Process Measurement, Instrumentation & Process Control systems

Course language: Arabic and English

Overview

Introduction:

In an industrial situation where it is required to measure and control some aspect of a process, it is often the application of the knowledge and the ingenuity of the Engineer or Technician which is relied upon to solve the measurement and control problem. Therefore a fundamental understanding of the principle of operation of a range of sensors/transducers and instrumentation techniques applicable in an industrial situation combined with an understanding and knowledge of Process control techniques and tuning methods equips the Engineer or Technician with the necessary skills and makes them invaluable in their workplace.

Delegates will investigate the operating principles and concepts of instrumentation and measurement systems and will acquire the knowledge relating to the characteristics and properties of the variables being measured.

Moreover, the delegate will gain an understanding of the Process control systems and methods used in a modern industrial system.

This is a hands-on, practical course and where applicable, theoretical studies will be supplemented with practical activities where the delegate will have the opportunity to design, develop, build, test and evaluate their own instrumentation systems within the seminar room.

Some of the main topics covered include:

Introduction to the principles and fundamentals of Process Measurement and Instrumentation systems and Process variables. Symbols and units used and sample calculations Principles of operation of Sensors and Transducers used for:

- Temperature Measurement
- Strain measurement
- Pressure measurement
- Flow measurement

- Level measurement
- Ultrasonic techniques for non-invasive process measurement
- Principles of Process Control and study of the main Control strategies used, leading to an explanation of the 3-term PID controller.
- Explanation of a method used to 'tune' a 3-term PID controller
- Practical activities to design, build, calibrate and signal condition a typical sensor application

The main objectives of this seminar are:

- To give an understanding of the principles of operation of a range of sensors and transducers
- By using a hands-on approach, enable the delegate to investigate the operation of an instrumentation system through designing, building and testing typical sensor combined with appropriate signal conditioning circuits
- To allow the delegate to become familiar and confident with a range of measurement techniques
- To understand the concepts of Process Control and acquire the knowledge relating to the characteristics and properties of a process variable being measured
- To become familiar and knowledgeable with PID control and develop the ability to 'tune' a process control system using PID control
- To have the confidence and knowledge to apply the above techniques and principles to solve an unfamiliar and bespoke measurement situation in the workplace

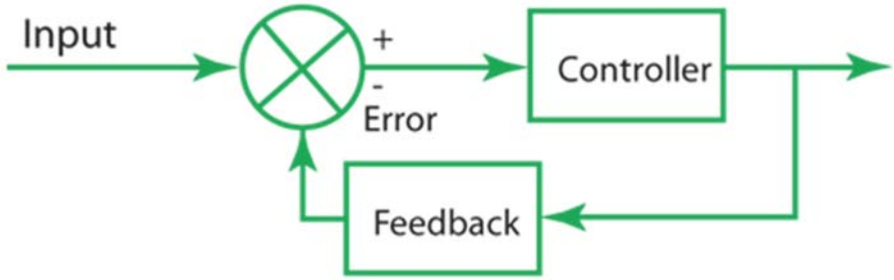
With this website we provide information to engineers, professionals and everybody who is interested in process automation and control. We try to cover all topics related to Process Automation and Control, like Distributed Control Systems DCS, Programmable Logic Controller PLC, Batch Control, Validation, ANSI/ISA S88.01, Field bus, Foundation Field bus, Profibus, AS-Interface, Device Net, PID, Advanced Control, Measurement, Human Machine Interface HMI, OLE for Process Control OPC, Measurement, Process Instrumentation, Industrial Automation Training, similarly, Distributed Control Systems DCS offer process modeling and simulation, something that can improve operator training a great deal. An accurate simulation model allows operators to train under "live" conditions without exposing the plant to the consequences of their mistakes.

Who should attend

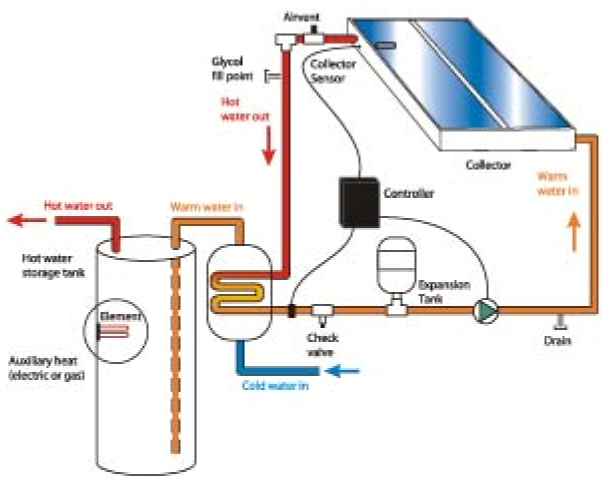
This seminar is suitable for and is designed to attract and be of benefit to a range of people who work in the instrumentation and process plant area. Typically but not exclusively this seminar will be of benefit to:

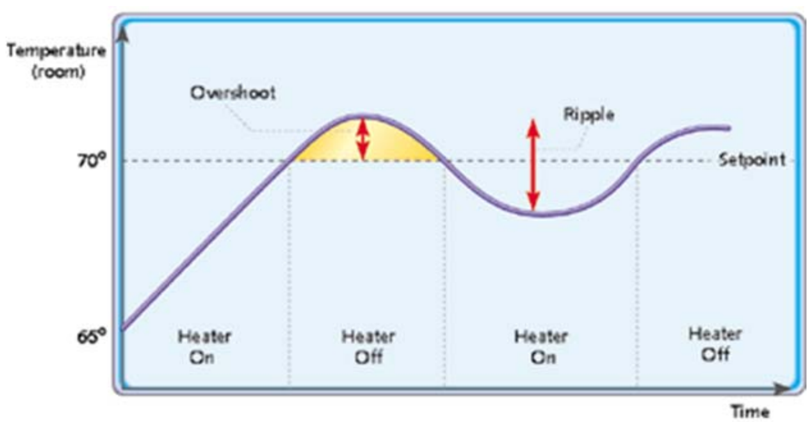
- Electronic Engineers and Technicians
- Chemical Engineers and Technicians
- Electrical Engineers and Technicians
- Electronic Design Engineers
- Instrumentation Technicians
- Electricians
- Installation and Maintenance Technicians
- Instrument and Process Control Technicians
- Instrument Fitters
- Maintenance Engineers
- Mechanical Engineers and Technicians
- Operations Engineers
- Process Technicians
- Production Professionals
- System Integrators
- Other professions (Engineers, Technicians) involved in the Process Industry who require an appreciation and understanding of the techniques used in Process Measurement and Control

About Course Provider



Active Indirect System





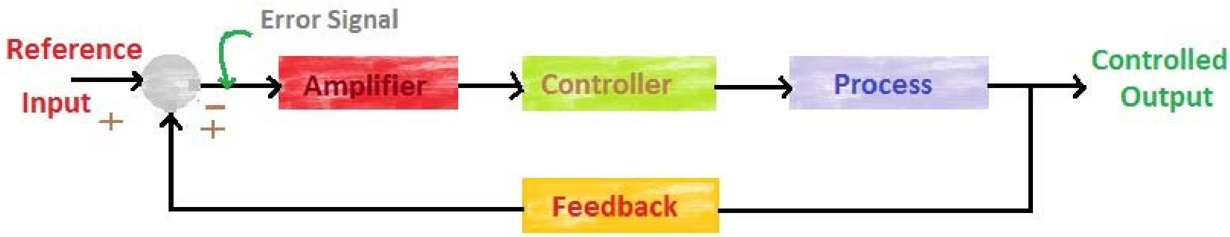
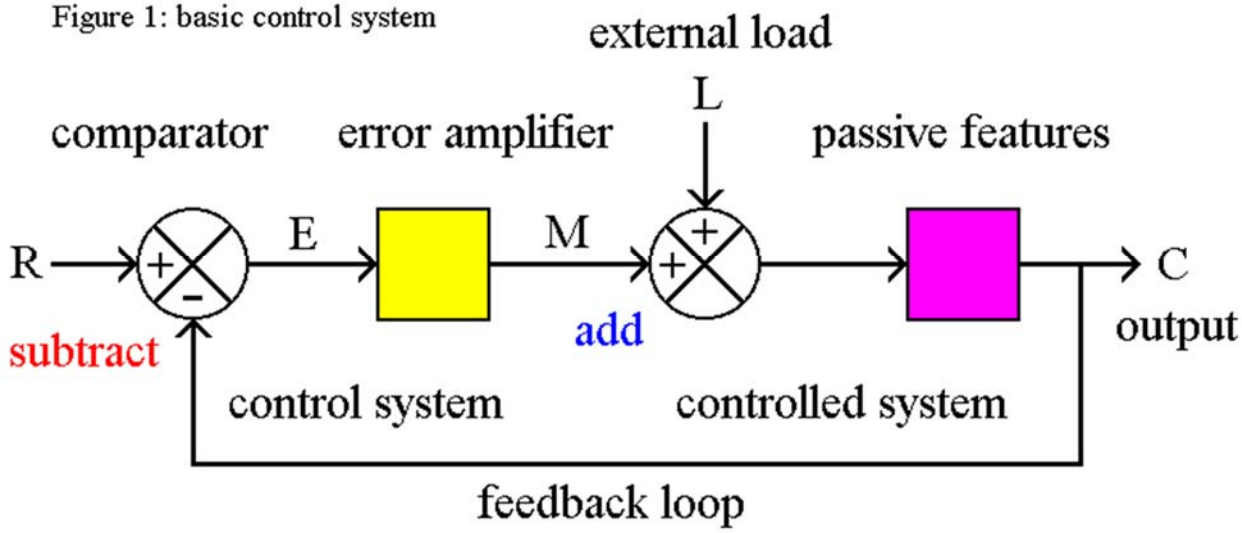
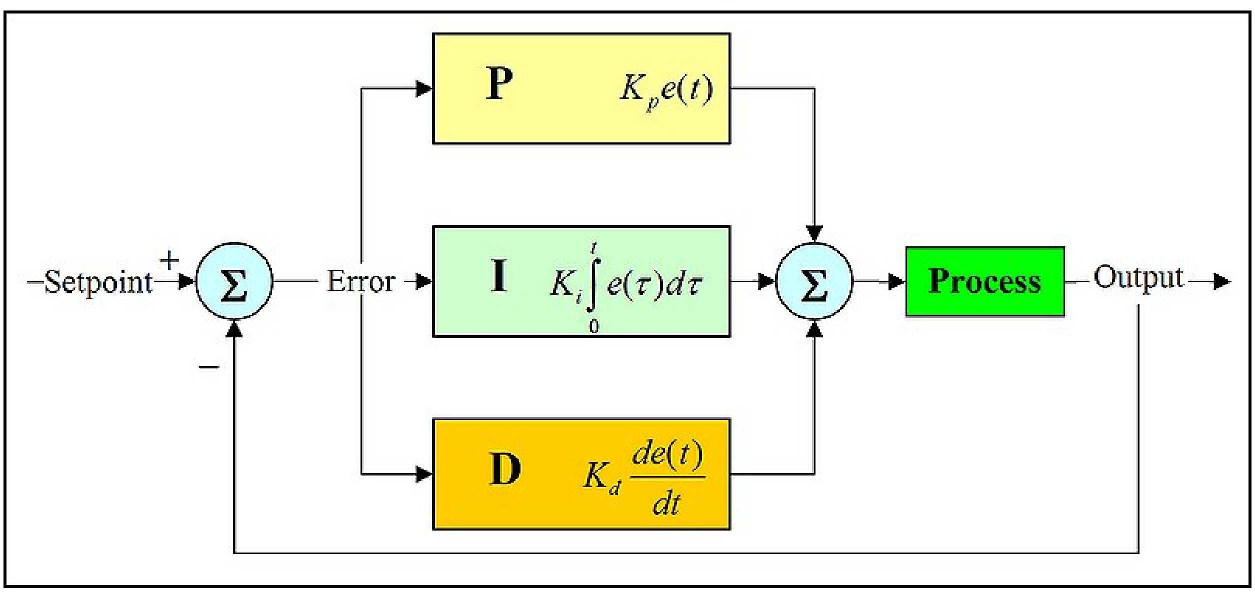
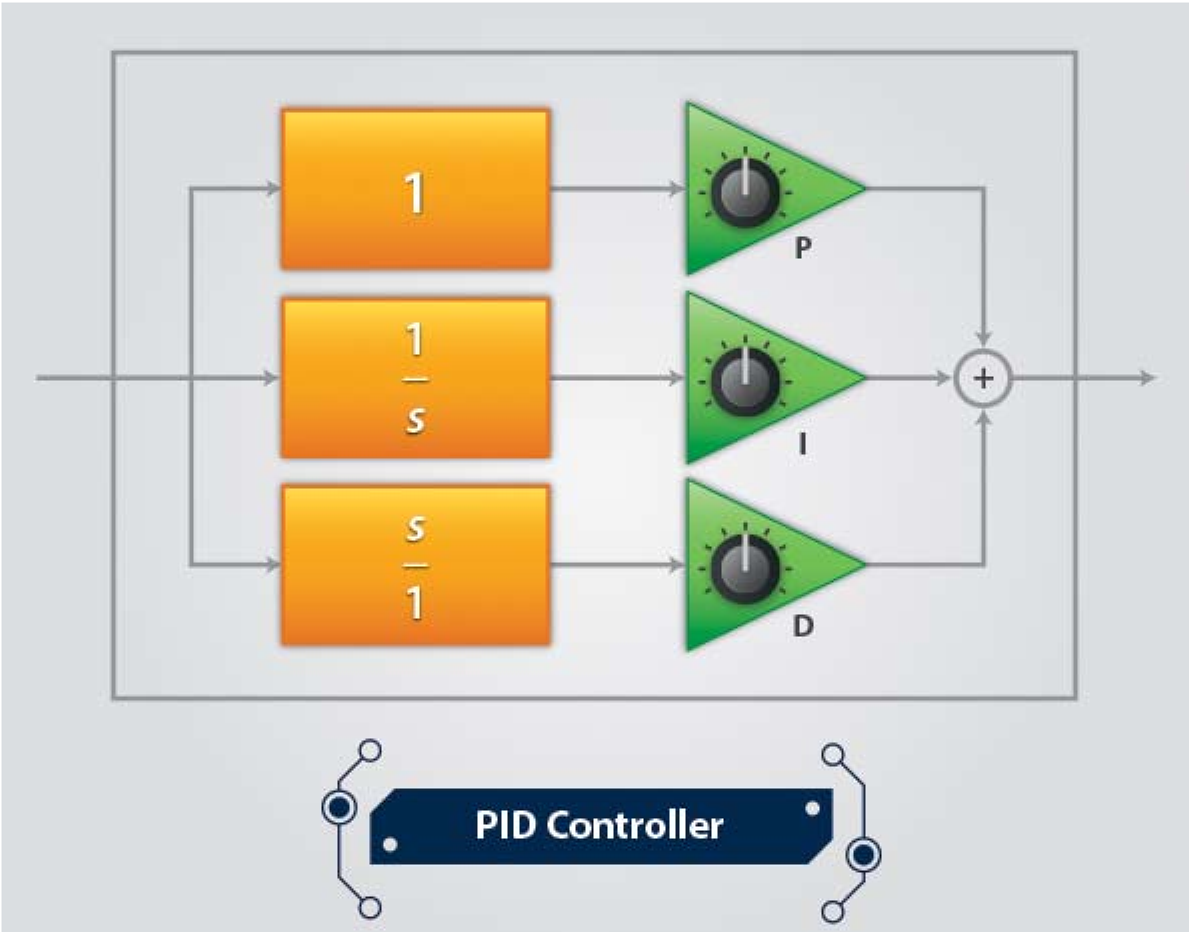
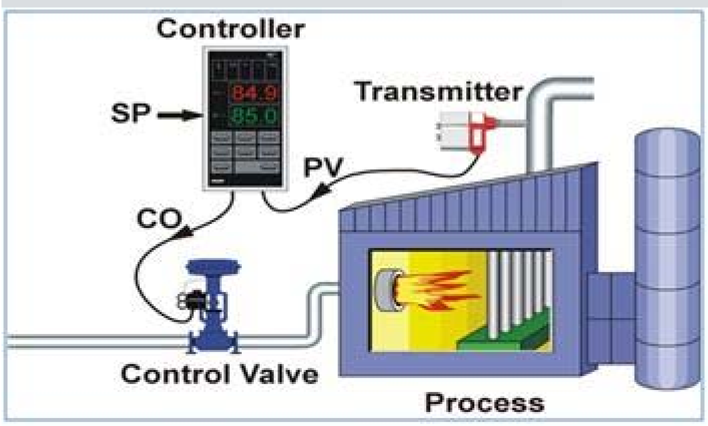


Figure 1: basic control system

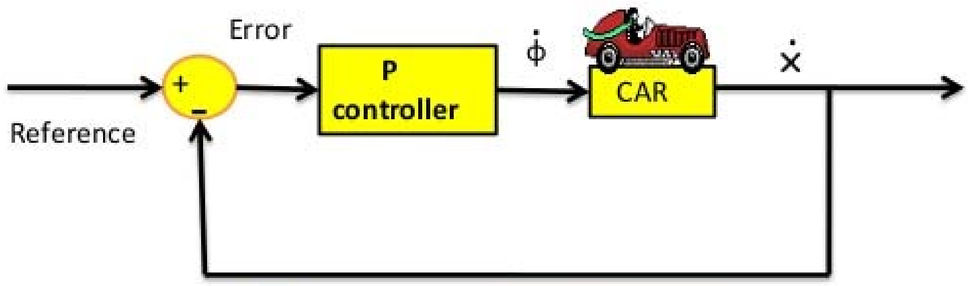


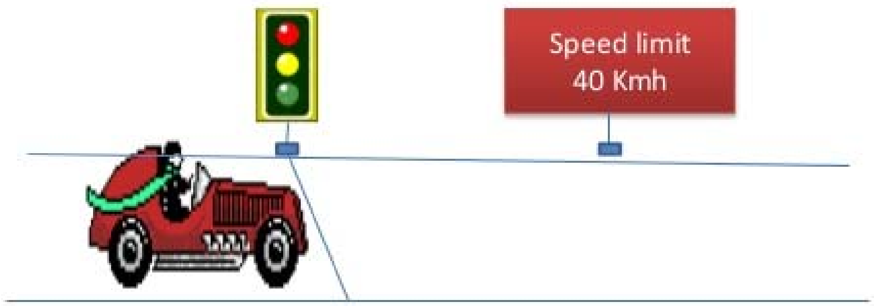



1
1
s
s
1
P
I
D
+
PID Controller

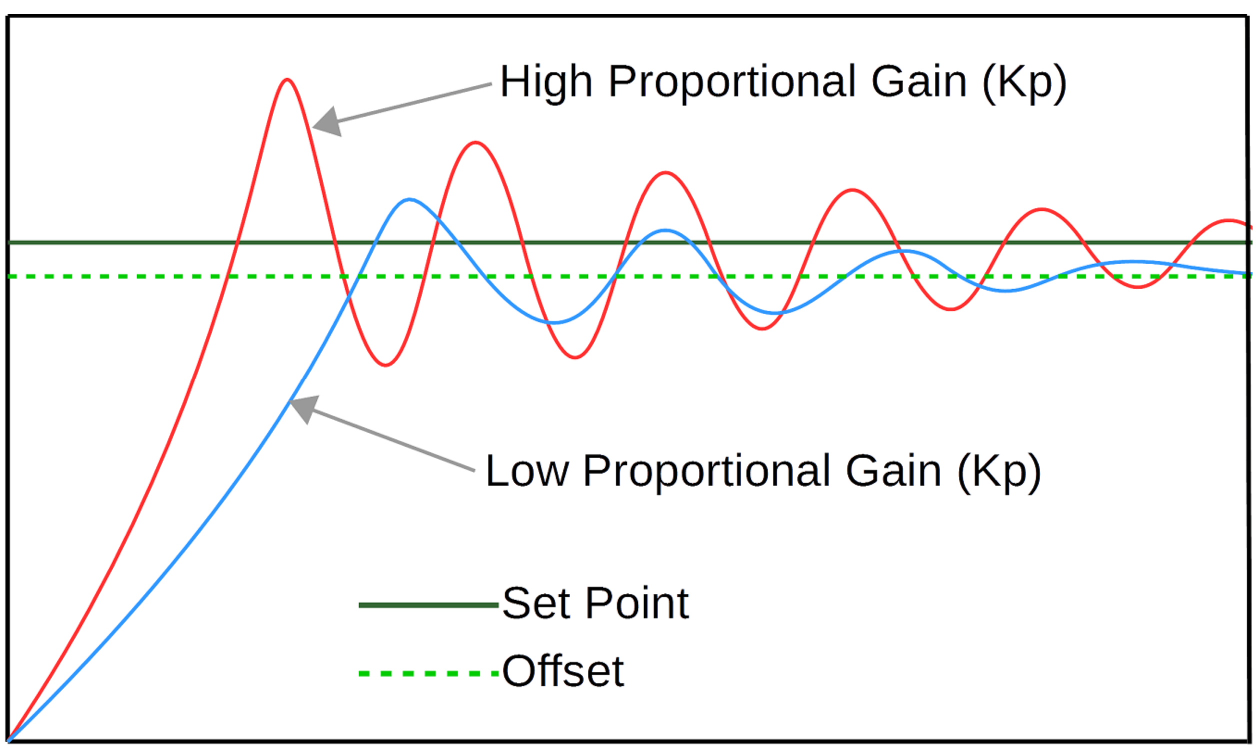

Controller
SP
84.9
85.0
Transmitter
PV
CO
Control Valve
Process

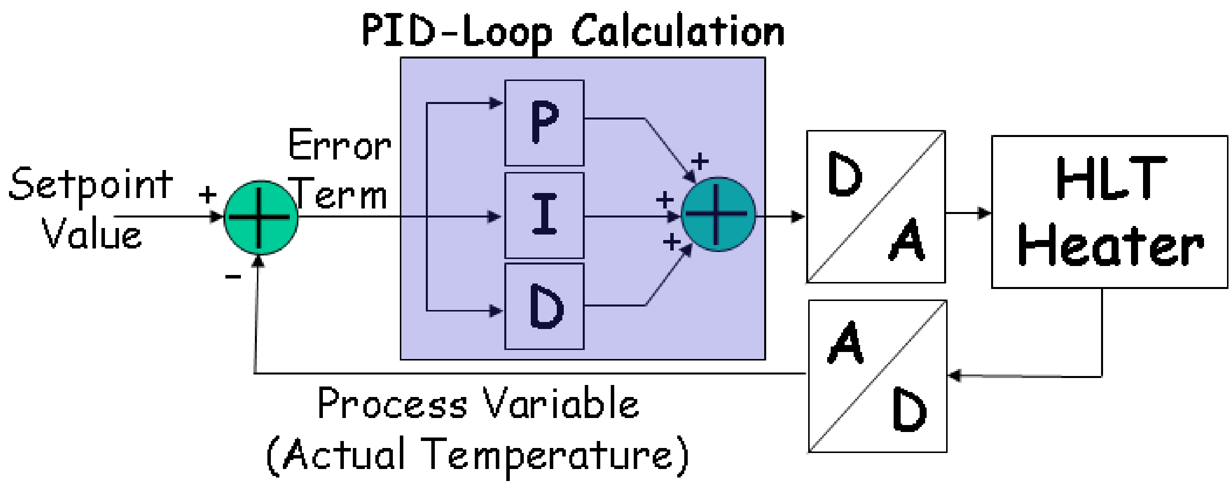
Close Loop control system for car with P controller-

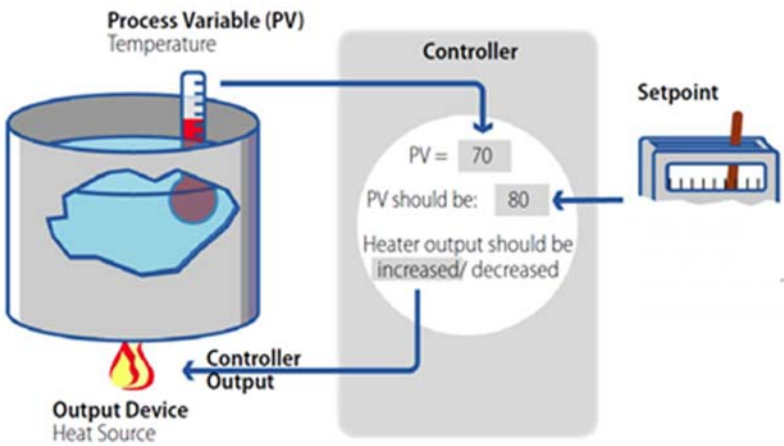


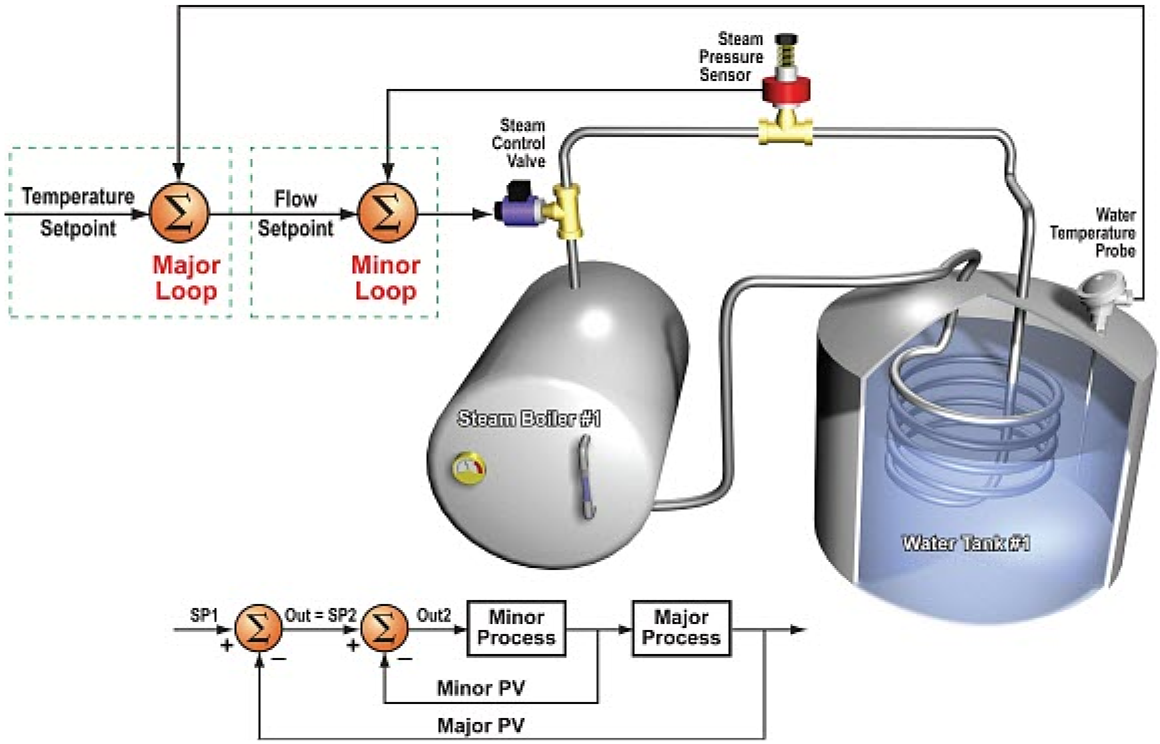


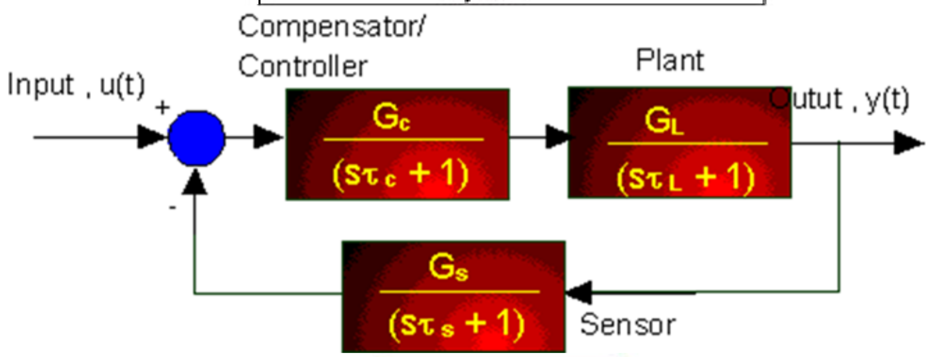
When Light turns **Green** ,you press the pedal to accelerate the car up to speed limit. In real life as you drive car to respond the step command ,you are actually unknowingly performing **Proportional Control Action.**

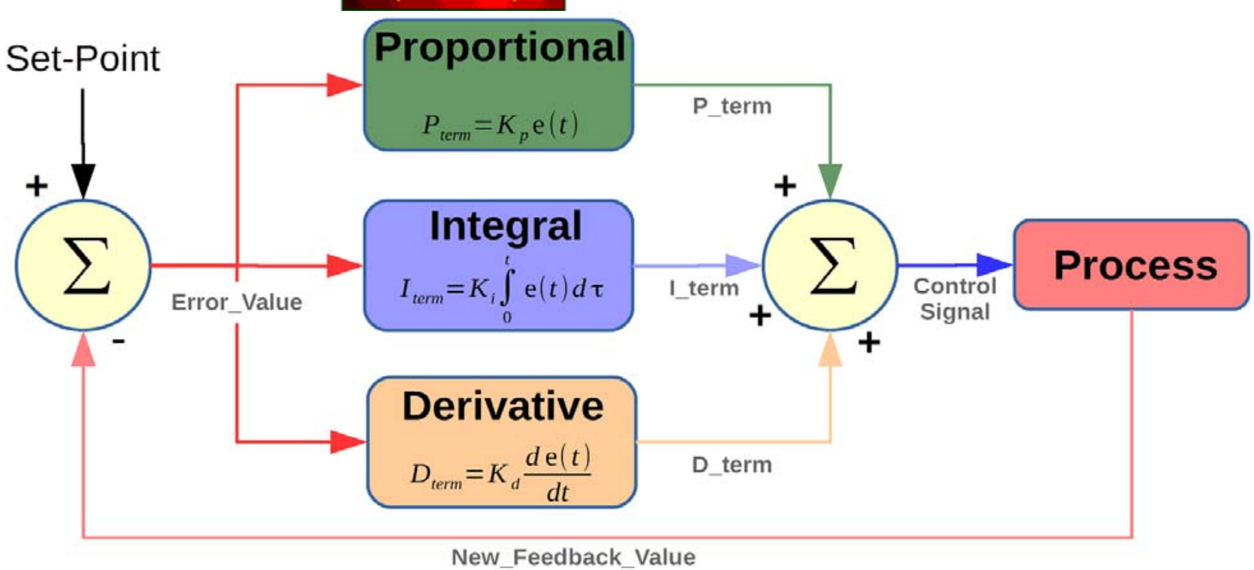


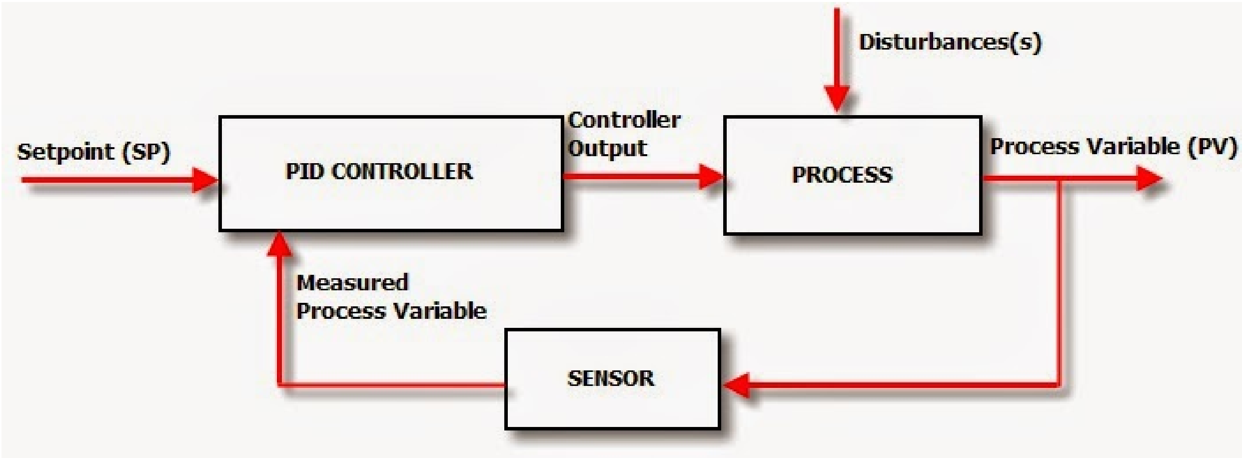

PID-Loop Calculation
Setpoint
Value
Error
Term
P
I
D
D
A
HLT
Heater
A
D
Process Variable
(Actual Temperature)


Process Variable (PV)
Temperature
Controller
PV = 70
PV should be: 80
Heater output should be
increased/ decreased
Setpoint
Controller
Output
Output Device
Heat Source


Steam
Pressure
Sensor
Steam
Control
Valve
Temperature
Setpoint
Major
Loop
Flow
Setpoint
Minor
Loop
Water
Temperature
Probe
Steam Boiler #1
Water Tank #1
SP1
Out = SP2
Out2
Minor
Process
Major
Process
Minor PV
Major PV

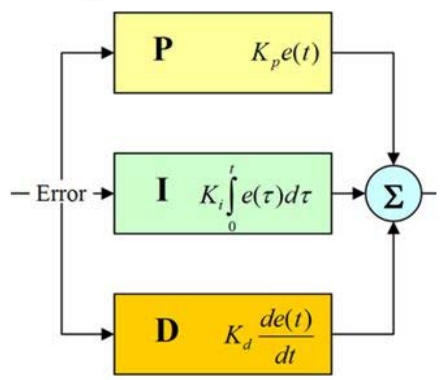

Compensator/
Controller
Plant
Input , u(t)
Oututut , y(t)
$\frac{G_c}{(s\tau_c + 1)}$
$\frac{G_L}{(s\tau_L + 1)}$
$\frac{G_s}{(s\tau_s + 1)}$
Sensor


Set-Point
Proportional
$P_{term} = K_p e(t)$
P_term
Integral
$I_{term} = K_i \int_0^t e(t) d\tau$
I_term
Derivative
$D_{term} = K_d \frac{d e(t)}{dt}$
D_term
Error_Value
Process
Control
Signal
New_Feedback_Value

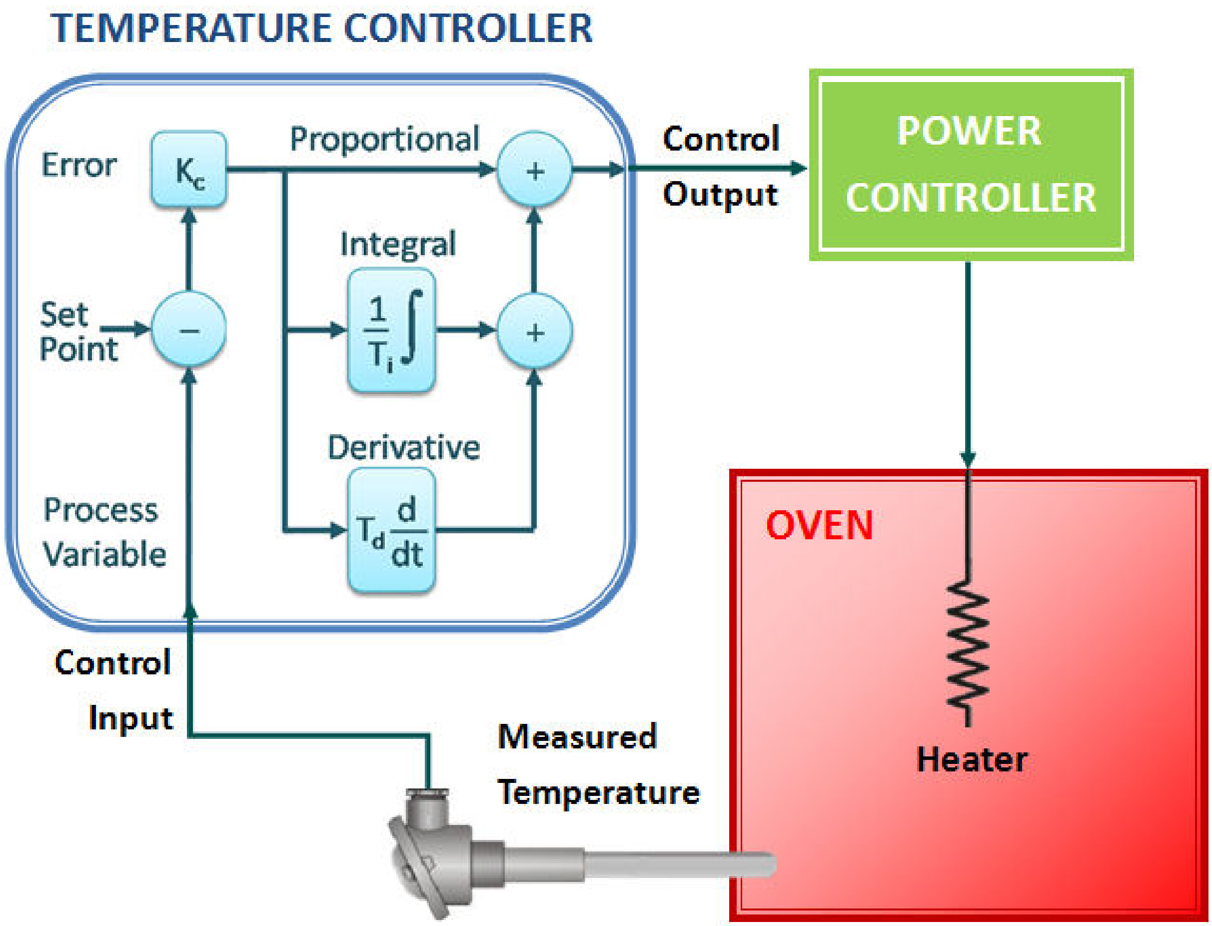


Proportional Integral Derivative (PID) Controller

- Closed loop controllers that only use proportional control can easily become unstable if the gain is too high or sluggish if the gain is set too low
- PID controllers help solve this problem
- It use the measured error compute an input to the Plant based on three distinct controls: **P**roportional, **I**ntegral and **D**erivative (see right)



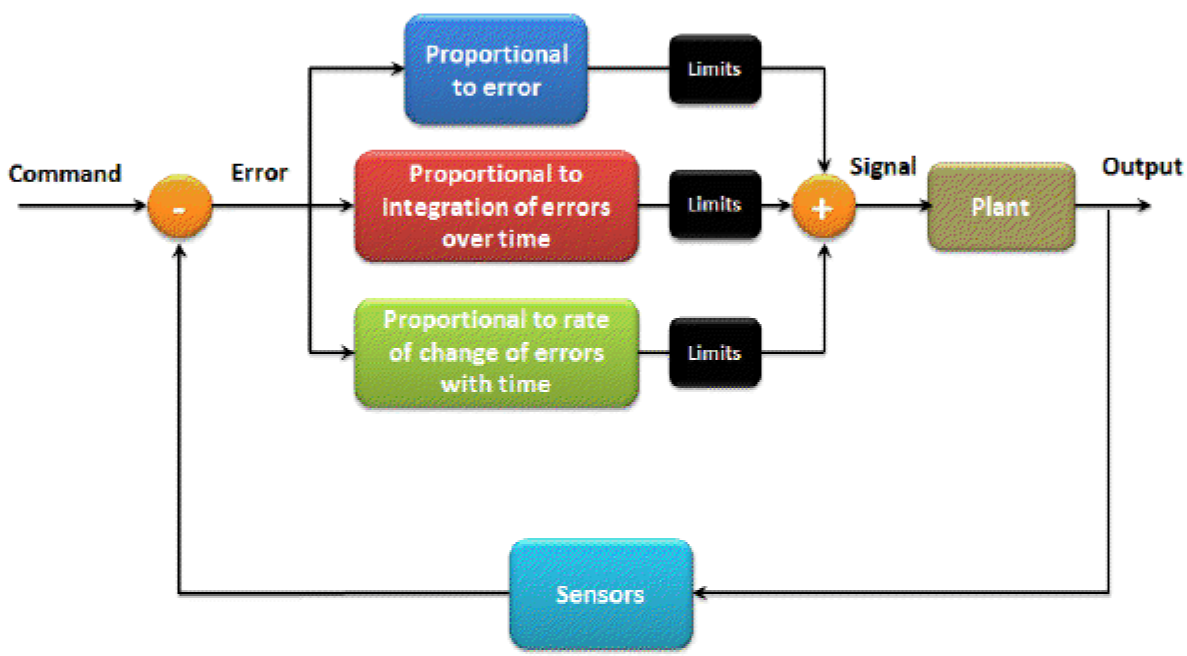
- Proportional control – Computed based on the actual error (times a gain factor). Thus, The larger the error, the bigger correction the control will make
  - Serves to control response time to error
  - For high gains or large errors, tends to overshoot and oscillate the desired output
  - There is typically a steady state error that cannot be corrected

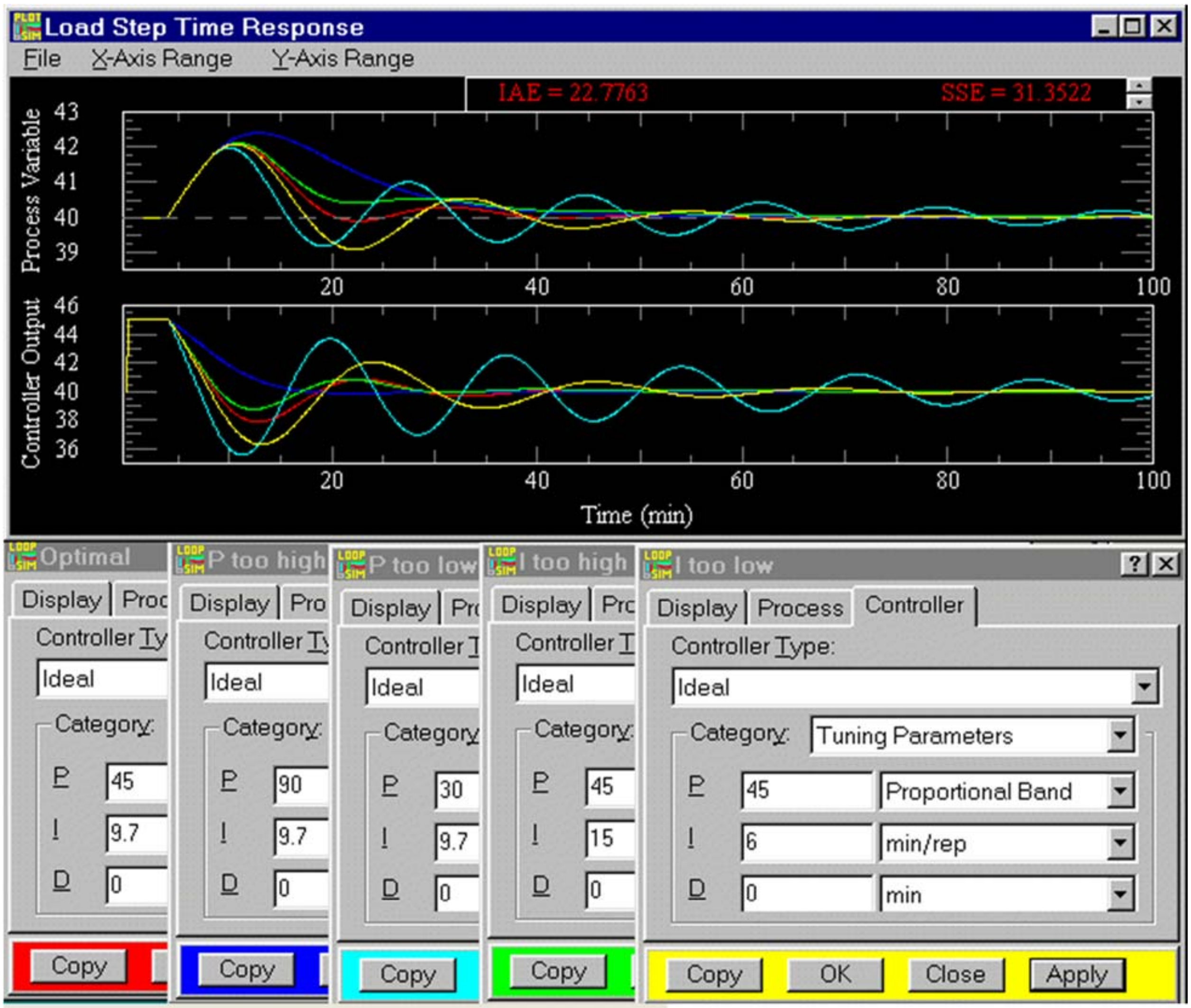


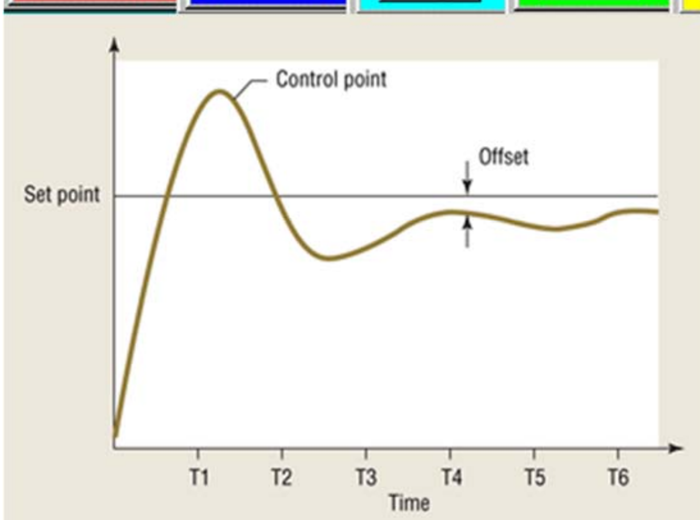
TEMPERATURE CONTROLLER
Error
Kc
Proportional
Integral
Set Point
Derivative
Process Variable
Control Output
POWER CONTROLLER
OVEN
Heater
Control Input
Measured Temperature

Problem Discussion

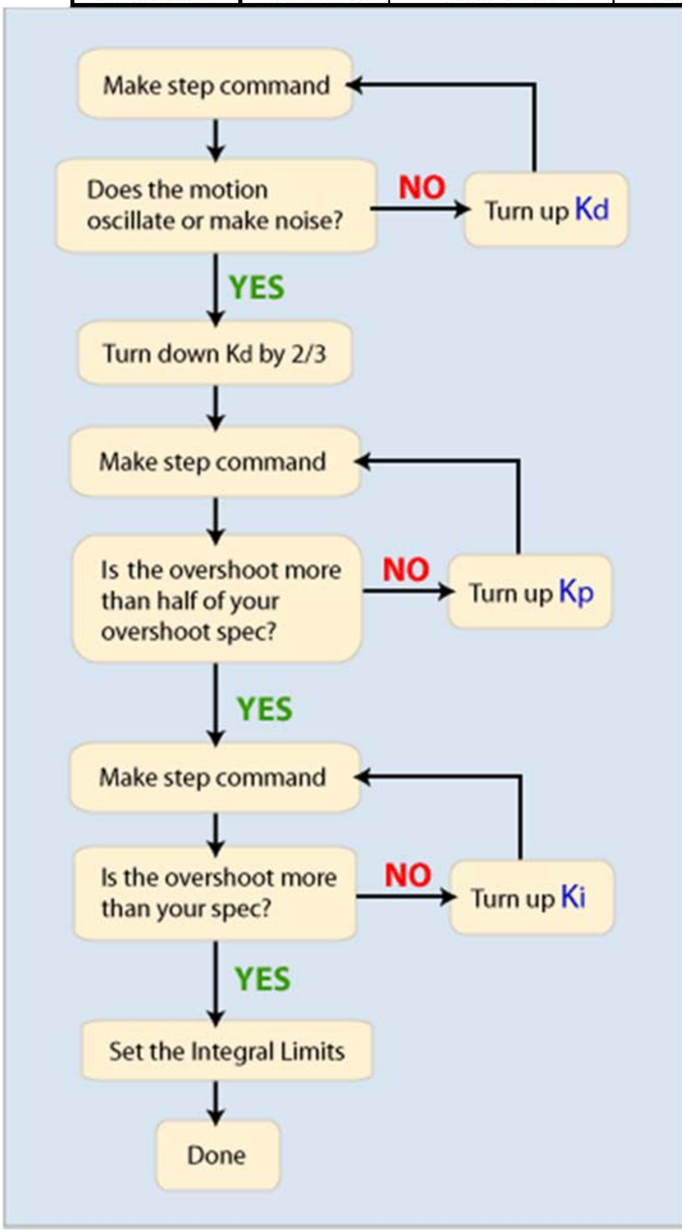
- For a stable controlled process, there exist offset when a P controller is used. Why?
- When we use a PI controller, there is no offset if the closed-loop system is stable. Please explain its reason.
- It is well known that derivative action is helpful to improve the stability of a closed-loop system, however, derivative action is not used in most industrial processes. Why?



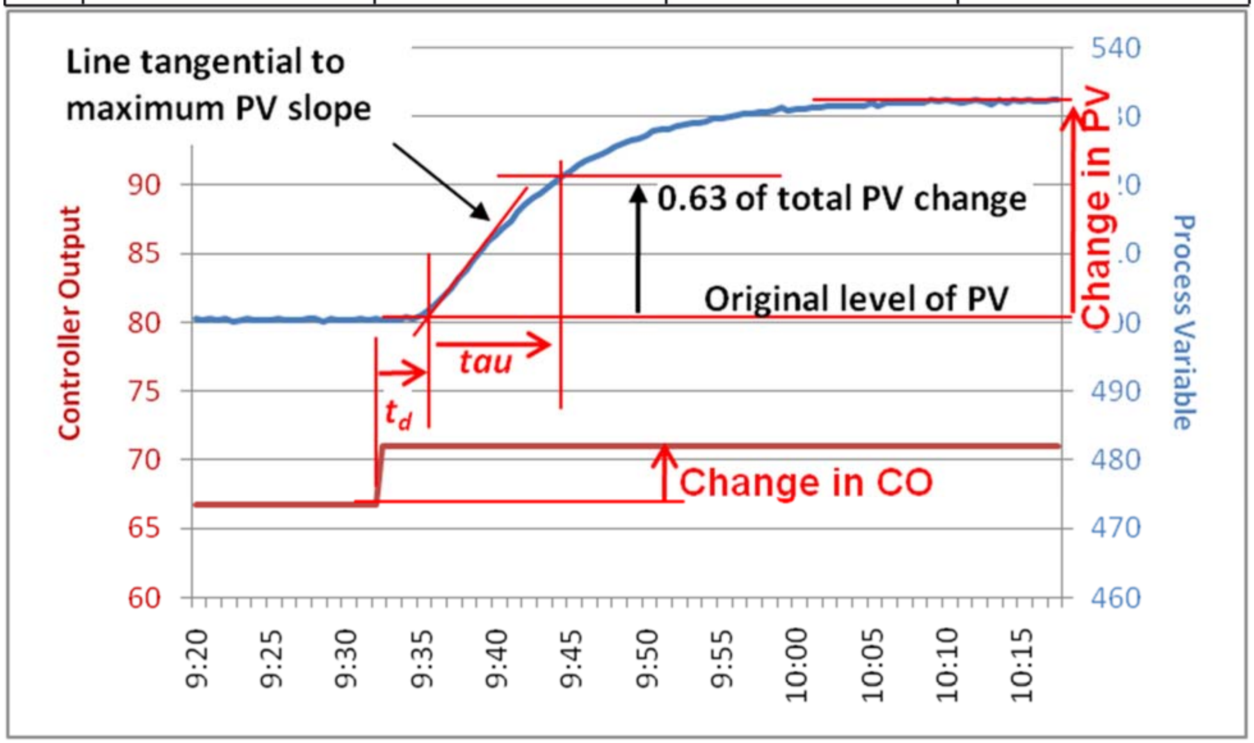

Load Step Time Response
File X-Axis Range Y-Axis Range
IAE = 22.7763
SSE = 31.3522
Process Variable
43
42
41
40
39
Controller Output
46
44
42
40
38
36
20
40
60
80
100
Time (min)
Optimal
P too high
P too low
I too high
I too low
Display Process Controller
Controller Type:
Ideal
Category:
Tuning Parameters
P 45 Proportional Band
I 6 min/rep
D 0 min
P 45 I 9.7 D 0
P 90 I 9.7 D 0
P 30 I 9.7 D 0
P 45 I 15 D 0
Copy
OK
Close
Apply


Control point
Offset
Set point
T1
T2
T3
T4
T5
T6
Time

(increase)	Rise Time	Oscillation or Overshoot	Settling Time	Error
P-Gain	Faster	Increase	Increase	Decrease
D-Gain	Minor	Decrease	Decrease	No Effect
I-Gain	Slower	Increase	Increase	Eliminate



	RISE TIME	OVERSHOOTS	SETTLING TIME	STEADY STATE ERROR
Kp	DECREASE	INCREASE	SMALL CHANGE	DECREASE
Ki	DECREASE	INCREASE	INCREASE	ELIMINATE
Kd	INCREASE	DECREASE	DECREASE	NO CHANGE



Conclusions

- **Proportional** action gives an output signal proportional to the size of the error **.**Increasing the proportional feedback gain ***reduces steady-state errors***, but high gains almost always ***destabilize the system.***
- **Integral** action gives a signal which magnitude depends on the time the error has been there. Integral control provides ***robust reduction in steady-state errors***, but often ***makes the system less stable.***
- **Derivative** action gives a signal proportional to the change in the Error. It gives sort of "**anticipatory**" control .**Derivative control** usually ***increases damping and improves stability,*** but has almost ***no effect on the steady state error***
- These ***3 kinds of control combined*** from the **classical PID controller**

PID Conclusions

- **Increasing the proportional feedback gain** ***reduces steady-state errors***, but high gains almost always ***destabilize the system.***

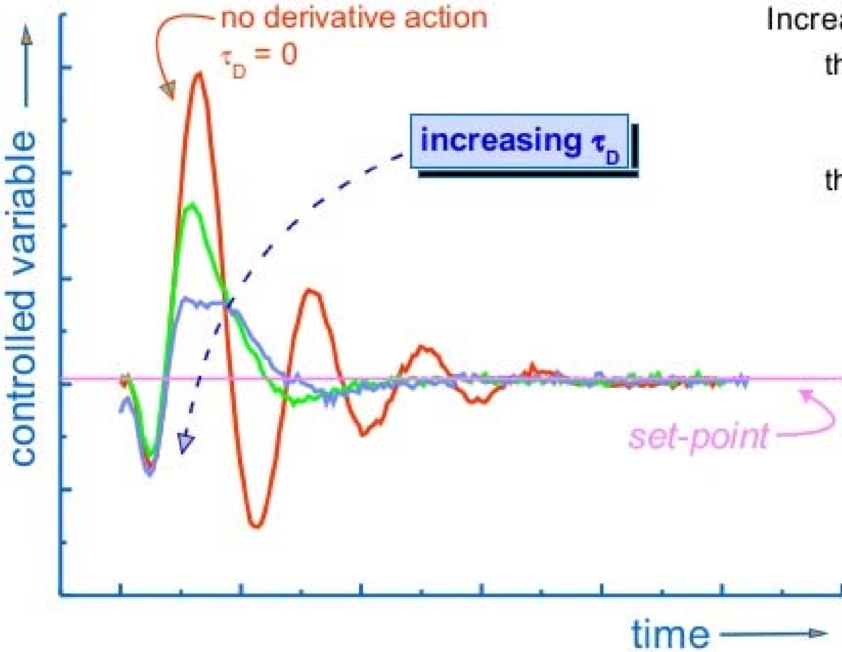
- **Integral control** provides ***robust reduction in steady-state errors***, but often ***makes the system less stable.***

- **Derivative control** usually ***increases damping and improves stability,*** but has almost ***no effect on the steady state error***

- These ***3 kinds of control combined*** from the **classical PID controller**

Performance of PID controllers

Response to a disturbance step change



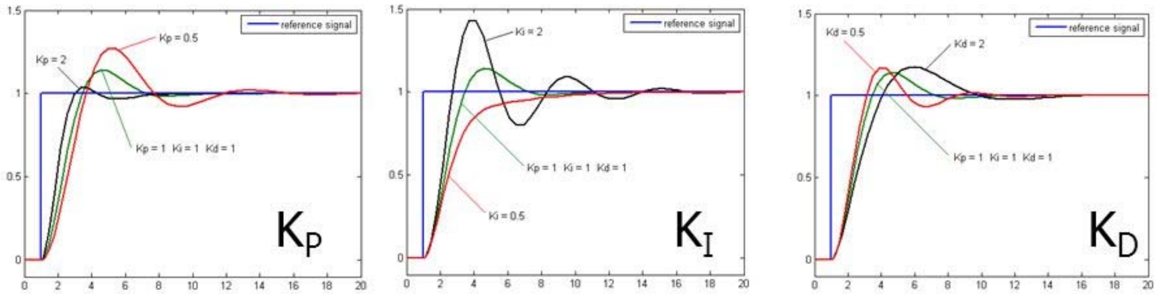
Increasing τ_D :

- the oscillations caused by the integral action are dampened
- the process response is speeded up

CAUTION

Noisy measurements may disrupt the controller performance !

Effect of Increasing PID Factors

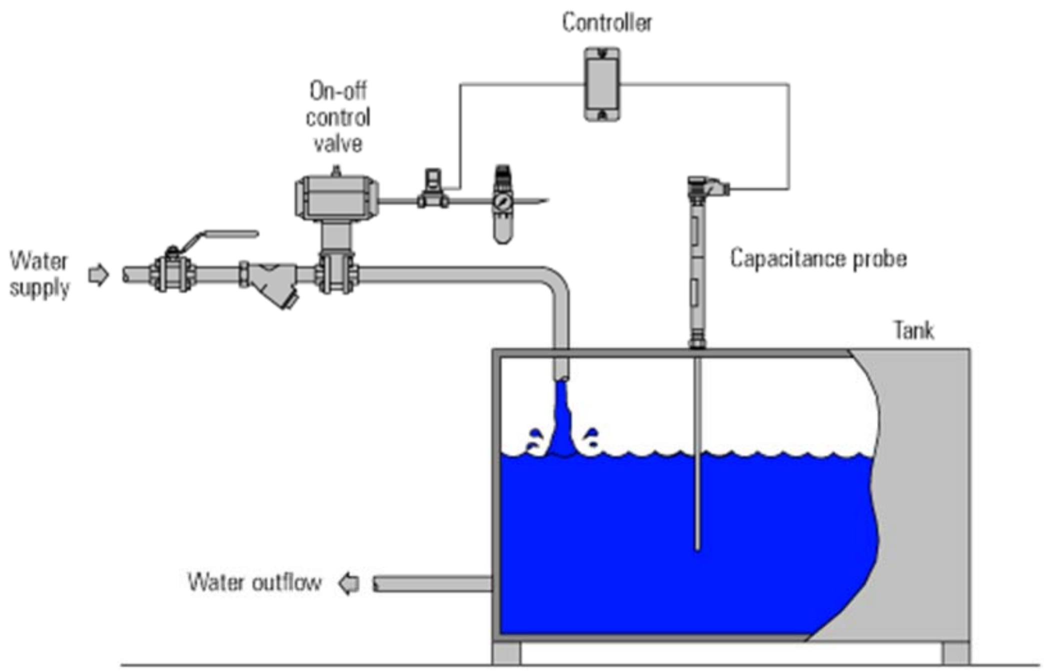


Response	Rise Time	Overshoot	Settling Time	S-S Error
K_P	Decrease	Increase	NT	Decrease
K_I	Decrease	Increase	Increase	Eliminate
K_D	NT	Decrease	Decrease	NT

NT: No trend

PID controller

- A Proportional-Integral-Derivative controller (PID controller) is a generic controller widely used in industrial control systems.
- PID controllers can be used to regulate flow, temperature, pressure, level, and many other industrial process variables.
- PID controller describes the mathematic calculations that are applied to calculate the error between the current result and the desired set-point.
- PID control equation involves three separate parameters; the Proportional, Integral and Derivative terms.
  - Proportional term responds instaneously to the current error (providing instaneous response).
  - Integral term (past errors) responds to the accumulation of errors in the form of average (providing a slow response that drives the steady-state error towards Zero).
  - Derivative term (future errors) responds to the rate at which the error is changing (providing some anticipatory response).


Controller
On-off
control
valve
Water
supply
Capacitance probe
Tank
Water outflow