Question 1

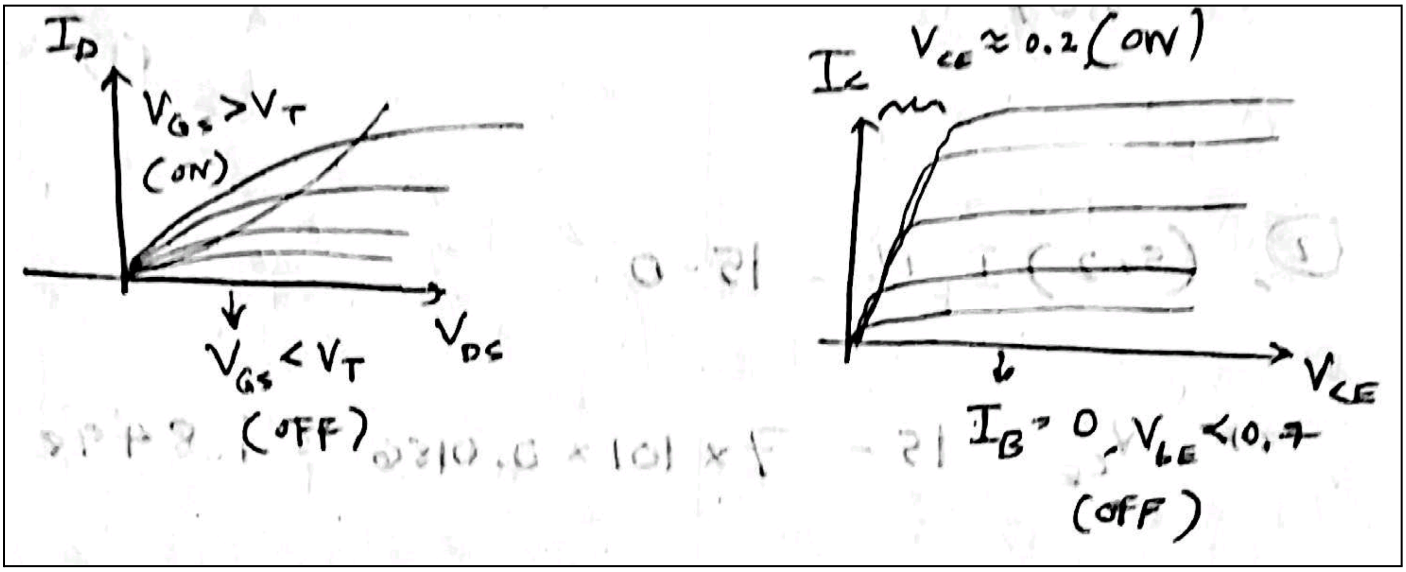
Set-01: (a) [1.5 marks]

Why can we use MOSFETs as switches? Explain briefly with necessary graphs.

Set-02: (a) [1.5 marks]
Why can we use BJTs as switches? Explain briefly with necessary graphs.

Answer
Set-01: Cutoff & Triode Mode in MOSFET's I-V graph resembles the OFF & ON state of a Switch's I-V graph. That's why we use MOSFETs as switches.

Set-02: Cutoff & Saturation Mode in BJT's I-V graph resembles the OFF & ON state of a Switch's I-V graph. That's why we use MOSFETs as switches.



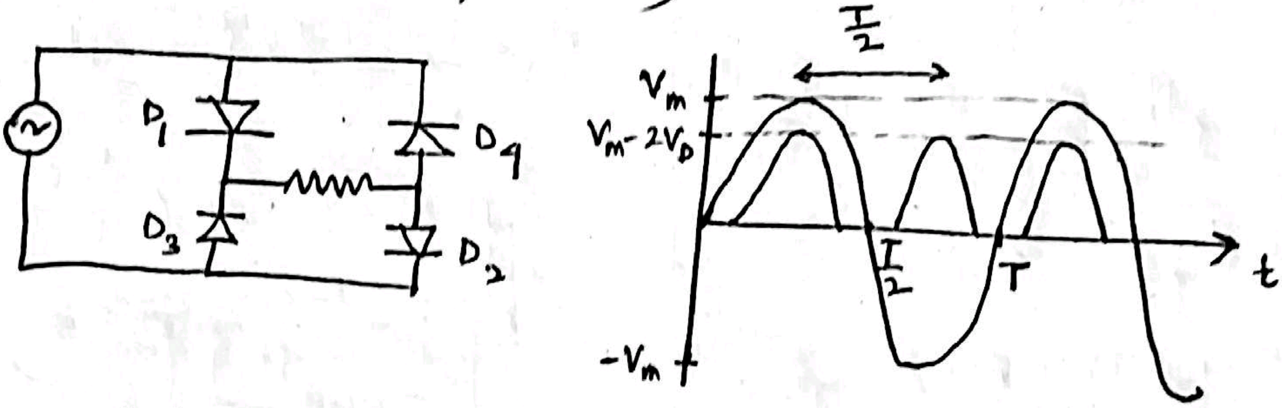
Set-01: (b) [2 marks]

Draw the input and output voltage waveforms of a full-wave rectifier with CVD model when a sinusoidal voltage is applied as input. Label the graph properly. Indicate the states of the diodes during the positive and negative half cycles of the input voltage.

Set-02: (b) [2 marks]

Draw the input and output voltage waveforms of a full-wave rectifier with CVD model when a sinusoidal voltage is applied as input. Label the graph properly. Indicate the states of the diodes during the positive and negative half cycles of the input voltage.

b) (Both set A-, Set-B)



+ve cycle: D_1, D_2 ON; D_3, D_4 OFF

-ve cycle: D_3, D_4 ON; D_1, D_2 OFF

Set-01: (c) [1 mark]

“A resistor is connected to the base of a BJT to build logic gates.” - Explain the reason briefly.

Set-01: (c) [1 mark]

“A resistor is connected to the base of a BJT to build logic gates.” - Explain the reason briefly.

c) To convert voltage to current, ~~to~~ for cascading of gates.

To limit current of base.

To allow control of base current via R_B

Set-01: (d) [1.5 marks]

Will the output waveform change if you increase the value of the load resistance of a full-wave rectifier with a capacitor? Explain briefly.

Set-A:

$R_L \uparrow \Rightarrow V_{ripple} \downarrow \Rightarrow V_{DC} \uparrow$ [Waveform less ripple]

Set-02: (d) [1.5 marks]

Will the output waveform change if you decrease the value of the load resistance of a full-wave rectifier with a capacitor? Explain briefly.

Set-B:

Waveform has more ripple

$R_L \downarrow \Rightarrow V_{ripple} = \frac{V_P}{fR_LC} \uparrow \Rightarrow V_{DC} = (V_P - V_{ripple}) \downarrow$

Question 2

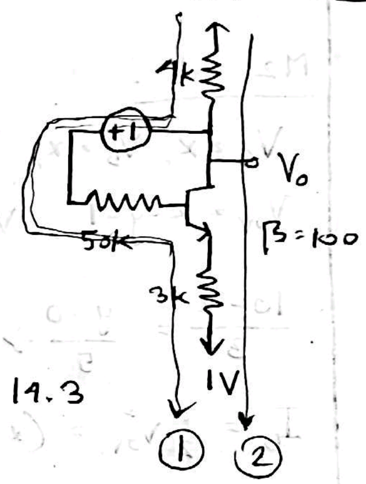
(a) [6 marks]

Q2 : Set-A

Assume active:

KVL ①,

$$4I_E - \cancel{1} + 50I_B = 15 - \cancel{1} + 0.7 + 3I_E$$



$$\Rightarrow 7 \times 101 \times I_B + 50 I_B = 14.3$$

$$\Rightarrow I_B = \frac{14.3}{757} = 0.0189\ mA$$

$I_C = 1.89\ mA$, $I_E = 1.908\ mA$

KVL ②, $(4+3)I_E + V_{CE} = 15 - 1$

$$\Rightarrow V_{CE} = 14 - 7 \times 1.908 = 0.644 > 0.2$$

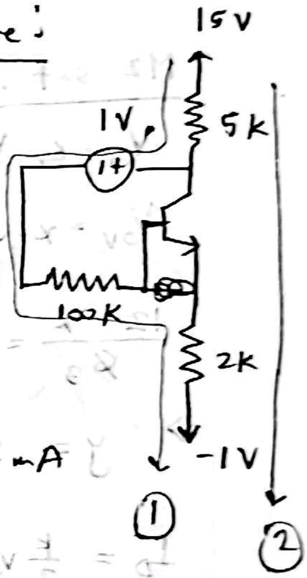
∴ In active mode

Set-B

Assume active:

KVL ①,

$$7 \times 101 \times I_B + 100 I_B + 0.7 + 1 = 15 - (-1)$$



$$\Rightarrow I_B = \frac{14.3}{807} = 0.0177\ mA$$

$I_C = 1.77\ mA$

$I_E = 1.789\ mA$

KVL ②, $V_{CE} = 15 - (-1) - 7I_E$

$$= 3.477 > 0.2$$

∴ In active mode

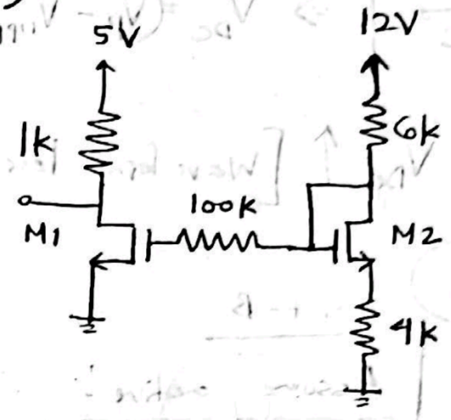
(b) [6 marks]

i) M2 : $V_G = V_D \Rightarrow V_G - V_S = V_D - V_S$

$\Rightarrow V_{GS} = V_{DS} \Rightarrow V_{GS} - V_T < V_{DS}$

$\therefore$ Must be in Saturation !

ii) Set A :



M2 sat :

$V_G = x,\ V_D = x,\ V_S = y$

$V_{ov} = x - y - 1$, $V_{DS} = x - y$

$\frac{12 - x}{\cancel{6}\,3} = \frac{y - 0}{\cancel{4}\,2} = I_D$

$\Rightarrow y = 8 - \frac{2}{3}x \Rightarrow x = 12 - \frac{3}{2}y$

$I_D = \frac{k}{2}V_{ov}^2 = (x - y - 1)^2$

$\Rightarrow \frac{y}{4} = (12 - \frac{3}{2}y - y - 1)^2$

$\Rightarrow \frac{y}{4} = \left[11 - \frac{5y}{2}\right]^2$

$\Rightarrow \frac{y}{\cancel{4}} = \frac{1}{\cancel{4}}\left[22 - 5y\right]^2$

$\Rightarrow y = 484 - 220y + 25y^2$

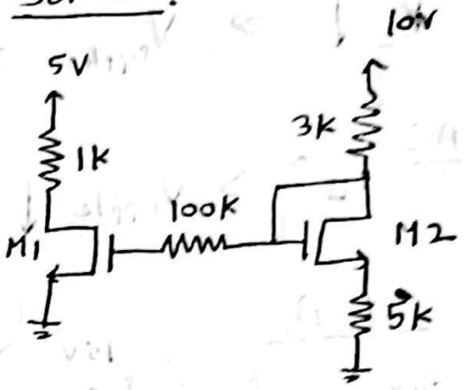
$\Rightarrow 25y^2 - 221y + 484 = 0$

$y = 4.84,\ 4 \longrightarrow V_G = V_D = 6$

$V_G = V_D = 4.74$ $\quad V_{GS} = 2 > V_T$ ✓

$V_{GS} < V_T$ ✗

Set B :



M2 sat :

$V_G = x,\ V_D = x,\ V_S = y$

$V_{ov} = x - y - 1$, $V_{DS} = x - y$

$\frac{10 - x}{3} = \frac{y - 0}{5} \Rightarrow x = 10 - \frac{3}{5}y$

$I_D = \frac{k}{2}V_{ov}^2 = (x - y - 1)^2$

$\Rightarrow \frac{y}{5} = (10 - \frac{3}{5}y - y - 1)^2$

$\Rightarrow \frac{y}{5} = (9 - \frac{8y}{5})^2$

$\Rightarrow \frac{y}{\cancel{5}} = \frac{1}{\cancel{25}\,5}(45 - 8y)^2$

$\Rightarrow 5y = 2025 - 720y + 64y^2$

$\Rightarrow 64y^2 - 725y + 2025 = 0$

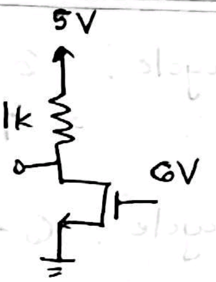
$\Rightarrow y = 6.328,\ 5$

$V_G = V_D = 6.203$ $\quad V_G = V_D = 7$

$V_{GS} < V_T$ ✗ $\quad V_{GS} = 2 > V_T$

✓

Must be in Triode:



$V_G = 6, V_S = 0, V_D = x$

$V_{ov} = 5V$

$$I_D = k\left[V_{DS}V_{ov} - \frac{1}{2}V_{DS}^2\right]$$

$$\Rightarrow \frac{5-x}{1} = \frac{1}{2}\left[5x - \frac{x^2}{2}\right]$$

$$\Rightarrow 5-x = \frac{1}{4}\left[10x - x^2\right]$$

$$\Rightarrow 20-4x = 10x - x^2$$

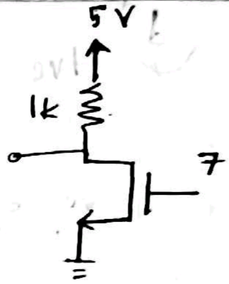
$$\Rightarrow x^2 - 14x + 20 = 0$$

$$\Rightarrow x = 12.385\,V,\ 1.615\,V$$

$V_{DS} > V_{ov}$ ✗

$V_{DS} < V_{ov}$ ✓

Must be in Triode:



$V_G = 7, V_S = 0, V_D = x$

$V_{ov} = 6V$

$$I_D = 5-x = \frac{1}{2}\left[6x - \frac{1}{2}x^2\right]$$

$$\Rightarrow 20-4x = 12x - x^2$$

$$\Rightarrow x^2 - 16x + 20 = 0$$

$$\Rightarrow x = 14.633,\ 1.366$$

$V_{DS} < V_{ov}$ ✓

(c) [2 marks]

Set A

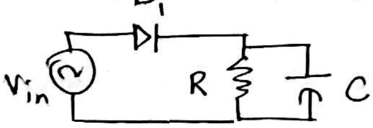
Q (C) $R = 5k$, $f = 1kHz$, $V_{D_0} = 0.5$

$f_{out} = \frac{1}{1\times10^{-3}} = 1kHz \rightarrow HW$ (half wave)

$V_{max} = 5V$, $V_{min} = 2.5\,V$

$V_{ripple} = 2.5V$, $C = \frac{V_p}{f_{out} R_{out} V_{ripple}}$

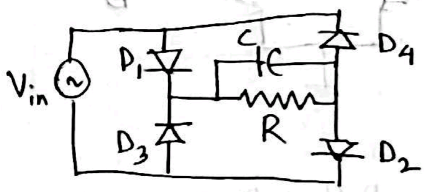
$V_p = 5 - 0.5 = 4.5V$ $= 3.6\times10^{-4}\,F$



Set-B

$R = 5k$, $f = 0.5\,kHz$, $V_{D_0} = 0.55\,V$

$f_{out} = \frac{1}{1\times10^{-3}} = 1kHz = 2f \rightarrow FW$ (full wave)

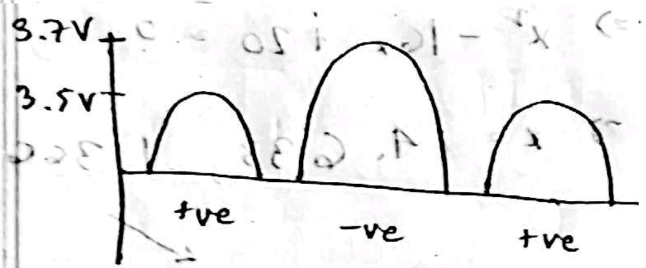


(d) [2 marks]

(d)

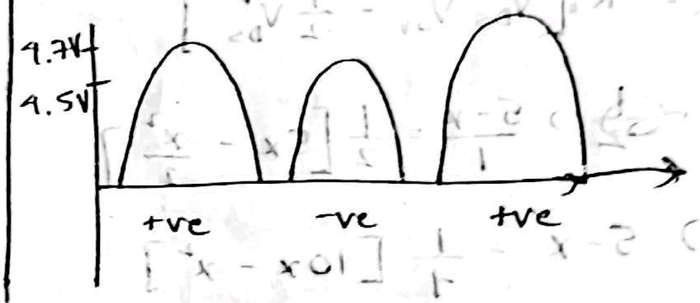
+ve cycle: $5 - 0.7 - 0.8 = 3.5V$

-ve cycle: $5 - 0.7 - 0.6 = 3.7V$



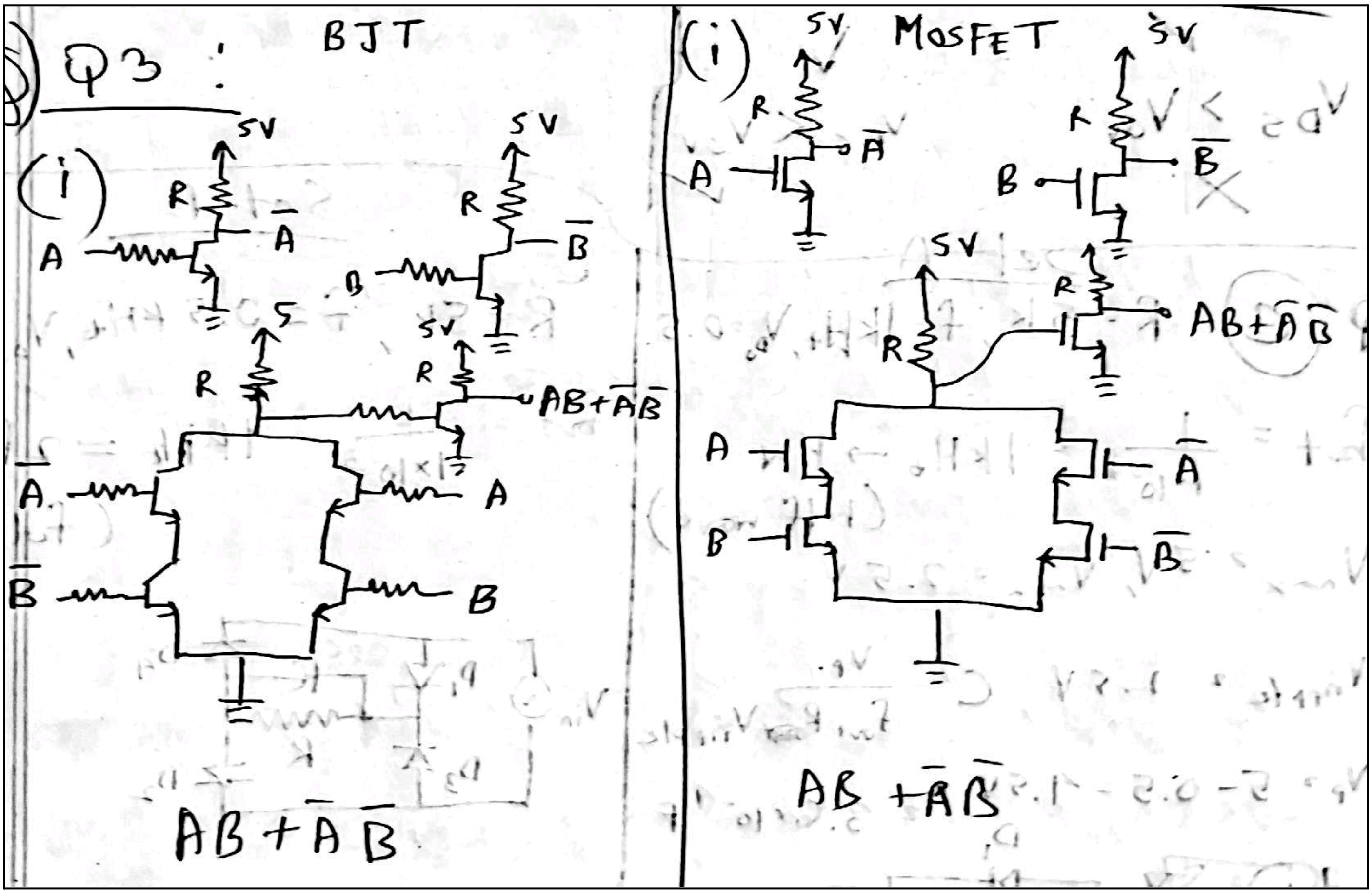
+ve cycle: $6 - 0.7 - 0.6 = 4.7V$

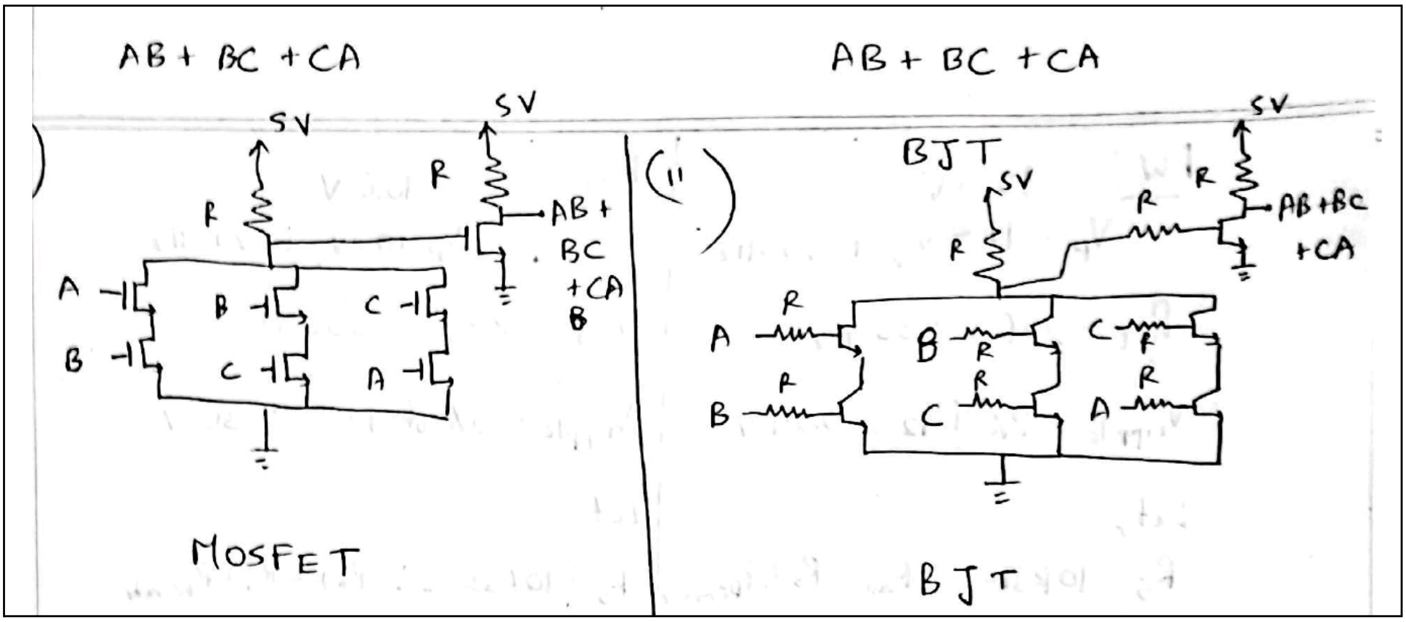
-ve cycle: $6 - 0.7 - 0.8 = 4.5V$



Question 3

(a) [3 marks]





(b) [5 marks]

b) $V_{in} = 12\sin(500\pi t)$

$V_m = 12$, $f = 250\ Hz$

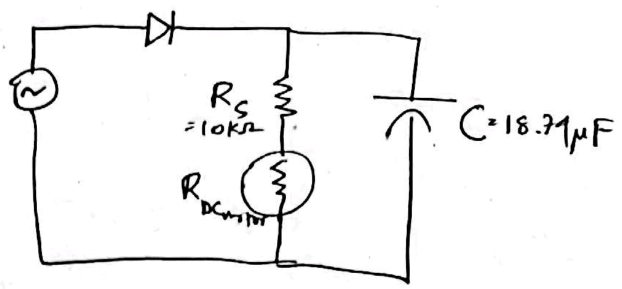
HW: $V_p = 11.3V$, $f_{out} = 250Hz$

$V_{ripple} = 2\%$ of $12 = 0.24\ V$

Let, $R_s = 10\ k\Omega$ $= 10{,}000$ $\therefore R_{out} = 10+0.05$ $= 10{,}050\Omega$

$$C = \frac{V_P}{V_{ripple}\, f_{out}(R_s + R_{motor})} = 1.874 \times 10^{-5}\ F = 18.74\ \mu F$$

$\therefore R_s = 10k\Omega$, $C = 18.74\mu F$



$V_{in} = 12\sin(500\pi t)$

$V_m = 12$, $f = 250\ Hz$

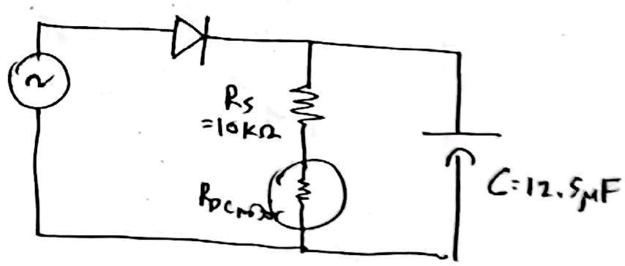
HW: $V_p = 11.3V$, $f_{out} = 250Hz$

$V_{ripple} = 3\%$ of $12 = 0.36\ V$

Let, $R_s = 10k\Omega$ $= 10{,}000\ \Omega$ $R_{out} = R_s + R_{motor}$ $= 10{,}050\ \Omega$

$$C = \frac{V_P}{V_{ripple}.f_{out}(R_s + R_{motor})} = 1.25 \times 10^{-5}\ F = 12.5\ \mu F$$

$\therefore R_s = 10k\Omega$, $C = 12.5\ \mu F$



FW:

10.6 V

$V_p = \cancel{11.3\,V}$, $f = 250\,Hz$

$f_{out} = 2 \times f = 500\ Hz$

$V_{ripple} = 2\%$ of $12 = 0.24\ V$

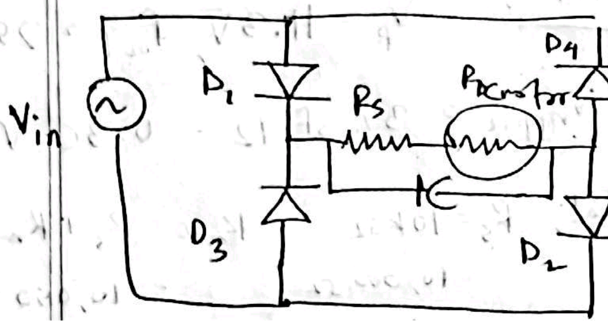
Let,

$R_S = 10k\Omega \quad \therefore R_{out} = R_s + R_{DCmotor}$

$= 10{,}000\ \Omega \qquad\qquad = 10{,}050\ \Omega$

$$C = \frac{V_p}{V_{ripple}\, f_{out}\, (R_{out})} = 8.79\ \mu F$$

$R_S = 10k\Omega$, $C = 8.79\ \mu F$



FW:

10.6 V

$V_p = \cancel{[illegible]}\,V$, $f = 250\,Hz$

$f_{out} = 2 \times f = 500\ Hz$

$V_{ripple} = 3\%$ of $12 = 0.36\ V$

Let,

$R_S = 10k\Omega \quad \therefore R_{out} = R_S + R_{DCmotor}$

$= 10{,}050\ \Omega$

$$C = \frac{V_p}{V_{ripple}\, f_{out}\, R_{out}} = 5.86\ \mu F$$

$R_S = 10k\Omega$, $C = 5.86\,\mu F$