User's Guide
Model 18
Cryogenic Temperature Monitor

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Certification
Cryogenic Control Systems, Inc. (Cryo-con) certifies that this product met its published specifications at the time of shipment. Cryo-con further certifies that its calibration measurements are traceable to the United States National Institute of Standards and Technology (NIST).

Warranty
This product is warranted against defects in materials and workmanship for a period of one year from date of shipment. During this period Cryo-con will, at its option, either repair or replace products which prove to be defective.

For products returned to Cryo-con for warranty service, the Buyer shall prepay shipping charges and Cryo-con shall pay shipping charges to return the product to the Buyer.

However, the Buyer shall pay all shipping charges, duties, and taxes for products returned to Cryo-con from another country.

Warranty Service
For warranty service or repair, this product must be returned to a service facility designated by Cryo-con.

Limitation of Warranty
The foregoing warranty shall not apply to defects resulting from improper or inadequate maintenance by the Buyer, Buyer supplied products or interfacing, unauthorized modification or misuse, operation outside of the environmental specifications for the product, or improper site preparation or maintenance.

The design and implementation of any circuit on this product is the sole responsibility of the Buyer. Cryo-con does not warrant the Buyer's circuitry or malfunctions of this product that result from the Buyer's circuitry.

In addition Cryo-con does not warrant any damage that occurs as a result of the Buyer's circuit or any defects that result from Buyer-supplied products.

Notice
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Cryo-con makes no warranty of any kind with regard to this material, including, but not limited to, the implied warranties of merchantability and fitness for a particular purpose.

Trademark Acknowledgement
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Safety
The Model 18 does not contain any user serviceable parts. Do not open the enclosure. Do not install substitute parts or perform any unauthorized modification to the product. For service or repair, return the product to Cryo-con or an authorized service center.

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Preparing the Monitor for Use

Model Identification

The model number is identified on the front and rear panel of the instrument as well as in various instrument displays.

Model	Description
Model 18-110	Cryogenic temperature monitor with eight standard multi-function sensor input channels set for AC power line voltages from 100 to 120VAC.
Model 18-220	Cryogenic temperature monitor with eight standard multi-function sensor input channels set for AC power line voltages from 200 to 240VAC.

Table 1: Model Identification

Supplied Items

Verify that you have received the following items with your monitor. If anything is missing, contact Cryogenic Control Systems, Inc. directly.

- Model 18 Cryogenic Temperature Monitor.
- User's Manual (PN 3038-029).
- Cryo-con software CD (PN 4034-029).
- Four dual input connector/cable assemblies (4034-038).
- Certificate of Calibration.

Verify the AC Power Line Voltage Selection.

The AC power line voltage is set to the proper value for your country when the instrument is shipped from the factory. This setting is marked on the rear panel just above the AC Power Entry module.

AC power line voltage setting is made by internal component selection. Refer to the section on AC Line Voltage Selection for details.

Apply Power to the Monitor

Connect the power cord and turn the monitor on by switching the power switch on the rear panel to the '1' position. The front panel will show a Power Up display with the model number and firmware revision.

While the Power Up display is shown, the monitor is performing a self-test procedure that verifies the proper function of internal data and program memories, remote interfaces and input channels. If an error is detected during this process, the monitor will freeze operation with an error message display. In this case, turn the unit off and refer to Appendix B: Troubleshooting Guide.

```
Cryo-con Model 18
Firmware Rev: 3.03C
IP: 192.168.0.4
```

Caution: Do not remove the instrument's cover or attempt to repair the monitor. Other than the AC line voltage selection jumpers, there are no user serviceable parts, jumpers or switches inside the unit. Further, there are no software ROM chips, trim pots, batteries or battery-backed memories. All firmware installation and instrument calibration functions are performed externally via the remote interfaces.

After about ten seconds, the self-test will complete and the monitor will begin normal operation.

> ⓘ **NOTE:** The Model 18 attempts to connect with the Ethernet as soon as power is applied. If there is a valid Ethernet connection, the power-up sequence is immediate. However, if there is no connection, the Model 18 will delay about 10 seconds before showing the power-up screen.

Factory Default Setup

A monitor with factory default settings will have an operational display like the one shown here. The dash (**-**) or dot (**.**) characters indicate that there is no sensor connected.

```
Channel A 301.455K
Channel B 312.523K
Channel C 362.321K
Channel D 394.312K
```

Note that, in some cases, there will be an erratic temperature display when no sensor is connected. This is not an error condition. The high input impedance of the monitor's input preamplifier causes erratic voltage values when unconnected.

Input Channel factory defaults are:

Sensor Units: Kelvin.
Sensor Type: Pt100 385 (DIN standard 100Ω Platinum RTD)
Alarm Enables: Off

To change these, press the **Enter** key then refer to the Input Channel Setup Menu section.

Instrument setup factory defaults are:

Display Filter Time Constant: 4.0 Seconds.
Display Resolution: 3 digits.
Data Logging: Off

To change these, press the **Enter** key and then select the System Setup Menu.

Network settings are:

IP Address: 192.168.0.4.
Subnet Address: 255.255.255.0

> ☞ **NOTE**: Factory defaults may be restored at any time by use of the following sequence: 1) Turn power to the Model 18 OFF. 2) Press and hold the **Enter** key while turning power back ON.

Technical Assistance

Trouble shooting guides and user's manuals are available on our web page at http://www.cryocon.com.

Technical assistance may be also be obtained by contacting Cryo-con as follows:

Cryogenic Control Systems, Inc.
PO Box 7012
Rancho Santa Fe, CA 92067

Telephone: 858 756-3900 FAX: 858 759-3515

e-mail: techsupport@cryocon.com

For updates to LabVIEW™ drivers, Cryo-con utility software and product documentation, go to our web site at http://www.cryocon.com and select the Download area.

Current Firmware Revision Level
As of October, 2008 the current firmware revision level for the Model 18 series is 3.03C. Note: Revision 3.01 was a critical update. Please consult the factory if you have an earlier version.

Revision 3.02 added a screen saver function.

Current Hardware Revision Level
As of August, 2008, the current hardware revision level for the Model 18 series is C. Hardware cannot be upgraded in the field.

Returning Equipment

If an instrument must be returned to Cryo-con for repair or recalibration, a Return Material Authorization (RMA) number must first be obtained from the factory. This may be done by Telephone, FAX or e-mail.

When requesting an RMA, please provide the following information:

1. Instrument model and serial number.
2. User contact information.
3. Return shipping address.
4. If the return is for service, please provide a description of the malfunction.

If possible, the original packing material should be retained for reshipment. If not available, consult factory for packing assistance.

Cryo-con's shipping address is:

Cryogenic Control Systems, Inc.
17279 La Brisa
Rancho Santa Fe, CA 92067

Options and Accessories

Instrument Accessories

Cryo-con Part #	Description
04-0310	AC Power Cord
4034-038	Dual Sensor Cable, 2 x 8 foot
4034-033	Shielded Sensor Connector Kit (DB9)
3012-020	Panel Mount hardware kit. See Appendix C
3012-021	Bench top instrument stand. See Appendix C
3012-022	Tilt-stand and carry handle. Appendix C
3038-029	Additional User's Manual/CD

Table 2: Model 18 Instrument Accessories

Cryogenic Accessories

Cryo-con Part #	Description
S900	S900 series Silicon Diode Temperature Sensors. Temperature range: 1.4 to 375K.
S700	S700 series Silicon Diode Temperature Sensors. Temperature range: 1.4 to 375K.
CP-100	CP-100 series Ceramic Wound RTD, 100Ω
GP-100	GP-100 series Glass Wound RTD, 100Ω
R400	Ruthenium-Oxide. Temperature range is 1.4 to 40K. Commonly used with superconducting magnets.
R500	Ultra-low temperature Ruthenium-Oxide. Temperature range is 1.0 to 40K.
XP-100	XP-100 series Thin Film Platinum RTD, 100Ω
XP-1K	XP-1K series Thin Film Platinum RTD, 1,000Ω

Table 3: Cryogenic Accessories

Specifications, Features and Functions

Specification Summary

User Interface

Display Type: 20 x 4 character or 140x32 graphics VFD.

Number of Inputs Displayed: Eight.

Keypad: Sealed Silicon Rubber.

Temperature Display: Six significant digits, autoranged.

Display Update Rate: 0.5 Seconds.

Display Units: K, C, F or native sensor units.

Display Resolution: User selectable to seven significant digits.

Input Channels

The eight input channels are identical and each may be independently configured for any of the supported sensor types.

Sensor Connection*:* 4-wire differential. DB-9 receptacles connect two channels. Connections are described in the "Sensor Connections" section.

Isolation: Sensor circuits are not electrically isolated from other internal circuits. However, there is a 'single point' internal connection to Earth (or Shield) ground in order to minimize noise coupling.

Input Protection: ±30 Volts maximum.

Supported Sensors*:* Include:

Type	Excitation	Temperature Range
Cernox™	10µA DC	1.4K to 420K
Ruthenium-Oxide	10µA DC	1.4K to 273K
Germanium	10µA DC	4.2K to 100K
Carbon Glass	10µA DC	1.4K to 325K
Silicon Diode	10µA DC	1.4 to 500K
Rhodium-Iron	1mA DC	1.4 to 800K
Platinum RTD	1mA DC	14 to 1200K
GaAlAs Diode	10µA DC	25K to 325K

Sensor Selection*:* Front Panel or remote interface. There are no internal jumpers or switches.

Accuracy, Resolution and Drift*:*

Diode Sensors

Configuration: DC Constant-Current

Excitation: 10µA DC

Input voltage range 0 – 2.50VDC.

Accuracy: ±(60µV + 0.005% * reading)

Drift: <25ppm/ºC

PTC Resistor Sensors

Configuration:DC, Constant-Current, Ratiometric resistance bridge.

Excitation: 1mA, 100µA or 10µA DC.

Resistance Ranges: 625Ω, 6.25KΩ and 62.5KΩ

Measurement Drift: <25ppm/ºC

Range	Maximum Resistance	Resolution	Accuracy
1mA	625Ω	0.6mΩ	± (0.002 + 0.01%)Ω
100µA	6.25KΩ	6mΩ	± (0.02 + 0.02%)Ω
10µA	62.5KΩ	60mΩ	± (3.0 + 0.04%)Ω

Table 4: Accuracy and Resolution for PTC Resistors

NTC Resistor Sensors

Configuration: DC, Constant-Current, Ratiometric resistance bridge.

Excitation Current: 10uA

Resistance Ranges: 250KΩ, 31KΩ.

Accuracy

250KΩ Range: ± (75.0 + 1.0%)Ω

31KΩ Range: ± (10.0 + 0.13%)Ω

Resolution: 0.0002% of range.

Drift: <25ppm/ºC

***Sample Rate**:* 0.8Hz per channel in all measurement modes.

***Digital Resolution**:* 24 bits.

Measurement Filter: 0.5, 1, 2, 4, 8 and 16 Seconds.

***Calibration Curves**:* Built-in curves for industry standard sensors plus eight user curves with up to 200 entries each. Interpolation is performed using a Cubic Spline.

CalGen®: Calibration curve generator fits any Diode or resistor sensor curve at 1, 2 or 3 user specified temperature points. CalGen® is implemented in the Utility software provided with the indicator.

Data Logging: Data logging of input channel data is performed into an internal, 40K byte circular buffer and is time-stamped with a real-time clock. Buffer memory is non-volatile and will retain valid data indefinitely without AC power. The Model 18 will log a maximum of 1,000 entries where each entry contains eight temperature readings.

Status Outputs

***Visual Alarms**:* Independent visual alarms can be configured for each input. They are displayed on the front panel as text characters and an LED indicator.

***Status reported via Remote Interface**:* Input channel alarms.

Remote Interfaces

Remote interfaces are electrically isolated to prevent ground loops.

Ethernet: Industry standard 10-BaseT. Electrically isolated

Language: Remote interface language is IEEE-488 SCPI compliant. National Instruments LabView™ drivers available for all interfaces.

Firmware

Internal firmware and all data tables are maintained in FLASH type memory.

General

Ambient Temperature*:* 25°°C ± 5°C for specified accuracy.

Mechanical*:* 5.75"W x 2.875"H x 8.75"D.

Weight*:* 3 Lbs.

Enclosure: Aluminum Extrusion. Machined Aluminum front and rear panels.

Power Requirement*:* 100 – 120 or 200 – 240 VAC. 50 or 60Hz, 15 Watts.

Performance Summary

Measurement Accuracy

Diode Sensors

The formulas for computing measurement accuracy while using diode sensors are:

$$MAV = 60 \cdot 10^{-6} + 5 \cdot 10^{-5} \cdot SenRdg$$

$$MAT = \frac{MAV}{SenSen}$$

Where:

MAV is the electronic Measurement Accuracy in Volts
MAT is the Measurement Accuracy in Kelvin
SenRdg is the sensor reading in Volts at the desired temperature.
SenSen is the sensor sensitivity in Volts / Kelvin at the desired temperature.

For example, if we want to calculate measurement accuracy using a Cryo-con S900 sensor at 10K, we would look up the sensor reading and sensitivity in the S900 data table in Appendix E. At 10K, we see that SenRdg is 1.36317 Volts and SenSen is 0.002604 Volts/Kelvin . Therefore,

$$MAV = 60 \cdot 10^{-6} + 5 \cdot 10^{-5} \cdot 1.36317$$

and

$$MAT = \frac{MAV}{0.002604}$$

The result is that MAV = 128µV and MAT = 49mK.

PTC and NTC Resistor Sensors

The formulas for PTC and NTC resistor sensors are stated above. As an example, here is a computation for a PTC resistor with the PTC100 input configuration:

Where:

$$MAR = 0.002 + 1.0 \cdot 10^{-4} \cdot SenVal$$

$$MAT = \frac{MAR}{SenRdg}$$

MAR is the electronic Measurement Accuracy in Ohms
MAT is the Measurement Accuracy in Kelvin
SenRdg is the sensor reading in Ohms at the desired temperature.
SenSen is the sensor sensitivity in Ohms / Kelvin at the desired temperature.

To calculate measurement accuracy using a 100Ω Platinum RTD in the PTC100 range with the sensor at 77.35K, we would look up the sensor reading and sensitivity in Appendix E. and see that SenRdg is 20.38Ω and SenSen is 0.423 Ω/Kelvin. Therefore, we compute MAR = 0.004038Ω and MAT = 9.5mK.

Input Channel Characteristics

There are eight independent, multi-purpose input channels; each of which can separately be configured for use with any supported sensor.

The sensor type is selected by the user and this establishes the input configuration. Values of excitation current, voltage gain etc. will be determined by the microprocessor and used to automatically configure the channel. There are no jumpers or optional cards required to configure the various sensors.

Input Configurations

A complete list of the input configurations supported by the Model 18 is shown below:

Sensor Type	Max. Voltage/ Resistance	Excitation Current	Typical Use
Diode	2.5V	10µA	Silicon Diode.
R250K10UA	250KΩ	10µA	NTC Resistors
R31K10UA	31.25KΩ	10µA	NTC Resistors
PTC1K	6.25KΩ	10µA	PTC / Low resistance NTC Resistors
PTC100	625Ω	10µA	PTC Resistors including Platinum 100 RTDs and Rhodium-Iron.
Snone	0	0	Disable Input Channel

Table 5: Input Configurations

ⓘ **Note:** A complete listing of factory installed sensors and their characteristics can be found in Appendix A.

Silicon Diode Sensors

Silicon Diode sensors (AKA 2-Volt diodes) are configured with a 10µA current source excitation and a 2.5 Volt input voltage range.

PTC Resistor Sensor Devices (RTDs)

The Model 18 supports all types of Positive-Temperature-Coefficient (PTC) resistive sensors. Various combinations of excitation current and full-scale input voltage allow the user to trade off accuracy vs. sensor self heating.

Standard calibration curves are provided for DIN43760 and IEC751 Platinum sensors.

NTC Resistor Sensor Devices

The Model 18 also supports almost all types of Negative-Temperature-Coefficient (NTC) resistive sensors. Examples of NTC resistor sensors include: Ruthenium-Oxide, Cernox™, Carbon Glass, Germanium and Thermistors.

A table of recommended setups for various types of resistor sensors is shown here:

Type	Sensor Type	Sensor Excitation	TC	Calibration Units
Platinum, 100Ω	PTC100	1.0mA DC	(+)	Ohms
Platinum, 1000Ω	PTC1K	100µA DC	(+)	Ohms
Platinum, 10KΩ	R250K10UA	10µA DC	(+)	Ohms
Rhodium-Iron	PTC100	1.0mA DC	(+)	Ohms
Carbon Glass	R250K10UA	10µA DC	(-)	LogOhm
Germanium	R250K10UA	10µA DC	(-)	LogOhm
Cernox™	R250K10UA	10µA DC	(-)	LogOhm
Ruthenium-Oxide				
>50KΩ	R250K10UA	10µA DC	(-)	LogOhm
<50KΩ	R31K10UA	10µA DC	(-)	LogOhm
Carbon-Ceramic	R250K10UA	10µA DC	(-)	LogOhm

Table 6: Resistor Sensor Configuration

Sensor Connections

All four sensor connections are made at the rear panel of the Model 18 using the two DB-9 receptacles provided. There are two channels on each connector.

Four Wire Sensor Connections

Silicon Diode and all resistor type sensors should be connected to the Model 18 using the four-wire method. It is strongly recommended that sensors be connected using shielded, twisted pair wire. Cable shields should be dressed for connection to the conductive backshell of the connector. Signal connection is as follows:

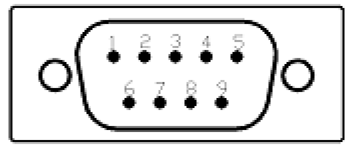


Figure 1: Input Connector

Input Channel	Connector	Signal	Pin
ChA	Lower	Current(+)	8
ChA	Lower	Current(-)	9
ChA	Lower	Sense(+)	4
ChA	Lower	Sense(-)	5
ChB	Lower	Current(+)	6
ChB	Lower	Current(-)	7
ChB	Lower	Sense(+)	1
ChB	Lower	Sense(-)	2
ChC	Upper	Current(+)	8
ChC	Upper	Current(-)	9
ChC	Upper	Sense(+)	4
ChC	Upper	Sense(-)	5
ChD	Upper	Current(+)	6
ChD	Upper	Current(-)	7
ChD	Upper	Sense(+)	1
ChD	Upper	Sense(-)	2

Table 7: Sensor Input Connector Pinout

Caution: To ensure proper low noise operation, cable shields should be connected to the metal backshell of the connector. Please refer to the section on shielding and grounding for further information.

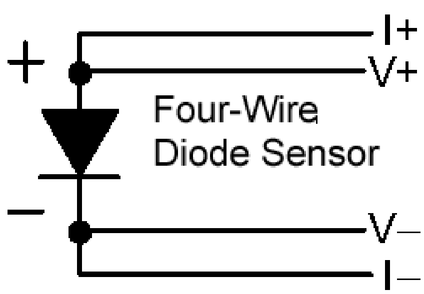
Color codes for the Dual Sensor Cable (Cryo-con part number 4034-038) are as follows:

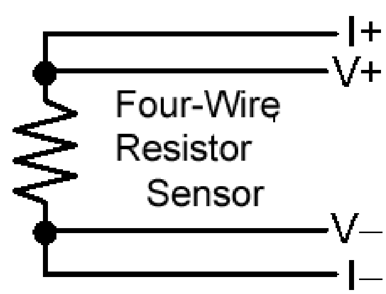
Input Channel	Color Code	Signal	Pin
ChA	White	Current(+)	8
ChA	Green	Current(-)	9
ChA	Red	Sense(+)	4
ChA	Black	Sense(-)	5
ChB	White	Current(+)	6
ChB	Green	Current(-)	7
ChB	Red	Sense(+)	1
ChB	Black	Sense(-)	2

Table 8: Dual Sensor Cable Color Codes

The cable used is Belden 8723. This is a dual twisted pair cable with individual shields and a drain wire. The shields and drain wire are connected to the DB9 connector's metal backshell in order to complete the shielding connection.

Four wire connections to the sensor are shown here for Diode and Resistor sensors:





Sensor Wiring

DC offsets can build up in cryogenic temperature measurement systems due to thermocouple effects within the sensor wiring. They are commonly referred to as Thermal EMFs. Careful wiring can minimize these effects.

The most effective method of minimizing thermocouple (DC) offsets is to wire temperature sensors so that connections between dissimilar metals are grouped together. For example, the connection between sensor leads and cryostat wiring should be kept close together. This way, the thermocouple junctions formed by the connection will have equal-but-opposite voltages and will cancel each other.

Frequently, sensor leads are made from the same material as the cryostat wires. Therefore, there is no significant thermocouple formed by this connection.

In a four-wire measurement scheme, only connections in the voltage sense lines can cause measurement errors. So, the sense wires should have adjacent contacts in a multi-pin connector in order to minimize any temperature difference between them.

Thermal EMF Issues

DC offsets can build up in cryogenic temperature measurement systems due to thermocouple effects within the sensor wiring. Careful wiring can minimize these effects. However, in a few systems, measurement errors induced by thermal EMFs can result in unacceptable measurement errors. These cases will require the use of an AC bias, or chopped sensor excitation, in order to remove DC offsets.

The Model 18 supports all sensor types with a DC measurement scheme. Therefore, thermocouple (DC) offsets are minimized by wiring temperature sensors so that connections between dissimilar metals are grouped together. For example, the connection between sensor leads and cryostat wiring should be kept close together. This way, the thermocouple junctions formed by the connection will have equal-but-opposite voltages and will cancel each other.

Frequently, sensor leads are made from the same material as the cryostat wires. Therefore, there is no significant thermocouple formed by this connection.

In a four-wire measurement scheme, only connections in the voltage sense lines can cause measurement errors. So, the sense wires should have adjacent contacts in a multi-pin connector in order to minimize any temperature difference between them.

Output Channel Features

Alarm Outputs

Alarm outputs include a LED indicator and an on-screen display.

Alarms may be asserted based on high or low temperature conditions.

There is a 0.25K hysteresis built into the high and low temperature alarms.

Remote Interfaces

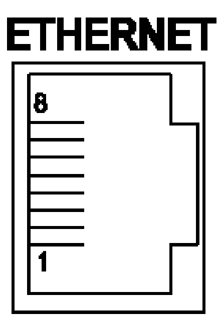
A 10-BaseT Ethernet interface is standard on the Model 18. All functions and read-outs available from the instrument may be completely controlled by any of these interfaces.

The 10-BaseT Ethernet connection is made via the RJ-45 connector on the rear panel.

The programming language used by the Model 18 is SCPI language compliant. The Standard Command Protocol for programmable Instruments (SCPI) is a sub section of the IEEE-488.2 standard and is a tree structured ASCII command language that is commonly used to program laboratory instruments.

Ethernet (LAN) Connection

The 10BaseT Ethernet network (RJ-45) system is used by the Model 18 for Ethernet network connectivity. The 10 Mbps twisted-pair Ethernet system operates over two pairs of wires. One pair is used for receiving data signals and the other pair is used for transmitting data signals. This means that four pins of the eight-pin connector are used.



Pin	Name	Description
1	+Tx	+ Transmit Data
2	-Tx	- Transmit Data
3	+RX	+ Receive Data
4	N/C	Not Connected
5	N/C	Not Connected
6	-Rx	- Receive Data
7	N/C	Not Connected
8	N/C	Not Connected

Figure 2: LAN RJ-45 Pinout

<u>10BaseT Straight Through (Patch) Cable</u>

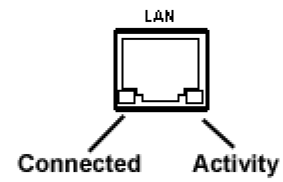
When connecting the Model 18 to a hub or switch, a standard 'patch' cable is used. This will connect the instrument's transmit lines to the hub's receive lines etc.

10BaseT Crossover Cable

When connecting the Model 18 directly to the computer, the transmit data pins of the computer should be wired to the receive data pins of the Model 18, and vice versa. The 10BaseT **crossover cable** should be used for this purpose. A crossover cable is usually a different color than the straight through patch cable.

Ethernet (LAN) Connector LEDs

The RJ-45 LAN connector on the rear panel of the Model 18 has two green LEDs. The left most LED indicates that a valid connection has been made to a hub or computer.



If the LAN is plugged in and the 'Connected' LED is not on, there is a problem that must be addressed before you can communicate with the instrument. Possible problems are:

1. Using the wrong type of cable. For example, using a Crossover Cable to connect the Model 18 to a hub instead of a computer. See the sections above.
2. Connection to the wrong type of hub. The hub must be capable of accepting 10-BaseT connections. Some older hubs do not support this.

The right most LED indicates activity on the LAN. It should flicker periodically during normal operation.

Rear Panel Connections

The rear panel of the Model 18 is shown here:

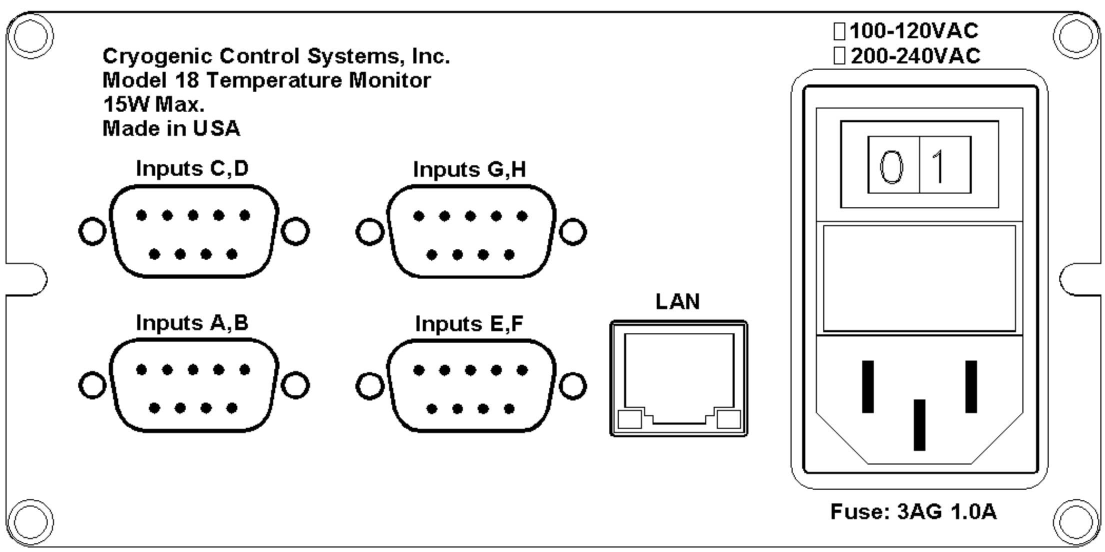


Figure 3: Model 18 Rear Panel Layout

AC Power Connection

The Model 18 requires single-phase AC power of 50 to 60 Hz. Voltages are set by the factory to either 110VAC or 220VAC.

Caution: *Protective Ground:* To minimize shock hazard, the instrument is equipped with a three-conductor AC power cable. Plug the power cable into an approved three-contact electrical outlet or use a three-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet.

The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Power requirement is 15 Watts.

User-replaceable fuses are incorporated in the Power Entry Module.

<u>AC Line Voltage Selection</u>
The Model 18-110 is set at the factory for AC line voltages of 100 – 120VAC and Model 18-220 is set for 200 – 240VAC. The selection is marked on the rear panel above the power entry module.

Voltage selection can be changed in the field by opening up the unit and moving jumper chips.

To change the voltage selection, please follow the procedure below:

1. Disconnect the AC power cord.
2. Lay the unit upside-down on a flat surface and remove the four screws that hold the rear panel in place.
3. Gently slide the circuit board out by about two inches. This will expose the voltage selection jumpers shown here.

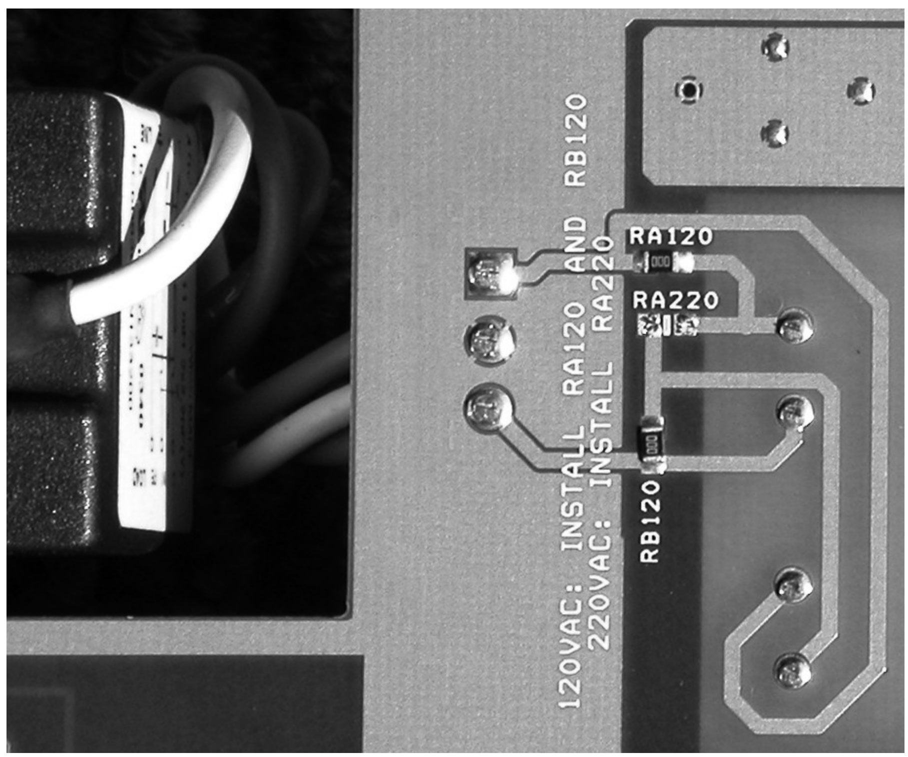


Figure 4: Voltage Selection Jumpers

4. Add or remove the chip jumpers required to select the desired voltage. Note: the chip jumpers are easily removed by using two soldering irons. If you do not have a chip, substitute a short piece of wire.
5. Slide the unit back together and re-install the four screws. Mark the voltage selection on the rear panel in the space provided.

Line Voltage	Remove	Install
100VAC - 120VAC	RA220	RA120, RB120
220VAC - 240VAC	RA120, RB120	RA220

Do NOT reconnect the AC power cord until the unit is completely reassembled.

Fuse Replacement

Access to the Model 18's fuses and voltage selector switch is made by using a screwdriver to open fuse drawer in the power entry module. The fuse drawer cannot be opened while the AC power cord is connected.

In the fuse drawer, there is one active fuse and one spare. Fuse current is determined by the AC line voltage.

Line Voltage	Fuse	Example
100VAC - 120VAC	1.0A slow-blow	Littelfuse 313 002
220VAC - 240VAC	0.5A slow-blow	Littelfuse 313 001

Table 9: AC Power Line Fuses

Mechanical, Form Factors and Environmental

Display

The display is a four line by twenty-character dot matrix VFD.

Enclosure

The Model 18 is bench mountable. Rack mounting can be done by using an optional rack mount kit.

Dimensions are: 5.75"W x 2.875"H x 8.75"D. Weight is 3Lbs.

Environmental and Safety Concerns.

Safety

The Model 18 protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature, and spread of fire from the instrument.

- Keep Away From Live Circuits: Operating personnel must not remove instrument covers. There are no internal user serviceable parts or adjustments. Refer instrument service to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.
- Cleaning: Do not submerge instrument. Clean exterior only with a damp cloth and mild detergent only.
- Grounding: To minimize shock hazard, the instrument is equipped with a three-conductor AC power cable. Plug the power cable into an approved three-contact electrical outlet only.

Safety Symbols

- Direct current (power line).
- Alternating current (power line).
- Alternating or dirrect current (power line).
- Three-phase alternating current (power line).
- Earth (ground)terminal.
- Protective conductor terminal.
- Frame or Chassis terminal.
- On (AC Power)
- Off (AC Power)
- Equipment protected throughout by double insulation or reinforced insulation (equivalent to Class II of IEC536).
- Caution: High voltages; danger of electric shock. Background color: Yellow; Symbol and outline: Black.
- Caution or Warning - See instrument documentation. Background color: Yellow; Symbol and outline: Black.
- Fuse.

Environmental Conditions

Environmental conditions outside of the conditions below may pose a hazard to the operator and surrounding area:

- Indoor use only.
- Altitude to 2000 meters.
- Temperature for safe operation: 5 °C to 40 °C.
- Maximum relative humidity: 80% for temperature up to 31 °C decreasing linearly to 50% at 40 °C.
- Power supply voltage fluctuations not to exceed ±10% of the nominal voltage.
- Over voltage category II.
- Pollution degree 2.
- Ventilation: The instrument has ventilation holes in its side covers. Do not block these holes when the instrument is operating.
- Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment is a definite safety hazard.

The User Interface

Overview

The Model 18 Cryogenic Temperature monitor’s user interface consists of a four line by 20-character Vacuum Fluorescent display and a five key keypad. Most features and functions of the instrument can be accessed via this simple and intuitive menu driven interface. Complex functions, such as downloading a new sensor calibration curve, require using one of the remote interfaces.

The Home Status Display

At the root of the instrument’s menu tree is the basic Home Status Display. This screen shows status information only.

Figure 5: Model 18 Front Panel

Navigating the Menu Tree

Setup and configuration functions are performed by working with the monitor’s menu tree. To access this tree from the Home Display, press the **Enter** key. The root menu shown here will be displayed.

```
ChA Setup          ■
ChB Setup
ChC Setup
ChD Setup
```

The (■) character in the far right column is the cursor. To exit this menu and return to the Home Display, press the (◄) key.

To navigate the menu, move the cursor up or down by pressing the ▲ or ▼ keys. The cursor will scroll down to show additional lines.

To select the line at the current cursor position, press the **Enter** key. In the case of the above display, pressing **Enter** will cause the monitor to display the input channel A setup, or ChA Setup menu.

If the cursor is positioned at a data entry menu line when the **Enter** key is pressed, the cursor will change into a data selection cursor as follows:

> ⧓ Indicates that the selection is an enumeration field where sequential choices will be displayed each time the ► or ◄ key is pressed. To make the displayed selection, press the **Enter** key. To abort the selection process without making any change, press the ▲ key.

# Indicates that the selection is a numeric entry field. Pressing the ▶ or ◀ keys will increment or decrement the displayed number. To enter the displayed value, press the **Enter** key. To abort entry without making any changes, press the ▲ key.

Key	Description
Enter	1) From Home screen, enter setup menu. 2) Within a setup menu, Enter data or select a field (cursor display will indicate function).
▲	1) Scroll Display UP. 2) When in a field selection mode, abort entry and return to scroll mode (cursor display will indicate function).
▼	Scroll Display DOWN.
▶	Scroll to NEXT selection.
◀	1) In data selection mode, scroll to PREVIOUS selection. 2) Within a setup menu, return up the menu tree to the previous level (cursor display will indicate function).

Table 10: Function Key Descriptions.

LED indicators

There are three LED indicators on the right hand side of the instrument. They indicate the following:

Alarm (Red) – An enabled alarm condition is asserted.

Restoring Factory Defaults

Factory default settings may be restored with the following simple procedure:

1. Turn AC power OFF.
2. Press and hold the **Enter** key while turning AC power back ON. Keep the key pressed until you see the power-up display indicating that defaults have been restored.

The Input Channel Temperature Displays

An Input Channel Temperature Display consists of the input channel designator, a temperature reading and the temperature units.

The input channel designator is a superscripted A to H. An input channel may also have a name that may be set by the user. On the Home Status display, only the first nine characters are displayed.

The temperature is a seven-character field and is affected by the Display Resolution setting in the system menu. This setting will be 1, 2, 3 or Full. Settings of 1, 2, or 3 indicate the number of digits to the right of the decimal point to display whereas the Full setting causes the display to be left justified in order to display the maximum number of significant digits possible.

K	Kelvin
C	Celsius
F	Fahrenheit
Ω	Ohms
V	Volts

Table 11: Temperature Units

If the sensor type is None, the Input Channel has been disabled, A blank display is shown.

Temperature units are selected in the individual input channel setup menus. Temperature Units may be K, C or F. When Sensor Units (S) is selected, the raw input readings are displayed. These will be in Volts or Ohms.

Sensor Fault Condition

A sensor fault condition is identified by a temperature display of seven dash (**-**) characters as shown here. The sensor is open, disconnected or shorted.

Ā-------K

Reading Out of Range Condition

If a temperature reading is within the measurement range of the instrument but is not within the specified Sensor Calibration Curve, a display of seven dot (**.**) characters is shown.

Ā.......K

Instrument Setup Menus

The root of the instrument's setup menus is accessed by pressing the **Enter** key from the Home display.

The Root Menu

The Root Menu displays the list of sub-menus that are used to configure the instrument.

Press the **Enter** key to descend into the sub-menu, or the ◀ key to return to the Home Status display.

Selections in the root menu are as follows:

Model 18 Root Menu		
1	ChA Setup ■	Press **Enter** to setup input channel A.
2	ChB Setup ■	Setup input channel B.
3	ChC Setup ■	Setup input channel C.
4	ChD Setup ■	Setup input channel D.
5	ChE Setup ■	Setup input channel E.
6	ChF Setup ■	Setup input channel F.
7	ChG Setup ■	Setup input channel G.
8	ChH Setup ■	Setup input channel H.
9	System Setup ■	Go to the System Setup Menu.
10	Net Config ■	Go to the Network Configuration Menu.
11	Time / Date Setup ■	Setup the instrument's time and date.

Table 12: Model 18 Root Menu

Input Channel Setup Menu

The Input Channel Setup menus are used to configure the eight input channels. They are accessed from the root menu.

The first character on each line of these menus is always the input channel identifier, which is a superscripted A, B, C, E, F, G or H.

Scrolling to a line using the ▲ or ▼ keys and then pressing the **Enter** key will cause the cursor to change from a block cursor to the data entry cursor type that corresponds to the type of data that may be entered in this field.

ChA, ChB, ChC, ChD Setup Menu		
1	A 77.123 K	Input channel units. Temperature is displayed in real time on the left and is in the selected units. Selections are K, C, F or S. Here, S selects sensor units (Volts or Ohms).
2	ASen:Pt100 385	Sensor type selection. Allows selection of any user or factory installed sensor.
4	AHigh Alarm:200.000#	Set point for the High Temperature alarm.
5	AHigh Enable: No	High temperature alarm enable. Selections are Yes or No.
6	ALow Alarm: 200.000#	Set point for the Low Temperature alarm.
7	ALow Alarm Ena:Yes	Low temperature alarm enable. Selections are Yes or No.

Table 13: Input Channel Setup Menus.

Temperature Units

The Units field (line 1) assigns the units that are used to display temperature for the input channel. Selections are K for Kelvin, C for Celsius, F for Fahrenheit and S for sensor units. Note that if the S option is selected, the actual sensor units will be displayed when the field is deselected. Sensor units are V for Volts and Ω for Ohms.

Sensor Type Selection
Line 2 selects the Sensor type for the input channel. When this field is selected, the scroll keys are used to scroll through all of the available sensor types. Factory installed sensors appear first and then user sensors. For a list of factory installed sensors, refer to Appendix A.

Setting a Temperature Alarm
The Alarm lines are used to setup alarm conditions. The Model 18 allows alarm conditions to be assigned independently to any of the input channels.

High temperature, low temperature alarms may be entered and enabled or disabled. Note that there is a 0.25K hysteresis in the assertion of high and low temperature alarms.

Alarm conditions are indicated on the front panel by the Alarm LED and (if enabled). They are also reported via the remote interfaces.

Pressing the ◀ key will return to the Root Menu.

The System Setup Menu

The System Functions Menu is used to set many of the instrument's parameters including display resolution, I/O port settings etc. It is selected from the Root Menu.

System Functions Menu		
1	DisplyTC: 2S	Sets the display time constant in seconds. Selections range from 0.5S to 16S
2	DisplyRS: 3	Sets the resolution. Selections are: 1, 2, 3 or Full.
3	Screen Save: Yes	Enable or disable the screen save mode. Choices are Yes and No
4	SS Time: 5 min	Screen saver time-out in minutes. Choices are: 5, 10, 15, 20, 25 and 30.
5	Data Log: OFF	Start or stop data logging to an internal buffer.
6	Data Log: 5 sec #	Internal data logging interval.
7	Data Log Cnt: 195	Current log count
8	Erase Data in Log	Erase internal data logging buffer.

Table 14: System Functions Menu

Display Time Constant
The first line of the System Functions Menu is Display TC or Display Time Constant. This is an enumeration field that sets the time constant used for all temperature displays. Choices are 0.5, 1.0, 2.0, 4.0, 8.0 and 16.0 Seconds.

The time constant selected is applied to all channels and is used to smooth data in noisy environments.

Display Resolution
The Display Resolution line (Display:RS) is used to set the temperature resolution of the front panel display. Settings of 1, 2 or 3 will fix the number of digits to the right of the decimal point to the specified value. A setting of FULL will left justify the display in order to show the maximum resolution possible.

The Screen Saver
The Model 18 has a built-in screen saver. When enabled, this will significantly increase the lifetime of the front panel display and will reduce the operating temperature of the instrument.

The screen saver is enabled by selecting YES in the Screen Save field. The screen saver timeout is selected by the SS Time field. This field determines how many minutes the instrument will wait until entering the screen saver mode.

The screen save mode is canceled by pressing any key.

Data Logging
The next four fields are used to configure internal data logging. Logging is turned off or on by using the Data Log: field. This will start or stop recording all input channel data to an internal non-volatile memory.

The data-logging interval, in seconds, is set by the next field.

The Data Log Cnt: field is display-only and shows how many samples there are in the log buffer.

The Erase Data in Log field is selected to erase the internal log memory. Press **Enter** to begin the erasure sequence. The unit will then request confirmation.

Data accumulated into the log may be read out by using Cryo-con's utility software, or by use of remote commands.

The Network Configuration Menu
The Network Configuration Menu is accessed from the System Setup Menu. It is used to configure basic Ethernet LAN settings. For advanced network settings, use a web browser to view the embedded web server.

Network Configuration Menu		
1	`IP=192.168.0.4 ■`	Press **Enter** to change the unit's Ethernet IP address.
2	`Reset Net Config.■`	Press **Enter** to reset all Ethernet LAN settings back to their original factory defaults.s

The Time / Date Setup Menu
The Time / Date Setup Menu is used to set the system's time and date settings.

Time / Date Setup Menu		
1	`Time: 11:04:03 ■`	Enter time in 24 hour format.
2	`Date: 7/1/04 ■`	Enter Date
3	`Daylight: No`	Enable automatic daylight savings compensation.

Basic Operating Procedures

Configuring a sensor

Before connecting a new sensor to the Model 18, the instrument should be configured to support it. Most common sensors are factory installed; others require a simple configuration sequence.

A complete list of sensors installed at the factory is shown in Appendix A. To configure the instrument for one of these sensors, proceed as follows:

1. To install the sensor on Input Channel A, press the **Enter** key, scroll down to the **ChA** field and press **Enter** again. This will take you to the Input Channel Setup menu for the selected channel. The first line of this display will show the current temperature in real-time and allow you to select the desired display units. To change the display units, press the **Enter** key and then use the ▶ or ◀ keys to sequence through the available options. Press **Enter** again to make your selection.
2. Press the ▼ key to go down to the **Sen:** filed. Here, you must press the **Enter** key and use the ▶ or ◀ key to scroll through all of the sensor types available. When the desired sensor is displayed, press the **Enter** key to configure the instrument.

   Select **None** to disable the input channel.

   At the end of the factory-installed sensors, eight user-installed selections will be shown. The default name for these is User Sensor N. However, this name can be changed in the instrument's WEB server to give a better indication of the sensor type that is connected.

   For most sensor types, installation is now complete and the ◀ key can be pressed to return to the Home Status display. The exceptions are NTC resistor sensors that use constant-voltage AC excitation. With these types of sensors, you will need to scroll down to the Bias Voltage field and select the desired constant-voltage excitation level.

Once sensor configuration is complete, review the section on Sensor Connections to connect the sensor to the instrument.

Using the Screen Saver

The screen saver mode in the Model 18 will significantly extend the life of the front panel VFD display and lower the operating temperature of the instrument. Using it is strongly recommended.

Function

When the screen saver is enabled, the instrument's temperature display screen will go into screen save mode after a selected timeout. It does not affect the setup screens. In the save mode, the display will be blank for five seconds and then will flash the model number on the display for one second.

The screen save mode only affects the front panel display. All other processing continues as normal. The Front panel LEDs, remote ports etc. function normally.

When an alarm condition is asserted, the unit will exit screen save mode.

Screen save mode can be canceled by pressing any key on the front panel.

Configuration

The screen save mode is configured by going to the System Setup Menu. Here, the mode can be enabled or disabled. Further, a timeout may be set.

Data Logging

The Model 18 has an internal data logging capability that uses non-volatile memory. Logging of input channel temperature data is performed to a circular buffer that contains up to 1,000 samples. Each sample contains all eight temperature readings plus a time stamp from a real time clock.

The data logging buffer may be read by using the Cryo-con Utility software package. This will save the logging buffer as a text file (.CSV) that can be opened by spreadsheet and text editor programs.

Data Logging Setup

The best way to setup data logging is by using the embedded web server. However, it can also be performed from the front panel.

The first step is to ensure that the instrument's real-time clock is set to the current time. This can be done by opening the embedded web page. The current time is shown on the bottom of the Status Page and the clock may be set by going to the System page.

From the front panel, the current time can be viewed and updated by going to the Time/Date Setup menu.

Data logging can be configured and enabled from the embedded web server's System page. The Logging Enable field turns logging on and off and the Interval field sets the logging sample rate. The Current Count field shows how many samples have been accumulated.

From the front panel, data logging may be configured by going to the System Setup menu and scrolling down to the Data Log Enable and Interval fields.

Once enabled, data logging will continue until stopped. When the input buffer is full, new samples will over-write the oldest samples.

Reading the Data Log Buffer

Reading, or uploading, the Model 18 data logging buffer is best done using the Cryo-con Utility Software.

Launch the software and connect to the instrument. Next, click on the Data Logging menu field and then click on Upload. This will launch a series of dialog boxes that will take you through the data logging process.

> ⓘ **Note:** The Cryo-con Utility software can perform data logging by continuously reading samples from a connected instrument. This is a different function than uploading the internal log buffer from the instrument. The internal data logging function does not require a connection to a computer.

System Shielding and Grounding Issues

Grounding Scheme

The grounding scheme used in all of Cryo-con's instruments is based on a Single-Point-Ground and is designed to minimize ground-loop and noise pickup by assuming that the Sensor elements are electrically floating.

The Single-Point-Ground

The internal Single-Point-Ground is the voltage reference point for the instrument's grounding scheme. All circuits are designed so that no current will normally flow through the connections to this ground. Therefore, it provides a good quality, low impedance path to ground for any undesired currents that are coupled into the equipment.

AC Power Entry

AC Power enters the instrument directly into a power entry module. This provides fusing, line voltage selection and RFI filtering.

The Building Ground, often referred to as "Earth-Ground", "Shield-Ground" or "Third-Wire-Ground" is connected to the shield of the Power Entry RFI filter, then to the instrument's Single-Point-Ground. Since the grounding and shielding scheme depends on having a good quality ground, this Earth-Ground connection is extremely important. Noise and ground loop problems are often traced to how this connection is made.

If your facility does not provide a building ground, it is strongly recommended that one be fabricated.

Sensor Connection

For best performance, all sensors connected to the instrument should be electrically isolated (floating) from any other grounds.

Sensors used in cryogenic thermometry are often high impedance. For example, a Silicon Diode temperature sensor will have about 160K ohms of impedance at 5K. Because of this, a very efficient antenna can develop around the sensor and its connections. Requiring these sensors to be floating and providing a low impedance path to ground is the most effective way to eliminate noise pickup from this antenna effect.

To ensure that the instrument's grounding scheme is working effectively:

1. Make sure that the sensors are floating.
2. Make sure that the input cable shields are connected to the connector's metal backshell.
3. Make sure that the Third-Wire-Ground is good quality and not conducting current.

LAN Remote Interface

The LAN interface is electrically isolated and cannot introduce ground loops.

The Model 18 Web Site

The Status Page

The Home, or Status Page is shown here:

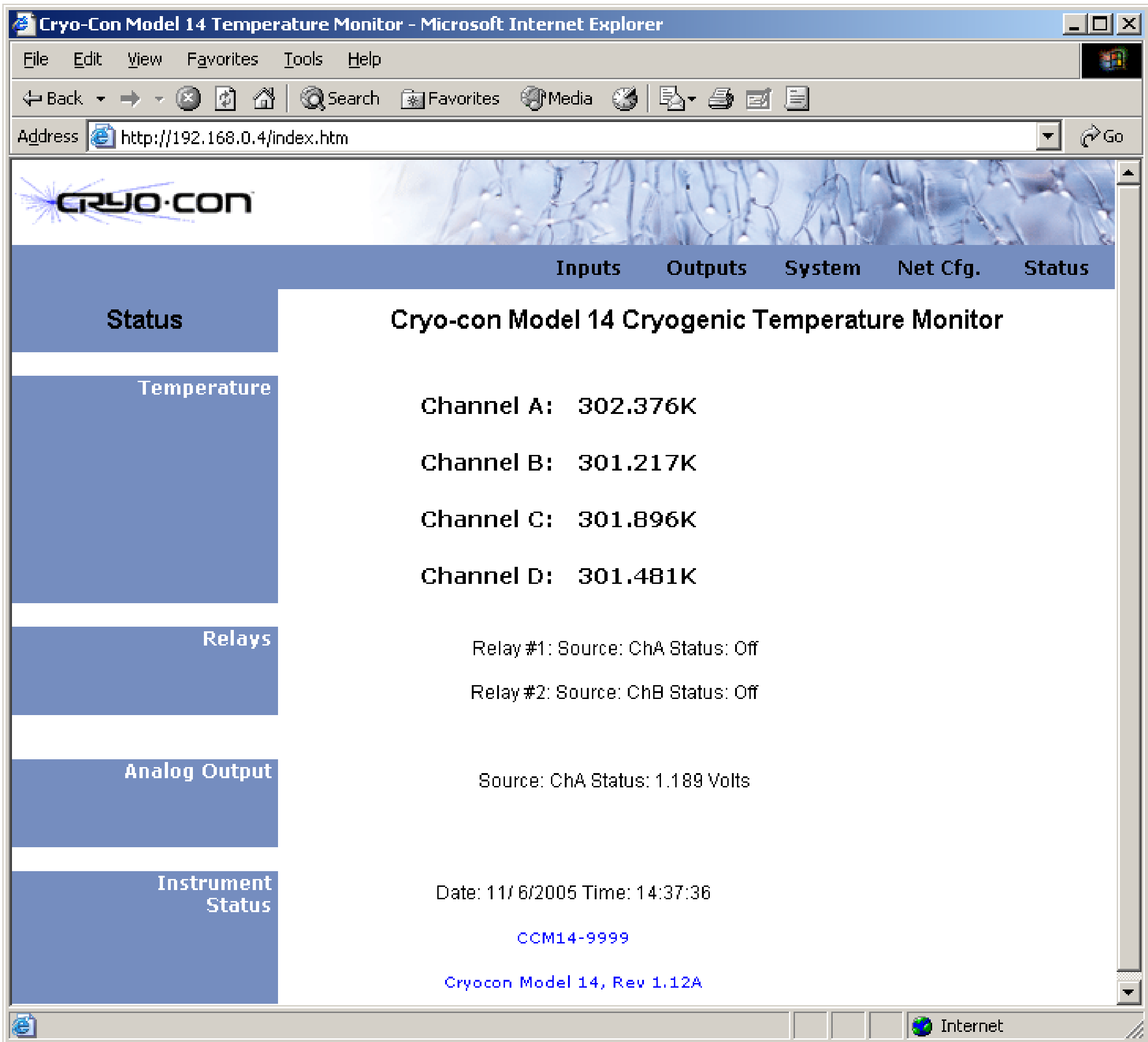


Figure 6: Model 18 Web Site Status Page

This page shows the current temperature and alarm conditions for both channels as well as the status of both relays and the analog output. Clicking on the Status field of the top navigation bar will refresh this page.

The Network Configuration page

The Network Configuration page is accessed by clicking on the Net Config. field of the top navigation bar.

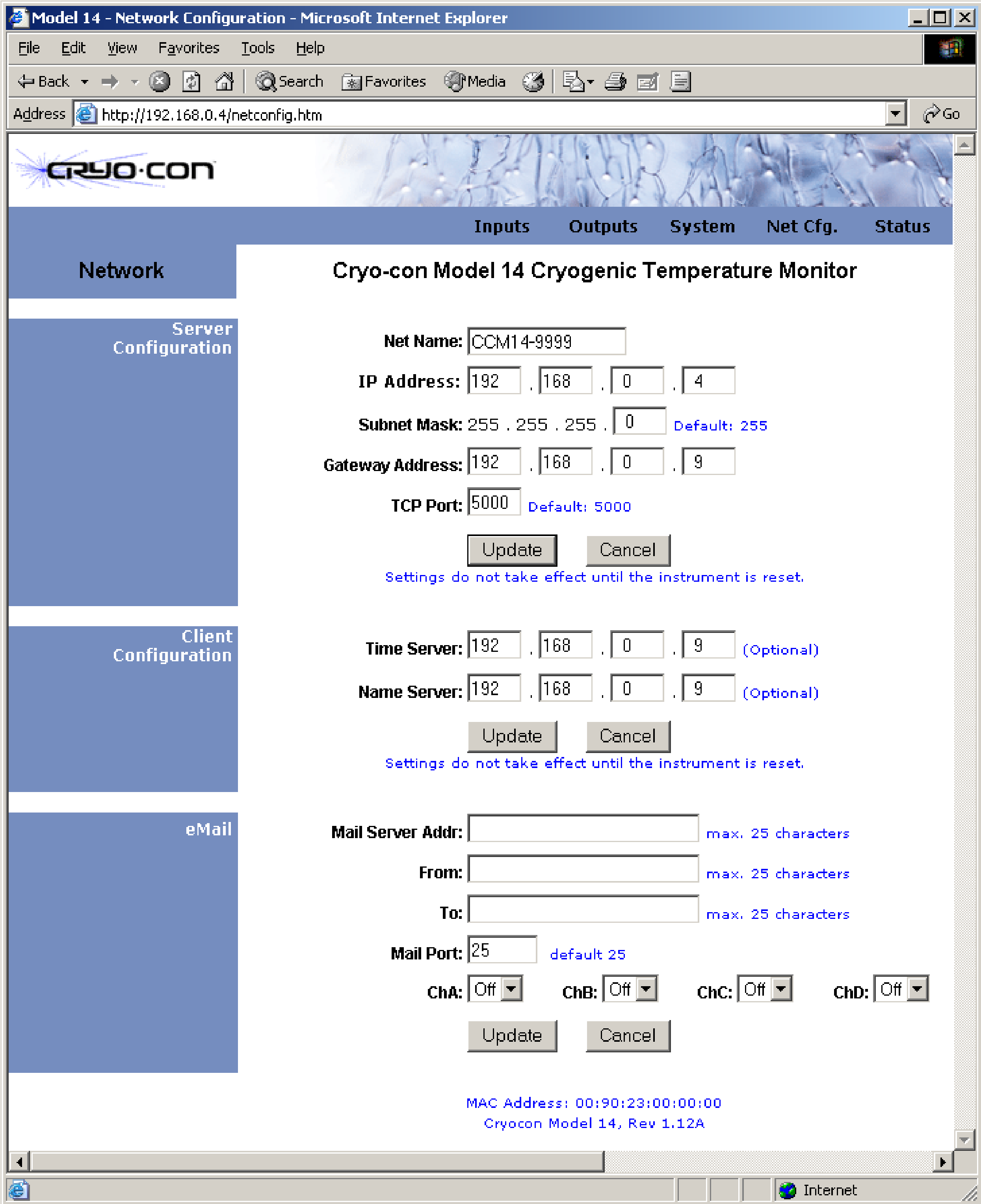


Figure 7: Network Configuration Page

This page is used to set the network parameters for the Model 18. These parameters are modified by entering new data and clicking on the Submit button.

Note that, if you change settings on this page, the Model 18 will reset to the new configuration and disconnect from your web browser. You will need to enter a new address in the browser to re-connect.

Configuring the Network Connection

The Network Name is optional and is used as a convenience to identify a specific instrument. The factory default is CCM14 + the last four digits of the unit's serial number.

The IP address and subnet mask default to: 192.168.0.4 and 255.255.255.0. These should be changed so that the unit is on the same IP segment as the user's network. This means that the first three fields of the IP should match the user's network and the last field should be unique to the unit.

Configuring E-mail

E-mail is configured from this page. First, a SMTP mail server address must be entered. It is the IP address of the computer which runs the e-mail server program.

Next is a 'from' and a 'to' E-mail address. Note that the 'from' address must be valid on the specified mail server.

The 'Mail Port' is usually port 25.

Finally, select the channels that you want to receive E-mail for. Mail will be sent whenever an enabled channel asserts an alarm condition.

Alarm conditions are setup on the Input Channel Configuration page.

☞ **NOTE:** If you are connecting the Model 18 to a Local Area Network with a gateway to the Internet, there must be an e-mail server program running on the gateway computer. Unlike sending e-mail from a computer, the Model 18 is an 'Internet Appliance' that requires a local e-mail server to forward e-mail. E-mail servers are inexpensive programs that are commonly available. Check with your systems administrator for details.

The Input Channel Configuration Page

This page is used to set the characteristics of each input channel including sensor type, units and alarm conditions.

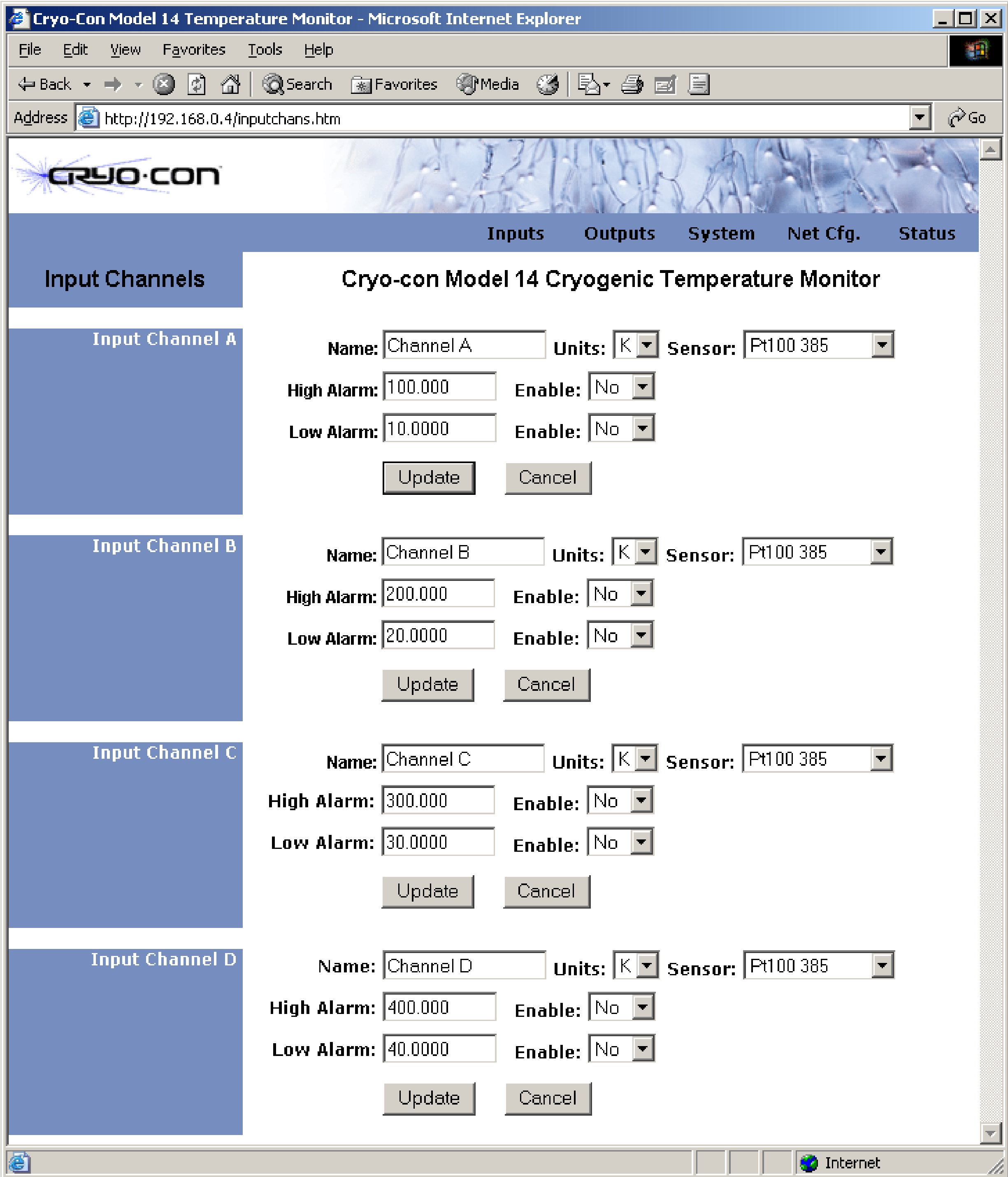


Figure 8: Input Channel Setup Web Page

The Output Channel Configuration Page

Output channels on the Model 18 include two dry-contact relays and an analog output. These may be completely configured using this web page.

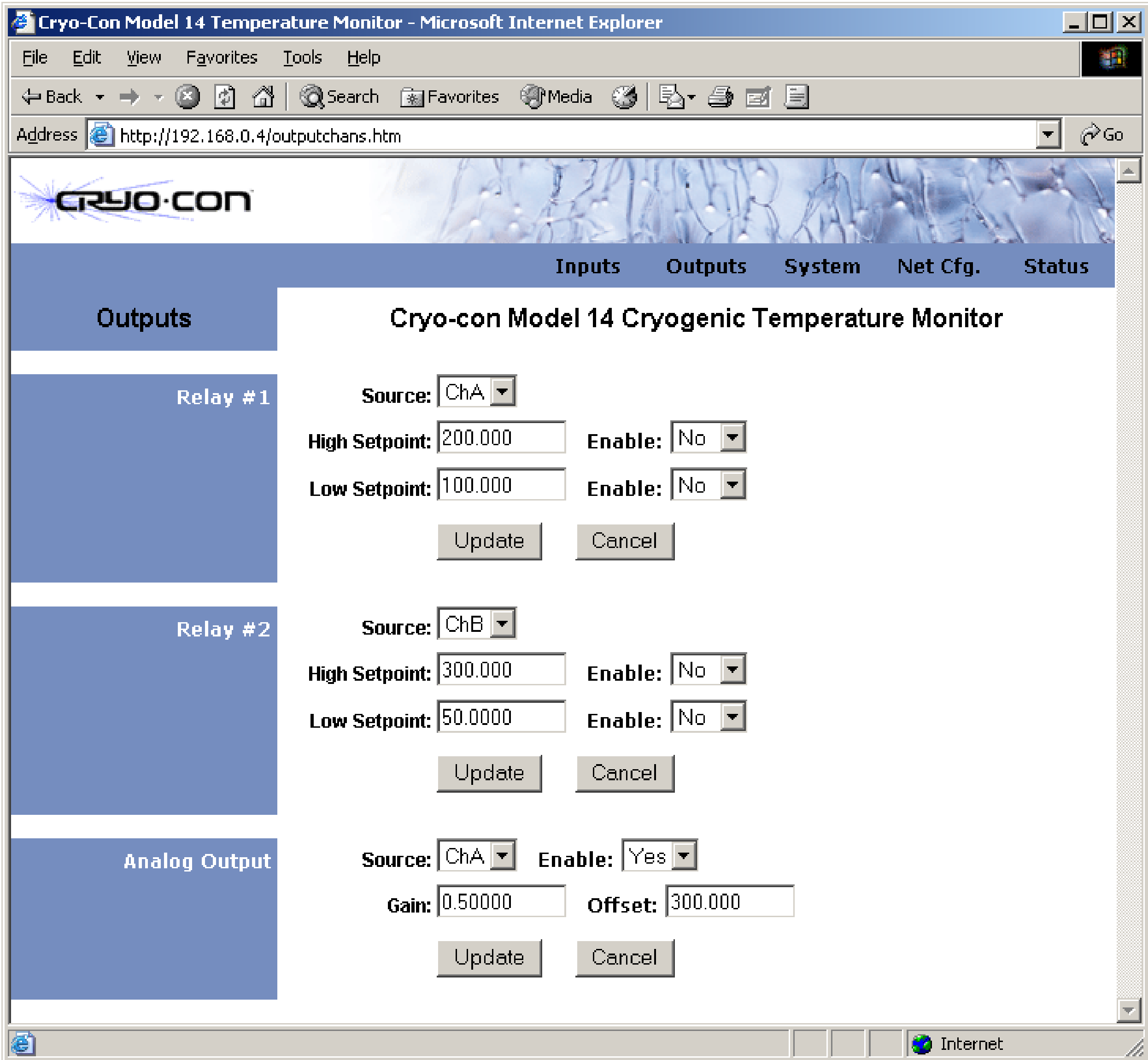


Figure 9: Output Channel Web Page

System Configuration Page

From the System Configuration page, temperature displays and data logging is configured.

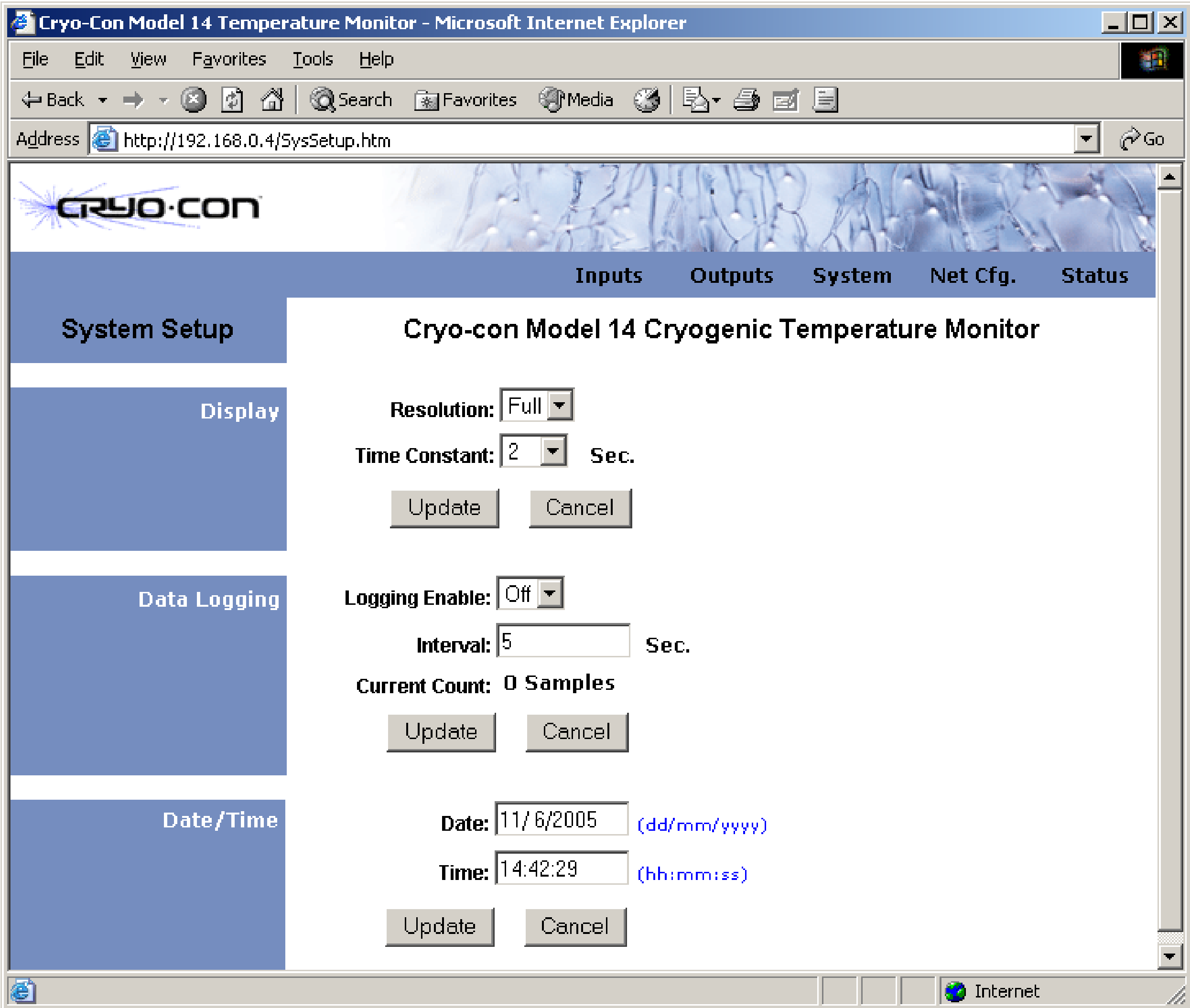


Figure 10: System Configuration Page

The Resolution filed is used to select the number of significant digits to the right of the decimal point for all temperature displays. Choices are 1, 2, 3 or Full. Selection of Full will left justify temperature displays for the maximum display width.

Time constant is an averaging filter that can be applied to temperature displays. It is in units of seconds.

The internal data logging capability can be configured from the Data Logging form. When enabled, internal logging will proceed continuously at the selected interval.

Cryo-con Utility Software

Cryo-con provides a PC compatible utility software package with all instruments. This is available on CD, or on the Internet.

Utility software can be used to control and configure any Cryo-con instrument via the LAN interface. It runs under all versions of the Windows operating system. This software provides several useful functions, including:

1. Real-time strip charts of temperature.
2. Data Logging. This function allows the user to record data from the instrument at a specified sample rate. The resulting file is compatible with most spreadsheet and data analysis software.
3. Download or upload sensor calibration curves. The software will accept curves in Cryo-con .CRV, Lakeshore .340 or Scientific Instrument's .txt format. In fact, it will read almost any table of temperature vs. sensor units.
4. Cryo-con's CalGen® function is implemented. This function allows the user to fit an existing sensor calibration curve to one- two- or three user-specified points. The result is a high accuracy sensor calibration at low cost.
5. Configuration of any of the instrument's remote interfaces.
6. Flexible 'Help' interface that documents all instrument remote commands with a cut-and-paste type interface.
7. 'Interactive Mode' provides interactive communication with the instrument over any of the remote interfaces.
8. Instrument calibration using a simple step-by-step menu driven process.

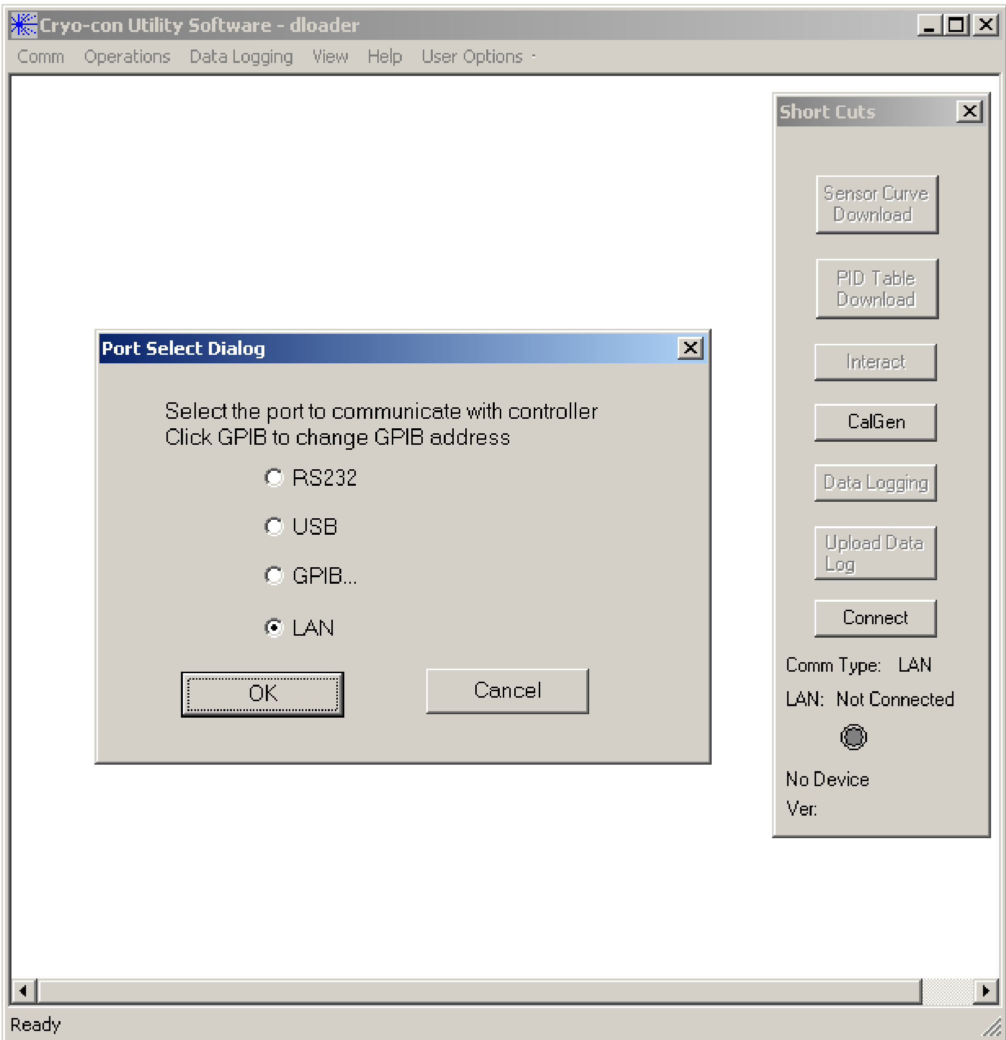
Installing the Utility Software

From a CD, the utility software package does not require installation. It can be executed from the CD directly by running the UTILITY.EXE program.

When the software is downloaded off of the Internet, it is in a self-extracting ZIP format and must first be un-zipped onto hard disk.

Connecting to an Instrument

The desired remote interface connection may be selected by clicking **Comm>Port Select** from the main menu.



Select the desired communications port and then click **OK**..

Click on the **Connect** button of the shortcut menu bar or on **Comm->Connect** from the main menu to connect to the instrument.

After a short delay, the connect LED should light and the instrument type will be displayed. Also, most of the grayed-out fields on the menu bars should activate.

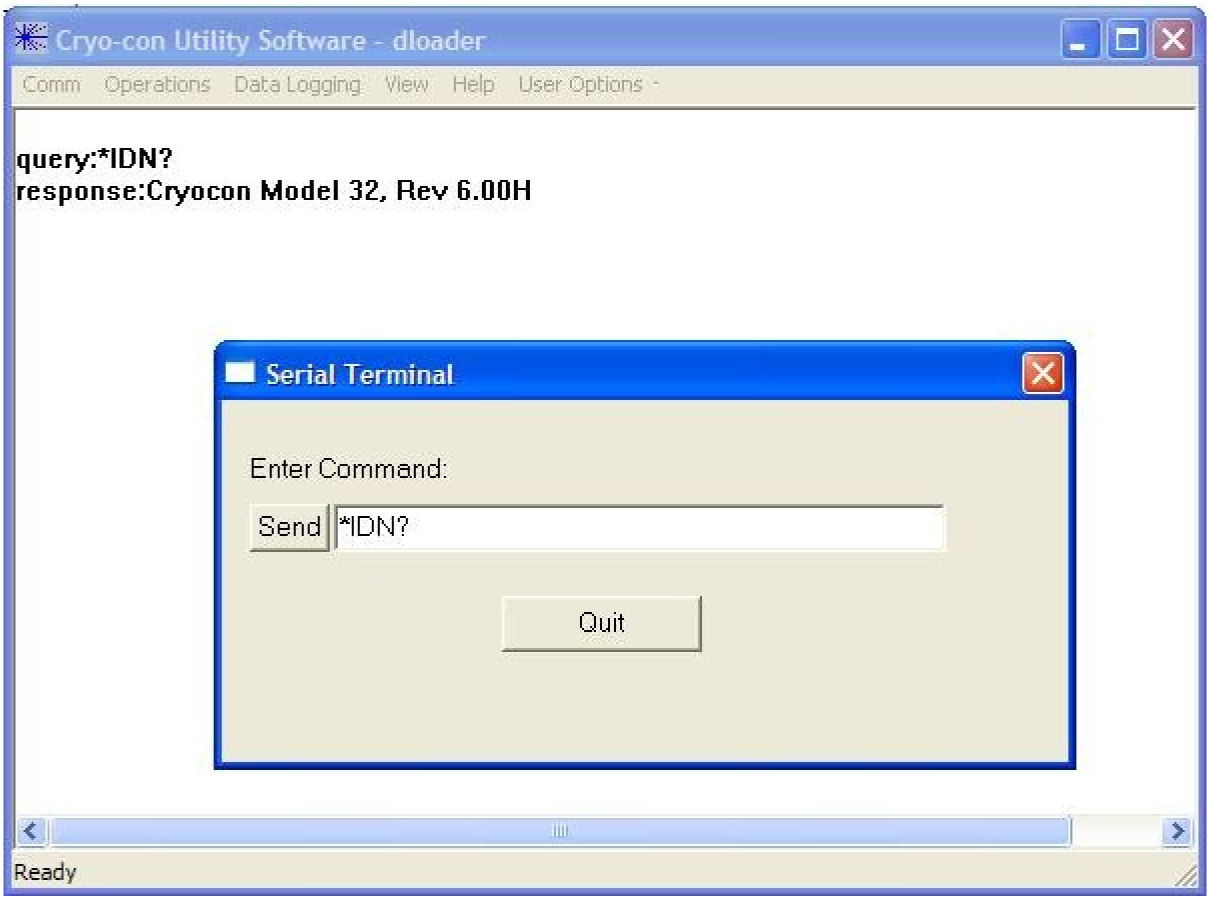
Using the Interactive Terminal

The Utility Software's Interactive Terminal mode allows the user to send commands to the instrument and view the response.

Terminal mode is selected by selecting **Comm>Interact** from the main menu or **Interact** from the shortcut bar. This will result in the display shown below.

To interact with the instrument, type a remote command into the dialog box and click **Send**. The command will be transmitted to the instrument and a response, if any, will be displayed on the background window.

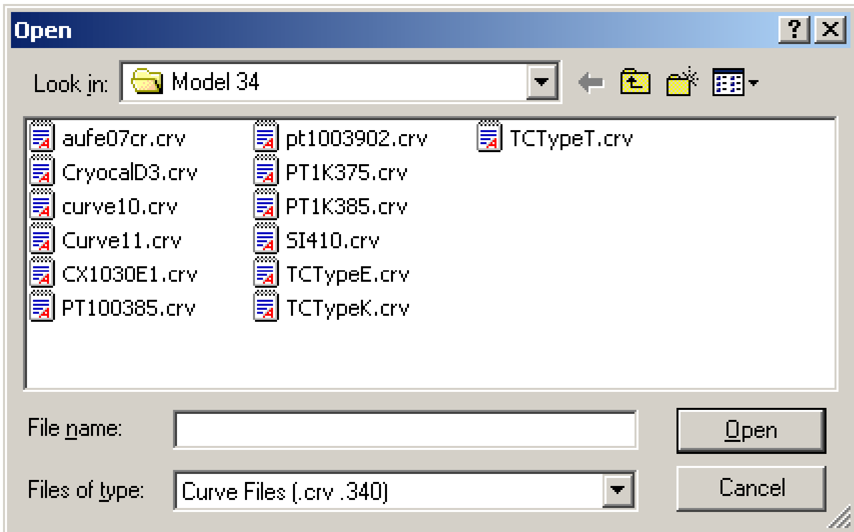
To exit terminal mode, click the **Quit** button on the dialog box.



Downloading or Uploading a Sensor Calibration Curve

Sensor calibration curves may be transferred between the PC and the instrument by using the Calibration Table menu.

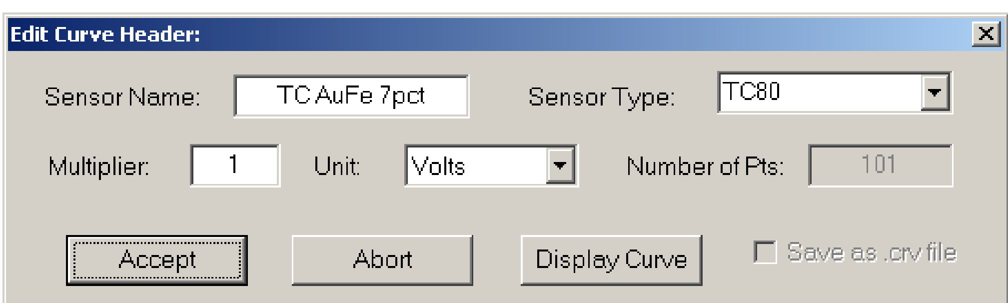
To download a curve (send it from the PC to the instrument), either select “Sensor Curve Download” from the shortcut bar or **Operations>Sensor Curve>Download** from the main menu. This will cause a file selection dialog box to appear as follows:



From this screen, the desired calibration curve is selected. Cryo-con calibration curves have the file extension of .CRV. Lakeshore curves with the extension .340 may also be selected. Scientific Instruments .txt files may be downloaded by first selecting a file type of *.* and then selecting the desired calibration curve file.

Cryo-con .CRV files are ASCII text files that may be edited by any text editor.

After selecting the file and clicking on **Open**, the selected file will be read and the Edit Curve Header dialog box will appear. This box contains information extracted from the curve file header that can be modified, if desired, before the curve is downloaded.



“Sensor Name” is any 15-character string and is only used to identify the sensor.

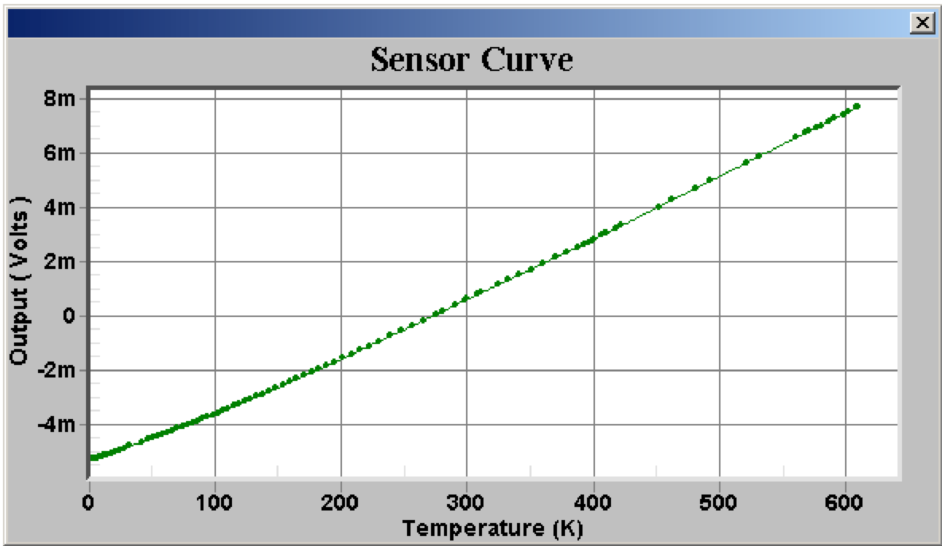
Sensor type can be selected from a pull-down menu or entered directly. Note that different models of Cryo-con instruments support different types of sensors. Therefore, it is important to enter a sensor type that is supported by the specific product. If the instrument receives a sensor type that it does not support, the ‘Diode’ type is selected. The section titled “Input Configurations” gives complete information on sensor types.

The Multiplier field is used to select the sign of the sensor's temperature coefficient. A value of –1 selects a Negative-Temperature-Coefficient sensor while a value of 1 selects a Positive-Temperature-Coefficient.

The Unit field selects the units used in the calibration curve. Choices are: Volts, Ohms or LogOhm.

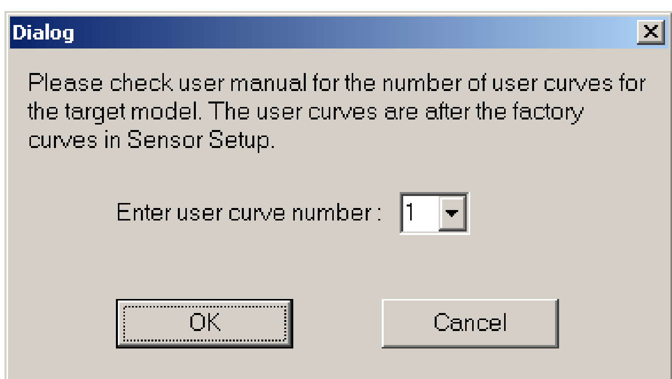
Checking the 'Save as .crv' will save the curve to disk as a Cryo-con .crv file.

The sensor curve may be viewed as a graph by clicking the 'Display Curve' button. An example plot is shown here:



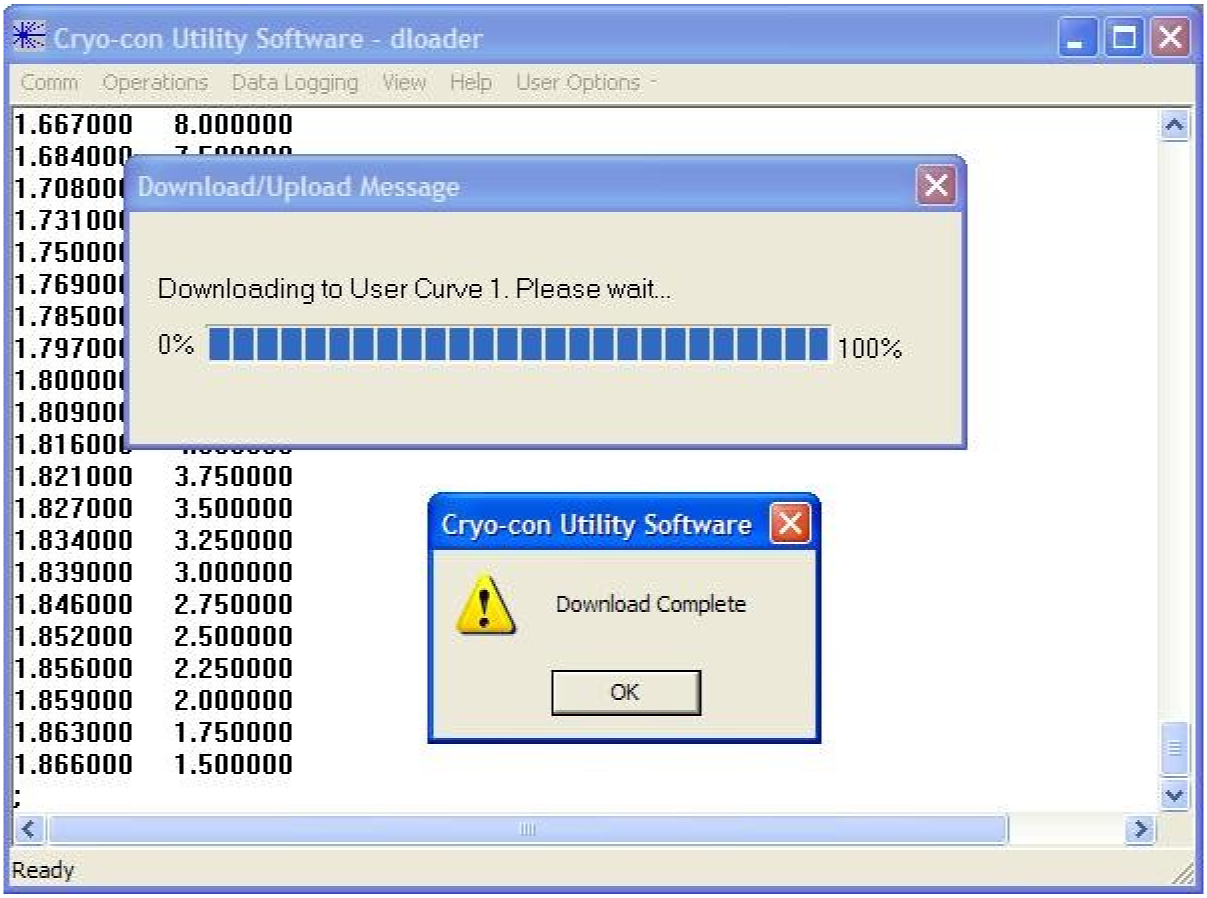
After completing any desired changes in the "Edit Curve Header" dialog box, click 'Accept' to proceed. Then the, curve number dialog box will appear:

A user calibration curve should be entered here. For the Model 18, user curves are 1 through 4.



When ‘OK’ is selected, the sensor calibration curve will be downloaded to the instrument. During the transfer, curve data points will be displayed in the window’s main pane. Upon completion, the Download Complete dialog box will appear:

Dismiss this dialog box to complete the download process.



To upload a calibration curve, use the same procedure and select **Upload**. This will transfer a curve from the instrument to the PC.

Using the Real-Time Strip Charts

The real-time strip chart feature of the Utility Software lets the user continuously display any combination of input channels on the computer display.

This function is initiated by selecting the **View** command on the Utility Software's main toolbar, then selecting the desired channels to monitor.

A strip chart will be displayed for each channel selected. The dialog box will show the channel's Input Identifier, Name String and a chart of current temperature.

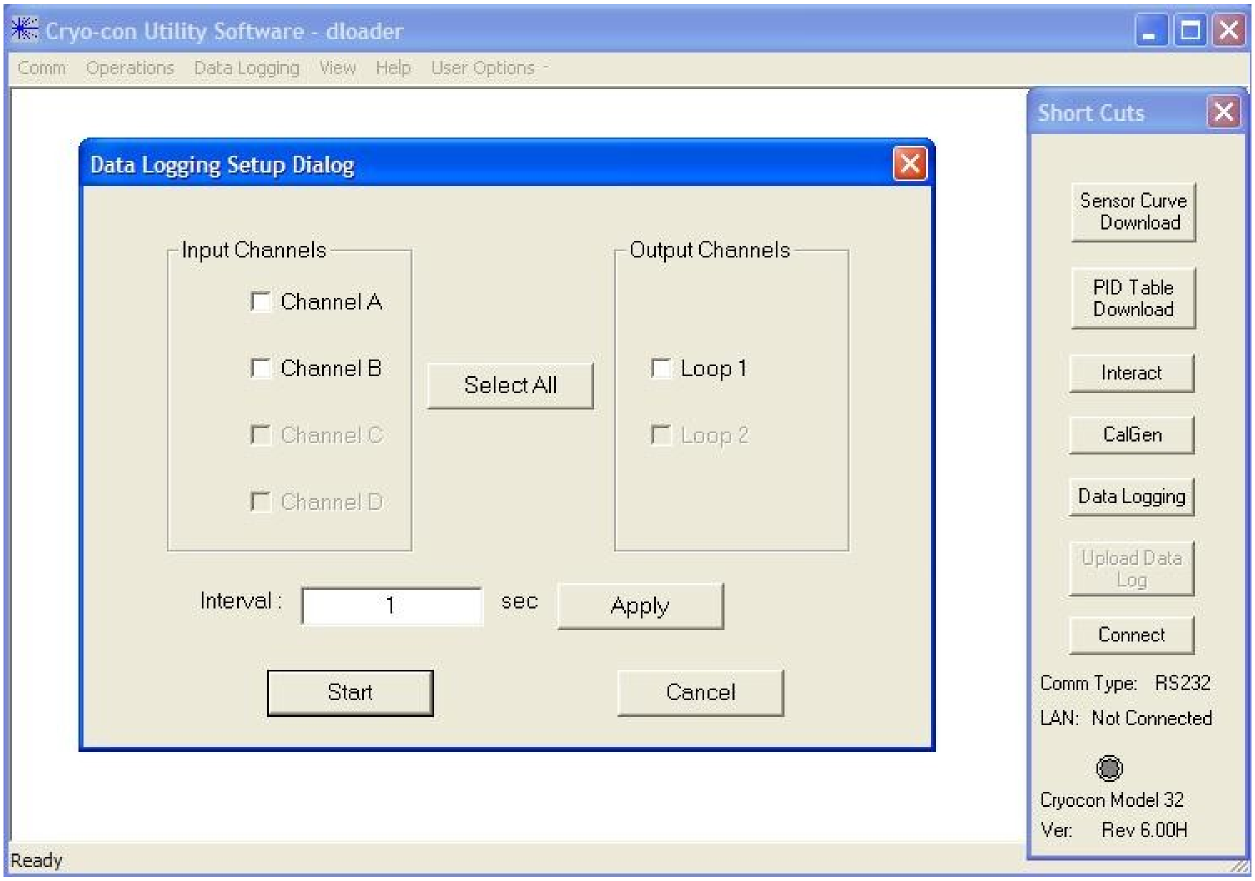
The update rate of the chart is locked to the program's Data Logging Interval. The section below details how to set this value.

Data Logging

The Utility Software will perform data logging on all of the instruments input and control output channels. The result is a disk file in Comma-Separated-Value, or CSV format. This format is compatible with any data analysis or charting software including Microsoft Excel.

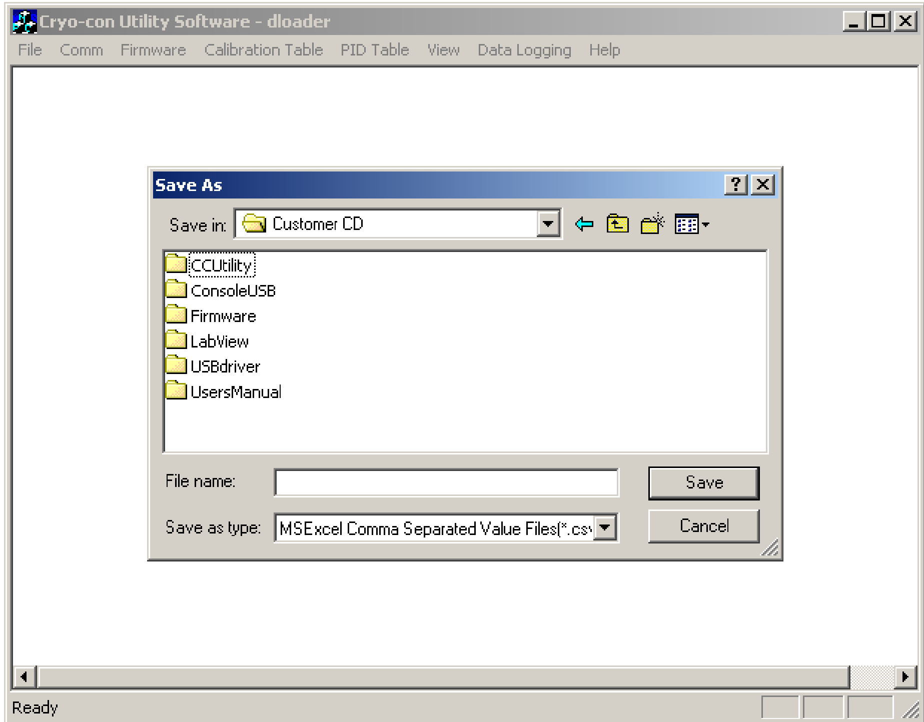
To initiate data logging, select the **Data Logging** button from the Utility Software's main menu. The Data Logging Setup dialog box will now appear.

On this dialog box, check the desired channels and set an Interval value in Seconds. The minimum interval is 0.1 Second.



When the **Start** button is clicked, a file selection dialog box will be shown.

From this dialog box, enter a file name and select the directory where data logging results will be saved.



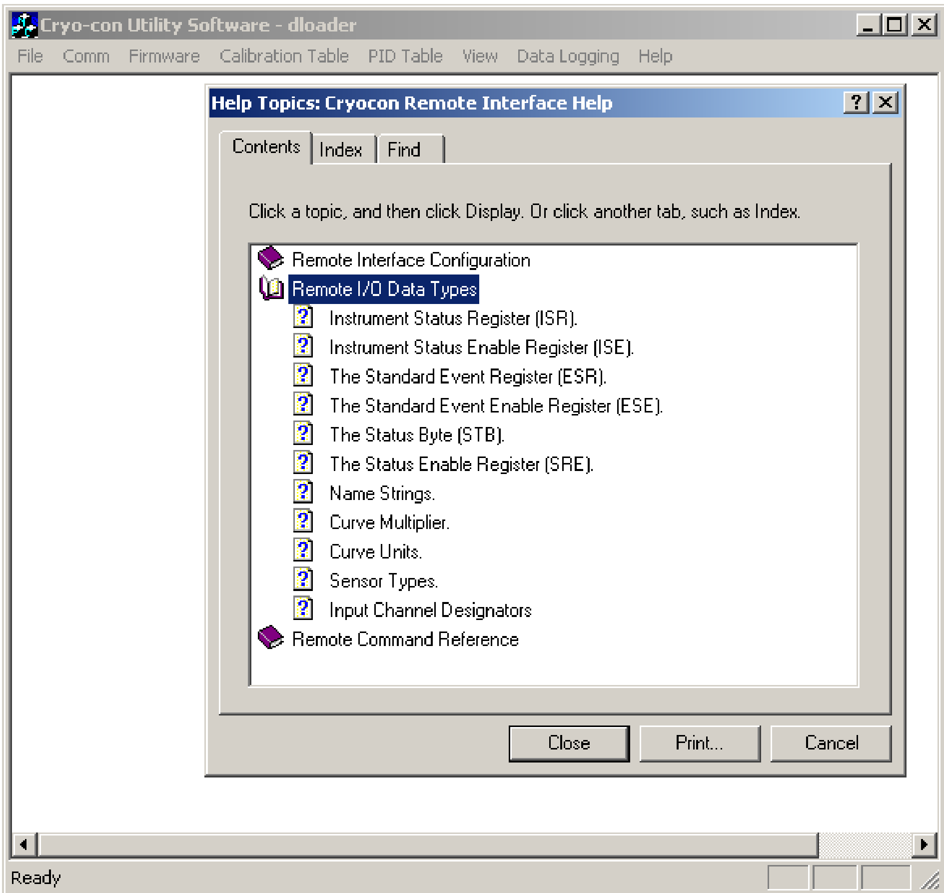
As soon as the **Save** button is clicked, the software will begin continuous data logging to the specified file.

While data logging is in progress, a dialog box will be displayed that allows the user to stop logging. When this **Stop** button is clicked, logging is stopped and the log file is closed.

Remote I/O command HELP

Help for the remote interfaces and remote commands is available by clicking on the **HELP>Contents** button from the Utility Software's main menu.

A standard HELP screen will be shown that is indexed and searchable.



CalGen® Calibration Curve Generator

The CalGen® feature is used to generate new calibration curves for Silicon Diode or resistor sensors. This provides a method for obtaining higher accuracy temperature measurements without expensive sensor calibrations.

Most Cryo-con™ temperature indicators support CalGen™ directly on the instrument. However, the utility software package implements the same algorithm and can be used with virtually any instrument capable of measuring temperature.

New Curves can be generated from any user selected sensor calibration curve and are written to a specified file.

For Diode sensors, the user may specify one, two or three data points. CalGen will generate the new curve based on fitting the input curve to the user specified points.

Platinum or other resistor calibration curves require one or two data points. The generated curve will be a best fit of the input curve to the two specified input points.

Since CalGen fits a sensor calibration curve to measured data, any errors in the instrument's measurement electronics are also effectively canceled.

CalGen® Initial Setup

To start the CalGen™ process, either select **CalGen®** from the shortcut bar, or select Operations>CalGen from the main menu. This will initiate the process of generating a new sensor curve.

Using CalGen With Diode Sensors

Options for generating Diode calibration curves are:

1. One point near 300K. The portion of a Diode Sensor curve above 30K will be fit to a user-specified point near 300K. This is a two-point fit where the 30K point is taken from the existing calibration curve. The portion of the curve below 30K is unaffected.
2. Two points: 300K and 77K. Here, two user-specified points are taken to fit the diode curve region above 30K. The entire curve is offset to match the 77K point, then, the >30K region is fit to the two points.
3. Three points: 300K, 77K and 4.2K. Two points above 30K are fit as in the selection above. Then, a third point is used to fit a single point in the high-sensitivity region below 20K.
4. One point near 4.2K. This is a two-point fit where the 20K point is taken from the existing calibration curve. The portion of the curve above 20K is unaffected.

Using CalGen® With Resistor Sensors

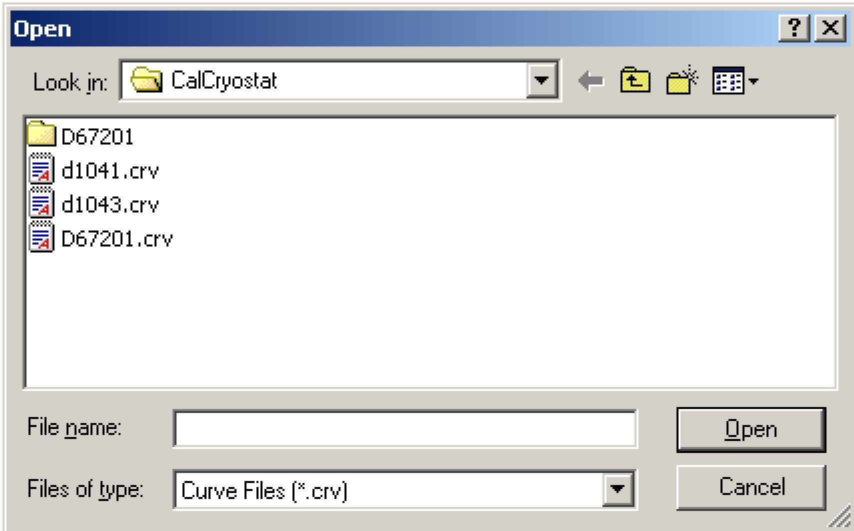
The calibration curve generation procedure for Platinum or other resistor sensors is the same as for the diode. However, these sensor curves are generated using two user specified points. Therefore, the selection of the number of points is not required.

Example CalGen® Procedure

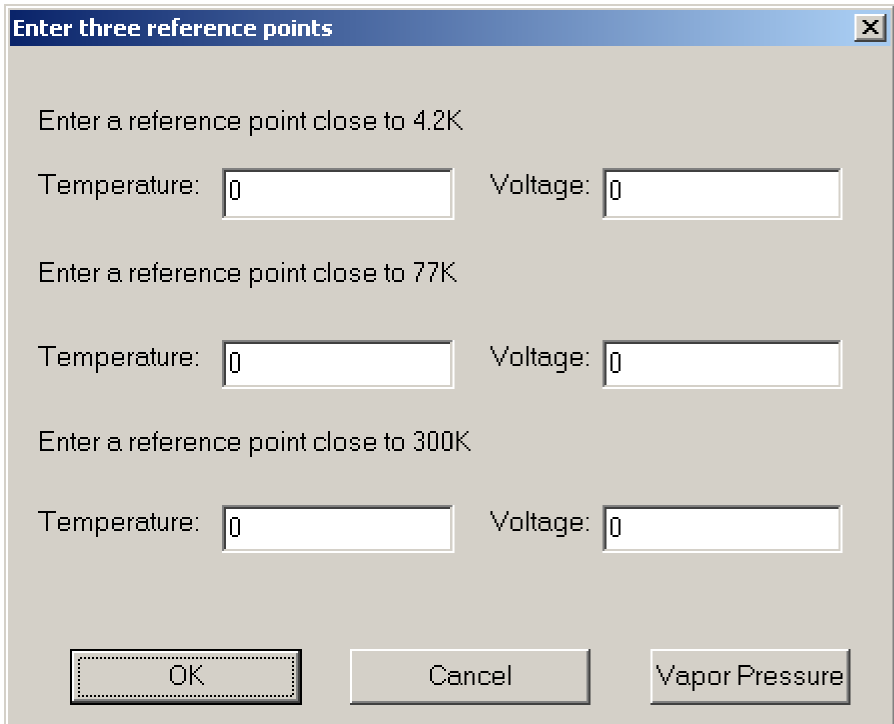
A complete procedure for calibrating a diode sensor at three points is shown here. Before the procedure can be started, the instrument must be connected and have a valid sensor connected.

The CalGen™ procedure will require the user to stabalize the input temperature at three user-selected points. It will capture data at each of these points and then generate a new curve from that data.

When a 3-point CalGen is started for a Silicon Diode sensor, the reference curve must first be selected. This is the curve that will be rotated and shifted to fit the selected points.


Open
Look in:
CalCryostat
D67201
d1041.crv
d1043.crv
D67201.crv
File name:
Files of type:
Curve Files (*.crv)
Open
Cancel

When the curve has been selected, the following dialog box will appear:



The process requires you to completely fill out this dialog box by selecting a temperature and then copying the voltage (or resistance) reading corresponding to that temperature from the instrument.

Note that the Vapor Pressure button will take the user to a convenient calculator that will compute the temperature of various cryogens from the current barometric pressure.

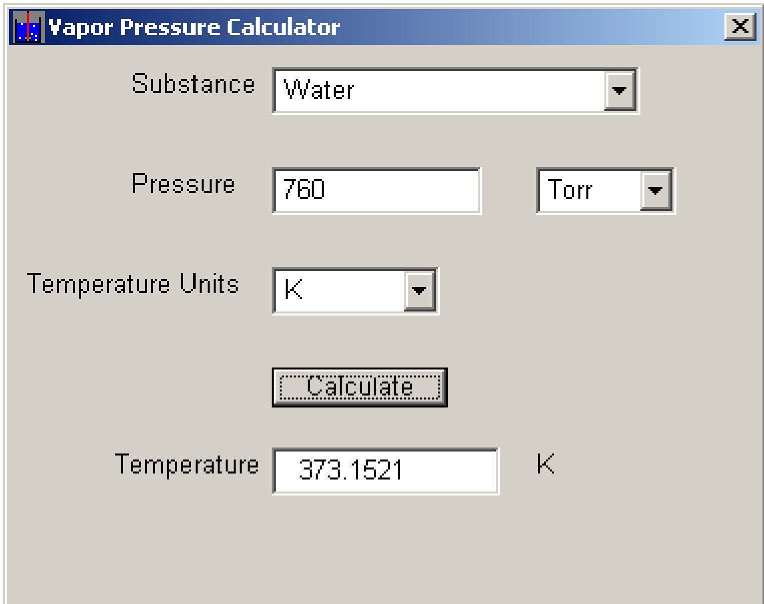
Once the dialog box has been completed, click OK to proceed.

To finish the process, you will be prompted to save the modified calibration curve to a file. Once complete, the file can be transferred to any Cryo-con™ instrument.

The Vapor Pressure Calculator.

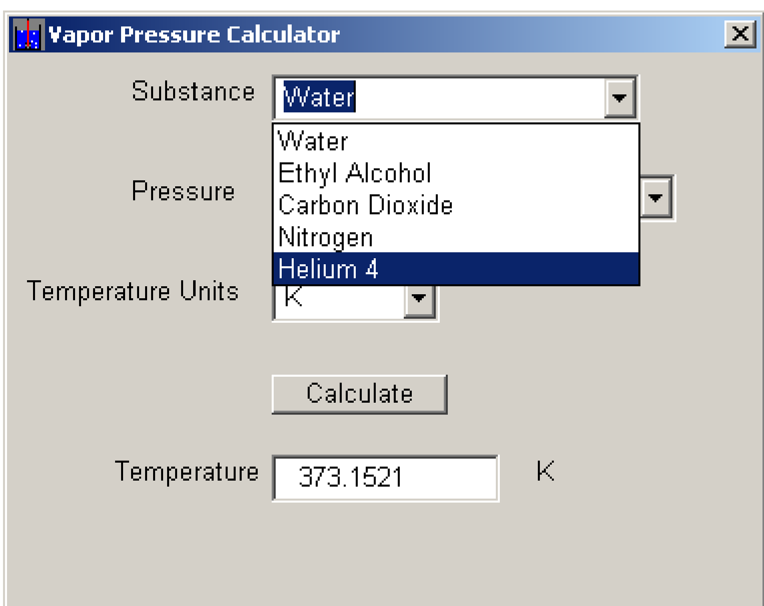
The Vapor Pressure Calculator is a convenient aid that computes the actual temperature of most cryogens given the current barometric pressure. It can be launched directly off of the utility disk by executing “Vapor Pressure Calculator.exe” or from the CalGen™ dialog as shown above.

A typical calculation is shown here:



You must select the Substance from a drop-down list and then select the barometric pressure and temperature units.

Substance selections are shown here:



Instrument Calibration

Calibration of the Model 18 requires the use of various voltage and resistance standards in order to generate calibration factors for the many measurement ranges available.

Calibration is ‘Closed-Case’. There are no internal mechanical adjustments required. The Model 18 cannot be calibrated from the front panel.

Calibration data is stored in the instrument’s non-volatile memory and is accessed only via the remote interfaces. Calibration of a measurement range is the simple process of generating an offset and gain value. However, since there are several input ranges available on each sensor input, the process can be time consuming.

Caution: Any calibration procedure will require the adjustment of internal data that can significantly affect the accuracy of the instrument. Failure to completely follow the instructions in this chapter may result in degraded instrument performance.
The Cryo-con utility software used in this procedure will first read all calibration data out of the instrument before any modifications. It is good practice to record these values for future reference and backup.

Cryo-con Calibration Services

When the instrument is due for calibration, contact Cryo-con for low-cost recalibration. The Model 18 is supported on our automated calibration systems which allow Cryo-con to provide this service at competitive prices.

Calibration Interval

The Model 18 should be calibrated on a regular interval determined by the measurement accuracy requirements of your application.

A 90-day interval is recommended for the most demanding applications, while a 1-year or 2-year interval may be adequate for less demanding applications. Cryo-con does not recommend extending calibration intervals beyond 2 years.

Whatever calibration interval you select, Cryo-con recommends that complete re-adjustment should always be performed at the calibration interval. This will increase your confidence that the instrument will remain within specification for the next calibration interval. This criterion for re-adjustment provides the best measure of the instrument’s long-term stability. Performance data measured using this method can easily be used to extend future calibration intervals.

Minimum Required Equipment

All calibrations require a computer with a LAN connection to the instrument. Additionally, reference standards are required for each input range as follows:

- The Silicon Diode input range (Calibration Type I10UA and V10UA) requires voltage references of 0.5 and 1.5 Volts DC and a resistance standard of 100KΩ
- The 100Ω Platinum range (Type R1MA) requires a 100Ω and a 10Ω resistor.
- The 10,000Ω range (Type R10UA) requires 10KΩ and 1KΩ resistors.

The test equipment recommended for complete calibration is a Fluke 5700A DMM calibrator.

The Basic Calibration Sequence

You must first connect the Model 18 to a computer via the LAN interface and then run the Utility Software provided with the instrument. The Utility Software must be version 7.4.2 or higher.

From the start-up menu of the Utility Software, click the Connect button in the bottom of the Short Cuts toolbar. The software will connect to the instrument and display the connection status below the button.

In case of an error, please correct the port connection settings and try again.

From the main menu, select Operations->Unit Cal. The program will read the current calibration values from the instrument and display a calibration screen as shown below. All calibration operations can be performed by using this screen.

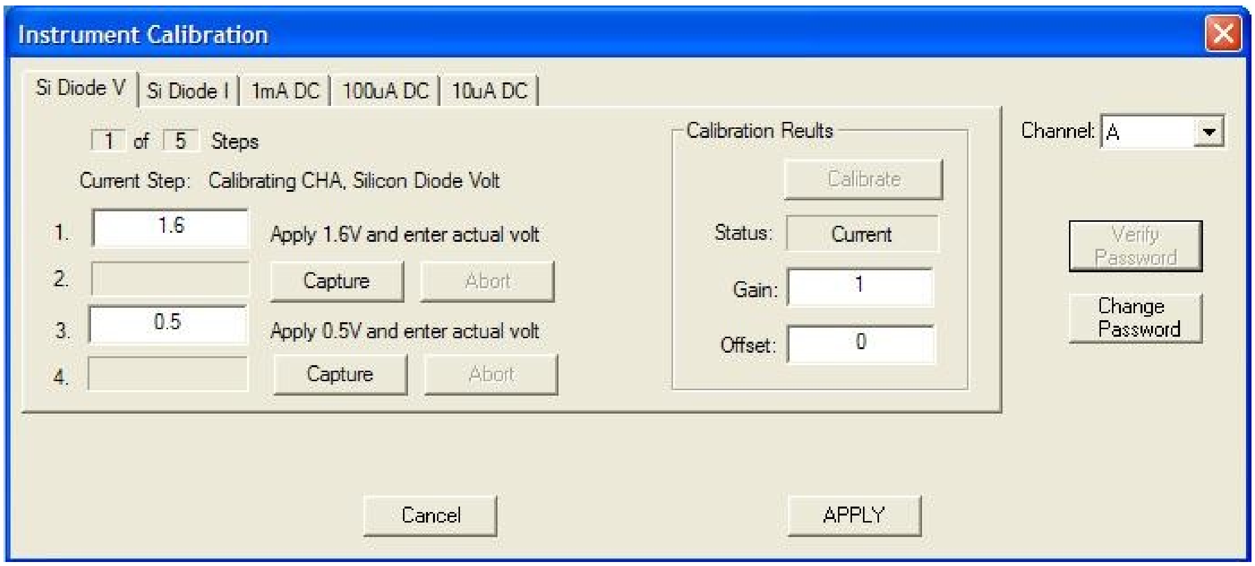


Figure 11: Instrument Calibration Screen

☞ **Note:** Cryo-con instruments will require a password before calibration data can be saved. The utility software will allow you to enter and change the password.

The default password is: **Cryocon**

On the far right of the screen, a drop-down box selects the channel to be calibrated. Be sure you have selected the correct channel. In order to perform a complete calibration, you will need to calibrate each channel individually.

Along the top of the screen, there are tabs that show the types of calibration that are supported by the instrument. To perform a complete calibration of a single input channel, all calibration types must be calibrated.

Note the **Calibration Results** box on the screen. The **Status** field will initially be set to 'Current' and the **Gain** and **Offset** values shown will be those read from the instrument.

☞ **Note:** If your calibration procedure requires saving historical values, you will want to record the Gain and Offset values shown on the initial screen before proceeding with actual calibration.

There are two methods available for calibration:

1. Automatic. The software will recommend voltages and resistances. You can set these values on the input channel and capture the instrument's actual readings. Then, the software will automatically generate offset and gain values for you.
2. Manual: You can manually enter Offset and Gain values and send them to the instrument.

Manual Calibration

To manually calibrate a range, select the desired range from the range type tabs and enter the desired Gain and Offset values in the boxes given and then, click the **APPLY** button.

Gain is a unit-less gain factor that is scaled to a nominal value of 1.0. It is usually computed by:

gain = (UT – LT) / (UM – LM)

where:
UT is the upper target and LT is the lower target.
UM is the upper measurement and LM is the lower measurement.

Gain values greater than 1.2 or less than 0.8 are rejected as out of range.

Offset is in units of Volts or Ohms depending on the calibration type. Nominal value is 0.0. Positive or negative numbers are accepted. It is usually calculated by:

Offset = UT - gain * UM

Automatic Calibration

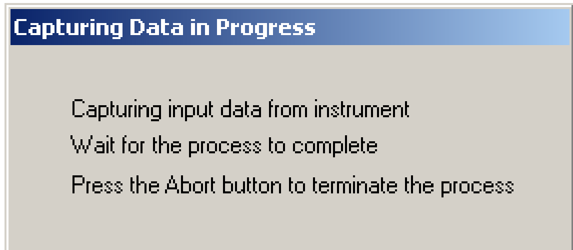
Automatic calibration uses the left-hand side of the calibration screen and is a four-step process:

1. Line 1 requires setting a upper target value on the input channel. Depending on the calibration range selected, this will be in Volts or Ohms.

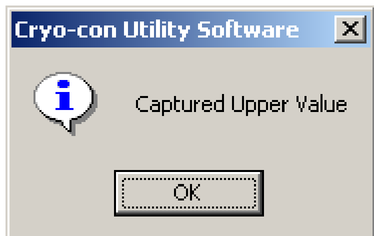
   First, establish a voltage or resistance on the selected input channel that is near the recommended value. Then, enter the actual value in the box provided.

2. Click the Capture button on Line 2. The software will wait for the reading to stabilize and then will capture the reading and display it in the edit box on Line 2.

   While waiting for a stable reading, the following dialog box will be displayed:



   When the capture is complete, dismiss the following dialog:



3. Line 3 requires setting a lower target value on the input channel. Depending on the calibration range selected, this will be in Volts or Ohms.

   First, establish a voltage or resistance on the selected input channel that is near the recommended value. Then, enter the actual value in the box provided.

4. Click the Capture button on Line 4. The software will wait for the reading to stabilize and then will capture the reading and display it in the edit box on Line 4.

When the above procedure is complete, you will have established upper and lower target values as well as upper and lower measurements. The edit boxes on lines 2 and 4 will contain the measured values. At this time, you may still change the target values on line 1 and 3 if desired.

Now, you can automatically compute the required gain and offset values by clicking on the **Calibrate** button in the **Calibration Results box**. This will change the **Status** field from 'Current' to 'Calibrated' and will update the **Offset** and **Gain** values with those calculated.

At this point, to values have been transmitted to the instrument!

In order to send the offset and gain values to the instrument's calibration memory, click the **APPLY** button. You will be required to confirm that you really want to update calibration memory.

Summary of Calibration Types

Calibration data must be generated for each input channel by sequencing through the various calibration types on each channel. A summary of types is given here:

Calibration Type	Voltage Range	Output Current	Description
SI DiodeV	0 – 2.5V	N/A	Voltage measurement for use with Silicon Diode temperature sensors.
SI Diode I	N/A	10µA	10µA constant-current source used with Silicon Diode sensors.
1mA DC	0-2.5VDC	1.0mA	DC measurement of 100 Platinum RTD sensors.
10uA DC	0-2.5VDC	10µA	DC measurement of 10K Ohm Platinum RTDs or other resistor sensors that use DC current excitation

Calibration of Silicon Diodes

Silicon Diode sensors require the application of a precision 10µ A current followed by reading the voltage-drop across the device. Therefore, calibration of a diode requires two steps: 1) Calibration of the input voltage reading and 2) Calibration of the 10µA current source.

Note that the voltage calibration must always be done first since the current source calibration requires a precision voltage reading.

Diode Voltage Calibration

To calibrate the diode voltage range, click on the **SI Diode V** tab and follow the sequence described above to send Gain and Offset values to the instrument.

The upper target requires connection of a 1.9 Volt source. The actual value is between 1.0 Volts and 2.4 Volts. If you do not have a precision voltage source, you can use a 1.5 Volt battery by using a high precision volt meter to measure it's actual voltage.

The lower target requires connection of a 0.5 Volt source. The actual value is between zero Volts and 0.6 Volts. If you do not have a precision voltage source, you can short the input channel for zero volts.

Constant-current Source Calibration

Calibration of the constant-current source is performed by using the **SI Diode I** tab. On this screen, only an upper target value is required since the current-source only requires a gain term.

The upper target requires connection of a 100KΩ resistor. The actual value should be within 10% of 100KΩ.

Calibration of DC resistors

Resistor sensors that use direct current excitation are calibrated by using the **1mA DC**, **100uA DC** and **10uA DC** tabs.

Resistors required for calibration are as follows:

- **1mA DC:** Upper - 100Ω, Lower - 10Ω.
- **100uA DC:** Upper 1,000Ω, Lower - 100Ω
- **10uA DC:** Upper - 10,000Ω, Lower - 1,000Ω

Remote Operation

Remote Interface Configuration

The Model 18 has a 10-BaseT Ethernet LAN remote interface. Connection is made on the rear panel of the instrument. For specifics about the connectors and cables required, refer to the section above on Rear Panel Connections.

Configuration of the remote interfaces is done at the instrument's front panel by using the Remote I/O Setup Menu.

All configuration information shown on this screen is stored in non-volatile memory and, once set up, will not change when power is turned off or a remote interface is reset.

Ethernet Configuration

Supported Protocols

HTTP: The Hypertext Transfer Protocol is a standard protocol used for transferring information between hosts over TCP/IP-based networks, the most common being the Internet. HTTP is often referred to as the World Wide Web protocol because it manipulates interconnected information around the globe.

The Model 18 HTTP server manages multiple connections simultaneously. HTTP is a client-server protocol. The client host initiates a transfer by contacting the server host. The most common HTTP client is a web browser, such as Microsoft Internet Explorer or Netscape Navigator. The web browser, referred to as the web client, issues HTTP requests to access information from the Model 18.

SMTP: The Simple Mail Transport Protocol is used to send E-mail from the Model 18 to a selected address.

TIMEP: The Time Protocol allows a client to obtain the date and time from a host TIMEP server. If a time server is available on the Local Area Network, the Model 18 will periodically query it to update it's internal clock.

TCP/IP: The Transmission Control Protocol / Internet Protocol provides reliable, flow-controlled, end-to-end, communication between two machines. TCP operates even if datagrams are delayed, duplicated, lost, delivered out of order, or delivered with corrupted or truncated data. TCP/IP uses port numbers to identify the many application protocols that can run over it.

In the Model 18, a TCP/IP port is available for communication using an ASCII command language. This is how the instrument interfaces to data acquisition software, including LabView™.

Ethernet IP Configuration

Each device on an Ethernet Local Area Network must have a unique IP Address. This is similar to IEEE-488 systems where each device required a unique 'GPIB' address. Further, the address assigned to the Model 18 must be within the range of the computers you want it to communicate with. The range is determined by the Subnet Mask.

The Model 18 is shipped with a default IP address of **192.168.0.4** and Subnet Mask of **255.255.255.0**.

You can configure the Model 18 to use any IP address from the front panel by going to the Network Configuration Menu.

Alternatively, You can configure your PC's Network connection with an IP address that is in the same range as the Model 18 IP address (**192.168.0.x**) and connect to the instrument using a **crossover** cable between your PC and the Model 18.

Once the IP is correctly set, you can go to the DOS-Prompt and ping 192.168.0.4. If you receive responses back, you can go to the Web browser and type in ***http://192.168.0.4*** and it will take you to the Model 18's Home Page.

From the Model 18's web page, you can completely configure the instrument to meet your network requirements.

Web site configuration

The Model 18 factory default settings are as follows:

IP address: 192.168.0.4
Subnet Mask: 255.255.255.0
Gateway: 192.168.0.1
TCP Data Socket: 5000

These settings are also entered into the Model 18 when the LAN Reset sequence is executed from the front panel.

The Model 18 does not support DHCP since dynamic addressing could possibly relocate the unit on the LAN with each power up.

LAN configuration is performed by the Network Configuration web page described in the "Network Configuration" section above. To display this page in your web browser, you must first connect to the Model 18.

When the above factory defaults are set, the Model 18 can be connected to a PC on the same LAN segment by using the LAN connector on the rear panel. If you are connecting to a LAN switch or hub, use a standard Category 5 Patch cable with standard RJ-45 connectors. If you wish to connect directly to a PC, use a Category 5 Crossover cable.

The PC may need to be configured to be on the same LAN segment as the Model 18. This is done by modifying the TCP/IP settings in the PC to have an IP of 192.168.0.xxx where <xxx> is in the range of 0 to 255 excluding 4 (The Model 18 address).

Once connected, you may change the network configuration of the Model 18 to have any desired values.

☞ **NOTE:** The Model 18 network configuration parameters may be reset to the factory default values by executing the LAN Reset sequence from the front panel. This will restore the IP address to 192.168.0.4 as well as other network settings.

TCP Data Socket Configuration

In order to communicate with the Model 18 in the SCPI command language, you must configure a TCP data socket application in your PC using remote port 5000.

Remote Programming Guide

General Overview

This brief is intended to assist the user interested in remote programming of any Cryo-con instrument. The remote interface language is common to all Cryo-con products.

Since the language supports both simple and advanced functions, it may initially seem complex. However, the use of English language keywords and a tree-structured architecture make it easy to read and learn.

Language Architecture

The programming language used by all Cryo-con instruments is described as follows:

- The industry standard SCPI language defined by the IEEE-488.2 standard is used. Therefore, anyone with experience in test and measurement will find it familiar.
- All Cryo-con instruments use the same language and future instruments will continue in the same fashion. Therefore, your investment in system software will not be lost when a product is revised or obsoleted.
- Keywords used in commands are common English words, not cryptic acronyms. This makes command lines easy to read and understand, even for someone that is not familiar with the instrument.
- The SCPI is a 'tree structured' language where commands are divided into groups and associated commands into sub-groups. This architecture simplifies composing commands and improves readability.

Purpose

If your intent is to remotely program a Cryo-con instrument with fairly simple sequences, you can skip to the section titled "Commonly Used Commands". This is a simple cheat-sheet format list of the commands that are most frequently used.

If you are an advanced user with a familiarity of the SCPI programming language, the section titled "Remote Command Descriptions" is a complete reference to all commands.

If you are not familiar with the SCPI language but need to perform advanced programming tasks, the SCPI is introduced in the next section.

For all users, the section titled "Debugging Tips" is often helpful and the "Remote Command Tree" is a single page listing that shows the syntax of each command.

An Introduction to the SCPI Language

SCPI is an acronym for **S**tandard **C**ommands for **P**rogrammable **I**nstruments. Commonly called 'skippy', it is an ASCII-based instrument command language defined by the IEEE-488.2 specification and is commonly used by test and measurement instruments.

SCPI commands are based on a hierarchical structure, also known as a tree system. In this system, associated commands are grouped together under a common node or root, thus forming subsystems. A portion the command tree for a Cryo-con instrument is shown here:

- INPut
  - TEMPerature
  - UNITs
  - VARIance
  - SLOPe
  - ALARm
  - NAMe
- SYSTem
  - BEEP
  - ADRS
  - LOCKout
- LOOP
  - SETPT
  - RANGe
  - RATe
- CONFig
  - SAVE
  - RESTore

In the above, INPut and LOOP are root keywords whereas UNITs and RATe are second-level keywords. A *colon* (:) separates a command keyword from lower-level keyword.

Command Format

The format used to show commands is shown here:

```
INPut {A |B |C |D}:ALARm:HIGH <value>;
    NAMe "name";
```

The command language is case-insensitive, but commands are shown here as a mixture of upper and lower case letters. The upper-case letters indicate the abbreviated spelling for the command. For shorter program lines, send the abbreviated form. For better program readability, send the long form.

For example, in the above statement, INP and INPUT are all acceptable.

Braces ({ }) enclose the parameter choices for a given command string. The braces are not sent as part of the command string.

A *vertical bar* (|) separates multiple parameter choices for a given command string.

Triangle brackets (< >) indicate that you must specify a numeric value for the enclosed parameter.

Double-quote (") marks must enclose string parameters.

Commands are terminated using a semicolon (;) character. The semicolon at the end of the line is assumed and is optional.

The {}, |, <> and " characters are for the illustration of the command syntax and not part of the command syntax.

Command Separators

A *colon* (:) is used to separate a command keyword from a lower-level keyword. You must insert a *blank space* to separate a parameter from a command keyword.

Compound Commands

A semicolon (;) is used as a terminator character that separates commands within the same subsystem. For example, sending the following command string:

```
INPut A:UNITs K;TEMPer?;
```

has the same effect as sending the following two commands:

```
INPut A:UNITs K;
INPut A:TEMPer?;
```

If multiple commands address different subsystems, the combination of a semicolon (;) and a colon (:) are used. The semi-colon terminates the previous command and the colon indicates that the next command is in a different subsystem. For example:

```
INPut A:TEMPer?;:LOOP 1:SETPt 123.45;
```

has the effect of sending the following two commands:

```
INPut A:TEMPer?;
LOOP 1:SETPt 123.45;
```

Queries
You can query the current value of most parameters by adding a question mark (?) to the command. For example, the following command set the setpoint on control loop 1 to 123.45:

```
LOOP 1:SETPt 123.45;
```

You can change it into a query that reads the setpoint by using the following:

```
LOOP 1:SETPt?;
```

The instrument's response will be a numeric string such as: 123.45.

Compound queries are commonly used to save programming steps. For example, the query:

```
LOOP 1:SETPt?;PGAin?;IGAin?;DGAin?;
```

reports the loop 1 setpoint, P-gain, I-gain and D-gain. An example response is:

```
123.45;20.0;60;12.5;
```

Note that the response is also separated by semicolons.

The representation of the decimal symbol for floating point numbers must be a period, '.', instead of comma, ',' as is customary used in some European countries.

Command Terminators
The termination of a command line is determined by the type of interface being used.

SCPI Common Commands
The IEEE-488.2 SCPI standard defines a set of common commands that perform basic functions like reset, self-test and status reporting. Note that they are called common commands because they must be common to all SCPI compliant instruments, not because they are commonly used.

Common commands always begin with an asterisk (*), are four to five characters in length and may include one or more parameters. Examples are:

```
*IDN?
*CLS
*OPC?
```

SCPI Parameter Types
The SCPI language defines several different data formats to be used in program messages and response messages.

Numeric Parameters: Commands that require numeric parameters will accept all commonly used decimal representations of numbers including optional signs, decimal points and scientific notation.

Enumeration Parameters: These are used to set values that have a limited number of choices. Query responses will always return an enumeration parameter in upper-case letters. Some examples of commands with enumeration parameters are:

```
INPut {A | B | C | D}:UNITs {K | C | F | S}
LOOP {1 | 2}:TYPe  {OFF | MAN | PID | TABLE | RAMPP}
```

String Parameters: String parameters can be up to 15 characters in length and can contain any ASCII characters excluding the double-quote ("). String parameters must be enclosed in double-quotes ("). For example:

```
CONFig 4:NAMe "Cold Plate"
```

Commonly Used Commands.

A complete summary of remote commands is given in the User's Manual chapter titled "Remote Command Summary". The manual also has complete descriptions of all remote commands. This section is intended to show a few of the more commonly used commands.

Function	Command	Comment
Instrument Identification		
Read the instrument identification string	***idn?**	Returns the instrument identification string in IEEE-488.2 format. For example:"Cryo-con,Model 18,204683,2.41" identifies the manufacturer followed by the model name, serial number and firmware revision code.
Input Channel Commands Parameter for the input is A, B, C or D corresponding to inputs A, B, C or D.		
Read the temperature on input channel B	**input? b**	Temperature is returned in the current display units. Format is a numeric string. For example: 123.4567
Set the temperature units on input channel A to Kelvin.	**input a:units k**	Choices are K- Kelvin, C- Celsius, F- Fahrenheit and S- native sensor units (Volts or Ohms).
Read the temperature units on channel B	**input b:units?**	Return is: K, C, F or S.

Table 15: Commonly Used Remote Commands

SCPI Status Registers

The Instrument Status Register

The Instrument Status Register (ISR) is queried using the SYSTEM:ISR? command.

The ISR is commonly used to generate a service request when various status conditions occur. In this case, the ISR is masked with the Instrument Status Enable (ISE) register.

The ISR is defined as follows:

ISR

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
Alarm						SFB	SFA

Where:

Bit7 – Alarm: Indicates that an alarm condition is asserted. Use the ALARM commands to query individual alarms.

Bit1 to Bit0 – SFx: Indicates that a sensor fault condition is asserted on an input channel. Use the INPUT commands to query the input channels.

The Instrument Status Enable Register

The Instrument Status Enable (ISE) Register is a mask register. It is logically “anded” with the contents of the ISR in order to set the Instrument Event (IE) bit in the Status Byte (STB) register. This can cause a service request to occur.

Bits in the ISE correspond to the bits in the ISR defined above.

The Standard Event Register

The Standard Event Register (ESR) is defined by the SCPI to identify various standard events and error conditions. It is queried using the Common Command *ESR? This register is often used to generate an interrupt packet, or service request when various I/O errors occur.

Bits in the ESR are defined as follows:

ESR

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
OPC		QE	DE	EE	CE		PWR

Where:

Bit7 – OPC: Indicates Operation Complete.

Bit5 – QE: Indicates a Query Error. This bit is set when a syntax error has occurred on a remote query. It is often used for debugging.

Bit4 – DE: Indicates a Device Error.

Bit3 – EE: Indicates an Execution Error. This bit is set when a valid command was received, but could not be executed. An example is attempting to edit a factory supplied calibration table.

Bit2 – CE: Indicates a Command Error. This bit is set when a syntax error was detected in a remote command.

Bit0 – PWR: Indicates power is on.

The Standard Event Enable Register
The Standard Event Enable Register (ESE) is defined by the SCPI as a mask register for the ESR defined above. It is set and queried using the Common Command *ESE.

Bits in this register map to the bits of the ESR. The logical AND of the ESR and ESE registers sets the Standard Event register in the Status Byte (STB).

The Status Byte
The Status Byte (STB) is defined by the SCPI and is used to collect individual status bits from the ESE and the ISR as well as to identify that the instrument has a message for the host in it's output queue. It is queried using the Common Command *STB?. Bits are defined as follows:

STB

Bit7	Bit6	Bit5	Bit4	Bit3	Bit2	Bit1	Bit0
	RQS	SE	MAV	IE			

Where:

Bit6 – RQS: Request for Service.

Bit5 – SE: Standard Event. This bit is set as the logical 'AND' of the ESR and ESE registers.

Bit4 – MAV: Message Available

Bit3 – IE: Instrument Event. This bit is set as the logical 'AND' of the ISR and ISE registers.

The Status Byte Register
The Status Enable Register (SRE) is defined by the mask register for the STB. It is set and queried using the Common Commands *SRE.

Debugging Tips

1. You can view the last command that the instrument received and the last response it generated by pressing the SYS key and scrolling down to the bottom of the menu. The last two lines show > and < characters in the first character location indicating input and output strings.
2. Some commands require the instrument to write to non-volatile flash type memory, which can be time consuming. In order to avoid overrunning the instrument, you may want to use compound commands that return a value, thus indicating that command processing is complete. For example:
   INPUT A:UNITS K;UNITS?
   will respond with the input units only after the command has completed. Another example:
   LOOP 1:SETPOINT 1234.5;:*OPC?
   Here, the operation complete command :*OPC? will return a '1' when command processing is complete.
3. It is often easiest to test commands by using the Cryo-con utility software. Run the program, connect to the instrument and use the Interact mode to send commands and view the response.
4. For ease of software development, keywords in all SCPI commands may be shortened. The short form of a keyword is the first four characters of the word, except if the last character is a vowel. If so, the truncated form is the first three characters of the word. Some examples are: inp for input, syst for system alar for alarm etc.

Remote Command Tree

SYSTEM commands
SYSTem:DISTc {0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64} SYSTem:RESeed SYSTem:HWRev? SYSTem:FWREV? SYSTem:DRES {FULL | 1 | 2 | 3} SYSTem:SSENa {YES | NO} SYSTem:SSTimer {5 | 10 | 15 | 20 | 25 | 30}

Input Commands
INPut? {A | ... | H} or INPut {A | ... | H}:TEMPerature? INPut {A | ... | H}:UNITs {K | C | F | S} INPut {A | ... | H}:NAMe “Instrument Name” INPut {A | ... | H}:SENPr? INPut {A | ... | H}:ISENix <ix> INPut {A | ... | H}:USENix <ix> INPut {A | ... | H}:ALARm? INPut { A | ... | H }:ALARm:HIGHest <setpt> INPut { A | ... | H }:ALARm:LOWEst <setpt> INPut { A | ... | H }:ALARm:HIENa { YES | NO } INPut { A | ... | H }:ALARm:LOENa { YES | NO }

Sensor Calibration Curve Commands
CALcur

Data Logging Commands
DLOG:RUN {OFF | ON} DLOG:TIMe <Seconds> DLOG:COUNt? DLOG:READ? DLOG:RESET DLOG:CLEAR

Network Commands
NETWork:IPADdress NETWork:MACaddress

Mail Commands
MAIL {A | ... | H} :ADDR “IPA” MAIL {A | ... | H}:FROM ”from e-mail address” MAIL {A | ... | H}:DEST “to e-mail address” MAIL {A | ... | H}:PORT <port number> MAIL {A | ... | H}:STATE {ON | OFF}

IEEE Common Commands
*CLS *ESE *ESR *OPC *IDN? *RST *SRE *STB

Remote Command Descriptions

IEEE Common Commands

*CLS

The *CLS common command clears the status data structures, including the device error queue and the MAV (Message Available) bit.

*ESE

The *ESE command sets the Standard Event Status Enable (ESE) Register bits. The ESE Register contains a bit mask for the bits to be enabled in the Standard Event Status (SEV) Register. A one in the ESE register will enable the corresponding bit in the SEV register. A zero will disable the bit.

The *ESE? Query returns the current contents of the ESE register.

*ESR

The *ESR query returns the contents of the Standard Event (SEV) status register.

*OPC

The *OPC command will cause the instrument to set the operation complete bit in the Standard Event (SEV) status register when all pending device operations have finished.

The *OPC Query places an ASCII ‘1’ in the output queue when all pending device operations have completed.

*IDN?

The *IDN? Query will cause the instrument to identify itself. The Model 18 will return the following string:

Cryocon, Model 18,<serial number>,<firmware revision>

Where: <serial number> is the unit's serial number and <firmware revision> is the revision level of the unit's firmware

*RST

Reset the instrument. This will cause a hardware reset in the Model 18. The reset sequence will take about 15 seconds to complete. During that time, the instrument will not be accessible over any remote interface.

The *RST command sets the Model 18 to it’s last power-up default setting.

*SRE

The *SRE command sets the Status Byte Enable (SRE) Register bits. The SRE Register contains a bit mask for the bits to be enabled in the Status Byte (STB) Register. A one in the SRE register will enable the corresponding bit in the STB register. A zero will disable the bit.

The *SRE? Query returns the current contents of the SRE register.

*STB?

The *STB query returns the contents of the Status Byte Register.

System Commands.

System commands are a group of commands associated with the overall status and configuration of the instrument rather than a specific internal subsystem.

`SYSTem:DISTc {0.5 | 1 | 2 | 4 | 8 | 16 | 32 | 64}`

Set or query the display filter time constant. The display filter is time-constant filter that is applied to all reported or displayed temperature data. Available time constants are 0.5, 1, 2, 4, 8, 16, 32 or 64 Seconds.

`SYSTem:RESeed`

Re-seeds the input channel's averaging filter, allowing the reading to settle significantly faster. The display filter may have filter time-constants that are very long. The RESEED command inserts the current instantaneous temperature value into the filter history, thereby allowing it to settle rapidly.

> ⓘ **Note:** The RESEED command is useful in systems where a computer is waiting for a reading to settle. Issuing the RESEED command will reduce the required settling time of the reading.

`SYSTem:HWRev?`

Queries the instrument's hardware revision level.

`SYSTem:FWREV?`

Queries the instrument's firmware revision level.

`SYSTem:DRES {FULL | 1 | 2 | 3}`

Sets or queries the instrument's display resolution. Choices are:

- FULL: The VFD will display temperature with the maximum possible resolution.
- 1, 2 or 3: The VFD display will display the specified number of digits to the right of the decimal point.

NOTE: This command only sets the number of digits displayed on the front panel display. It does NOT affect the internal accuracy of the instrument or the format of measurements reported on the remote interfaces.

The main use for this command is to eliminate the flicker in low order digits when the instrument is used in a noisy environment.

`SYSTem:SSENa {YES | NO}`

Sets or queries the screen saver enable.

When enabled, the screen saver mode will be entered after the selected timeout. The screen will go blank but all other processing will continue.

Screen saver is canceled by pressing any key on the front panel.

`SYSTem:SSTimer {5 | 10 | 15 | 20 | 25 | 30}`

Sets the screen saver timeout to 5, 10, 15, 20, 25 or 30 minutes.

Input Commands

The INPUT group of commands are associated with the configuration and status of the four input channels.

Parameter references to the input channels may be:

- Numeric ranging in value from zero to seven.
- Channel ID tags including CHA or CHB.
- Alphabetic including A or B.

INPut? {A|…|H} or
INPut {A|…|H}:TEMPerature?

The INPUT query reports the current temperature reading on any of the input channels. Temperature is filtered by the display time constant filter and reported in display units. Query only.

INPut {A|…|H}:UNITs {K | C | F | S}

Sets or queries the display units of temperature used by the specified input channel. Units may be K for Kelvin, C for Celsius, F for Fahrenheit or S for primitive sensor units. In the case of sensor units, the instrument will determine if the actual units are Volts or Ohms based on the actual sensor type.

INPut {A|…| H}:SENPr?

The INPUT:SENPR query reports the reading on a selected input channel. For diode sensors, the reading is in Volts while resistor sensors are reported in Ohms. The reading is not filtered by the display time-constant filter. However, the synchronous input filter has been applied. Query only.

INPut {A|…|H}:ISENix <ix>

Sets or queries the sensor index number assigned to an input channel for FACTORY installed sensors. For user installed sensors, use to the USENIX command below.

A sensor index, <ix>, is taken from a table. A sensor index of zero indicates that there is no sensor connected. Refer to Appendix A in the User's Manual for the sensor index table and a complete description of sensors and indexing.

> ⓘ **Note:** The use of the ISENIX command to assign a factory-installed sensor and the USENIX command to assign a user sensor are preferred to the use of the obsolete SENIX command.

The SENTYPE command may be used to query the name of a factory-installed sensor at a specific index.

INPut {A|…|H}:USENix <ix>

Sets or queries the sensor index number assigned to an input channel for USER installed sensors. For factory installed senssors, use the ISENIX command described above. An index number of 0 through 7 indicates user sensor curves 1 through 8.

> ⓘ **Note:** The use of the ISENIX command to assign a factory installed sensor and the USENIX command to assign a user sensor are preferred to the use of the obsolete SENIX command.

INPut {A|…|H}:ALARm?

Queries the alarm status of the specified input channel. Status is a two character string where:

--	indicates that no alarms are asserted
SF	indicates a Sensor Fault condition.
HI	indicates a high temperature alarm
LO	indicates a low temperature alarm.

There is a 0.25K hysteresis in the assertion of a high or low temperature alarm condition.

The user selectable display time constant filter is applied to input channel temperature data before alarm conditions are tested.

INPut {A|…|H}:ALARm:HIGHest <setpt>

Sets or queries the temperature setting of the high temperature alarm for the specified input channel. When this temperature is exceeded, an enabled high temperature alarm condition will be asserted.

Temperature is assumed to be in the display units of the selected input channel. There is a 0.25K hysteresis in the assertion of a high or low temperature alarm condition.

<setpt> is the alarm setpoint temperature.

INPut {A|…|H}:ALARm:LOWEst <setpt>

Sets or queries the temperature setting of the low temperature alarm for the specified input channel. When the input channel temperature is below this, an enabled low temperature alarm condition will be asserted.

Temperature is assumed to be in the display units of the selected input channel. There is a 0.25K hysteresis in the assertion of a high or low temperature alarm condition.

<setpt> is the alarm setpoint temperature.

INPut {A|…|H}:ALARm:HIENa {YES | NO}

Sets or queries the high temperature alarm enable for the specified input channel. An alarm must be enabled before it can be asserted.

INPut {A|…|H}:ALARm:LOENa {YES | NO }

Sets or queries the low temperature alarm enable for the specified input channel. An alarm must be enabled before it can be asserted.

Sensor Calibration Curve Commands

The CALCUR commands are used to transfer sensor calibration curves between the instrument and the host controller.

Curves are referenced by an index number. In the Model 18, there are eight user curves numbered 1 through 8.

The CALCUR data block consists of many lines of ASCII text. The format is the same as the file format for user calibration curves, which is detailed in the section User Calibration Curve File Format.

CALCUR <index>

Sets or queries sensor calibration curve data.

Uses a fragmented message protocol to sens many lines of ASCII text to the instrument.

Note: It is much easier to use Cryo-con's Utility Software to send and receive sensor calibration curves.

Network Commands

The following commands are used to configure the Model 18's Ethernet interface.

NETWork:IPADdress "IPA"

Sets or queries the instrument's IP address. The address is expressed as an ASCII string, so the input parameter must be enclosed in quotes. For example, the default IP address parameter is "192.168.0.4".

NETWork:MACADdress?

Queries the instrument's MAC address. The address is returned as an ASCII string. Cryo-con MAC addresses range from 00:50:C2:6F:40:00 to 00:50:C2:6F:4f:ff. They cannot be changed by the user.

Mail Commands

The Model 18 can send e-mail over the Ethernet port when an alarm condition is asserted on an enabled input channel. The following remote commands are used to configure e-mail. However, it is much easier to configure e-mail using the instrument's embedded web server.

MAIL {A | ... | H}:ADDR "IPA"

Set or query the e-mail server IP address. Parameter format is an ASCII string and must be enclosed in quotation marks. For example: "192.168.0.1".

MAIL {A | ... | H}:FROM "from e-mail address"

Set or query the 'from' e-mail address. Parameter is an ASCII String. For example: "model18@mynetwork.com".

MAIL {A | ... | H}:DEST "to e-mail address"

Set or query the 'from' e-mail address. Parameter is an ASCII String. For example: "model18@mynetwork.com".

MAIL {A | ... | H}:PORT <port number>

Set or query the e-mail port. Parameter is integer and default is 25.

MAIL {A | ... | H}:STATE {ON | OFF}

Set or query the input channel e-mail send enables. If a channel is enabled, e-mail will be sent when an alarm condition is asserted on the selected input channel.

Code snippet in C++

The following code opens a Cryo-con instrument at address 192.168.0.4 on the Local Area Network. It is written in Microsoft Visual C++ and uses the eZNET LAN library provided on the Cryo-con utility CD.

```
// -----  Example Ethernet LAN program using C++  -----
// TCPIP declarations
#include “TCPIPdrv.h”

   TCPIPdrv LAN; //Define global LAN object
   char IPA[ ] = “192.168.0.4”; //Instrument’s IP address on the LAN
   char tempstr[257]; //temporary character string

   //Open the instrument.
   If(!LAN.open(IPA)){
      //can’t connect...
      LAN.close();
      throw (“Can’t talk to instrument”);
   };
   //read the IDN string
   LAN.IO(”*IDN?”,tempstr,256);
   printf(”IDN is %s\n”,tempstr); //Print IDN

   //read the MAC address
   LAN.IO(”net:mac?”,tempstr,256);
   printf(”MAC is: %s\n”,tempstr);

   //Start temperature control
   LAN.IO(“control”);

   //Stop temperature control
   LAN.IO(“stop”);

   //Read channel B input
   LAN.IO(”input? B”,tempstr,256);
   printf(”Channel B temperature is: %s\n”,tempstr);

   //send compound command to input channel A and wait for it to finish.
   LAN.IO(”INPUT A:UNIT S;ISENIX 33;:*OPC?”,tempstr,256);

   //close the instrument
   LAN.close();
```

EU Declaration of Conformity

According to ISO/IEC Guide 22 and EN 45014

Product Category:	Process Control Equipment
Product Type:	Temperature Measuring and Control System
Model Numbers:	Model 18
Manufacturer's Name:	Cryogenic Control Systems, Inc.
Manufacturer's Address:	
	P. O. Box 7012 Rancho Santa Fe, CA 92067 Tel: (858) 756- 3900, Fax: 858. 759. 3515

The before mentioned products comply with the following EU directives:

89/336/EEC, "Council Directive of 3 May 1989 on the approximation of the laws of the Member States relating to electromagnetic compatibility"

73/23/EEC, "Council Directive of 19 February 1973 on the harmonization of the laws of Member States relating to electrical equipment designed for use within certain voltage limits".

The compliance of the above mentioned product with the Directives and with the following essential requirements is hereby confirmed:

Emissions	Immunity	Safety
EN 55011,1998	EN 50082-1, 1997	EN 61010, 1994 A2: May 96

The technical files and other documentation are on file with Mr. Guy Covert, President and CEO.

As the manufacturer we declare under our sole responsibility that the above mentioned products comply with the above named directives.

Guy D. Covert
President, Cryogenic Control Systems, Inc.
October 15, 2005

Appendix A: Installed Sensor Curves

Factory Installed Curves

The following is a list of factory-installed sensors and the corresponding sensor index (ISENIX).

ISENIX	Name	Description
0	None	No Sensor. Used to turn the selected input channel off.
1	Cryocon S700	Cryo-con S700 series Silicon Diode. Range: 1.4 to 500K. 10μA constant current excitation.
2	LS DT-670	Lakeshore DT-670 series Silicon Diode, Curve 11. Range: 1.4 to 500K. 10μA constant current excitation.
3	LS DT-470	Lakeshore DT-470 series Silicon Diode, Curve 10. Range: 1.4 to 500K. 10μA constant current excitation.
4	CD-12A	Cryo Industries CD-12A Silicon Diode. Range: 1.4 to 500K. 10μA constant current excitation.
5	SI 410 Diode	Scientific Instruments, Inc. 410 Diode Curve. Range: 1.5 to 450K. 10μA excitation.
6	Cryocon S800	Cryo-con S800 series Silicon Diode. Range: 1.4 to 500K. 10μA constant current excitation.
7	Cryocon S900	Cryo-con S900 series Silicon Diode. Range: 1.4 to 500K. 10μA constant current excitation.
8	CTI Si Diode	CTI Silicon Diode. Range: 10 to 300K. 10μA constant current excitation.
20	Pt100 385	DIN43760 standard 100Ω Platinum RTD. Range: 23 to 873K, 1mA excitation.
21	Pt1K 385	1000Ω at 0°C Platinum RTD using DIN43760 standard calibration curve. Range: 23 to 1023K, 100μA excitation.
22	Pt10K 385	10KΩ at 0°C Platinum RTD. Temperature coefficient 0.00385, Range: 23 to 873K, 10μA excitation.
23	RhFe 27, 1mA	Rhodium-Iron. 27Ω at 0°C. 1mA DC excitation. 1.5 to 873K
32	RO-105 DC 10uA	SI RO-105 Ruthenium-Oxide sensor with DC excitation. This is the recommended configuration for this high resistance sensor. 2 to 273K
34	Cryocon R400	Cryocon R400 Ruthenium-Oxide sensor with DC excitation. This is the recommended configuration for this high resistance sensor. 2 to 273K

The isenix remote command is used to set factory installed sensors. For example, the command:

INPUT B ISENIX 34 would set input B to use the R400 sensor.

INPUT A:ISENIX 1 would set input A to use the S700 Diode.

INPUT A:ISENIX 0 would turn input A off by setting the sensor to 'none'.

User Installed Sensor Curves

The user may install up to eight custom sensors. This table shows the sensor index and default name of the user curves:

usenix index	User Number	Default Name
0	1	User Sensor 1
1	2	User Sensor 2
2	3	User Sensor 3
3	4	User Sensor 4
4	5	User Sensor 5
5	6	User Sensor 6
6	7	User Sensor 7
7	8	User Sensor 8

When using the CALCUR commands, only user curves are addressed, therefore, the user index (usenix) shown above is used.

The USENIX, remote commands address user installed curves. For example:

CALCUR 2 would address user curve #2.

INPUT A:USENIX 1 would set input A to use User Sensor 2.

Sensor Curves on CD

The following sensors are available on the CD supplied:

File	Description
Cryocon S700	Cryo-con S700 series Silicon Diode. Range: 1.4 to 500K. 10µA constant current excitation.
CryocalD3.crv	Cryocal D3 Silicon Diode. Range: 1.5 to 300K
SI410.crv	Scientific Instruments, Inc. SI-410 Silicon Diode. Range: 1.5 to 450K
Curve10.crv	Lakeshore Curve 10 Silicon Diode curve for DT-470 series diodes. Range: 1.4 to 495K.
Curve11.crv	Lakeshore Curve 10 Silicon Diode curve for DT-670 series diodes. Range: 1.4 to 500K.
PT100385.crv	Cryocon CP-100, DIN43760 or IEC751 standard Platinum RTD, 100Ω at 0°C. Range: 23 to 1020K
PT1K385.crv	DIN43760 or IEC751 standard Platinum RTD, 1000Ω at 0°C. Range: 23 to 1020K
PT1003902.crv	Platinum RTD, 100Ω at 0°C Temperature coefficient 0.003902 Ω/C. Range: 73K to 833K.
PT1K375.crv	Platinum RTD, 1000Ω at 0°C Temperature coefficient 0.00375 Ω/C. Range: 73K to 833K.
aufe07cr.crv	Chromel-AuFe 7% Thermocouple. Range: 3 to 610K
TCTypeE.crv	Thermocouple, Type E. Range: 3.2 to 1273K
TCTypeK.crv	Thermocouple, Type K. Range: 3.2 to 1643K
TCTypeT.crv	Thermocouple, Type T. Range: 3.2 to 673K
CX1030E1.crv	CX1030 example curve. Range: 4 to 325K

User Calibration Curve File Format

Sensor calibration curves may be sent to any Cryo-con instrument by using a properly formatted text file. This file has the extension .crv. It consists of a header block, lines of curve data and is terminated by a single semicolon (;) character.

The header consists of four lines as follows:

Sensor Name: Sensor name string
Sensor Type Enumeration : {DIODE | PTC100 | PTC1K | R250K10UA | R31K10UA}
Multiplier: Signed numeric
Units: Units of calibration curve: {OHMS | VOLTS | LOGOHM}

The Sensor Name string can be up to 15 characters and is used to identify the individual sensor curve. When downloaded to a Cryo-con instrument, this name will appear in the sensor selection menu of the embedded web server and will appear on all sensor selection fields on the front panel.

The Sensor Type Enumeration identifies the required input configuration of the input channel. For the Model 18, selections are: DIODE, PTC100, PTC1K, R31K10UA and R250K10UA. These configurations are described in the section titled Input Configurations.

The Multiplier field is a signed, decimal number that identifies the sensor's temperature coefficient and curve multiplier. Generally, for Negative-Temperature-Coefficient (NTC) sensors, the value of the multiplier is -1.0 and for a Positive-Temperature-Coefficient (PTC) sensor, the value is 1.0.

As an advanced function, the multiplier field can be used as a multiplier for the entire calibration curve. For example, a 10KΩ Platinum RTD can use a calibration curve for a 100Ω Platinum RTD by using a multiplier of 100.0.

The fourth line of the header is the sensor units field. This may be Volts, Ohms or Logohm. Generally, Diode type sensor curves will be in units of Volts and most resistance sensors will be in units of Ohms. However, many resistance sensors used at low temperature have highly nonlinear curves. In this case, the use of Logohm units will give a more linear curve and will provide better interpolation accuracy. Logohm is the base-10 logarithm of Ohms.

Examples of sensor calibration curves that are in units of Ohms include Platinum RTDs and Rhodium-Iron RTDs. Examples of sensors that best use Logohm include Cernox™, Ruthenium-Oxide and Carbon-Ceramic.

After the header block, there are from two to 200 lines of sensor calibration data points. Each point of a curve contains a sensor reading and the corresponding temperature. Sensor readings are in units specified by the units line in the curve header. Temperature is always in Kelvin.

The format of an entry is:

<sensor reading> <Temperature>

Where <sensor reading> is a floating-point sensor reading and <Temperature> is a floating-point temperature in Kelvin. Numbers are separated by one or more white spaces.

Floating point numbers may be entered with many significant digits. They will be converted to 32 bit floating point which supports about six significant digits.

The last entry of a table is indicated by a semicolon (;) character with no characters on the line.

> ⓘ **NOTE:** All curves must have a minimum of two entries and a maximum of 200 entries.

Entries may be sent to the instrument in any order. The instrument will sort the curve in ascending order of sensor reading before it is copied to Flash RAM. Entries containing invalid numeric fields will be deleted before they are stored.

The following is an example of a calibration curve transmitted to the instrument via the LAN interface:

```
Good Diode
Diode
–1.0
volts
0.34295   300.1205
0.32042   273.1512
0.35832   315.0000
1.20000   3.150231
1.05150   8.162345
0.53234   460.1436
;
```

In summary:

1. The first line is a name string that can be up to 15 characters. Longer strings are truncated by the instrument.

   The second line identifies the instrument's input configuration and must be one of the allowed selections described in the Input Configurations section.
2. The third line is the multiplier field and is 1.0 for PTC sensors and -1.0 for NTC sensors.
3. The fourth line of the header is the sensor units and must be Volts, Ohms or Logohm.
4. Curve entries must be the sensor reading followed by the temperature in units of Kelvin. Values are separated by one or more white spaces. Tab characters are not allowed.
5. The last line in the file has a single semicolon (;) character. All lines after this are rejected.
6. Files are stored with the extension .crv so that they can be used with the Cryo-con Utility Software.

Appendix B: Troubleshooting Guide

Error Displays

Display	Condition
A-------K Or an erratic display of temperature.	Input channel voltage measurement is out of range. Ensure that the sensor is connected and properly wired. Ensure that the polarity of the sensor connections is correct. Refer to the Sensor Connections section. Many sensors can be checked with a standard Ohmmeter. For resistor sensors, ensure that the resistance is correct by measuring across both the Sense and Excitation contacts. For a diode sensor, measure the forward and reverse resistance to ensure a diode-type function.
A.......K	Input channel is within range, but measurement is outside the limits of the selected sensor's calibration curve. Check sensor connections as described above. Ensure that the proper sensor has been selected. Refer to the Input Channel Setup Menus section. Change the sensor units to Volts or Ohms and ensure that the resulting measurement is within the selected calibration curve.

Temperature Measurement Errors

Symptom	Condition
Noise on temperature measurements.	Possible causes: Excessive noise pickup, especially AC power line noise. Check your wiring and shielding. Sensors must be floating, so check that there is no continuity between the sensor connection and ground. Check for shielding problems by temporarily removing the input connector's back-shell. If the noise changes significantly, current is being carried by the shields and is being coupled into the monitor. Use a longer display filter time constant to reduce displayed noise.

Symptom	Condition
DC offset in temperature measurements.	Possible causes: The wrong sensor type or sensor calibration curve is being used. Refer to the Input Channel Setup Menu section. A four-wire measurement is not being used. Some cryostats use a to a two-wire measurement internally. This can cause offset errors due to lead resistance.
No temperature	Review the Error Displays section above.

reading.	

Remote I/O problems

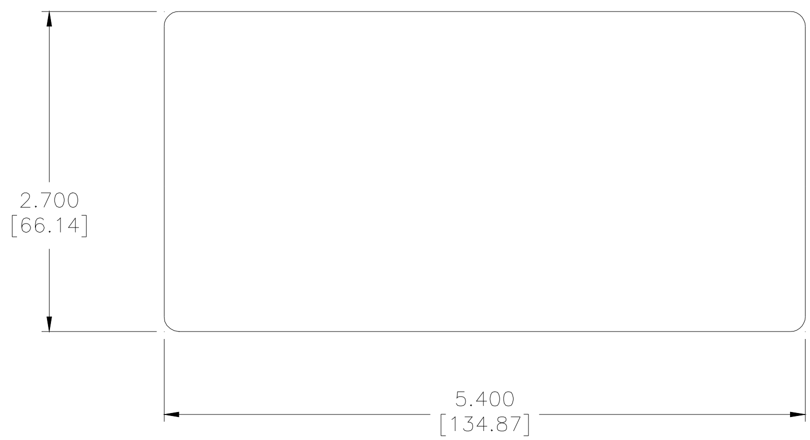
Symptom	Condition
Can’t talk to the LAN interface.	Possible causes: A Category 5 crossover patch cable is being used where a Category 5 patch cable should be used, or visa-versa. The TCP settings between the monitor and the PC are incompatible. Review the network configuration section. PC Client software not configured to use TCP Data Socket 5000. Debugging tip: Cryo-con utility software can be used to talk to the monitor over the LAN Data Socket port using the terminal mode. All command and response strings are displayed. Since the software provides the proper interface setup, it is a good way to establish initial connection.

Appendix C: Enclosure Options

Panel Mounting

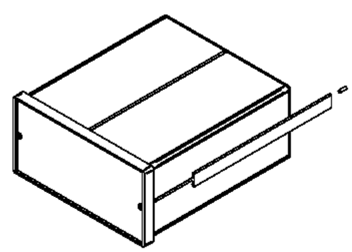
Panel Cutout

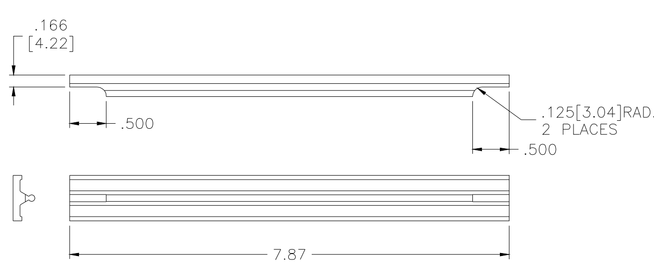
Shown here is a cut-out drawing for panel mounting of the Model 18.



Panel Mount Kit

The Model 18 mounts to panel by sliding the enclosure through a panel cut-out hole and then installing the panel mount kit, Cryo-con part number 4012-020. Drawings and assembly of the panel mount kit are shown here.





Instrument Stand

The Instrument Stand accessory, Cryo-con part number 4012-021, is used to mount the Model 18 on a bench top. It tilts the instrument up by 15° for an improved viewing angle.

Appendix E: Sensor Data Tables

Silicon Diode

Silicon diode sensors offer good sensitivity over a wide temperature range and are reasonably interchangeable.

Use in magnetic fields is not recommended.

Silicon diode sensors use a constant-current DC excitation of 10µA.

Cryo-con S900 Silicon Diode
Name: cryocon S900 Configuration: Diode

T(K)	Volts	mV/K
1.4	1.63864	-36.56
4.2	1.53960	-33.91
10	1.36317	-26.04
20	1.17370	-11.34
30	1.10343	-3.12
50	1.07399	-1.46
77.35	1.02511	-1.69
100	0.98740	-1.85
150	0.89011	-2.03
200	0.78272	-2.17
250	0.67085	-2.28
300	0.55665	-2.36
355	0.42759	-2.33
400	0.32161	-2.38
450	0.20231	-2.37
500	0.09077	-2.12

Cryo-con S800 Silicon Diode
Name: cryocon S800 Configuration: Diode

T(K)	Volts	mV/K
1.4	1.87515	-36.86
4.2	1.75099	-49.16
10	1.47130	-43.45
20	1.18867	-15.93
30	1.10594	-3.90
50	1.07079	-1.47
77.35	1.02356	-1.86
100	0.98170	-1.85
150	0.88365	-2.03
200	0.77887	-2.13
250	0.67067	-2.20
300	0.55955	-2.22
355	0.44124	-2.10
385	0.37611	-2.26

Scientific Instruments SI-430 and SI-440
Name: SI 430 Diode Configuration: Diode
Name: SI 440 Diode Configuration: Diode

T(K)	Volts	mV/K
1.4	1.63864	-36.56
4.2	1.53960	-33.91
10	1.36317	-26.04
20	1.17370	-11.34
30	1.10343	-3.12
50	1.07399	-1.46
77.35	1.02511	-1.69
100	0.98740	-1.85
150	0.89011	-2.03
200	0.78272	-2.17
250	0.67085	-2.28
300	0.55665	-2.36
355	0.42759	-2.33
400	0.32161	-2.38
450	0.20231	-2.37
500	0.09077	-2.12

Scientific Instruments SI-410
Name: SI 410 Diode Configuration: Diode

T(K)	Volts	mV/K
1.4	1.71488	-10.54
4.2	1.64660	-32.13
10	1.39562	-35.28
20	1.17592	-20.43
30	1.10136	-1.75
50	1.06957	-1.59
77.35	1.14905	-1.72
100	0.98322	-1.82
150	0.88603	-2.00
200	0.78059	-2.14
250	0.67023	-2.23
300	0.55672	-2.28
350	0.44105	-2.32
400	0.32319	-2.36
450	0.20429	-2.38

Lakeshore DT-670 Silicon Diode Name: LS DT-670 Configuration: Diode		
T(K)	**Volts**	**mV/K**
1.4	1.64429	-12.49
4.2	1.57848	-31.59
10	1.38373	-26.84
20	1.19775	-15.63
30	1.10624	-1.96
50	1.07310	-1.61
77.35	1.02759	-1.73
100	0.98697	-1.85
150	0.88911	-2.05
200	0.78372	-2.16
250	0.67346	-2.24
300	0.55964	-2.30
350	0.44337	-2.34
400	0.32584	-2.36
450	0.20676	-2.39
500	0.09068	-2.12

Lakeshore DT-470 Silicon Diode Name: LS DT-470 Configuration: Diode		
T(K)	**Volts**	**mV/K**
1.4	1.6981	-13.1
4.2	1.6260	-33.6
10	1.4201	-28.7
20	1.2144	-17.6
30	1.1070	-2.34
50	1.0705	-1.75
77.35	1.0203	-1.92
100	0.9755	-2.04
150	0.8687	-2.19
200	0.7555	-2.31
250	0.6384	-2.37
300	0.5189	-2.4
350	0.3978	-2.44
400	0.2746	-2.49
450	0.1499	-2.46
475	0.0906	-2.22

GaAlAs Diode

GaAiAs diode sensors offer good sensitivity over a wide range of temperatures. However, they do not follow a standard calibration curve.

Useful in magnetic fields below 5T and a temperature above 30K. Outside of this range, a Ruthenium-Oxide sensor offers better performance.

GaAiAs diode sensors use a constant-current DC excitation of 10µA. The Model 18 limits low temperature operation to 25K since that is outside of the limits for use in magnetic fields.

Shaded entries are outside of the Model18's temperature range.

Lakeshore TG-120 GaAlAs Diode Name: User Supplied Configuration: Diode		
T(K)	**Volts**	**mV/K**
1.4	5.3909	-97.5
4.2	4.7651	-214
10	3.7521	-148
20	2.5341	-97.5
30	1.8056	-48.2
50	1.4637	-2.82
77.35	1.4222	-1.24
100	1.3918	-1.48
150	1.2985	-2.25
200	1.1738	-2.64
250	1.0383	-2.77
300	0.8978	-2.85
350	0.7531	-2.99
400	0.6066	-2.97
450	0.4556	-3.08
475	0.3778	-3.15

Platinum RTD

Platinum RTD sensors feature high stability, low magnetic field dependence and excellent interchangeability. They conform to the DIN43760 standard curve.

The Model 18 uses 1.0mA Constant-Current AC excitation.

Platinum RTD, DIN43760 and IEC751 Name: Pt100 385 Configuration: PTC100 Name: Pt1K 385 Configuration: PTC1K Name: Pt10K 385 Configuration: PTC10K		
T(K)	**Ohms**	**Ω/K**
20	2.2913	0.085
30	3.6596	0.191
50	9.3865	0.360
77.35	20.380	0.423
100	29.989	0.423
150	50.788	0.409
200	71.011	0.400
250	90.845	0.393
300	110.354	0.387
400	148.640	0.383
500	185.668	0.378
600	221.535	0.372
700	256.243	0.366
800	289.789	0.360
900	324.302	0.318
1123	390.47	0.293

Rhodium-Iron

Rhodium-Iron sensors feature high stability, low magnetic field dependence and reasonable interchangeability.

The Model 18 supports them with 1.0mA Constant-Current AC excitation.

Rhodium-Iron 27Ω Name: RhFe 27 1mA Configuration: PTC100		
T(K)	Ohms	Ω/K
1.4	1.5204	0.178
4.2	1.9577	0.135
10	2.5634	0.081
20	3.1632	0.046
30	3.5786	0.040
50	4.5902	0.064
77.4	6.8341	0.096
100	9.1375	0.106
150	14.463	0.105
200	19.641	0.102
250	24.686	0.101
300	29.697	0.101
350	34.731	0.101
400	39.824	0.103

Cernox™

Cernox™ temperature sensors do not follow a standard calibration curve. Data shown here is for typical sensors.

The Model 18 supports Cernox™ using a 10µA Constant-Current DC excitation that allows low temperature operation to about 2.0K. Below that, sensor self-heating errors may occur.

Shaded entries are outside of the Model 18's temperature range.

Lakeshore Cernox™ CX-1010
Name: User Supplied Config: PTC1K

T(K)	Ohms	Ω/K
0.1	21389	-558110
0.2	4401.6	-38756
0.3	2322.4	-10788
0.4	1604.7	-4765.9
0.5	1248.2	-2665.2
1	662.43	-514.88
1.4	518.97	-251.77
2	413.26	-124.05
3	328.95	-58.036
4.2	277.32	-32.209
6	234.44	-17.816
10	187.11	-8.063
20	138.79	-3.057
30	115.38	-1.819
40	100.32	-1.252
50	89.551	-0.929
77.35	70.837	-0.510
100	61.180	-0.358
150	47.782	-0.202
200	39.666	-0.130
250	34.236	-0.090
300	30.392	-0.065

Lakeshore Cernox™ CX-1030
Name: User Supplied Config: PTC1K

T(K)	Ohms	Ω/K
0.3	31312	-357490
0.4	13507	-89651
0.5	7855.7	-34613
1	2355.1	-3265.2
1.4	1540.1	-1264.9
2	1058.4	-509.26
3	740.78	-199.11
4.2	574.20	-97.344
6	451.41	-48.174
10	331.67	-19.042
20	225.19	-6.258
30	179.12	-3.453
40	151.29	-2.249
50	132.34	-1.601
77.35	101.16	-0.820
100	85.940	-0.552
150	65.864	-0.295
200	54.228	-0.184
250	46.664	-0.124
300	41.420	-0.088
350	37.621	-0.065
400	34.779	-0.050
420	33.839	-0.045

Lakeshore Cernox™ CX-1050
Name: User Supplied Config: R31K10UA

T(K)	Ohms	Ω/K
1.4	26566	-48449
2	11844	-11916
3	5733.4	-3042.4
4.2	3507.2	-1120.8
6	2252.9	-432.14
10	1313.5	-128.58
20	692.81	-30.871
30	482.88	-14.373
40	373.11	-8.392
50	305.19	-5.507
77.35	205.67	-2.412
100	162.81	-1.488
150	112.05	-0.693
200	85.800	-0.397
250	69.931	-0.253
300	59.467	-0.173
350	52.142	-0.124
400	46.782	-0.093
420	45.030	-0.089

Lakeshore Cernox™ CX-1070 Name: User Supplied Config: R31K10UA		
T(K)	**Ohms**	**Ω/K**
4.2	5979.4	-2225.3
6	3577.5	-794.30
10	1927.2	-214.11
20	938.93	-46.553
30	629.90	-20.613
40	474.89	-11.663
50	381.42	-7.490
77.35	248.66	-3.150
100	193.29	-1.899
150	129.60	-0.854
200	97.626	-0.477
250	78.723	-0.299
300	66.441	-0.201
350	57.955	-0.143
400	51.815	-0.106
420	49.819	-0.094

Lakeshore Cernox™ CX-1080 Name: User Supplied Config: R31K10UA		
T(K)	**Ohms**	**Ω/K**
20	6157.5	-480.08
30	3319.7	-165.61
40	2167.6	-79.551
50	1565.3	-45.401
77.35	836.52	-15.398
100	581.14	-8.213
150	328.75	-3.057
200	220.93	-1.506
250	163.73	-0.863
300	129.39	-0.545
350	106.98	-0.368
400	91.463	-0.261
420	86.550	-0.231

Ruthenium-Oxide

Cryo-con R500

The R500 Ruthenium-Oxide temperature sensor is designed primarily for ultra-low temperature operation. Features include interchangeability and operation in high magnetic fields.

The Model 18 using 10µA Constant-current DC excitation will operate with the R500 down to 1.5K.

Shaded entries are outside of the Model 18's temperature range.

Cryo-Con R500 Ruthenium-Oxide Name: cryocon R500 Config: R31K10UA		
T(K)	**Ohms**	**Ω/K**
0.05	29072	-628083
0.1	13114	-145658
0.2	6996	-30943
0.3	5053	-13345
0.5	3503	-4760
1	2327	-1203
1.4	1985	-660.6
2	1723	-343.5
3	1508	-152.4
4.2	1378	-80.4
6	1277	-40.9
10	1178	-15.4
20	1101	-4.08
30	1053	-4.0
40	1009	-3.5

Cryo-con R400

The R400 Ruthenium-Oxide temperature sensor is designed for operation between 2.0K and 273K with high sensitivity below 40K. They feature interchangeability and operation in high magnetic fields.

Applications include low temperature superconducting magnet systems and liquid helium systems.

The Model 18 using 10µA Constant-current DC excitation will operate with the R400 over it's full temperature range.

Cryo-con R400 Ruthenium-Oxide Name: cryocon R400		Config: R250K10UA
T(K)	**Ohms**	**Ω/K**
2	239556	-17787
3	221769	-13961
4	207807	-11343
6	187171	-7647
10	163317	-3907
20	138709	-1400
30	128199	-745
40	122128	-474
100	108595	-108
200	102432	-34
273	100604	-0.05

Shaded entries are outside of the Model 18's temperature range.

Scientific Instruments RO-600 Name: SI RO-600		Config: R31K10UA
T(K)	**Ohms**	**Ω/K**
0.05	29072	-628083
0.1	13114	-145658
0.2	6996	-30943
0.3	5053	-13345
0.5	3503	-4760
1	2327	-1203
1.4	1985	-660.6
2	1723	-343.5
3	1508	-152.4
4.2	1378	-80.4
6	1277	-40.9
10	1178	-15.4
20	1101	-4.08
30	1053	-4.0
40	1009	-3.5

Scientific Instruments RO-105 Name: SI RO-105		Config: R250K10UA
T(K)	**Ohms**	**Ω/K**
2	239556	-17787
3	221769	-13961
4	207807	-11343
6	187171	-7647
10	163317	-3907
20	138709	-1400
30	128199	-745
40	122128	-474
100	108595	-108
200	102432	-34
273	100604	-0.05

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