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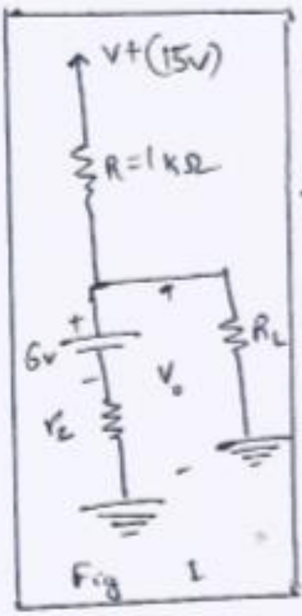
BEC Assignment

Atharva Deshpande
S20190010043

1.



$V_z = 6V$, $I_z = 6mA$, $r_z = 25\Omega$ & $I_{zk} = 0.2mA$

(a) No Load, $V_o = ?$

Solⁿ: $V_{z_0} = 6 - 25 \times 6 \times 10^{-3}$

$= 6 - 150 \times 10^{-3}$

$= 6 - 0.15$

$= 5.85\ V$

$I = \dfrac{15 - 5.85}{1025} = 8.926\ mA$

$\therefore V_o = 5.85 + \dfrac{8.926 \times 25}{1000} = 6.073\ V$

$\therefore \boxed{V_o = 6.073\ V}$

(b) $R_L = 4K\Omega$, $\Delta V_o = ?$

Solⁿ: $i_L = \dfrac{6.073}{4000} = 0.001518 = 1.518\ mA$

$\therefore \Delta V_o = -25 \times \dfrac{1.518}{1000} = -0.03795\ V$

$\therefore \boxed{\Delta V_o = -37.950\ mV}$

(c) Minimum value of R_L for which zener diode will operate = ?

Solⁿ: $i_R = \dfrac{15 - 5.85}{1000} = 9.15\ mA$

$i_L = (9.15 - 0.2)\ mA = 8.95\ mA$

$\therefore R_{L_{min}} = \dfrac{5.85}{8.95}\ K\Omega = 0.65363 \times 1000\ \Omega$

$\therefore \boxed{R_{L_{min}} = 653.63\ \Omega}$

2.
Soln

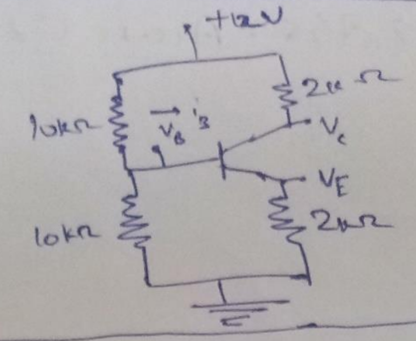


Fig 2

$$i_B = \frac{12 - V_B}{10k} + \frac{0 - V_B}{10k}$$

$\therefore V_B = 6 - (5k) i_B$ —— (i)

Now, $V_E = (2k) \cdot i_E$

~~Also~~, $V_{BE} = 0.6 \text{ V}$

$\therefore 6 - 5 i_B - 2 i_E = 0.6 \text{ V}$

$\therefore (5k) i_B + (2k) i_E = 5.4$ —— (ii)

And $i_E = i_c + i_B = \beta i_B + i_B = (\beta + 1) i_B$

$\therefore i_E = (49 + 1) i_B = 50 i_B$ —— (iii)

$\therefore i_B (105k) = 5.4$ —— [from (ii) & (iii)]

$\therefore \boxed{i_B = 51.4 \ \mu A}$

Now, $i_c = \beta i_B = 49 \times 51.4 \times 10^{-3} \text{ mA} = 2.519 \text{ mA}$

$\therefore \boxed{i_c = 2.519 \text{ mA}}$

$i_E = 50 \times 51.4 \times 10^{-3} \text{ mA}$ —— [from (iii)]

$\therefore \boxed{i_E = 2.571 \text{ mA}}$

$\therefore V_B = 6 - 5 \times 51.4 \times 10^{-3} = 5.742 \text{V}$

$\therefore \boxed{V_B = 5.742 \text{ V}}$ → $V_E = 5.742 - 0.6$

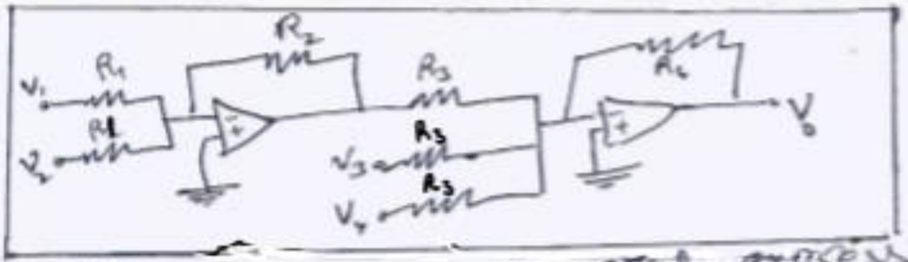
$\boxed{V_E = 5.142}$

$V_c = 12 - 2 \times 2.519 = 6.962 \text{ V}$

$\therefore \boxed{V_c = 6.962 \text{ V}}$

Since, $V_{BC} < 0$
& $V_{BE} > 0$
$\therefore$ The Mode of operation is FORWARD ACTIVE

3.
Sol^n



Let's derive a general expression for V_o

$$V_o = V_1\left(-\frac{R_2}{R_1}\right)\left(-\frac{R_4}{R_3}\right) + V_2\left(-\frac{R_2}{R_1}\right)\left(-\frac{R_4}{R_3}\right) - \frac{R_4}{R_3}V_3 - \frac{R_4}{R_3}V_4$$

$$= (V_1 + V_2)\left(\frac{R_2 R_4}{R_1 R_3}\right) - \left(\frac{R_4}{R_3}\right)(V_3 + V_4)$$

$$\therefore \boxed{V_o = (V_1 + V_2)\left(\frac{R_2 R_4}{R_1 R_3}\right) - (V_3 + V_4)\left(\frac{R_4}{R_3}\right)} \quad \text{—— (1)}$$

(a) If all the Resistors are $= R$.

$$\boxed{V_o = V_1 + V_2 - V_3 - V_4} \quad \ldots \text{[from (1)]}$$

(b) $R_1 = R$, $R_2 = 2R$, $R_3 = 4R$, $R_4 = 6R$

From (1),

$$\therefore V_o = (V_1 + V_2)\frac{(2R)(6R)}{(R)(4R)} - \left(\frac{6R}{4R}\right)(V_3 + V_4)$$

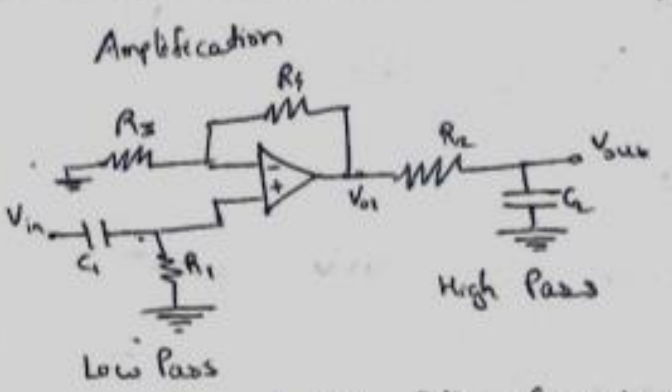
$$= 3(V_1 + V_2) - \frac{3}{2}(V_3 + V_4)$$

$$= 3\left[V_1 + V_2 - \frac{V_3}{2} - \frac{V_4}{2}\right]$$

$$\therefore \boxed{V_o = 3\left(V_1 + V_2 - \frac{V_3}{2} - \frac{V_4}{2}\right)}$$

4.

Sol^n:



Band Pass Active Filter (Non-inverting)

$C_1 = C_L$

$C_2 = C_H$

$f_L = 1500\ Hz$, $f_H = 3700\ Hz$, $R_1 = R_2 = R_3 = R_4 = 2.3\ k\Omega$

Band Pass Gain (BPG) $= \left(1 + \frac{R_4}{R_3}\right) = (1+1) = 2$ $\boxed{\therefore BPG = 2}$

(i) $C_L = \frac{1}{2\pi R f_L} = \frac{1}{2\pi \times 2.3 \times 15 \times 10^5} = 0.00461 \times 10^{-5}\ F$

$\therefore \boxed{C_L = 46.1\ nF}$ ...... (Low Pass Capacitance)

$C_H = \frac{1}{2\pi R f_H} = \frac{1}{2\pi \times 2.3 \times 37 \times 10^5} = 0.00187 \times 10^{-5} F$

$\therefore \boxed{C_H = 18.7\ nF}$ ..... (High Pass Capacitance)

(ii) $\frac{V_{out}}{V_{in}} = \frac{1}{\sqrt{1 + \left(\frac{f}{3700}\right)^2}} \times \frac{1}{\sqrt{1 + \left(\frac{f}{1500}\right)^2}} \times 2 \times \frac{f}{f_L}$

$= \frac{1}{750} \times \frac{f}{\sqrt{\left(1 + \left(\frac{f}{3700}\right)^2\right)\left(1 + \left(\frac{f}{1500}\right)^2\right)}}$

$\therefore \boxed{V_{out} = \frac{V_{in}\ f}{750\sqrt{\left(1 + \left(\frac{f}{3700}\right)^2\right)\left(4 + \left(\frac{f}{1500}\right)^2\right)}}}$

4. (iii)

(a) $f = f_L/4 = 1500/4 = 375\,Hz$

$$\therefore \frac{V_{out}}{V_{in}} = \frac{1}{2}\frac{1}{\cancel{375}} \times \frac{\cancel{375}\ 1}{\sqrt{1+\left(\frac{375}{3700}\right)^2}\sqrt{1+\left(\frac{1}{4}\right)^2}}$$

$$= \frac{1}{2}\frac{4}{\sqrt{1.01027}\sqrt{17}} = 0.4824$$

$$\therefore \boxed{V_{out} = (0.4824)\,V_{in}}$$

(b) $f = f_L$

$$\therefore \frac{V_{out}}{V_{in}} = \frac{1}{\cancel{375}} \times \frac{\cancel{1500}\ 4}{\sqrt{1+\left(\frac{1500}{3700}\right)^2}\sqrt{1+1^2}} \times \frac{1}{2}$$

$$= \frac{1}{2}\frac{2\sqrt{2}}{\sqrt{1.16435}} = 1.3106$$

$$\therefore \boxed{V_{out} = (1.3106)\,V_{in}}$$

(c) $f = f_H$

$$\therefore \frac{V_{out}}{V_{in}} = \frac{1}{2}\cdot\frac{1}{375} \times \frac{(3700)}{\sqrt{1+(1)^2}\sqrt{1+\left(\frac{3700}{1500}\right)^2}}$$

$$= \frac{1}{2}\frac{9.867}{\sqrt{2}\sqrt{7.0844}} = 1.3106$$

$$\therefore \boxed{V_{out} = (1.3106)\,V_{in}}$$

(d) $f = 4f_H$

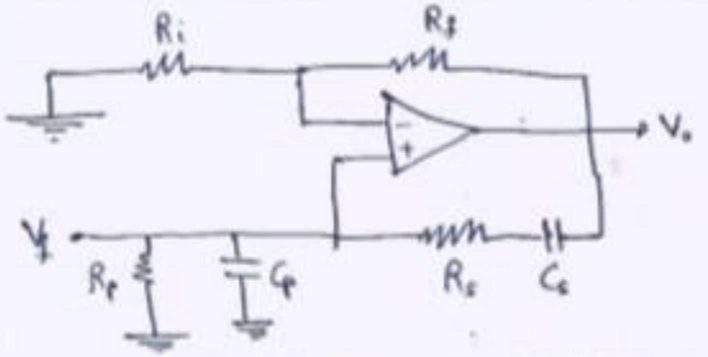
$$\therefore \frac{V_{out}}{V_{in}} = \frac{1}{2}\frac{1}{\cancel{375}} \times \frac{4 \times \overset{9.867}{\cancel{3700}}}{\sqrt{1+4^2}\sqrt{1+\left(\frac{4\times 37}{15}\right)^2}}$$

$$= \frac{39.468}{\sqrt{17}\sqrt{98.351}}\frac{1}{2} = 0.4824$$

$$\therefore \boxed{V_{out} = (0.4824)\,V_{in}}$$

5. $R_s = 5\,k\Omega$, $R_p = 12\,k\Omega$, $C_s = 47nf$, $C_p = 35nF$

Here based on the terminologies, $R_1 = 5K\Omega$, $R_2 = 12k\Omega$, $C_1 = 47nf$ & $C_2 = 35nf$



Wien Bridge Oscillator

(i) As we know,

$$\beta = \frac{j\omega R_2 C_1}{1 - \omega^2 R_1 R_2 C_1 C_2 + j\omega(R_1 C_1 + R_2 C_2 + R_2 C_1)}$$

$$= \frac{j\omega(12\times10^3)(47\times10^{-9})}{1-\omega^2(12\times5\times10^6)(47\times35\times10^{-18}) + j\omega(5\times47+35\times12+12\times47)\times10^{-6}}$$

$$= \frac{j\omega(564)\times10^{-6}}{1-\omega^2(987\times10^{-10}) + j\omega(1219)\times10^{-6}}$$

$$= \frac{j\omega(564)}{10^6 - \omega^2(987\times10^{-4}) + j\omega(1219)}$$

$$= \frac{j\omega}{1773.049 - \omega^2(1.75\times10^{-4}) + j\omega(2.161)}$$

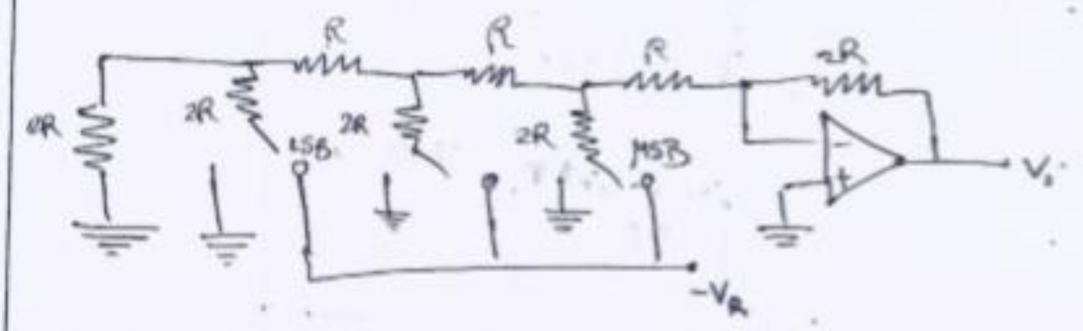
$$\therefore \boxed{\beta = \frac{j\omega}{1773.049 - \omega^2(1.75\times10^{-4}) + j\omega(2.161)}}$$

(ii) $$f = \frac{1}{2\pi\sqrt{R_1R_2C_1C_2}} = \frac{1}{2\pi\sqrt{6\times10^7\times47\times35\times10^{-18}}} = \frac{1}{2\pi\sqrt{987\times10^{-10}}}$$

$$= \frac{10^5}{2\pi\sqrt{987}} = 506.595\ Hz$$

$\therefore \boxed{f = 506.595\ Hz}$ for $\omega = \frac{1}{\sqrt{R_1R_2C_1C_2}}$ & β to be real

6.
Solⁿ



R-2R Ladder DAC

(i) For an N-bit ADC, having R-2R ladder,

$$V_o = -\frac{R_f}{R_{Th}} \frac{V_R}{2^N} \sum_0^{N-1} S_k 2^k.$$

Here, $n = 3$, $R_f = 2R$, $R_{Th} = 2R$ (As there even number of 2R resistors)

$V_R = -V_R$

$$\therefore V_o = -\frac{2R}{2R}\frac{(-V_R)}{2^3}\left(S_0 2^0 + S_1 2^1 + S_2 2^2\right)$$

$$= +\frac{V_R}{8}\left(S_0 2^0 + S_1 2^1 + S_2 2^2\right)$$

$$\therefore \boxed{V_o = +\frac{V_R}{8}\left(S_0 + 2S_1 + 4S_2\right)}$$

(ii) (a) Input sequence : 011 ($S_2 S_1 S_0$)

$$\therefore V_o = +\frac{V_R}{8}(1+2)$$

$$\therefore \boxed{V_o = +\frac{3V_R}{8}}$$

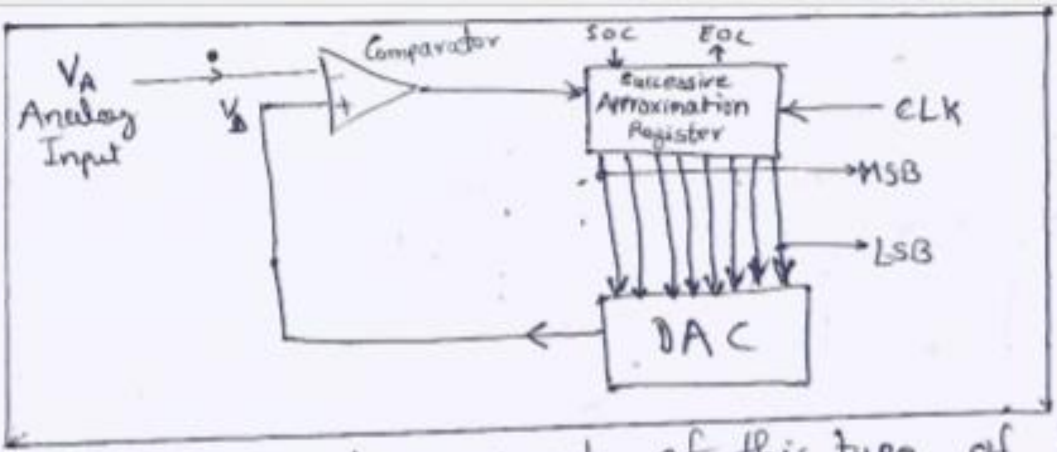
(b) Input Sequence : 101 ($S_2\ S_1\ S_0$)

$$\therefore \boxed{V_o = +\frac{5V_R}{8}}$$

(c) Input Sequence : 111

$$\therefore \boxed{V_o = +\frac{7V_R}{8}}$$

7.



The basic ~~type~~ principle of this type of A / D converter is that the unknown analog input voltage is approximated against an n-bit digital value by trying one bit at a time, beginning with the MSB.

This type of ADC operates by successively dividing the voltage range by half, as explained in the following steps:

(1) The MSB is initially set to 1 with the ~~remaing~~ remaining 7 bits set as 0000000. The digital equivalent voltage is compared with the unknown analog input voltage.

(2) If the analog input voltage is higher than the digital equivalent voltage, the MSB is retained as 1 and the second MSB is set to 1. Otherwise, the MSB is set to 0 and the second MSB is set to 1. Comparison is made as given in step (1) to decide whether to retain or reset the second MSB.

An 8-bit ADC was used. In order to find the input voltage.
we know the output signal = 01100101
the input voltage would have been $= 2^6 + 2^5 + 2^2 + 1$

Hence,
$$V_A = 101\,V$$

From here we have to reverse Engineer how the conversion would have started.

	Step taken	Status
(i) MSB bit is set to 1 $V_D = [10000000]_2 = 128V > V_A = 101V$	(1)	Not Approved
(ii) $\therefore V_D = [01000000]_2 = 64V < V_A = 101V$	(2)	Approved
(iii) Then, keep the next bit as 1 $V_D = [01100000]_2 = 96V < V_A = 101V$	(1)	Approved

9.

(iv) Again keep the next bit as 1

$V_D = [0111 0000]_2 = 112\,V > V_A = 101\,V$

(v) $\therefore V_D = [01101000]_2 = 104\,V > V_A = 101\,V$

(vi) $\therefore V_D = [01100100]_2 = 100\,V < V_A = 101\,V$

(vii) Now, $V_D = [01100110]_2 = 102\,V > V_A = 101\,V$

(viii) Finally, $V_D = [01100101]_2 = 101\,V = (V_A = 101\,V)$

Step	Status
(1)	Not Approved
(2)	Not Approved
(2)	Approved
(1)	Not Approve
(2)	Approved & Accepted

This is how we got the output digital sequence as 01100101.