



# LakeShore®

## Model 332 Temperature Controller

**Two control loops: 50 W and 10 W**

**Scalable excitation current for optimal NTC RTD performance to 1 K**

**Current reversal for resistance temperature sensors**

**Supports diode, RTD, and thermocouple sensor**



The Lake Shore Model 332 Temperature Controller creates a new standard for high-resolution temperature measurement in an easy-to-use temperature controller. The Model 332 offers high resolution with negative temperature coefficient (NTC) resistance temperature detectors (RTDs) to temperatures as low as 1 K. The Model 332 includes a 50 W heater output on the first control loop and a 10 W output on the second loop. The Model 332 provides greater flexibility in cryocooler applications that require a second heater to support fine and coarse control, or to support two control applications.

Automatic scalable excitation current allows the Model 332 to support Cernox™ and other NTC RTDs to temperatures as low as 1 K. At low temperature, where resistance is high (up to 75,000 ohms), the Model 332 provides an excitation current of 1  $\mu$ A to minimize sensor self-heating. At higher temperatures, where resistance is low and concerns for sensor self-heating are minimal, the Model 332 provides an excitation current of 1 mA for a better signal to noise ratio and high measurement resolution. Excitation currents of 10  $\mu$ A and 100  $\mu$ A are also available. The Model 332 also uses current reversal to eliminate thermal EMF errors.

The Model 332 supports diodes, RTDs, and thermocouples. It includes current reversal for NTC/PTC RTDs, autotuning, IEEE-488 parallel and RS-232C serial interfaces, alarms, relays, and analog voltage output.



**Table 1 - Model 332 Sensor Performance Chart for Selected Sensors**

Sensor Type	Silicon Diode	GaAlAs Diode	100 Ω Platinum RTD 500 Ω Full Scale	Rox™	Germanium GR-200A-1500	Germanium GR-200A-250	Cernox™ CX-1050	Cernox™ CX-1030	Thermocouple 25 mV
Temperature Coefficient	Negative	Negative	Positive	Negative	Negative	Negative	Negative	Negative	Positive
Input Range	0-2.5 V	0-7.5 V	0-500 Ω	0-7500 Ω	AutoRange see Table 5	AutoRange see Table 5	AutoRange see Table 5	AutoRange see Table 5	± 25 mV
Sensor Excitation*** (constant current)	10 μA ±0.05%	10 μA ±0.05%	1 mA	10 μA ±0.05%	75 mV max 4 ranges from 75Ω-75000Ω	75 mV max 4 ranges from 75Ω-75000Ω	75 mV max 4 ranges from 75Ω-75000Ω	75 mV max 4 ranges from 75Ω-75000Ω	Not Applicable
Display Resolution (sensor units)	100 μV	100 μV	10 mΩ	100 mΩ	5 digits	5 digits	5 digits	5 digits	0.1 μV
Example LSCI Sensor	DT-670-SD-13 with 1.4H calibration	TG-120-SD with 1.4H calibration	PT-103 with 14J calibration	RX-102A-AA with 1.4D calibration	GR-200A-1500 with 1.4D calibration	GR-200A-250 with 0.3D calibration	CX-1050-SD with 1.4L calibration	CX-1030-SD with 0.3L calibration	Chromel versus AuFe 0.07%
Standard Sensor Curve	LSCI Curve 10	Requires calibrated sensor	DIN 43760	Requires calibrated sensor	Requires calibrated sensor	Requires calibrated sensor	Requires calibrated sensor	Requires calibrated sensor	By Type
Typical Sensor Sensitivity*	-31.6 mV/K at 4.2 K -1.73 mV/K at 77 K -2.3 mV/K at 300 K -2.12 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	-80 Ω/K at 4.2 K -4 Ω/K at 20 K -1.06 Ω/K at 40 K	-64200 Ω/K at 1.4 K -668 Ω/K at 4.2 K -0.078 Ω/K at 77 K	-8450 Ω/K at 1 K -68.9 Ω/K at 4.2 K -0.054 Ω/K at 77 K	-42800 Ω/K at 2 K -2290 Ω/K at 4.2 K -2.15 Ω/K at 77 K -0.131 Ω/K at 300 K	-8670 Ω/K at 1 K -138 Ω/K at 4.2 K -0.828 Ω/K at 77 K -0.067 Ω/K at 300 K	12.6 μV/K at 4.2 K 22.4 μV/K at 300 K
Measurement Resolution: Sensor Units	10 uV	20 uV	2 mΩ	40 mΩ	AutoRange see Table 5	AutoRange see Table 5	AutoRange see Table 5	AutoRange see Table 5	0.4 μV
Temperature Equivalence	0.3 mK at 4.2 K 5.8 mK at 77 K 4.4 mK at 300 K 4.7 mK at 475 K	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	10.6 mK at 30 K 4.8 mK at 77 K 5.2 mK at 300 K 5.6 mK at 800 K	<1 mK at 4.2 K 10 mK at 20 K 38 mK at 40 K	<10 μK at 1.4 K <sup>4</sup> 30 μK at 4.2 K <sup>3</sup> 3.8 mK at 77 K <sup>1</sup>	<10 μK at 1 K <sup>3</sup> 40 μK at 4.2 K <sup>2</sup> 5.5 mK at 77 K <sup>1</sup>	<10 μK at 2 K <sup>4</sup> <10 μK at 4.2 K <sup>3</sup> 1.2 mK at 77 K <sup>2</sup> 2.3 mK at 300 K <sup>1</sup>	<10 μK at 1 K <sup>3</sup> 20 μK at 4.2 K <sup>2</sup> 3.6 mK at 77 K <sup>2</sup> 4.5 mK at 300 K <sup>1</sup>	32 mK at 4.2 K 18 mK at 300 K
Electronic Accuracy: Sensor Units	±80 μV ±0.005% of reading	±80 μV ±0.01% of reading	±0.004 Ω ±0.01% of reading	±0.10 Ω ±0.04% of reading	AutoRange see Table 5	AutoRange see Table 5	AutoRange see Table 5	AutoRange see Table 5	±1 μV ±0.05% ** of reading
Temperature Equivalence	±5 mK at 4.2 K ±75 mK at 77 K ±47 mK at 300 K ±40 mK at 475 K	±3 mK at 4.2 K ±180 mK at 77 K ±60 mK at 300 K ±38 mK at 475 K	±23 mK at 30 K ±14 mK at 77 K ±39 mK at 300 K ±95 mK at 800 K	±8.1 mK at 4.2 K ±134 mK at 20 K ±491 mK at 40 K	±0.2 mK at 1.4 K <sup>4</sup> ±1 mK at 4.2 K <sup>3</sup> ±38 mK at 77 K <sup>1</sup>	±0.2 mK at 1 K <sup>3</sup> ±2 mK at 4.2 K <sup>2</sup> ±47 mK at 77 K <sup>1</sup>	±0.3 mK at 2 K <sup>4</sup> ±1 mK at 4.2 K <sup>3</sup> ±30 mK at 77 K <sup>2</sup> ±130 mK at 300 K <sup>1</sup>	±0.2 mK at 1 K <sup>3</sup> ±2 mK at 4.2 K <sup>2</sup> ±57 mK at 77 K <sup>2</sup> ±224 mK at 300 K <sup>1</sup>	±288 mK at 4.2 K ±58 mK at 300 K
Temperature Accuracy including Electronic Accuracy, CalCurve, and Calibrated Sensor	±26 mK at 4.2 K ±130 mK at 77 K ±107 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	±24.1 mK at 4.2 K ±238 mK at 20 K ±705 mK at 40 K	±6 mK at 1.4 K <sup>4</sup> ±6 mK at 4.2 K <sup>3</sup> ±128 mK at 77 K <sup>1</sup>	±6 mK at 1 K <sup>3</sup> ±7 mK at 4.2 K <sup>2</sup> ±137 mK at 77 K <sup>1</sup>	±6 mK at 2 K <sup>4</sup> ±7 mK at 4.2 K <sup>3</sup> ±80 mK at 77 K <sup>2</sup> ±270 mK at 300 K <sup>1</sup>	±6 mK at 1 K <sup>3</sup> ±8 mK at 4.2 K <sup>2</sup> ±107 mK at 77 K <sup>2</sup> ±364 mK at 300 K <sup>1</sup>	Calibration not available from Lake Shore
Control Stability: Sensor Units Temperature Equivalence	±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	AutoRange see Table 5 ±1 mK at 4.2 K ±20 mK at 20 K ±76 mK at 40 K	AutoRange see Table 5 ±20 μK at 1.4 K <sup>4</sup> ±60 μK at 4.2 K <sup>3</sup> ±7.6 mK at 77 K <sup>1</sup>	AutoRange see Table 5 ±20 μK at 1 K <sup>3</sup> ±80 μK at 4.2 K <sup>2</sup> ±11 mK at 77 K <sup>1</sup>	AutoRange see Table 5 ±8 μK at 2 K <sup>4</sup> ±20 μK at 4.2 K <sup>3</sup> ±2.4 mK at 77 K <sup>2</sup> ±4.58 mK at 300 K <sup>1</sup>	AutoRange see Table 5 ±20 μK at 1.4 K <sup>3</sup> ±40 μK at 4.2 K <sup>2</sup> ±7.2 mK at 77 K <sup>2</sup> ±9 mK at 300 K <sup>1</sup>	0.8 μV 64 mK at 4.2 K 36 mK at 300 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>2 K & B≤10 T	Not Recommended	Not Recommended	Recommended for T>2 K & B≤19 T	Recommended for T>2 K & B≤19 T	Not Recommended

\* Typical sensor sensitivities were taken from representative calibrations for the sensor listed.

\*\*Accuracy specification does not include errors from room temperature compensation.

\*\*\*Current reversal eliminates thermal EMF voltage errors for resistor sensors.

<sup>1</sup>NTC RTD range 75 Ω

<sup>2</sup>NTC RTD range 750 Ω

<sup>3</sup>NTC RTD range 7500 Ω

<sup>4</sup>NTC RTD range 75000 Ω

## Specifications

### Thermometry

Number of inputs	2
Input configuration	Each input is factory configured as either diode/RTD or thermocouple
Isolation	Sensor inputs optically isolated from other circuits but not from each other
A/D resolution	24 bit
Input accuracy	Sensor dependent – Refer to Table 5
Meas. resolution	Sensor dependent – Refer to Table 5
Max update rate	10 readings per second on each input with the following exceptions: 5 readings per second when configured as NTC RTD 75 k $\Omega$ with reversal on 5 readings per second on input A when configured as thermocouple
Auto range	Auto range available to automatically select appropriate NTC RTD range
User curves SoftCal	Room for twenty 200-point CalCurves or user curves Improves accuracy of DT-470 diode to $\pm 0.25$ K from 30 to 375 K; improves accuracy of platinum RTDs to $\pm 0.25$ K from 70 to 325 K; stored as user curves
Math Filter	Maximum, minimum, and linear equation (Mx+B) or M(x+B) Averages 2 to 64 input readings

### Control

Control loops	2
Control type	Closed loop digital PID with manual heater power output, or open loop
Tuning	AutoTune (one loop at a time), manual PID, zones
Control stability	Sensor dependent, refer to performance chart
PID control settings	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 0 – 100% with 0.001% setting resolution
Manual heater power	10 temperature zones with P, I, D, manual heater power output, and heater range
Zone control	10 temperature zones with P, I, D, manual heater power output, and heater range
Setpoint ramping	0.1 to 100 K/min
Protection	Curve temperature limits, power up heater off, short-circuit protection

### 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, $\Omega$
Display source	Temperature, sensor units, max, min, and linear equation
Display update rate	All readings twice per second
Temp 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 or graphical display in percent of full scale for power or current
Heater output resolution	1% numeric or 2% graphical
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

**Table 2 - Sensor Input Configuration**

	Diode/RTD	Thermocouple
<b>Measurement type</b>	Four-lead differential with current reversal	Two-lead, room temperature compensated
<b>Excitation</b>	Constant current	Not applicable
<b>Supported sensors</b>	Diodes: silicon, GaAlAs RTDs: 100 $\Omega$ platinum, 1000 $\Omega$ platinum, germanium, Carbon Glass, Cernox, ROX, Thermox	Most thermocouple types
<b>Standard Curves</b>	DT-470, DT-500D, DT-670, PT-100, PT-1000, RX-102A, RX-202A	Type E, Type K, Type T, AuFe0.07% vs. Ch, AuFe0.03% vs. Ch
<b>Input connector</b>	6-pin DIN	Ceramic isothermal block

**Table 3 - Heater Output Specifications**

	Loop 1	Loop 2
<b>Heater output type</b>	Variable DC current source	Variable DC current source
<b>Heater output D/A resolution</b>	18 bit	16 bit
<b>Max heater power</b>	50 W	10 W
<b>Max heater output current</b>	1 A	1 A
<b>Heater output compliance</b>	50 V	10 V
<b>Heater source impedance</b>	N/A	0.1 $\Omega$ maximum
<b>Heater output ranges</b>	3 decade steps in power	1
<b>Heater load type</b>	Resistive	Resistive
<b>Heater load range</b>	10 $\Omega$ to 100 $\Omega$ recommended	10 $\Omega$ minimum
<b>Heater load for max power</b>	50 $\Omega$	10 $\Omega$
<b>Heater noise (&lt;1 kHz) RMS</b>	50 $\mu$ V + 0.017% of output voltage	<0.3 mV
<b>Isolation</b>	Optical isolation between output and other circuits	None
<b>Heater connector</b>	Dual banana	Detachable terminal block

**Table 4 - Loop 1 Full Scale Heater Power at Typical Resistance**

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

## Specifications, continued

### Interface

#### IEEE-488.2 interface

Features SH1,AH1,T5,L4,SR1,RL1,PP0,DC1,DT0,C0,E1  
 Reading Rate To 10 readings per second on each input  
 Software Support LabView driver

#### Serial interface

Electrical Format RS-232C  
 Max. Baud Rate 9600 baud  
 Connector DE-9  
 Reading Rate To 10 readings per second 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 & low setpoint, deadband, latching or non-latching, audible on/off  
 Actuators Display annunciator, beeper, relays

#### Relays

Number 2  
 Contacts Normally open (NO), normally closed (NC), and common (COM)  
 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

Scale **(when not used as control loop 2 output)**  
 Update Rate User selected  
 Data Source 10 readings per second  
 Settings Temperature, sensor units, linear equation  
 Range Input, source, top of scale, bottom of scale, or manual  
 Resolution  $\pm 10$  V  
 Accuracy 0.3 mV  
 Maximum Output Power  $\pm 2.5$  mV  
 Minimum Load Resistance 1 W (jumper selected)  
 Source Impedance 100  $\Omega$  (short-circuit protected)  
 Source Impedance 0.01  $\Omega$

### 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., 150 VAC  
 Size 217 mm wide x 90 mm high x 317  
 mm deep (8.5 x 3.5 x 14.5 inches),  
 half rack  
 Weight 4.8 kilograms (10.5 pounds)

### Ordering Information

#### Standard temperature controllers

Part Number	Description
332S	Two diode/resistor inputs
332S-T1	One diode/resistor, one thermocouple input
332S-T2	Two thermocouple inputs

#### Power options

Select one - the instrument will be configured for selected power and fuses

VAC-100	Instrument configured for 100 VAC with U.S. power cord
VAC-120	Instrument configured for 120 VAC with U.S. power cord
VAC-220	Instrument configured for 220 VAC with European power cord
VAC-240	instrument configured for 240 VAC with European power cord
VAC-120-All	Instrument configured for 120 VAC with U.S. power cord and universal European power cord and fuses for 220/240 setting (extra charge for this option)

#### Accessories included

106-009	Heater output connector (dual banana jack)
106-233	Sensor input mating connector (6-pin DIN plugs)
106-739	Terminal block, 8-pin
MAN-332	User manual

#### CalCurve™ options

8001-332	CalCurve, factory-installed, consists of a calibrated sensor breakpoint table factory-installed into nonvolatile memory
8002-05-332	CalCurve, field-installed, consists of a calibrated sensor breakpoint table loaded into nonvolatile memory

#### 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

**Table 5 - Input Range Specifications**

	Input Range	Excitation Current	Resolution	Electronic Accuracy	Display Resolution
NTC-RTD	0 - 75 $\Omega$	1 mA	0.3 m $\Omega$ +0.000% of reading	$\pm 0.001 \Omega \pm 0.04\%$ of reading	1 m $\Omega$
	0 - 750 $\Omega$	100 $\mu$ A	3 m $\Omega$ +0.001% of reading	$\pm 0.01 \Omega \pm 0.04\%$ of reading	10 m $\Omega$
	0 - 7500 $\Omega$	10 $\mu$ A	20 m $\Omega$ +0.001% of reading	$\pm 0.1 \Omega \pm 0.04\%$ of reading	100 m $\Omega$
	0 - 75000 $\Omega$	1 $\mu$ A	0.15 $\Omega$ +0.003% of reading	$\pm 1.0 \Omega \pm 0.04\%$ of reading	1 $\Omega$
PTC-RTD	0 - 250 $\Omega$	1 mA	2 m $\Omega$	$\pm 0.004 \Omega \pm 0.01\%$ of reading	10 m $\Omega$
	0 - 500 $\Omega$	1 mA	2 m $\Omega$	$\pm 0.004 \Omega \pm 0.01\%$ of reading	10 m $\Omega$
	0 - 1000 $\Omega$	1 mA	20 m $\Omega$	$\pm 0.04 \Omega \pm 0.02\%$ of reading	100 m $\Omega$
Diode	0 - 2.5 $\Omega$	10 $\mu$ A $\pm 0.05\%$	10 $\mu$ V	$\pm 80 \mu$ V $\pm 0.005\%$ of reading	100 $\mu$ V
	0 - 7.5 $\Omega$	10 $\mu$ A $\pm 0.05\%$	20 $\mu$ V	$\pm 80 \mu$ V $\pm 0.005\%$ of reading	100 $\mu$ V
Thermocouple	$\pm 25$ mV	Not applicable	0.4 $\mu$ V	$\pm 1 \mu$ V $\pm 0.05\%$ of reading	1 $\mu$ V
	$\pm 50$ mV	Not applicable	0.4 $\mu$ V	$\pm 1 \mu$ V $\pm 0.05\%$ of reading	1 $\mu$ V



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