# TE 046
# DISPOSITIVOS ELETRÔNICOS

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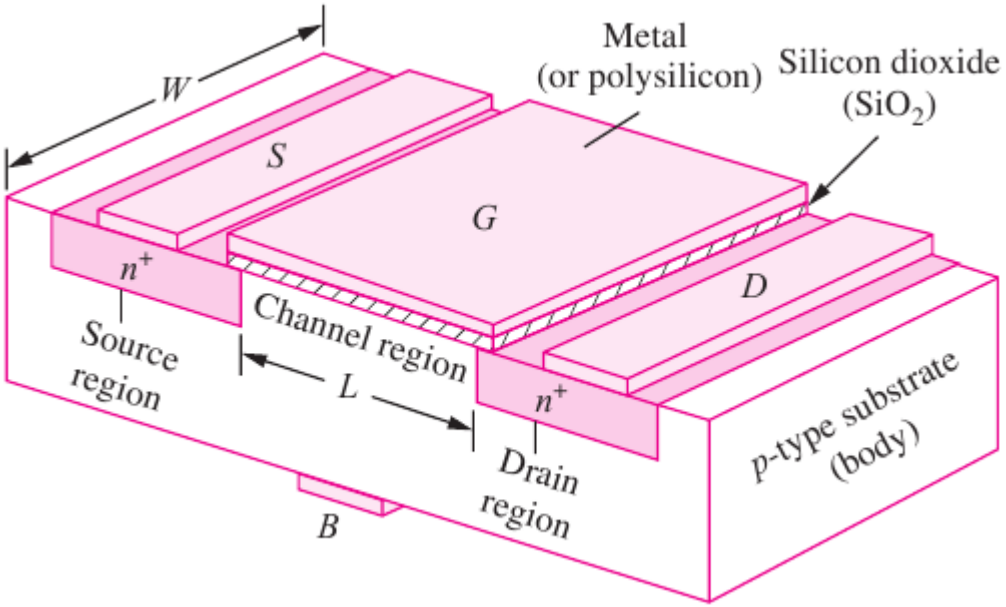
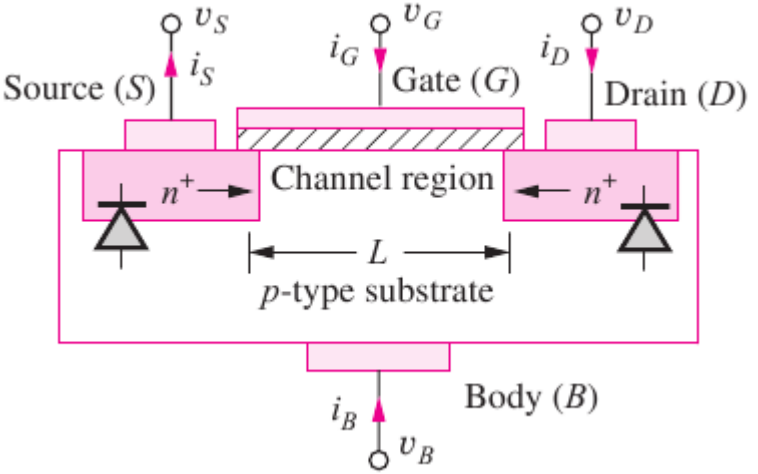
# CAPÍTULO 6 - TRANSISTOR DE EFEITO DE CAMPO MOS

## 5.1 ESTRUTURA FÍSICA DO TRANSISTOR MOS




Desenho esquemático do MOSFET canal n



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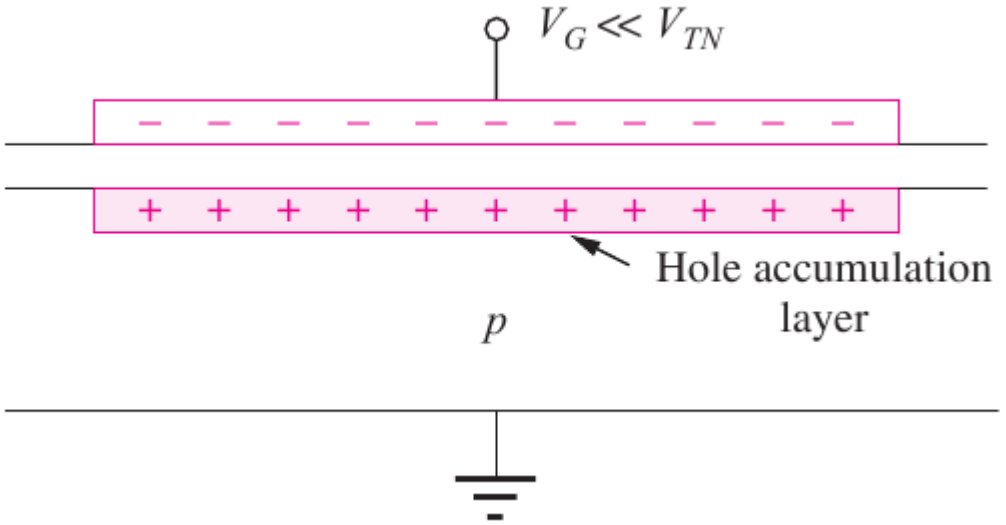
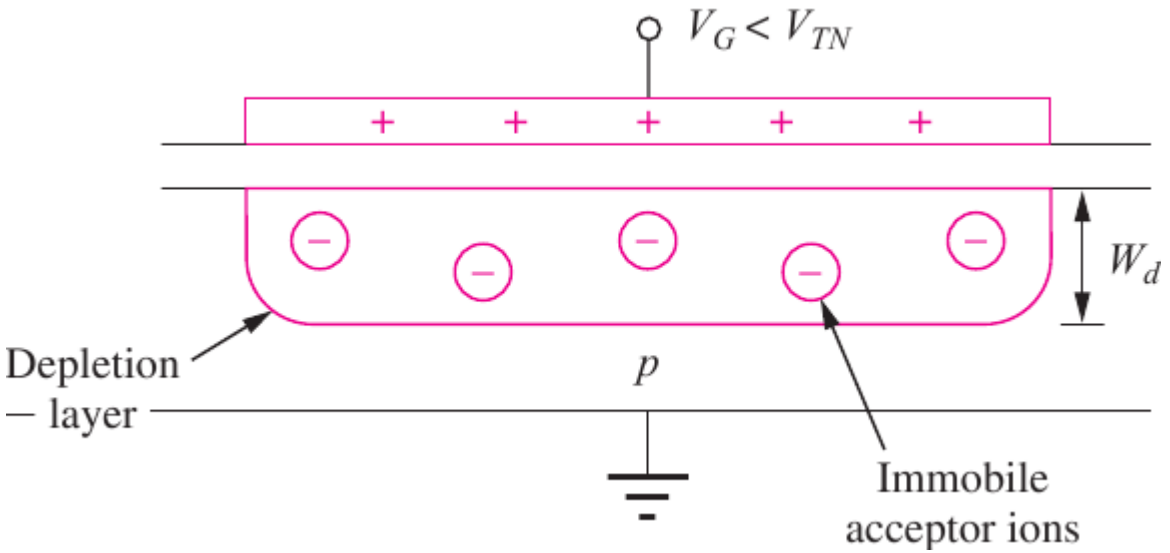
# 5.2 OPERAÇÃO DO TRANSISTOR MOS

## 5.2.1 O Capacitor MOS

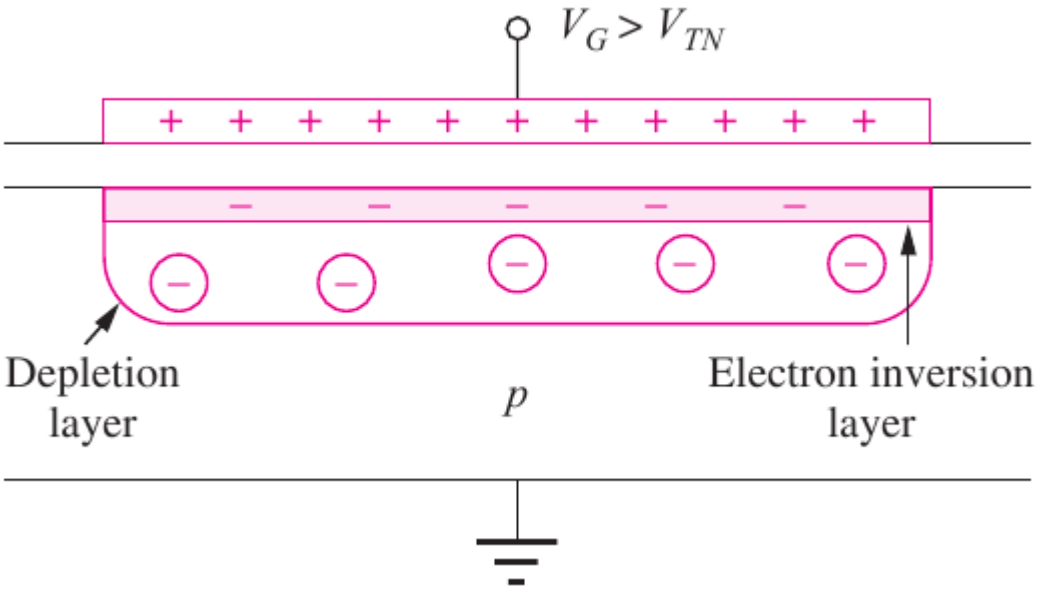
### Acumulação



# Depleção

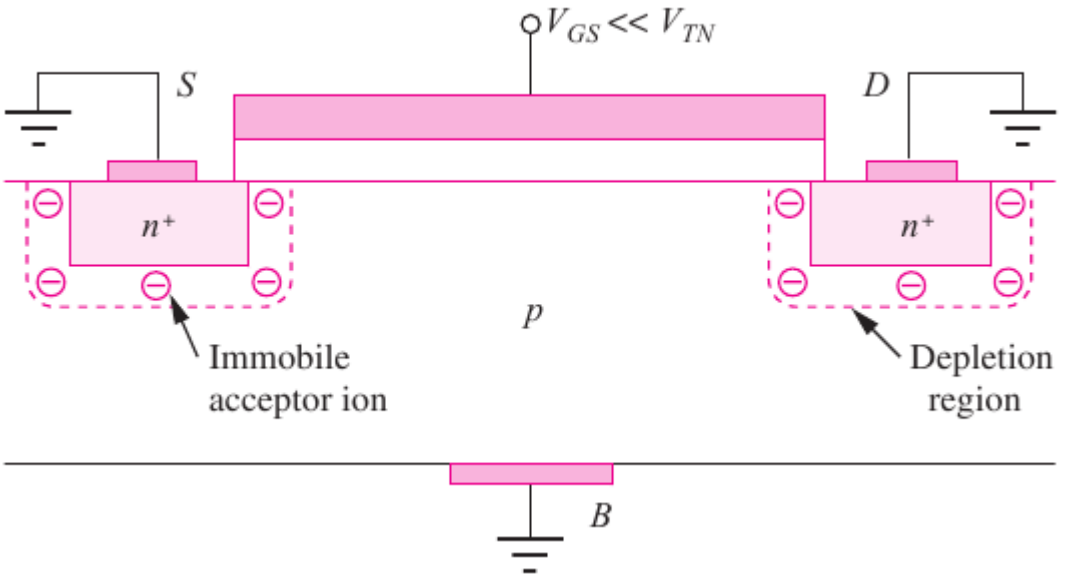


# Inversão



## 5.2.2 Análise Qualitativa do Transistor MOS

### Acumulação



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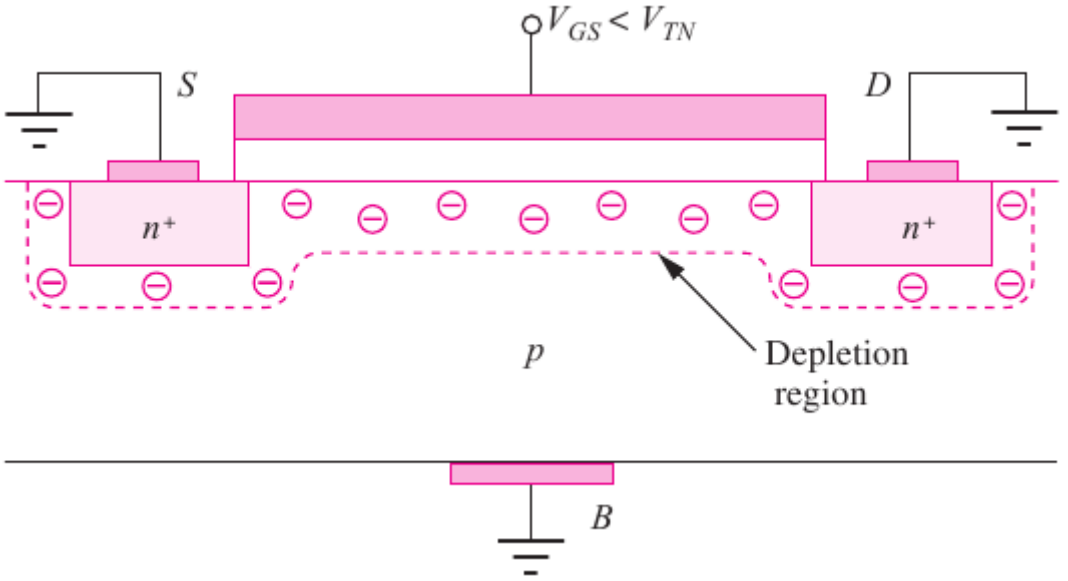
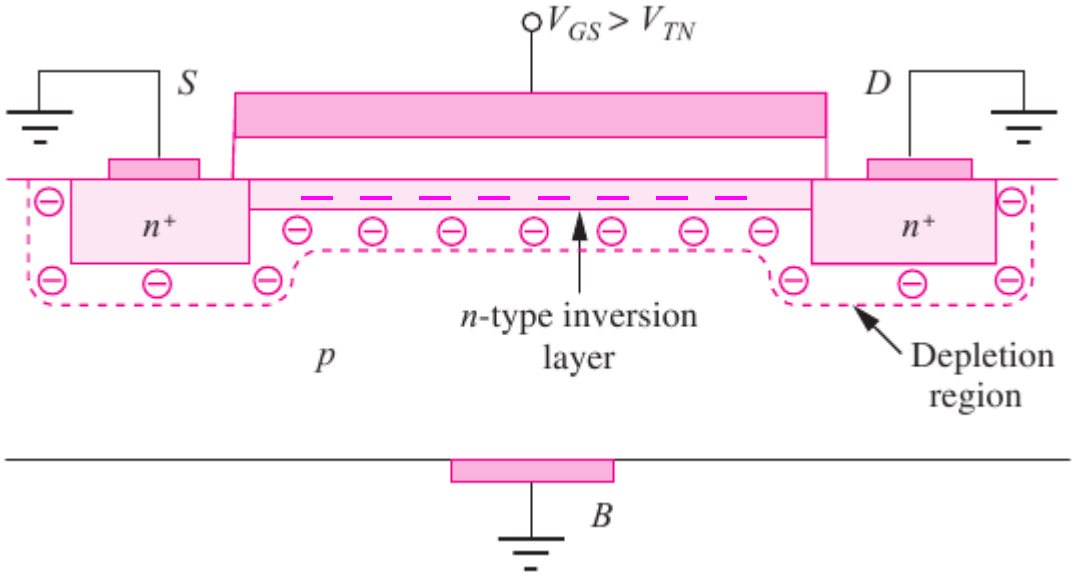
# Depleção



# Inversão



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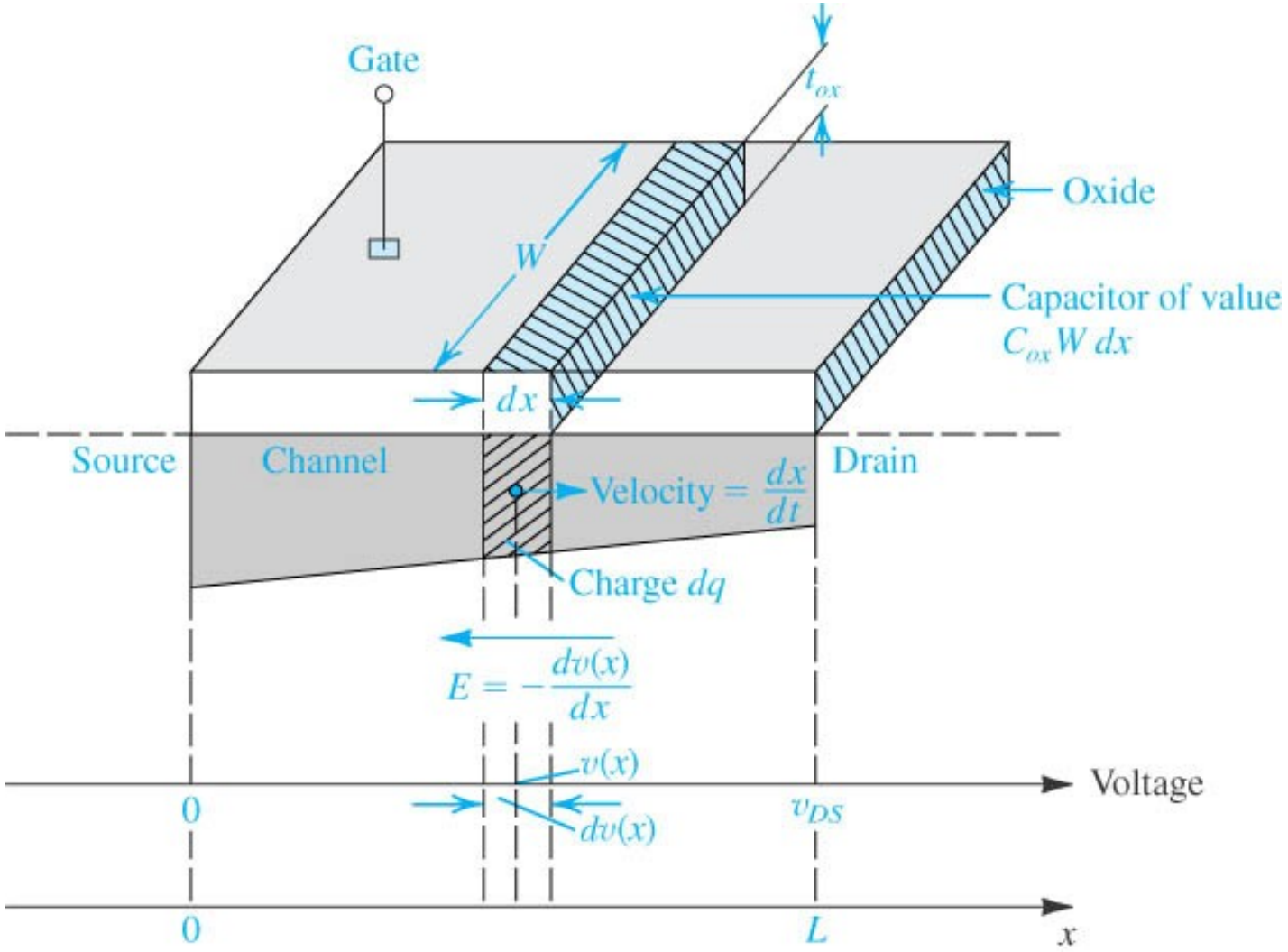
# 5.3 DETERMINAÇÃO DA CARACTERÍSTICA I-V DO MOSFET



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Exemplo: Considere um processo de fabricação MOS no qual $L_{min} = 0{,}18$ μm, $\mu_n = 440$ cm$^2$/V.s e $V_T = 0{,}35$ V.

a) Para um MOSFET de W/L = 2 μm/0,2 μm calcule $V_{GS}$ e $V_{DSmmin}$ para operar o transistor na saturação com uma corrente de 25 μA.

b) Para o dispositivo em a) ache o valor de $V_{GS}$ necessário para operar o dispositivo como um resistor de 1000 Ω, para $V_{DS}$ muito pequeno.



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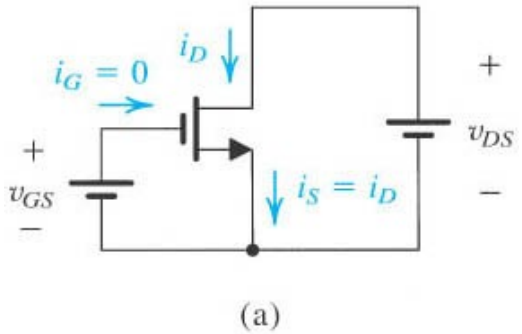
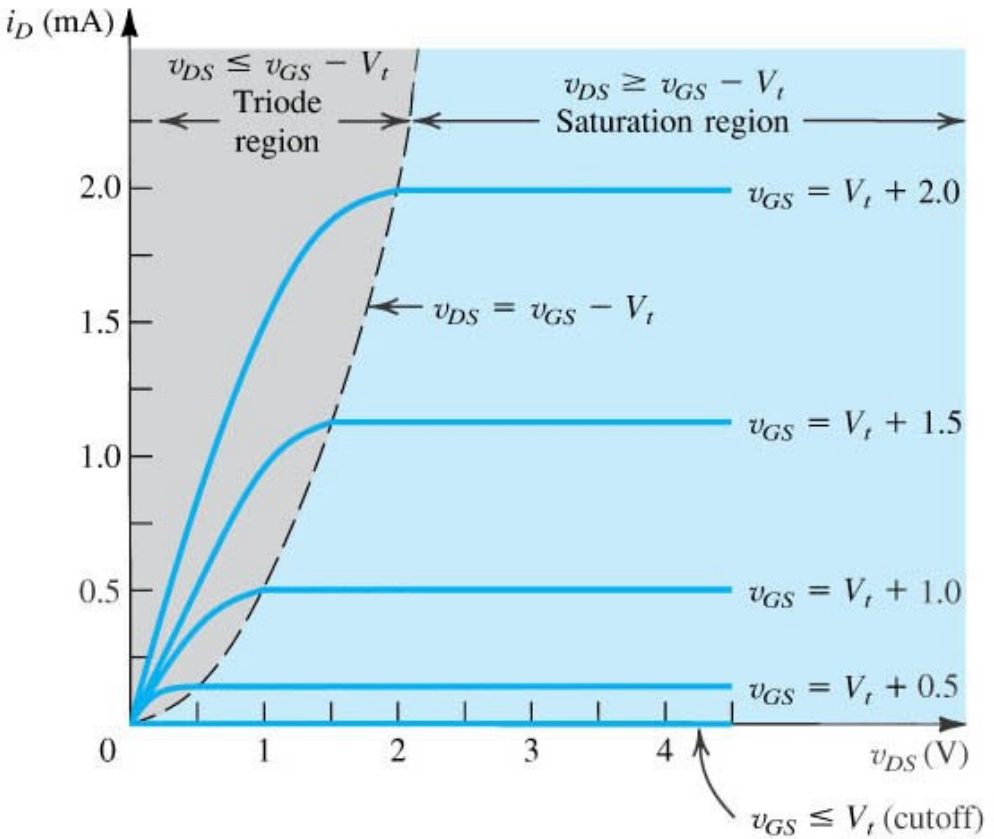
# 5.3.1 Característica $I_D$ - $V_{DS}$

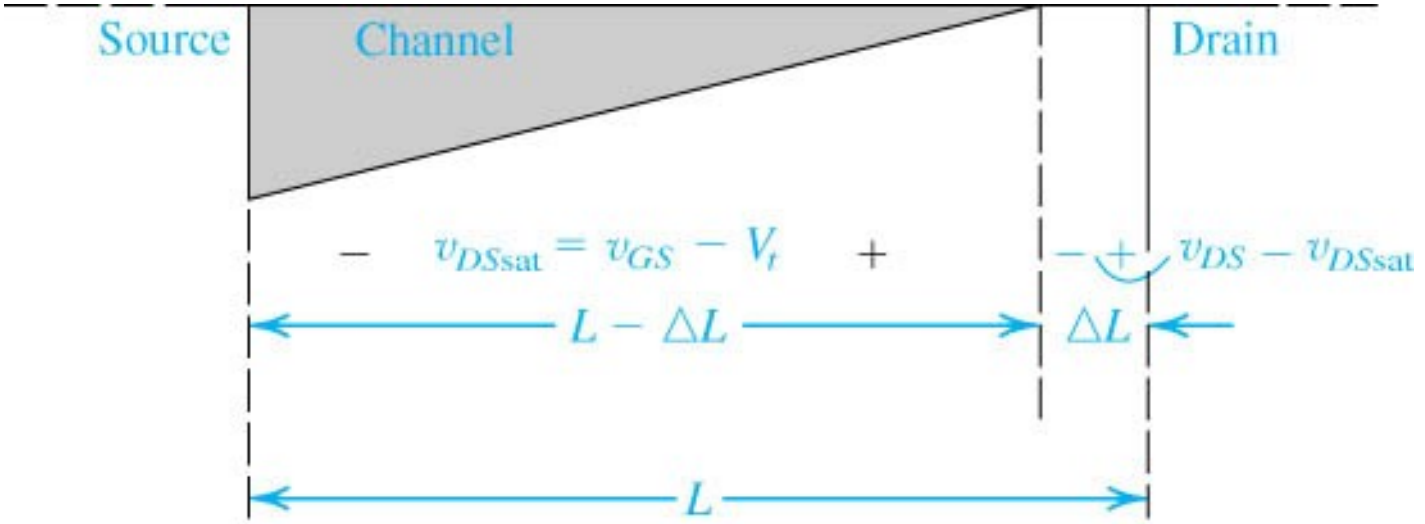


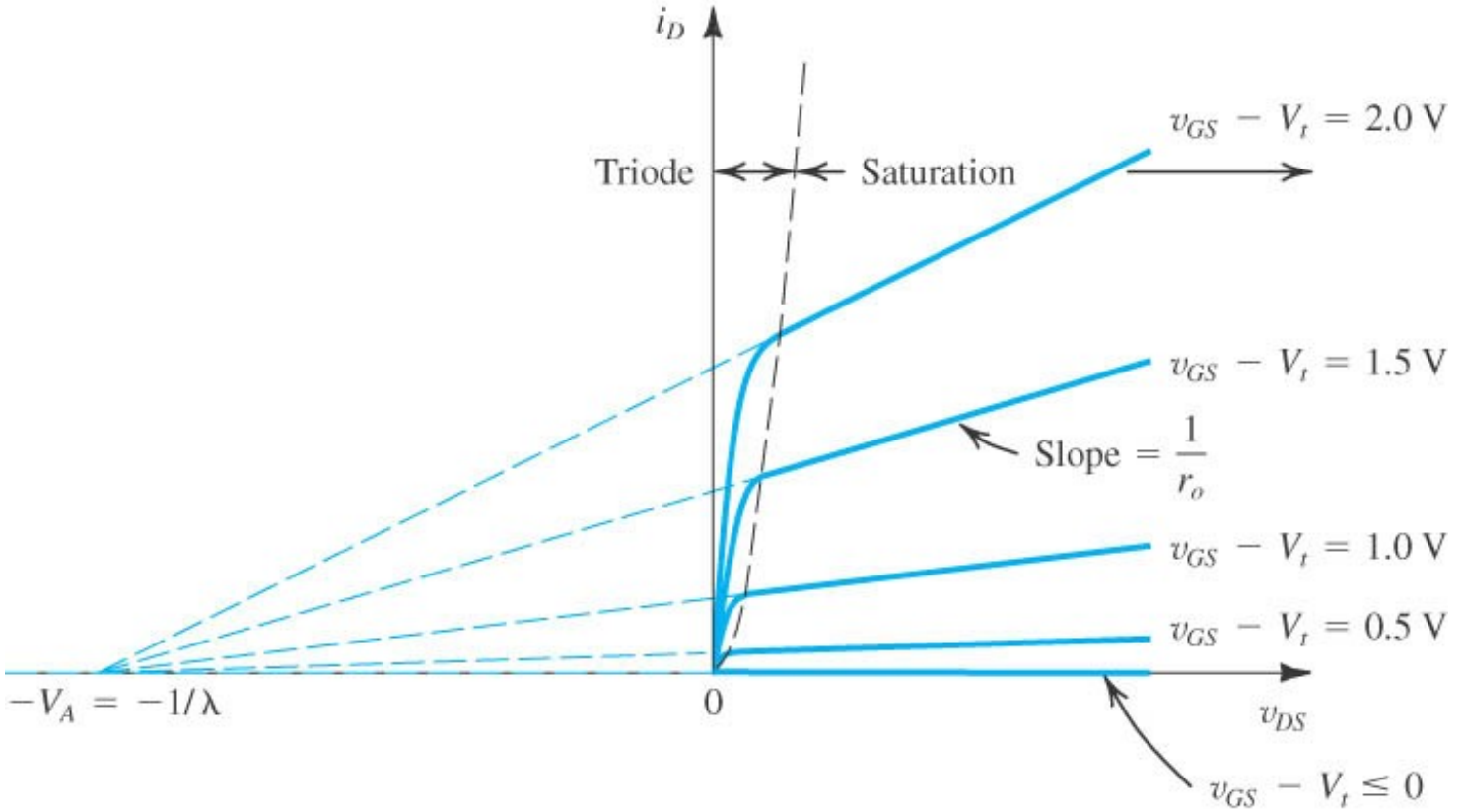

(a)




(b)

## 5.3.2 Característica de saída na saturação (modulação do comprimento do canal)




$i_D$
Triode
Saturation
$v_{GS} - V_t = 2.0$ V
$v_{GS} - V_t = 1.5$ V
Slope $= \frac{1}{r_o}$
$v_{GS} - V_t = 1.0$ V
$v_{GS} - V_t = 0.5$ V
$-V_A = -1/\lambda$
0
$v_{DS}$
$v_{GS} - V_t \leq 0$



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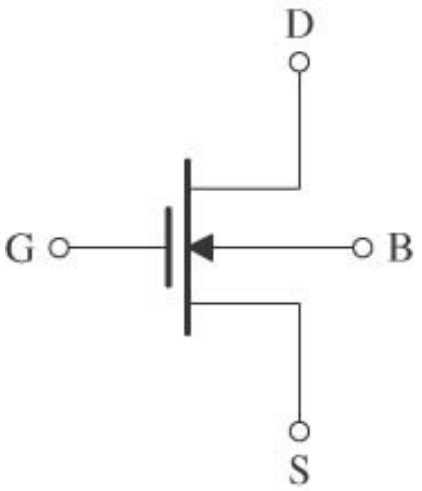
# Resumo e Simbologia

## Região triodo

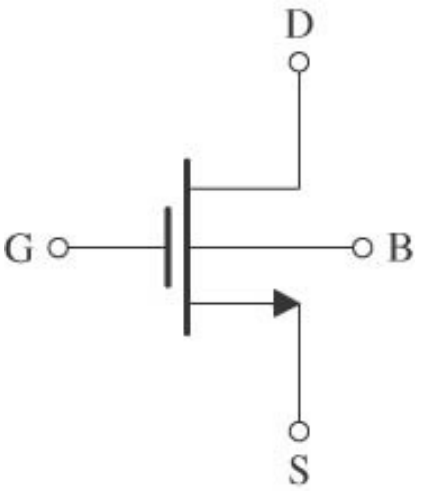
$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}\left[(v_{GS}-V_{Tn})v_{DS}-\frac{1}{2}v_{DS}^{\,2}\right]$$

## Saturação

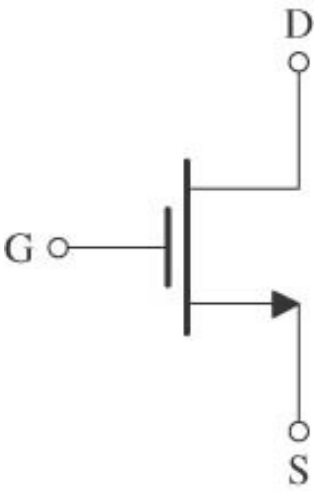
$$i_D = \frac{1}{2}\mu_n C_{ox}\frac{W}{L}(v_{GS}-V_{Tn})^2$$



(a)



(b)



(c)



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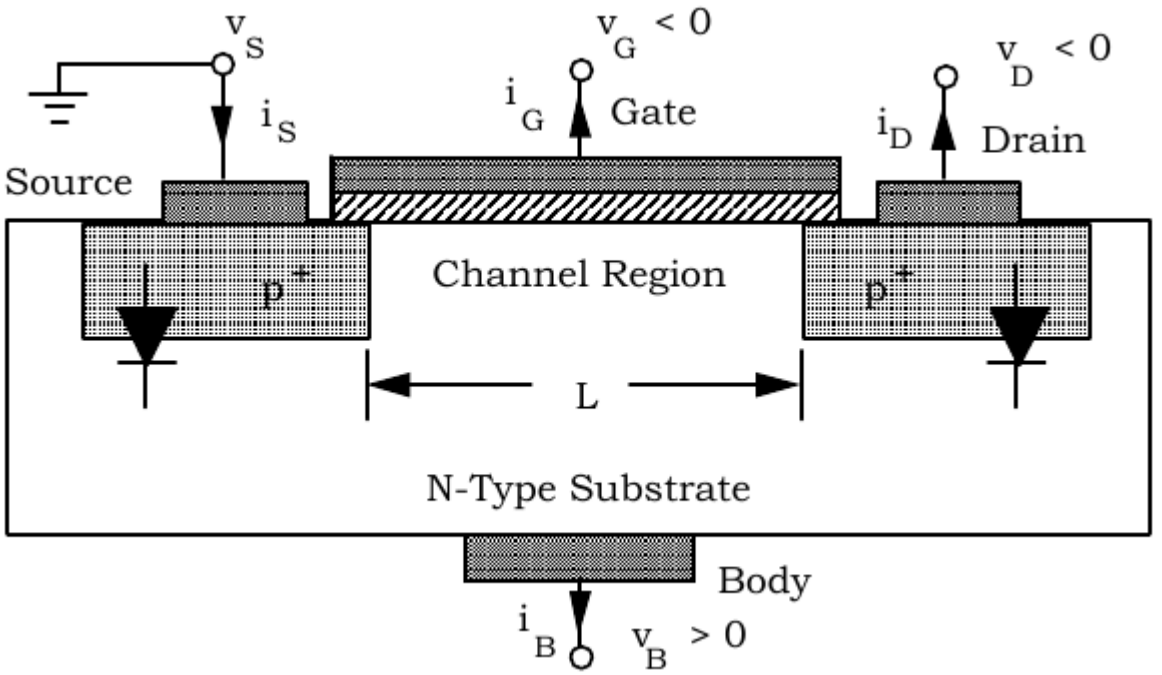
# 5.4 TRANSISTOR PMOS



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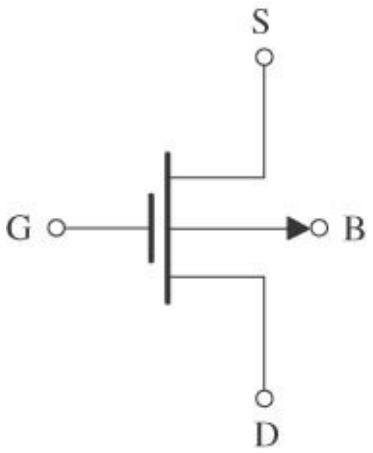
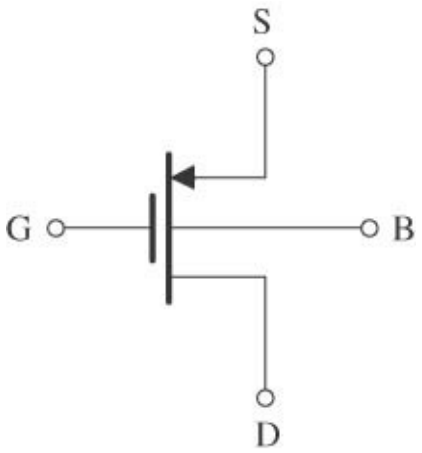
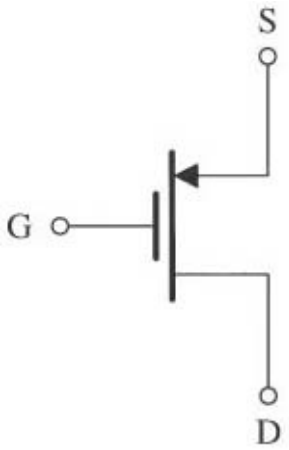
# Resumo e Simbologia



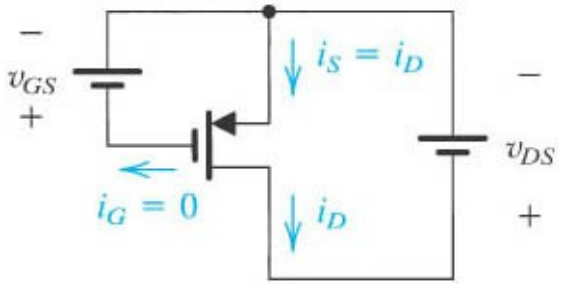
(a)



(b)



(c)



(d)

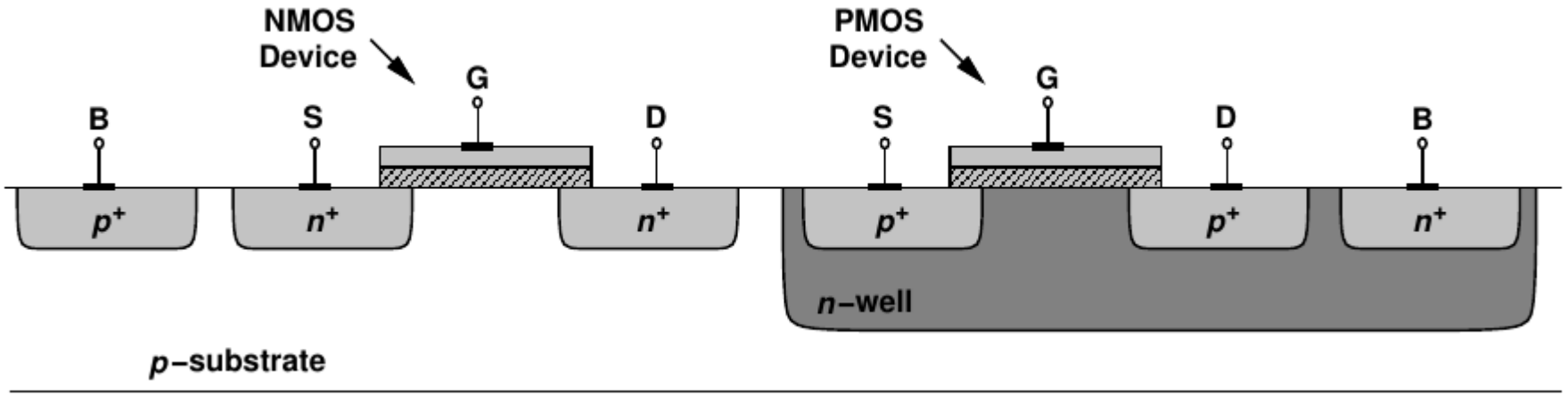
## Região triodo

$$i_D = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}\left[(v_{GS} - V_{Tp})v_{DS} - \frac{1}{2}v_{DS}^2\right]$$

## Saturação

$$i_D = \frac{1}{2}\mu_p C_{ox}\frac{W}{L}(v_{GS} - V_{Tp})^2$$

# 5.5 TECNOLOGIA CMOS



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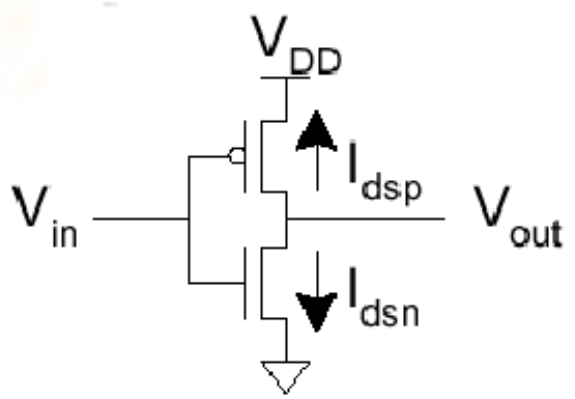
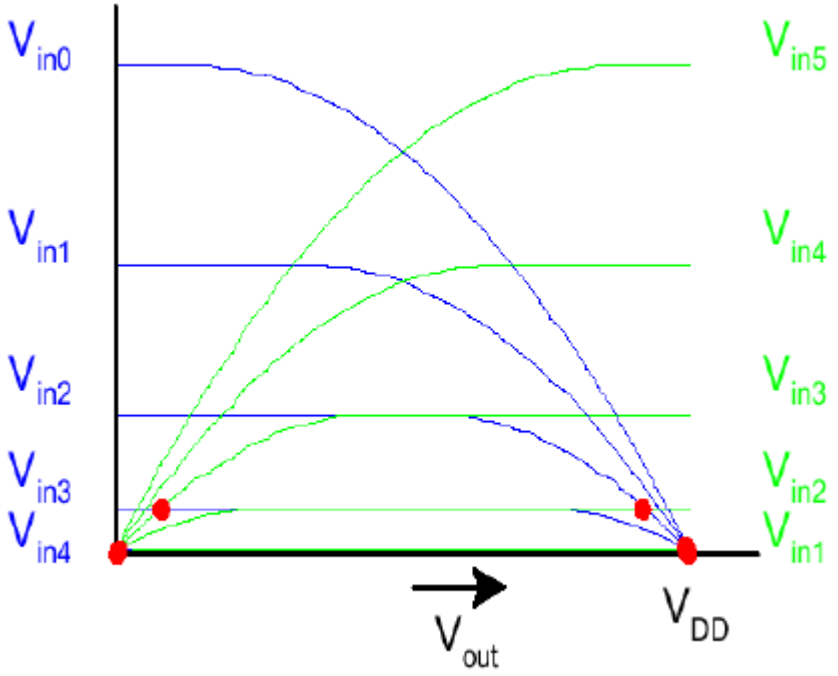
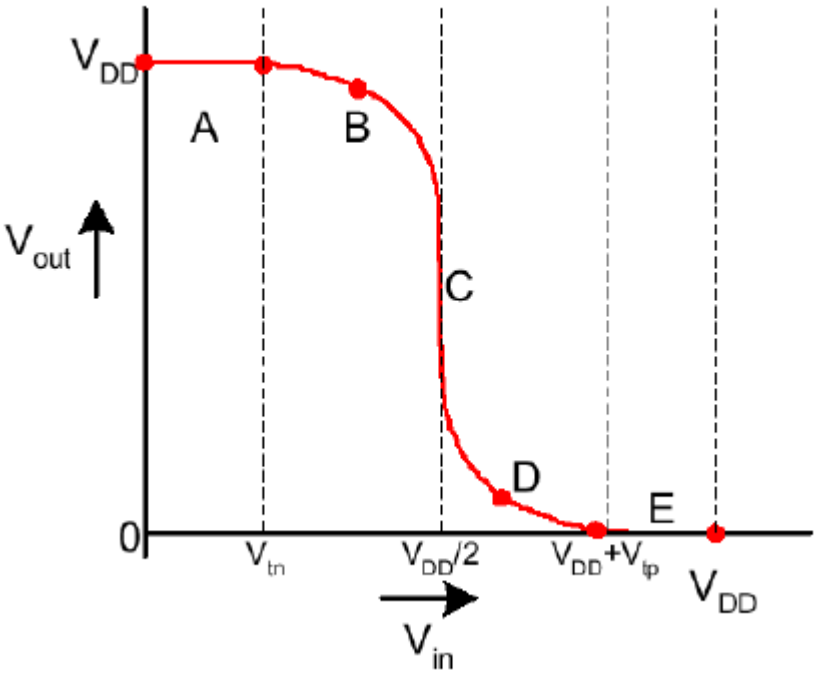
# 5.6 INVERSOR LÓGICO CMOS

## CARACTERÍSTICA DE TRANSFERÊNCIA DC

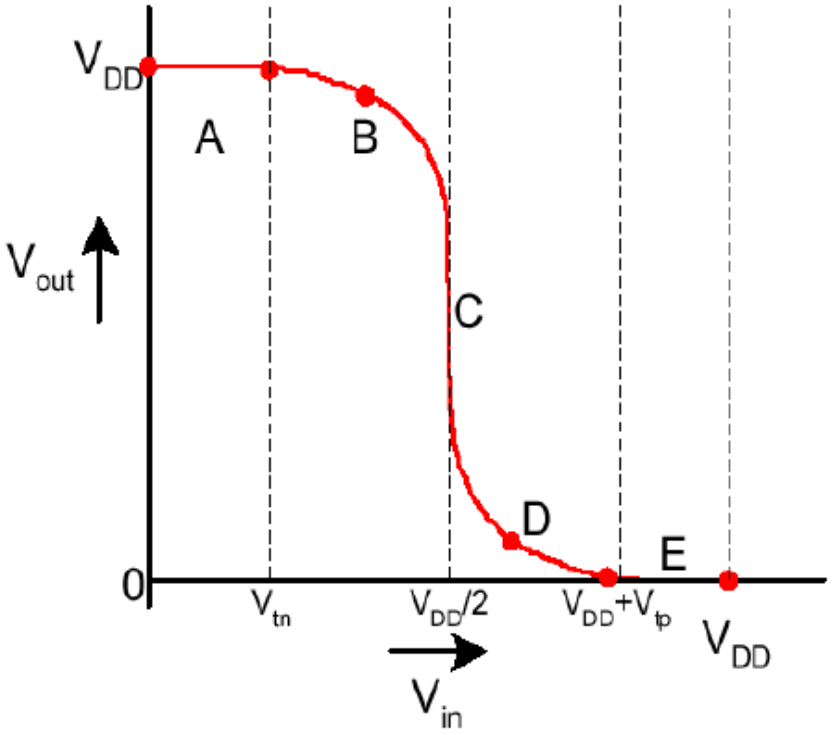


# REGIÕES DE OPERAÇÃO

| Region | nMOS | pMOS |
|---|---|---|
| A | Cutoff | Linear |
| B | Saturation | Linear |
| C | Saturation | Saturation |
| D | Linear | Saturation |
| E | Linear | Cutoff |



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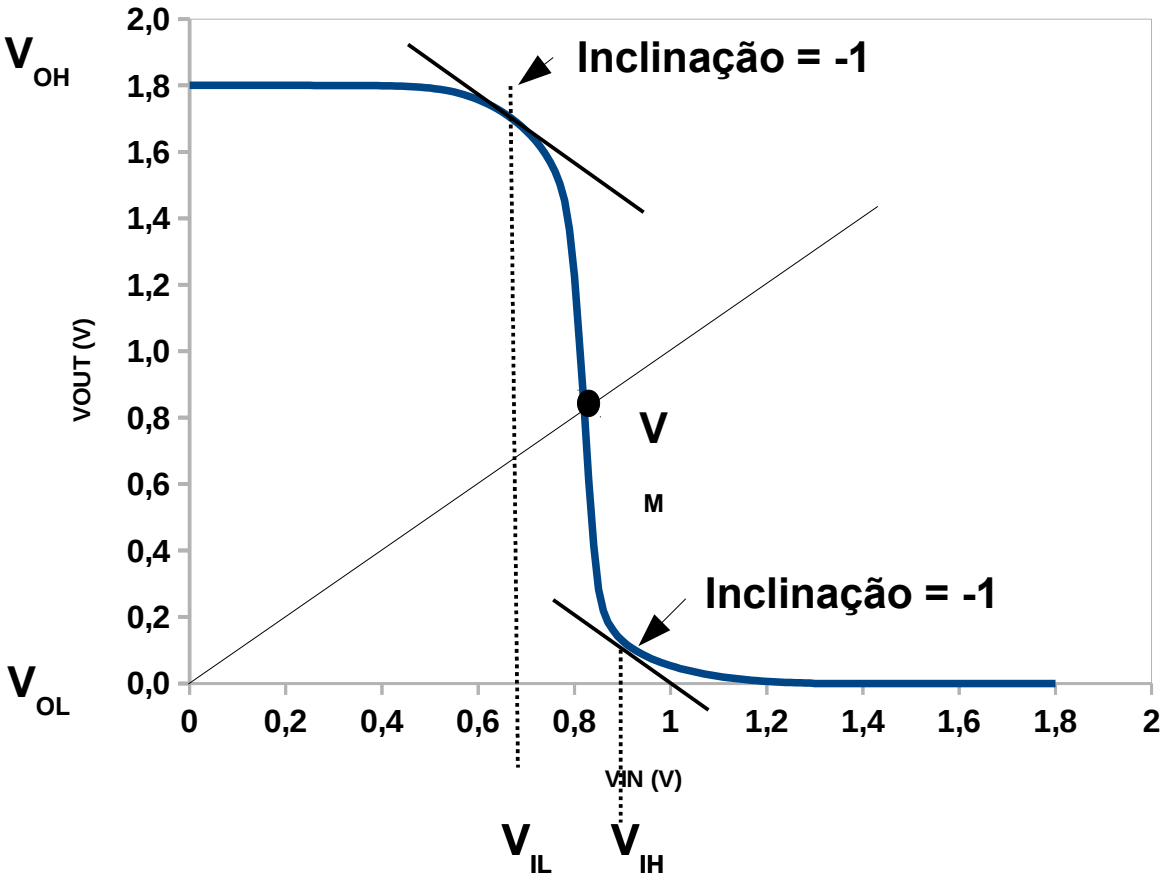
# NÍVEIS LÓGICOS




## Determinação de $V_M$

Ambos transistores saturados

$$\frac{k_n}{2}(V_M - V_{tn})^2 = \frac{k_p}{2}(V_{DD} - V_M - |V_{tp}|)^2$$

$$V_M = \frac{r(V_{DD} - |V_{tp}|) + V_{tn}}{1 + r}$$

onde $$r = \sqrt{\frac{k_p}{k_n}}$$

$$k_{n(p)} = k'_{n(p)} \left(\frac{W}{L}\right)_{n(p)}$$



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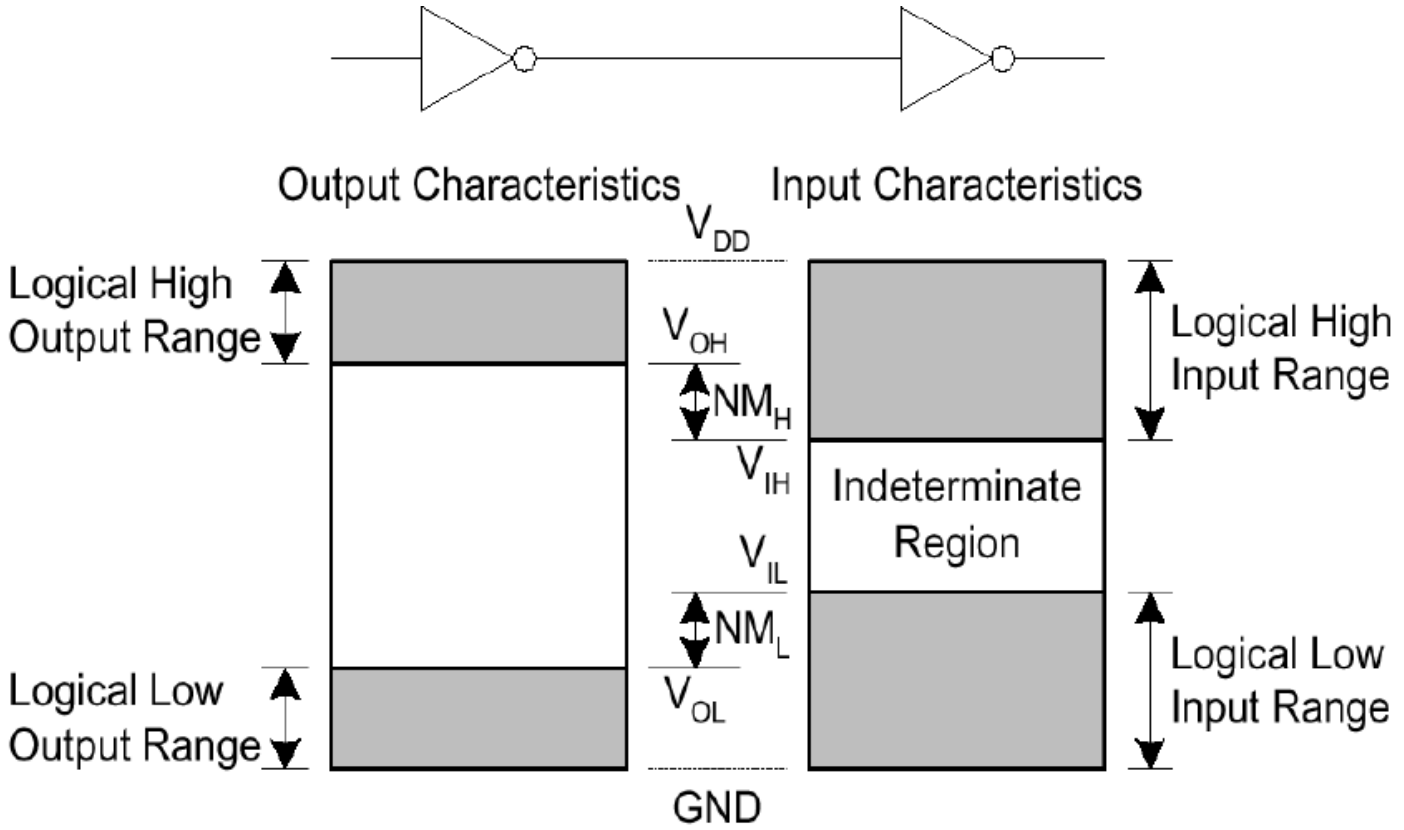
# MARGENS DE RUÍDO



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