**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**

<table>
<thead>
<tr>
<th>Sensor Type</th>
<th>Silicon Diode</th>
<th>GaAs Diodes</th>
<th>Silicon Diode</th>
<th>GaAs Diodes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Temperature Coefficient</td>
<td>Negative</td>
<td>Positive</td>
<td>Negative</td>
<td>Positive</td>
</tr>
<tr>
<td>Sensor Units</td>
<td>V/deg (V)</td>
<td>V/deg (V)</td>
<td>Ohms/deg (Ω/°C)</td>
<td>Ohms/deg (Ω/°C)</td>
</tr>
<tr>
<td>Input Range</td>
<td>0 - 2.5 V</td>
<td>0 - 7.5 V</td>
<td>0 - 500 Ω</td>
<td>0 - 500 Ω</td>
</tr>
<tr>
<td>Sensor Excitation</td>
<td>diode/RTD inputs, one diode/RTD input and one factory configured and compatible with either diode/RTDs</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Factory-Configured Inputs</td>
<td>Temperature Accuracy</td>
<td>Humidity (constant current with sensor excitation)</td>
<td>Input Range</td>
<td>Sensor Units</td>
</tr>
<tr>
<td>- Magnetic Field Use</td>
<td>Temperature Equivalents</td>
<td>Sensor Units</td>
<td>Display Resolution</td>
<td></td>
</tr>
<tr>
<td>- Electronic Accuracy</td>
<td>5%</td>
<td>±0.004%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>- Temperature Equivalents</td>
<td>0.05%</td>
<td>±0.01%</td>
<td>10%</td>
<td>10%</td>
</tr>
<tr>
<td>- Sensor Units</td>
<td>0.3 mK at 4.2 K</td>
<td>±80 µV ±0.005% RDG</td>
<td>0.3 mK at 4.2 K</td>
<td>±80 µV ±0.005% RDG</td>
</tr>
<tr>
<td>- Display Resolution</td>
<td>10 µA ±0.05%</td>
<td>±0.005%</td>
<td>10 µA ±0.05%</td>
<td>±0.005%</td>
</tr>
<tr>
<td>- Measurement Resolution</td>
<td>0.05 µV</td>
<td>±0.001%</td>
<td>10 µA</td>
<td>±0.005%</td>
</tr>
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</tr>
<tr>
<td>- Sensor Units</td>
<td>1.25 mV/K at 20 K</td>
<td>±19 mK at 77 K</td>
<td>1.25 mV/K at 20 K</td>
<td>±19 mK at 77 K</td>
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<tr>
<td>- Measurement Resolution</td>
<td>0.05 µV</td>
<td>±0.001%</td>
<td>10 µA</td>
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</tbody>
</table>

**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.

- **GaAs 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. GaAs diodes require calibration.

- **Platinum RTDs** offer high uniform sensitivity from 300 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.

**Model 331 Temperature Range with Lake Shore Sensors**

- **Diodes**
  - Silicon Diode: DT-470
  - GaAs Diode: TG-120

- **Positive Temperature Coefficient RTDs**
  - 100 Ω Platinum: PT-100
  - Rhodium-Iron: RF-800-4

- **Negative Temperature Coefficient RTDs**
  - Germanium: GR-200A-1000
  - Carbon-Glass™: CSR-1000
  - Cernox™: CX-1050 AA or SD
  - High Temperature Cernox™: CX-1030 AA or SD
  - Thermocouple: TX-104-GH

**Thermocouples**

- Type K: 9006-006
- Type E: 9006-004
- Type T: 9006-002
- Chromal-Alumina 0.070: 9006-002

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
Sequential keypad Yes Yes
Alarms Yes Yes
Serial interface Yes Yes
IEEE-488 interface Yes Yes
Two control loops Yes Yes
Analog voltage output Yes Yes
Relays Yes Yes

Autotuning

The Model 331S and 331E autotuning feature automates the tuning process. With its own measurements of system characteristics and based on typical dynamic cyrogenic systems, the autotuning function computes proportion, integral, and derivative control gains. In the Model 331S, the autotuning feature 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 than 2 mV of accuracy for each diode. SoftCal™ configured as thermocouple)

Model 331 Specifications

Thermometry

Number of inputs: 2
Input configuration: Each input is factory configured for either diode / RTD or thermocouple
Measurement type: Diode / RTD
Excitation: Diodes: Silicon, GaAlAs
RTD: 100Ω Platinum, Cernox™, Rox™, Thermox™
Supported Sensors: Type E, Type J, Type K, Type T, 4-wire platinum, 3-wire platinum
Input Connector: 6-pin DIN

Model 331 Front Panel Features

Display 2 line by 20 character, 9 mm character height, vacuum fluorescent display
Number of reading displays: 1 to 4
Display units: °C, °F, °K, V, mV
Reading Source: Temperature, sensor units, max, min, and linear equation

<table>
<thead>
<tr>
<th>Front Panel</th>
<th>Setpoint 1</th>
<th>123.45%</th>
</tr>
</thead>
</table>

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.

Software Support: LabView driver (consult factory for availability)

Serial Interface

Electrical Formal: RS-232C
Max baud rate: 9600 Baud
Connector: DB-9
Reading rate: 10 readings per second on each input (9600 baud)
Special Interface Features: Model 330 command emulation mode

Alarms

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

Relays (331S)

Number: 2
Contacts: Normally Open (NO), Normally Closed (NC), and Combin (C)
Contact resistance: 5 VDC, 5 A
Operation: Activate relays in high, low, or both alarms for either input or manual
Max current per relay: 1A
Max voltage: 12V
Resolution: 0.3 mV
Accuracy: 12.5 mV
Minimum Load Resistance: 100 Ω (short circuit protected)

General

Ambient Temperature: 15 - 35 °C at sealed accuracy
Power Requirement: 100 - 120, 200 - 240 VAC ~, 5% - 15%, 50 or 60 Hz, 12 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)
331E-T1 Two Diode / Resistor Inputs
331S-T1 One Diode / Resistor Input, One Thermocouple Input
331S-T2 Two Thermocouple Inputs
331E-T2 Two Thermocouple Inputs

Temperature Controllers: all features of the 331S are included
331E-T1 Two Diode / Resistor Inputs
331S-T1 One Diode / Resistor Input, One Thermocouple Input
331E-T2 Two Thermocouple Inputs
331S-T2 Two Thermocouple Inputs

Accessories included

115-006 Detachable 120 VAC line cord
106-333 Sensor input mating connector (6-pin DIN plug)
110-009 Heater output connector (dual banana jack)
106-729 Terminal block, 6-pin

Manuf. 331-user manual

Options

331C CalCurve™, Factory Installed. Consists of the breakpoint table from a calibrated sensor stored in the instrument.
9002-05 Field Installed. Consists of the breakpoint table from a calibrated sensor loaded into a nonvolatile memory for customer installation

Accessories available

4905 I interface (2.5 long) IEEE-488 (GPIB) computer interface cable
3000-assembly. Includes extender required for simultaneous use of IEEE and relay terminal block
5W-1 Rack mount kit for mounting two 1/2 rack temperature controllers in 482.60 mm (19”) rack, 90 mm (3.5”) high
5W-2 Rack mount kit for mounting two 1/2 rack temperature controllers in 482.60 mm (19”) rack, 135 mm (5.25”) high

LakeShore Cryotronics, Inc.
575 McCorkle Blvd.
Westerly, Ohio 43082
Tel: (614) 911-2244
Fax: (614) 818-1600
E-mail: sales@lakeshore.com
www.lakeshore.com

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