Set-01

Question 1:

(a) From the ckt given-

$V_G = 5\,V$ ← 0.5 Mark

$V_D = 6\,V$ ← 0.5 Mark

Total - 2 Marks

Let's assume, $V_S = x$

To operate in saturation-

$$V_{DS} \geq V_{GS} - V_T$$

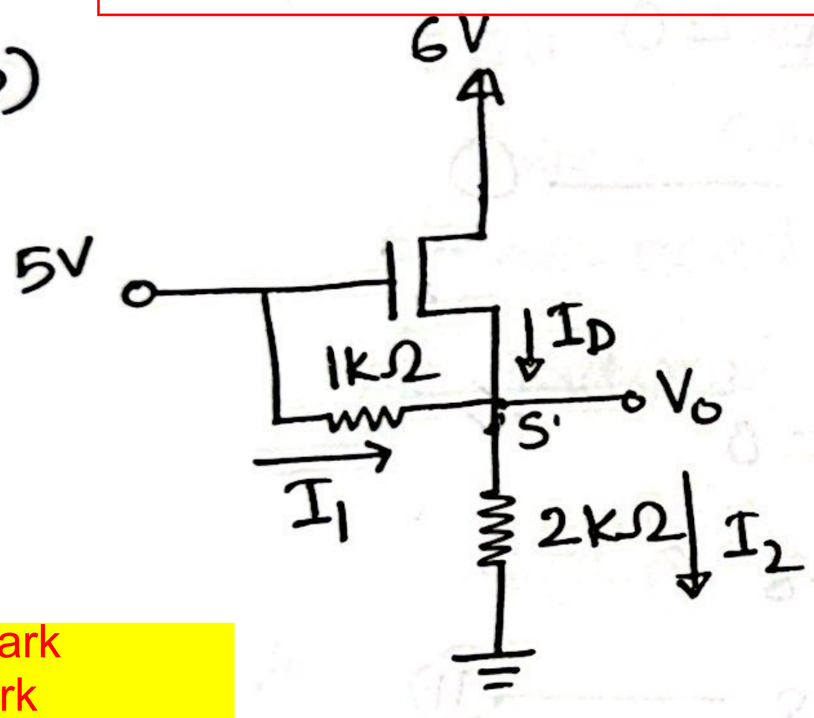
$$\Rightarrow V_D - V_S \geq V_G - V_S - V_T$$

$$\Rightarrow \boxed{6 - x \geq 5 - x - 1}$$

This condition is always true. Hence the MOSFET will operate in Sat.

1 Mark

(b)



Previously we proved the mosfet will operate in saturation.

So,

$$I_D = \frac{1}{2} K (V_{GS} - V_T)^2$$

$$[\text{KCL at } S' \text{ node}]\ I_2 - I_1 = \frac{1}{2} \times 1 (\because 5 - x - 1)^2 \quad [\text{Assuming } V_S = x]$$

$$\Rightarrow \frac{x}{2} - \left(\frac{5-x}{1}\right) = \frac{1}{2}(4-x)^2$$

$$\Rightarrow x - 10 + 2x = 16 - 8x + x^2$$

$$\Rightarrow x^2 - 11x + 26 = 0$$

$$\Rightarrow x = 7.56, 3.43$$

↓ not acceptable for Saturation.

KCL - 1 Mark
VO - 1 Mark
I1 - 1 Mark
I2 - 1 Mark
ID - 1 Mark
Verification - 1 Mark

Total - 6 Marks

Give 3 marks for wrong assumption but correct procedure

$\therefore V_o = V_S = x = 3.43\,V$

$$I_1 = \frac{5 - 3.43}{1K\Omega} = 1.57\,mA \qquad I_D = I_2 - I_1 = 0.145\,mA$$

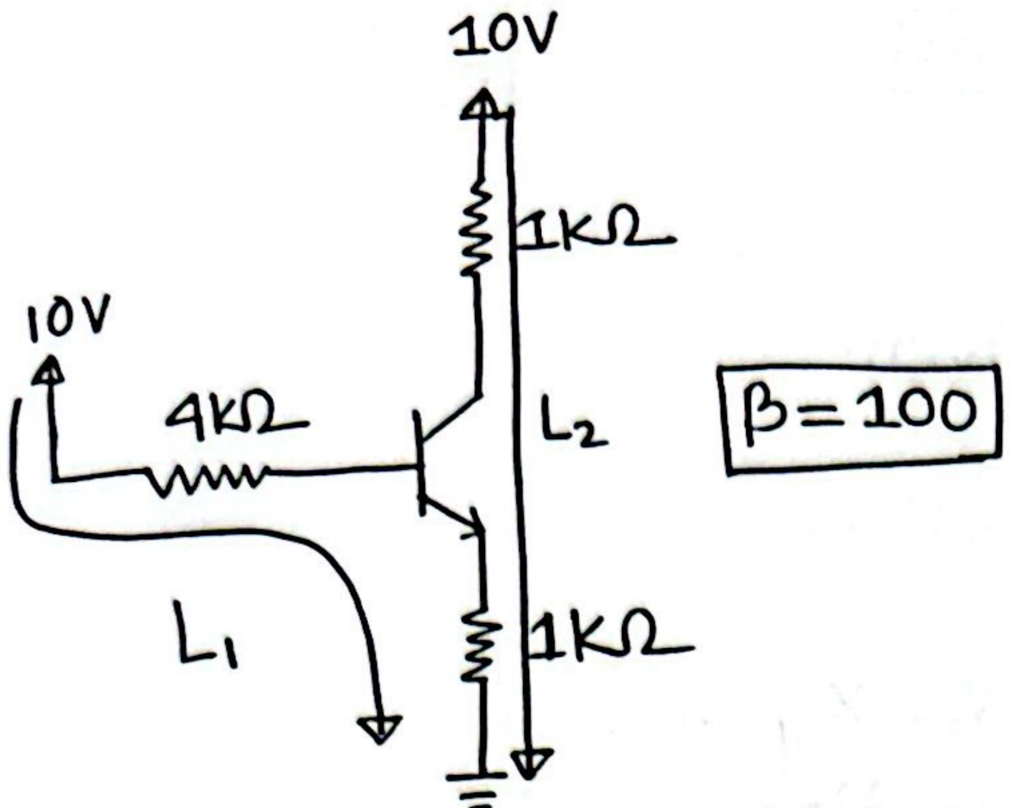
$$I_2 = \frac{3.43}{2} = 1.72\,mA$$

Validation:

$V_{DS} = 6 - 3.43 = 2.57$
$V_{GS} = 5 - 3.43 = 1.57$

$\Rightarrow \boxed{V_{DS} > V_{GS} - V_T}$

(c)



$\beta = 100$

KVL in L1 - 1 mark
KVL in L2 - 1 mark
IB - 1 mark
IC - 1 mark
IE - 1 mark
VC - 1 mark
VE - 1 mark
Verification - 1 mark

total - 8 marks

Give 4 marks for wrong assumption but correct procedure

Let's assume the ~~me~~ BJT is in Saturation.

$\therefore V_{BE,sat} = 0.8V$

$V_{CE,sat} = 0.2V$

Applying KVL along L_1

$$-10V + 4I_B + 0.8 + I_E = 0$$

$$\Rightarrow 4I_B + I_E = 9.2 \quad \text{——— (I)}$$

Applying KVL along L_2

$$-10 + I_C + 0.2 + I_E = 0$$

$$\Rightarrow I_E - I_B + I_E = 9.8$$

$$\Rightarrow 2I_E - I_B = 9.8 \quad \text{——— (II)}$$

from (I) and (II)

$I_B = 0.95\,mA$

$I_E = 5.37\,mA$

$\therefore I_C = 4.421\,mA$

$V_E = (5.37\,mA \times 1) = 5.37\,V$

Validation:

$$\frac{I_C}{I_B} < \beta$$

$$\Rightarrow \boxed{\frac{4.42}{0.95} < 100} \rightarrow \text{This is TRUE}$$

(d) From the graph-

$$T = (1.25 - 0.25)\,ms$$
$$= 1\,ms$$

1 mark

Total - 4 marks

$$\therefore f_{out} = \frac{1}{T} = 1\,KHz$$

1 mark

$$V_{avg} = 5 + \frac{(10-5)}{2}$$

$$V_{avg} = 7.5\ V$$

2 mark

Question 2:

Given,

$$V_{in} = 10\sin(200\pi t)$$

$$f_{in} = 100\ Hz$$

1 mark

Total - 10 marks

$$f_{out} = 200\ Hz$$

So, we need to design a F.W. rectifier.

1 mark

$$V_{out(max)} = 10 - 2 \times V_{D0}$$
$$= 8.6\ V$$

1 mark

$$V_{ro(p-p)} = 0.43\ V.$$

1 mark

We know-

$$V_{ro(p-p)} = \frac{V_{out(max)}}{f_{out}\,RC}$$

1 mark

Let's assume- $R = 5K\Omega$

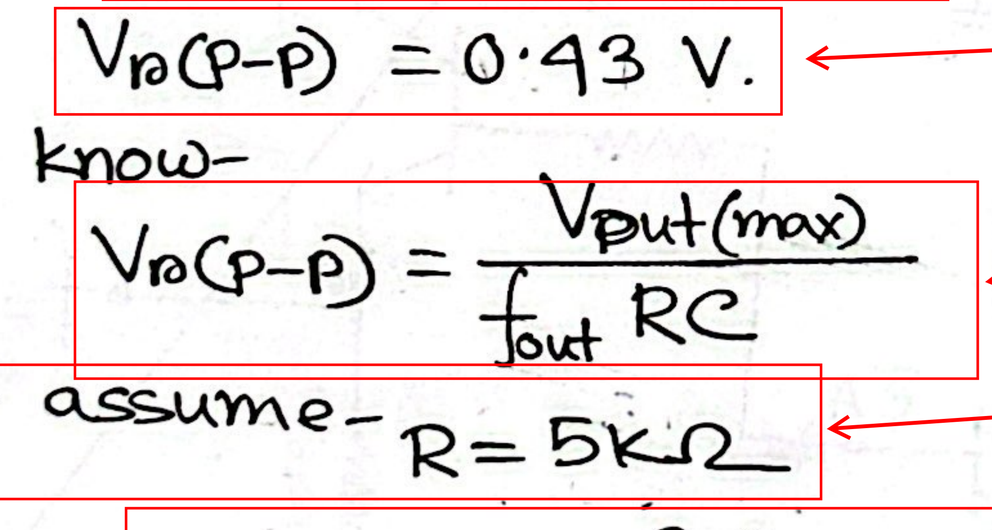
1 mark

$$\therefore C = \frac{8.6}{0.43 \times 200 \times 5 \times 10^3}$$

$$= 20\ \mu F$$

1 mark

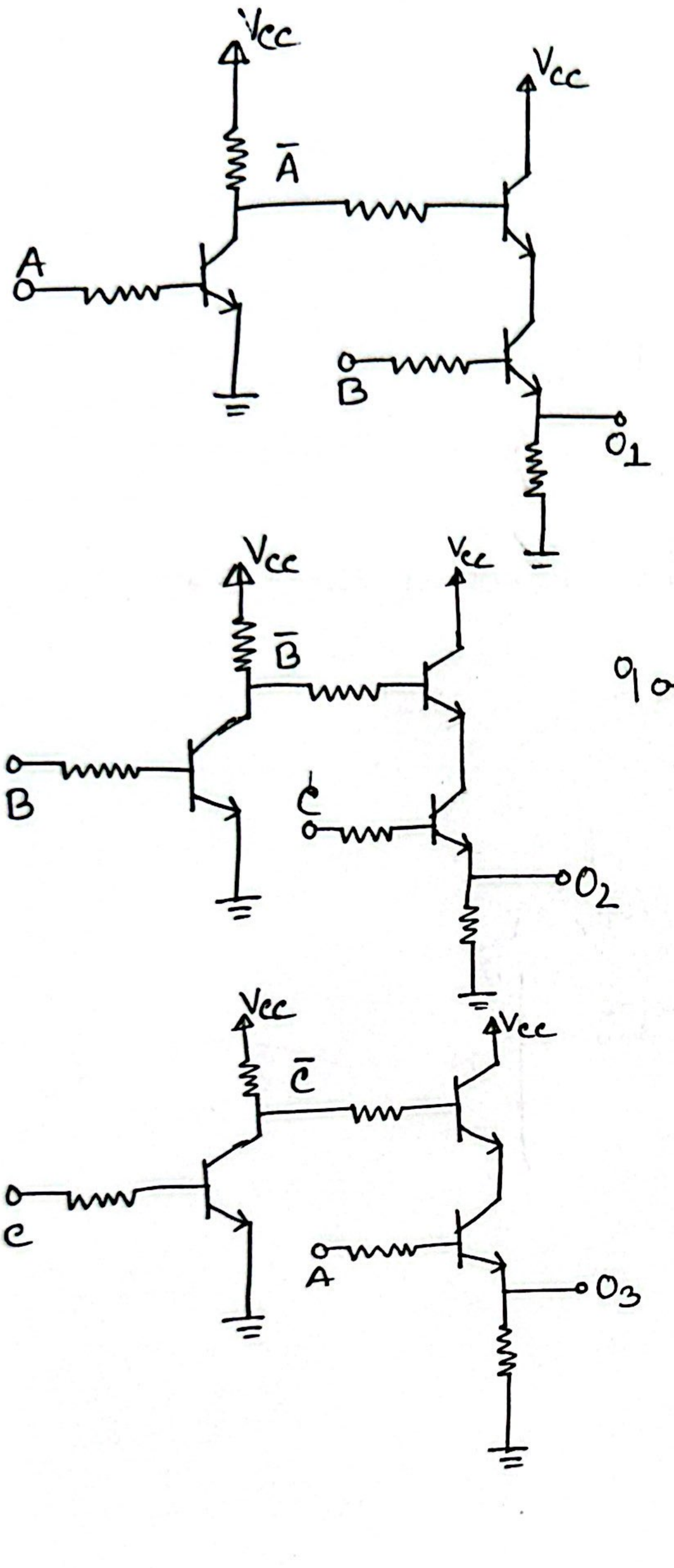
Designed ckt:



3 marks

(b) $f = \bar{A}B + \bar{B}C + \bar{C}A$

$= O_1 + O_2 + O_3$



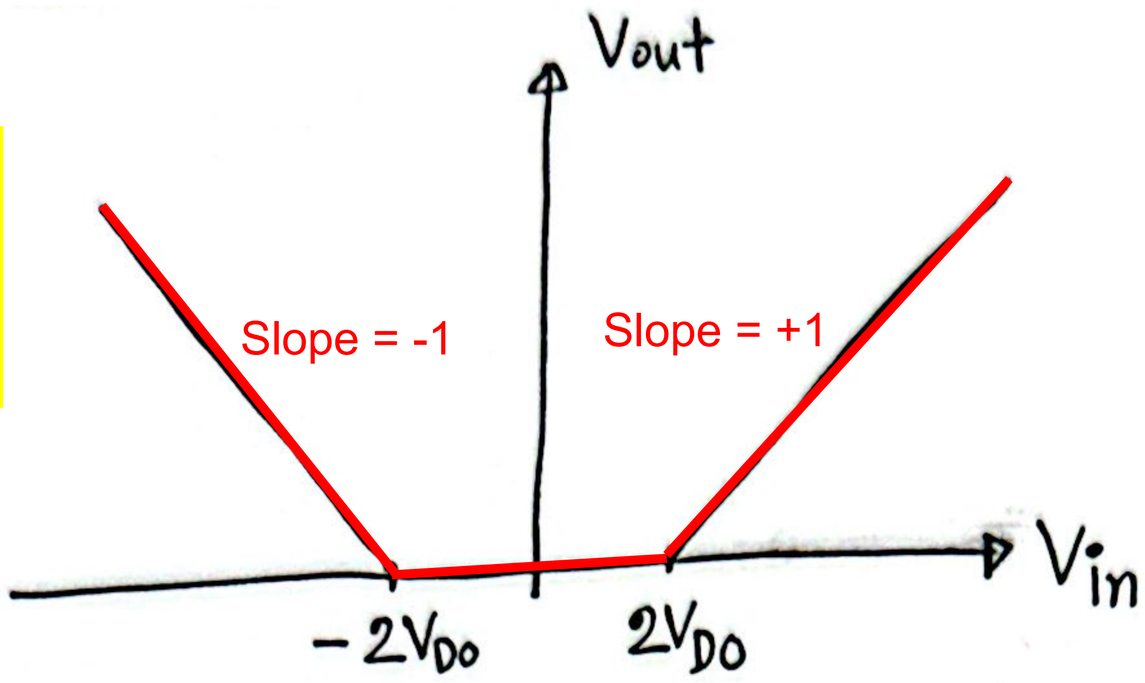
This circuit is drawn differently & it's valid. You may have taught a different way of drawing logic circuits.

Give partial marks according to your judgement.

Total - 10 marks

Question 3

(a)



Graph - 2 marks
Label - 2 marks

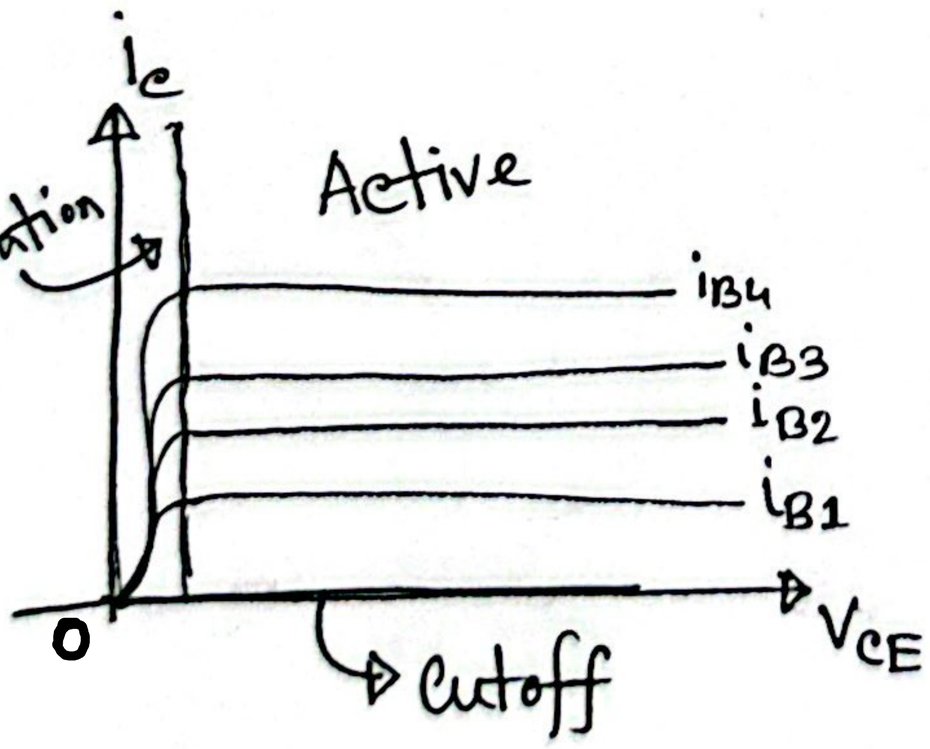
total - 4 marks

(b) MOSFET is an electronic device. The "Triode" & "Cutoff" region in the I-V graph of a MOSFET is almost similar to the "ON" state & the "OFF" state in the I-V graph of a switch respectively. This resemblance allows MOSFETs to act like switches by turning current flow ON or OFF electronically. Hence, MOSFETs can be used as an electronic switches.

total - 2 marks

give partial marks according to the answer

(c)



Graph - 1.5 marks
Label - 1 mark

Identifying Operating Regions - 3*0.5 = 1.5 marks

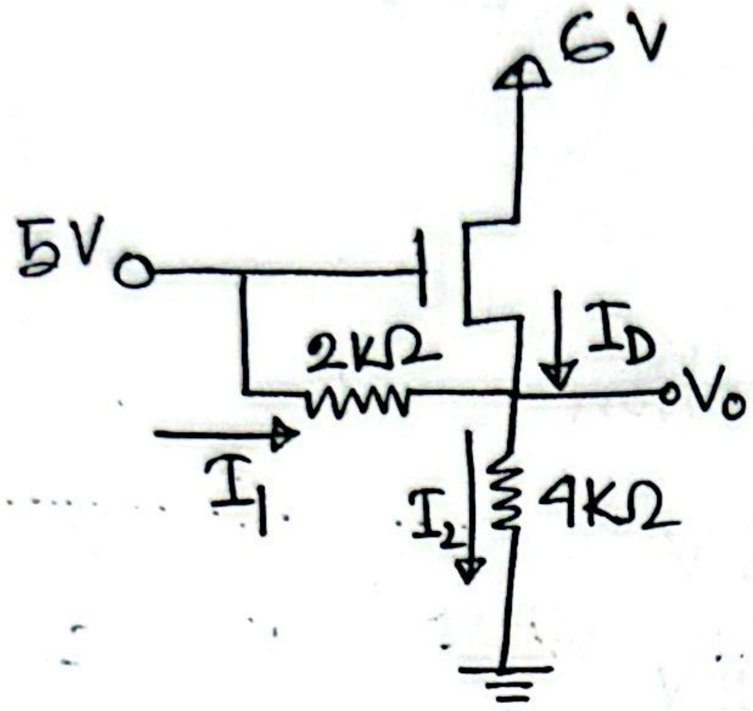
Total - 4 marks

Set-02

Question 1:

(a) Same as set-01 1(a)

(b)



Assumption — saturation

$$I_D = \frac{1}{2} K (V_{GS} - V_T)^2$$

$$\Rightarrow I_2 - I_1 = \frac{1}{2} \times \frac{1}{2} (5 - x - 1)^2 \quad [\text{Assuming } V_S = x]$$

$$\Rightarrow \frac{x}{4} - \left(\frac{5-x}{2}\right) = \frac{1}{4}(4-x)^2$$

$$\Rightarrow x - 10 + 2x = 16 - 8x + x^2$$

$$\Rightarrow x = 7.56, 3.43$$

↓

not acceptable

$$V_o = V_S = x = 3.43 \text{ V}$$

$$I_1 = \frac{5 - 3.43}{2k} = 0.785 \text{ mA} \qquad I_D = I_2 - I_1 = 0.0725 \text{ mA}$$

$$I_2 = \frac{3.43}{4k} = 0.8575 \text{ mA}$$

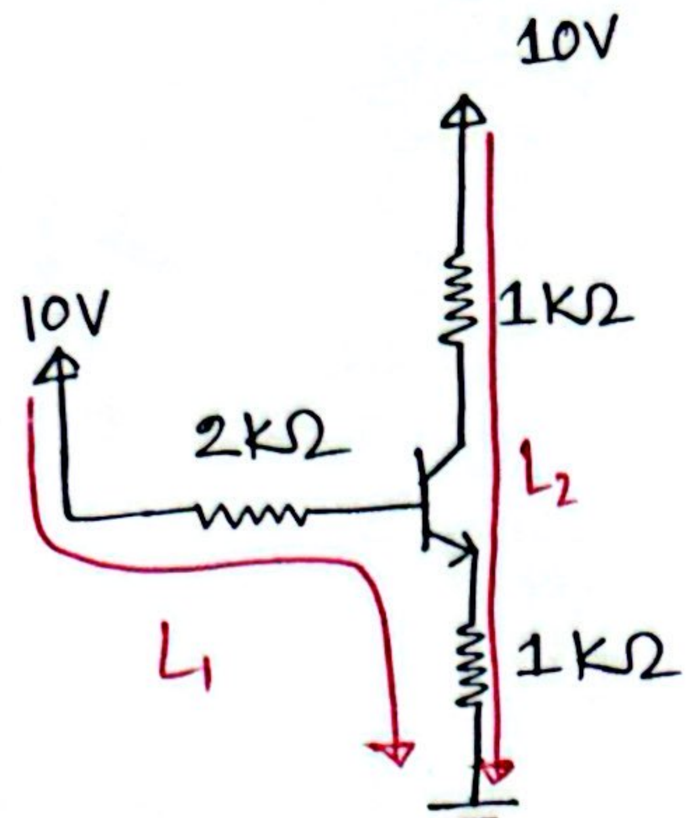
Validation:

$$V_{DS} = 6 - 3.43 = 2.57 \text{ V}$$

$$V_{GS} = 5 - 3.43 = 1.57 \text{ V}$$

$$V_{DS} > V_{GS} - V_T$$

(c)



$\boxed{\beta = 100}$

Assumption — Saturation

$$V_{BE,sat} = 0.8\ V$$

$$V_{CE,sat} = 0.2\ V$$

Applying KVL along L_1

$$-10 + 2I_B + 0.8 + I_E = 0$$

$$\Rightarrow 2I_B + I_E = 9.2 \quad \text{——} (1)$$

Applying KVL along L_2

$$-10 + I_C + 0.2 + I_E = 0$$

$$\Rightarrow I_E - I_B + I_E = 9.8$$

$$\Rightarrow 2I_E - I_B = 9.8 \quad \text{——} (11)$$

Solving (1) & (11)

$$I_B = 1.72\ mA$$

$$I_E = 5.76\ mA$$

$$\therefore I_C = 4.04\ mA$$

$$V_E = 5.76\ V$$

Validation:

$$\frac{I_C}{I_B} < \beta$$

$$\Rightarrow \frac{4.04}{1.72} < 100 \quad \boxed{\text{TRUE}}$$

(d) $T = (1.25 - 0.25)\,ms$

$= 1\,ms$

$f_{out} = 1\,kHz$

$V_{avg} = 10 + \left(\frac{20-10}{2}\right)$

$\boxed{V_{avg} = 15\ V}$

Question 2

Given,

$V_{in} = 10\sin(200\pi t)$

$f_{in} = 100\ Hz$

$f_{out} = 100\ Hz$

Design requirement:- H.W. rectifier

$V_{out(max)} = 10 - 0.7 = 9.3\ V$

$V_{rp(p-p)} = 0.93\ V$

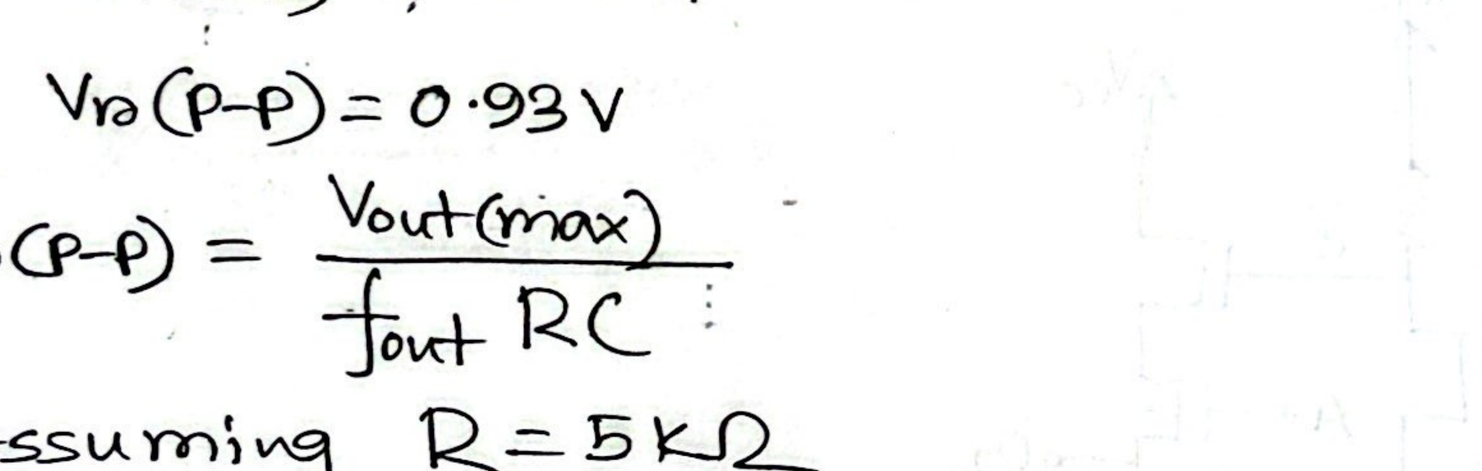
$V_{rp(p-p)} = \frac{V_{out(max)}}{f_{out} RC}$

Assuming $R = 5k\Omega$

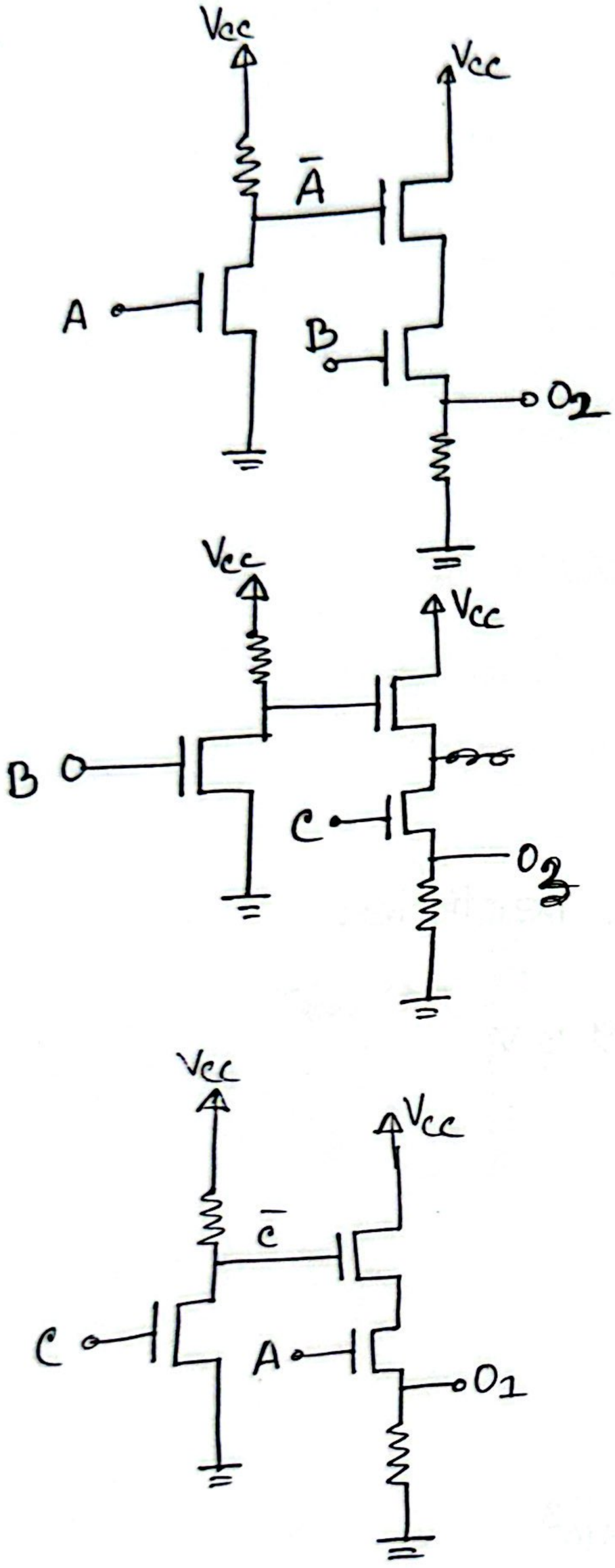
$C = \frac{9.3}{0.93 \times 100 \times 5 \times 10^3}$

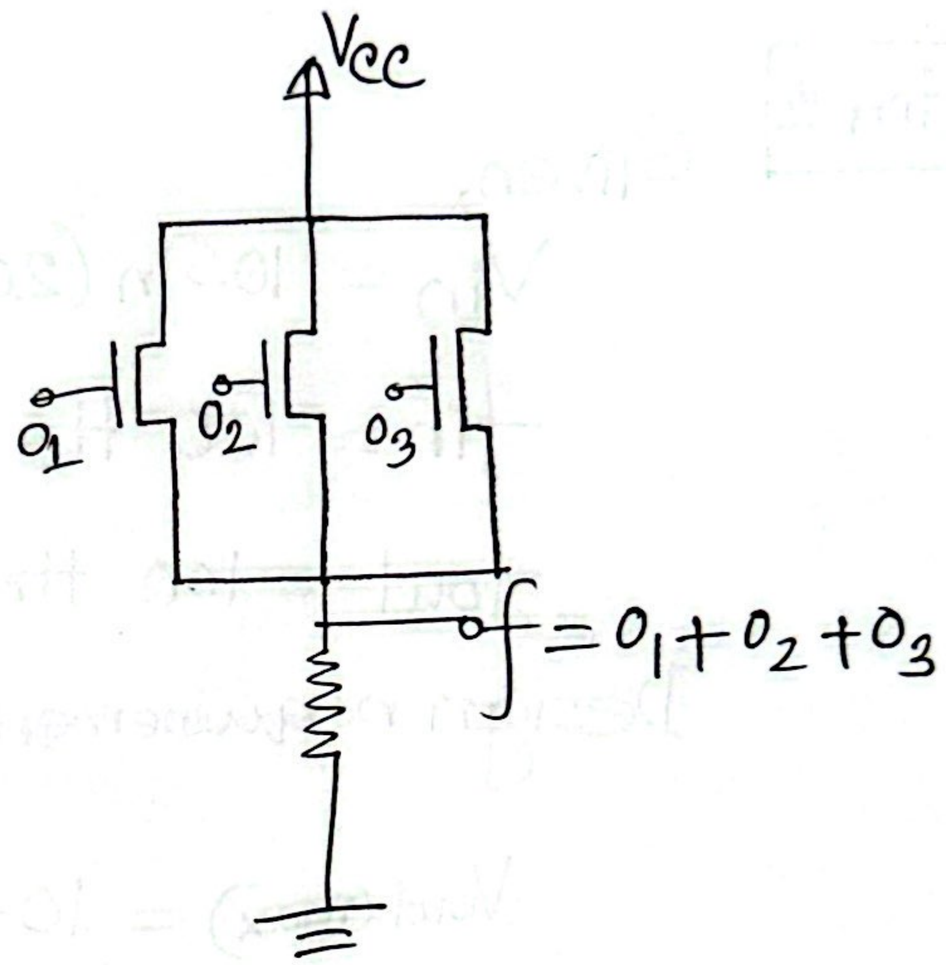
$= 20\mu F$

Designed ckt:



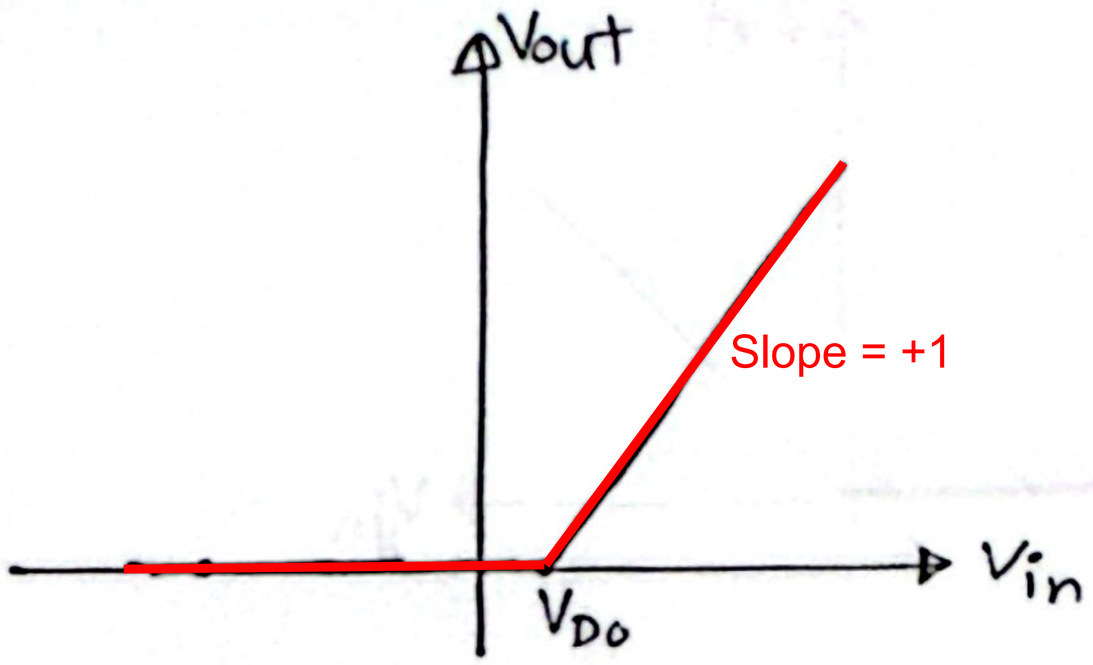
(b) $f = \bar{C}A + \bar{A}\cdot B + \bar{B}C = O_1 + O_2 + O_3$





Question 3

(a)



(b) BJT is an electronic device. The "Saturation" & "Cutoff" region in the I-V graph of a BJT is almost similar to the "ON" state & the "OFF" state in the I-V graph of a switch respectively. This resemblance allows BJTs to act like switches by turning current flow ON or OFF electronically. Hence, BJTs can be used as an electronic switches.

(c)