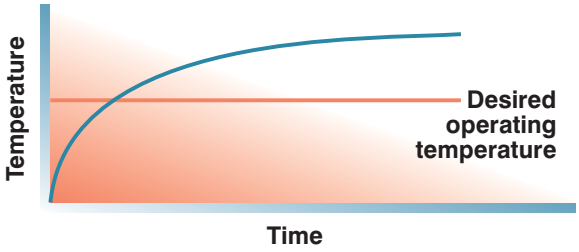
Temperature Controllers

Uncontrolled system

If powered without any regulation, a heater will rise in temperature until heat losses (increasing with temperature) equal heat input. This may be acceptable in rare situations, but normally is to be avoided because the equilibrium temperature is highly unpredictable.

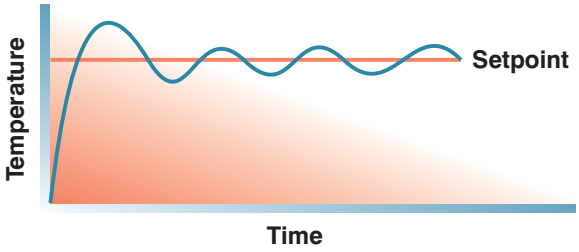
In most cases we want to control heater temperature. We can then ramp up to setpoint faster without fear of overshooting and burning out the heater.



On/off control

On/off is the most basic form of control: Full power on below setpoint, power off above setpoint. Electronic on/off controllers offer faster reaction time and tighter control than thermostats. All on/off controllers have a differential (hysteresis or deadband) between the on and off points to reduce rapid cycling and prolong switch life.

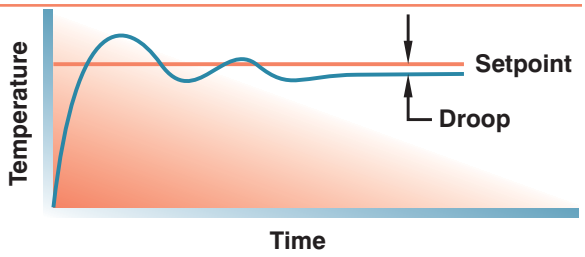
With on/off control, temperature never stabilizes but always oscillates around the setpoint.



Proportional control

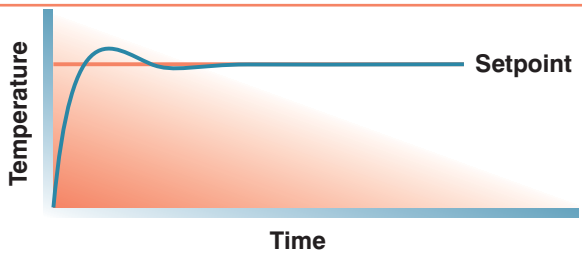
A proportional controller reduces power as the heater approaches setpoint. This reduces oscillation for steadier control. Note that most controllers are “time proportioning,” where they scale power by rapid on/off switching. Short cycle times usually require a solid state relay for power switching.

Simple proportional controllers can experience “droop” where the temperature settles at a point near the setpoint but not exactly on it.



PID controllers

Proportional/Integral/Derivative controllers solve the problem of droop and otherwise improve control accuracy through advanced digital algorithms. They have various tuning parameters for best control, but typically have some preset modes suitable for most situations.



Controller model	Control method	Supply power	Sensor input	Controlled output
CT198	On/off	4.75–60 VDC	None (uses high-TCR heater element as sensor)	Same as supply power
CT325	On/off	4.75–60 VDC	PD: 100 Ω platinum RTD PF: 1000 Ω platinum RTD TF: 50 kΩ thermistor	Same as supply power
CT15	PID, proportional, on/off (selectable)	100–240 VAC	PD: 100 Ω platinum RTD PF: 1000 Ω platinum RTD J, K, or T thermocouple	Internal SSR rated to 3.5 A at 250 VAC External SSR optional
CT16A	Fuzzy Logic, PID, proportional, on/off (selectable)	100–240 VAC (12–24 VDC optional)	PD: 100 Ω platinum RTD PF: 1000 Ω platinum RTD NB: 100 Ω nickel RTD Most thermocouple types	Internal SSR rated to 2.0 A at 240 VAC External SSR optional

Custom controllers

In high volume applications, a specially designed controller often gives the best performance and price. Controllers can be stand alone devices or embedded in other electronics.

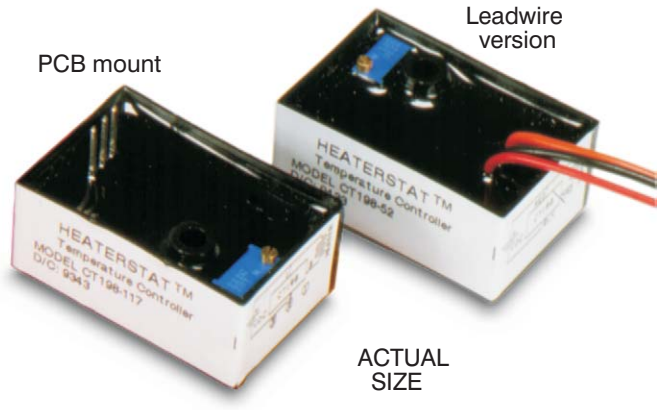
How Thermofoil heaters improve control accuracy

- Intimate thermal contact means less lag time.
- Profiling and multiple elements give more options for directing the heat where needed.
- Flexible Thermal-Ribbon™ sensors and combination heater/sensors ensure tight coupling between the heater, heated object, and control sensor.
- High watt density produces nimble response.

Heaterstat™ Sensorless DC Controller

- Uses heater as temperature sensor — no separate sensor or thermostat required
- Solid-state on/off control with adjustable setpoint
- Low power consumption — ideal for battery operated and vehicular devices
- Small PCB mount package
- Low cost
- For use with Minco Thermofoil™ and Thermal-Clear™ heaters

This unique DC controller does not require a separate sensor for temperature input. Instead, the Heaterstat takes temperature readings from its heater, a special model with a high temperature coefficient. You get accurate, efficient electronic control at prices comparable to thermostats.



Operation

The diagram below shows how the Heaterstat works. It periodically powers the heater just long enough to check resistance. If heater temperature is *above* setpoint (left side of graph), power shuts off within 0.010 seconds.

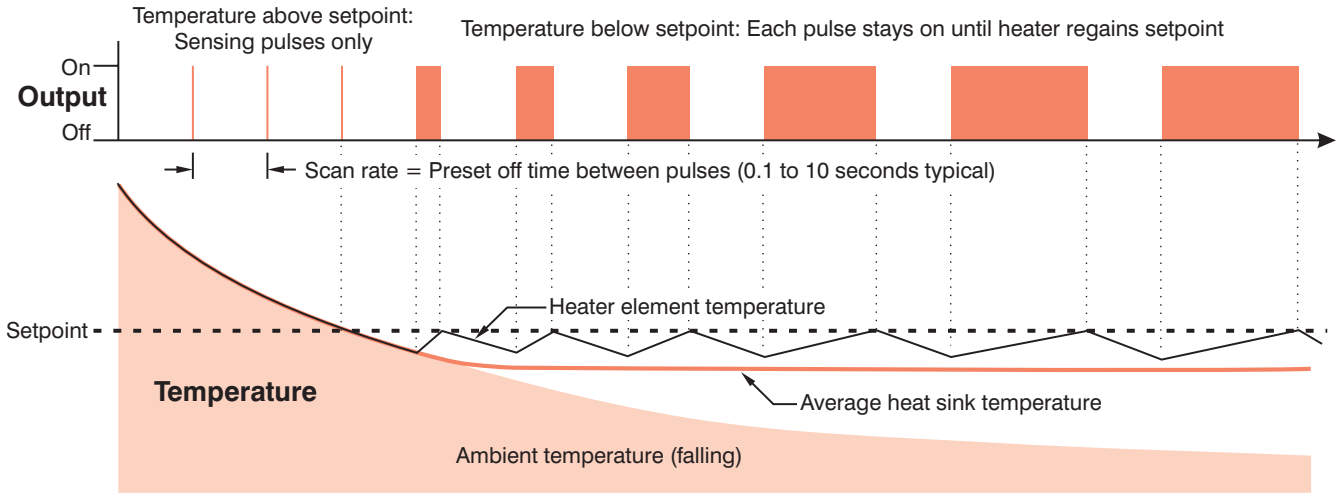
If heater temperature is *below* setpoint, the Heaterstat leaves power on and continually reads resistance until element temperature reaches setpoint. It then shuts off and waits until time for the next pulse.

Scan rate, the off-time between pulses, is factory set from 0.1 to 10 seconds (1 second is standard). Faster scans provide tighter control while slower scans conserve power during idle times (a 0.010 second pulse every 10 seconds takes only 0.1% of full-on power).

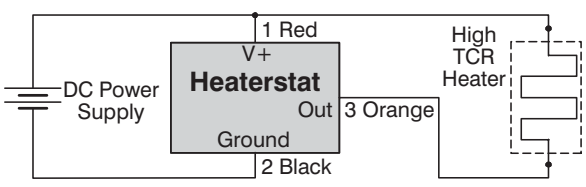
Applications

The Heaterstat's unique design makes it the ideal companion to Minco heaters for precise thermal control. Here are some ideas:

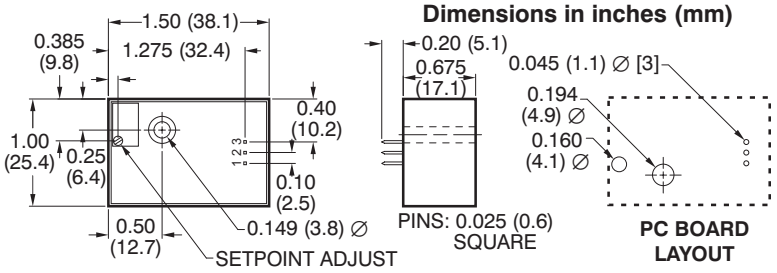
- Improve performance of LCD's or other electronics in cold storage areas.
- Replace bulky, slow-responding thermostats.
- Regulate temperature of miniature or low-mass heaters in situations where a temperature sensor is impractical or will impede response.
- Protect portable medical devices from effects of cold.
- Maintain temperature of critical circuit board components, such as crystals.
- Independently control individual sections of large area heaters, using one Heaterstat per zone.



Wiring



Dimensions in inches (mm)



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Heaterstat™ Sensorless DC Controller

Specifications

Setpoint range: Nominal resistance ±20% min. Specify heater resistance to produce the necessary heat output in watts, given available voltage.

Connections: Three pins on 0.1" centers or AWG 22 wires.

Power supply voltage: 4.75 to 10 VDC or 7.5 to 60 VDC, depending on model. Ripple up to 10% has negligible effect; simple unregulated DC supplies are adequate for most applications.

Nominal heater current: 0.05 to 4 amps, depending on model. See ranges below. Higher current possible with special models.

Nominal heater current	Minimum current for proper sensing	Maximum current (1 minute)	Output ON resistance in series with heater (pin 3 to 2)	Minimum output OFF resistance
CT198				
0.05 to 0.2 A	0.012 A	0.5 A	2.3	50K
0.21 to 0.5	0.050	1.0	0.8	50K
0.51 to 1.5	0.125	2.0	0.5	50K
1.51 to 3.0	0.350	4.0	0.3	50K
CT248				
2.50 to 4.0	1.0	5.0	0.25	50K

Scan rate (temperature above setpoint): 1 second standard. 0.1 seconds to 10 seconds optional.

Scan pulse width: 10 milliseconds.

LED indicator: Indicates heater power on. Optional on leadwire versions.

Calibration accuracy: ±0.2% std*. Note that standard resistance tolerance on heaters is ±10%.

Hysteresis: 0.05%*.

Setpoint drift due to:
Self-heating: ±0.2%* (±0.4% for 1.5 to 4 A range).
Ambient temperature: ±0.02%/°C* (±0.06%/°C for 1.5 to 4 A range).
Supply voltage change: ±0.03%/volt*.

Supply voltage ripple effects: Negligible, assuming 50/60 Hz, 10% max. ripple.

Controller supply current:
Output ON: 3 mA max.
Output OFF: 2 mA max; 1 mA typical at 10 VDC.

Ambient temperature:
Operating: -40 to 70 C (-40 to 158 F).
Storage: -55 to 85 C (-67 to 185 F).

Relative humidity: 90% max.

Physical: Epoxy sealed for moisture resistance. Will withstand wave soldering and water/detergent wash; contact Minco before cleaning with other chemicals.

Weight: 1 ounce (25 g).

* To convert resistance deviations to temperature:

$$\Delta T = \%\,deviation\left(T + \frac{1}{TCR}\right)$$

Where:
TCR = Temperature coefficient of resistance (/ /°C)
T = Setpoint temperature (°C)
ΔT = Temperature deviation (°C)

For example, assume a Heaterstat setpoint of 50°C, and heater TCR of 0.00536 Ω/Ω/°C (nickel foil). Calibration accuracy is ±0.2% of nominal resistance, which translates to temperature as:

$$\Delta T = \pm 0.2\%\left(50°C + \frac{1}{0.00536}\right) = \pm 0.47°C$$

Mounting: Mounting hole for #6 screw through, or #8 thread forming screw.

Heater: Wire-wound or etched-foil heater with high temperature coefficient of resistance (TCR).

Heater element	TCR (Ω/Ω/°C)
Copper foil or wire (Cu)	0.00427
Nickel foil (Ni)	0.00536
Nickel wire (Ni)	0.00672
Nickel-iron foil or wire (NiFe)	0.00519

Design considerations

Minco will be pleased to provide assistance with any of the design steps below. Do not hesitate to call on us.

Heater: A heater intended for use with a Heaterstat must have a temperature-sensitive element. All Thermal-Clear heaters meet this requirement, as do foil heaters with resistances from the last two columns of the model table.

Installation: The Heaterstat is small enough to mount directly to printed circuit boards and will withstand both wave soldering and water wash. Secure it to the board through the mounting hole. If you intend to adjust the setpoint after installation you will need a hole in the board opposite the setpoint trimmer. The leadwire version does not require a circuit board.

System accuracy: The Heaterstat, by its design, controls the temperature of the heater instead of the heat sink. The heater's element always runs hotter than the surface to which it is mounted. For best accuracy under changing ambient conditions your design should attempt to either reduce this gradient or stabilize it to a predictable level. Some suggestions are:

- Use the proper amount of heat. Try to size the heater to run at least 50% of the time in normal operation and at no more than 5 watts per square inch.
- Maximize contact between the heater and heat sink.
- Stabilize the system. Maintain a fairly constant supply voltage and insulate the assembly from changes in ambient temperature.
- Specify standard 1-second scan rate or faster.
- Consider the CT325 miniature DC controller

Setpoint calibration: A Heaterstat is factory calibrated to the nominal resistance of the heater at the setpoint temperature. Standard heaters, however, have a resistance tolerance of ±10%, or >25°C. For best results we recommend you recalibrate your Heaterstat after installation. Simply adjust the setpoint until temperature settles at the desired value as verified by a digital thermometer such as the Minco TI142.

Where recalibration is impractical you can improve accuracy by ordering Heaterstats and heaters in matched sets. Minco can compensate for heater tolerance by calibrating the controller to the actual measured resistance of its mating heater rather than to the nominal resistance. The heater and controller will be marked with matching serial numbers. When ordering a Heaterstat for a matched set, specify model CT698 instead of CT198.

Heaterstat™ Sensorless DC Controller

Standard models

Specifications:
One second scan rate.
6" (150 mm) leadwires.
LED power indicator.
Calibration: Setpoint factory-calibrated to specified resistance.

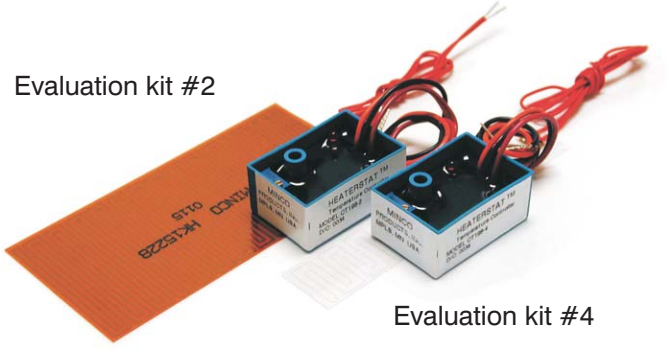
Model Number	Setpoint range (Ω)		Supply voltage (VDC)	
	Minimum	Maximum	Minimum	Maximum
CT198-1000	4.50	6.75	5	9.5
CT198-1001	5.63	8.44	8	16
CT198-1002	7.03	10.55	8	21
CT198-1003	8.79	13.18	8	26
CT198-1004	10.99	16.48	8	33
CT198-1005	13.73	20.60	8	41
CT198-1006	17.17	25.75	8	50
CT198-1007	21.46	32.19	8	50
CT198-1008	26.82	40.23	8	50
CT198-1009	33.53	50.29	8	50
CT198-1010	41.91	62.86	8	50
CT198-1011	52.39	78.58	8	50
CT198-1012	65.48	98.23	8	50
CT198-1013	81.85	122.78	8	50
CT198-1014	102.32	153.48	8	50
CT198-1015	127.90	191.85	8	50
CT198-1016	159.87	239.81	8	50
CT198-1017	199.84	299.76	8	50
CT198-1018	249.80	374.70	8	50
CT198-1019	312.25	468.38	8	50
CT198-1020	390.31	585.47	8	50
CT198-1021	487.89	731.84	9	50
CT198-1022	609.86	914.80	11	50

How to order standard models

CT198-1019	**Model number** CT198 = Heaterstat (nominal setpoint) CT698 = Heaterstat matched to heater
R	**Setpoint calibration code** R = Nominal heater resistance (CT198) T = Heaterstat/heater matched set (CT698)
365	**Initial calibration setpoint** Setpoint calibration code = R: Nominal heater resistance at set point temperature (in ohms).* Must be within allowable range for specified model. Setpoint calibration code = T: Temperature setpoint. Specify temperature and scale (°C or °F) Ex: 120F represents 120°F
L	**Leads** L = Leadwires (standard) P = Pins (LED not available)
1	**Scan rate** 0.1 to 10 seconds (1 second standard)
CT198-1019R365L1 ← Sample part number	

Evaluation kits

Test the concept and performance of Heaterstats before investing in a custom design. Each includes a controller and matching heater. You just supply electric power.



Evaluation kit #2

Evaluation kit #4

Evaluation kit #4

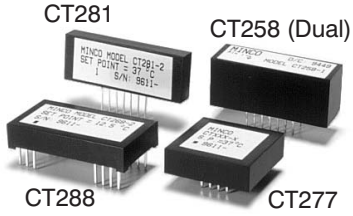
Contains H15227 Thermal-Clear transparent heater and CT198-4. Order CT198-K4.
Setpoint: Adjustable from -40 to 95°C.
Voltage: 4.75 to 10 VDC. 5 VDC nominal.
Watts: 1.7 W at 5 VDC and 50°C.
Heater dimensions: 0.75" × 4" (19 × 102 mm).
Scan rate: 10 seconds; LED indicator.

Evaluation kit #2

Contains HK15228 Kapton-insulated Thermofoil heater and CT198-2. Order CT198-K2.
Setpoint: Adjustable from 0 to 120°C.
Voltage: 7.5 to 38 VDC. 24 VDC nominal.
Watts: 40 W at 24 VDC and 80 C.
Heater dimensions: 2" × 4" (51 × 102 mm).
Scan rate: 1 second; LED indicator.

Miniature Heaterstat controllers

Minco can furnish SIP or DIP packages using remote digital setpoint adjustment.



* To determine heater resistance at temperature *T*:

$$R_T = \frac{R_{Ref} \times [(T \times TCR) + 1]}{(T_{Ref} \times TCR) + 1}$$

For example, model H6708R86.6 is 86.6 Ω (R_{Ref} = 86.6) at 0°C (T_{Ref} = 0) with a nickel wire element (TCR = 0.00672). At a control temperature of 60°C (T = 60), heater resistance (R_T) is:

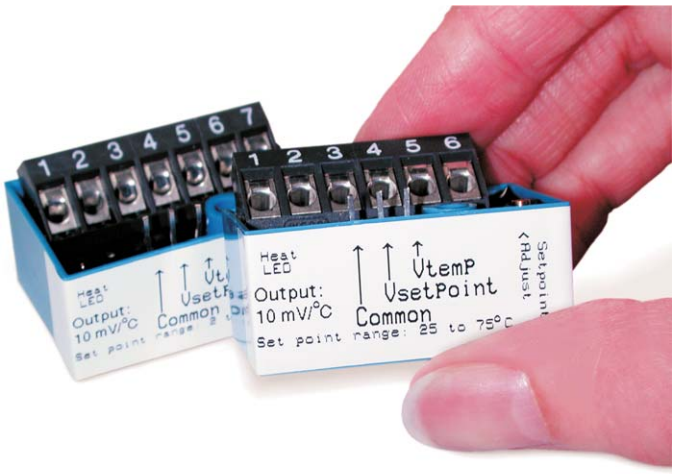
$$\frac{86.6 \times [(60 \times 0.00672) + 1]}{(0 \times 0.00672) + 1} = 122\,\Omega$$

The desired Heaterstat model with leadwires is:
CT198-1014R122L1
Resistance versus temperature tables are available at:
www.minco.com/sensorcalc

K

CT325 Miniature DC Controller

- Simple setup with voltage output pins for process and setpoint temperatures
- Tight control with ±0.5°C (1°F) deadband!
- Miniature package 1×1×1.5" (25×25×37 mm)
- Solid state on/off control with adjustable setpoint
- Uses standard 100 Ω or 1000 Ω platinum RTD or 50 kΩ thermistor sensor input
- Single DC power source provides power to the controller and heater up to 240 watts
- 3-wire RTD connection cancels lead resistance



The CT325 Miniature DC Temperature Controller is designed for use with Minco Thermofoil™ heaters and RTD or thermistor sensors. It offers inexpensive on/off temperature control of your process or equipment with accuracy many times better than bimetal thermostats.

Simply adjust the setpoint by connecting a standard voltmeter to the setpoint terminal and monitoring the 0.010 volt/°C output while adjusting the trim potentiometer. A second test point shows the actual temperature.

Operating from your 4.75 to 60 volt DC power supply, the controller can switch up to 4 amps power to the heater. A bright LED indicates when power is applied to the heater.

The entire unit is epoxy filled for moisture resistance, with a through-hole for a mounting bolt. A terminal block provides the power input, sensor input and heater output connections.

Specifications

Input: 100 Ω or 1000 Ω platinum RTD, 0.00385 Ω/Ω/°C, 2 or 3-leads, or 50 kΩ NTC thermistor, 2-lead.

Setpoint range:
2 to 100°C (36 to 212°F) for platinum RTD input.
2 to 200°C (36 to 392°F) for platinum RTD input.
25 to 75°C (77 to 167°F) for thermistor input.
Consult factory for other ranges.

Setpoint stability: 0.02% of span/°C.

Vtemp signal: 0.010 V/°C over specified range.

	Platinum RTD sensor		Thermistor sensor	
	2°C	0.02 V	25°C	0.25 V
	50°C	0.50 V	50°C	0.50 V
	100°C	1.00 V	75°C	0.75 V
	200°C	2.00 V		
Accuracy:	±1% of full scale		±2% of full scale	
Linearity:	0.1% of span		2% of span	

Deadband: 0.5°C.

Input power: 4.75 to 60 VDC.

Output: Open drain, 4 amps max. DC.

Leadwire compensation (3-wire RTD):
±0.06°C/Ω for 100 Ω or 1000 Ω platinum up to 25 Ω per leg.

Fault protection: Heater disabled on RTD short or thermistor open. No heater protection; external fuse recommended.

Operating ambient temperature range:
-40 to 70°C (-40 to 158°F).

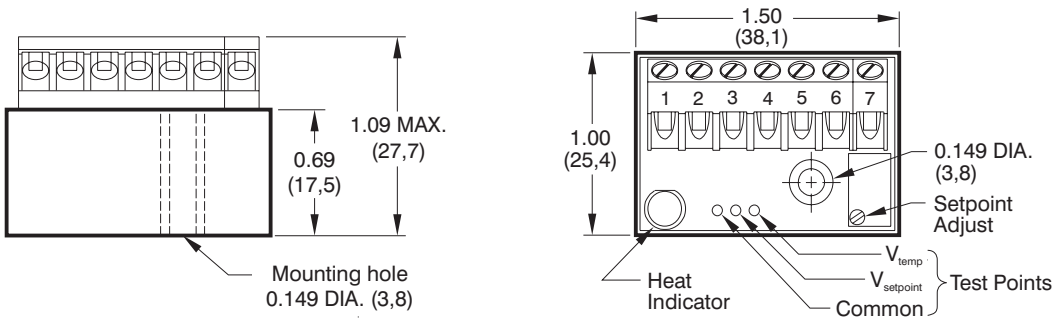
Relative humidity: 0 to 95% non-condensing.

Physical: Polycarbonate case, epoxy sealed. 1 oz. (28g).

Connections: Terminal block for wires AWG 22 to AWG 14.

Mounting: Mounting hole for #6 screw through or #8 thread forming screw.

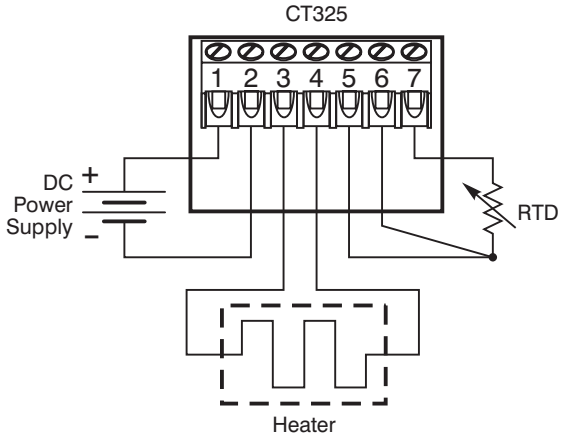
Dimensions

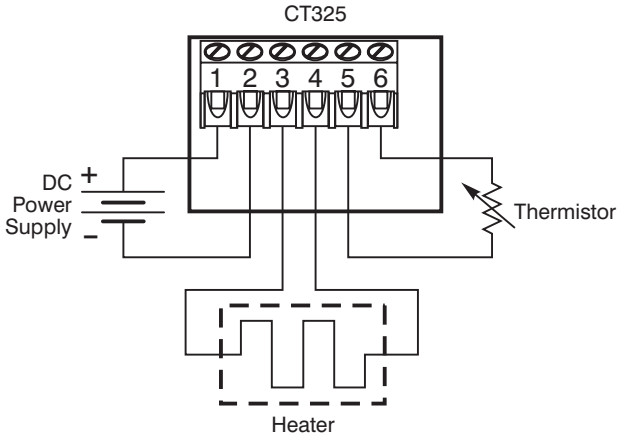


Dimensions are in inches (mm)

CT325 Miniature DC Controller

Wiring diagrams





How to order

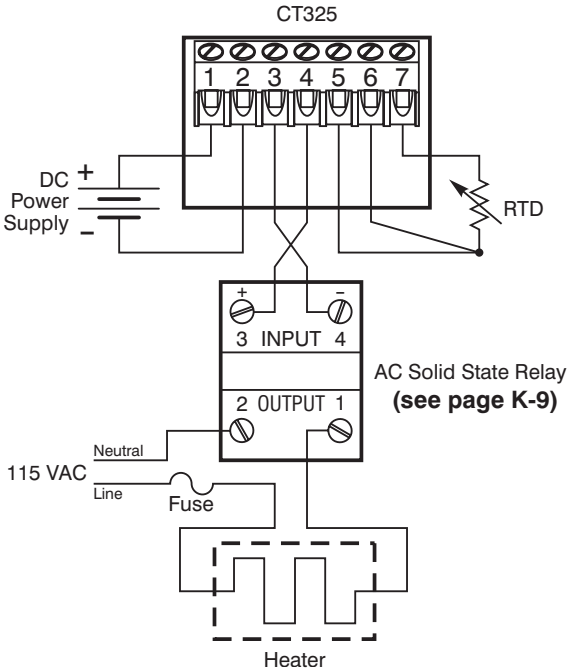
CT325	**Model number: CT325**
PD	**Sensor type:** PD = 100 Ω platinum RTD (2 to 100°C) PF = 1000 Ω platinum RTD (2 to 100°C) TF = 50 kΩ thermistor (25 to 75°C)
1	**Power supply:** 1 = 4.75 to 10 VDC 2 = 7.5 to 60 VDC
B	**Temperature range:** A = 25 to 75°C (TF sensor type only) B = 2 to 100°C (PD or PF sensor type only) C = 2 to 200°C (PD or PF sensor type only)
5	**Deadband:** 5 = 0.5°C
CT325PD1B5 ← Sample part number	

Custom design options

Minco can customize the design of the CT325 for special applications. Specific temperature ranges, other sensor options, and special packaging are possible for volume OEM applications. Proportional controllers are available in a slightly larger package.

AC powered heaters

The CT325 can provide the control signal to an external solid state relay (page K-9) to switch AC power. Use 15 VDC as the control voltage.



K

CT15 Temperature Controller

Advanced microprocessor control at an analog price. This single display controller can also serve as a simple indicator or indicating alarm.

User programmable functions (standard)

Control modes:

- PID: preset, programmable, Self-Tune
- On/off
- Manual (open loop)

Other features:

- Ramp to setpoint
- Anti-reset windup
- Digital sensor input correction
- Digital input filter adjustable for noisy or jittery processes
- 4 security levels
- Setpoint limits
- Non-volatile memory needs no battery backup
- Input fault timer

Factory options (specified in part number)

Alarms:

- Two independent setpoints: High, low, absolute, or deviation
- Single mechanical relay
- Manual or automatic reset, selectable inhibit

Control/monitor inputs:

RTD's are recommended for best accuracy.

- RTD: 100 Ω platinum, 2 or 3-wire, 0.00385 TCR (PD or PE)
- Thermocouple: J (factory default), K, T (selectable)

Control outputs:

- Solid state relay (SSR)
- Mechanical relay
- Switched voltage output to control external SSR

A solid state relay (SSR) is recommended for long life with proportional control. CT15 can be ordered with an internal SSR. For DC power or higher current ratings order external SSR's to be controlled by the switched voltage output of the controller (output option 2).

Specifications

Display: One 4 digit, 7 segment, 0.3" high red LED, °C or °F.

Control action: Selectable for Reverse (normally heating) or Direct (normally cooling).

Ramp: One ramp time adjustable from 0 to 100 hours.

Accuracy: ±0.25% of span, ±1° or 1 count.

Resolution: 1° or 0.1°, selectable.

Temperature stability: 100 ppm/°C typical, 200 ppm/°C max.

Isolation: Relay and SSR outputs are isolated. Current, voltage, and switched voltage outputs must not share common grounds with the input.

Supply voltage: 100 to 240 VAC nom., +10/-15%, 50 to 400 Hz, single phase; 132 to 240 VDC, nom., +10/-20%. 5 VA maximum.

Note: Do not confuse controller power with heater power. The controller does not pass power to the heater, but only acts as a switch. As an example, the controller could be operating on 115 VAC but controlling 12 VDC to the heater.

Temperature range:
Operating: -10 to 55°C (14 to 131°F).

Humidity range:
0 to 90% RH up to 40°C (104°F) non-condensing.
10 to 50% RH at 55°C (131°F) non-condensing.

Memory backup: Non-volatile memory (no batteries required).

Control output ratings:

- AC SSR: 3.5 A @ 250 VAC @ 25°C typical; derates to 1.25 A @ 55°C. Minimum 48 VAC and 100 mA minimum load required.
- Relay, Form A contact (SPST):
  3 A @ 250 VAC resistive.
  1.5 A @ 250 VAC inductive.
  Pilot duty: 250 VA, 2 A @ 125 VAC or 1 A @ 250 VAC.
- Switched voltage (non-isolated): 5 VDC @ 25 mA.

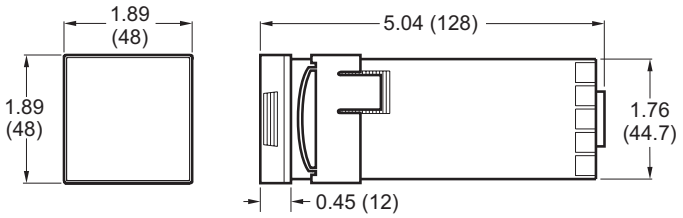
Alarm relay rating:
3 A @ 250 VAC resistive.
1.5 A @ 250 VAC inductive.
Pilot duty: 250 VA, 2 A @ 125 VAC or 1 A @ 250 VAC.

Weight: 227 g (8 oz.).

Agency approvals: UL & CSA.

Front panel rating: IP66; meets UL Type 4X.

Dimensions



PANEL CUTOUT: 1.775" × 1.775" (45 mm × 45 mm)
MAXIMUM PANEL THICKNESS: 0.25" (6.35 mm)
DIMENSIONS IN INCHES (mm)

How to order CT15

CT15	**Model number: CT15**
1	**Alarm relay:** 0 = No 1 = Yes
2	**Input:** 1 = J, K, or T thermocouple 2 = 100 Ω platinum RTD, type PD or PE
1	**Output:** 1 = Built-in AC SSR 2 = Switched voltage (5 VDC) for external SSR 3 = Built-in mechanical relay
CT15121 ← Sample part number	

See page K-9 for high power solid state relays (SSR) and other accessories.

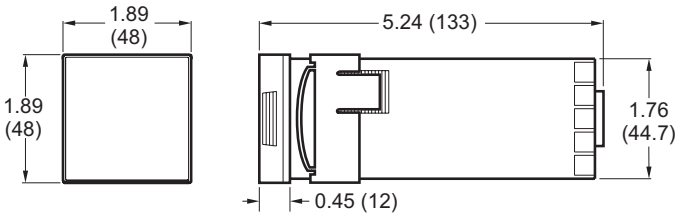
CT16A Temperature Controller

This economical controller packs sophisticated PID control into a compact 1/16 DIN enclosure. A wide range of control modes, sensor input types, and relay or SSR outputs give versatile control of Thermofoil™ heaters and lets you easily connect to other electronics.

Features

- Dual displays continuously show the set point and the actual temperature reading in resolutions of 1°, 0.1°, or engineering units
- Universal Input fits any measurement: Select from 10 thermocouple types, 4 RTD types, voltage, and current signals
- Isolated Outputs for safe, easy wiring
- Loop Break protection handles sensor or heater failure
- Peak / Valley records the maximum and minimum temperatures
- Front panel is waterproof and corrosion-resistant, making it ideal for sanitary applications. Illuminated keypad for easy operation
- Limit the temperatures which the operator can set via four password-protected Security Levels
- Controller can Self-Tune for best PID control
- Control modes: Self-Tune, pre-set or adjustable PID values, simple On/Off control, and open loop
- Fuzzy Logic provides better response time and reduces overshoot in processes with unpredictable inputs
- Alarms at one or two temperatures
- Alarm Relay option is programmable for high, low, absolute, or deviation, can be reset manually or automatically, and it controls a single electromechanical relay with voltage-free contacts
- Ramp & Soak option handles complex heating profiles of 16 segments with front-panel activation and a selectable time base (CT16A3)
- Auto / Manual option easily switches to manual control for set up or experiments (CT16A3)
- RS-232 or RS-485 Serial Communications access the temperature readings and all control parameters (optional)
- Retransmit either the sensed temperature or the set point as a voltage or current signal to a computer or recorder (optional)
- Vary the Set Point using a potentiometer, a voltage, or a current signal (optional)
- 4-Stage Set Point to quickly switch from one temperature to the next (optional)

Dimensions



PANEL CUTOUT: 1.775" × 1.775" (45 mm × 45 mm)
MAXIMUM PANEL THICKNESS: 0.25" (6.35 mm)
DIMENSIONS IN INCHES (mm)

Specifications

Selectable inputs:

- RTD: 2 or 3-wire, Minco types PD or PE (100 Ω IEC platinum), PA (100 Ω NIST platinum), PF (1000 Ω IEC platinum), or NA (120 Ω Nickel)
- Thermocouple: Type J (factory default), K, T, L, E, R, S, B, C, or N
- DC current: 0-20 mA or 4-20 mA (use with Temptran™ transmitters)
- DC voltage: 0-10 or 2-10 VDC, -10 to 10 mVDC, scalable

Input impedance:

- Voltage: 5000 Ω
- Thermocouple: 3 megohms minimum
- Current: 10 Ω
- RTD current: 200 μA

Sensor break or short protection: Selectable output: disabled, average output before fault, or preprogrammed output. Adjustable delay: 0.0 to 540.0 minutes.

Loop break protection: Error message is initiated and output is turned off in case of shorted sensor or open heater circuit. Break time adjustable from OFF to 9999 seconds.

Cycle rate: 1 to 80 seconds.

Setpoint range: Selectable from -212 to 2320°C (-350 to 4208°F), input dependent.

Displays: Two 4 digit, 7 segment 0.3" high LED's. Process Value red, Setpoint Value green. °C or °F.

Control action: Reverse (usually heating) or Direct (usually cooling), selectable.

Ramp/soak: (CT16A3 only) 16 separate ramp and soak times are adjustable in minutes or seconds from 0 to 9999. When the program has ended, you may choose to repeat, hold, revert to local setpoint, or turn the outputs off.

Accuracy: ±0.25% of span ±1 count.

Resolution: 1° or 0.1°, selectable.

Line voltage stability: ±0.05% over supply voltage range.

Temperature stability: 4 μV/°C (2.3 μV/°F) typical, 8 μV/°C (4.5 μV/°F) max. (100 ppm/°C typical, 200 ppm/°C max.).

Isolation:
Relay and SSR: 1500 VAC to all other inputs and outputs.
SP1 and SP2 current and voltage: 500 VAC to all other inputs and outputs, but not isolated from each other.
Process output (options 934, 936): 500 VAC to all other inputs and outputs.

Supply voltage: 100 to 240 VAC nom., +10/-15%, 50 to 400 Hz, single phase; 132 to 240 VDC, nom., +10/-20%. 5 VA maximum. 12 & 24 volt AC/DC optional.

Note: Do not confuse controller power with heater power. The controller does not supply power to the heater, but only acts as a switch. For example, the controller could be powered by 115 VAC, but controlling 12 VDC to the heater.

Operating temperature range: -10 to 55°C (14 to 131°F).

Memory backup: Non-volatile memory (no batteries required).

K

CT16A Temperature Controller

Control output ratings:

- AC SSR (SPST): 2.0 A combined outputs A & B @ 240 VAC @ 25°C (77°F); derates to 1.0 A @ 55°C (130°F). Minimum 48 VAC and 100 mA minimum load required. An SSR is recommended for longer life than a mechanical relay.
- Mechanical relay, SPST Form A (Normally Open) or Form B (Normally Closed):
  3 A resistive, 1.5 A inductive @ 240 VAC;
  pilot duty: 240 VA; 2 A @ 120 VAC or 1 A @ 240 VAC.
- Switched voltage (isolated): 15 VDC @ 20 mA.
- Proportional current (isolated): 0 to 20 mA, 600 max.
- DC SSR: 1.75 A @ 32 VDC max.
- Alarm relay, SPST Form A (Normally Open):
  3 A @ 240 VAC resistive; 1/10 HP @ 120 VAC.

Weight: 227 g (8 oz.).

Agency approvals: UL & CE.

Front panel rating: Type 4X (IP66).

Additional options for CT16A (board level)

924: Analog remote setpoint (0 to 10 VDC). Vary the setpoint using a voltage signal.

926: Analog remote setpoint (4 to 20 mADC). Vary the setpoint using a current signal.

928: Analog remote setpoint (0 to 10,000 ohms). Vary the setpoint using a potentiometer.

934: Analog retransmission of Process Variable or Set Variable, 4 to 20 mADC. For use as recorder, transmitter or computer A/D input. Linearized 4 to 20 mA DC signal follows the Process or Set variable. Scalable.

936: Analog retransmission of Process Variable or Set Variable, 0 to 10 VDC. Similar to option 934, but output signal is linearized 0 to 10 VDC.

948: 4-Stage setpoint. Four preset setpoints may be selected by external contacts. Each set point has its own set of PID values giving controller 4 distinct "recipes" for different process situations.

992: RS-485 Computer communication link. Allows remote computer to read and write all control parameters.

993: RS-232 Computer communication link. Allows remote computer to read and write all control parameters.

9502: 12 to 24 VDC / VAC power option. Controller is powered by low voltage instead of line voltage.

Note: Only option 9502 can be combined with another board level option.

How to order CT16A

CT16A	**Model number: CT16A**
2	**Feature set:** 2 = Standard 3 = Enhanced (ramp & soak, Auto/manual)
1	**Alarm relay:** 0 = No 1 = Yes
1	**Output A:** 1 = Built-in AC SSR 2 = Pulsed voltage (15 VDC) for external SSR 3 = Mechanical relay, SPST (normally open) 4 = Mechanical relay, SPST (normally closed) 5 = Current 8 = DC SSR
0	**Output B:** 0 = None 1 = Built-in AC SSR 2 = Pulsed voltage (15 VDC) for external SSR 3 = Mechanical relay, SPST (normally open) 4 = Mechanical relay, SPST (normally closed) 5 = Current 8 = DC SSR
-992	**Options (leave blank for none)**
CT16A2110-992 ← Sample part number	

Accessories

AC744: 1-10 A, 24 to 280 VAC SSR

AC745: 1-25 A, 24 to 280 VAC SSR

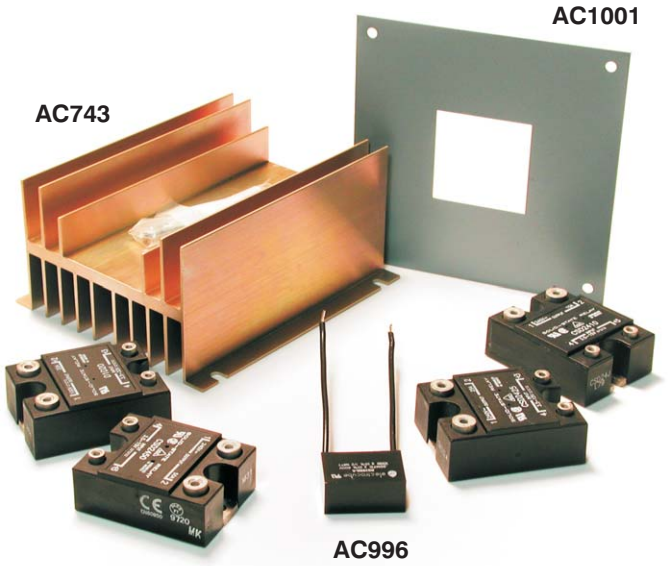
AC746: 1-50 A, 24 to 280 VAC SSR

AC1009: 1-20 A, 0 to 100 **VDC** SSR

AC743: SSR heat sink for high current or ambient temperature

AC996 R/C Snubber: Highly recommended to prolong relay contact life, if using the mechanical relay or SSR output to drive a relay or solenoid. Also, for the CT16A AC SSR output, make sure that the coil HOLDING current is greater than 100 mA and voltage is minimum 48 VDC.

AC1001: Steel 1/16 to 1/4 DIN adapter plate. 127 × 127 mm gray steel with 45 × 45 mm centered hole.

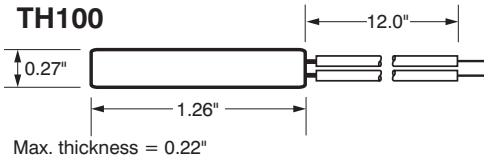


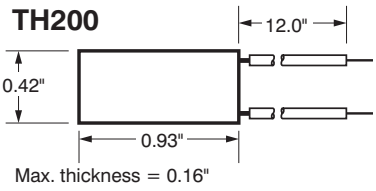
Accessories

Thermostats

Thermostats provide basic heater control at little cost. You can also use them as thermal cutoffs in conjunction with other control systems. All thermostats come with a 1.5" (38.1 mm) long, silicone rubber coated sleeve for electrical insulation (case is electrically live), and mounting adhesive.

These thermostats are ordered separately. For information on ordering heaters with factory installed thermostats contact Minco's Sales Department.





Specifications

Stock models:
TH100 creep action, 120 VAC maximum.
TH200 snap action, 240 VAC maximum.
Setpoint tolerance: ±5°C (±9°F).
Open/close differential: 5 to 10°C, typical.
Maximum current:
Model TH100: 6 amps at 120 VAC;
8 amps at 12 VDC;
4 amps at 24 VDC.
Model TH200: 4 amps at 240 VAC.
Life rating: 100,000 cycles.
Approvals: UL, CSA.

How to order

TH100	**Model number: TH100 (creep action)**
T40	**Setpoint options:** 5°C, 20°C, 40°C, 60°C, 80°C, 100°C, 150°C, 200°C
TH100T40 ← Sample part number	

TH200	**Model number: TH200 (snap action)**
T80	**Setpoint options:** 60°C, 80°C, 100°C, 150°C
TH200T80 ← Sample part number	

Pre-cut insulators

Trimmed to the same size as heaters, these pads provide thermal insulation to minimize heat loss. You can also place them between clamping plates and heaters for uniform pressure. Optional pressure sensitive adhesive (PSA) backing permits easy installation. It will not bond permanently and may be removed later without damaging the heater.

Material	Thickness	Temperature limit		R factor
		with PSA	no PSA	Uncompressed
Neoprene	0.125" (3.18 mm)	107°C	107°C	23.1 °C × m/W
Silicone rubber foam	0.125" (3.18 mm)	204°C	204°C	9.2 °C × m/W
Mica	0.010" (0.25 mm)	N/A	600°C	2.5 °C × m/W
Ceramic paper*	0.125" (3.18 mm)	N/A	600°C	11.5 °C × m/W

** Every mica heater comes with two sheets of ceramic paper free of charge. Order extra sheets here.*

How to order

IN	**IN = Insulating pad**
5334	**Matching heater model number**
N1	**Material:** N1 = Neoprene, R1 = Silicone rubber, M1 = Mica, C1 = Ceramic paper
B	**Pressure sensitive adhesive:** A = No PSA, B = With PSA backing (N/A with ceramic or mica)
IN5334N1B ← Sample part number	

You can estimate heat loss with the following formula:

$$\text{Heat loss}\,(W) = \frac{A\,(T_f - T_a)}{1000\,R\,L}$$

where:

W = Watts of heat lost through insulation
A = Heater area in square mm
T_f = Heat sink temperature in °C
T_a = Ambient temperature in °C
R = R factor in °C × m/W
L = Thickness of insulation in mm

K

Temperature Sensors

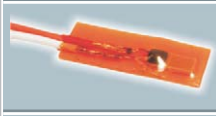
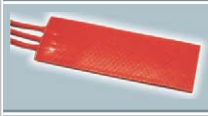
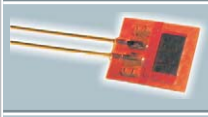
Minco is a leading manufacturer of temperature sensors. We currently stock more than 1,800 different models of sensor for immediate shipment. We also offer complete custom design capabilities. No one else can match our ability to tailor the sensor to your thermal system with the ideal combination of price, thermal responsiveness, stability, accuracy, and ease of installation.

Below is a selection of popular sensors for use with our heating elements and controllers. Request Bulletin TS-102 for Minco's full range of sensors and accessories, or visit www.minco.com/support for technical and application information.

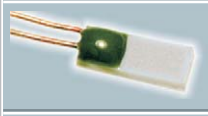
Note: Except where noted, all RTD's have 100±0.12% ohm platinum element, TCR = 0.00385 Ω/Ω/°C (Pt100 per IEC 751 Class B).

Thermal-Ribbon RTD's and thermocouples

Flexible Thermal-Ribbons mount easily to surfaces, alongside heaters or on top of them. All are available with self-stick adhesive.

	Model	Material	Dimensions	Temperature
	**S665PDY40A*** (100 Ω) **S665PFY40A*** (1000 Ω) **TS665TFY40A*** (50 kΩ at 25°C NTC thermistor)	Kapton substrate with elastomer cover, 2 or 3 PTFE leads	0.2" × 0.5" (5 × 12 mm) Lead length: 40" (1000 mm)	-50 to 155°C -58 to 311°F (except TS665 to 125°C/257°F)
	**S667PDY40A*** (100 Ω) **S667PFY40A*** (1000 Ω) (Available with 2 leads only) *Immersible*	Silicone rubber substrate with elastomer cover, 2 silicone rubber leads	0.2" × 0.6" (5 × 16 mm) Lead length: 40" (1000 mm)	-50 to 155°C -58 to 311°F
	**S17624PDYT40A*** (100 Ω) **S17624PFYT40A*** (1000 Ω) **S17624PSYT40A*** (10,000 Ω) *Wide temperature range*	Kapton substrate and cover, 2 or 3 PTFE leads	0.2" × 0.6" (5 × 15 mm) Lead length: 40" (1000 mm)	-50 to 200°C -58 to 392°F
	**S467PDY36A*** (100 Ω) **S468PFY36A*** (1000 Ω) *Flexible model designed for moist environments*	Silicone rubber body, 2 or 3 rubber leads	S467: 0.5" × 1.5" (13 × 38 mm) S468: 0.5" × 3.0" (13 × 76 mm) Lead length: 36" (900 mm)	-62 to 200°C -80 to 392°F
	**S651PDY24A*** (100 Ω) *Miniature spot sensor with wire-wound RTD element*	Kapton with foil backing 2 or 3 PTFE leads	0.30" × 0.30" (7.6 × 7.6 mm) Lead length: 24" (600 mm)	-200 to 200°C -328 to 392°F
	**TC40JT36A*** (Type J) **TC40KT36A*** (Type K) **TC40TT36A*** (Type T) *Patch-style thermocouple*	Kapton with PTFE leads	0.75" × 0.75" (19 × 19 mm) Lead length: 36" (900 mm)	-200 to 200°C -328 to 392°F

RTD probes and elements

	Model	Material	Dimensions	Temperature
	**S614PDY12T*** (100 Ω) **S614PFY12T*** (1000 Ω) *General purpose encased sensor*	Stainless steel, 2 or 3 PTFE leads	0.188" ∅ × 2" long 4.8 ∅ × 51 mm long Lead length: 12" (300 mm)	-269 to 260°C -452 to 500°F
	**S853PD120Y36*** (100 Ω) *Tip sensitive probe*	Stainless steel with copper alloy tip, 2 or 3 PTFE leads	0.250" ∅ × 12" long 6.4 ∅ × 305 mm long (other lengths available) Lead length: 36" (900 mm)	-50 to 260°C -58 to 500°F
	**S245PD12** (100±0.12 Ω) **S245PD06** (100±0.06 Ω) **S247PF12** (1000±0.12 Ω) **S247PF06** (1000±0.06 Ω)	Ceramic/glass body, silver leads	S245: 0.08" × 0.09" (2.0 × 2.3 mm) S247: 0.08" × 0.20" (2.0 × 5.0 mm) Lead length: 0.6" (15 mm)	-70 to 400°C -94 to 752°F
	**S270PD12** (100±0.12 Ω) **S270PD06** (100±0.06 Ω) *High temperature, high precision element*	Ceramic body, platinum leads	0.047" ∅ × 0.59" long (1.28 ∅ × 15 mm long) Lead length: 0.4" (10 mm)	-200 to 850°C -328 to 1562°F

*** Part number codes:** Change the "Y" to "Z" for 3-lead model. For Thermal-Ribbon models only, change the "A" to "B" for acrylic PSA backing.