

Cryogenic Temperature Controller

Model 26



The Model 26 cryogenic temperature controller was designed for applications requiring high output power while still supporting a wide range of temperature sensors. Four inputs and four independent control loops provide a total output power of 150W.

Highlights of the Model 26:

- **Operation from 500mK to over 1,500K** with an appropriate sensor.
- **Four multipurpose input channels** support Diode, Platinum RTD and most cryogenic NTC resistor temperature sensors. Thermocouple inputs are optional.
- **Four high-power independent control loops:** Loop #1: 100-Watt, four-range; Loop #2: 50-Watt three-range; Loop #3 and #4: 10-Volt two-range.
- **Large, bright and highly configurable display.**
- **Synchronous input filter** improves control stability in cryocooler based systems.
- Two large **10-Ampere** dry-contact relays.
- **Data logging** to internal Non-Volatile memory.
- Fail-safe **cryostat protection** features protect user equipment from damage.
- Table mode control automatically switches the loop input sensor to allow smooth, continuous control over a wide range of temperature.
- Remote interfaces include **Ethernet** and USB. IEEE-488.2 (GPIB) is optional.
- Protect your system software: Remote command language is **IEEE-488.2 SCPI** compliant.
- National Instruments, Inc. **LabVIEW™** drivers available for all interfaces.

Applications:

Probe Stations

- 100W + 50W outputs for high temperature operation.
- Rapid sample warm-up.

Large cryocoolers

- High power outputs control large cryocoolers over a wide range that includes room temperature.
- Proprietary cryocooler thermal signature removal offers the best control stability in the industry for cryocooler based systems.

Oven based systems

- Control from cryogenic temperature to >900K.
- Thermocouple support on any input.

Cryogen-Free systems

- Cryocooler thermal signature subtraction.
- Four input channels

General purpose laboratory

- Four inputs, four independent control loops.
- Ethernet connectivity for ease of remote control.
- Temperature activated relays and alarms.
- Instrument control via any web browser.

Superconducting Magnets

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

For precision low temperature applications consider the Model 24C.



Flexible Sensor Inputs

The Model 26 has four independent and identical input channels, each of which support all temperature sensor types in any combination.

An important feature of the input channels is that they support resistor temperature sensors by implementing a ratio-metric AC resistance bridge. This bridge uses separate, balanced circuits to simultaneously measure both the voltage drop across the 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. The Model 26 provides robust for support these sensors by using constant-voltage AC excitation. In their warm region, these sensors have low resistance and low sensitivity. Maintaining a constant-voltage will increase excitation current to improve measurement accuracy. Conversely, at low temperature, measurement errors are dominated by sensor self-heating. In this region, constant-voltage excitation reduces excitation current as temperature decreases.

Another source of error at ultra-low temperature is sensor self-heating due to DC offsets produced by the measurement electronics. The Model 26 first measures the DC offset excitation current flowing through the sensor then actively tracks and cancels it.

Ultra-low temperature measurements can be negatively affected by coarse steps in sensor excitation current. The Model 26 prevents this by using a step-less, continuously variable excitation source. Since the excitation current is measured to higher accuracy than it can be set, precision is maintained, even with a continuously variable 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.

Silicon diode sensors are supported over their full temperature range by using 10µA DC constant-current excitation.

Model 26 Supported Sensors		
	Temperature Range	Example Sensors
Silicon Diode	1.4 - 500K	Cryo-con S950, 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	500mK - 400K	AdSem, Inc.
CLTS	4 - 300K	Vishay CLTS-2B
Silicon Thermistor	2.0 - 720K	AdSem, Inc.
Cernox™	500mK - 325K	Lakeshore, all types
Carbon-Ceramic	500mK - 300K	Temati
Ruthenium Oxide	500mK - 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 26'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	Thermocouple
Input Configuration	Constant-Current DC	Constant-Current AC / DC	Constant-Voltage AC Resistance Bridge	DC voltage
Input Range	0.1V - 2.25V	1.0mA: 0.1 - 500Ω 100µA: 1.0K - 5.0KΩ CLTS: 300Ω	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% 0.5Ω to 100KΩ: 0.15% ± 0.15%	0.05%
Resolution: % Range	10µV	0.0003%	0.0003%	0.0003%
Excitation	10µA DC	1.0mA, 100µA	10mV 2.5mA to 100nA	N/A

The Model 26 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 without expensive sensor calibrations.

Input Channel Statistics: The Model 26 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 100W into 25Ω or 50W into 50Ω resistive loads. Four full-scale ranges are available in decade increments down to 500mW.

Loop #2 is a three-range linear heater with that will provide up to 50 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 and 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 26 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 26 will perform a **temperature ramp** function using a specified maximum ramp rate and target setpoint.

User Interface

The Model 26's user interface is based on a large, high resolution graphics display plus a full 21-key keypad. With this bright and exceptionally wide viewing angle display, complete instrument status can be seen at a glance, even from across the room.

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.



As with all Cryo-con products, unique labels may be assigned to each sensor input.

Cryostat Protection

Damage to a cryostat or critical sample is a serious problem with any cryogenic system. The Model 26 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.

Control loop faults will also be generated if the temperature of the output circuits is too high or the resistance of the connected load is too low.

Lowest Noise

The Model 26 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 26 implements a shielding scheme that allows the construction of a complete RFI shield around the instrument and cryostat.

Alarms and Relays

The Model 26 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.

A fail-safe mode is implemented that will activate a relay only when the input temperature is within specified limits.

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** and **USB**. IEEE-488.2(GPIB) is optional.

The Model 26 connects directly to any **Ethernet Local-Area-Network** (LAN) to bring fast Ethernet connectivity to all common data acquisition software programs including LabView™.

The instrument's **embedded web server** allows the instrument to be viewed and configured from any web browser.

In order to eliminate ground-loop and noise pickup problems commonly associated with **IEEE-488 (GPIB)** systems, the Model 26 moves the internal GPIB circuitry to an optional module that connects directly to the Ethernet interface. This module is completely transparent to the GPIB system.

LabView™ drivers are supplied for the Ethernet TCP/IP, GPIB and USB interfaces.

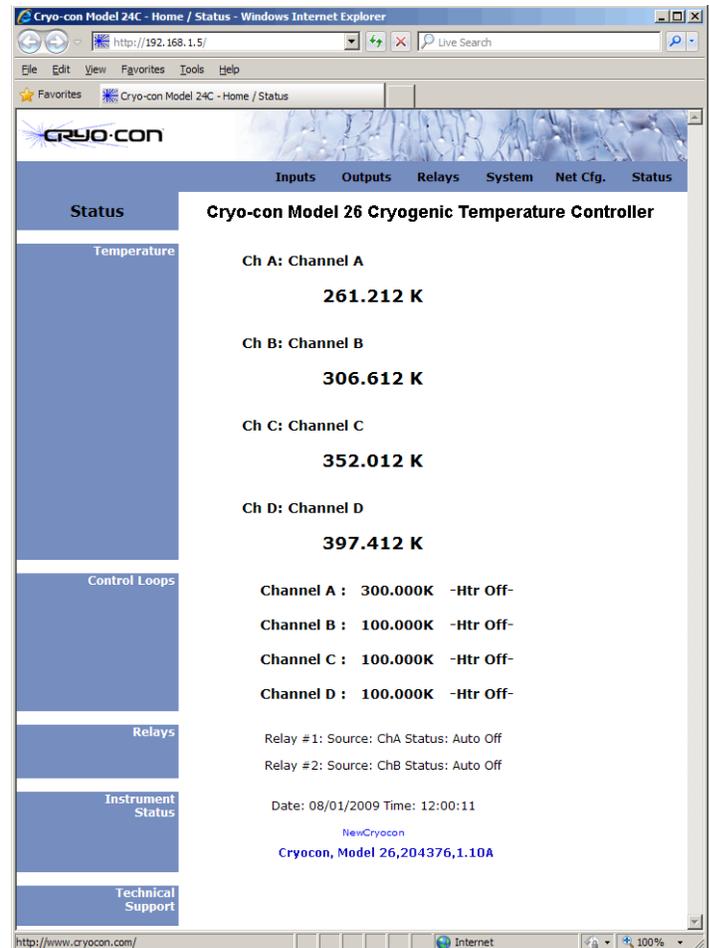
The Model 26's **remote command language** is **SCPI** compliant according to the IEEE-488.2 specification. SCPI establishes a common language and syntax across various types of instruments. It is easy to learn and easy to read. The SCPI command language is identical in all Cryo-con products so that 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.



The screenshot shows the Cryo-con Model 26 web interface in a Windows Internet Explorer browser window. The page title is "Cryo-con Model 26 Cryogenic Temperature Controller". The interface is divided into several sections:

- Status:** Displays the current temperature for four channels:
 - Ch A: Channel A: 261.212 K
 - Ch B: Channel B: 306.612 K
 - Ch C: Channel C: 352.012 K
 - Ch D: Channel D: 397.412 K
- Control Loops:** Shows the setpoint and heater status for each channel:
 - Channel A: 300.000K -Htr Off
 - Channel B: 100.000K -Htr Off
 - Channel C: 100.000K -Htr Off
 - Channel D: 100.000K -Htr Off
- Relays:** Shows the status of two relays:
 - Relay #1: Source: ChA Status: Auto Off
 - Relay #2: Source: ChB Status: Auto Off
- Instrument Status:** Displays the date and time: "Date: 08/01/2009 Time: 12:00:11".
- Technical Support:** Provides the model and version information: "Cryocon, Model 26,204376,1.10A".

Utility Software: Utility software is provided that connects any Windows based personal computer to the Model 26 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:** 6-pin recepticals provide 4-wire measurement connection plus a continuous shield through the backshell.
- **Thermocouple Option:** Connects to any of the input connectors. Up to 4 modules supported.
- **Loop #1:** 100-Watt heater output. Three-pin detachable terminal block.
- **Loop #2:** 50-Watt heater, part of a 10 pin detachable terminal block.
- **Loop #3 and #4:** 10 / 5.0-Volt output. Detachable terminal block.
- **Relay #1 and #2:** Dry contact relay. Detachable terminal block.
- **Ethernet:** RJ-45 with LAN activity indicator LEDs.
- **IEEE-488.2:** Option, connects to Ethernet port.
- **USB:** Host, serial port emulator.
- **AC Power:** RFI filtered Power Entry Module including fuse drawer and line voltage selector.

Ordering Information

Product	Description
Model 26	Controller with four multi-function sensor input channels and four control loops.
	Controller includes: User's Manual, Cryo-con software CD, four input connectors, heater connector, terminal block plug, detachable power cord and a certificate of calibration. Specify power cord when ordering: -120 Detachable USA power cord. -230 Detachable universal Euro (Shuko) line cord.

Options	Description
4039-005	Thermocouple Input Module. Field installable. Supports all thermocouple types. 
4001-002	IEEE-488.2 (GPIB) Option, field installable.

Accessories	Description
4026-016	Additional input connector kit consisting of four 6-pin circular input connectors.
4026-018	Additional output connector kit consisting of a 3-pin heater connector and a 10-pin terminal block receptacle.
4122-030	Single instrument 2U rack mount kit.
4034-031	Two instrument shelf rack mount kit
4034-032	One instrument shelf rack mount kit

Specifications

User Interface

Display Type: 240x64 graphics TFT LCD with LED back-light.
Number of Inputs Displayed: One to Four.
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 four 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 type: Ratio-metric resistance bridge.-
Bridge Modes: Constant-Current or Constant-Voltage. AC or DC.
AC Excitation: 7.5Hz bipolar square wave.
Voltage Excitation: 10mV. Minimum excitation current is 100nA, maximum is 2.5mA.
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 Configurations

Four user configurations 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: Four output ranges of 100W, 50W, 5.0W and 500mW.
Resolution: 5.0ppm of full-scale power (16 bits).
Readbacks: Heater output power, Heatsink temperature.
Connection: Detachable terminal block.

Loop #2 Heater Output

Short circuit protected linear current source.
Ranges: Three output ranges of 50W, 5.0W and 5.0W into 50Ω.
Resolution: 5.0ppm of full-scale power (16 bits).
Readbacks: Heater output power, Heatsink temperature.
Connection: Detachable terminal block.

Loop #3 and #4 Analog 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: 4.0ppm of full-scale power (16 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.
USB 2.0: serial port emulator. Data rates to 115,200 Baud.
IEEE-488.2 (GPIB): External Option, field installable.
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: 6 Lbs.
Power Requirement: 90–240VAC, 50-60Hz, 220VA.
Conformity: European CE certified.
Calibration: NIST traceable.

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