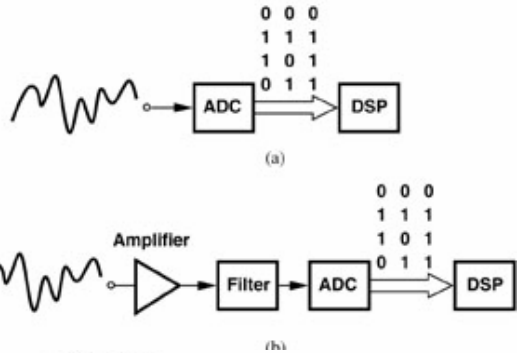
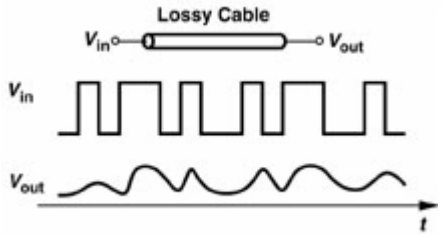
ΕΙΣΑΓΩΓΗ ΣΤΗΝ ΑΝΑΛΟΓΙΚΗ ΣΧΕΔΙΑΣΗ

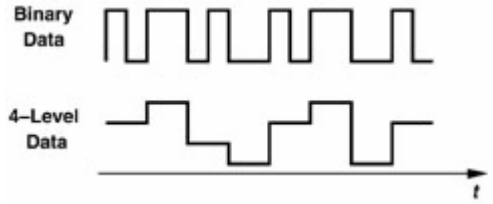
Γιατί Αναλογικά;

Επεξεργασία Φυσικών σημάτων.

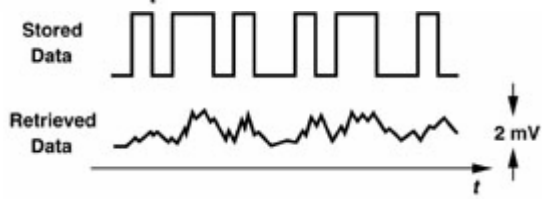


Ψηφιακές επικοινωνίες.

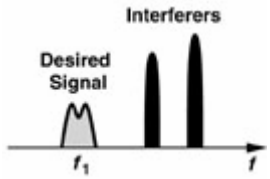




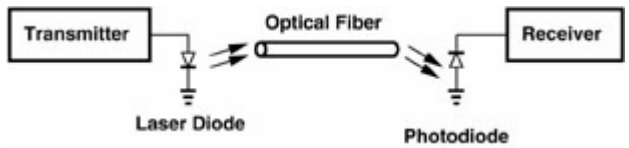
Ηλεκτρονικά Οδήγησης Δίσκων



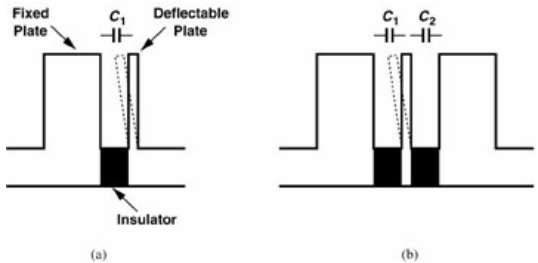
Ασύρματοι Δέκτες.



Οπτικοί Δέκτες.



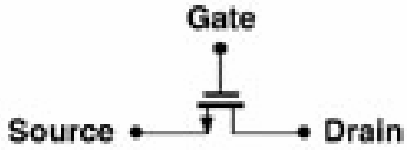
Αισθητήρες.



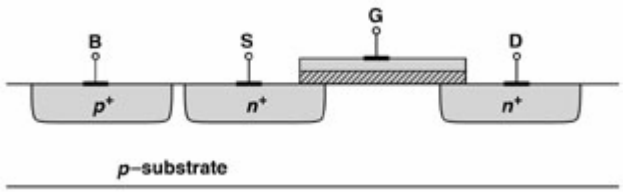
Μικροεπεξεργαστές και Μνήμες.

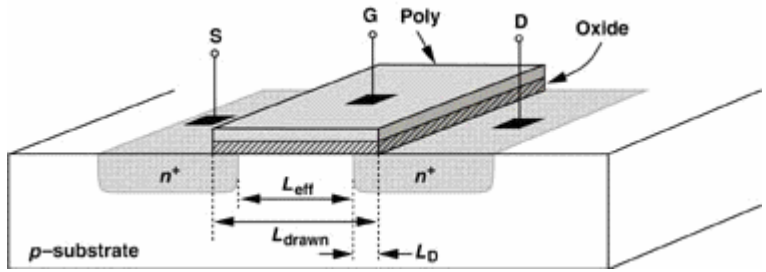
ΦΥΣΙΚΗ ΤΩΝ ΒΑΣΙΚΩΝ ΔΙΑΤΑΞΕΩΝ MOS

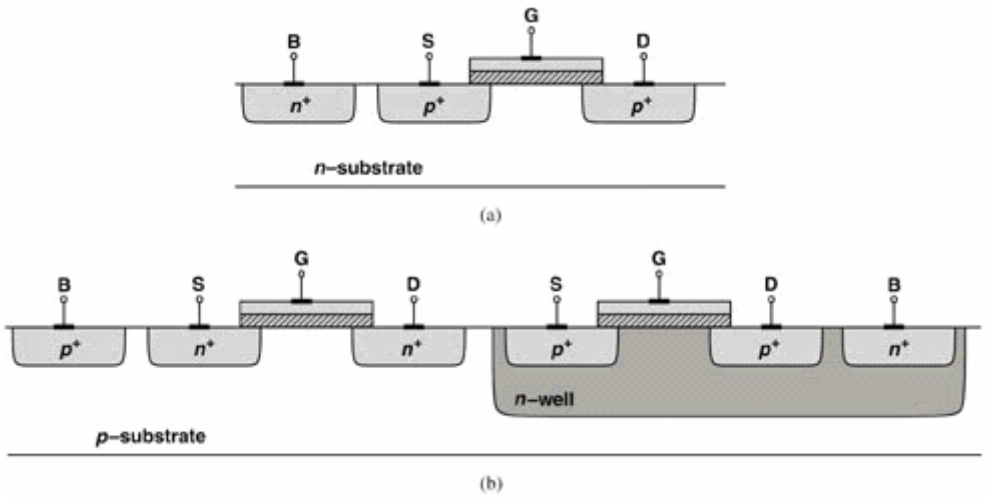
Το MOSFET σαν διακόπτης



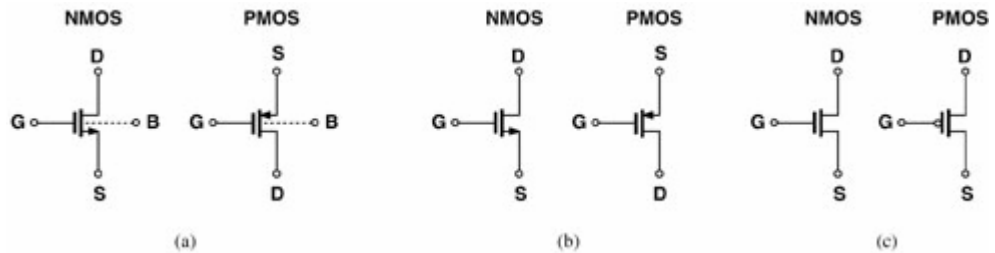
Η δομή του MOSFET







Συμβολισμοί των MOS



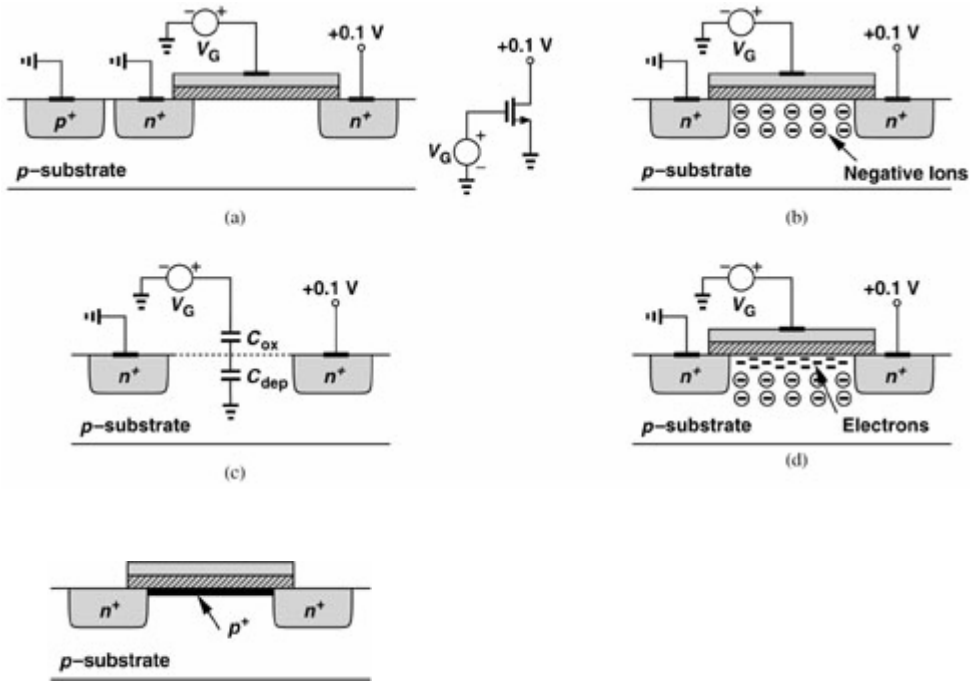
Χαρακτηριστικές I/V του MOS

Η τάση κατωφλίου:

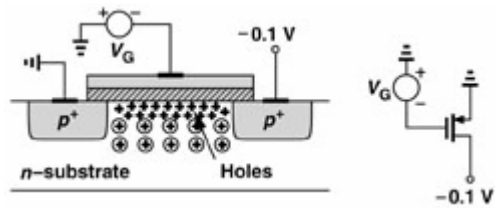
$$V_{TH} = \Phi_{MS} + 2\Phi_F + \frac{Q_{dep}}{C_{ox}}$$

$$\Phi_F = (kT/q)\ln(N_{sub}/n_i)$$

$$Q_{dep} = \sqrt{4q\varepsilon_s |\Phi_F| N_{sub}}$$

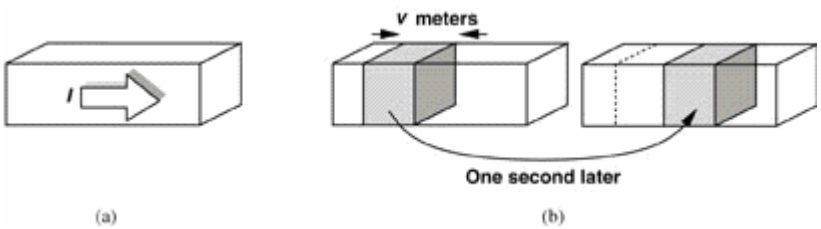


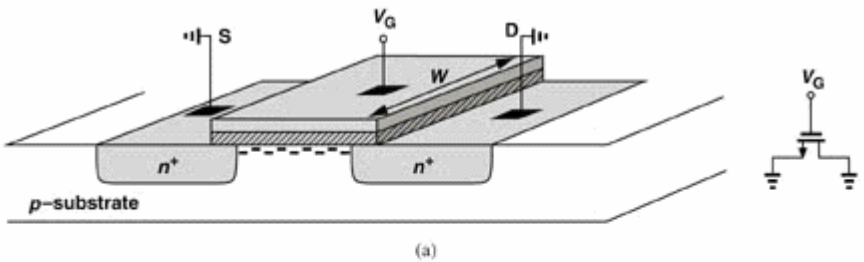
PMOS



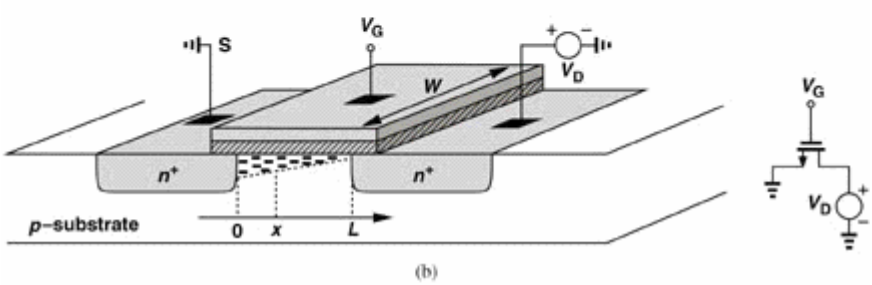
Παραγωγή των χαρακτηριστικών I/V

$$I = Q_d \cdot \upsilon$$





$$Q_d = WC_{ox}(V_{GS} - V_{TH})$$



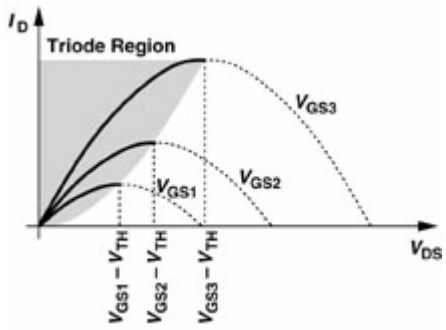
$$Q_d(x) = WC_{ox}[V_{GS} - V(x) - V_{TH}]$$

$$I_D = -WC_{ox}[V_{GS} - V(x) - V_{TH}]\upsilon$$

$$\upsilon = \mu E, E(x) = -\frac{dV(x)}{dx} \Rightarrow \qquad I_D = WC_{ox}[V_{GS} - V(x) - V_{TH}]\mu_n \frac{dV(x)}{dx},$$

$$\int_{x=0}^{L} I_D dx = \int_{V=0}^{V_{DS}} WC_{ox}[V_{GS} - V(x) - V_{TH}]\mu_n dV(x),$$

$$I_D = \mu_n C_{ox} \frac{W}{L}[(V_{GS} - V_{TH})V_{DS} - \frac{1}{2}V_{DS}^2].$$



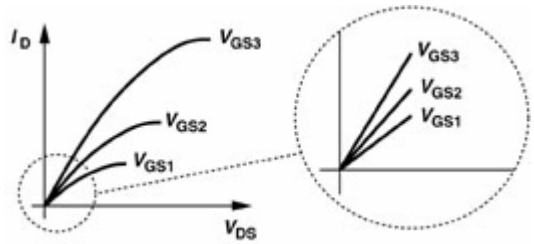
$$\partial I_D / \partial V_{DS} = 0 \qquad \text{για} \qquad V_{DS} = V_{GS} - V_{TH}$$

$$I_D = \frac{1}{2}\mu_n C_{ox} \frac{W}{L}(V_{GS} - V_{TH})^2$$

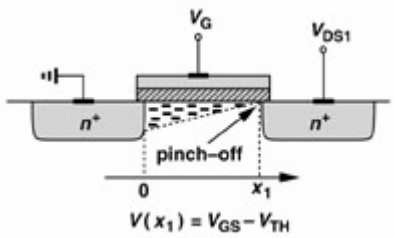
$V_{GS} - V_{TH}$ τάση υπεροδήγησης

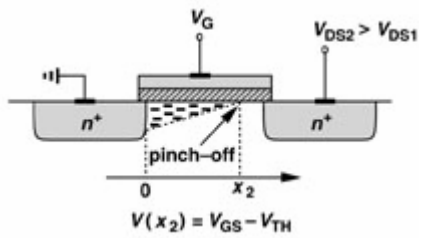
Αν $V_{DS} << 2(V_{GS} - V_{TH}),$ $I_D \approx \mu_n C_{ox} \frac{W}{L}(V_{GS} - V_{TH})V_{DS},$

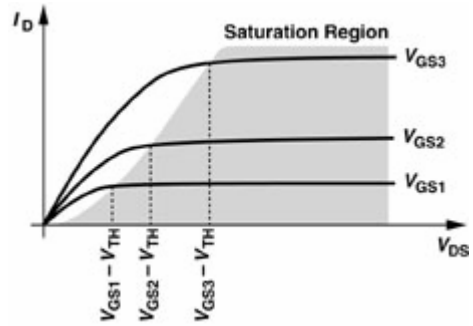
$$R_{on} = \frac{1}{\mu_n C_{ox} \frac{W}{L}(V_{GS} - V_{TH})}$$



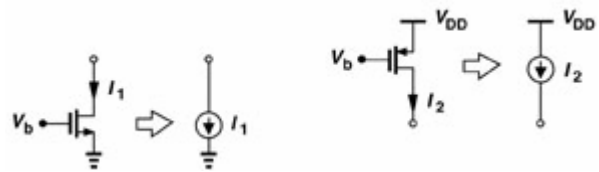
$$V_{DS} > (V_{GS} - V_{TH})$$





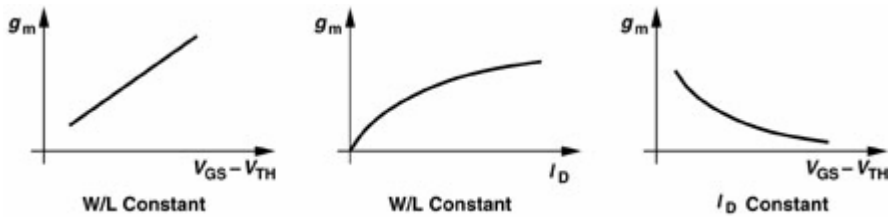


$$I_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L'}(V_{GS} - V_{TH})^2$$

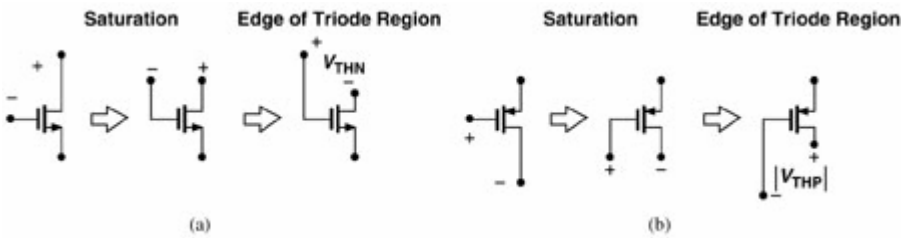


PMOS $$I_D = -\mu_p C_{ox}\frac{W}{L}\left[(V_{GS} - V_{TH})V_{DS} - \frac{1}{2}V_{DS}^2\right].$$ $$I_D = -\frac{1}{2}\mu_p C_{ox}\frac{W}{L'}(V_{GS} - V_{TH})^2$$

$$g_m = \left.\frac{\partial I_D}{\partial V_{GS}}\right|_{V_{DS}} = \mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})$$

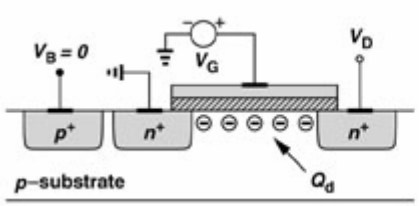


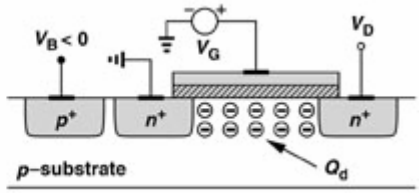
$$g_m = \sqrt{2\mu_n C_{ox}\frac{W}{L}I_D} = \frac{2I_D}{V_{GS} - V_{TH}}$$

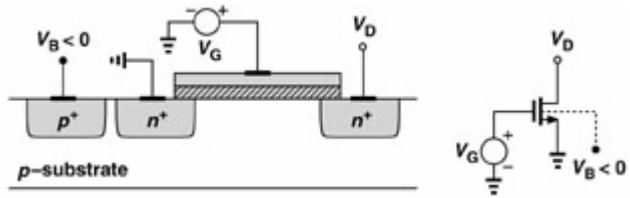


Φαινόμενα δευτέρας τάξεως

Το φαινόμενο Σώματος

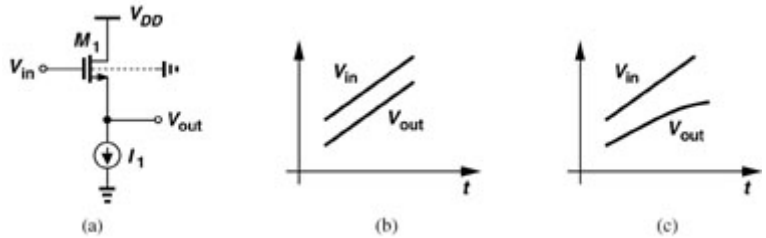






$$V_{TH} = V_{TH0} + \gamma(\sqrt{2\Phi_F + V_{SB}} - \sqrt{2\Phi_F})$$

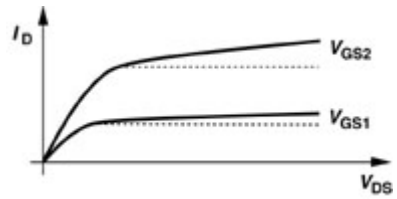
$$\gamma = \sqrt{2q\varepsilon_s N_{sub}}/C_{ox}$$



$$I_1 = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{in} - V_{out} - V_{TH0})^2$$

Διαμόρφωση του Μήκους του Καναλιού

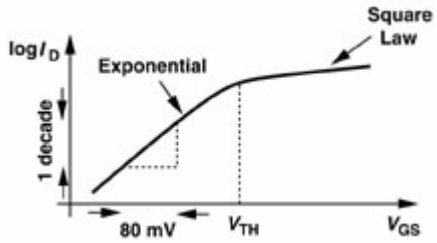
$$I_D \approx \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS} - V_{TH})^2(1 + \lambda V_{DS})$$



λ=συντελεστής διαμόρφωσης μήκους καναλιού ~1/L

Υποκατωφλική Αγωγιμότητα

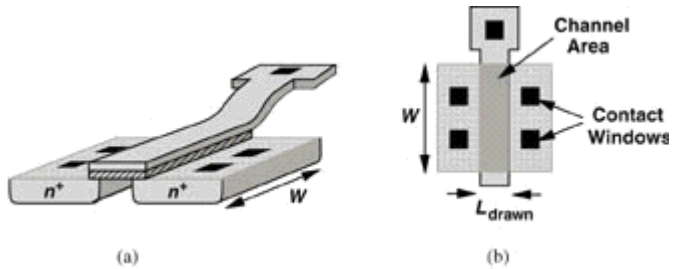
$$I_D = I_0 \exp\frac{V_{GS}}{\zeta V_T}$$ ζ>1



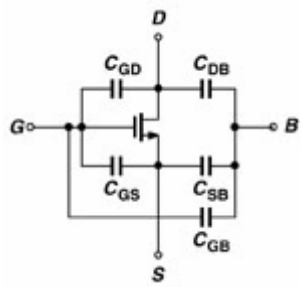
$$g_m = \frac{I_D}{\zeta V_T}$$

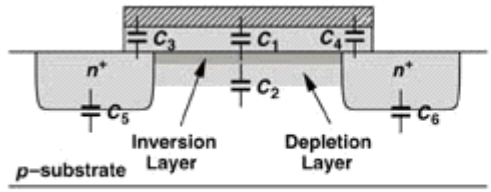
Μοντέλα των διατάξεων MOS

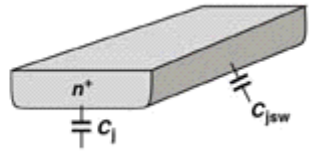
Το ανάπτυγμα της διάταξης MOS



Οι χωρητικότητες της διάταξης MOS

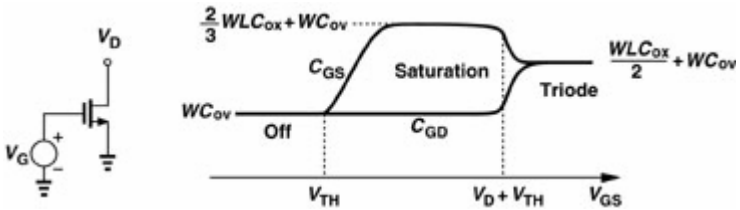






$$C_1 = WLC_{ox} \qquad C_2 = WL\sqrt{2q\varepsilon_s N_{sub}/(2\Phi_F)} \qquad C_{3,}\ C_4\,(C_{ov})$$

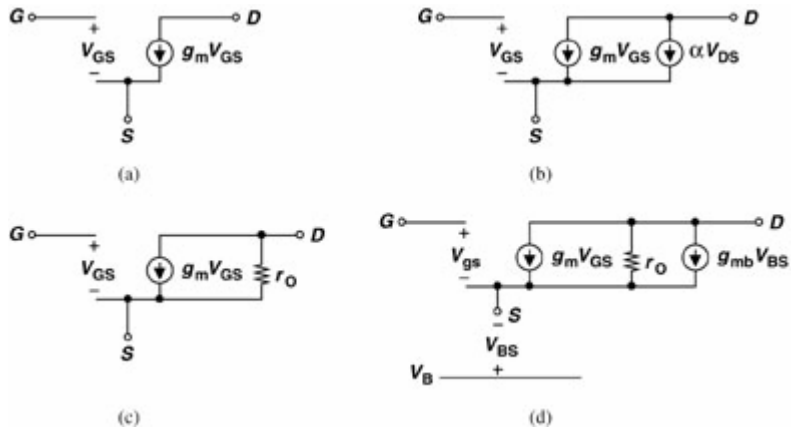
$$C_j = C_{j0}/[1 + V_R(2\Phi_F)]^m \qquad C_{jsw}$$



Το μοντέλο μικρού σήματος του MOS

$$g_m = \left.\frac{\partial I_D}{\partial V_{GS}}\right|_{V_{DS}} = \mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH}) = \sqrt{2\mu_n C_{ox}\frac{W}{L}I_D} = \frac{2I_D}{V_{GS}-V_{TH}}$$

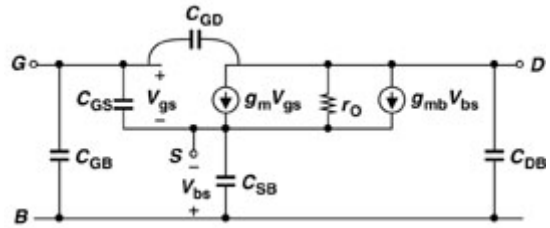
$$r_D = \frac{\partial V_{DS}}{\partial I_D} = \frac{1}{\partial I_D/\partial V_{DS}} = \frac{1}{\frac{1}{2}\mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})^2\lambda} \approx \frac{1}{\lambda I_D}$$



$$g_{mb} = \frac{\partial I_D}{\partial V_{BS}} = \mu_n C_{ox}\frac{W}{L}(V_{GS}-V_{TH})\left(-\frac{\partial V_{TH}}{\partial V_{BS}}\right).$$

$$\frac{\partial V_{TH}}{\partial V_{BS}} = -\frac{\partial V_{TH}}{\partial V_{SB}} = -\frac{\gamma}{2}(2\Phi_F + V_{SB})^{-1/2}$$

$$g_{mb} = g_m\frac{\gamma}{2\sqrt{2\Phi_F+V_{SB}}} = \eta g_m$$



Οι παράμετροι του βασικού μοντέλου των διατάξεων MOS

Μοντέλο NMOS			
LEVEL=1	VTO=0.7	GAMMA=0.45	PHI=0.9
NSUB=9e+14	LD=0.08e-6	UO=350	LAMBDA=0.1
TOX=9e-9	PB=0.9	CJ=0.56e-3	CJSW=0.35e-11
MJ=0.6	MJSW=0.2	CGDO=0.4e-11	JS=1.0e-8
Μοντέλο PMOS			
LEVEL=1	VTO=-0.8	GAMMA=0.4	PHI=0.8
NSUB=5e+14	LD=0.09e-6	UO=100	LAMBDA=0.2
TOX=9e-9	PB=0.9	CJ=0.94e-3	CJSW=0.32e-11
MJ=0.5	MJSW=0.3	CGDO=0.3e-11	JS=0.5e-8