Transistors à effet de champ (FET)

1ère année IFIPS
Département Electronique

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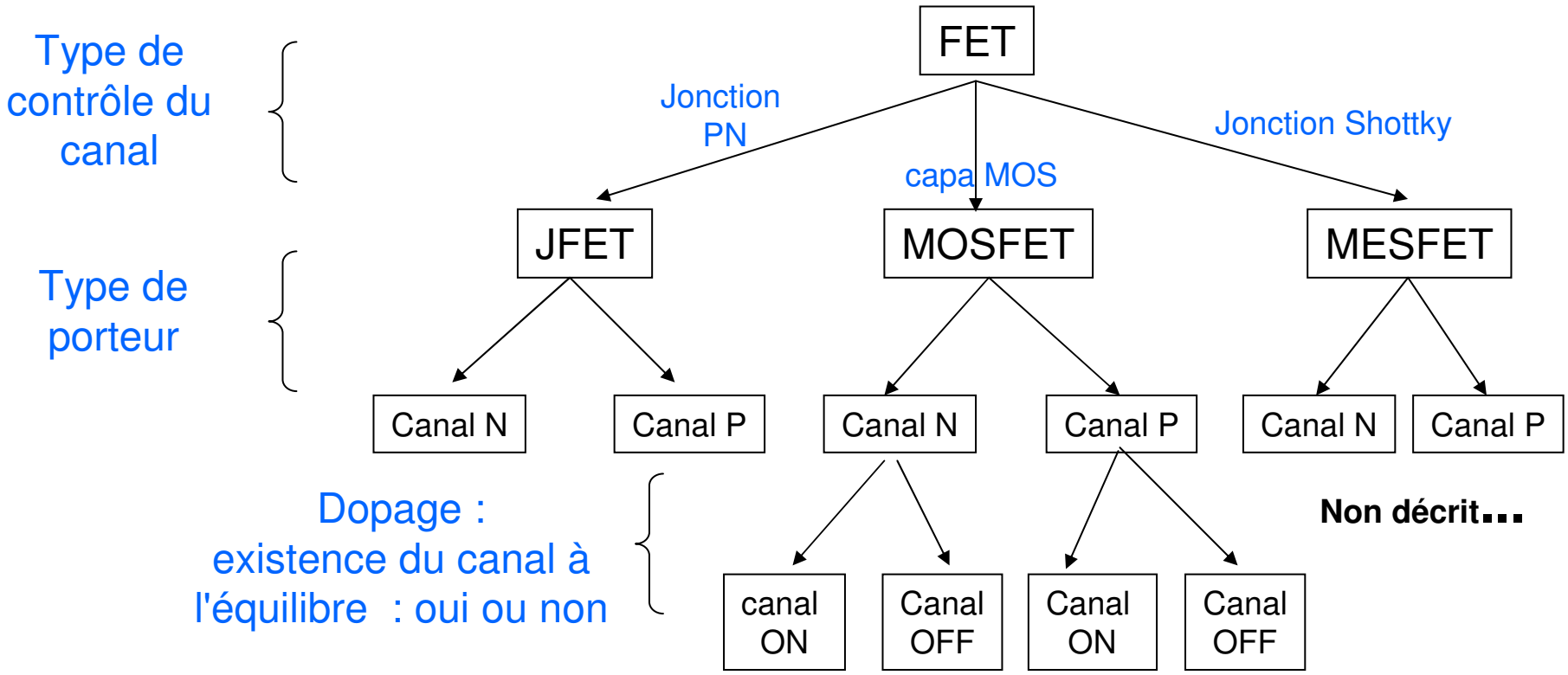
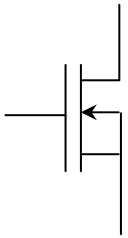
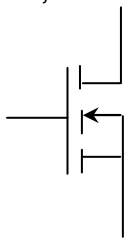
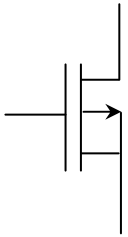
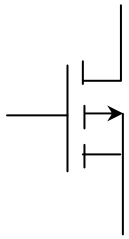
Introduction à l'effet de champ



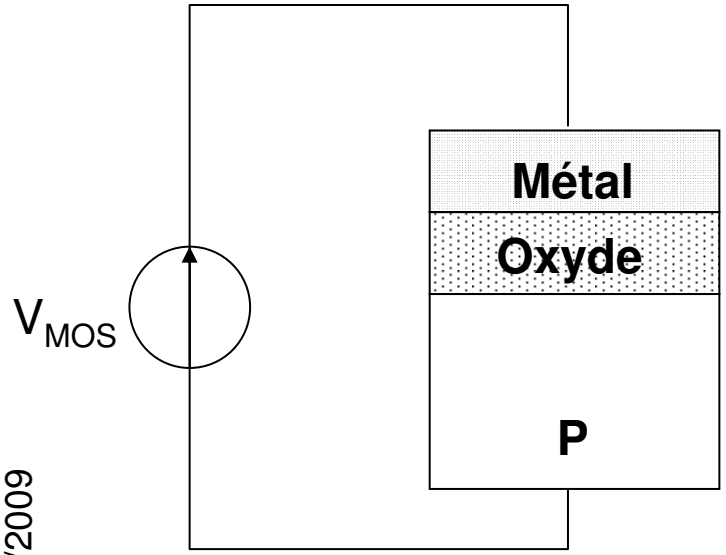
4 grands types de transistors MOS :

	Normally ON *(à appauvrissement)*	Normally OFF *(à enrichissement)*
NMOS	NMOS, Normally ON 	NMOS, Normally OFF 
PMOS	PMOS, Normally ON 	PMOS, Normally OFF 

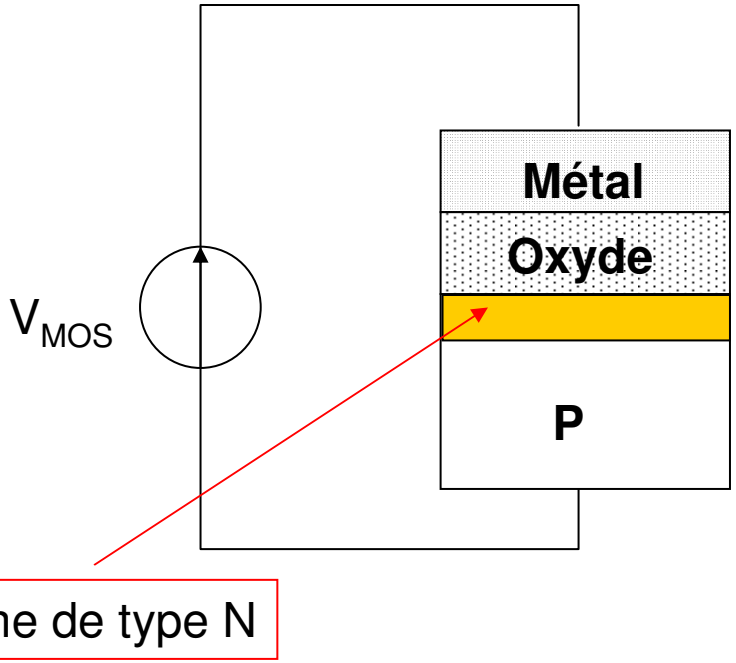
Capacité MOS : l'essentiel

Il existe une tension de seuil V_T telle que :

$V_{MOS} < V_T$

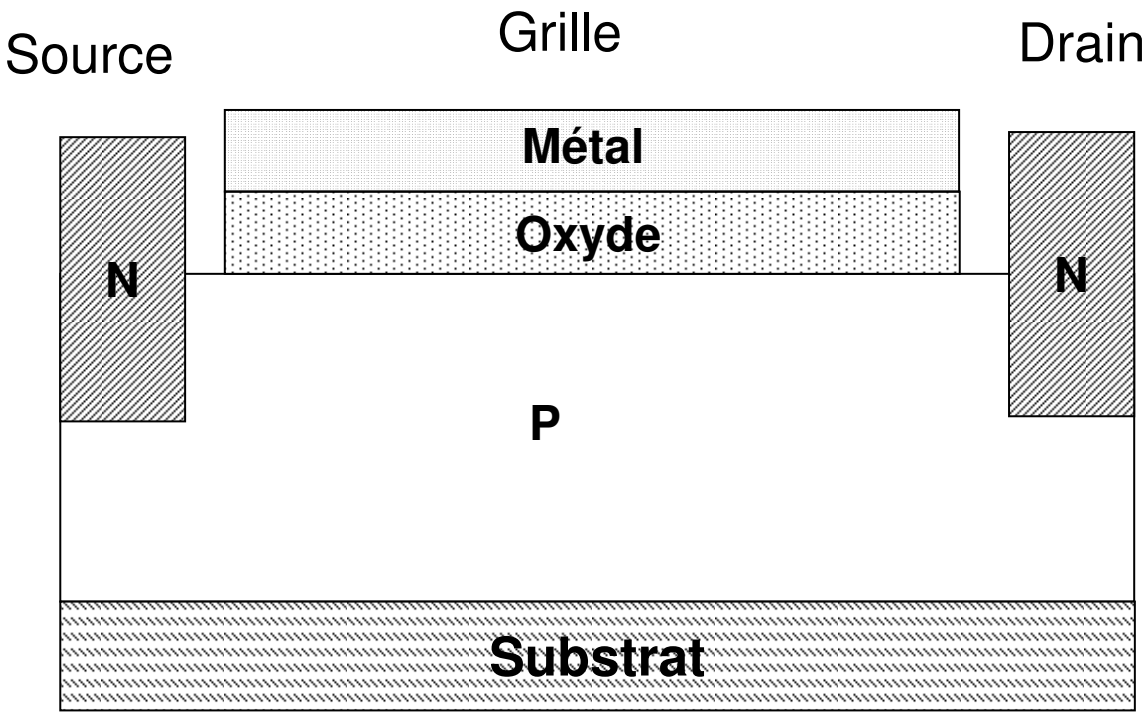


$V_{MOS} > V_T$

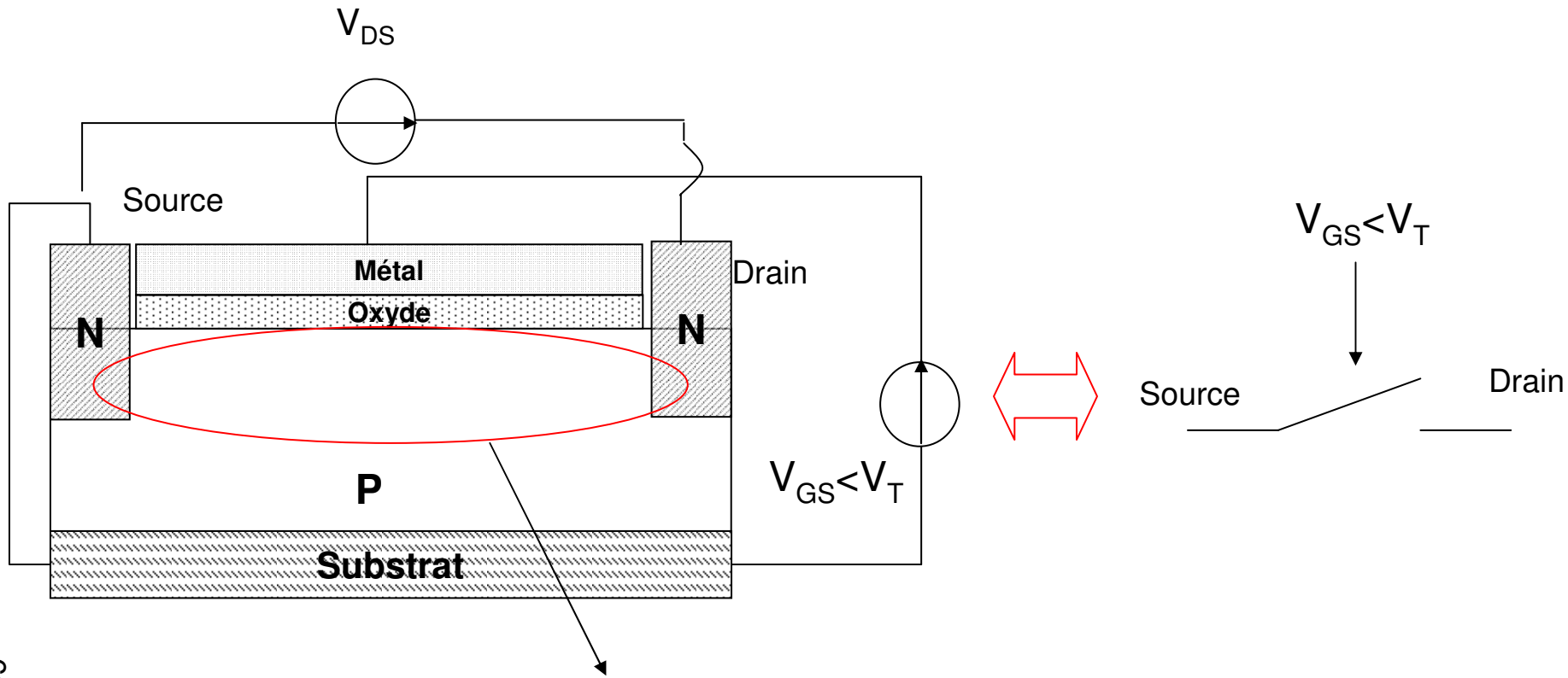


La structure reste à l'équilibre

Structure d'un transistor MOS (NMOS):



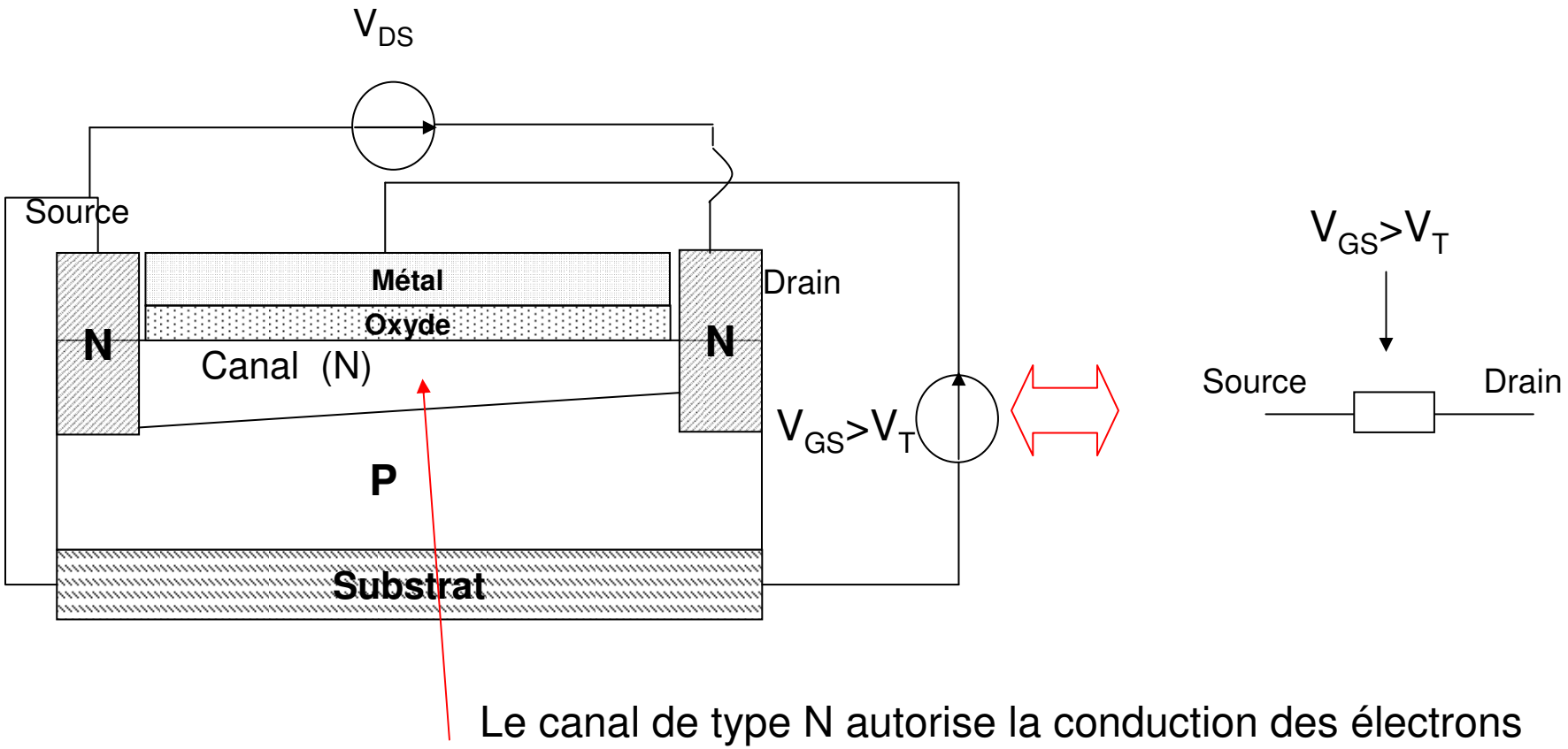
Transistor MOS en dessous du seuil : $V_{GS} < V_T$



Deux zones N séparées par une large zone P : même avec une tension V_{DS}, la conduction entre la source et le drain est impossible

Le transistor est **bloqué** (interrupteur ouvert)

Transistor MOS au dessus du seuil : $V_{GS} > V_T$



Le canal de type N autorise la conduction des électrons du drain vers la source sous la tension V_{DS}

Le transistor est **passant** (interrupteur fermé résistif)

Pincement du canal

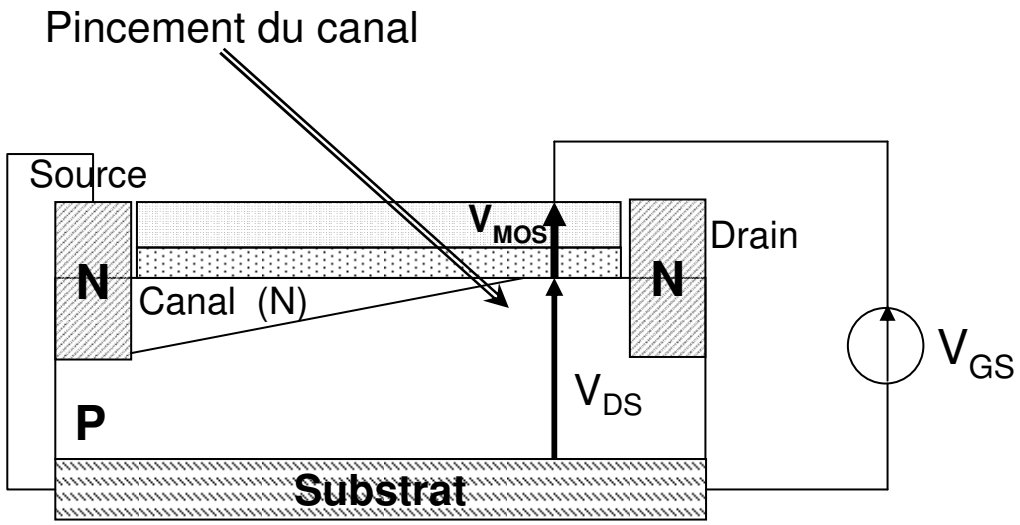
Côté source :

$V_{MOS} = V_{GS}$

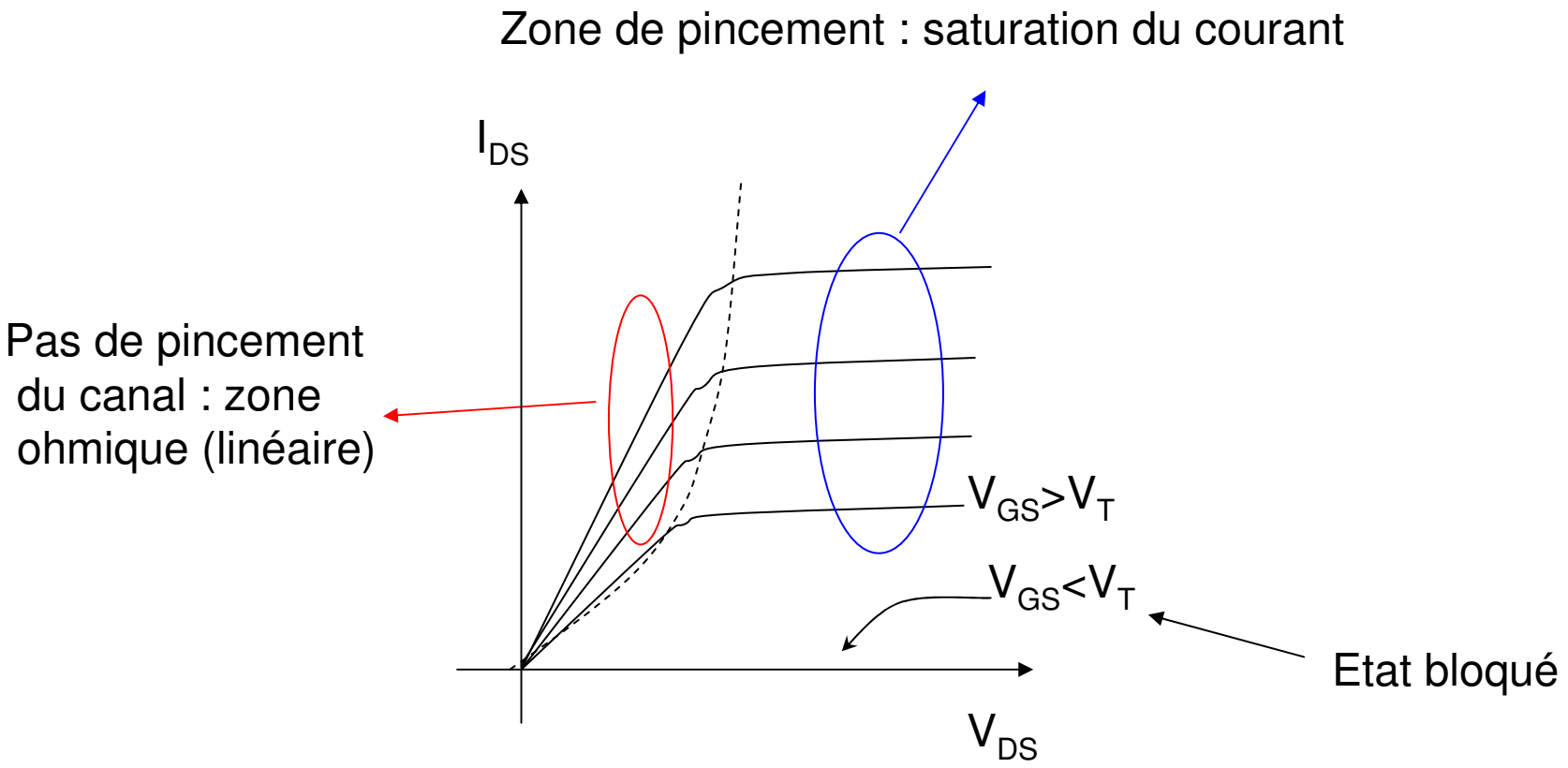
Côté drain :

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

On peut donc avoir $V_{MOS} > V_T$ côté source et $V_{MOS} < V_T$ côté drain si V_{DS} est importante:
Le canal est pincé (disparition locale du canal) pour $V_{DS} > V_{DSsat}$

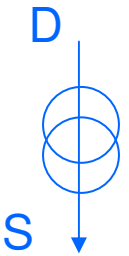


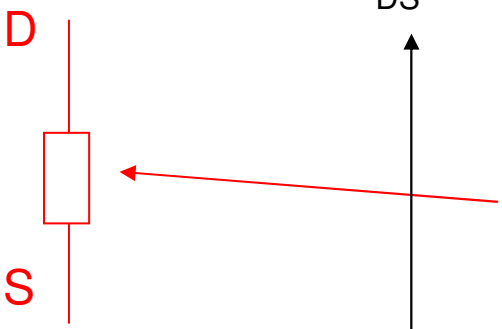
Caractéristique $I_{DS} = f(V_{DS})$, paramétrée par V_{GS}



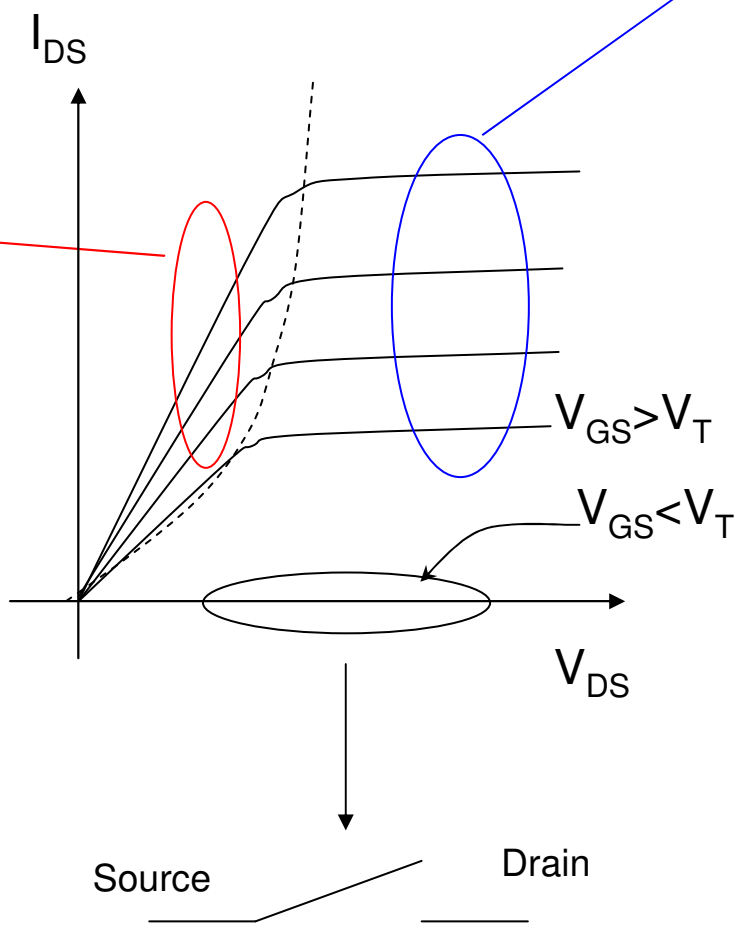
Caractéristique $I_{DS} = f(V_{DS})$, paramétrée par V_{GS}

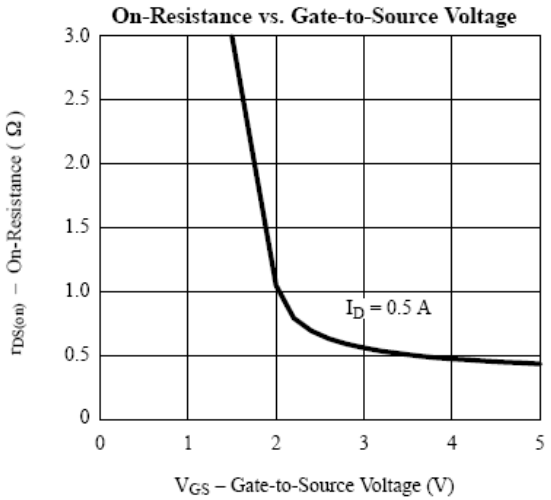
I_{DS} indépendant de V_{DS}





$$R_{DSon} = \frac{1}{K(V_{GS} - V_T)}$$





Caractéristique réelle (2N7000)

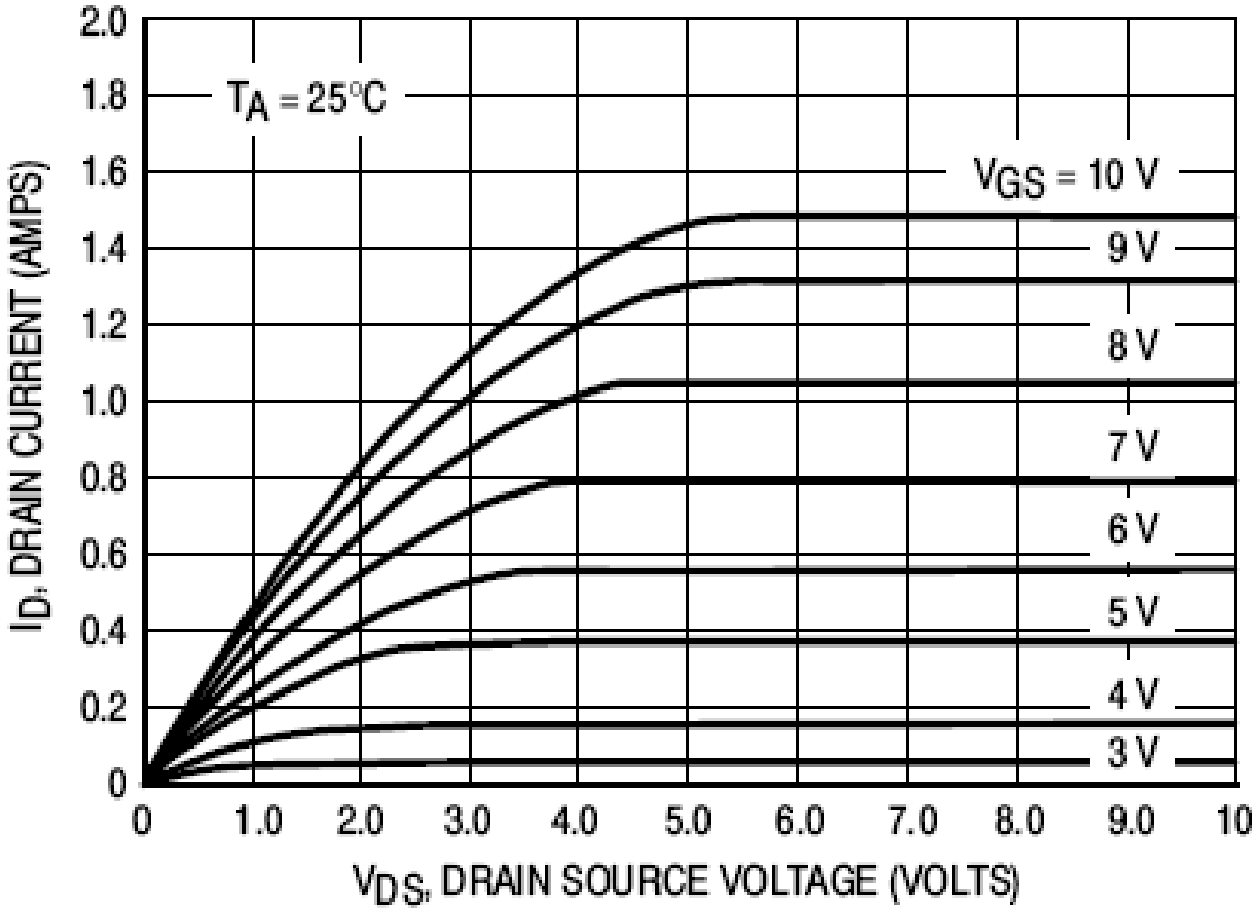
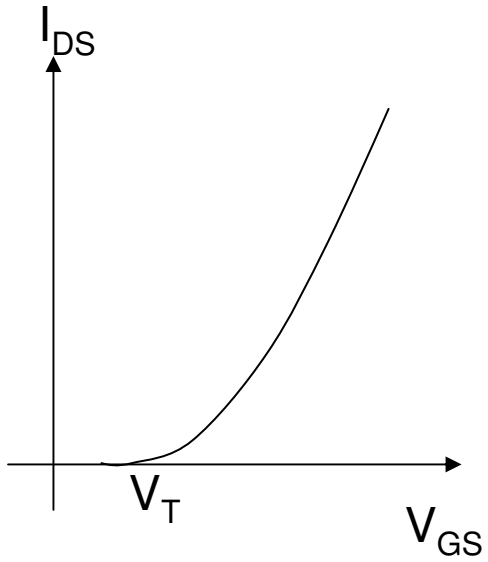


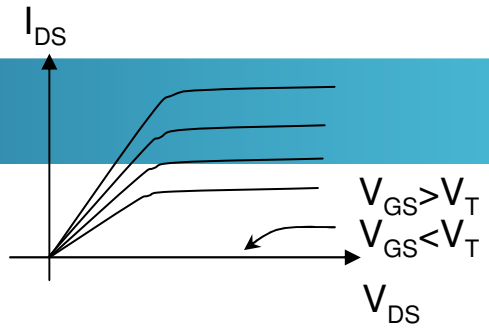
Figure 1. Ohmic Region

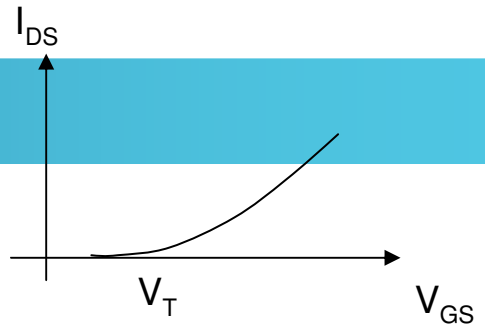
Caractéristique $I_{DS} = f(V_{GS})$, dans la zone de pincement



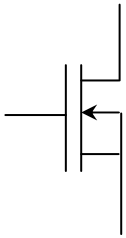
$$I_{DS} = I_{DSS}\left(1 - \frac{V_{GS}}{V_T}\right)^2$$

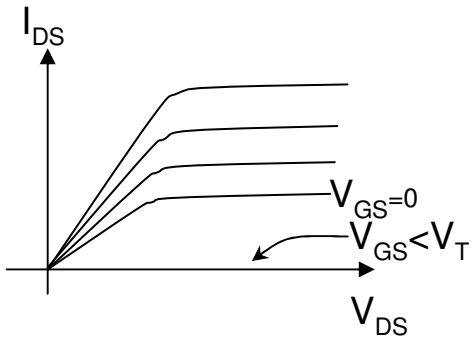
NMOS, Normally OFF

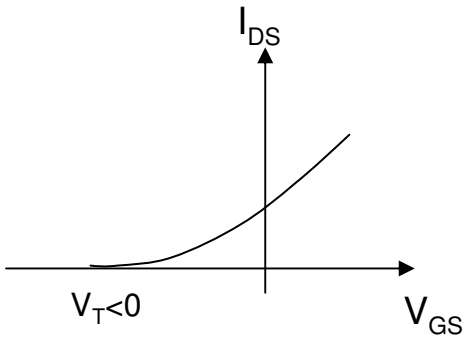




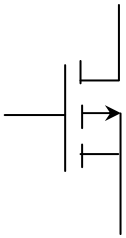
NMOS, Normally ON

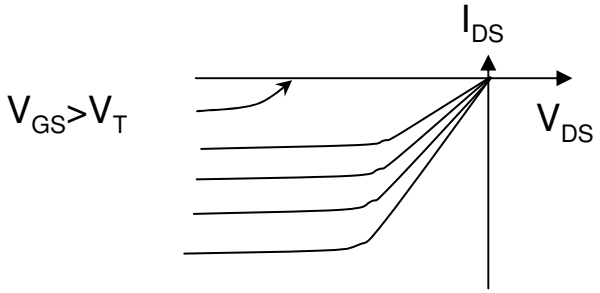


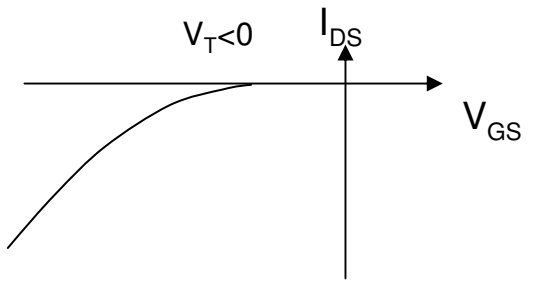




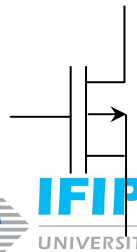
PMOS, Normally OFF

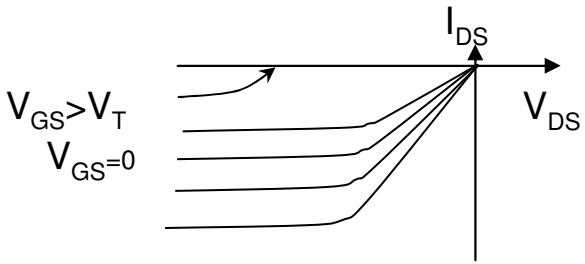


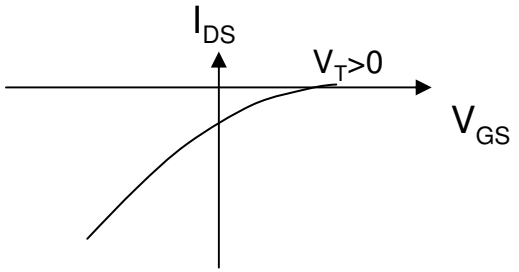




PMOS, Normally ON







C. Koeniguer 2008/2009

Caractéristiques réelles : variations en fonction de la température

$R_{DSon}(T)$

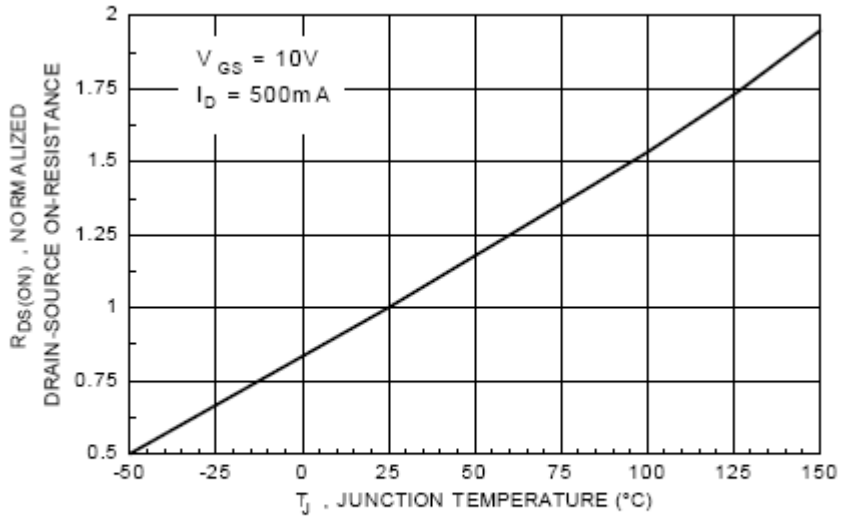


Figure 3. On-Resistance Variation with Temperature

$g_m(T)$

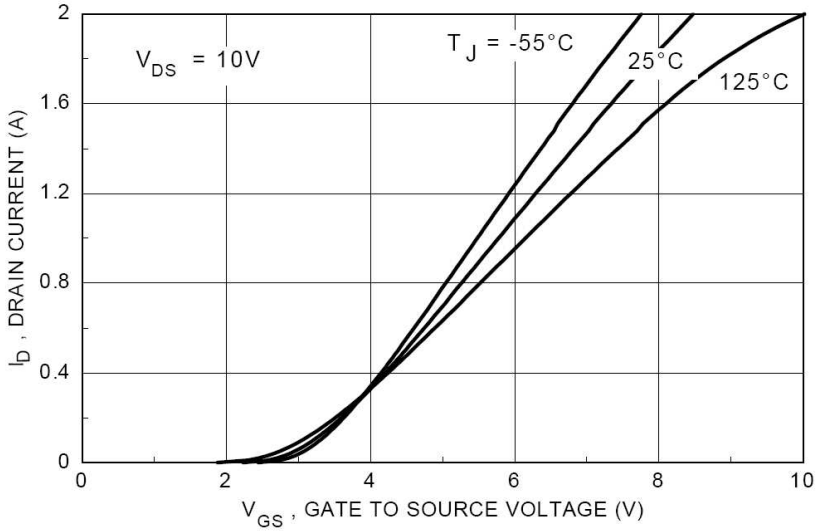
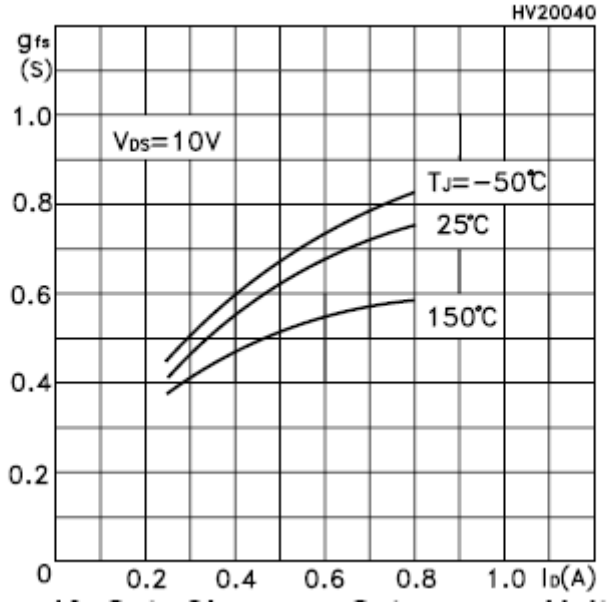
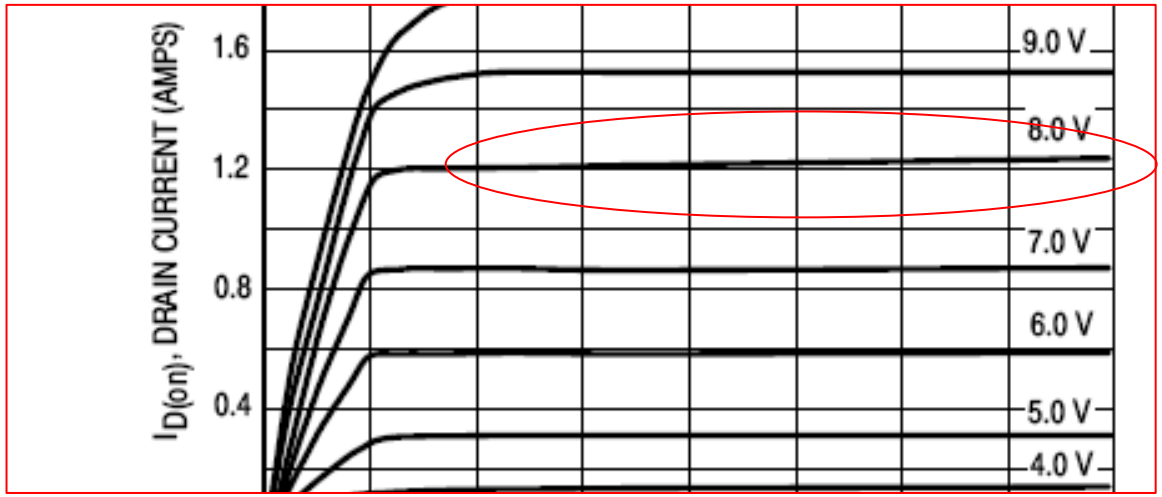
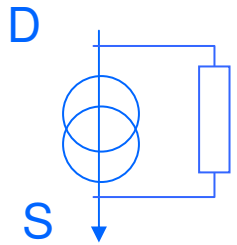


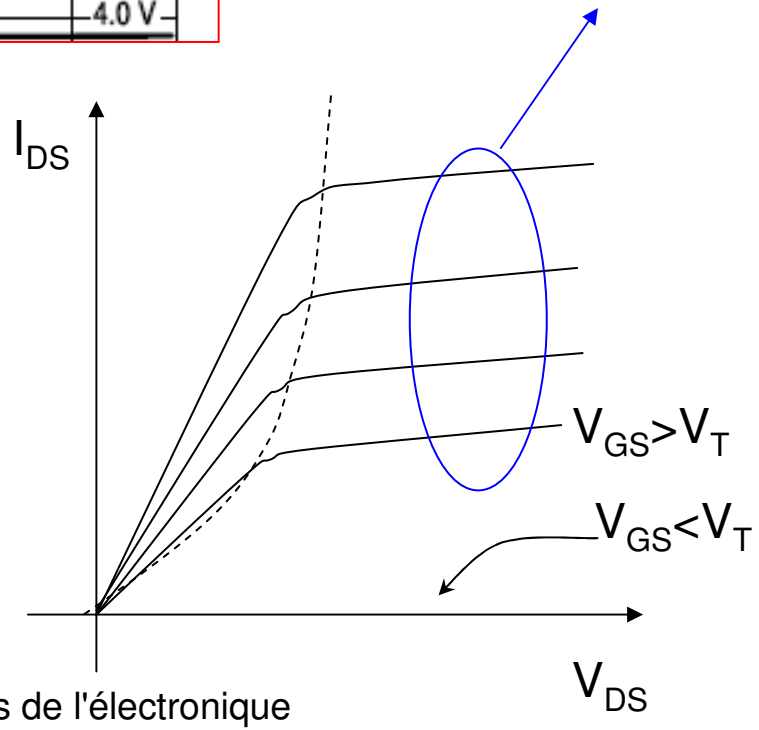
Figure 5. Transfer Characteristics



Caractéristiques réelles : r_{DS} dans la zone de pincement







Aire de sécurité :

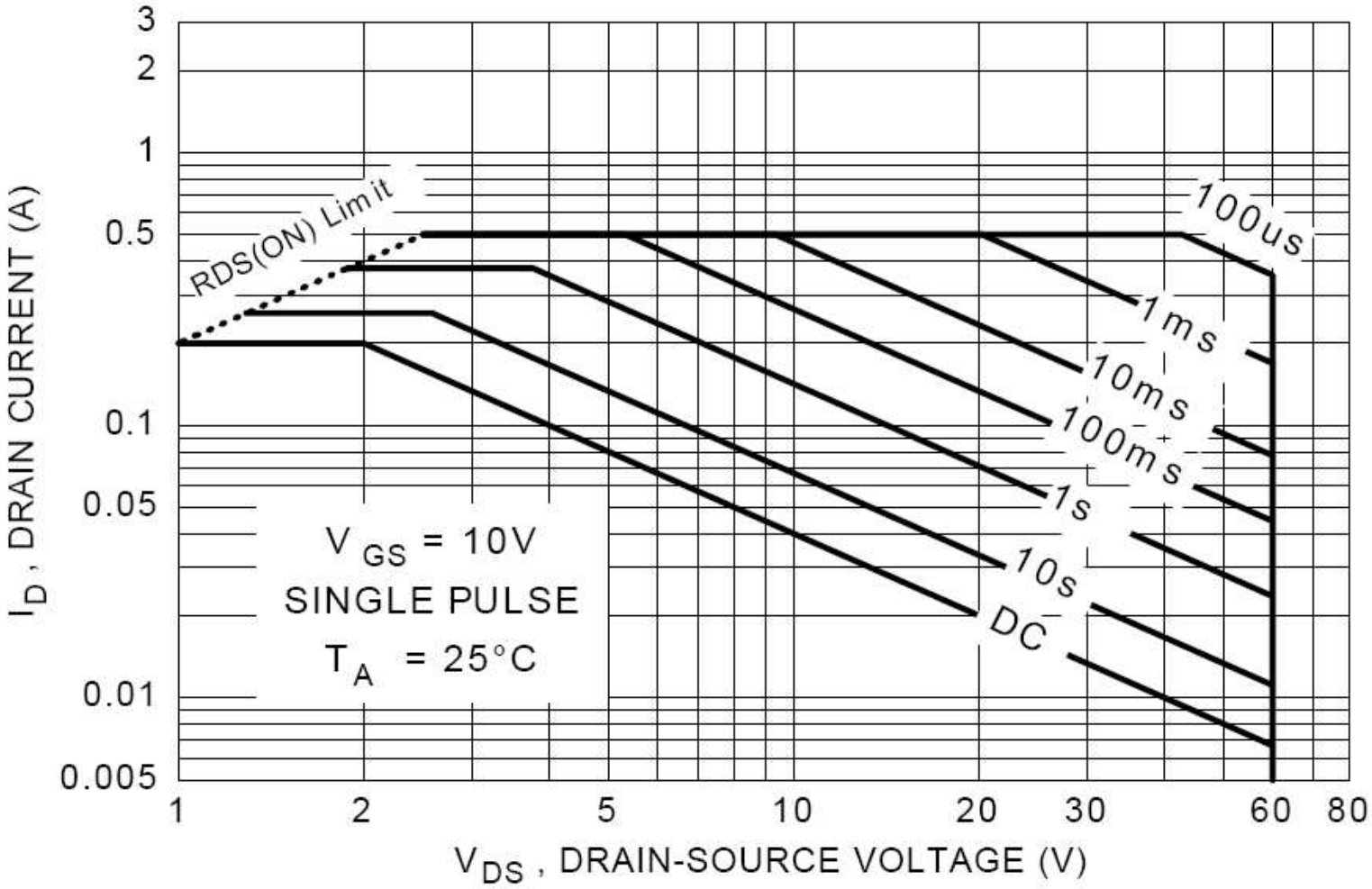
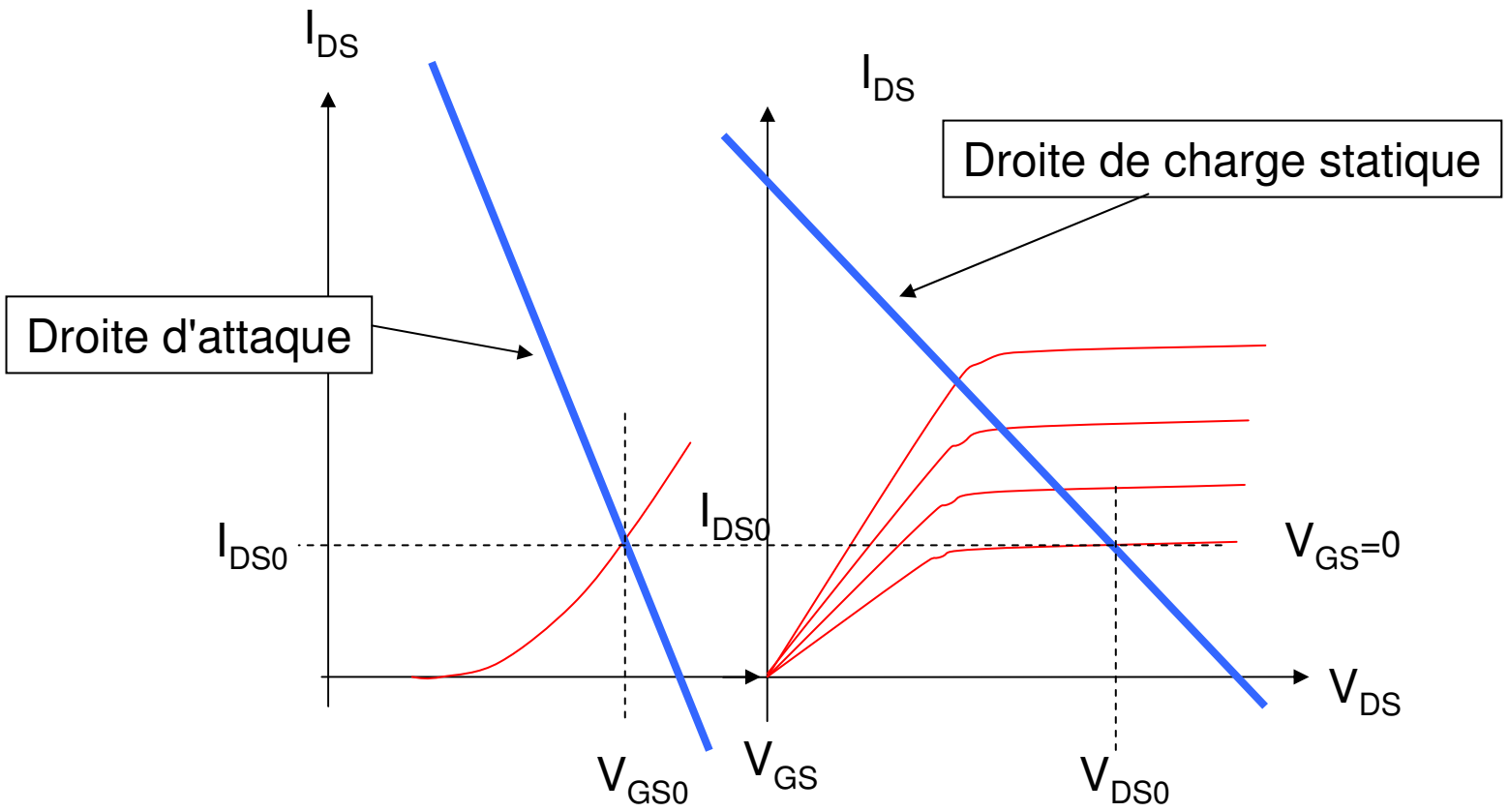
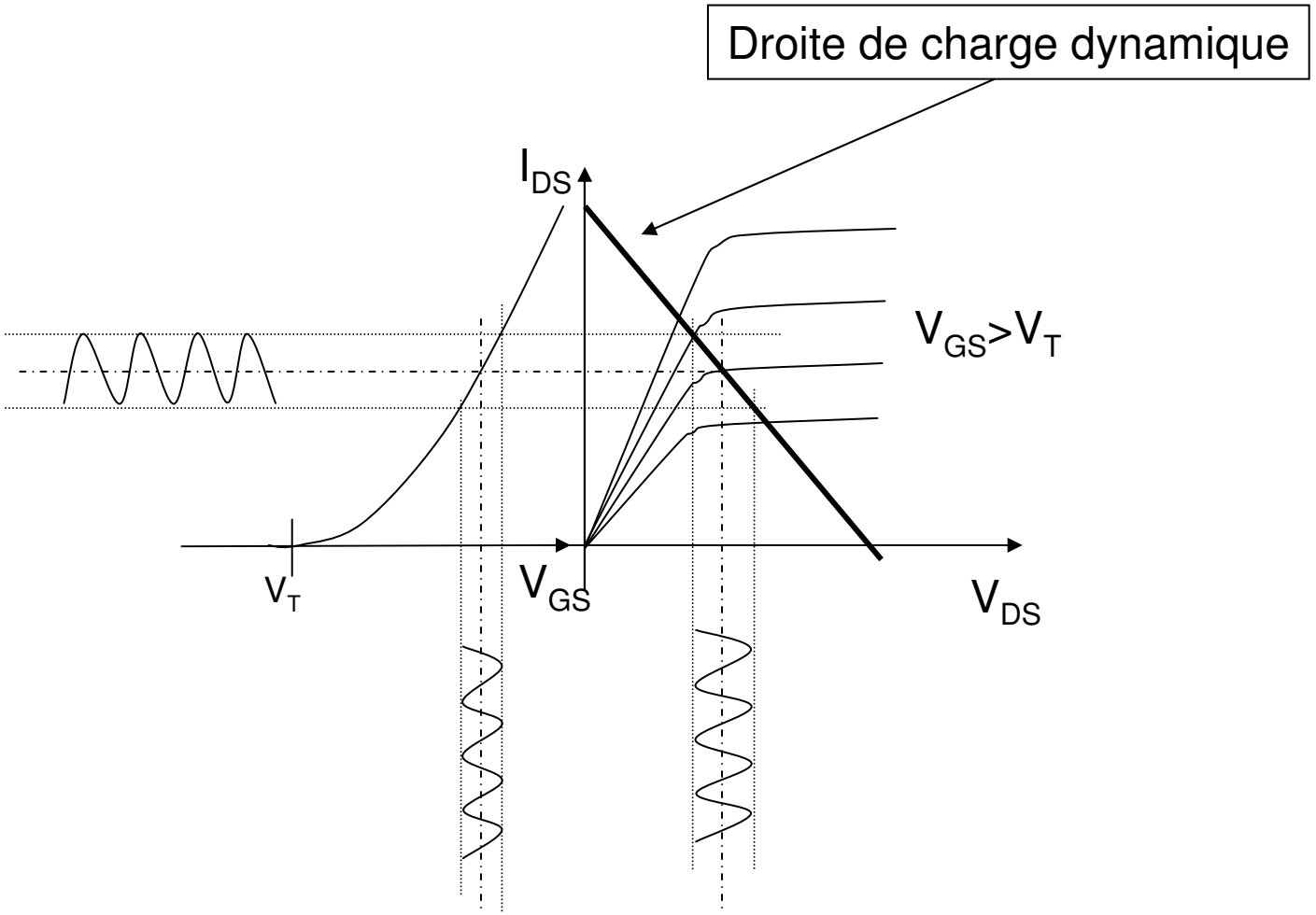


Figure 13. 2N7000 Maximum Safe Operating Area

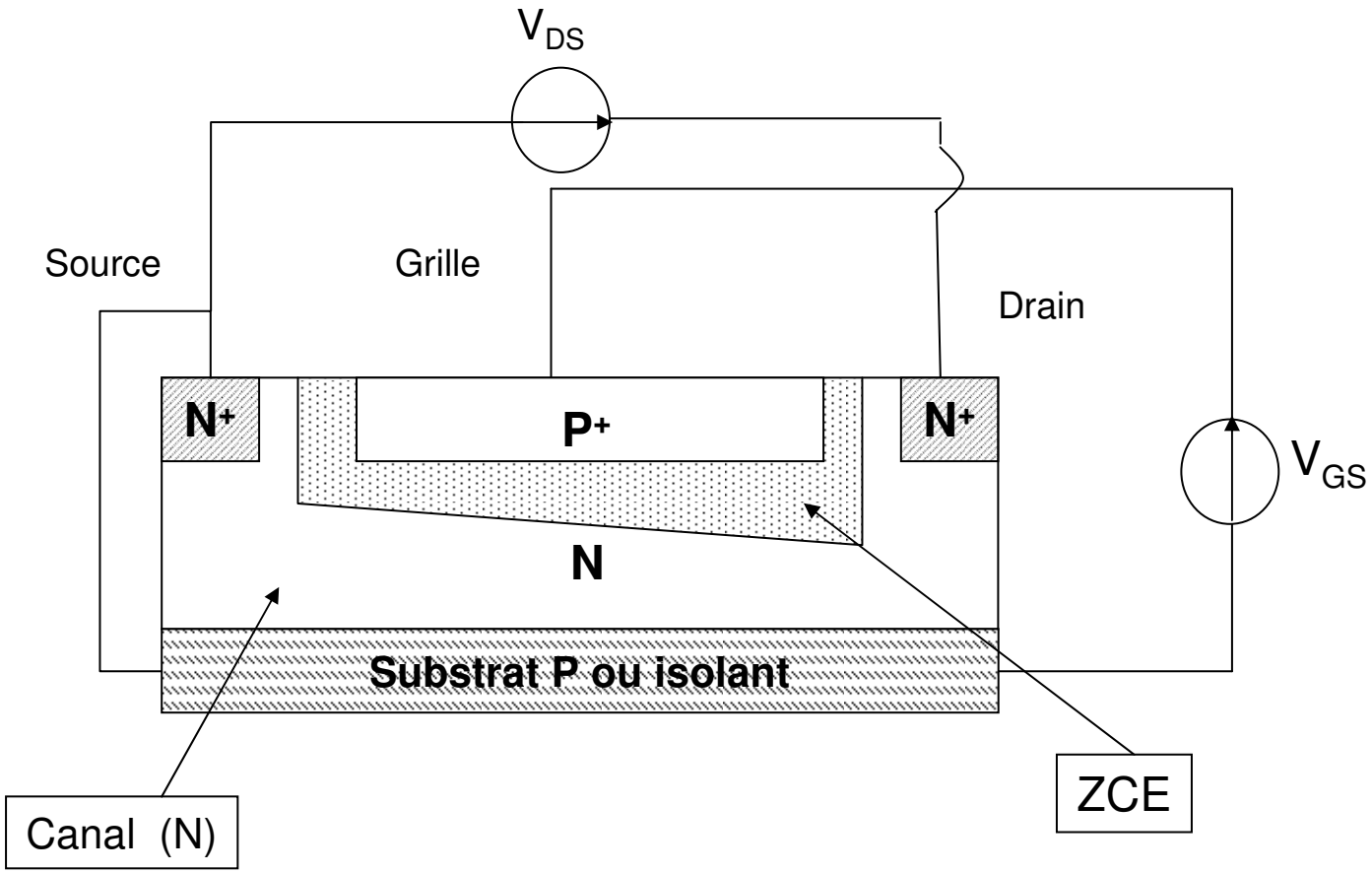
Polarisation d'un transistor NMOS Normally OFF



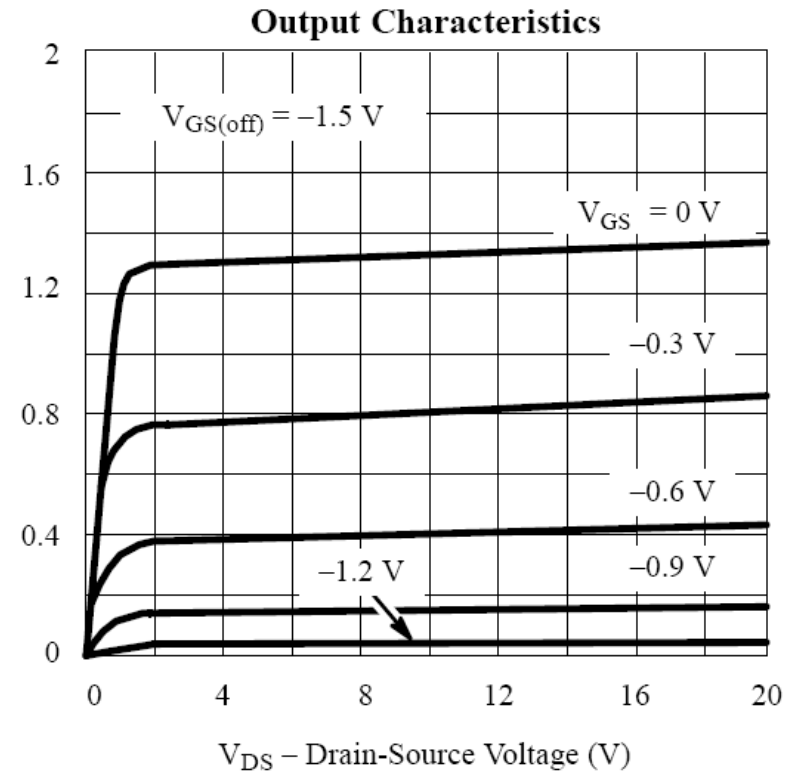
Régime dynamique

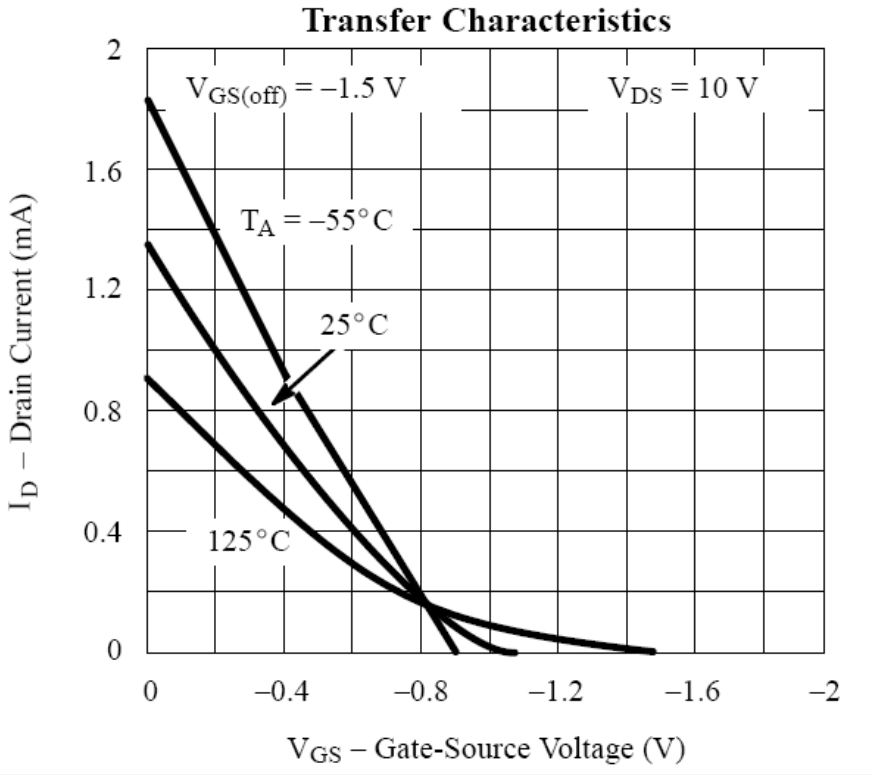


Structure simplifiée d'un JFET canal N

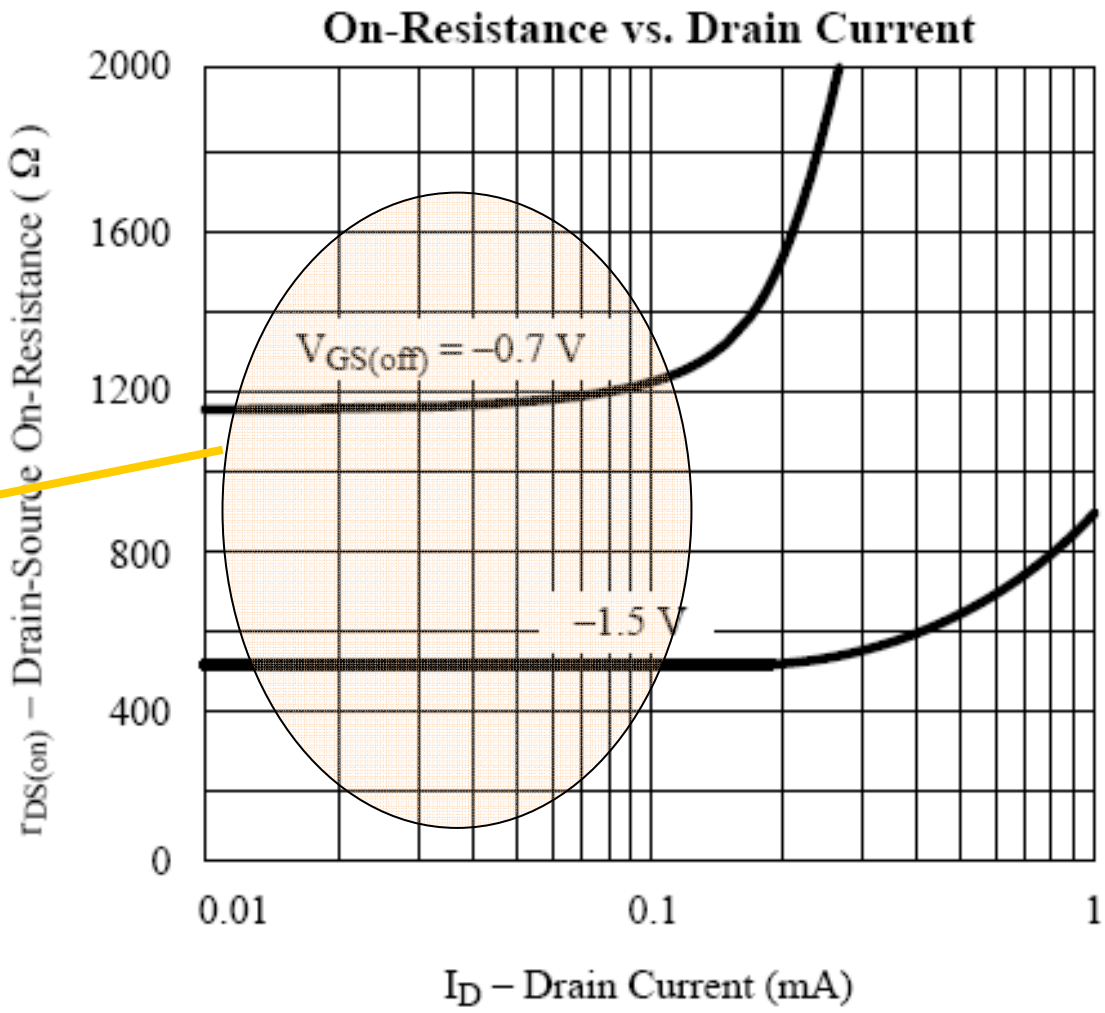


Caractéristiques d'un JFET canal N





Exemple de r_{DSON} pour un JFET canal N



Zone ohmique