Data Sheet

Temperature controllers

Principles

Definition of terms

Alarms, high, low or 'out of limits' - many controllers are equipped with alarm outputs. These are normally an extra relay (usually of lower current rating) which can be used to indicate an unwanted condition. For example if the contactor controlling the heater in a kiln was to weld close the heater would be permanently energised and the kiln temperature would increase well above the set point. An alarm, set at a suitable temperature above the set point, could be used to indicate this condition. An alarm on temperature rise is a high alarm, an alarm on temperature fall is a low alarm. An 'out of limits' alarm is a combination of both high and low ie. if the temperature is outside a given band about the setpoint the alarm will operate.

Approach control - this refers to the temperature range over which the derivative term operates such that outside a given band (normally expressed as a percentage of span or proportional band) the derivative term is disabled.

Auto reset - see Integral.

Cycle time - with a controller incorporating a relay as the output device the only way of varying the output is by adjusting the ratio between on and off times (mark to space ratio). It is normal to make the sum of the on and off times a fixed time and vary the on time. The fixed time is called cycle or proportional time.

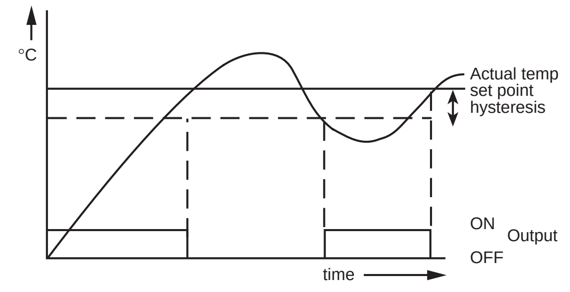
Default - many modern controllers have pre-programmed 'default' settings to enable the unit to work in most applications without the user having to programme the unit.

Derivative - this is based on the first derivative of the error temperature (or a set ratio of the rate of change of error temperature) with respect to time.

Gain - see Proportional band.

Hysteresis - this only applies to ON/OFF controllers. To reduce the number of times the relay switches a 'dead band' is added. For example with a controller set to 100°C, as the temperature rises to 100°C the controller will switch off. However, the temperature will probably continue to increase and reach a peak before falling back. If the controller has 5°C hysteresis the controller will not switch on again until the temperature has fallen to 95°C.

Figure 1 **Hysteresis**



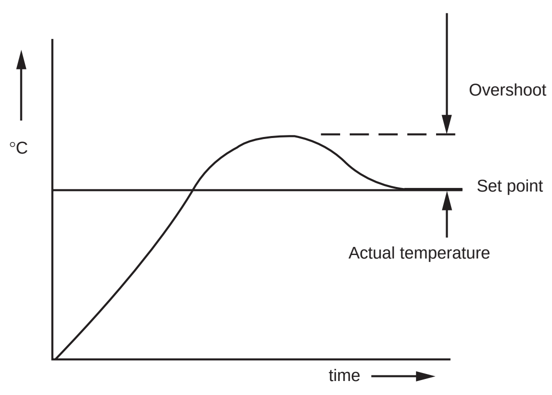
Integral - this is based on the integral of the error temperature and is the sum of the error signal over time. This term removes offsets between set temperature and actual temperature and is sometimes referred to as auto reset.

Manual reset - if an integral term is not used an error will exist between demanded temperature and the actual temperature achieved. Many temperature controllers have the facility to remove this offset by adding or subtracting a fixed amount from the actual temperature measured. Thus the controller attempts to achieve a temperature which is slightly different than the actual set temperature improving accuracy of control.

ON/OFF; ON/OFF controller - the simplest form of control, if the temperature sensed is below the set temperature the output will be on, if the temperature is above it will be off (for a heating load).

Overshoot - with the simpler types of controllers when heating a load from cold the temperature of the load will increase past the set point, and not to the set point, and then fall back. The excess temperature is called overshoot.

Figure 2 **Overshoot**



Polling ratio - the derivative polling ratio is the update time for calculation of the derivative term and applies to digital controllers only.

Proportional - this is where the output is proportional to an error signal. This is normally the demanded temperature minus the actual temperature, ie, the output is a set ratio of demand minus actual temperature.

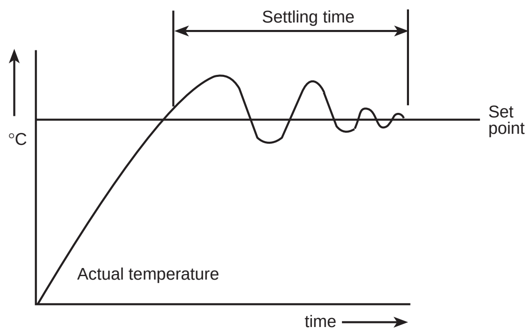
Proportional band - the proportional band is the range of temperatures over which the proportional term operates and is usually expressed as a percentage of the span of the controller. For example a proportional controller of 100°C span, with a 10% proportional band and set to control at 50°C will be fully on up to 45°C and then fall linearly to zero output at 55°C.

Proportioning time - see Cycle time.

Set point - the temperature to which the controller is set and therefore the temperature to be maintained in the equipment being controlled.

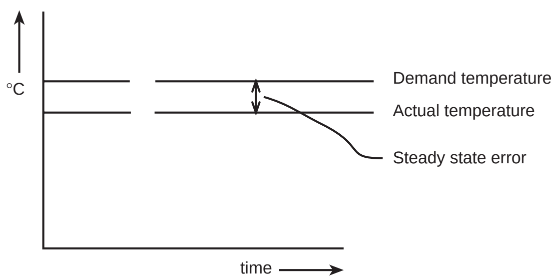
Settling time - the time taken for the controller to achieve stable control is normally referred to as settling time. This is not only important on warm up but in response to changes in set point or any other disturbance.

Figure 3 **Settling time**



Steady stage error - a fixed error from the set point, when the controller has settled.

Figure 4 **Steady state error**



Controller terminology

PD controller (proportional plus derivative) - a controller with both proportional and derivative terms.

PID controller (proportional derivative plus integral) - a controller with proportional, derivative and integral terms.

PIPD controller (proportional, integral proportional derivative) - a controller with PID terms and approach control.

3 term controller - a PID controller.

4 term controller - a PIPD controller.

Types of controllers

ON/OFF controller

Advantages - Simple, compact, low cost.

Disadvantages - poor control, will hunt around set point, tendency to overshoot.

PD controllers

Advantages - better control than ON/OFF types proportional term can be used to reduce hunting and the derivative term can control overshoot.

Disadvantages - more complex than ON/OFF types but exhibits steady state errors.

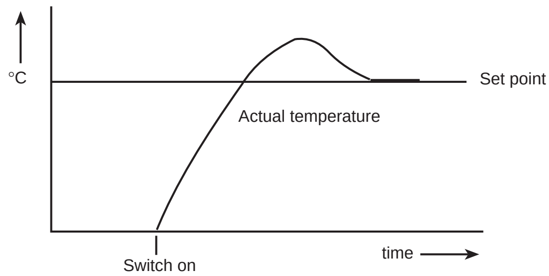
PID or PIPD controllers

Advantages - excellent control can be achieved when correctly set. The integral term will remove steady state errors.

Disadvantages - higher cost, more complex, much more skill may be required to set up successfully.

Application notes

Figure 5 **Excessive overshoot**



Excessive overshoot is a very common problem in temperature control. If an ON/OFF controller is being used nothing can be done and if it is necessary to reduce the overshoot a more sophisticated controller of the PD or PID types should be used.

With PD types the derivative term should be increased to reduce the overshoot, this also applies to PID controllers.

However, if the derivative term is increased too much a very slow temperature rise to the setpoint will result. If the controller has an approach control setting this can be used to restrict the band over which the derivative term works and gives fast warm up as well as reduced overshoot.

Simple methods of input simulation

With temperature controllers using type K inputs the **RS** current/voltage source 1030 (**RS** stock nos. 610-348 or 611-745) can be used to simulate the thermocouple. Simply look up the EMF output of the desired thermocouple at the desired temperature in EMF tables (given in the *Labfacility Temperature Handbook,* **RS** stock no. 220-6193) and set the 1030 to that voltage, not forgetting to subtract the EMF for ambient temperature.

Similarly a resistance box (such as **RS** stock no. 610-297) can be used to simulate a Pt100; element. Data on the resistance versus temperature relationship can also be found in the same book.

Selection guide

Series 1 temperature controllers

Available in two ON/OFF versions only. In all new applications the more sophisticated series 2 controllers should be used.

0°C to +400°C ON/OFF controller
type K input (RS stock no. 348-144).

Technical specification

Supply voltage	110 Vac or 240Vac
	50Hz ± 10%
Power consumption	Less than 4VA
Scale range	0°C to +400°C
Scale calibration	1% of FSD at
	+25°C amb
Repeatability of set point	0.5% of FSD at
	+25°C amb
Set point hysteresis	± 2% of FSD
Cold junction compensation	+0.2% °C/°C
Ambient temperature range	-10°C to +50°C
Output relay contact (SPDT) rated	240Vac 5A resistive
Input sensor	NiCr/NiA (BS 4937-K)
Case material: modified PPO	
Case colour: beige	

-50°C to +100°C ON/OFF controller
Pt 100 input (RS stock no. 346-378).

Technical specification

Supply voltage	110 Vac or 240Vac
	50 Hz ± 10%
Power consumption	Less than 4VA
Scale range	-50°C to +100°C
Scale calibration	±21/2% of FSD at
	+25°C amb
Repeatability of set point	0.5% of FSD at
	+25°C amb
Set point hysteresis	less than 5%
Ambient temperature range	-10°C to +50°C
Output relay contact (SPDT) rated	240Vac 5A resistive
Deviation meter output	+20°C ±20%
Input sensor	Platinum resistance
	BS 1904 Grade II
Case material: modified PPO	
Case colour: beige	

Series 2 temperature controllers

This is a sophisticated range of ON/OFF and proportional plus derivative controllers for either type K or Pt100 inputs.

ON/OFF controllers

RS stock no.	Temperature range	Sensor
344-596	-50°C to +150°C	Pt100
344-619	0°C to +100°C	Pt100
344-546	0°C to +200°C	type K
344-552	0°C to +400°C	type K
344-568	0°C to +800°C	type K

Proportional plus derivative controllers

RS stock no.	Temperature range	Sensor
344-603	-50°C to +150°C	Pt100
344-625	0°C to +100°C	Pt100
344-574	0°C to +200°C	type K
344-120	0°C to +400°C	type K
344-580	0°C to +800°C	type K

Technical specification

Supply voltage	110Vac or 240Vac
	+10 to -15%, 47 to 63 Hz
Suitable sensors type K	to BS497: Pt4
Pt100	to BS1904
Setting accuracy	±2% of full scale
Hysteresis	0.5% of full scale
Prop. band (PD types)	0 to 20% of full scale
Cycle time (PD types)	20s
Output relay	5A at 240Vac or 30Vdc
Operating temperature range	-10°C to +50°C
Storage temperature range	-20°C to +85°C
Electrical isolation	3.75kV for 1 minute

CAL 9900 series autotune PID temperature controllers including cool strategy function

This is a range of comprehensive, but compact proportional integral plus derivative controllers with autotune and approach control. The flexibility of this type of controller enables it to be successfully used in the majority of applications. Relay output, relay/SSR output and SSR output versions are available operating on 240V or 110V supplies. A dedicated solid state relay is also available.

Output	Operating voltage	**RS** stock no.
SP1 relay, SP2 relay	240Vac	354-925
SP1 relay, SP2 relay	110Vac	354-919
SP1 SSR, SP2 relay	240Vac	354-947
SP1 SSR, SP2 relay	110Vac	354-931
SP1 SSR, SP2 SSR	240Vac	354-969
SP1 SSR, SP2 SSR	110Vac	354-953

Technical specification

Supply voltage	110 or 240Vac + 10% -15%
Power consumption	5VA
Ambient temperature range	0°C to +50°C
Front bezel sealing	IP54
Rear sealing	IP30
Display type	10mm 7 segment LED
Relay switching	SP15A
capabilities (where applicable)	SP2 3A
Case material	Flame retardance Polycarbonate
Sensor types	
Thermocouple	B, E, J, K, L, N, R, S, T
Platinum resistance	Pt 100
Accuracy	
normal resolution	±0.25 +1°C
(excluding errors)	
high resolution	±0.25 +0.5°C
	(of full scale)
Stability	0.15% of full scale
Control terms (SP1)	
Proportional time	0.05 to 81s or ON/OFF
Proportional band	0.5 to 100% of full scale
Hysteresis (ON/OFF mode)	0.25 to 50% of full scale
Derivative time	1 to 255s or out
Approach control	0.5 to 9 times prop. band
Integral time	0.2 to 43 mins or out
Control terms (SP2)	
Proportional time	0.05 to 60 secs or ON/OFF
cool strategy	0.15 to 10 secs
	0.15 to 20 secs
	0.06 to 15 secs
Proportional band	0.5 to 100%
Hysteresis	0.25 to 50%
Error indication	1.2 or 4% of full scale/segment
Input/Output isolation	3kV rms

CAL 9900 dedicated solid state relay (RS stock no. 616-087)

The SSR replaces the normal socket and provides a 1 amp solid state switching capability on the SP1 output of the CAL 9900 controller. The SSR is suitable for use with all CAL 9900 controllers incorporating an SSR output on SP1.

96 × 96 PID temperature controller (RS stock no. 340-083)

A highly versatile 3-term temperature controller offering the following features:

- 3 separate relay outputs
- Front panel indication of output state
- Switching capability of 5A @ 240Vac
- Sensor selectable for 9 types of thermocouples, PT100, mV or mA input
- Display can be set to indicate measured temperatures of deviation
- User friendly mnemonic display for ease of use
- 115 or 240Vac switch selectable
- Capable of driving solid state relays.

Specification

Power supply	115 or 240Vac +10%/-15% 47-63 Hz
Power consumption	6VA max.
Operating temperature range	0°C to +50°C
Storage temperature range	-20°C to +80°C
Calibration	±0.25% @ 20°C
Stability	<0.015% of span per °C amb.
Linearity	<0.15% of span
Data retention	5 years min.
Supply isolation	3.75kV for 1 min.

Sensor types and ranges

Type J thermocouple	0°C to +800°C
Type K thermocouple	0°C to +1200°C
Type N thermocouple	0°C to +1300°C
Type T thermocouple	-250°C to +350°C
Type R thermocouple	0°C to +1600°C
Type S thermocouple	0°C to +1800°C
PT100 elements	-200°C to +250°C
Linear inputs	-50mV to +50mV
	-20mA to +20mA (2V drop)

96 × 906 solid stage relay adaptor (RS stock no. 342-067)

A plug-in module for the 96×96 temperature controller which replaces the output relay allowing the direct drive of solid state relays or contactors.

This module is suitable for use in all fast switching, or high duty cycle applications, to prevent rapid relay wear and premature failure.

Up to three adaptors may be used with each temperature controller; one for SP1, one for SP2/Alarm 2 and one for Alarm 1. However, it is normally not necessary to use solid state relays for slower switch alarm outputs, therefore one adaptor in heating applications or two adaptors in heating/cooling applications are usually required.

RS offer a range of solid state relays, see our current catalogue for details.

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