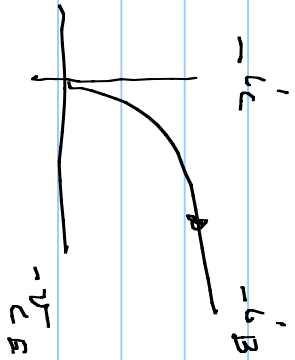


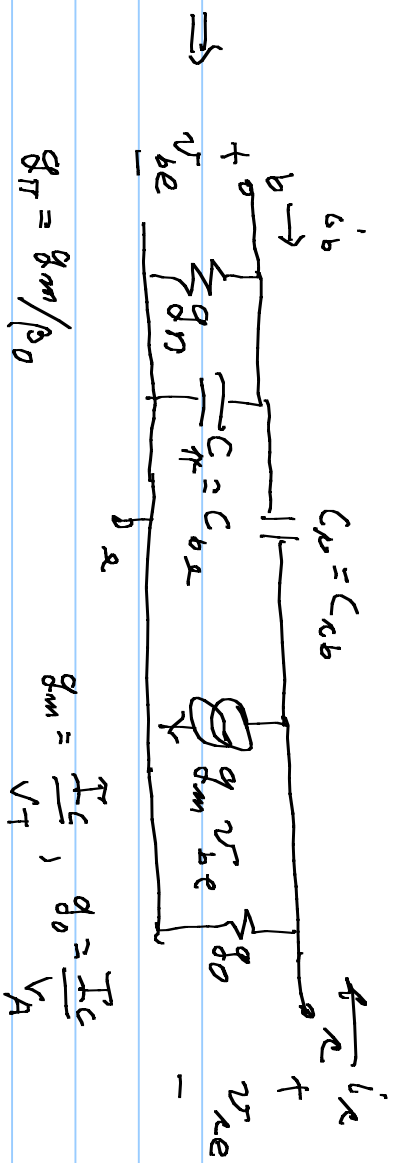
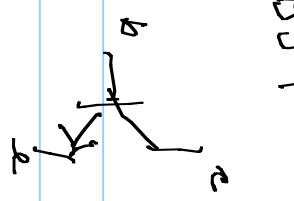
\Rightarrow takes $\frac{d i_C}{d V_{CE}}$



$$\frac{\partial i_C}{\partial V_{CE}} = \frac{\partial(-i_E)}{\partial(-V_{CE})} \quad \text{same sign as for MPM}$$

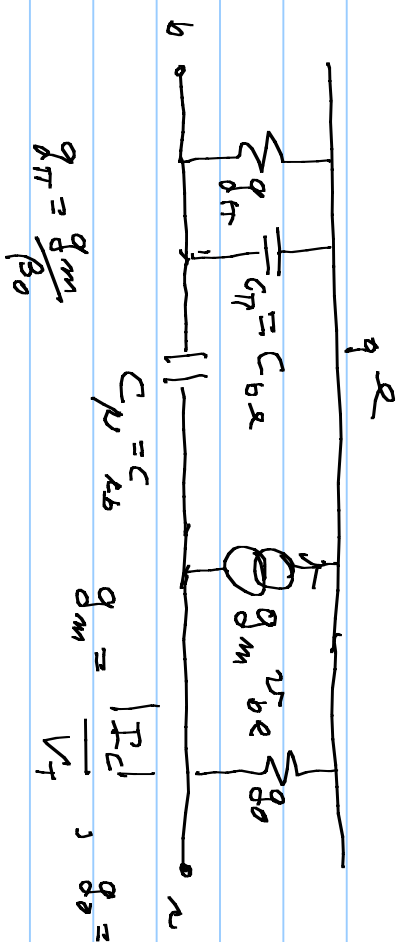
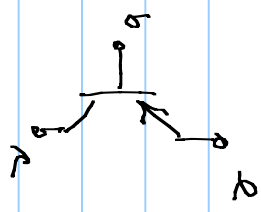
\Rightarrow small signal equivalent for PMP looks like that for MPM

BST



$$g_{\pi} = g_m / \beta_0$$

$$g_m = \frac{I_C}{V_T}, \quad g_o = \frac{I_C}{V_A}$$



$$g_{\pi} = \frac{g_m}{\beta_0}$$

$$C_{\mu} = C_{bc}, \quad g_m = \frac{|I_C|}{V_T}, \quad g_o = \frac{|I_C|}{|V_A|}$$

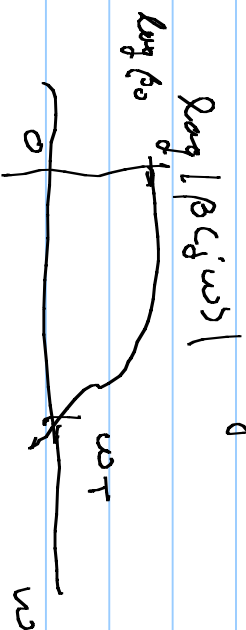
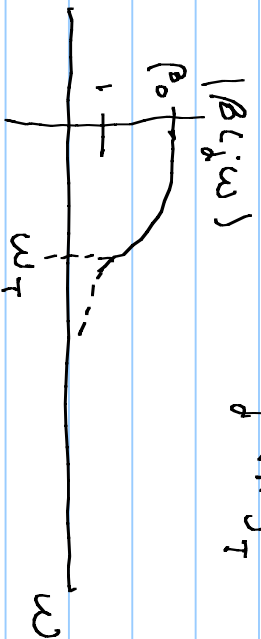
$$\frac{i_b}{i_c} = \frac{y_{21} \times v_{be}}{y_{11} \times v_{be}} = \frac{y_{21}}{y_{11}} \begin{bmatrix} i_b \\ v_{be} \end{bmatrix} = \begin{bmatrix} y_{11} \\ y_{21} \end{bmatrix} \begin{bmatrix} v_{be} \\ v_{ce} \end{bmatrix}$$

$$\begin{aligned} &= \beta(A) = \frac{g_m - \alpha C_{\mu}}{g_{\pi} + \alpha(C_{\pi} + C_{\mu})} \\ &\quad \times \quad \times \quad \times \\ &\quad \times \quad \times \quad \times \end{aligned}$$

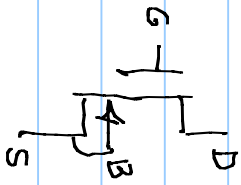
0 x check when $v_{ce} = v_{be} = 0$

$$\begin{aligned}
 \beta(\omega) &= \frac{g_m \left(1 - \frac{A}{g_m} C_p\right)}{g_n \left(1 + \frac{A}{g_n} (C_T + C_U)\right)} = \frac{g_m \left(1 - \frac{A}{g_m} C_T\right)}{g_n \left(1 + \frac{A}{g_n} (C_T + C_p)\right)} \quad \beta_0 = \beta(\omega) \Big|_{\omega=0} \\
 &= \beta_0 \left(\frac{1 - A/g_m}{1 + A/g_n} \right) \approx \beta_0 \text{ at } A=0 \quad (\text{at } \omega \approx 0)
 \end{aligned}$$

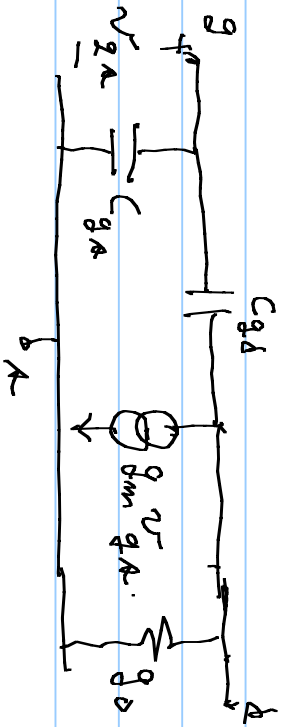
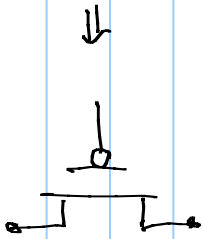
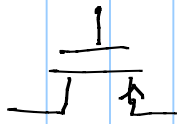
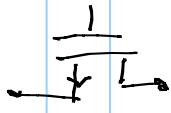
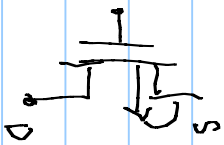
frequency $\omega_T = j\omega_T$ at which $|\beta(\omega)| = 1 \Rightarrow$ transition frequency
 $\omega_T = j\omega_T$ "gain loss"



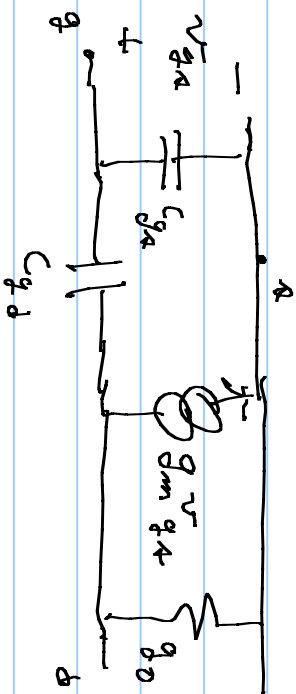
NMOS



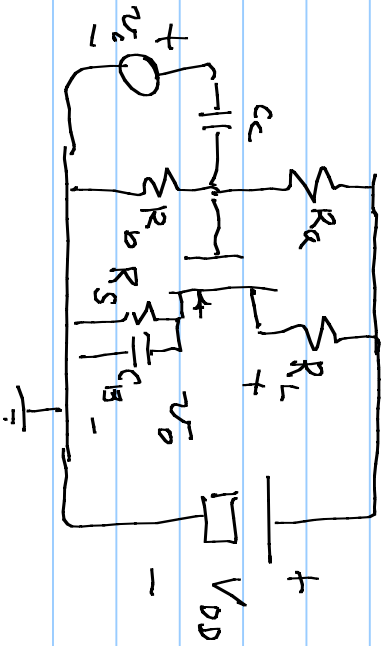
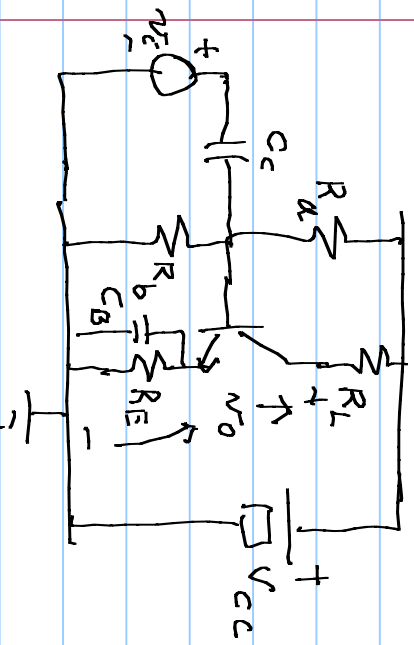
PMOS



NMOS

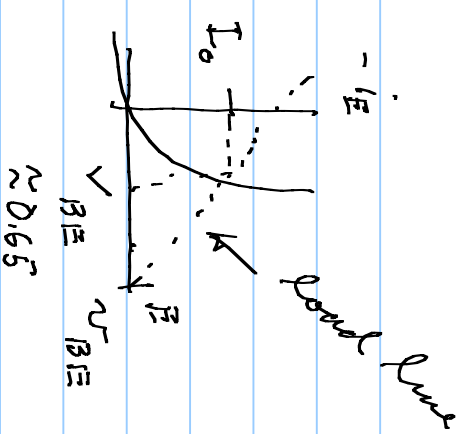
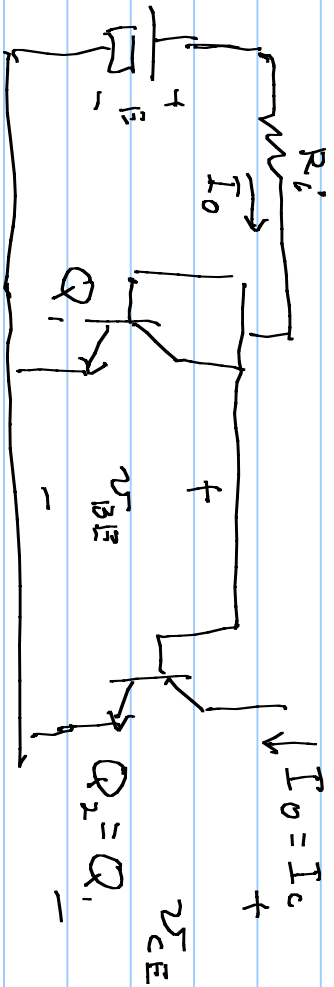


Biasing



$$ideal A_v = \frac{v_o}{v_i} = -g_m R_L \quad \text{actually } A_v(\omega) \Big|_{\omega=0}$$

current source & mirrors



given I_0 solve for R_i :

$$R_i = \frac{V_{BE} - 0.65}{I_0}$$

$$V_{BE} = R_i I_0 + V_{BE} \approx 0.65$$

