Control Systems

Monday, November 14, 2016 3:17 PM

Control systems

A control system is a device or set of devices that manage, command, direct, or regulate the behavior of other devices or systems.

Examples

→ Thermostat

→ Cruise Control

→ Hydraulic ram positioning

→ Pump pressure control

→ Servos

→ Printers

There are two main classes of control systems: open-loop and closed-loop

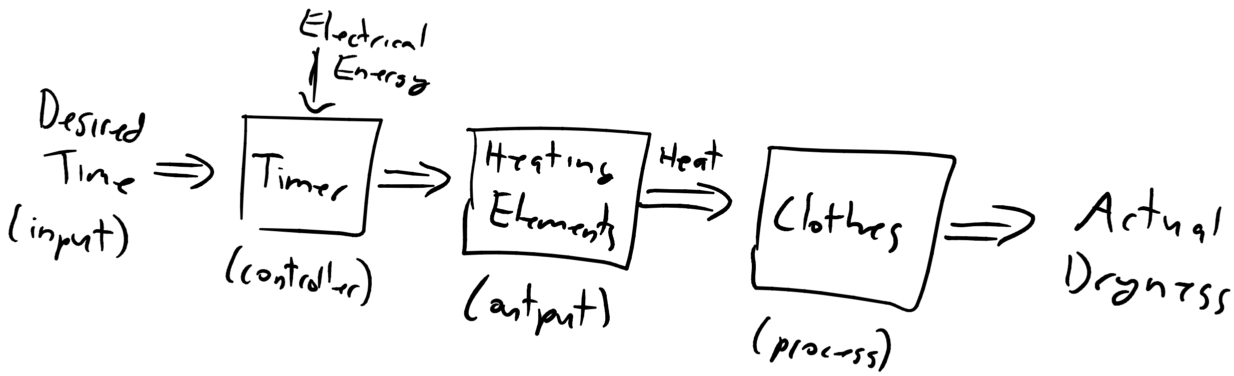
Open-Loop Control

An open loop controller has no knowledge of the outside world or state of the system. It executes pre-determined outputs based on a basic model of the system.

<u>Examples</u>

→ Timed clothes dryer

→ CNC Machines (most)



* Open loop systems will drive to their setpoint no matter what is happening with the system in reality. No error correction capability!

* Can't handle disturbances. (Imagine if your cruise control just locked the gas pedal - only works on straight flat road with no wind or other disturbances)

* If a human sees the change and ad

...rbances)

* If a human sees the change and adjusts the system we call it "feed forward" correction.

Closed Loop Control

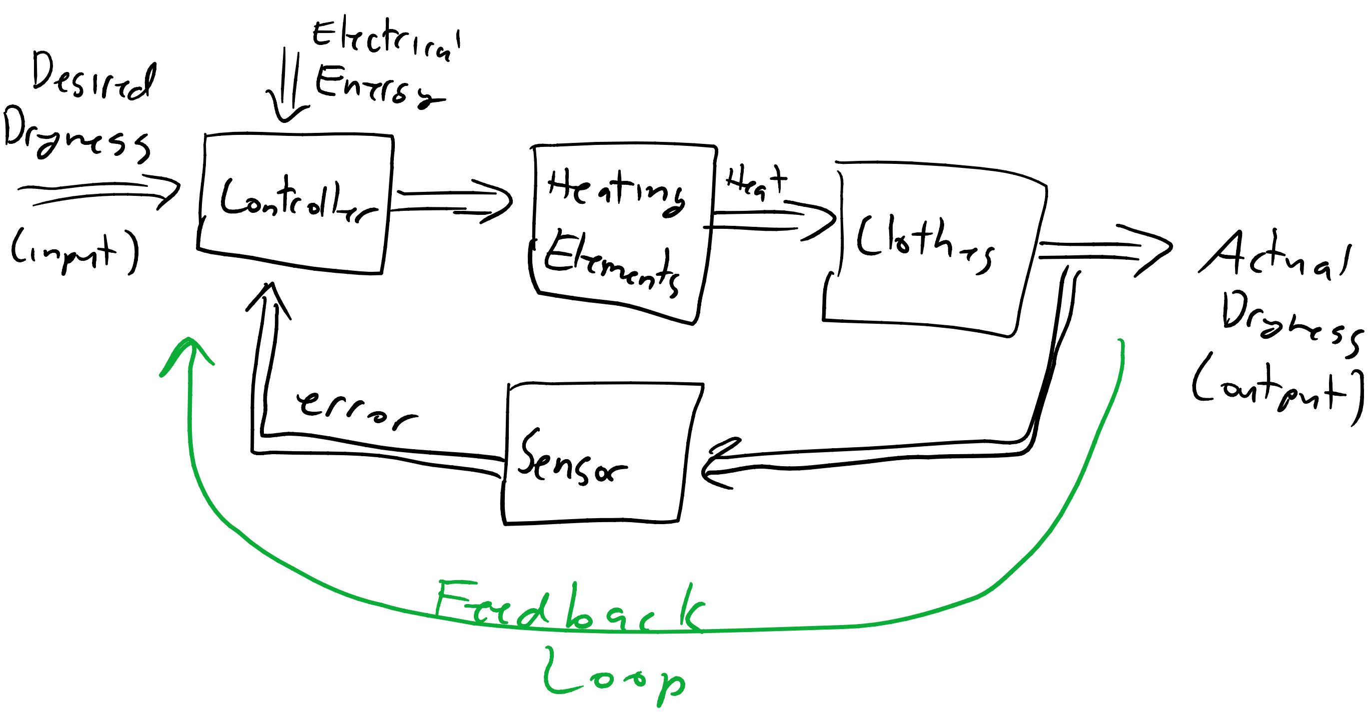
Closed loop systems have feedback from the process they are controlling and can therefore adapt and make corrections.

Examples

⇒ Cruise control

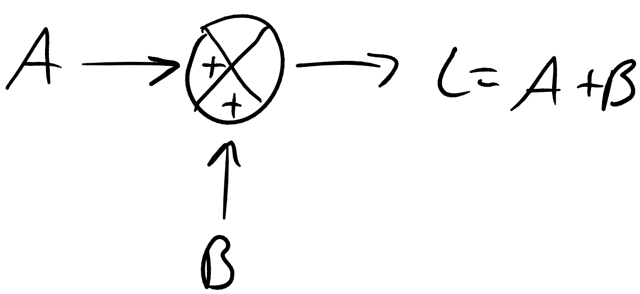
⇒ Moisture sensing dryers

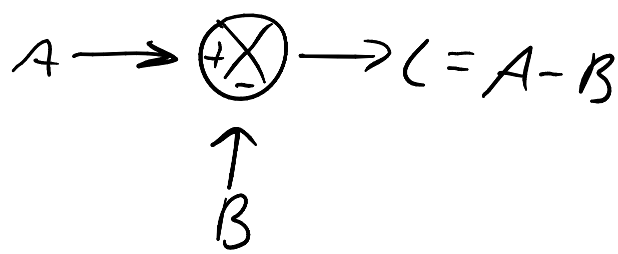
⇒ Thermostat



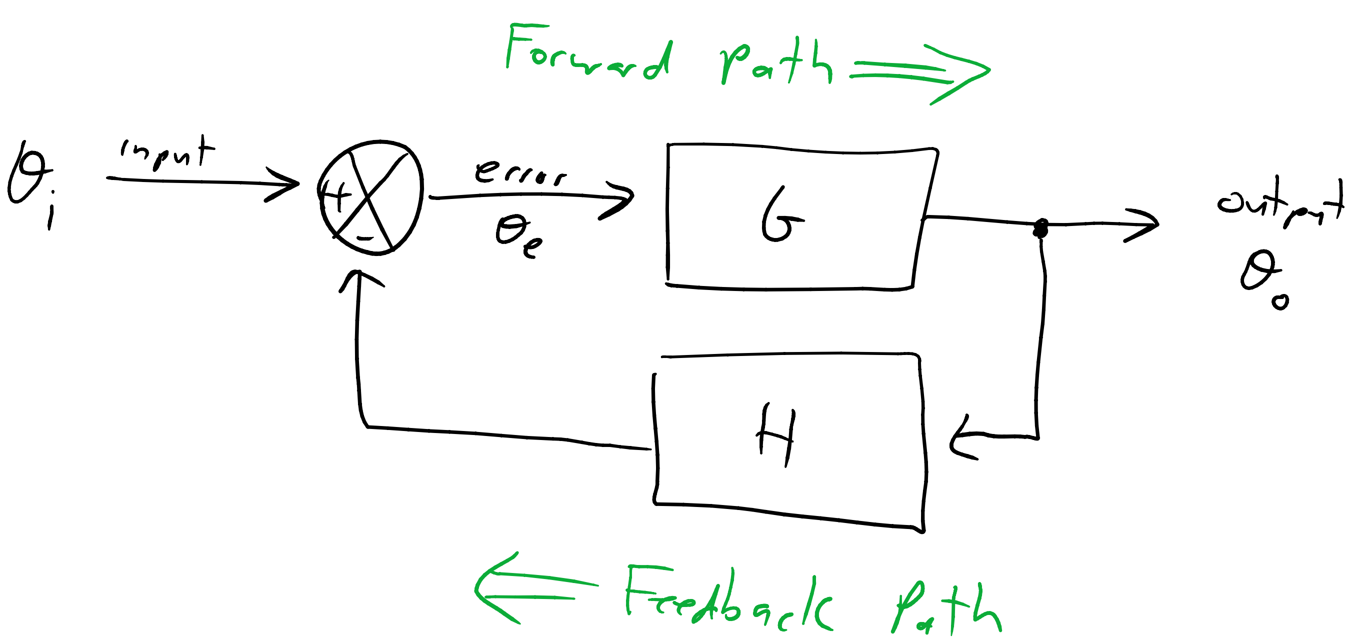
* Robust to external disturbances
* Reduced sensitivity to the specific system controlled
* More stable than open-loop

$\otimes$ represents a summing point



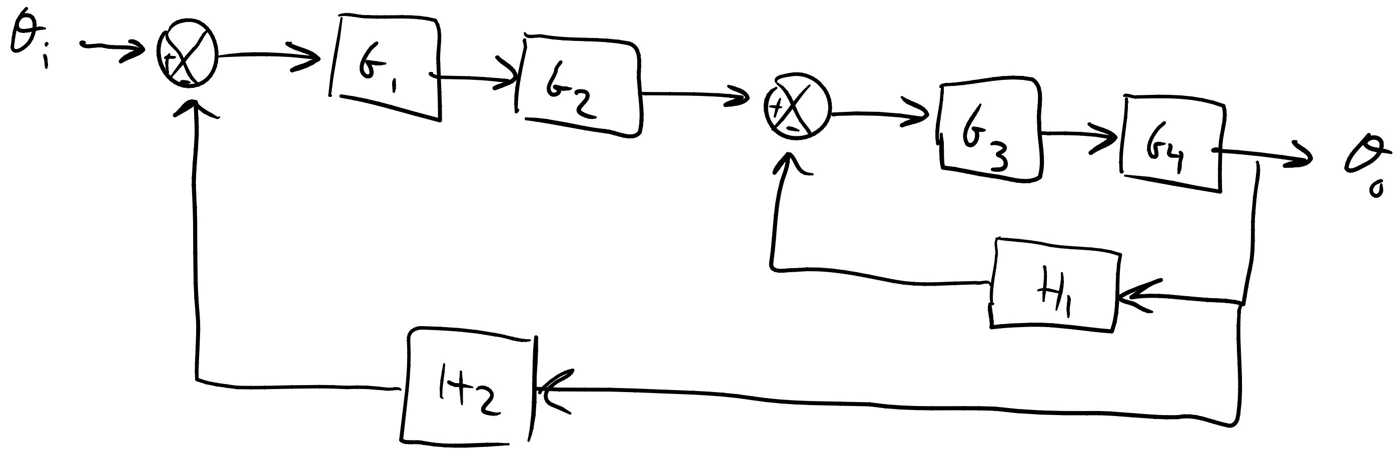


Representation of a Closed-Loop System

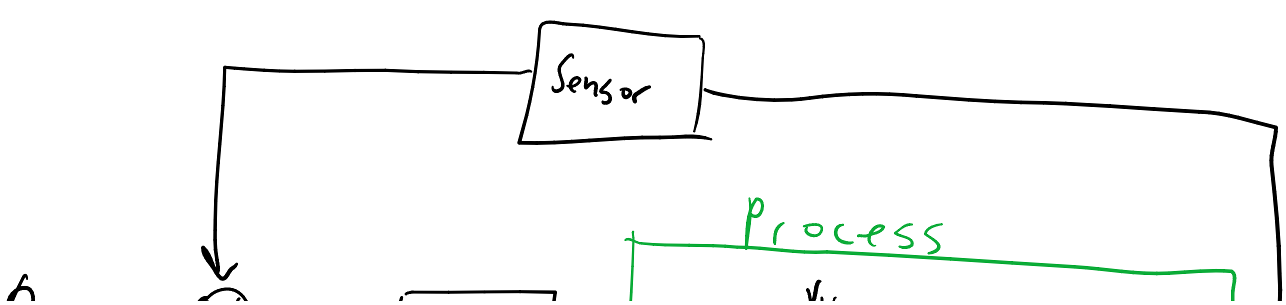


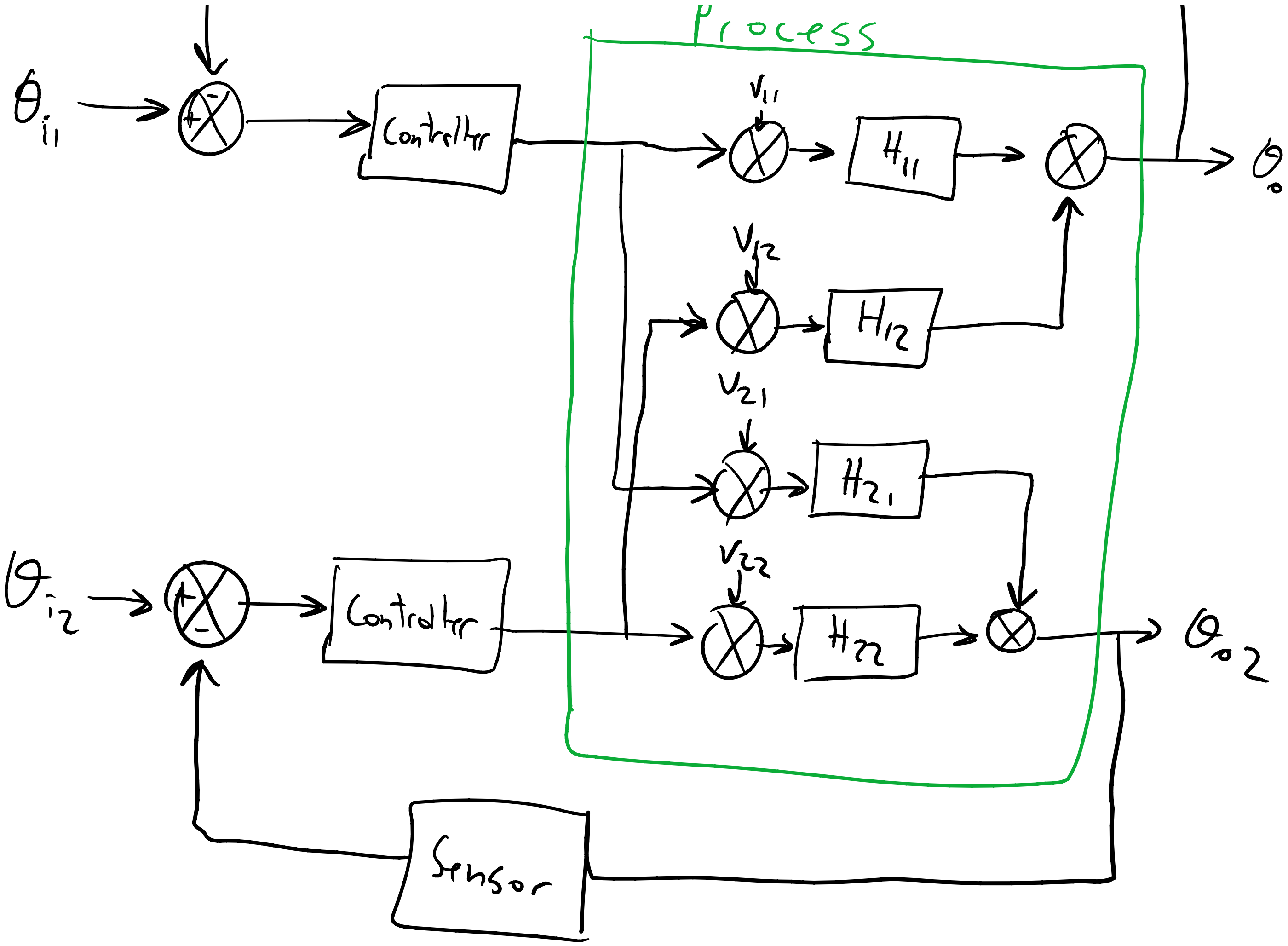
Often we encounter systems with multiple control loops in different configurations.

Multiloop Control - Each manipulated variable depends on only a single controlled variable. (Furnace fuel and air to control temperature of a flame)

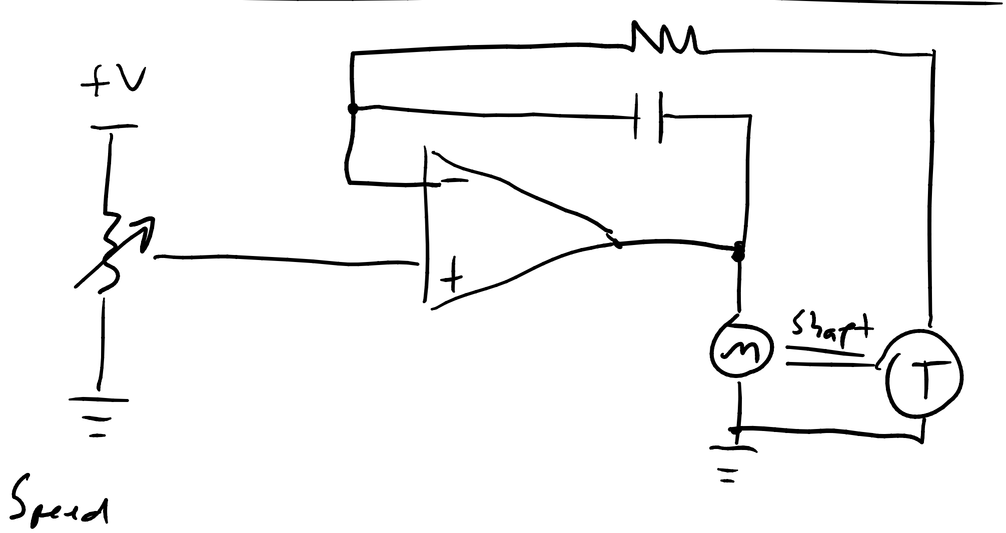


Multivariable control - Each manipulated variable can depend on two or more controlled variables.





A simple DC Motor Controller



Setting

There are several ways to implement a control System. We will cover some of the most common.

Logic Control

* Implemented with relays in the old days
* Now implemented on microcontrollers and programmable logic controllers (PLCs)
* Use a series of binary inputs and logic to determine the action to take.
* Often designed using the ladder logic paradigm

Examples

⇒ Elevators

⇒ Washing machines

⇒ Simple industrial control

⇒ Simple industrial control

On-Off Control

The system has two states: on and off. This is often called bang-bang control.

Examples

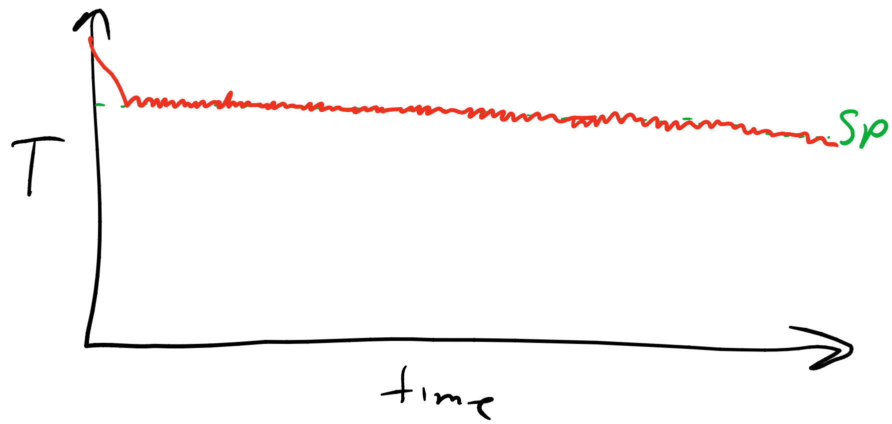
⇒ Thermostat

⇒ Refridgerator

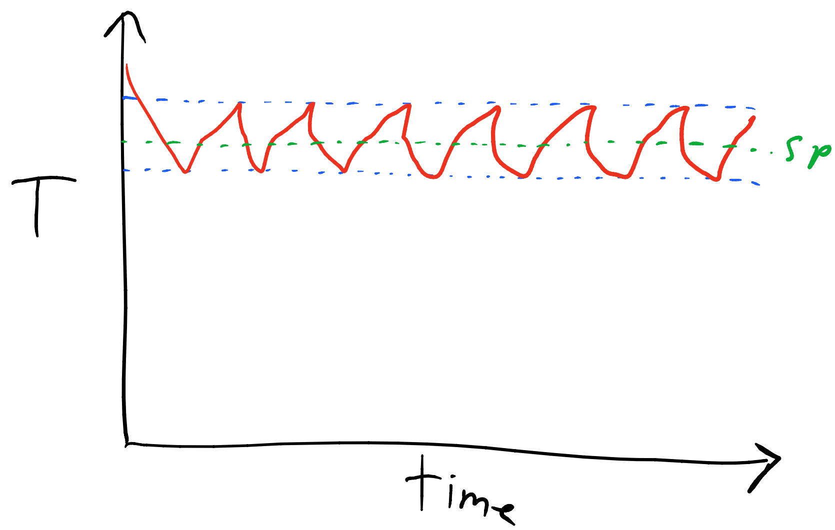
⇒ Air compressor

* Can rapidly switch which is often hard on equipment and possibly expensive. Generally some hysteresis is added to the system to produce a deadband.

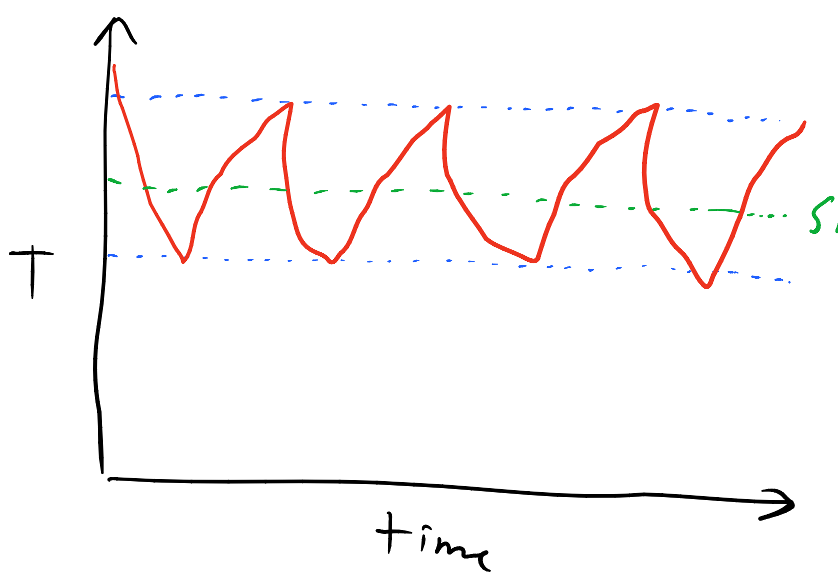
Simple Freezer Example



* no hysteresis
* Rapid on/off



* hysteresis
* reduced duty cycle
* small temperature error



* Larger dead band
* Low duty cycle
* Large variation from set point

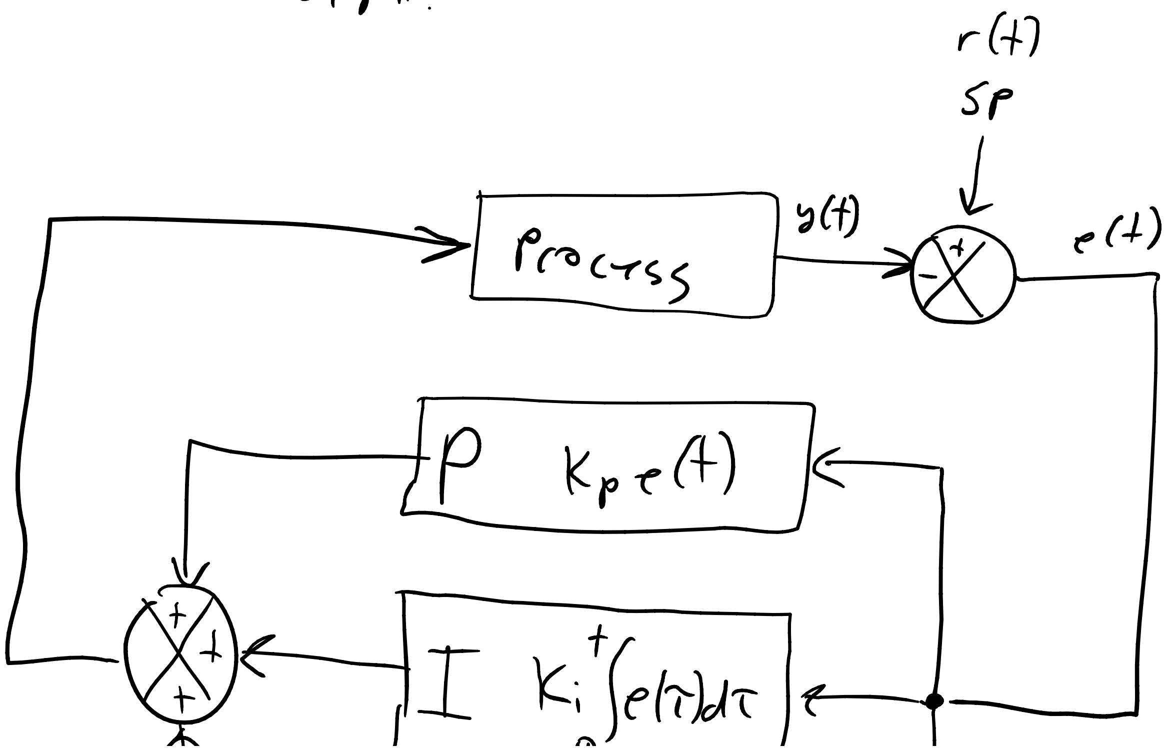
Linear Control

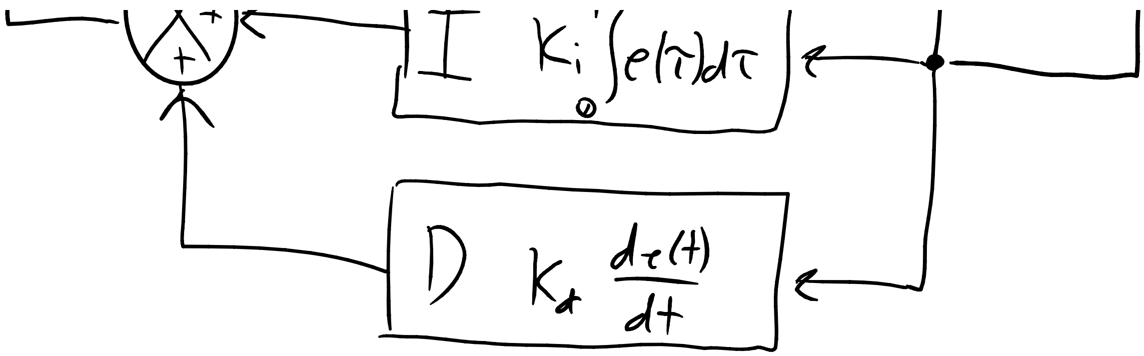
Control signal is produced with linear negative feedback. The output may be a directly variable signal or a pulse-width modulation duty cycle control.

* Without proper damping simple linear proportional control is unstable.

PID Control

PID control takes into account the past, present, and predicted future state of the system to determine the control output.





Proportional - Output is directly scaled with the magnitude of the signal. This is the "present" term in a PID controller. Kicks a system with mass or inertia into oscillations when used alone.

Intergral - A sum of error over time. The "past" term. Keeps small errors from persisting due to a small proportional term. Too slow to use alone.

Differential - Predicts the future of the system. Helps stop overshooting of the control system. Excess K_d results in a jittery control.