Model 340 Temperature Controller

Features

- Operates down to 100 mK with appropriate NTC RTD sensors
- Two sensor inputs; expandable to ten sensor inputs
- Supports diode, RTD, capacitance, and thermocouple sensors
- Sensor excitation current reversal eliminates thermal EMF errors
- Two autotuning control loops: 100 W and 1 W
- IEEE-488 and RS-232C interfaces, analog outputs, digital I/O, and alarm relays

Product Description

The Model 340 is our most advanced temperature controller and offers unsurpassed resolution, accuracy, and stability for temperature measurement and control applications to as low as 100 mK. Operating with diodes, platinum RTDs, and negative temperature coefficient (NTC) resistor sensors, the Model 340 is expandable to ten sensor inputs or to operate with thermocouple or capacitance sensors. It has two control loops, with the first loop powered to 100 W.

Sensor Inputs

The Model 340 features two inputs with high-resolution 24-bit analog-to-digital converter and low noise circuit design, providing temperature readings with resolution as low as 0.1 mK at 4.2 K. Sensors are optically isolated from other instrument functions for quiet and repeatable sensor measurements.

Appropriate sensor excitation and input gain can be selected from the front panel. An autorange mode keeps the power in NTC resistors low to reduce self-heating as sensor resistance changes by many orders of magnitude. Automatic current reversal with rounded square wave excitation for NTC resistors eliminates the effect of thermal EMF.

Standard temperature response curves for silicon diodes, platinum RTDs, and many thermocouples are included. Up to twenty 200-point CalCurves™ for Lake Shore calibrated sensors or user curves can be loaded into non-volatile memory via a computer interface or the instrument front panel. CalCurves™ can be installed at the factory when purchased with a Model 340, or they can be field installed using the data card slot. A built-in SoftCal™[1] algorithm can also be used to generate curves for silicon diodes and platinum RTDs, for storage as user curves.

[1] *The Lake Shore SoftCal™ algorithm for silicon diode and platinum RTD sensors is a good solution for applications that need more accuracy than a standard sensor curve but do not warrant traditional calibration. SoftCal™ uses the predictability of a standard curve to improve the accuracy of an individual sensor around a few known temperature reference points.*

Temperature Control
The Model 340 offers two proportional-integral-derivative (PID) control loops. A PID control algorithm calculates control output based on temperature setpoint and feedback from the control sensor. Wide tuning parameters accommodate most cryogenic cooling systems and many small high-temperature ovens. Control output is generated by a high-resolution digital-to-analog converter for smooth continuous control. The user can manually set the PID values or the autotuning feature of the Model 340 can automate the tuning process.

The main heater output for the Model 340 is a well-regulated variable DC current source. Heater output is optically isolated from other circuits to reduce interference and ground loops. Heater output can provide up to 100 W of variable DC power to control Loop 1. Features have been added to the Model 340 to minimize the possibility of overheating delicate sensors and wiring in cryostats. These features include setpoint temperature limit, heater current range limit, internal heater diagnostics, and a fuse in the heater output wiring. The Model 340 also has the ability to run a second independent control loop, intended to reduce the temperature gradients in one cooling system rather than to run two different cooling systems.

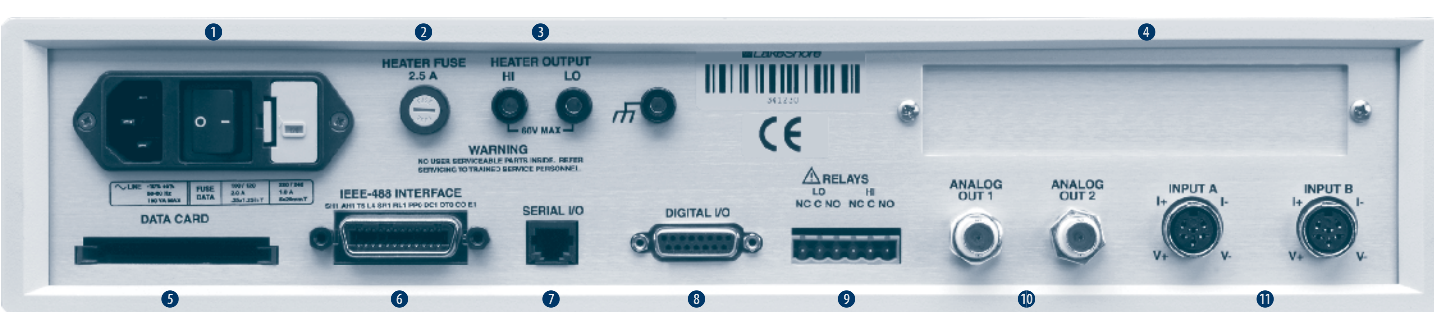
The setpoint ramp feature allows smooth, continuous changes in setpoint. This feature permits faster experiment cycles, since data can be taken as the system is changing in temperature. It can also be used to make a more predictable approach to a setpoint temperature. The zone feature can automatically change control parameter values for operation over a large temperature range. Values for ten different temperature zones can be loaded into the instrument, which will select the next appropriate zone value on setpoint change.

The Model 340 can run a set of instrument instructions called an internal program. Each program represents the temperature changes needed to conduct a user's experiment. The setpoint can be changed or ramped up and down, and other controller parameters can be programmed. For simple experiments the internal program eliminates the need for computer control. It is also common for the internal program to be used along with the computer interface so the computer is not slowed down by temperature control overhead.

Several math features are included to improve usability and aid in setting up experiments. It is often useful to have reading filters and maximum and minimum calculations easily available on the front panel. The Model 340 also computes a linear equation on reading data to allow flexibility in how the display represents experimental inputs.

Interface
The Model 340 can be fully involved in computer-controlled experiments. It is equipped with IEEE-488 and RS-232C interfaces. Either interface can send settings to the Model 340 and collect reading data from it. Even the analog outputs, relays, and Digital I/O can be controlled by computer interface.

The Model 340 has several features to make it more valuable as part of a larger measuring system. Two analog voltage outputs can be used to report a voltage that is proportional to the temperature of an input. The outputs can be controlled manually as a voltage source for any other application. Two relays can be used with the alarm setpoints in latching mode for error detection, or in nonlatching mode for simple on and off control. Digital I/O can be used with an external scanner or manually.

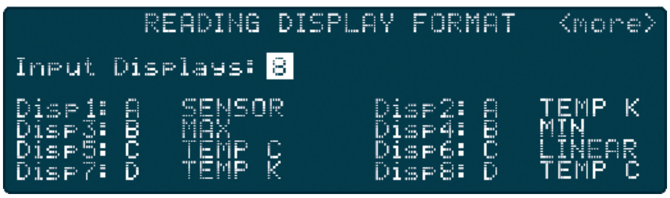


❶ - *Line input assembly*
❷ - *Heater fuse*
❸ - *Heater output*
❹ - *Option slots*
❺ - *Data card*
❻ - *IEEE-488 interface*
❼ - *Serial (RS-232C) I/O*
❽ - *Digital I/O*
❾ - *Relays*
❿ - *Analog outputs*
⓫ - *Standard sensor inputs*

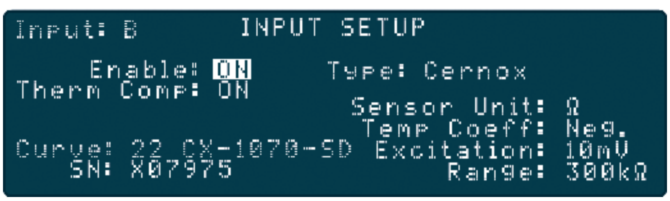
Configurable Display

The Model 340 includes a graphic LCD with fluorescent backlight display that is fully configurable and can display up to eight readings.

This shows a variation of the display with a large loop 1 heater output graphic bar where the PID parameters are not displayed, but the heater output is more prominent.



The user can display 1 to 8 readings from any of the available inputs. The units available are the sensor units of mV, V, Ω, kΩ, nF, or temperature units of °C or K. Results of the math feature can also be selected.



The user can select the sensor type, and the controller will automatically select the sensor units, excitation, and range. If 'special' type is selected, the user can choose any available excitation and input range.

Additional Inputs Available For Model 340

The following optional inputs are available for the Model 340. Only one can be installed at a time, and the standard inputs stay in the instrument and remain fully functional. Calibration for the option is stored on the card so it can be installed in the field without recalibration.

3462 Dual Standard Input Option Card

Adds two standard inputs to the Model 340, appearing on the display as C and D. The card has separate A/Ds and excitation for each sensor. A microprocessor on the card manages the A/D and communication with the Model 340. Allows the Model 340 to read four sensors and use any of them as a control sensor.

3464 Dual Thermocouple Input Option Card

Adds two new thermocouple inputs to the Model 340, appearing on the display as C and D. The card has separate A/Ds and excitation for each sensor. A microprocessor on the card manages the A/D and communication with the Model 340. Thermocouple inputs range from cryogenic temperature to 1000 °C, with built-in room temperature compensation. Curves for thermocouple types E, K, and AuFe 0.07% vs. Cr are included. The user can add other types.

3465 Single Capacitance Input Option Card

Adds a new capacitance input to the Model 340, appearing on the display as C. The card has separate A/D and excitation for the sensor. A microprocessor on the card manages the A/D and communication with the Model 340. The 3465 is intended to control temperature in strong magnetic fields using a Lake Shore Model CS-501 capacitance temperature sensor.

3468 Eight Channel Input Option Card

Adds eight sensor inputs to the Model 340. The optional inputs are broken into two groups of four and appear on the display as C1–C4 for Input C, D1–D4 for Input D. The 3468 includes two A/D converters, one for each group of four inputs, and individual excitation for each sensor. Each input group must use the same sensor type, but the two groups can be different. The multiplexed inputs provide new readings for all eight inputs twice each second. The 3468 inputs are not recommended for temperature control because the reading rate is too slow to allow good stability.

A variety of sensor types are supported by the Model 3468, but not as many as the standard inputs. Diode and platinum configurations have similar specifications to the standard inputs, reduced only slightly to account for multiplexing. However, the NTC RTD configuration is quite different than the standard inputs. The option has a limited resistance range of 7.5 kΩ with a fixed current excitation of 10 µA. This limitation significantly reduces the low temperature range of the inputs. The option also does not support current reversal to reduce the effect of thermal EMF voltages. The original standard inputs remain fully functional allowing the Model 340 to measure 10 sensors when the option is installed.

Sensor Temperature Range (sensors sold separately)

		Model	Useful Range	Magnetic Field Use
Diodes *340/3462*	**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 *340/3462*	**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 *340/3462*	**Cernox™**	CX-1010	0.3 K to 325 K[3]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1030-HT	0.3 K to 420 K[3, 5]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1050-HT	1.4 K to 420 K[3]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1070-HT	4 K to 420 K[3]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1080-HT	20 K to 420 K[3]	T > 2 K & B ≤ 19 T
	Germanium	GR-50-AA	0.1 K to 5 K[4]	Not Recommended
	Germanium	GR-300-AA	0.3 K to 100 K[4]	Not Recommended
	Germanium	GR-1400-AA	1.4 K to 100 K[4]	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[4]	T > 2 K & B ≤ 19 T
	Carbon-Glass	CGR-1-2000	2 K to 325 K[4]	T > 2 K & B ≤ 19 T
	Rox™	RX-102	0.1 K to 40 K[5]	T > 2 K & B ≤ 10 T
	Rox™	RX-103	1.4 K to 40 K	T > 2 K & B ≤ 10 T
	Rox™	RX-202	0.1 K to 40 K[5]	T > 2 K & B ≤ 10 T
Thermocouples *3464*	**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
Capacitance *3465*		CS-501	1.4 K to 290 K	Not recommended
Diodes *3468*	**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 *3468*	**100 Ω Platinum**	PT-102/3	14 K to 800 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[2] *3468*	**Cernox™**	CX-1010	2 K to 325 K[5]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1030-HT	3.5 K to 420 K[3,6]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1050-HT	4 K to 420 K[3,6]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1070-HT	15 K to 420 K[3]	T > 2 K & B ≤ 19 T
	Cernox™	CX-1080-HT	50 K to 420 K[3]	T > 2 K & B ≤ 19 T
	Germanium	GR-300-AA	1.2 K to 100 K[4]	Not recommended
	Germanium	GR-1400-AA	4 K to 100 K[4]	Not recommended
	Carbon-Glass	CGR-1-500	4 K to 325 K[5]	T > 2 K & B ≤ 19 T
	Carbon-Glass	CGR-1-1000	5 K to 325 K[5]	T > 2 K & B ≤ 19 T
	Carbon-Glass	CGR-1-2000	6 K to 325 K[5]	T > 2 K & B ≤ 19 T
	Rox™	RX-102A	1.4 K to 40 K[5]	T > 2 K & B ≤ 10 T

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.

[2] Single excitation current may limit the low temperature range of NTC resistors
[3] Non-HT version maximum temperature: 325 K
[4] Low temperature limited by input resistance range
[5] Low temperature specified with self-heating error: ≤ 5 mK
[6] Low temperature specified with self-heating error: ≤ 12 mK

Sensor Selection

Typical Sensor Performance – *see Appendix F for sample calculations of typical sensor performance*

340/3462	Example Lake Shore sensor	Temp	Nominal resistance/ voltage	Typical sensor sensitivity[7]	Measurement resolution: temperature equivalents	Electronic accuracy: temperature equivalents	Temperature accuracy including electronic accuracy, CalCurve™, and calibrated sensor	Electronic control stability[8]: 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	0.5597 V	-2.3 mV/K	4.4 mK	±47 mK	±79 mK	±8.8 mK
		500 K	0.0907 V	-2.12 mV/K	4.8 mK	±40 mK	±90 mK	±9.6 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	±69 mK	±91 mK	±10.4 mK
		300 K	0.5189 V	-2.4 mV/K	4.2 mK	±45 mK	±77 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	5.391 V	-97.5 mV/K	0.1 mK	±7 mK	±19 mK	±0.2 mK
		77 K	1.422 V	-1.24 mV/K	8.1 mK	±180 mK	±202 mK	±16.2 mK
		300 K	0.8978 V	-2.85 mV/K	3.6 mK	±60 mK	±92 mK	±7.2 mK
		475 K	0.3778 V	-3.15 mV/K	3.2 mK	±38 mK	±88 mK	±6.4 mK
100 Ω Platinum RTD 500 Ω Full Scale	PT-103 with 14J calibration	30 K	3.660 Ω	0.191 Ω/K	5.3 mK	±13 mK	±23 mK	±10.6 mK
		77 K	20.38 Ω	0.423 Ω/K	2.4 mK	±10 mK	±22 mK	±4.8 mK
		300 K	110.35 Ω	0.387 Ω/K	2.6 mK	±34 mK	±57 mK	±5.2 mK
		500 K	185.668 Ω	0.378 Ω/K	2.7 mK	±55 mK	±101 mK	±5.4 mK
Cernox™	CX-1010-SD with 0.3L calibration	0.3 K	2322.4 Ω	-10785 Ω/K	3 µK	±0.2 mK	±3.7 mK	±6 µK
		0.5 K	1248.2 Ω	-2665.2 Ω/K	12 µK	±0.5 mK	±5 mK	±24 µK
		4.2 K	277.32 Ω	-32.209 Ω/K	94 µK	±6.2 mK	±11.2 mK	±188 µK
		300 K	30.392 Ω	-0.0654 Ω/K	15 mK	±540 mK	±580 mK	±30 mK
Cernox™	CX-1050-SD-HT[9] with 1.4M calibration	1.4 K	26566 Ω	-48449 kΩ/K	6 µK	±0.4 mK	±5.4 mK	±12 µK
		4.2 K	3507.2 Ω	-1120.8 kΩ/K	90 µK	±3.4 mK	±8.4 mK	±180 µK
		77 K	205.67 Ω	-2.4116 Ω/K	1.3 mK	±68 mK	±84 mK	±2.6 mK
		420 K	45.03 Ω	-0.0829 Ω/K	12 mK	±520 mK	±585 mK	±24 mK
Germanium	GR-50-AA with 0.05A calibration	0.1 K	2317 Ω	-71858 Ω/K	4 µK	±41 µK	±4.2 mK	±8 µK
		0.3 K	164 Ω	-964 Ω/K	31 µK	±0.2 mK	±4.4 mK	±62 µK
		1 K	34 Ω	-31.3 Ω/K	32 µK	±1.2 mK	±6.2 mK	±64 µK
		5 K	13 Ω	-0.624 Ω/K	481 µK	±20 mK	±43 mK	±962 µK
Germanium	GR-300-AA with 0.3D calibration	0.3 K	35184 Ω	-512156 Ω/K	6 µK	±73 µK	±4.3 mK	±12 µK
		1.4 K	449 Ω	-581 Ω/K	17 µK	±0.7 mK	±4.9 mK	±34 µK
		4.2 K	94 Ω	-26.6 Ω/K	38 µK	±2.5 mK	±7.5 mK	±75 µK
		100 K	2.7 Ω	-0.024 Ω/K	12.6 mK	±309 mK	±332 mK	±25 mK
Germanium	GR-1400-AA with 1.4D calibration	1.4 K	35889 Ω	-94794 Ω/K	32 µK	±0.4 mK	±4.6 mK	±63 µK
		4.2 K	1689 Ω	-862 Ω/K	35 µK	±1.7 mK	±5.9 mK	±70 µK
		10 K	253 Ω	-62.0 Ω/K	48 µK	±3.0 mK	±8.0 mK	±97 µK
		100 K	2.8 Ω	-0.021 Ω/K	14.4 mK	±356 mK	±379 mK	±29 mK
Carbon-Glass	CGR-1-500 with 1.4L calibration	1.4 K	103900 Ω	-520000 Ω/K	58 µK	±0.6 mK	±4.6 mK	±116 µK
		4.2 K	584.6 Ω	-422.3 Ω/K	24 µK	±1.2 mK	±5.2 mK	±48 µK
		77 K	14.33 Ω	-0.098 Ω/K	3.1 mK	±140 mK	±165 mK	±6.2 mK
		300 K	8.55 Ω	-0.0094 Ω/K	32 mK	±1.1 K	±1.2 K	±64 mK
Rox™	RX-102A-AA with 0.3B calibration	0.5 K	3701 Ω	-5478 Ω/K	19 µK	±0.7 mK	±5.2 mK	±38 µK
		1.4 K	2005 Ω	-667 Ω/K	45 µK	±2.4 mK	±7.4 mK	±90 µK
		4.2 K	1370 Ω	-80.3 Ω/K	375 µK	±16 mK	±32 mK	±750 µK
		40 K	1049 Ω	-1.06 Ω/K	29 mK	±1.1 K	±1.2 K	±58 mK
Thermocouple 50 mV ***3464***	Type K	75 K	-5862.9 µV	15.6 µV/K	26 mK	±0.25 K[10]	Calibration not available from Lake Shore	±52 mK
		300 K	1075.3 µV	40.6 µV/K	10 mK	±0.038 K[10]		±20 mK
		600 K	13325 µV	41.7 µV/K	10 mK	±0.184 K[10]		±20 mK
		1505 K	49998.3 µV	36.006 µV/K	12 mK	±0.73 K[10]		±24 mK
Capacitance 150 nF ***3465***	CS-501GR	4.2 K	6 nF	27 pF/K	7.4 mK	±2.08 K	Calibration not available from Lake Shore	±14.8 mK
		77 K	9.1 nF	52 pF/K	3.9 mK	±1.14 K		±7.8 mK
		200 K	19.2 nF	174 pF/K	1 mK	±0.4 K		±2 mK

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

Specifications

Input Specifications

	Sensor temperature coefficient	Input range	Excitation current	Display resolution	Measurement resolution	Electronic accuracy offset	Electronic control stability[11]
Diode *340/3462*	negative	0 V to 2.5 V	10 μA ±0.05%[12,13]	10 μV	10 μV	±80 μV ±0.005% of rdg	20 μV
	negative	0 V to 7.5 V	10 μA ±0.05%[12,13]	10 μV	10 μV	±80 μV ±0.01% of rdg	20 μV
PTC RTD *340/3462*	positive	0 Ω to 250 Ω	1 mA[14]	1 mΩ	1 mΩ	±0.002 Ω ±0.01% of rdg	2 mΩ
	positive	0 Ω to 500 Ω	1 mA[14]	1 mΩ	1 mΩ	±0.002 Ω ±0.01% of rdg	2 mΩ
	positive	0 Ω to 2500 Ω	0.1 mA[14]	10 mΩ	10 mΩ	±0.03 Ω ±0.02% of rdg	20 mΩ
NTC RTD 1 mV *340/3462*	negative	0 Ω to 10 Ω	100 μA[14]	100 μΩ	1 mΩ	±0.02% rng ±0.1% rdg	2 mΩ
	negative	0 Ω to 30 Ω	30 μA[14]	100 μΩ	3 mΩ	±0.02% rng ±0.1% rdg	6 mΩ
	negative	0 Ω to 100 Ω	10 μA[14]	1 mΩ	10 mΩ	±0.02% rng ±0.1% rdg	20 mΩ
	negative	0 Ω to 300 Ω	3 μA[14]	1 mΩ	30 mΩ	±0.02% rng ±0.1% rdg	60 mΩ
	negative	0 Ω to 1 kΩ	1 μA[14]	10 mΩ	0.1 Ω	±0.02% rng ±0.1% rdg	0.2 Ω
	negative	0 Ω to 3 kΩ	300 nA[14]	10 mΩ	0.3 Ω	±0.02% rng ±0.1% rdg	0.6 Ω
	negative	0 Ω to 10 kΩ	100 nA[14]	0.1 Ω	1 Ω	±0.02% rng ±0.1% rdg	2 Ω
	negative	0 Ω to 30 kΩ	30 nA[14]	0.1 Ω	3 Ω	±0.02% rng ±0.1% rdg	6 Ω
NTC RTD 10 mV *340/3462*	negative	0 Ω to 30 Ω	300 μA[14]	100 μΩ	300 μΩ	±0.02% rng ±0.05% rdg	600 μΩ
	negative	0 Ω to 100 Ω	100 μA[14]	1 mΩ	1 mΩ	±0.02% rng ±0.05% rdg	2 mΩ
	negative	0 Ω to 300 Ω	30 μA[14]	1 mΩ	3 mΩ	±0.02% rng ±0.05% rdg	6 mΩ
	negative	0 Ω to 1 kΩ	10 μA[14]	10 mΩ	10 mΩ	±0.02% rng ±0.05% rdg	20 mΩ
	negative	0 Ω to 3 kΩ	3 μA[14]	10 mΩ	30 mΩ	±0.02% rng ±0.05% rdg	60 mΩ
	negative	0 Ω to 10 kΩ	1 μA[14]	0.1 Ω	0.1 Ω	±0.02% rng ±0.05% rdg	0.2 Ω
	negative	0 Ω to 30 kΩ	300 nA[14]	0.1 Ω	0.3 Ω	±0.02% rng ±0.05% rdg	0.6 Ω
	negative	0 Ω to 100 kΩ	100 nA[14]	1 Ω	3 Ω	±0.02% rng ±0.05% rdg	6 Ω
	negative	0 Ω to 300 kΩ	30 nA[14]	1 Ω	30 Ω	±0.02% rng ±0.25% rdg	60 Ω
Thermocouple *3464*	positive	±25 mV	NA	0.1 μV	0.2 μV	±1 μV ±0.05% of rdg[15]	0.4 μV
	positive	±50 mV	NA	0.1 μV	0.4 μV	±1 μV ±0.05% of rdg[15]	0.8 μV
Capacitance *3465*	positive or negative	0 nF to 150 nF	4.88 kHz 1 V square wave	10 pF	2.0 pF	±50 pF ±0.1% of rdg	4.0 pF
	positive or negative	0 nF to 15 nF	4.88 kHz 1 V square wave	1 pF	0.2 pF	±50 pF ±0.1% of rdg	0.4 pF
Diode *3468*	negative	0 V to 2.5 V	10 μA ±0.05%[12,13]	100 μV	20 μV	±160 μV ±0.01% of rdg	40 μV
	negative	0 V to 7.5 V	10 μA ±0.05%[12,13]	100 μV	20 μV	±160 μV ±0.02% of rdg	40 μV
PTC RTD *3468*	positive	0 Ω to 250 Ω	1 mA ±0.3%[14]	10 mΩ	2 mΩ	±0.004 Ω ±0.02% of rdg	4 mΩ
	positive	0 Ω to 500 Ω	1 mA ±0.3%[14]	10 mΩ	2 mΩ	±0.004 Ω ±0.02% of rdg	4 mΩ
	positive	0 Ω to 5000 Ω	1 mA ±0.3%[14]	100 mΩ	20 mΩ	±0.06 Ω ±0.04% of rdg	40 mΩ
NTC RTD *3468*	negative	0 Ω to 7500 Ω	10 μA ±0.05%[14]	100 mΩ	50 mΩ	±0.1 Ω ±0.04% of rdg	0.1 Ω

[11] Control stability of the electronics only, in an ideal thermal system
[12] Current source error has negligible effect on measurement accuracy
[13] Diode input excitation current can be set to 1 mA – refer to the Model 331 user manual for details
[14] Current source error is removed during calibration
[15] Accuracy specification does not include errors from room temperature compensation

Thermometry

Number of inputs 2 included (additional inputs optional)
Input configuration Each input is factory configured as diode/RTD. Thermocouple and capacitance are optional and sold as additional input cards.
Isolation Sensor inputs optically isolated from other circuits but not from each other
A/D resolution 24-bit analog-to-digital
Input accuracy Sensor dependent – refer to Input Specifications table
Measurement resolution Sensor dependent – refer to Input Specifications table
Maximum update rate Up to 20 readings per s on an input, 40 readings per s on all inputs
Autorange Automatically selects appropriate NTC RTD range
User curves Forty 200-point CalCurves™, or user curves
SoftCal™ Improves accuracy of DT-470 diode or platinum RTD sensors
Math Maximum and minimum of input readings and linear equation
Filter Averages input readings to quiet display, settable time constant

Sensor Input Configuration

	Diode/RTD	Thermocouple	Capacitance
Measurement type	4-lead differential	2-lead, room temperature compensated	4-lead
Excitation	Constant current with current reversal for RTDs	NA	4.88 kHz, 1 V square wave
Supported sensors	Diodes: Silicon, GaAlAs RTDs: 100 Ω Platinum, 1000 Ω Platinum, Germanium, Carbon-Glass, Cernox™, and Rox™	Most thermocouple types	CS-501GR
Standard curves	DT-470, DT-500D, DT-670, PT-100, PT-1000, RX-102A, RX-202A	Type E, Type K, Type T AuFe 0.07% vs. Cr, AuFe 0.03% vs. Cr,	None
Input connector	6-pin DIN	Ceramic isothermal block	6-pin DIN

Control

Control loops	2
Control type	Closed-loop digital PID with manual heater power output, or open loop
Tuning	Autotune (one loop at a time), manual PID, zones
Control stability	Sensor dependent – to 2× measurement resolution (in an ideal thermal system)
PID control settings	
Proportional (gain)	0 to 1000 with 0.1 setting resolution
Integral (reset)	1 to 1000 with 0.1 setting resolution
Derivative (rate)	1 to 1000 s with 1 s resolution
Manual output	0 to 100% with 0.01% setting resolution
Zone control	10 temperature zones with P, I, D, manual heater power out, and heater range
Setpoint ramping	0.1 K per min to 100 K per min
Safety limits	Setpoint limit, curve temp limits, heater output, slope limit, heater range limit, power up heater off, and short-circuit protection

Heater Output Specifications

	Loop 1	Loop 2
Heater output type	Variable DC current source	Variable DC voltage
Heater output D/A resolution	18-bit	14-bit
Max heater power	100 W	1 W
Max heater output current	2 A	0.1 A
Heater output compliance	50 V	10 V
Heater source impedance	NA	0.01 Ω
Heater output ranges	5 decade steps in power	1
Heater load type	Resistive	Resistive
Heater load range	10 Ω to 100 Ω recommended	100 Ω minimum
Heater load for max power	25 Ω	100 Ω
Heater noise (<1 kHz) RMS	50 μV + 0.001% of output voltage	<0.3 mV
Isolation	Optical isolation between output and other circuits	None
Heater connector	Dual banana	BNC

Loop 1 Full Scale Heater Power at Typical Resistance

Heater resistance	Heater range	Maximum current 2 A	1 A	0.5 A	0.25 A
10 Ω	5	40 W	10 W	2.5 W	625 mW
	4	4 W	1 W	250 mW	62.5 mW
	3	0.4 W	100 mW	25 mW	6.25 mW
	2	40 mW	10 mW	2.5 mW	625 μW
	1	4 mW	1 mW	250 μW	62.5 μW
25 Ω	5	100 W	25 W	6.25 W	1.56 W
	4	10 W	2.5 W	625 mW	156 mW
	3	1 W	250 mW	62.5 mW	15.6 mW
	2	100 mW	25 mW	6.25 mW	1.56 mW
	1	10 mW	2.5 mW	625 μW	156 μW
50 Ω	5	50 W	50 W	12.5 W	3.12 W
	4	20 W	5 W	1.25 W	312 mW
	3	2 W	500 mW	125 mW	31.2 mW
	2	200 mW	50 mW	12.5 mW	3.12 mW
	1	20 mW	5 mW	1.25 mW	312 μW

Front Panel

Display	Graphic LCD with fluorescent backlight
No. of reading displays	1 to 8
Display units	Temperature in K, °C, or sensor units
Temp display resolution	0.0001 K below 10 K, 0.001 K above 10 K
Sensor units display resolution	Sensor dependent, to 6 digits
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 – bar graph display of heater output available
Heater output resolution	0.1% numeric or 2% graphical
Keypad	Numeric plus special function
Front panel features	Front panel curve entry, display brightness control, and keypad lock-out

Interfaces

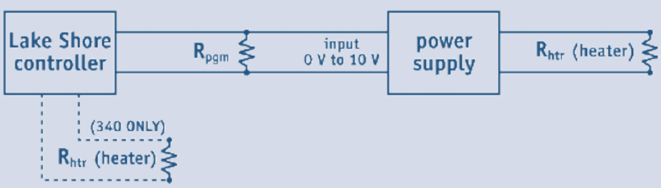
IEEE-488.2 interface	
Features	SH1, AH1, T5, L4, SR1, RL1, PP0, DC1, DT0, C0, E1
Reading rate	To 20 readings per s
Software support	National Instruments LabVIEW™ driver
Serial interface	
Electrical format	RS-232C
Max baud rate	19,200 baud
Connector	RJ-11
Reading rate	To 20 readings per s
Alarms	
Number	Two, high and low, for each installed input
Data source	Temperature, Sensor Units, and Linear Equation
Settings	Source, High and Low Setpoint, Latching or Non-Latching, and Audible On/Off
Actuators	Display, annunciator, beeper, and relays
Relays	
Number	2
Contacts	Normally open (NO), normally closed (NC), and common
Contact Rating	30 VDC at 2 A
Operation	Activate relays on high or low alarms for any input, or manual off/on
Connector	Detachable terminal block
Analog voltage outputs	(when not used as control loop 2 output)
Number	2
Scale	User selected
Update rate	20 readings per s
Data source	Temperature, Sensor Units, and Linear Equation
Settings	Input, Source, Top of Scale, Bottom of Scale, or Manual
Range	±10 V
Resolution	1.25 mV
Accuracy	±2.5 mV
Max output power	1 W
Min load resistance	100 Ω (short-circuit protected)
Source impedance	0.01 Ω
Digital I/O	5 inputs and 5 outputs – TTL voltage level compatible
Data card	PC card Type II slot used for curve transfer, setup storage, and data-logging

General

Ambient temp range	20 °C to 30 °C (68 °F to 86 °F) for specified accuracy; 15 °C to 35 °C (59 °F to 95 °F) for reduced accuracy
Power requirements	100, 120, 220, 240 VAC (+5%, -10%), 50 or 60 Hz; 190 VA
Size	432 mm W × 89 mm H × 368 mm D (17 in × 3.5 in × 14.5 in), full rack
Weight	8 kg (17.6 lb) approx.
Approval	CE mark

Extending Temperature Controller Heater Power

It is often necessary to extend the heater power of a cryogenic temperature controller to conduct experiments above room temperature. This diagram illustrates a practical way to increase the control output of the Model 340 to several hundred watts. A programming resistor, R_{pgm}, is placed across the controller's heater output current source. As the heater output current changes, a changing voltage is generated across R_{pgm}. That voltage is used to program a large external power supply. R_{pgm} should be chosen so that a low current range of the controller can be used. The control output of loop 2 on the Model 340 is a voltage, thus it can be connected directly to the external power supply without R_{pgm}.



3003 Heater Output Conditioner

The heater output conditioner is a passive filter which further reduces the already low Model 340 heater output noise. The typical insertion loss for the Model 3003 is 20 dB at or above line frequency, and >40 dB at or above double line frequency. A 144 mm W × 72 mm H × 165 mm D (5.7 in × 2.8 in × 6.5 in) panel mount enclosure houses this option, and it weighs 1.6 kg (3.5 lb).

Ordering Information

Part number	Description
340	2 diode/resistor inputs temperature controller
Select a power configuration*:	
VAC-100	Instrument configured for 100 VAC with U.S. power cord
VAC-120	Instrument configured for 120 VAC with U.S. power cord
VAC-120-ALL	Instrument configured for 120 VAC with U.S. power cord and universal Euro line cord and fuses for 220/240 VAC setting
VAC-220	Instrument configured for 220 VAC with universal Euro line cord
VAC-240	Instrument configured for 240 VAC with universal Euro line cord
Other country line cords available, consult Lake Shore	
Accessories included	
106-009	Heater output connector (dual banana jack)
G-106-233	Sensor input mating connector (6-pin DIN plug); 2 included
106-737	6-pin terminal block used for relays connector – accepts up to 12 AWG wire
2001	4-wire RJ11 cable assembly, 4.6 m (14 ft) long, used with RS-232C interface
2003	RJ11 to DE-9 adapter – adapts RJ11 receptacle to female DE-9 connector; connects Model 340 to customer computer rear RS-232C serial port
——	Calibration certificate
MAN-340	Model 340 user manual
Options and accessories	
2002	RJ11 to DB-25 adapter
2003	RJ11 to DE-9 adapter
3003	Heater output conditioner
3462	2-channel card for additional standard sensors
3464	2-channel card for thermocouple sensors
3465	1-channel card for capacitance sensors
3468	8-channel scanner card for silicon diodes, PTC and NTC RTD sensors
3507-2SH	Cable assembly for 2 sensors and 1 heater
8001-340	CalCurve™, factory installed – the breakpoint table from a calibrated sensor stored in the instrument
8072	IEEE-488 computer interface interconnect cable assembly
CAL-340-CERT	Instrument calibration with certificate
CAL-3462-CERT	3462 card recalibration with certificate
CAL-3464-CERT	3464 card recalibration with certificate
CAL-3465-CERT	3465 card recalibration with certificate
CAL-3468-CERT	3468 card recalibration with certificate
HTR-25	25 Ω, 25 W cartridge heater
HTR-50	50 Ω, 50 W cartridge heater
RM-1	Rack mounting kit

USD