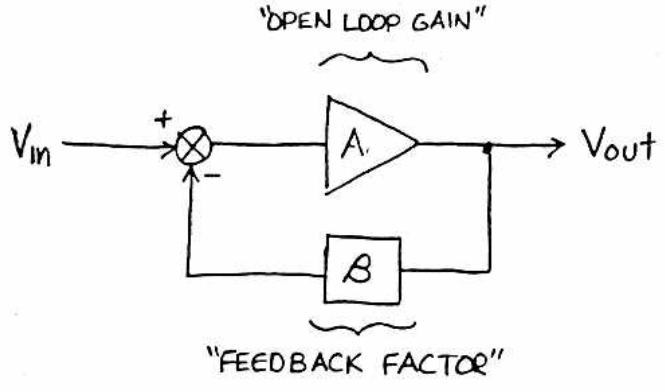
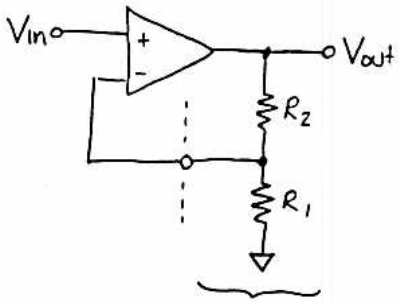
EE3204

OP-AMP as a classical feedback system





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

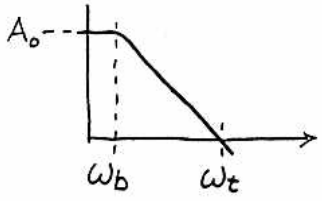
Equation around loop; A finite

"CLOSED LOOP GAIN"

$$V_{out} = A(V_{in} - \beta V_{out}) \Rightarrow \boxed{\frac{V_{out}}{V_{in}} = \frac{A}{1 + A\beta}} \Rightarrow \frac{1}{\beta} \text{ as } A \to \infty$$

Real op-amp has a single pole (STC) transfer function:

$$A = A(s) = \frac{A_o}{1 + \frac{s}{\omega_b}}$$



Substitute

$$\frac{V_{out}}{V_{in}} = \frac{\frac{A_o}{1 + s/\omega_b}}{1 + \frac{A_o\beta}{1 + s/\omega_b}} \Rightarrow \boxed{\frac{V_{out}}{V_{in}} = \frac{\left(\frac{A_o}{1 + A_o\beta}\right)}{1 + \frac{s}{[(1 + A_o\beta)\omega_b]}}}$$

From general lowpass form:

LOW FREQUENCY CLOSED LOOP GAIN

$$A_{CL} = \frac{A_o}{1 + A_o\beta} \to \frac{1}{\beta} \text{ as } A_o \to \infty$$

CLOSED LOOP 3dB FREQUENCY

$\omega_{3dB} = (1 + A_o\beta)\omega_b$ ω_b INCREASED BY FACTOR $(1 + A_o\beta)$

"GAIN-BANDWIDTH PRODUCT"

$$A_{CL} \times \omega_{3dB} = \left(\frac{A_o}{\cancel{1 + A_o\beta}}\right)(\cancel{1 + A_o\beta})\omega_b = A_o\omega_b \boxed{= \omega_t}$$

INDEPENDENT OF CLOSED LOOP GAIN!

CLOSED LOOP BANDWIDTH	×	CLOSED LOOP GAIN	=	GAIN-BANDWIDTH PRODUCT

(CONSTANT FOR A GIVEN OP-AMP)

FOR LM741, f_t = 1 MHz

FOR LM318, f_t = 15 MHz