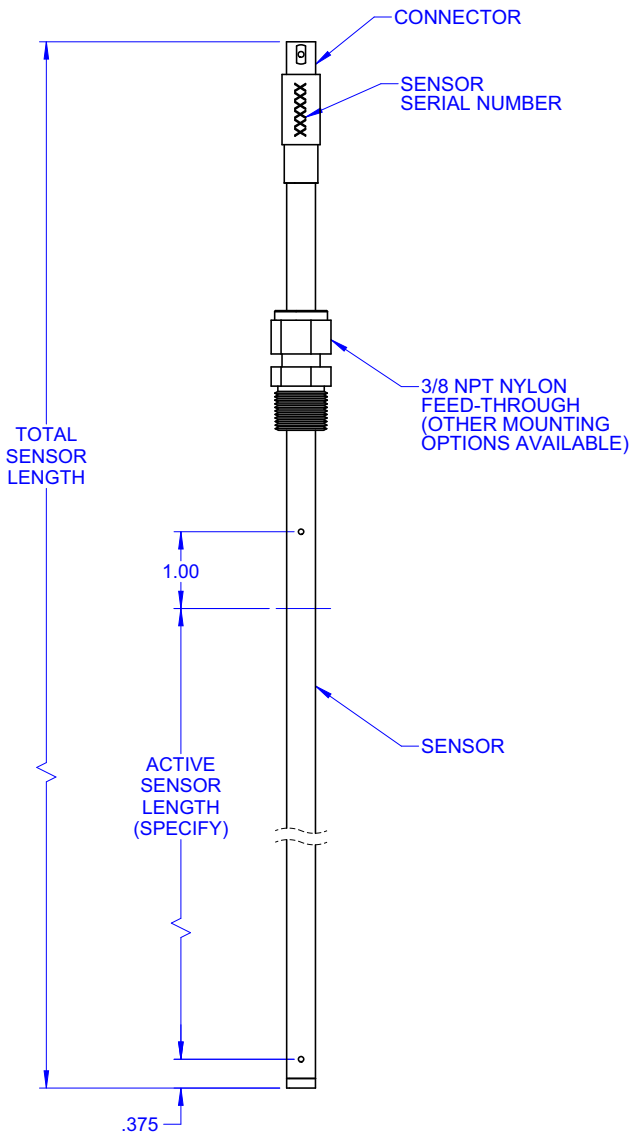
1. The tz database is a collaborative compilation of information about the world's time zones, primarily intended for use with computer programs and operating systems. The topic of worldwide timezones is a complex issue so please refer to the on-line resource noted above.

CAPACITANCE-BASED LEVEL CALIBRATION

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.

NOTE **Without entry of the active length, the instrument will not be able to read out in units other than percent.**



Typical Capacitance-based Liquid Level Sensor

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.

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 as illustrated at left.

RELATIONSHIP BETWEEN CALIBRATION AND SENSOR LENGTH

The capacitance-based method of measuring the liquid level operates by measuring the period of a signal from an oscillator, which can be internal or contained in an external oscillator/transmitter unit. As the liquid level varies, the value of the sensor 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 MIN and MAX settings correspond to the minimum and maximum oscillation periods, 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 MAX and MIN calibration points. The measured value for the length will be used in configuring the instrument for operation.

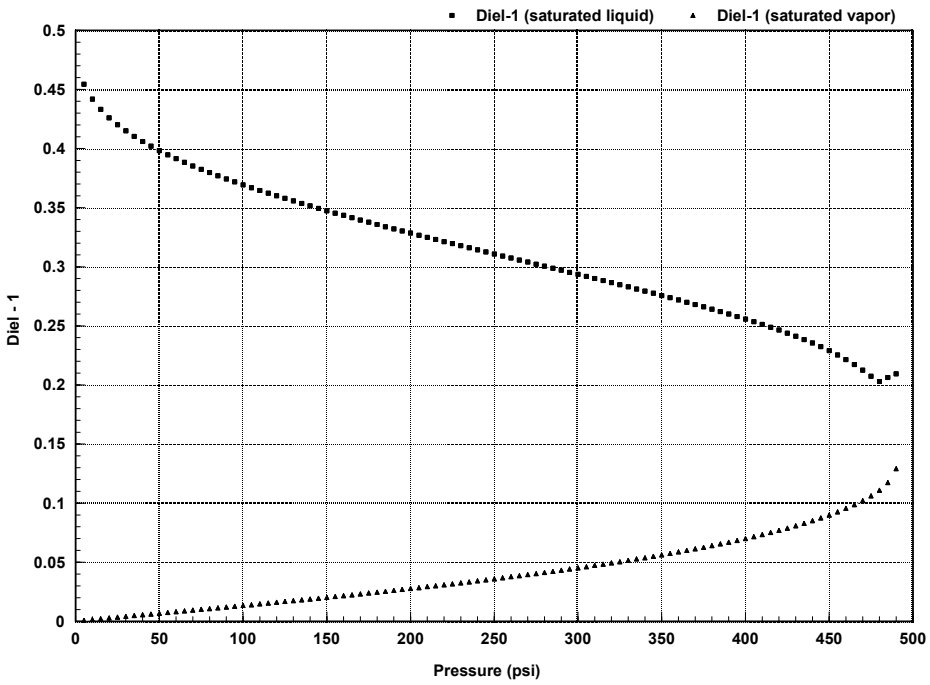
VARIATIONS IN THE DIELECTRIC WITH CHANGING DENSITY

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. The figure below illustrates the variations in dielectric for nitrogen vs. pressure under *saturated* conditions.[1] 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 65) 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 70 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.

NOTE **All references to "dielectric constant" herein refer to the unitless relative dielectric to ε_0 (e_0 is the dielectric constant of a vacuum).**

1. Data obtained from NIST Standard Reference Database 12.



Dielectric vs. pressure for nitrogen under saturated conditions.

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 and avoid saturation of the signal during the calibration.

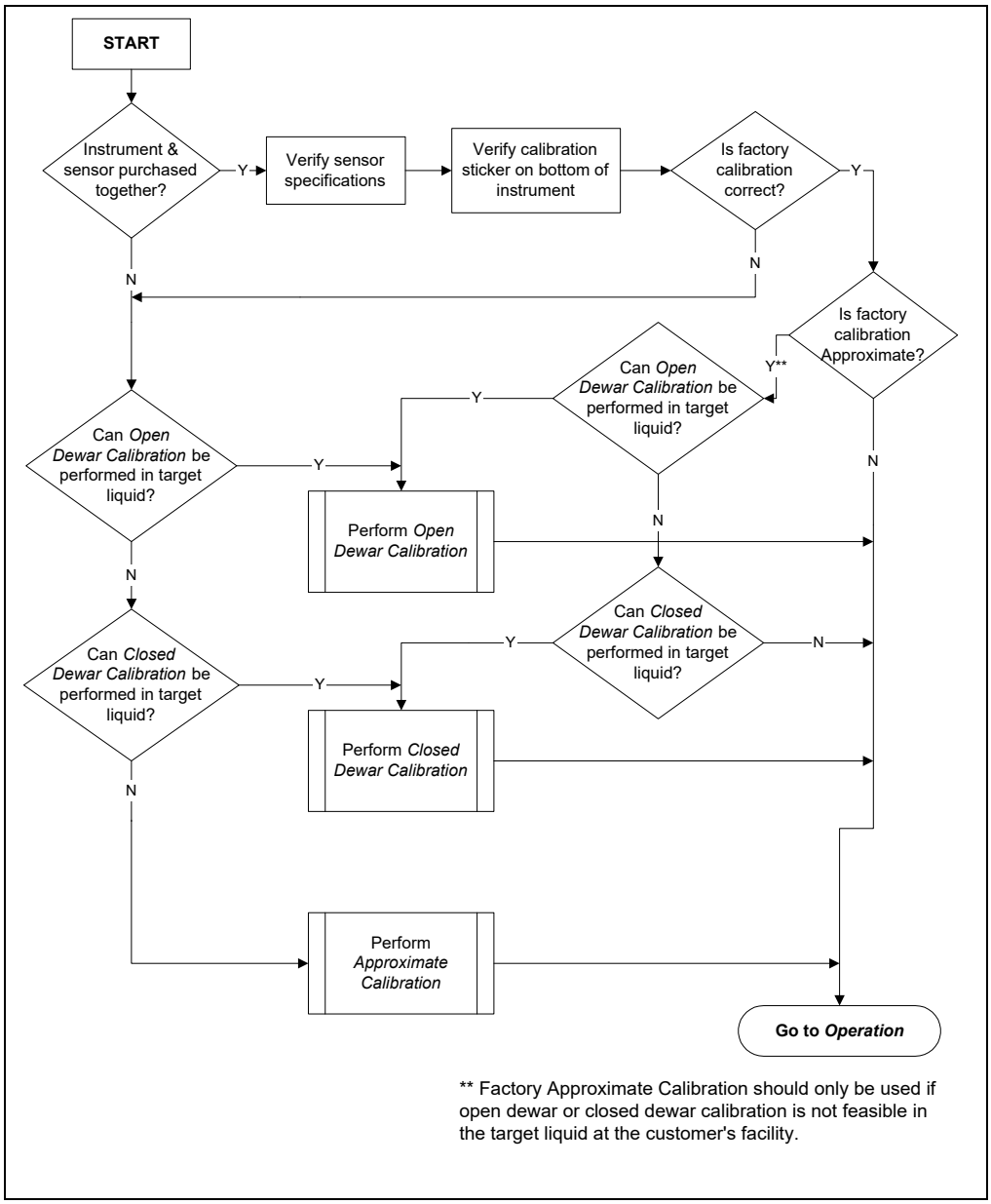
Occasionally customers ask AMI to calibrate an instrument and sensor for a liquid which is not available at AMI for calibration purposes and/or for a sensor which is too long to be calibrated at our facilities.

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 70. 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 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.

SELECTION OF CAPACITANCE SENSOR CALIBRATION METHODS

As a quick guide for selection of the best calibration method available, a calibration selection diagram is presented below.



Calibration method selection diagram.

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 previous 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.

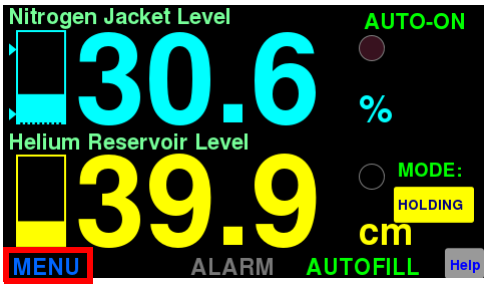
Each Model 1700 Instrument must be calibrated with a sensor before use. If the instrument was purchased with a sensor to be used in liquid nitrogen, the instrument has been calibrated at the factory.

PRE-CALIBRATION PROCEDURE

ENTER CAPACITANCE SENSOR INFORMATION

The following recommended pre-calibration steps apply to *all types of calibrations*.

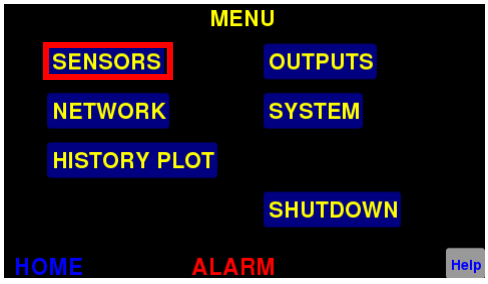
1. Press the **MENU** button in the lower left corner of the display screen.



MENU Selection

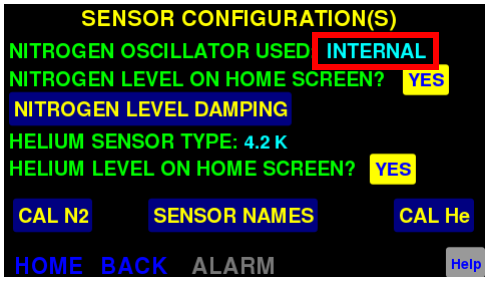
2. Choose the **SENSORS** selection from the **MENU** screen.

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.



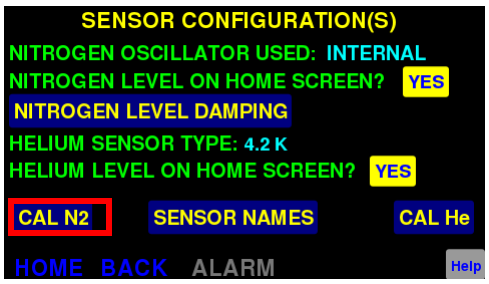
SENSORS Selection

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



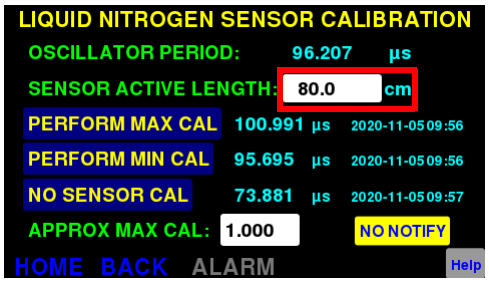
SENSOR CONFIGURATIONS Screen

5. Press the **CAL N2** button



CAL N2 Selection

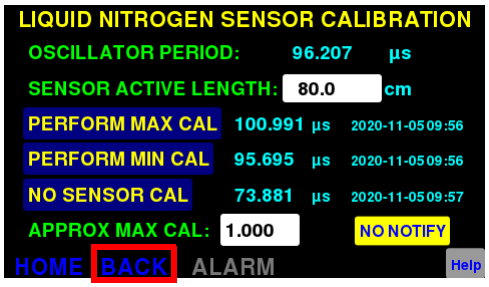
6. Touch in the **SENSOR ACTIVE LENGTH** field and using the numerical keypad, enter the sensor active length in the selected units. Press **ENTER** and then **SAVE** at the bottom of the screen when finished



SENSOR ACTIVE LENGTH field

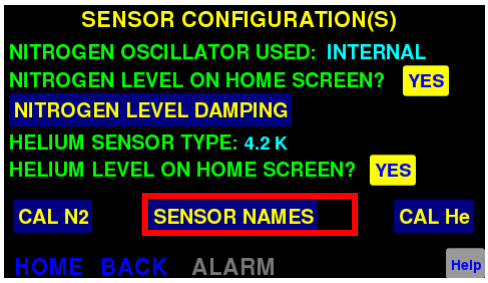
NOTE **Tapping the units symbol (in or cm) allows selection of the available unit selections for that channel.**

7. Press the back button in the screen footer to revert back to the **SENSOR CONFIGURATION(S)** screen.



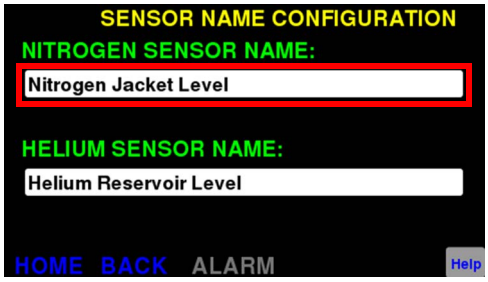
Footer BACK Button Selection

8. Press the **SENSOR NAME(S)** button.



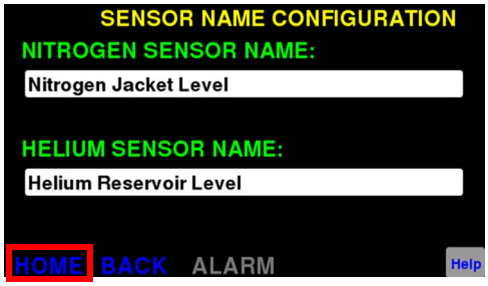
SENSOR NAME(S) Selection

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



SENSOR NAME CONFIGURATION Screen

10. Press **HOME** in the screen footer to return to the level display screen.



HOME Selection

PERFORMING LOSS OF SENSOR CALIBRATION

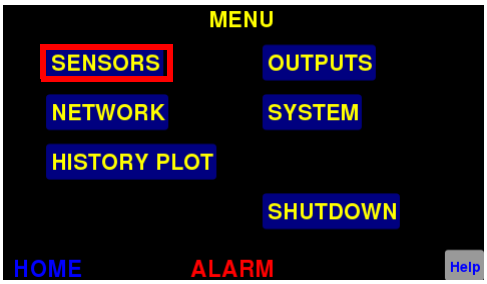
The Model 1700 will detect when the liquid level sensor has been disconnected from the instrument and display a notification on the front panel. If the instrument has been configured for autofill, the fill valve will be shut, requiring operator intervention to resume autofill operation. This loss of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

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 ft) coaxial cable to the input of the oscillator/transmitter unit but leave the cable disconnected from the sensor BNC connector.

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

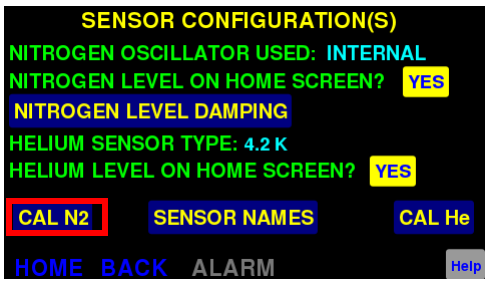
MENU Selection

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



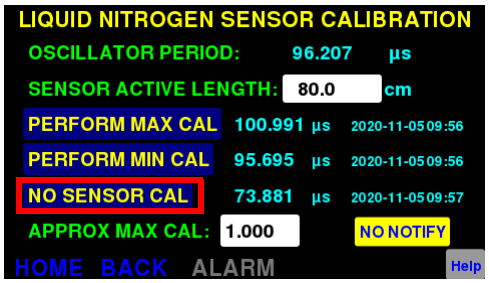
SENSORS Selection

3. From the **SENSOR CONFIGURATION(S)** screen, choose **CAL N2**.



CAL N2 Selection

4. Select the **NO SENSOR CAL** button.
5. When the calibration procedure is completed, choose **SAVE** in the footer of the screen.
6. Press **HOME** to return to the home screen.
7. Connect the BNC cable to the liquid level sensor.

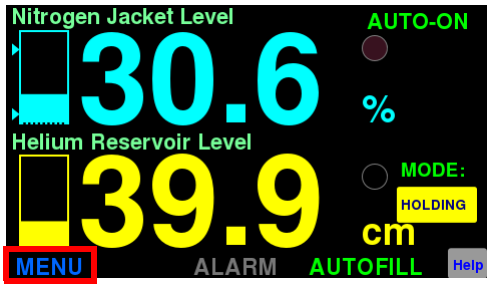


NO SENSOR CAL button

OPEN DEWAR CALIBRATION

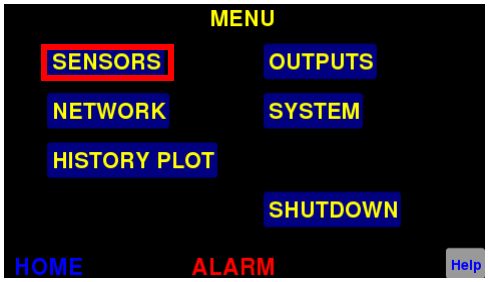
The *Open Dewar Calibration* requires the customer to have access to a filled dewar where the full active length of the sensor can be dipped.

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



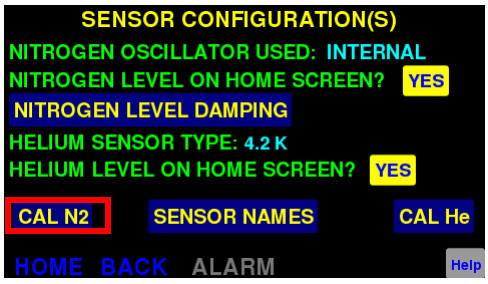
MENU Selection

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



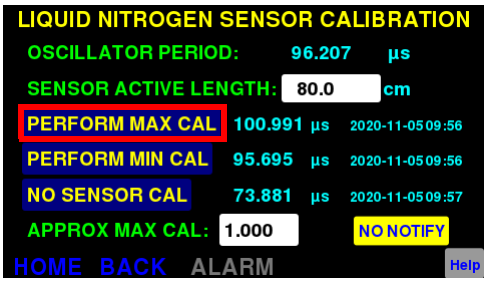
SENSORS Selection

3. Press the **CAL N2** button



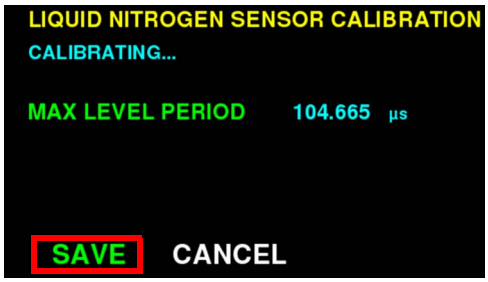
CAL N2 Selection

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.



PERFORM MAX CAL Selection

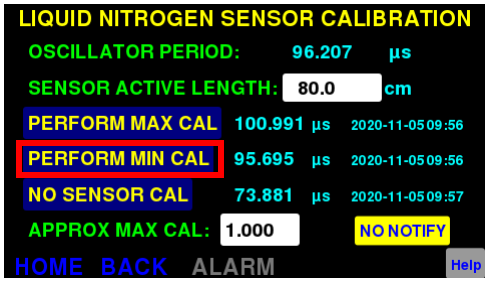
5. The instrument will display the following screen as it takes data. Once the calibration measurement stabilizes, press the **SAVE** button. The operator *must* press the **SAVE** button for the new cal point to be saved.



Updating MAX CAL Period

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. While displaying "**CALIBRATING...**", the instrument will display the **MIN LEVEL PERIOD**. Press the **SAVE** button to save the new minimum level calibration point.



PERFORM MIN CAL Selection

NOTE **Note that the periods listed to the right of the PERFORM MAX CAL and PERFORM 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.**

CLOSED DEWAR CALIBRATION

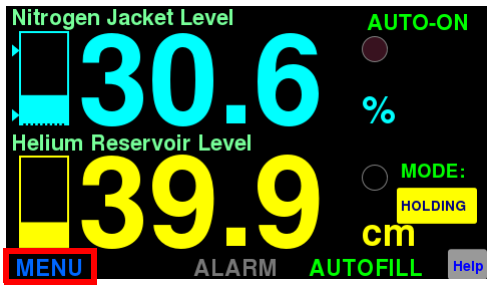
A calibration can be performed in a closed dewar system by monitoring the liquid level while transferring the target liquid to an initially empty (or near empty) dewar at a constant rate. In order to insure success with the closed dewar technique, it is necessary to prepare the instrument by presetting 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.

PRESETTING THE MAXIMUM AND MINIMUM CALIBRATION POINTS

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

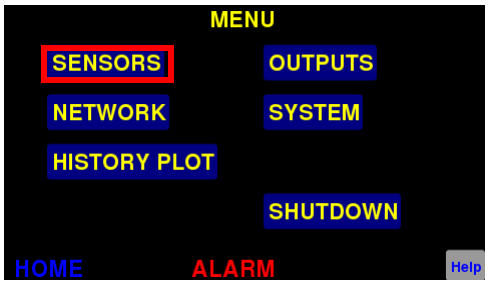
1. Connect the sensor coaxial cable to the BNC connector on the rear panel of the instrument (see page 13). *Do not connect the sensor.* Energize the instrument.

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



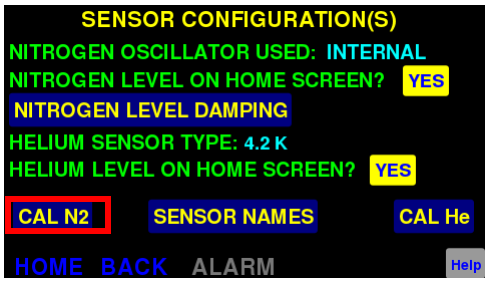
MENU Selection

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



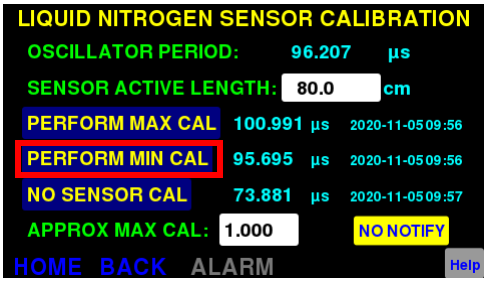
SENSORS Selection

4. Press the **CAL N2** button



CAL N2 Selection

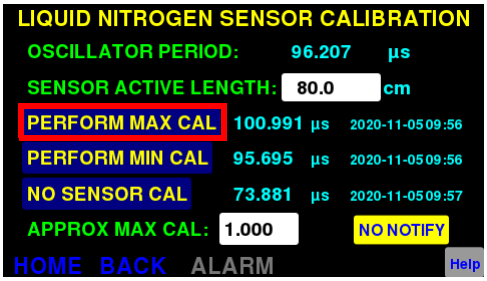
5. Press the **PERFORM MIN CAL** button.
6. While displaying "**CALIBRATING...**", the instrument will display the **MIN LEVEL PERIOD**. Press the **SAVE** button to save the new minimum level calibration point.



PERFORM MIN CAL Selection

NOTE **Note that the period 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 pressing **PERFORM MAX CAL**.
9. While displaying "**CALIBRATING...**", the instrument will display the **MAX LEVEL PERIOD**. Press the **SAVE** button to save the new maximum level calibration point.



PERFORM MAX CAL Selection

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

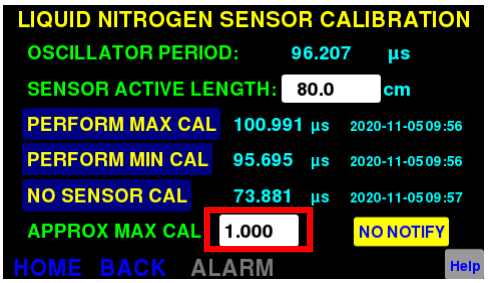
$$C_{adj} = 1.20\left[1 + \frac{2.1(L_{active})}{5.2(L_{total})}\right]\left[\frac{\varepsilon - 1}{0.454}\right]$$

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

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

12. Using the pop up numeric key-pad, enter the C_{adj} value and press the **APPLY** button.

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



APPROX MAX CAL Entry

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 47. to configure the recorder output or current loop output.

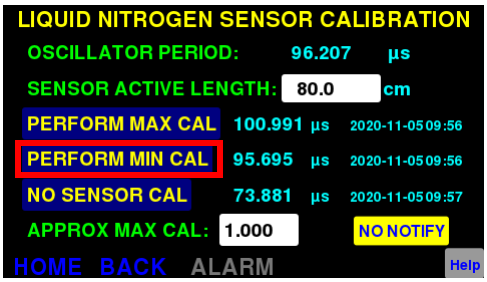
4. Commence filling the dewar. While the sensor is cooling down, there may be a slow drift in the displayed liquid level. However, when the liquid actually touches the bottom of the sensor, contact with the liquid surface may become apparent by virtue of more random and frequent fluctuations in the displayed 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 save 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. Press the **PERFORM MIN CAL** button.

6. While displaying "**CALIBRATING...**", the instrument will display the **MIN LEVEL PERIOD**. Press the **SAVE** button to save the new minimum level calibration point.



PERFORM MIN CAL Selection

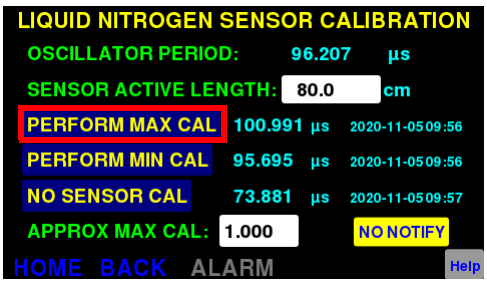
NOTE **Note that the period listed to the right of the PERFORM MIN CAL button is updated as well as the date and time stamp of the calibration point.**

7. 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 **PERFORM MAX CAL** procedure below. The level on the sensor when the **PERFORM MAX CAL** procedure is finished and saved becomes the 100% level.

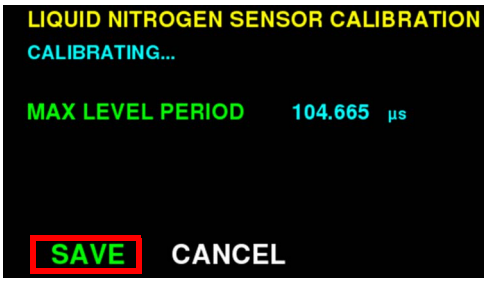
NOTE **If the instrument displayed a 100% reading before a break is observed in the slope of the level trace, then the maximum calibration point set prior to the current procedure has interfered. If this occurs, the customer has two options: 1) stop the procedure, repeatedly multiply C_{adj} by 1.20 (see steps 4 and 5 of the presetting procedure) and enter as the new APPROX MAX CAL value 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 pressing **PERFORM MAX CAL**.



PERFORM MAX CAL Selection

9. While displaying "**CALIBRATING...**", the instrument will display the **MAX LEVEL PERIOD**. Press the **SAVE** button to save the new maximum level calibration point.



Updating MAX CAL Period

NOTE **Note that the period 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:

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

where L_{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:*

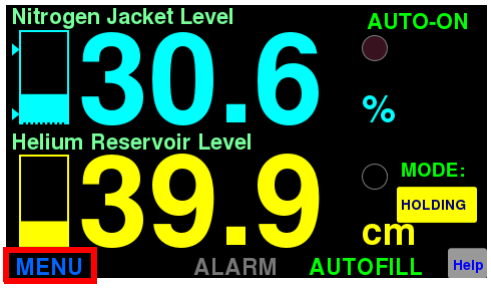
When the sensor is calibrated by the closed dewar procedure, the actual length of calibration will be 21" (distance between the bottom and top holes in the sensor). When the liquid is 1" below the upper hole, the display will show 95.2% [e.g. 100% – (1"/21" x 100%)]. When the liquid level reaches this point during usage, perform the **PERFORM MAX CAL** operation and **SAVE** the result. 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").

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.

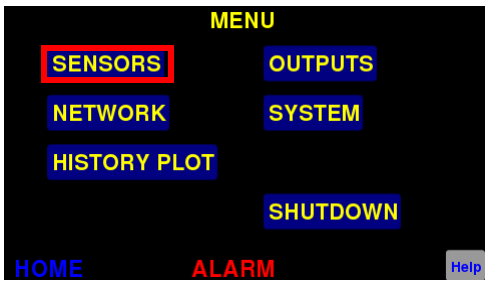
If the target liquid is not available for dipping, a substitute non-conducting reference liquid can be used. If the full length of the sensor cannot be dipped, then a partial length dip can be performed. If both situations are encountered, then a partial length dip can be performed in a substitute reference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

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



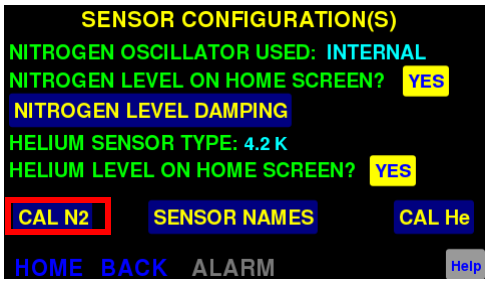
MENU Selection

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



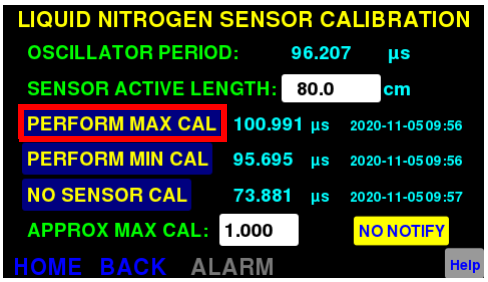
SENSORS Selection

3. Press the **CAL N2** button



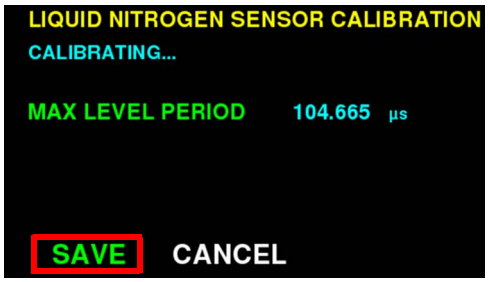
CAL N2 Selection

4. Position the capacitance sensor in the target liquid at the 100% level. Hold the sensor at this location and perform the maximum level calibration by pressing **PERFORM MAX CAL**.



PERFORM MAX CAL Selection

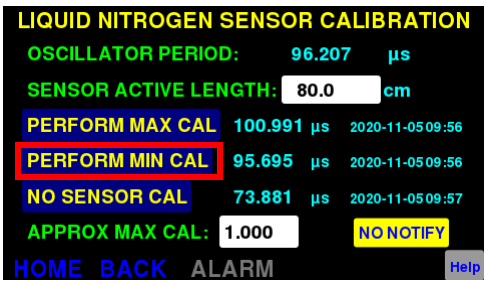
5. While displaying "**CALIBRATING...**", the instrument will display the **MAX LEVEL PERIOD**. Press the **SAVE** button to save the new maximum level calibration point.



Updating MAX CAL Period

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. While displaying "**CALIBRATING...**", the instrument will display the **MIN LEVEL PERIOD**. Press the **SAVE** button to save the new minimum level calibration point.



PERFORM MIN CAL Selection

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

NOTE **The minimum and maximum calibrations 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, ε_1, and the target liquid, ε_2, must be known to complete the approximate calibration. These values must

be placed in the equation:

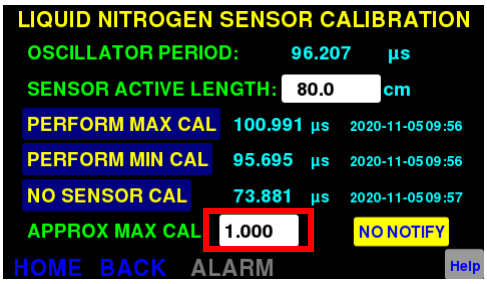
$$\text{APPROX MAX CAL} = \left[\frac{\varepsilon_2 - 1}{\varepsilon_1 - 1}\right]\frac{L_{active}}{L_{dipped}}$$

where L_{dipped} is the length of the sensor dipped in the reference liquid and L_{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, $(\varepsilon_2 - 1)/(\varepsilon_1 - 1)$, becomes 1. If the full active length of the sensor can be dipped, then the length ratio, L_{active} / L_{dipped} , becomes 1.**

Note that ε_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 MAX CAL** field and using the numerical keypad that pops up, enter the value to be applied and press **SAVE** in the footer.



APPROX MAX CAL Entry

NOTE **The calibration values are retained in the instrument memory, therefore it is possible to repeatedly adjust the APPROX MAX CAL value without losing the original MIN/MAX calibration points.**

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:

$$\text{APPROX MAX CAL} = \left[\frac{1.53 - 1}{1.454 - 1}\right]\frac{100}{30} = 3.891$$

A value of 3.891 would be entered as the **APPROX MAX CAL** factor as outlined in step 10 above. The sensor is now approximately calibrated for 100" active length operation in liquid argon.

11. 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.

Proceed to the *Operation* section for directions for configuring the instrument.

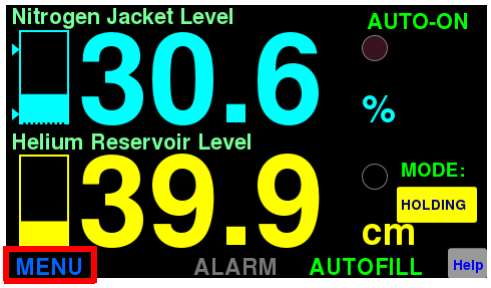
SUPERCONDUCTIVITY-BASED (LIQUID HELIUM) LEVEL CALIBRATION

The instrument has been internally calibrated for use with AMI liquid helium level sensors at the AMI facility. However, it is still necessary to verify, and if necessary enter, the *correct active length* for the connected sensor.

NOTE **If the instrument was purchased *with* a helium level sensor, the active length will be set at AMI prior to shipping.**

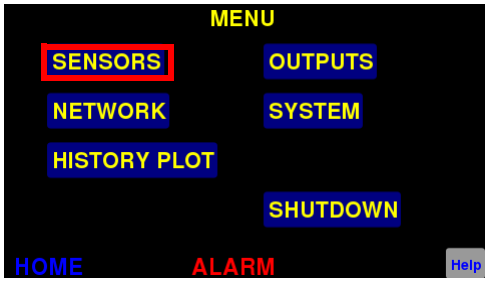
VERIFY THE LIQUID HELIUM SENSOR TYPE

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



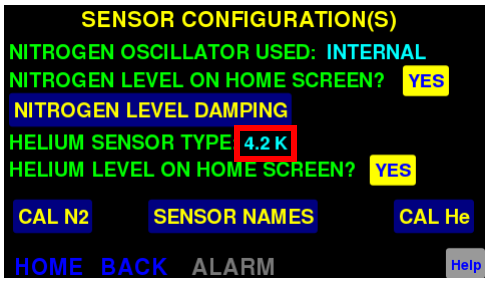
MENU Selection

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



SENSORS Selection

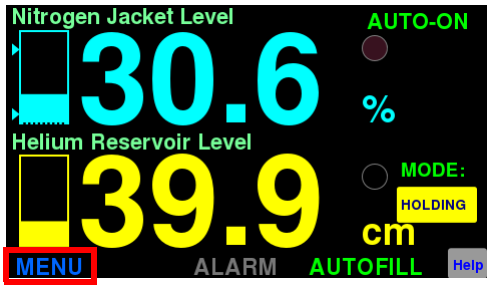
3. Verify that the **HELIUM SENSOR TYPE** (either **4.2K** or **2K** is correct for the sensor to be used with the instrument. If not, contact the factory for assistance.



SENSOR TYPE Selection

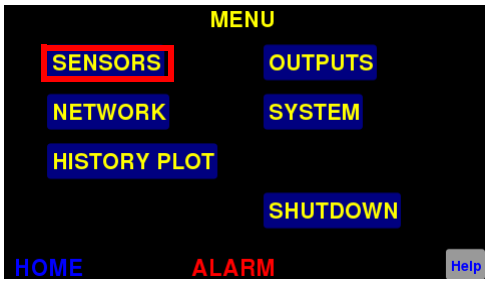
SENSOR SAMPLE INTERVAL

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



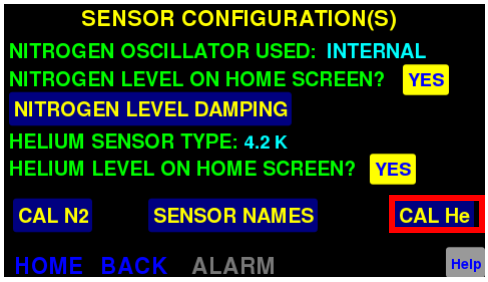
MENU Selection

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



SENSORS Selection

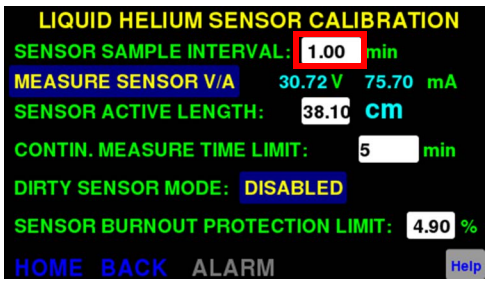
3. Choose the **CAL He** button.



CAL He Selection

4. Press in the **SENSOR SAMPLE INTERVAL** field. A pop up numeric keypad will be launched.

5. Enter the desired sample interval time in minutes and press **ENTER** and then **SAVE**.

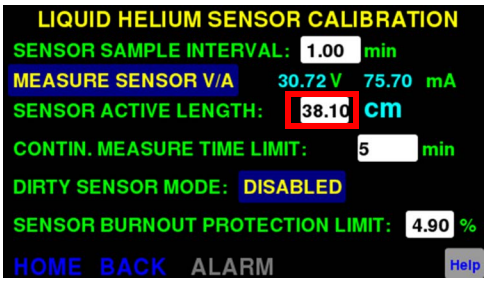


Enter the SENSOR SAMPLE INTERVAL

SENSOR ACTIVE LENGTH

1. Press in the **SENSOR ACTIVE LENGTH** field. A pop up numeric keypad will be launched.
2. Enter the **SENSOR ACTIVE LENGTH** in the selected units and press **ENTER** and then **SAVE**.

NOTE **Tapping the units symbol (in or cm) allows selection of the available unit selections for that channel.**

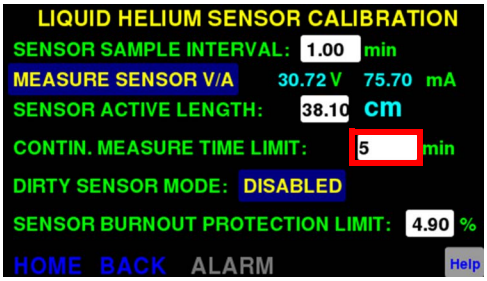


Enter SENSOR ACTIVE LENGTH

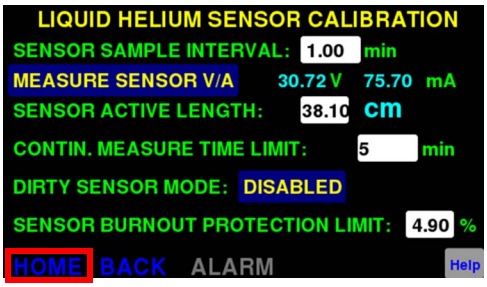
CONTINUOUS MEASURE TIME LIMIT

The Continuous measure time limit feature sets a maximum time that the instrument will keep the liquid helium level sensor energized. If the instrument is left in the **CONTINUOUS** mode for the **CONTIN. MEASURE TIME LIMIT** interval, the instrument will revert back to the sample and **HOLDING** mode to prevent excessive liquid helium boil off.

1. Press in the **CONTIN. MEASURE TIME LIMIT** field. A pop up numeric keypad will be launched.
2. Enter the maximum time in minutes that the sensor should remain energized in the continuous mode. Entering a value of zero disables the feature.
3. Press **ENTER** on the keypad and then **SAVE** at the bottom of the screen.
4. Press the **HOME** button in the screen footer to return to the home screen.



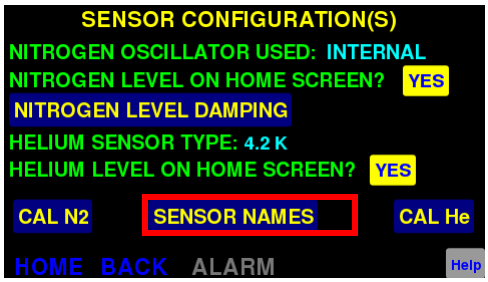
Enter CONTIN. MEASURE TIME LIMIT



Footer HOME Button Selection

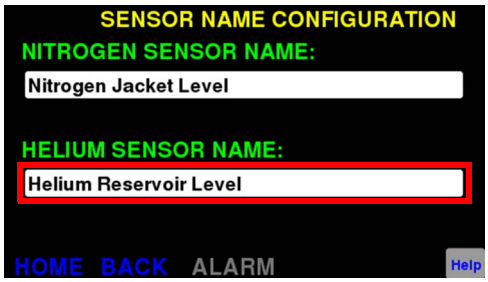
SENSOR NAME

1. Press the **MENU** > **SENSORS** > **SENSOR NAME(S)** buttons.



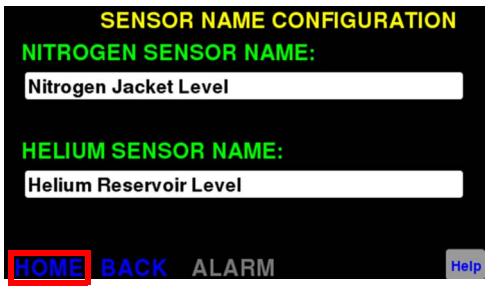
SENSOR NAME(S) Selection

2. Touch in the **HELIUM SENSOR NAME** field. The keyboard will be displayed. Edit the displayed name and press **ENTER** and then **SAVE** at the bottom of the screen.



HELIUM SENSOR NAME Field

3. Press **HOME** in the screen footer to return to the level display screen.



HOME Selection Button

REMOTE INTERFACE REFERENCE

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 provided for the serial and Ethernet return data. The serial and Ethernet interfaces accept SCPI syntax for commands and queries.

The Model 1700 provides a web browser connection (port 80) via TCP/IP and presents a mirror of the local display which has hot spots that can be clicked or tapped, and which also accepts keyboard entry for textual and numerical input. The instrument's IP address can be ascertained by referring to the section titled "IP Addressing Scheme" on page 48. By using a web browser to connect to the instrument, all functionality of the Model 1700 can be controlled via the remote connection.

Communication with the Model 1700 via Ethernet or RS-232 (serial) interface can also be accomplished via the interactive mode of a commercially available terminal emulation program, or by socket (port 7180) or COM port programming. 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 should wait for the reply from the Model 1700 before sending another command even if the reply consists of only termination characters*.

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.

- Triangle brackets < > indicate that you must supply a value.
- Parentheses ( ) within < > indicate alternative units are available.
- Capitalized portions of the commands indicate acceptable abbreviations.

For example, the command `CONFigure:RELAY1:CHannel {0|1|2}` indicates that the command `CONFigure:RELAY1:CHannel` has three parameter options: `0`, `1`, or `2`, with `0` (disabled) being the default value.

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. Default settings are shown in bold.

System-Related Commands

(see page 87 for more information)

```
*IDN?
*RST
*TST?

N2?
HE?

SERial_NUMber?
DATE_MANUfacture?
HardWare_VERsion?
FirmWare_VERsion?
Scpi_VERsion?

SYStem:BEEPer:IMMediate <seconds>
SYStem:BEEPer:STATe {0|1}
SYStem:BEEPer:STATe?

SYStem:KLOCK {0|1}
SYStem:KLOCK?

SYStem:DATE <yyyy>,<mm>,<dd>
SYStem:DATE?

SYStem:TIME <hh>,<mm>,<ss>
SYStem:TIME?

SYStem:REBOOT

IPV4addr?
```

```
MACADDR?
GATEWAY?
HOSTname?

SCREENCAP
SYStem:LOcal
SYStem:REMote
```

Display Configuration Commands and Queries

(see page 90 for more information)

```
DISPlay:N2?
CONFigure:NAME:SENSor:N2 "<string>"
NAME:SENSor:N2?

DISPlay:HE?
CONFigure:NAME:SENSor:HE "<string>"
NAME:SENSor:HE?
```

Relay Configuration Commands and Queries

(see page 91 for more information)

```
CONFigure:RELay1:CHannel {0|1|2}
RELay1:CHannel?

CONFigure:RELay1:SETpoint <level>
RELay1:SETpoint?

CONFigure:RELay1:OPeration {0|1}
RELay1:OPeration?

CONFigure:RELay2:CHannel {0|1|2}
RELay2:CHannel?

CONFigure:RELay2:SETpoint <level>
RELay2:SETpoint?

CONFigure:RELay2:OPeration {0|1}
RELay2:OPeration?

{RELay1|RELay2}:STATus?
```

Alarm Configuration Commands and Queries

(see page 92 for more information)

```
CONFigure:ALArm1:CHannel {0|1|2}
ALArm1:CHannel?

CONFigure:ALArm1:SETpoint <level>
ALArm1:SETpoint?

CONFigure:ALArm1:OPeration {0|1}
ALArm1:OPeration?

CONFigure:ALArm2:CHannel {0|1|2}
ALArm2:CHannel?

CONFigure:ALArm2:SETpoint <level>
ALArm2:SETpoint?

CONFigure:ALArm2:OPeration {0|1}
ALArm2:OPeration?

{ALArm1|ALArm2}:STATus?

ALARm:MUTE {0|1} or {NO|YES}
ALARm:MUTE?
```

Measurement Commands and Queries

(see page 93 for more information)

```
MEASure:N2:LEVel?
MEASure:N2:PERIod?

MEASure:HE:LEVel?
MEASure:HE:HOLD
MEASure:HE:CONTinuous
MEASure:HE:SAMPle
MEASure:HE:VOLTage?

MEASure:ADC0?
MEASure:ADC1?
MEASure:ADC2?
```

Fill Control and Queries

(see page 94 for more information)

```
CONFigure:FILL:CHannel {0|1|2}
FILL:CHannel?

CONFigure:FILL:A <level>
FILL:A?

CONFigure:FILL:B <level>
FILL:B?

CONFigure:INTerval:FILL <minutes>
INTerval:FILL?
```

HE Channel Sampling Commands and Queries

(see page 98 for more information)

```
CONFigure:INTerval:SAMPle <minutes>
INTerval:SAMPle?

CONFigure:HE:TIME_limit <minutes>
HE:TIME_limit?

LOG_LHE {0|1}
LOG_LHE?

HElium_PowerSupply?
DIRTy_sen_mode?
```

Assignment Commands and Queries

(see page 96 for more information)

```
CONFigure:SOURCE:REC_out {0|1|2}
SOURCE:REC_out?

CONFigure:SOURCE:CURrent_LOOP {0|1|2}
SOURCE:CURrent_LOOP?
```

N2 Channel Calibration Commands and Queries

(see page 97 for more information)

```
CONFigure:N2:LENgth <value>
N2:LENgth?

MINCAL
MINCAL?

MAXCAL
MAXCAL?

NOSENSorCAL
NOSENSorCAL?

APPROXMAXCAL <value>
APPROXMAXCAL?
```

HE Channel Calibration Commands and Queries

(see page 98 for more information)

```
CONFigure:HE:LENgth <value>
HE:LENgth?
```

Remote Units Commands and Queries

(see page 98 for more information)

```
CONFigure:N2:UNIT {0|1|2} or {PERCENT|INCH|CM}
N2:UNIT?

CONFigure:HE:UNIT {0|1|2} or {PERCENT|INCH|CM}
HE:UNIT?
```

RS-232 CONFIGURATION

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.

The Model 1700 uses the following *fixed* parameters related to the RS-232 interface:

- *Parity:* No Parity
- *Data Bits*: 8 Data Bits
- *Number of Start Bits*: 1 bit
- *Number of Stop Bits*: 1 bit
- *Flow Control*: None

The baud rate default is 115200, but is adjustable in the SYSTEM CONFIGURATION > RS232 SETUP menu (see page 49).

SERIAL PORT CONNECTOR AND CABLING

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

The Model 1700 uses only three wires of the rear-panel DB9 connector: pin 2 (transmit), pin 3 (receive), and pin 7 (common). There are no software or hardware handshaking options. 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).

COMMAND/RETURN TERMINATION CHARACTERS

All commands are transmitted and received as ASCII values and are case insensitive. The Model 1700 can be configured to return `<CR>` (i.e. a *carriage return*) or `<CR><LF>` (i.e. a *carriage return* followed by a *linefeed*) at the end of a serial transmission (see page 49). The Model 1700 can accept `<CR>`, `<LF>`, `<CR><LF>`, or `<LF><CR>` as termination characters from an external computer.

ETHERNET CONFIGURATION

The Model 1700 provides a 10/100Base-T Ethernet interface as a standard feature. It complies with the IEEE 802.3u 100Base-TX and 802.3 10Base-T standards.

The Model 1700 allows its IP address, subnet mask and gateway IP address to be assigned either statically or dynamically. To make these values static and assign them manually, set IP Address Assignment to Static (see page 48) and then set the values using the Edit parameter

list. To enable the values to be dynamically assigned by a network DHCP server, set IP Address Assignment to DHCP.

The system name (also known as *host name* or *computer name*), can be set using the Network screen (see page 48) or via remote communications (either Ethernet or RS-232).

All network parameters (even those assigned by a DHCP server) can be viewed using the Network submenu (see page 48).

ETHERNET CONNECTOR

The Model 1700 uses a standard RJ-45 jack for Ethernet communications. The Ethernet jack pinout is fully documented on page 110 in the *Appendix*.

TERMINATION CHARACTERS

All commands and queries are transmitted and received as ASCII values and are case insensitive. The Model 1700 always transmits <*CR*><*LF*> (a *carriage return* followed by a *linefeed*) at the end of an Ethernet transmission. The Model 430 can accept <*CR*>, <*LF*>, <*CR*><*LF*>, or <*LF*><*CR*> as termination characters from an external computer.

PORT ASSIGNMENT

The Model 1700 accepts remote connections to port 7180. Multiple connections to port 7180 are allowed.

COMMAND 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.

SYSTEM RELATED COMMANDS

- `*IDN?`

Returns the identification string of the Model 1700. The identification string contains the manufacturer name, model number, serial number, and firmware revision code. Example output:

```
AMERICAN MAGNETICS INC.,MODEL 1700,1700-16-002,2.4.32015
```

- `*RST`

Performs a Factory Restore if a restore file is available. All prior settings are lost!

- `*TST?`

Returns a value incremented by “1” for each query to the requesting interface if unit is functioning. Return value does not indicate any operational status other than a functioning interface.

- `N2?`

Returns “0” if the instrument is not configured to read liquid nitrogen level, “1” if it is with the internal oscillator, and a “2” if it is with an external oscillator/transmitter.

- `HE?`

Returns “0” if the instrument is not configured to read liquid helium level, “1” if the instrument is configured to read 4.2K liquid helium level for sensors of active length ≤ 40 inches, “2” if the instrument is configured to

read 4.2K liquid helium level for sensors of active length ≤ 80 inches, “3” if the instrument is configured to read 2K liquid helium level for sensors of active length ≤ 40 inches, or “4” if the instrument is configured to read 2K liquid helium level for sensors of active length ≤ 80 inches.

- `SERial_NUMber?`

Returns the serial number of the instrument as a string, for example: `1700-16-002`.

- `DATE_MANUfacture?`

Returns the date of manufacture as a string in the form $yyyy\text{-}mm\text{-}dd$, for example: `2016-11-30`.

- `HardWare_VERsion?`

Returns the hardware version of the instrument.

- `FirmWare_VERsion?`

Returns the firmware version of the instrument, for example: `2.4.32015`.

- `Scpi_VERsion?`

Returns the SCPI command version of the instrument.

- `SYStem:BEEPer:IMMediate` <*seconds*>

The receipt of this command with a valid argument causes an audible tone to be generated by the instrument. The duration time parameter is specified in seconds.

- `SYStem:BEEPer:STATe {`**0**`|1}`

Enables/disables the beeper. When `STATe` “0” (OFF) is selected, no instrument condition, except the `SYStem:BEEPer:IMMediate` command, shall cause an audible beep to be emitted. When the instrument restarts, this value is reset to a default of “1” (ON).

- `SYStem:BEEPer:STATe?`

Returns present beeper state. A value of “0” indicates the beeper is disabled. A value of “1” indicates it is enabled.

- `SYStem:KLOCK {`**0**`|1}`

This command locks the local controls of an instrument if set to a value of “1” (ON). This includes all front panel, keyboard, or other local

interfaces. The state of the lock defaults to “0” (OFF) when the instrument is restarted.

- `SYStem:KLOCK?`

Returns the state of the instrument local controls lock. A return value of “0” indicates the lock is OFF. A return value of “1” indicates the local interfaces, such as the touch display, of the instrument are locked.

- `SYStem:DATE <yyyy>,<mm>,<dd>`

Sets the date per <*yyyy*> as a four-digit number; <*mm*> month with range of 1 to 12 inclusive; <*dd*> day of the month. Do not include the <> characters in the command.

- `SYStem:DATE?`

Returns the system date if the form <*yyyy*>,<*mm*>,<*dd*>.

- `SYStem:TIME <hh>,<mm>,<ss>`

This command is used to set the instrument’s clock:

<*hh*> Range of hours is 0 to 23 inclusive.
<*mm*> Range of minutes is 0 to 59 inclusive.
<*ss*> Range of seconds is 0 to 60.

Do not include the <> characters in the command.

- `SYStem:TIME?`

Returns the system time if the form <*hh*>,<*mm*>,<*ss*>.

- `SYStem:REBOOT`

Reboots the instrument.

- `SYStem:RESTORE`

Reboots the instrument and sets all parameters back to factory defaults. All prior settings are lost!

- `IPV4ADDR?`

Returns the presently assigned TCP/IP version 4 address in the form: `xxx.xxx.xxx.xxx`

- `MACADDR?`

Returns the MAC address of the network interface.

- `GATEWAY?`

Returns the Gateway address of the network interface.

- `HOSTname?`

Returns the hostname of the network interface.

- `SCREENCAP`

Snaps a TGA-formatted (TARGA) image of the current local display screen of the instrument and places it in the “Log files” folder of the instrument’s network share.

- `SYSTem:LOCal`

Enables the front panel touchscreen. All front panels controls are enabled by default after a power-up or `REBOOT` command.

- `SYSTem:REMote`

Disables front panel touchscreen.

DISPLAY CONFIGURATION COMMANDS AND QUERIES

- `DISPLAY:N2?`

Returns a “0” if the instrument is not configured to display liquid nitrogen level on the home screen and a “1” if it is.

- `CONFigure:NAME:SENSor:N2 "<`*string*`>"`

Sets the displayed name of the nitrogen level sensor.

- `NAME:SENSor:N2?`

Returns the displayed name of the nitrogen level sensor.

- `DISPLAY:HE?`

Returns a “0” if the instrument is not configured to display liquid helium level on the home screen and a “1” if it is.

- `CONFigure:NAME:SENSor:HE "<`*string*`>"`

Sets the displayed name of the helium level sensor.

- `NAME:SENSor:HE?`

Returns the displayed name of the helium level sensor.

RELAY CONFIGURATION COMMANDS AND QUERIES

- `CONFigure:RELay1:CHannel {0|1|2}`

Assigns relay №1 as disabled (`0`), or to nitrogen (`1`) or helium (`2`).

- `RELay1:CHannel?`

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.

- `CONFigure:RELay1:SETpoint <level>`

Configures the relay №1 trip setpoint in the currently assigned channel’s units.

- `RELay1:SETpoint?`

Returns the relay №1 setpoint in the current units.

- `CONFigure:RELay1:OPeration {0|1}`

Configures relay №1 such that it closes when the level is ≤ the setpoint (`0`) or ≥ the setpoint (`1`).

- `RELay1:OPeration?`

Returns a “0” if relay №1 closes when the level is ≤ the setpoint and a “1” if the relay closes when the relay is ≥ the setpoint.

- `CONFigure:RELay2:CHannel {0|1|2}`

Assigns relay №2 to disabled (`0`), or to nitrogen (`1`) or helium (`2`).

- `RELay2:CHannel?`

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.

- `CONFigure:RELay2:SETpoint <level>`

Configures the relay №2 trip setpoint in the currently assigned channel’s units.

- `RELay2:SETpoint?`

Returns the Relay №2 setpoint in the current units.

- `CONFigure:RELay2:OPeration {0|1}`

Configures relay №2 such that it closes when the level is ≤ the setpoint (`0`) or ≥ the setpoint (`1`)

- `RELay2:OPeration?`

Returns a “0” if relay №2 closes when the level is ≤ the setpoint and a “1” if the relay closes when the level is ≥ the setpoint.

- `{RELay1|RELay2}:STATus?`

Returns the present status of the specified relay. A return value of “0” indicates the relay is not closed. A value of “1” indicates the relay is closed.

ALARM CONFIGURATION COMMANDS AND QUERIES

- `CONFigure:ALArm1:CHannel {`**`0`**`|1|2}`

Assigns alarm №1 as disabled (`0`), or to nitrogen (`1`) or helium (`2`).

- `ALArm1:CHannel?`

Returns a “0” if alarm №1 is disabled, a “1” if the alarm is assigned to the nitrogen channel, and a “2” if the alarm is assigned to the helium channel.

- `CONFigure:ALArm1:SETpoint <`*level*`>`

Configures the alarm №1 trip setpoint in the currently assigned channel’s units.

- `ALArm1:SETpoint?`

Returns the alarm №1 setpoint in the current units.

- `CONFigure:ALArm1:OPeration {`**`0`**`|1}`

Configures alarm №1 such that it alarms when the level is ≤ the setpoint (`0`) or ≥ the setpoint (`1`).

- `ALArm1:OPeration?`

Returns a “0” if alarm №1 alarms when the level is ≤ the setpoint and a “1” if it alarms when the level is ≥ the setpoint. Alarm №1 is considered as the “legacy” HI level alarm when the alarm condition is set to level ≥ a setpoint.

- `CONFigure:ALArm2:CHannel {`**`0`**`|1|2}`

Assigns alarm №2 to disabled (`0`), or to nitrogen (`1`) or helium (`2`).

- `ALArm2:CHannel?`

Returns a “0” if alarm №2 is disabled, a “1” if the alarm is assigned to the nitrogen channel, and a “2” if the alarm is assigned to the helium channel.

- `CONFigure:ALArm2:SETpoint <`*level*`>`

Configures the alarm №2 trip setpoint in the currently assigned channel’s units.

- `ALArm2:SETpoint?`

Returns the alarm №2 setpoint in the current units.

- `CONFigure:ALArm2:OPeration {`**0**`|1}`

Configures alarm №2 such that it alarms when the level is ≤ the setpoint (`0`) or ≥ the setpoint (`1`)

- `ALArm2:OPeration?`

Returns a “0” if alarm №2 alarms when the level is ≤ the setpoint and a “1” if it alarms when the level is ≥ the setpoint. Alarm №2 is considered as the “legacy” LO level alarm when the alarm condition is set to level ≤ a setpoint.

- `{ALArm1|ALArm2}:STATus?`

Returns the present status of the specified alarm. A return value of “0” indicates the alarm is inactive. A value of “1” indicates the alarm is active.

- `ALARm:MUTE {0|1}` *or* `{NO|YES}`

Mutes the audible alarm for any active alarm(s) when set to “1” or “YES”. Unmutes the audible alarm if set to “0” or “NO”.

- `ALARm:MUTE?`

Returns “0” if audible alarm is muted. Returns “1” if not muted.

MEASUREMENT COMMANDS AND QUERIES

- `MEASure:N2:LEVel?`

Returns the liquid nitrogen level in the current units.

- `MEASure:N2:PERIod?`

Returns the liquid nitrogen level measurement period in microseconds.

- `MEASure:HE:LEVel?`

Returns the liquid helium level in the current units.

- `MEASure:HE:HOLD`

Changes liquid helium level measurement operation from Continuous to Sample and Hold.

- `MEASure:HE:CONTinuous`

Changes liquid helium level measurement operation from Sample and Hold to Continuous mode.

- `MEASure:HE:SAMPle`

Energizes the liquid helium level sensor, makes a reading and returns to Sample and Hold mode.

- `MEASure:HE:VOLTage?`

Returns the last measured liquid helium level sensor voltage in volts.

- `MEASure:ADC0?`

Returns the last measured liquid helium level sensor voltage in volts.

- `MEASure:ADC1?`

Returns the liquid helium sensor power supply voltage in volts.

- `MEASure:ADC2?`

Returns the liquid helium sensor excitation current in milliamperes.

FILL CONTROL AND QUERIES

- `CONFigure:FILL:CHannel {0|1|2}`

Assigns the auto fill control relay to either no channel (disabled) (`0`), nitrogen (`1`), or helium (`2`).

- `FILL:CHannel?`

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.

- `CONFigure:FILL:A <level>`

Sets the A setpoint (control band upper limit) in the assigned channel's current units. The A setpoint (autofill stop) must be greater than the B setpoint (fill start) and must also be between 0% and 100%.

- `FILL:A?`

Returns the A setpoint (control band upper limit) in the assigned channel's current units.

- `CONFigure:FILL:B <level>`

Sets the B setpoint (control band lower limit) in the assigned channel's current units. The B setpoint (autofill start) must be less than the A setpoint (fill stop) and must also be between 0% and 100%.

- `FILL:B?`

Returns the B setpoint (control band lower limit) in the assigned channel's current units.

- `CONFigure:INTerval:FILL <minutes>`

Sets the fill timer in minutes. If the level does not reach or exceed the A setpoint within the fill time, the fill is terminated. Setting the value of FILL to "0" disables the fill timer function.

- `INTerval:FILL?`

Returns the fill timer setting in minutes.

HE CHANNEL SAMPLING COMMANDS AND QUERIES

- `CONFigure:INTerval:SAMPle <minutes>`

Sets the liquid helium sampling interval in minutes.

- `INTerval:SAMPle?`

Returns the sampling interval in minutes if the instrument is configured with a helium channel.

- `CONFigure:HE:TIME_limit <minutes>`

Sets the continuous measurement time limit for liquid helium measurements in minutes, after which time the instrument will return to sampling mode.

- `HE:TIME_limit?`

Returns the continuous measurement time limit in minutes.

- `LOG_LHE {0|1}`

Enables (1) or disables (0) liquid helium level logging.

- `LOG_LHE?`

Returns “0” if the liquid helium level logging is disabled, or “1” if enabled.

- `HElium_PowerSupply?`

Returns the helium power supply configuration of the instrument where “0” is not installed, “1” is standard, and “2” is XL version.

- `DIRTy_sen_mode?`

Returns a “0” if the instrument’s dirty sensor mode is disabled for the helium channel and a “1” if it is enabled.

ASSIGNMENT COMMANDS AND QUERIES

- `CONFigure:SOURCE:REC_out {0|1|2}`

Configures the 0-10 V_{DC} Recorder Output source to disabled (`0`), assigned to the nitrogen channel (`1`), or the helium channel (`2`).

- `SOURCE:REC_out?`

Returns a “0” if the 0-10 V_{DC} 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.

- `CONFigure:SOURCE:CURrent_LOOP {0|1|2}`

Configures the 4-20 mA Current Loop output source to disabled (`0`), assigned to the nitrogen channel (`1`), or the helium channel (`2`).

- `SOURCE:CURrent_LOOP?`

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.

N2 CHANNEL CALIBRATION COMMANDS AND QUERIES

- `CONFigure:N2:LENgth <value>`

Configures the liquid nitrogen sensor active length in current units. Returns an error code if the current units are percent.

- `N2:LENgth?`

Returns the configured active length of the liquid nitrogen sensor in current units. Returns an error code if the current units are percent.

- `MINCAL`

Performs and saves a **MIN** calibration point calibration for the liquid nitrogen sensor.

- `MINCAL?`

Returns the last saved **MIN** calibration point in microseconds for the liquid nitrogen sensor.

- `MAXCAL`

Performs and saves a **MAX** calibration point calibration for the liquid nitrogen sensor.

- `MAXCAL?`

Returns the last saved **MAX** calibration point in microseconds for the liquid nitrogen sensor.

- `NOSENSorCAL`

Calibrates and saves the **LOSS OF SENSOR** condition for the liquid nitrogen sensor.

- `NOSENSorCAL?`

Returns the last saved **LOSS OF SENSOR** calibration point in microseconds for the liquid nitrogen sensor.

- `APPROXMAXCAL <value>`

Sets the **Approx Cal (Max) Multiplier** factor (see page 70) to a decimal value. The value is nominally 1.000 for no modification to the MAX calibration point.

- `APPROXMAXCAL?`

Returns the **Approx Cal (Max) Multiplier** factor (see page 70) as a decimal value.

HE CHANNEL CALIBRATION COMMANDS AND QUERIES

- `CONFigure:HE:LENgth <value>`

Configures the liquid helium sensor active length in current units. Returns an error if the current units are percent.

- `HE:LENgth?`

Returns the configured active length of the liquid helium sensor in current units. Returns an error code if the current units are percent.

REMOTE UNITS COMMANDS AND QUERIES

- `CONFigure:N2:UNIT {0|1|2}` *or* `{PERCENT|INCH|CM}`

Sets the liquid nitrogen level units of measurement to percent (`0` or `PERCENT`), inches (`1` or `INCH`), or centimeters (`2` or `CM`). The default is `PERCENT` units.

- `N2:UNIT?`

Returns the current liquid helium level units in use as either `C`, `I`, or `%`.

- `CONFigure:HE:UNIT {0|1|2}` *or* `{PERCENT|INCH|CM}`

Sets the liquid helium level units of measurement to percent (`0` or `PERCENT`), inches (`1` or `INCH`), or centimeters (`2` or `CM`). The default is `PERCENT` units.

- `HE:UNIT?`

Returns the current liquid helium level units in use as either `C`, `I`, or `%`.

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.

Error Code	Meaning	Valid Range
-1	LO (or relay №2[a]) setpoint out of range	0 ≤ LO (or relay №2[a]) ≤ LENGTH
-2	Fill B setpoint (fill start) out of range	0 ≤ B < A
-3	Fill A setpoint (fill stop) out of range	B < A ≤ LENGTH
-4	HI (or relay №1[a]) setpoint out of range	0 ≤ HI (or relay №1[a]) ≤ LENGTH
-5	Attempted to set or query for LENGTH in PERCENT units mode	
-6	Invalid argument, value out of maximum calibration range	1 cm ≤ value ≤ 650 cm (LN2) 0 < value ≤ 213.36 cm (HE)
-7	INTERVAL setting out of range	0 ≤ INTERVAL ≤ 999 min[b] (or) 0 ≤ INTERVAL ≤ 99999 min[c]
-8	Unrecognized command	
-9	Invalid argument, value was negative or non-numeric	
-10	Approximate calibration *factor* out of range	0.1 ≤ factor ≤ 999.9
-11	Command exceeds SCPI input buffer limit	256 characters, including spaces, etc.
-12	Command invalid for selected channel or interface in present configuration	

a. Applies to dual instrument configuration

b. For Version HW = 4712

c. For Version HW = 4900

SERVICE AND REPAIR

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.

USER REPLACEABLE PARTS

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

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

BATTERY REPLACEMENT

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

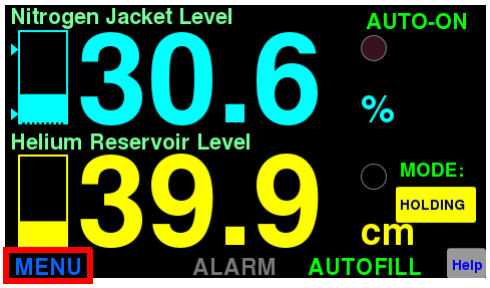
WARNING **This procedure should only be performed by a technician who is familiar with electronic instrumentation and trained in electrical safety and ESD precautions. Always disconnect the power cord and any external wiring before removing the instrument cover.**

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

LOW BATTERY INDICATION

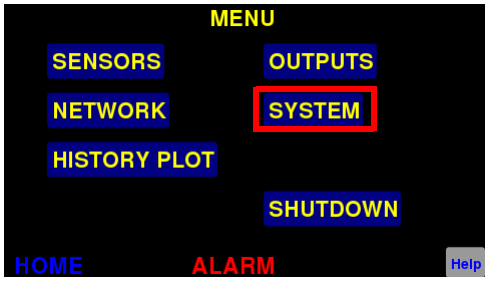
Battery status is displayed in the **SYSTEM DATE & TIME** dialog. To access the dialog:

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



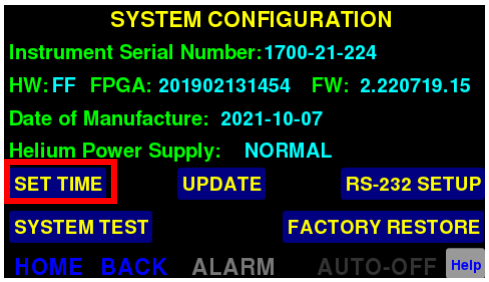
Menu Selection From Home Screen

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



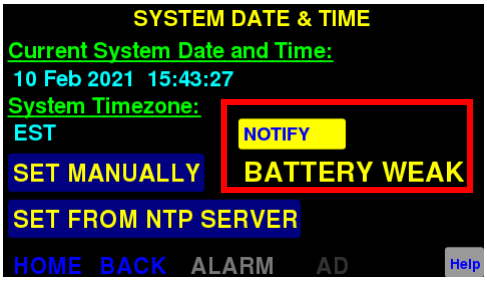
MENU Selection Screen

3. From the **SYSTEM CONFIGURATION** screen choose **SET TIME**.



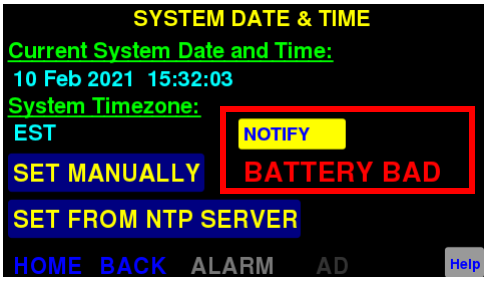
SYSTEM CONFIGURATION Screen

4. The battery status is displayed in the **SYSTEM DATE & TIME** screen. If the battery is weak and should be replaced soon, the message will appear as shown at right.



Weak Battery Indication

5. If the battery is expired, the message will appear as shown at right.



Expired Battery Indication

NOTE **The NOTIFY button state will cause a warning message to appear in the the HOME screen footer. NO NOTIFY supresses the HOME screen warning.**

The following sections detail how to replace the battery.

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)

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.

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.

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)

PROCEDURE

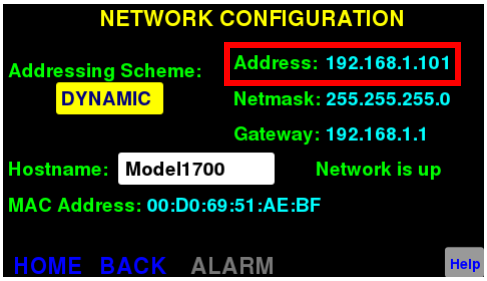
1. Unplug the instrument from the AC power source.
2. Using the T-15 driver, remove the four 8-32 machine screws on the sides of the instrument cover. Set these screws aside as they will be re-used.
3. Using the T-10 driver, remove the four 6-32 machine screws on the rear of the instrument cover. Set 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.

FIRMWARE UPGRADE VIA ETHERNET

The following procedure can be utilized by users to upgrade the Model 1700 by downloading firmware upgrade archives (.tar.gz) from the AMI support website.

1. Connect the instrument to a computer network via Ethernet cable and energize the instrument.

2. When the instrument has completed booting, note the IP Address: **MENU > NETWORK > Address**. There should be a message in green on the screen indicating "Network is up".



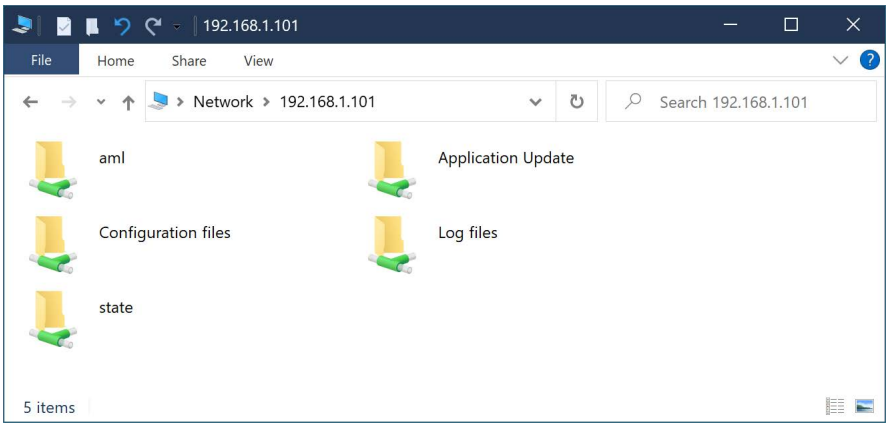
Network Configuration Screen

3. Determine the currently installed version of firmware. From the home page, press **MENU > SYSTEM > FW Version**.

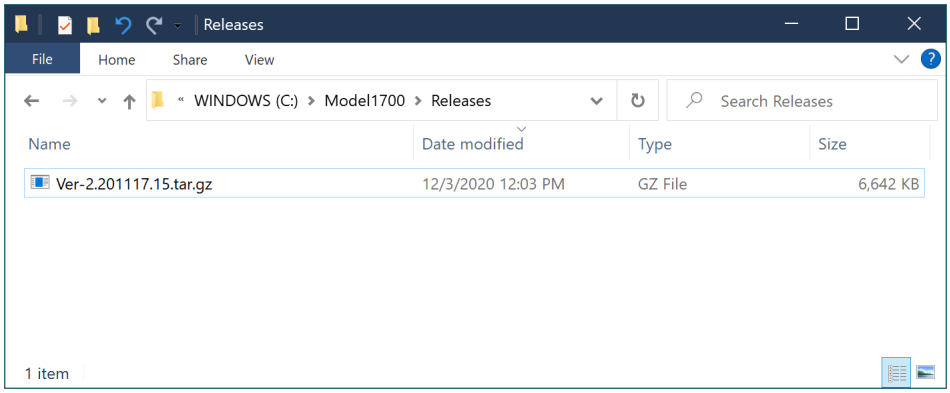
4. Download the available new version of firmware and place on a PC on the same network as the instrument.

NOTE **The following steps assume the computer is Windows-based.**

5. Start Windows Explorer and enter the instrument's IP address noted from Step 2 above in the address field. Be sure to use the format such as `\\192.168.1.101`. Ensure the Explorer screen looks similar to the following.



6. Open a second Windows Explorer and locate the previously downloaded firmware file:



7. Drag the firmware file to the instrument's Application Update folder in the first Explorer screen.

8. Install the new firmware by pressing **MENU > SYSTEM > UPDATE** on the instrument and choose the name of the firmware file copied to the instrument. It is likely the top choice of the files listed.

9. Press INSTALL on the instrument when prompted.

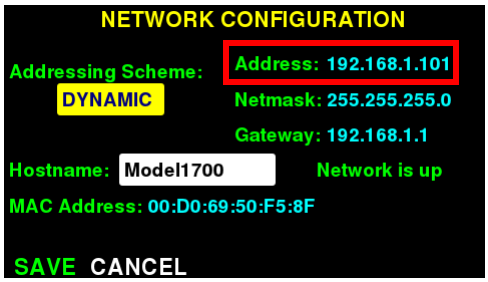
10. The instrument will install the new firmware and reboot when completed.

UPGRADE VIA SCP

If the instrument's file shares are not visible on the local network, it is possible to copy the firmware upgrade directly to the instrument using the `root` login and password using SCP (Secure Copy) over Ethernet.

1. Connect the instrument to the local computer network via Ethernet cable and energize the instrument.

2. When the instrument has completed booting, note the IP Address: **MENU > NETWORK > Address**. There should be a message in green on the screen indicating "Network is up".



Network Configuration Screen

3. Determine the currently installed version of firmware. From the home page, press **MENU > SYSTEM > FW Version**.

4. Download the available new version of firmware and place on a Windows, Linux, or Mac computer on the same network as the instrument.

5. Open a command line application and set the current directory to the folder where the newly download firmware from the prior step resides.

6. Enter the following command where the example IP address of `192.168.1.101` is replaced by the IP of the instrument noted in step 2 above, and the example firmware file of `Ver-2.22719.15.tar.gz` is replaced by the actual file downloaded from AMI:

   ```
   scp ./Ver-2.220719.15.tar.gz root@192.168.1.101:/update
   ```

   Note that you will prompted to enter the root account password to complete the file transfer. If you do not know the password, contact an Authorized AMI Technical Support Representative for assistance.

7. Install the new firmware by pressing **MENU > SYSTEM > UPDATE** on the instrument and choose the name of the firmware file copied to the instrument via SCP. It is likely the top choice of the files listed.

8. Press INSTALL on the instrument when prompted.

The instrument will install the new firmware and reboot when completed.

APPENDIX

SERIAL (RS-232) CONNECTOR

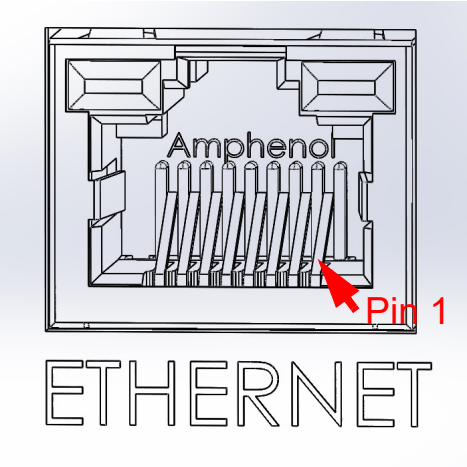
Serial (RS-232) Pin Out

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.

Serial (RS-232) Pin Definitions

Pin	Mnemonic	Function
1	N/C	
2	TXD	Transmit Data
3	RXD	Receive Data
4	N/C	
5	GND	Signal Ground
6	N/C	
7	N/C	
8	N/C	
9	N/C	

ETHERNET CONNECTOR



Ethernet Connector Socket Pin out

Ethernet RJ-45 Connector Pin Definitions

Pin	Mnemonic	Function
1	TXD+	Transmit differential output +
2	TXD-	Transmit differential output -
3	RXD+	Transmit differential input +
4	not used	
5		
6	RXD	Transmit differential input -
7	not used	
8		

LIQUID HELIUM CONNECTOR J1 WIRING

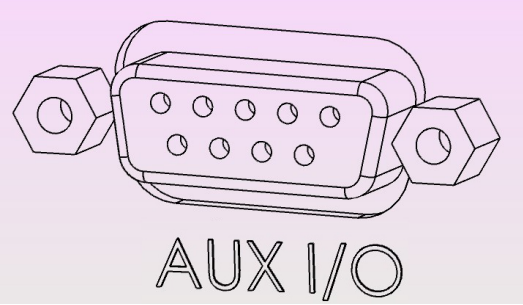
The LHe connector is a 9-pin D-sub female connector.

Liquid Helium (LHe) Level Sensor Connector

LHe Level Connector Pin Definitions

Pin	Function	AMI Standard Wiring Color
1	Sensor I+	Red
2	+48 VDC P/S Test Point	
3	+5 VDC P/S Test Point	
4	-12 VDC P/S Test Point	
5	P/S Test Points Common	
6	Sensor V-	Yellow
7	Sensor I-	Black
8	Sensor V+	Blue
9	+12 VDC P/S Test Point	

AUX I/O CONNECTOR



Aux I/O Connector

The AUX I/O connector is a 9-pin D-sub female connector.

Aux I/O Pin Definitions

Pin	Function	Polarity
1	4-20 mA Current Loop	+
2		–
3	0-10 VDC Output	+
4		–
5	Relay № 1 Dry Contact	N/A
6		
7	Relay № 2 Dry Contact	N/A
8		
9	N/A	

NOTE **If the Model 1700 is being used to replace a Model 13x instrument, a M-M 9-pin gender changer will be necessary to change the female AUX I/O connector on the Model 1700 to a male type.**

DIELECTRIC CONSTANTS FOR CRYOGENIC LIQUIDS

Common Cryogenic Liquid Dielectric Constants[a]

Liquid	Dielectric Constant
Argon (Ar)	1.5034
Carbon Dioxide (CO_2)	2.5911
Hydrogen (H_2)	1.2307
Methane (CH_4)	1.6257
Nitrogen (N_2)	1.4327
Propane (C_3H_8)	1.8029
Oxygen (O_2)	1.4872

a. NIST RefProp version 9.1

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

INSTRUMENT DISPLAYS "LOSS OF SENSOR" CONDITION FOR LN_2 LEVEL MEASUREMENT

This message indicates one of two things: the signal from the external oscillator/transmitter has been lost (disconnection) or the capacitance measured by the instrument is significantly less than the minimum capacitance expected during level measurement[1]. Ensue the instrument has been calibrated (especially "Performing Loss of Sensor Calibration" on page 61) and is properly connected via coaxial cable(s) to the BNC connector on the back of the instrument.

INSTRUMENT DISPLAYS "LOSS OF SENSOR" CONDITION FOR LHE LEVEL MEASUREMENT

This message indicates that the instrument cannot get sensor excitation current to flow in the sensor circuit[2]. Check that the sensor is wired correctly and that the sensor is connected to the proper connector on the back of the instrument. When the wiring is corrected, place the instrument in MEASURE CONTINUALLY mode and the Loss of Sensor condition should be cleared at which time the instrument can be placed back in SAMPLE & HOLD mode if desired.

INSTRUMENT DISPLAYS "SENSOR SHORTED" CONDITION FOR LN_2 LEVEL MEASUREMENT

This message indicates that the sensor oscillator circuit has ceased oscillating. This is usually caused by a contaminated level sensor where a conductive substance (usually water) is shorting out the sensor tubes.[3] Dry or clean out the sensor and this condition is usually removed. Note

1. The threshold is the midpoint between the MINimum CALibration and the NO SENSOR CALibration.
2. The threshold is approximately 1 mA.
3. The threshold is approximately 200 kohms with a sensor capacitance of 2 nF.

that the sensor resistance measured across the BNC connector should be $>10^7$ ohms.[1]

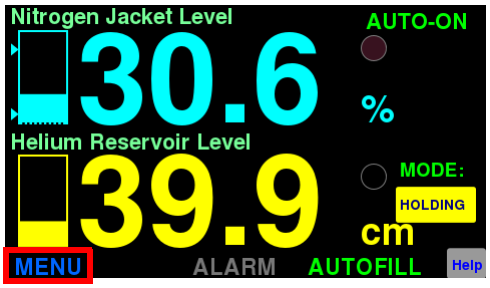
INSTRUMENT DISPLAYS "SENSOR PROTECTED" CONDITION FOR LHE MEASUREMENT

This message indicates that the LHe level sensor circuit is of a higher impedance than expected for the selected active sensor length.[2] The protection means that the normal sensor excitation has been stopped and the sensor is intermittently pulsing the current to see if the resistance is back in the expected range. This condition is usually seen when the instrument is set for an active length greater than the level sensor connected to the instrument. See "Sensor Active Length" on page 76. This condition will also occur if a LHe level sensor is energized in a vacuum since the level sensor's sensing element will heat up to an abnormally high temperature and with its positive temperature coefficient, present a larger than expected resistance to the instrument.

SYSTEM TEST SCREENS

The instrument provides various system test functions that can be performed from the front panel touchscreen. The system test functions are not available to the web browser interface nor the SCPI remote interface over serial or Ethernet connections. To access the test functions:

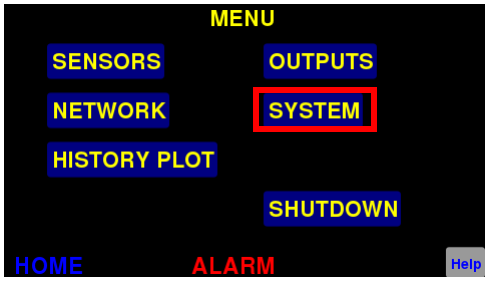
1. From the home screen, choose **MENU**.



Menu Selection From Home Screen

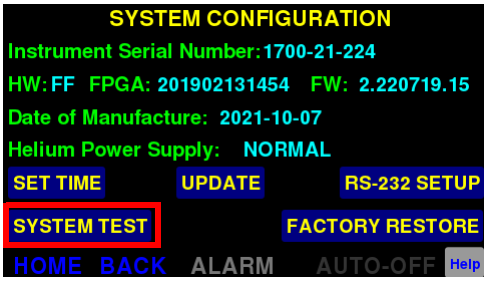
1. Any resistance between the sensor elements will cause the instrument to read higher than actual level.
2. The threshold is 5% greater resistance than the SENSOR ACTIVE LENGTH resistance.

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



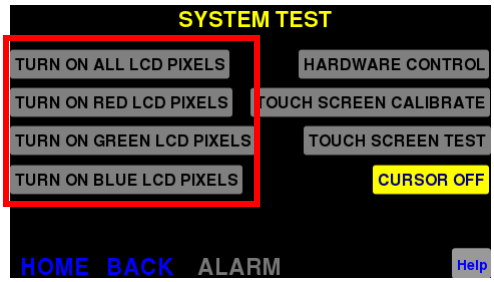
MENU Selection Screen

3. From the **SYSTEM CONFIGURATION** screen choose **SYSTEM TEST**.



SYSTEM CONFIGURATION Screen

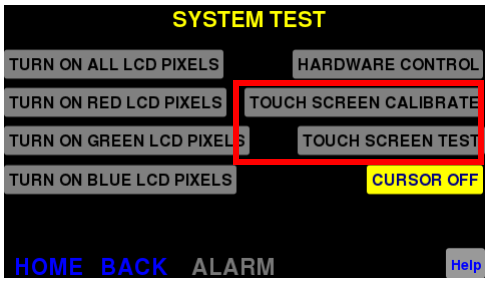
4. In the **SYSTEM TEST** screen, several selections are available to test the touchscreen colors. Pressing a pixel test button will cause the screen to show a scrolling test pattern. When touched again, the display will then return to normal.



SYSTEM TEST Pixel Tests

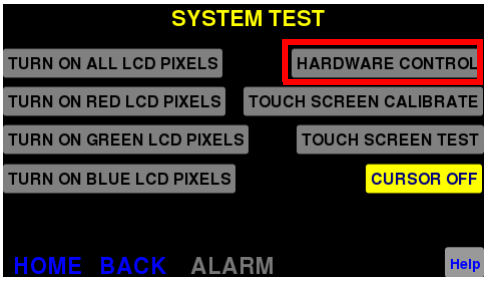
5. To calibrate or test the touch function of the screen, use the **TOUCH SCREEN CALIBRATE** or **TOUCH SCREEN TEST** selections in the **SYSTEM TEST** screen.

   The calibrate function will display a screen with touch targets. Touch all the targets as they are displayed to complete the calibration. The instrument will then automatically store the new touch calibration.



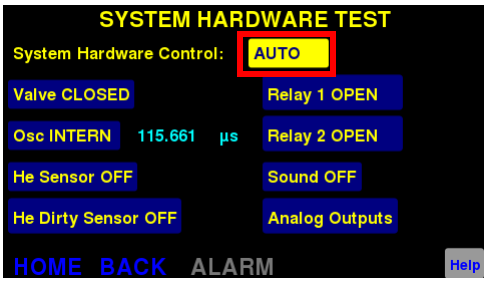
SYSTEM TEST Touch Cal/Test

6. The **HARDWARE CONTROL** selection in the **SYSTEM TEST** screen allows the user to observe in real time and/or manually test various functions of the instrument hardware. Press the **HARDWARE CONTROL** button to move to the detailed test screen.



Hardware Test Selection

7. The **HARDWARE CONTROL** screen includes several controls to manually exercise the hardware. However, to do so the operator must press the Control button to toggle it from **AUTO** to **MANUAL** mode.



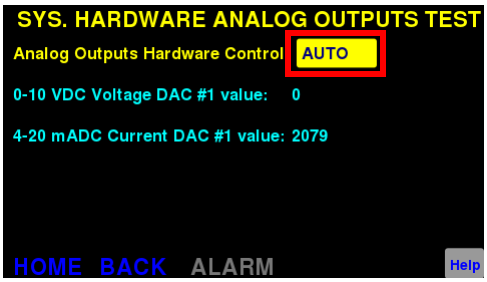
Hardware Control Screen

8. Once in **MANUAL** mode, the user can touch any of the buttons to toggle the state of the hardware. The **Analog Outputs** button is, however, not a toggle but will move the operator to the **ANALOG OUTPUTS TEST** screen.

NOTE **In the AUTO mode, the Test screen displays the real time measurement or state of each labeled function.**

NOTE **When changing to MANUAL test mode, please be aware that the automatic functions of the instrument will be overridden. Functions such as autofill will be interrupted, or a fill initiated, by the manual actions. Be sure the system is in a *safe condition* before exercising manual control.**

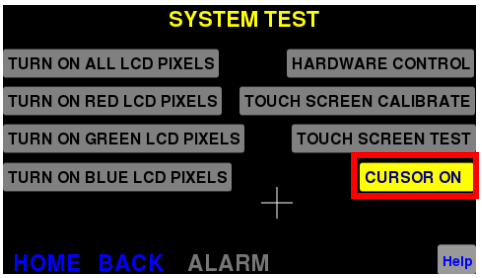
9. The **ANALOG OUTPUTS TEST** screen requires the operator press the Control button to toggle from **AUTO** to the **MANUAL** mode to exercise control over the output values. The output values range from 0 to 4095 where 0 is the minimum output value and 4095 is the maximum output value. Tap a value to enter a manual override.



Analog Outputs Tests Screen

NOTE **The hardware control state will return to AUTO after a few seconds if the operator does not explicitly return to automatic control. However, the state of the hardware or autofill functions are *not guaranteed to be the same* as when the MANUAL control state was entered.**

10. Finally, the **CURSOR ON/OFF** button in the **SYSTEM TEST** screen allows the operator to turn the cursor off and on. The cursor display can be useful for verifying the touchscreen response if it appears to function incorrectly.
11. Use the **HOME** button to return to the main level display.

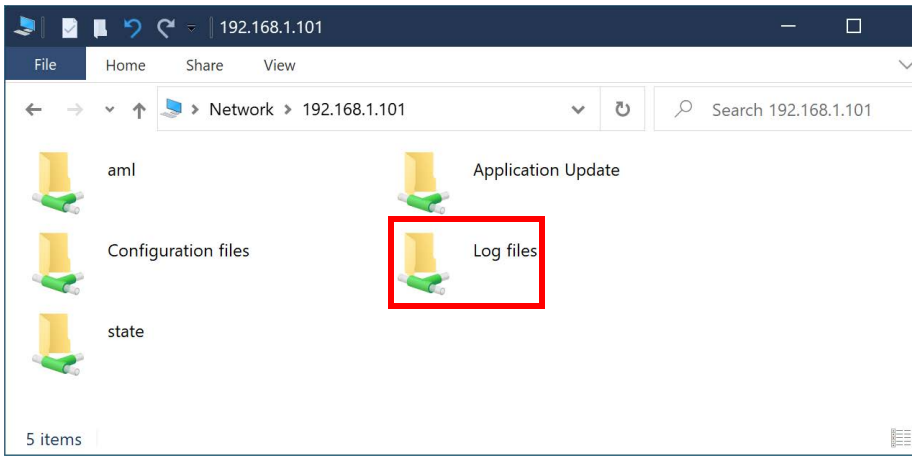


CURSOR Display Selection

SYSTEM LOGS

The Model 1700 provides a logging feature that saves detailed information regarding the liquid level and system events. The information can be very useful in troubleshooting suspected system errors.

The Model 17XX family of liquid level instruments keeps log files in a local Ethernet network accessible folder via Samba file shares. The log folder is labeled "`Log files`" and can found on a network by opening a file explorer at the instrument IP address or hostname.



In the `Log files` folder, there will be a variety of logging files:

`He.log`: Contains a log of liquid helium measurement events, with each entry timestamped and a record of the hardware bits at that time.

`N2-1.log`: Contains a log of liquid nitrogen measurement events, with each entry timestamped and a record of the hardware bits at that time.

`operations.csv`: Contains a log of all operations/events, with each entry timestamped and appropiate data for the event in a comma separated file format.

LOG FILE FORMATS

The text based logging format is in a comma separated value format. It consist of a unix timestamp, followed by the current level, and then the status bits encoded in a hexadecimal number.

The status bits contains information for both the channels, even if the channels are disabled.

The status bits are a summation of the hardware flags, each flag has a unique bit position, and so the status byte displayed is a hexadecimal representation of those bits.

Refer to the Status Bits table on page 122 for the bit values assigned for each hardware flag.

A log entry is made when either the level changes by 0.1% or if the status bits change from last entry. Levels and bits are checked every second.

A Unix timestamp is the time in seconds since Jan 1, 1970 in Coordinated Universal Time.

DESCRIPTION OF THE HE.LOG FORMAT

Here is an example of a measurement, with the helium level changing from 26.3 to 45.1:

```
    timestamp, %level, status bits
#1  1626706702,  26.3,028
#2  1626706703,  45.1,038
```

Entry #1: timestamped at Mon Jul 19 2021 10:58:22 (Eastern Daylight Time) with a previously read level of 26.3. The status bits (028) indicated that the external/internal N2 sensor oscillator selection was internal, and that the helium sensor was active and dirty sensor mode was off. The level updated when the helium measurement cycle completed, as recorded in the next entry.

NOTE **Note that even if an instrument is not configured for nitrogen measuring, there will be inactive status bits for that nitrogen channel in the status word.**

Entry #2: timestamped at Mon Jul 19 2021 10:58:22 with a last read level of 45.1. The status bits (028) indicated that the external/internal N2 sensor oscillator selection was internal, and that the helium sensor was active and dirty sensor mode was off. The level had changed between entry #2 and #3, so when the unit stopped measuring (turning off the helium sensor) it updated the level, which changed to 45.1

Refer to the Status Bits table on page 122 for the bit values assigned for each hardware flag.

DESCRIPTION OF THE N2-1.LOG FORMAT

Here is an example of measurements of changing level, with a loss of sensor event for the liquid nitrogen measurements:

```
    timestamp, %level, status bits
#1  1626708988,  88.2,000020
#2  1626708989,  77.8,000020
#3  1626708990,  54.1,000020
#4  1626708991,  41.3,000020
#5  1626708992,  34.4,000020
#6  1626708994,  16.1,000020
#7  1626708996,   0.0,000221
#8  1626708999,  16.1,000020
```

Entry #1: timestamped at Mon Jul 19 2021 11:36:28 (Eastern Daylight Time) with a read level of 88.2%. The status bits (`000020`) indicated that the external/internal N2 sensor oscillator selection was internal.

Entries #2-#6: shows the level changing over a 5 second span, settling at 16.1%

Entry #7: timestamped at Mon Jul 19 2021 11:36:36 showed a loss of sensor event. The level will be 0.0%, and the status bits show that the sensor was disconnected and the alarm bit was set.

Entry #8: timestamped at Mon Jul 19 2021 11:36:36 showed back to normal operation, with a reading of 16.1%.

Refer to the Log Status Bits table on page 122 for information on the status bits.

DESCRIPTION OF THE OPERATIONS LOGGING FILE

The `operations.csv` file is a text file that records a log of all operations/events: remote, local, and SCPI.

This file contains operations log entries in a comma separated value format, as follows:

```
<unix timestamp>, <class>, <data field 1>, <data field 2>, <data field 3>
```

A data field can be empty, that is, no text.

An overview of the classes:

Class	Description of Event
AF	Master System Autofill
AL	Alarm(s)
BT	Battery Status
CE	System commands
N1	Liquid Nitrogen channel sensor
LE	GUI page load event
LF	GUI link (AML function link)
LL	GUI link (AML page link)
LS	GUI link (system variable)
RY	Hardware Relay Status
SC	SCPI command that modified the instrument
SF	State file operation
PU	Power Up
TG	GUI toggle
VM	Modification of a instrument variable

More detailed information on each class is available from your Authorized AMI Technical Representative.

Here is a simple example of operations logging file entries for a shutdown initiation:

```
   timestamp, class,data1,data2,data3
#1 1626712173,LL,MENU,menu.aml,
#2 1626712191,LL,SHUTDOWN,../shutdown.aml,
#3 1626712200,LL,SHUTDOWN ,../shutdown.aml,
#4 1626712200,SF,shmem_dump,checksum,6A7E48E4
#5 1626712200,CE,shutdown,,
```

Line by line description:

```
1626712173,LL,MENU,menu.aml,
```

The operator pressed the MENU button on the home page.

Menu.aml indicated the screen page loaded was menu.aml, that is, the MENU page.

The class LL indicates that this was a link label button event, that is, the label on the button was MENU, and that the linked page loaded was menu.aml.

```
1626712191,LL,SHUTDOWN,../shutdown.aml,
```

The operator pressed the SHUTDOWN menu button which then loaded the ../shutdown.aml page.

```
1626712200,LL,SHUTDOWN ,../shutdown.aml,
```

The operator touched the SHUTDOWN command button which then executed the shutdown procedure.

```
1626712200,SF,shmem_dump,checksum,6A7E48E4
```

The instrument saved the variables to the state file. Class SF indicates this is a state file operation.

```
1626712200,CE,shutdown,,
```

The command executed (CE) was the shutdown command. The data fields #2 and #3 in this line are empty as shown by the two commas after the shutdown command.

LOG STATUS BITS TABLE

Status Bit Representation (in hexadecimal)

STATUS_Alarm	0x00001
STATUS_relay1	0x00002
STATUS_relay2	0x00004
STATUS_Ext_1_osc	0x00020
STATUS_Valve_1_open	0x00040
STATUS_N2_1_LossOfSensor	0x00200
STATUS_N2_1_SensorShorted	0x00400
STATUS_PowerUp	0x00800
STATUS_He_1_Burnout_Timeout	0x04000
STATUS_He_1_LossOfSensor	0x08000

GLOSSARY

ABBREVIATIONS AND ACRONYMS

Term	Meaning
AC; ac	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.
ASCII	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
BNC connector	A miniature quick connect/disconnect RF connector used for coaxial cable, featuring two bayonet lugs on the female connector.
CR *or* <CR>	Text Carriage-Return character
Cryogen	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.
D-Sub	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)
DB9	Type of electrical connector containing 9 pins arranged in two parallel rows of 4 pins and 5 pins each
DCE	Data Circuit-terminating Equipment - a device that sits between the Data Terminal Equipment (DTE) and a data transmission circuit.
DHCP	Dynamic Host Configuration Protocol; a computer networking protocol which dynamically distributes the IP address to networked devices
dt	Rate of change
DTE	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).

Term	Meaning
ECL	Electrical Connection Lubricant - also known as Dielectric Tune-up Grease, a protective lubricant that prevents corrosion.
E_o	Power supply output voltage
i, I	Electrical current flow
I_o	Power supply output current
IEC	International Electrotechnical Commission
IEEE	Institute of Electrical and Electronics Engineers
I/O	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.
IP	Internet Protocol; when used with “address”, refers to a numerical Internet address
kG	kilogauss: a magnetic field unit of measurement
LED	Light-Emitting Diode; a semiconductor device that emits light when energized - used for visual status indication
LF *or* <LF>	Text Linefeed character
LHe	Liquid Helium
LN2	Liquid Nitrogen
Max	Maximum
Min	Minimum
MSDS	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.
RG-59/U	A specific type of coaxial cable, often used for low-power video and RF signal connections, with a characteristic impedance of 75 ohms.
R_{lead}	Electrical circuit lead or wiring resistance
RS-232	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.
SCPI	Standard Commands for Programmable Instruments
V	Volts
VA	Volt-amperes (V x I); a unit of electrical reactive power
V_{lead}	Voltage (I x R) developed across circuit lead or wiring resistance due to current flow

Term	Meaning
V_m	Magnet voltage
V_s	Power supply voltage

A

B

C

N

O

P

R

S

T

U

V

W