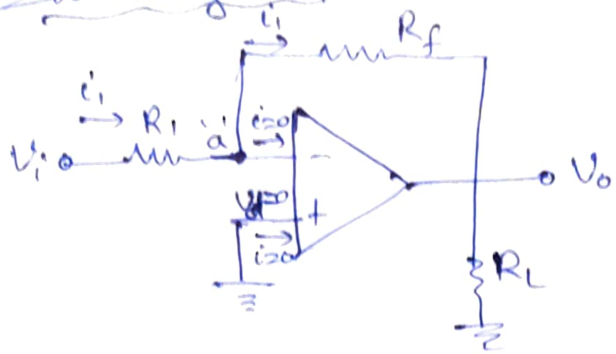
Inverting Amplifier



→ For simplicity, assume an ideal op-amp

→ As $V_d = 0$, node 'a' is at ground potential & the ~~current~~ i_1 through R_1 is

$$i_1 = \frac{V_i}{R_1}$$

→ Since op-amp draws no current, all the current flowing through R_1 must flow through R_f

→ The o/p voltage

$$V_o = -i_1 R_f = -V_i \frac{R_f}{R_1}$$

→ The gain of inverting amplifier (also referred as closed loop gain) is

$$A_{CL} = \frac{V_o}{V_i} = -\frac{R_f}{R_1}$$

→ The negative sign indicates a phase shift of 180° between V_i and V_o

$$\frac{V_a - V_i}{R_1} + \frac{V_a - V_o}{R_f} = 0$$

Since $V_a = 0$

$$\frac{-V_i}{R_1} + \frac{-V_o}{R_f} = 0$$

$$\Rightarrow \frac{V_o}{V_i} = A_{CL} = \frac{-R_f}{R_1}$$

→ Since inverting i/p terminal is at virtual ground, the effective i/p impedance is R_1

→ If resistances R_i and R_f are replaced by impedances Z_1 and Z_f respectively then the voltage gain, A_{CL} will be $A_{CL} = -\frac{Z_f}{Z_i}$

→ This expression for voltage gain ~~of ~~ it will be used in op-amp applications, such as integrator, differentiator, etc.

Q → Design an amplifier with a gain of −10 and i/p resistance equal to 10kΩ

$R_1 = 10K\Omega$

$A_{CL} = -10$

$R_f = -A_{CL} R_i = -(-10)\times 10K = 100K\Omega$

Q. If $R_1 = 10\,k\Omega$, $R_f = 100\,k\Omega$, $V_i = 1V$. A load of $25\,k\Omega$ is connected to o/p terminal. Calculate (i) i_1 (ii) V_o (iii) i_L and total current i_o into the o/p pin

(a) $i_1 = \frac{V_i}{R_1} = \frac{1V}{10\,k\Omega} = 0.1\,mA$

(b) $V_o = -\frac{R_f}{R_1} V_i = -\frac{100k}{10k} \times 1 = -10V$

(c) $i_L = \frac{V_o}{R_L} = \frac{10V}{25\,k\Omega} = 0.4\,mA$ $(\uparrow)$

(d) $i_o = i_1 + i_L = 0.5\,mA$ $(\leftarrow)$