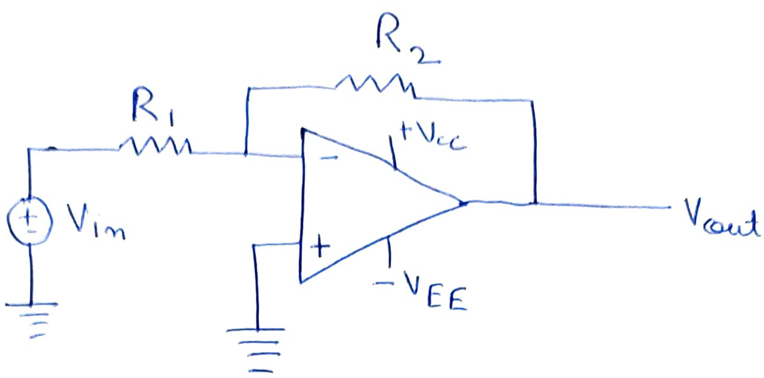
Analog Electronics Quiz-2 Solutions

Q1

a)



Inverting Amplifier

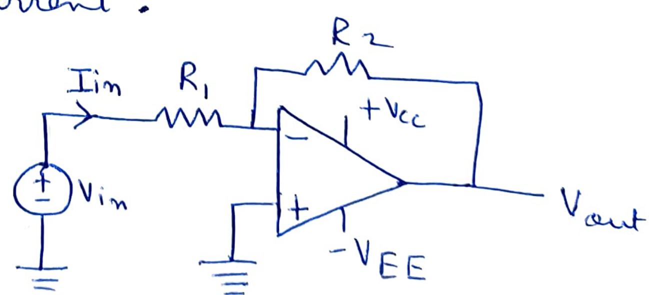
b) Using the 2 golden rules of OP-Amps we can write the following KCL equations for the circuit given above

$$\frac{V_{in} - 0}{R_1} = \frac{0 - V_{out}}{R_2}$$

$$\Rightarrow \boxed{\frac{V_{out}}{V_{in}} = -\frac{R_2}{R_1}} \Rightarrow \text{Gain of the inverting amplifier}$$

c) Input impedance is defined as the ratio of input source voltage and input source current.

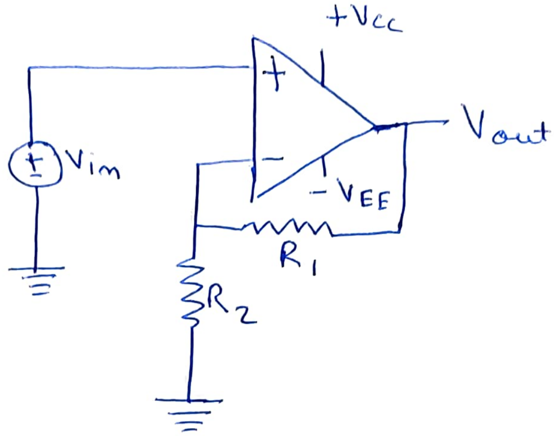
$$\Rightarrow Z_{in} = \frac{V_{in}}{I_{in}}$$



For the given circuit $I_{in} = \frac{V_{in} - 0}{R_1} \Rightarrow \frac{V_{in}}{I_{in}} = R_1 = Z_{in}$

Hence input impedance for inverting amplifier $= R_1$

d)



Non-Inverting Amplifier

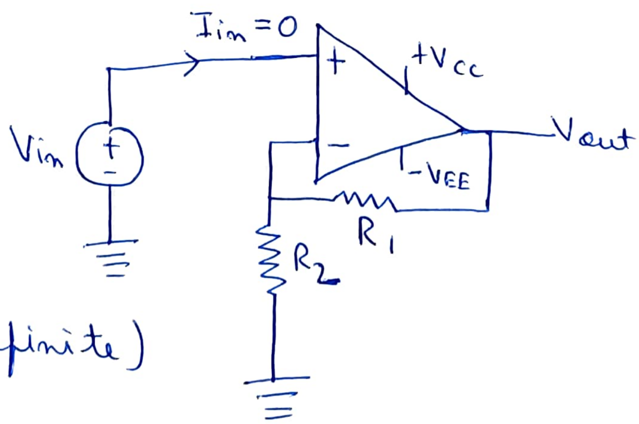
e) Using the 2 golden rules of OP-Amps we can write the following equation

$$V_{in} = \frac{R_2 \, V_{out}}{R_1 + R_2}$$

$$\Rightarrow \boxed{\frac{V_{out}}{V_{in}} = 1 + \frac{R_1}{R_2}}$$

f) Input impedance will be defined for Non inverting amplifier circuit as

$$Z_{in} = \frac{V_{in}}{I_{in}}$$



From Golden rule of OP-Amp, $I_{in} = 0$

Hence $Z_{in} = \infty$ (Infinite)

Hence a non inverting amplifier has infinite input impedance.

Q2

a) For the input bias current to be minimum for the given circuit, the equivalent impedances at both the input terminals of the OPAmp must be same.

Equivalent impedance at inverting terminal $= \dfrac{R_1 R_2}{R_1 + R_2}$

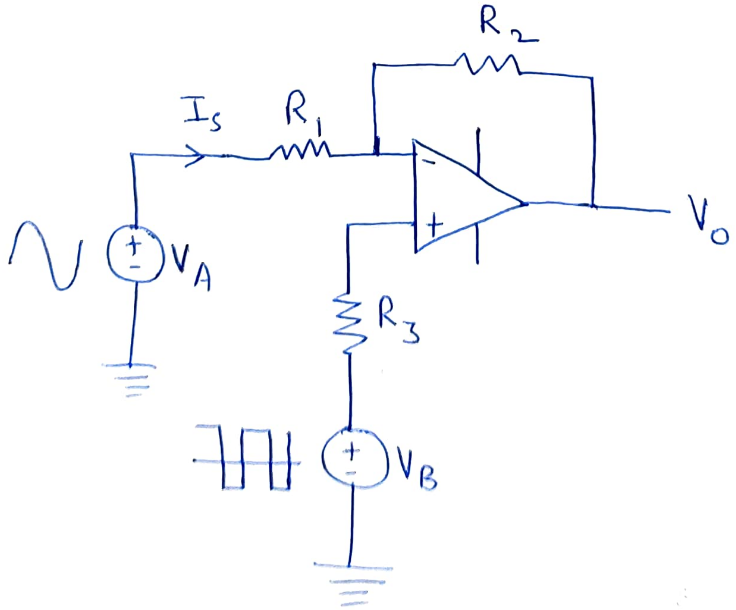
Equivalent impedance at non inverting terminal $= R_3$

For minimum input bias current, $R_3 = \dfrac{R_1 R_2}{R_1 + R_2}$

$$\Rightarrow R_3 = \frac{10\,k\Omega \times 90\,k\Omega}{100\,k\Omega}$$

$$\Rightarrow R_3 = 9\,k\Omega$$

b)



Using 2 Golden rules of OP-Amps we can express I_s as

$$I_s = \frac{V_A - V_B}{R_1}$$

$$V_A = \sin 2000\pi t$$

$$V_B = 0.5\, sgn\left(\sin(2\pi \times 500\, t)\right) = 0.5\, sgn\left(\sin(1000\pi t)\right)$$

$$R_1 = 10\, k\Omega$$

$$\boxed{I_s(t) = \frac{\sin(2000\pi t) - 0.5\, sgn\left(\sin(1000\pi t)\right)\ V}{10^4\, \Omega}}$$

Here sgn represent sign function.

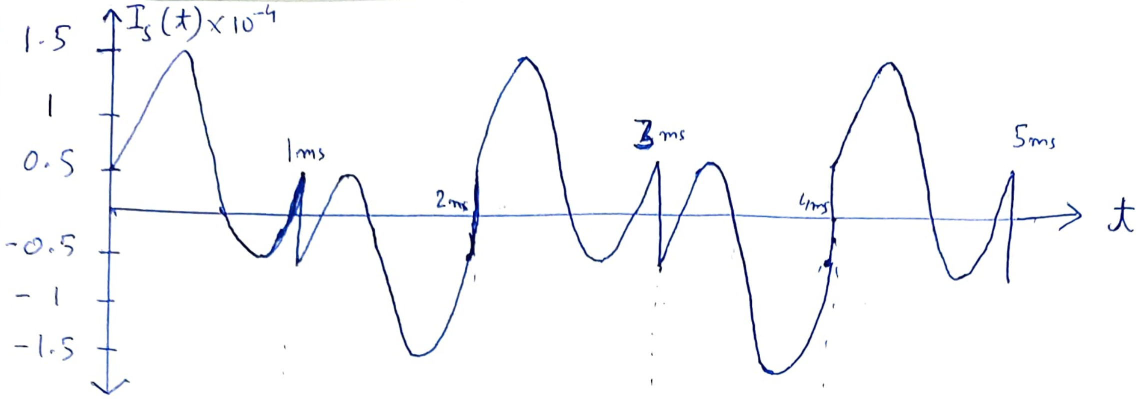
Similarly $$\frac{V_B - V_o}{R_2} = I_s$$

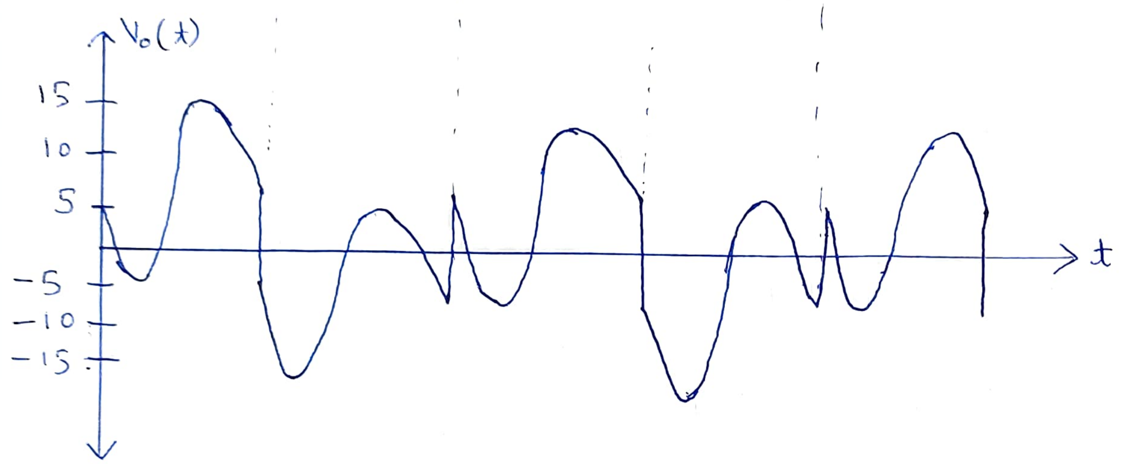
$$\Rightarrow V_o = V_B - I_s R_2$$

$$\Rightarrow V_o(t) = 0.5\, sgn\left(\sin(1000\pi t)\right) - 9\left(\sin(2000\pi t) - 0.5\left(sgn\left(\sin 1000\pi t\right)\right)\right)$$

$$\Rightarrow V_o(t) = 0.5\, sgn\left(\sin(1000\pi t)\right) - 9\sin(2000\pi t) + 4.5\, sgn\left(\sin(1000\pi t)\right)$$

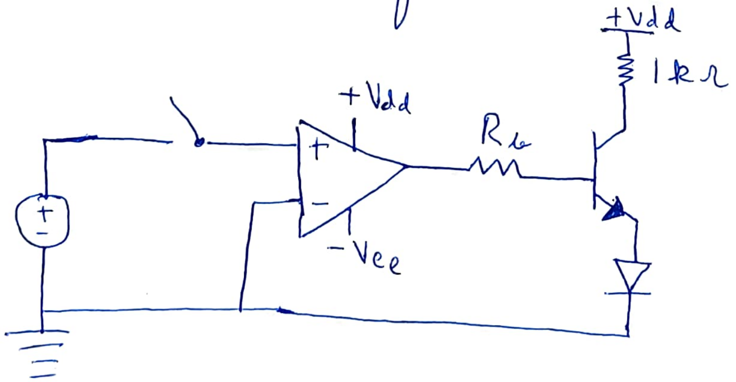
$$V_o(t) = \boxed{5\, sgn\left(\sin(1000\pi t)\right) - 9\sin(2000\pi t)}$$



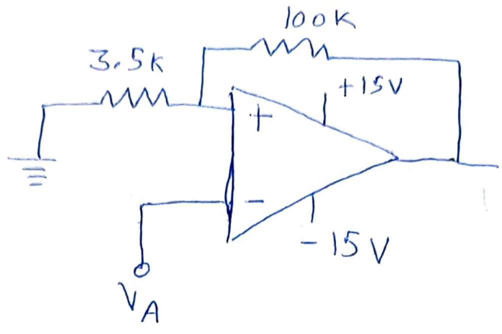


Q3

a) In the given circuit when the switch is pressed to turn ON the LED, very high base current will flow into the transistor and it will get damaged. In order to avoid that, a current limiting resistor should be placed in between OP-Amp's output and base of the transistor as shown.



b)



Correct Schmitt Trigger Circuit

The input voltage V_A should be applied at the inverting terminal of the OP-Amp and the remaining end of the input resistor should be grounded.

The feedback resistor (connected between output & non inverting terminal) should be of larger value than the input resistor.

Value of input resistor should be chosen appropriately in order for the threshhold voltage $= \pm 0.5V$