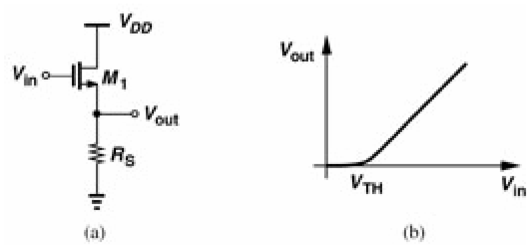
Ακολουθητής πηγής



Αν Vin<V_{TH} =>Vout=0

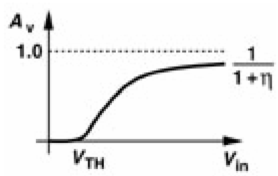
Αν Vin>V_{TH} => $\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{in}-V_{TH}-V_{out})^2 R_S = V_{out}$

Επειδή για $V_{in}\le V_{DD}$ πάντοτε $V_{DS} > V_{GS} - V_T$

$$\frac{1}{2}\mu_n C_{ox}\frac{W}{L}2(V_{in}-V_{TH}-V_{out})(1-\frac{\partial V_{TH}}{\partial V_{in}}-\frac{\partial V_{out}}{\partial V_{in}})R_S = \frac{\partial V_{out}}{\partial V_{in}}$$

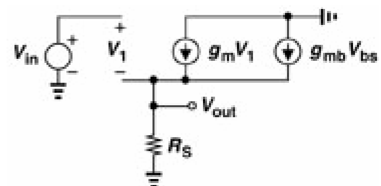
$$\partial V_{TH}/\partial V_{in} = \eta\partial V_{out}/\partial V_{in}$$

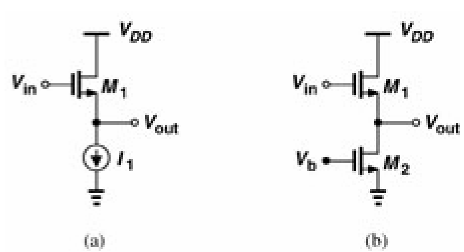
$$\frac{\partial V_{out}}{\partial V_{in}} = \frac{\mu_n C_{ox}\frac{W}{L}(V_{in}-V_{TH}-V_{out})R_S}{1+\mu_n C_{ox}\frac{W}{L}(V_{in}-V_{TH}-V_{out})R_S(1+\eta)}$$



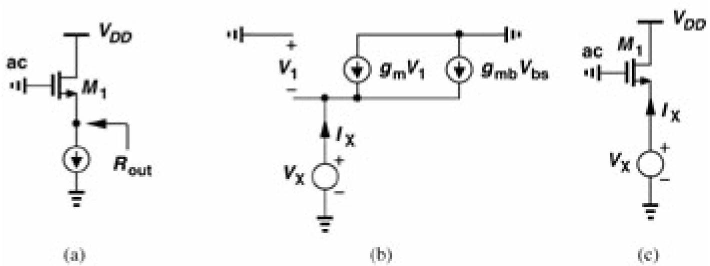
$$g_m = \mu_n C_{ox}\frac{W}{L}(V_{in}-V_{TH}-V_{out})$$

$$A_\upsilon = \frac{g_m R_S}{1+(g_m+g_{mb})R_S}$$



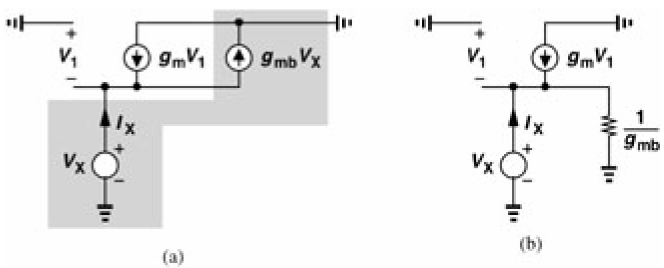


Αντίσταση εξόδου

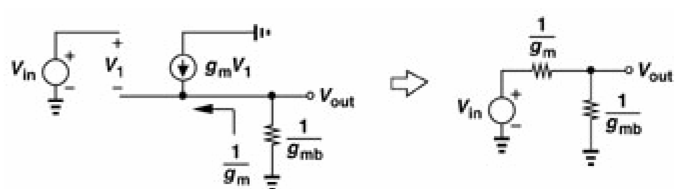


$$I_\chi - g_m V_\chi - g_{mb} V_\chi = 0$$

$$R_{out} = \frac{1}{g_m + g_{mb}}$$

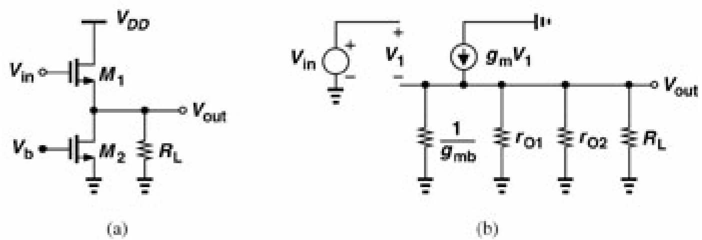


$$R_{out} = \frac{1}{g_m} \Big\| \frac{1}{g_{mb}} = \frac{1}{g_m + g_{mb}}$$



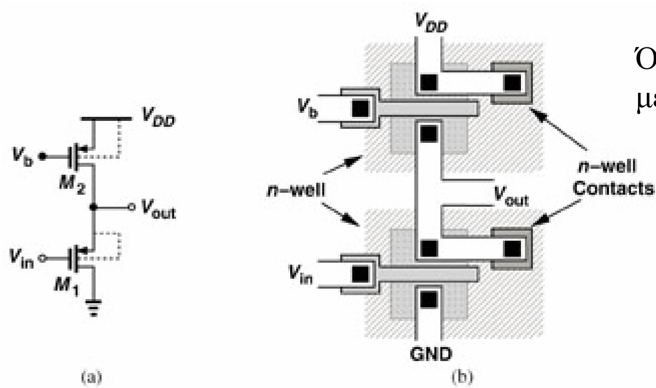
Αν $R_S=\infty$ =>

$$A_\upsilon = \frac{\frac{1}{g_{mb}}}{\frac{1}{g_m} + \frac{1}{g_{mb}}} = \frac{g_m}{g_m + g_{mb}}$$

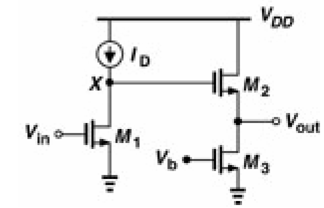


Αν $\lambda \neq 0$ =>

$$A_\upsilon = \frac{\frac{1}{g_{mb}} \| r_{D1} \| r_{D2} \| R_L}{\frac{1}{g_{mb}} \| r_{D1} \| r_{D2} \| R_L + \frac{1}{g_m}}$$

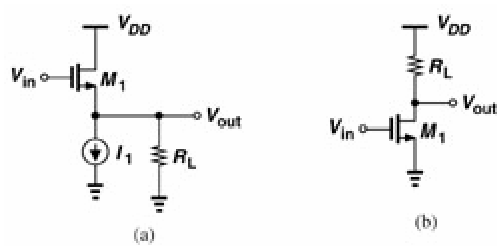


Όχι φαινόμενο σώματος αλλά μεγαλύτερη αντίσταση εξόδου.



Ολίσθηση της DC τάσης κατά V_{GS}.

$$V_X = V_{GS2} + V_{DS3} \geq V_{GS2} + (V_{GS3} - V_{TH3})$$

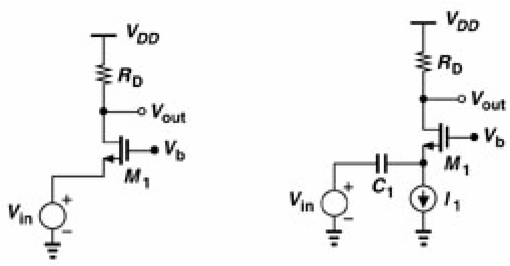


Η απολαβή για μικρή R_L.

$$\frac{V_{out}}{V_{in}}\Big|_{SF} \approx \frac{R_L}{R_L + \frac{1}{g_{m1}}}$$

$$\frac{V_{out}}{V_{in}}\Big|_{CS} \approx -g_{m1} R_L$$

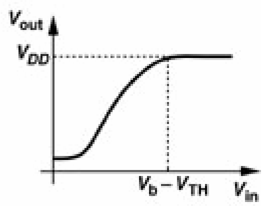
Βαθμίδα Κοινής Πύλης



(a) (b)

Αν $V_{in} \geq V_b - V_{TH}$ => $V_{out} = V_{DD}$

Αν $V_{in} < V_b - V_{TH}$ => $I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_b - V_{in} - V_{TH})^2$



Αν $V_{DD} - \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_b - V_{in} - V_{TH})^2 R_D = V_b - V_{TH}$ τρίοδος

Στον κόρο $V_{out} = V_{DD} - \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_b - V_{in} - V_{TH})^2 R_D$ $\frac{\partial V_{out}}{\partial V_{in}} = -\mu_n C_{ox}\frac{W}{L}(V_b - V_{in} - V_{TH})(-1 - \frac{\partial V_{TH}}{\partial V_{in}})$

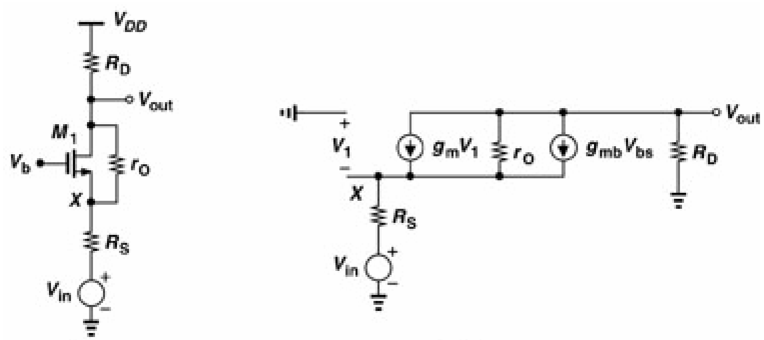
$\partial V_{TH} / \partial V_{in} = \partial V_{TH} / \partial V_{SB} = \eta$

$$\frac{\partial V_{out}}{\partial V_{in}} = \mu_n C_{ox}\frac{W}{L}R_D(V_b - V_{in} - V_{TH})(1+\eta) = g_m(1+\eta)R_D$$

Το φαινόμενο σώματος αυξάνει την απολαβή !

Αντίσταση εισόδου για λ=0 $1/(g_m + g_{mb}) = 1/[g_m(1+\eta)]$ Το φαινόμενο σώματος μειώνει την αντίσταση εισόδου

Για $\lambda \neq 0$ και $R_s \neq 0$



(a) (b)

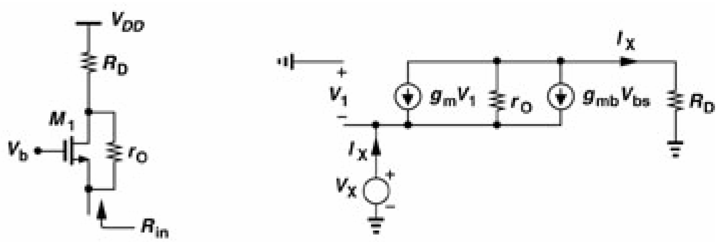
$$V_1 - \frac{V_{out}}{R_D}R_S + V_{in} = 0$$

$$r_D(-\frac{V_{out}}{R_D} - g_m V_1 - g_{mb}V_1) - \frac{V_{out}}{R_D}R_S + V_{in} = V_{out}$$

$$r_D[-\frac{V_{out}}{R_D} - (g_m + g_{mb})(V_{out}\frac{R_S}{R_D} - V_{in})] - \frac{V_{out}}{R_D}R_S + V_{in} = V_{out}$$

$$\frac{V_{out}}{V_{in}} = \frac{(g_m + g_{mb})r_D + 1}{r_D + (g_m + g_{mb})r_D R_S + R_S + R_D}R_D$$

Οι αντιστάσεις εισόδου και εξόδου της τοπολογίας κοινής πύλης

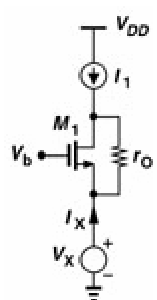


(a) (b)

$$R_D I_X + r_D[I_X - (g_m + g_{mb})V_\chi] = V_X$$

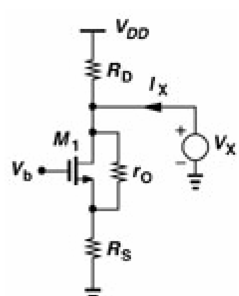
$$R_{in} = \frac{V_X}{I_X} = \frac{R_D + r_D}{1+(g_m + g_{mb})r_D} \approx \frac{R_D}{(g_m + g_{mb})r_D} + \frac{1}{g_m + g_{mb}}$$

$R_D=0$ => $\dfrac{V_X}{I_X} = \dfrac{r_D}{1+(g_m + g_{mb})r_D} = \dfrac{1}{\frac{1}{r_D} + g_m + g_{mb}}$ Όπως στον ακολουθητή πηγής.



R_{in}=>∞

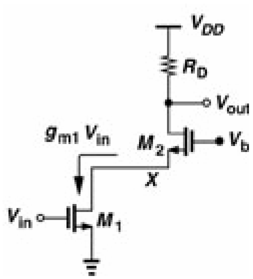
Άρα, η αντίσταση εισόδου της βαθμίδας κοινής πύλης είναι σχετικά μικρή μόνο αν η R_D είναι μικρή.



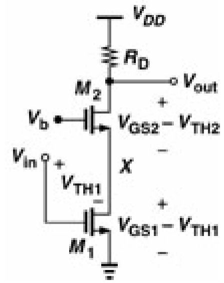
$$R_{out} = \{[1+(g_m + g_{mb})r_D]R_S + r_D\} \| R_D$$

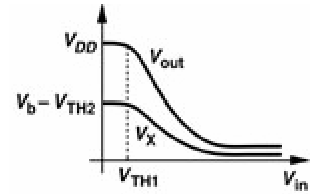
Όπως στον CS με εκφυλισμό πηγής.

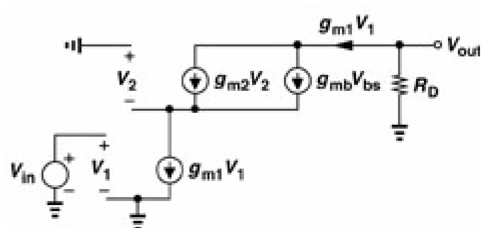
Συνδεσμολογία σειράς (cascode)



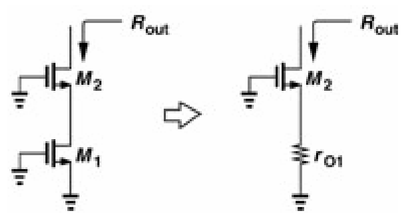
Για $V_X \geq V_{in}-V_{TH1}$ -> M1 στον κόρο.
Επειδή $V_X=V_b-V_{GS2}$ => $V_b-V_{GS2} \geq V_{in}-V_{TH1}$ και επομένως $V_b>V_{in}+V_{GS2}-V_{TH1}$.
Για να είναι το M2 στον κόρο, πρέπει $V_{out} \geq V_b-V_{TH2}$ => $V_{out} \geq V_{in}-V_{TH1}+V_{GS2}-V_{TH2}$
αν το V_b επιλεγεί έτσι ώστε να τοποθετεί το M1 στην αρχή του κόρου.





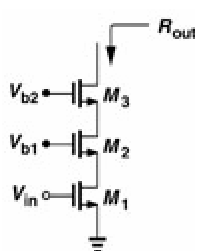


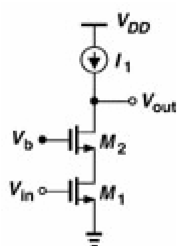
Αν λ=0 =>
$A_υ=A_{υCS}$



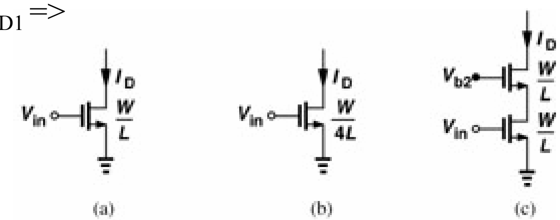
$$R_{out}=[1+(g_{m2}+g_{mb2})r_{D2}]r_{D1}+r_{D2}$$

Υψηλή αντίσταση εξόδου.

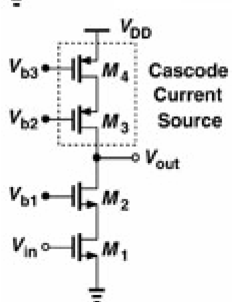




$G_m \approx g_{m1}$ και $R_{out} \approx (g_{m2}+g_{mb2})r_{D2}r_{D1}$ =>
$Aυ=(g_{m2}+g_{mb2})r_{D2}\, g_{m1}\, r_{D1}$



$$g_m r_D=\sqrt{2\frac{W}{L}\mu_n C_{ox} I_D}\,\frac{1}{\lambda I_D}$$

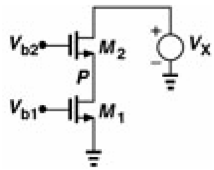


$$V_{DD}-(V_{GS1}-V_{TH1})-(V_{GS2}-V_{TH2})-|V_{GS3}-V_{TH3}|-|V_{GS4}-V_{TH4}|$$

$$R_{out}=\{[1+(g_{m2}+g_{mb2})r_{D2}]r_{D1}+r_{D2}\}\|\{[1+(g_{m3}+g_{mb3})r_{D3}]r_{D4}+r_{D3}\}$$

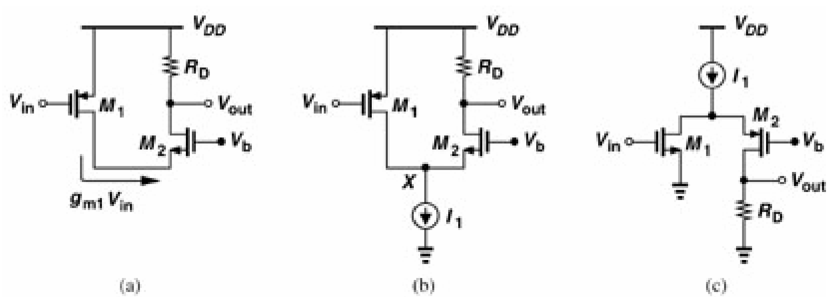
$$|A_υ| \approx g_{m1}R_{out} \qquad\qquad |A_υ| \approx g_{m1}[(g_{m2}r_{D2}r_{D1})\|(g_{m3}r_{D3}r_{D4})]$$

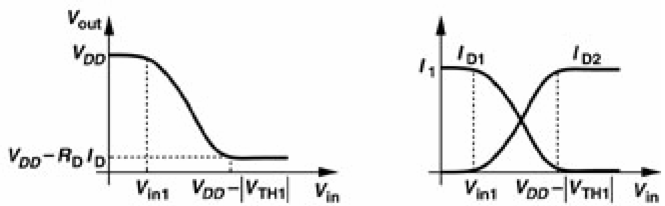
Ιδιότητα θωράκισης

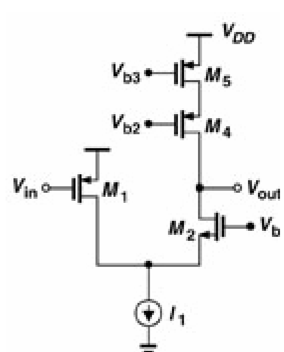


$$I_{D2} = \frac{1}{2}\mu_n C_{ox}(\frac{W}{L})_2[2(V_{b2} - V_P - V_{TH2})(V_X - V_P) - (V_X - V_P)^2]$$

Αναδιπλωμένη συνδεσμολογία σειράς







Για $V_{in} < V_{DD} - |V_{TH1}|$ => M1στον κόρο

$$I_{D2} = I_1 - \frac{1}{2}\mu_p C_{ox}(\frac{W}{L})_1(V_{DD} - V_{in} - |V_{TH1}|)^2$$

Για V_{in}<< => $I_{D2}=0$

$$\frac{1}{2}\mu_p C_{ox}(\frac{W}{L})_1(V_{DD} - V_{in} - |V_{TH1}|)^2 = I_1$$

$$V_{in} = V_{DD} - \sqrt{\frac{2I_1}{\mu_p C_{ox}(W/L)_1}} - |V_{TH1}|$$

V_χ -> V_{DD}