Control engineering

Charbel Bouery, PhD

27 janvier 2026

ISEN NANTES

Contents

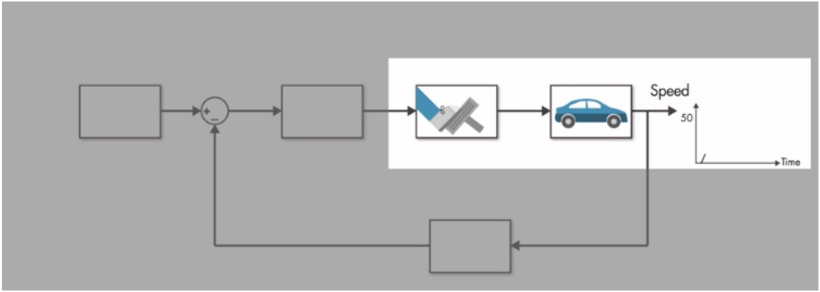
Chapter 1 : Introduction to control engineering

Example 1 : Cruise control

A car needs to get from point A to point B as fast as possible without exceeding the speed limit (50 mph)

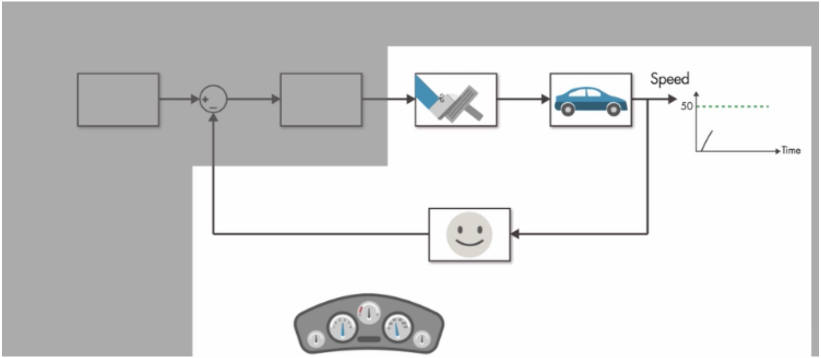
Example 1 : Cruise control

When the driver steps on the gaz pedal the car speed starts to change



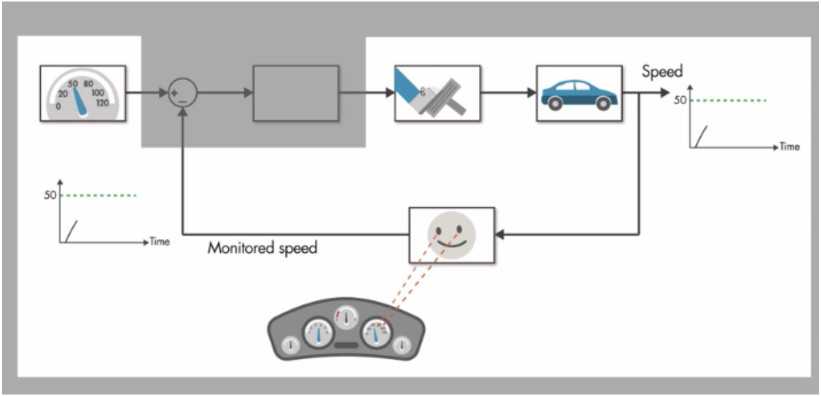
Example 1 : Cruise control

Since the driver cannot exceed the speed limit, he needs to look at the speedometer to see at what speed he is driving



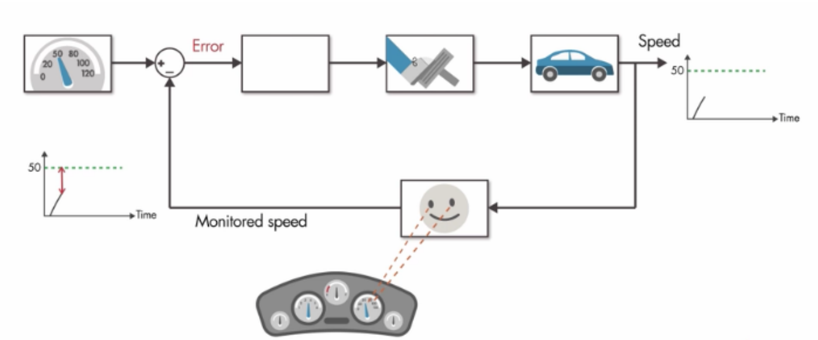
Example 1 : Cruise control

Then he compares the actual speed of the car to the speed that he wants (reference).



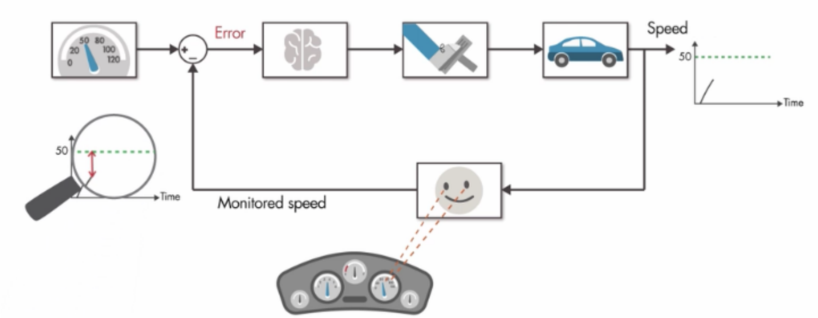
Example 1 : Cruise control

This is done by finding the difference between the desired and the monitored speed (Actual speed), this difference is called the error.



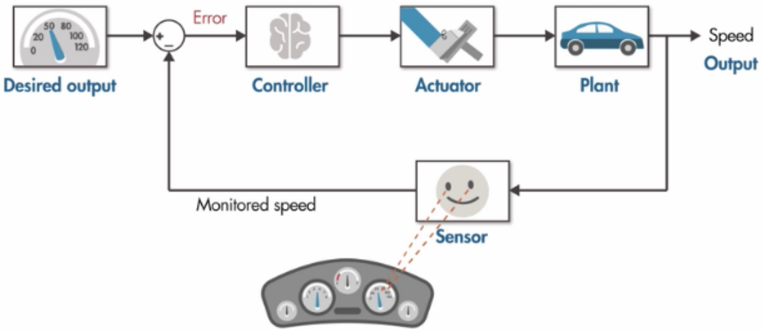
Example 1 : Cruise control

Based on the error, the driver makes a decision, if the error is positive, he decides to apply more gaz, (if it is negative, he will apply a brake), until the error goes to zero (until the speed of the car gets to its desired value i.e. 50 mph)



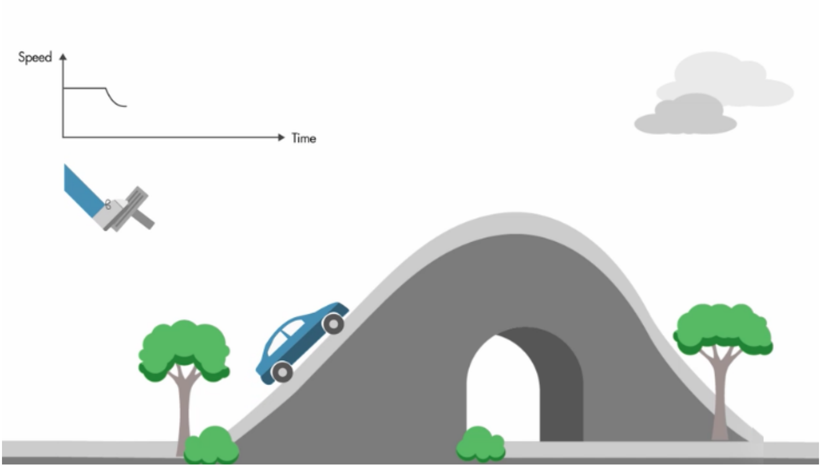
Example 1 : Cruise control

Components in a control system



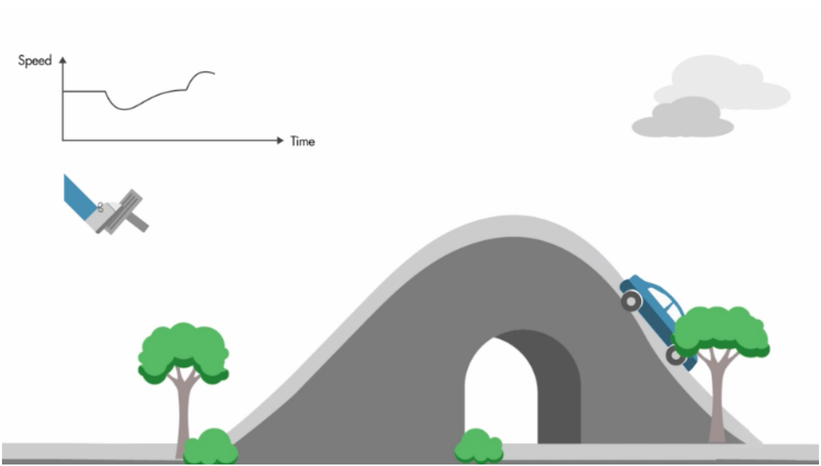
Example 1 : Cruise control

Now if the driver is going uphill, the speed of the car will start slowing down, and he will need to press further on the gaz pedal to maintain the speed to the desired value (50mph)

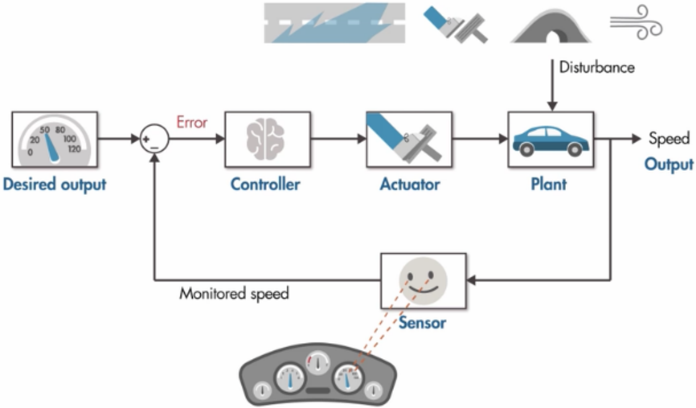


Example 1 : Cruise control

And when he goes downhill, he needs to press on the brake pedal. The hill in this example is called a disturbance in control theory.

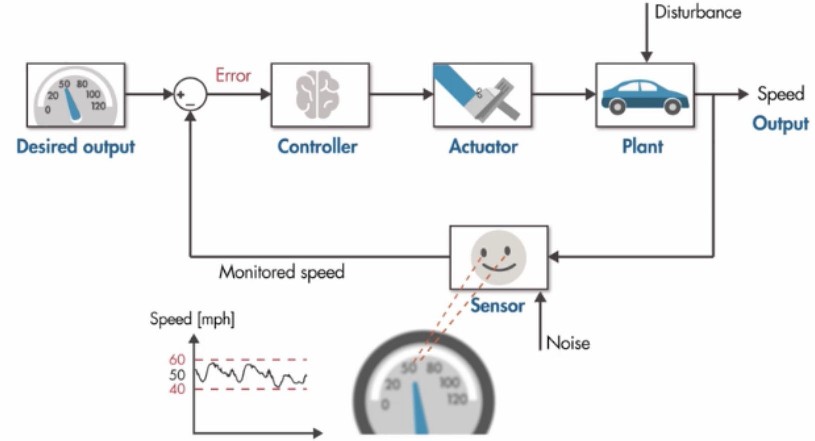


Example 1 : Cruise control

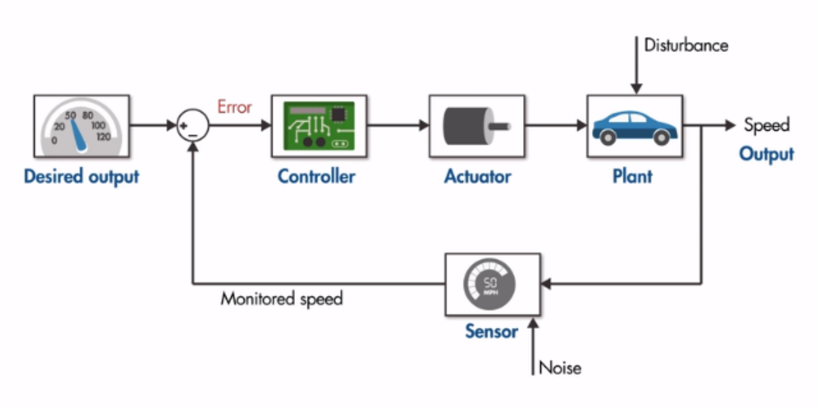


Example 1 : Cruise control

Sensors can be affected by noise and monitored speed values start to fluctuate.



Example 1 : Cruise control



Example 2 : Liquid level control

We wish to maintain the liquid level in a tank to a constant value by controlling the incoming flow rate as shown. Liquid enters the tank at the top and flows out via the exit pipe at the bottom.

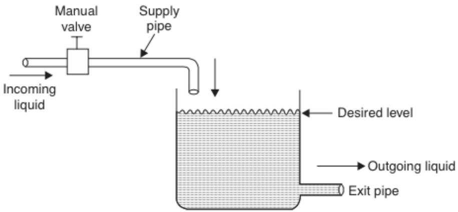


Figure – *System for maintaining the proper liquid level in a tank.*

Example 2 : Liquid level control

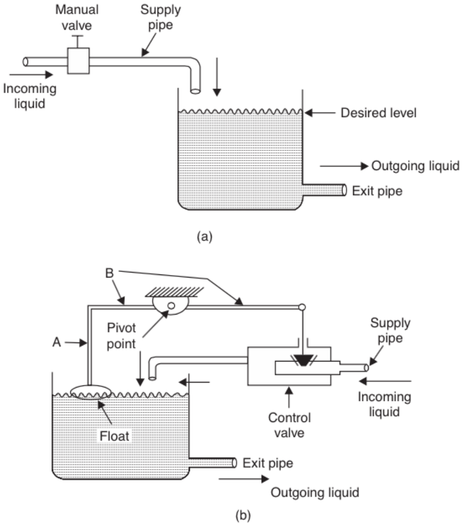
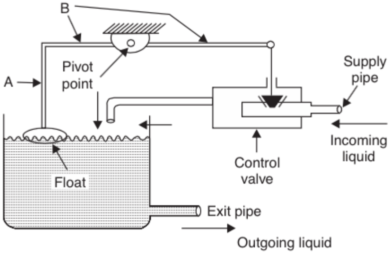


Figure – *System for maintaining the proper liquid level in a tank*
(a) an open-loop system : it has no feedback and is not self-correcting
(b) a closed-loop system : it has feedback and is self-correcting

Example 2 : Liquid level control

Closed-loop system

In the subfigure (b) shown beneath, it the liquid level falls a little, the float moves down, thereby opening the tapered valve to increase the inflow of liquid. If liquid level rises a little too high, the float moves up, and the tapered valve closes a little to reduce the inflow of liquid.
By proper sizing the valve and mechanical linkage, the liquid level can be controlled to the desired set point.



(b)

Example 2 : Liquid level control

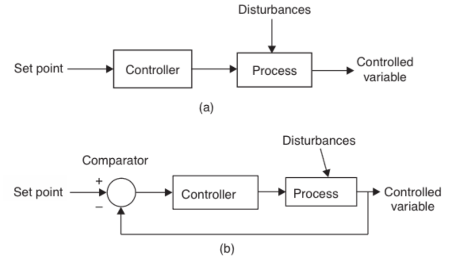
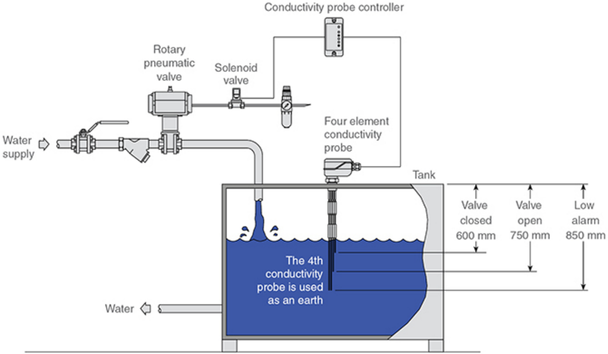


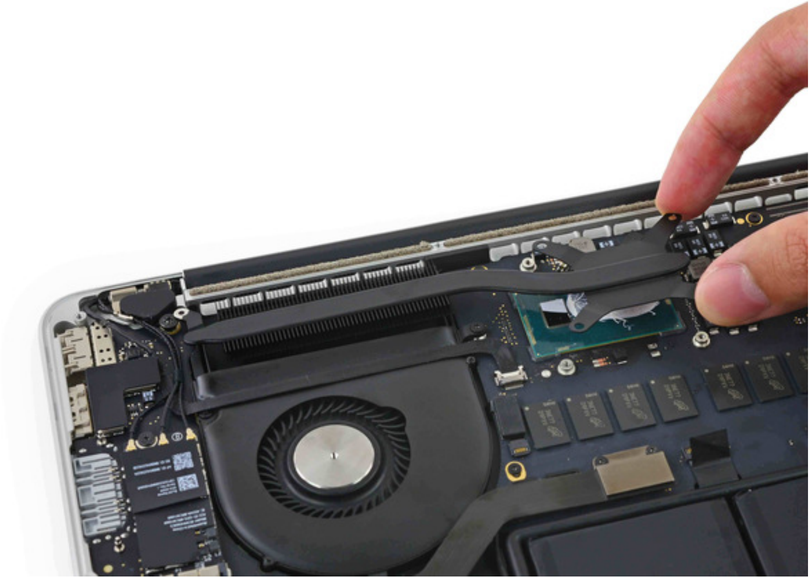
Figure – *block diagrams that show the cause-effect relationships between the different parts of the system : (a) for an open-loop system (b) for a closed loop system*

- The setting represent the location of the float that satisfies the desired height.
- The comparator (represented by the float) compares the value of actual liquid level and the setting and send a signal that depend on the magnitude of the difference between them.
- The controller in the block diagram is the tapered valve in the actual mechanical drawing.

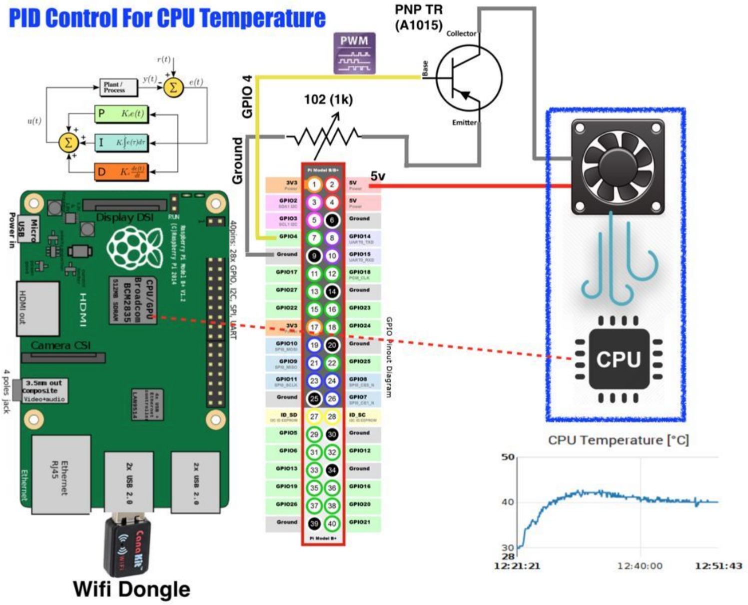
Controlling liquid level using a micro-controller and a sensor



Example 3 : CPU temperature control



Example 3 : CPU temperature control



Example 4 : Industrial temperature control

The figure shows another industrial process control system for controlling the temperature of a pre-heated process fluid in a jacketed kettle

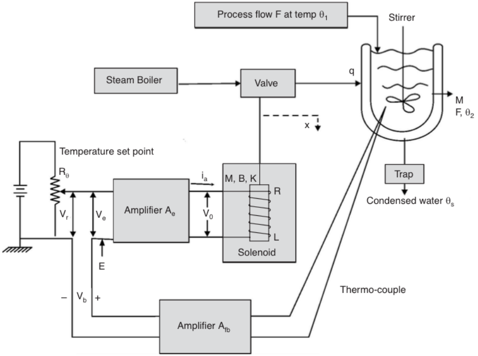


Figure – *Feedback control system for temperature control of a process fluid.*

Feedback control

Feedback control

The feedback control is an operation, which, in the presence of disturbing forces, tends to reduce the difference between the actual state of a system and a desired state of the system and which does so on the basis of this difference.

Performance

Performance

Two major measures of performance are apparent :

- transient response
- steady state error

The choice of these measures depend on the nature of the problem