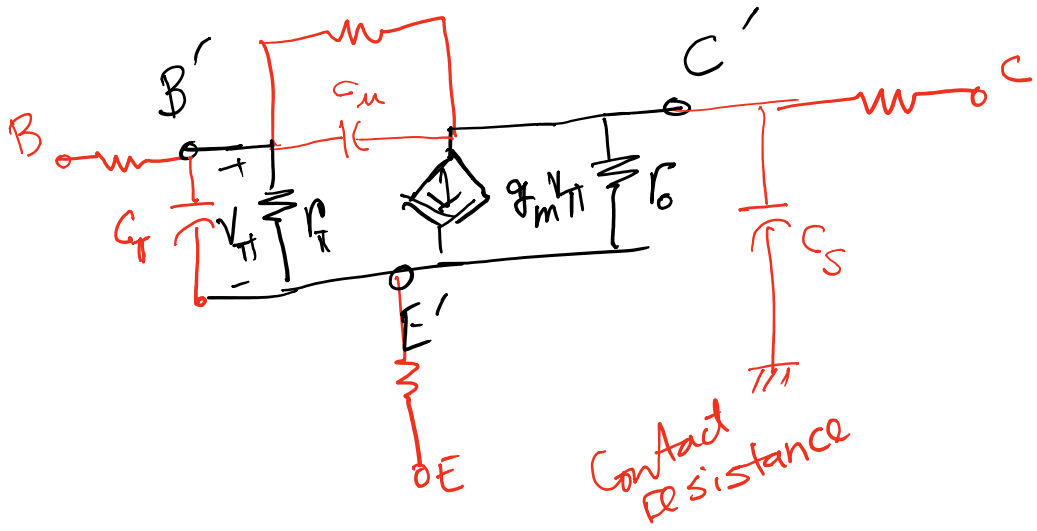
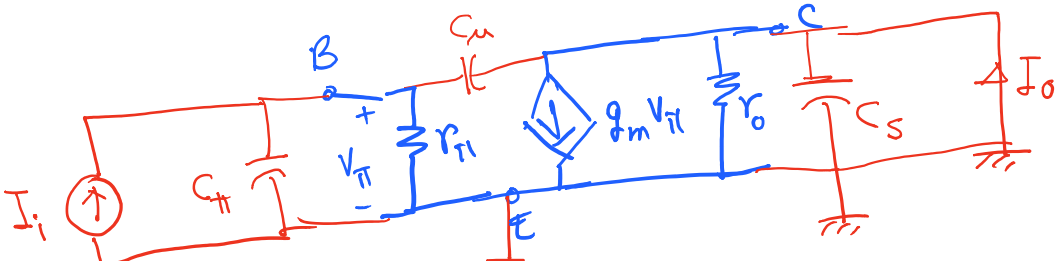
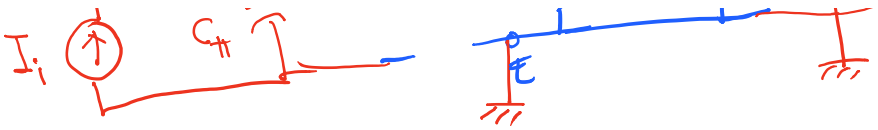
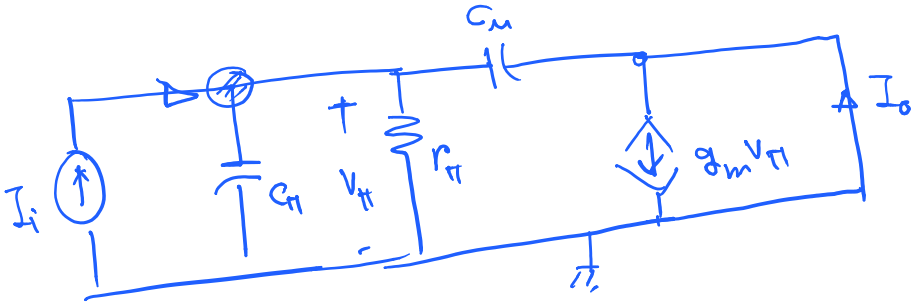
High Frequency Model

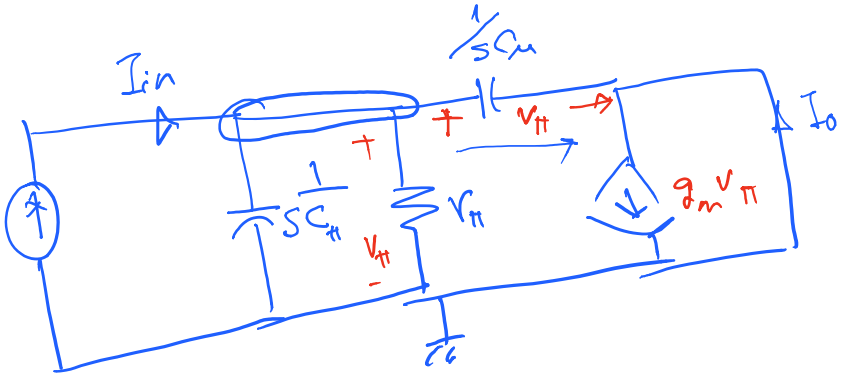
Monday, October 10, 2016 8:57 AM











$$I_{in} = \frac{V_\pi}{\frac{1}{sC_\pi}} + \frac{V_\pi}{r_\pi} + \frac{V_\pi}{\frac{1}{sC_\mu}} = \frac{V_\pi}{r_\pi} + V_\pi\left[C_\pi + C_\mu\right]s$$

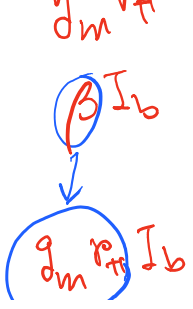
$$= \frac{V_\pi}{r_\pi}\left[1 + \left[C_\pi + C_\mu\right] r_\pi s\right]$$

$$I_o = g_m V_\pi - \frac{V_\pi}{\frac{1}{sC_\mu}} = g_m V_\pi - V_\pi s C_\mu$$

$$= V_\pi\left(g_m - sC_\mu\right)$$

$$A_I\Big|_{sc.} = \frac{I_o}{I_{in}} = \frac{V_\pi\left(g_m - sC_\mu\right)}{\frac{V_\pi}{r_\pi}\left[1 + \left(C_\pi + C_\mu\right) s r_\pi\right]}$$

$$= \frac{r_\pi g_m - sC_\mu r_\pi}{1 + s r_\pi\left(C_\pi + C_\mu\right)}$$



$$= \frac{r_\pi g_m}{1 + s r_\pi (C_\pi + C_\mu)}$$

$g_m r_\pi I_b$

$$\simeq \frac{r_\pi g_m}{1 + s r_\pi (C_\pi + C_\mu)}$$

$r_\pi g_m \gg s C_\mu r_\pi$

$$= \frac{\beta}{1 + s r_\pi (C_\pi + C_\mu)}$$

$s\tau = 1 \quad (s = \frac{1}{\tau})$

$\frac{s}{10} = 1$

$s = 10$

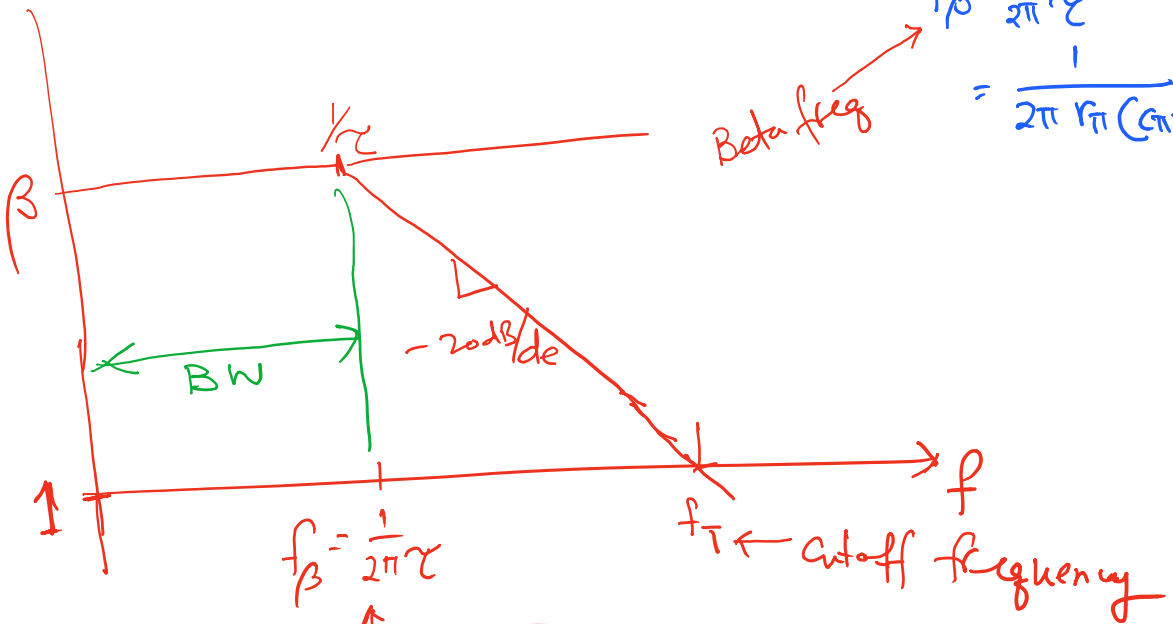
$$= \frac{\beta}{1 + s\tau}$$

$\tau = r_\pi [C_\pi + C_\mu]$

$f_\beta = \frac{1}{2\pi\tau}$

$= \frac{1}{2\pi r_\pi (C_\pi + C_\mu)}$

Beta freq



Beta frequency,
Corner freq
3-dB freq

$$|A_I| = \left| \frac{\beta}{1 + s\tau} \right| = \left| \frac{\beta}{1 + j\omega\tau} \right| = \frac{\beta}{\sqrt{1 + (\omega\tau)^2}}$$

$$\simeq \frac{\beta}{\omega\tau}$$

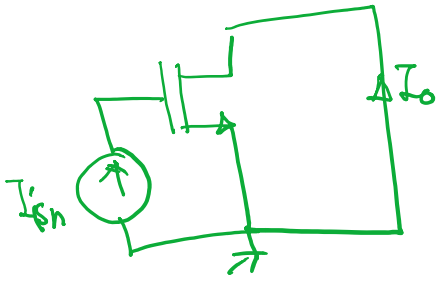
$$|A_I| = 1 = \frac{\beta}{\omega_T \tau}$$

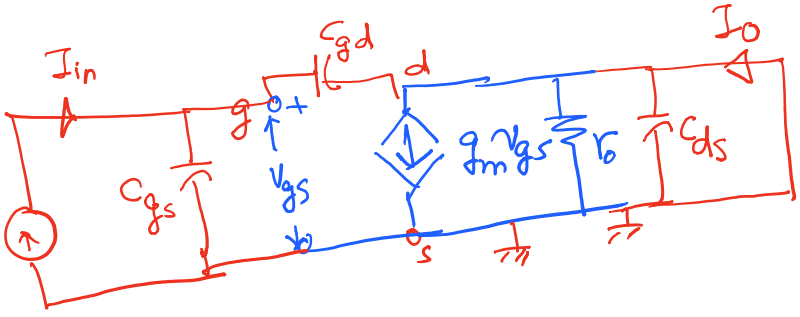
$$\therefore \quad \omega_T = \frac{\beta}{\tau}$$

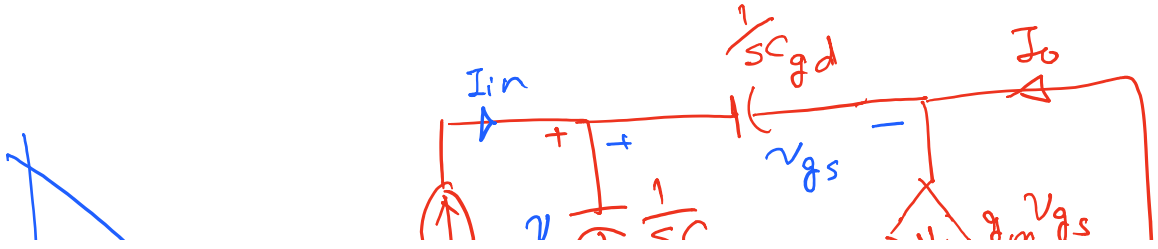
$$\rightarrow \quad f_T = \frac{\beta}{2\pi\tau} = \frac{\beta}{2\pi r_\pi [C_\mu + C_\pi]}$$

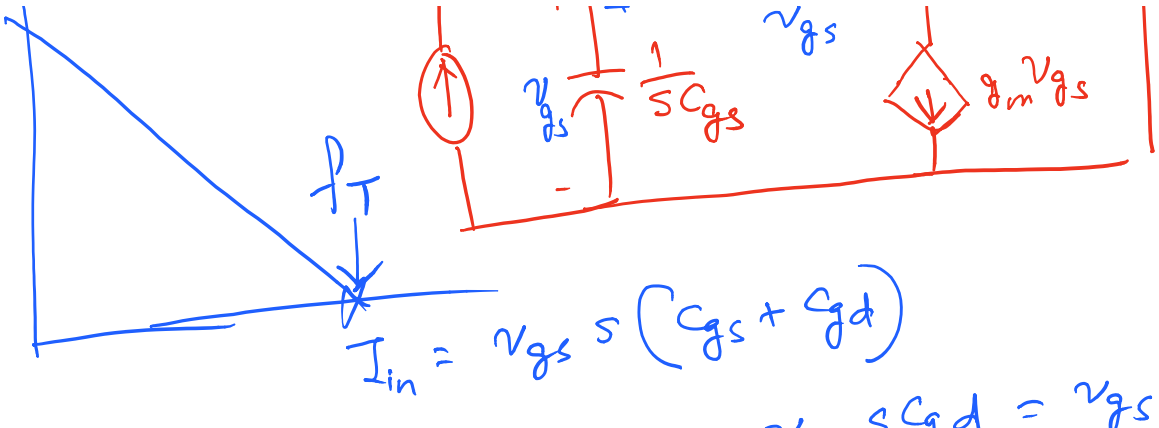
$$f_T = \beta f_\beta = \text{Gain} \times \text{Bandwith}$$

MOSFET









$$I_{in} = v_{gs}\, s\left(C_{gs} + C_{gd}\right)$$

$$I_o = g_m v_{gs} - v_{gs}\, sC_{gd} = v_{gs}\left(g_m - sC_{gd}\right)$$

$$\therefore A_I\Big|_{sc} = \frac{I_o}{I_{in}} = \frac{g_m - sC_{gd}}{s\left(C_{gs}+C_{gd}\right)} \simeq \frac{g_m}{s\left(C_{gs}+C_{gd}\right)}$$

$$1 = \frac{g_m}{\omega_T\left(C_{gs}+C_{gd}\right)} \qquad \therefore \omega_T = \frac{g_m}{C_{gs}+C_{gd}}$$