Model 22 Temperature Controller.

The Cryo-con Model 22 is a precision two channel Cryogenic Temperature Controller designed for single control loop applications.

Major highlights of the Model 22 include:

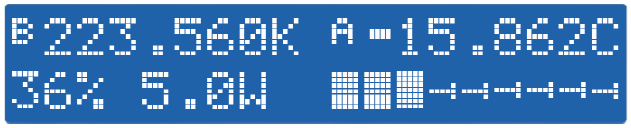
- **Two multipurpose input channels that can be configured from the front panel for Diode, Platinum RTD and most cryogenic NTC resistive temperature sensors.**
- **High-resolution electronics enhanced with Digital Signal Processing technology provides unsurpassed measurement accuracy.**
- **Control Loop digital signal dithering extends output resolution to produce smooth analog-like control and Millikelvin accuracy.**
- **Proven, tested autotuning optimized for cryogenic systems.**
- **50 or 25 Watt, three range linear heater output.**
- **Extremely low noise design allows operation in the most demanding of cryogenic environments.**
- **CalGen® feature allows the user to custom fit any Diode, Thermocouple or Platinum sensor calibration curve.**
- **Remote interfaces include RS-232 and IEEE-488.2 (GPIB). Industry standard SCPI command language.**
- **National Instruments, Inc. LabVIEW™ drivers are available and support all remote interfaces.**
- **NIST traceable instrument calibration. European CE certified.**
- **Power switch on front panel.**

The Model 22 was designed for use in extremely **low noise** environments that cryogenic systems often require. Linear-mode power supplies are used throughout and sensor excitation current sources are not multiplexed.

Modern components and proven noise management techniques were carefully applied to every sensor excitation and heater output circuit. A very effective shielding and grounding scheme allows the user to further reduce conducted noise.

> The Model 22 does not require the use of external filters or excitation sources.

The Model 22's **user interface** consists of a large character type VFD display and a 20 key keypad. All features and functions of the instrument can be accessed via this simple and intuitive menu driven interface.



At the root of the instrument's menu tree is the basic Operate Screen. This consists of four independent, user configurable zones. Displays can be configured to show only the desired information, without unnecessary clutter.

The Model 22 has two **sensor input channels**. Each channel can be independently configured to support either Silicon Diode sensors or a wide variety of resistor sensors.

Sensor configuration is performed from the instrument's front panel. There are no internal jumpers, switches or daughter boards.

Measurement accuracy is obtained by using a ratiometric resistance bridge followed by 24-bit analog to digital conversion at a minimum sample rate of 10Hz per channel.

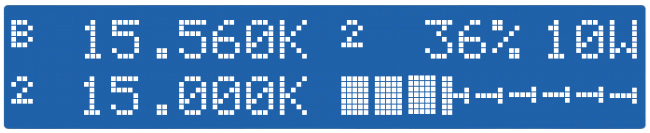
Accuracy is further enhanced by extensive use of Digital Signal Processing (DSP) techniques and 32-bit floating-point arithmetic.

Conversion from sensor readings into temperature is performed by using a Cubic Spline interpolation algorithm. The Model 22 includes several built-in curves that support most industry standard temperature sensors.

Additionally, four **user calibration curves** are available. Each curve may have up to 160 entries and may be entered or edited from the front panel, or transferred via any of the available remote interfaces.

New calibration curves may be generated using the **CalGen®** feature to fit any existing Diode or Platinum calibration curve at up to three user specified temperature points.

Temperature displays are autoranged to show the most number of significant digits. Built-in digital filters can be used to smooth temperature data. Six filters are provided with time constants from 0.5 seconds to 64 seconds.



Conversion of a sensor measurement into temperature is performed by using a Cubic Spline interpolation algorithm. The Model 22 includes built-in curves that support most industry standard temperature sensors. Additionally, four **user calibration curves** are available. Each user curve may have up to 160 entries and may be entered or edited from the front panel, or transferred via any of the available remote interfaces.

New calibration curves may be generated using the **CalGen®** feature to fit any existing Diode, Thermocouple, Platinum or NTC resistor calibration curve at up to three user specified temperature points. This provides an easy and effective method for obtaining higher accuracy temperature measurements without expensive sensor calibrations.

The Model 22 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 LMS best-fit straight line of temperature history data.

The **Heater channel** is a linear, low noise RFI filtered current source that can provide up to 1.0 Ampere into a 50Ω or 25Ω load. Three full-scale ranges are available in decade increments.

Set-point resolution is equal to the full six-digit precision of a 32-bit floating-point number. All of the numeric entry fields on the Model 22 display use a character-scrolling feature to accommodate up to 20 input digits.

Control modes are Manual, PID, Ramp and PID Table. Transitions between modes will not generate a glitch in the heater output level.

The industry standard Proportional-Integral-Derivative or PID control loop is implemented as a DSP algorithm and is enhanced to allow user control of set-point overshoot. Other enhancements include the

minimization of integrator wind-up and reduction of derivative action noise.

The direction of the control loop can be easily reversed to accommodate thermoelectric type coolers where power is applied to cool rather than heat.

The resolution of any digital control loop is frequently limited by it's output quantizer, or DAC. However, the Model 22 uses an **output signal dither** technique to extend loop accuracy well beyond these hardware limits.

Signal dithering forces the average value of the heater output to converge to the desired high-resolution output, rather than to the nearest quantization level of the output DAC.

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

Cryogenic systems often require control over a wide range of temperature. Control loop tuning parameters required for stable control will be significantly different at different temperatures within this range. For this reason, the Model 22 offers **PID tables** that store optimum tuning parameters vs. temperature.

Two PID tables are available. Each contains PID and heater range settings for up to 8 temperature set-points. While controlling in the PID Table mode, the Model 22 will generate optimum loop coefficients by interpolation of the PID table entries.

The Model 22 will perform a **temperature ramp** function using a specified maximum ramp rate and target set-point. Once placed in a ramping control mode, a ramp is initiated by changing the set-point. The unit will then progress to the new set-point at the selected ramp rate. Upon reaching the new set-point, ramp mode will be terminated and standard PID type regulation will be performed.

For cryocooler applications, the Model 22 offers an adaptive **Cryocooler Filter**. This filter will synchronously subtract the cooler's thermal signal from the input in order to provide a significant improvement in baseline temperature control.

User equipment may be protected from excessive heating by use of the **Over Temperature Disconnect Monitor**. This monitor will disable the heater if an over temperature condition exists on any selected input channel. A mechanical relay is used to disconnect the controller's heater ensuring that the user's equipment is protected regardless of the reason for the fault condition.

Two complete **User Configurations** are available. Each configuration can be used to save and restore the complete state of the instrument including set-points, heater configurations, PID tables, sensor calibration curves, input channel data, etc.

A visual and audible **alarm** may be independently programmed to assert or clear based on a high or low temperature condition or a detected sensor fault.

The internal **architecture** of the Model 22 is based on a fast, 32-bit micro controller and FLASH memory. These memories contain the unit's firmware as well as various data tables and can be reprogrammed via the remote ports.

Firmware updates are maintained on the Internet and are always available free of charge. They include new features, new calibration curves and bug fixes. Updating the Model 22's firmware is a five-minute procedure that is performed by the Utility Software provided.

Standard **Remote Interfaces** include RS-232 and IEEE-488.2 (GPIB). All interfaces are electrically isolated to prevent ground loops.

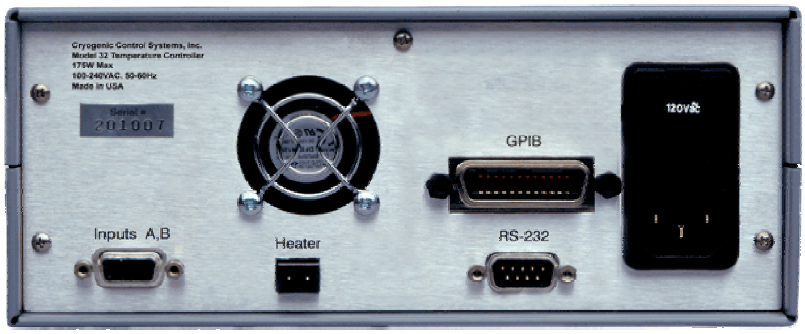
To further assist in the development of system software using the Model 22, a complete set of **LabVIEW™** drivers are available. These drivers support the GPIB and Serial interfaces.

Utility software is provided that connects any Windows based personal computer to the Model 22 via any of its remote interfaces. Software performs:

- Continuous monitoring of all inputs and outputs.
- Downloading or uploading sensor calibration curves.
- Flexible **data logging** of temperature and heater power.
- Downloading or uploading PID tables.
- A Terminal mode to communicate with the controller.
- **Downloading firmware** updates to the controller's flash memory.
- Flexible 'Help' interface to controller functions.

Rear panel connections to the Model 22

- Two 4-wire sensor connections are made using a single DB-9 receptacle.
- Heater output connector.
- Standard IEEE-488.2 (GPIB) connector.
- RS-232 connector (pins).
- RFI filtered Power Entry Module including power cord connector, fuse drawer and line voltage selector.



Ordering Information

	Description
Model 22-50W	Model 22 Controller with a 50-Watt 3-range linear heater.
Model 22-25W	Model 22 Controller with a 25-Watt 3-range linear heater.

Sensor Performance Data

Sensor Type	Silicon Diode	100Ω Platinum DIN43760	1000Ω Platinum DIN43760	Ruthenium Oxide	Carbon Glass™	Cernox™
Sensor Sensitivity	300K: 2.4mV/K 77K: 1.9mV/K 4.2K: 30mV/K	800K: 0.36Ω/K 300K: 0.39Ω/K 77K: 0.42Ω/K 30K: 0.19Ω/K	600K: 3.7Ω/K 300K: 3.9Ω/K 77K: 4.2Ω/K 30K: 1.9Ω/K	2.0K: 358Ω/K 4.2K: 80.3Ω/K 20K: 4.1Ω/K	4.2K: 422Ω/K 77K: 0.1Ω/K 300K: 0.01Ω/K	4.2K: 2290Ω/K 77K: 2.15Ω/K 300K: 0.13Ω/K
Measurement Accuracy	300K: 21μV 77K: 23μV 4.2K: 44μV	800K: 2.4mΩ 300K: 2.4mΩ 77K: 1.2mΩ 30K: 1.2mΩ	600K: 38mΩ 300K: 38mΩ 77K: 4.7mΩ 30K: 4.7mΩ	2.0K: 29mΩ 4.2K: 29mΩ 20K: 29mΩ	4.2K: 30mΩ 77K: 0.3mΩ 300K: 0.3mΩ	4.2K: 117mΩ 77K: 5mΩ 300K: 1.2mΩ
Temperature Measurement Accuracy	300K: 8.7mK 77K: 12mK 4.2K: 1.6mK	800K: 6.7mK 300K: 6.2mK 77K: 2.8mK 30K: 6.3mK	600K: 10mK 300K: 10mK 77K: 1.1mK 30K: 2.5mK	2.0K: 0.1mK 4.2K: 0.4mK 20K: 7.4mK	4.2K: 0.07mK 77K: 3mK 300K: 31mK	4.2K: 0.1mK 77K: 22mK 300K: 9mK
Measurement Resolution	300K: 7.4μV 77K: 7.4μV 4.2K: 15μV	800K: 1.8mΩ 300K: 1.8mΩ 77K: 460μΩ 30K: 460μΩ	600K: 15mΩ 300K: 15mΩ 77K: 1.8mΩ 30K: 1.8mΩ	2.0K: 11mΩ 4.2K: 11mΩ 20K: 11mΩ	4.2K: 11mΩ 77K: 0.2mΩ 300K: 0.2mΩ	4.2K: 46mΩ 77K: 1.8mΩ 300K: 0.5mΩ
Temperature Resolution	300K: 3.0mK 77K: 3.8mK 4.2K: 500μK	800K: 5.1mK 300K: 4.7mK 77K: 1.1mK 30K: 2.4mK	600K: 4mK 300K: 4mK 77K: 0.5mK 30K: 1.0mK	2.0K: 32μK 4.2K: 0.13mK 20K: 2.9mK	4.2K: 30μK 77K: 1.2mK 300K: 12mK	4.2K: 50μK 77K: 0.85mK 300K: 3.5mK
Control Stability	300K: 3.0mK 77K: 3.8mK 4.2K: 500μK	800K: 5.1mK 300K: 4.7mK 77K: 1.1mK 30K: 2.4mK	600K: 4mK 300K: 4mK 77K: 0.5mK 30K: 1.0mK	2.0K: 32μK 4.2K: 0.13mK 20K: 2.9mK	4.2K: 80μK 77K: 1.2mK 300K: 12mK	4.2K: 80μK 77K: 0.85mK 300K: 3.5mK
Power Dissipation	4.2K: 17μW 77K: 12μW	30K: 3.7μW 77K: 20μW	30K: 37μW 77K: 200μW	2.0K: 172nW 4.2K: 137nW	4.2K: 58nW 77K: 14μW	4.2K: 513nW 77K: 161μW
Magneto-resistance	Very Large	Moderate	Moderate	<2% for H<2T	Moderate	<1% for H<2T

Silicon Diode sensors use a fixed excitation current of 10μA and an input voltage range of 0 to 2.5V.

Both Negative and Positive Temperature Coefficient (NTC) / (PTC) resistor sensors are supported using a ratiometric bridge technique to cancel low frequency noise.

PTC sensor types include: **Platinum** and **Rhodium-Iron**. Excitation currents are 1.0mA, 100μA and 10μA DC. Corresponding full-scale resistance ranges are: 312Ω, 3.2K and 31KΩ.

NTC sensors include: **Ruthenium Oxide**, **Carbon Glass™**, **Germanium** and **Cernox™.** Constant-current sensor excitation of 10μA is used with a maximum sensor resistance range of 8KΩ.

GaAlAs and GaAs Diode sensors are directly supported from 25 to 475K. The maximum input voltage range of the controller imposes this limitation.

Model 22 Supported Sensors		
	Temperature Range	**Example Sensors**
Silicon Diode	1.4 – 475K	Cryo-con® S700 Scientific Inst. SI-410 Lakeshore DT-670
Gallium Aluminum Arsenide Diode	25 – 475K	Scientific Inst. GA-300 Lakeshore TG-120
Platinum RTD	14 – 1200K	Cryo-con® CP-100 Cryo-con® GP-100
Rhodium-Iron	1.4 – 800K	Oxford PHZ 0002
Germanium	1.2 – 100K	Lakeshore GR-200A
Carbon Glass™	3 – 325K	Lakeshore CGR-1-500
Cernox™	2 – 325K	Lakeshore CX-1050
Ruthenium Oxide	2 – 40K	Cryo-con® R-450

Specifications

User Interface

Display Type: 20 x 2 character VFD, 9mm character height.
Number of Inputs Displayed: Two.
Keypad: Sealed Silicon Rubber.
Temperature Display: Six significant digits, autoranged.
Display Update Rate: 0.5 Seconds.

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. DB-9 receptacle.
Sensor Types: See Supported Sensor Table.
Sensor Selection: Front Panel. There are no internal jumpers or switches.
Sensor Resolution: Sensor Dependent. See Sensor Performance Data table.
Excitation: Constant current: 1mA, 100μA or 10μA
Resistance Measurement type: Ratiometric bridge.
Sample Rate: 10Hz per channel.
Measurement Resolution: Sensor Dependent. See Sensor Performance Data table.
Digital Resolution: 24 bits.
Measurement Drift: <15ppm/°C
Measurement Filter: 0.5, 1, 2, 4, 8, 16, 32 and 64 Seconds.
Calibration Curves: Built-in curves for industry standard sensors plus four user curves with up to 200 entries each. Interpolation is performed using a Cubic Spline.
CalGen®: Calibration curve generator fits Diode or Platinum sensors at 1, 2 or 3 user specified temperature points.

User Setups

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

Control Outputs

The standard Model 22 has a single control output.

Number of Loops: One.
Control Input: Either sensor input.
Loop Update Rate: 10Hz.
Control Type: PID table, Enhanced PID, Ramp or Manual.
Autotune: Minimum bandwidth PID loop design.
PID Tables: Two user PID tables available for storage of Set Point vs. PID and heater range. Each table may have up to 16 entries.
Setpoint Accuracy: Six significant digits.
Fault Monitor: 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.

Standard Heater Output

Type: Short circuit protected linear current source. Maximum compliance is 50V on the 50-Watt option and 25V on the 25Watt option.
Ranges: Three output ranges of 1.0A, 0.33A and 0.10A full-scale, which correspond to 50W, 5.0W and 0.5W when used with a 50Ω load.
Load Resistance: 25Ω or 50Ω determined by the 25 Watt or 50 Watt option. Heaters down to 10Ω can be used with the 25-Watt option.
Minimum Load: 10Ω with the 25-Watt heater, 40Ω with the 50 Watt heater.
Digital Resolution: 0.0015% of full-scale range.
Readback: Heater output power, Heatsink temperature.

User Setups

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

Status Outputs

Each status output may be programmed to assert upon detection of a high or low temperature as well as a sensor fault condition on any input channel.

Audible and Visual Alarms: Independent audible and visual alarms. Status reporting via remote interfaces.

Remote Interfaces

Remote interfaces are electrically isolated to prevent ground loops.

RS-232: Serial port is an RS-232 standard null modem with male DB9 connector. Rates are 300, 1200, 4800, 9600, 19,200 and 38,400 Baud.
GPIB: Full IEEE-488.2 compliant.
Language: Remote interface language is IEEE SCPI compliant. National Instruments LabVIEW™ drivers available for all interfaces.

Firmware

Internal firmware and all data tables are maintained in FLASH type memory and may be upgraded via the remote interface ports. Instrument firmware updates are available on the Internet.

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: 10 Lbs.
Power Requirement: 100, 120, 220 or 240VAC, 50 or 60Hz, 150VA.

Contact Information

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