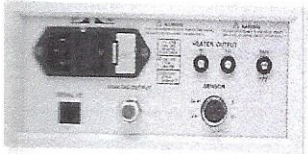
Model 321 Autotuning Temperature Controller

- Autotuning – no need for the user to select PID parameters (manual setting mode included).
- SoftCal™ – improves system accuracy with instrument's software and DT-470 diode sensor.
- Thermometry
  - Single sensor input.
  - Four-lead sensor measurement.
  - Space for one CalCurve™.
- Sensor types
  - Silicon diodes.
  - Platinum RTDs.
  - Thermocouple.
- Control
  - Control stability to ±0.1 K.
  - Three term PID control loop.
  - 25 watt max. heater power.
  - One lower power range.
- Zone storage of control parameters (PID and Heater range).
- Setpoint ramping.
- Interface
  - Display of sensor temperature in K, °C or sensor units in volts, ohms.
  - Separate setpoint display.
  - Serial interface included.
  - Analog output of temperature.



Model 321 rear panel.

See Reference Section for information on SoftCal™ CalCurve™ and Curve 10.

The Model 321 is a microcontroller based autotuning temperature controller which provides a simple, low cost answer to basic control needs.

There are three models: the 321-01 for silicon diode temperature sensors, the 321-02 for platinum RTDs, and the 321-04 for thermocouples.

Differential input allows four-lead measurement of the sensor signal. A high resolution A/D converter digitizes the signal for use in thermometry, control and autotuning.

Precision thermometry is the most basic building block of any digital controller and is necessary for stable, accurate control. Careful analog design provides the Model 321 with stable and repeatable measurements. The accuracy of the Model 321 thermometry can be enhanced with the use of Lake Shore calibrated sensors and CalCurve™ or by the use of SoftCal™.

Control software in the Model 321 compares the measured value of the control sensor to the desired control setpoint and acts with the three term (PID) function to minimize the difference. Control parameters can be entered manually or by the autotuning algorithm. Two heater ranges, with the high providing 25 watts and the low 2.5 watts, allow for a variety of cryogenic cooling systems. The power output of the Model 321 is a quiet, variable DC current to ensure as little noise coupling as possible between the heater and experiment.

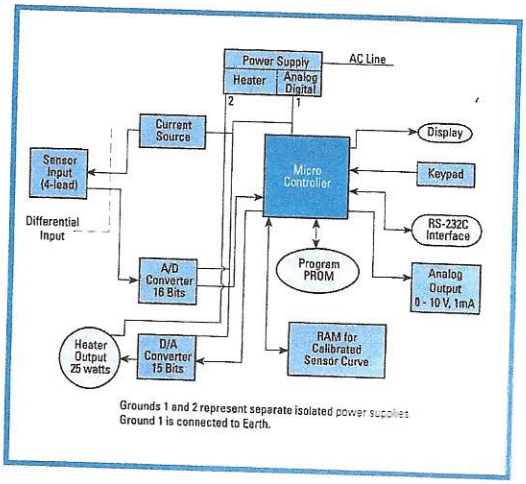
The Model 321 allows up to ten temperature zones to be entered. Each temperature zone has its own PID and Heater range settings. If the setpoint is changed from one zone to another, the PID and Heater range settings will change to those entered for the new zone.

The setpoint ramp, settable from 0.1 to 99.9 K/min, allows the user to set the rate that the setpoint increases or decreases when the setpoint is changed. For example: The setpoint is 50 K and the ramp rate is 1 K/min. The user changes the setpoint to 110 K. The Model 321 will change the setpoint in 0.1 K increments so that in one minute the temperature will reach 51 K and in one hour the temperature will reach its new setpoint of 110 K. The controller automatically changes the PID and Heater range as the temperature setpoint passes through the different temperature zones if the setpoint ramp and zone features are used together.

Autotuning is one more step in Lake Shore's commitment to bringing convenience along with performance to the cryogenic measurement and control market. Autotuning utilizes information gathered during setpoint changes to optimize the control parameters.

The built in serial interface provides remote access to data and stored parameters in the Model 321 and allows setting of most front panel functions. The serial interface of the Model 321 is compatible with the Model 320 to eliminate the need for reprogramming.

The instrument displays the temperature in K, °C or sensor units. The two row by sixteen character alphanumeric display simultaneously displays temperature, setpoint, % heater current and heater range.



Sensor Input and Display Performance Chart

321-Suffix	321-01	321-02	321-04 [1]
Sensor type	**Silicon diode**	**100 Ω Platinum RTD**	**Thermocouple**
Sensor temperature coefficient	Negative.	Positive.	Positive.
Sensor units	Volts (V).	Ohms (Ω).	Millivolts (mV).
Maximum temperature	475 K.	800 K.	1000 °C.
Input range	0 – 2.5 V.	0 – 300 Ω.	±45 mV.
Sensor excitation (constant current)	10 µA ±0.05%.	500 µA ±0.01%.	Not applicable.
Example Lake Shore sensor	DT-470-CO-13.	PT-103.	Ch-AuFe 0.07%.
Sensor temperature range	1.4 K – 475 K.	30 K – 800 K.	1.4 K – 325 K.
Standard sensor curve	LSCI Curve 10.	DIN 43760.	NBS/NIST generated.
Typical sensor sensitivity	-30 mV/K at 4.2 K -1.9 mV/K at 77 K -2.4 mV/K at 300 K -2.2 mV/K at 475 K.	0.19 Ω/K at 30 K 0.42 Ω/K at 77 K 0.39 Ω/K at 300 K 0.33 Ω/K at 800 K.	16 µV/K at 4.2 K 20 µV/K at 300 K.
Measurement resolution **Sensor units** **Temperature equivalence**	 0.04 mV. 1.3 mK at 4.2 K 21 mK at 77 K 16 mK at 300 K 18 mK at 475 K.	 5 mΩ. 26 mK at 30 K 12 mK at 77 K 13 mK at 300 K 15 mK at 800 K.	 0.5 µV. 31 mK at 4.2 K 25 mK at 300 K.
Display resolution and setpoint setting **Sensor units** **Temperature units**	 0.1 mV < 2 V. 1 mV ≥ 2 V. 0.1 K (°C).	 0.01 Ω < 200 Ω. 0.1 Ω ≥ 200 Ω. 0.1 K (°C).	 2 µV. – 0.1 K (°C).
Measurement accuracy – sensor units	±0.2 mV ±0.02% RDG.	±20 mΩ ±0.05% RDG.	±2 µV ±0.05% RDG.
Temperature accuracy with calibrated sensor and 8001 CalCurve™. Includes all sensor and instrument errors.	±0.1 K at 4.2 K ±0.3 K at 77 K ±0.2 K at 300 K ±0.2 K at 475 K.	±0.2 K at 30 K ±0.2 K at 77 K ±0.3 K at 300 K ±0.6 K at 800 K.	±0.4 K at 4.2 K [2] ±0.2 K at 300 K [2].
Measurement temperature coefficient **Sensor units (% reading/°C ambient)** **Temperature equivalence**	 ±0.01% + 8.5 µV. ±8 mK/°C at 4.2 K ±77 mK/°C at 77 K ±33 mK/°C at 300 K ±9 mK/°C at 475 K.	 (±0.01% + 5.6 µΩ)/°C. ±33 mK/°C at 4.2 K ±22 mK/°C at 77 K ±64 mK/°C at 300 K ±171 mK/°C at 800 K	 (±0.018% +1.0 µV)/°C. ±100 mK/°C at 30 K ±55 mK/°C at 300 K
Magnetic field use	Recommended T ≥ 40 K and B ≤ 5 T.	Recommended for T ≥ 4.2 K and B ≤ 2.5 T.	Not recommended.

Note

(1) All thermocouple data is for uncompensated inputs.

(2) Sensor calibration and 8001 CalCurve™ are not available for thermocouples. The error listed is for the instrument only.

The performance chart identifies the input configurations possible with this instrument. System performance with any of the inputs depends greatly on sensor characteristics. Much of the typical data presented here is based on the Lake Shore sensor listed in each column. Other sensors of the same type can be used with the instrument. Similar performance can be expected if the sensor sensitivities match.

Specifications

Thermometry
- **Number of inputs:** One.
- **Measurement type:** Four-lead differential.
- **Sensor type:** Model 321-01: Silicon Diode; Model 321-02: Platinum RTD; Model 321-04: Thermocouples.
- **Accuracy:** Based on model and sensor type (see chart on the previous page).
- **Update rate:** 1 per second.
- **Precision curve storage:** One 99 point curve entered over the serial interface.
- **SoftCal™:** Improves system accuracy to ±0.25 K from 30 K to 375K with DT-470 diode sensor entered in voltage or temperature. See Reference Section.

Control
- **Control type:** Digital, three term PID with autotune.
- **Control stability:** Better than ±0.1 K in a properly designed system for diode and platinum sensors.
- **Setpoint setting resolution:** 0.1 in temperature (K or °C).
- **Heater output type:** Analog DC current source.
- **Heater setting resolution:** 15 bit (in current).
- **Heater ranges:** 25 watts, 2.5 watts.
- **Max power to heater:** 25 watts.
- **Max current to heater:** 1 amp.
- **Heater output compliance:** 25 volts.
- **Heater load:** 20 ohms or greater to operate, 25 ohms required for full power.
- **Heater noise:** 0.005% of full scale power.(1)
- **Ramp rate:** 0.1 to 99.9 K/min.
- **Control zones:** Ten (10).

Front Panel
- **Display:** Two row by sixteen character alphanumeric LCD displaying sensor and setpoint.
- **Display units:** Temperature in K or °C. Sensor units in volts (321-01), ohms (321-02), or millivolts (321-04).
- **Temperature resolution:** 0.1 K or °C.
- **Sensor unit resolution:** See chart on previous page.
- **Keypad:** Numeric keypad.

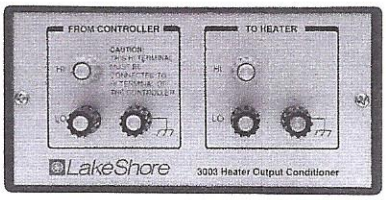
Interface
- **Serial interface:** 300 or 1200 baud, RJ11 connector, RS-232C electrical standard.

Analog Output
- **Range:** 0 to 10 volts at 1 mA max. (voltage source).
- **Resolution voltage:** 1.22 mV.
- **Accuracy:** ±0.04% of full scale output + measurement accuracy.
- **Maximum resolution in temperature:** 0.1 K.
- **Default output:** 0 to 10 V represents 0 to 1000 K (10 mV/K).
- **Settability:** User definable maximum and minimum with 0.1 K resolution.

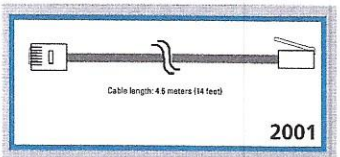
General
- **Ambient temperature range:** 15 – 35 °C.
- **Power requirements:** 100, 120, 220, 240 VAC (+5%-10%); 50 or 60 Hz; 135 VA.
- **Enclosure type:** Half rack.
- **Size:** 217 mm wide x 90 mm high x 317 mm deep (8.54" x 3.5" x 12.5").
- **Weight:** 2.7 kg (6 lb).

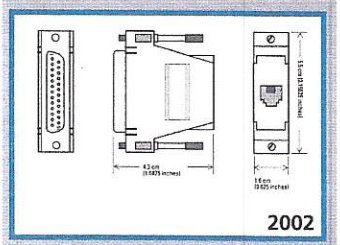
Note

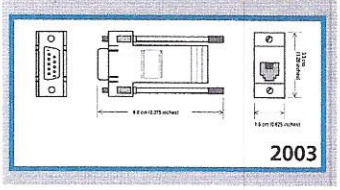
(1) Heater noise is lowered by 20 db (factor of 10) with a Model 3003 Heater Output Conditioner.



Ordering Information







Model	Inputs
321-01	Silicon diode.
321-02	Platinum.
321-04	Thermocouple.

Please specify AC line voltage requirement (90 – 110 VAC, or 105 – 125 VAC, or 210 – 250 VAC).

Accessories included

115-006	Detachable 120 VAC line cord.
100-233	Sensor mating connector.
106-009	Heater output connector.
MAN-321	Users manual.

Options

8001	CalCurve™ (requires calibrated sensor).

Accessories available

Adapters

2002	RJ11 to DB25 adapter. Connects RJ11 cable to the RS-232C serial port on rear of computer.
2003	RJ11 cable to DB9 connector adapter.

Rack mount kits

3022	Rack mount kit for mounting one Model 321, 82.60 mm (19") rack.
3026	Rack mount kit for mounting two Model 321s, 82.60 mm (19") rack.

Heaters

HTR-25	25 ohm cartridge heater, 25 watt, ¼" dia x 1" long.
HTR-50	50 ohm cartridge heater, 25 watt, ¼" dia x 1" long.
3003	Heater output conditioner.

Cables

2001	RJ11 4.66 m (14 ft) modular serial cable.
8271-20	Sensor/heater cable assembly for diode and platinum sensors.

High Level Software Available for this Instrument

See page 2-21.