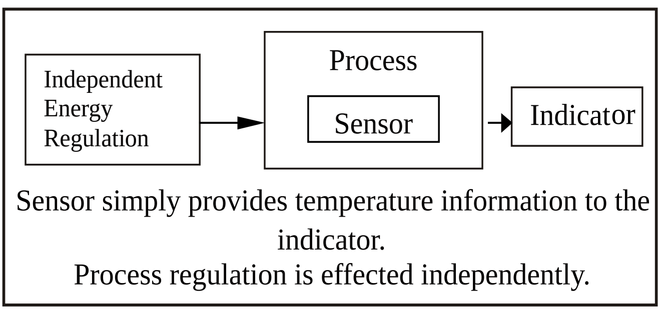
12. ELECTRONICS & INSTRUMENTATION FOR TEMPERATURE

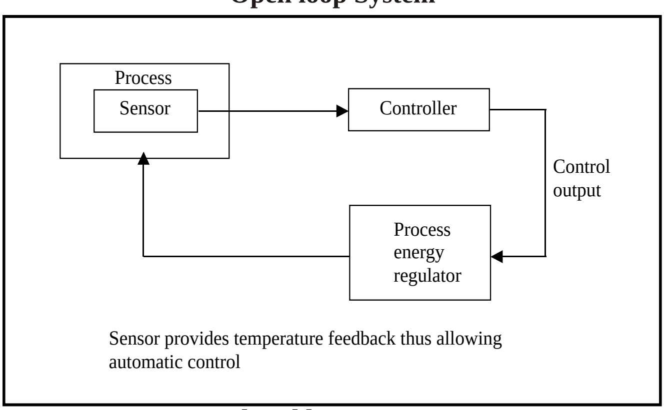
12.1 INTRODUCTION

The range requirement in instrumentation ranges from a simple display of a single temperature value to multi sensor data acquisition and logging or from a simple controller to multi zone communicating control systems. Other requirements may include transmission and signal conditioning, analogue recording, alarm monitoring and communications.

Fundamentally, instrumentation will be in one of the two forms, open loop or closed loop. Open loop is where there is no system feedback and therefore no control action; the measuring instrument(s) exerts no influence over the process behavior other than possible alarm action, which may result in "power-down". Closed loop is where there is direct or indirect feedback from the instrument to the process energy temperature regulator resulting in control of the process temperature.



Open loop System



Closed loop System

12.2 TEMPERATURE INDICATORS

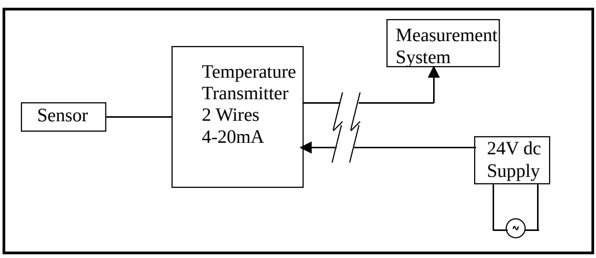
Temperature indicators are the basic instruments which are required either locally or required in the control room for the process parameters monitoring.

Display Size	0.8”, 1”, 3”, 4” and 8”
Digits	$3^{1/2}$, 4 digit
Size	48x96 mm, 96x96 mm or large
Supply	230VAC or 24VDC
Input	Thermocouple K, J, T, R, S, B, RTD, mA, V

12.3 TRANSMITTERS AND SIGNAL CONDITIONING

Temperature transmitters are widely used in measurement systems because their use allows long cable run back to the associated instrumentation. They also perform signal conditioning.

A 2-wire temperature transmitter accepts a thermocouple or 3 wires PT100 input and convert the “temperature” output into a 4-20 mA current signal. The transmitter usually requires a 24v dc supply, which is connected in series with the 2-wire interface (or is provided by the host instruments). The amplified temperature signal can be transmitted via a long cable run if required, a considerable advantage with large site installation.



Temperature Transmitter circuit

The output can either be linear with temperature (usually the case with Pt100 inputs) or linear with thermocouple voltage (not linear with temperature usually the case with thermocouple inputs). It is important to as certain linearity or otherwise since this will have ramification as far as the indicator is concerned. If the interface is non-linear with temperature, the indicator must display the appropriate transfer characteristic in order to give an accurate temperature readout (e.g. scaled for the Type K curve).

Transmitter scaling must be specified as required e.g. 0 to 400°C = 4 to 20mA. Remember, this must correspond to the instrument scaling to avoid measurement errors. Input to output isolation is not necessarily incorporated as standard and it is essential to use electrically insulated sensors if isolation is not incorporated.

Signal conditioning is the process of modifying the raw input signal in one or more ways to facilities communication and measurement. The transmitter is a simple form of signal conditioner but signal conditioners usually provide linearisation, scaling facilities and other functions. The most common form of signal conditioner housing is a DIN rail-mounting module.

Signal conditioners are particularly useful when different parameters are in a process (e.g. Pt100 and thermocouple outputs, flow rates, pressure and force). The output from all of the appropriate sensors or transducers can be rationalized into a common interface such as 4-20mA or 1-5V. Transfer characteristics can also usually be applied to suit a range of sensors and transducers resulting in a linear function. On this basis, standard process indicators can be utilized thus simplifying the instrumentation.

Programmable and so-called “smart” transmitters effectively combine transmission and signal conditioning function. In addition to manipulating the input-output function, a variety of transmission modes can be selected. Isolation of input to output further enhances their scope of application; for example a multi- sensor installation with individual transmitters can be used without danger of earth loops establishing spurious potentials. Programming is performed via a PC using software normally supplied or via plug- in mode.

◈ 12.4 PID EXPLAINED

Only very crude control of temperature can be achieved by causing heater power to be simply switch on and off accordingly to an under or over temperature condition respectively. Ultimately, the heater power will be regulated to achieve a desired system temperature but refinement can be employed to enhance the control accuracy.

Such refinement is available in the form of proportional (P), integral (I), and derivative (D) function applied to the control loop. These function, referred to as control “terms” can be used in combination according to system requirement. The desired temperature is usually referred to as the set-point (SP).

To achieve optimum temperature control whether using on off, P, PD, or PID techniques, ensure that:

Adequate heater power is available (ideally control will be achieved with 50% power applied).

The temperature sensor, be it thermocouple or PRT, is located within reasonable "thermal" distance of the heater such that it will respond to change in heater temperature but will be representative of the load temperature (the "thing" being heated).

Adequate " thermal mass" in the system to minimize its sensitivity to varying load or ambient condition.

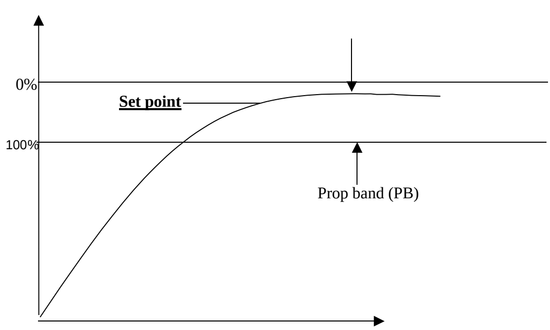
Good thermal transfer between heater and load.

The controller temperature range and sensor type are suitable try to choose a range that result in a mid-scale set point.

12.4.1 CONTROL FUNCTION SIMPLY DESCRIBED

12.4.1 (a) ON OFF : usually simplest and cheapest but control may be oscillatory. Best confined to alarm function only or when "thermostatic" type control is all that is required, but this may be the most suitable means of control in some application.

12.4.1. (b) PROPORTIONAL (P) : a form of anticipatory action, which slows the temperature rise when approaching set point. Variation is more smoothly corrected but an offset will occur (between set and achieved temperature) as condition varies. Average heater power over a period of time is regulated and applied power is proportional to the error between sensor temperature and set point. The region over which power is thus varied is called the proportional band it is usually defined as a percentage of full scale. Offset is the deviation of the sensor temperature from the desired value. This can be adjusted out manually by means of a potentiometer adjustment or automatically.



Proportional Control

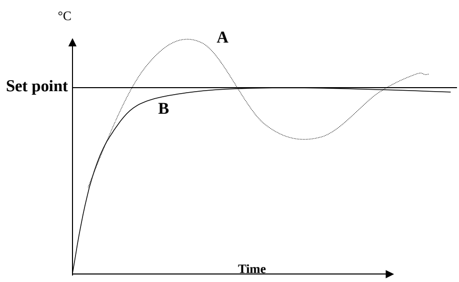
12.4.1 (c) PROPORTIONAL + DERIVATIVE (PD): the derivative term when combined with proportional action improve control by sensing change and correcting for them quickly. The proportional action is effective intensified to achieve a quicker response.

12.4.1 (d) PROPORTIONAL + INTEGRAL + DERIVATIVE (PID): adding an integral term to Pd control can provide automatic and continuous elimination of any offset. Integral action operates in the steady state condition by shifting the proportional band upscale or downscale until the system temperature and set point coincide.

◈ 12.5 CHOOSING P, PD, or PID: although superior control can be achieved in many case with PID control action value of the PID terms inappropriate to the application can cause problem.

If an adequately powered system with good thermal response exists and the best possible control accuracy is required, full PID control is recommend.

If somewhat less critical precision is demanded, the simpler PD action will suffice and will suit a broad range of application.



A --- Start up with out the benefit of D and non-optimized P.
B Start up with optimized PD and overshoot inhibition