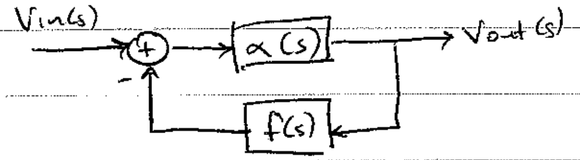
6.003 Recitation Friday March 19, Sections 3 & 4

Today: ① Basic principles of negative feedback
② The seven benefits of negative feedback
"Squirrels do love running swiftly in snow"

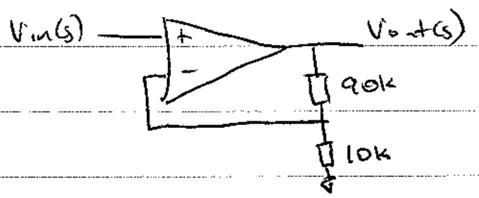


$$\frac{V_{out}(s)}{V_{in}(s)} = \frac{\alpha(s)}{1+\alpha(s)f(s)} = \frac{1}{f(s)}\,\frac{L(s)}{1+L(s)}, \quad \text{where } L(s)=\alpha(s)f(s)$$

If $L(s) \gg 1$, then $\left|\frac{L(s)}{1+L(s)}\right| \simeq 1$, independent of the exact value of $L(s)$,

thus $\frac{V_{out}(s)}{V_{in}(s)} \simeq \frac{1}{f(s)}$, indep. of the exact value of $\alpha(s)$.

Simple example:



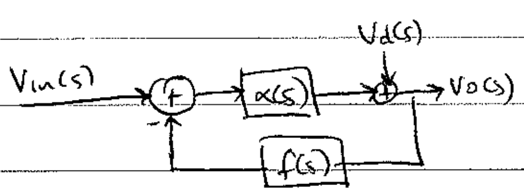
$$\frac{V_{out}}{V_{in}} = \frac{1}{0.1}\,\frac{\overbrace{10^4 \times 0.1}^{L(s)}}{10^4\times 0.1+1} = 9.999,$$

where $f(s) = 0.1$, $\alpha(s) = 10^4$

Now suppose $\alpha(s) = 10^5 \neq 10^4$, then $\frac{V_{out}}{V_{in}} = 9.9999$ [very similar because the loop transmission is large]

Benefit one: Sensitivity to $\alpha(s)$ is greatly reduced as long as $|\alpha(s)f(s)| \gg 1$.

Benefit two: Distortion and disturbance rejection at the output of the feedback loop.



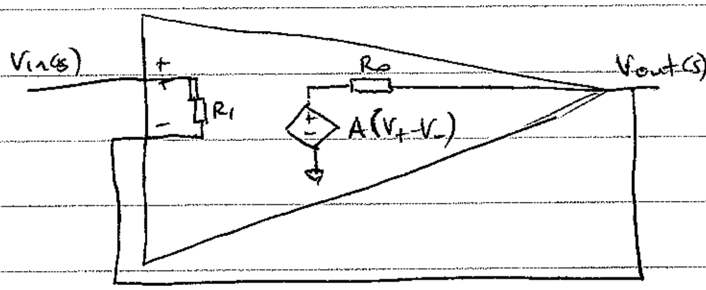
$$\frac{V_o(s)}{V_d(s)} = \frac{1}{1+\alpha(s)f(s)}$$

Benefit Three: Linearization of input-output transfer function with a linear $f(s)$ even if $\alpha(s)$ is nonlinear as long as $\alpha(s)f(s) >> 1$.

eg) lecture example of a power amplifier driven by a preamp.

Note: these nonlinearities can be viewed as disturbances from $\alpha(s)$.

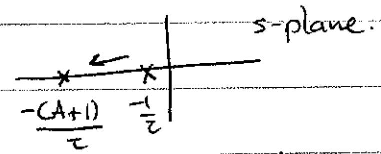
Benefit Four: Resistance or impedance transformations



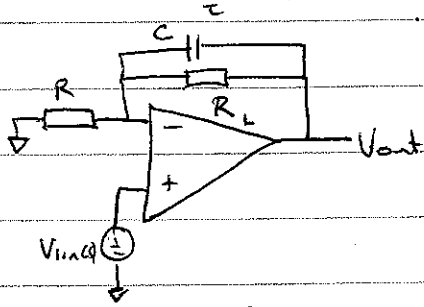
Closed-loop input impedance is $R_i(1+A)$ ← increased

Closed-loop output impedance is $\frac{R_o}{1+A}$ ← decreased.

Benefit Five: Speedup eg) in motors



Benefit Six: Inverse transfer functions



, $f(s) = \frac{R}{R + \frac{1}{sC}}$

Implement $1/f(s)$ with $f(s)$ in feedback path. $f(V_{out}) \simeq V_{in}$ [+ s − inputs almost equal].

Closed loop $= 1 + \frac{1}{RCs}$.

Benefit Seven: Stabilization of unstable systems. eg) - inverted pendulum

- magnetic levitation.