Model 335
Temperature Controller

Lake Shore CRYOTRONICS

Model 335 Temperature Controller

- Operates down to 300 mK with appropriate NTC RTD sensors
- Two sensor inputs
- Two configurable PID control loops providing 50 W and 25 W or 75 W and 1 W
- Autotuning automatically calculates PID parameters
- Automatically switch sensor inputs using zones to allow continuous measurement and control from 300 mK to 1 505 K
- Custom display set-up allows you to label each sensor input
- USB and IEEE-488 interfaces
- Supports diode, RTD, and thermocouple temperature sensors
- Sensor excitation current reversal eliminates thermal EMF errors for resistance sensors
- ±10 V analog voltage output, alarms, and relays
- CE certification
- Full 3 year standard warranty

Introduction

Designed with the user and ease of use in mind, the Model 335 temperature controller offers many user-configurable features and advanced functions that until now have been reserved for more expensive, high-end temperature controllers. The Model 335 is the first two-channel temperature controller available with user configurable heater outputs delivering a total of 75 W of low noise heater power—50 W and 25 W, or 75 W and 1 W. With that much heater power packed into an affordable half-rack sized instrument, the Model 335 gives you more power and control than ever.

Control outputs are equipped with both hardware and software features allowing you, and not your temperature controller, to easily control your experiments. Output one functions as a current output while output two can be configured in either current or voltage mode. With output two in voltage mode, it functions as a ±10 V analog output while still providing 1 W of heater power and full closed loop proportional-integral-derivative (PID) control capability. Alarms and relays are included to help automate secondary control functions. The improved autotuning feature of the Model 335 can be used to automatically calculate PID control parameters, so you spend less time tuning your controller and more time conducting experiments.

The Model 335 supports the industry's most advanced line of cryogenic temperature sensors as manufactured by Lake Shore, including diodes, resistance temperature detectors (RTDs), and thermocouples. The controller's zone tuning feature allows you to measure and control temperatures seamlessly from 300 mK to over 1 500 K. This feature automatically switches temperature sensor inputs when your temperature range goes beyond the useable range of a given sensor. You'll never again have to be concerned with temperature sensor over or under errors and measurement continuity issues.

The intuitive front panel layout and keypad logic, bright vacuum fluorescent display, and LED indicators enhance the user-friendly front panel interface of the Model 335. Four standard display modes are offered to accommodate different instrument configurations and user preferences. Say goodbye to sticky notes and hand written labels, as the ability to custom label sensor inputs eliminates the guesswork in remembering or determining the location to which a sensor input is associated. These features, combined with USB and IEEE-488 interfaces and intuitive menu structure and logic supports efficiency and ease of use.

As a replacement to our popular Model 331 and 332 temperature controllers, the Model 335 offers software emulation modes for literal drop-in compatibility. The commands you are accustomed to sending to the Model 331 and 332 will either be interpreted directly or translated to the most appropriate Model 335 setting. The Model 335 comes standard-equipped with all of the functionality of the controllers it replaces, but offers additional features that save you time and money.

With the Model 335, you get a temperature controller you control from the world leader in cryogenic thermometry.

Sensor inputs

The Model 335 offers two standard sensor inputs that are compatible with diode and RTD temperature sensors. The field-installable Model 3060 option adds thermocouple functionality to both inputs.

Sensor inputs feature a high-resolution 24-bit analog-to-digital converter and each of the two powered outputs function as separate current sources. Both sensor inputs are optically isolated from other circuits to reduce noise and to deliver repeatable sensor measurements. Current reversal eliminates thermal electromagnetic field (EMF) errors in resistance sensors. Ten excitation currents facilitate temperature measurement and control down to 300 mK using appropriate negative temperature coefficient (NTC) RTDs. Autorange mode automatically scales excitation current in NTC RTDs to reduce self heating at low temperatures as sensor resistance changes by many orders of magnitude. Temperatures down to 1.4 K can be measured and controlled using silicon or GaAlAs diodes. Software selects the appropriate excitation current and signal gain levels when the sensor type is entered via the instrument front panel. To increase your productivity, the unique zone setting feature automatically switches sensor inputs, enabling you to measure temperatures from 300 mK to over 1 500 K without interrupting your experiment.

The Model 335 includes standard temperature sensor response curves for silicon diodes, platinum RTDs, ruthenium oxide RTDs, and thermocouples. Non-volatile memory can also store up to 39 200-point CalCurves for Lake Shore calibrated temperature sensors or user curves. A built-in SoftCal algorithm can be used to generate curves for silicon diodes and platinum RTDs that can be stored as user curves. Temperature sensor calibration data can be easily loaded into the Model 335 temperature controller and manipulated using the Lake Shore curve handler software program.

Temperature control

Providing a total of 75 W of heater power, the Model 335 is the most powerful half rack temperature controller available. Designed to deliver very clean heater power, precise temperature control is ensured throughout your full scale temperature range for excellent measurement reliability, efficiency and throughput. Two independent PID control outputs can be configured to supply 50 W and 25 W or 75 W and 1 W of heater power. Precise control output is calculated based on your temperature setpoint and feedback from the control sensor. Wide tuning parameters accommodate most cryogenic cooling systems and many high-temperature ovens commonly used in laboratories. PID values can be manually set for fine control or the improved autotuning feature can automate the tuning process.

The Model 335 autotuning method calculates PID parameters and provides feedback to help build zone tables. The setpoint ramp feature provides smooth, continuous setpoint changes and predictable approaches to setpoint without the worry of overshoot or excessive settling times. The instrument's zone tuning feature automatically switches temperature sensor inputs when your temperature range goes beyond the useable range of a given sensor. This feature combined with the instrument's ability to scale the sensor excitation through ten pre-loaded current settings allows the Model 335 to provide continuous measurement and control from 300 mK to 1 505 K.

Both control outputs are variable DC current sources referenced to chassis ground. As a factory default, outputs 1 and 2 provide 50 W and 25 W of continuous power respectively, both to a 50 Ω or 25 Ω load. For increased functionality, output 2 can also be set to voltage mode. When set to voltage mode, it functions as a ±10 V analog output while still providing 1 W of heater power and full closed loop PID control capability. While in this mode, output 1 can provide up to 75 W of heater power to a 25 Ω load.

Temperature limit settings for inputs are provided as a safeguard against system damage. Each input is assigned a temperature limit, and if any input exceeds that limit, both control channels are automatically disabled.

Interface

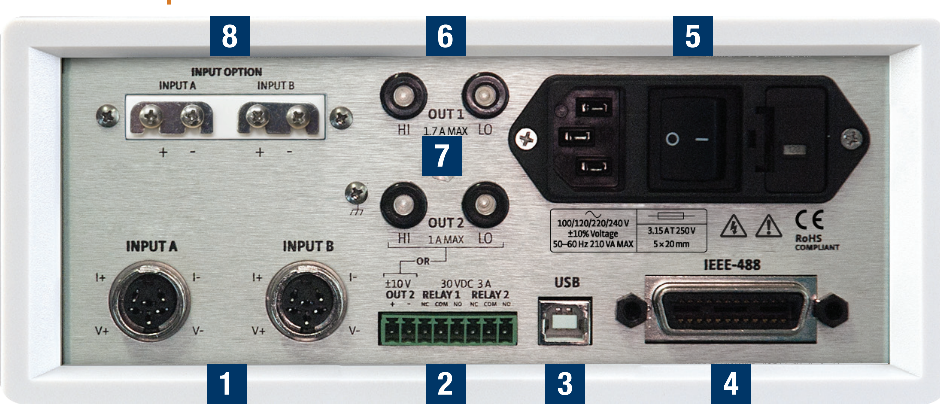
The Model 335 is standard equipped with universal serial bus (USB) and parallel (IEEE-488) interfaces. In addition to gathering data, nearly every function of the instrument can be controlled via computer interface. You can download the Lake Shore curve handler software program to your computer to easily enter and manipulate sensor calibration curves for storage in the instrument's non-volatile memory.

The USB interface emulates an RS-232C serial port at a fixed 57 600 baud rate, but with the physical plug-ins of a USB. It also allows you to download firmware upgrades, ensuring the most current firmware version is loaded into your instrument without having to physically change your instrument.

Both sensor inputs are equipped with a high and low alarm which offers latching and non-latching operation. The two relays can be used in conjunction with the alarms to alert you of a fault condition and perform simple on-off control. Relays can be assigned to any alarm or operated manually.

The ±10 V analog voltage output can be configured to send a voltage proportional to temperature to a strip chart recorder or data acquisition system. You may select the scale and data sent to the output, including temperature or sensor units.

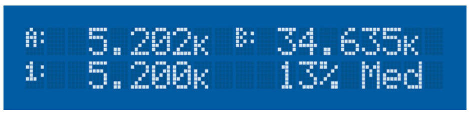
Model 335 rear panel



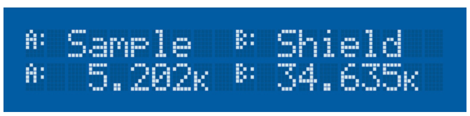
1 Sensor input connectors
2 Terminal block (analog outputs/relays)
3 USB interface
4 IEEE-488 interface
5 Line input assembly
6 Output 2 heater
7 Output 1 heater
8 Thermocouple option inputs

Configurable display

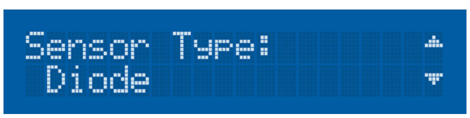
The Model 335 offers a bright, vacuum fluorescent display that simultaneously displays up to four readings. You can display both control loops, or if you need to monitor just one input, you can display just that one in greater detail. Or you can custom configure each display location to suit your experiment. Data from any input can be assigned to any of the locations, and your choice of temperature sensor units can be displayed. For added convenience, you can also custom label each senor input, eliminating the guesswork in remembering or determining the location to which a sensor input is associated.



Two input/one loop display with labels
Standard display option featuring two inputs and associated outputs.



Custom display with labels
Reading locations can be user configured to accommodate application needs. Here, the input names are shown above the measurement readings along with the designated input letters.



Intuitive menu structure
Logical navigation allows you to spend more time on research and less time on setup.

Model 3060 thermocouple input option

The field installable Model 3060 thermocouple input option adds thermocouple functionality to both inputs. While the option can be easily removed, this is not necessary as the standard inputs remain fully functional when they are not being used to measure thermocouple temperature sensors. Calibration for the option is stored on the card so it can be installed in the field and used with multiple Model 335 temperature controllers without recalibration.

Sensor selection

Sensor temperature range (sensors sold separately)

		Model	Useful range	Magnetic field use
Diodes	Silicon diode	DT-670-SD	1.4 K to 500 K	T ≥ 60 K & B ≤ 3 T
	Silicon diode	DT-670E-BR	30 K to 500 K	T ≥ 60 K & B ≤ 3 T
	Silicon diode	DT-414	1.4 K to 375 K	T ≥ 60 K & B ≤ 3 T
	Silicon diode	DT-421	1.4 K to 325 K	T ≥ 60 K & B ≤ 3 T
	Silicon diode	DT-470-SD	1.4 K to 500 K	T ≥ 60 K & B ≤ 3 T
	Silicon diode	DT-471-SD	10 K to 500 K	T ≥ 60 K & B ≤ 3 T
	GaAlAs diode	TG-120-P	1.4 K to 325 K	T > 4.2 K & B ≤ 5 T
	GaAlAs diode	TG-120-PL	1.4 K to 325 K	T > 4.2 K & B ≤ 5 T
	GaAlAs diode	TG-120-SD	1.4 K to 500 K	T > 4.2 K & B ≤ 5 T
Positive temperature coefficient RTDs	100 Ω platinum	PT-102/3	14 K to 873 K	T > 40 K & B ≤ 2.5 T
	100 Ω platinum	PT-111	14 K to 673 K	T > 40 K & B ≤ 2.5 T
	Rhodium-iron	RF-800-4	1.4 K to 500 K	T > 77 K & B ≤ 8 T
	Rhodium-iron	RF-100T/U	1.4 K to 325 K	T > 77 K & B ≤ 8 T
Negative temperature coefficient RTDs	Cernox™	CX-1010	0.3 K to 325 K[1]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1030-HT	0.3 K to 420 K[1, 3]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1050-HT	1.4 K to 420 K[1]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1070-HT	4 K to 420 K[1]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1080-HT	20 K to 420 K[1]	T > 2 K & B ≤ 19 T
	Germanium	GR-300-AA	0.35 K to 100 K[3]	Not recommended
	Germanium	GR-1400-AA	1.8 K to 100 K[3]	Not recommended
	Carbon-glass	CGR-1-500	1.4 K to 325 K	T > 2 K & B ≤ 19 T
	Carbon-glass	CGR-1-1000	1.7 K to 325 K[2]	T > 2 K & B ≤ 19 T
	Carbon-glass	CGR-1-2000	2 K to 325 K[2]	T > 2 K & B ≤ 19 T
	Rox™	RX-102	0.3 K to 40 K[3]	T > 2 K & B ≤ 10 T
	Rox™	RX-103	1.4 K to 40 K	T > 2 K & B ≤ 10 T
	Rox™	RX-202	0.3 K to 40 K[3]	T > 2 K & B ≤ 10 T
Thermocouples *Option—3060*	Type K	9006-006	3.2 K to 1505 K	Not recommended
	Type E	9006-004	3.2 K to 934 K	Not recommended
	Chromel-AuFe 0.07%	9006-002	1.2 K to 610 K	Not recommended

[1] Non-HT version maximum temperature: 325 K
[2] Low temperature limited by input resistance range
[3] Low temperature specified with self-heating error: ≤ 5 mK

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

Cernox™ thin-film RTDs offer high sensitivity and low magnetic field-induced errors over the 0.3 K to 420 K temperature range. Cernox sensors require calibration.

Platinum RTDs offer high uniform sensitivity from 30 K 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.

Typical sensor performance

	Example Lake Shore sensor	Temperature	Nominal resistance/ voltage	Typical sensor sensitivity[4]	Measurement resolution: temperature equivalents	Electronic accuracy: temperature equivalents	Temperature accuracy including electronic accuracy, CalCurve™, and calibrated sensor	Electronic control stability[5]: temperature equivalents
Silicon diode	DT-670-CO-13 with 1.4H calibration	1.4 K	1.664 V	-12.49 mV/K	0.8 mK	±13 mK	±25 mK	±1.6 mK
		77 K	1.028 V	-1.73 mV/K	5.8 mK	±76 mK	±98 mK	±11.6 mK
		300 K	0.5596 V	-2.3 mV/K	4.3 mK	±47 mK	±79 mK	±8.7 mK
		500 K	0.0907 V	-2.12 mV/K	4.7 mK	±40 mK	±90 mK	±9.4 mK
Silicon diode	DT-470-SD-13 with 1.4H calibration	1.4 K	1.6981 V	-13.1 mV/K	0.8 mK	±13 mK	±25 mK	±1.6 mK
		77 K	1.0203 V	-1.92 mV/K	5.2 mK	±68 mK	±90 mK	±10.4 mK
		300 K	0.5189 V	-2.4 mV/K	4.2 mK	±44 mK	±76 mK	±8.4 mK
		475 K	0.0906 V	-2.22 mV/K	4.5 mK	±38 mK	±88 mK	±9 mK
GaAlAs diode	TG-120-SD with 1.4H calibration	1.4 K	5.3909 V	-97.5 mV/K	0.2 mK	±8.8 mK	±21 mK	±0.4 mK
		77 K	1.4222 V	-1.24 mV/K	16 mK	±373 mK	±395 mK	±32 mK
		300 K	0.8978 V	-2.85 mV/K	7 mK	±144 mK	±176 mK	±14 mK
		475 K	0.3778 V	-3.15 mV/K	6.4 mK	±114 mK	±164 mK	±13 mK
100 Ω platinum RTD 500 Ω full scale	PT-103 with 14J calibration	30 K	3.660 Ω	0.191 Ω/K	1.1 mK	±13 mK	±23 mK	±2.2 mK
		77 K	20.38 Ω	0.423 Ω/K	0.5 mK	±10 mK	±22 mK	±1.0 mK
		300 K	110.35 Ω	0.387 Ω/K	5.2 mK	±39 mK	±62 mK	±10.4 mK
		500 K	185.668 Ω	0.378 Ω/K	5.3 mK	±60 mK	±106 mK	±10.6 mK
Cernox™	CX-1010-SD with 0.3L calibration	0.3 K	2322.4 Ω	-10785 Ω/K	8.5 µK	±0.1 mK	±3.6 mK	±17 µK
		0.5 K	1248.2 Ω	-2665.2 Ω/K	26 µK	±0.2 mK	±4.7 mK	±52 µK
		4.2 K	277.32 Ω	-32.209 Ω/K	140 µK	±3.8 mK	±8.8 mK	±280 µK
		300 K	30.392 Ω	-0.0654 Ω/K	23 mK	±339 mK	±414 mK	±46 mK
Cernox™	CX-1050-SD-HT[6] with 1.4M calibration	1.4 K	26566 Ω	-48449 Ω/K	20 µK	±0.3 mK	±5.3 mK	±40 µK
		4.2 K	3507.2 Ω	-1120.8 Ω/K	196 µK	±2.1 mK	±7.1 mK	±392 µK
		77 K	205.67 Ω	-2.4116 Ω/K	1.9 mK	±38 mK	±54 mK	±3.8 mK
		420 K	45.03 Ω	-0.0829 Ω/K	18 mK	±338 mK	±403 mK	±36 mK
Germanium	GR-300-AA with 0.3D calibration	0.35 K	18225 Ω	-193453 Ω/K	4 µK	±48 µK	±4.2 mK	±8 µK
		1.4 K	449 Ω	-581 Ω/K	41 µK	±481 µK	±4.7 mK	±82 µK
		4.2 K	94 Ω	-26.6 Ω/K	56 µK	±1.8 mK	±6.8 mK	±112 µK
		100 K	2.7 Ω	-0.024 Ω/K	6.3 mK	±152 mK	±175 mK	±12.6 mK
Germanium	GR-1400-AA with 1.4D calibration	1.8 K	15288 Ω	-26868 Ω/K	28 µK	±302 µK	±4.5 mK	±56 µK
		4.2 K	1689 Ω	-862 Ω/K	91 µK	±900 µK	±5.1 mK	±182 µK
		10 K	253 Ω	-62.0 Ω/K	73 µK	±1.8 mK	±6.8 mK	±146 µK
		100 K	2.8 Ω	-0.021 Ω/K	7.1 mK	±177 mK	±200 mK	±14.2 mK
Carbon-glass	CGR-1-500 with 1.4L calibration	1.4 K	103900 Ω	-520000 Ω/K	13 µK	±0.1 mK	±4.1 mK	±26 µK
		4.2 K	584.6 Ω	-422.3 Ω/K	63 µK	±0.8 mK	±4.8 mK	±126 µK
		77 K	14.33 Ω	-0.098 Ω/K	4.6 mK	±108 mK	±133 mK	±9.2 mK
		300 K	8.55 Ω	-0.0094 Ω/K	16 mK	±760 mK	±865 mK	±32 mK
Rox™	RX-102A-AA with 0.3B calibration	0.5 K	3701 Ω	-5478 Ω/K	41 µK	±0.5 mK	±5 mK	±82 µK
		1.4 K	2005 Ω	-667 Ω/K	128 µK	±1.4 mK	±6.4 mK	±256 µK
		4.2 K	1370 Ω	-80.3 Ω/K	902 µK	±8 mK	±24 mK	±1.8 mK
		40 K	1049 Ω	-1.06 Ω/K	62 mK	±500 mK	±537 mK	±124 mK
Thermocouple 50 mV *Option—3060*	Type K	75 K	-5862.9 µV	15.6 µV/K	26 mK	±0.25 K[7]	Calibration not available from Lake Shore	±52 mK
		300 K	1075.3 µV	40.6 µV/K	10 mK	±0.038 K[7]		±20 mK
		600 K	13325 µV	41.7 µV/K	10 mK	±0.184 K[7]		±20 mK
		1505 K	49998.3 µV	36.006 µV/K	11 mK	±0.73 K[7]		±22 mK

[4] Typical sensor sensitivities were taken from representative calibrations for the sensor listed
[5] Control stability of the electronics only, in an ideal thermal system
[6] Non-HT version maximum temperature: 325 K
[7] Accuracy specification does not include errors from room temperature compensation

Model 335 Specifications

Input specifications

	Sensor temperature coefficient	Input range	Excitation current	Display resolution	Measurement resolution	Electronic accuracy[6]	Measurement temperature coefficient	Electronic control stability[1]
Diode	Negative	0 V to 2.5 V	10 µA ±0.05%[2,3]	100 µV	10 µV	±80 µV ±0.005% of rdg	(10 µV + 0.0005% of rdg)/°C	±20 µV
		0 V to 10 V	10 µA ±0.05%[2,3]	1 mV	20 µV	±320 µV ±0.01% of rdg	(20 µV + 0.0005% of rdg)/°C	±40 µV
PTC RTD	Positive	0 Ω to 10 Ω	1 mA[4]	1 mΩ	0.2 mΩ	±0.002 Ω ±0.01% of rdg	(0.01 mΩ + 0.001% of rdg)/°C	±0.4 mΩ
		0 Ω to 30 Ω	1 mA[4]	1 mΩ	0.2 mΩ	±0.002 Ω ±0.01% of rdg	(0.03 mΩ + 0.001% of rdg)/°C	±0.4 mΩ
		0 Ω to 100 Ω	1 mA[4]	10 mΩ	2 mΩ	±0.004 Ω ±0.01% of rdg	(0.1 mΩ + 0.001% of rdg)/°C	±4 mΩ
		0 Ω to 300 Ω	1 mA[4]	10 mΩ	2 mΩ	±0.004 Ω ±0.01% of rdg	(0.3 mΩ + 0.001% of rdg)/°C	±4 mΩ
		0 Ω to 1 kΩ	1 mA[4]	100 mΩ	20 mΩ	±0.04 Ω ±0.02% of rdg	(1 mΩ + 0.001% of rdg)/°C	±40 mΩ
		0 Ω to 3 kΩ	1 mA[4]	100 mΩ	20 mΩ	±0.04 Ω ±0.02% of rdg	(3 mΩ + 0.001% of rdg)/°C	±40 mΩ
		0 Ω to 10 kΩ	1 mA[4]	1 Ω	200 mΩ	±0.4 Ω ±0.02% of rdg	(10 mΩ + 0.001% of rdg)/°C	±400 mΩ
NTC RTD 10 mV	Negative	0 Ω to 10 Ω	1 mA[4]	1 mΩ	0.15 mΩ	±0.002 Ω ±0.06% of rdg	(0.01 mΩ + 0.001% of rdg)/°C	±0.3 mΩ
		0 Ω to 30 Ω	300 µA[4]	1 mΩ	0.45 mΩ	±0.002 Ω ±0.06% of rdg	(0.03 mΩ + 0.0015% of rdg)/°C	±0.9 mΩ
		0 Ω to 100 Ω	100 µA[4]	10 mΩ	1.5 mΩ	±0.01 Ω ±0.04% of rdg	(0.1 mΩ + 0.001% of rdg)/°C	±3 mΩ
		0 Ω to 300 Ω	30 µA[4]	10 mΩ	4.5 mΩ	±0.01 Ω ±0.04% of rdg	(0.3 mΩ + 0.0015% of rdg)/°C	±9 mΩ
		0 Ω to 1 kΩ	10 µA[4]	100 mΩ	15 mΩ +0.002% of rdg	±0.1 Ω ±0.04% of rdg	(1 mΩ + 0.001% of rdg)/°C	±30 mΩ ±0.004% of rdg
		0 Ω to 3 kΩ	3 µA[4]	100 mΩ	45 mΩ +0.002% of rdg	±0.1 Ω ±0.04% of rdg	(3 mΩ + 0.0015% of rdg)/°C	±90 mΩ ±0.004% of rdg
		0 Ω to 10 kΩ	1 µA[4]	1 Ω	150 mΩ +0.002% of rdg	±1.0 Ω ±0.04% of rdg	(10 mΩ + 0.001% of rdg)/°C	±300 mΩ ±0.004% of rdg
		0 Ω to 30 kΩ	300 nA[4]	1 Ω	450 mΩ +0.002% of rdg	±2.0 Ω ±0.04% of rdg	(30 mΩ + 0.0015% of rdg)/°C	±900 mΩ ±0.004% of rdg
		0 Ω to 100 kΩ	100 nA[4]	10 Ω	1.5 Ω +0.005% of rdg	±10.0 Ω ±0.04% of rdg	(100 mΩ + 0.002% of rdg)/°C	±3 Ω ±0.01% of rdg
Thermocouple *Option—3060*	Positive	±50 mV	NA	1 µV	0.4 µV	±1 µV ±0.05% of rdg[5]	(0.1 µV + 0.001% of rdg)/°C	±0.8 µV

[1] Control stability of the electronics only, in ideal thermal system
[2] Current source error has negligible effect on measurement accuracy
[3] Diode input excitation can be set to 1 mA
[4] Current source error is removed during calibration
[5] Accuracy specification does not include errors from room temperature compensation
[6] Accuracy at T_{cal}, typically 23.5 °C ±1.5 °C

Sensor input configuration

	Diode/RTD	Thermocouple
Measurement type	4-lead differential	2-lead differential, room temperature compensated
Excitation	Constant current with current reversal for RTDs	NA
Supported sensors	**Diodes:** Silicon, GaAlAs **RTDs:** 100 Ω Platinum, 1000 Ω Platinum, Germanium, Carbon-Glass, Cernox™, and Rox™	Most thermocouple types
Standard curves	DT-470, DT-670, DT-500-D, DT-500-E1, PT-100, PT-1000, RX-102A, RX-202A	Type E, Type K, Type T, AuFe 0.07% vs. Cr, AuFe 0.03% vs. Cr
Input connector	6-pin DIN	Screw terminals in a ceramic isothermal block

Thermometry

Number of inputs 2
Input configuration Inputs can be configured from the front panel to accept any of the supported input types. Thermocouple inputs require an optional input card that can be installed in the field. Once installed the thermocouple input can be selected from the front panel like any other input type.
Isolation Sensor inputs optically isolated from other circuits but not each other
A/D resolution 24-bit
Input accuracy Sensor dependent, refer to Input Specifications table
Measurement resolution Sensor dependent, refer to Input Specifications table
Maximum update rate 10 rdg/s on each input, 5 rdg/s when configured as 100 kΩ NTC RTD with reversal on
Autorange Automatically selects appropriate NTC RTD or PTC RTD range
User curves Room for 39 200-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 and minimum
Filter Averages 2 to 64 input readings

Control

Control outputs 2

Heater outputs

Control type Closed loop digital PID with manual heater output or open loop; warm up mode (output 2 only)
Update rate 10/s
Tuning Autotune (one loop at a time), PID, PID zones
Control stability Sensor dependent, see Input Specifications table
PID control settings
- **Proportional (gain)** 0 to 1000 with 0.1 setting resolution
- **Integral (reset)** 1 to 1000 (1000/s) with 0.1 setting resolution
- **Derivative (rate)** 1 to 200% with 1% resolution
- **Manual output** 0 to 100% with 0.01% setting resolution

Zone control 10 temperature zones with P, I, D, manual heater out, heater range, control channel, ramp rate
Setpoint ramping 0.1 K/min to 100 K/min
Warm up heater mode settings (output 2 only)
- **Warm up percentage** 0 to 100% with 1% resolution
- **Warm up mode** Continuous control or auto-off

Monitor output settings (output 2 voltage only)
- **Scale** User selected
- **Data source** Temperature or sensor units
- **Settings** Input, source, top of scale, bottom of scale, or manual

Output 1

Type	Variable DC current source		
Control modes	Closed loop digital PID with manual output or open loop		
D/A resolution	16-bit		
	25 Ω setting		**50 Ω setting**
Max power	75 W*	50 W	50 W
Max current	1.73 A	1.41 A	1 A
Voltage compliance (min)	43.3 V	35.4 V	50 V
Heater load for max power	25 Ω	25 Ω	50 Ω
Heater load range	10 Ω to 100 Ω		
Ranges	3 (decade steps in power)		
Heater noise	0.12 µA RMS (dominated by line frequency and its harmonics)		
Heater connector	Dual banana		
Grounding	Output referenced to chassis ground		
Safety limits	Curve temperature, power up heater off, short circuit protection		

*75 W only available when output 2 is in voltage mode

Output 2

Type	Variable DC current source or voltage source		
	Current mode		**Voltage mode**
Control modes	Closed loop digital PID with manual output, zone, open loop		Closed loop digital PID with manual output, zone, open loop, warm up, monitor out
D/A resolution	15-bit		16-bit (bipolar)/15-bit (unipolar)
	25 Ω setting	**50 Ω setting**	**N/A**
Max power	25 W	25 W	1 W
Max current	1 A	0.71 A	100 mA
Voltage compliance (min)	25 V	35.4 V	±10 V
Heater load for max power	25 Ω	50 Ω	100 Ω
Heater load range	10 Ω to 100 Ω		100 Ω min (short circuit protected)
Ranges	3 (decade steps in power)		N/A
Heater noise	0.12 µA RMS		0.3 mV RMS
Heater connector	Dual banana		Detachable terminal block
Grounding	Output referenced to chassis ground		
Safety limits	Curve temperature, power up heater off, short circuit protection		

Update rate 10/s
Range ±10 V
Resolution 16-bit, 0.3 mV
Accuracy ±2.5 mV
Noise 0.3 mV RMS
Minimum load resistance 100 Ω (short-circuit protected)
Connector Detachable terminal block

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, and min
Display update rate 2 rdg/s
Temperature display resolution 0.001° from 0° to 99.999°, 0.01° from 100° to 999.99°, 0.1° above 1000°
Sensor units display resolution Sensor dependent, to 5 digits
Other displays Sensor name, setpoint, heater range, heater output, and PID
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, alarm, tuning
LED annunciators Remote, alarm, control outputs
Keypad 25-key silicone elastomer keypad
Front panel features Front panel curve entry, display brightness control, and keypad lock-out

Interface

IEEE-488.2
- **Capabilities** SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT0, C0, E1
- **Reading rate** To 10 rdg/s on each input
- **Software support** LabVIEW™ driver (see www.lakeshore.com)

USB
- **Function** Emulates a standard RS-232 serial port
- **Baud rate** 57,600
- **Connector** B-type USB connector
- **Reading rate** To 10 rdg/s on each input
- **Software support** LabVIEW™ driver (see www.lakeshore.com)

Special interface features Model 331/332 command emulation mode

Alarms
- **Number** 2, high and low for each input
- **Data source** Temperature or sensor units
- **Settings** Source, high setpoint, low setpoint, deadband, latching or non-latching, audible on/off, and visible on/off
- **Actuators** Display annunciator, beeper, and relays

Relays
- **Number** 2
- **Contacts** Normally open (NO), normally closed (NC), and common (C)
- **Contact rating** 30 VDC at 3 A
- **Operation** Activate relays on high, low, or both alarms for any input, or manual mode
- **Connector** Detachable terminal block

General

Ambient temperature 15 °C to 35 °C at rated specifications; 5 °C to 40 °C at reduced specifications
Power requirement 100, 120, 220, 240 VAC, ±10%, 50 or 60 Hz, 210 VA
Size 217 mm W × 90 mm H × 317 mm D (8.5 in × 3.5 in × 14.5 in), half rack
Weight 5.1 kg (11.3 lb)
Approval CE mark, RoHS

Ordering information

Part number	Description
335	2 diode/RTD inputs and 2 control outputs temperature controller—includes one dual banana jack heater output connector (106-009), two 6-pin DIN plug sensor input mating connectors (G-106-233), one 8-pin terminal block (G-107-773), a calibration certificate and user manual
335-3060	Model 335 with 3060 option card installed
3060	2-thermocouple input option for Model 335, uninstalled

Please indicate your power/cord configuration:

1 100 V—U.S. cord (NEMA 5-15)
2 120 V—U.S. cord (NEMA 5-15)
3 220 V—Euro cord (CEE 7/7)
4 240 V—Euro cord (CEE 7/7)
5 240 V—U.K. cord (BS 1363)
6 240 V—Swiss cord (SEV 1011)
7 220 V—China cord (GB 1002)

Accessories

6201	1 m (3.3 ft long) IEEE-488 (GPIB) computer interface cable assembly
8001-335	CalCurve™, factory installed – the breakpoint table from a calibrated sensor stored in the instrument (extra charge for additional sensor curves)
CAL-335-CERT	Instrument recalibration with certificate
CAL-335-DATA	Instrument recalibration with certificate and data
112-177	Cable assembly for 2 sensors and 2 heaters (335), 10 ft
112-178	Cable assembly for 2 sensors and 2 heaters (335), 20 ft

All specifications are subject to change without notice

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