Base width modulation or Early Effect $\Rightarrow$ The output current is depend upon the input current as well as output voltage.

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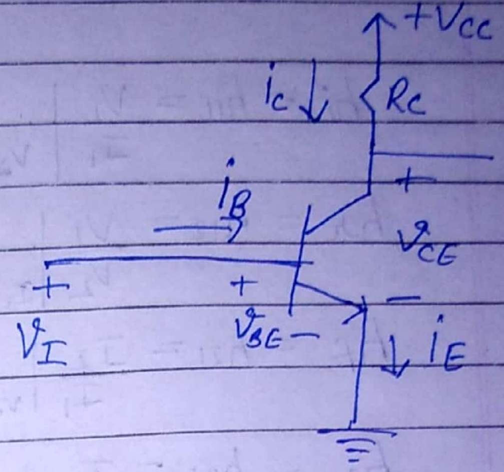
BJT as an Amplifier & as a Switch



$v_o = V_{cc} - i_c R_c$

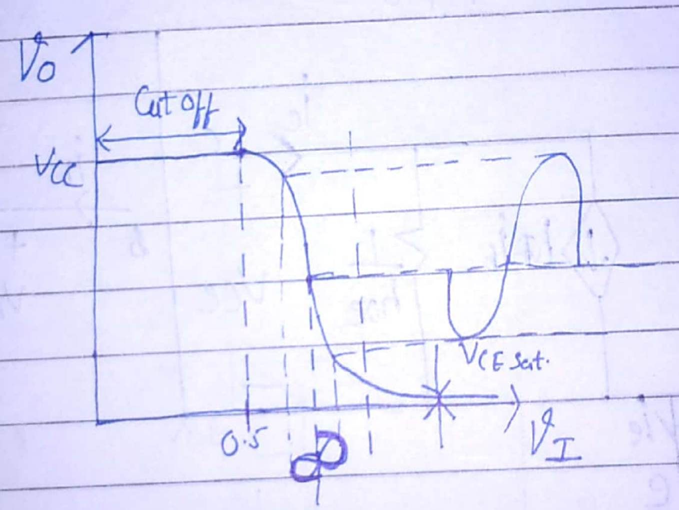
$v_o = V_{cc} - I_s e^{v_{BE}/V_T} \cdot R_c$

$v_o = V_{cc} - I_s e^{v_I/V_T} \cdot R_c$

for $v_I \leq 0.5\,V$

$v_o = V_{cc}$

for $v_I > 0.5\,V$



$$v_o = V_{cc} - I_s e^{v_I/V_T} \cdot R_c$$

$$\frac{d v_o}{d v_I} = 0 - I_s e^{v_I/V_T} \cdot \frac{1}{V_T} \cdot R_c$$

$$A_v = \frac{-R_c}{V_T}\left[I_s e^{v_I/V_T}\right]$$

$$\boxed{A_v = \frac{-R_c\, i_c}{V_T} = -\frac{V_{R_C}}{V_T}}$$

−ve sign indicates that input & output phase difference is 180°.

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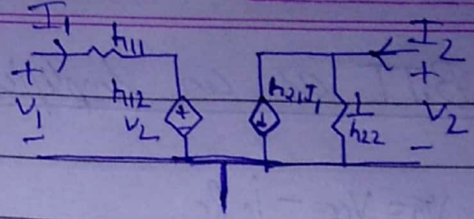
$V_1 = h_{11} I_1 + h_{12} V_2$

$I_2 = h_{21} I_1 + h_{22} V_2$

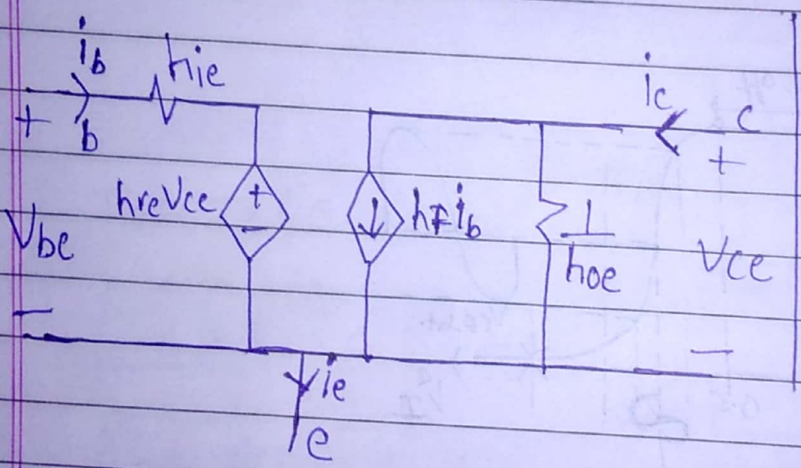


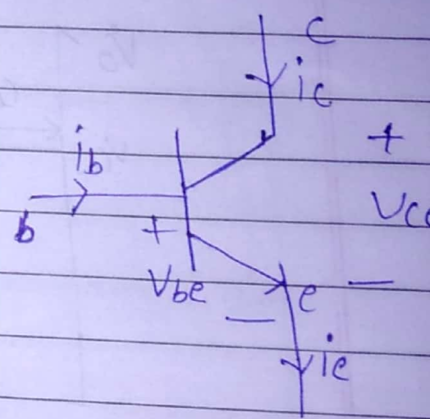
$h_i = h_{11} = \left.\frac{V_1}{I_1}\right|_{V_2=0}$ ⇒ Short ckt. i/p impedance

$h_r = h_{12} = \left.\frac{V_1}{V_2}\right|_{I_1=0}$ ⇒ open ckt. - reverse transfer voltage gain

$h_f = h_{21} = \left.\frac{I_2}{I_1}\right|_{V_2=0}$ ⇒ Short ckt. forward transfer current gain

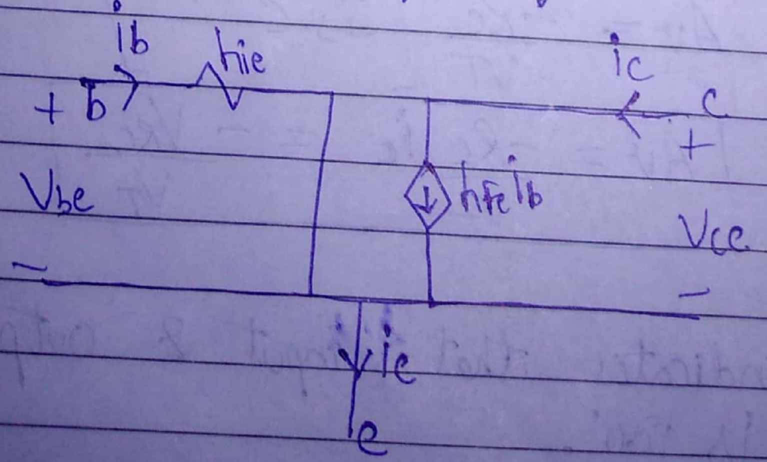
$h_o = h_{22} = \left.\frac{I_2}{V_2}\right|_{I_1=0}$ ⇒ open ckt. O/P admittance





h_{re} is very-very small

$\frac{1}{h_{oe}}$ is very-very large



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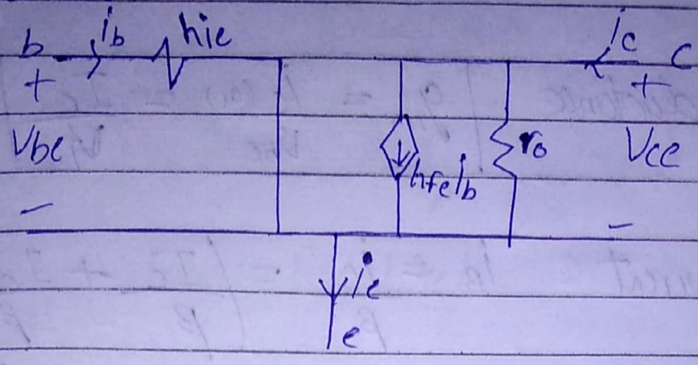
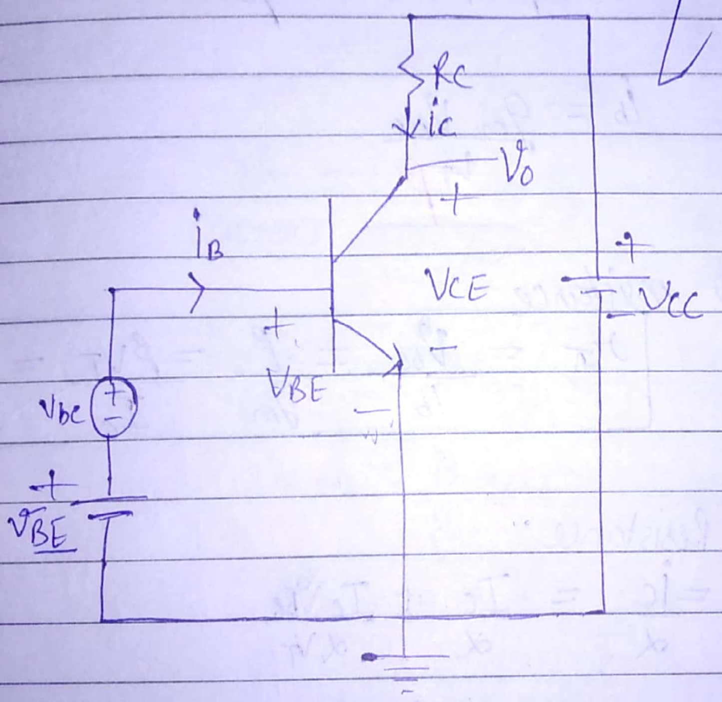
r_o is connected to show the effect of base width modulation.



Small signal operation & Model



$$v_{BE} = v_{be} + V_{BE}$$

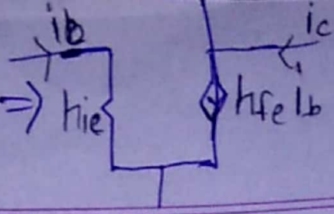
$$\underset{(ac+dc)}{i_c} = I_S e^{v_{BE}/V_T} = I_S e^{(v_{be}+V_{BE})/V_T}$$

$$= I_S e^{V_{BE}/V_T} \cdot e^{v_{be}/V_T}$$

$$i_c = I_C e^{v_{be}/V_T}$$

$$\because v_{be} << V_T$$

$$\underset{(ac+dc)}{i_c} = I_C \left[1 + \frac{v_{be}}{V_T}\right] = \underset{DC}{I_C} + \underset{ac}{I_C \frac{v_{be}}{V_T}}$$

hybrid π modal $\Rightarrow$ 

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$$\underset{(ac)}{i_c} = \frac{I_c V_{be}}{V_T}$$

Transconductance $\boxed{g_m = \frac{i_{c(ac)}}{V_{be}} = \frac{I_c}{V_T}}$

Base Current $i_B = \frac{i_c}{\beta} = \left(\underset{bc}{\frac{I_c}{\beta}} + \underset{ac}{\frac{I_c V_{be}}{\beta V_T}}\right)$

$$i_b = \frac{I_c V_{be}}{\beta V_T} = \frac{g_m V_{be}}{\beta}$$

$$i_b = \frac{g_m V_{be}}{\cancel{V_T}\beta}$$

base ~~i/p~~ resistance

$$\boxed{r_\pi = \frac{V_{be}}{i_b} = \frac{\beta}{g_m} = \frac{\beta V_T}{I_c} = \frac{V_T}{I_B}}$$

25/09/19 Emitter Resistance

$$\underset{ac+dc}{i_E} = \frac{i_c}{\alpha} = \frac{I_c}{\alpha} + \frac{I_c V_{be}}{\alpha V_T}$$

$$\underset{ac+dc}{i_E} = \underset{dc}{I_E} + \underset{ac}{\frac{I_c V_{be}}{\alpha V_T}}$$

$$i_e = \frac{I_c V_{be}}{\alpha V_T}$$

Emitter resistance $(r_e) = \frac{V_{be}}{i_e}$

$$\boxed{r_e = \frac{\alpha V_T}{I_c} = \frac{\alpha}{g_m} = \frac{V_T}{I_E}}$$

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$$r_\pi > r_e$$

$$r_\pi = \frac{\beta}{g_m} = \left(\frac{\alpha}{1-\alpha}\right)\frac{1}{g_m}$$

$$\boxed{r_\pi = \frac{r_e}{1-\alpha}} = \frac{r_e}{1-\frac{\beta}{1+\beta}} = \frac{r_e(1+\beta)}{1+\beta-\beta}$$

$$\boxed{r_\pi = (1+\beta)\, r_e}$$

Gain

$$\underset{(ac+dc)}{v_o} = V_{CC} - \underset{(ac+dc)}{i_c R_C}$$

$$= V_{CC} - \left[I_C + I_C\frac{v_{be}}{V_T}\right]R_C$$

$$\underset{(ac+dc)}{v_o} = \underbrace{V_{CC} - I_C R_C}_{dc} - \underbrace{\frac{I_C v_{be} R_C}{V_T}}_{ac}$$

$$\underset{(ac)}{v_o} = \frac{-I_C v_{be} R_C}{V_T}$$

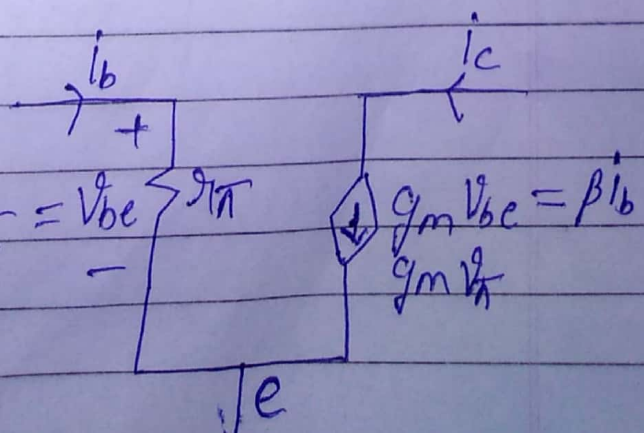
$$\text{Gain} = \frac{v_{o(ac)}}{v_{be}} = \frac{-I_C R_C}{V_T}$$

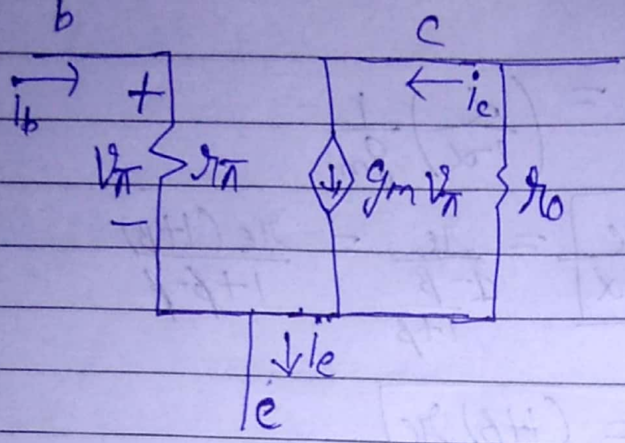
$$\boxed{\text{Gain} = \frac{-V_{RC}}{V_T}}$$

$$\boxed{\text{Gain} = -g_m R_C}$$

-ve sign indicates that 180° phase diff. b/w input & output.

Hybrid - π Model



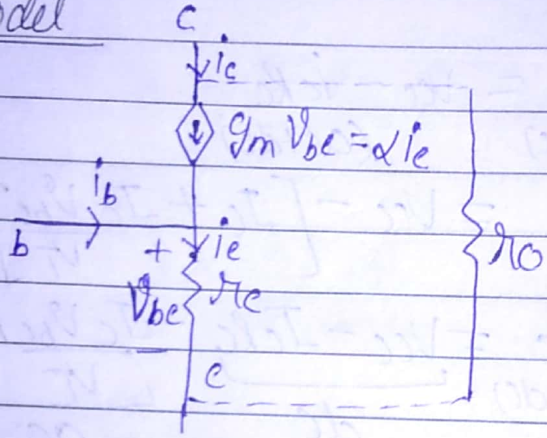


$$i_c = I_c + I_c \frac{v_{be}}{V_T}$$

$$g_m v_{be} = \frac{I_c}{V_T} v_{be} = \frac{\beta I_B v_{be}}{V_T}$$

$$= \beta \frac{v_{be}}{r_\pi} = \beta \frac{i_b \cancel{r_\pi}}{\cancel{r_\pi}}$$

T-Model



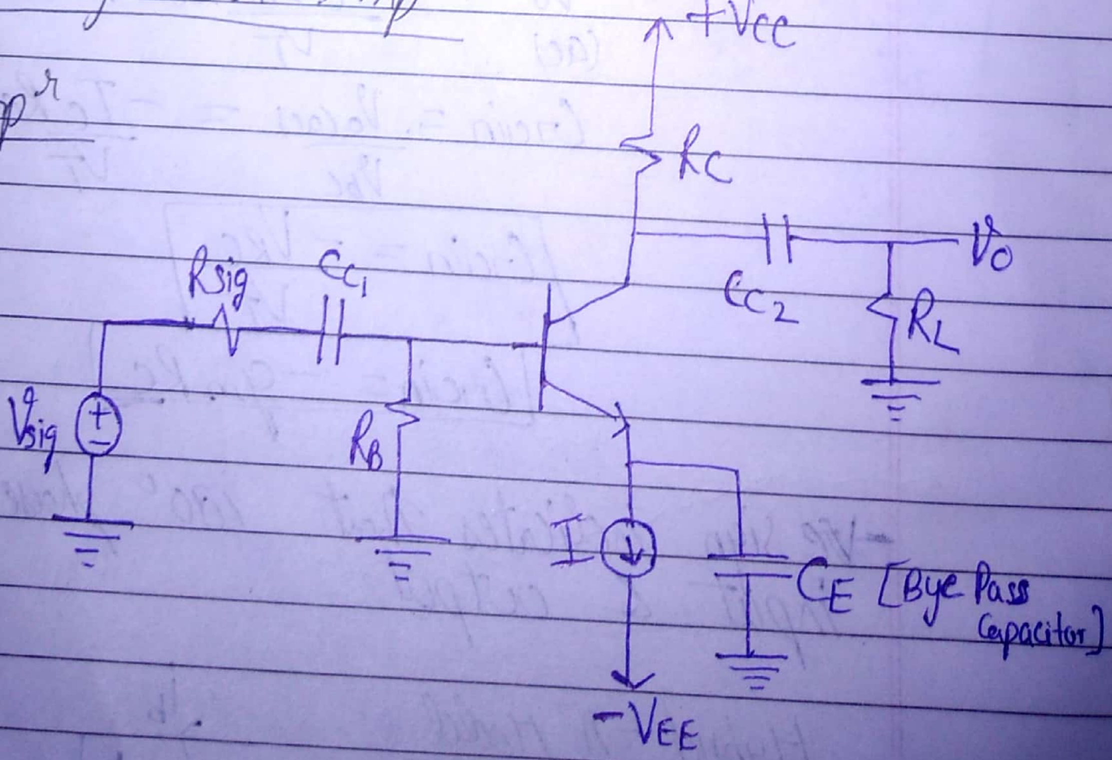
$$g_m v_{be} = \frac{I_C}{V_T} v_{be} = \frac{\alpha I_E v_{be}}{V_T}$$

$$= \alpha \frac{v_{be}}{r_e} = \alpha \frac{i_e \cancel{r_e}}{\cancel{r_e}}$$

$$= \alpha i_e$$

Single Stage BJT Amp^r

1) CE Amp^r



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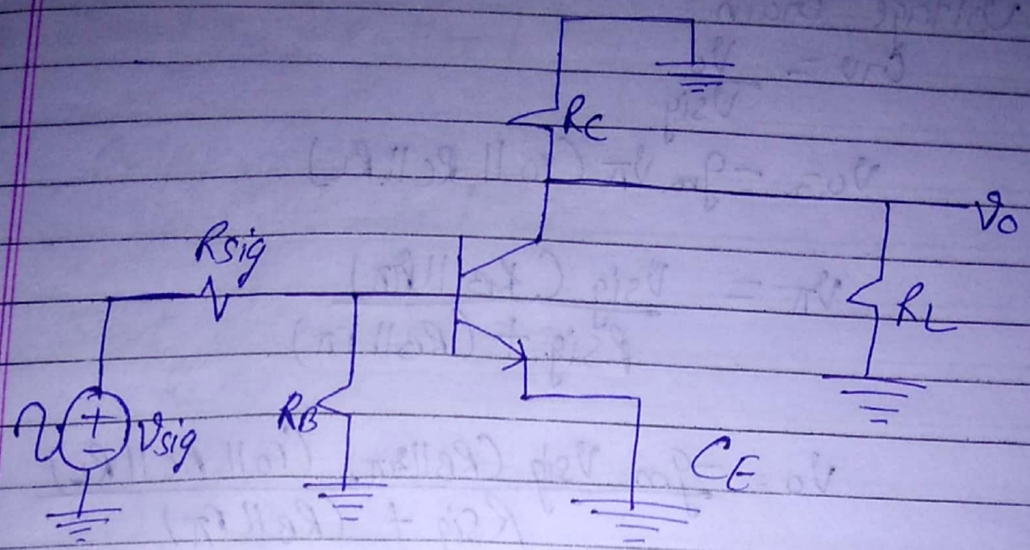
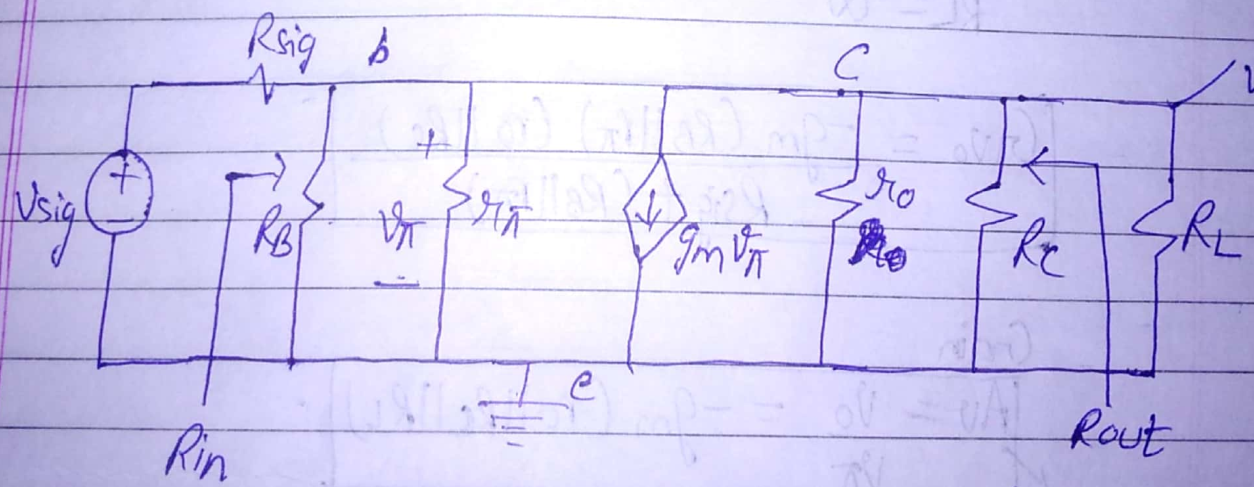
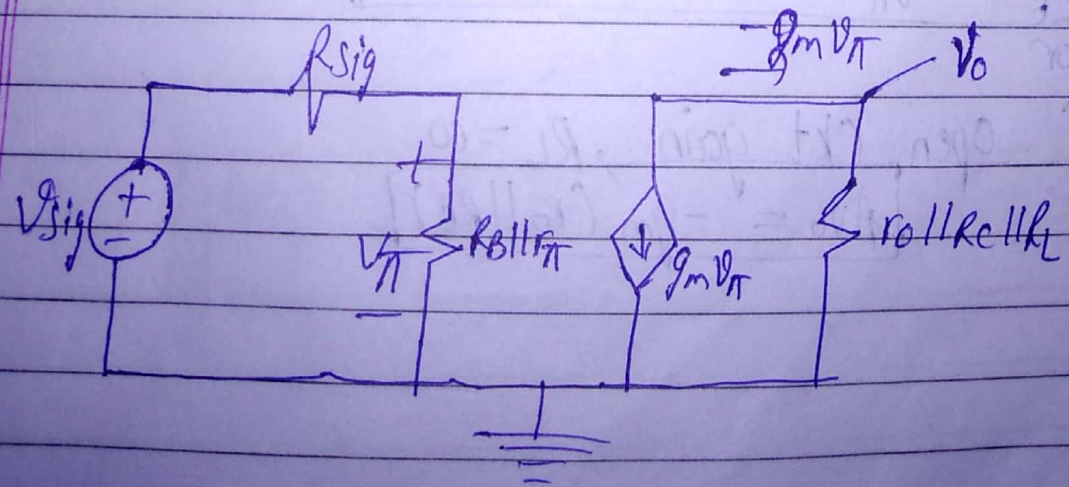


$$X_C = \frac{1}{2\pi f C}$$

DC analysis

$f = 0$





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Voltage Gain

$$G_v = \frac{v_o}{v_{sig}}$$

$$v_o = -g_m v_\pi (r_o \| R_C \| R_L)$$

$$v_\pi = \frac{v_{sig}(R_B \| r_\pi)}{R_{sig} + (R_B \| r_\pi)}$$

$$v_o = \frac{-g_m v_{sig} (R_B \| r_\pi)(r_o \| R_C \| R_L)}{R_{sig} + (R_B \| r_\pi)}$$

overall gain

$$\boxed{G_v = \frac{v_o}{v_{sig}} = \frac{-g_m (R_B \| r_\pi)(r_o \| R_C \| R_L)}{R_{sig} + (R_B \| r_\pi)}}$$

open Ckt gain

$R_L = \infty$

$$\boxed{G_{vo} = \frac{-g_m (R_B \| r_\pi)(r_o \| R_C)}{R_{sig} + (R_B \| r_\pi)}}$$

Gain

$$\boxed{A_v = \frac{v_o}{v_\pi} = -g_m (r_o \| R_C \| R_L)}$$

Transistor Gain

Open Ckt gain, $R_L = \infty$

$$\boxed{A_{vo} = -g_m (r_o \| R_C)}$$

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Input resistance

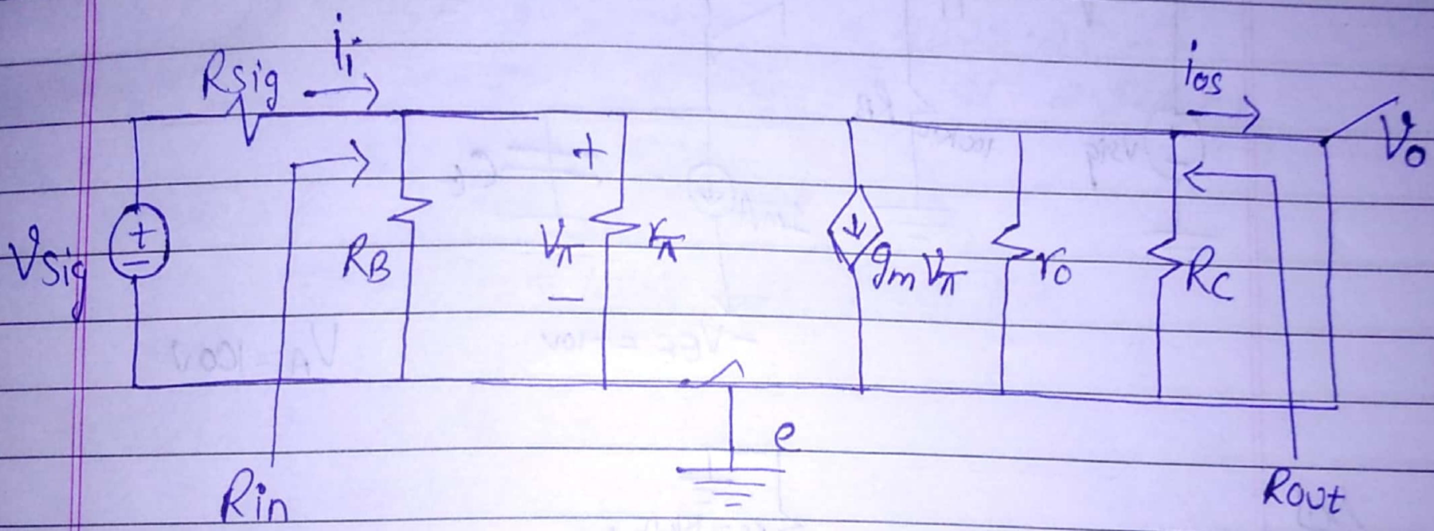
$$\boxed{R_{in} = R_B \parallel r_\pi}$$

Output Resistance

$$\boxed{R_{out} = R_C \parallel r_o}$$

Short ckt current gain

$R_L = 0$



$$A_{is} = \frac{i_{os}}{i_i}$$

$$i_{os} = -g_m v_\pi$$

$$i_i = \frac{v_{in}}{R_{in}} = \frac{v_\pi}{R_B \parallel r_\pi}$$

$$\boxed{A_{is} = \frac{-g_m V_\pi}{V_\pi/(R_B \parallel r_\pi)} = -g_m (R_B \parallel r_\pi)}$$

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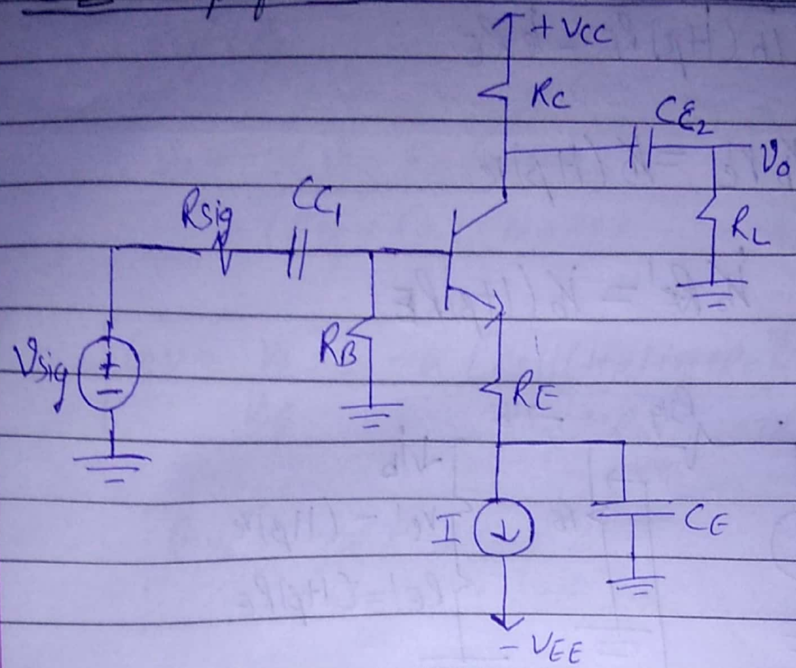
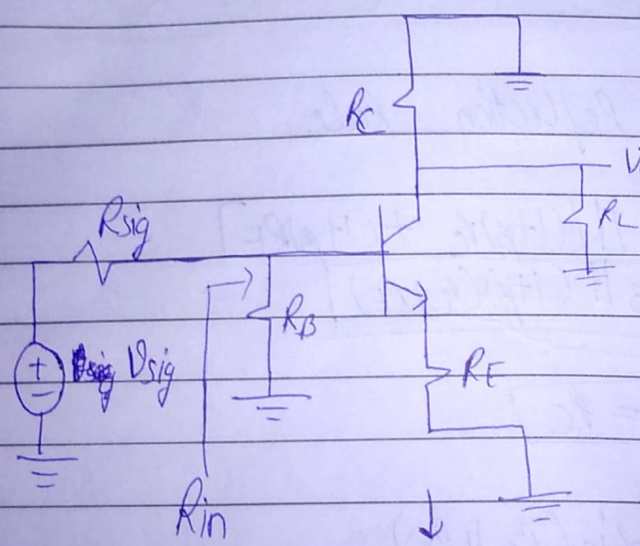
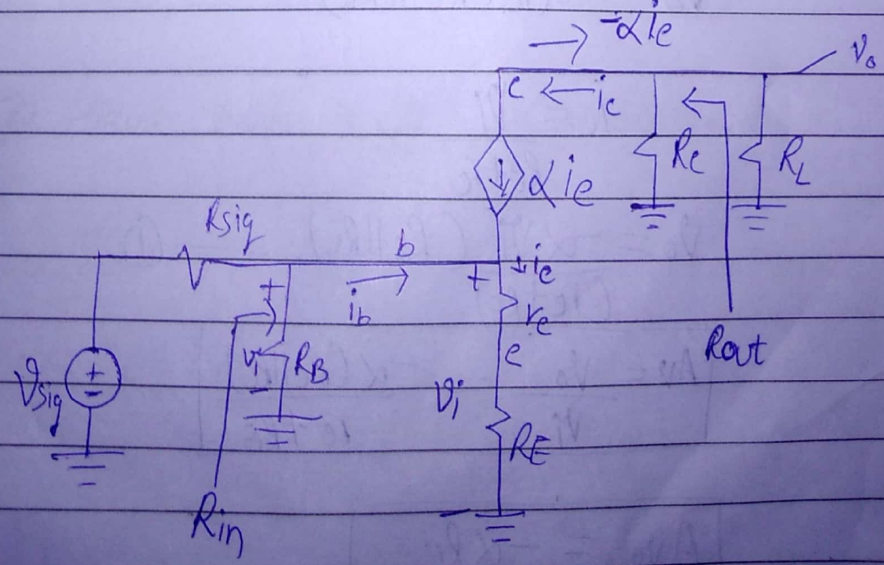
CE amplifier with emitter resistance







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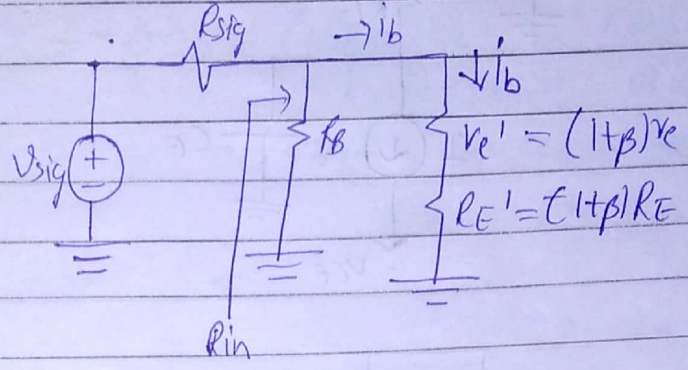
$$i_b(1+\beta)r_e = i_e r_e$$
$$i_b(1+\beta)R_E = i_e R_E$$

$$i_b r_e' = i_b(1+\beta)r_e$$

$$i_b R_E' = i_b(1+\beta)R_E$$



<u>Resistance Reflection Rule</u>

$$R_{in} = R_B \,||\, [(1+\beta)r_e + (1+\beta)R_E]$$
$$\boxed{R_{in} = R_B \,||\, (1+\beta)(r_e+R_E)}$$

$$\boxed{R_{out} = R_C}$$

$$v_o = -\alpha i_e (R_C \,||\, R_L)$$

$$i_e = \frac{v_i}{R_E + r_e}$$

$$v_o = \frac{-\alpha v_i}{(r_e+R_E)}(R_C||R_L) \quad \text{—— (1)}$$

$$\boxed{A_v = \frac{v_o}{v_i} = \frac{-\alpha(R_C||R_L)}{r_e+R_E}}$$

$$\boxed{A_{vo} = \frac{-\alpha R_C}{r_e+R_E}}$$

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$R_{in}\uparrow, R_{out}\downarrow, G_v\downarrow \Rightarrow$ for voltage amplifier

$$V_i = \frac{V_{sig}}{R_{sig}+R_{in}} \times R_{in}$$

$$V_o = \frac{-\alpha\, V_{sig}\, R_{in}\,(R_C \| R_L)}{(R_{sig}+R_{in})(r_e+R_E)}$$

$$\boxed{G_v = \frac{V_o}{V_{sig}} = \frac{-\alpha\,[R_B \| (1+\beta)(r_e+R_E)](R_C \| R_L)}{(R_{sig}+R_{in})(r_e+R_E)}}$$

$$\boxed{G_{v_o} = \frac{-\alpha\, R_{in} R_C}{(R_{sig}+R_{in})(r_e+R_E)}}$$

Short Ckt. Current Gain

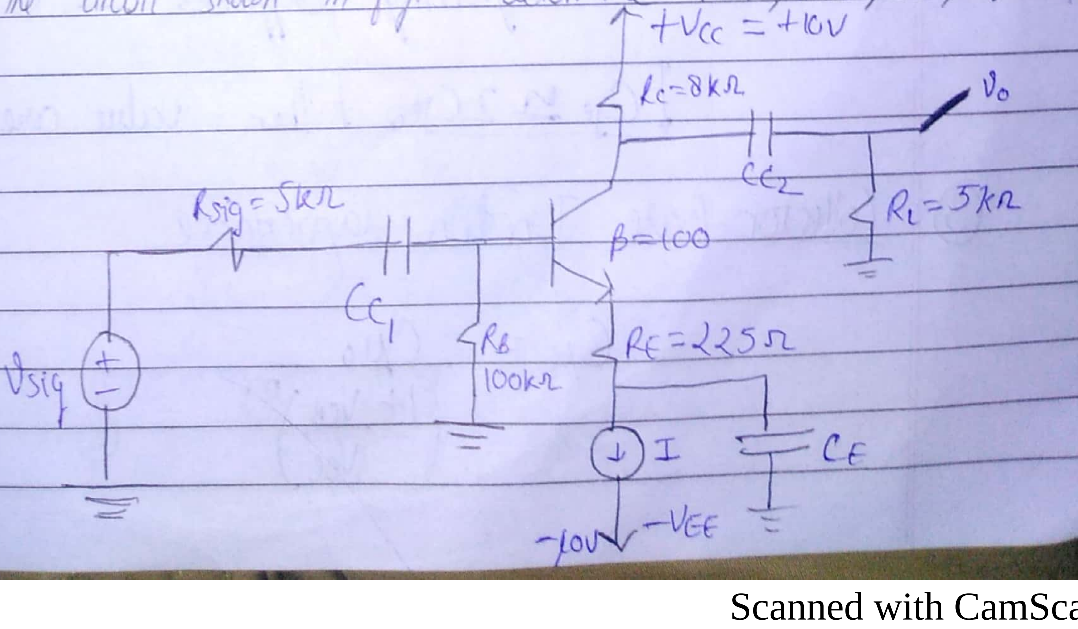
$$A_{is} = \frac{i_{os}}{i_i}$$

$$i_{os} = -\alpha i_e$$

$$i_i = \frac{V_i}{R_{in}} = \frac{i_e(R_E+r_e)}{R_{in}}$$

$$\boxed{A_{is} = \frac{-\alpha i_e}{i_e(R_E+r_e)/R_{in}} = \frac{-\alpha R_{in}}{R_E+r_e}}$$

Q For The circuit shown in fig:- determine R_{out}, A_{vo}, A_v, G_v & A_{is}.



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BJT Internal Capacitance

① Base Charging capacitance or Diffusion Capacitance

$$Q = \tau_F\, i_c$$

τ_F → Forward Transit time

$$C_{de} = \frac{dQ}{dv_{BE}} = \tau_F \frac{di_c}{dv_{BE}} = \tau_F \frac{d}{dv_{BE}}\left(I_S e^{v_{BE}/V_T}\right)$$

$$= \tau_F I_S e^{v_{BE}/V_T} \cdot \frac{1}{V_T}$$

$$C_{de} = \tau_F \frac{i_c}{V_T} = \tau_F \frac{(I_C + i_c)}{V_T} \simeq \tau_F \frac{I_C}{V_T} \simeq \tau_F g_m$$

② Emitter Base Junction Capacitance

$$C_{je} = \frac{C_{jeo}}{\left(1 - V_{BE}/V_{oe}\right)^m}$$

where C_{jeo} = Value of C_{je} at $V_{BE} = 0$
V_{oe} = Emitter Base Junction built in voltage. $\simeq 0.9V$

m = grading coefficient $\simeq 0.5$

$\boxed{C_{je} \simeq 2C_{jeo}}$ When value are not given

③ Collector Base Junction Capacitance

$$C_\mu = \frac{C_{\mu o}}{\left(1 + \frac{V_{CB}}{V_{oc}}\right)^m}$$

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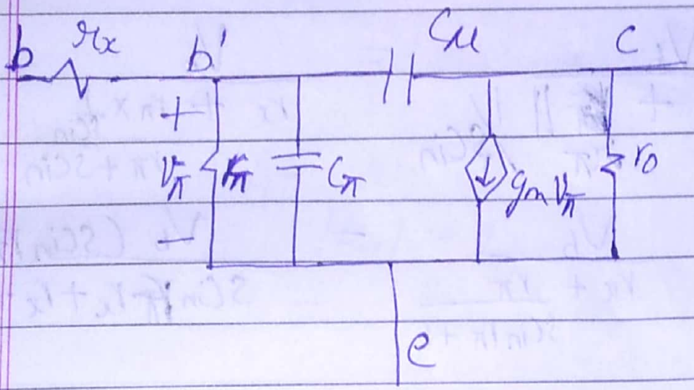
where $C_{\mu 0}$ = Value of C_μ at $V_{CB} = 0$

V_{0c} = CBJ built in voltage $\simeq 0.75V$

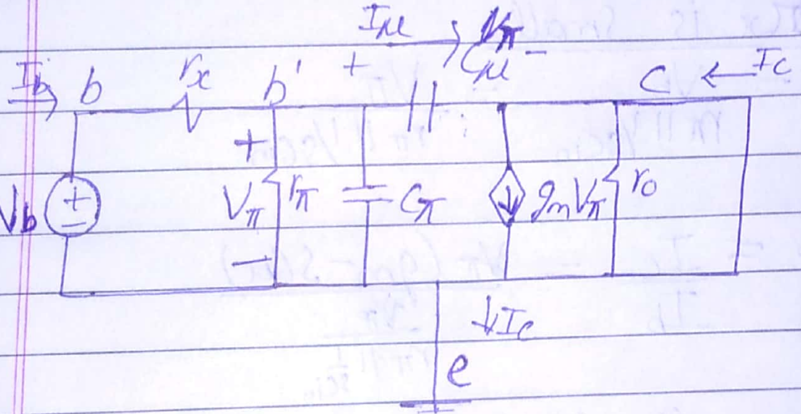
m = grading coefficient $\simeq 0.2 - 0.5$

04/10/19 **High frequency model**



$C_\pi = C_{de} + C_{je}$

$I_b \rightarrow$ Function of freq.



Short ckt Current gain

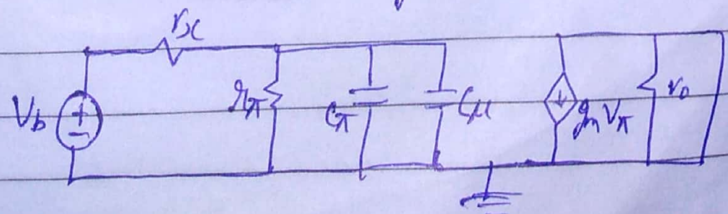
$$\text{Current gain} = \frac{I_c}{I_b}$$

$$I_c + I_\mu = g_m V_\pi$$

$$I_c = g_m V_\pi - I_\mu$$

$$I_c = g_m V_\pi - \frac{V_\pi}{1/SC_\mu} \Rightarrow g_m V_\pi - SC_\mu V_\pi$$

$$I_c = V_\pi (g_m - SC_\mu)$$



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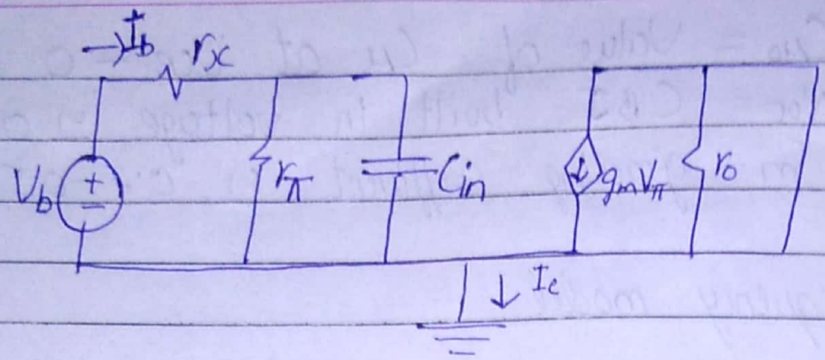
$C_{in} = C_\pi + C_\mu$



$$I_b = \frac{V_b}{r_x + r_\pi \,||\, 1/sC_{in}} = \frac{V_b}{r_x + \frac{r_\pi \times \frac{1}{sC_{in}}}{r_\pi + sC_{in}}}$$

$$= \frac{V_b}{r_x + \frac{r_\pi}{sC_{in} r_\pi + 1}} = \frac{V_b (sC_{in} r_\pi + 1)}{sC_{in} r_\pi r_x + r_x + r_\pi}$$

r_x is small

$$I_b = \frac{V_b}{r_\pi \,||\, 1/sC_{in}} = \frac{V_\pi}{r_\pi \,||\, 1/sC_{in}}$$

$$h_{fe} = \frac{I_c}{I_b} = \frac{V_\pi (g_m - sC_\mu)}{\frac{V_\pi}{r_\pi \,||\, \frac{1}{sC_{in}}}}$$

$$= (g_m - sC_\mu)\, r_\pi \,||\, \frac{1}{sC_{in}}$$

$$= (g_m - sC_\mu) \left(\frac{r_\pi \times \frac{1}{sC_{in}}}{r_\pi + 1/sC_{in}} \right)$$

$$h_{fe} = \frac{(g_m - sC_\mu)\, r_\pi}{(sC_{in} r_\pi + 1)}$$

$$g_m \gg sC_\mu$$

$$\boxed{h_{fe} = \frac{g_m r_\pi}{(sC_{in} r_\pi + 1)}}$$

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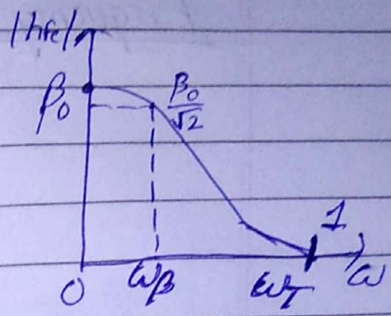
$$h_{fe} = \frac{\beta_0}{sC_{in} r_\pi + 1} \qquad \therefore \; r_\pi = \frac{\beta}{g_m}$$

$$|h_{fe}| = \frac{\beta_0}{j\omega C_{in} r_\pi + 1}$$



$$|h_{fe}| = \frac{\beta_0}{\sqrt{(\omega C_{in} r_\pi)^2 + 1}}$$

At $\omega = \omega_T$

$$|h_{fe}| = 1$$

$$1 = \frac{\beta_0}{\sqrt{(\omega_T C_{in} r_\pi)^2 + 1}}$$

$$\beta_0^2 = (\omega_T C_{in} r_\pi)^2 + 1$$

$$\beta_0^2 - 1 = (\omega_T C_{in} r_\pi)^2$$

$$\boxed{\omega_T = \frac{\sqrt{\beta_0^2 - 1}}{C_{in} r_\pi}}$$

$$\boxed{\omega_T \simeq \frac{\beta_0}{C_{in} r_\pi}}$$

At $\omega = \omega_\beta$

$$|h_{fe}| = \frac{\beta_0}{\sqrt{2}} = 0.707\beta_0$$

$$\frac{\beta_0}{\sqrt{(\omega_\beta C_{in} r_\pi)^2 + 1}} = \frac{\beta_0}{\sqrt{2}}$$

$$2 = (\omega_\beta C_{in} r_\pi)^2 + 1$$

$$\boxed{\omega_\beta = \frac{1}{C_{in} r_\pi}}$$

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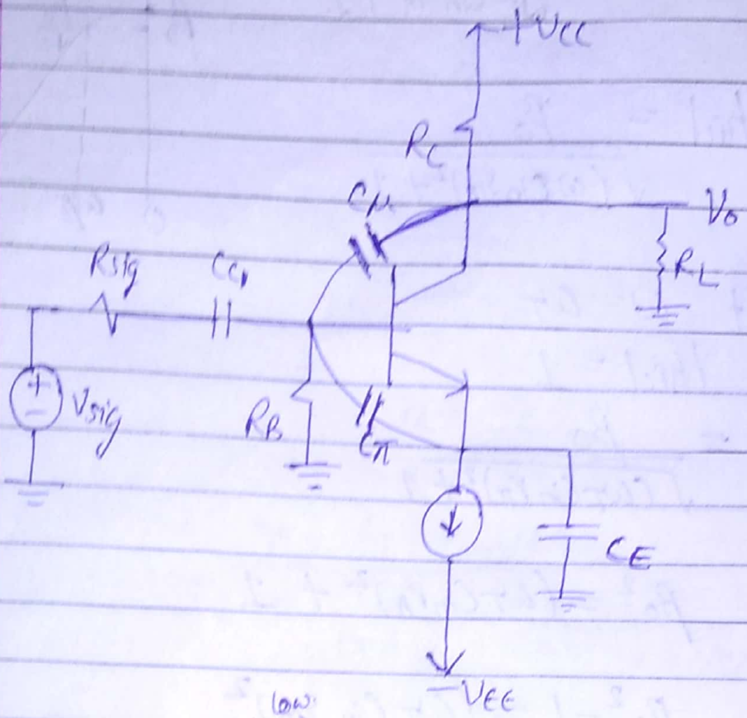
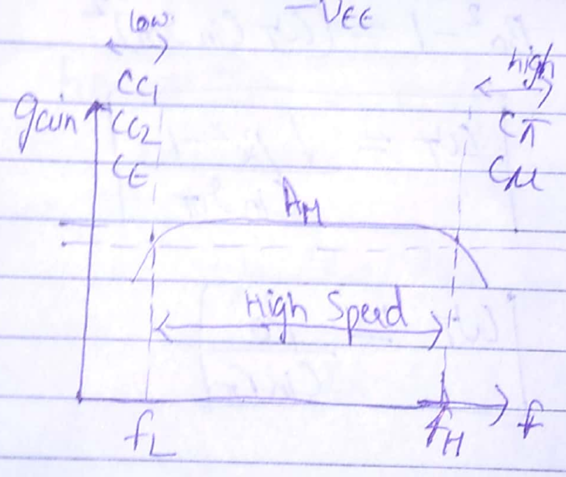
$$\boxed{\omega_T = \beta_0 \omega_\beta}$$

Frequency Response of CE Amp^r

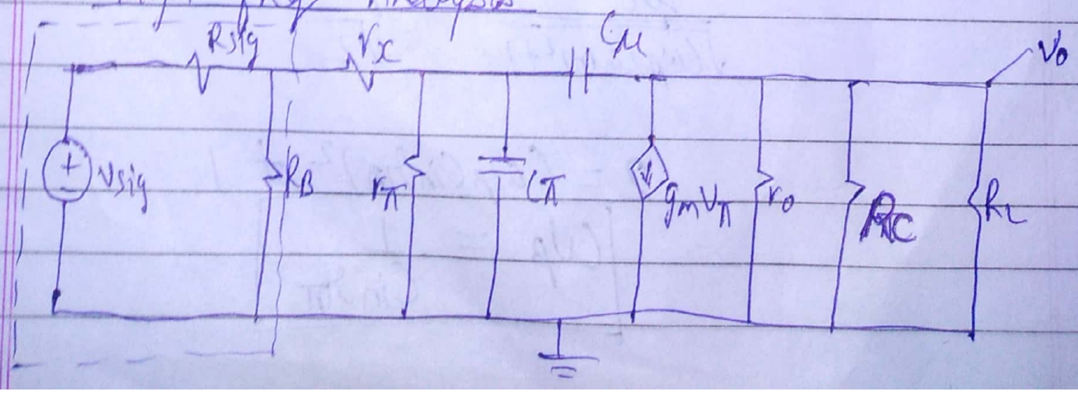




$$\boxed{BW = \uparrow \omega_H - \omega_L \downarrow}$$ $$\boxed{BW = \uparrow f_H - f_L \downarrow}$$

High freq. Analysis

Apply T.T



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$$R_L' = r_o \| R_C \| R_L$$

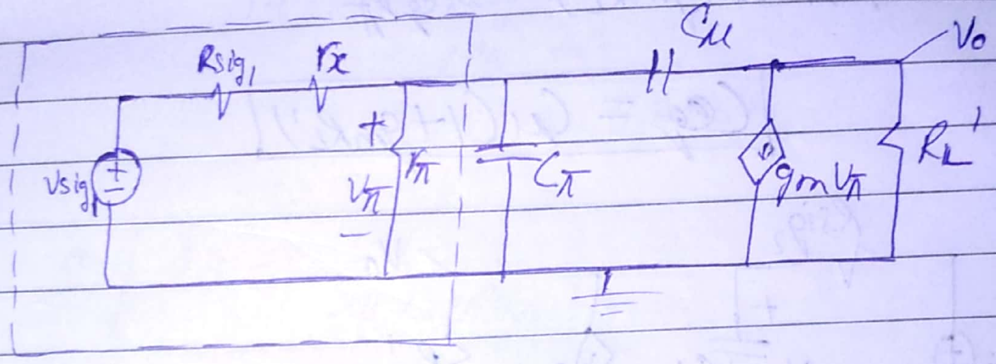
$$v_{sig_1} = \frac{v_{sig} R_B}{R_{sig} + R_B}$$

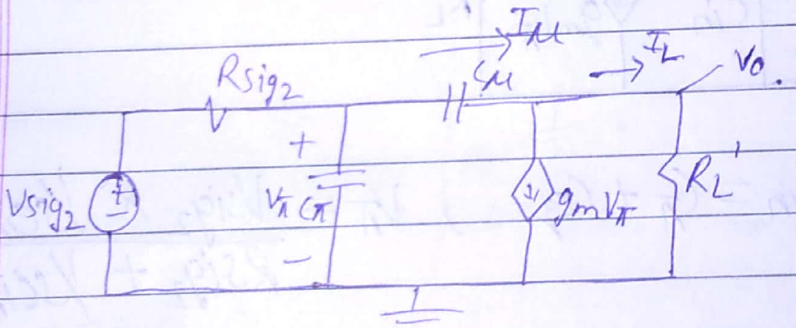
$$R_{sig_1} = R_{sig} \| R_B$$

$$V_{sig2} = \frac{v_{sig_1} r_\pi}{R_{sig_1} + r_x + r_\pi}$$

$$R_{sig_2} = (R_{sig_1} + r_x) \| r_\pi$$

Apply Thevenin's Theorem





$$I_L = I_\mu - g_m V_\pi$$

$$V_o = I_L R_L' = (I_\mu - g_m V_\pi) R_L' \simeq -g_m V_\pi R_L'$$

$$g_m V_\pi >> I_\mu$$

$$I_\mu = \frac{V_\pi - V_o}{1/sC_\mu} = sC_\mu (V_\pi - V_o)$$

$$I_\mu = sC_\mu (V_\pi + g_m V_\pi R_L')$$

$$I_\mu = sC_\mu V_\pi (1 + g_m R_L')$$

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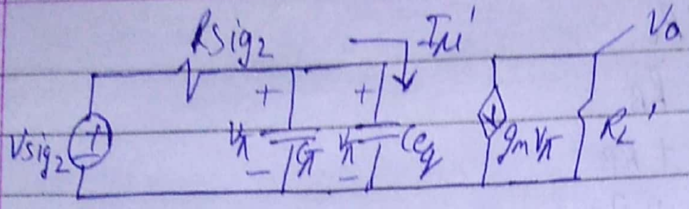
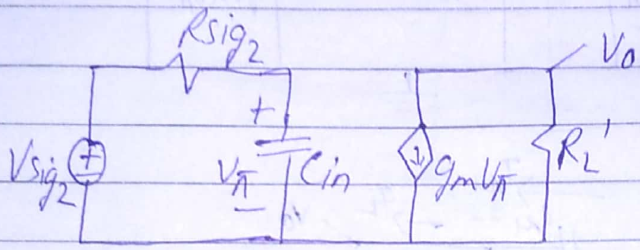


$$I_\mu' = \frac{V_\pi}{1/sC_{eq}} = sC_{eq} V_\pi$$

$$I_\mu = I_\mu'$$

$$sC_\mu V_\pi (1 + g_m R_L') = sC_{eq} V_\pi$$

$$\boxed{C_{eq} = C_\mu (1 + g_m R_L')}$$



$$C_{in} = C_\pi + C_{eq} \quad , \quad V_\pi = \frac{V_{sig_2} \times 1/sC_{in}}{R_{sig_2} + 1/sC_{in}}$$

$$V_o = -g_m V_\pi R_L' = -g_m \left(\frac{V_{sig_2}}{sC_{in} R_{sig_2} + 1} \right) R_L'$$

$$= -g_m \left(\frac{V_{sig_1} \, r_\pi}{R_{sig_1} + r_x + r_\pi} \right) \frac{R_L'}{(sC_{in} R_{sig_2} + 1)}$$

$$V_o = -g_m \left(\frac{V_{sig} R_B}{R_{sig} + R_B} \right) \frac{r_\pi}{(R_{sig_1} + r_x + r_\pi)} \left(\frac{R_L'}{sC_{in} R_{sig_2} + 1} \right)$$

$$\text{Gain} = \frac{V_o}{V_{sig}} = \left\{ \frac{-g_m R_B \, r_\pi R_L'}{(R_{sig} + R_B)(R_{sig_1} + r_x + r_\pi)} \right\} \frac{1}{(sC_{in} R_{sig_2} + 1)}$$

$$\boxed{\text{Gain} = \frac{A_M}{(sC_{in} R_{sig_2} + 1)}}$$

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* Product of gain & band width is = to Const.

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$s = j\omega$

$\omega = \omega_H$

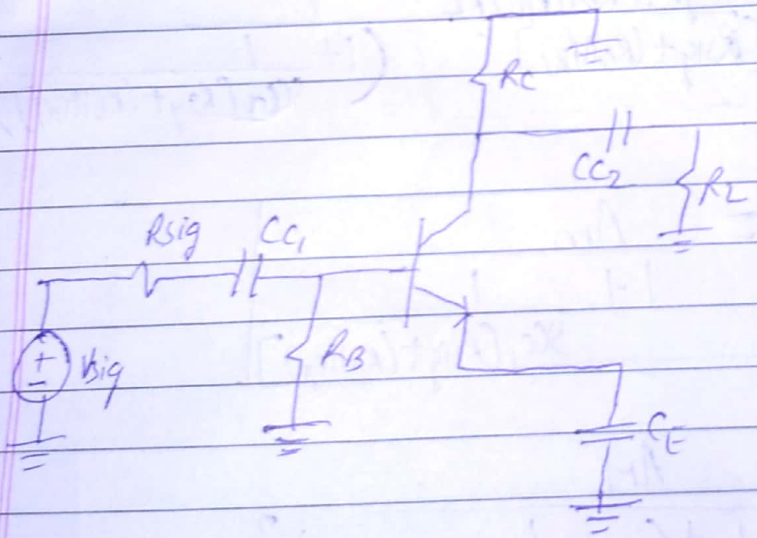
$|Gain| = \frac{A_M}{\sqrt{2}}$ $\quad$ $|Gain| = \frac{A_M}{\sqrt{1+(\omega C_{in} R_{sig_2})^2}}$

$$\frac{A_M}{\sqrt{2}} = \frac{A_M}{\sqrt{1+(\omega_H C_{in} R_{sig_2})^2}}$$

$$1 + (\omega_H C_{in} R_{sig_2})^2 = 2$$

$$\omega_H = \frac{1}{C_{in} R_{sig_2}}$$

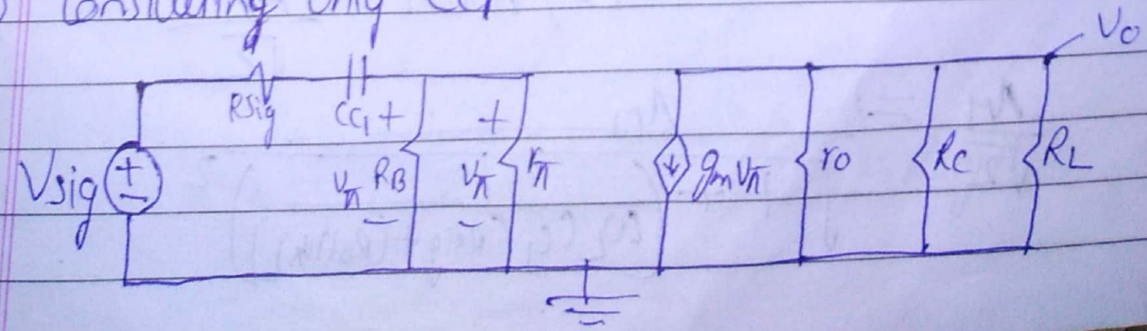
$$\uparrow \boxed{f_H = \frac{1}{2\pi C_{in}\uparrow R_{sig_2}\downarrow}}$$



Low Freq. Analysis

(1) Considering only C_{C_1}

Apply Superposition Theorem



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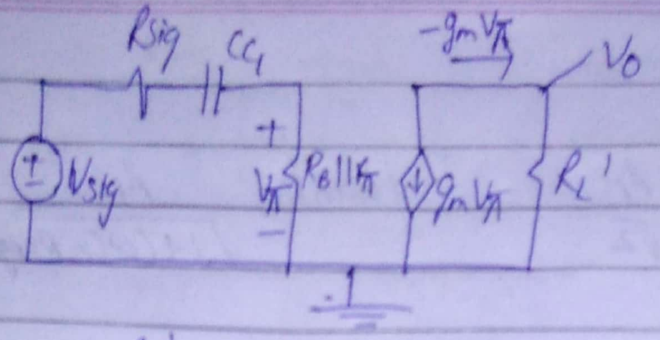

$R_L' = r_o \| R_C \| R_L$

$V_o = -g_m V_\pi R_L'$

$$V_\pi = \frac{V_{sig}\,(R_B \| r_\pi)}{R_{sig} + \frac{1}{sC_{C_1}} + (R_B \| r_\pi)}$$

$$V_o = \frac{-g_m V_{sig} (R_B \| r_\pi) R_L'}{R_{sig} + \frac{1}{sC_{C_1}} + (R_B \| r_\pi)}$$

$$\text{Gain} = \frac{V_o}{V_{sig}} = \frac{-g_m (R_B \| r_\pi) R_L'}{[R_{sig} + (R_B \| r_\pi)]} \cdot \frac{1}{\left(1 + \frac{1}{sC_{C_1}[R_{sig} + (R_B \| r_\pi)]}\right)}$$

$$\boxed{\text{Gain} = \frac{A_m}{1 + \frac{1}{sC_{C_1}[R_{sig} + (R_B \| r_\pi)]}}}$$

$$|\text{Gain}| = \frac{A_M}{\sqrt{1 + \left(\frac{1}{\omega C_{C_1}[R_{sig} + (R_B \| r_\pi)]}\right)^2}}$$

At $\omega = \omega_L$, $|\text{Gain}| = \frac{A_M}{\sqrt{2}}$

$$\frac{A_M}{\sqrt{2}} = \frac{A_M}{\sqrt{1 + \left(\frac{1}{\omega_L C_{C_1}[R_{sig} + (R_B \| r_\pi)]}\right)^2}}$$

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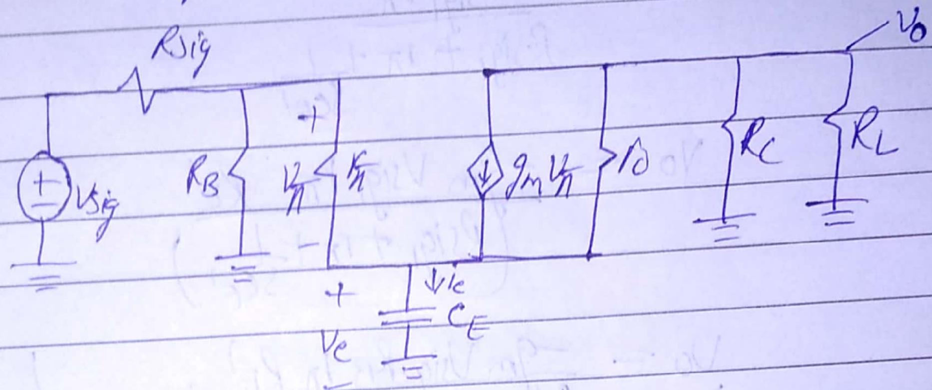
$$\omega_{L_1} = \frac{1}{C_{C_1}\left[R_{sig} + (R_B \| r_\pi)\right]}$$

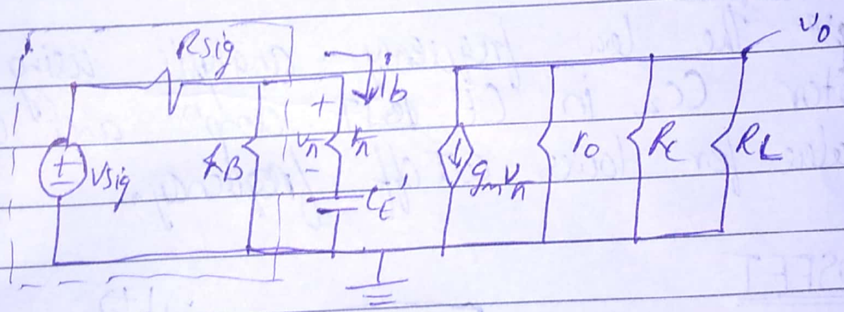
$$\boxed{Gain = \frac{A_M}{1 + \frac{\omega_{L_1}}{j\omega}}}$$

② Considering only C_E



$$V_e = i_e \frac{1}{sC_E}$$

Apply Thev



$$i_b \frac{1}{sC_E'} = \frac{i_e}{sC_E}$$

$$\frac{i_b}{C_E'} = \frac{i_b(1+\beta)}{C_E}$$

$$\boxed{C_E' = \frac{C_E}{1+\beta}}$$

$$V_{sig_1} = \frac{V_{sig} R_B}{R_{sig} + R_B}, \quad R_{sig_1} = R_{sig} \| R_B$$

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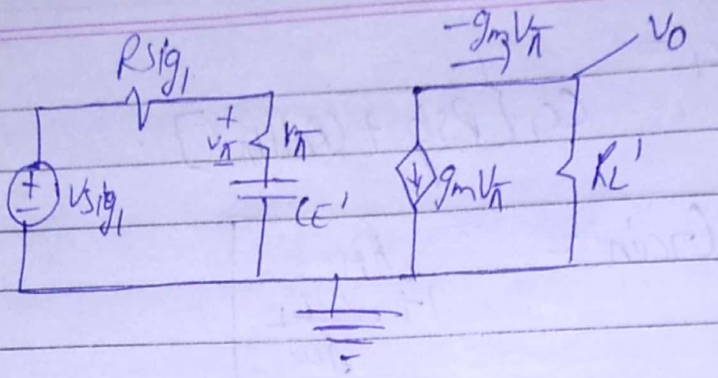


$$V_o = -g_m V_\pi R_L'$$

$$V_\pi = \frac{V_{sig_1} V_\pi}{R_{sig_1} + r_\pi + \frac{1}{SC_E'}}$$

$$V_o = \frac{-g_m V_{sig_1} r_\pi R_L'}{\left(R_{sig_1} + r_\pi + \frac{1}{SC_E'}\right)}$$

$$V_o = \frac{-g_m V_{sig} R_B r_\pi R_L'}{(R_{sig} + R_B)(R_{sig_1} + r_\pi)} \frac{1}{\left(1 + \frac{1}{SC_E'(R_{sig} + r_\pi)}\right)}$$

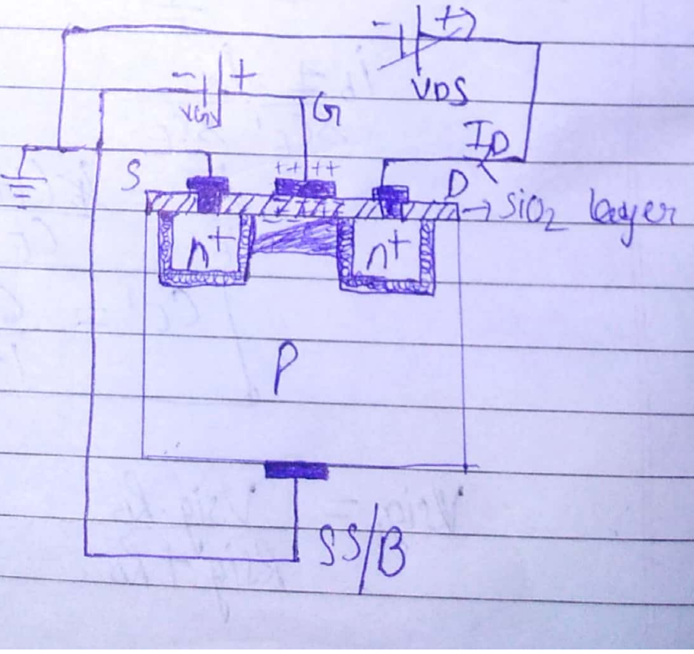
14/10/19

Assignment

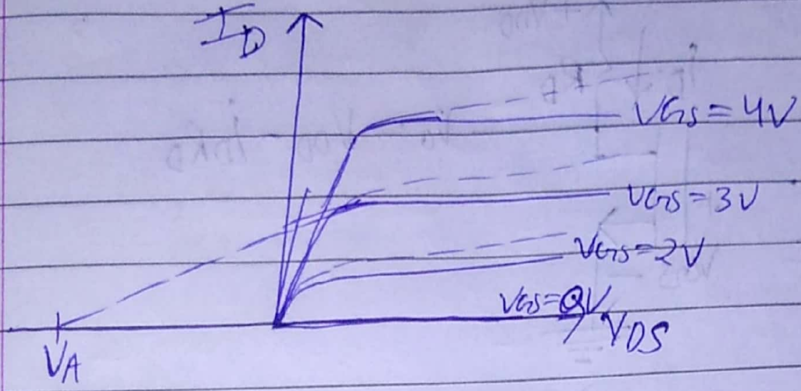
Q Analyse the low frequency analysis using Capacitor C_{C_2} in CE BJT ampn and Calculate the value for lower cut off frequency.

MOSFET

① E-MOSFET

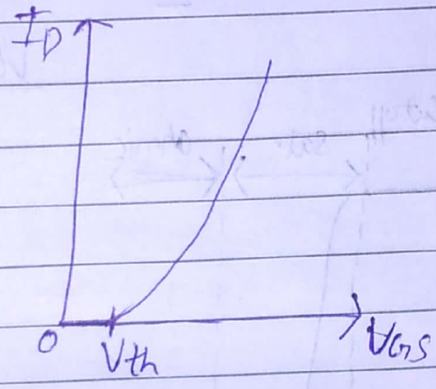


Drain Characteristics



$$r_0 = \frac{V_A}{I_D}$$

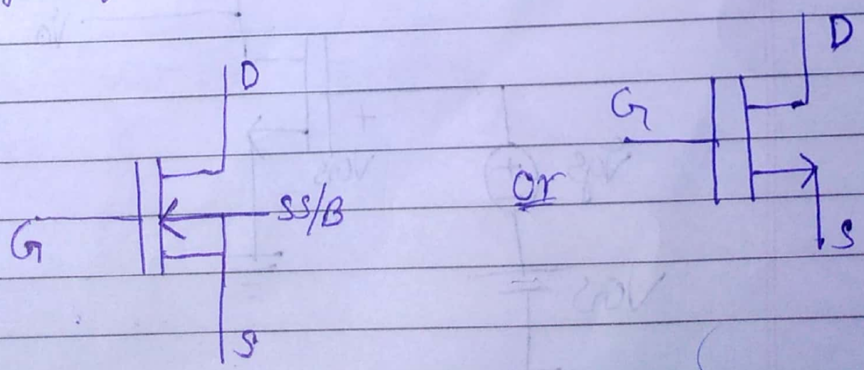
Transfer characteristics



15/10/19 $I_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{th})^2$ [valid for saturation region]

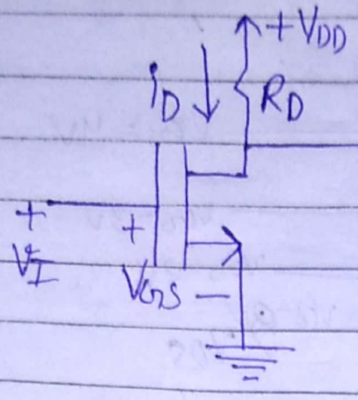
μ_n = mobility of electron
C_{ox} = oxide capacitance per unit area
W = width of the ~~channel~~ SiO_2 layer
L = length of the channel

Symbol



n-Channel

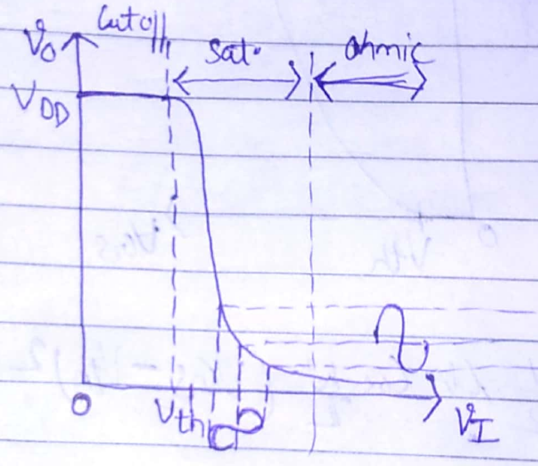
MOSFET as an Ampr & as a switch



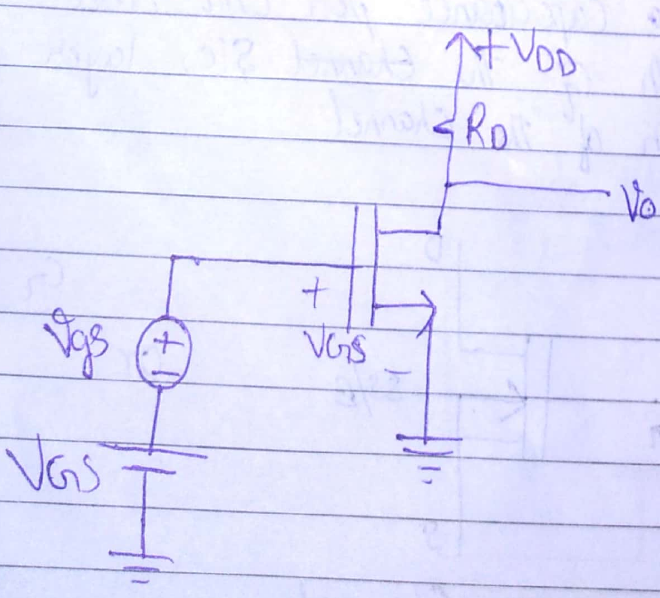
$v_o = V_{DD} - i_D R_D$

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

$V_{GS} \geq V_{th}$



Small Signal opn & Model



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$$g_m = \frac{i_D}{v_{gs}}$$

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

$$i_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (\underline{v_{gs}} + \underline{V_{GS} - V_{th}})^2$$

$$i_D = \frac{1}{2} \mu_n C_{ox} \frac{W}{L} \underbrace{v_{gs}^2}_{\text{Very-very small}} + \frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{th})^2 + \frac{1}{2} \mu_n C_{ox} \frac{W}{L} \times 2 v_{gs} (V_{GS} - V_{th})$$

$$\underset{ac+dc}{i_D} = \underbrace{\frac{1}{2} \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{th})^2}_{DC \;\to\; I_D} + \underbrace{\mu_n C_{ox} \frac{W}{L} v_{gs} (V_{GS} - V_{th})}_{ac}$$

$$\underset{ac}{i_d} = \mu_n C_{ox} \frac{W}{L} v_{gs} (V_{GS} - V_{th})$$

$$g_m = \frac{i_d}{v_{gs}} = \mu_n C_{ox} \frac{W}{L} (V_{GS} - V_{th})$$

$$\boxed{g_m = K_n' \frac{W}{L} V_{ov}}$$

$V_{ov} = V_{GS} - V_{th}$ = overdrive voltage

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$$\underset{ac+dc}{V_o} = V_{DD} - i_D R_D$$

$$= V_{DD} - \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left(V_{GS} - V_{th}\right)^2 R_D$$

$$= V_{DD} - \frac{1}{2} k_n' \frac{W}{L}\left[\underbrace{V_{gs}}_{a} + \underbrace{V_{GS} - V_{th}}_{b}\right]^2 R_D$$

$$= V_{DD} - \underbrace{\frac{1}{2} k_n' \frac{W}{L} V_{gs}^2}_{\text{small}} - \frac{1}{2} k_n' \frac{W}{L}\left(V_{GS} - V_{th}\right)^2 R_D - \frac{1}{2} k_n' \frac{W}{L} 2 V_{gs}\left(V_{GS} - V_{th}\right) R_D$$

$$\underset{ac+dc}{V_o} = V_{DD} - \frac{1}{2} k_n' \frac{W}{L}\left(V_{GS} - V_{th}\right)^2 R_D - k_n' \frac{W}{L} V_{gs}\left(V_{GS} - V_{th}\right) R_D$$

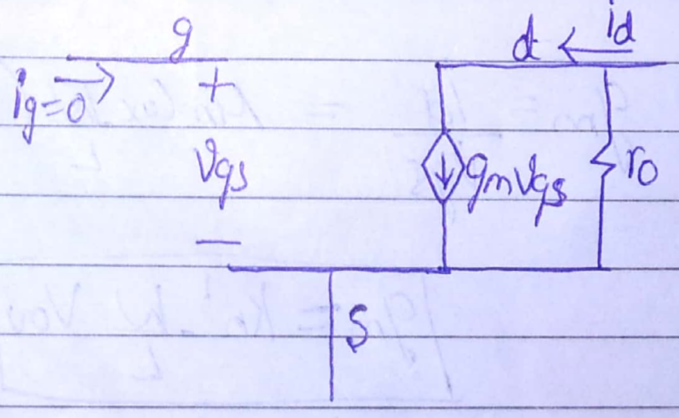
$$\underset{ac}{V_o} = -k_n' \frac{W}{L} V_{gs}\left(V_{GS} - V_{th}\right) R_D$$

$$\text{Gain} = \frac{V_{o(ac)}}{V_{gs}} = -k_n' \frac{W}{L}\left(V_{GS} - V_{th}\right) R_D$$

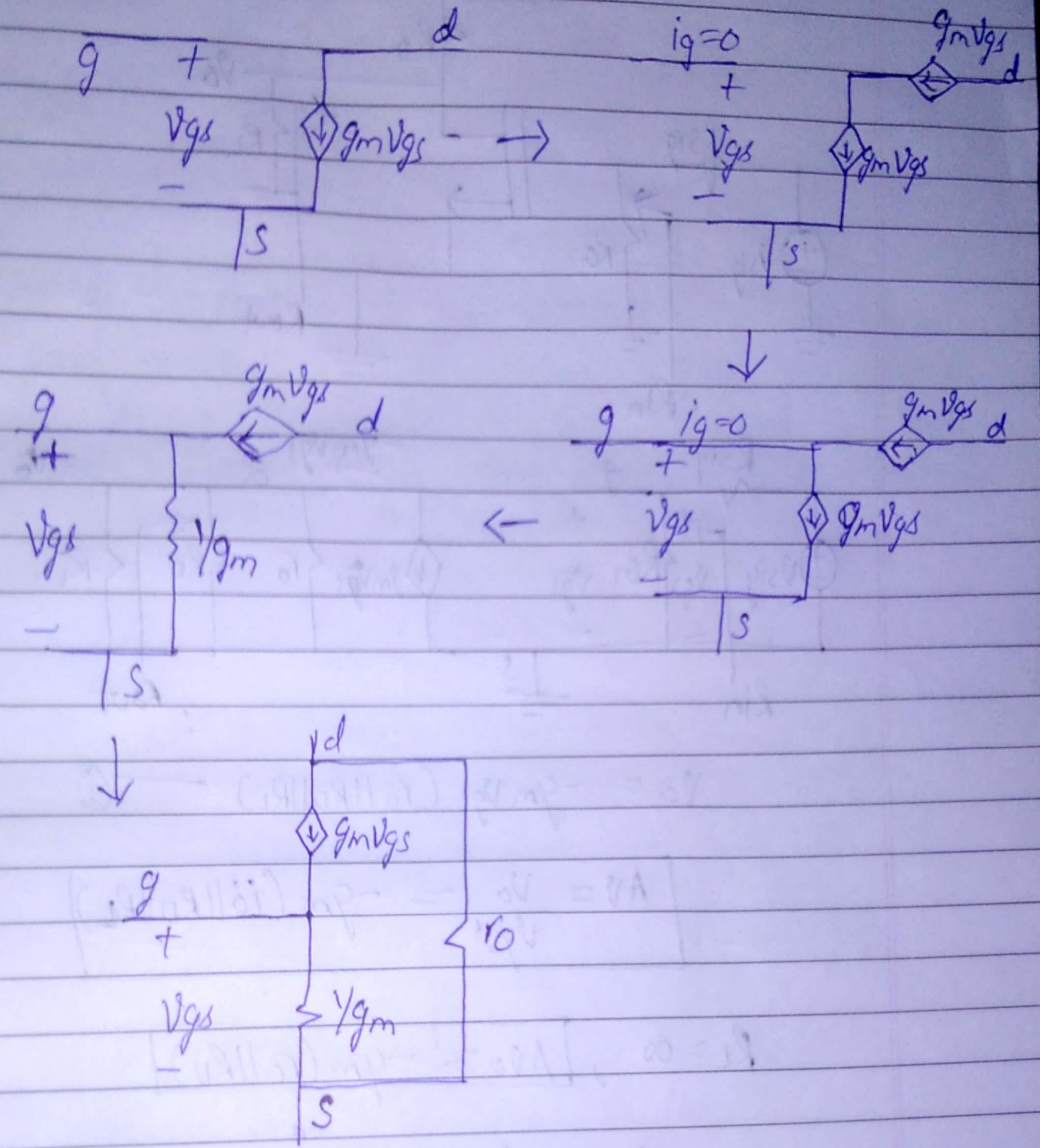
$$\boxed{\text{Gain} = -g_m R_D}$$

Hybrid model

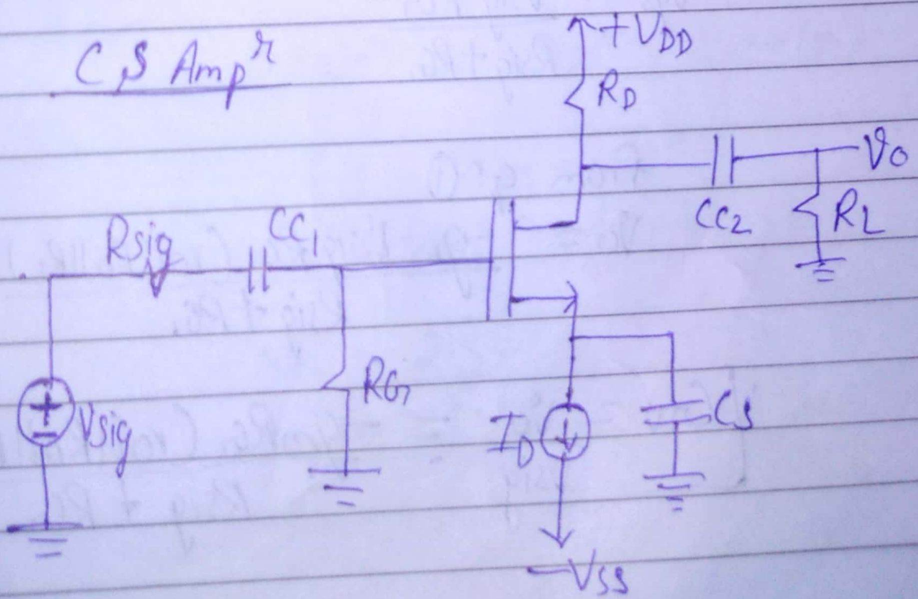
$$= \frac{i_d}{V_{gs}}$$

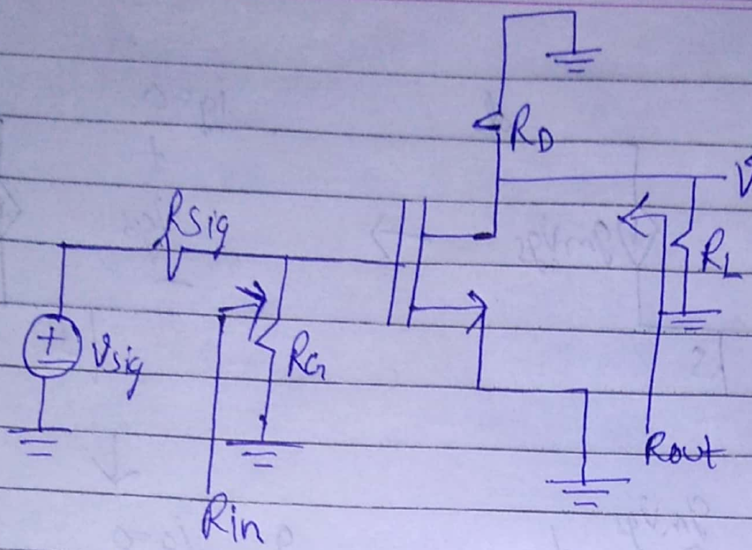


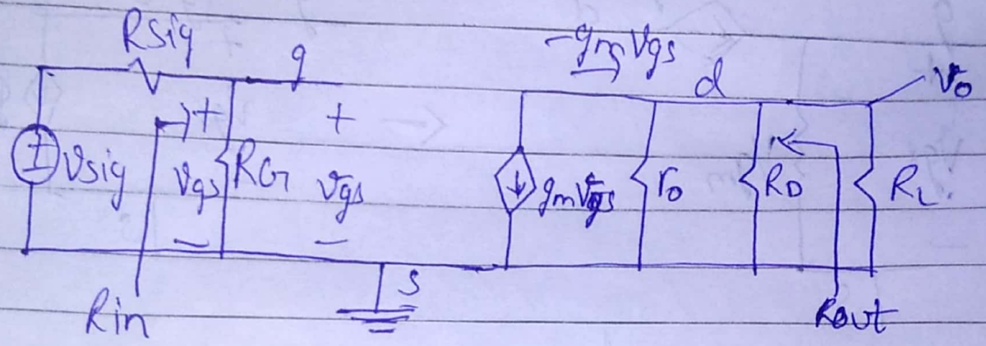
T-Model



C,S Amp^r







$$V_o = -g_m V_{gs} (r_o \| R_D \| R_L) \quad \text{--- } (1)$$

$$\boxed{A_v = \frac{V_o}{V_{gs}} = -g_m (r_o \| R_D \| R_L)}$$

$R_L = \infty$, $\boxed{A_{vo} = -g_m (r_o \| R_D)}$

$$V_{gs} = \frac{V_{sig} R_G}{R_{sig} + R_G}$$

from eq^n (1)

$$V_o = \frac{-g_m V_{sig} R_G (r_o \| R_D \| R_L)}{R_{sig} + R_G}$$

$$\boxed{G_v = \frac{V_o}{V_{sig}} = \frac{-g_m R_G (r_o \| R_D \| R_L)}{R_{sig} + R_G}}$$

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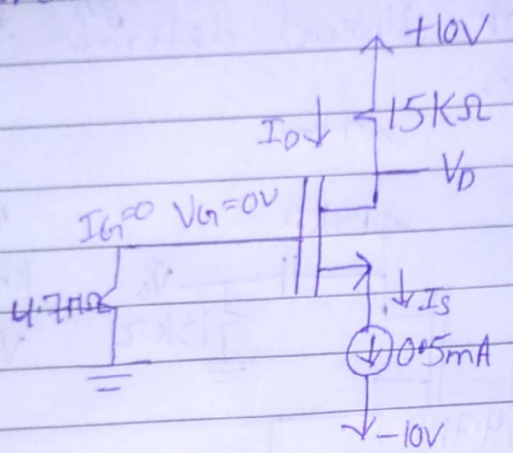
$R_L = \infty$, $\boxed{G_{vo} = \frac{-g_m R_G (r_o \| R_D)}{(R_{sig} + R_G)}}$

$R_{in} = R_G$
$R_{out} = r_o \| R_D$

17/10/19 For the circuit shown in fig. determine V_{ov}, V_{GS}, V_G, V_S and V_D. Also calculate the value of g_m and r_o if $V_A = 75V$. What is the maximum possible signal swing at the drain terminal for which the MOSFET remains is saturation region.



$V_{th} = 1.5V$

$k_n' \frac{W}{L} = 1 mA/V^2$

Sol

$V_{ov} = V_{GS} - V_{th}$

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

$0.5 \times 10^{-3} = \frac{1}{2} \times 10^{-3} (V_{GS} - 1.5)^2$

$1 = (V_{GS} - 1.5)^2$

$\boxed{V_{GS} = 2.5V}$, $0.5V$ ×

$V_{ov} = 2.5 - 1.5$

$\boxed{V_{ov} = 1V}$

$V_{GS} = V_G - V_S$

$V_S = -V_{GS}$

$\boxed{V_S = -2.5V}$

$\boxed{V_G = 0V}$

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$$V_D = 10 - (15\times10^3 \times 0.5\times10^{-3})$$
$$\boxed{V_D = 2.5V}$$

$V_{DS} = V_D - V_S$
$= 2.5 - (-2.5)$
$V_{DS} = 5V$

$V_{DS} \geq (V_{GS} - V_{tn})$ Saturation
$V_{DS} < (V_{GS} - V_{tn})$ ohmic

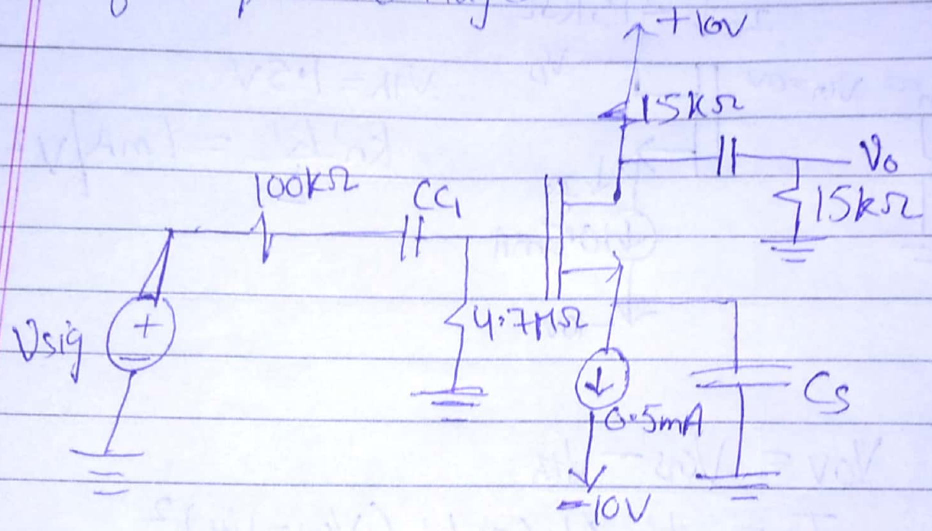
Saturation Region

$g_m = k_n' \frac{W}{L}(V_{GS} - V_{tn})$
$= 10^{-3} \times 1 = 1ms$

$V_{D\,max} = 10V$

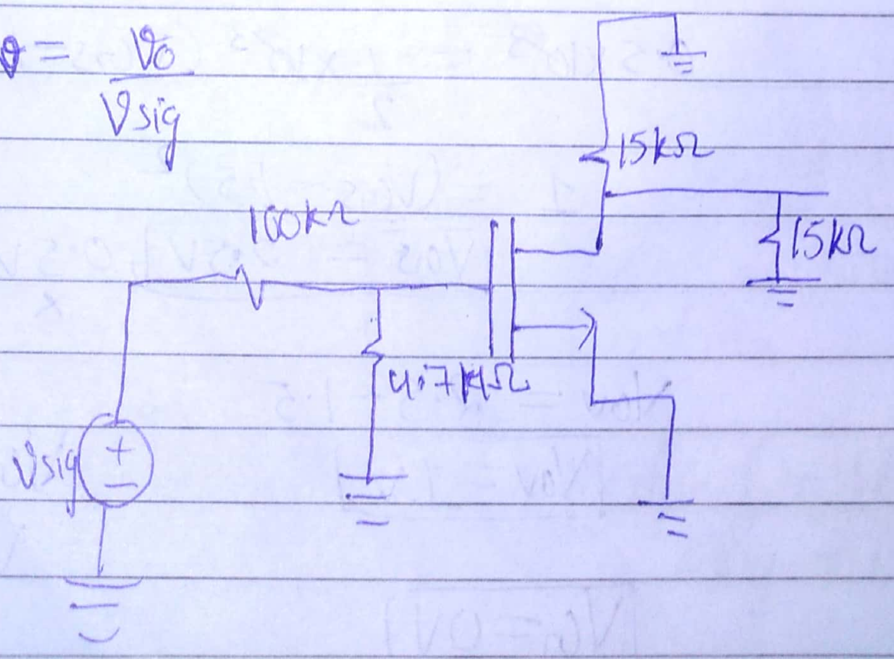
$r_o = \frac{V_A}{I_D} = 150k\Omega$

Q For the ckt shown in fig. determine G_V. If V_{sig} is 0.4V peak to peak sinosoid determine the value of output voltage.



$V_A = 75V$
$k_n' \frac{W}{L} = 1mA/V^2$
$V_{tn} = 1.5V$

Sol $G_V = \frac{V_o}{V_{sig}}$



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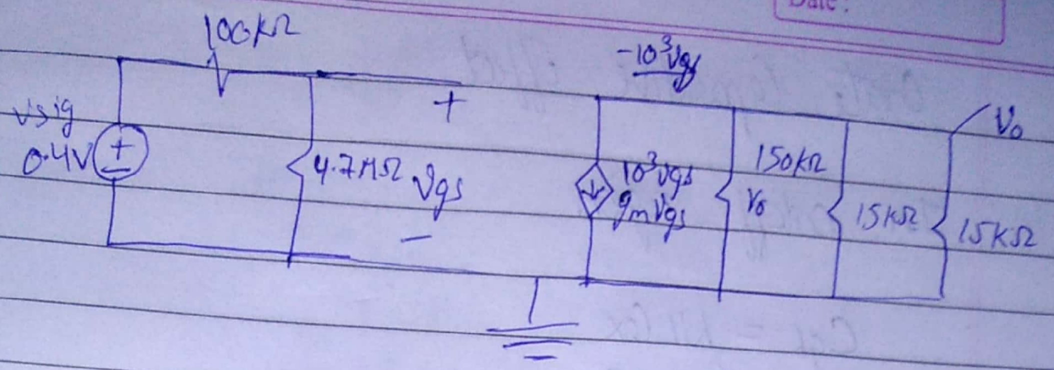


$$V_o = -10^{-3} V_{gs} (150k \parallel 15k \parallel 15k)$$

$$V_{gs} = \frac{V_{sig} \times 4.7\times10^6}{100\times10^3 + 4.7\times10^6}$$

$$G_v = \frac{V_o}{V_{sig}}$$

$$V_{gs} = \frac{0.4\times 4.7\times10^6}{10^3[100+4700]}$$

$$=$$

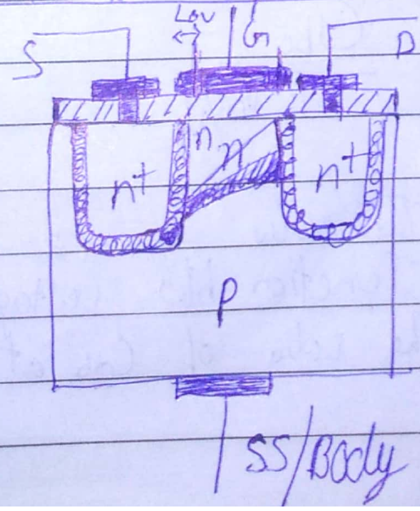
$$G_v = -10^{-3}(150k \parallel 15k \parallel 15k) \times \frac{4.7\times10^6}{(100\times10^3 + 4.7\times10^6)}$$

$$= -6.99 \text{ V/V}$$

$$V_{sig} = 0.4 V_{pp}$$

$$V_o = G_v V_{sig} = -6.99 \times 0.4 V_{pp}$$
$$= -2.76 V_{pp}.$$

3/10/19 MOSFET Internal Capacitances



C_{ox}

C_{gb}

C_{gb}

C_{gs}

C_{sb}

C_{db}

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C_{ov} = overlap Capacitance

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Gate Capacitive Effect

(i) In cutoff region

$$C_{gb} = WLC_{ox}$$
$$C_{gs} = C_{gd} = 0$$

(ii) In Ohmic region

$$C_{gb} = 0$$
$$C_{gs} = C_{gd} = \frac{1}{2} WLC_{ox}$$

(iii) In Saturation region

$$C_{gd} = 0$$
$$C_{gs} = \frac{2}{3} WL\,C_{ox}$$

overlap capacitance

$$C_{ov} = WL_{ov}C_{ox}$$

Body Capacitance

$$C_{sb} = \frac{C_{sbo}}{\sqrt{1 + V_{SB}/V_0}}$$

$$C_{db} = \frac{C_{dbo}}{\sqrt{1 + V_{DB}/V_0}}$$

where C_{sbo} = The value of C_{sb} at $V_{sb} = 0$

V_0 = Junction bias voltage

C_{dbo} = The value of C_{db} at $V_{db} = 0$

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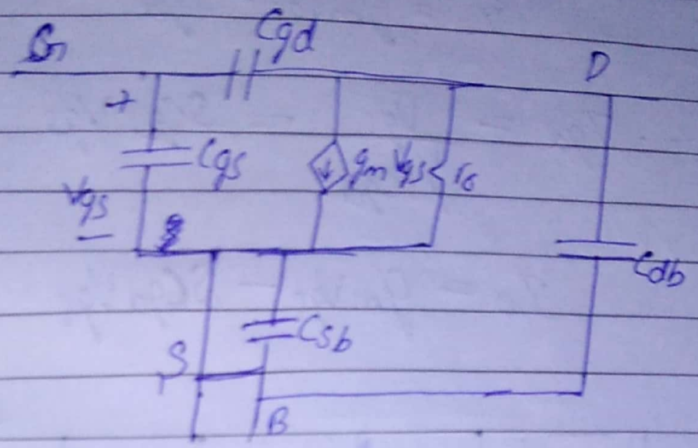
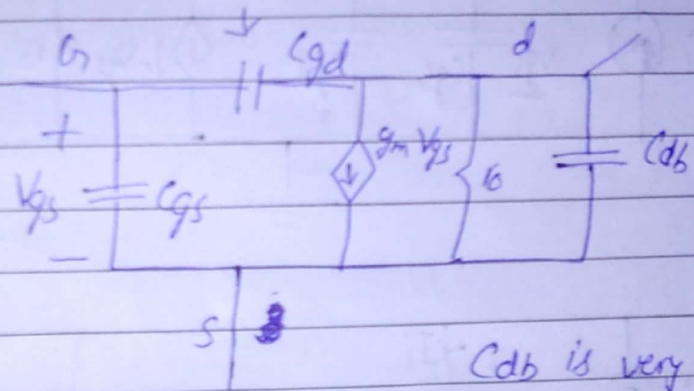
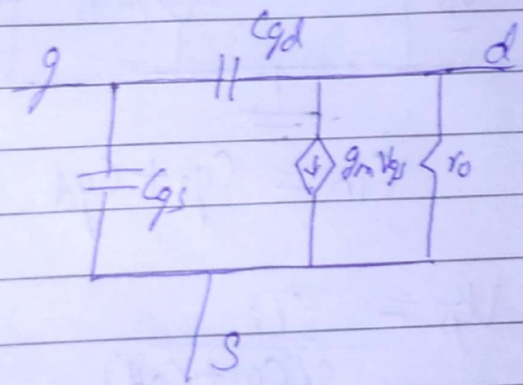
High Frequency Model

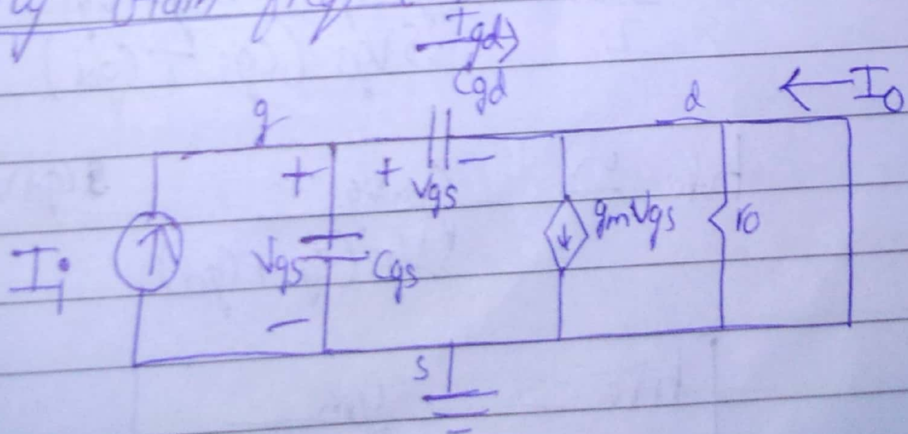




Cdb is very very small



Unity Gain freq. (f_T)



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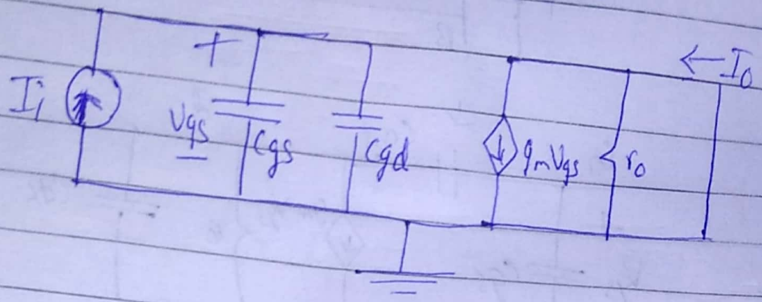
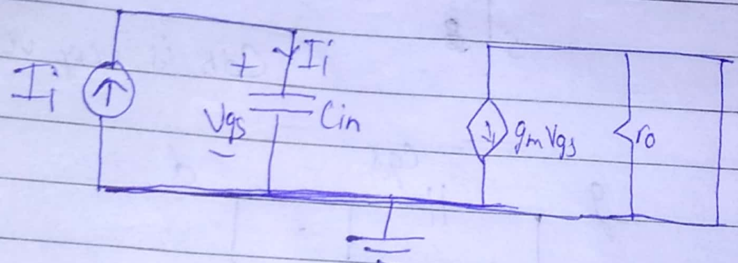
$$I_{gd} + I_o = g_m V_{gs}$$

$$I_o = g_m V_{gs} - I_{gd}$$

$$I_{gd} = \frac{V_{gs}}{1/sC_{gd}} = sC_{gd} V_{gs}$$

$$I_o = g_m V_{gs} - sC_{gd} V_{gs}$$





$$C_{in} = C_{gs} + C_{gd}$$

$$I_i = V_{gs}\, s(C_{gs} + C_{gd})$$

$$V_{gs} = \frac{I_i}{s(C_{gs} + C_{gd})}$$

$$h_{fe} = \frac{I_o}{I_i} = \frac{g_m V_{gs} - sC_{gd} V_{gs}}{sV_{gs}(C_{gs} + C_{gd})}$$

$$sC_{gd} V_{gs} << g_m V_{gs}$$

$$h_{fe} \simeq \frac{g_m V_{gs}}{sV_{gs}(C_{gs} + C_{gd})}$$

$$\boxed{h_{fe} = \frac{g_m}{s(C_{gs} + C_{gd})}}$$

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$$h_{fe} = \frac{g_m}{j\omega(C_{gs}+C_{gd})}$$

$$\boxed{|h_{fe}| = \frac{g_m}{\omega(C_{gs}+C_{gd})}}$$

At $\omega = \omega_T$, $|h_{fe}| = 1$

$$1 = \frac{g_m}{\omega_T(C_{gs}+C_{gd})} \Rightarrow \boxed{\omega_T = \frac{g_m}{C_{gs}+C_{gd}}}$$

Unity gain frequency.

Q Determine C_{de}, C_{je}, C_π, C_μ, f_T for a BJT operating at $I_C = 1mA$ and CBJ reverse bias of ~~two~~ 2V. The device has $\tau_F = 20ps$, $C_{jeo} = 20fF$, $C_{\mu o} = 20fF$, $V_{oe} = 0.9V$, $V_{oc} = 0.5V$ and $m_{CBJ} = 0.33$. Also draw the high freq. model indicating all the values. Given that $V_A = 100V$, $\beta = 100$

Sol (i) $C_{de} = \tau_F g_m = \tau_F \frac{I_C}{V_T}$

$$= \frac{20\times10^{-12} \times 10^{-3}}{25\times10^{-3}}$$

$$= 0.8\times10^{-12} F$$

$$= 0.8 pF$$

(ii) $C_{je} = \frac{C_{jeo}}{(1 - V_{BE}/V_{OE})^m} \simeq 2C_{jeo}$

$$C_{je} = 40fF$$

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(iii) $C_\pi = C_{de} + C_{je}$
$= 0.8\times10^{-12} + 40\times10^{-15}$
$= 0.84\times10^{-12}F$
$= 0.84\,pF$

(iv) $C_\mu = \dfrac{C_{\mu 0}}{\left(1+\dfrac{V_{CB}}{V_{0C}}\right)^m}$

$= \dfrac{20}{\left(1+\dfrac{2}{0.5}\right)^{0.33}}$

$= \dfrac{20}{\left(\dfrac{2.5}{0.5}\right)^{0.33}} = \dfrac{20}{1.7}$

$C_\mu = 11.76\,fF$

(v) $f_T = \omega_T = \dfrac{\beta_0}{C_{in} r_\pi} = \dfrac{\beta_0}{(C_\pi + C_\mu)\dfrac{\beta_0}{g_m}} = \dfrac{g_m}{C_\pi + C_\mu}$

$= \dfrac{g_m}{2\pi(C_\mu + C_\pi)} = \dfrac{I_C}{2\pi V_T(C_\pi + C_\mu)}$

$= \dfrac{10^{-3}}{2\pi\times25\times10^{-3}(0.84\times10^{-12}+11.75\times10^{-15})}$

$= \dfrac{1}{2\pi\times25\times10^{-12}\times0.85175}$

$= 7.47\times10^{9}\,Hz$

$\omega_T = 7.47\,GHz$

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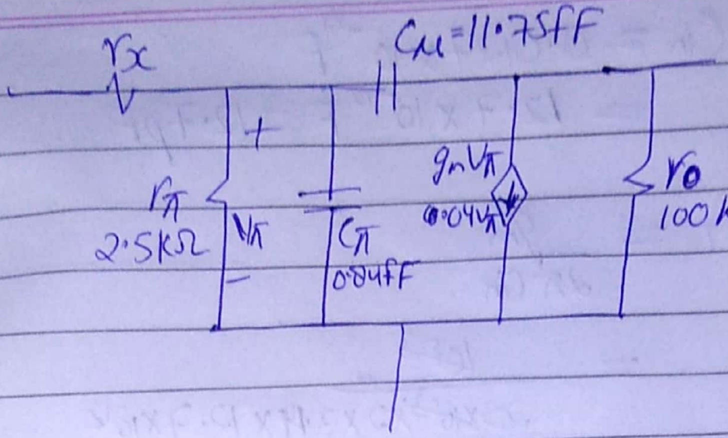

$$r_\pi = \frac{\beta_0}{g_m} = \frac{100 \times 25 \times 10^{-3}}{10^{-3}}$$
$$= 2.5k\Omega$$

$$g_m = \frac{I_C}{V_T} = \frac{10^{-3}}{25 \times 10^{-3}}$$
$$= 0.04S$$

$$r_o = \frac{V_A}{I_C} = \frac{100}{10^{-3}} = 100k\Omega$$

Q Given that $I_C = 1mA$, $C_\mu = 2pF$ and $|h_{fe}| = 10$ at 50 MHz. Determine $f_T = ?$ and $C_\pi = ?$

Sol

$$f_T = \frac{g_m}{2\pi(C_\mu + C_\pi)}$$

$$|h_{fe}| = \frac{\beta_0}{\sqrt{(\omega C_{in} r_\pi)^2 + 1}} = \frac{\beta_0}{\sqrt{(2\pi f C_{in} r_\pi)^2 + 1}}$$

$$10 = \frac{\beta_0}{\sqrt{(2\pi \times 50 \times 10^6 C_{in} r_\pi)^2 + 1}}$$ → neglect because 2 unknown

$$10 = \frac{\cancel{\beta_0}}{2\pi \times 50 \times 10^6 \times C_{in} \times \cancel{\beta_0}/g_m}$$

$$C_{in} = \frac{g_m}{2\pi \times 50 \times 10^6 \times 10}$$

$$= \frac{10^{-3}}{2\pi \times 50 \times 10^6 \times 10 \times 25 \times 10^{-3}}$$

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$$C_{in} = 0.0127 \times 10^{-9} F$$
$$= 12.7 \times 10^{-12} F = 12.7 pF$$

$$f_T = \frac{g_m}{2\pi C_{in}}$$

$$= \frac{10^{-3}}{25 \times \cancel{10^{-3}} \times 2 \times 3.14 \times 12.7 \times 10^{-12}}$$

$$= 501 \times 10^{6} Hz$$

$$f_T = 501 MHz$$

$$C_{in} = C_\mu + C_\pi$$
$$12.7 pf = C_\pi + 2 pf$$
$$C_\pi = 10.7 pf$$

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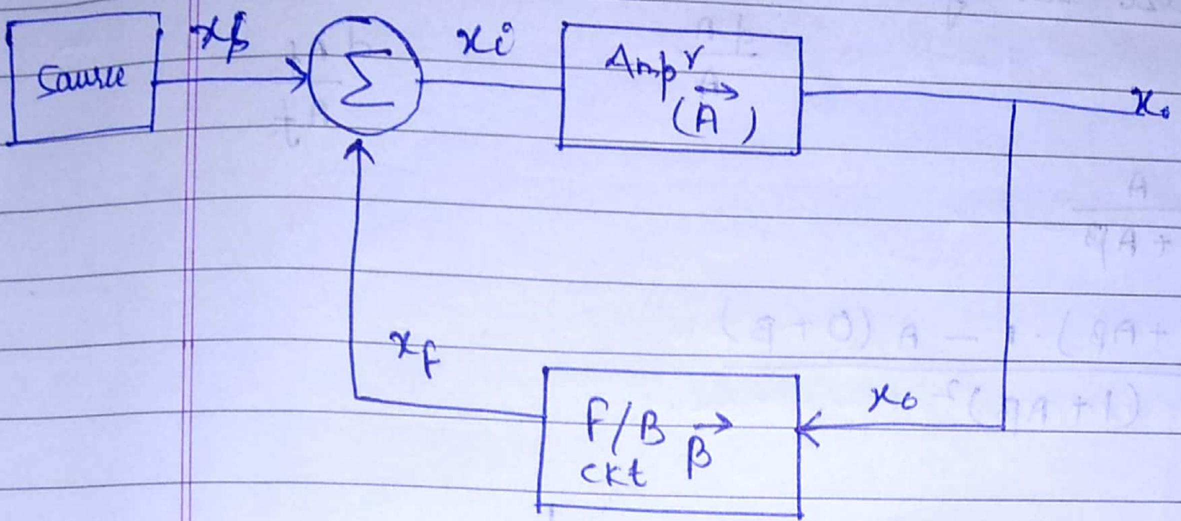
General feedback structure:-

Desenstize the gain



$x_i = x_s - x_f$

$A = \frac{x_o}{x_i}$

$\beta = \frac{x_f}{x_o}$

$A_f = \frac{x_o}{x_s}$

$$A_f = \frac{x_o}{x_s} = \frac{x_o}{x_i + x_f}$$

$$= \frac{x_o / x_i}{1 + x_f / x_i}$$

$$= \frac{x_o / x_i}{1 + \frac{x_f}{x_i} \times \frac{x_o}{x_o}}$$

$$\boxed{A_f = \frac{A}{1 + A\beta}}$$

$A_f < A$

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- Properties of Negative feed back.

1 Densensitize the gain:-

A $\frac{dA}{A}$ A_f $\frac{dA_f}{A_f}$

$$A_f = \frac{A}{1+A\beta}$$

$$\frac{dA_f}{dA} = \frac{(1+A\beta)\cdot 1 - A(0+\beta)}{(1+A\beta)^2}$$

$$\frac{dA_f}{dA} = \frac{1+A\beta - A\beta}{(1+A\beta)^2} = \frac{1}{(1+A\beta)^2}$$

$$dA_f = \frac{dA}{(1+A\beta)^2}$$

$$\frac{dA_f}{A_f} = \frac{dA}{(1+A\beta)^2 A_f}$$

$$\frac{dA_f}{A_f} = \frac{dA}{(1+A\beta)^{\cancel{2}} \cdot \frac{A}{\cancel{1+A\beta}}}$$

$$\boxed{\frac{dA_f}{A_f} = \frac{1}{(1+A\beta)} \cdot \frac{dA}{A}}$$

2 Increase the bandwidth

$$B.W = f_H - f_L$$
$$= f_{HL} - f_{Lf}$$
$$f_{Hf} > f_H$$

$$f_{Lf} < f_L$$

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- Heigh frequency Response

$$A = \frac{A_M}{1 + \frac{s}{\omega_H}}$$

$$A_f = \frac{A}{1 + A\beta}$$

$$= \frac{\frac{A_m}{(1 + s/\omega_H)}}{1 + \frac{A_m\beta}{(1 + s/\omega_H)}}$$

$$A_f = \frac{A_m}{1 + s/\omega_H + A_m\beta}$$

$$= \frac{A_m}{(1 + A_m\beta) + s/\omega_H}$$

$$A_f = \frac{A_m / (1 + A_m\beta)}{1 + \frac{s}{\omega_H(1 + A_m\beta)}} \quad \text{—— (1)}$$

$$A_f = \frac{A_{mf}}{1 + \frac{s}{\omega_{Hf}}} \quad \text{—— (2)}$$

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$$A_{mf} = \frac{A_m}{(1+A_m\beta)}$$

$$\omega_{Hf} = \omega_H(1+A_m\beta)$$

$$\omega_{Hf} > \omega_H$$

- Low frequency Response:-

$$A = \frac{A_m}{1+\frac{\omega_L}{S}}$$

$$A_f = \frac{A}{1+A\beta}$$

$$A_f = \frac{\frac{A_m}{1+\omega_L/S}}{1+\frac{A_m\beta}{\left(1+\frac{\omega_L}{S}\right)}}$$

$$A_f = \frac{A_m}{1+\omega_L/S+A_m\beta}$$

$$= \frac{A_m/(1+A_m\beta)}{1+\frac{\omega_L}{S(1+A_m\beta)}}$$

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$$A_f = \frac{A_{mf}}{1 + \frac{\omega_{Lf}}{s}}$$

$$A_{mf} = \frac{A_m}{1 + A_m\beta}$$

$$\omega_{Lf} = \frac{\omega_L}{(1 + A_m\beta)}$$

$$\omega_{Lf} < \omega_L$$

(3) Reduce the non linear Distortion:

$$v_o = A\,(v_{in} + v_{in}^2 + v_{in}^3) \ldots\ldots$$
$$= A v_{in} + A v_{in}^2 + A v_{in}^3$$

$$v_{of} = A_f\,(v_{in} + v_{in}^2 + v_{in}^3)$$
$$= A_f v_{in} + A_f v_{in}^2 + A_f v_{in}^3$$

As $A_f < A$ so $\boxed{v_{of} < v_o}$ non linear Distortion,

- Various type of

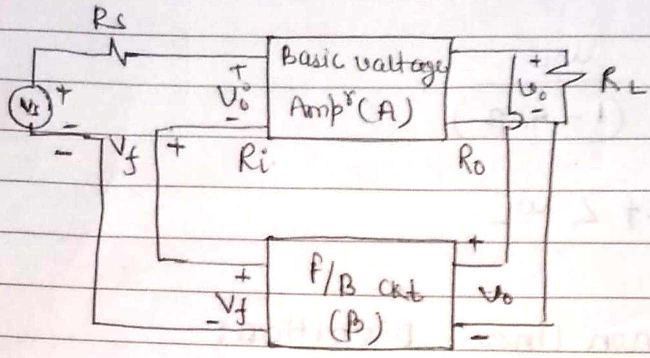
• Basic Topologiest:-

① • Valtage amplifier

$V_i = V_s - V_f$

$R_{if} > R_i$

$R_{of} < R_o$

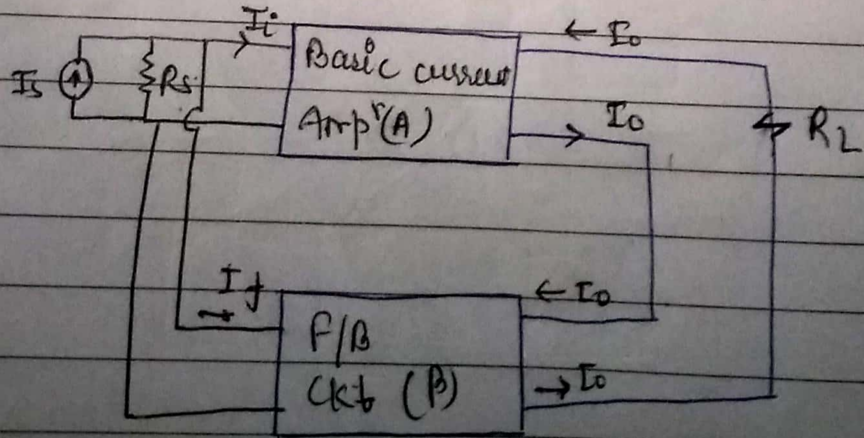


other name → Series shunt f/B Amp^r
Valtage sampaling valtage mixing Amp^r
Valtage series f/B
o/p sample
i/p side

② current amplifies:-

$R_{if} < R_i$

$R_{of} > R_o$



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$$A = \frac{I_o}{I_i}$$

$$\beta = \frac{I_f}{I_o}$$

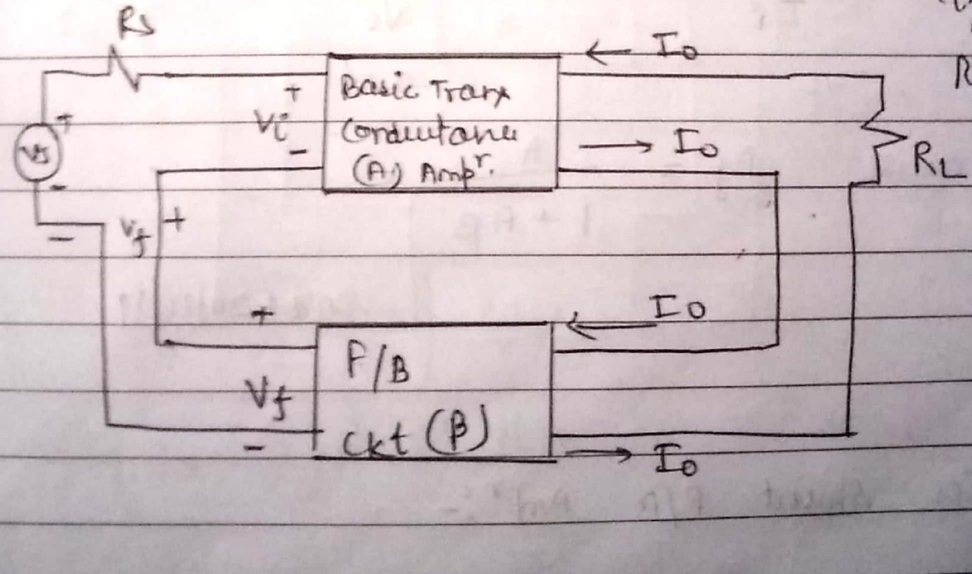
other name – shunt series f/B Amp^r.
Current sampling current mixing Amp^r.
Current shunt f B

O/P sample — i/p side

③ Trans Conductance Amp^r

$R_{if} > R_i$

$R_{of} > R_o$



other name series series f/B Amp^r
Current sampling Voltage mixing Amp^r
Current series f/B

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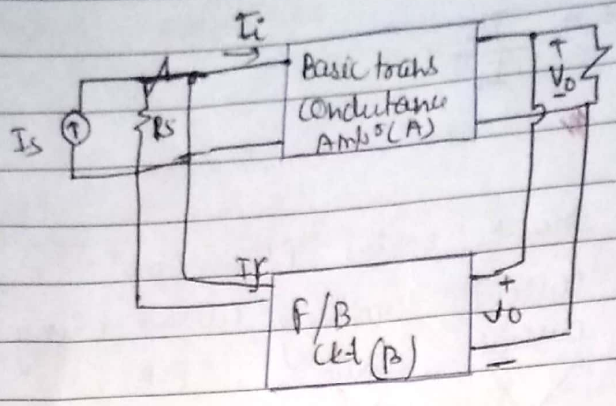
④ TRANS RESISTANCE Ampr

$R_{if} < R_i$
$R_{of} < R_o$



Other name :- Shunt Shunt F/B Ampr.
Voltage Sampling Current mixing Ampr
Voltage ~~Current~~ Shunt F/B

$$A = \frac{V_o}{I_i} \qquad \beta = \frac{I_f}{V_o}$$

Ω Ω^{-1}

Because $A_f = \dfrac{A}{1 + A\beta}$

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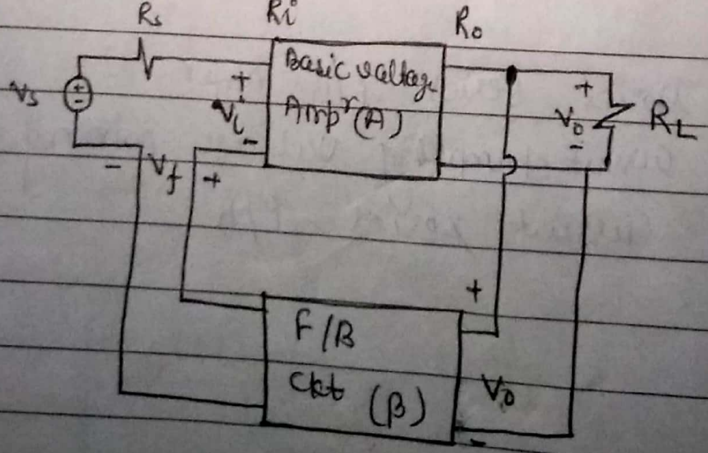
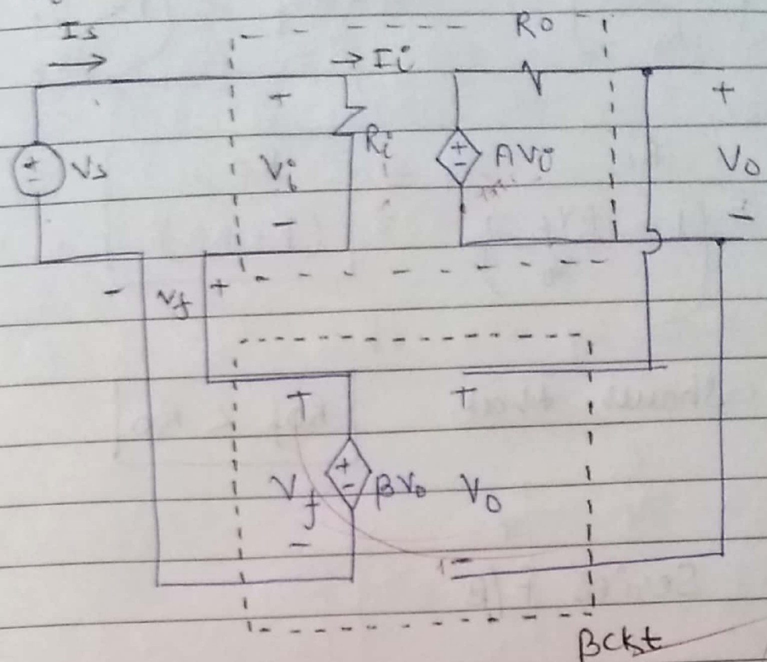
① Series shunt F/B Ampr :-



$A = \frac{V_o}{V_i} \Rightarrow V_o = AV_i$



$\beta = \frac{V_f}{V_o}$

$$\boxed{V_f = \beta V_o}$$

$$R_{if} = \frac{V_s}{I_s} = \frac{V_i + V_f}{I_i}$$

$V_i = V_s - V_f$

$V_s = V_i + V_f$

$I_s = I_i$

series connection

$$= \frac{V_i}{I_i}\left(1 + \frac{V_f}{V_i}\right)$$

$$= R_i\left(1 + \frac{V_f}{V_i} \times \frac{V_o}{V_o}\right)$$

$\frac{V_f}{V_o} = \beta, \quad \frac{V_o}{V_i} = A$

$$\boxed{R_{if} = R_i(1 + A\beta)}$$

this shows that $R_{if} > R_i$

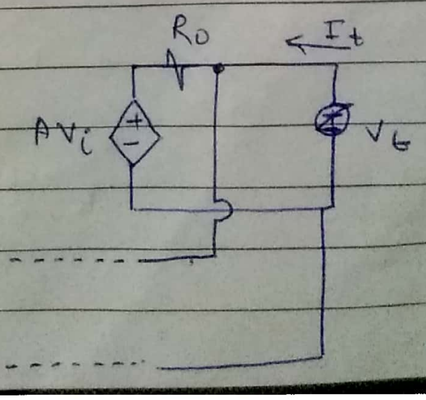
for $R_{of} \Rightarrow$

$V_s = 0$

$V_i = V_s - V_f$

$V_i = -V_f$

If we calculate output resistance than input voltage will be zero.



V_t = test voltage

I_t = test current

$R_{of} = \frac{V_t}{I_t}$

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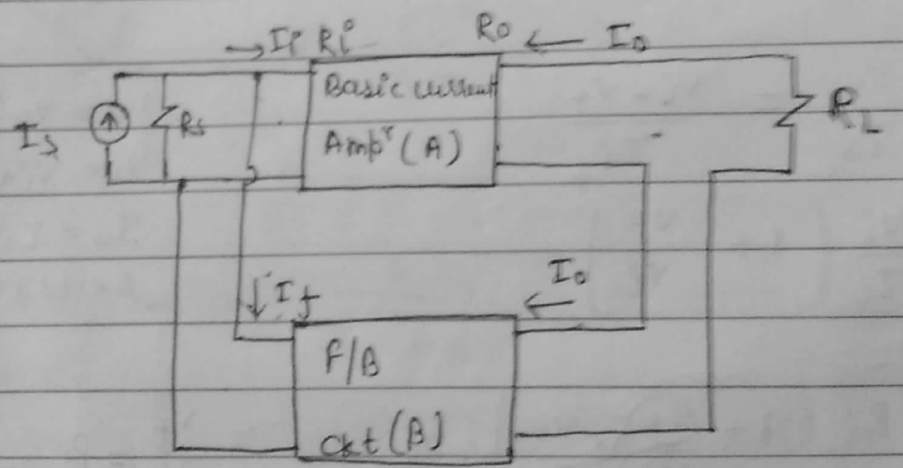
$$R_{of} = \frac{V_t}{\left(\frac{V_t - AV_f}{R_o}\right)} = \frac{R_o V_t}{V_t + AV_f} = \frac{R_o}{\left(1 + \frac{AV_f}{V_t}\right)}$$

$$R_{of} = \frac{R_o}{\left(1 + \frac{AV_f}{V_o}\right)} = \boxed{\frac{R_o}{(1+A\beta)}}$$

It shows that $\boxed{R_{of} < R_o}$

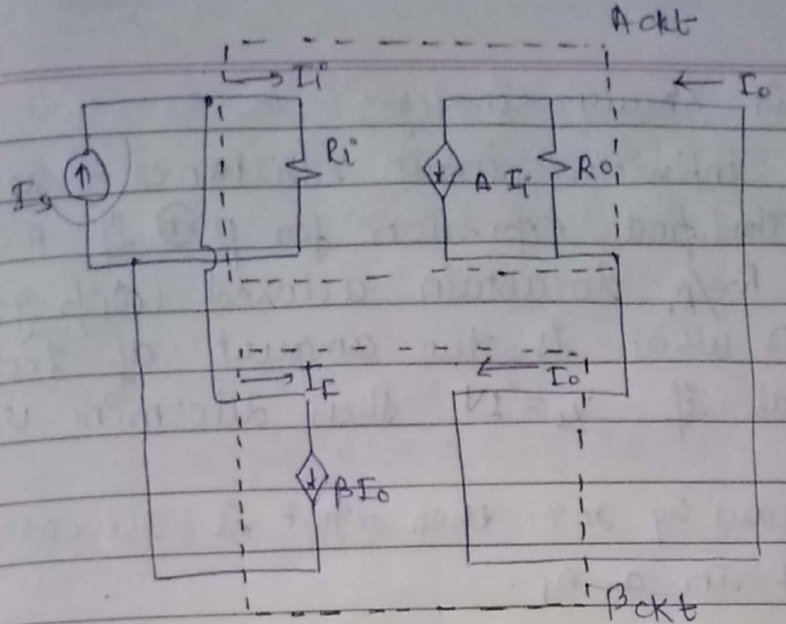
2. Shunt Series F/B



$A = \frac{I_o}{I_i} \Rightarrow I_o = AI_i$

$\beta = \frac{I_f}{I_o} \Rightarrow I_f = \beta I_o$

$I_i = I_s - I_f$



$$R_{if} = \frac{V_s}{I_s} = \frac{V_i}{I_i + I_f} = \frac{V_i}{I_i\left(1 + \frac{I_f}{I_i}\right)} = \frac{R_i}{1 + \frac{I_f}{I_i} \times \frac{I_o}{I_o}}$$

$$\boxed{R_{if} = \frac{R_i}{(1 + A\beta)}}$$

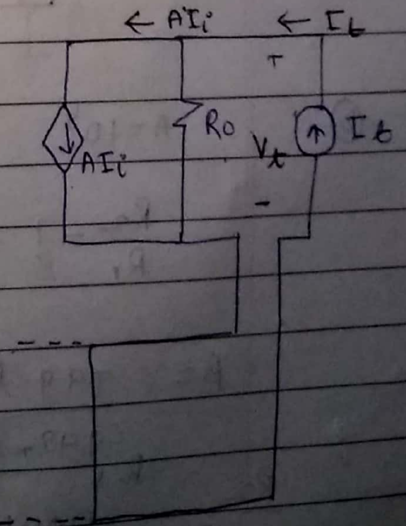
$$\boxed{R_{if} < R_i}$$

~~for~~ R_{of}

$$I_s = 0$$

$$I_i = I_s - I_f$$

$$I_i = -I_f$$



$$R_{of} = \frac{V_t}{I_t} = \frac{(I_t - AI_i)R_o}{I_t}$$

$$= R_o\left(1 + \frac{AI_f}{I_t}\right)$$

$$= R_o\left(1 + \frac{AI_f}{I_o}\right)$$

$$\boxed{R_{of} = R_o(1 + A\beta)}$$

this eq shows

$$\boxed{R_{of} > R_o}$$

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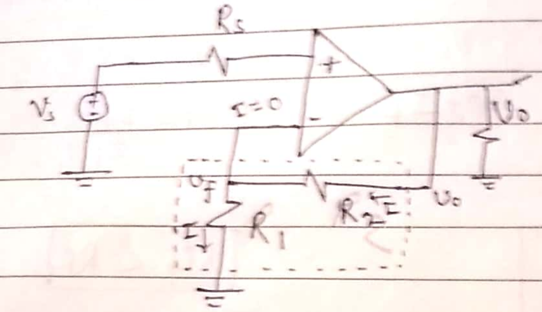
Qu. for circuit shown in fig. (a) Opam as infinitine input resistance zero output resistance find expression for β (b) if $A = 10^4$ the find R_2/R_1 to abtain a closed loop gain of 10. (c) what is the amount of feedback in decimal if $V_s = 1V$ then determine V_o, V_f & V_i
(d) if A decrease by 20% then what is the corresponding decreament in a A_f.



(a)
$$V_f = V_o - I R_2$$
$$V_f = \frac{V_o R_1}{R_1 + R_2}$$
$$\boxed{\beta = \frac{V_f}{V_o} = \frac{R_1}{R_1 + R_2}}$$

(b) $A = 10^4$

$\frac{R_2}{R_1} = ?$

$$A_f = 10 = \frac{A}{1 + A\beta}$$
$$\Rightarrow 10 = \frac{10^4}{1 + 10^4 \beta}$$
$$1 + 10^4 \beta = 10^3$$
$$\beta = \frac{10^3 - 1}{10^4}$$
$$\beta = \frac{999}{10^4} = 0.0999$$

$$\beta = \frac{999\, R_1}{\underset{R_1}{999} + \underset{R_2}{9001}}$$
$$\frac{R_2}{R_1} = \frac{9001}{999}$$
$$\boxed{\frac{R_2}{R_1} = 9.01}$$

(c) $1+A\beta = 10^3$

$20 \log (1+A\beta) = 20 \log 10^3$

$= 60\,dB$

(d) $V_s = 1$

$V_o = A_f V_s = 10\,V$

$V_f = \beta \cdot 10 \times 0.099 = 0.999\,V$

$V_i = V_s - V_f = 1 - .999$

$= 0.001\,V = 1\,mV$

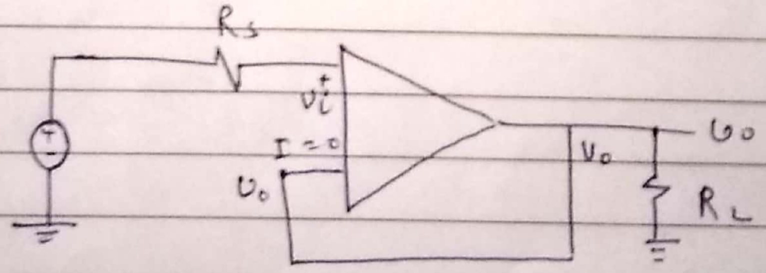
(e) $\frac{dA}{A} = 20\%$

$$\frac{dA_f}{A_f} = \frac{1}{(1+A\beta)} \frac{dA}{A}$$

$$= \frac{1}{10^3} \times 20\%$$

decrement $\frac{20}{1000} = 0.02\%$

Que.2



Question same as first question.

$\beta = 1 = \frac{V_f}{V_o} = \frac{V_o}{V_o} = 1$

if gain is 1 of any circuit impedance matching.

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Shivalal

Que-3 for current Ampr $R_i = 100\,\Omega$ & $R_o = 100\,k\Omega$
Given that the basic ampr gain is 100 and f/B ckt gain is 0.8 then determine input & output resistance with feedback.

$\beta = 0.8 \qquad A = 100$

$R_{if} = \frac{R_i}{(1 + A\beta)} \qquad R_{of} = R_o(1 + A\beta)$

$1 + A\beta = 1 + 100 \times 0.8 = 1 + 80 = 81$

$R_{if} = \frac{100}{81} \qquad R_{of} = 100 \times 81$

$= 8100\,k\Omega$

$R_{if} = 1.2346\,\Omega$

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