BJT equations.

DC Analysis

$$I_C = I_S\, e^{|V_{BE}|/V_T} \qquad V_T = 25\,mV \text{ at } T = 300K$$

$$I_B = I_C/\beta \qquad I_B = \frac{I_E}{\beta+1}$$

$$I_E = I_C + I_B$$

$$I_C = \alpha I_E \qquad \beta = \frac{\alpha}{1-\alpha}\ ;\ \alpha = \frac{\beta}{\beta+1}$$

Ac Analysis

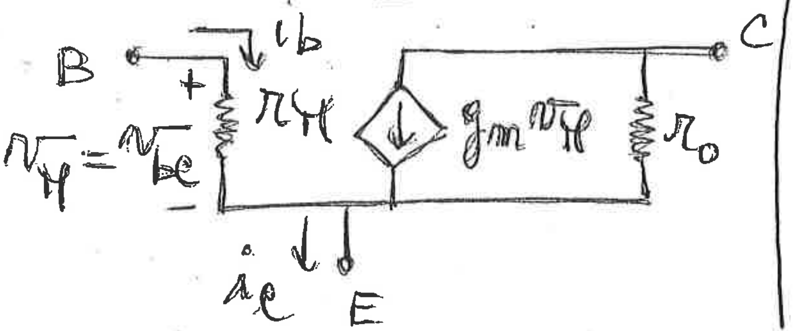
$$g_m = \frac{I_C}{V_T}\ ;\ r_\pi = \frac{V_T}{I_B} = \frac{\beta}{g_m}\ ;\ r_o = \frac{V_A}{I_C}$$

$$r_e = \frac{\alpha}{g_m} = \frac{V_T}{I_E}\ ;\ r_\pi = (\beta+1)\, r_e$$

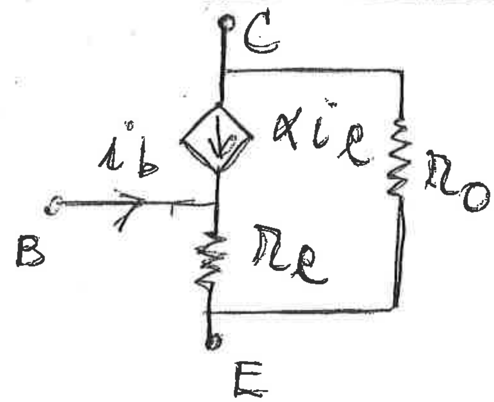
Small signal equivalent circuit

Hybrid π-model

midgap range

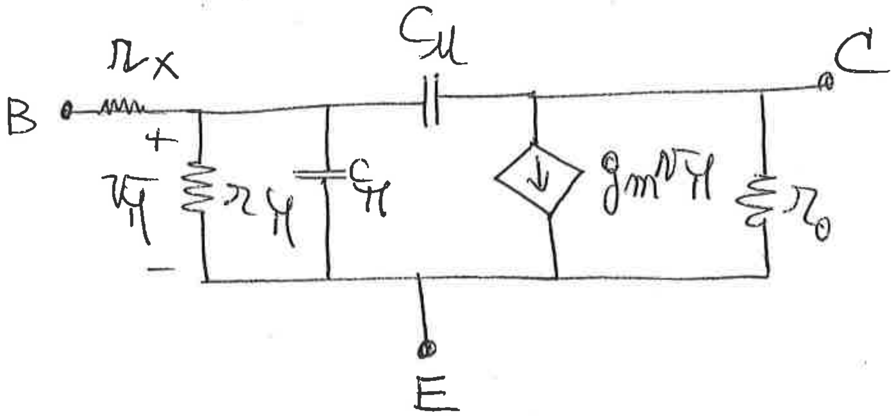


T-model



High-frequency hybrid-π

more complete model



MOSFET Equations

Triode mode

$$I_D = k_n'\left(\frac{W}{L}\right)\left[(V_{GS}-V_t)V_{DS}-\frac{1}{2}V_{DS}^2\right]$$

$n \to p$ for PMOS

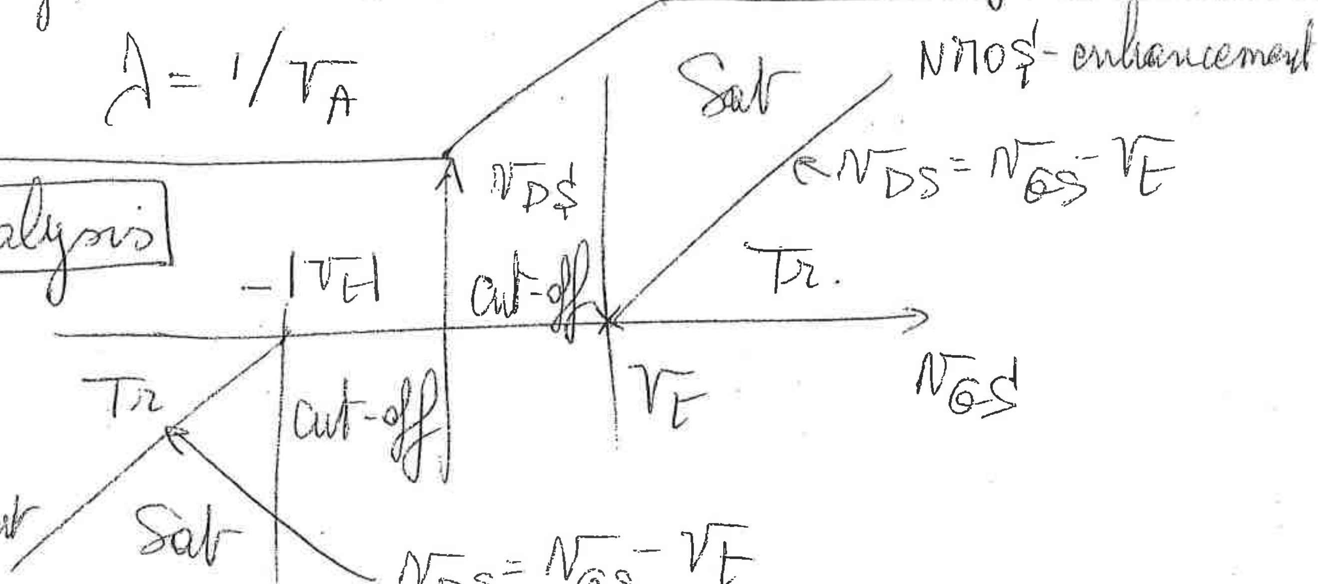
Saturation mode

$$I_D = \frac{1}{2}k_n'\left(\frac{W}{L}\right)\left[V_{GS}-V_t\right]^2(1+\lambda V_{DS})$$

Typically, we assume $\lambda = 0$ in DC analysis.

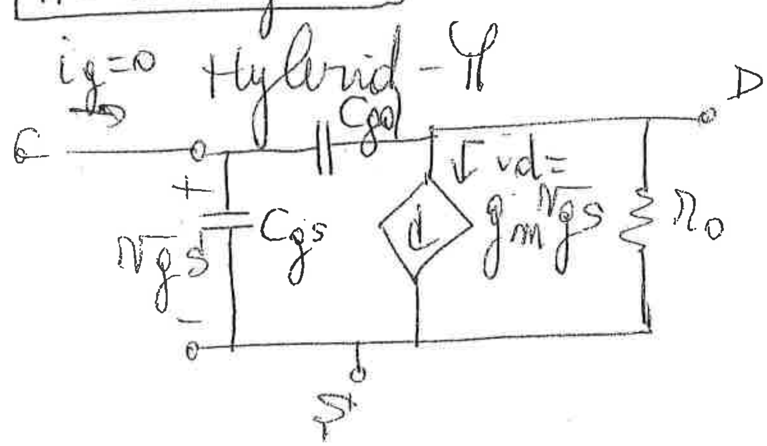
$\lambda = 1/V_A$

DC analysis

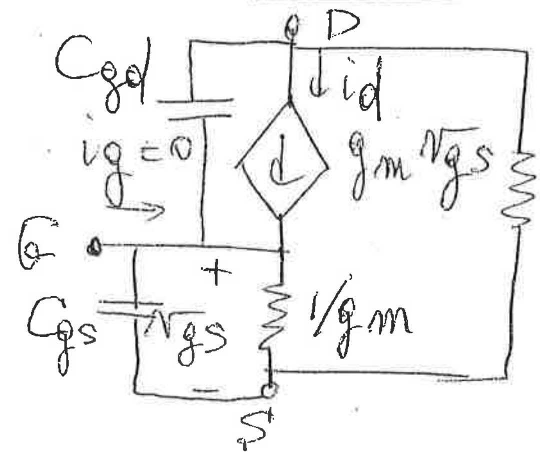


AC analysis

Hybrid-π



T-model



$$g_m = k_n'\frac{W}{L}(V_{GS}-V_t)$$

$r_o = \frac{V_A}{I_D}$; $r_o = \infty$ if neglected