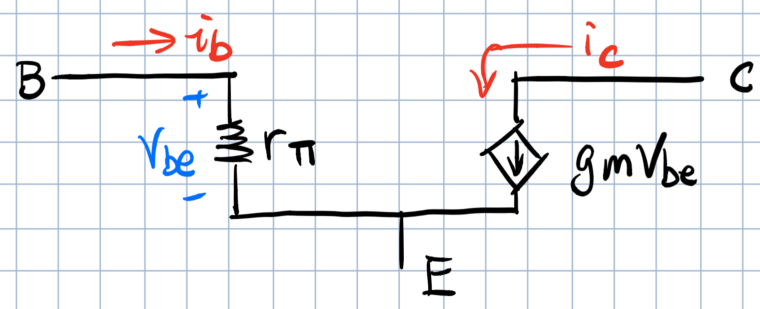
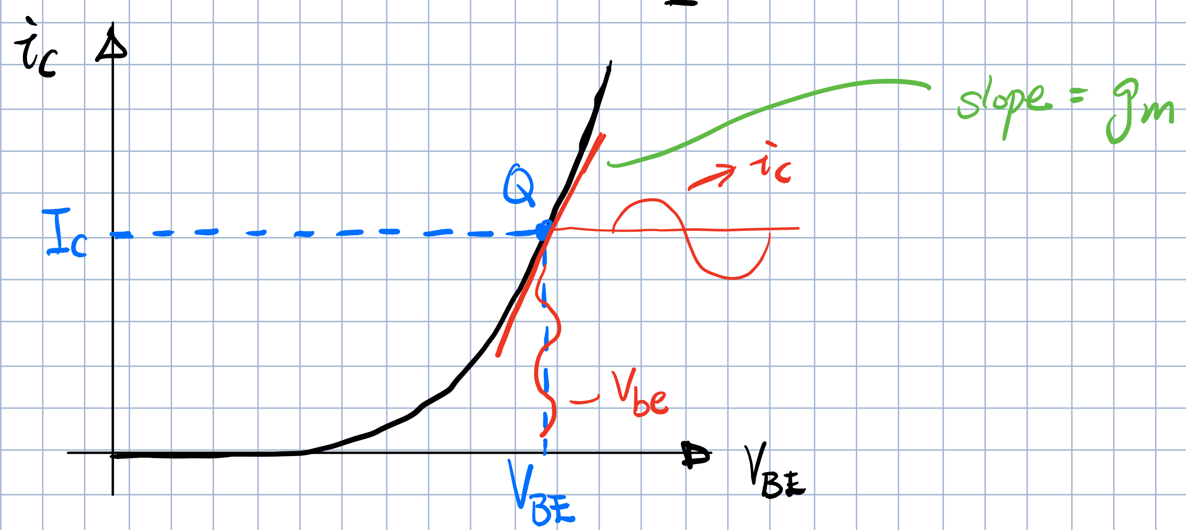
$$i_B = \underbrace{I_B}_{DC} + \underbrace{i_b}_{ac}$$

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

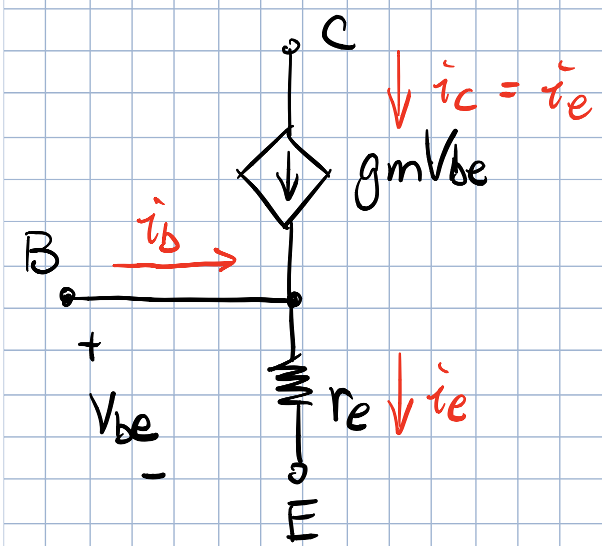
hybrid-π model:





$$i_E = I_E + i_e, \quad i_e = \frac{i_c}{\alpha} = \frac{g_m v_{be}}{\alpha} = \frac{v_{be}}{\frac{\alpha}{g_m}} = \frac{v_{be}}{r_e}$$

$$\frac{\alpha}{g_m} \to r_e$$

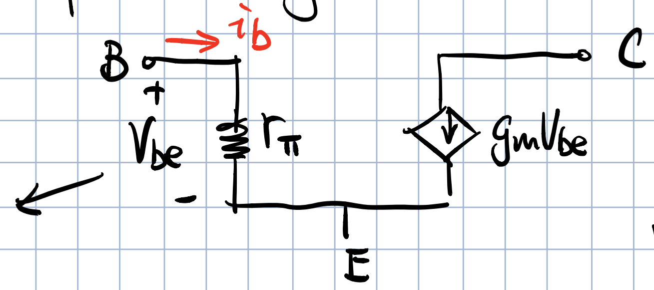


T-model

$$g_m = \frac{I_C}{V_T}$$

$$v_{be} = r_e i_e$$

compare to hybrid-π :



$V_{be} = r_\pi i_b$

$r_\pi i_b = r_e i_e$

but $i_e = (\beta+1) i_b$,

$r_e (\beta+1) \cancel{i_b} = r_\pi \cancel{i_b}$

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

Basic Amplifier (CS / CE)

→ transistors must be biased to operate in $\boxed{\text{active}}$ region

MOSFET "saturation mode"

BJT "active mode"

→ keep input signal small

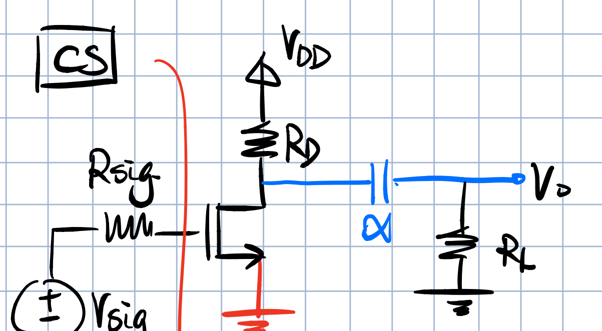
MOSFET: $V_{gs} << 2V_{ov}$

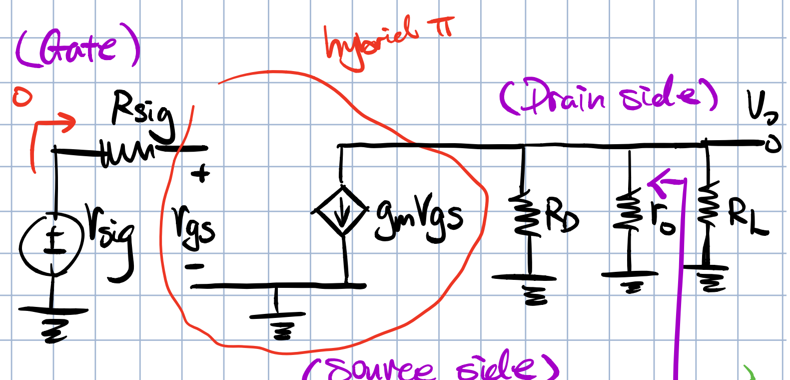
BJT: $V_{be} << V_T$

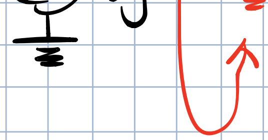
→ Study voltage gain $\left(\frac{V_o}{V_i}\right)$, input resistance ($R_{in}$) output resistance ($R_{out}$)

Common Source (CS) / Common emitter (CE)

$\boxed{\text{CS}}$







In this case, $V_{gs} = V_{sig}$.

R_{out}

Voltage gain $= V_o / V_{sig}$, $V_o = -g_m V_{gs} \times (R_D // R_L // r_o)$

$$= -g_m (R_D // R_L // r_o)$$

$$= -\frac{(R_D // R_L // r_o)}{\frac{1}{g_m}}$$

resistance in the drain.

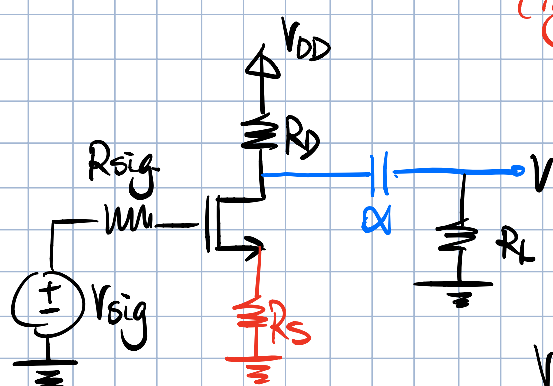
resistance in the source.

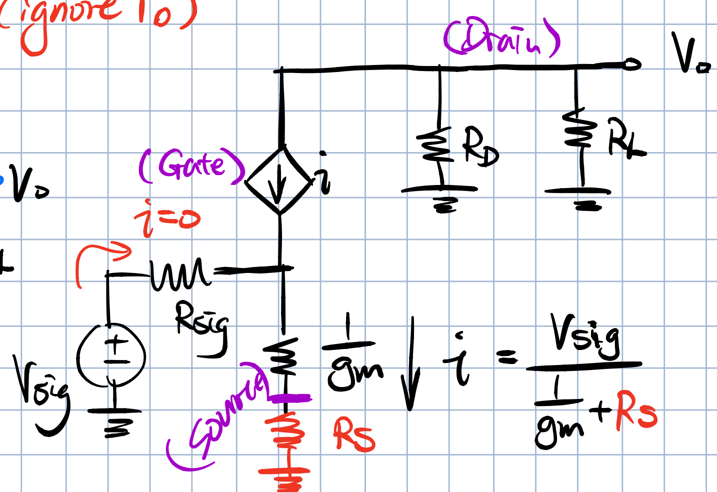
$R_{in} = \infty$ (no current in the gate)

$R_{out} = R_D // r_o$

CS but with a source resistance (R_s)

(ignore r_o)





$\frac{1}{g_m}$ $\downarrow i = \frac{V_{sig}}{\frac{1}{g_m} + R_s}$