PID 101

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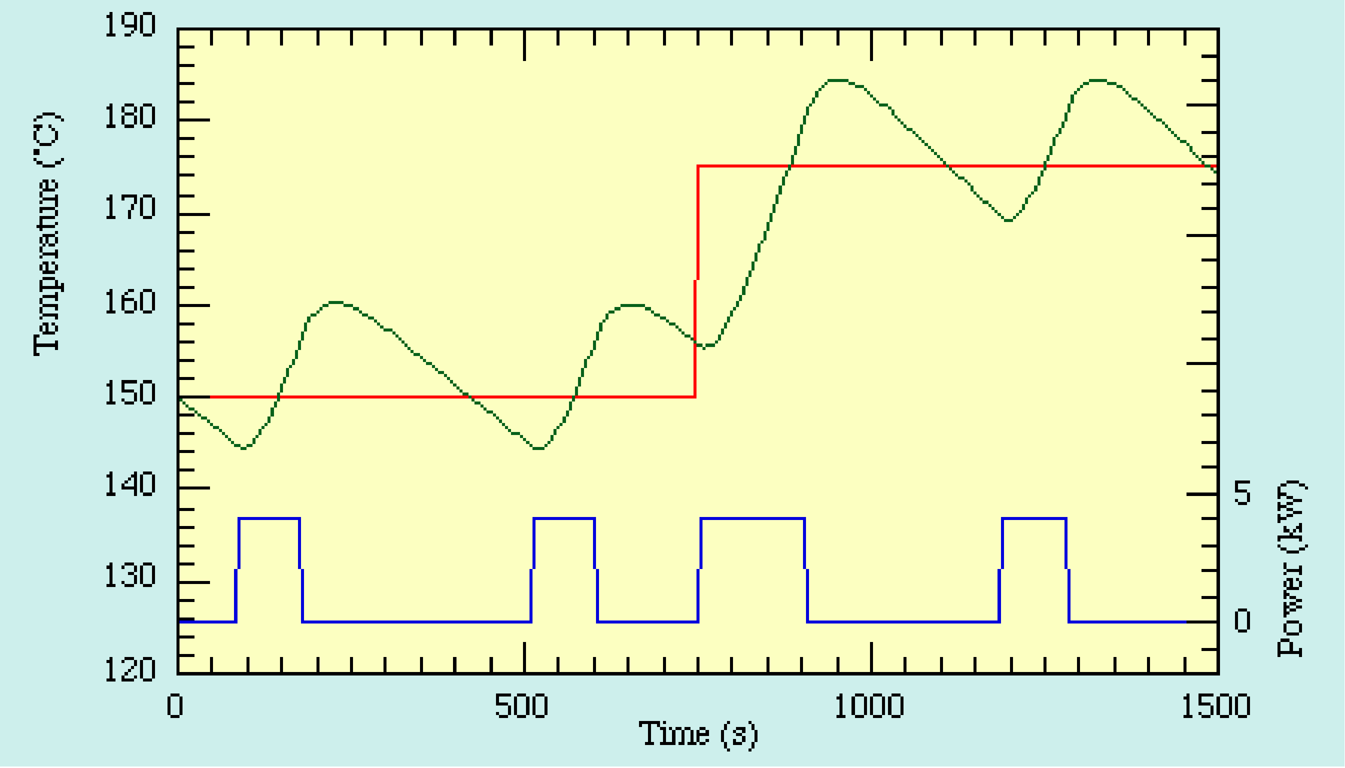
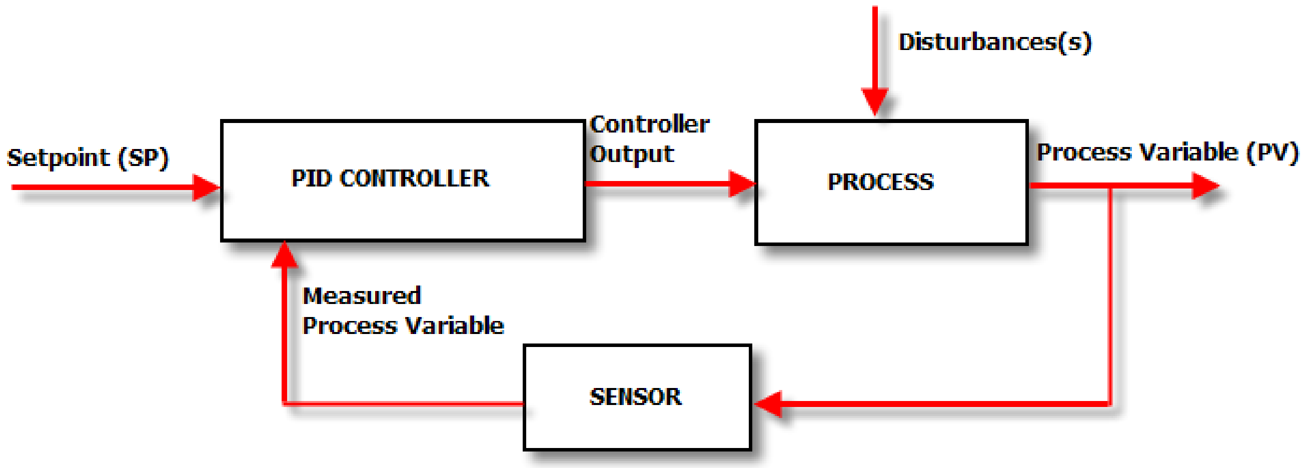
On-Off Control

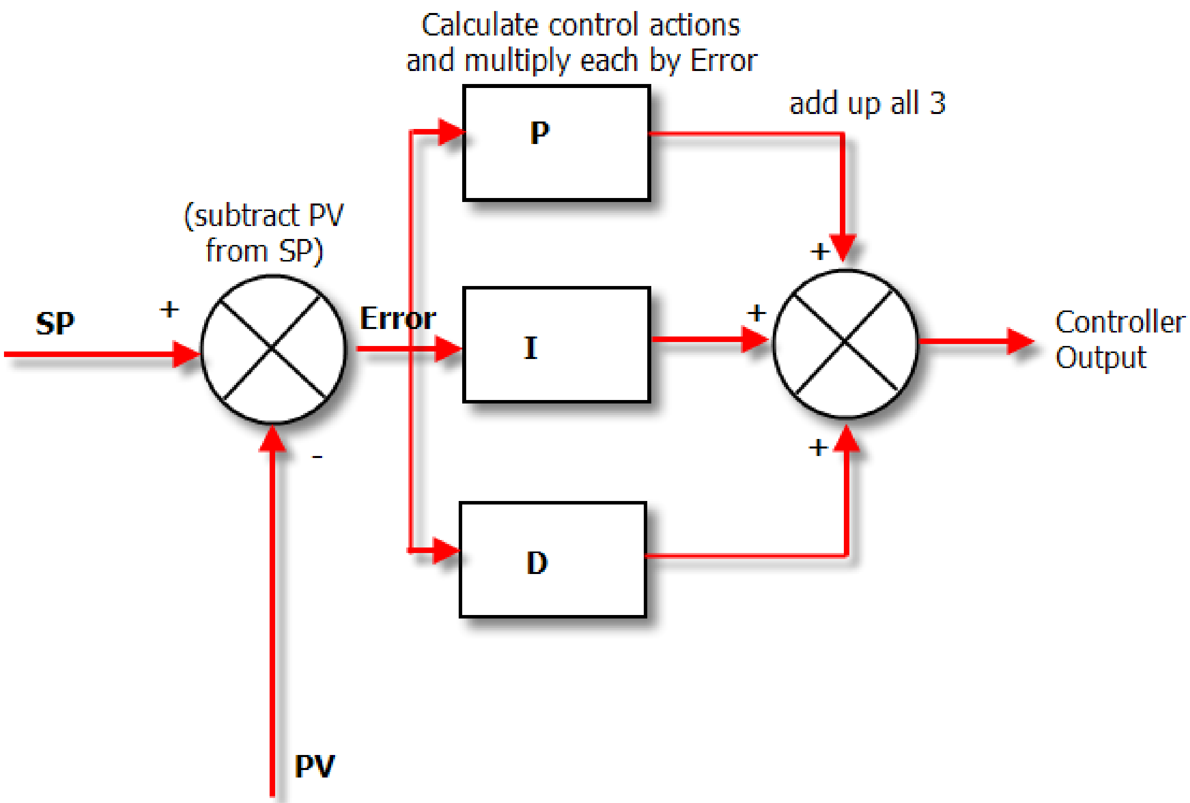
Simplest form of control.



Typical PID Control



What a PID does

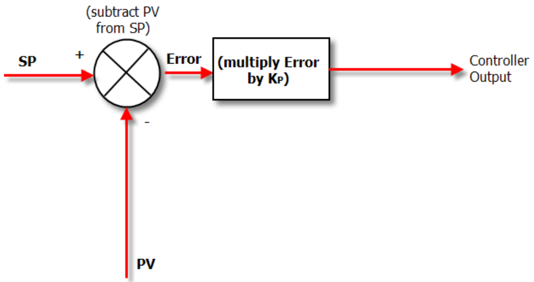


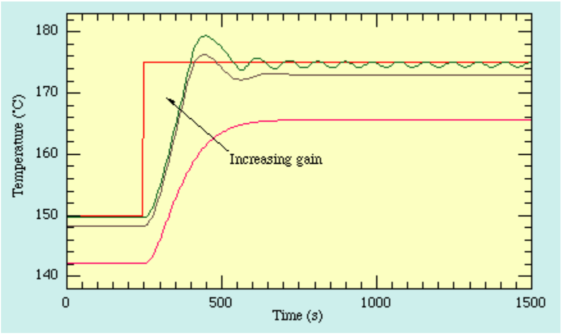
Modes of Operation

- Proportional
  - Used sometimes
- Proportional-Integral
  - Very popular
- Proportional-Integral-Derivative
  - Used sometimes
- Proportional-Derivative
  - rare

Proportional Control

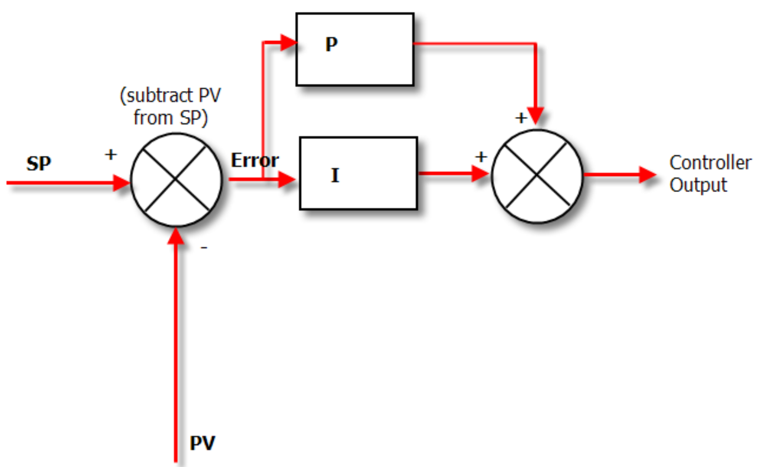
- Better than the On-off
- System responds faster to changes in set-point
- However becomes progressively underdamped and eventually unstable.
- The final steady state can lie below the set-point.





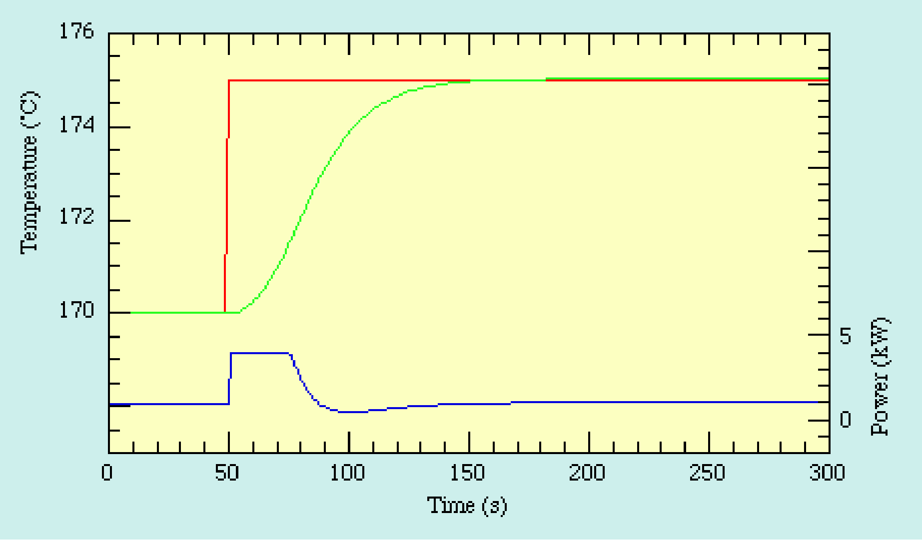
Proportional–Integral Control

- Steady state can be achieved
- The response can be oscillatory and needs time to settle.
- System responds faster to changes in set-point.



Proportional–Integral-Derivative

- Allow you to have bigger P and I gains and still keep the loop stable, The response can be oscillatory and needs time to settle.
- However, the derivative is suseptable noise on your signal, causing the control signal to jump around.



The Characteristics of P, I, and D controllers

A proportional controller (Kp) will have the effect of reducing the rise time and will reduce, but never eliminate, the steady-state error.

An integral control (Ki) will have the effect of eliminating the steady-state error, but it may make the transient response worse.

A derivative control (Kd) will have the effect of increasing the stability of the system, reducing the overshoot, and improving the transient response.

Proportional Control

By only employing proportional control, a steady state error occurs.

Proportional and Integral Control

The response becomes more oscillatory and needs longer to settle, the error disappears.

Proportional, Integral and Derivative Control

All design specifications can be reached.

The Characteristics of P, I, and D controllers

CL RESPONSE	RISE TIME	OVERSHOOT	SETTLING TIME	S-S ERROR
Kp ↑	Decrease	Increase	Small Change	Decrease
Ki	Decrease	Increase	Increase	Eliminate
Kd	Small Change	Decrease	Decrease	Small Change

Tips for Designing a PID Controller

1. Obtain an open-loop response and determine what needs to be improved
2. Add a proportional control to improve the rise time
3. Add a derivative control to improve the overshoot
4. Add an integral control to eliminate the steady-state error
5. Adjust each of Kp, Ki, and Kd until you obtain a desired overall response.

Lastly, please keep in mind that you do not need to implement all three controllers (proportional, derivative, and integral) into a single system, if not necessary. For example, if a PI controller gives a good enough response (like the above example), then you don't need to implement derivative controller to the system. Keep the controller as simple as possible.

Integration Windup

- See the following:
- https://uk.mathworks.com/help/simulink/examples/anti-windup-control-using-a-pid-controller.html
- Demo in class.