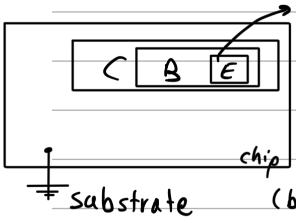
H1 → H2 → H3 → AVLSI → Success!

Transistor

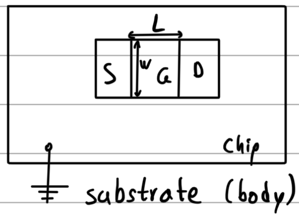
BJT	MOS
CE	CS
CB	CG
CC	CD



A_E: εμβαδό εκπομπού

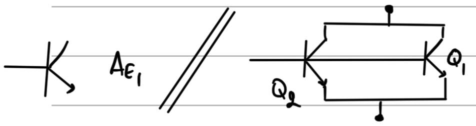
$A_E \uparrow \Rightarrow I_C \uparrow$

Καθορίζεται από το εργοστάσιο (κατασκευή)



$\frac{W}{L} \uparrow \Rightarrow I_D \uparrow$

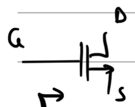
W, L ορίζονται από σχεδιασμό



$2 \cdot A_{E_1}$

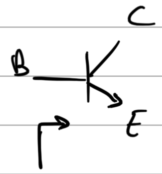
BJT: $I_C = f(\exp(V_{BE}))$ → ενεργός περιοχή (active region)

MOS: $I_D = f(V_{GS}^2)$ → κορεσμός (saturation)



$R_{in} \simeq \infty$ $\quad I_G \simeq 0$

χαμηλές συχνότητες



Rin

Rin πεπερασμένη

$I_B \neq 0$:

$$\frac{g_m}{I_D} < \frac{g_m}{I_C}$$

Το BJT δίνει καλύτερη ενίσχυση για ίδια κατανάλωση ρεύματος

Συχνότητα λειτουργίας

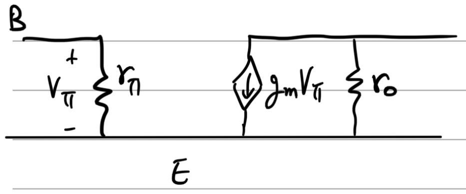
Το BJT είναι γρηγορότερο από το αντίστοιχο MOS ίδιας γεωμετρίας

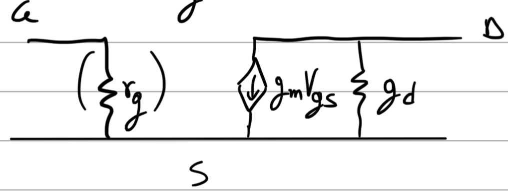
π.χ. 90nm BJT $\overset{f}{>}$ 90nm MOS

μέχρι και 22nm MOS

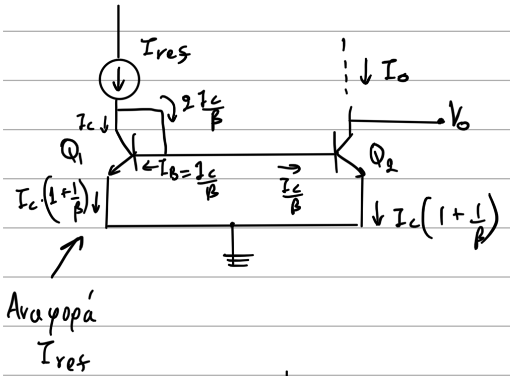
ΙΚΑΣ ΧΣ

$r_g \to \infty$





Απλός καθρέφτης ρεύματος BJT (Current mirror)



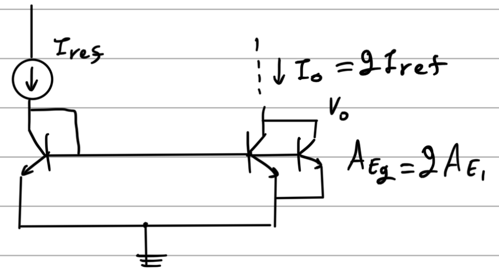
$I_o = f(I_{ref})$: καθρεφτισμός

$$I_{ref} = I_c + 2\frac{I_c}{\beta} = \left(1+\frac{2}{\beta}\right)I_c$$

$$I_o = I_c$$

$$\Rightarrow \frac{I_o}{I_{ref}} = \frac{\beta}{\beta+2} \overset{\beta\gg}{\simeq} 1$$

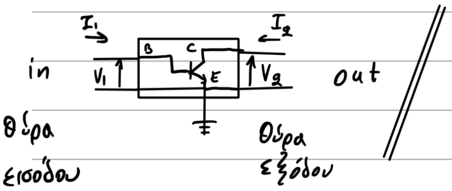
$$\frac{I_o}{I_{ref}} = \frac{A_{E_2}}{A_{E_1}}$$

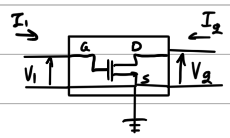


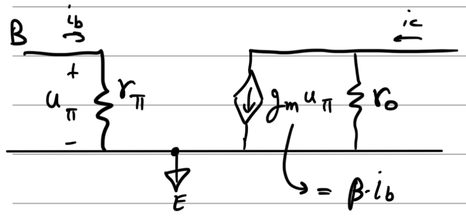
Για m ... BJTs

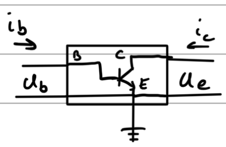
$$\frac{I_o}{I_{ref}} = \frac{m}{1+\frac{m+1}{\beta}} \xrightarrow{\beta\gg} \simeq m$$

Δίθυρα





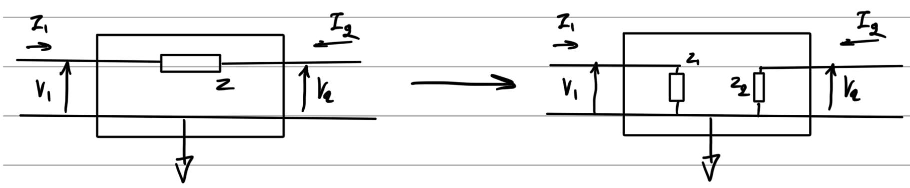




$$u_b = h_{11} i_b + h_{12} u_c$$
$$i_c = h_{21} i_b + h_{22} u_c$$

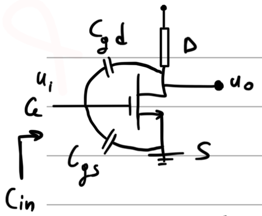
$$r_\pi = \frac{u_\pi}{i_b} = \frac{u_b}{i_b}$$

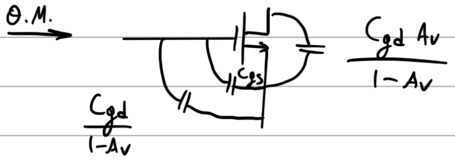
Θεώρημα Miller



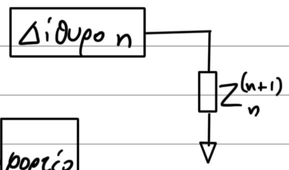
$$Z_1 = \frac{Z}{1-A_v}, \quad Z_2 = \frac{Z}{1-\frac{1}{A_v}} = \frac{Z A_v}{A_v - 1}$$

$$A_v = \frac{V_2}{V_1}$$

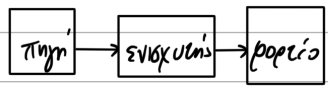


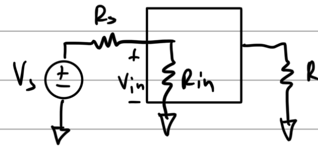


$$C_{in} = C_{gs} + C_{gd}(1 - A_v) = C_{gs} + C_{gd}(1 + |A_v|), \quad A_v = \frac{u_o}{u_i}$$



Ιδανικός ενισχυτής τάσης: $R_i = \infty$, $R_o = 0$



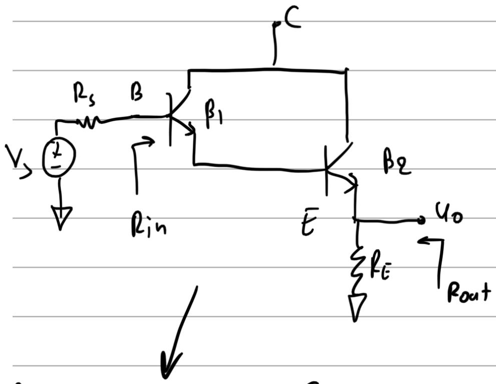


$$V_{in} = \frac{R_{in}}{R_{in} + R_s} V_s$$

Ενισχυτής Cascode

π.χ. CB + CE

$\beta_{ολ} \simeq \beta_1 \beta_2$



Συνδεσμολογία CC-CC

Υψηλής απόδοσης ακόλουθος τάσης

$$R_{in} = (\beta_1 + 1)\left[r_{e1} + (\beta_2 + 1)(r_{e2} + R_E)\right]$$

$$r_\pi = (\beta + 1) r_e$$

$$R_{out} = R_E \,//\, \left(r_{e2} + \frac{r_{e1} + \frac{R_s}{\beta_1 + 1}}{\beta_2 + 1}\right)$$