Solutions to Quiz-1 paper (Group-A) IEC103.

Q1 Consider an amplifier operating from $\mp 10V$ power supplies. It is fed with a sinusoidal voltage having 1V peak and delivers a sinusoidal voltage output of 9V peak to a $1K\Omega$ load. The amplifier draws a current of 9.5 mA from each of its two power supplies. The input current of the amplifier is found to be sinusoidal with 0.1 mA peak. Find the voltage gain (in dB), the current gain (in dB), the power gain (in dB), the power drawn from the dc supplies, the power dissipated in the amplifier, and the amplifier efficiency.

Sol. $A_V = \frac{9}{1} = 9 \text{ V/V}$

or $A_V = 20\log(9) = 19.1 \text{ dB}$

$I_{o\,(peak)} = \frac{9V}{1K\Omega} = 9 \text{ mA (peak)}$

$A_i = \text{current gain} = \frac{I_o\,(peak)}{I_i\,(peak)} = \frac{9}{0.1} = 90 \text{ A/A}$

or $A_i = 20\log(90) = 39.1 \text{ dB}$

$P_L = V_o(rms)\, I_o(rms) = \frac{9}{\sqrt{2}} \times \frac{9\times10^{-3}}{\sqrt{2}} = 40.5 \text{ mW}$

$P_I = V_i(rms)\, I_i(rms) = \frac{1}{\sqrt{2}} \times \frac{0.1\times10^{-3}}{\sqrt{2}} = 0.05 \text{ mW}$

$A_p = \frac{P_L}{P_I} = \frac{40.5}{0.05} = 810 \text{ W/W} = 10\log(810) \text{ dB} = 29.1 \text{ dB}$

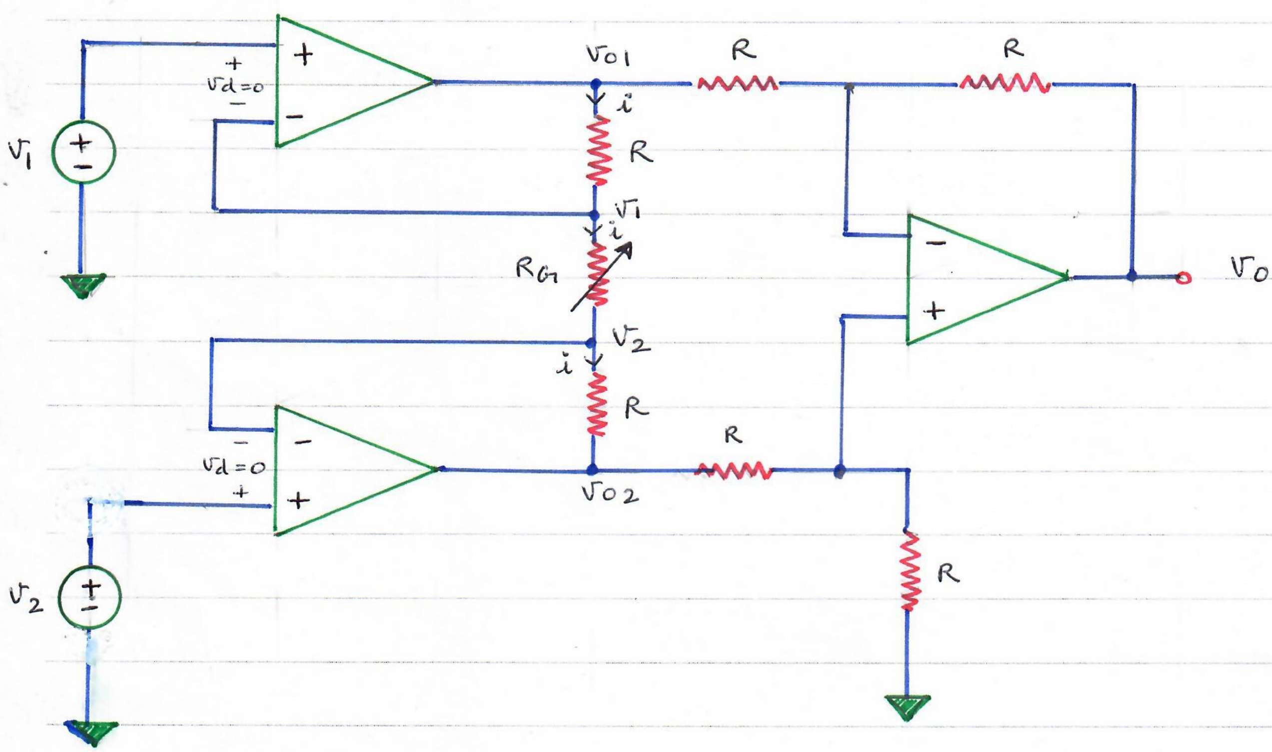
$P_{dc} = 10\times9.5\times10^{-3} + -10\times(-9.5\times10^{-3}) = 190 \text{ mW}$

$P_{dissipated} = P_{dc} + P_I - P_L = 190 + 0.05 - 40.5 = 149.6 \text{ mW}$

$\eta = \frac{P_L}{P_{dc}} \times 100 = 21.3\%$

Q2) Draw the circuit of an instrumentation amplifier (using op-amps) and derive the expression for the output voltage in terms of input voltages.

Sol. The circuit diagram of an instrumentation amplifier is as shown below.



$$V_o = -\frac{R}{R} V_{01} + \left(\frac{R}{R+R}\right) V_{02} \times \left(1 + \frac{R}{R}\right)$$

$$V_o = -V_{01} + \frac{1}{2} \times 2 \times V_{02} = V_{02} - V_{01}$$

$$i = \frac{V_1 - V_2}{R_G} = \frac{V_{01} - V_{02}}{R + R_G + R} = \frac{V_{01} - V_{02}}{R_G + 2R}$$

$$\Rightarrow \quad V_{01} - V_{02} = \frac{R_G + 2R}{R_G} (V_1 - V_2) = \left(1 + \frac{2R}{R_G}\right)(V_1 - V_2)$$

but $\boxed{V_o = V_{02} - V_{01} = \left(1 + \frac{2R}{R_G}\right)(V_2 - V_1)}$

Q3) Derive the transfer function of the circuit shown in Fig. Q3 and draw the asymptotic bode plot of the output voltage as the frequency of the input sinusoidal voltage is varied from 0 to ∞. What type of filter is it? what is the cut-off frequency?

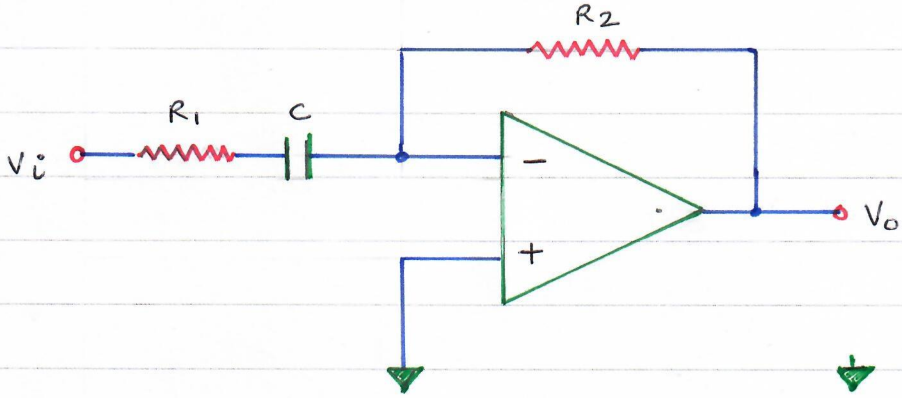
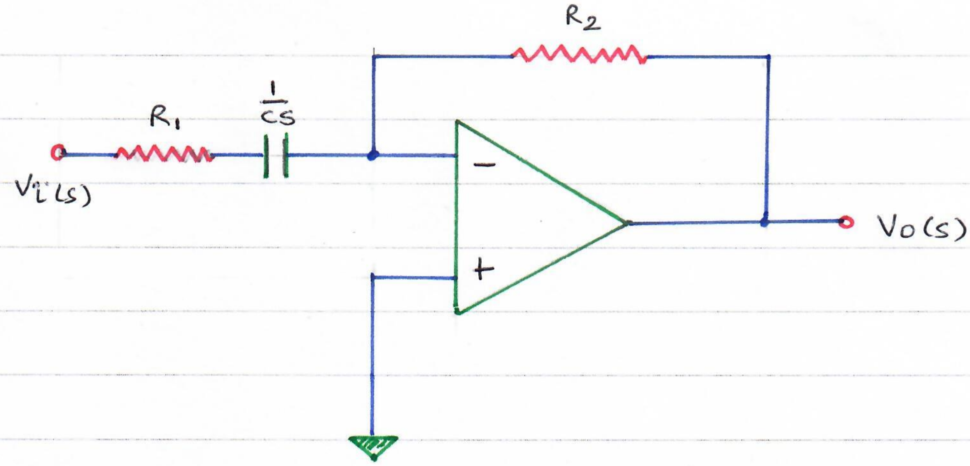


Fig. Q3

Sol.



$s = j\omega$

$Z_F(s) = R_2$

The above circuit is an inverting amplifier with $Z_f(s) = R_2$ and $Z_1(s) = (R_1 + 1/cs)$. and $\dfrac{V_o(s)}{V_i(s)} = \dfrac{-Z_f(s)}{Z_1(s)}$

$$V_o(s) = \frac{-R_2}{(R_1 + 1/cs)} V_i(s)$$

Transfer function $= H(s) = \dfrac{V_o(s)}{V_i(s)} = \dfrac{-R_2}{(R_1 + 1/Cs)}$

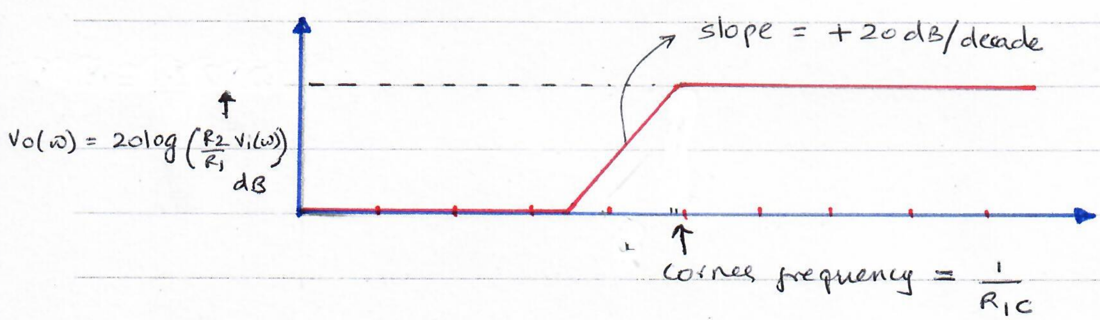
$$\Rightarrow H(j\omega) = \frac{-R_2}{R_1 + \frac{1}{j\omega C}}$$

$$|H(\omega)| = \left| \frac{-j\omega R_2 C}{1 + j\omega R_1 C} \right| = \frac{\omega R_2 C}{\sqrt{1 + (\omega R_1 C)^2}}$$

when $\omega = 0$ $|H(j\omega)| = 0$ and when $\omega = \infty$, $|H(j\omega)| = \frac{R_2}{R_1}$

The corner frequency of the circuit is $\frac{1}{R_1 C}$

The frequency response of the circuit is as given below.



Asymptotic bode plot

The circuit is a high pass filter.