Advanced Control

Introduction

What is advanced control? It is really nothing. Just by practice you will get better and better.

Let's start.

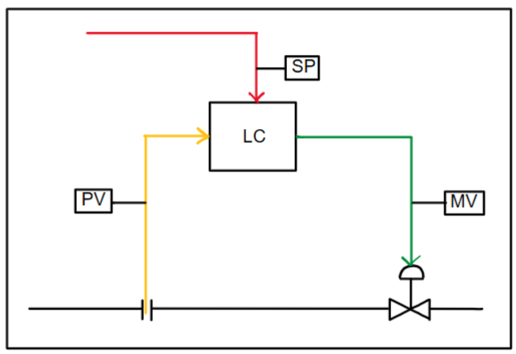
We start the advanced control by asking some simple question:

1.What is a controller?

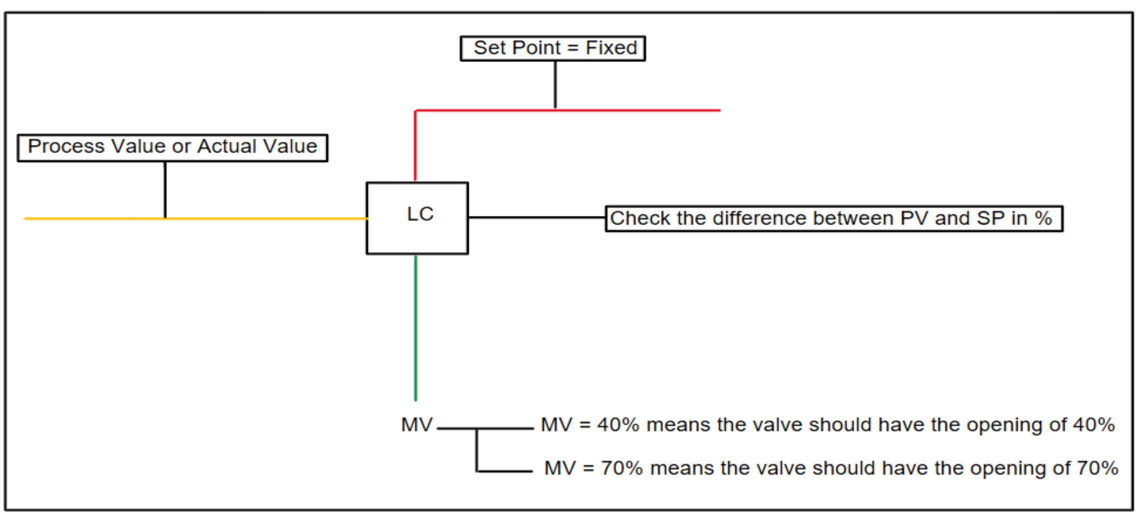
In monitoring system or FCS, a controller is used to maintain a specific parameter within the range.

2.How does it function?

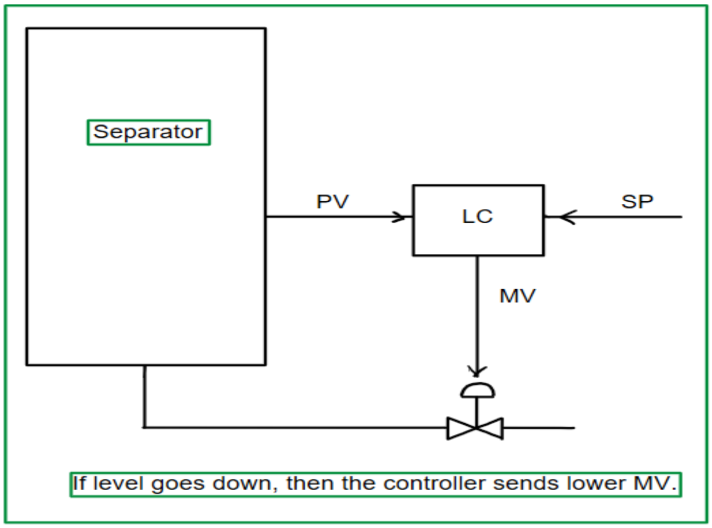
At all times the controller receives the actual value from transmitter and checks it against set point which is set by a control room operator and finally issues or sends a measured value or MV. In a simple way, the MV is the difference of PV and SP.



Could you please give an example? Yes, of course, here is the example.



That was very good but I mean something real. Ok don't worry! How about this:

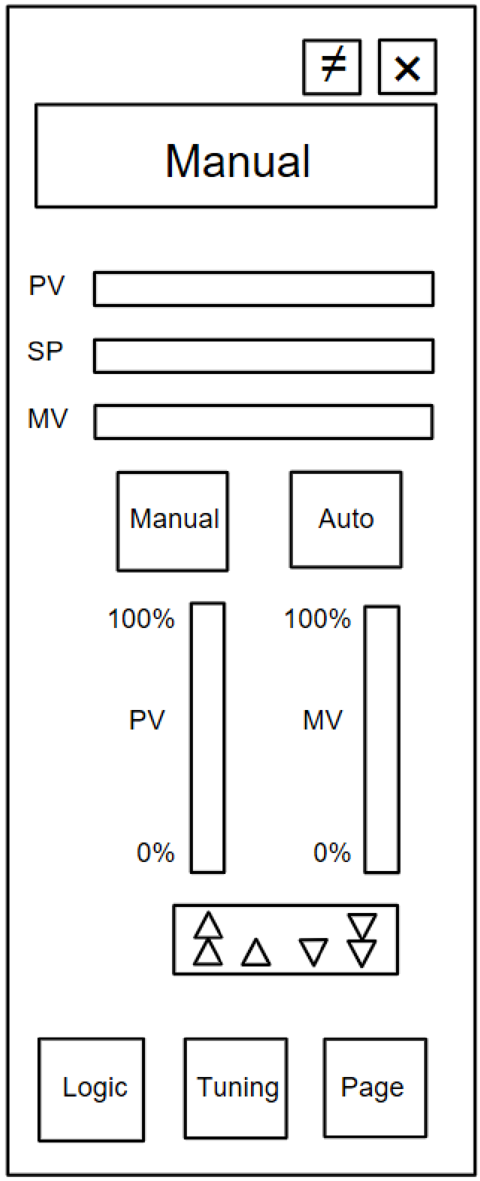


Now you got the whole story. Right? So far, you should have understood what a controller is, how it functions, the terminologies like PV, SP, MV and how they work together in an industrial example.

Next question, How the controller is shown on FCS to the control room operator and how the operator manipulates it. It seems a little vague to me. # It is perfectly normal, don't worry.

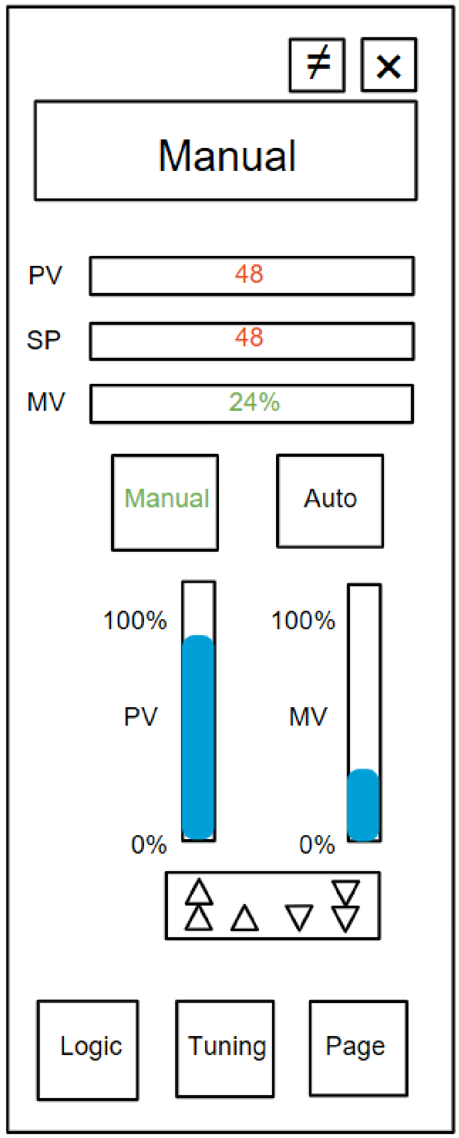
It is shown on the next page. Professionals call it Face-plate. The faceplate has some parts. The first part is just an indication specifying if the controller is in Manual or Auto Mode. The second part is where PV, SP, and MV are shown and you can change SP and MV. Then we have Auto or Manual modes selection. When the operator selects the manual mode for the controller, it means he or she can specify the output of the controller or MV but they cannot modify the set point. In this mode the PV tracking for set point shall be active to prevent bump (bump less transfer) when controller returns from manual mode to auto.

Then we have, auto mode. The operator in auto mode can modify the set point. Below the auto-manual icons there are two scales one for PV and another one for MV. Lastly, we have some box like icons, which gives the operator the access to tuning section, logic, the page the controller is in.

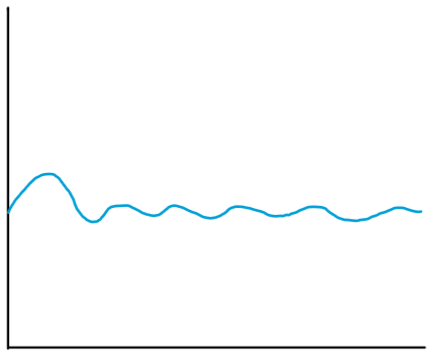


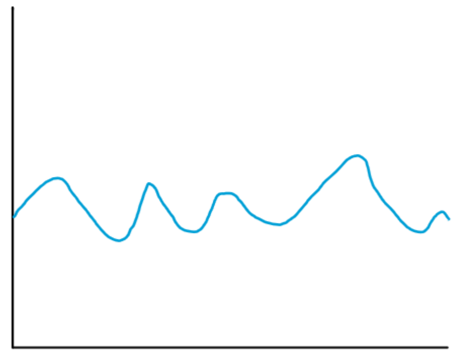
Now let's check it in real example:

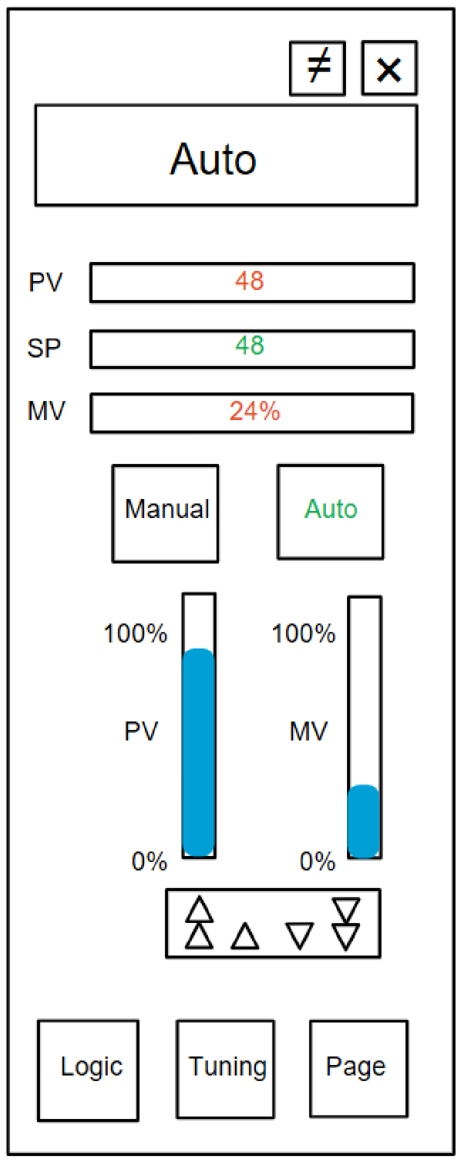
At the inlet of most petrochemicals there is a K.O drum to separate the water droplets from the gas stream. The pressure of the exiting gas which is now free of water should be regulated to be suitable for downstream process. The pressure control is carried out by a PIC. The inlet pressure is 52barg and the outlet pressure should be 48barg. At first the operator puts the valve in manual mode and everything is in good shape. The PV is 48barg, which is the same as SP but the operator cannot modify them. At this mode the operator can modify the MV and has set it to 24%, which means the pressure control valve opening should be 24%. How the operator can be assured that he has given the right MV? By checking the actual pressure value or PV at the valve outlet which is 48barg.



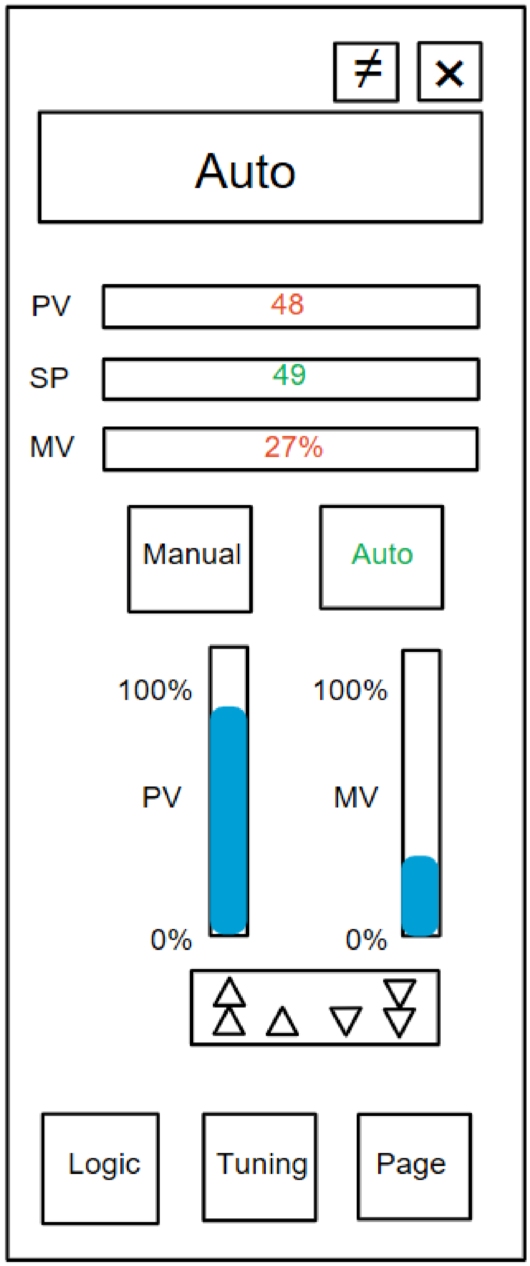
Now the operator decides to change the mode to Auto mode. To do so, at first the trend of outlet pressure should be in steady state like the left side. Then, the operator clicks the Auto, then the mode changes to Auto but this time MV is de-activated and the SP is activated so that the operator can change the SP.





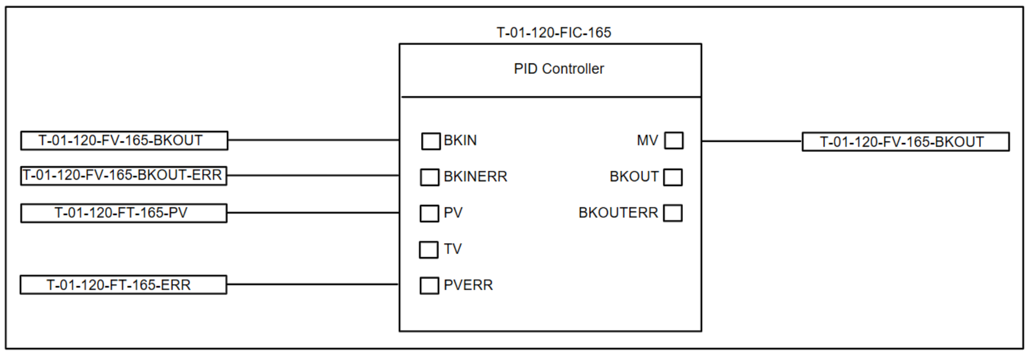

≠
×
Auto
PV
48
SP
48
MV
24%
Manual
Auto
100%
PV
0%
100%
MV
0%
Logic
Tuning
Page

Now if the operator decides to increase the SP to 49barg, then the changes would be like below:



Pay attention that this time the MV this time changed to 27%, which means the opening of control valve increases from 24% to 27% and as a result, more gases would pass and increase the pressure.

Now let's open the logic to see what we have behind it and how the controller works:

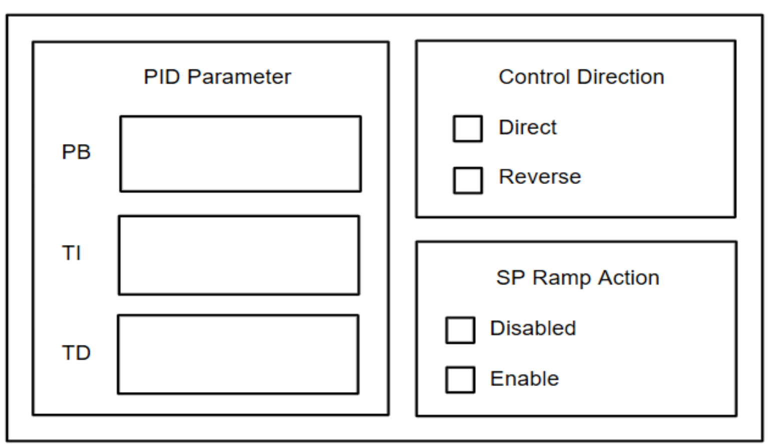


At first glance it seems a bit ambiguous. Right?

Here we have a PID controller which is the brain behind all of this calculation. It has some inputs and outputs, namely:

1. BKIN: Feedback input
2. BKINERR: Feedback status input
3. PV: We already know about it
4. TV: Track input value
5. PVERR: PV in fault or not. ON: Abnormal, OFF: Normal
6. MV: We already know about it
7. BKOUT: Feedback output value
8. BKOUTERR: Feedback status value

Now let's open Tunning to see what we have.



1. PB: Proportional Band Size
2. TI: Integral Time
3. TD: Derivative Time
4. Direct: The MV increases with increase of PV. SP is not changed
5. Reverse: The MV decreases with increase of PV. SP is not changed.

Note:
During start-ups, it is not like this that we use Aspen Dynamic mode and see which tuning parameter value suits best. In fact, it is done like this that we use typical values from the following table and see how the real system and the controller interact with each other.

Type of loop	PB Gain = 100/PB, Proportion Band Size (%)	Integral Time(s) TI	Derivative Time(S) TD
Flow	400	20	0
Level	125	180	0
Pressure	100	40	0
Temperature	100	300	0
Other	100	60	0

So far you have acquired tremendous amount of practical knowledge about logic, tuning, behavior of the controller in a short period of time. Now let's focus on the type of controllers to prepare our mind for next sessions.

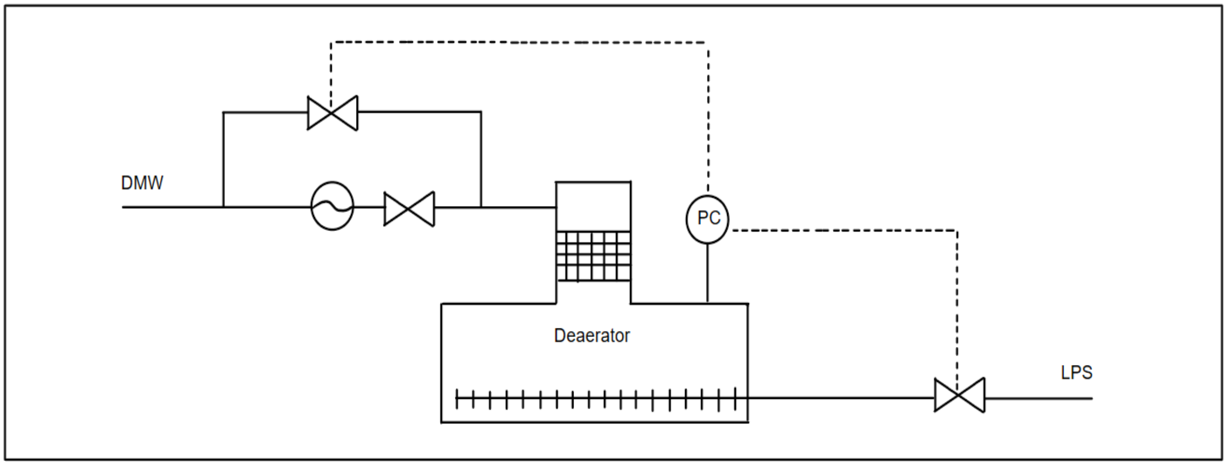
We have different types of controllers such as:

1. Simple control loop
2. Split-range control
3. Cascade control
4. Override
5. Complex loops

What are the definitions and how can I use them?

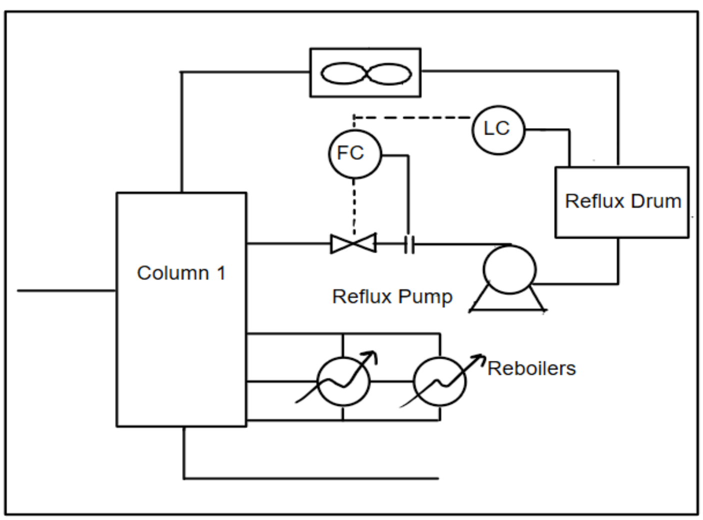
1. Simple control loop: In this loop we only have a flow controller, pressure controller, temperature controller or level controller. The controller receives the process value from the transmitter and compares it with the set point and signals a MV to final element.
2. Split-range control: We use this type of control when two or more final elements can impact the parameter which should be monitored. To better understand the situation, imagine the deaerator. The thermal performance of the deaerator is controlled by LPS flowrate which

helps to vaporize and remove the trapped oxygen. It is also impacted by the DMW temperature.
At the same both the LPS pressure and DMW temperature can impact the pressure inside the deaerator which should be kept in the range. In this system, we have to use split-range control to split the role between two control valves.



3. Cascade control: We use cascade control when we want to increase loop speed and surpass disturbances. Cascade control loop consists of two PID single loop, the output of main loop is used as the external presetting of the sub-loop and the sub-loop controls the final output of the regulating valve. The common cascade controls include temperature + flow, temperature + pressure, temperature + temperature, liquid level + flow, pressure + flow.

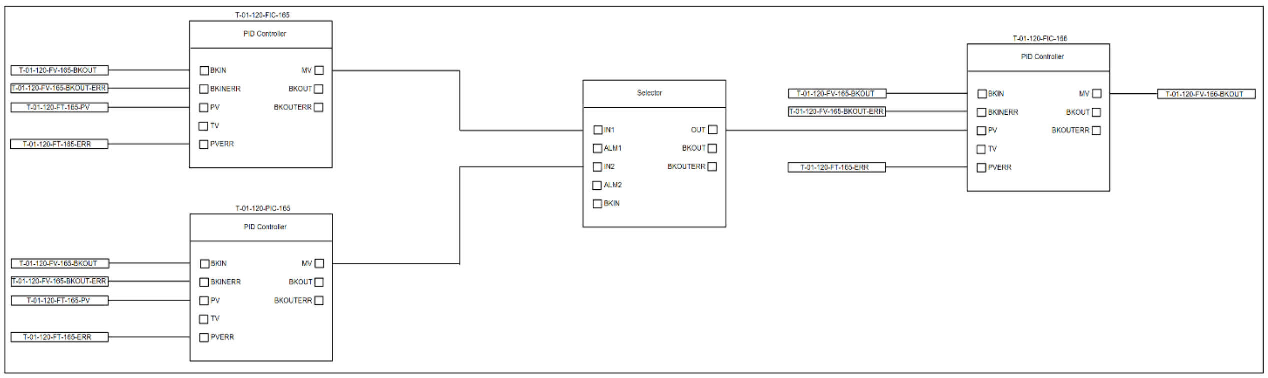
   The example could be the reflux flow and reflux drum level which should be maintained at the same time.



In this case the LIC is the master controller and the FIC is the slave control.

4.Override control:

Override control is in essence a type of alternative control. In the normal operation condition, the control output won't be out of gauge and therefore direct output can be adopted. In the abnormal operation condition, the output will reach the limit value, in which condition limiting approach will be required to select the safe control output. The common override control types are low selection override control and high selection override control. The double loop low selection override control is taken as the sample below:



5.Complex loops: This loop is a combination of simple, split-range, cascade, override loops. The typical example is firing control of fired heaters.

Appendix

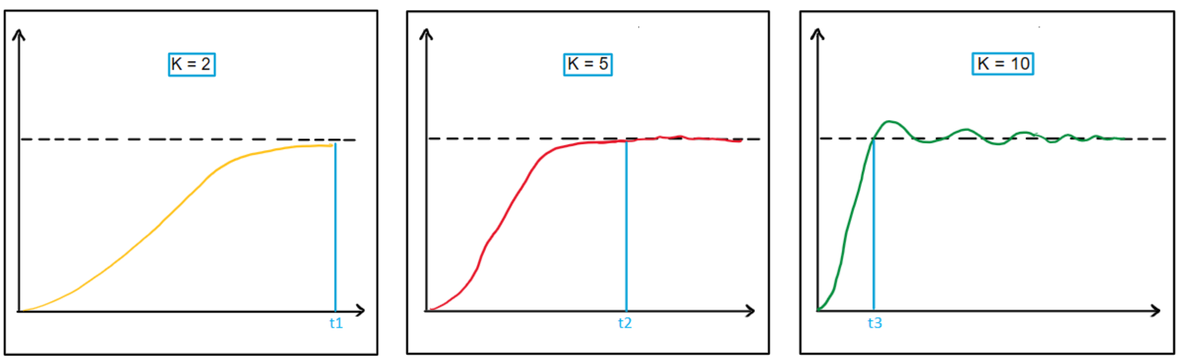
Feedback control loop

1.Proportional Action

$$MV = B + K_c\,e$$

Where:

1. MV is controller output
2. B is the initial value
3. K_c is proportional gain – Notice $P_B = \frac{1}{Kc}$
4. E is the error or e = PV-SP



2. Integral Action

$$MV = B + \frac{1}{Ti}\int edt$$

Where:

1.T_i is the integral (reset) time constant

2. t is time

3.Proportional + Integral Action

$$MV = K_c\,e + \frac{1}{Ti}\int edt$$