MINCO

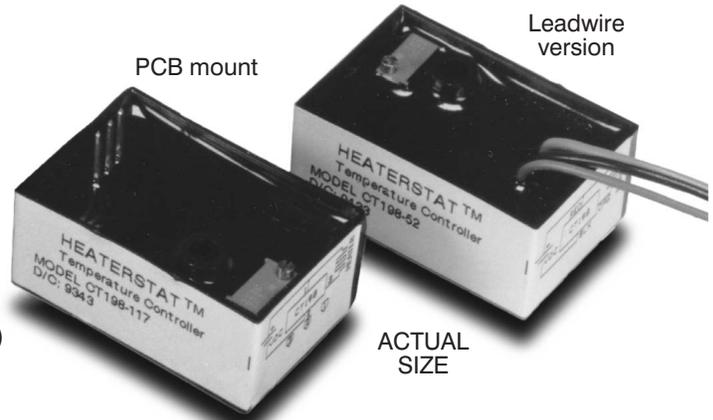# Heaterstat™
Sensorless Temperature Controller

◆ 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

◆ Control 3 A (model CT198) or up to 4 A (model CT248)

PCB mount

Leadwire version

ACTUAL SIZE

This unique DC controller does not require a separate sensor for temperature input. Instead, the CT198 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.
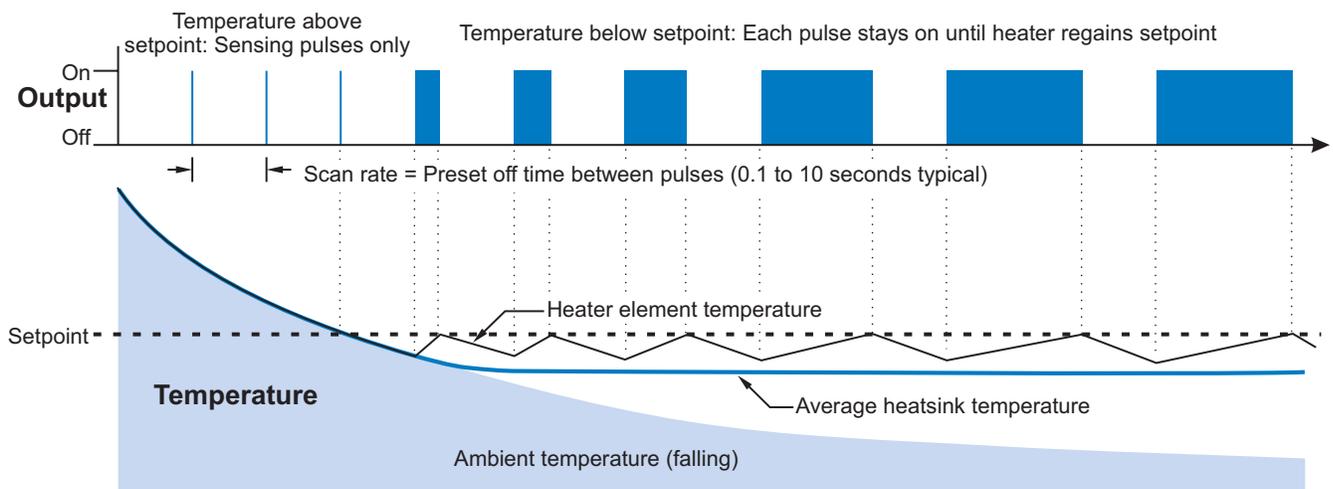
If heater temperature is *below* setpoint, the Heaterstat leaves power on and continually reads resistance until element temperature reaches setpoint. It then shuts off and waits until time for the next pulse.

Scan rate, the off-time between pulses, is factory set from 0.1 to 10 seconds. 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:

• Control temperature of transparent LCD heaters in portable computers and instruments.

• Improve performance of 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.

Temperature above setpoint: Sensing pulses only

Temperature below setpoint: Each pulse stays on until heater regains setpoint

On

Output

Off

Scan rate = Preset off time between pulses (0.1 to 10 seconds typical)

Setpoint

Heater element temperature

Temperature

Average heatsink temperature

Ambient temperature (falling)

Specifications: CT198/CT248 Heaterstat

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

Heater element	TCR ($\Omega/\Omega/°C$)
Copper foil or wire	0.00427
Nickel foil	0.00536
Nickel wire	0.00672
Nickel-iron foil or wire	0.00519

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 leadwires.

Pin	Lead color	
1	Red	Power supply (V+)/Heaters (+)
2	Black	Ground (V-)
3	Orange	Heater (-)

Power supply voltage: 4.75 to 10 VDC or 7.5 to 60 VDC, depending on model. Ripples up to 10% have negligible effect; simple unregulated DC supplies will be 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): User specified from 0.1 to 10 seconds.

Scan pulse width: 10 milliseconds max.

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 load).
> Ambient temperature: ±0.02%/°C* (±0.06%/°C for 1.5 to 4 A load).
> 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: ABS case, epoxy sealed for moisture resistance. Will withstand wave soldering and water/detergent wash; contact Minco before cleaning with other chemicals.
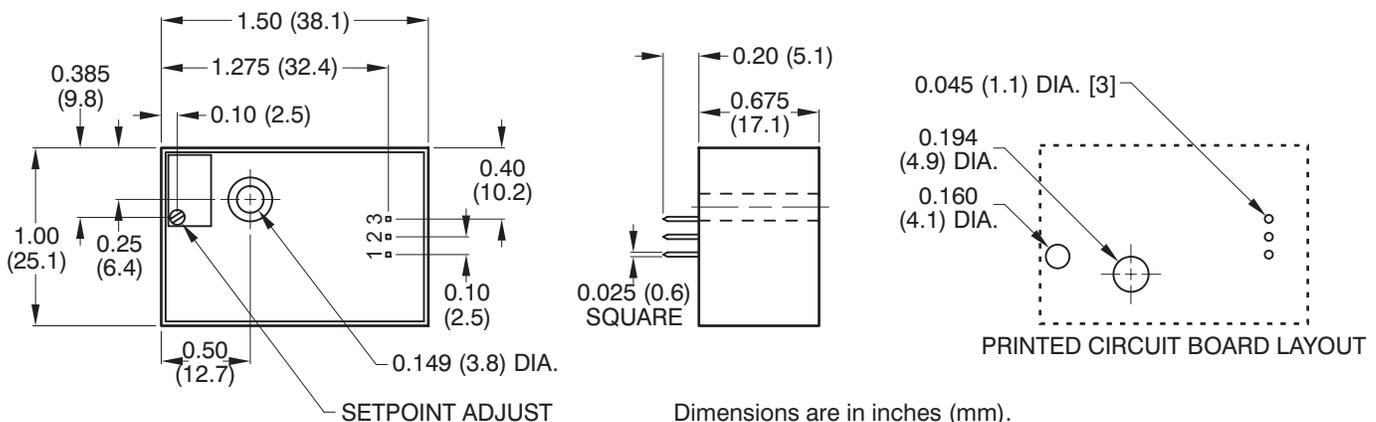
Weight: 1 ounce (25 g).

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

*See resistance/temperature calculations on page 3.

Wiring diagram

Dimensions

SETPOINT ADJUST

Dimensions are in inches (mm).

PRINTED CIRCUIT BOARD LAYOUT
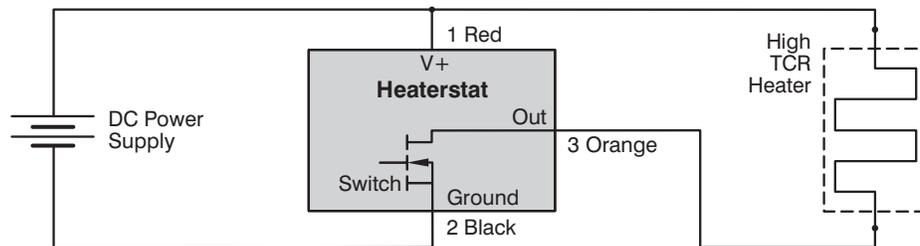
Designing a Heaterstat System

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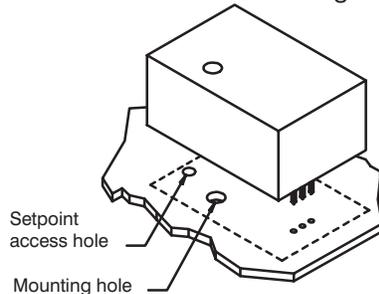
Heater

Because the Heaterstat uses its heater as a temperature sensor, you must specify and order your heater and controller as a set. Request Minco Bulletin HS-201 for design data on Thermofoil heaters, Bulletin HS-2 for transparent LCD heaters. Note that the Heaterstat will only work with standard catalog foil heaters that have high TCR elements.

1. Determine the heat level, in watts, that your system requires. Minco Application Aid #21 can help you estimate heat requirements. Test thermal behavior with a standard heater and variable voltage source before proceeding to custom design.

2. Calculate heater resistance and current, using Ohm's law, given the available voltage and desired wattage.

Installation

The Heaterstat is small enough to mount directly to printed circuit boards, and will withstand both wave soldering and water washdown. If you intend to adjust the setpoint after installation you will need a hole in the board opposite the setpoint trimmer. Secure the unit to the board through the mounting hole.

Setpoint access hole

Mounting hole

The leadwire version does not require a circuit board. Install it with bolts or screws into the mounting hole.

If heater resistance is low, extra resistance from extension leads and contact resistance can result in temperature errors. You may need to use larger gauge wires or adjust the setpoint to compensate.

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.

- Maximize contact between the heater and heat sink. Use foil elements instead of wire when possible, cover as much of the heat sink as possible with the heater, and make sure your mounting adhesive is free of voids.

- Stabilize the system. Maintain a fairly constant supply voltage and insulate the assembly from changes in ambient temperature.

- Specify faster scan rates. Minimizing the off times helps keep average element temperature nearer the setpoint temperature, even with overpowered heaters.

Setpoint calibration

A standard 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.

Resistance/temperature calculations

Many Heaterstat specifications are expressed in resistance rather than temperature. To convert to temperature:

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

where:

TCR = Temperature coefficient of resistance ($\Omega/\Omega/°C$)

T = Setpoint temperature (°C)

ΔT = Temperature deviation (°C)

For example, assume a Heaterstat setpoint of 50°C and heater TCR of 0.0057 $\Omega/\Omega/°C$ (nickel foil). Calibration accuracy is ±0.2% of nominal resistance, which translates to temperature as: $\Delta T = 0.2\% \left(50°C + \frac{1}{0.0057} \right) = \pm 0.45°C$

(Also see the note on system accuracy above.)

How to order custom models

Please furnish the following information when specifying a new Heaterstat design:

Temperature setpoint
Heater resistance at setpoint
Heater supply voltage
Scan rate (0.1 to 10 seconds)
Pins or wire leads
LED (leadwire version only) or no LED
Length of wire leads, if appropriate (6" or 150 mm standard)
Calibrate to nominal heater resistance or to individual heaters

Non-standard options

Minco can customize Heaterstats to meet your application requirements. Some options are:

- Alternative packaging, pin arrangements, or connectors.

- Remote setpoint potentiometer, including serial input digital types.

- Higher power ratings.

CT281   CT258 (Dual)

CT288   CT277
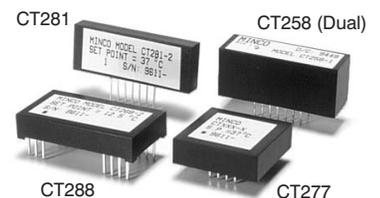
Circuit board style Heaterstats with digital setpoint adjustment.

Standard models

Specifications:
One second scan rate.
6" (150 mm) leadwires.
LED power indicator.
Calibration: Setpoint factory-calibrated to specified resistance.
Contact Minco for assistance in selecting compatible heaters.

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

R365	**Initial calibration setpoint in ohms**
	    Must be within allowable range for
	    specified model

L	**L = Leadwires**
1	**1 = 1 second scan rate**
CT198-1019R365L1	Sample part number

To determine resistance at temperature T:
$R_T = [R_R \times (T \times TCR + 1)] / (T_R \times TCR + 1)$
Example: Model H6708R86.6 is 86.6 Ω (Ref. resistance R_R) at 0°C (Ref. temp. T_R) with a nickel element (0.0057 TCR). At control temperature 60°C (T) resistance R_T is:

$[86.6 \times (60 \times 0.0057 + 1)] / (0 \times 0.0057 + 1) = 116.2\ \Omega$
You should therefore choose model CT198-1014.
For help see www.minco.com/sensorcalc

Evaluation kits

These kits let you 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.
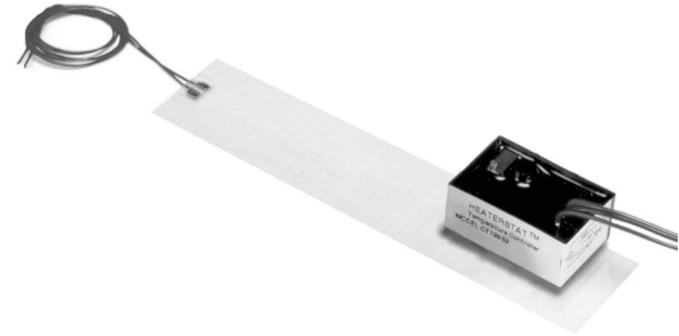
Evaluation kit #4

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 / 50°C.
Heater dimensions: 0.75" x 4" (19 x 102 mm).
Scan rate: 10 seconds; LED indicator.

Evaluation kit #2

Contains HK15228 polyimide-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 / 80°C.
Heater dimensions: 2" x 4" (51 x 102 mm).
Scan rate: 1 second; LED indicator.