ELECTRÓNICA 1 — AULA 6

TRANSISTOR MOS — CONFIGURAÇÕES BÁSICAS

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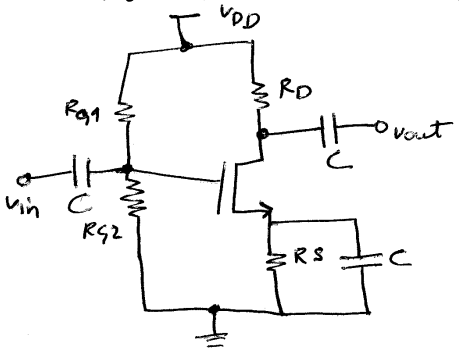
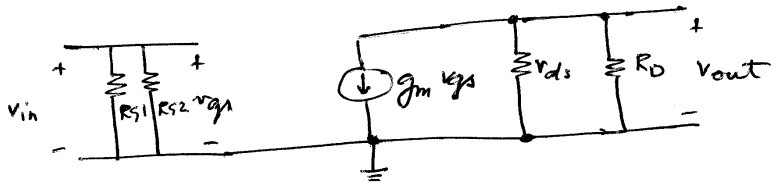
1) Configuração SOURCE (fonte) comum



- Condensadores C são curto-circuitos para pequeno sinal;
- fontes de tensão independentes são curto-circuitos para pequeno sinal

modelo de pequeno sinal



ganho $A_V = \frac{v_{out}}{v_{in}} = \frac{-g_m (r_{ds} \| R_D) v_{gs}}{v_{in}} = -g_m (r_{ds} \| R_D)$

$(v_{gs} = v_{in})$

com $g_m = \frac{2 I_D}{(V_{GS} - V_T)}$

e $r_{ds} = \frac{1}{\lambda I_D}$

NOTAS

- ganho negativo (amplificador inverte o sinal)

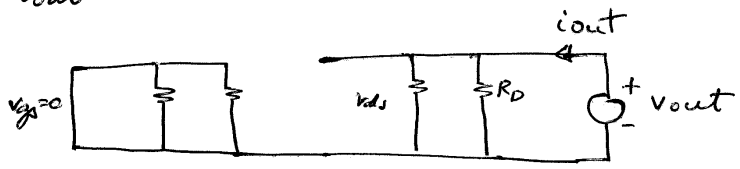
$$v_{ds} \gg R_D \Rightarrow A_v \simeq -g_m R_D$$

resistência de entrada R_{in}

$$R_{in} = \frac{v_{in}}{i_{in}} = (R_{G1} \parallel R_{G2}) = \frac{R_{G1} \times R_{G2}}{R_{G1} + R_{G2}}$$

resistência de saída R_{out}

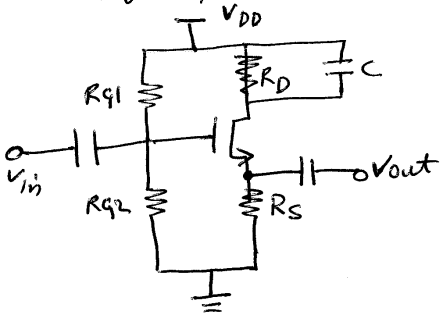
$$R_{out} = \frac{v_{out}}{i_{out}} = (r_{ds} \parallel R_D) \simeq R_D$$



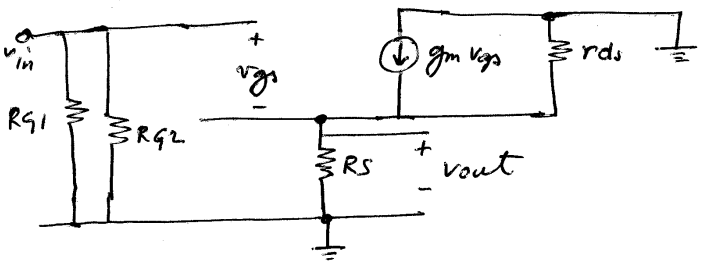
NOTAS

- resistência de entrada pode ser muito grande (> 1MΩ)
- resistência de saída é elevada e está relacionada com o ganho

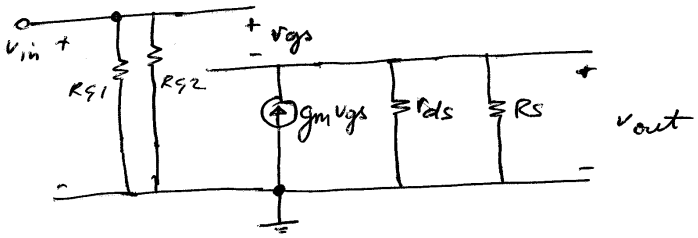
2) Configuração de dreno (drain) comum



modelo de pequeno sinal



simplificando



$$\begin{cases} v_{out} = g_m (r_{ds} \| R_S)\, v_{gs} \\ v_{in} = v_{gs} + v_{out} \end{cases}$$

$$v_{out} = g_m (r_{ds} \| R_S)\,(v_{in} - v_{out})$$

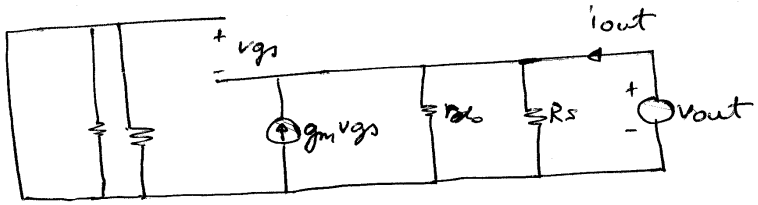
$$[1 + g_m (r_{ds} \| R_S)]\, v_{out} = g_m (r_{ds} \| R_S)\, v_{in}$$

logo $$A_V = \frac{v_{out}}{v_{in}} = \frac{g_m (r_{ds} \| R_S)}{1 + g_m (r_{ds} \| R_S)} \simeq \frac{g_m R_S}{1 + g_m R_S} \simeq 1$$

NOTA: ganho menor que 1

$R_{in} = (R_{G1} \| R_{G2})$
normalmente muito elevado

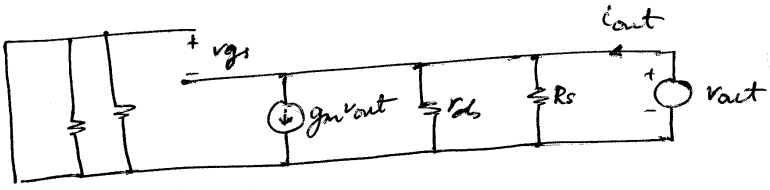
Cálculo da resistência de saída



$$R_{out} = \frac{v_{out}}{i_{out}} =$$

mas $v_{out} = -v_{gs}$

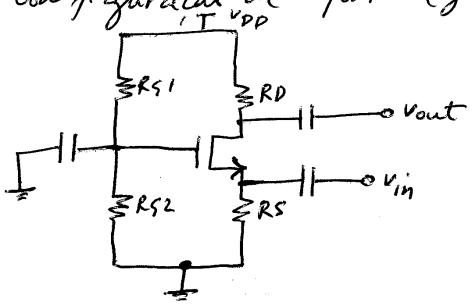
logo pode-se simplificar



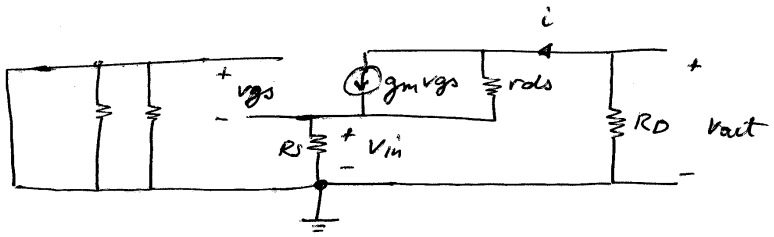
$$R_{out} = \frac{1}{g_m} \parallel r_{ds} \parallel R_S \simeq \frac{1}{g_m}$$

NOTA: Rout é normalmente um valor baixo; este amplificador funciona como <u>buffer</u> (elevada impedância de entrada, baixa impedância de saída)

3) Configuração de porta (gate) comum



modelo de pequeno sinal



$v_{in} = - v_{gs}$

$v_{out} = - R_D \, i$

$v_{out} = (i - g_m v_{gs}) r_{ds} + v_{in}$

Substituindo

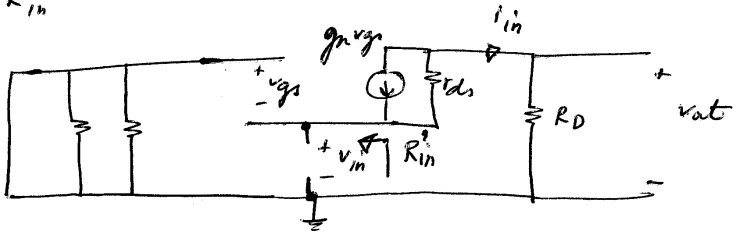
$$v_{out} = \left(- \frac{v_{out}}{R_D} + g_m v_{in} \right) r_{ds} + v_{in}$$

$$\left(1 + \frac{r_{ds}}{R_D} \right) v_{out} = \left(1 + g_m r_{ds} \right) v_{in}$$

$$\text{logo} \quad A_V = \frac{v_{out}}{v_{in}} = \frac{1 + g_m r_d}{1 + \frac{r_{ds}}{R_D}} \simeq g_m R_D$$

Resistência de entrada R_{in}

$R_{in} = R_S \parallel R'_{in}$



$$R'_{in} = \frac{v'_{in}}{i'_{in}}$$

$$i'_{in} = - g_m v_{gs} + \frac{v'_{in} - v_{out}}{r_{ds}}$$

$$i'_{in} = + g_m v'_{in} + \frac{v'_{in} - R_D i'_{in}}{r_{ds}}$$

$$i_{in}\, r_{ds} = g_m v_{in} + v_{in} - R_D\, i_{in}$$

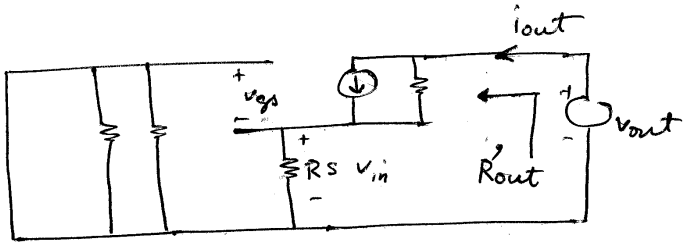
$$i_{in}\,(r_{ds} + R_D) = (1 + g_m r_{ds})\, v_{in}$$

Logo $$R'_{in} = \frac{v_{in}}{i_{in}} = \frac{r_{ds} + R_D}{1 + g_m r_{ds}} \simeq \frac{1}{g_m}$$

Logo
$$R_{in} = R_S \parallel \frac{1}{g_m} \simeq \frac{1}{g_m}$$

Cálculo de Rout

$$R_{out} = R_D \parallel R'_{out}$$



$$R'_{out} = \frac{v_{out}}{i_{out}}$$

mas
$$i_{out} = g_m v_{gs} + \frac{v_{out} - v_{in}}{r_{ds}}$$

$$i_{out} = -g_m v_{in} + \frac{v_{out} - v_{in}}{r_{ds}}$$

mas $i_{out} = \frac{v_{in}}{R_S}$

logo $$i_{out} = -g_m R_S\, i_{out} + \frac{v_{out} - R_S\, i_{out}}{r_{ds}}$$

$$r_{ds}\, i_{out} = -g_m r_{ds} R_S\, i_{out} + v_{out} - R_S\, i_{out}$$

$$(R_S + r_{ds} + g_m r_{ds} R_S)\, i_{out} = v_{out} \longrightarrow R'_{out} \simeq (1 + g_m R_S)\, r_{ds}$$