Innovative Solutions in Cryogenic Instrumentation

Cryogenic Temperature Controller

Model 22C

The model 22C is a two-input, four-control loop cryogenic temperature controller capable of operation to <200mK. While enhanced for ultra-low temperature operation, a wide variety of general purpose sensors and heaters are also supported.

Highlights of the Model 22C:

- **Two multipurpose input channels support Diode, Platinum RTD and most cryogenic NTC resistive temperature sensors. Thermocouple inputs are optional.**
- **Operation from 200mK to over 1500K with an appropriate sensor. Step-less constant-voltage AC excitation of resistive sensors minimizes errors and extends their useful temperature range.**
- **Four independent control loops: Loop #1: 50-Watt, three-range; Loop #2: 25-Watt two-range; Loop #3 and #4: 10-Volt two-range.**
- **Large, bright and highly configurable display.**
- **Synchronous input filter improves control accuracy and stability in cryocooler based systems.**
- **Two large 10-Ampere dry-contact relays.**
- **Data logging to internal Non-Volatile memory.**
- **Table mode control automatically switches the loop input sensor to allow smooth, continuous control over a wide range of temperature.**
- **Remote interfaces include Ethernet, IEEE-488.2 (GPIB) and USB 2.0. LabView™ drivers available for all interfaces.**

Applications:

Helium 3 refrigerators and ULT:

- Step-less constant-voltage AC sensor excitation with levels from 10mV to 1.0mV and current as low as 10nA.
- Each input channels support both NTC resistor and diode sensors.
- High precision heater outputs for excellent control stability.
- Low power heater ranges support ULT systems.

Superconducting Magnets:

- Robust support for the NTC temperature sensors used in magnet systems.
- Continuous data logging to non-volatile memory.

General purpose laboratory:

- Twp inputs support a wide variety of temperature sensors.
- Four independent control loops.
- Ethernet connectivity for ease of remote control.
- Internal data logging.
- Temperature activated relays and alarms.
- Instrument status and control via a standard web browser. E-mail on alarms.
- Data acquisition / computer control

Cryogen-Free systems:

- Proprietary cryocooler thermal signature removal.
- Two input channels

For applications that require high output power, consider the Model 26.

Flexible Sensor Inputs

The Model 22C has two identical input channels, each of which implements a ratio-metric AC resistance bridge. This bridge uses separate, balanced circuits to simultaneously measure both the voltage drop across the temperature sensor and the current flowing through it. By measuring current with higher accuracy than it can be set, precision resistance measurements are obtained, even at low excitation levels.

Negative-Temperature-Coefficient (NTC) resistors are often used as low temperature thermometers, especially at ultra-low temperature. Examples include Ruthenium-oxide, Carbon-Glass, Cernox™, Carbon-Ceramic, Germanium and several others. Their resistance and sensitivity increase dramatically at low temperature but their sensitivity is usually poor at warmer temperatures.

The Model 22C provides robust support for NTC resistor sensors by using constant-voltage AC excitation. In the warm region where the sensor has low resistance and low sensitivity, constant-voltage will apply a high excitation current to improve measurement accuracy. At low temperature where the sensor has high sensitivity and high resistance, measurement errors are dominated by sensor self-heating. Constant-voltage excitation reduces this error by reducing power dissipated in the sensor as temperature decreases.

A common source of error at ultra-low temperature is sensor self-heating due to DC offsets in the measurement electronics. The Model 22C resistance bridge measures the actual current flowing through the sensor to actively cancel DC offsets by using a feedback loop to offset it's excitation source.

Ultra-low temperature systems can be negatively affected by coarse steps in excitation current. The Model 22C prevents this by using a step-less, continuously variable excitation source.

Positive Temperature Coefficient (PTC) resistor sensors including Platinum, CLTS and Rhodium-Iron RTDs use the resistance bridge in a constant-current, AC or DC excitation mode.

Platinum RTD sensors use a built-in DIN standard calibration curve that has been extended to 14K for cryogenic use. Lower temperature use is possible with custom calibrations.

Silicon diode sensors are supported over their full temperature range by using the bridge in a 10µA DC constant-current mode.

Model 22C Supported Sensors		
	Temperature Range	**Example Sensors**
Silicon Diode	1.4 - 500K	Cryo-con S900 SI-440, 430, 410 Lakeshore DT-670, 470
Platinum RTD	14 - 1200K	Cryo-con CP-100 Cryo-con GP-100 Cryo-con XP-100 Cryo-con XP-1K
Rhodium-Iron	1.4 - 800K	Oxford PHZ 0002
Germanium Thermistor	200mK - 400K	AdSem, Inc.
CLTS	4 to 300K	Vishay CLTS-2B
Silicon Thermistor	0.5 - 720K	AdSem, Inc.
Cernox™	200mK - 325K	Lakeshore, all types
Carbon-Ceramic	200mK - 300K	Temati
Ruthenium Oxide	200mK - 270K	SI RO-600
Thermistor	193 - 523K	Measurement Specialties
Thermocouple	1.4 to 1500K	All thermocouple types.

Thermocouple sensors are supported by using an optional thermocouple module. This module plugs into any of the Model 22C's input channels. It is powered by the instrument to provide amplification, cold-junction compensation and connection to copper. Up to four modules can be connected to a single instrument.

Input Specifications				
	Diode sensors	**PTC resistor sensors**	**NTC resistor sensors Constant-Voltage mode**	**Thermocouple (Option)**
Input Configuration	Constant-Current DC	Constant-Current AC / DC	Autoranging Constant-Voltage AC Resistance Bridge	DC voltage
Input Range	0.1V - 2.25V	1.0mA: 0.1 - 500Ω 100µA: 1.0K – 5.0KΩ	Minimum: 0.5Ω Maximum: 100KΩ	± 70mV
Accuracy: % Rdg ± % Range	0.005% ± 80µV	PTC100: 0.01% ± 0.004Ω PTC1K: 0.02%± 0.04Ω	14Ω to 30KΩ: 0.05% + 0.04% 5Ω to100KΩ: 0.15% + 0.15%	0.05%
Resolution: % Range	10µV	0.0003%	0.0003%	0.0003%
Excitation	10µA DC	1.0mA, 100µA	10mV, 3.0mV, 1.0mV 1.25mA to 10nA	N/A

The Model 22C includes built-in **sensor calibration curves** that support most industry standard temperature sensors. Additionally, eight **user calibration curves** are available for custom or calibrated sensors. Each user curve may have up to 200 entries.

For all sensor types, conversion of a sensor reading into temperature is performed by using a **Cubic Spline** interpolation algorithm. In addition to providing higher accuracy than conventional linear interpolation, the spline function eliminates discontinuities during temperature ramps or sweeps by ensuring that the first and second derivatives are continuous.

New calibration curves may be generated using the **CalGen**® feature. This provides an easy and effective method for obtaining higher accuracy temperature measurements without expensive sensor calibrations.

Input Channel Statistics: The Model 22C continuously tracks temperature history independently on each input channel and provides a statistical summary that indicates the channel's minimum, maximum, average and standard deviation. Also shown are the slope and the offset of the best-fit straight line of temperature history data.

Data logging is performed by continuously recording input temperature data to an internal 1,365 entry buffer. Data is time stamped. Non-volatile memory is used so that data will survive a power failure.

Four Control Loops

The **Loop #1** heater output is a linear, low noise RFI filtered current source that can provide up to 1.0 Ampere into 50Ω or 25Ω resistive loads. Three full-scale ranges are available in decade increments down to 500mW.

Loop #2 is a two-range linear heater with that will provide 25 or 2.5-Watts into a 50Ω load.

Loop #3 and #4 are non-powered analog voltage outputs designed to control an external booster power supply. Output is zero to 10-Volts or zero to 5.0-Volts by user selection. The controller's relays may be used to turn the external supply on or off.

Control stability is enhanced by the use of an over-sample plus dither algorithm that increases output resolution beyond the limit of the output quantizer.

All control loops are completely independent and any loop may be controlled by any sensor input. Control modes are **Manual**, **PID**, **Ramp, PID Table and Ramp Table**.

The field proven **Autotune** function of the Model 22C involves the use of a specific output waveform to first develop a process model, then generate the optimum P, I and D coefficients.

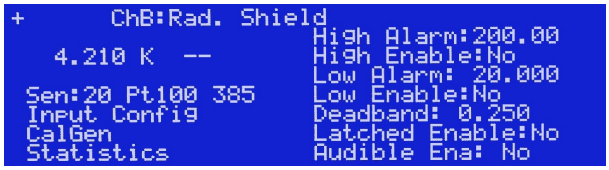
PID tables are available that can be used to store optimum control parameters vs. point temperature. Each entry of a PID table contains a setpoint, a control input, PID values and a heater output range setting. When the point is changed, the controller will automatically generate new PID values, a controlling input channel and heater range.

The Model 22C will perform a **temperature ramp** function using a specified maximum ramp rate and target setpoint.

User Interface

The Model 22C's user interface consists of a large, bright TFT type Liquid Crystal Display and a full 21-key keypad. In this user-friendly interface, all features and functions of the instrument can be accessed via this simple and intuitive menu driven interface.

The Home screen projects four user configurable zones that allow the real-time display of all input channel, control loop and instrument status information. From this screen, accessing any of the instrument's configuration menus requires only a single key press.



Innovative instrument configuration menus show real-time status information so the user can *instantly* view the results of any changes made.

Cryostat Protection

Damage to a cryostat or critical sample is a serious problem with any cryogenic system. The Model 22C implements the most robust set of protection features in the industry.

The **Over Temperature Disconnect** feature will disable the heater if an over temperature condition exists on any selected input channel. A fail-safe mechanical relay is used to disconnect the controller's heater thereby ensuring that the user's equipment is always protected.

The **Maximum Setpoint** feature is used to prevent the user from inadvertently entering a higher point than the equipment can tolerate and a **Maximum Power Limit** will ensure that the controller can never exceed heater power output above the set limit.

Lowest Noise

The Model 22C was designed for use in the extremely low noise environments that cryogenic systems often require.

The grounding scheme facilitates the establishment of a single-point-ground. This is essential to the elimination of ground-loops and power-line noise pickup, especially in systems that require multiple instruments.

To minimize radiated noise pickup, The Model 22C implements a shielding scheme that allows the construction of a complete RFI shield around the instrument and cryostat.

Alarms and Relays

The Model 22C supports visual, remote and audible alarms. Additionally, there are two 10-Ampere dry-contact mechanical relays. Each may be independently programmed to assert or clear based on a high or low temperature condition or a detected sensor fault.

Alarms may be latched. These are asserted on an alarm condition and will remain asserted until cleared by the user.

Remote Control

Standard Remote Interfaces include Ethernet, IEEE-488.2(GPIB) and USB 2.0.

The Model 22C connects directly to any **Ethernet Local-Area-Network** (LAN).

The **TCP/IP and UDP data port servers** brings fast Ethernet connectivity to all common data acquisition software programs including LabView™.

Using the Ethernet **HTTP** protocol, the instrument's **embedded web server** allows the instrument to be viewed and configured from any web browser.

LabView™ drivers are supplied for the Ethernet TCP/IP, UDP, IEEE-488.2 (GPIB) and USB 2.0 interfaces.

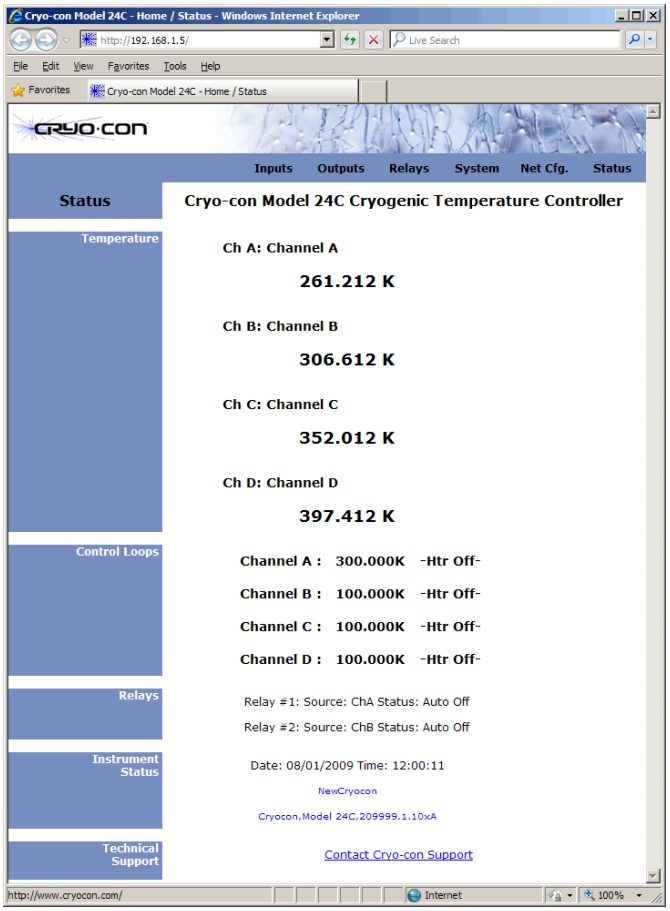
The Model 22C's **remote command language** is **SCPI** compliant according to the IEEE-488.2 specification. SCPI establishes a common language and syntax across various types of instruments. It is easy to learn and easy to read. The SCPI command language is identical in all Cryo-con products so that your investment in system software is always protected.

Command Scripts can be used to completely configure an instrument including setting custom sensor calibration curves and PID tables. Further, scripts can query and test data.

An **Applications Program Interface (API)** package is supplied that facilitates communication with the instrument using the TCP/IP interface. It is supplied as a Microsoft Windows™ DLL that is easily linked with C, C++ or Basic programs.

Firmware updates

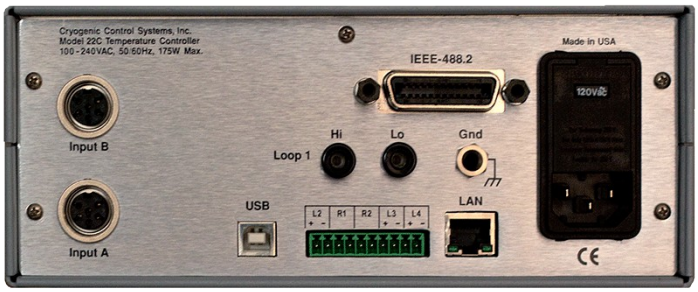
Full instrument firmware updates may be installed by using the Ethernet connection. Cryo-con provides firmware updates, on request, via e-mail. They are **free of charge** and generally include enhancements and new features as well as problem fixes.



Utility Software: Utility software is provided that connects any Windows based personal computer to the Model 22C via any of its remote interfaces. This software provides a graphical control panel that greatly simplifies instrument setup and configuration. Features include:

- Continuous strip-chart monitoring of all inputs and outputs.
- Downloading, uploading, viewing and editing of sensor calibration curves and PID tables and command scripts.

Rear Panel Connections



- **Input Connectors:** DIN-6 recepticals provide 4-wire measurement connection plus a continuous shield through the backshell.
- **Thermocouple Option:** Connects to any of the input connectors. Up to 2 modules supported.
- **Loop #1:** 50-Watt heater output. Dual Banana Plug with chassis ground lug.
- **Loop #2:** 25-Watt heater, part of a 10 pin detachable terminal block.
- **Loop #3 and #4:** non-powered outputs. Detachable terminal block.
- **Relay #1 and #2:** Dry contact relays. Detachable terminal block.
- **Ethernet:** RJ-45 with LAN activity indicators.
- **IEEE-488.2:** Standard IEEE-488.2 (GPIB) connector.
- **USB:** USB client connector.
- **AC Power:** RFI filtered Power Entry Module including fuse drawer and line voltage selector.

Ordering Information

Product	Description
Model 22C	Controller with two multi-function sensor input channels and four control loops.
	Controller includes: User's Manual, Cryo-con software CD, two input connectors, heater connector, terminal block plug, detachable power cord and a certificate of calibration. Specify AC Line Voltage or required power cord when ordering (may be changed in the field): -**100** Configured for 90 - 100VAC with detachable USA power cord. **-120** Configured for 110 - 120VAC with detachable USA power cord. **-230** Configured for 220 - 230VAC with detachable universal Euro (Shuko) line cord. **-240** Configured for 240VAC with detachable universal Euro (Shuko) line cord.

Option	Description
4039-004	Thermocouple Input Module. Field installable. Supports all thermocouple types. 

Accessories	Description
4022-016	Input connector kit consisting of two DIN-6 sensor input connectors.
4124-018	Output connector kit consisting of a dual banana plug heater connector and a 10-pin terminal block receptacle.
4034-031	Two instrument shelf rack mount kit.
4034-032	One instrument shelf rack mount kit
4022-030	Single instrument 2U rack mount kit.

Specifications

User Interface

Display Type: 240x64 graphics TFT LCD with LED back-light.
Number of Inputs Displayed: Two.
Keypad: Sealed Silicon Rubber.
Temperature Display: Six significant digits, auto-ranged.
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

There are two input channels, each of which may be independently configured for any of the supported sensor types.

Sensor Connection: 4-wire differential. DIN-6 Connector.
Thermocouple Connection: External option. Field installable.
Sensor Types: See Supported Sensor Table.
Sensor Selection: Front Panel or remote interface.
Input Configurations: See input specifications table.
Bridge Modes: Passive, Constant-Current or Constant-Voltage.
Bridge type: Ratiometric resistance bridge. Two ADCs per input channel.
AC Excitation Frequency: 7.5Hz bipolar square wave.
Voltage Excitations: 10mV, 3.0mV and 1.0mV. Minimum excitation current is 10nA, maximum is 1.25mA.
DC Offset: <8nA by active cancellation.
Sample Rate: 15Hz per channel.
Digital Resolution: 24 bits.
Measurement Accuracy: See input specifications table.
Measurement Drift: 15ppm/°C. <10Ω. or >10KΩ: 30ppm/°C.
Isolation:Input channel circuits are electrically isolated from all other internal circuitry but not from each other.
Measurement Filter: 0.5, 1, 2, 4, 8, 16, 32 and 64 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.

Data Logging

Data logging is performed to an internal 1,365 entry circular buffer and is time-stamped with a real-time clock. Buffer memory is non-volatile and will retain valid data without AC power. All four input channel temperatures are recorded.

User Setups

Four User Setups are available that save and restore the complete configuration of the instrument.

Control Outputs

Number of Independent Control Loops: Four.
Control Input: Any sensor input.
Loop Update Rate: 15Hz per loop.
Isolation: Control loop circuitry is referenced to chassis ground.
Control Type: PID table, Enhanced PID, Ramp or Manual.
Autotune: Minimum bandwidth PID loop design.
PID Tables: Six user PID tables available for storage of setpoint and heater range vs. PID and heater range. 16 entries/table.
Set-point Accuracy: Six+ significant digits.
Fault Monitors: Control loops are disconnected upon detection of a control sensor fault or excessive internal temperature.
Over Temperature Disconnect: Heater may be relay disconnected from user equipment when a specified temperature is exceeded on any selected input.

Loop #1 Primary Heater Output

Short circuit protected linear current source.

Ranges: Three output ranges of 1.0A, 333mA and 100mA full-scale, correspond to 50W, 5.0W and 0.5W into a 50Ω load.
Load Resistance: Selectable at 25Ω or 50Ω
Minimum Load: 10Ω in 25W setting, 40Ω in 50W setting.
Resolution: 1.0ppm of full-scale power (20 bits).
Readbacks: Heater output power, Heatsink temperature.
Connection: Dual banana plug.

Loop #2 Heater Output

Short circuit protected linear current source.

Ranges: Two output ranges of 710mA and 224mA full-scale, which correspond to 25W and 2.5W into a 50Ω load.
Load Resistance: 50Ω for maximum output
Resolution: 1.0ppm of full-scale power (20 bits).
Readbacks: Heater output power, Heatsink temperature.
Connection: Detachable terminal block.

Loop #3 and #4 Control Outputs

Analog voltage outputs that are intended to drive an external booster supply.

Output: zero to 10 / 5.0-Volts. Output impedance: ~2,000Ω.
Resolution: 1.0ppm of full-scale power (20 bits).
Connection: Detachable terminal block.

Status Outputs

Audible and Visual Alarms: Independent audible remote and visual alarms.
Relays: Two dry-contact relays. N.O. contacts available. Ratings are 125VAC @ 10A. Maximum switching power: 150W.
Status reported via Remote Interface: Sensor fault, Heater over temperature fault.

Remote Interfaces

Maximum reading rate for all interfaces is >40 rdg/s.

Ethernet: Connects to any Ethernet Local Area Network. Electrically isolated. **TCP/IP** and **UDP** servers provide remote control by using an ASCII command language. **HTTP** provides built-in web server. **SMTP** sends e-mail based on alarm conditions.
IEEE-488.2 (GPIB): Full IEEE-488.2 compliant.
USB 2.0: Serial port emulation. Baud Rates to115,200.
Programming Language: IEEE-488.2 SCPI compatible.
LabVIEW™ drivers available for all interfaces.

Firmware

Instrument firmware can be updated in the field via the Ethernet connection. Firmware updates are available via the Internet free of charge.

General

Ambient Temperature: 25°C ± 5°C for specified accuracy.
Mechanical: 8.5"W x 3.5"H x 12"D. One half-width 2U rack. Instrument bail standard, rack mount kit optional.
Weight: 9 Lbs.
Power Requirement: 100, 120, 230 or 240VAC +5% -10%. 50 or 60Hz, 150VA. Field selectable.
Conformity: European CE certified.
Calibration: NIST traceable.

Contact Information

Cryogenic Control Systems, Inc.
PO Box 7012
Rancho Santa Fe, CA 92067
Tel: (858) 756-3900 Fax: (858) 759-3515
E-mail: sales@cryocon.com Web: www.cryocon.com