Chapter 1: Introduction

FIGURE 1-1 ***Model 335 front view***

1.1 Product Description

Features:

- 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 1505 K
- Custom display setup 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 outputs, alarms, and relays

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.

1.1.1 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.

1.1.2 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 1505 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 25Ω 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.

1.1.3 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.

Sensor input connectors ⓬ USB interface ⓭ Line input assembly ⓯ Output 2 heater
Terminal block (analog outputs and relays) ❸ IEEE-488 interface ⓮ Output 1 heater ❽ Thermocouple option inputs

FIGURE 1-2 ***Model 335 rear panel***

1.1.4 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/Output 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.

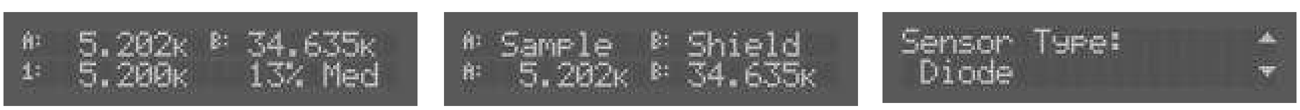

FIGURE 1-3 ***Displays showing two input/output display with labels, custom display with labels and the intuitive menu structure***

1.1.5 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.

1.2 Sensor Selection

Silicon diodes are the best choice for general cryogenic use from 1.4 K to above room temperature. 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.

		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 *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

TABLE 1-1 ***Sensor temperature range***

	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 77 K 300 K 500 K	1.664 V 1.028 V 0.5597 V 0.0907 V	-12.49 mV/K -1.73 mV/K -2.3 mV/K -2.12 mV/K	0.8 mK 5.8 mK 4.4 mK 4.7 mK	±13 mK ±76 mK ±47 mK ±40 mK	±25 mK ±98 mK ±79 mK ±90 mK	±1.6 mK ±11.6 mK ±8.8 mK ±9.4 mK
Silicon Diode	DT-470-SD-13 with 1.4H calibration	1.4 K 77 K 300 K 475 K	1.6981 V 1.0203 V 0.5189 V 0.0906 V	-13.1 mV/K -1.92 mV/K -2.4 mV/K -2.22 mV/K	0.8 mK 5.2 mK 4.2 mK 4.5 mK	±13 mK ±69 mK ±45 mK ±38 mK	±25 mK ±91 mK ±77 mK ±88 mK	±1.6 mK ±10.4 mK ±8.4 mK ±9 mK
GaAlAs Diode	TG-120-SD with 1.4H calibration	1.4 K 77 K 300 K 475 K	5.391 V 1.422 V 0.8978 V 0.3778 V	-97.5 mV/K -1.24 mV/K -2.85 mV/K -3.15 mV/K	0.2 mK 16 mK 7 mK 6.4 mK	±7 mK ±180 mK ±60 mK ±38 mK	±19 mK ±202 mK ±92 mK ±88 mK	±0.4 mK ±32 mK ±14 mK ±13 mK
100 Ω Platinum RTD 500 Ω Full Scale	PT-103 with 14J calibration	30 K 77 K 300 K 500 K	3.660 Ω 20.38 Ω 110.35 Ω 185.668 Ω	0.191 Ω/K 0.423 Ω/K 0.387 Ω/K 0.378 Ω/K	1.1 mK 0.5 mK 5.2mK 5.3 mK	±13 mK ±10 mK ±39 mK ±60 mK	±23 mK ±22 mK ±62 mK ±106 mK	±2.2 mK ±1.0 mK ±10.4 mK ±10.6 mK
Cernox™	CX-1010-SD with 0.3L calibration	0.3 K 0.5 K 4.2 K 300 K	2322.4 Ω 1248.2 Ω 277.32 Ω 30.392 Ω	-10785 Ω/K -2665.2 Ω/K -32.209 Ω/K -0.0654 Ω/K	8.5 µK 26 µK 140 µK 23 mK	±0.1 mK ±0.2 mK ±3.8 mK ±339 mK	±3.6 mK ±4.7 mK ±8.8 mK ±414 mK	±17 µK ±52 µK ±280 µK ±46 mK
Cernox™	CX-1050-SD-HT[6] with 1.4M calibration	1.4 K 4.2 K 77 K 420 K	26566 Ω 3507.2 Ω 205.67 Ω 45.03Ω	-48449 Ω/K -1120.8 Ω/K -2.4116 Ω/K -0.0829 Ω/K	20 µK 196 µK 1.9 mK 18 mK	±0.3 mK ±2.1 mK ±38 mK ±338 mK	±5.3 mK ±7.1 mK ±54 mK ±403 mK	±40 µK ±392 µK ±3.8 mK ±36 mK
Germanium	GR-300-AA with 0.3D calibration	0.35 K 1.4 K 4.2 K 100 K	18225 Ω 449 Ω 94 Ω 2.7 Ω	-193453 Ω/K -581 Ω/K -26.6 Ω/K -0.024 Ω/K	4 µK 41 µK 56µK 6.3 mK	±48 µK ±481 µK ±1.8 mK ±152 mK	±4.2 mK ±4.7 mK ±6.8 mK ±175mK	±8 µK ±82 µK ±112 µK ±12.6 mK
Germanium	GR-1400-AA with 1.4D calibration	1.8 K 4.2 K 10 K 100 K	15288 Ω 1689 Ω 253 Ω 2.8 Ω	-26868 Ω/K -862 Ω/K -62.0 Ω/K -0.021 Ω/K	28 µK 91 µK 73 µK 7.1 mK	±302 µK ±900 µK ±1.8 mK ±177 mK	±4.5 mK ±5.1 mK ±6.8 mK ±200 mK	±56 µK ±182 µK ±146 µK ±14.2 mK
Carbon-Glass	CGR-1-500 with 1.4L calibration	1.4 K 4.2 K 77 K 300 K	103900 Ω 584.6 Ω 14.33 Ω 8.55 Ω	-520000 Ω/K -422.3 Ω/K -0.098 Ω/K -0.0094 Ω/K	13 µK 63 µK 4.6 mK 16 mK	±0.1 mK ±0.8 mK ±108 mK ±760 mK	±4.1 mK ±4.8 mK ±133 mK ±865 mK	±26 µK ±126 µK ±9.2 mK ±32 mK
Rox™	RX-102A-AA with 0.3B calibration	0.5 K 1.4 K 4.2 K 40 K	3701 Ω 2005 Ω 1370 Ω 1049 Ω	-5478 Ω/K -667 Ω/K -80.3 Ω/K -1.06 Ω/K	41 µK 128µK 902 µK 62 mK	±0.5 mK ±1.4 mK ±8 mK ±500 mK	±5 mK ±6.4 mK ±24 mK ±537 K	±82 µK ±256 µK ±1.8 mK ±124 mK
Thermocouple 50 mV 3060-F	Type K	75 K 300 K 600 K 1505 K	-5862.9 µV 1075.3 µV 13325 µV 49998.3 µV	15.6 µV/K 40.6 µV/K 41.7 µV/K 36.006 µV/K	26 mK 10 mK 10 mK 11 mK	±0.25 K[7] ±0.038 K[7] ±0.184 K[7] ±0.73 K[7]	Calibration not available from Lake Shore	±52 mK ±20 mK ±20 mK ±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

TABLE 1-2 ***Typical sensor performance***

1.3 Model 335 Specifications

Full specifications are provided on our website. Please see: https://www.lakeshore.com/335.

1.3.1 Input Specifications

	Sensor temperature coefficient	Input range	Excitation current	Display resolution	Measurement resolution	Electronic accuracy (at 25 °C)	Measurement temperature coefficient	Electronic 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	±0.002Ω ±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
		0Ω to 100 kΩ	100 nA[4]	10 Ω	1.5Ω +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	Positive	±50 mV	NA	1 µV	0.4µV	±1 µV ±0.05% of rdg[5]	(0.1 µV + 0.001% of rdg)/°C	±0.8µV

[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

TABLE 1-3 ***Input specifications***

1.3.2 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

TABLE 1-4 ***Sensor input configuration***

1.3.3 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

1.3.4 Control

There are two control outputs.

1.3.4.1 Heater Outputs (Outputs 1 and 2)

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

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*

TABLE 1-5 ***Output 1***

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		

TABLE 1-6 ***Output 2***

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
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

1.3.5 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

1.3.6 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 (contact Lake Shore for availability)
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 (contact Lake Shore for availability)
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

1.3.7 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	7.6 kg (16.8 lb)
Approval	CE mark

1.4 Safety Summary and Symbols

Observe these general safety precautions during all phases of instrument operation, service, and repair. Failure to comply with these precautions or with specific warnings elsewhere in this manual violates safety standards of design, manufacture, and intended instrument use. Lake Shore Cryotronics, Inc. assumes no liability for Customer failure to comply with these requirements.

The Model 335 protects the operator and surrounding area from electric shock or burn, mechanical hazards, excessive temperature, and spread of fire from the instrument. Environmental conditions outside of the conditions below may pose a hazard to the operator and surrounding area.

- Indoor use
- Altitude to 2000 m
- Temperature for safe operation: 5 °C to 40 °C
- Maximum relative humidity: 80% for temperature up to 31 °C decreasing linearly to 50% at 40 °C
- Power supply voltage fluctuations not to exceed ±10% of the nominal voltage
- Overvoltage category II
- Pollution degree 2
- IPX0: not protected against harmful ingress of water

Ground the Instrument
To minimize shock hazard, the instrument is equipped with a 3-conductor AC power cable. Plug the power cable into an approved 3-contact electrical outlet or use a 3-contact adapter with the grounding wire (green) firmly connected to an electrical ground (safety ground) at the power outlet. The power jack and mating plug of the power cable meet Underwriters Laboratories (UL) and International Electrotechnical Commission (IEC) safety standards.

Ventilation
The instrument has ventilation holes in its side covers. Do not block these holes when the instrument is operating.

Do Not Operate in an Explosive Atmosphere
Do not operate the instrument in the presence of flammable gases or fumes. Operation of any electrical instrument in such an environment constitutes a definite safety hazard.

Keep Away from Live Circuits
Operating personnel must not remove instrument covers. Refer component replacement and internal adjustments to qualified maintenance personnel. Do not replace components with power cable connected. To avoid injuries, always disconnect power and discharge circuits before touching them.

Do Not Substitute Parts or Modify Instrument
Do not install substitute parts or perform any unauthorized modification to the instrument. Return the instrument to an authorized Lake Shore Cryotronics, Inc. representative for service and repair to ensure that safety features are maintained.

Cleaning
Do not submerge instrument. Clean only with a damp cloth and mild detergent. Exterior only.

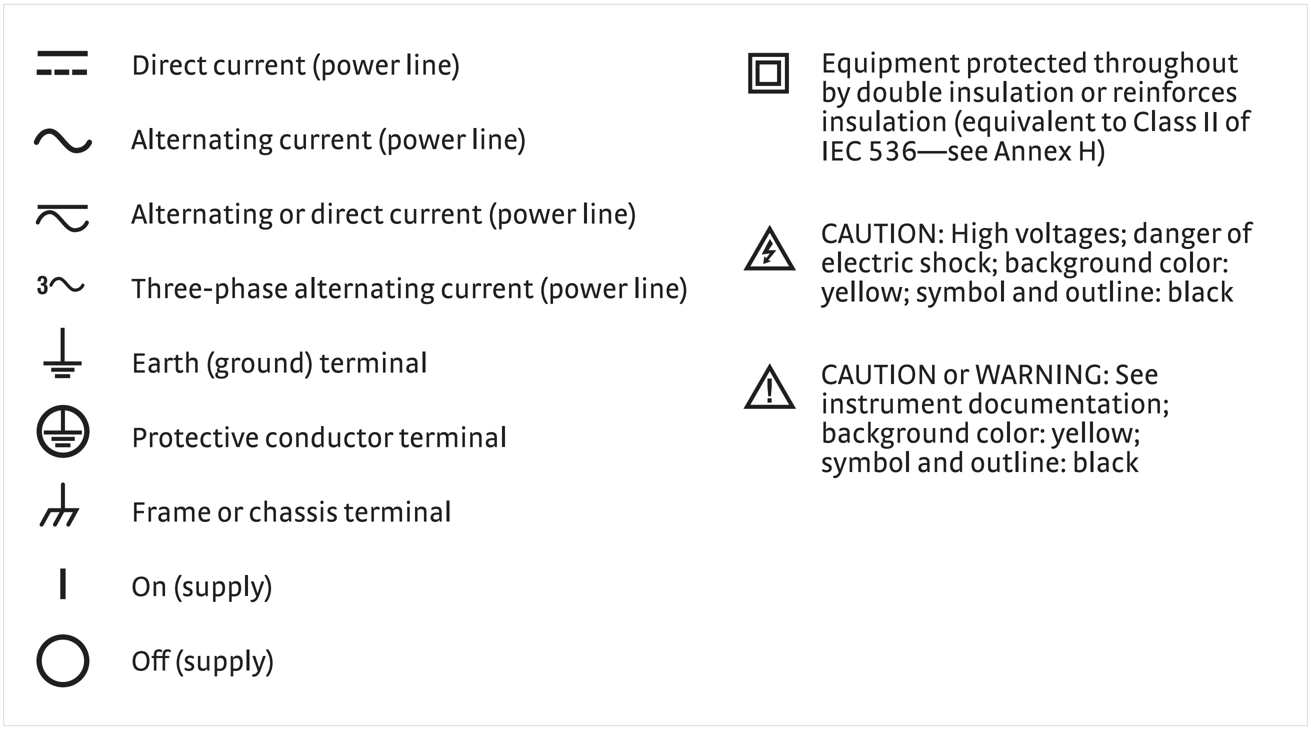

FIGURE 1-4 ***Safety symbols***

6.3 USB Interface

The Model 335 USB interface provides a convenient way to connect to most modern computers, as a USB interface is provided on nearly all new PCs as of the writing of this manual. The USB interface is implemented as a virtual serial com port connection. This implementation provides a simple migration path for modifying existing RS-232 based remote interface software. It also provides a simpler means of communicating than a standard USB implementation.

6.3.1 Physical Connection

The Model 335 has a B-type USB connector on the rear panel. This is the standard connector used on USB peripheral devices, and it allows the common USB A-type to B-type cable to be used to connect the Model 335 to a host PC. The pin assignments for A-type and B-type connectors are shown in section 8.10. The maximum length of a USB cable, as defined by the USB 2.0 standard, is 5 m (16.4 ft). This length can be extended using USB hubs every 5 m (16.4 ft) up to 5 times, for a maximum total length of 30 m (98.4 ft).

6.3.2 Hardware Support

The USB interface emulates an RS-232 serial port at a fixed 57,600 baud rate, but with the physical connections of a USB. This programming interface requires a certain configuration to communicate properly with the Model 335. The proper configuration parameters are listed in TABLE 6-5.

Baud rate	57,600
Data bits	7
Start bits	1
Stop bits	1
Parity	Odd
Flow control	None
Handshaking	None

TABLE 6-5 ***Host com port configuration***

The USB hardware connection uses the full speed (12,000,000 bits/s) profile of the USB 2.0 standard; however, since the interface uses a virtual serial com port at a fixed data rate, the data throughput is still limited to a baud rate of 57,600 bits/s.

6.3.3 Installing the USB Driver

The Model 335 USB driver has been made available through Windows® Update. This is the recommended method for installing the driver, as it will ensure that you always have the latest version of the driver installed. If you are unable to install the driver from Windows® Update, refer to section 6.3.3.3 to install the driver from the web.

These procedures assume that you are logged into a user account that has administrator privileges.

6.3.3.1 Installing the Driver From Windows® Update in Windows® 7 and Vista®

1. Connect the USB cable from the Model 335 to the computer.
2. Turn on the Model 335.
3. When the Found New Hardware wizard appears, select **Locate and install driver software (recommended)**.
4. If User Account Control (UAC) is enabled, a UAC dialog box may appear asking if you want to continue. Click **Continue**.
5. The Found New Hardware wizard should automatically connect to Windows® Update and install the drivers.

NOTE **If the Found New Hardware wizard is unable to connect to Windows® Update or find the drivers, a message to "Insert the disc that came with your Lake Shore Model 335" will be displayed. Click Cancel and refer to section 6.3.3.3 to install the driver from the web.**

6. When the Found New Hardware wizard finishes installing the driver, a confirmation message stating "the software for this device has been successfully installed" will appear. Click **Close** to complete the installation.

6.3.3.2 Installing the Driver From Windows® Update in Windows® XP

1. Connect the USB cable from the Model 335 to the computer.
2. Turn on the Model 335.
3. When the Found New Hardware wizard appears, select **Yes, this time only** and click **Next**.
4. Select **Install the software automatically (Recommended)** and click **Next**.
5. The Found New Hardware wizard should automatically connect to Windows® Update and install the drivers.

NOTE **If the Found New Hardware wizard is unable to connect to Windows® Update or find the drivers, a message saying Cannot Install this Hardware will be displayed. Click the Cancel button and refer to section 6.3.3.3 to install the driver from the web.**

6. When the Found New Hardware wizard finishes installing the driver a confirmation message stating "the wizard has finished installing the software for Lake Shore Model 335 Temperature Controller" will appear. Click **Finish** to complete the installation.

6.3.3.3 Installing the Driver From the Web

The Model 335 USB driver is available on the Lake Shore website. To install the driver it must be downloaded from the website and extracted. Use the procedure in section 6.3.3.1 through section 6.3.4 to download, extract, and install the driver using Windows® 7, Vista® and XP.

6.3.3.3.1 Download the driver:

1. Locate the Model 335 USB driver on the downloads page on the Lake Shore website.
2. Right-click on the USB driver download link, and select **save target/link as**.
3. Save the driver to a convenient place, and take note as to where the driver was downloaded.

6.3.3.3.2 Extract the driver:

The downloaded driver is in a ZIP compressed archive. The driver must be extracted from this file. Windows® provides built-in support for ZIP archives. If this support is disabled, a third-party application, such as WinZip™ or 7-Zip, must be used.

For Windows® 7 and Vista®:

1. Right click on the file and click **extract all.**
2. An Extract Compressed (Zipped) Folders dialog box will appear. It is recommended the default folder is not changed. Take note of this folder location.
3. Click to clear the **Show extracted files when complete** checkbox, and click **Extract**.

For Windows® XP:

1. Right-click on the file and click **extract all**.
2. The Extraction wizard will appear. Click **Next**.

3. It is recommended the default folder is not changed. Take note of this folder location and click **Next**.
4. An "Extraction complete" message will be displayed. Click to clear the **Show extracted files** checkbox, and click **Finish**.

6.3.3.3.3 Manually install the driver

Manually installing drivers differ between versions of Windows®. The following sections describe how to manually install the driver using Windows® 7, Vista® and XP. To install the driver you must be logged into a user account that has administrator privileges.

For Windows® 7 and Vista®:

1. Connect the USB cable from the Model 335 to the computer.
2. Turn on the Model 335.
3. If the Found New Hardware wizard appears, click **Ask me again later**.
4. Open Device Manager. Use this procedure to open Device Manager.
    a. Click the Windows® **Start** button and type Device Manager in the **Start Search** box.
    b. Click on the Device Manager link in the Search Results Under Programs dialog box.
    c. If User Account Control is enabled click **Continue** on the User Account Control prompt.
5. Click **View** and ensure the **Devices by Type** check box is selected.
6. In the main window of Device Manager, locate **Other Devices** in the list of device types. In many instances this will be between Network adapters and Ports (COM & LPT). If the **Other Devices** item is not already expanded, click the + icon.
   Lake Shore Model 335 should appear indented underneath **Other Devices**. If it is not displayed as Lake Shore Model 335, it might be displayed as USB Device. If neither are displayed, click **Action** and then **Scan for hardware changes**, which may open the Found New Hardware wizard automatically. If the Found New Hardware wizard opens, click **Cancel**.
7. Right-click on Lake Shore Model 335 and click **Update Driver Software**.
8. Click **Browse my computer for driver software**.
9. Click **Browse** and select the location of the extracted driver.
10. Ensure the **Include subfolders** check box is selected and click **Next**.
11. When the driver finishes installing a confirmation message stating "Windows has successfully updated your driver software" should appear. Click **Close** to complete the installation.

For Windows® XP:

1. Connect the USB cable from the Model 335 to the computer.
2. Turn on the Model 335.
3. The Found New Hardware wizard should appear. If the Found New Hardware wizard does not appear, the following procedure can be used to open the Hardware Update wizard which can be used instead:
    a. Open Device Manager. Use this procedure to open the Device Manager:
        - Right-click on **My Computer** and then click **Properties**. This will open the System Properties dialog.
        - Click the **Hardware** tab and then click **Device Manager**.
    b. Click **View** and ensure the **Devices by Type** check box is selected.

c. In the main window of Device Manager, locate the **Ports** (COM & LPT) device type. In many instances this will be between the Network adapters and Processors items. If the **Ports** (COM & LPT) item is not already expanded, click the + icon. Lake Shore Model 335 should appear indented underneath **Ports** (COM & LPT). If it is not displayed as Lake Shore Model 335, it might be displayed as USB Device. If neither are displayed, click **Action** and then select **Scan for hardware changes**, which may open the Found New Hardware wizard automatically. If the Found New Hardware wizard opens, continue to step 4.
d. Right-click on Lake Shore Model 335 and click **Update Driver**.

4. Select **No, not at this time** and click **Next**.
5. Select **Search for the best driver in these locations**, click to clear the **Search removable media** check box, and click the **Include this location in the search** check box.
6. Click **Browse** and open the location of the extracted driver.
7. Click **Next**.
8. When the driver finishes installing a confirmation message stating "The wizard has finished installing the software for Lake Shore Model 335 Temperature Controller" should appear. Click **Finish** to complete the installation.

6.3.4 Communication

Communicating via the USB interface is done using message strings. The message strings should be carefully formulated by the user program according to some simple rules to establish effective message flow control.

6.3.4.1 Character Format

A character is the smallest piece of information that can be transmitted by the interface. Each character is ten bits long and contains data bits, bits for character timing, and an error detection bit. The instrument uses 7 bits for data in the American Standard Code for Information Interchange (ASCII) format. One start bit and one stop bit are necessary to synchronize consecutive characters. Parity is a method of error detection. One parity bit configured for odd parity is included in each character.

ASCII letter and number characters are used most often as character data. Punctuation characters are used as delimiters to separate different commands or pieces of data. A special ASCII character, line feed (LF 0AH), is used to indicate the end of a message string. This is called the message terminator. The Model 335 will accept either the line feed character alone, or a carriage return (CR 0DH) followed by a line feed as the message terminator. The instrument query response terminator will include both carriage return and line feed.

6.3.4.2 Message Strings

A message string is a group of characters assembled to perform an interface function. There are three types of message strings: commands, queries and responses. The computer issues command and query strings through user programs, the instrument issues responses. Two or more command or query strings can be chained together in one communication, but they must be separated by a semi-colon (;). The total communication string must not exceed 255 characters in length.

A command string is issued by the computer and instructs the instrument to perform a function or change a parameter setting. The format is:

`<command mnemonic><space><parameter data><terminators>.`

Command mnemonics and parameter data necessary for each one is described in section 6.4. Terminators must be sent with every message string.

A query string is issued by the computer and instructs the instrument to send a response. The query format is:

<query mnemonic><?><space><parameter data><terminators>.

Query mnemonics are often the same as commands with the addition of a question mark. Parameter data is often unnecessary when sending queries. Query mnemonics and parameter data if necessary is described in section 6.4. Terminators must be sent with every message string. The computer should expect a response very soon after a query is sent.

A response string is the instrument's response or answer to a query string. The response can be a reading value, status report or the present value of a parameter. Response data formats are listed along with the associated queries in section 6.4. The response is sent as soon as possible after the instrument receives the query.

6.3.5 Message Flow Control

It is important to remember that the user program is in charge of the USB communication at all times. The instrument cannot initiate communication, determine which device should be transmitting at a given time, or guarantee timing between messages. All of this is the responsibility of the user program.

When issuing commands the user program alone should:

- Properly format and transmit the command including the terminator as one string
- Guarantee that no other communication is started for 50 ms after the last character is transmitted
- Not initiate communication more than 20 times/s

When issuing queries or queries and commands together, the user program should:

- Properly format and transmit the query including the terminator as one string
- Prepare to receive a response immediately
- Receive the entire response from the instrument including the terminator
- Guarantee that no other communication is started during the response or for 50 ms after it completes
- Not initiate communication more than 20 times/s

Failure to follow these simple rules will result in inability to establish communication with the instrument or intermittent failures in communication.

6.4 Command Summary

This section provides a listing of the interface commands. A summary of all the commands is provided in TABLE 6-6. All the commands are detailed in section 6.4.1, and are presented in alphabetical order.

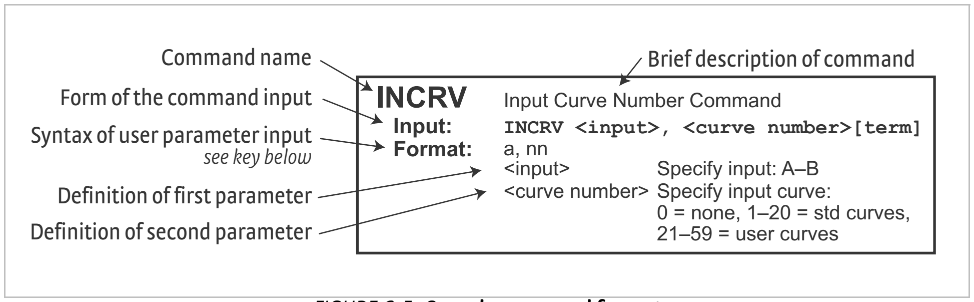

FIGURE 6-5 ***Sample command format***

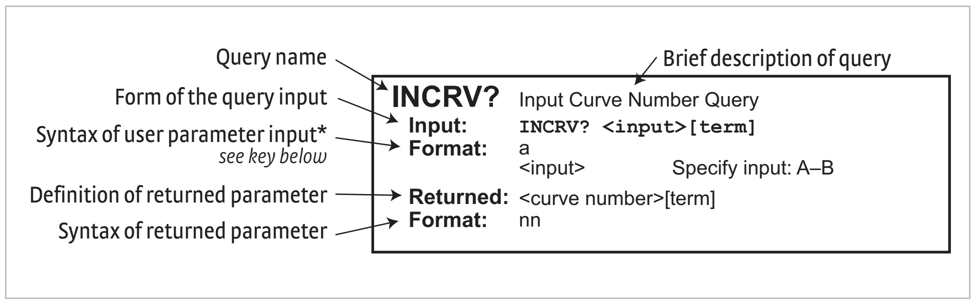

FIGURE 6-6 ***Sample query format***

Command	Function	Page	Command	Function	Page
*CLS	Clear Interface Cmd	107	INNAME	Sensor Input Name Cmd	117
*ESE	Event Status Enable Register Cmd	107	INNAME?	Sensor Input Name Query	117
*ESE?	Event Status Enable Register Query	107	INTYPE	Input Type Parameter Cmd	118
*ESR?	Standard Event Status Register Query	108	INTYPE?	Input Type Parameter Query	118
*IDN?	Identification Query	108	KRDG?	Kelvin Reading Query	119
*OPC	Operation Complete Cmd	108	LEDS	Front Panel LEDS Cmd	119
*OPC?	Operation Complete Query	108	LEDS?	Front Panel LEDS Query	119
*RST	Reset Instrument Cmd	108	LOCK	Front Panel Keyboard Lock Cmd	119
*SRE	Service Request Enable Register Cmd	109	LOCK?	Front Panel Keyboard Lock Query	119
*SRE?	Service Request Enable Register Query	109	MDAT?	Minimum/Maximum Data Query	119
*STB?	Status Byte Query	109	MNMXRST	Minimum and Maximum Function Reset Cmd	119
*TST?	Self-Test Query	109	MODE	Remote Interface Mode Cmd	120
*WAI	Wait-to-Continue Cmd	109	MODE?	Remote Interface Mode Query	120
ALARM	Input Alarm Parameter Cmd	110	MOUT	Manual Output Cmd	120
ALARM?	Input Alarm Parameter Query	110	MOUT?	Output Manual Heater Power (MHP) Output Query	120
ALARMST?	Input Alarm Status Query	110	OPST?	Operational Status Query	120
ALMRST	Reset Alarm Status Cmd	110	OPSTE	Operation Status Enable Cmd	120
ANALOG	Monitor Out Parameter Cmd	111	OPSTE?	Operational Status Enable Query	120
ANALOG?	Monitor Out Parameter Query	111	OPSTR?	Opertional Status Register Query	121
ATUNE	Autotune Cmd	111	OUTMODE	Output Mode Command	121
BRIGT	Display Brightness Cmd	111	OUTMODE?	Output Mode Query	121
BRIGT?	Display Brightness Query	112	POLARITY	Output Voltage Polarity Command	122
CRDG?	Celsius Reading Query	112	POLARITY?	Output Voltage Polarity Query	122
CRVDEL	Curve Delete Cmd	112	PID	Control Loop PID Values Cmd	121
CRVHDR	Curve Header Cmd	112	PID?	Control Loop PID Values Query	121
CRVHDR?	Curve Header Query	112	RAMP	Control Setpoint Ramp Parameter Cmd	122
CRVPT	Curve Data Point Cmd	113	RAMP?	Control Setpoint Ramp Parameter Query	122
CRVPT?	Curve Data Point Query	113	RAMPST?	Control Setpoint Ramp Status Query	122
DFLT	Factory Defaults Cmd	113	RANGE	Heater Range Cmd	123
DIOCUR	Diode Excitation Current Parameter Cmd	113	RANGE?	Heater Range Query	123
DIOCUR?	Diode Excitation Current Parameter Query	113	RDGST?	Input Reading Status Query	123
DISPFLD	Custom ModeDisplay Field Cmd	114	RELAY	Relay Control Parameter Cmd	123
DISPFLD?	Custom Mode Display Field Query	114	RELAY?	Relay Control Parameter Query	123
DISPLAY	Display Setup Cmd	114	RELAYST?	Relay Status Query	124
DISPLAY?	Display Setup Query	114	SCAL	Generate SoftCal Curve Cmd	124
EMUL	Model 331/332 Emulation Mode Cmd	115	SETP	Control Setpoint Cmd	124
EMUL?	Model 331/332 Emulation Mode Query	115	SETP?	Control Setpoint Query	124
FILTER	Input Filter Parameter Cmd	115	SRDG?	Sensor Units Input Reading Query	125
FILTER?	Input Filter Parameter Query	115	TEMP?	Thermocouple Junction Temperature Query	125
HTR?	Heater Output Query	115	TLIMIT	Temperature Limit Cmd	125
HTRSET	Heater Setup Cmd	116	TLIMIT?	Temperature Limit Query	125
HTRSET?	Heater Setup Query	116	TUNEST?	Control Tuning Status Query	125
HTRST?	Heater Status Query	116	WARMUP	Warmup Supply Parameter Cmd	126
IEEE	IEEE-488 Parameter Cmd	116	WARMUP?	Warmup Supply Parameter Query	126
IEEE?	IEEE-488 Interface Parameter Query	117	ZONE	Control Loop Zone Table Parameter Cmd	126
INCRV	Input Curve Number Cmd	117	ZONE?	Output Zone Table Parameter Query	126
INCRV?	Input Curve Number Query	117			

TABLE 6-6 ***Command summary***

6.4.1 Interface Commands

This section lists the interface commands in alphabetical order.

✱	Begins common interface command
?	Required to identify queries
s[n]	String of alphanumeric characters with length "n." Send these strings using surrounding quotes. Quotes enable characters such as commas and spaces to be used without the instrument interpreting them as delimiters.
nn…	String of number characters that may include a decimal point.
dd	Dotted decimal format, common with IP addresses. Always contains 4 dot separated 3-digit decimal numbers, such as 192.168.000.012.
[term]	Terminator characters
<…>	Indicates a parameter field, many are command specific.
<state>	Parameter field with only On/Off or Enable/Disable states.
<value>	Floating point values have varying resolution depending on the type of command or query issued.

TABLE 6-7 ***Interface commands key***

✱CLS — Clear Interface Command

Input `✱CLS[term]`

Remarks Clears the bits in the Status Byte Register, Standard Event Status Register, and Operation Event Register, and terminates all pending operations. Clears the interface, but not the controller. The related controller command is ✱RST.

✱ESE — Event Status Enable Register Command

Input `✱ESE <bit weighting>[term]`

Format nnn

Remarks Each bit is assigned a bit weighting and represents the enable/disable mask of the corresponding event flag bit in the Standard Event Status Register. To enable an event flag bit, send the command ✱ESE with the sum of the bit weighting for each desired bit. Refer to section 6.2.5 for a list of event flags.

Example To enable event flags 0, 4, and 7, send the command ✱ESE 145[term]. 145 is the sum of the bit weighting for each bit.

Bit	Bit Weighting	Event Name
0	1	OPC
2	4	QXE
4	16	EXE
5	32	CME
7	128	PON
Total:	181	

✱ESE? — Event Status Enable Register Query

Input `✱ESE?[term]`

Returned <bit weighting>[term]

Format nnn (refer to section 6.2.5 for a list of event flags)

✱ESR? Standard Event Status Register Query

Input **✱ESR?[term]**
Returned <bit weighting>
Format nnn
Remarks The integer returned represents the sum of the bit weighting of the event flag bits in the Standard Event Status Register. Refer to section 6.2.5 for a list of event flags.

✱IDN? Identification Query

Input **✱IDN?[term]**
Returned <manufacturer>,<model>,<instrument serial>/<option serial>, <firmware version>[term]
Format s[4],s[8],s[7]/s[7],n.n

<manufacturer>	Manufacturer ID
<model>	Instrument model number
<instrument serial>	Instrument serial number
<option card serial>	Option card serial number
<firmware version>	Instrument firmware version

Example LSCI,MODEL335,1234567/1234567,1.0

✱OPC Operation Complete Command

Input **✱OPC[term]**
Remarks Generates an Operation Complete event in the Event Status Register upon completion of all pending selected device operations. Send it as the last command in a command string.

✱OPC? Operation Complete Query

✱OPC?[term]
Returned 1[term]
Remarks Places a 1 in the controller output queue upon completion of all pending selected device operations. Send as the last command in a command string.
Not the same as ✱OPC.

✱RST Reset Instrument Command

Input **✱RST[term]**
Remarks Sets controller parameters to power-up settings.

✱SRE Service Request Enable Register Command

Input **✱SRE <bit weighting>[term]**

Format nnn

Remarks Each bit has a bit weighting and represents the enable/disable mask of the corresponding status flag bit in the Status Byte Register. To enable a status flag bit, send the command ✱SRE with the sum of the bit weighting for each desired bit. Refer to section 6.2.6 for a list of status flags.

Example To enable status flags 4, 5, and 7, send the command ✱SRE 208[term]. 208 is the sum of the bit weighting for each bit.

Bit	Bit Weighting	Event Name
4	16	MAV
5	64	ESB
7	128	OSB
Total:	208	

✱SRE? Service Request Enable Register Query

Input **✱SRE?[term]**

Returned <bit weighting>[term]

Format nnn (refer to section 6.2.6 for a list of status flags)

✱STB? Status Byte Query

Input **✱STB?[term]**

Returned <bit weighting>[term]

Format nnn

Remarks Acts like a serial poll, but does not reset the register to all zeros. The integer returned represents the sum of the bit weighting of the status flag bits that are set in the Status Byte Register. Refer to section 6.2.6 for a list of status flags.

✱TST? Self-Test Query

Input **✱TST?[term]**

Returned <status>[term]

Format n

<status> 0 = no errors found, 1 = errors found

Remarks The Model 335 reports status based on the test done at power up.

✱WAI Wait-to-Continue Command

Input **✱WAI[term]**

Remarks Causes the IEEE-488 interface to hold off until all pending operations have been completed. This is the same function as the ✱OPC command, except that it does not set the Operation Complete event bit in the Event Status Register.

ALARM — Input Alarm Parameter Command

Input **ALARM <input>,<off/on>,<high value>,<low value>, <deadband>,<latch enable>, <audible>,<visible> [term]**

Format a,n, ±nnnnnn, ±nnnnnn, +nnnnnn,n,n,n

<input>	Specifies which input to configure: A or B.
<off/on>	Determines whether the instrument checks the alarm for this input, where 0 = off and 1 = on.
<high setpoint>	Sets the value the source is checked against to activate the high alarm.
<low setpoint>	Sets the value the source is checked against to activate low alarm.
<deadband>	Sets the value that the source must change outside of an alarm condition to deactivate an unlatched alarm.
<latch enable>	Specifies a latched alarm (remains active after alarm condition correction) where 0 = off (no latch) and 1 = on.
<audible>	Specifies if the internal speaker will beep when an alarm condition occurs. Valid entries: 0 = off, 1 = on.
<visible>	Specifies if the Alarm LED on the instrument front panel will blink when an alarm condition occurs. Valid entries: 0 = off, 1 = on

Remarks Configures the alarm parameters for an input.

Example **ALARM A,0[term]** turns off alarm checking for Input A.
ALARM B,1,270.0,0,0,1,1,1[term] turns on alarm checking for input B, activates high alarm if kelvin reading is over 270, and latches the alarm when kelvin reading falls below 270. Alarm condition will cause instrument to beep and the front panel Alarm LED to blink.

ALARM? — Input Alarm Parameter Query

Input **ALARM? <input>[term]**

Format a
<input> A or B

Returned <off/on>,<high value>,<low value>,<deadband>,<latch enable>,<audible>,<visible> [term]

Format n,±nnnnnn,±nnnnnn,+nnnnnn,n,n,n (refer to command for description)

ALARMST? — Input Alarm Status Query

Input **ALARMST? <input>[term]**

Format a
<input> A - B

Returned <high state>,<low state>[term]

Format n,n
<high state> 0 = Off, 1 = On
<low state> 0 = Off, 1 = On

ALMRST — Reset Alarm Status Command

Input **ALMRST[term]**

Remarks Clears both the high and low status of all alarms, including latching alarms.

ANALOG — Monitor Out Parameter Command

Input `ANALOG <output>,<input>,<units>,<high value>,<low value>,<polarity>[term]`

Format n,n,n,±nnnnn,±nnnnn,n

<output> Output 2 is the only valid entry and must be included (included for compatibility with other Lake Shore temperature instruments). 2 = Output 2

<input> Specifies which input to monitor. 0 = none, 1 = Input A, 2 =Input B

<units> Specifies the units on which to base the output voltage: 1 = kelvin, 2 = Celsius, 3 = sensor units

<high value> If output mode is Monitor Out, this parameter represents the data at which the Monitor Out reaches +100% output.Entered in the units designated by the <units> parmeter. Refer to OUTMODE command.

<low value> If output mode is Monitor Out, this parameter represents the data at which the analog output reaches -100% output if bipolar, or 0% output if positive only. Entered in the units designated by the <units> parmeter.

<polarity> Specifies output voltage is 0 = unipolar (positive output only) or 1 = bipolar (positive or negative output)

Example **ANALOG 2,1,1,100.0,0.0,0[term]** sets Output 2 Voltage mode to monitor Input A kelvin reading with 100.0 K at +100% output (+10.0 V) and 0.0 K at 0% output (0.0 V).

Remarks Use the OUTMODE command to set the output mode to Monitor Out. The <input> parameter in the ANALOG command is the same as the <input> parameter in the OUTMODE command. It is included in the ANALOG command for backward compatibility with previous Lake Shore temperature monitors and controllers. The ANALOG command name is also named as such for backward compatibility.

ANALOG? — Monitor Out Parameter Query

Input `ANALOG? <output>[term]`

Format n

Returned <input>,<units>,<high value>,<low value>,<polarity>[term]

Format n,n,±nnnnn,±nnnnn,n (refer to command for definition)

ATUNE — Autotune Command

Input `ATUNE <output>,<mode>,[term]`

Format n,n

<output> Specifies the output associated with the loop to be Autotuned: 1 or 2.

<mode> Specifies the Autotune mode. Valid entries: 0 = P Only, 1 = P and I, 2 = P, I, and D.

Example **ATUNE 2,1 [term]** initiates Autotuning of control loop associated with output 2, in P and I mode.

Remarks If initial conditions required to Autotune the specified loop are not met, an Autotune initialization error will occur and the Autotune process will not be performed. The TUNEST? query can be used to check if an Autotune error occurred.

BRIGT — Display Brightness Command

Input `BRIGT <brightness value>[term]`

Format n

<brightness value> 0–3

Remarks Sets the display brightness for the front panel display 0=25%, 1=50%, 2=75%, 3=100%.

BRIGT? Display Brightness Query

Input `BRIGT?[term]`
Returned <brightness value>[term]
Format n (refer to command for description)

CRDG? Celsius Reading Query

Input `CRDG? <input>[term]`
Format a
<input> A or B
Returned <temp value>[term]
Format ±nnnnnn
Remarks Also see the RDGST? query.

CRVDEL Curve Delete Command

Input `CRVDEL <curve>[term]`
Format nn
<curve> Specifies a user curve to delete. Valid entries: 21–59.
Example **CRVDEL 21[term]** deletes User Curve 21.

CRVHDR Curve Header Command

Input `CRVHDR <curve>,<name>,<SN>,<format>,<limit value>,<coefficient>[term]`
Format nn,s[15],s[10],n,+nnn.nnn,n
<curve> Specifies which curve to configure. Valid entries: 21–59.
<name> Specifies curve name. Limited to 15 characters.
<SN> Specifies the curve serial number. Limited to ten characters.
<format> Specifies the curve data format. Valid entries: 1 = mV/K, 2 = V/K, 3 = Ω/K, 4 = log Ω/K.
<limit value> Specifies the curve temperature limit in kelvin.
<coefficient> Specifies the curves temperature coefficient. Valid entries: 1 = negative, 2 = positive.
Remarks Configures the user curve header. The coefficient parameter will be calculated automatically based on the first two curve datapoints. It is included as a parameter for compatability with the CRVHDR? query.
All parameter fields must be filled with a value. If the sensor does not have a serial number, enter NONE in this parameter field.
Example **CRVHDR 21,DT-470,00011134,2,325.0,1[term]** configures User Curve 21 with a name of DT-470, serial number of 00011134, data format of volts versus kelvin, upper temperature limit of 325 K, and negative coefficient.

CRVHDR? Curve Header Query

Input `CRVHDR? <curve>[term]`
Format nn
<curve> Valid entries: 1–59.
Returned <name>,<SN>,<format>,<limit value>,<coefficient>[term]
Format s[15],s[10],n,+nnn.nnn,n (refer to command for description)

CRVPT Curve Data Point Command

Input `CRVPT <curve>,<index>,<units value>,<temp value>[term]`

Format nn,nnn,±nnnnnn,+nnnnnn

<curve> Specifies which curve to configure. Valid entries: 21–59.

<index> Specifies the points index in the curve. Valid entries: 1–200.

<units value>Specifies sensor units for this point to six digits.

<temp value>Specifies the corresponding temperature in kelvin for this point to six digits.

Remarks Configures a user curve data point.

Example **CRVPT 21,2,0.10191,470.000,N[term]** sets User Curve 21 second data point to 0.10191 sensor units and 470.000 K.

CRVPT? Curve Data Point Query

Input `CRVPT? <curve>,<index>[term]`

Format nn,nnn

<curve> Specifies which curve to query: 1–59.

<index> Specifies the points index in the curve: 1–200.

Returned <units value>,<temp value>[term]

Format ±nnnnnn,+nnnnnn (refer to command for description)

Remarks Returns a standard or user curve data point.

DFLT Factory Defaults Command

Input `DFLT 99[term]`

Remarks Sets all configuration values to factory defaults and resets the instrument. The “99” is included to prevent accidentally setting the unit to defaults.

DIOCUR Diode Excitation Current Parameter Command

Input `DIOCUR <input>,<excitation>[term]`

Format a,n

<input> Specifies which input to configure: A or B.

<excitation > Specifies the Diode excitation current: 0 = 10 μA, 1 = 1 mA.

Remarks The 10 μA excitation current is the only calibrated excitation current, and is used in almost all applications. Therefore the Model 335 will default the 10 μA current setting any time the input sensor type is changed in order to prevent an accidental change. If using a current that is not 10 μA, the input sensor type must first be configured to Diode (INTYPE command). If the sensor type is not set to Diode when the DIOCUR command is sent, the command will be ignored.

DIOCUR? Diode Excitation Current Parameter Query

Input `DIOCUR? <input>[term]`

Format a

<input> A or B

Returned <excitation> [term]

Format n (refer to command for description)

DISPFLD — Custom Mode Display Field Command

Input `DISPFLD <field>,<source>,<units>[term]`

Format n,n,n

<field> Specifies field (display location) to configure: 1–4.

<source> Specifies item to display in the field: 0 = None, 1 = Input A, 2 = Input B, 3 = Setpoint 1, 4 = Setpoint 2, 5=Output 1, 6=Output 2

<units> Valid entries: 1 = kelvin, 2 = Celsius, 3 = sensor units, 4 = minimum data, 5 = maximum data, 6 = sensor name.

Example **DISPFLD 2,1,1[term]** displays kelvin reading for Input A in display field 2 when display mode is set to Custom.

Remarks Since each display field is only ten characters, only the first nine characters of the sensor name will be displayed when the units for a field are set to display the sensor name. However, if two adjacent fields are assigned to the same sensor name, then the entire twenty character line can be used, allowing all fifteen sensor name characters to be displayed.

This command only applies to the readings displayed in the Custom display mode. All other display modes have predefined readings in predefined locations, and will use the Preferred Units parameter to determine which units to display for each sensor input. Refer to section 4.3 for details on display setup

DISPFLD? — Custom Mode Display Field Query

Input `DISPFLD? <field>[term]`

Format n

<field> Specifies field (display location) to query: 1–4.

Returned <input>,<units>[term]

Format n,n (refer to command for description)

DISPLAY — Display Setup Command

Input `DISPLAY <mode>[term]`

Format n

<mode> Specifies display mode: 0 = Input A, 1 = Input A Max/Min, 2 = Two Input, Loop A, 3=Input B, 4=Input B Max/Min, 5=Two Input, Loop B, 6=Custom, 7=Two Loop

Remarks When the input display mode is set to Custom, use the DISPFLD command to configure the display.

DISPLAY? — Display Setup Query

Input `DISPLAY?[term]`

Returned <mode>[term]

Format n (refer to command for description)

EMUL — Model 331/332 Interface Emulation Mode Command

Input: `EMUL <emulation mode>,<PID scaling mode>[term]`

Format: nn

<emulation mode>	0=None (335), 1=331, 2=332
<PID scaling mode>	PID control scaling: 0=335 (Temperature), 1=331/332 (Sensor)

Remarks: The 331 and 332 emulation modes provide a means of using the Model 335 in place of a Model 331 or 332 in a software controlled system without updating the software. The emulation mode setting only affects remote operation; front panel operation of the Model 335 is not changed. Please reference the Model 331 or 332 user's manual for information on the interface commands for those models. For more information on using the emulation modes, see section 5.11.

EMUL? — Model 331/332 Interface Emulation Mode Query

Input: `EMUL? [term]`

Returned: <emulation mode>,<PID scaling mode>[term]

Format: n,n (refer to command for description)

FILTER — Input Filter Parameter Command

Input: `FILTER <input>,<off/on>,<points>,<window>[term]`

Format: a,n,nn,nn

<input>	Specifies input to configure: A or B.
<off/on>	Specifies whether the filter function is 0 = Off or 1 = On.
<points>	Specifies how many data points the filtering function uses. Valid range = 2–64.
<window>	Specifies what percent of full scale reading limits the filtering function. Reading changes greater than this percentage reset the filter. Valid range = 1 to 10%.

Example: **FILTER B,1,10,2[term]** filter input B data through ten readings with 2% of full scale window.

FILTER? — Input Filter Parameter Query

Input: `FILTER? <input>[term]`

Format: a

<input>	Specifies input to query: A or B.

Returned: <off/on >,<points>,<window>[term]

Format: n,nn,nn (refer to command for description)

HTR? — Heater Output Query

Input: `HTR? <output>[term]`

Format: n

<output>	Heater output to query: 1 = Output 1, 2 = Output 2

Returned: <heater value>[term]

Format: ±nnn.n

<heater value>	Percent of full scale current for Output 1 and Output 2 in Current mode, or percent of full scale voltage for Output 2 in Voltage mode.

HTRSET Heater Setup Command

Input `HTRSET <output>,<type>,<heater resistance>,<max current>,<max user current>,<current/power>[term]`

Format n,n,n,n,+n.nnn,n

<output>	Specifies which heater output to configure: 1 or 2.
<type>	Output type (Output 2 only): 0=Current, 1=Voltage
<htr resistance>	Heater Resistance Setting: 1 = 25 Ω, 2 = 50 Ω.
<max current>	Specifies the maximum heater output current: 0 = User Specified, 1 = 0.707 A, 2 = 1 A, 3 = 1.141 A, 4 = 1.732 A
<max user current>	Specifies the maximum heater output current if max current is set to User Specified.
<current/power>	Specifies whether the heater output displays in current or power (current mode only). Valid entries: 1 = current, 2 = power.

Example **HTRSET 2,0,1,2,0,1[term]** Heater Output 2 uses the current source output, the 25 Ω heater setting, has a maximum current of 1 A, the maximum user current is set to 0 A because it is not going to be used since a discrete value has been chosen, and the heater output will be displayed in units of current.

Remarks Max current will be limited to 1 A on Output 1 if the heater resistance is set to 50 Ω. If the heater resistance is set to 25 Ω on Output 1, then the max current will be limited to 1.414 A if Output 2 is in Current mode, or 1.732 A if Output 2 is in Voltage mode. See section 4.5.1.3 for more information on the max current setting.

HTRSET? Heater Setup Query

Input `HTRSET? <output>[term]`

Format n

<output> Specifies which heater output to query: 1 or 2.

Returned <type>,<htr resistance>,<max current>,<max user current>,<current/power>[term]

Format n,n,n,+n.nnn,n

HTRST? Heater Status Query

Input `HTRST? <output>[term]`

Format n

<output> Specifies which heater output to query: 1 or 2.

Returned <error code>[term]

Format n

<error code> Heater error code: 0 = no error, 1 = heater open load, 2 = heater short.

Remarks Error condition is cleared upon querying the heater status, which will also clear the front panel error message.

IEEE IEEE-488 Interface Parameter Command

Input `IEEE <address>[term]`

Format nn

<address> Specifies the IEEE address: 1–30. (Address 0 and 31 are reserved.)

Example **IEEE 4[term]** after receipt of the current terminator, the instrument responds to address 4.

IEEE? IEEE-488 Interface Parameter Query

Input `IEEE?[term]`

Returned <address>[term]

Format nn (refer to command for description)

INCRV Input Curve Number Command

Input `INCRV <input>,<curve number>[term]`

Format a,nn

<input> Specifies which input to configure: A or B.

<curve number> Specifies which curve the input uses. If specified curve type does not match the configured input type, the curve number defaults to 0. Valid entries: 0 = none, 1–20 = standard curves, 21–59 = user curves.

Remarks Specifies the curve an input uses for temperature conversion.

Example **INCRV A,23[term]** Input A uses User Curve 23 for temperature conversion.

INCRV? Input Curve Number Query

Input `INCRV? <input>[term]`

Format a

<input> Specifies which input to query: A or B.

Returned <curve number>[term]

Format nn (refer to command for description)

INNAME Sensor Input Name Command

Input `INNAME <input>,<name>[term]`

Format a,s[15]

<input> Specifies input to configure: A or B.

<name> Specifies the name to associate with the sensor input.

Example **INNAME A, "Sample Space"[term]** the string "Sample Space" will appear on the front panel display when possible to identify the sensor information being displayed.

Remarks Be sure to use quotes when sending strings, otherwise characters such as spaces, and other non alpha-numeric characters, will be interpreted as a delimiter and the full string will not be accepted. It is not recommended to use commas or semi-colons in sensor input names as these characters are used as delimiters for query responses.

INNAME? Sensor Input Name Query

Input `INNAME? <input>[term]`

Format a

<input> Specifies input to query: A or B.

Returned <name>[term]

Format s[15] (refer to command for description)

INTYPE Input Type Parameter Command

Input `INTYPE <input>,<sensor type>,<autorange>,<range>,<compensation>,<units> [term]`

Format a,n,n,n,n,n

<input> Specifies input to configure: A or B

<sensor type> Specifies input sensor type:
0 = Disabled
1 = Diode
2 = Platinum RTD
3 = NTC RTD
4 = Thermocouple

<autorange> Specifies autoranging: 0 = off and 1 = on.

<range> Specifies input range when autorange is off:

Diode	0 = 2.5 V
	1 = 10 V
PTC RTD	0 = 10 Ω
	1 = 30 Ω
	2 = 100 Ω
	3 = 300 Ω
	4 = 1 kΩ
	5 = 3 kΩ
	6 = 10 kΩ
NTC RTD	0 = 10 Ω
	1 = 30 Ω
	2 = 100 Ω
	3 = 300 Ω
	4 = 1 kΩ
	5 = 3 kΩ
	6 = 10 kΩ
	7 = 30 kΩ
	8 = 100 kΩ
Thermocouple	0 = 50 mV

TABLE 6-8 ***Input range***

<compensation> Specifies input compensation where 0 = off and 1 = on. Reversal for thermal EMF compensation if input is resistive, room compensation if input is thermocouple. Always 0 if input is a diode.

<units> Specifies the preferred units parameter for sensor readings and for the control setpoint: 1 = kelvin, 2 = Celsius, 3 = Sensor

Example **INTYPE A,2,1,0,1,1[term]** sets Input A sensor type to Platinum RTD, autorange on, thermal compensation on, and preferred units to kelvin.

Remarks The <autorange> and <range> parameters do not apply to thermocouple sensor type, and the <autorange> and <compensation> parameters do not apply to diode sensor type. When configuring diode or thermocouple sensor types, these parameters must be included, but are ignored. A setting of 0 for each is recommended in this case.

INTYPE? Input Type Parameter Query

Input `INTYPE? <input>[term]`

Format a

<input> Specifies input to query: A or B.

Returned <sensor type>,<autorange>,<range>,<compensation>,<units> [term]

Format n,n,n,n,n (refer to command for description)

Remarks If autorange is on, the returned range parameter is the currently auto-selected range.

KRDG? Kelvin Reading Query

Input `KRDG? <input>[term]`
Format a
<input> Specifies which input to query: A –B.
Returned <kelvin value>[term]
Format ±nnnnnn
Remarks Also see the RDGST? query.

LEDS Front Panel LEDS Command

Input `LEDS <off/on>[term]`
Format n
<off/on> 0 = LEDs Off, 1 = LEDs On
Remarks If set to 0, front panel LEDs will not be functional. Function can be used when display brightness is a problem.
Example **LED 0[term]** turns all front panel LED functionality off.

LEDS? Front Panel LEDS Query

Input `LEDS?[term]`
Returned <off/on> [term]
Format n (refer to command for description)

LOCK Front Panel Keyboard Lock Command

Input `LOCK <state>,<code>[term]`
Format n,nnn
<state> 0 = Unlocked, 1 = Locked
<code> Specifies lock-out code. Valid entries are 000 –999.
Remarks Locks out all front panel entries except pressing **ALL OFF** to immediately turn off all heater outputs. Refer to section 4.7.
Example **LOCK 1,123[term]** enables keypad lock and sets the code to 123.

LOCK? Front Panel Keyboard Lock Query

Input `LOCK?[term]`
Returned <state>,<code>[term]
Format n,nnn (refer to command for description)

MDAT? Minimum/Maximum Data Query

Input `MDAT? <input>[term]`
Format a
<input> Specifies which input to query: A or B.
Returned <min value>,<max value>[term]
Format ±nnnnnn,±nnnnnn
Remarks Returns the minimum and maximum input data. Also see the RDGST? query.

MNMXRST Minimum and Maximum Function Reset Command

Input `MNMXRST[term]`
Remarks Resets the minimum and maximum data for all inputs.

MODE Remote Interface Mode Command

Input `MODE <mode>[term]`

Format n

<mode> 0 = local, 1 = remote, 2 = remote with local lockout.

Example **MODE 2[term]** places the Model 335 into remote mode with local lockout.

MODE? Remote Interface Mode Query

Input `MODE?[term]`

Returned <mode>[term]

Format n (refer to command for description)

MOUT Manual Output Command

Input `MOUT <output>,<value>[term]`

Format n,+nnnnn[term]

<output> Specifies output to configure: 1 or 2.

<value> Specifies value for manual output.

Example **MOUT 1,22.45[term]** Output 1 manual output is 22.45%.

Remarks Manual output only applies to outputs in Closed Loop PID, Zone, or Open Loop modes.

MOUT? Manual Output Query

Input `MOUT? <output>[term]`

Format n

<output> Specifies which output to query: 1 or 2.

Returned <value>

Format +nnnnn[term] (refer to command for description)

OPST? Operational Status Query

Input `OPST? [term]`

Returned <bit weighting> [term]

Format nnn

Remarks The integer returned represents the sum of the bit weighting of the operational status bits. Refer to section 6.2.5.2 for a list of operational status bits.

OPSTE Operational Status Enable Command

Input `OPSTE <bit weighting> [term]`

Format nnn

Remarks Each bit has a bit weighting and represents the enable/disable mask of the corresponding operational status bit in the Operational Status Register. This determines which status bits can set the corresponding summary bit in the Status Byte Register. To enable a status bit, send the command OPSTE with the sum of the bit weighting for each desired bit. Refer to section 6.2.5.2 for a list of operational status bits.

OPSTE? Operational Status Enable Query

Input `OPSTE?[term]`

Returned <bit weighting> [term]

Format nnn (Refer to section 6.2.5.2 for a list of operational status bits)

OPSTR? Operational Status Register Query

Input `OPSTR? [term]`

Returned <bit weighting> [term]

Format nnn

Remarks The integers returned represent the sum of the bit weighting of the operational status bits. These status bits are latched when the condition is detected. This register is cleared when it is read. Refer to section 6.2.5.2 for a list of operational status bits.

OUTMODE Output Mode Command

Input **OUTMODE <output>,<mode>,<input>,<powerup enable>[term]**

Format n,n,n,n

<output>	Specifies which output to configure: 1 or 2.
<mode>	Specifies the control mode. Valid entries: 0 = Off, 1 = Closed Loop PID, 2 = Zone, 3 = Open Loop, 4 = Monitor out, 5 = Warmup Supply
<input>	Specifies which input to use for control: 0 = None, 1 = A, 2 = B
<powerup enable>	Specifies whether the output remains on or shuts off after power cycle. Valid entries: 0 = powerup enable off, 1 = powerup enable on.

Example **OUTMODE 1,2,1,0[term]** Output 1 configured for Zone control mode, using Input A for the control input sensor, and will turn the output off when power is cycled.

Remarks Modes 4 and 5 are only valid for Output 2 in Voltage mode.

OUTMODE? Output Mode Query

Input **OUTMODE? <output>[term]**

Format n

<output>	Specifies which output to query: 1 or 2.

Returned <mode>,<input>,<powerup enable>[term]

Format n,n,n (refer to command for description)

PID Control Loop PID Values Command

Input **PID <output>,<P value>,<I value>,<D value>[term]**

Format n,+nnnnn,+nnnnn,+nnnn

<output>	Specifies which output's control loop to configure: 1 or 2.
<P value>	The value for output Proportional (gain): 0.1 to 1000.
<I value>	The value for output Integral (reset): 0.1 to 1000.
<D value>	The value for output Derivative (rate): 0 to 200.

Remarks Control settings, (P, I, D, and Setpoint) are assigned to outputs, which results in the settings being applied to any loop formed by the output and its control input.

Example **PID 1,10,50,0[term]** Output 1 P is 10, I is 50, and D is 0%.

PID? Control Loop PID Values Query

Input **PID? <output>[term]**

Format n

<output>	Specifies which output's control loop to query: 1 or 2.

Returned <P value>,<I value>,<D value>[term]

Format +nnnnn,+nnnnn,+nnnn (refer to command for description)

POLARITY — Output Voltage Polarity Command

Input `POLARITY <output>,<polarity>[term]`

Format n,n

<output>	Output for which to configure the polarity setting: 2
<polarity>	Specifies output voltage is 0=unipolar (positive output only) or 1=bipolar (positive or negative output)

Remarks The polarity command only applies to Output 2, and only when output type is voltage.

POLARITY? — Output Voltage Polarity Query

Input `POLARITY?[term]`

Returned <polarity>[term]

Format n (refer to command for description)

RAMP — Control Setpoint Ramp Parameter Command

Input `RAMP <output>,<off/on>,<rate value>[term]`

Format n,n,nnnn

<output>	Specifies which output's control loop to configure: 1 or 2.
<off/on>	Specifies whether ramping is 0 = Off or 1 = On.
<rate value>	Specifies setpoint ramp rate in kelvin per minute from 0.1 to 100. The rate is always positive, but will respond to ramps up or down. A rate of 0 is interpreted as infinite, and will therefore respond as if setpoint ramping were off.

Example **RAMP 1,1,10.5[term]** when Output 1 setpoint is changed, ramp the current setpoint to the target setpoint at 10.5 K/minute.

Remarks Control loop settings are assigned to outputs, which results in the settings being applied to the control loop formed by the output and its control input.

RAMP? — Control Setpoint Ramp Parameter Query

Input `RAMP? <output>[term]`

Format n

<output>	Specifies which output's control loop to query: 1 or 2.

Returned <off/on>,<rate value>[term]

Format n,nnnn (refer to command for description)

RAMPST? — Control Setpoint Ramp Status Query

Input `RAMPST? <output>[term]`

Format n

<output>	Specifies which output's control loop to query: 1 or 2.

Returned <ramp status>[term]

Format n

<ramp status>	0 = Not ramping, 1 = Setpoint is ramping.

RANGE — Heater Range Command

Input `RANGE <output>,<range>[term]`

Format n,n

<output>	Specifies which output to configure: 1 or 2.
<range>	For Outputs 1 and 2 in Current mode: 0 = Off, 1 = Low, 2 = Medium, 3 = High For Output 2 in Voltage mode: 0 = Off, 1 = On

Remarks The range setting has no effect if an output is in the Off mode, and does not apply to an output in Monitor Out mode. An output in Monitor Out mode is always on.

RANGE? — Heater Range Query

Input `RANGE? <output>[term]`

Format n

<output>	Specifies which output to query: 1 or 2.

Returned <range>[term]

Format n (refer to command for description)

RDGST? — Input Reading Status Query

Input `RDGST? <input>[term]`

Format a

<input>	Specifies which input to query: A or B.

Returned <status bit weighting>[term]

Format nnn

Remarks The integer returned represents the sum of the bit weighting of the input status flag bits. A "000" response indicates a valid reading is present.

Bit	Bit Weighting	Status Indicator
0	1	invalid reading
4	16	temp underrange
5	32	temp overrange
6	64	sensor units zero
7	128	sensor units overrange

RELAY — Relay Control Parameter Command

Input `RELAY <relay number>,<mode>,<input alarm>,<alarm type>[term]`

Format n,n,a,n

<relay number>	Specifies which relay to configure: 1 or 2.
<mode>	Specifies relay mode. 0 = Off, 1 = On, 2 = Alarms.
<input alarm>	Specifies which input alarm activates the relay when the relay is in alarm mode: A or B.
<alarm type>	Specifies the input alarm type that activates the relay when the relay is in alarm mode. 0 = Low alarm, 1 = High Alarm, 2 = Both Alarms.

Example **RELAY 1,2,B,0[term]** relay 1 activates when Input B low alarm activates.

RELAY? — Relay Control Parameter Query

Input `RELAY? <relay number>[term]`

Format n

<relay number>	Specifies which relay to query: 1 or 2.

Returned <mode>,<input alarm>,<alarm type>[term]

Format n,a,n (refer to command for description)

RELAYST? Relay Status Query

Input **RELAYST? <relay number>[term]**

Format n

<relay number> Specifies which relay to query: 1 or 2.

Returned <status>[term]

Format n 0 = Off, 1 = On.

SCAL Generate SoftCal Curve Command

Input **SCAL <std>,<dest>,<SN>,<T1 value>,<U1 value>,<T2 value>,<U2 value>,<T3 value>,<U3 value>[term]**

Format n,nn,S[10],+nnnnnn,±nnnnnn,+nnnnnn,±nnnnnn,+nnnnnn,±nnnnnn

<std> Specifies the standard curve from which to generate a SoftCal™ curve. Valid entries: 1, 6, 7.

<dest> Specifies the user curve to store the SoftCal™ curve. Valid entries: 21–59.

<SN> Specifies the curve serial number. Limited to ten characters.

<T1 value> Specifies first temperature point in kelvin.

<U1 value> Specifies first sensor units point.

<T2 value> Specifies second temperature point in kelvin.

<U2 value> Specifies second sensor units point.

<T3 value> Specifies third temperature point in kelvin.

<U3 value> Specifies third sensor units point.

Remarks Generates a SoftCal™ curve. Refer to Paragraph 5.3.

Example **SCAL 1,21,1234567890,4.2,1.6260,77.32,1.0205,300.0,0.5189[term]** generates a three-point SoftCal™ curve from standard curve 1 and saves it in user curve 21.

SETP Control Setpoint Command

Input **SETP <output>,<value>[term]**

Format n,±nnnnnn

<output> Specifies which output's control loop to configure: 1 or 2.

<value> The value for the setpoint (in the preferred units of the control loop sensor).

Example **SETP 1,122.5[term]** Output 1 setpoint is now 122.5 (based on its units).

Remarks Control settings, that is, P, I, D, and Setpoint, are assigned to outputs, which results in the settings being applied to the control loop formed by the output and its control input.

SETP? Control Setpoint Query

Input **SETP? <output>[term]**

Format n

<output> Specifies which output to query: 1 or 2.

Returned <value>[term]

Format ±nnnnnn (refer to command for description)

SRDG? Sensor Units Input Reading Query

Input `SRDG? <input>[term]`

Format a

<input> Specifies which input to query: A or B.

Returned <sensor units value>[term]

Format ±nnnnnn

Remarks Also see the RDGST? command.

TEMP? Thermocouple Junction Temperature Query

Input `TEMP?[term]`

Returned <junction temperature>[term]

Format +nnnnn

Remarks Temperature is in kelvin. This query returns the temperature of the ceramic thermocouple block used in the room temperature compensation calculation.

TLIMIT Temperature Limit Command

Input `TLIMIT <input>,<limit>[term]`

Format n+nnnn

<input> Specifies which input to configure: A or B.

<limit> The temperature limit in kelvin for which to shut down all control outputs when exceeded. A temperature limit of zero turns the temperature limit feature off for the given sensor input.

Example **TLIMIT B,450[term]** if the temperature of the sensor on Input B exceeds 450 K, all control outputs will be turned off.

Remarks A temperature limit setting of 0 K turns the temperature limit feature off.

TLIMIT? Temperature Limit Query

Input `TLIMIT? <input>[term]`

Format a

<input> Specifies which input to query: A or B.

Returned < limit>[term]

Format +nnnn (refer to command for description)

TUNEST? Control Tuning Status Query

Input `TUNEST?[term]`

Returned <tuning status>,<output>,<error status>,<stage status>[term]

Format n,n,n,nn

<tuning status> 0 = no active tuning, 1 = active tuning.

<output> Heater output of the control loop being tuned (if tuning): 1 = Output 1, 2 = Output 2

<error status> 0 = no tuning error, 1 = tuning error

<stage status> Specifies the current stage in the Autotune process. If tuning error occurred, stage status represents stage that failed.

Remarks If initial conditions are not met when starting the autotune procedure, causing the autotuning process to never actually begin, then the error status will be set to 1 and the stage status will be stage 00.

WARMUP — Warmup Supply Parameter Command

Input **WARMUP <output>,<control>,<percentage>[term]**

Format n,n,+nnn.nn

<output>	Output 2 is the only valid entry and must be included.
<control>	Specifies the type of control used: 0 = Auto Off, 1 = Continuous
<percentage>	Specifies the percentage of full scale (10 V) Monitor Out voltage to apply to turn on the external power supply.

Example **WARMUP 1,50[term]** Output 2 in Voltage mode will use continuous control, with a 5 V (50.50%) output voltage for activating the external power supply.

Remarks Warmup mode applies only to Output 2 in Voltage mode. The Output Type parameter must be configured using the HTRSET command, and the Output mode and Control Input parameters must be configured using the OUTMODE command.

WARMUP? — Warmup Supply Parameter Query

Input **WARMUP? <output>[term]**

Returned <control>,<percentage>[term]

Format n,+nnn.nn (refer to command for description)

ZONE — Control Loop Zone Table Parameter Command

Input **ZONE <output>,<zone>,<upper bound>,<P value>,<I value>, <D value>,<mout value>,<range>,<input>,<rate>[term]**

Format n,nn,+nnnnn, +nnnnn,+nnnnn,+nnnn,+nnnnn, n,n, +nnnn [term]

<output>	Specifies which heater output to configure: 1 or 2.
<zone>	Specifies which zone in the table to configure. Valid entries are: 1–10.
<upper bound>	Specifies the upper Setpoint boundary of this zone in kelvin.
<P value>	Specifies the P for this zone: 0.1 to 1000.
<I value>	Specifies the I for this zone: 0.1 to 1000.
<D value>	Specifies the D for this zone: 0 to 200%.
<mout value>	Specifies the manual output for this zone: 0 to 100%.
<range>	Specifies the heater range for this zone. Valid entries: 0 = Off, 1 = Low, 2 = Med, 3 = High.
<input>	Specifies the sensor input to use for this zone. 0 = Default (Use previously assigned sensor), 1 = Input A, 2 = Input B,
<rate>	Specifies the ramp rate for this zone: 0.1 –100 K/min.

Remarks Configures the output zone parameters. Refer to Paragraph 2.9.

Example **ZONE 1,1,25.0,10,20,0,0,2,2,10[term]** Output 1 zone 1 is valid to 25.0 K with P = 10, I = 20, D = 0, a heater range of medium, sensor input B, and a ramp rate of 10 K/min.

ZONE? — Output Zone Table Parameter Query

Input **ZONE? <output>,<zone>[term]**

Format n,nn

<output>	Specifies which heater output to query: 1 or 2.
<zone>	Specifies which zone in the table to query. Valid entries: 1–10.

Returned < upper boundary>,<P value>,<I value>,<D value>,<mout value>,<range>,<input>,<rate>[term]

Format +nnnnn,+nnnnn,+nnnnn,+nnnn, +nnnnn,n,n, +nnnn (refer to command for description)