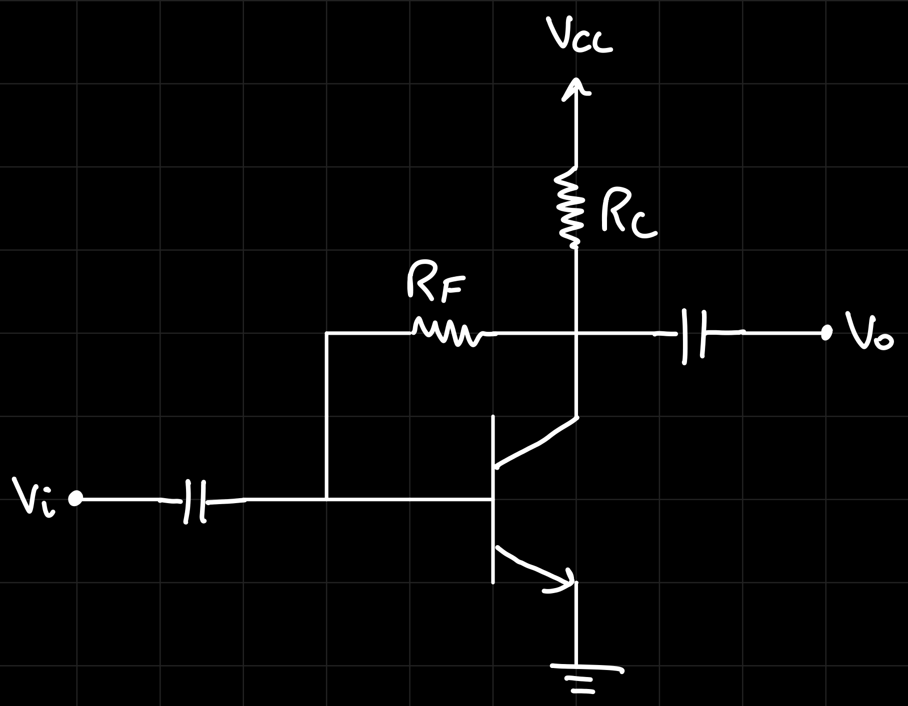
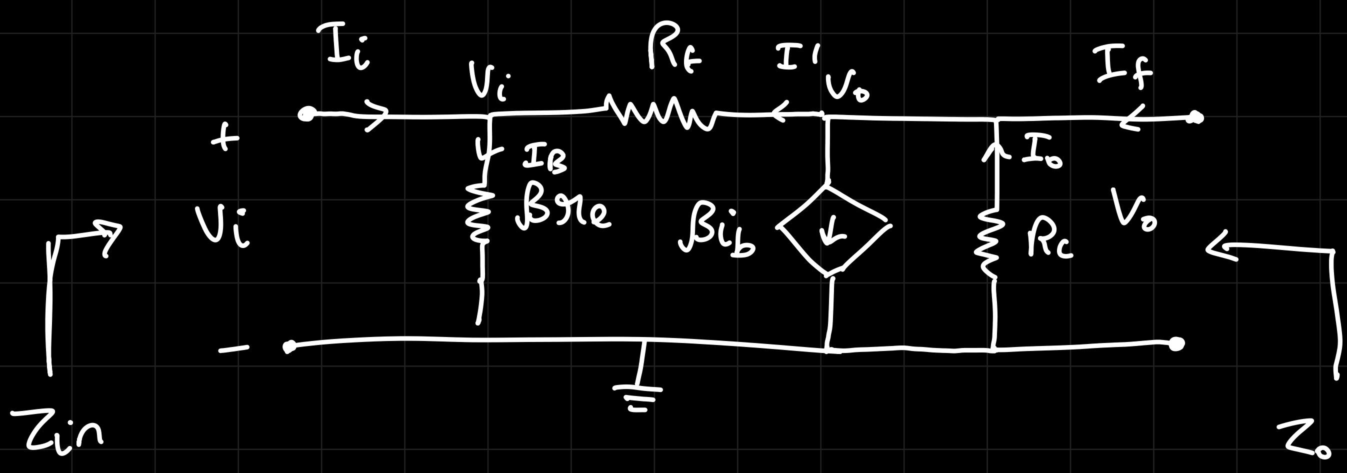
* AC Analysis of feedback biasing



$R_E = 0 \rightarrow \pi$ model



$$V_o = -I_o R_c$$

$$I_o = \beta I_B + I'$$

assume $I' <<< \rightarrow \quad I_o = \beta I_B$

$$V_o = -\beta I_B R_c$$

$$I_B = \frac{V_i}{\beta r_e}$$

$$\boxed{\frac{V_o}{V_i} = -\frac{R_c}{r_e}}$$

Quizz: 4 questions

2 × AC analysis BJT
1 × AC MOSFET
1 × DC MOSFET

$$I' = \frac{V_o - V_i}{R_f} = \frac{V_o}{R_f} - \frac{V_i}{R_f}$$

$$= -\frac{V_i \cdot R_c}{r_e R_f} - \frac{V_i}{R_f}$$

$$V_o = -\beta I_B R_c$$

$$I_i + I' = I_B$$

$$I_b - I_i = \frac{V_o}{R_f} - \frac{V_i}{R_f}$$

$$I_b - I_i = -\frac{\beta I_B R_c}{R_f} - \frac{V_i}{R_f}$$

$$I_b - I_i = \frac{-\beta V_i R_c}{\beta r_e R_f} - \frac{V_i}{R_f}$$

$$I_b - I_i = \frac{-V_i(R_c + r_e)}{r_e R_f}$$

$$I_b = \frac{V_i}{\beta r_e}$$

$$\frac{V_i}{\beta r_e} + \frac{V_i(R_c + r_e)}{r_e R_f} = I_i$$

$$\frac{1}{\beta r_e} + \frac{R_c + r_e}{r_e R_f} = \frac{1}{Z_{in}}$$

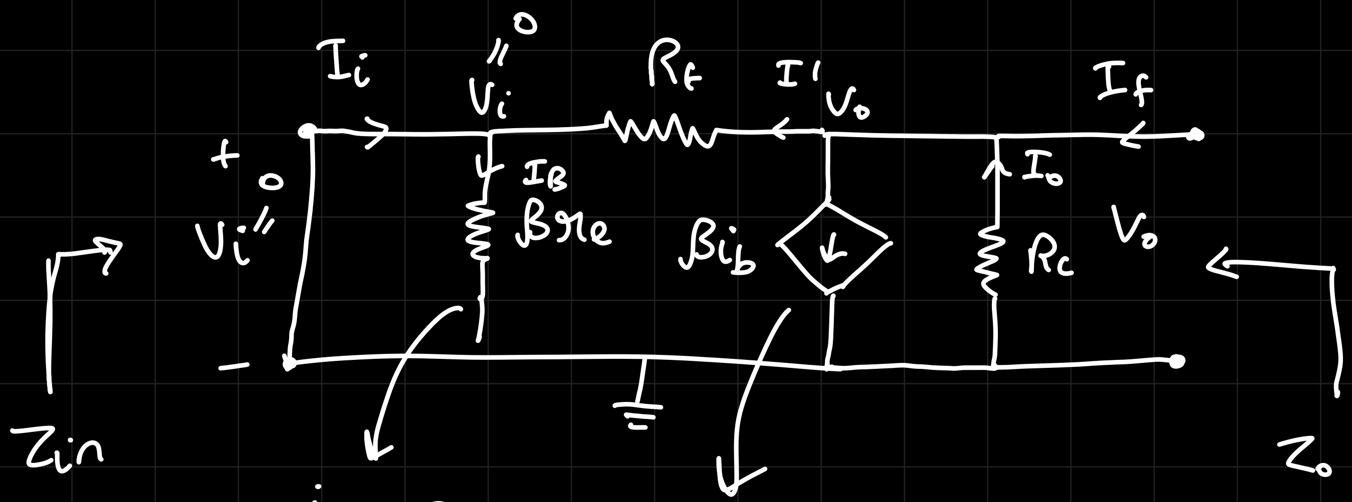
$$\frac{\beta \cancel{r_e} + \cancel{r_e} R_f}{\cancel{r_e} R_f + \beta \cancel{r_e}(R_c + r_e)} = Z_{in}$$

$$\frac{\beta + R_f}{\beta(R_c + r_e) + R_f} = Z_{in}$$

$$Z_{in} = \frac{1}{\frac{1}{R_f} + \left(\frac{\ }{\beta r_e} + \frac{R_c}{r_e R_f}\right)}$$

$$Z_o = \frac{V_o}{I_f}$$

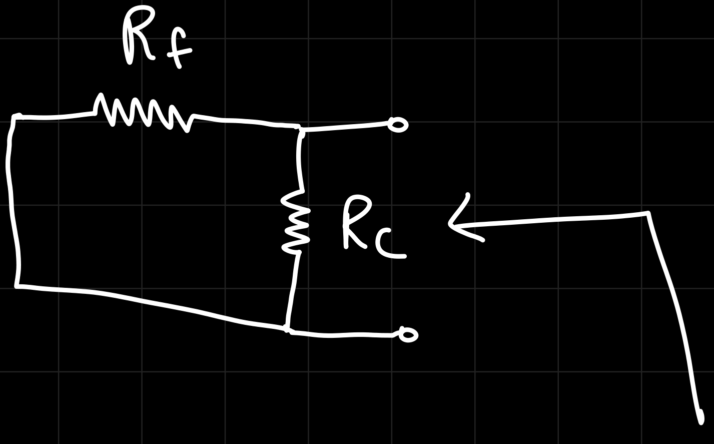
like 2port network problems, remove input V



$i_b = 0$

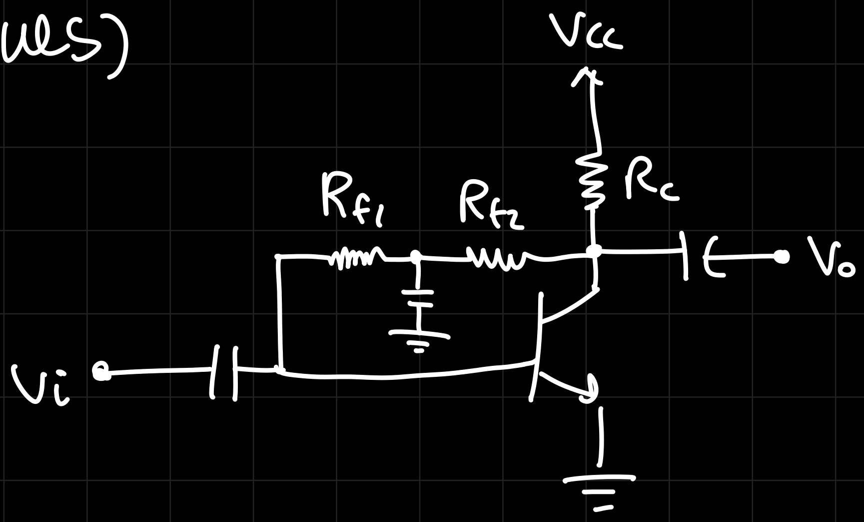
$\beta i_b = 0$

$$i_b = \frac{V_i}{\beta r_e} = 0$$

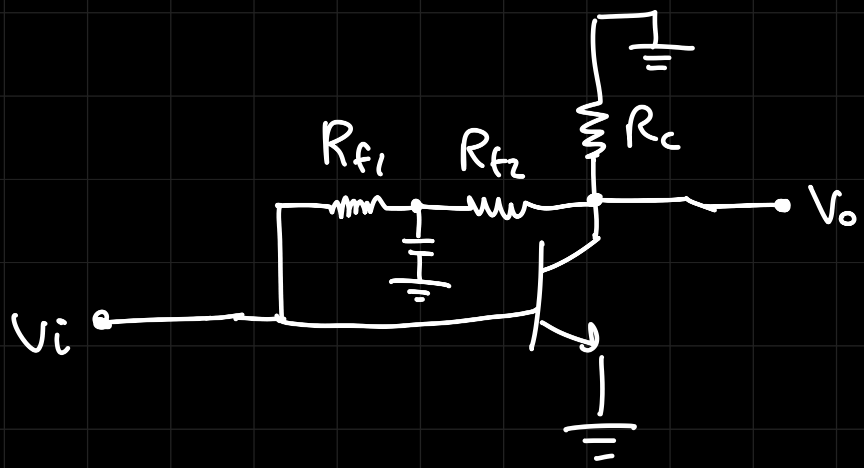


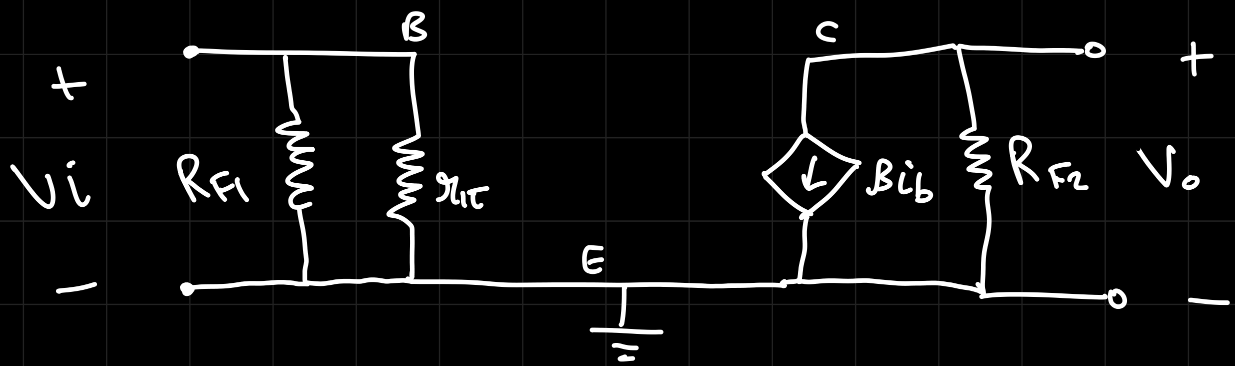
$Z_o = R_c \parallel R_f$ $\quad Z_o$

ques)

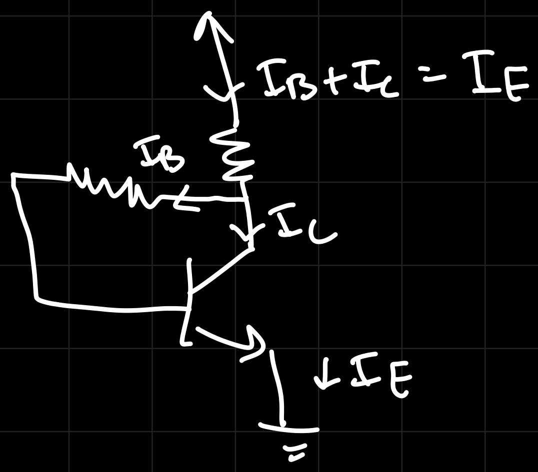


AC →



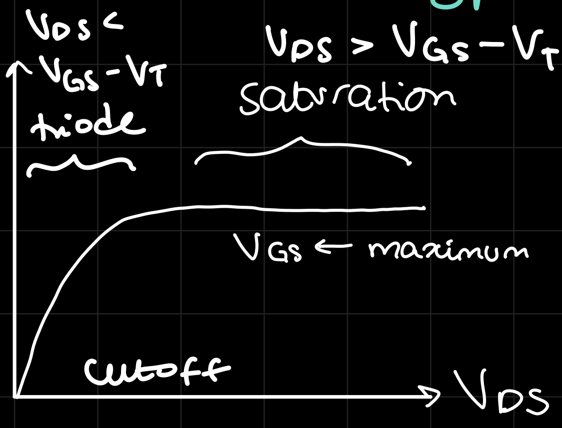


called "feedback" because
we are getting I_E in Collector
and Emitter side



MOSFET (numerical)

enhancement type



Nmos : $\simeq$ parallel plate capacitor (principle)

saturation mode: $V_{DS} > V_{GS} - V_T$

$$i_D = \frac{1}{2} \mu_n C_{ox} \times \frac{W}{L} \times [V_{GS} - V_T]^2$$

μ_n: e^- mobility $\left(\frac{m^2}{V\,sec}\right)$

C_{ox}: oxide capacitance

Triode mode : $V_{DS} < V_{GS} - V_T$

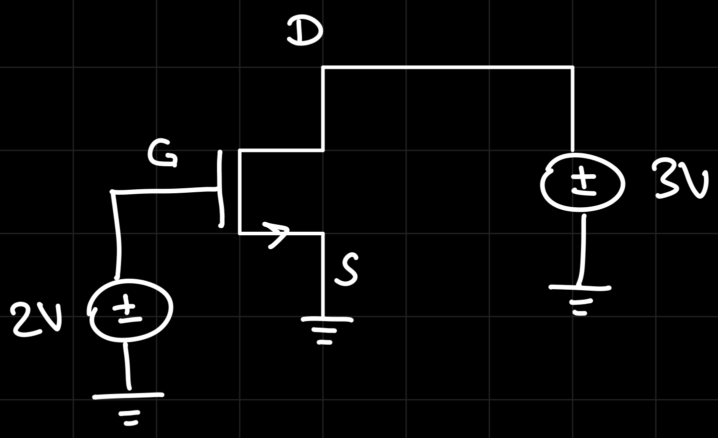
$$i_D = \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_T) \times \left(V_{DS} - \frac{1}{2} V_{DS}^2\right)$$

Cutoff mode : $V_{GS} < V_T$

$$I_d = 0$$

→ for the given circuit shown,
$V_T = 0.6V$
find the region of operation

$V_T = +ve \rightarrow$ n channel
$= -ve \rightarrow$ p channel



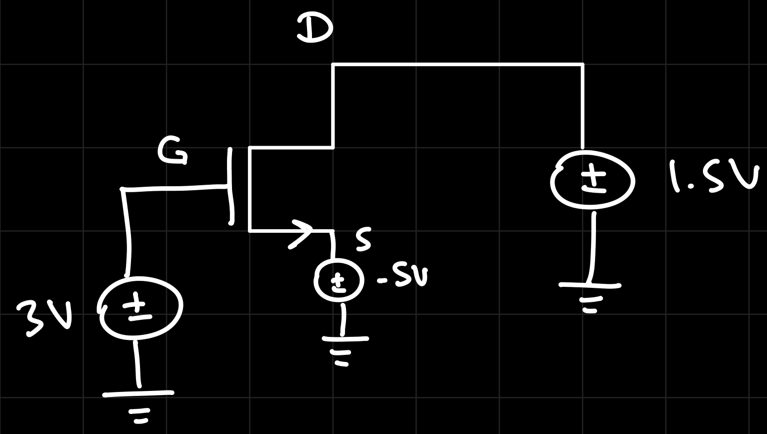
$$-2 + V_{GS} = 0$$
$$V_{GS} = 2V$$

$$-3 + V_{DS} = 0$$
$$V_{DS} = 3V$$

$$V_{DS} = 3V > V_{GS} - V_T = 1.3V$$

saturation

g) determine mode of operation



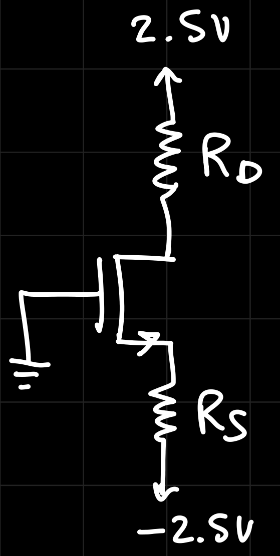
$$-3 + V_{GS} + 0.5 = 0$$
$$V_{GS} = 2.5\,V$$

$$-1.5 + V_{DS} + 0.5 = 0$$
$$V_{DS} = 1V$$

$$V_{DS} = 1V \quad < \quad V_{GS} = 2.5 - 0.6 = 1.9\,V$$

Triode mode

8)



Calculate R_D and R_S

given : $V_T = 1V$

$\mu_n C_{ox} = 60\mu AV^{-2}$

$\frac{W}{L} = \frac{120\mu m}{3\mu m} = 40$

$I_D = 0.3mA$

$V_D = 0.4V$

$V_{GS} - 2.5 + R_S I_S = 0$

$V_{GS} + R_S I_S = 2.5$

$-2.5 + R_D I_D + V_{DS} + R_S I_S - 2.5 = 0$

assume sat

$0.3 \times 10^{-3} = 60 \times 10^{-6} \times 40 (V_{GS} - V_T)^2$

$R_D = \frac{2.5 - V_D}{I_D} k = \frac{2.5 - 0.4}{0.3} k = \frac{2.1}{0.3} k = 7k\Omega$

$$V_{DS} = V_D - V_S$$
$$V_{GS} = V_G - V_S$$
note: $V_G = 0$

$V_D = 0.4V$ (given)

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

$\downarrow$

$V_T = 1V$

$$V_{GS} - V_T = -V_S - 1$$
$$V_{DS} = 0.4 - V_S$$

$V_{DS} > V_{GS} - V_T \rightarrow$ SATURATION mode

$$I_d = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_T)^2$$

10-1

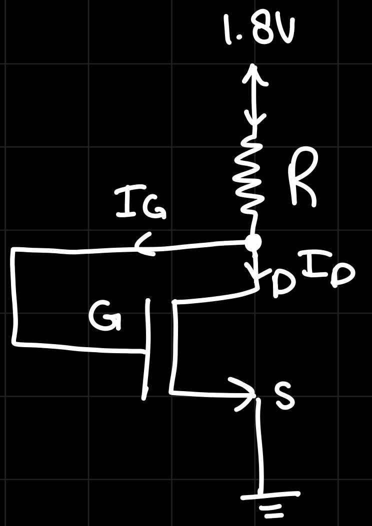
$$0.6 \times \cancel{10^{-3}} = 6\cancel{0} \times \cancel{10^{-6}} \times 4\cancel{0} \times (V_{GS} - V_T)^2$$

$$0.25 = (V_{GS} - V_T)^2$$

$$V_{GS} - V_T = 0.5V$$
$$V_{GS} = 1.5V \rightarrow V_{GS} = \underbrace{V_G}_{=0} - V_S \Rightarrow V_S = -1.5V$$

$$R_S = \frac{V_S - (-2.5)}{I_S} = \frac{V_S + 2.5}{I_D} = \frac{1}{0.3}k\Omega = \underline{3.33k\Omega}$$

9}



given:

$V_D = 0.7V$

$V_{th} = 0.5V$

$\mu_n C_{ox} = 0.4m$

$\frac{W}{L} = 4$

$$R = \frac{1.8 - 0.7}{I_D (\simeq I_S)}$$

$V_D = 0.7v$, $V_S = 0v$, $V_G = 0.7v$ (shorted)

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

saturation

because $V_S = 0$ so $V_D \geq V_G - V_T$

$0.7 \geq 0.7 - 0.5$

$$I_d = \frac{1}{2} \times 0.4 \times 10^{-3} \times 4 \times (V_G - V_T)^2$$

$$= 0.8 \times 10^{-3} \times 0.04$$

$$= \underline{32 \mu A}$$

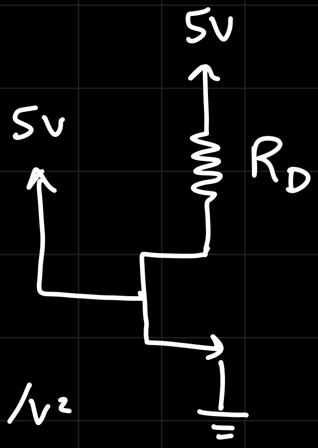
$$R = \frac{1.8 - 0.7}{32} M\Omega = \frac{1.1}{32} = \underline{34 k\Omega}$$

Q3

$V_D = 0.1V$

$V_T = 1V$

$\mu_n C_{ox} \frac{W}{L} = 1mA/V^2$



$-5 + I_D R_D + V_{DS} = 0$

$V_{GS} = 5V$

$V_G = 5V$

$V_{GS} - V_T = 4V$

$V_{DS} = 0.1$

triode mode

$I_d = 10^{-3} \times (4) \times (0.1 - \frac{1}{2}(0.01))$

$= 10^{-3} \times 4 \times 10^{-1} - 5 \times 10^{-3}$

$= 10^{-4} \times 4 - 5 \times 10^{-3}$

$\Rightarrow (4 - 50) 10^{-4}$

$\Rightarrow$