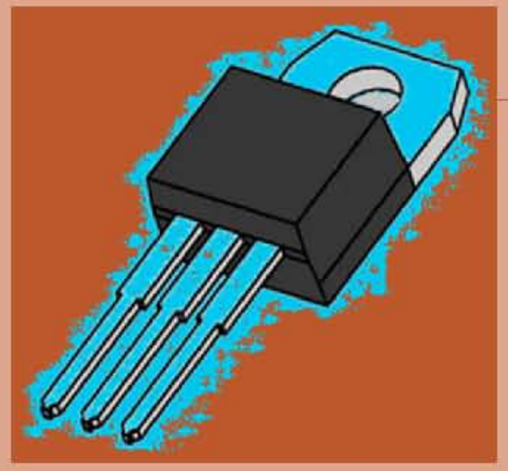
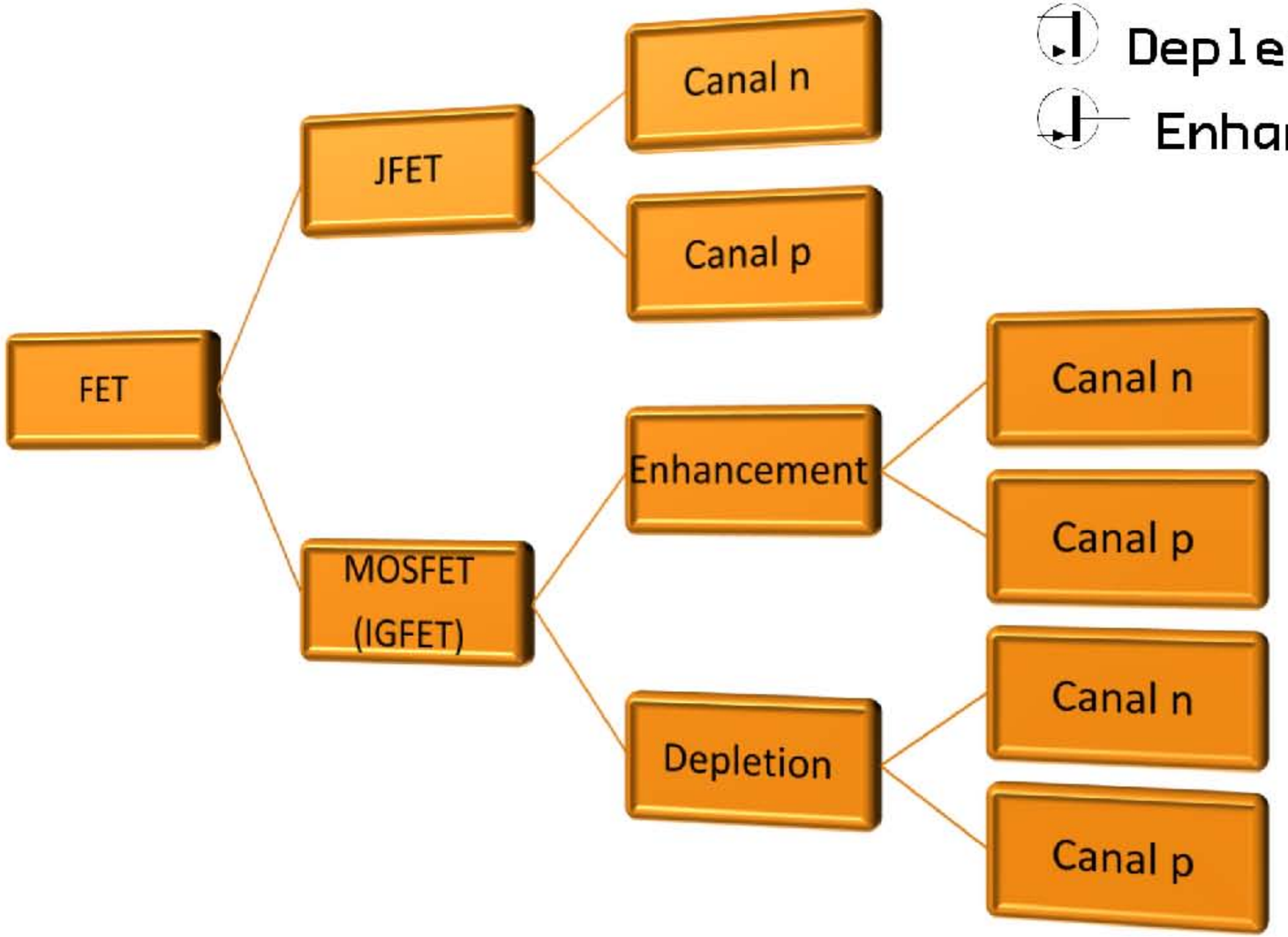
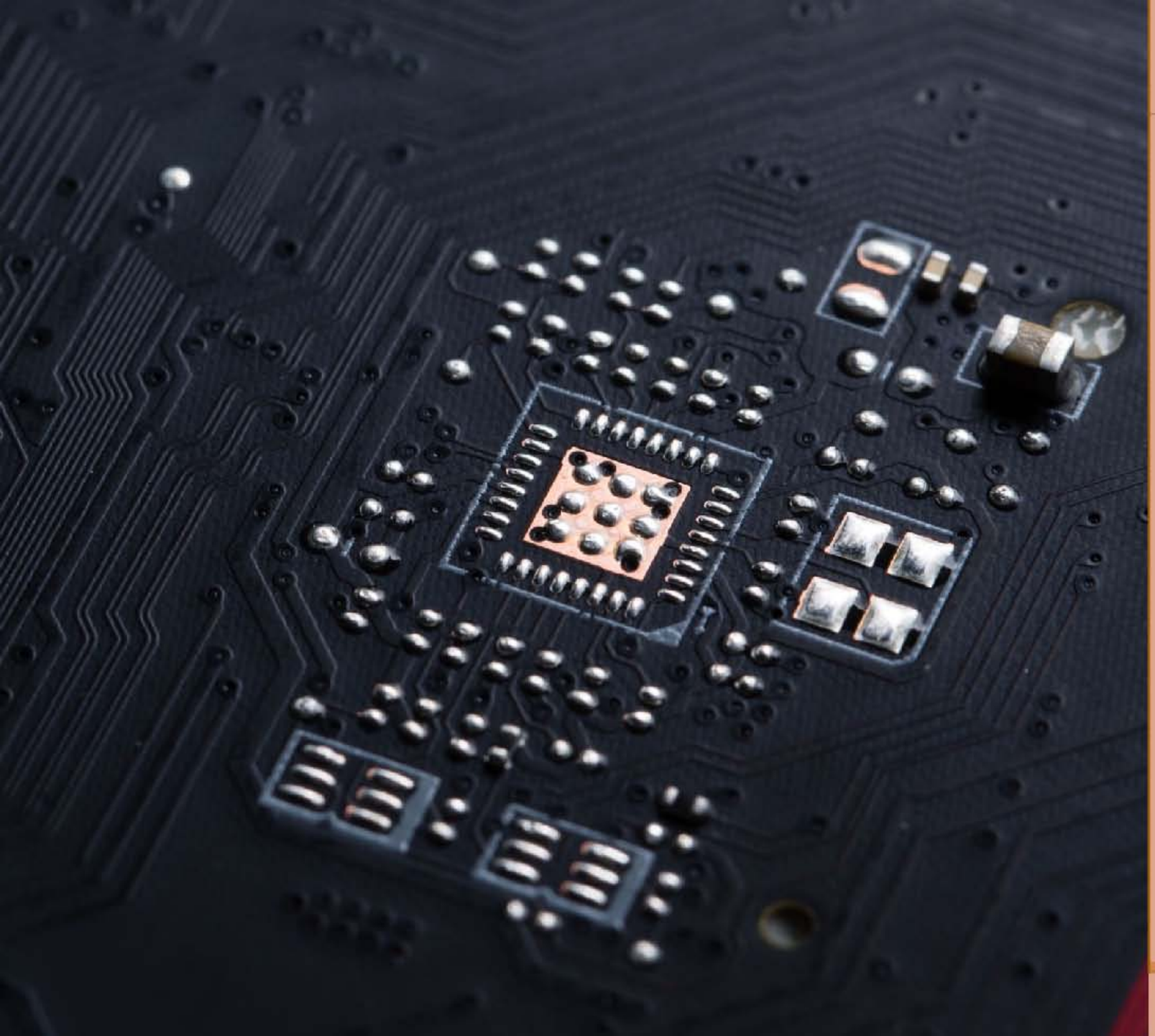
Transistor de efeito de campo



Tipos



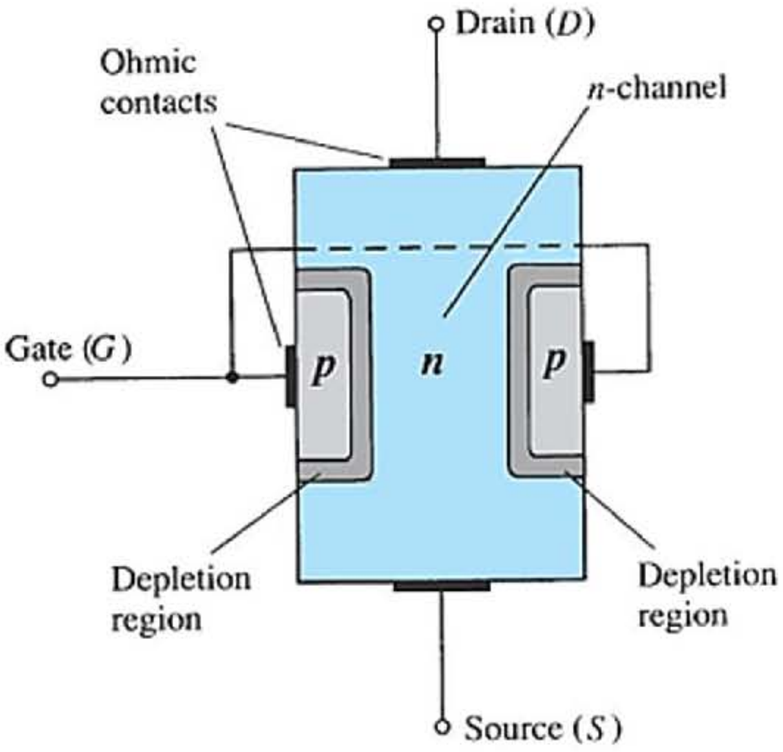
- Depletion ou empobrecimento
- Enhancement ou enriquecimento.

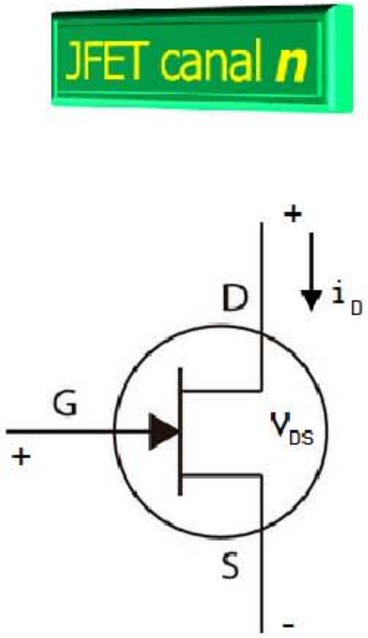


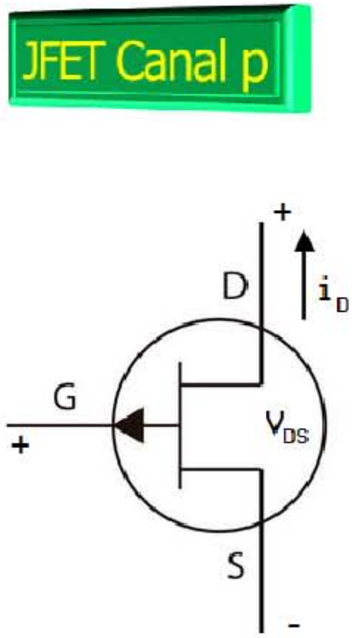
Transistor JFET

Partes

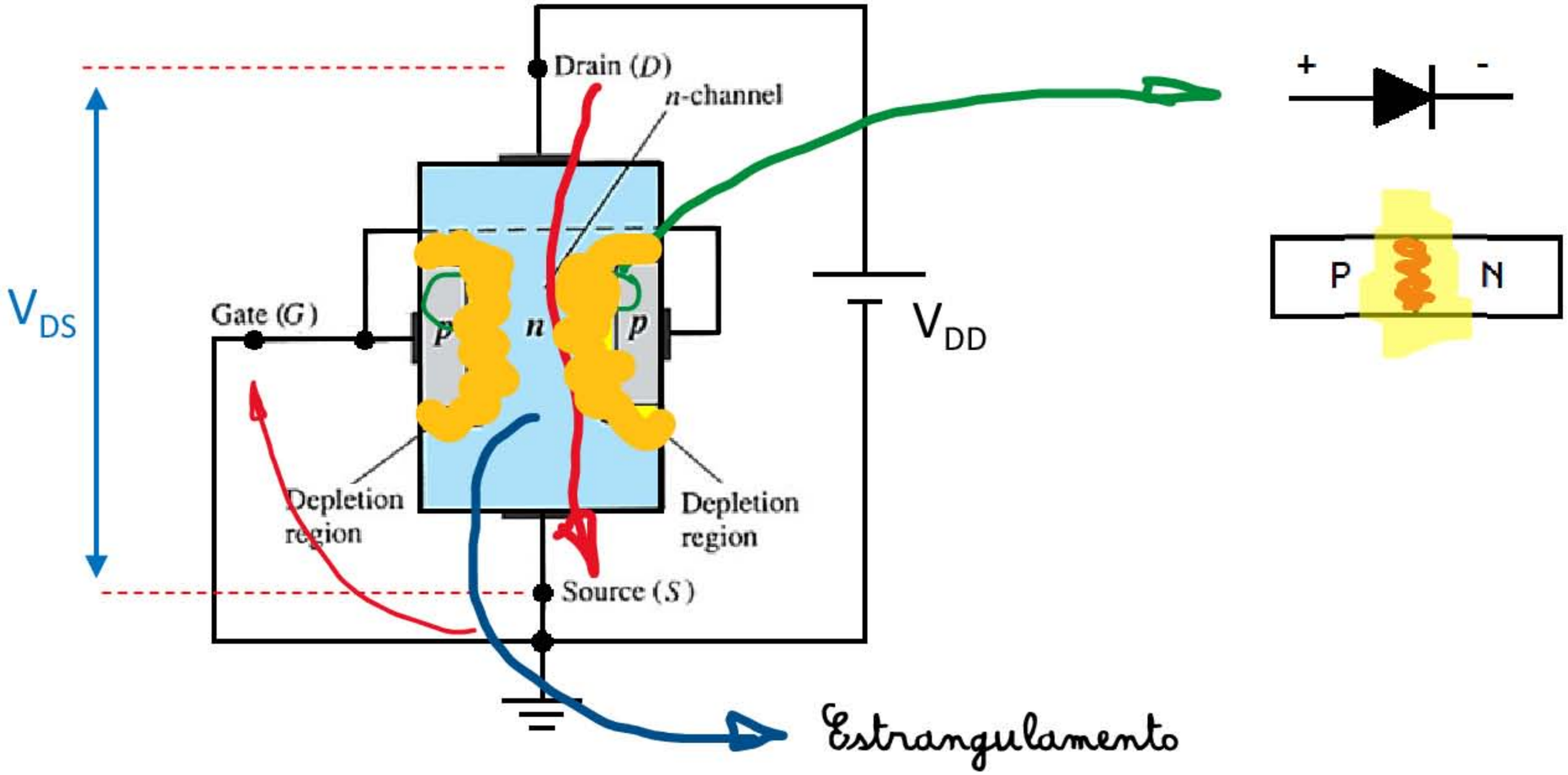
- O terminal Gate controla o fluxo de elétrons que flui do Source para o Drain





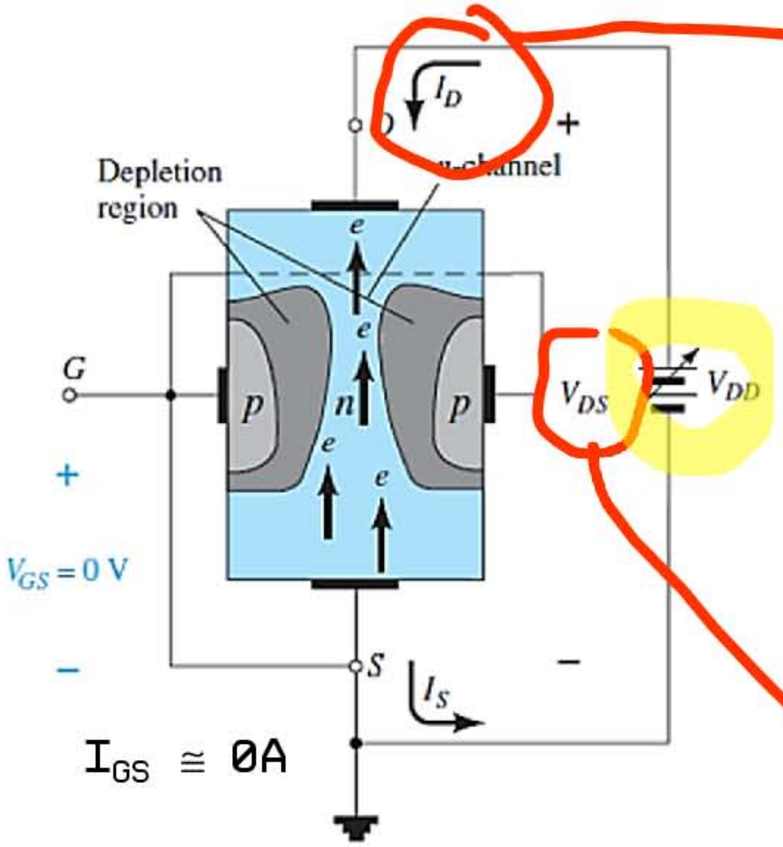


Considerações

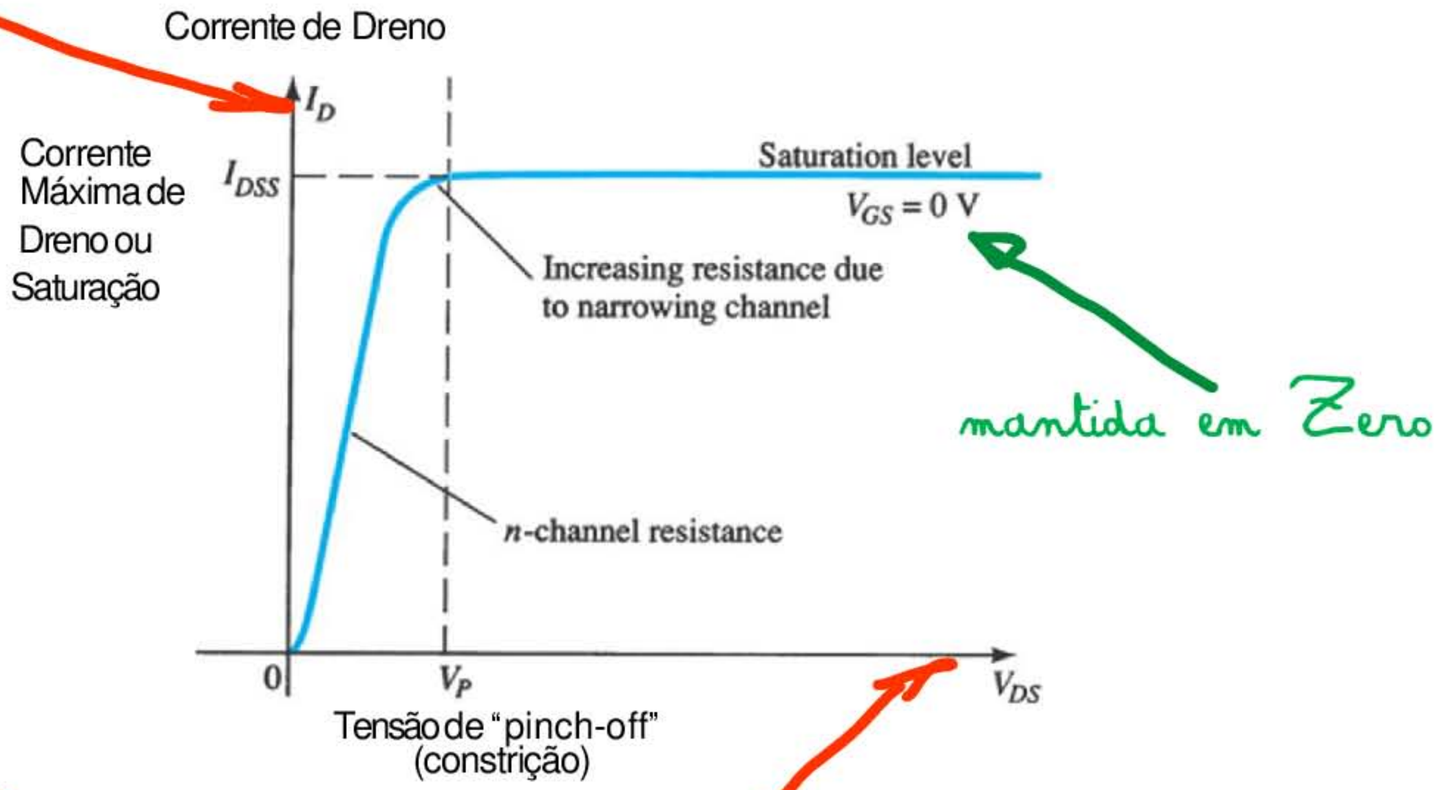


Operação

- Iniciando com $V_{GS} = 0$ e $V_{DS} = 0V$

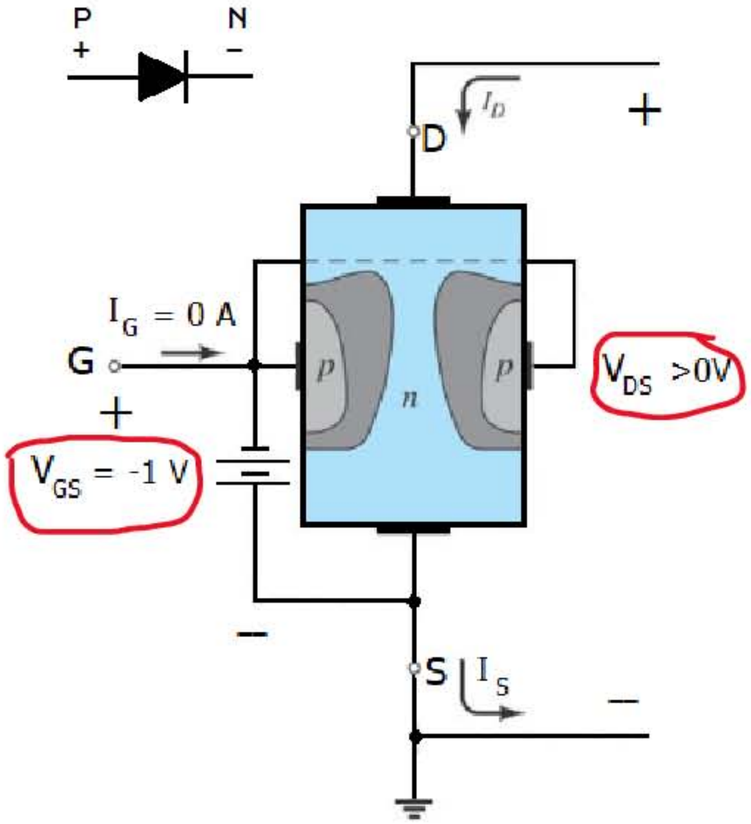


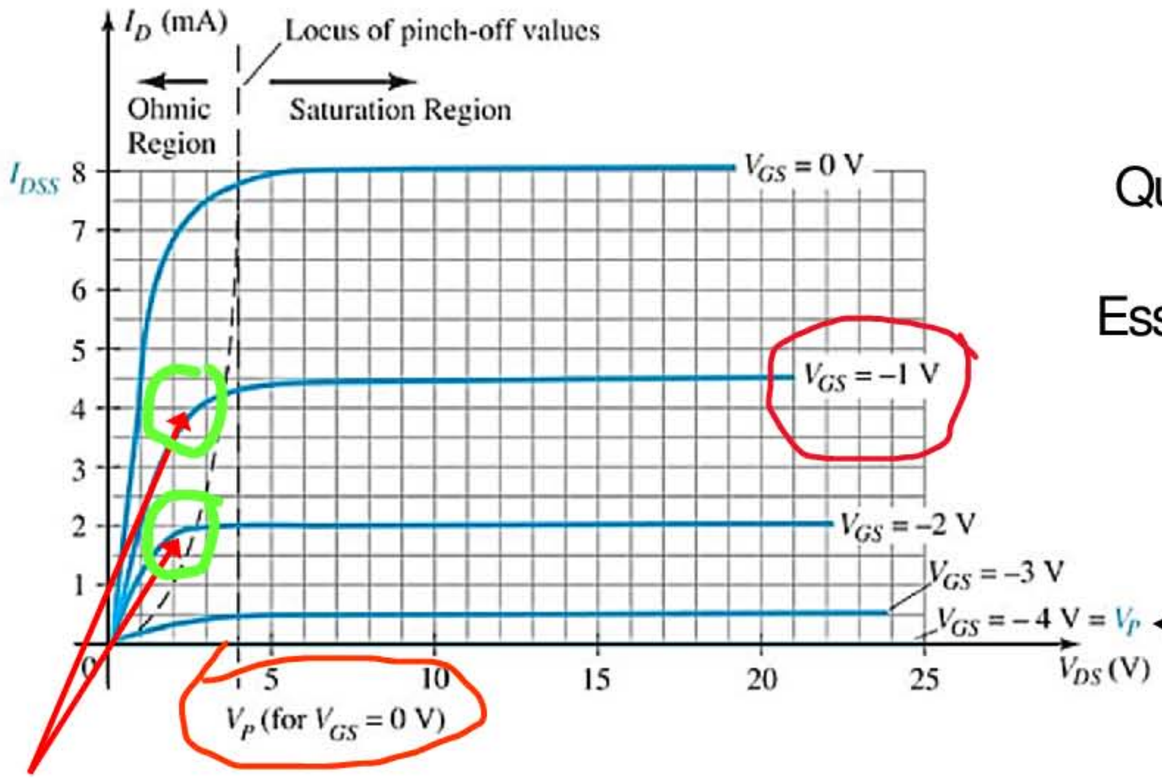
$I_{GS} \cong 0A$



mantida em Zero

Agora $V_{GS} < 0$ e $V_{DS} > 0$





Quando $V_{GS} = - V_P$ o FET desliga e daí $I_D = 0$
Essa tensão é chamada de V_{GSOFF}

Com $V_{GS} < 0$ o pinch-off ocorre com V_{DS} menor

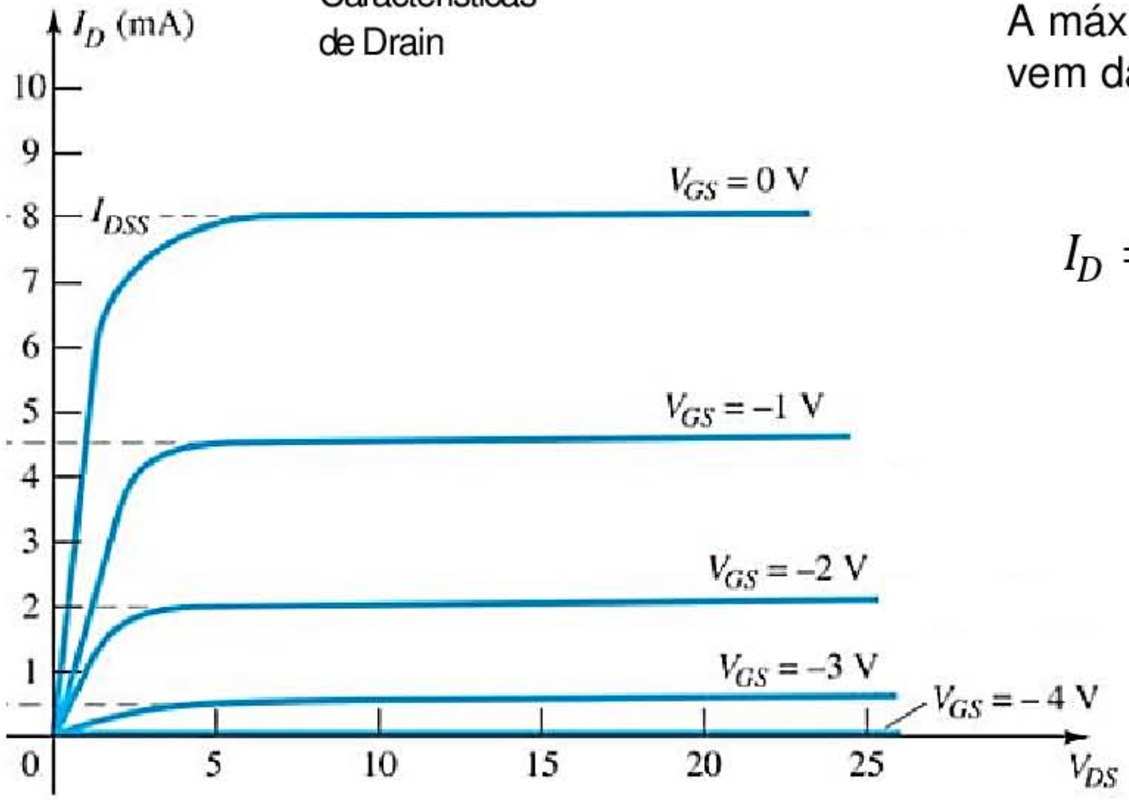
$V_{GS} = 0$ e $V_{DS} > 0$

Máxima condução

$V_{GSOFF} = -4V$

Estrangulamento do datasheet

Curvas Características de Drain



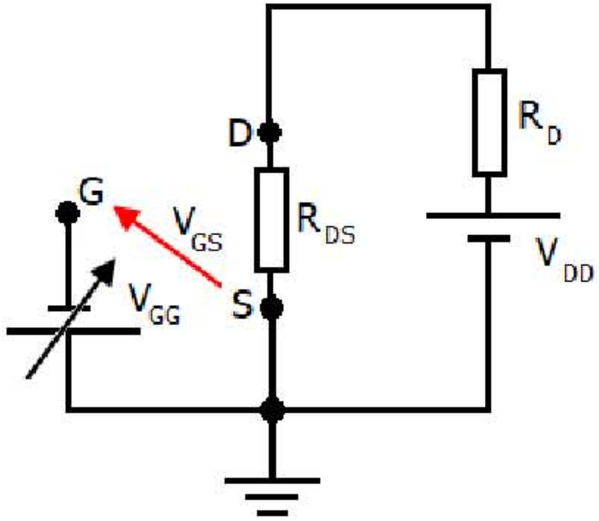
A máxima corrente de condução vem da equação de Shockley

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

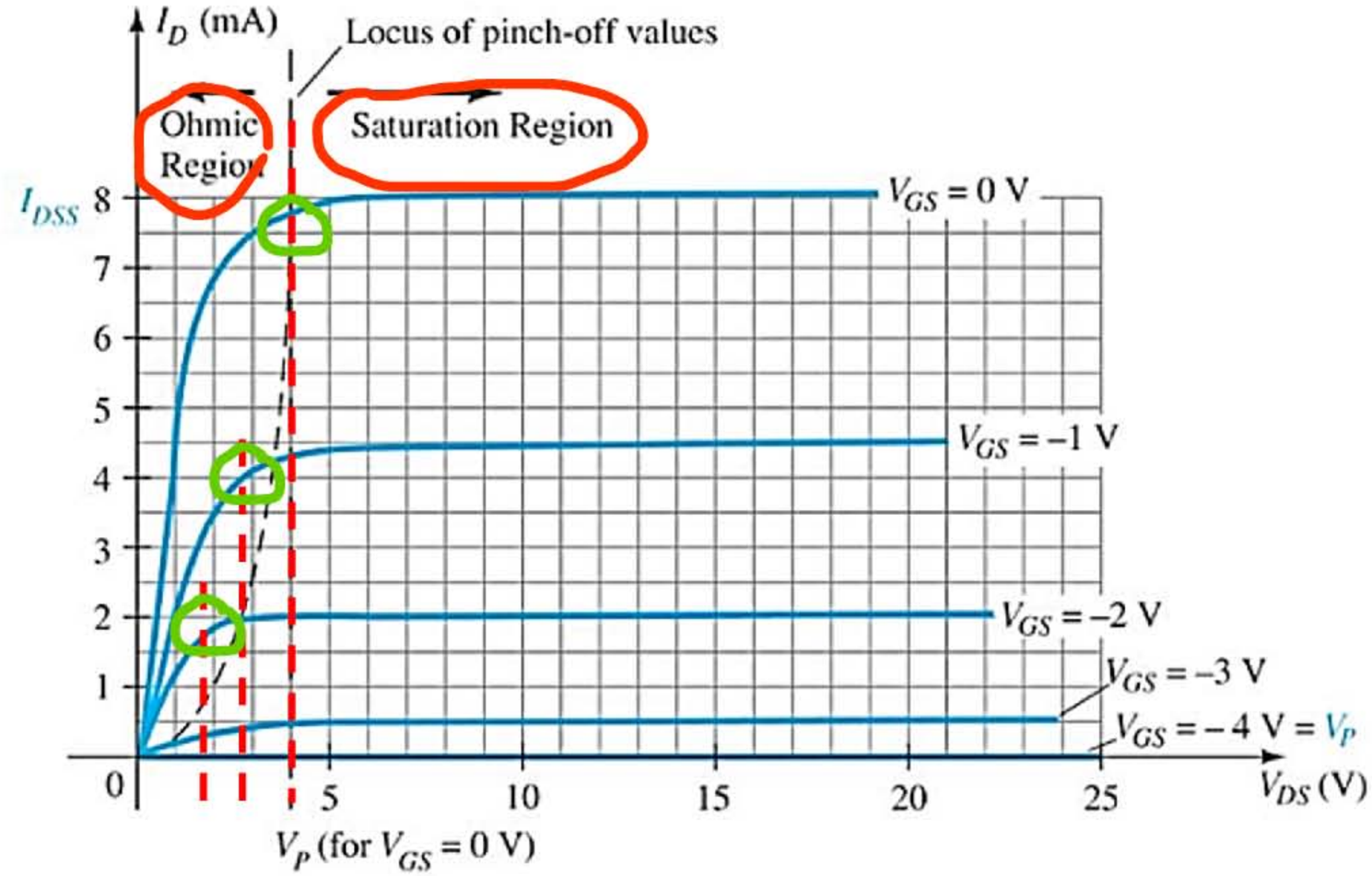
$V_{GS} < 0$ e $V_{DS} > 0$

O JFET se comporta como um resistor variável controlado pela tensão aplicada entre Gate e Source

$$R_{DS} = \frac{R_{DSOFF}}{\left(1 - \frac{V_{GS}}{V_{GSOFF}}\right)^2}$$



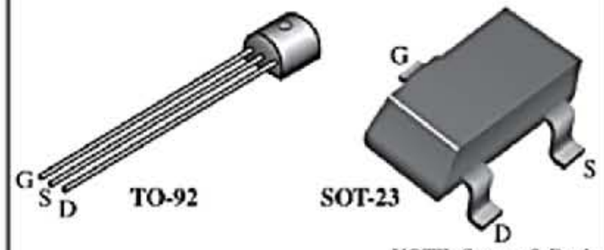
Note que o pinch-off ou seja V_{GSOFF} se desloca



Datasheet 2N5457 e MMBF5457

FAIRCHILD
SEMICONDUCTOR ™

2N5457 **MMBF5457**



NOTE: Source & Drain are interchangeable

N-Channel General Purpose Amplifier
This device is a low-level audio amplifier and switching transistor, and can be used for analog switching applications.

ABSOLUTE MAXIMUM RATINGS

Symbol	Parameter	Value	Units
V_{DS}	Drain-Source Voltage	25	V
V_{DG}	Drain-Gate Voltage	25	V
V_{GS}	Gate-Source Voltage	–25	V
I_{GF}	Forward Gate Current	10	mA
T_j, T_{stg}	Operating and Storage Junction Temperature Range	–55 to +150	°C

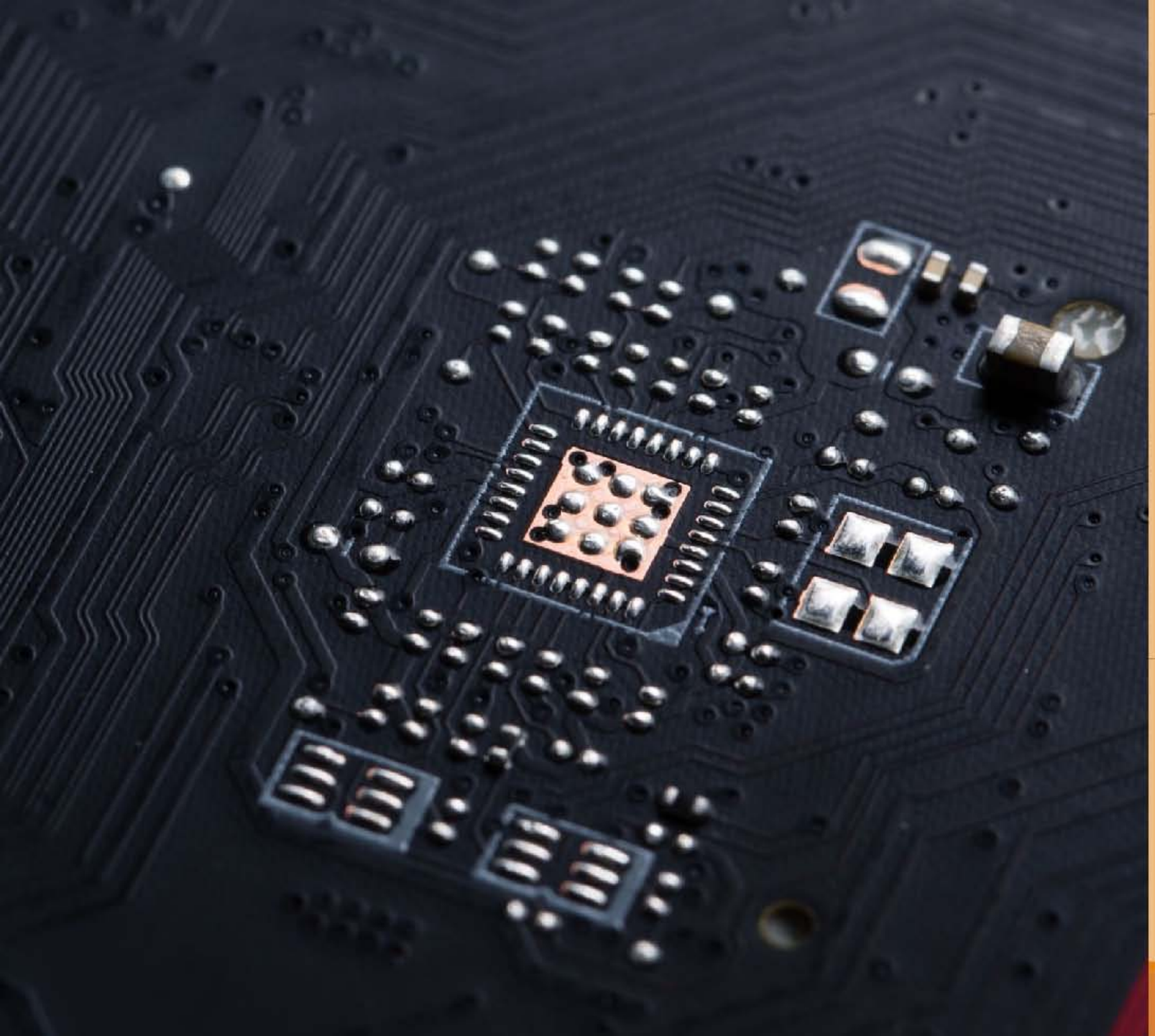
OFF CHARACTERISTICS

$V_{(BR)GSS}$	Gate-Source Breakdown Voltage	$I_G = 10\ \mu A$, $V_{DS} = 0$		–25			V
I_{GSS}	Gate Reverse Current	$V_{GS} = -15$ V, $V_{DS} = 0$ $V_{GS} = -15$ V, $V_{DS} = 0$, $T_A = 100°C$				–1.0 –200	nA nA
$V_{GS(off)}$	Gate-Source Cutoff Voltage	$V_{DS} = 15$ V, $I_D = 10$ nA	5457	–0.5		–6.0	V
V_{GS}	Gate-Source Voltage	$V_{DS} = 15$ V, $I_D = 100\ \mu A$	5457		–2.5		V

V_P

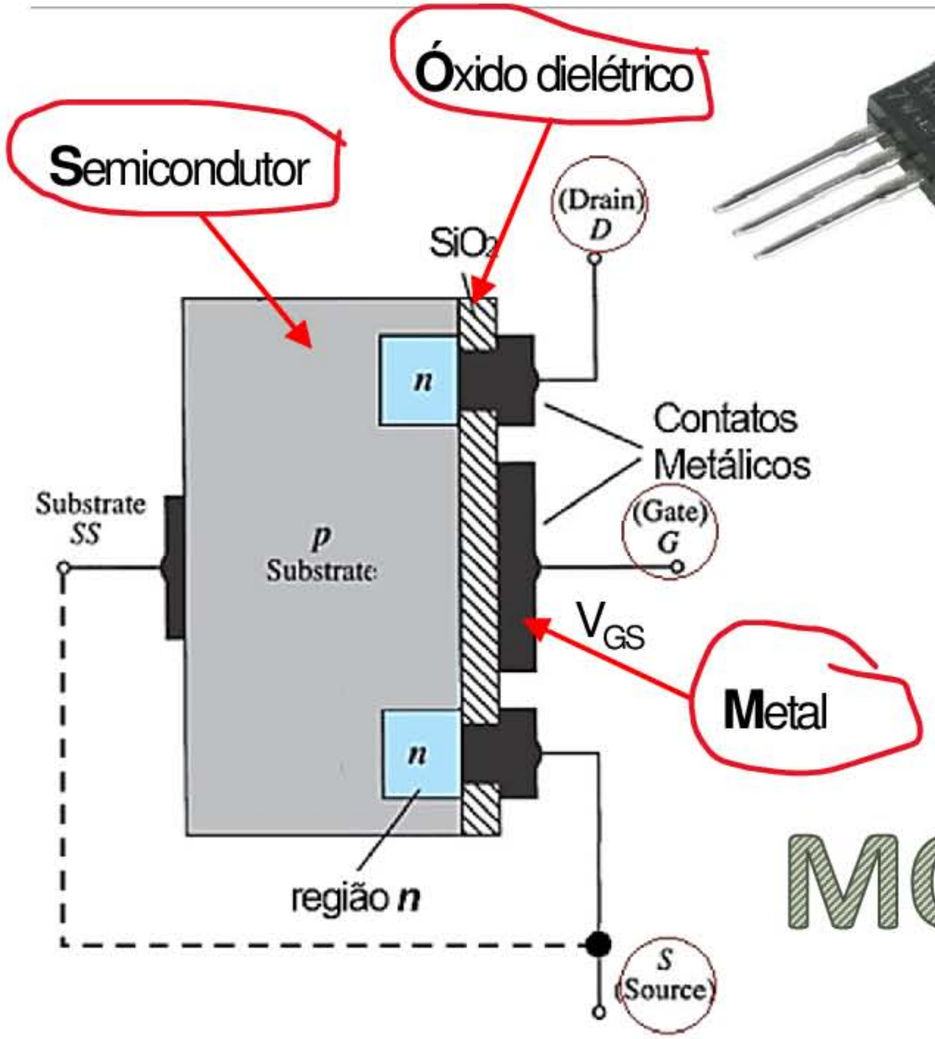
ON CHARACTERISTICS

I_{DSS}	Zero-Gate Voltage Drain Current	$V_{DS} = 15$ V, $V_{GS} = 0$	5457	1.0	3.0	5.0	mA



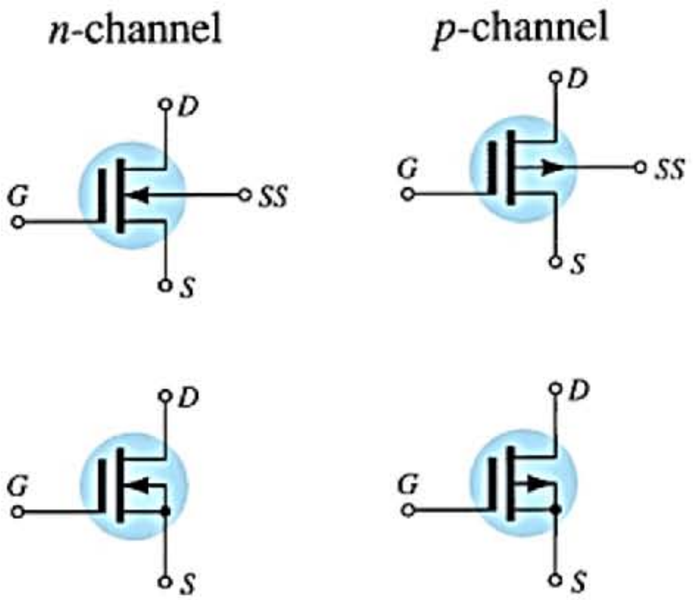
Transistor MOSFET

Características



MOSFET (Depletion) canal ***n***

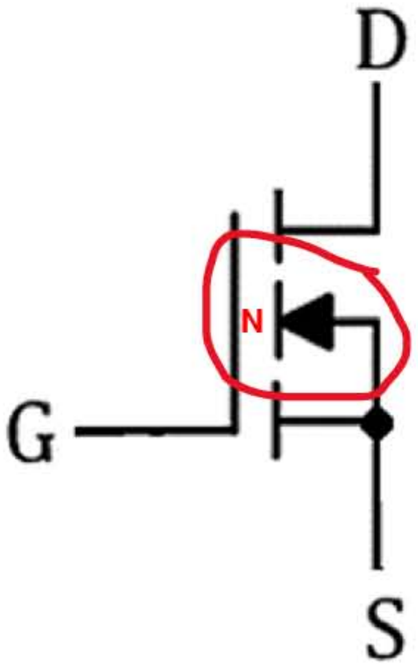
MOSFET (Depletion) canal ***p***



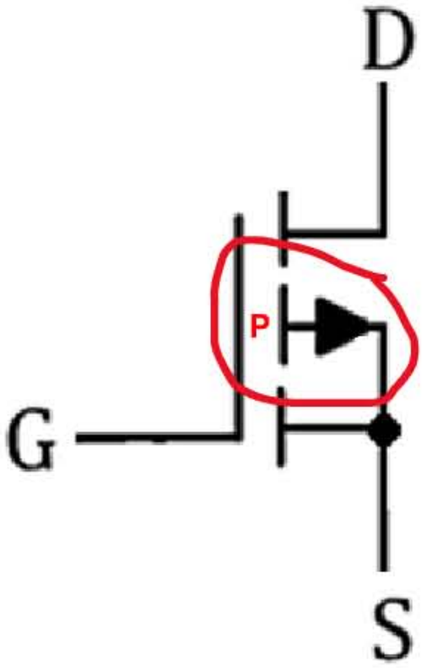
MOSFET

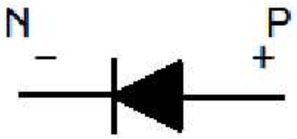
Sobre a simbologia

NMOS

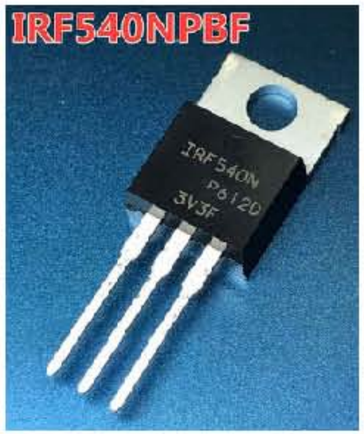


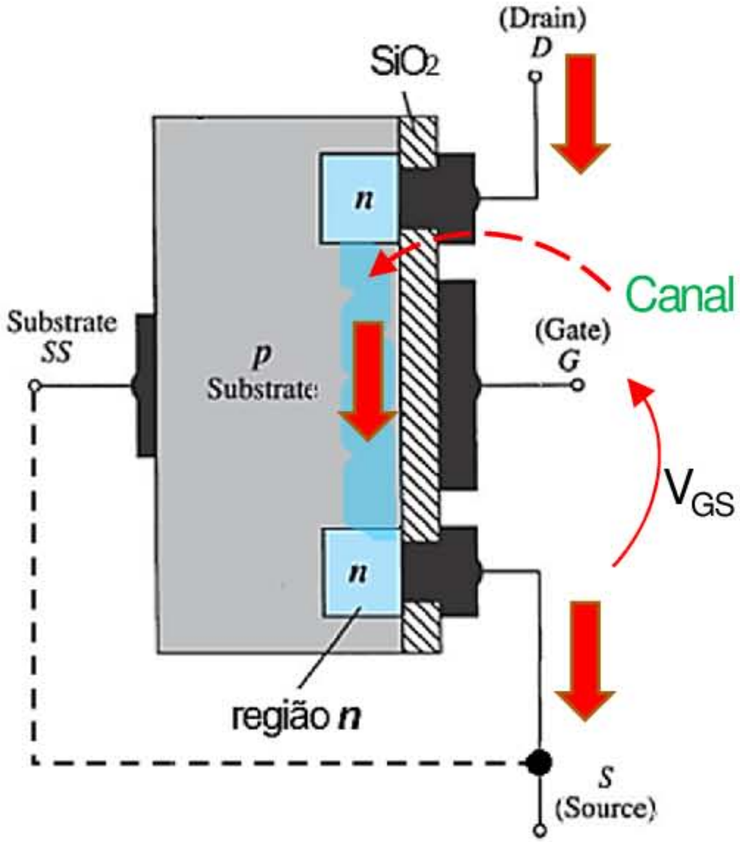
PMOS

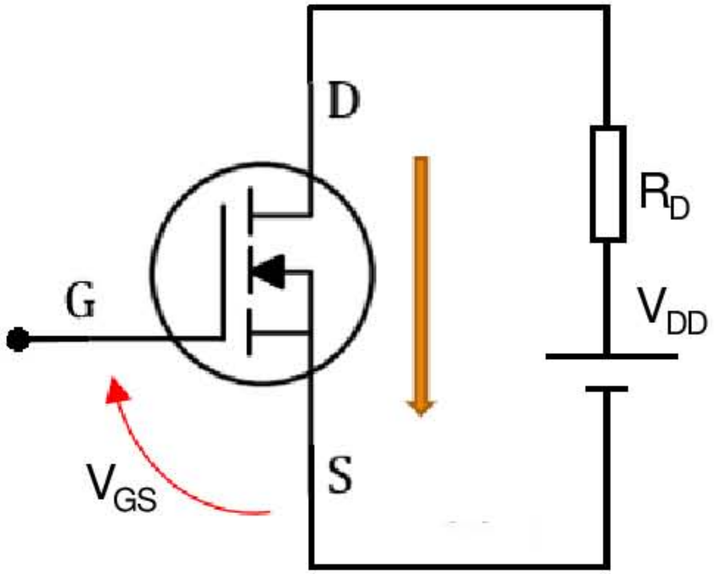




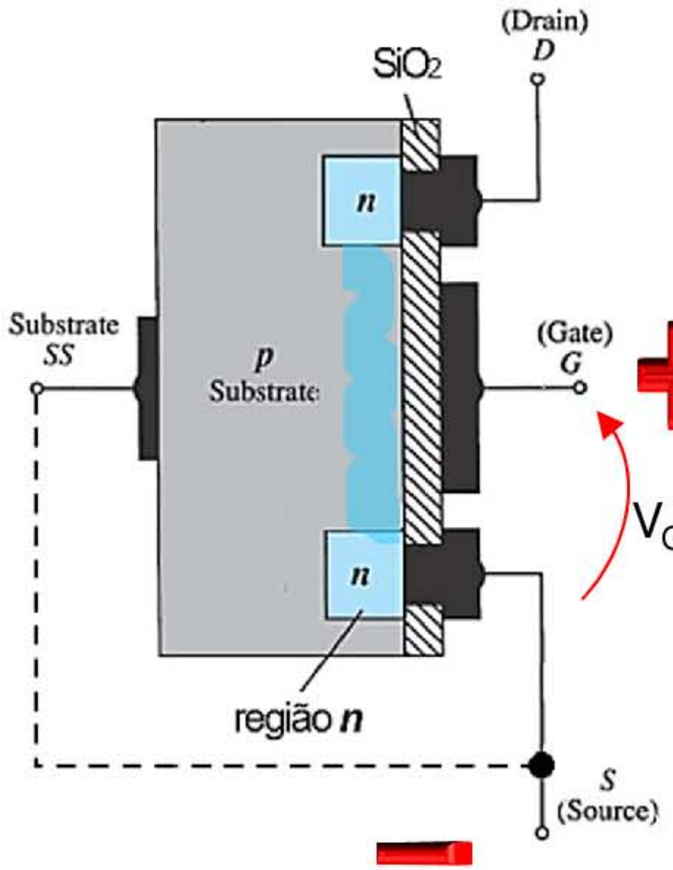
Entendendo

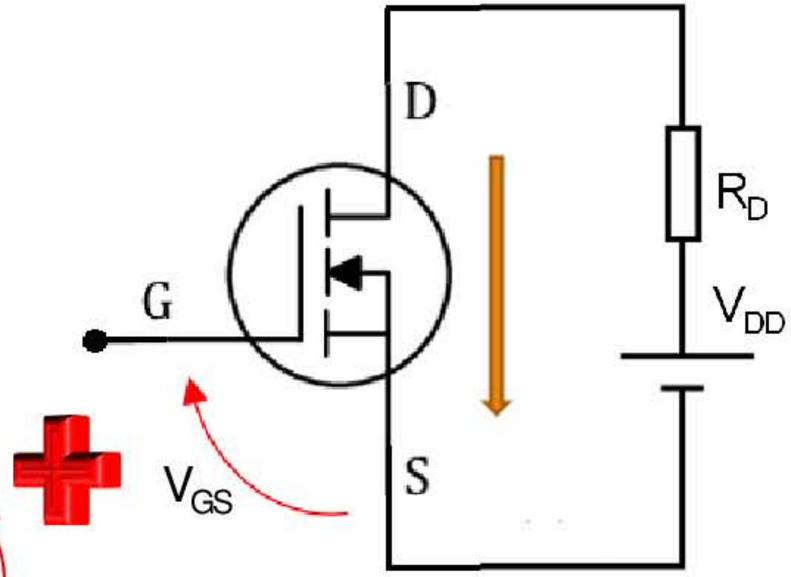

IRF540NPBF

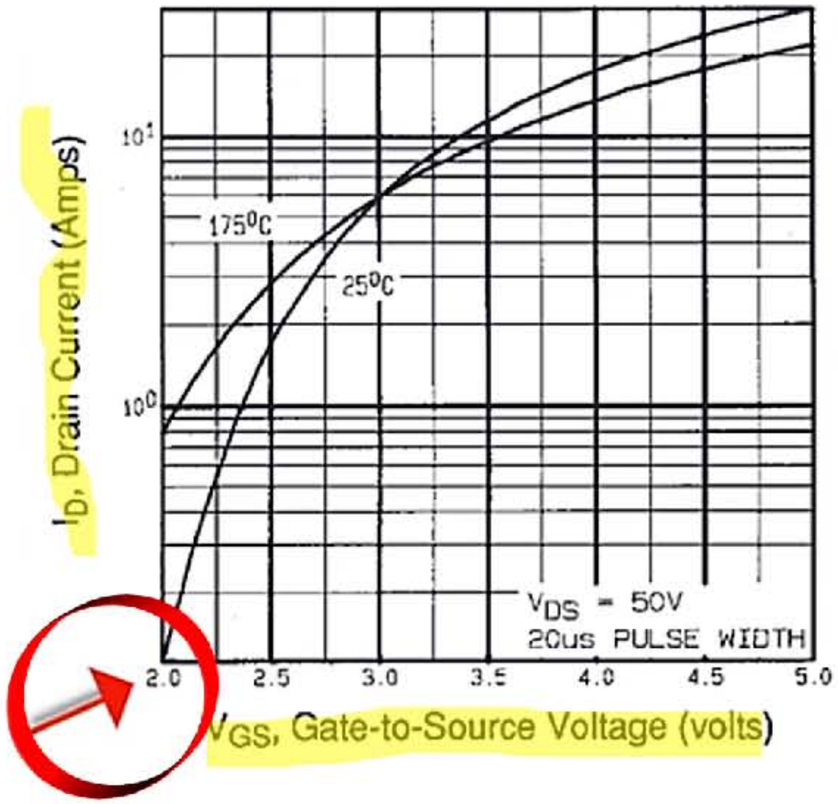

(Drain)
D
SiO2
n
Canal
Substrate
SS
p
Substrate
(Gate)
G
VGS
n
região n
S
(Source)


D
RD
G
VDD
VGS
S

Funcionamento





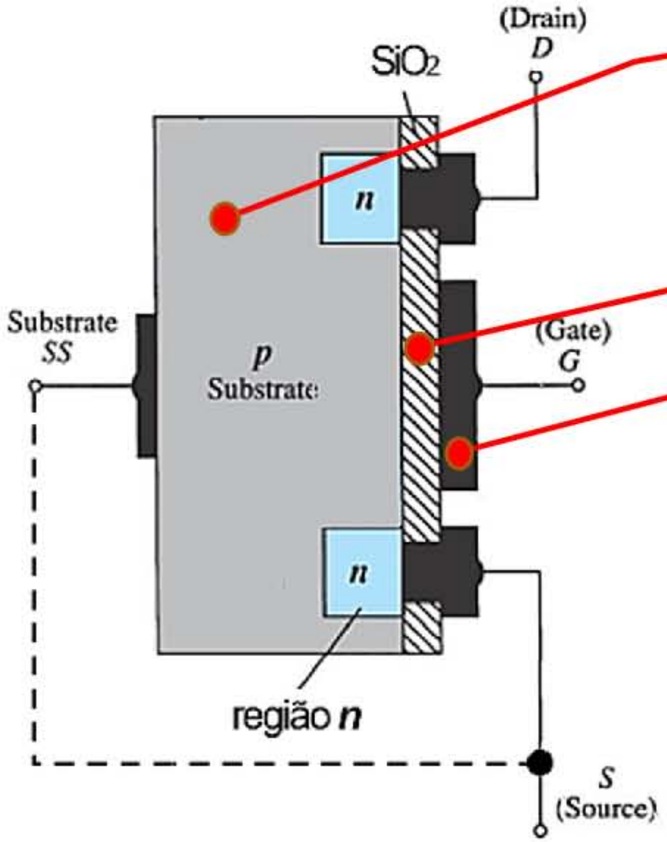


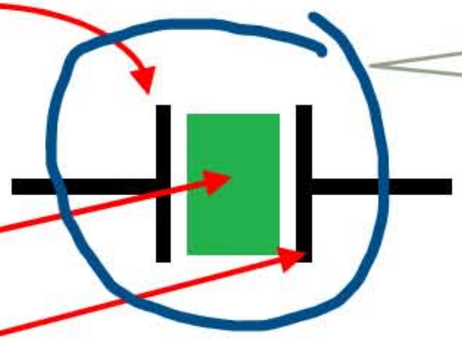
	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{GS(th)}$	Gate Threshold Voltage	2.0	—	4.0	V	$V_{DS} = V_{GS}$, $I_D = 250\mu A$

- Tensão Threshold é a mínima tensão segundo o qual o MOSFET inicia a condução

Capacitância

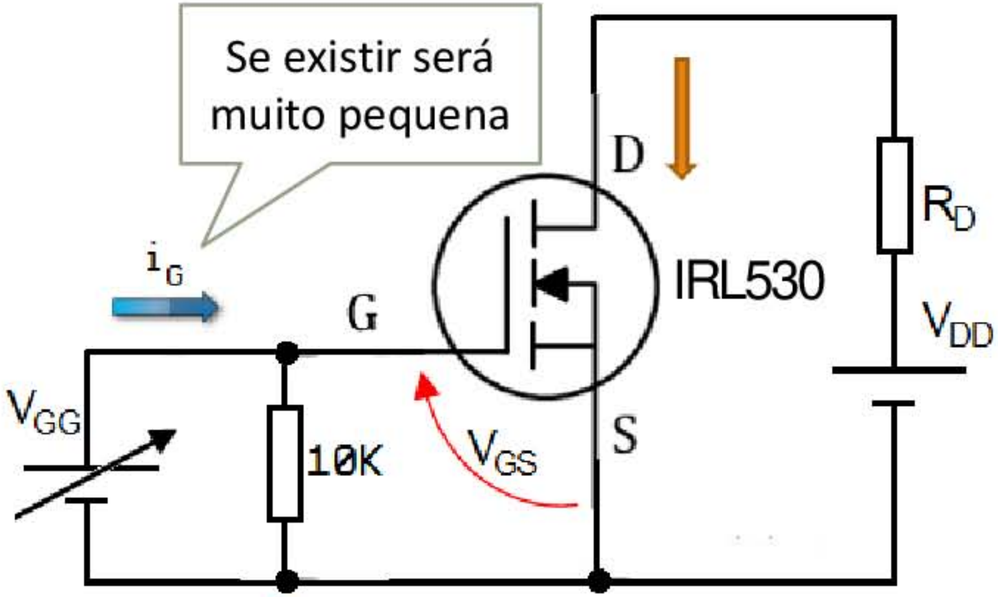
- Entre o Source e o Gate teremos uma capacitância formada por





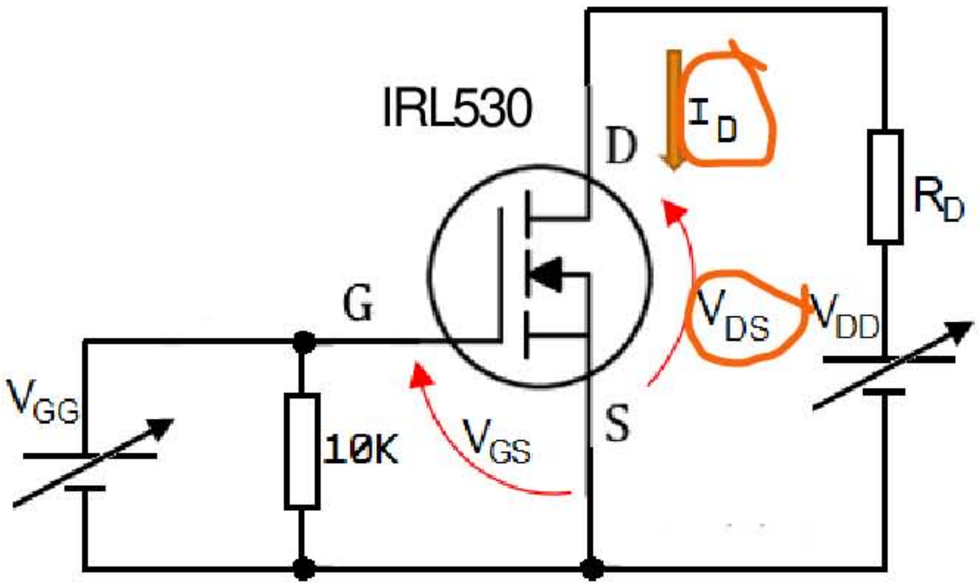
Devido a esta capacitância estrutural, em CC não haverá problema, mas em caso de algum sinal variável, teremos um sério problema com carga e descarga nas transições.

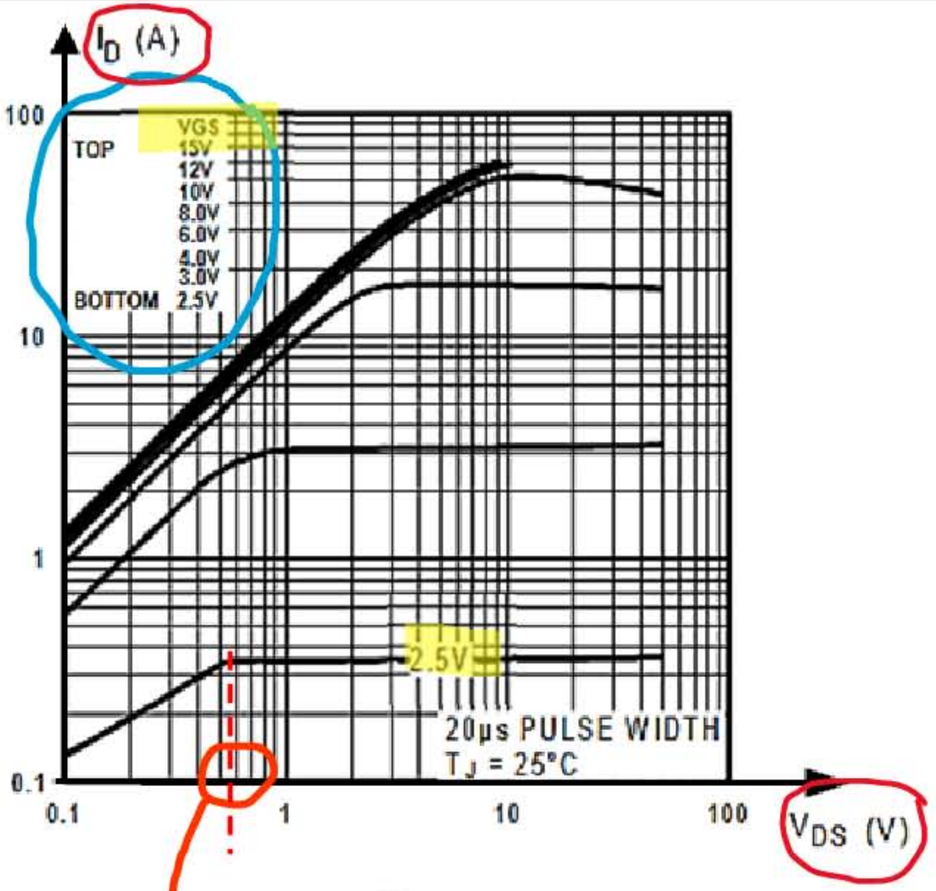
Se existir será muito pequena



Isto é indesejável e corrigível com a colocação de um resistor próximo de 10 KΩ

$I_D \times V_{DS}$

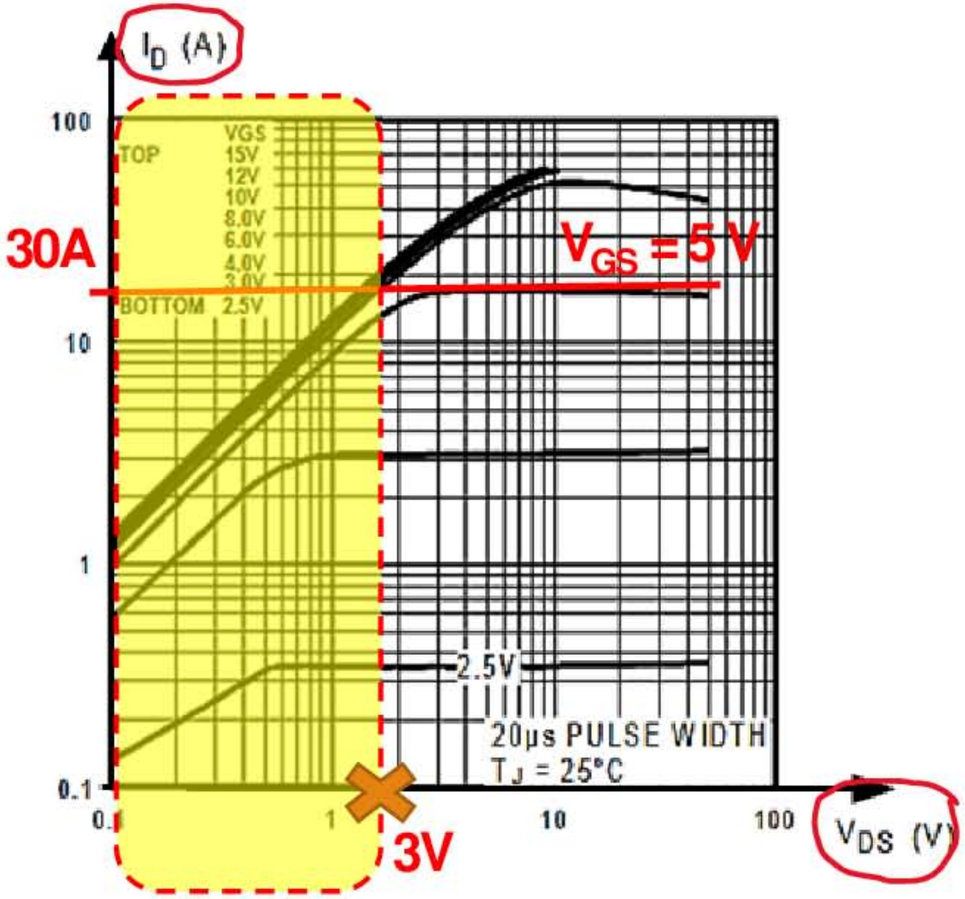




$V_{GS} - V_{TH}$

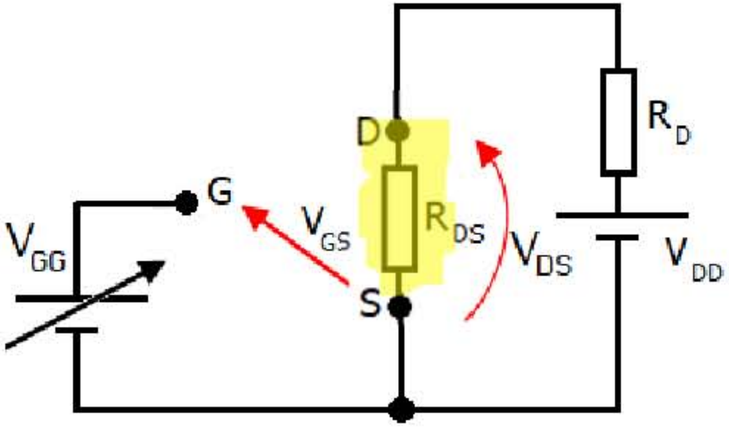
2 V
vem do datasheet

Resistência do canal R_{DS}



Zona linear puramente resistiva

$$R_{DS} = \frac{\Delta V_{DS}}{\Delta I_D} = \frac{3}{30} = 0.1\,\Omega$$



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

2V

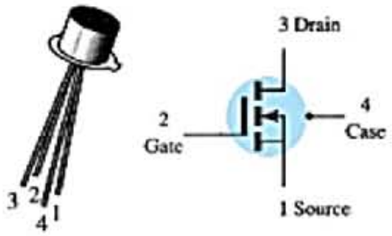
Detalhes

	Parameter	Min.	Typ.	Max.	Units	Conditions
$V_{(BR)DSS}$	Drain-to-Source Breakdown Voltage	100	—	—	V	V_{GS} = 0V, I_D = 250μA
$V_{GS(th)}$	Gate Threshold Voltage	1.0	—	2.0	V	V_{DS} = V_{GS}, I_D = 250μA
I_{GSS}	Gate-to-Source Forward Leakage	—	—	100	nA	V_{GS} = 16V
	Gate-to-Source Reverse Leakage	—	—	-100		V_{GS} = -16V
$R_{DS(on)}$	Static Drain-to-Source On-Resistance	—	—	0.100	Ω	V_{GS} = 10V, I_D = 9.0A ④
		—	—	0.120		V_{GS} = 5.0V, I_D = 9.0A ④
		—	—	0.150		V_{GS} = 4.0V, I_D = 8.0A ④

Datasheet 2N4351

2N4351

MOSFET SWITCHING



N-CHANNEL – ENHANCEMENT

MAXIMUM RATINGS

Rating	Symbol	Value	Unit
Drain–Source Voltage	V_{DS}	25	Vdc
Drain–Gate Voltage	V_{DG}	30	Vdc
Gate–Source Voltage*	V_{GS}	30	Vdc
Drain Current	I_D	30	mAdc
Total Device Dissipation @ $T_A = 25°C$ Derate above 25°C	P_D	300 1.7	mW mW/°C
Junction Temperature Range	T_J	175	°C
Storage Temperature Range	T_{stg}	–65 to +175	°C

* Transient potentials of ± 75 Volt will not cause gate-oxide failure.

ELECTRICAL CHARACTERISTICS ($T_A = 25°C$ unless otherwise noted.)

Characteristic	Symbol	Min	Max	Unit
OFF CHARACTERISTICS				
Drain-Source Breakdown Voltage ($I_D = 10\ \mu A$, $V_{GS} = 0$)	$V_{(BR)DSX}$	25	–	Vdc
Zero-Gate-Voltage Drain Current ($V_{DS} = 10$ V, $V_{GS} = 0$) $T_A = 25°C$ $T_A = 150°C$	I_{DSS}	– –	10 10	nAdc μAdc
Gate Reverse Current ($V_{GS} = \pm 15$ Vdc, $V_{DS} = 0$)	I_{GSS}	–	± 10	pAdc
ON CHARACTERISTICS				
Gate Threshold Voltage ($V_{DS} = 10$ V, $I_D = 10\ \mu A$)	$V_{GS(Th)}$	1.0	5	Vdc
Drain-Source On-Voltage ($I_D = 2.0$ mA, $V_{GS} = 10$V)	$V_{DS(on)}$	–	1.0	V
On-State Drain Current ($V_{GS} = 10$ V, $V_{DS} = 10$ V)	$I_{D(on)}$	3.0	–	mAdc

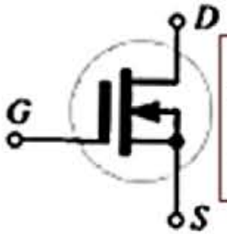
V_T

MOSFET

Depletion

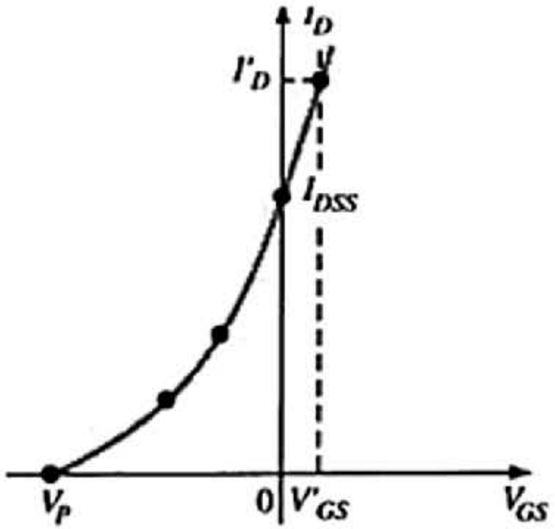
V_{GS} baixo e $V_P < 0$

$$I_G = 0, I_D = I_S$$



I_{DSS}
V_P

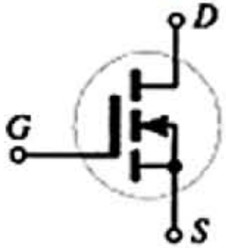
$$I_D = I_{DSS}\left(1 - \frac{V_{GS}}{V_P}\right)^2$$



Enhenced

V_{GS} alto e $V_P > 0$

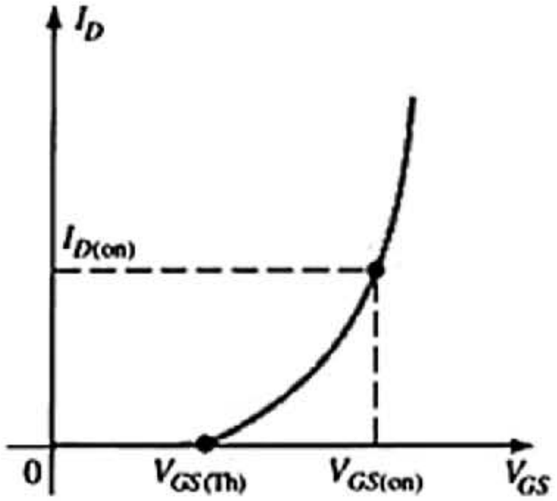
$$I_G = 0, I_D = I_S$$



V_T
$I_{D(on)}$
V_{GSTH}

$$I_D = k(V_{GS} - V_{GSTH})^2$$

$$k = \frac{I_{D(on)}}{(V_{GS} - V_{GSTH})^2}$$



Referências bibliográficas

- Cadenas, A. ; "Como o MOSFET funciona de forma muito fácil e detalhada (Classe 52)", Canal do Youtube acesso em 18/04/2023

- Melo, Emerson G. ; "LOM3206 – ELETRÔNICA AULA 5"; Departamento de Engenharia de Materiais - Polo Urbo-Industrial, Gleba AI-6, Loren

Até a próxima !