

MINCO

CT281 HEATERSTAT™ INSTRUCTIONS

GENERAL

The CT281 Heaterstat™ is a temperature controller which gates DC power to the heater and does not use a separate temperature sensor. Instead, it uses a high TCR (Temperature Coefficient of Resistance) heater to sense and control heat output - no separate sensor or thermostat is required. The solid-state electronics are more durable than a mechanical thermostat due and have an adjustable setpoint which allows you to fine-tune the setpoint temperature for your application. A DC power source, a Heaterstat, and a matching heater are all that is required.

OPERATION

Figure 1 shows the operation of the Heaterstat. Every 1, 2, or 10 seconds, depending upon the model chosen, the heater is powered momentarily to check the element temperature. If temperature is above setpoint the Heaterstat turns off the power within 10 milliseconds. Increased element resistance is read as increased temperature. If the element temperature reads below setpoint, heater power stays on until the setpoint is reached. The Heaterstat then returns to the periodic scanning mode.

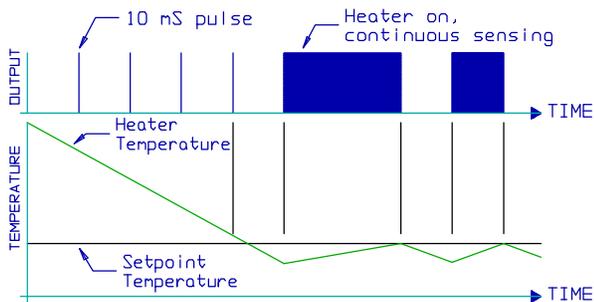


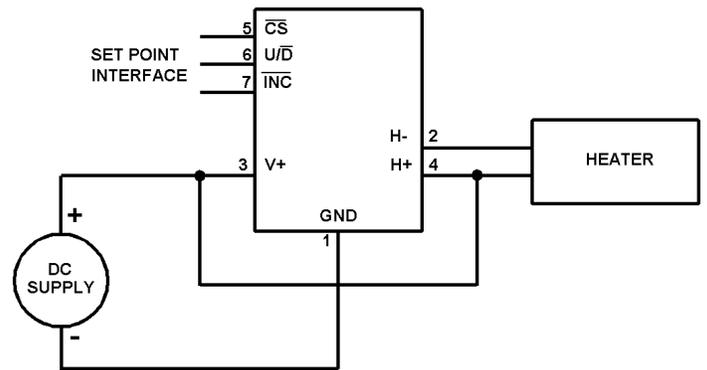
Figure 1

INSTALLATION

The Heaterstat is small enough to mount directly to printed circuit boards, and will withstand ordinary wave soldering and water washing. Test before washing with other chemicals.

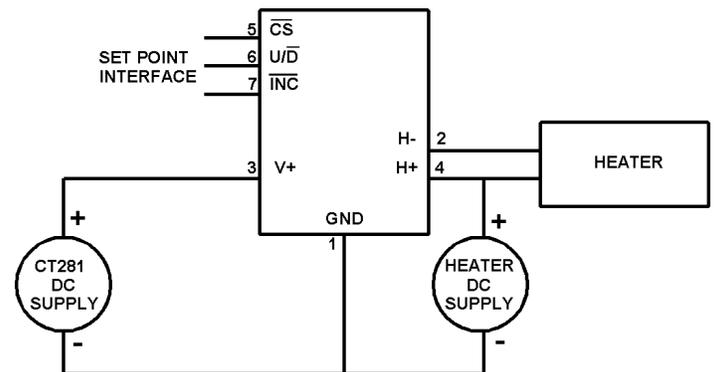
POWER

Both the CT281 and the heater may use the same supply (Figure 2). If a higher voltage is required for the heater, wire as in Figure 3.



SINGLE SUPPLY

Figure 2



TWO SUPPLIES

Figure 3

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HEATER MOUNTING:

Some Minco heaters are supplied with #10 pressure-sensitive adhesive for easy installation. #10 PSA is suitable for flat or slightly curved surfaces and has a temperature limit of 100°C.

To use PSA:

1. Remove the white (unmarked) backing paper. Be careful not to touch the adhesive.
2. Press the flat side of the heater onto the adhesive and rub it down.
3. Trim the excess adhesive.
4. Remove any dirt or oil from the mounting surface.
5. Carefully lift the marked backing paper and peel it away, leaving the adhesive on the heater.
6. Press the heater onto the mounting surface and rub it to remove any entrapped air.

Bulletin HS-201 and Application Aid #22 describe the complete range of options for heater mounting. Refer to them for custom designed heaters. For the best performance, always design for maximum contact between the heater and heat sink.

DESIGN NOTES

The Heaterstat has been designed to replace mechanical thermostats in some applications. Reliability, low-cost, solid-state operation, and efficient heating are its primary benefits. If your system requires precision control, then you must consider several other factors besides the simple calibration tolerances of the heater and the Heaterstat. Close control will require some experimentation and careful design.

Understand that the Heaterstat controls the temperature of the heater element, not the object you are heating (heat sink). In most cases, you must control the heater at a temperature greater than your desired heat sink temperature. To understand why, consider a thermal system during warm-up. It is obvious that the temperature of the object being heated will lag behind the temperature of the heating element; there is a thermal gradient and a time lag between the heater and the heat sink. Even after the system has stabilized, the heater element will be warmer than the heat sink. While this gradient can be minimized with Minco Thermofoil™ heaters, it can never be eliminated. Since the Heaterstat is controlling the temperature of the element, the heat sink will settle at a somewhat lower temperature.

In a stable system (i.e. constant thermal load and constant input power), this thermal gradient can be calibrated out by increasing the setpoint. In an unstable system, this gradient will vary with operating conditions, causing the heat sink temperature to go up and down even though the element is controlling at the right temperature.

How can you optimize control accuracy?

- Use the proper amount of heat. Excess wattage causes element temperature to reach setpoint very rapidly, which means that the heating takes place in short bursts and the heat sink never catches up to the heater. As a rule of thumb, try to size the heater so it runs 50% of the time in normal operation.
- Use a foil heater instead of wire unless you need transparency. The thermal gradient is inversely proportional to the area the element covers. Minco Thermofoil heaters have 50% element coverage.
- Maximize contact area of the heater. For example, wrap heaters around cylinders instead of mounting on one end.
- Make sure the heater element is in close contact with the object being heated, using thin, void-free adhesive layers.
- Stabilize the system by insulating the assembly from changes in ambient temperature.
- Stabilize the system by minimizing changes in input power; use a regulated power supply.
- Stabilize the system by reducing changes in the thermal load.
- Increase the scan rate. This is the time between heating pulses when the controller is off. Common scan rates are 1, 2 and 10 seconds. A 1 second scan rate checks the heater element every second, allowing the controller to act quickly under varying conditions. The drawback is that minimum power is increased.

CALIBRATION

The typical Heaterstat has been factory-calibrated to the resistance of your heater at the desired control temperature. Depending upon your application, you may not have to change the setpoint.

The accuracy of the setpoint, as received from the factory, depends to a large degree on the resistance tolerance of the heater. A typical tolerance is $\pm 10\%$ for a Thermofoil etched-foil heater, and $\pm 2\%$ for a Minco wire heater. A 40 Ω heater will have a $\pm 4 \Omega$ tolerance, that equates to a $\pm 20^\circ\text{C}$ error for a balco heating element. Tighter tolerances will improve accuracy and interchangeability, but at increased cost. When close calibration is essential, Minco can calibrate heaters and controllers in matched sets. In this case, it is important to connect the heater leads directly to the leads or pins or as close as is practical. This will minimize errors due to extension leadwire or circuit traces.

The best calibration method is with the heater installed in the system as it will actually be used. Then, using a separate temperature meter and sensor in contact with the heat sink or heater, adjust the Heaterstat's set point until the proper temperature is achieved. This will compensate for typical thermal gradients, heater tolerances, and any circuit traces or extension leadwire to the heater.

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Alternately, the heater may be placed in a temperature-controlled bath (note that most standard heaters are not suitable for direct immersion in water). Use an ammeter to monitor the current to the heater then adjust the setpoint to the point where the current (heat) just begins to cycle on and off.

A third calibration method is to simulate the heater's resistance at setpoint with a decade box or fixed resistor. This method may be difficult because you must supply a precise resistance which can also dissipate a lot of wattage. Care must be taken to prevent the heat from shifting the resistance value.

Be sure to thoroughly test your prototype system under all operating conditions.

DIGITAL SETPOINT CONTROL

The CT281 has a digital interface for adjusting the setpoint temperature. The interface operates like an up/down counter linked to a setpoint potentiometer. The INC, U/D, and CS inputs control the movement of the setpoint potentiometer wiper along a 99 element resistor array. With the CS set low, the digital setpoint potentiometer is selected and enabled to respond to the U/D and INC inputs. High to low transitions on INC will increment or decrement (depending on the state of the U/D input) a seven bit counter. The output of this counter is decoded to select one of 100 wiper positions along the resistive array. Incrementing the counter increases the setpoint temperature.

The value of the counter is stored in non-volatile memory whenever CS transitions high while the INC input is also high. When the CT281 is powered down, the last counter position stored will be maintained in the non-volatile memory. When power is restored, the contents of the memory are recalled and the counter is reset to the value last stored.

The adjustment system you connect may move the wiper and deselect the device without having to store the latest wiper position in nonvolatile memory. The wiper movement is performed as described above; once the new position is reached, the system would keep INC low while taking CS high. The new wiper position would be maintained until changed by the system or until a power off/on cycle recalled the previously stored data. This allows the system to always power-on to a preset value stored in nonvolatile memory; then during operation minor adjustments can be made if desired.

Up/Down

The U/D input controls the direction of the wiper movement and whether the counter is incremented or decremented. A logic HIGH from the host system to the CT281 directs the wiper, and the temperature set point, upward. The state of U/D may be changed while CS remains low.

Increment

The INC line is negative-edge triggered. Toggling INC will move the wiper in the direction indicated by the logic level on the U/D input.

Chip Select

The counter is selected when the CS input is low. The current counter value is stored in nonvolatile memory when CS is returned high while the INC input is also high.

Wiper

The wiper, when at either fixed terminal, acts like its mechanical equivalent and does not move beyond the last position. That is, the counter does not wrap around when clocked to either extreme.

Interface driver requirements

The 3 setpoint control input lines have 100k ohm pull-up resistors to internal Vcc (approx. 5 VDC). The user's interface should be an open collector design that allows the inputs to float when an input high is desired. An input is considered low when the voltage is less than 0.8 volts. Figure 5 shows an example interface with a microcontroller.

Below is a simple software routine written in 'C' to increase the setpoint of the controller via computer by x steps.

```
CS    =address (port A, pin 1)
UPDN  =address (port A, pin 2)
INC    =address (port A, pin 3)
X      =# of steps, user input
UPDN = 1
INC = 0
CS = 0
for (i=0; i<x; i++){
    INC = 1
    DELAY (500 us)
    INC = 0
}
INC = 1
CS = 1
```

To decrease the setpoint by x steps, use same code but set UPDN = 0.

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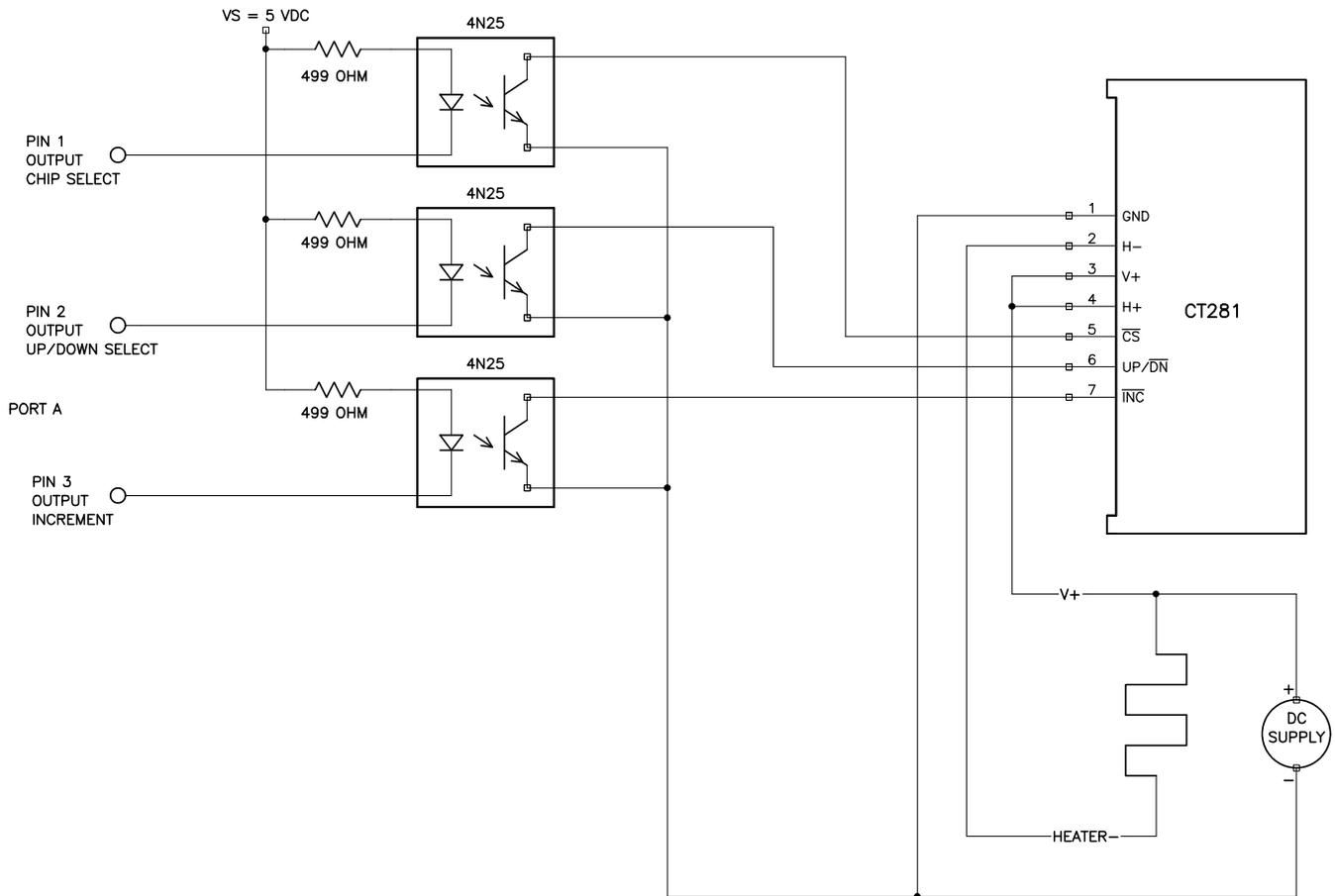


Figure 5

RELATED LITERATURE:

[Bulletin CT198](#) provides ordering information and physical and electrical specifications for the standard Heaterstat.

[Bulletin HS-201](#) describes Thermofoil etched-foil heaters. Included are insulation comparisons, mounting methods, wattage ratings, standard models, and a custom design guide.

[Bulletin HS-1](#) discusses Thermal-Clear transparent heaters.

[Application Aid #21](#) presents simplified methods for estimating heater power requirements.

[Application Aid #22](#) recommends adhesives for heater installation.

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A.C. CONDITIONS OF TEST

Input Pulse Levels	0V to 3.0V
Input Rise and Fall Times	10ns
Input Reference Levels	1.5V

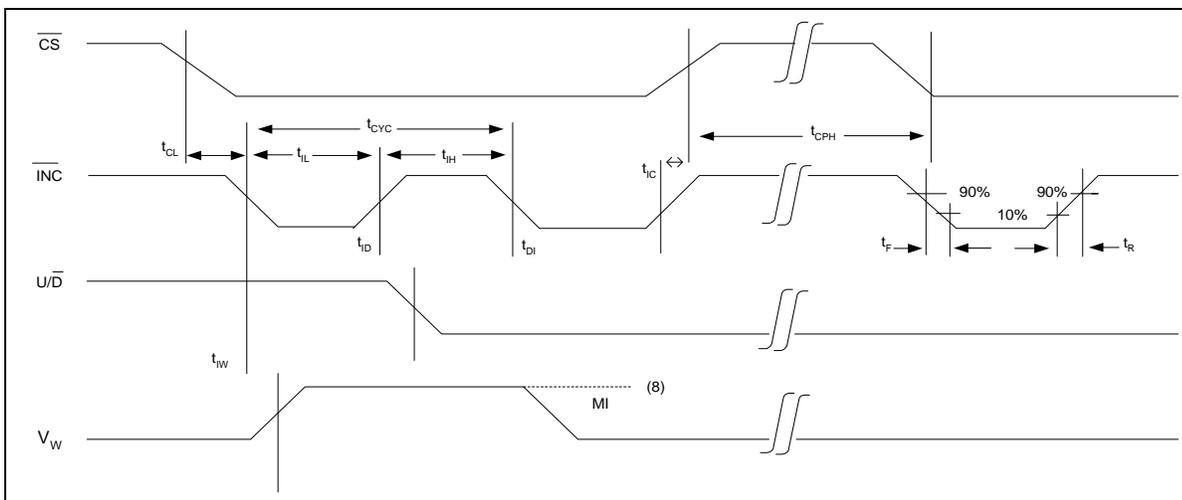
MODE SELECTION

$\overline{\text{CS}}$	$\overline{\text{INC}}$	$\text{U}/\overline{\text{D}}$	Mode
L	f	H	Wiper Up
L	f	L	Wiper Down
f	H	X	Store Wiper Position
H	X	X	Standby
f	L	X	No Store, Return to Standby

A.C. OPERATING CHARACTERISTICS (Over recommended operating conditions unless otherwise specified)

Symbol	Parameter	Limits			Units.
		Min.	Typ. ⁽⁶⁾	Max.	
t_{Cl}	CS to INC Setup	100			ns
t_{ID}	INC High to U/D Change	100			ns
t_{DI}	U/D to INC Setup	1			μs
t_{IL}	INC Low Period	.5			μs
t_{IH}	INC High Period	.5			μs
t_{IC}	INC Inactive to CS Inactive	1			μs
t_{CPH}	DS Deselect Time	20			ms
t_{IW}	INC to V_w Change		100	500	μs
t_{CYC}	INC Cycle Time	1			μs
$t_{\text{R}}, t_{\text{F}}^{(7)}$	INC Input Rise and Fall Time			500	μs
$t_{\text{PU}}^{(7)}$	Power up to Wiper Stable			500	μs
$t_{\text{R}} V_{\text{CC}}^{(7)}$	V_{CC} Rise Time	0.5			V/ μs

A.C. Timing



- Notes:
- (6) Typical values are for $T_A = 25^\circ\text{C}$ and nominal supply voltage.
 - (7) This parameter is periodically sampled and not 100% tested.
 - (8) MI in the A.C. timing diagram refers to the minimum incremental change in the V_w output due to a change in the wiper position.

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MODEL CT281-____ SPECIFICATIONS

Note: For your convenience, certain specifications have been converted to temperature using nominal values and placed in ().

Heater Data:

Minco Model Number:
Resistance: $\Omega \pm$ _____ % at _____ °C
Element: Copper / Nickel / Nickel-iron
Nominal TCR: 0.00427 / 0.00570 / 0.00519 $\Omega/\Omega/^\circ\text{C}$

Standard calibration:

Setpoint: Ω (_____ °C)
CT198 accuracy: $\pm 0.2\%$ (\pm _____ °C)
Combined w/heater: \pm _____ % (\pm _____ °C)

Calibrated matched sets (heater & controller):

Setpoint: °C or _____ °F
System accuracy: \pm _____ °C or \pm _____ °F

Setpoint range: to _____ Ω (_____ to _____ °C)

Hysteresis: 0.05% maximum

Maximum Setpoint drift due to:

Self-heating: $\pm 0.3\%$ maximum
Ambient temp.: $\pm 0.03\%/^\circ\text{C}$ maximum
Supply voltage: $\pm 0.03\%$ /volt maximum

Ambient:

Operating temperature: -40 to 70°C (-40 to 158°F)
Storage temperature: -55 to 85°C (-67 to 185°F)
Relative humidity: 90% max. continuous

Power supply: VDC

Supply voltage range: to _____ VDC

Output:

Nominal heater current: Amps
Minimum current for proper sensing: Amps
Maximum continuous current: Amps
Output ON resistance: Ω
Output OFF resistance: 50 K Ω

Scan rate, temp. above setpoint:

..... Approximately _____ seconds

Scan pulse width: 10 milliseconds max.

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 typ. @ 10 VDC)

Physical: Epoxy sealed, glass-fibre filled Diallyl Phthalate Case.

Dimensions: 1.6 x 0.6 x 0.25"

Connections: Three .100" spaced pins
or _____ inch leadwire

Weight: 25 ounce (7 g)

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

When quality and performance are as important as price, call...

MINCO

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