MOSFET Device Equation Sheet

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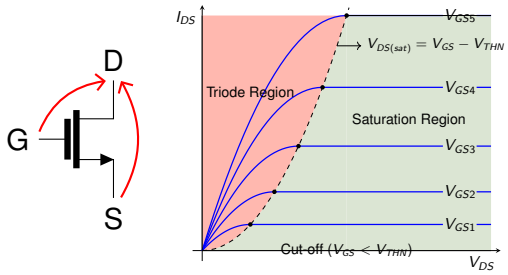
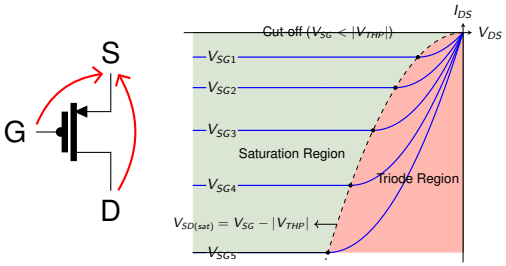
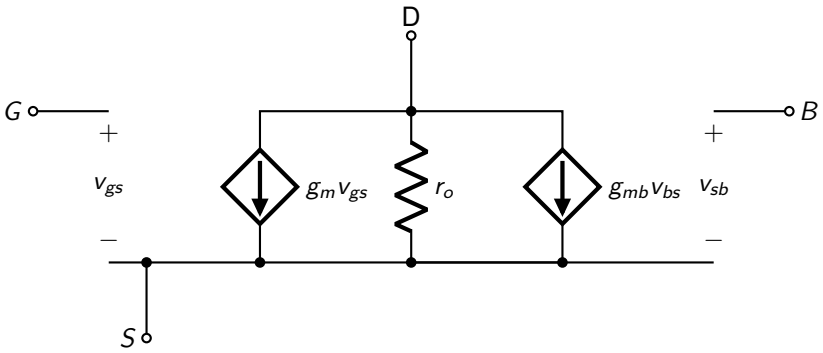
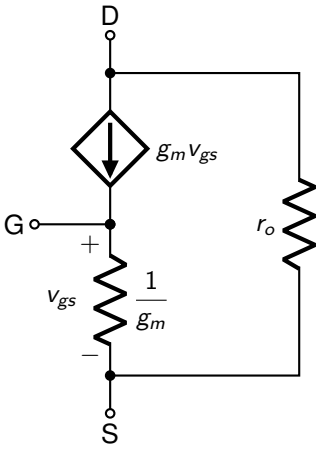
Large Signal Models:

	NMOS	PMOS
	 $k_n = k_n' \frac{W}{L}$; $k_n' = \mu_n C_{ox}$; $V_{THN} > 0$	 $k_p = k_p' \frac{W}{L}$; $k_p' = \mu_p C_{ox}$; $V_{THP} < 0$
Cut-off	$V_{GS} < V_{THN}$ $I_{DS} = 0$	$V_{SG} < \lvert V_{THP} \rvert$ $I_{SD} = 0$
Triode	$V_{GS} \geq V_{THN}$ and $V_{DS} < V_{GS} - V_{THN}$ $I_{DS} = \frac{k_n}{2}\{2(V_{GS} - V_{THN})V_{DS} - V_{DS}^2\}$	$V_{SG} \geq \lvert V_{THP} \rvert$ and $V_{SD} < V_{SG} - \lvert V_{THP} \rvert$ $I_{SD} = \frac{k_p}{2}\{2(V_{SG} - \lvert V_{THP} \rvert)V_{SD} - V_{SD}^2\}$
Saturation (Active)	$V_{GS} > V_{THN}$ and $V_{DS} \geq V_{GS} - V_{THN}$ $I_{DS} = \frac{k_n}{2}(V_{GS} - V_{THN})^2(1 + \lambda_n V_{DS})$	$V_{SG} > \lvert V_{THP} \rvert$ and $V_{SD} \geq V_{SG} - \lvert V_{THP} \rvert$ $I_{SD} = \frac{k_p}{2}(V_{SG} - V_{THP})^2(1 + \lambda_p V_{SD})$

Small Signal Model:



(a) Hybrid-π Model



(b) T-Model

$$
\begin{aligned}
g_m &= \mu_n C_{ox} \frac{W}{L}(V_{GS} - V_{TH}) = \sqrt{2\mu_n C_{ox} \frac{W}{L} I_D} = \frac{2I_D}{(V_{GS} - V_{TH})} \\
g_{mb} &= \eta g_m \\
r_o &= \frac{1}{\lambda I_D} = \frac{V_A}{I_D}
\end{aligned}
$$