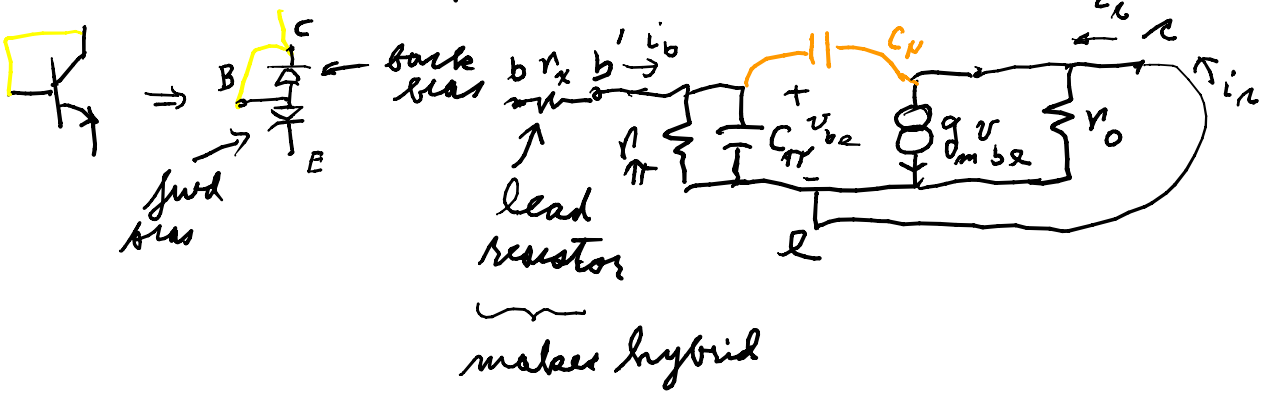
EE 303H
09/22/11

Note Title 9/21/2011

Hybrid-π p. 708, f_T p. 709



makes hybrid

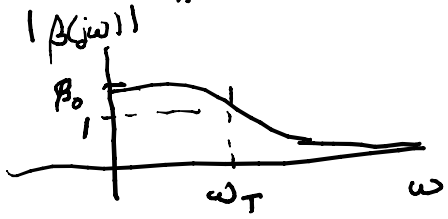
$$\left.\frac{i_c}{i_b}\right|_{v_{ce}=0} = \beta(j\omega), \quad \omega \approx 0 \Rightarrow \beta_0 = h_{fe}\big|_{\omega=0} \quad \text{DC}$$

$$v_{be} = \frac{1}{g_\pi + sC_\pi} \cdot i_b$$

$$i_c = g_m v_{be} = \frac{g_m}{g_\pi + sC_\pi} \cdot i_b$$

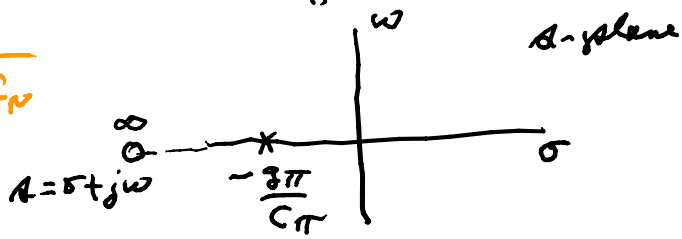
$$\beta(s) = \frac{g_m/g_\pi}{1 + s C_\pi/g_\pi} = \frac{\beta_0}{1 + s\frac{C_\pi}{g_\pi}}$$

$$|\beta(j\omega)| = \frac{\beta_0}{\sqrt{1+\omega^2 C_\pi^2/g_\pi^2}} = 1 \quad \text{in } \omega$$

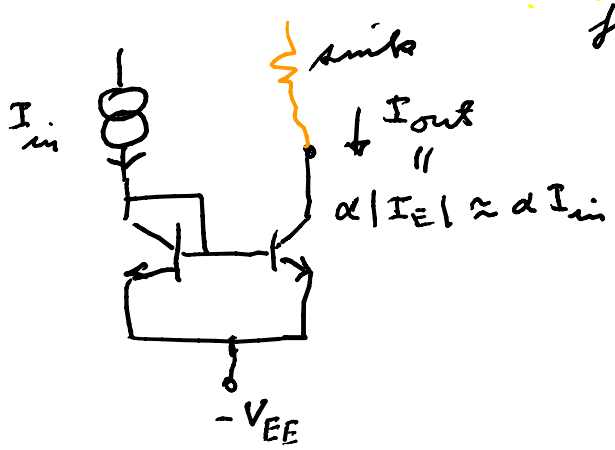


$$\beta_0^2 = 1 + \omega_T^2 C_\pi^2/g_\pi^2 \approx \omega_T = \frac{g_\pi \beta_0}{C_\pi} = \frac{(g_m/\beta_0)\beta_0}{C_\pi} = \frac{g_m}{C_\pi}$$

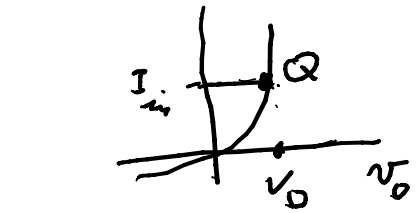
with $C_\mu \Rightarrow f_T = \frac{1}{2\pi} \cdot \frac{g_m}{C_\pi + C_\mu}$

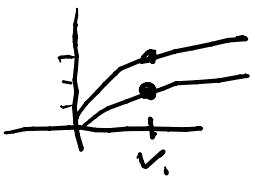


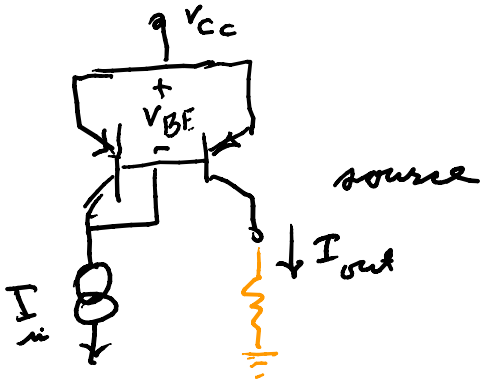
Current mirror p. 452 & 534 → analysis for base current present



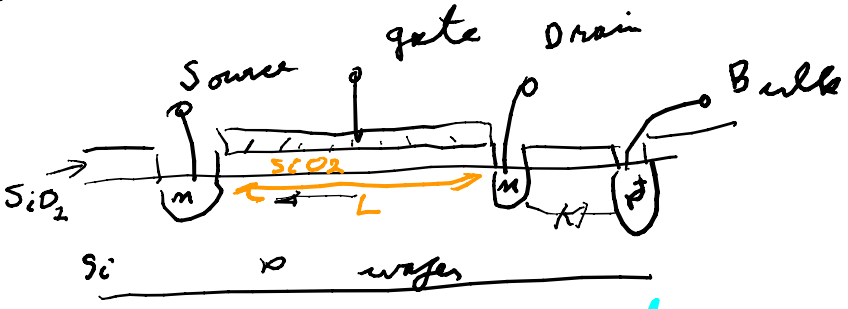
i_O

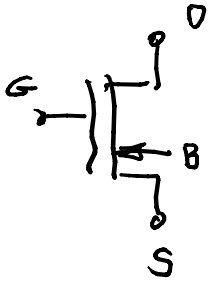


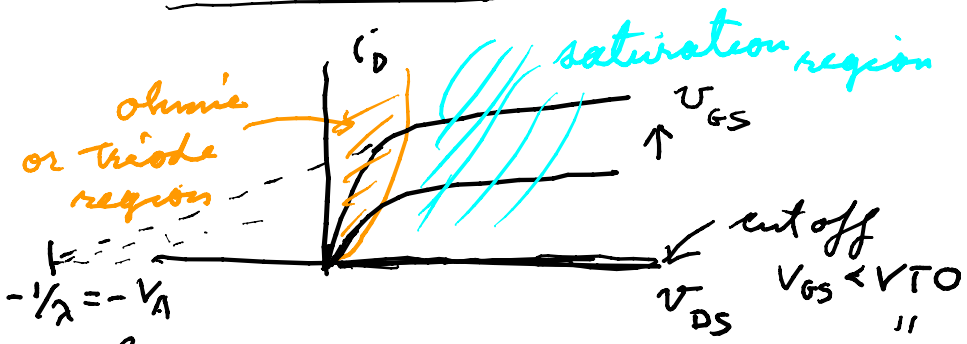




MOS transistors







$V_{GS} < VTO$ = Turn on = threshold

p. 250
fig. 5.13

assume we off BS diode
i.e. short B to S

$$i_D = \left(\frac{KP}{2}\right)\cdot\frac{W}{L}\cdot\begin{cases} 0 & v_{GS} \le VTO \quad (V_{th}) \quad \text{cut-off} \\ \left\{2(v_{GS}-VTO)v_{DS} - v_{DS}^2\right\}(1+\lambda v_{DS}), & 0 \le v_{DS} \le v_{GS}-VTO \quad \text{ohmic} \\ (v_{GS}-VTO)^2(1+\lambda v_{DS}), & v_{GS}-VTO \le v_{DS} \quad \text{saturation} \end{cases}$$

(V_{th} = VTO; λ = LAMBDA)

KP, VTO, λ are Spice parameters (also γ = GAMMA)

if $V_{BS} \neq 0$, then VTO $\Rightarrow V_{th}$ = threshold voltage

see p. 324
eq. (5.107)

$$V_{th} = VTO + \gamma\left[\sqrt{2\phi_f + V_{SB}} - \sqrt{2\phi_f}\right]$$

$2\phi_f \approx 0.6$

cancel if $V_{SB} = 0$

Small signal π equivalent $V_{SB} = 0$