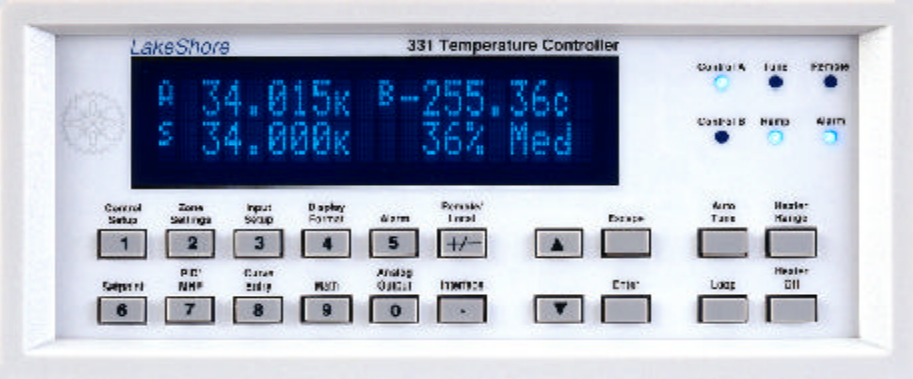
Model 331 Temperature Controllers

- **Two sensor inputs**
- **Supports diodes, NTC/PTC RTDs, and thermocouples**
- **Current reversal for NTC/PTC RTDs**
- **Two control loops**
- **IEEE-488 and RS-232 interfaces**
- **Alarms, relays, and analog voltage output**
- **Autotuning**
- **Model 330 command emulation mode**



Product Description

Intelligently designed and well-integrated for high performance and ease of use, the Model 331 Temperature Controllers are suitable for most cryogenic and many higher temperature measurement and control applications. The Model 331 Temperature Controllers combine the easy operation and unsurpassed reliability of the Model 330 with improved sensor input and interface flexibility, including compatibility with negative temperature coefficient (NTC) RTDs. Backed by Lake Shore's tradition of excellence in cryogenic sensors and instrumentation, the Model 331 Temperature Controllers set the standard for mid-price range temperature control instruments.

The Model 331 Temperature Controllers are available in two versions. The Model 331S is fully equipped for interface and control flexibility. The Model 331E shares measurement and display capability with the Model 331S, but does not include the IEEE-488 interface, relays, analog voltage output, or a second control loop. The purchaser's choice of Model 331S or 331E must be specified at time of order and cannot be reconfigured in the field.

Sensor Inputs

The Model 331 Temperature Controllers are designed for high performance with sensors across the 1.4 to over 1000 K temperature range and in difficult sensing conditions, including magnetic fields. The Model 331 Temperature Controllers feature two inputs, with a high-resolution 24-bit analog-to-digital converter and separate current source for each input. Sensors are optically isolated from other instrument functions for quiet and repeatable sensor measurements. Sensor data from each input can be read up to ten times per second, with display updates twice each second.

Standard temperature response curves for silicon diodes, platinum RTDs, and many thermocouples are included. Up to twenty 200-point CalCurves™ for Lake Shore calibrated sensors or user curves can be loaded into non-volatile memory *via* computer interface or the instrument front panel. A built-in SoftCal™ algorithm can also be used to generate curves for silicon diodes and platinum RTDs, for storage as user curves.

Temperature Control

The Model 331E offers one and Model 331S two proportional-integral-derivative (PID) control loops. A PID control algorithm calculates control output based on temperature setpoint and feedback from the control sensor. Wide tuning parameters accommodate most cryogenic cooling systems and many small high temperature ovens. Control output is generated by a high-resolution digital-to-analog converter for smooth continuous control. The first control loop drives heater output. Both versions also include manual control mode.

Heater output for the Models 331S and 331E is a well-regulated variable DC current source. Heater output is optically isolated from other circuits to reduce interference and ground loops. Heater output can provide up to 50 W of continuous power as resistive heater load and includes two lower ranges for systems with less cooling power. Heater output is short circuit protected to prevent instrument damage if the heater load is accidentally shorted.

The setpoint ramp feature allows smooth continuous changes in setpoint and can also make the approach to a setpoint temperature more predictable. The zone feature can automatically change control parameter values for operation over a large temperature range; values for ten different temperature zones can be loaded into the instrument, which will select the next appropriate value on setpoint change.

Interface

Model 331E is equipped with a serial RS-232C interface, while Model 331S includes serial RS-232C and parallel IEEE-488 interfaces. Maximum reading rate can be achieved with either interface. The most frequently used functions can be accomplished from the instrument front panel with one or two keystrokes. Nearly every function on the instrument front panel can also be performed *via* computer interface. Both versions include Model 330 command emulation mode for drop-in interchangeability with Model 330 temperature controllers in existing systems.

High and low alarms for each input can be used in latching mode, requiring user intervention before alarms reset. For the Model 331S, alarms can also be used in conjunction with relays in non-latching mode, where alarms automatically reset when the activation condition ends, to perform simple on-off control functions. Relay assignments are configurable so that one relay may be assigned to each input or both assigned to a single input for high/low control.

The Model 331S's analog voltage output can be configured to send a voltage proportional to temperature to a strip chart recorder or data acquisition system. The user may select the scale and data sent to the output, including temperature, sensor units, or linear equation results. Under manual control, the analog voltage output can also serve as a voltage source for any other application.

Model 331 Sensor Input Performance

Sensor Type	Silicon Diode	GaAlAs Diode	100 Ω Platinum RTD 500 Ω Full scale	1000 Ω Platinum RTD	Rox™	Thermox™	Carbon-Glass™	Cernox™	Thermocouple 25 mV	Thermocouple 50 mV
Temperature Coefficient	Negative	Negative	Positive	Positive	Negative	Negative	Negative	Negative	Positive	Positive
Sensor Units	Volts (V)	Volts (V)	Ohms (Ω)	Ohms (Ω)	Ohms (Ω)	Ohms (Ω)	Ohms (Ω)	Ohms (Ω)	mV	mV
Input Range	0 - 2.5 V	0 - 7.5 V	0 - 500 Ω	0 - 5000 Ω	0 - 7500 Ω	0 - 7500 Ω	0 - 7500 Ω	0 - 7500 Ω	±25 mV	±50 mV
Sensor Excitation (Constant Current with Current Reversal)	10 µA ±0.05%	10 µA ±0.05%	1 mA	1 mA	10 µA±0.05%	10 µA±0.05%	10 µA±0.05%	10 µA ±0.05%	Not applicable	Not applicable
Display Resolution Sensor Units	100 µV	100 µV	1 0 mΩ	10 0 mΩ	10 0 mΩ	10 0 mΩ	10 0 mΩ	100 mΩ	1 uV	1 uV
Example LSCI sensor	DT-470-CO-13 with 1.4H calibration	TG-120-SD with 1.4H calibration	PT-103 with 14J calibration	PT-1001(1) with 1.4G calibration	RX-102A-AA with 0.3E calibration	TX-104-GB with 70L calibration	CGR-1-500 with 1.4L calibration	CX-1050-SD with 1.4L calibration	Chromel-AuFe 0.07%	Type K
Standard Curve	LSCI Curve 10	Requires calibrated sensor	DIN 43760	Scaled from DIN 43760	Requires calibrated sensor	Requires calibrated sensor	Requires calibrated sensor	Requires calibrated sensor	By type	By type
Typical Sensor Sensitivity(2)	-33.6 mV/K at 4.2 K -1.9 mV/K at 77 K -2.4 mV/K at 300 K -2.2 mV/K at 475 K	-210 mV/K at 4.2 K -1.25 mV/K at 77 K -2.85 mV/K at 300 K -3.15 mV/K at 475 K	0.19 Ω/K at 30 K 0.42 Ω/K at 77 K 0.39 Ω/K at 300 K 0.36 Ω/K at 800 K	1.9 Ω/K at 30 K 4.2 Ω/K at 77 K 3.9 Ω/K at 300 K 3.6 Ω/K at 800 K	-80 Ω/K at 4.2 K -4 Ω/K at 20 K -1.06 Ω/K at 40 K	-485 Ω/K at 105 K -0.84 Ω/K at 200 K -0.037 Ω/K at 300 K	-422.3 Ω/K at 4.2 K -0.098 Ω/K at 77 K -0.0094Ω/K at 300 K	-2290 Ω/K at 4.2K -2.15 Ω/K at 77K -0.131 Ω/K at 300K	12.6 uV/K at 4.2 K 22.4 uV/K at 300 K	0.92 uV/K at 4.2 K 40 uV/K at 300 K 36 uV/K at 1500 K
Measurement Resolution: Sensor Units Temperature Equivalents	10 µV 0.3 mK at 4.2 K 5.5 mK at 77 K 4.2 mK at 300 K 4.5 mK at 475 K	20 µV 0.1 mK at 4.2 K 16.0 mK at 77 K 7.1 mK at 300 K 6.3 mK at 475 K	2 mΩ 10.6 mK at 30 K 4.8 mK at 77 K 5.2 mK at 300 K 5.6 mK at 800 K	20 mΩ 11 mK at 30 K 4.8 mK at 77 K 5.2 mK at 300 K 5.6 mK at 800 K	40 m Ω <1 mK at 4.2 K 10 mK at 20 K 38 mK at 40 K	40 m Ω <1 mK at 105 K 48 mK at 200 K 1.081K at 300 K	40 m Ω <1 mK at 4.2 K 408 mK at 77 K 4.255 K at 300 K	40 mΩ <1 mK at 4.2 K 18.6 mK at 77 K 305 mK at 300 K	0.4 uV 32 mK at 4.2 K 18 mK at 300 K	0.4 uV 435 mK at 4.2 K 10 mK at 300 K 11 mK at 1500 K
Electronic Accuracy: Sensor Units Temperature Equivalents	±80 µV ±0.005% RDG ±5 mK at 4.2 K ±70 mK at 77 K ±45 mK at 300 K ±40 mK at 475 K	±80 µV ±0.01% RDG ±3 mK at 4.2 K ±180 mK at 77 K ±60 mK at 300 K ±38 mK at 475 K	±0.004 Ω±0.01% RDG ±23 mK at 30 K ±14 mK at 77 K ±39 mK at 300 K ±95 mK at 800 K	±0.04 Ω±0.02% RDG ±25 mK at 30 K ±19 mK at 77 K ±67 mK at 300 K ±172 mK at 800 K	±0.10 Ω±0.04% RDG ±8.1 mK at 4.2 K ±134 mK at 20 K ±491 mK at 40 K	±0.10 Ω±0.04% RDG ±4.8 mK at 105 K ±131 mK at 200 K ±2.729 K at 300 K	±0.10 Ω±0.04% RDG <1 mK at 4.2 K ±1.078 K at 77 K ±11.00 K at 300 K	±0.10 Ω±0.04% RDG ±1 mK at 4.2 K ±77 mK at 77 K ±881 mK at 300 K	(3) ±1 uV ±0.05% RDG ±288 mK at 4.2 K ±58 mK at 300 K	(3) ±1 uV ±0.05% RDG ±4.6 K at 4.2K ±38 mK at 300K ±722 mK at 1500K
Temperature Accuracy including electronic accuracy, CalCurve, and calibrated sensor	±26 mK at 4.2 K ±125 mK at 77 K ±105 mK at 300 K ±100 mK at 475 K	±20 mK at 4.2 K ±255 mK at 77 K ±180 mK at 300 K ±123 mK at 475 K	±48 mK at 30 K ±39 mK at 77 K ±84 mK at 300 K ±195 mK at 800 K	±50 mK at 30 K ±44 mK at 77 K ±112 mK at 300 K ±272 mK at 800 K	±24.1 mK at 4.2 K ±238 mK at 20 K ±705 mK at 40 K	±32 mK at 105 K ±171 mK at 200 K ±2.800 K at 300 K	±7 mK at 4.2 K ±1.138 K at 77 K ±11.46 K at 300 K	±8 mK at 4.2 K ±127 mK at 77 K ±1.031 K at 300 K	Calibration not available from Lake Shore	Calibration not available from Lake Shore
Control Stability: Sensor Units Temperature Equivalents	±20 µV ±0.6 mK at 4.2 K ±11 mK at 77 K ±8.4 mK at 300 K ±9 mK at 475 K	±40 µV ±0.2 mK at 4.2 K ±32 mK at 77 K ±14 mK at 300 K ±13 mK at 475 K	±4 mΩ ±22 mK at 30 K ±9.5 mK at 77 K ±10 mK at 300 K ±11 mK at 800 K	±40 mΩ ±22 mK at 30 K ±9.5 mK at 77 K ±10 mK at 300 K ±12 mK at 800 K	±80 mΩ ±1 mK at 4.2 K ±20 mK at 20 K ±76 mK at 40 K	±80 mΩ ±1mK at 105 K ±96 mK at 200 K ±2.162 K at 300 K	±80 mΩ ±1 mK at 4.2 K ±816 mK at 77 K ±8.510 K at 300 K	±80 mΩ ±1mK at 4.2 K ±38 mK at 77 K ±610 mK at 300 K	±0.8 uV 64 mK at 4.2 K 36 mK at 300 K	±0.8 uV 870 mK at 4.2 K 20 mK at 300 K 22 mK at 1500 K
Magnetic Field Use	Recommended for T ≥ 60 K & B ≤ 3 T	Recommended for T > 4.2 K & B ≤ 5 T	Recommended for T > 40 K & B ≤ 2.5 T	Recommended for T > 40 K & B ≤ 2.5 T	Recommended for T > 2 K & B ≤ 10 T	Not Recommended	Recommended for T > 2 K & B ≤ 19 T	Recommended for T > 2 K & B < 19 T	Recommended for T > 2 K & B < 19 T	Not Recommended

(1) No longer available from Lake Shore.

(2) Typical sensor sensitivities were taken from representative calibrations for the sensor listed.

(3) Accuracy specification does not include errors from room temperature compensation.

Factory-Configured Inputs

Sensor inputs for both versions of the Model 331 are factory configured and compatible with either diode/RTDs or thermocouple sensors. The purchaser's choice of two diode/RTD inputs, one diode/RTD input and one thermocouple input, or two thermocouple inputs must be specified at time of order and cannot be reconfigured in the field. Software selects appropriate excitation current and signal gain levels when sensor type is entered *via* the instrument front panel.

The Diode/RTD input configuration is compatible with most diode and negative and positive temperature coefficient RTDs. Current reversal eliminates thermal EMF voltage errors for resistor sensors.

The Thermocouple input configuration is compatible only with thermocouple sensors. Room temperature compensation is included for any type of thermocouple in use. Appropriate temperature response curves for many types of thermocouples are included; temperature response curves may be entered as user curves for other thermocouples.

Sensor Selection Guide

For more information, see Lake Shore's Temperature Measurement and Control Catalog.

Silicon diodes are the best choice for general cryogenic use from 1.4 K to above room temperature. Economical to use because they follow a standard curve and are interchangeable in many applications, silicon diodes are not suitable for use in ionizing radiation or magnetic fields.

GaAlAs diodes offer high sensitivity from 1.4 K to above room temperature, with better sensitivity than silicon diodes at temperatures below 25 K. They are useful in moderate magnetic fields. GaAlAs diodes require calibration.

Platinum RTDs offer high uniform sensitivity from 30 to over 800 K; with excellent reproducibility, they are useful as thermometry standards. They follow a standard curve above 70 K and are interchangeable in many applications, but are not useful at cryogenic temperatures below 20 K.

Rhodium-Iron RTDs offer high stability and high resistance to ionizing radiation across a wide temperature range from 1.4 to 400 K, with a linear response above 100 K. They are not recommended for use in magnetic fields below 77 K. Rhodium-Iron RTDs require calibration.

Cernox™ and High Temperature Cernox™ RTDs offer excellent sensitivity at low cryogenic temperatures, with resistance to strong magnetic fields and ionizing radiation. Sensitivity decreases at higher temperatures. Cernox™ sensors require calibration.

Rox™ RTD thick film sensors are useful in low temperature applications in magnetic fields, with a very low incidence of magnetic field errors. Each model adheres to a single resistance *versus* temperature curve. The Rox™ Models RX-102A and RX-202A are useful to temperatures as low as 50 mK, with accuracy to within ±5 mK at 50 mK; the RX-202A also offers an upper temperature range to 300 K.

Thermocouples offer uniform sensitivity over a wide temperature range and measure the highest temperatures possible with the Model 331 Temperature Controllers. While many types are inexpensive and standard curves are available, thermocouples are less accurate than other sensors; repeatability is highly dependent upon installation.

Model 331 Temperature Range with Lake Shore Sensors*

Diodes	Model	Useful Range
Silicon Diode	DT-470	1.4 - 475 K
GaAlAs Diode	TG-120	1.4 - 475 K
Positive Temperature Coefficient RTDs		
100 Ω Platinum	PT-100	30 - 800 K
Rhodium-Iron	RF-800-4	1.4 - 400 K
Negative Temperature Coefficient RTDs		
Germanium	GR-200A-1000	2 - 100 K
Germanium	GR-200A-250	1.2 - 40 K
Carbon Glass™	CGR-1-500	3 - 325 K
Cernox™	CX-1050 AA or SD	3.5 - 325 K
Cernox™	CX-1030 AA or SD	2 - 325 K
High Temperature Cernox™	CX-1030 AA or SD	2 - 420 K
Rox™	RX-102A	2 - 40 K
Rox™	RX -202A	3 - 40 K
Thermox™	TX-104-GB	110 - 325 K
Thermocouples		
Type K	9006-006	3.2 - 1500 K
Type E	9006-004	3.2 - 930 K
Type T	9006-008	3.2 - 670 K
Chromel-AuFe 0.07%	9006-002	1.4 - 610 K

Single excitation current may limit the low temperature range of NTC resistors.

* Sensors sold separately

Model 331S Rear Panel Connections

1 - Line input assembly

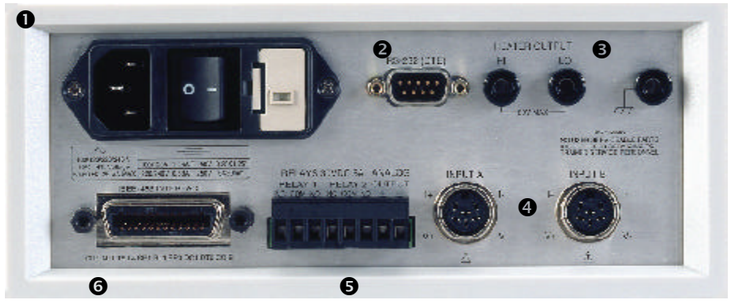
2 - Serial I/O interface

3 - Heater output

4 - Sensor input connectors

5 - Terminal block (for relays and analog output)

6 - IEEE-488 interface



Interface Features of Models 331S and 331E

Feature	331S	331E
Numeric keypad	*	*
Front panel curve entry	*	*
Alarms	*	*
Serial interface	*	*
IEEE-488 interface	*	
Two control loops	*	
Analog voltage output	*	
Relays	*	

Autotuning

The Model 331S and 331E autotuning feature automates the tuning process. With its own measurements of system characteristics and based on characteristics of typical cryogenic systems, the autotuning function computes proportional, integral, and derivative setting values. On the Model 331S, the autotune function tunes one control loop at a time. Because setting an inappropriate heating range is potentially dangerous to some loads, the Model 331S and 331E autotuning feature does not attempt to automate that step of the tuning process.

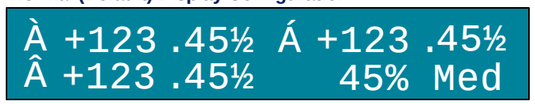
SoftCal™

Lake Shore's SoftCal™ algorithm for silicon diode and platinum RTD sensors is a good solution for applications that need more accuracy than a standard sensor curve but not traditional calibration. SoftCal™ uses the predictability of a standard curve to improve an individual sensor's accuracy around a few known temperature reference points. Both versions of the Model 331 generate SoftCal™ curves.

Configurable Display

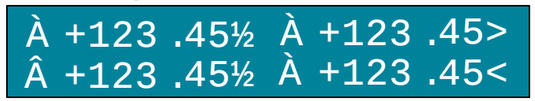
Both versions of the Model 331 include a bright vacuum fluorescent display that simultaneously displays up to four readings. Display data includes input and source annunciators for each reading. All four display locations can be configured by the user. Data from either input may be assigned to any of the four locations; the user's choice of temperature, sensor units, and maximum, minimum, or linear equation results can be displayed. Heater range and control output as current or power can also be continuously displayed for immediate feedback on control operation.

Normal (Default) Display Configuration



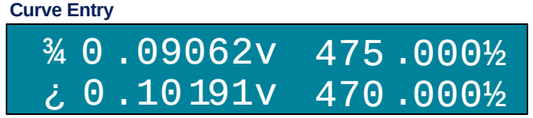
The two line by twenty character vacuum fluorescent display provides four reading locations. Readings from each input and the control setpoint can be expressed in any combination of temperature or sensor units, with heater output expressed as a percent of full scale current or power for the selected heater range.

Flexible Configuration



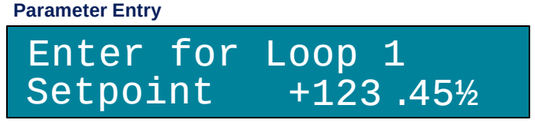
Reading locations can be configured by the user to meet application needs. This example shows the live reading from input A, the control setpoint, and maximum and minimum readings captured by the instrument's math feature. Character preceding the reading indicates input A or B or setpoint S. Character following the reading indicates measurement units or the math function in use.

Curve Entry



The Model 331 display offers the flexibility to support curve, SoftCal™, and zone entry. Although less expedient than curve entry *via* computer interface, curve entry may be performed accurately and to full resolution *via* the display and keypad, as shown.

Parameter Entry



Fields for parameter entry are accessed *via* the keypad and display. This example shows the parameter entry prompt for the first control loop setpoint, with setpoint units in Kelvin.

Model 331 Specifications

Thermometry

Number of Inputs: 2

Input Configuration: Each input is factory configured for either diode / RTD or thermocouple

	Diode / RTD	Thermocouple
Measurement Type:	Four-lead differential with current reversal	Two lead, room temperature compensated
Excitation:	Constant current	NA
Supported Sensors:	Diodes: Silicon, GaAlAs RTDs: 100 Ω Platinum, 1000 Ω Platinum, Germanium,Carbon-Glass, Cernox™, Rox™, Thermox™	Most thermocouple types
Standard Curves:	DT-470, DT-500D, DT-600, PT-100, PT-1000, RX-102A, RX-202A	Type E, Type K, Type T, AuFe 0.07% Vs CH, AuFe 0.03% Vs CH
Input Connector:	6-pin DIN	Ceramic isothermal block

Isolation: Sensor inputs optically isolated from other circuits but not each other

A/D Resolution: 24 bit

Input Accuracy: Sensor dependent; see Sensor Input Performance chart

Measurement Resolution: See Sensor Input Performance chart

Maximum Update Rate: 10 readings/s on each input (except 5 readings/s on input A when configured as thermocouple)

User Curves: Room for 20 200-point CalCurves or user curves

SoftCal: Improves accuracy of DT-470 diode to ±0.25 K from 30 K to 375 K. Improves accuracy of Platinum RTDs to ±0.25 K from 70 K to 325 K. Stored as user curves

Math: Maximum, Minimum, and Linear Equation (Mx + B) or M(x+B)

Filter: Averages 2 to 64 input readings

Control

Control Loops: 2 on 331S, 1 on 331E

Control Type: Closed loop digital PID with Manual Heater or open loop

Tuning: AutoTune (one loop at a time), PID, PID zones

Control Stability: Sensor dependent; see Sensor Input Performance chart

PID Control Parameters:

- Proportional (Gain): 0 – 1000 with 0.1 setting resolution
- Integral (Reset): 1 – 1000 (1000/s) with 0.1 setting resolution
- Derivative (Rate): 1 – 200% with 1% resolution
- Manual Heater: 0 – 100% with 0.01% setting resolution

Zone Control: 10 temperature zones with P, I, D, Manual Heater, and Heater Range

Setpoint Ramping: 0.1 to 100 K/min

Protection: Curve temperature limits, power up heater off, short circuit protection

	Loop 1	Loop 2
Heater Output Type:	Variable DC current source	Variable DC voltage source
Heater Output D/A Resolution:	18 bit	16 bit
Max Heater Power:	50 W	1 W
Max Heater Output Current:	1 A	0.1 A
Heater Output Compliance:	50 V	10 V
Heater Output Ranges:	3 decade steps in power	1
Heater Load Type:	Resistive	Resistive
Heater Load Range:	10 Ω to 100 Ω recommended	100 Ω minimum
Heater Load for Max Power:	50 Ω	100 Ω
Heater Noise (<1 kHZ) RMS:	50 µV + 0.01% of output voltage	< 0.3 mV
Isolation:	Optical isolation between output and other circuits	None
Heater Connector:	Dual banana	Detachable terminal block

Loop 1 Full Scale Heater Power at Typical Resistance

Heater Resistance	Heater Range	Heater Power
10 Ω	Low Med High	100 mW 1 W 10 W
25 Ω	Low Med High	250 mW 2.5 W 25 W
50 Ω	Low Med High	500 mW 5 W 50 W

Front Panel

Display: 2 line by 20 character, 9 mm character height, vacuum fluorescent display

Number of reading displays: 1 to 4

Display Units: K, °C, V, mV, Ω

Reading Source: Temperature, sensor units, max, min, and linear equation

Display Update Rate: All readings twice per second

Temperature Display Resolution: 0.001˚ between 0˚ - 99.999˚, 0.01˚ between 100˚ - 999.99˚, 0.1˚ above 1000˚

Sensor Units Display Resolution: Sensor dependent, to 5 digits

Other Displays: Setpoint, Heater Range, and Heater Output (user selected)

Setpoint Setting Resolution: Same as display resolution (actual resolution is sensor dependent)

Heater Output Display: Numeric display in percent of full scale for power or current

Heater Output Resolution: 1%

Display Annunciators: Control Input, Remote, Alarm, Tuning, Ramp, Max, Min, Linear

Keypad: 20 full travel keys, numeric and specific functions

Front Panel Features: Front panel curve entry, display brightness control, keypad lock-out

Interface

IEEE-488 Interface (331S)

- Features: SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT0, C0, E1
- Reading Rate: To 10 readings/s on each input
- Software Support: LabView driver (consult factory for availability)

Serial Interface

- Electrical Format: RS-232C
- Max Baud Rate: 9600 BAUD
- Connector: DE-9
- Reading Rate: To 10 readings/s on each input (at 9600 baud)

Special Interface Features: Model 330 command emulation mode

Alarms

- Number: 4, high and low for each input
- Data Source: Temperature, Sensor Units, Linear Equation
- Settings: Source, High Setpoint, Low Setpoint, Deadband, Latching or Non-Latching, Audible On/Off
- Actuators: Display annunciator, beeper, relays

Relays (331S)

- Number: 2
- Contacts: Normally Open (NO), Normally Closed (NC), and Common (C)
- Contact Rating: 30 VDC at 5 A
- Operation: Activate relays on high, low, or both alarms for either input or manual
- Connector: Detachable terminal block

Analog Voltage Output (331S)

- Scale: User selected
- Update Rate: 10 readings per second
- Data Source: Temperature, Sensor Units, Linear Equation
- Settings: Input, source, top of scale, bottom of scale, or manual
- Range: ±10 V
- Resolution: 0.3 mV
- Accuracy: ±2.5 mV
- Minimum Load Resistance: 100 Ω (short circuit protected)

General

Ambient Temperature: 15 - 35 ˚C at rated accuracy. 10 - 40 ˚C at reduced accuracy

Power Requirement: 100, 120, 220, 240 VAC, +5% -10%, 50 or 60 Hz, 120 VA

Size: 217 mm W x 90 mm H x 317 mm D (8.5" x 3.5" x 14.5"), half rack

Weight: 4.77 kg (10.5 lbs)

Ordering Information

Part number	Description (Input configuration cannot be changed in the field.)
Standard Temperature Controllers, all features included	
331S	Two Diode / Resistor Inputs
331S-T1	One Diode / Resistor Input, One Thermocouple Input
331S-T2	Two Thermocouple Inputs
Economy Temperature Controllers, all features of the 331S are included except IEEE-488 interface, relays, analog voltage output, and a second control loop	
331E	Two Diode / Resistor Inputs
331E-T1	One Diode / Resistor Input, One Thermocouple Input
331E-T2	Two Thermocouple Inputs
Accessories included	
115-006	Detachable 120 VAC line cord
106-233	Sensor input mating connector (6-pin DIN plugs)
106-009	Heater output connector (dual banana jack)
106-739	Terminal block, 8-pin
MAN-331	User's manual
Options	
8001	CalCurve™, Factory Installed. Consists of the breakpoint table from a calibrated sensor stored in the instrument.
8002-05	CalCurve™, Field Installed. Consists of the breakpoint table from a calibrated sensor loaded into a nonvolatile memory for customer installation
Accessories available	
4005	1 meter (3.3' long) IEEE-488 (GPIB) computer interface cable assembly. Includes extender required for simultaneous use of IEEE cable and relay terminal block
RM-1/2	Rack mount kit for mounting one 1/2 rack temperature controller in 482.60 mm (19") rack, 90 mm (3.5") high
RM-2	Rack mount kit for mounting two 1/2 rack temperature controllers in 482.60 mm (19") rack, 135 mm (5.25") high

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