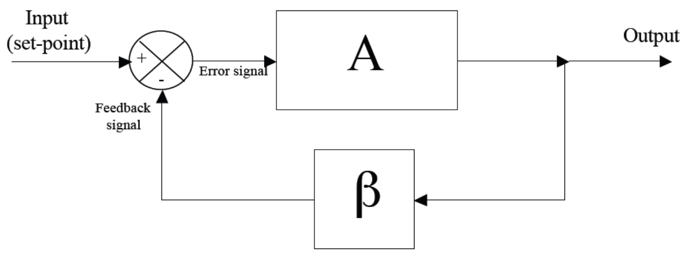
Summary of lecture 2 (28th November 2019)

Control systems, PID control, and Operational amplifiers

Generic negative-feedback control system:

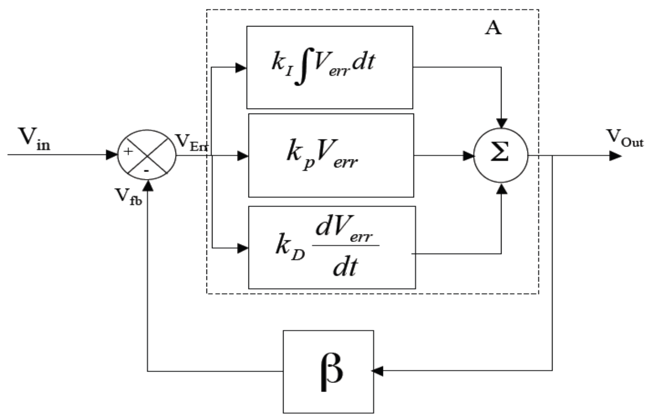


$$\frac{V_{out}}{V_{in}} = \frac{A}{1 + A\beta}$$

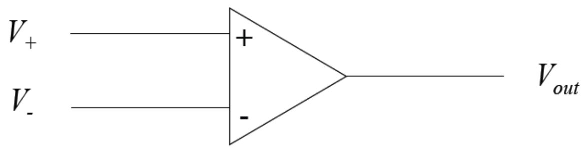
If the open-loop gain of the system is very high, such that $A\beta >> 1$ then the gain simplifies to $\frac{V_{out}}{V_{in}} = \frac{1}{\beta}$ so the gain depends only on the FEEDBACK term, not the open-loop gain.

PID control:

The ***proportional+differential+integral*** (PID) control system is an improvement to the 'bang-bang' (on-off) and proportional control systems.



The 'Operational amplifier' (op-amp):



$$V_{out} = A(V_+ - V_-)$$

The open-loop gain (A) of an op-amp is very large, ~10^5 – 10^8.

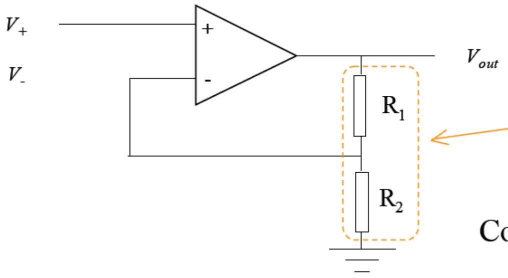
Note: Op-amps *also* require dc power connections to operate – these are often not shown on schematic circuit diagrams!

'Golden Rules' for op-amps with negative-feedback:

1. The output drives such that the inputs are at the same voltage
2. No current flows into the inputs
3. Loading does not affect the output

Note: these only apply for negative feedback with $A\beta >> 1$.

Non-inverting amplifier:



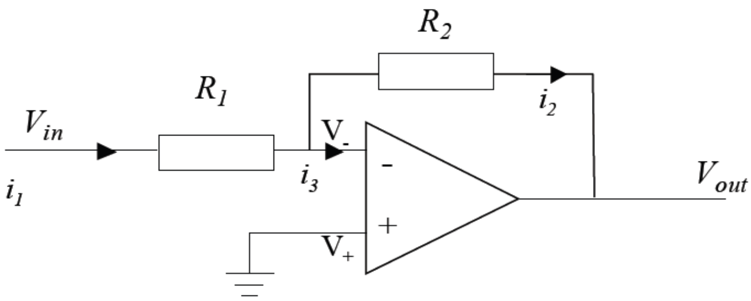
From potential-divider equation:

$$\beta = \frac{R_2}{R_1 + R_2}$$

Connect pot. divider to inverting input to give feedback…

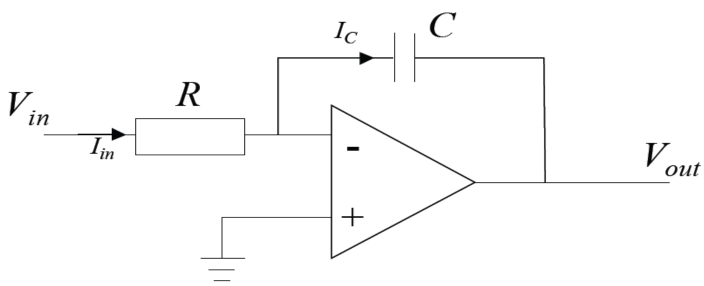
$$\text{Gain} = \frac{V_{out}}{V_{in}} = \frac{1}{\beta} = 1 + \frac{R_1}{R_2}$$

Inverting amplifier:



$$\text{Gain} = \frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1}$$

Integrator:



$$V_{out} = -\frac{1}{RC}\int V_{in}\,dt + V_{initial}$$