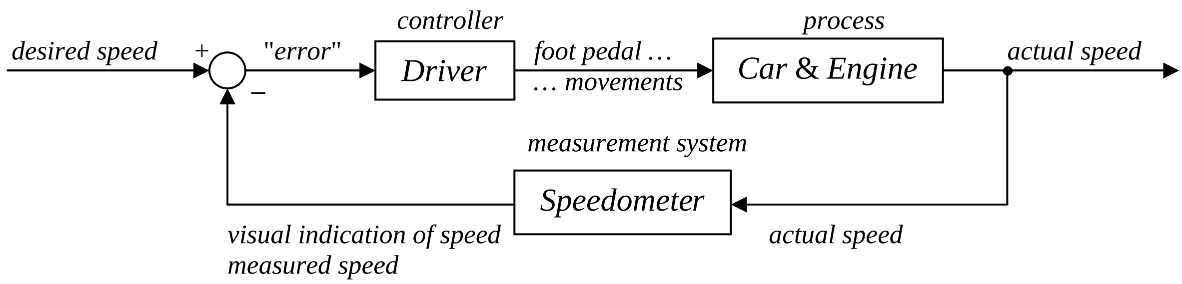
ACI-20016 Basic Course in Automation Technology
TUT Exercise 1 Problem 1

Compare with *controlling course of travel* .



Driver : brains, nerve system, feet

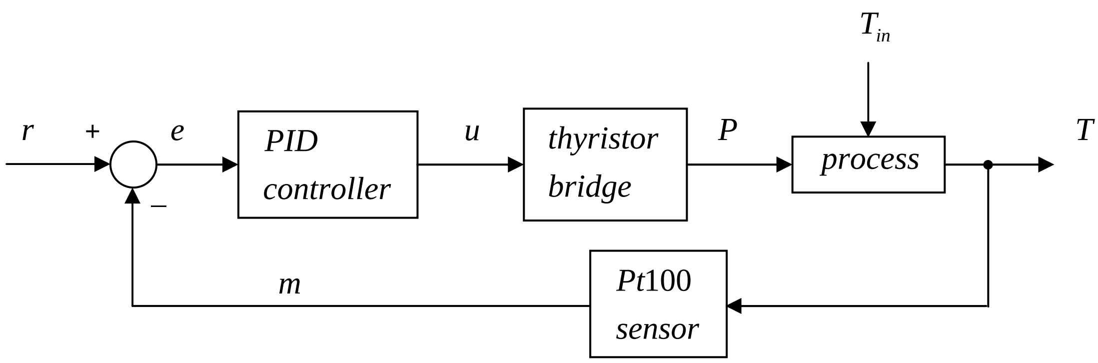
Other block diagrams may be possible ... both more detailed ones and rougher ones.

"*error*" = *actuating error* = *desired speed* – *measured speed*

control error = *desired speed* - *actual speed*

control error = *actuating error* + (*measured speed* - *actual speed*)

Think the heater as a part of the process. Without feedforward ... and showing the *actuating error* , which in reality is formed by the controller:



T	temperature of water inside the tank, *to be controlled*
r	*set point* (reference value, desired value, target value, goal) of temperature
T_{in}	temperature of the incoming cold water, *a disturbance*
m	*measurement* of outflow temperature
e	*actuating error,* $e = r - m$
u	*control input*
P	heating power

Measurement error $v_m = T - m$

Control Error $v = r - T$

Observe that these errors are not equal to each other:

$$e - v = (r - m) - (r - T) = r - m - r + T = T - m = v_m$$

Hence

$$e = v + v_m$$

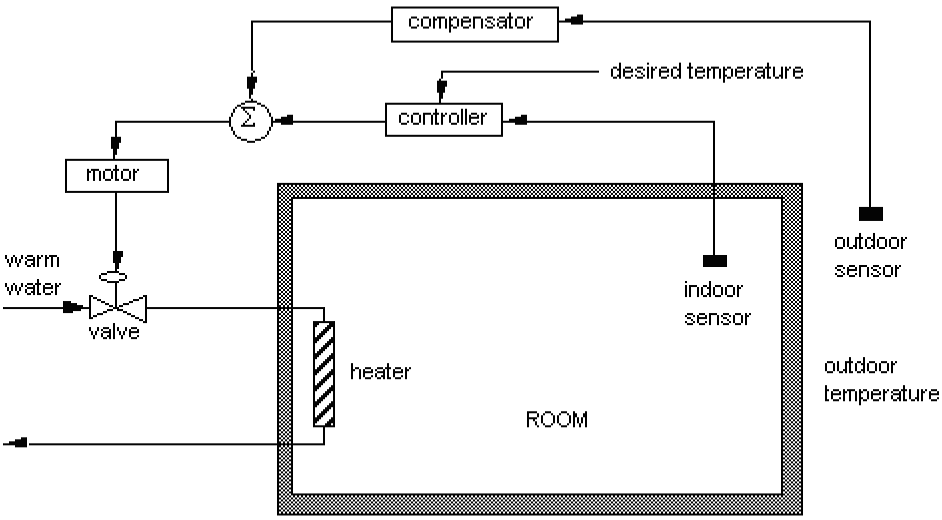
$$actuating\ \ error = control\ \ error + measurement\ \ error$$

The *unknown* control error would be a better input to the controller than the actuating error. However, these errors are close to each other, if the sensor (and the measurement system as whole) is fast and accurate enough. Therefore listen to the wishes of a measurement engineer, when he/she wants to purchase a better sensor!

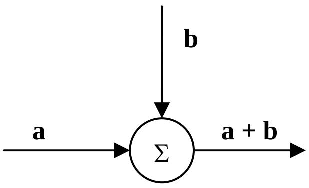
PS1. The "actuator" could also include both the thyristor bridge and the heater.
Then the process would include only the tank.

PS2. A measurement engineer likes a measurement system, the output of which follows the input signal, the variable to be measured, "in real time". A control engineer likes a closed loop system, the output of which follows the input, the set point, "in real time". Similar problems?

***Structure* diagram:**

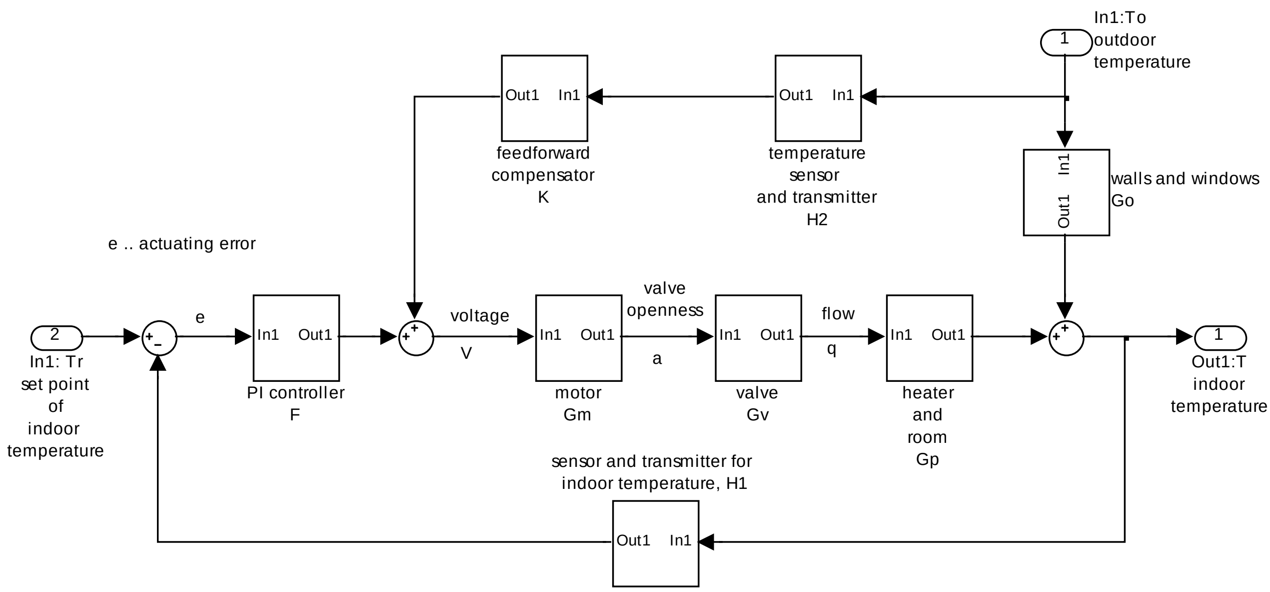


In several books as well as in some graphical interfaces of control and simulation software *summing* of *two functions* a , b is presented as follows:



This is used for both structure and block diagrams as well as for diagrams combining features of different diagrams.

***Block* diagrams**: a crude one could be documented from that of the lecture text (**L01.pdf**). Another block diagram built from *Simulink*-blocks (**Appendix B** of **DB**) displays *additions* and *subtractions* of functions:



Here the block diagrams *assume* , that the whole effect of the disturbance to the process output can be described by an *additive* part of the whole response. Many laymen and engineers find such intuitive assumptions natural while strictly taken some mathematical approximations are needed to justify them as we will se in **L02-L04**.

A typical *commercial PID controller* device combines both the *feedback* and *feedforward* control. This control principles could also be used in direct electrical heating.

Remark

Multivariable control strategies are often based on applying *feedforward* control : there some of the "disturbances" to an process output are ... *set points of the other process outputs*. *Example*:

Consider a tank with both a cold water inflow and a hot water outflow. Suppose that both the water level and the temperature inside the tank should be controlled. The level can be controlled by adjusting the inflow. That can be done by a **SISO** (*Single Input Single Output*) controller.

Unfortunately, level control will typically affect the temperature, since the increase of the level is obtained by feeding water in a unsuitable temperature. This disturbance effect can at least partially be compensated in advance by proper and early adjustment of the heating power ... using a *feedforward compensator*, the input of which is the measured or estimated inflow (or basically, the set point of the level since the inflow is chosen based on this set point!). Due to typical (*inaccuracy*) reasons we should also have feedback control for the temperature. Another **SISO** (feedback) controller is needed for that. Heating power can also be used to raise the temperature on possible demand.

An extra problem for motivation of you:

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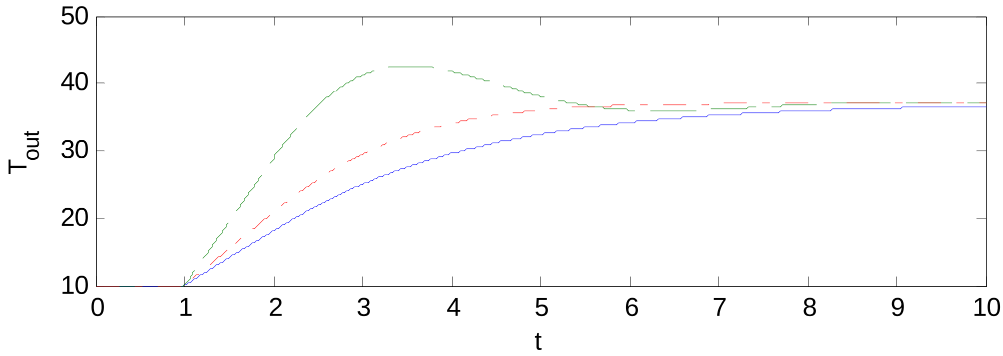
You will take a shower in the evening. How are you going to adjust the temperature? Draw a block diagram for temperature of water on your skin:

Make a practical test, i.e. take the shower. Which of the following *shapes* (curve form) did the water-on-skin temperature function T_{out} (of time t) have (here "*zero time*" is the start time) in your trial ? :



Welcome to *Lecture 02* to listen the theory of the curves and that of tea/coffee water cooking!