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Session 18
Amplifiers with FET transistors - Exercises

Electronic Components and Circuits

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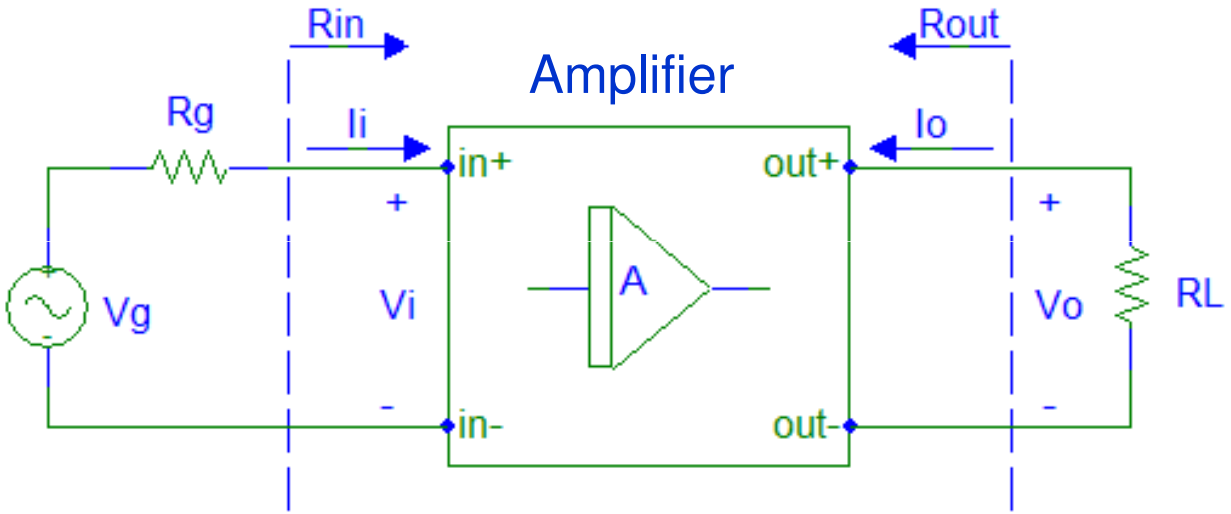
FET transistor amplifier configurations

Goals:

- Analysis of small-signal circuits corresponding to single-stage FET amplifiers:
  - Common-Source.
  - Common-Drain.
  - Common-Gate.

Amplifiers characteristic parameters



- Voltage Gain, Av and Gv

$$A_v = \frac{V_o}{V_i} \qquad G_v = \frac{V_o}{V_g}$$

- Current Gain, Ai

$$A_i = \frac{i_o}{i_i}$$

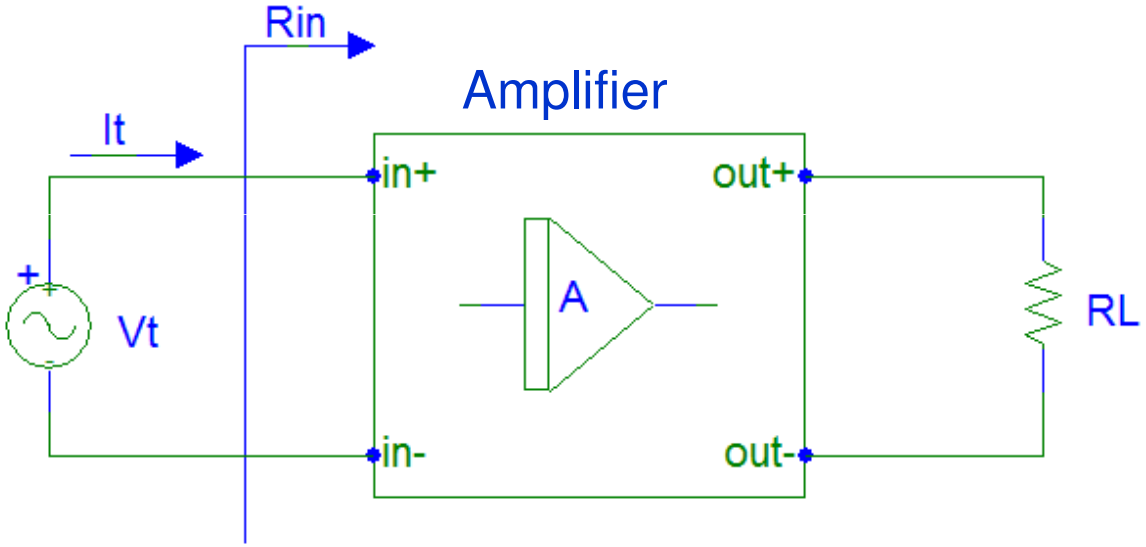
- Input resistance, Rin

$$R_{in} = \frac{V_i}{i_i}$$

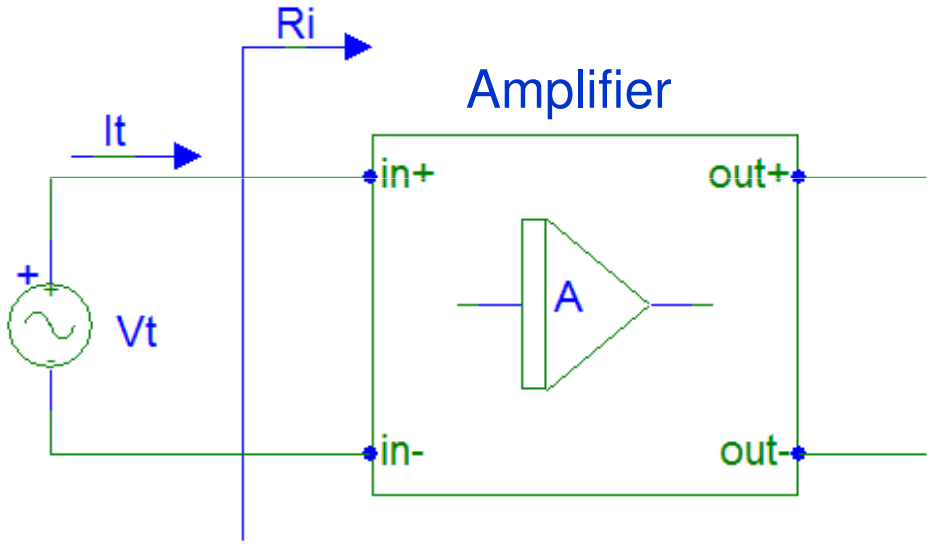
- Output resistance, Rout

$$R_{out} = \frac{V_o}{i_o}$$

Measuring Input Resistance

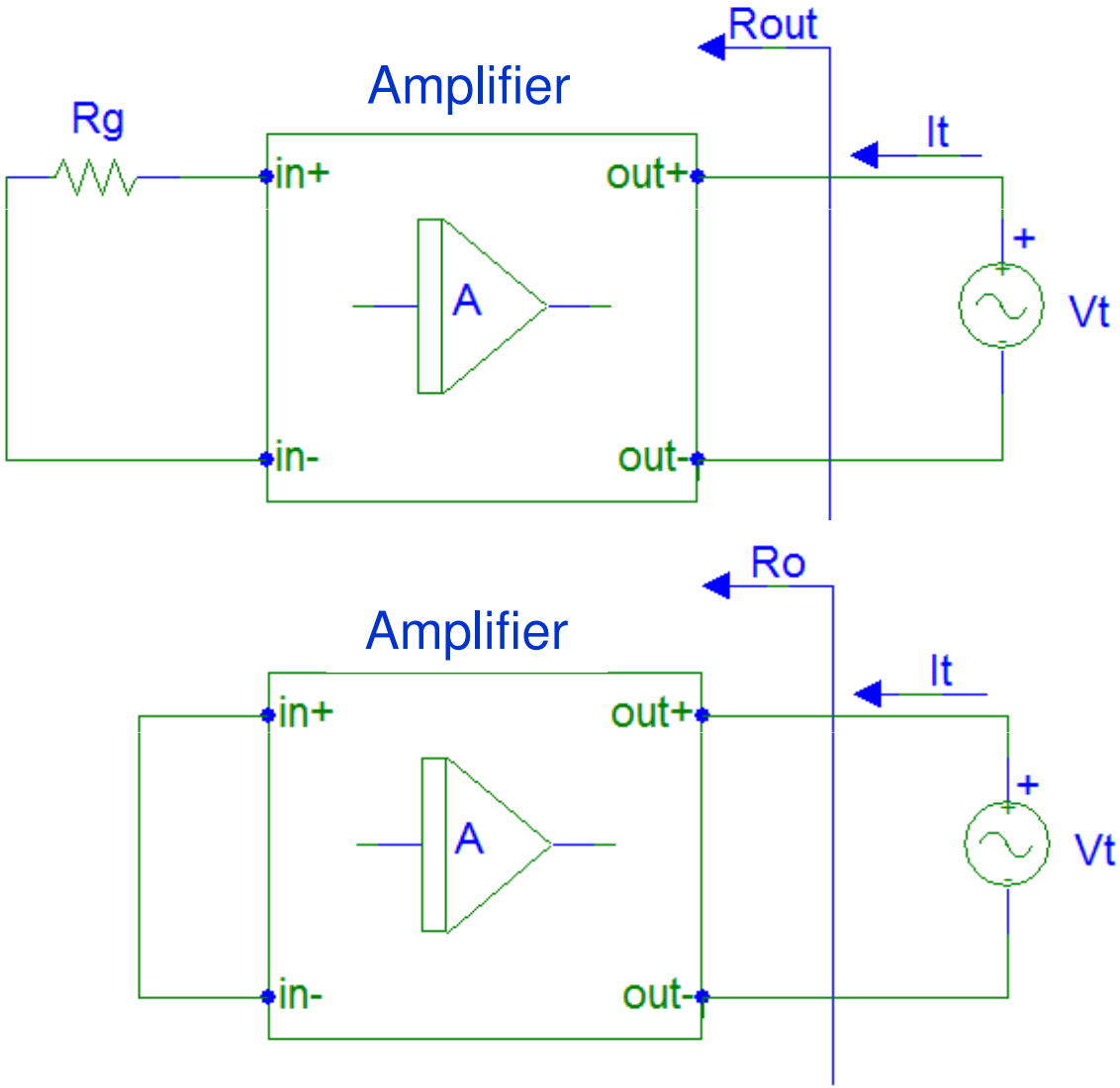


$$R_{in} = \frac{V_t}{i_t}$$



$$R_i = \left.\frac{V_t}{i_t}\right|_{R_L \to \infty}$$

Calculating Output Resistance

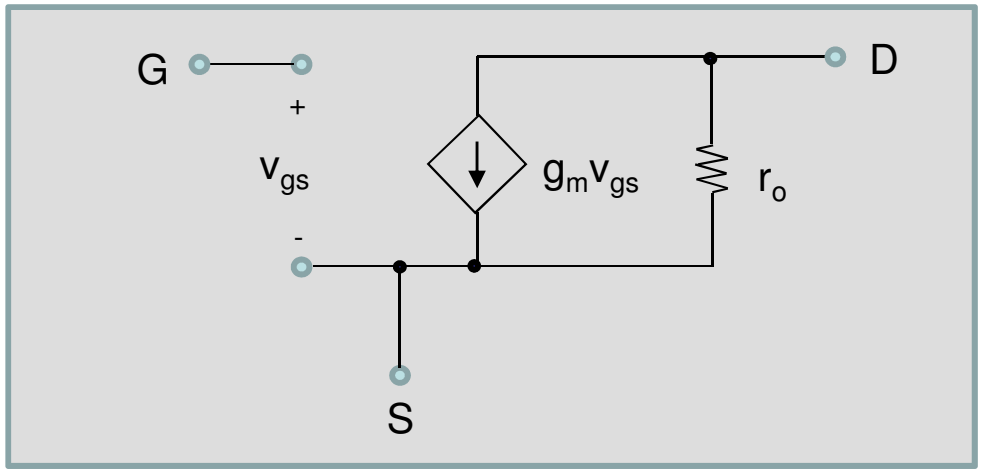


$$R_{out} = \left.\frac{V_t}{i_t}\right|_{V_g=0}$$

$$R_o = \left.\frac{V_t}{i_t}\right|_{V_i=0}$$

Small-signal equivalent circuit

(low and medium frequencies)



- With MOSFETs

$$g_m = \left.\frac{\partial i_D}{\partial V_{GS}}\right|_{v_{ds}=V_{DSQ}} = 2K(V_{GS} - V_t)$$

$$r_o = \frac{V_A}{I_D}$$

- With JFETs

$$g_m = \left.\frac{\partial i_D}{\partial V_{GS}}\right|_{v_{ds}=V_{DSQ}} = -2\frac{I_{DSS}}{V_p}\left(1 - \frac{V_{GS}}{V_p}\right)$$

Analysis of small-signal amplifier circuits

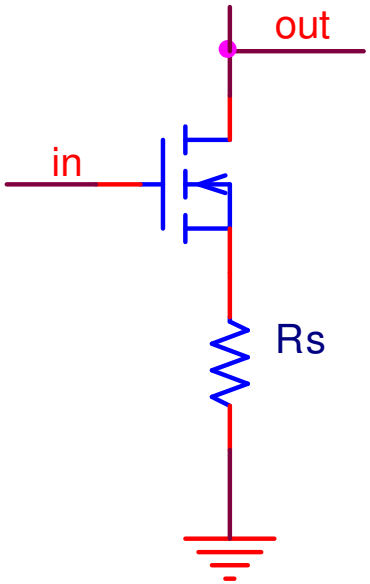
METHODOLOGY

1. Analyze the biasing circuit (DC), removing all power sources (superposition) and considering the coupling and decoupling capacitors as open-circuits. Find the bias point.
2. Find the transistor small-signal parameters (from the bias point voltages and currents).
3. Represent the small-signal equivalent circuit of the devices and the external circuit, removing the DC sources (superposition) and considering the capacitors at medium frequencies.
4. Find the amplifier characteristics.

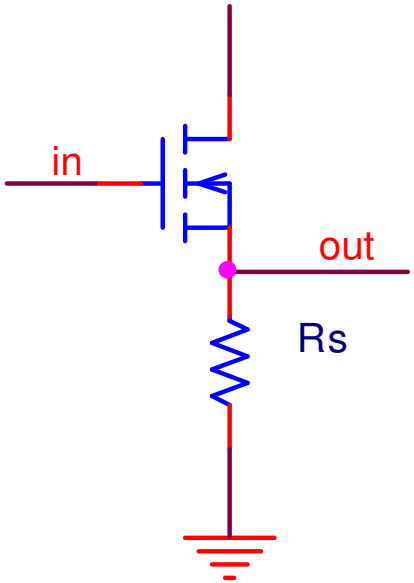
Single-stage MOS amplifiers

- Common-Source amplifier
- Common-Drain or Source-Follower configuration
- Common-Gate amplifier

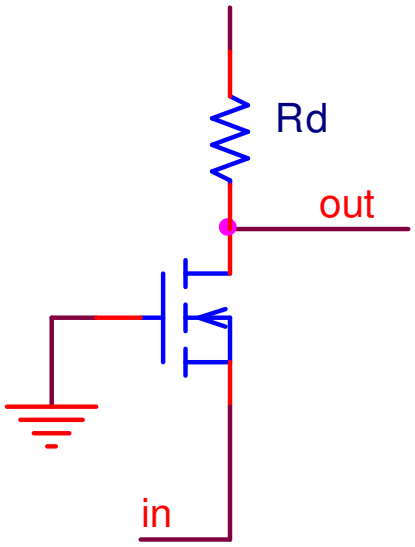
Common-Source



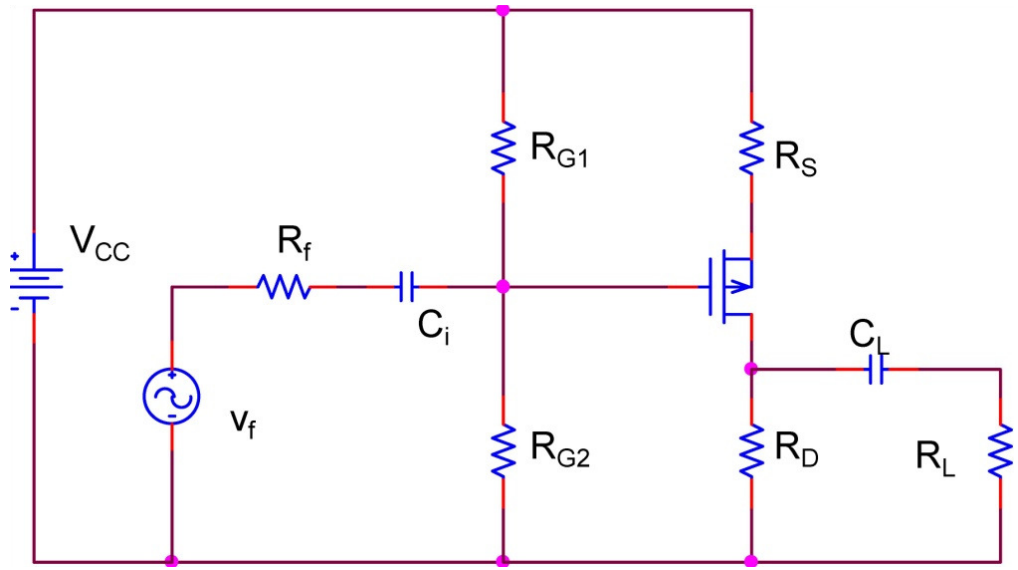
Common-Drain



Common-Gate



Class exercise 1

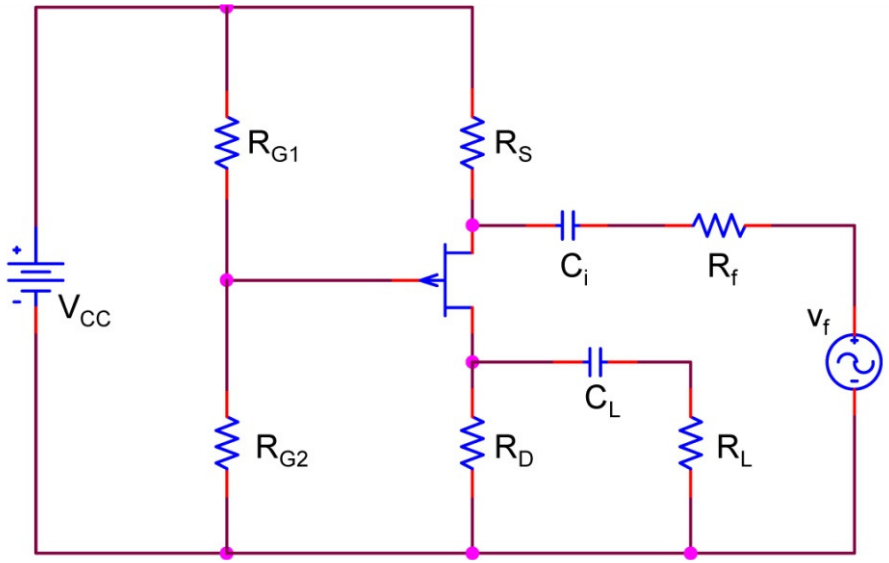


Data:

V_{CC} = 10V
R_{G1} = 100KΩ,
R_{G2} = 100KΩ,
R_S = 1kΩ,
R_D = 330Ω
R_L = 10kΩ
R_f = 50Ω
K=1 mA/V²
$|V_t|=3V$
$|V_A|=\infty$

a) Find the bias-point values: I_D, V_G, V_S and V_D
b) Find the small-signal parameter g_m
c) Find R_i, R_o and Av_o for this amplifier
d) Find the circuit gain Av considering R_f and R_L

Class exercise 2



Data:

V_{CC} = 20V
R_{G1} = 39KΩ,
R_{G2} = 160KΩ,
R_S = 1KΩ,
R_D = 1.1KΩ
R_L = 1kΩ
R_f = 50Ω
$|V_p|$=5V
$|V_A|$=∞
I_{DSS}=20mA

a) Find the bias-point values: I_D, V_G, V_S and V_D
b) Find the small-signal parameter g_m
c) Find R_i, R_o and Av_o for this amplifier
d) Find the circuit gain Av considering R_f and R_L