INC 341 Feedback Control Systems: Lecture 1 Introduction to Feedback Control Systems

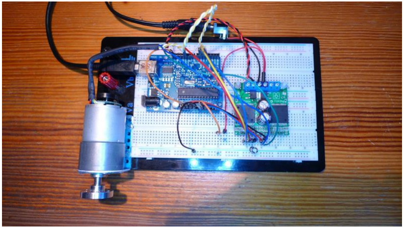
Asst. Prof. Dr.-Ing. Sudchai Boonto

Department of Control Systems and Instrumentation Engineering
King Mongkut's University of Technology Thonburi

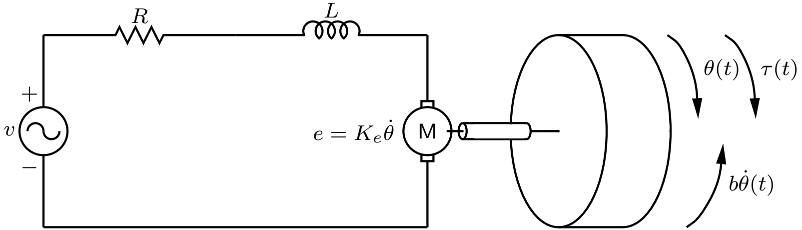
Why do we need control?

- What is it?
- What are variables that usually we want to control?
- How can we control them?

- One of your answers may be "Using a microcontroller".
- Is that stupid?



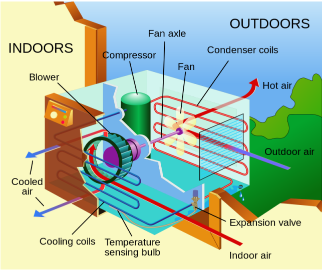
What should we start?

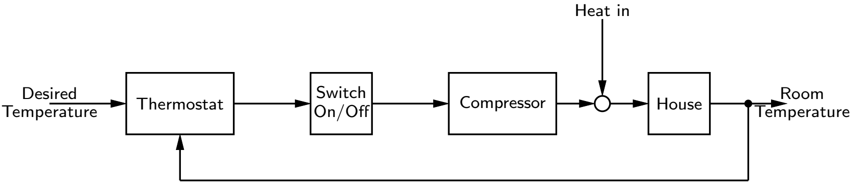


- Define your consider variables.
- Draw an electrical circuit and mechanical part.
- Explain the relationship between an input and an output of your system.
- You learned all of these techniques in "Signals and Systems" related subject.

Room Temperature Control Systems

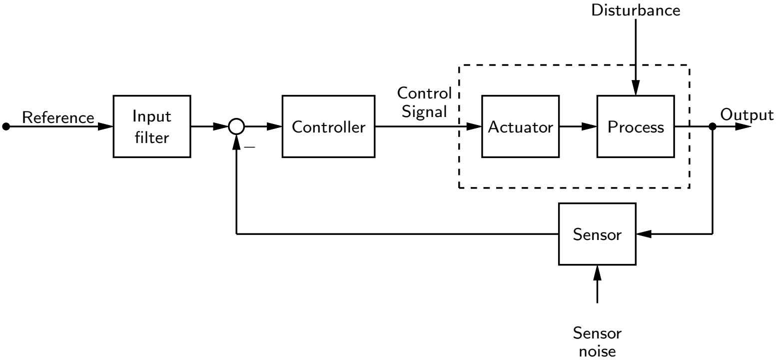
Assuming that you pass Signals and Systems.





Component block diagram

of an elementary feedback control



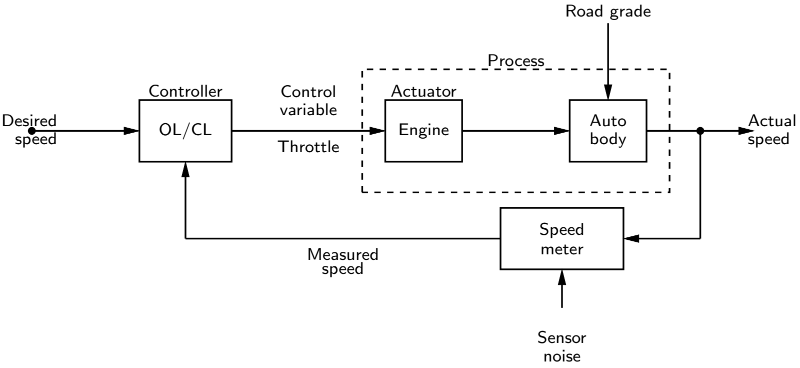
- Input filter to convert the reference signal to electrical signal for manipulation by the controller
- The comparator to compute the difference between the reference signal and the sensor output to give the controller a measure of the system error.

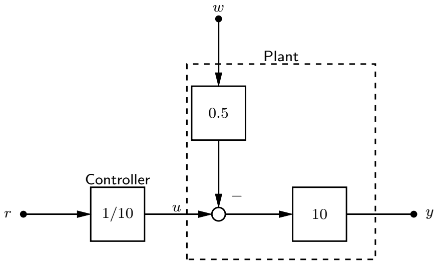
Why do we need feedback control?

Automobile cruise control

There are two configurations of control system

- Open-loop control
- Closed-loop control





In this case, it is easy to see that

$$y_{ol} = 10(u = 0.5w) = 10\left(\frac{r}{10} - 0.5w\right)$$
$$= r - 5w$$

The error in output speed is

$$e_{ol} = r - y_{ol} = 5w$$
$$\%error = 500\frac{w}{r}$$

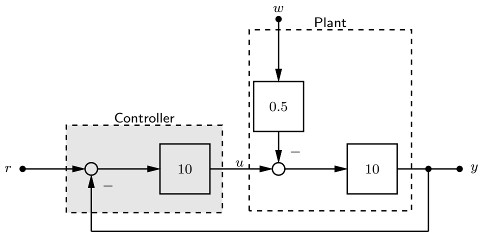
If $r = 65$

- the road is level (smooth) then $w = 0$, the error will be zero.
- $w = 1$, the speed will be 60 and the error is 7.69%
- $w = 2$, the speed will be 55 and the error is 15.38%

If there is an error in the plant gain in open-loop control, the percent speed error would be the same as the percent plant-gain error.

Automobile cruise control

Closed-loop control



$$u = 10(r - y_{cl})$$
$$y_{cl} = 10(u - 0.5w) = 10(10(r - y_{cl}) - 0.5w)$$
$$y_{cl} = \frac{100}{101}r - \frac{5}{101}w$$
$$e_{cl} = r - y_{cl} = \frac{1}{101}(r + 5w)$$

the feedback has reduced the sensitivity of the speed error by the factor of 101.

If $r = 65$

- $w = 0$,

$$y_{cl} = (100/101)65 = 64.35$$
$$\%error = 1\%$$

- $w = 1(1\%$road grade),

$$y_{cl} = (6500 - 5)/101 = 64.30$$
$$\%error = 1.0769\%$$

- $w = 2(2\%$road grade),

$$y_{cl} = (6500 - 10)/101 = 64.26$$
$$\%error = 1.1385\%$$

You can see that 1% road grade increase the $\%error$ just about 0.07%.

Feedback control system design

the design trade-off

- The closed-loop system can reduce the error sensitivity from the output disturbance. In this example, we use the loop gain is of 100. However, we cannot use too high loop gain. It can make the system unstable.
- The feedback control it is the subject that studies about how to design the dynamics and static loop gain such that the closed-loop is still stable.

A History of Control Systems

- Liquid-level control: the Greeks began feedback system around 300 B.C.
- Drebbel's incubator for hatching chicken eggs, in 1624
- James Watt's Fly-ball governor, in 1728
- The control theory started in 1868
- ...

Reference

1. Norman S. Nise, "*Control Systems Engineering*,6^{th} edition, Wiley, 2011
2. Gene F. Franklin, J. David Powell, and Abbas Emami-Naeini, "*Feedback Control of Dyanmic Systems*",4^{th} edition, Prentice Hall, 2002