P3360 / AEP 3630

Lecture 10

Negative Feedback

Good amp :

- $R_{in} \gg R_s$
- $R_{out} \ll R_L$
- $G(\omega) = \text{const}$

"Bare" op-amp problems :

- small active range
- large G variations
- $G \propto \frac{1}{\omega}$ for $\omega_c \gtrsim 10\,\text{Hz}$
- Rout is fairly large

$v_{out} =$

- throw away ________________ to make a stable circuit, indep. of ________________

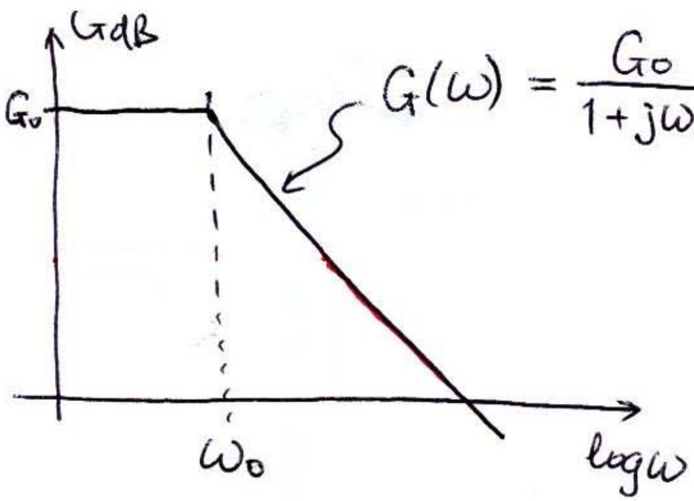
Advantages of negative F.B.

(1)

(2)

$(v_{in})_{active} =$

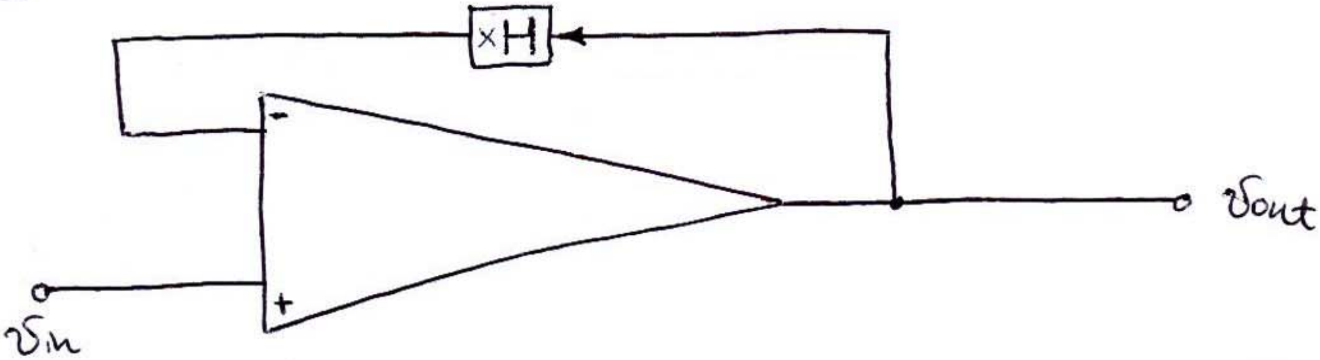
(3)



$$G(\omega) = \frac{G_0}{1 + j\omega/\omega_0}$$

$G_{CL} =$

(4)



$R_{in,CL} \equiv$

⑤

v_{out} =

v_{out} =

$R_{out,CL}$ =

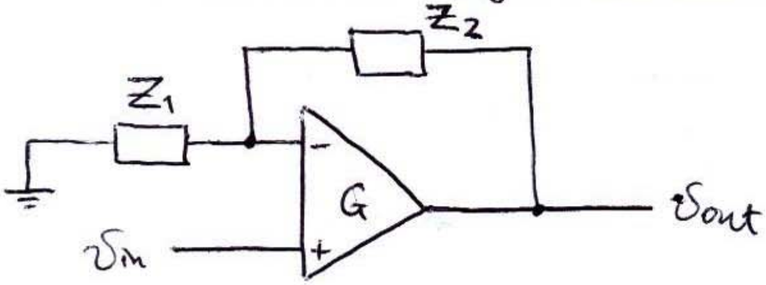
Rules for analyzing negative F.B circuits

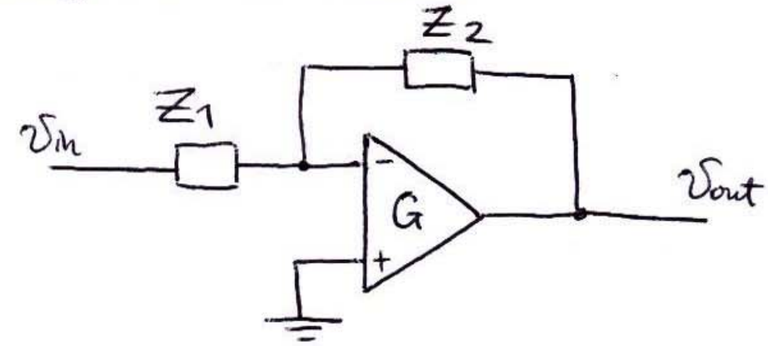
1) current rule :
2) voltage rule :

P3360/AEP 3630

Lecture 11

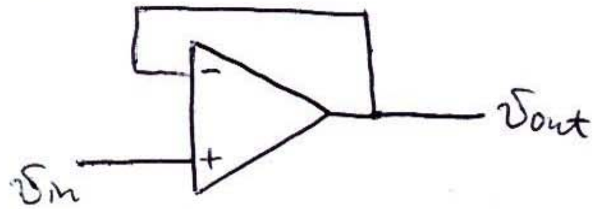
Two basic configurations with negative feedback





Applications of neg. feedback

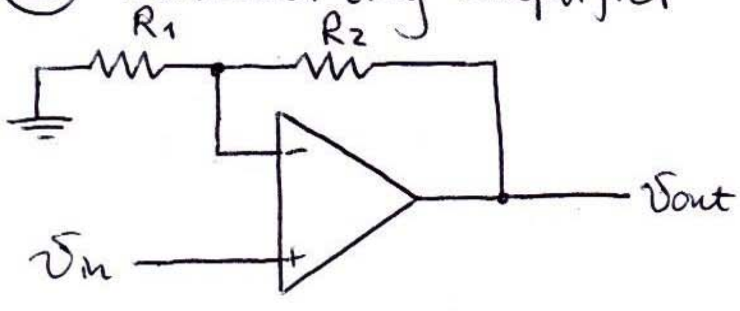
① voltage follower



$$G_{CL} = \frac{G}{1+GH} \approx 1 \quad , \; G \gg 1$$

- draws no current
- drive low Z load with high Z source

② noninverting amplifier

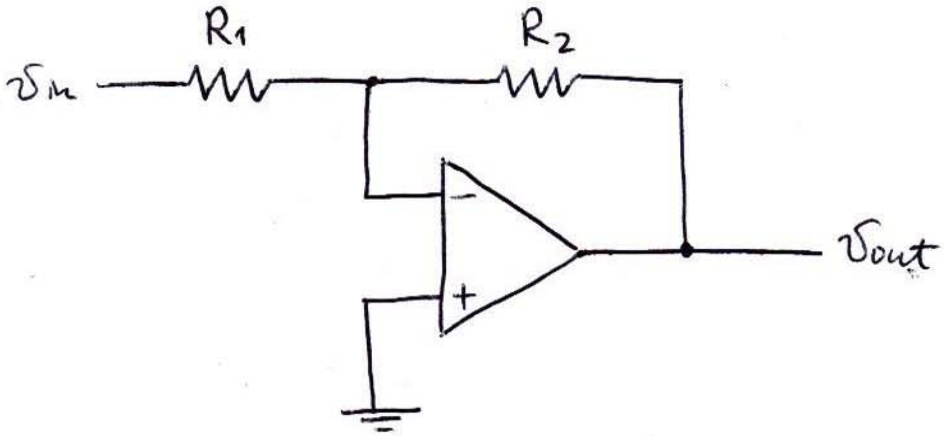


$$G_{CL} = \frac{R_1+R_2}{R_1}$$

$$R_{in,CL} = R_{in}(1+GH)$$

$$R_{out,CL} = \frac{R_{out}}{1+GH}$$

③ inverting amplifier



$$G_{CL} = -\frac{1}{H'} = -\frac{R_2}{R_1}$$

④ summing circuit

Active filters

Feedback network contains $Z(\omega)$

Pros:

-

-

-

Cons:

-

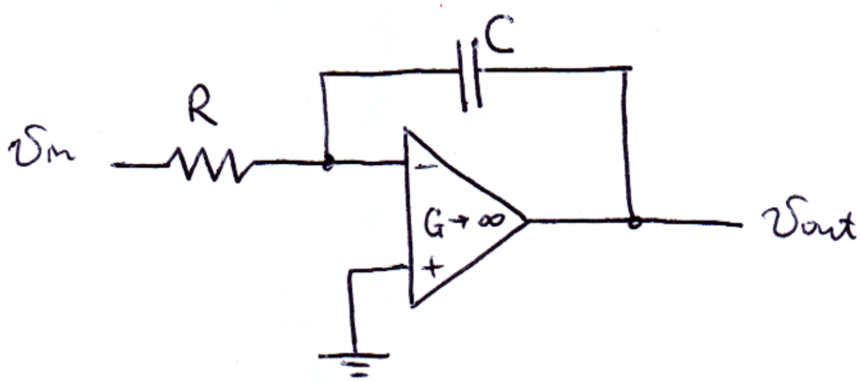
Q: ideal integrator & differentiator: poles & zeros of $G(s)$?

P3360/AEP3630

Lecture 12

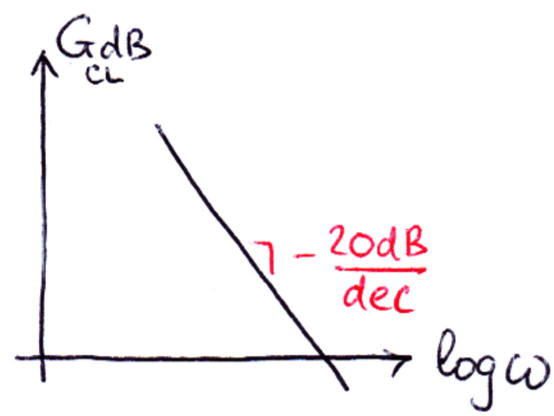
Integrator

$v_{out} \propto \int v_{in}\, dt \quad , \Rightarrow \quad G_{CL}(s) \propto$



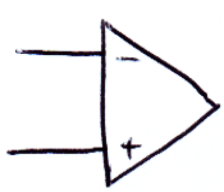
AC response :

$G_{CL}(\omega) =$

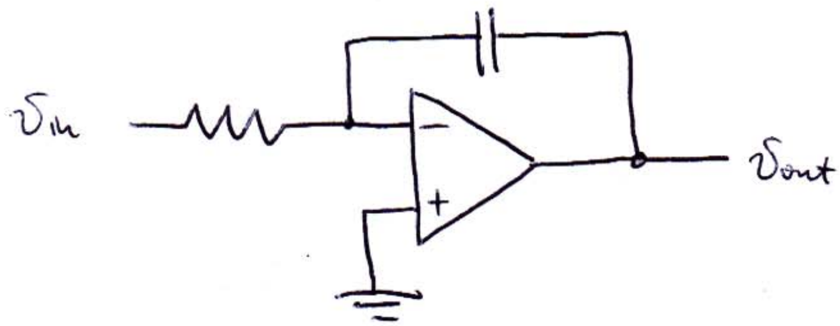


Problem 1 :

Problem 2 :

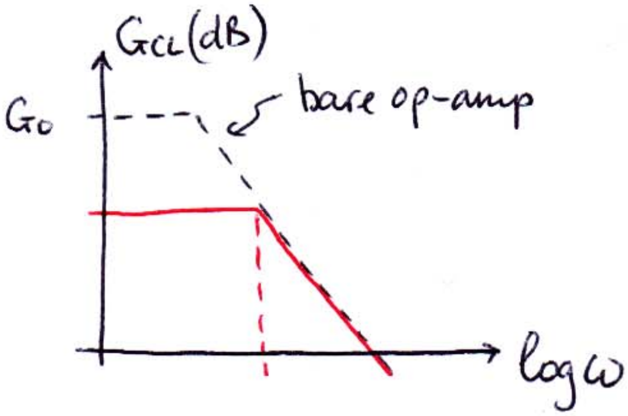


Leaky integrator



$G_{CL}(\omega) \approx$

$G_{CL}(\omega) =$

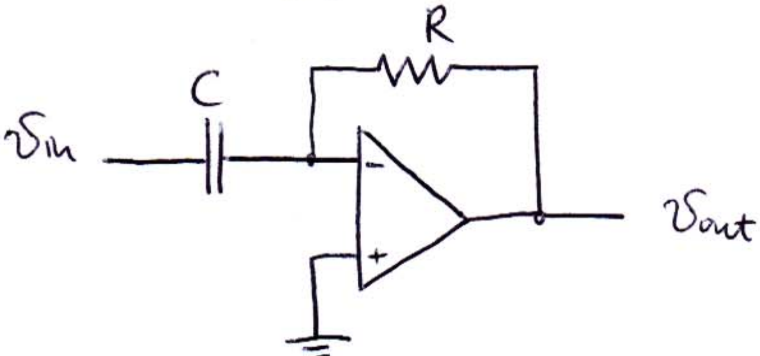


Pros:

Cons:

Differentiator

$v_{out} \propto \frac{d}{dt} v_{in}$, $\Rightarrow$ $G_{CL}(s) \propto$

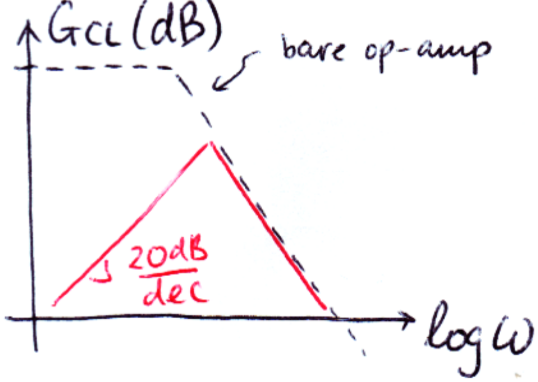


AC response:

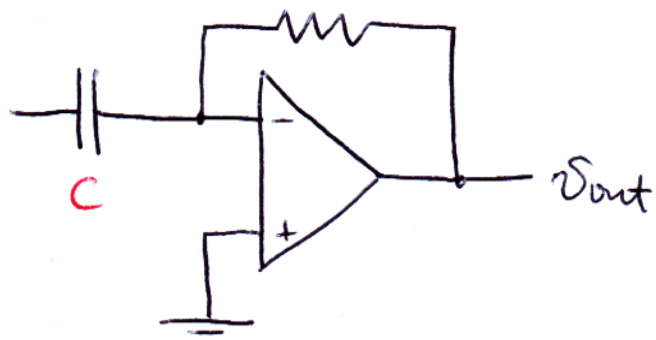
$G_{CL}(\omega) =$

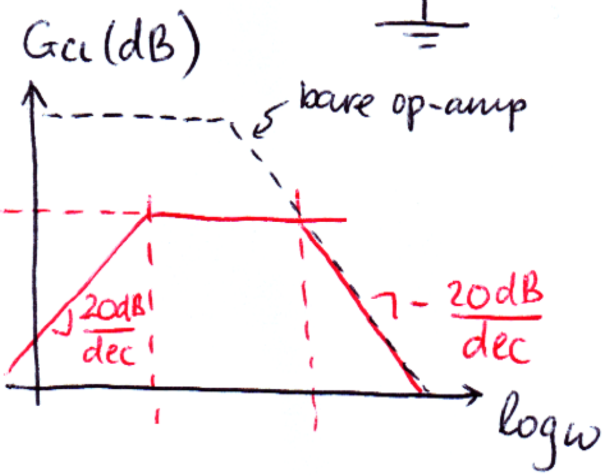
Problem :

(3)



Soln :

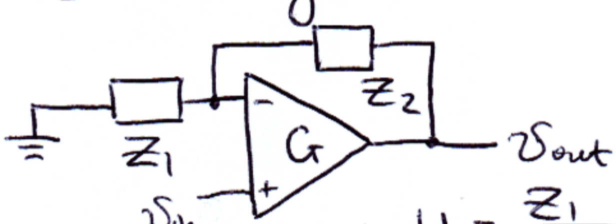




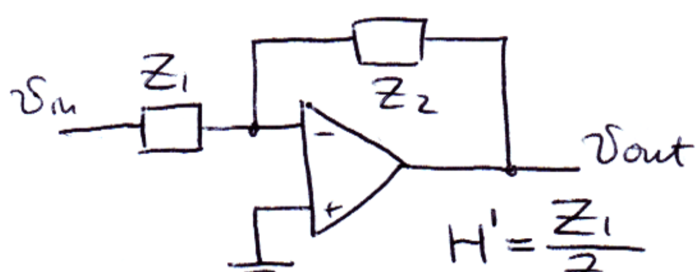
Pros:

Cons:

Stability



$H = \frac{Z_1}{Z_1 + Z_2}$

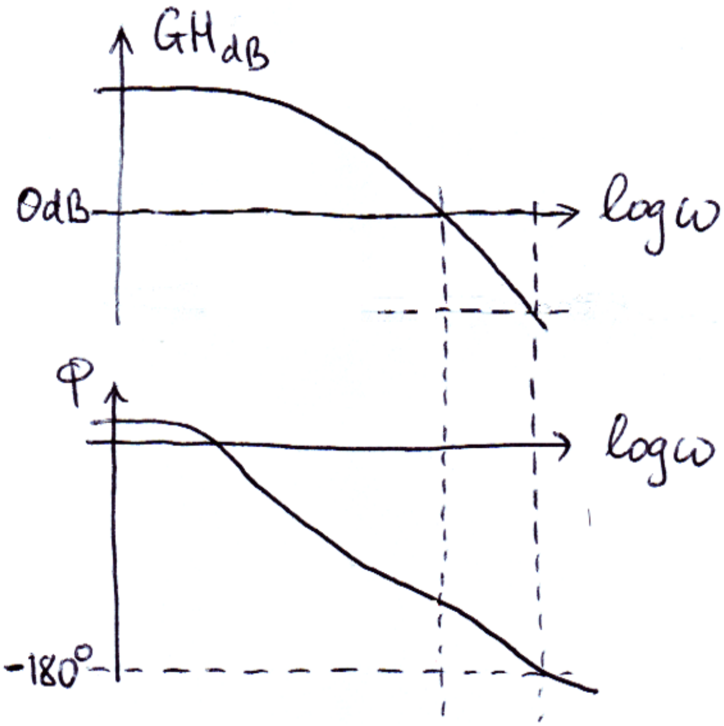


$H' = \frac{Z_1}{Z_2}$

$$G_{CL} = \frac{1}{H}\,\frac{1}{1+\frac{1}{GH}}$$

$$G_{CL} = -\frac{1}{H'}\,\frac{1}{\left(1+\frac{1}{G}\right)+\frac{1}{GH'}}$$

Phase & gain margins



Nyquist plots

Nyquist criterion of stability: