Curs 7
Electronica Digitala
UNIVERSITATEA POLITEHNICA BUCURESTI
FACULTATEA DE AUTOMATICA SI CALCULATOARE

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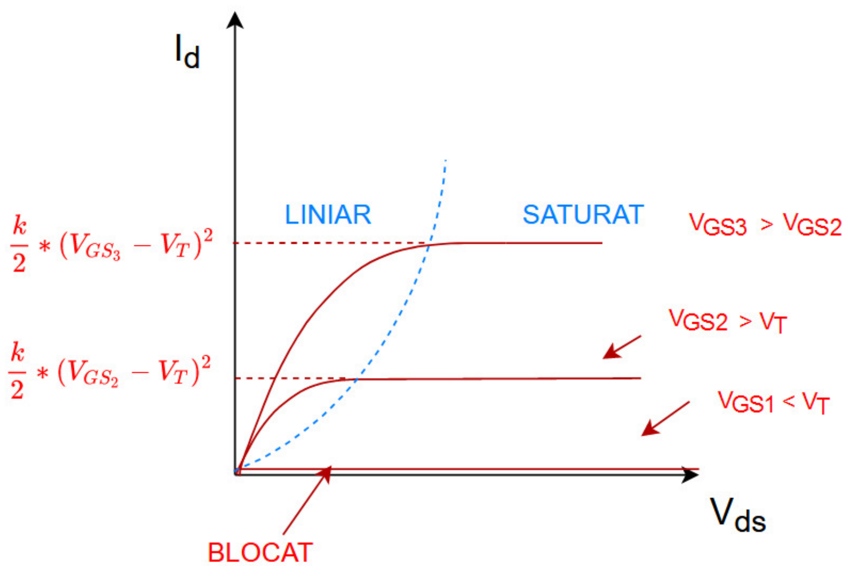
1 Dependenta curentului de drena in functie de starea tranzistorului

$$I_D = \begin{cases} 0 & V_{GS} < V_T & BLOCAT \\ k((V_{GS} - V_T) * V_{DS} - \frac{(V_{DS})^2}{2}) & V_{GS} > V_T, V_{DS} \leq V_{GS} - V_T & LINIAR \\ k(\frac{(V_{GS} - V_T)^2}{2}) & V_{GS} > V_T, V_{DS} > V_{GS} - V_T & SATURAȚIE \end{cases}$$



Daca $V_{GS} < V_T$, tranzistorul este blocat si curentul este 0 indiferent de V_{DS} (tensiunea aplicata intre drena si sursa) $\Rightarrow$ circuit deschis pentru orice V_{GS} mai mic decat V_T (threshold voltage = tensiunea de prag, constanta a tranzistorului, depinde de geometria si de gradul de dopaj al acestuia).

Daca $V_{GS} > V_T$, tranzistorul se deschide si curentul de drena va depinde de V_{DS} . Pana la un anumit punct va creste, iar de la un punct va deveni constant, se stabilizeaza (K - constanta de fabricatie).

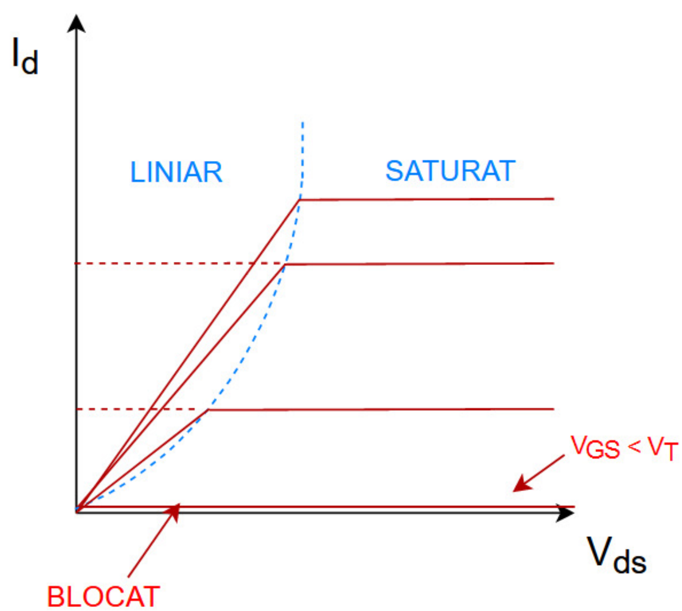
Cu cat crestem tensiunea de intrare in tranzistor, intre poarta si sursa, cu atat creste si curentul.

1.1 Model simplificat

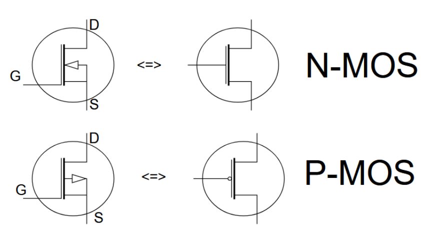
Pentru modelul simplificat, se inlocuieste cu o rezistenta, transformandu-se functia patratica in una liniara prin aproximarea $V_{DS} = V_{GS} - V_T$.

In acest caz, curentul I_D va avea o crestere **liniara**, proportionala cu V_{DS}.

$$I_D = \begin{cases} 0 & V_{GS} < V_T & BLOCAT \\ \frac{k}{2}(V_{GS} - V_T) * V_{DS} & V_{GS} \geq V_T, V_{DS} < V_{GS} - V_T & LINIAR \\ \frac{k}{2}(V_{GS} - V_T)^2 & V_{GS} \geq V_T, V_{DS} \geq V_{GS} - V_T & SATURAT \end{cases}$$

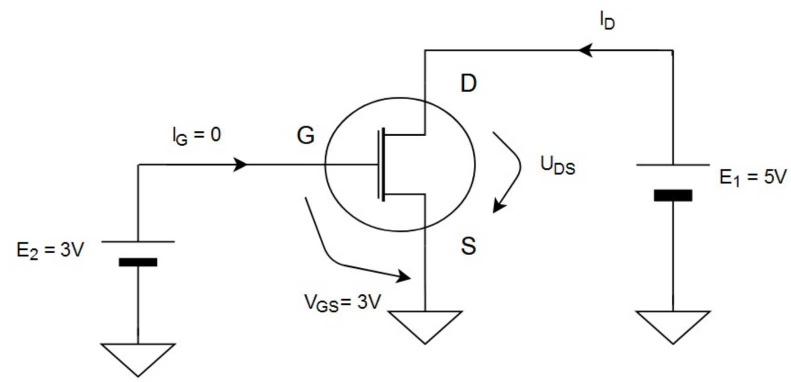


Graficul modelului simplificat



1.2 Aplicatii

(1)



$V_T = 1V$

$K = 10\frac{mA}{(V)^2}$

$I_D = ?$

$V_{GS} = E2 > V_T \Rightarrow Tranzistor - CONDUCTIE$

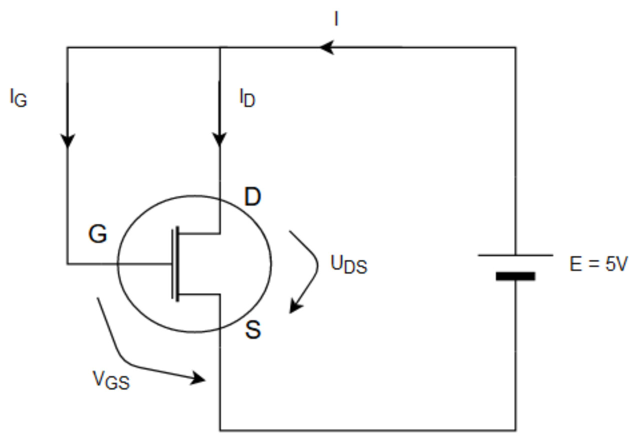
$V_{DS} = E1 = 5V > V_{GS} - V_T = 2V \Rightarrow Tranzistor - SATURATIE$

$I_D = \frac{k}{2}(V_{GS} - V_T)^2 =$

$= \frac{10\frac{mA}{(V)^2}}{2}(3V - 1V)^2 =$

$= 20mA$

(2)



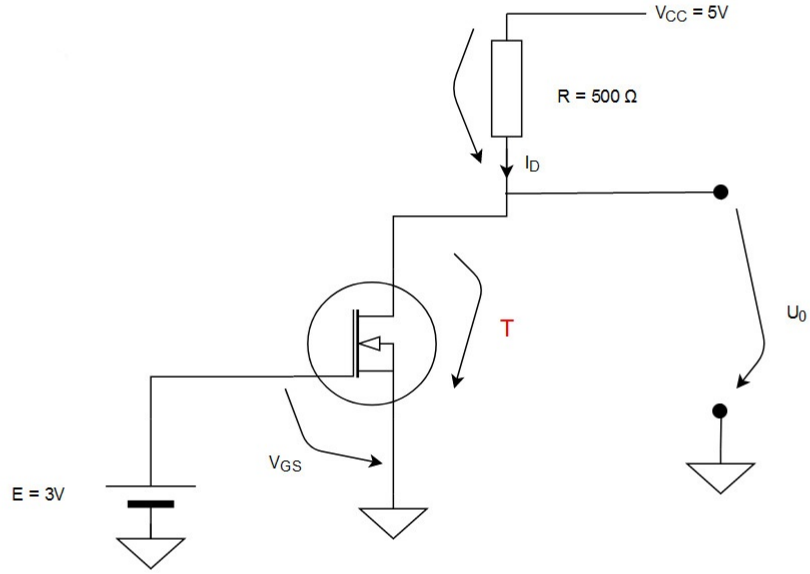
$V_T = 1V$

$K = 10\frac{mA}{(V)^2}$

$I = ?$

$V_{GS} = E = 5V > V_T \Rightarrow Tranzistor - CONDUCTIE$
$V_{DS} = E = 5V > V_{GS} - V_T = 4V \Rightarrow Tranzistor - SATURATIE$
$I = I_D + I_C, (I_C = 0)$
$= I_D =$
$= \frac{k}{2}(V_{GS} - V_T)^2 =$
$= \frac{10\frac{mA}{(V)^2}}{2}(4V)^2 =$
$= 80mA$

(3)



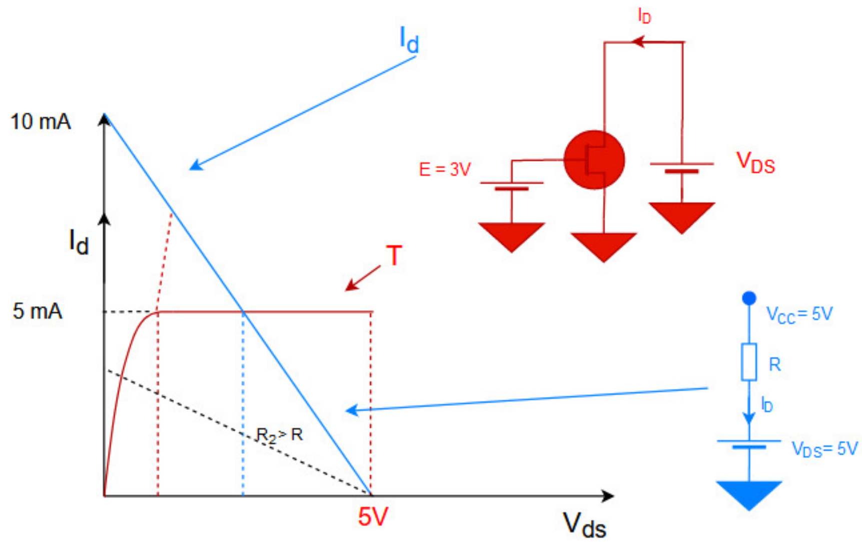
$V_T = 2V$

$K = 10 \dfrac{mA}{(V)^2}$

$U_0 = ?$

$V_{CC} = I_D R + V_{DS}$

$V_{DS} = V_{CC} - I_D R \Rightarrow I_D = \dfrac{V_{CC} - V_{DS}}{R}$



PP. tranzistor - SATURAT

$$\Rightarrow I_D = \frac{k}{2}(V_{GS} - V_T)^2 =$$
$$= \frac{10\frac{mA}{(V)^2}}{2}(3V - 2V)^2 =$$
$$= 5mA$$

$$V_{DS} = V_{CC} - I_D R =$$
$$= 5V - 5mA * 0,5K\Omega =$$
$$= 2,5V$$
$$\Rightarrow V_{DS} > V_{GS} - V_T$$
$$2,5V > 3V - 2V$$

$\Rightarrow$ PP. facuta este ADEVARATA.

Obs.: O alta varianta era de a presupune, fara graficul ajutator, starea tranzistorului.

PP. tranzistor - LINIAR

$$\Rightarrow I_D = \begin{cases} \frac{k}{2}(V_{GS} - V_T)V_{DS} = \frac{10\frac{mA}{(V)^2}}{2}(3V - 2V) * V_{DS} = \frac{5mA}{V} * V_{DS} \\ \frac{V_{CC} - V_{DS}}{R} \end{cases}$$

$$\frac{V_{CC} - V_{DS}}{R} = \frac{k}{2}(V_{GS} - V_T) * V_{DS} =$$

$$\frac{5V - V_{DS}}{0,5K} = \frac{5mA}{V} * V_{DS}$$

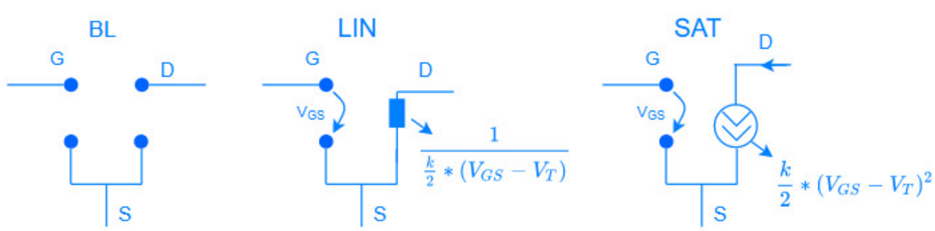
$$5V - V_{DS} = 2,5V_{DS}$$

$$\Rightarrow V_{DS} = \frac{5}{3,5} \approx 1,4V$$

$$V_{DS} < V_{GS} - V_T$$

$$1,4V < 3V - 2V$$

$\Rightarrow$ PP. facuta este FALSA.



- Daca tranzistorul este in zona liniara, se comporta ca o rezistenta, iar in regiunea de saturatie este o sursa de curent constant.