RHOMBERG	**Temperature Controllers** **General Specifications & Technical Information**	**TC410 TC515 TC600**

The Rhomberg TC410, TC515 and TC600 temperature controllers can all be programmed to either employ ON/OFF control or autotune PID control. All controllers utilise the same PID algorithm. The following sections describe the different control methods.

The Basics of On/Off Control

In this simple form of control, the controller output switches off when the process temperature reaches the setpoint. The process cools until the recovery level is reached and power is reapplied to the process. The resulting process temperature oscillates through this hysteresis band (the band between setpoint and recovery levels) as illustrated in Figure 1.
On/Off control is ideal for large capacity processes (processes that have slow temperature change and are insensitive to disturbances) because the hysteresis band can be set very narrow, minimising temperature oscillations.

Simple Example:
The thermostat of a household heater uses On/Off control. When the room temperature reaches the setpoint, a switch opens and turns the heater off. The switch remains off until the room temperature drops below the setpoint causing the switch to close turning the heater on again. The heat is either ON or OFF.

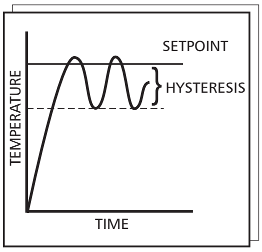


Figure 1: *On/Off Characteristics*

The Basics of Trip & Recovery Control

Trip and Recovery mode facilitates control of two independent setpoints. In heating, for instance, each trip point represents the temperature above which the relay is de-energised and the heating mechanism is de-activated. The recovery points then represent a temperature below which the relay is re-energised and the heating mechanism is turned on.
This feature can also be used in cooling applications. Each trip point will then represent the temperature below which the relay is de-energised and the cooling mechanism is de-activated. The recovery points then represent the temperature above which the relay is re-energised and the cooling mechanism is turned on.
A typical application where two fans are used to control a process is shown in Figure 2. The first fan is activated at 300° and remains on until the temperature falls below 250°, whilst the second switches on at 350° and switches off at 280°.

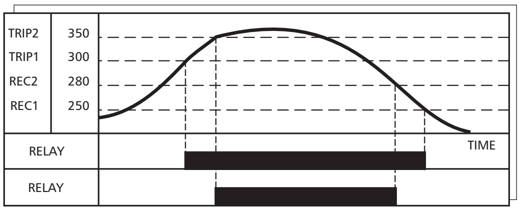


Figure 2: *Trip & Recovery Mode used in a cooling application*

The Basics of PID Control

In applications where precision control is required, including small capacity processes that react quickly to disturbances, it is necessary to provide a more sophisticated method of temperature regulation than that of On/Off control.

For example, On/Off control would be ineffective for the control of the temperature of a bathroom shower as the person would be subjected to alternative bursts of HOT and COLD water, neither of which is desirable. It is necessary to establish a proportion of hot to cold water to continually maintain the required temperature.

Proportional Control (P)

Proportional control provides added temperature stability by eliminating fluctuations in temperature by setting the proportion of power supplied to the process depending on the difference between process and setpoint temperatures.

Unfortunately, the process temperature only settles at the setpoint if the heat source (heater) exactly matches the heat load of the process. However, heaters and processes are rarely matched and therefore the process temperature usually settles at a value offset from the setpoint as shown in Figure 3.

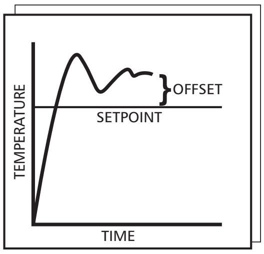


Figure 3: *Proportional Control Characteristics*

Proportional and Integral Control (PI)

To compensate for the offset resulting in proportional only control, a second control term known as integral action is introduced.

Integral action eliminates the offset by responding to duration of the error signal (through integration) and automatically forcing the process temperature to settle exactly at the setpoint after a period of time. This is achieved by small adjustments in the proportional output.

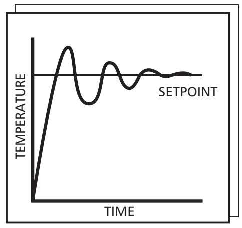


Figure 4: Proportional and Integral Control Characteristics

Proportional, Integral and Derivative Control (PID)

In many small capacity processes, the controller must respond quickly to large and rapid changes in temperature caused by disturbances. Derivative action provides additional temperature stability by reacting to the rate of change of the process temperature. This is achieved by setting the controller output to oppose any temperature deviation from the setpoint. This has the additional advantage of reducing initial temperature overshoots when the process temperature reaches the setpoint for the first time.

Simple Example:

An injection moulding machine benefits from PID control. Proportional control ensures that the plastic temperature is stable and does not oscillate. Integral control maintains accuracy by keeping the temperature exactly at the setpoint over long periods. Derivative action forces the temperature back to the setpoint quickly when the cold plastic pellets enter the melting chamber.
For optimum PID control, the controller parameters (P,I and D values) should be tuned for each temperature process. In Thermoline, when selecting a setpoint, the proportional band is tuned automatically. This facilitates precision control at the setpoint temperature and makes the unit easy to set up.

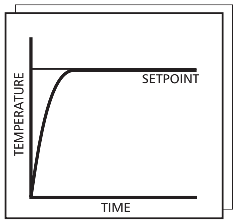
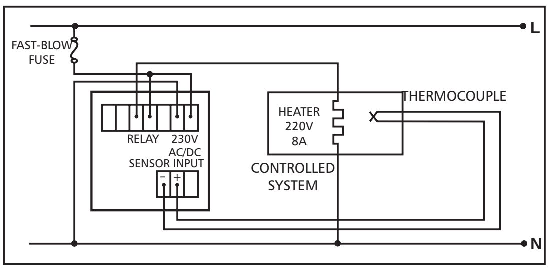


Figure 5: Proportional, Integral and Derivative Control Characteristics

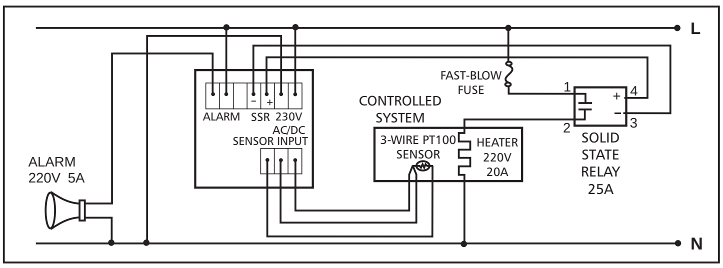
Anti-Reset Wind-up (Manual reset)

Anti-reset wind-up, sometimes referred to as manual reset, is automatically calculated during the auto-tune procedure, but can also be manually set, if required. It is used in conjunction with proportional, integral and derivative terms to speed up the time it takes a process to reach its setpoint temperature while minimising overshoot.
The term represents the percentage power that a proportional only system would require to maintain the setpoint tempeature.
Example: A user woud set the anti-reset term to 30 for a system requiring 30% power to maintain the setpoint temperature.

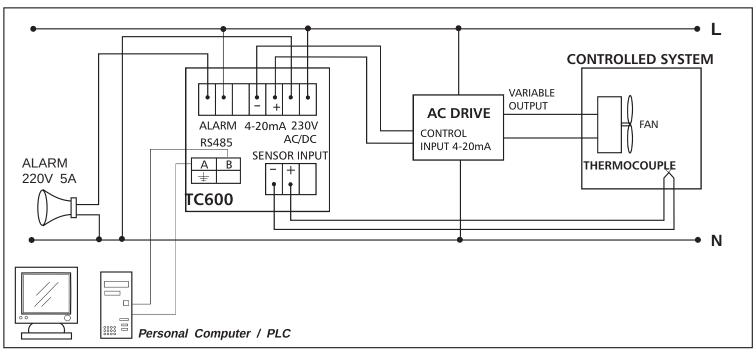
Application Examples & Dimensional Drawing



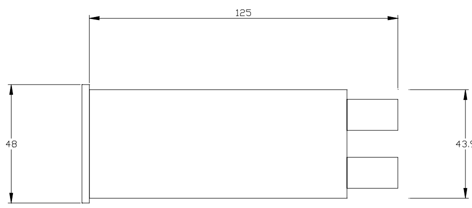
Example 1: **Relay Control Output (TC410, TC515 or TC600 units - 'ER' option)**



Example 2: **Solid State Drive Output (for solid state relay) and Relay Output for Alarm (TC515 or TC600 units - 'ESR' option)**



Example 3: **4-20mA Control Output, Relay Output for Alarm and RS485 Modbus serial communications (TC600-U0-240EBR)**



Dimensions: **Side View**