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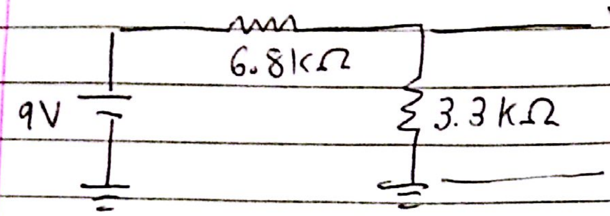
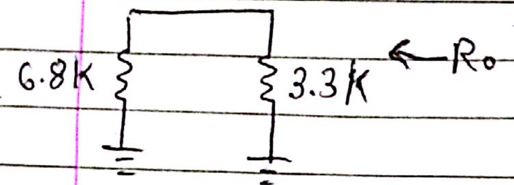
ECE 255 HW1 (Section 2)

1.7



$$V_o = \left(\frac{3.3}{3.3+6.8}\right) 9$$

$$= 9\left(\frac{3.3}{10.1}\right) = \underline{2.94\,V}$$



$$R_o = (3.3 \parallel 6.8)\,k\Omega = \underline{2.22\,k\Omega}$$

For ±5% Resistor tolerance, $V_{o\text{-}low} = 9\left(\frac{3.3(1-0.05)}{3.3(1-0.05)+6.8(1+0.05)}\right)$

$$= \underline{2.75\,V}$$

$$V_{o\text{-}high} = 9\left(\frac{3.3(1+0.05)}{3.3(1+0.05)+6.8(1-0.05)}\right)$$

$$= \underline{3.14\,V}$$

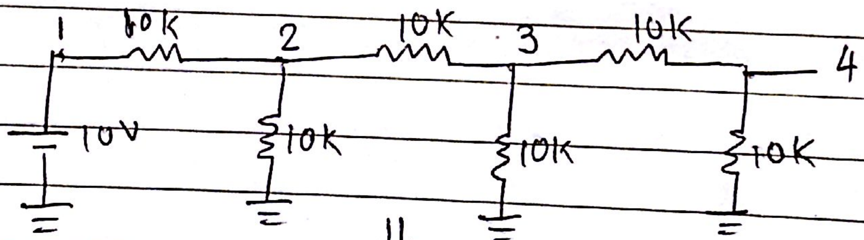
V_o has a range of $\underline{2.75\,V \text{ to } 3.14\,V}$

$$R_{o\text{-}low} = \frac{3.3(1-0.05)\times 6.8(1-0.05)}{3.3(1-0.05)+6.8(1-0.05)}$$

$$= \underline{2.11\,k\Omega}$$

$$R_{o\text{-}high} = \frac{3.3(1+0.05)\times 6.8(1+0.05)}{3.3(1+0.05)+6.8(1+0.05)} = \underline{2.33\,k\Omega}$$

1.15



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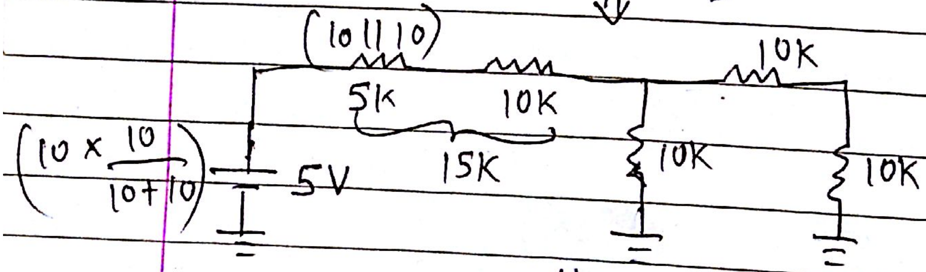

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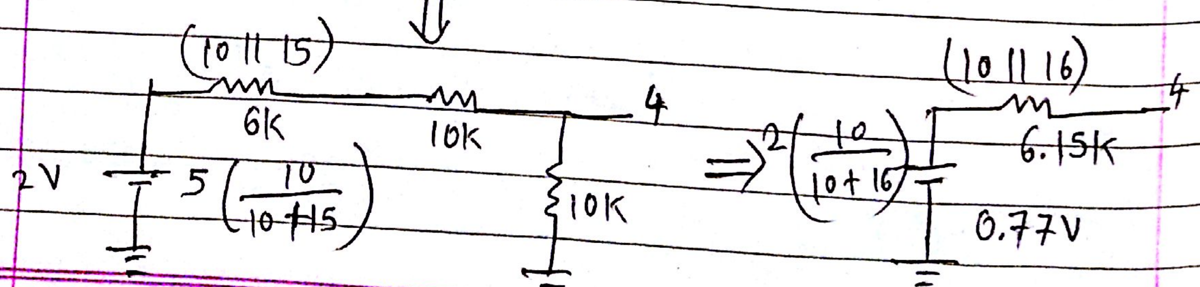
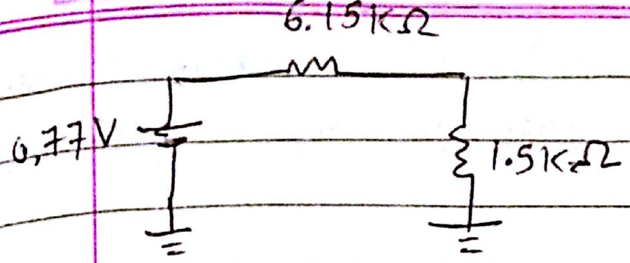
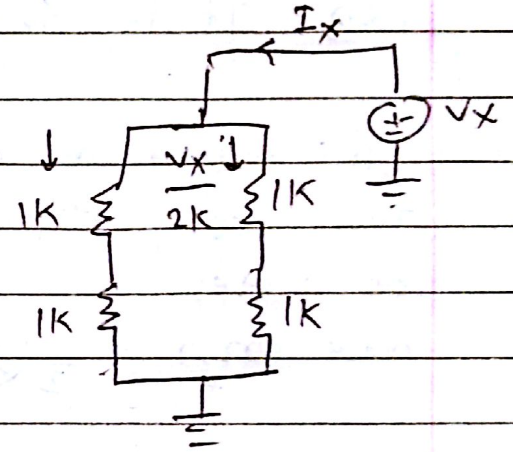




$$I = \frac{0.77}{6.15 + 1.5} = \underline{0.1\ mA}$$

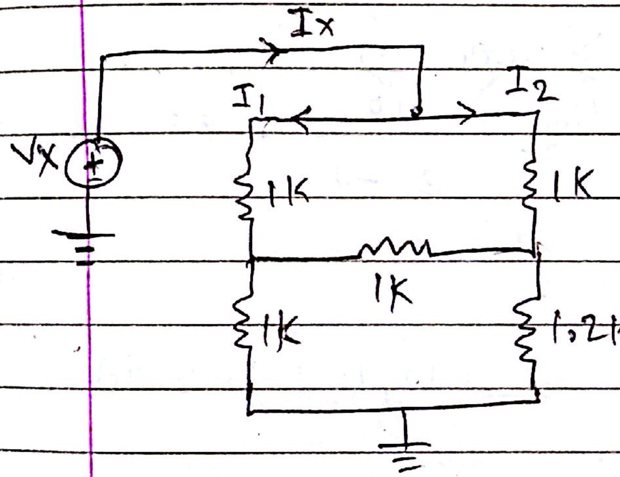
1.18 Due to symmetricity in circuit, there will be no current in R5.

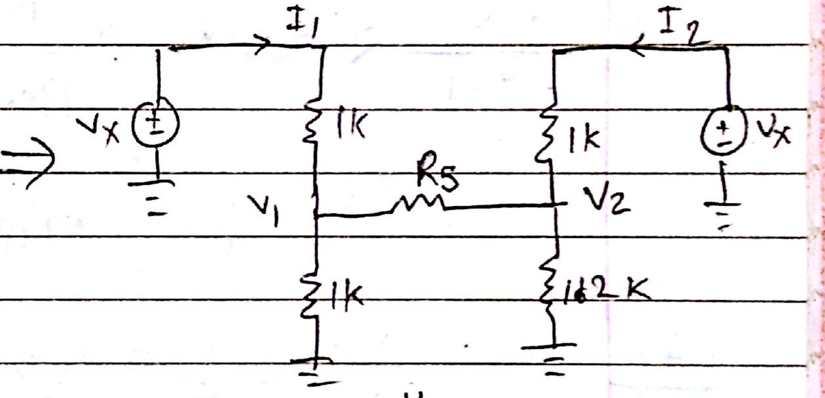


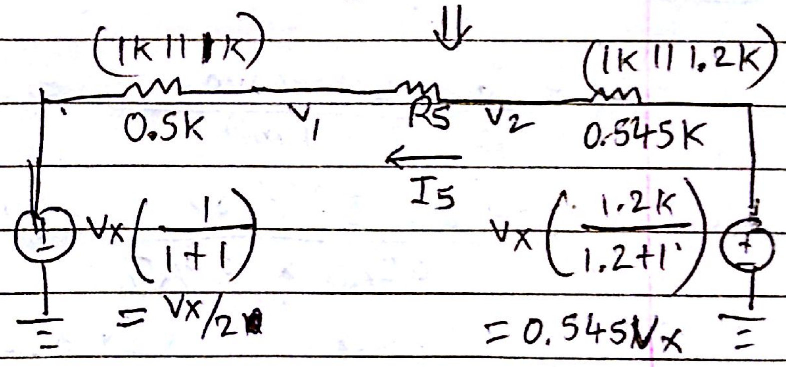
$$I_x = \frac{V_x}{2K} + \frac{V_x}{2K}$$

$$= \frac{V_x}{1K} \Rightarrow R_{eq} = \underline{1k\Omega}$$

Now, R4 is raised to 1.2kΩ.







$$I_5 = \frac{0.545 V_x - 0.5 V_x}{0.5 + 1 + 0.545}$$

$$= 0.022 V_x$$

$$V_1 = \frac{V_x}{2} + 0.022 V_x \times 0.5 = 0.511\ V_x$$

$$V_2 = V_1 + I_5 R_5 = 0.533\ V_x$$

$$I_1 = \frac{V_x - V_1}{1K} = 0.489\ V_x, \quad I_2 = \frac{V_x - V_2}{1K} = 0.467\ V_x$$

$$I_x = I_1 + I_2 = 0.956\ V_x \Rightarrow R_{eq} = \frac{V_x}{I_x} = \underline{1.05\ k\Omega}$$

1.36 (a) For N bit ADC, there will be 2^N possibilities (levels) from 0 to V_{FS}. So $(2^N - 1)$ possible steps with step size given by $\frac{V_{FS}}{2^N - 1}$

This is analog change corresponding to a change in LSB. It is the resolution of ADC.

(b) The maximum error occurs when the analog signal is at the middle of a step.

step

$$\text{max error} = \frac{1}{2}(\text{step size}) = \frac{1}{2}\frac{V_{FS}}{2^N - 1}$$

called quantization error

(c) $\frac{10V}{2^N - 1} \le 5\,mV \Rightarrow 2^N - 1 \ge 2000 \Rightarrow N = 11$

$$\text{Resolution} = \frac{10}{2^{11} - 1} = 4.9\,mV$$

$$\text{Quant. error} = \frac{4.9}{2} = 2.4\,mV.$$

1.40 $A_v = \frac{v_o}{v_i} = \frac{2.2}{0.2} = 11\,V/V$ or $20\log 11 = 20.8\,dB$

$$A_i = \frac{i_o}{i_i} = \frac{2.2V/100\,\Omega}{1\,mA} = 22\,A/A \text{ or } 20\log A_i = 26.8\,dB$$

$$A_p = \frac{P_o}{P_i} = \frac{(2.2/\sqrt{2})^2/100}{0.2/\sqrt{2} \times 10^{-3}/\sqrt{2}} = 242\,W/W \text{ or } 10\log A_p = 23.8\,dB$$

Supply power $= 2 \times 3V \times 20\,mA = 120\,mW$

output power $= \frac{V_{rms}^2}{R_L} = (2.2/\sqrt{2})^2/100\,\Omega = 24.2\,mW$

input power $= \frac{24.2}{242} = 0.1\,mW$ (negligible)

amplifier dissipation = supply power − output power
$= 120 - 24.2 = 95.8\,mW$

amplifier efficiency $= \frac{O.P.}{I.P.} \times 100 = \frac{24.2}{120} \times 100 = 20.2\%$