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, $A_v$ and $G_v$
  
  \[
  A_v = \frac{V_o}{V_i} \quad G_v = \frac{V_o}{V_g} \quad A_i = \frac{i_o}{i_i}
  \]

- Current Gain, $A_i$

- Input resistance, $R_{in}$
  
  \[
  R_{in} = \frac{V_i}{i_i}
  \]

- Output resistance, $R_{out}$
  
  \[
  R_{out} = \frac{V_o}{i_o}
  \]
Measuring Input Resistance

\[ R_{in} = \frac{V_t}{i_t} \]

\[ R_i = \frac{V_t}{i_t} \bigg|_{R_L \to \infty} \]
Calculating Output Resistance

\[ R_{out} = \frac{V_t}{i_t} \bigg|_{V_g=0} \]

\[ R_o = \frac{V_t}{i_t} \bigg|_{V_t=0} \]
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
Class exercise 1

Data:
$V_{CC} = 10V$
$R_{G1} = 100K\Omega,$
$R_{G2} = 100K\Omega,$
$R_S = 1k\Omega,$
$R_D = 330\Omega$
$R_L = 10k\Omega$
$R_f = 50\Omega$
$K = 1 \text{ mA/V}^2$
$|V_A| = \infty$
$|V_t| = 3V$

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 $A_{v_o}$ for this amplifier
d) Find the circuit gain $A_v$ considering $R_f$ and $R_L$
Class exercise 2

Data:
\( V_{CC} = 20\,V \)
\( R_{G1} = 39\,K\Omega, \)
\( R_{G2} = 160\,K\Omega, \)
\( R_{S} = 1\,K\Omega, \)
\( R_{D} = 1.1\,K\Omega \)
\( R_{L} = 1\,k\Omega \)
\( R_{f} = 50\,\Omega \)
\(|V_{p}| = 5\,V \)
\(|V_{A}| = \infty \)
\( I_{DSS} = 20\,mA \)

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 \( A_{v_{o}} \) for this amplifier
d) Find the circuit gain \( A_{v} \) considering \( R_{f} \) and \( R_{L} \)