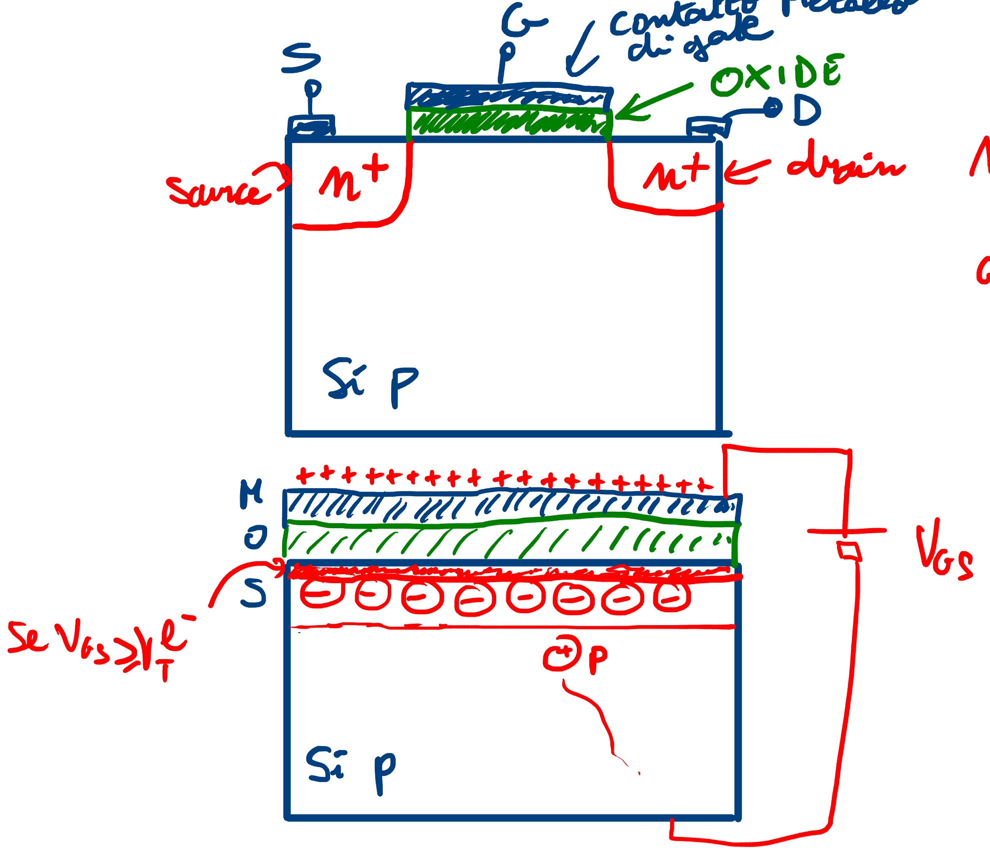
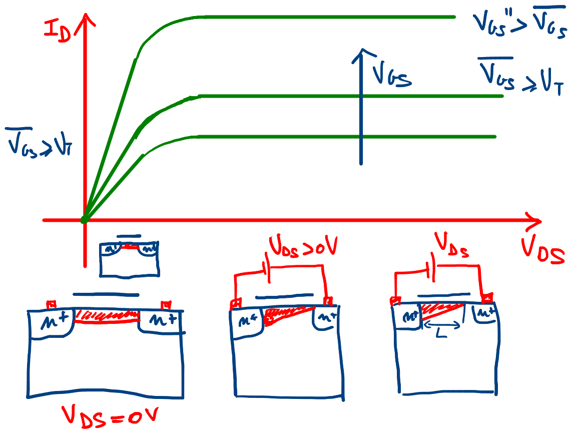
FET Field Effect Transistor





OHMICA o TRIODO

$V_{GS}, V_{GD} \geq V_T \quad \vee \quad \begin{cases} V_{GS} > V_T \\ V_{DS} < V_{GS} - V_T \end{cases}$

$$I_{DS} = \underbrace{\mu_n C_{ox} \frac{W}{L}}_{K_n} \frac{V_{DS}}{2} (V_{GS} + V_{GD} - 2V_T)$$

$\mu_n \left[cm^2/Vs \right]$ $\qquad \mu_n \simeq 2\mu_p$

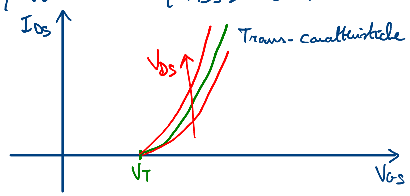
$V_{GD} = V_{GS} - V_{DS}$

$C_{ox} = \frac{\varepsilon_{ox}}{t_{ox}} \left[\frac{F}{cm^2} \right]$

SATURAZIONE

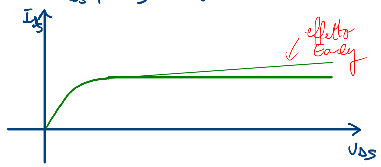
$$I_{DS} = \mu_n C_{ox} \frac{W}{L} \cdot \frac{1}{2} \cdot (V_{GS} - V_T)^2$$

$\begin{cases} V_{GS} > V_T \\ V_{GD} < V_T \end{cases} \quad \vee \quad \begin{cases} V_{GS} > V_T \\ V_{DS} > V_{GS} - V_T \end{cases}$

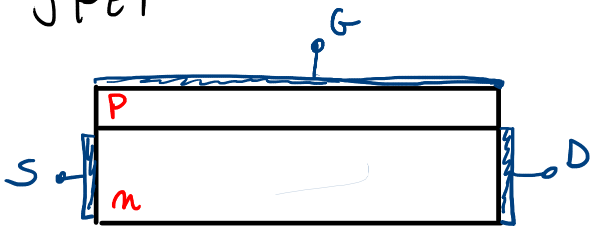


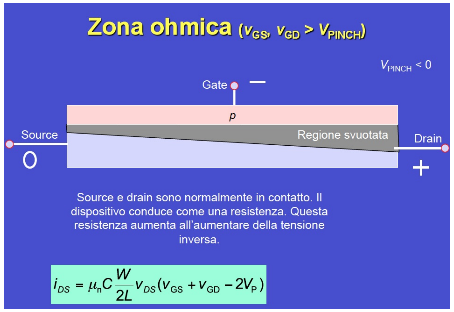
EFFETTO EARLY

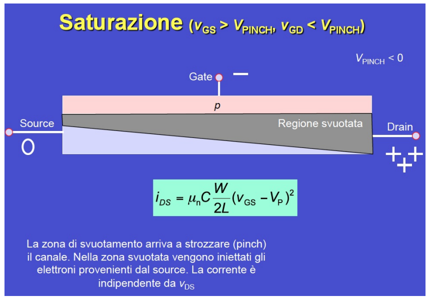
Se $V_{DS} \uparrow \Rightarrow L \downarrow$

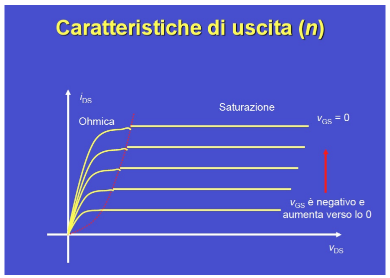


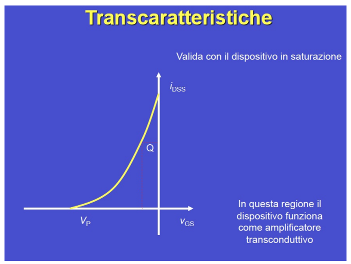
JFET

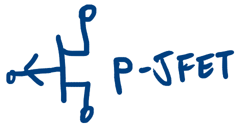

G
P
S
n
D

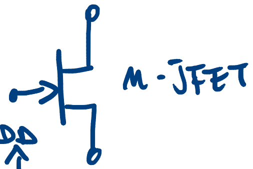

Zona ohmica (v_{GS}, v_{GD} > V_{PINCH})
V_{PINCH} < 0
Gate
−
p
Source
Regione svuotata
Drain
0
+
Source e drain sono normalmente in contatto. Il dispositivo conduce come una resistenza. Questa resistenza aumenta all'aumentare della tensione inversa.
$i_{DS} = \mu_n C \frac{W}{2L} v_{DS}(v_{GS} + v_{GD} - 2V_P)$

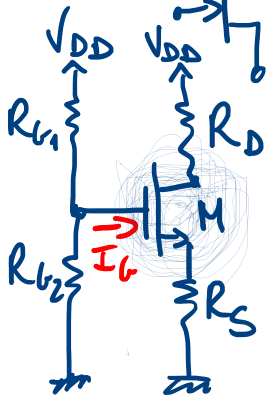

Saturazione (v_{GS} > V_{PINCH}, v_{GD} < V_{PINCH})
V_{PINCH} < 0
Gate
−
p
Source
Regione svuotata
Drain
0
+++
$i_{DS} = \mu_n C \frac{W}{2L}(v_{GS} - V_P)^2$
La zona di svuotamento arriva a strozzare (pinch) il canale. Nella zona svuotata vengono iniettati gli elettroni provenienti dal source. La corrente è indipendente da v_{DS}


Caratteristiche di uscita (n)
i_{DS}
Ohmica
Saturazione
v_{GS} = 0
v_{GS} è negativo e aumenta verso lo 0
v_{DS}


Transcaratteristiche
Valida con il dispositivo in saturazione
i_{DSS}
Q
V_P
v_{GS}
In questa regione il dispositivo funziona come amplificatore transconduttivo







$I_G \simeq 0$

$$V_G = \frac{R_{G2}}{R_{G1}+R_{G2}} V_{DD}$$

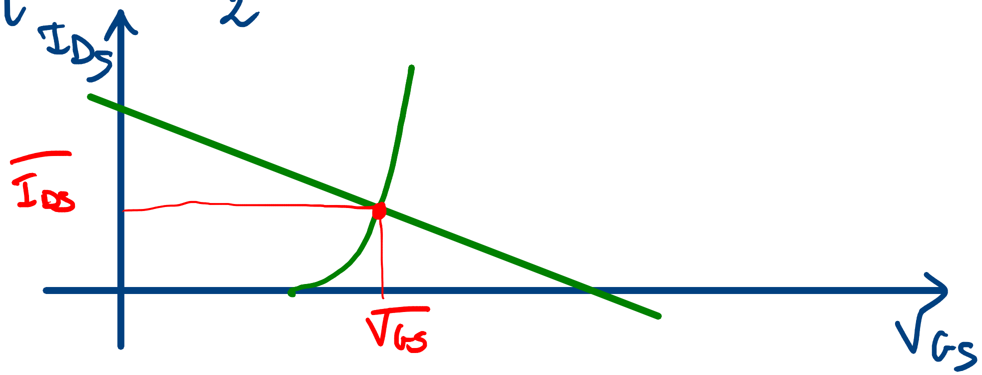
$I_G \simeq 0$

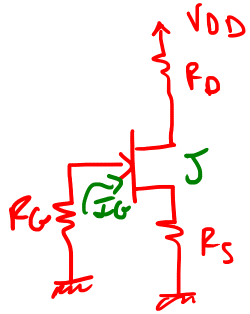
$$\boxed{I_D \simeq I_S}$$

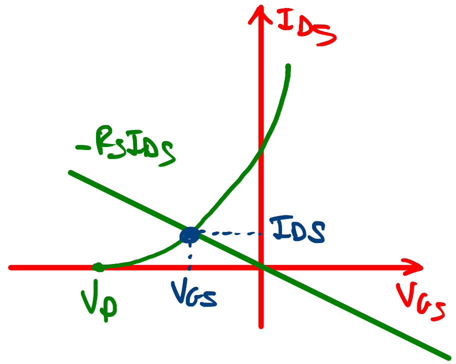
$$V_{GS} = V_G - V_S$$

$$V_S = R_S I_{DS}$$

$$\begin{cases} V_{GS} = \dfrac{R_{G2}}{R_{G2}+R_{G1}} V_{DD} - R_S I_{DS} \\ I_{DS} = \dfrac{K}{2}\left(V_{GS}-V_T\right)^2 \end{cases}$$



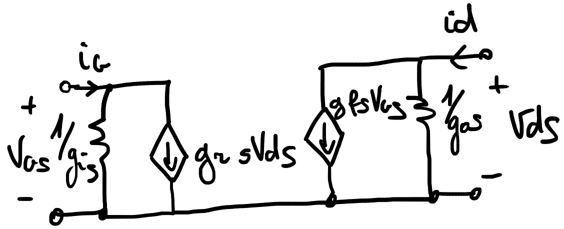




$$V_{GS} = V_G - V_S$$

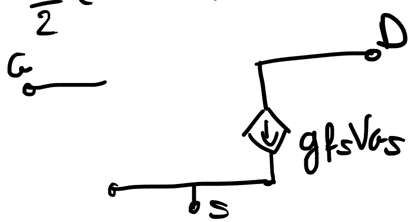
$$V_G = 0 = R_G \cdot I_G \quad (I_G = 0) \Rightarrow V_{GS} = -R_S I_{DS}$$

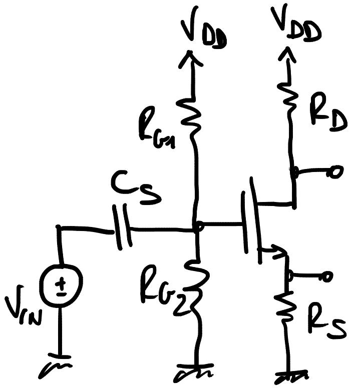
$$V_S = R_S I_{DS}$$



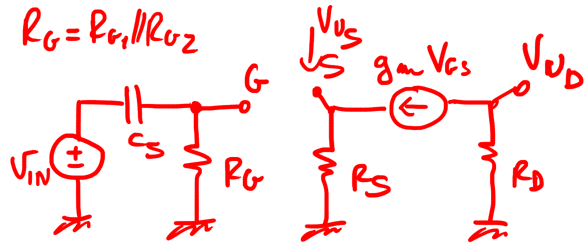
$$g_{fs} = \left.\frac{\delta I_{DS}}{\delta V_{GS}}\right|_{V_{DS}=0} = k(V_{GS}-V_T)$$

$$I_{DS} = \frac{K}{2}(V_{GS}-V_T)^2$$





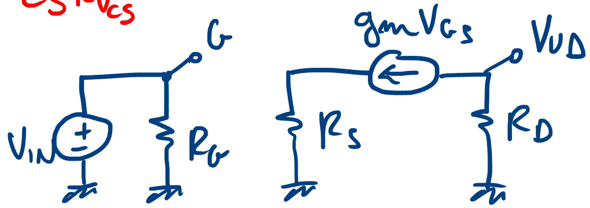
$R_G = R_{G1} // R_{G2}$



$$A_{VD} = \frac{A_\infty s}{(s+\omega_p)} = \frac{V_{UD}}{V_{IN}}$$

$$\omega_p = \frac{1}{C_S R_{V_{CS}}} \qquad R_{V_{CS}} = R_G$$

Calcolo A_∞



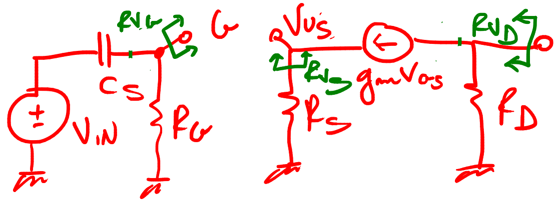
$$V_{UD} = -R_D g_m V_{GS}$$

$$\begin{cases} V_{GS} = V_G - V_S \\ V_G = V_{IN} \\ V_S = R_S g_m V_{GS} \end{cases}$$

$$V_{GS} = V_{IN} - R_S g_m V_{GS}$$

$$V_{GS} = \frac{V_{IN}}{1+R_S g_m}$$

$$V_{UD} = -\frac{R_D g_m V_{IN}}{1+R_S g_m} \Rightarrow A_\infty = \frac{-R_D g_m}{1+R_S g_m} \overset{\text{se } R_S g_m \gg 1}{\simeq} -\frac{R_D}{R_S}$$



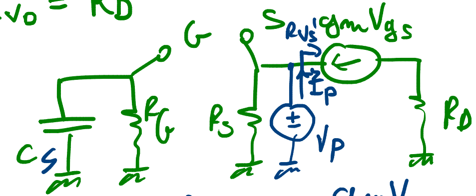
$$A_{V_E} = \frac{V_{US}}{V_{IN}} = \frac{A_{0S}\, s}{(s+\omega_p)}$$

$$V_{GS} = \frac{V_{IN}}{1+g_m R_S} \qquad V_{US} = R_S g_m V_{GS}$$

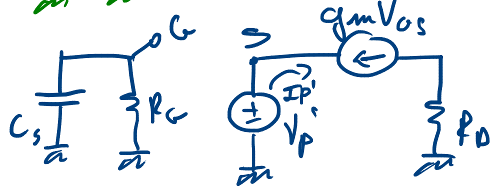
$$A_{0S} = \frac{R_S g_m}{1+R_S g_m} \overset{1 \ll R_S g_m}{\simeq} 1$$

$R_{VG} \to +\infty$

$R_{Vo} = R_D$



$$R_{VS} = R_S // R'_{VS}$$



$$R'_{VS} = \frac{V'_p}{I'_p}$$

$$I'_p = -g_m V_{GS}$$

$V_G = 0$

$V_S = V'_p$

$V_{GS} = -V'_p$

$$\frac{V'_p}{I'_p} = \frac{1}{g_m} \Rightarrow R_{VS} = R_S // 1/g_m$$