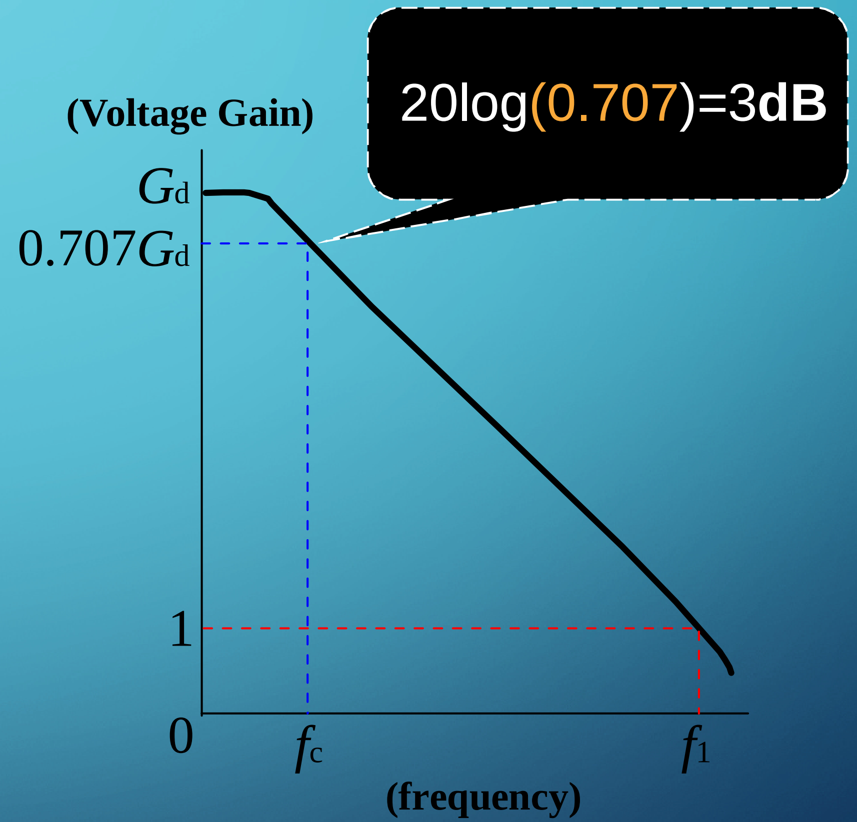
NETWORK THEORY

LECTURE 8

SECTION-D :NETWORK SYNTHESIS

FREQUENCY-GAIN RELATION

- Ideally, signals are amplified from DC to the highest AC frequency
- Practically, bandwidth is limited
- 741 family op-amp have an limit bandwidth of few KHz.
- Unity Gain frequency f_1: the gain at unity
- Cutoff frequency f_c: the gain drop by 3dB from dc gain G_d



GB Product : $f_1 = G_d f_c$

GB PRODUCT

Example: Determine the cutoff frequency of an op-amp having a unit gain frequency f_1 = 10 MHz and voltage differential gain G_d = 20**V**/m**V**

Sol:

Since f_1 = 10 MHz

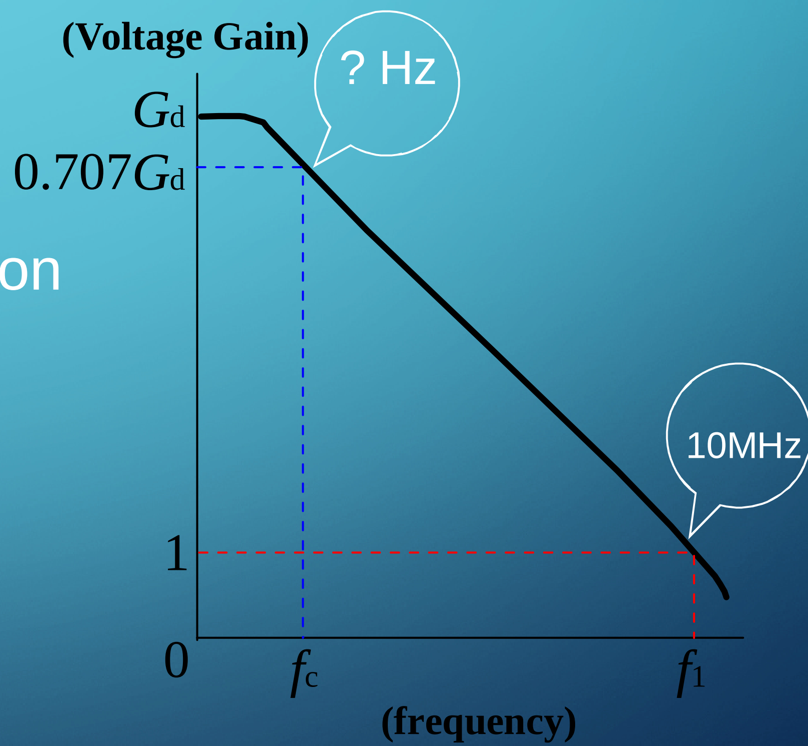
By using GB production equation

$$f_1 = G_d \, f_c$$

$f_c = f_1 / G_d$ = 10 MHz / 20 V/mV

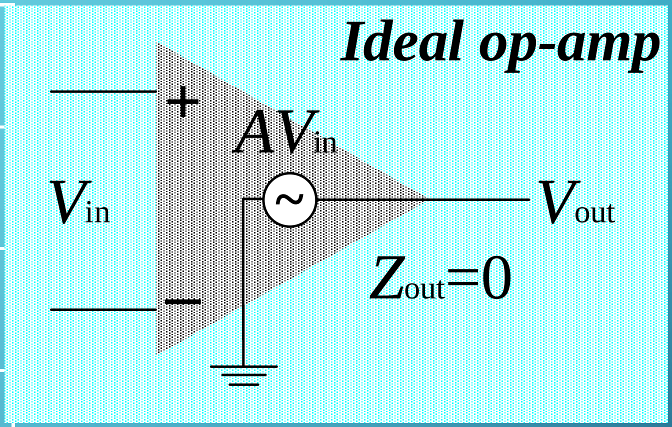
$= 10 \times 10^6 / 20 \times 10^3$

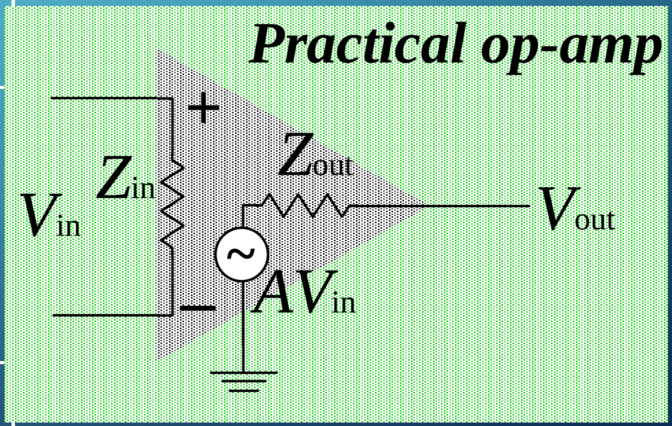
= 500 Hz



IDEAL VS PRACTICAL OP-AMP

	Ideal	Practical
Open Loop gain *A*	$\propto$	10^5
Bandwidth *BW*	$\propto$	10-100Hz
Input Impedance Z_{in}	$\propto$	>1MΩ
Output Impedance Z_{out}	0 Ω	10-100 Ω
Output Voltage V_{out}	Depends only on $V_d = (V_+ - V_-)$ Differential mode signal	Depends slightly on average input $V_c = (V_+ + V_-)/2$ Common-Mode signal
CMRR	$\propto$	10-100dB





IDEAL OP-AMP APPLICATIONS

Analysis Method :

Two ideal Op-Amp Properties:

(1) The voltage between V_+ and V_- is zero $V_+ = V_-$

(2) The current into both V_+ and V_- termainals is zero

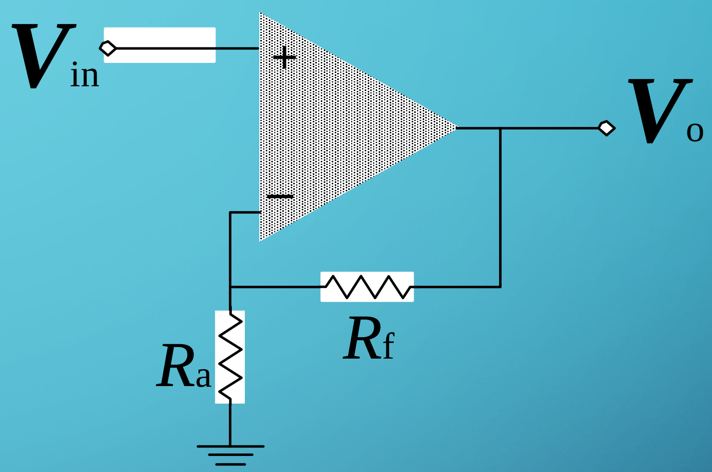
For ideal Op-Amp circuit:

(1) Write the kirchhoff node equation at the noninverting terminal V_+

(2) Write the kirchhoff node eqaution at the inverting terminal V_-

(3) Set $V_+ = V_-$ and solve for the desired closed-loop gain

Noninverting Amplifier



(1) Kirchhoff node equation at V_+ yields, $V_+ = V_i$

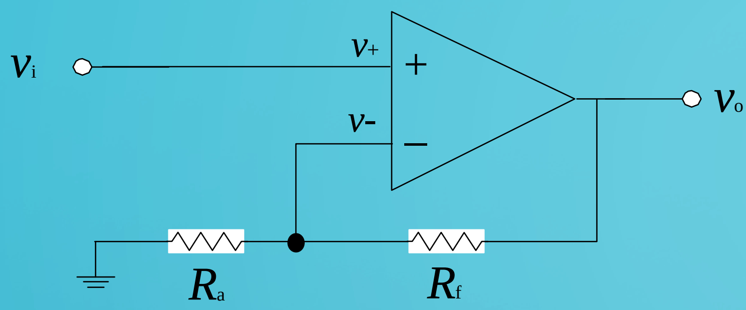
(2) Kirchhoff node equation at V_- yields, $\frac{V_- - 0}{R_a} + \frac{V_- - V_o}{R_f} = 0$

(3) Setting $V_+ = V_-$ yields

$$\frac{V_i}{R_a} + \frac{V_i - V_o}{R_f} = 0$$

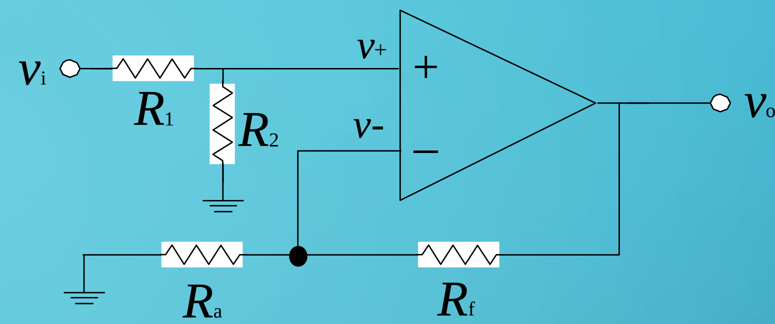
or

$$\frac{V_o}{V_i} = 1 + \frac{R_f}{R_a}$$



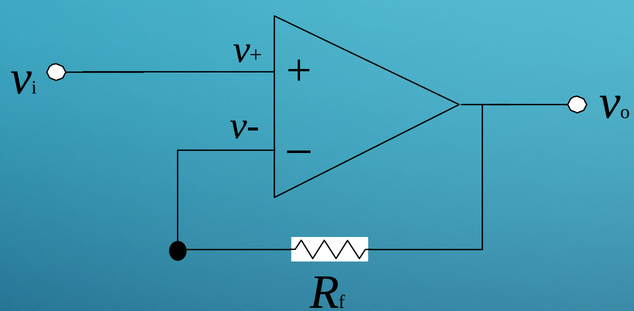
Noninverting amplifier

$$v_o = (1 + \frac{R_f}{R_a}) v_i$$



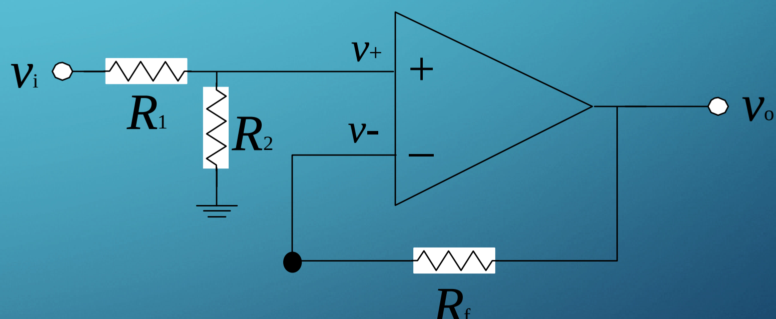
Noninverting input with voltage divider

$$v_o = (1 + \frac{R_f}{R_a})(\frac{R_2}{R_1 + R_2}) v_i$$



Voltage follower

$$v_o = v_i$$



Less than unity gain

$$v_o = \frac{R_2}{R_1 + R_2} v_i$$