FEEDBACK CONCEPTS IN OP AMPS CIRCUITS

ECEN – 457 (ESS)

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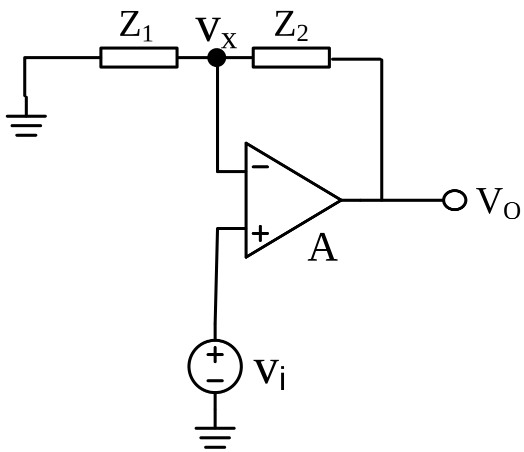
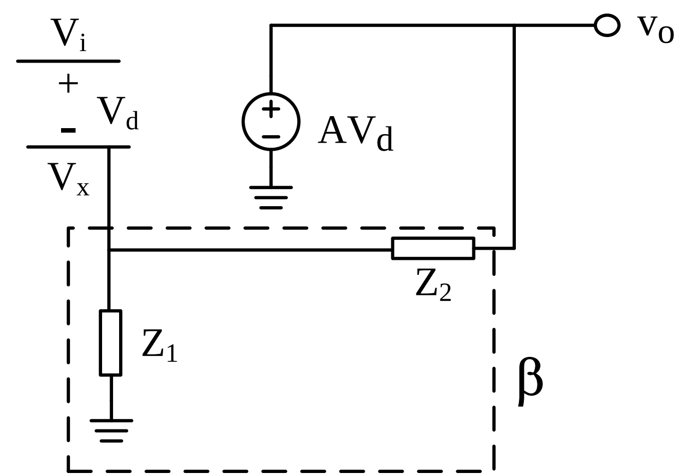


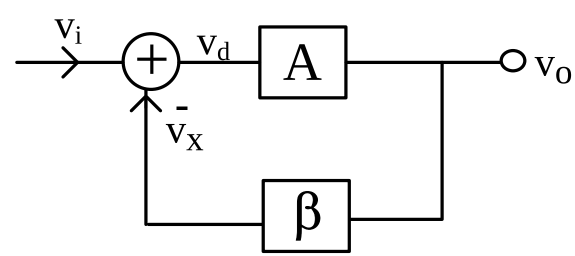
From Circuit

$$A_{\substack{\text{Closed}\\ \text{Loop}}} = \frac{1+\dfrac{Z_2}{Z_1}}{1+\dfrac{1}{A}\left(1+\dfrac{Z_2}{Z_1}\right)} \qquad (1)$$

Where

$$\beta = \left(1+\frac{Z_2}{Z_1}\right)^{-1}$$





From Block Diagram

$$A_{CL} = \frac{v_o}{v_i} = \frac{A}{1+\beta A} \qquad (2)$$

$$\frac{v_o}{v_i} = \frac{A}{1+T} \quad ; \quad T = \beta A$$

From (1)

$$A_{\substack{\text{Closed}\\\text{Loop}}} = \frac{\frac{1}{\beta}}{1+\frac{1}{A\beta}} = \frac{A}{1+A\beta}$$

$$A_{\substack{\text{Closed}\\\text{Loop}}} = A_{CL} = \left.\frac{A}{1+A\beta}\right|_{A\beta>>1} \cong \frac{A}{A\beta} = \frac{1}{\beta} = 1+\frac{Z_2}{Z_1}$$

Sensitivity Concept

$$S_x^f = \frac{\partial f}{\partial x}\frac{x}{f}$$

This will be a metric to discuss effects of process variations on closed loop gain.

Let $f = A_{CL}$ and $x = A$, thus

$$S_A^{A_{CL}} = \frac{\partial A_{CL}}{\partial A} \frac{A}{A_{CL}}$$

$$\frac{\partial A_{CL}}{\partial A} = \frac{(1+\beta A) - A\beta}{(1+\beta A)^2} = \frac{1}{(1+\beta A)^2}$$

$$S_A^{A_{CL}} = \frac{1}{(1+\beta A)^2} \frac{A}{\frac{A}{1+\beta A}} = \frac{1}{1+\beta A} = \frac{1}{1+T}$$

We can write also as

$$\frac{\Delta A_{CL}}{A_{CL}} \cong S_A^{A_{CL}} \frac{\Delta A}{A}$$

EXAMPLE: We want to know how much change in the closed loop gain will occur due to changes in the feedback component or/and in the open loop gain A.

$A = 10^5$

$\Delta A = \pm 10\%$

$\beta = 10^{-3}$, $T = A\beta = 10^2$

Thus

$$\frac{\Delta A_{CL}}{A_{CL}} = \frac{1}{1+T}\left(\frac{\pm \Delta A}{A}\right) = \frac{\pm 1}{1+100} \times 10\% = \pm 0.099\%$$

Exercise. Try for $\beta = 4 \times 10^{-3}$, $A = 2 \times 10^5$ and $\Delta A = \pm 25\%$

What is

$\frac{\Delta A_{CL}}{A_{CL}}$?