

# Cryogenic Temperature Monitors

## Models 18i / 14i / 12i



The Model 18i / 14i / 12i monitors are eight-, four- and two- channel cryogenic temperature monitors designed for use in laboratory and industrial control systems. These compact monitors include industrial grade security, distributed instrument protocols, user programmability, Power over Ethernet, internal data logging, and a large easy to read display.

## Highlights:

- **Eight, Four or Two** multipurpose input channels support Diode, Platinum RTD and most cryogenic NTC temperature sensors.
- Operation from **<500mK** to over **1,200K** with an appropriate sensor.
- Large, bright highly configurable TFT-LCD display.
- Two 10-Ampere dry-contact relay outputs.
- Flexible input power: Power over Ethernet or 10 - 30V AC/DC.
- Industrial grade security: Configurable **firewall**, **HTTPS encryption** and **authentication**.
- **User programmable.**
- Embedded **web 2.0 server** provides complete control, eliminates the need for external support software.
- Continuous **data logging** into internal memory.
- Remote interface is **Ethernet**. GPIB is a field installable option. LabView™ drivers available, LXI Discovery.
- Distributed instrument networks supported by an embedded **EPICS CA** server.
- Remote command language is IEEE-488.2 **SCPI** compliant, ensuring your system software will not become obsolete.

## Applications:

### Industrial Control Systems:

- Embedded Linux operating system for industrial grade security.
- Modbus protocol directly interfaces to most industrial Programmable Logic Controllers (PLCs).
- Embedded EPICS CA server.

### Cryogen-Free Systems:

- Up to eight input channels
- Two high current relay outputs

### General Purpose Laboratory:

- Supports virtually every type of cryogenic temperature sensor.
- Ethernet connectivity for ease of remote control.
- Temperature activated relays and alarms.
- Embedded **web 2.0 server** provides instrument status, control and configuration via a standard web browser, eliminates the need for external support software.

### Distributed Instrumentation:

- Ethernet facilitates separation of instruments over great distances. Power over Ethernet simplifies power distribution by providing power and data on a single cable.
- Built-in Embedded EPICS CA server supports large scale distributed instrumentation networks.

### Superconducting Magnets:

- Robust support for the NTC temperature sensors.
- Internal data logging to NV memory records time stamped data and survives power failure

### Data Acquisition / Computer Control:

- Secure Ethernet connection.
- Remote command language is IEEE-488 SCPI compliant protects your system software from obsolescence.
- LabView™ drivers for all remote interfaces

## Cryogenic Thermometry

The Model 18i has eight identical and independent input channels where the Model 14i has four and the 12i two. In every other way, the monitors are identical.

Each input is capable of supporting the same wide range of sensor types. They are not scanned or multiplexed.

**Negative-Temperature-Coefficient (NTC)** resistor sensors are often used as low temperature thermometers. Examples include **Ruthenium-oxide**, **Carbon-Glass**, **Cernox™**, **Carbon-Ceramic**, **Germanium** and several others. The Model 18i / 14i / 12i provides robust support for these sensors by using continuously variable constant-voltage AC excitation. In the warm region where these sensors have low resistance and low sensitivity, constant-voltage excitation will apply a higher 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 self-heating by reducing excitation current as temperature decreases.

Low temperature systems can also be negatively affected by coarse steps in excitation current. The Model 18i / 14i / 12i 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 constant-current, AC excitation. 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** and **GaAlAs diode** sensors are supported over their full temperature range by using 10µA constant-current DC excitation.

The Model 18i / 14i / 12i 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 monitor's built-in **CalGen®** feature. This provides an easy and effective method for obtaining higher accuracy temperature measurements without expensive sensor calibrations.

Model 18i / 14i / 12i Supported Sensors		
	Temperature Range	Example Sensors
<b>Silicon Diode</b>	1.4 - 500K	Cryo-con S950, S900 SI-440, 430, 410 Lakeshore DT-670, 470
<b>Platinum RTD</b>	14 - 1200K	Cryo-con CP-100 Cryo-con GP-100 Cryo-con XP-100 Cryo-con XP-1K
<b>Rhodium-Iron</b>	1.4 - 800K	Oxford PHZ 0002
<b>Germanium Thermistor</b>	500mK - 400K	AdSem, Inc.
<b>CLTS</b>	4 - 300K	Vishay CLTS-2B
<b>Silicon Thermistor</b>	1.0 - 720K	AdSem, Inc.
<b>Cernox™</b>	500mK - 325K	Lakeshore, all types
<b>Carbon-Ceramic</b>	500mK - 300K	Temati
<b>Ruthenium Oxide</b>	500mK - 270K	SI RO-600
<b>GaAlAs diode</b>	1.4K - 500K	Lakeshore TG-120
<b>Thermistor</b>	193 - 523K	Measurement Specialties

**Input Channel Statistics:** The Model 18i / 14i / 12i 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.

Input Specifications			
	Diode sensors	PTC resistor sensors	NTC resistor sensors
<b>Input Configuration</b>	Constant-Current DC	Constant-Current AC	Constant-Voltage AC
<b>Input Range</b>	0.1 – 2.50V 0.1 – 7.10V	1.0mA: 0.1 - 450Ω 100µA: 1.0 – 4.5KΩ	Minimum: 5Ω Maximum: 100KΩ
<b>Accuracy:</b> % Rdg ± % Range	0.005% ± 80µV	0.01% ± 0.004Ω 0.02% ± 0.04Ω	14 – 30KΩ: 0.05% ± 0.05% 4 – 100KΩ: 0.15% ± 0.15%
<b>Resolution:</b> % Range	10µV	2mΩ 20mΩ	0.0003%
<b>Excitation</b>	10µA DC	1.0mA, 100µA	10mV, AC, Step-less 1.25mA to 100nA

## Easy to use

The monitor's front panel consists of a large, bright TFT-LCD display, a 4-key keypad, an audio alarm and three status LEDs.

Several display formats may be selected. Up to eight temperature readings may be displayed simultaneously or two channels with input names and temperature shown in a large easy to read font. Additional screens include temperature readings along with relay and alarm status information.

A single key press takes the screen to a menu tree where most features and functions of the instrument can be configured.

A:	263.000	K	--
B:	271.322	K	Hi
C:	279.643	K	--
D:	287.964	K	--
E:	296.285	K	--
F:	304.606	K	Lo
G:	312.928	K	--
H:	321.249	K	Lo

A:	Sample Holder	123.456K
B:	Rad. Shield	234.567K

## Input Power

The monitor is shipped with a 12VDC@1A external power supply but may be powered by any source providing 10 to 30 Volts AC or DC.

The IEEE 802.3af Power over Ethernet (PoE) specification is also supported, allowing the monitor to be powered by it's local area network connection. Since PoE provides both instrument power and data over a single cable, remote data acquisition and high channel count systems can be simplified. PoE requires the use of a powered hub.

## Alarms and Relays

Two 10A dry-contact relay outputs can be asserted based on temperature setpoints from user selected input channels.

Visual, remote and audible alarms are supported. Each may be programmed to assert or clear based on temperature setpoints.

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

## Remote Control

The standard interface for remote control is Ethernet. GPIB is a field installable option.

**TCP** and **UDP** data port servers bring fast Ethernet connectivity to data acquisition software including LabView™.

Remote interfaces implement an IEEE-488.2 SCPI compliant remote command language that is easy to read and learn.

**LabView™** drivers are available for all remote interfaces. LXI Discovery supported.

## Security

Use of the embedded Linux operating system provides the Model 18i / 14i / 12i monitors with industrial grade security. A built-in, user configurable firewall protects the instrument from unauthorized transactions. HTTP Digest access authentication protects the web server. HTTPS provides authenticated, encrypted communication.

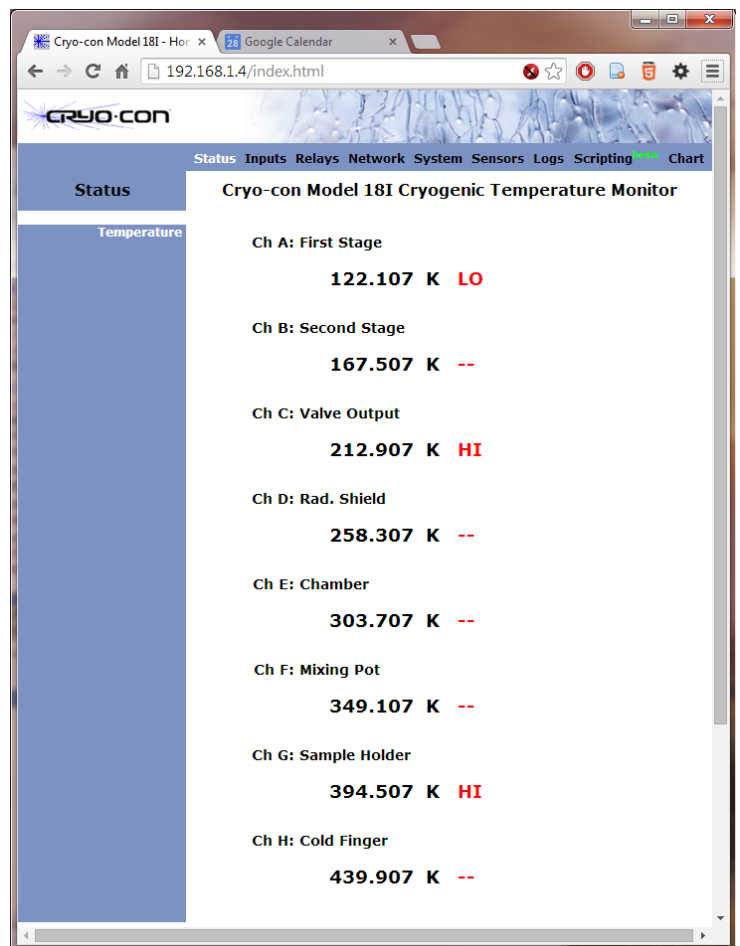
## Modbus

Modbus/TCP is an open industrial automation protocol that allows the Model 18i / 14i / 12i to interface directly to most Programmable Logic Controllers using the TCP interface. As a Modbus client, the monitor reports temperature data as well as alarm and relay status.

## EPICS CA Server

The Experimental Physics and Industrial Control System (EPICS) is a set of open source software tools that are used to create distributed real-time control systems for large scale scientific and industrial applications.

To support these applications, the Model 18i / 14i / 12i implements a Channel Access server based on EPICS R3.15.



## Data logging

Data Logging is performed by continuously recording temperature and status to an internal 2-Gigabyte memory buffer. Data is time stamped so that the actual time of an event can be determined. Non-volatile memory is used so that data will survive a power failure.

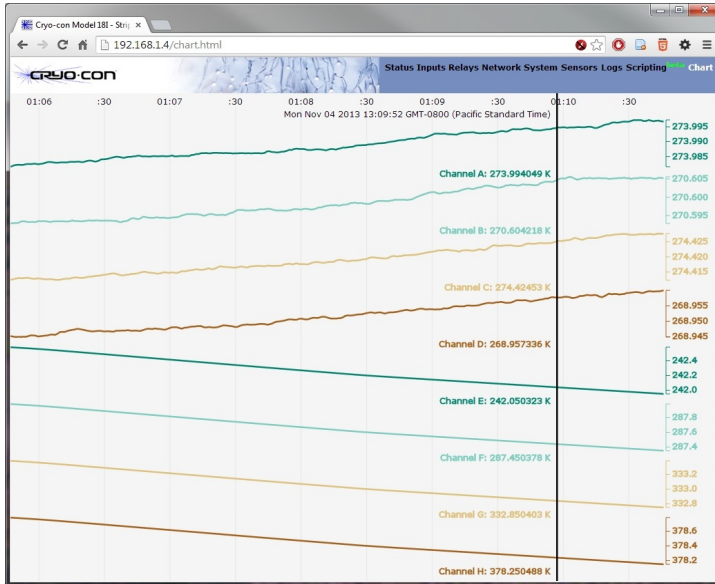
## Web 2.0 Server

Using secure Ethernet **HTTPS** protocol, the monitor's **embedded web server** provides complete instrument control and configuration without the need for external platform-dependent software.

Instrument status can be viewed in real time and configured from any web browser.

Custom sensor calibration tables and data-logging files may be uploaded or downloaded.

Instrument firmware updates may be installed. Updates are free of charge and generally include enhancements and new features.



## User Programmable

The Model 18i / 14i / 12i can be programmed by the user using the IPython scripting language. All functions of the instrument are available to the programming interface and are executed as standard remote commands.

The screenshot shows an IPython Notebook interface in a web browser. The browser address bar shows the URL: 192.168.1.4/ipython/846406ec-44ad-497b-ae91-a3ba2f78. The notebook title is 'IP[y]: Notebook IDN World (autosaved)'. The interface includes a menu bar (File, Edit, View, Insert, Cell, Kernel, Help) and a toolbar with icons for file operations and execution. A code cell contains the following Python code:

```
In [2]: from scp import Instrument
with Instrument() as i:
    print i.ask("*IDN?")
```

The output of the code cell is: 

```
Cryocon,Model 18I,209993,2.00A
```

Python is a robust scripting language that includes conditional execution, loops and time delays.

Scripts are developed and debugged within the web browser.

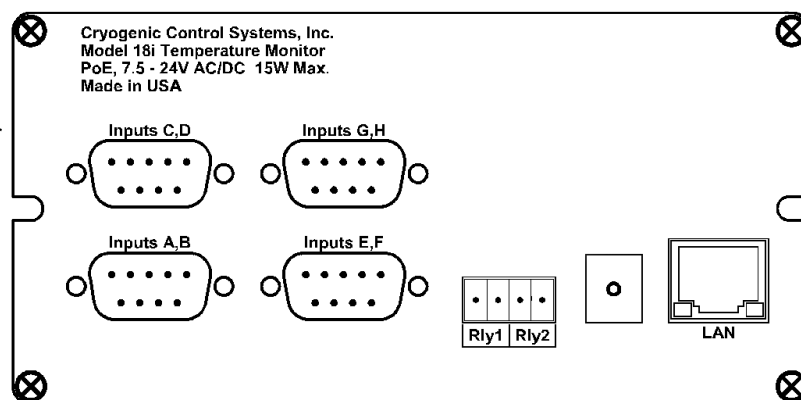
## Ordering Information

Part Number	Description
<b>Model 18i</b>	Eight-channel monitor. Includes 12VDC external power supply.
<b>Model 14i</b>	Four-channel monitor. Includes 12VDC external power supply.
<b>Model 12i</b>	Two-channel monitor. Includes 12VDC external power supply.
<b>4001-002</b>	IEEE-488.2 (GPIB) Option, field installable.
<b>05-0007</b>	International version of the external 12V power supply including multi-blade kit.
<b>3012-020</b>	Panel Mount hardware kit.



## Rear panel connections

- **Input Connectors:** Four DB-9 recepticals provide 4-wire measurement for two sensors each.
- **LAN:** Standard RJ-45 Ethernet connector. Power over Ethernet connection, GPIB Option.
- **Power input:** 10 to 30V AC/DC.
- **Relays:** 4-pin detachable terminal block.



## Specifications

### Input Channels

The Model 18i has eight input channels and the 14i has four and the 12i has two. All are identical and independent, each capable of supporting a wide range of sensor types.

**Sensor Connection:** 4-wire differential. DB9 Connectors.

**Sensor Types:** See Supported Sensor Table.

**Sensor Selection:** Front Panel or remote interface.

**Input Configurations:** See input specifications table.

**Excitation Modes:** Constant-Current or Constant-Voltage.

**AC Excitation Frequency:** 1.625Hz bipolar square wave.

**Voltage Excitation:** 10mV. Minimum excitation current is 100nA, maximum is 1.25mA.

**Sample Rate:** 15Hz per channel, all modes.

**Digital Resolution:** 24 bits.

**Measurement Accuracy:** See input specifications table.

**Measurement Drift:** 30ppm/°C.

**Isolation:** Input channels are not isolated.

**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.

### User Interface

**Display Type:** Graphics TFT LCD, 4mm and 8mm character height.

**Number of Inputs Displayed:** Up to 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:** Up to seven significant digits.

### Data Logging

Time stamped temperature data can be logged into an internal 2-Gigabyte buffer. Memory is non-volatile and will retain valid data during loss of power. All eight input channel temperatures are recorded and time stamped.

### Status Outputs

**Audible and Visual Alarms:** Independent audible, remote and visual alarms. Alarms can be latched.

**Relays:** Two dry-contact relays. N.O. contacts.

**Modes:** Manual, Auto and fail-safe.

**Contact ratings:** 10A@125VAC or 5A@30VDC.

### User Programs

The instrument is programmed using the IPython scripting language. Instrument interface implemented using standard SCPI commands. Language documentation available at [ipython.org](http://ipython.org).

### Remote Interfaces

Maximum reading rate for all interfaces is 10 rdg/s.

**Ethernet:** Connects to any Ethernet Local Area Network.

Electrically isolated. **TCP** and **UDP** servers provide remote control by using an ASCII command language. **HTTP** provides built-in web server. **SMTP** sends e-mail.

**IEEE-488.2 (GPIB):** External Option, field installable.

**Programming Language:** IEEE-488.2 SCPI compatible.

**Modbus:** Full implementation of the open Modbus/TCP industrial automation protocol.

**LabVIEW™** drivers available for all interfaces.

### General

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

**Mechanical:** 5.6"W x 2.9"H x 8.8"D. **Weight:** 3.5 Lbs.

**Power Requirement:** IEEE-802.3af Power over Ethernet or 10 - 30V AC/DC. (External power supply included) 24VA.

**AC Power Switch:** Front panel.

**Approval:** CE mark, RoHS

**Calibration:** NIST traceable.



### Architecture

**Microprocessor:** 32-bit ARM9, 450Mhz.

**OS:** Embedded Linux, Kernel version 4.5.



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