Exam-1 on Micro-Electronics-1, EE.ELE.270, Period-3, Spring-2024

TITLE: Design a NMOS Common Source Amplifier with PMOS Current-Source Load

TASKS:

NOTE: The answers/solutions should include Explanations, Schematic pictures and the relevant Simulation Results.
Add also the Operating Point Voltages and Currents on the schematic by using Data Labels.

1) In the table of choices you have receved an exact **N**MOS transistor sizes (***L*** and ***W***) and specified Bias Point: Drain-Current and Drain-Source Voltage of operation. Plot the NMOS transistor Output V/A Characteristics (***Id*** as function of ***Vds*** and parameter ***Vgs***) and also its Transfer V/A Characteristics (***Id*** as function of ***Vgs*** and parameter ***Vds***). What is the Threshold Voltage of the NMOS transistor ? Find and write down the needed Gate-Source Voltage (within 10mV accuracy) which you should apply to the **N**MOS to operate at the requested Bias Point.

2) Please design the ***W*** and the ***L*** of a **P**MOS transistor, which matches *(in a manner explained in Exercise # 3 and 4)* the given **N**MOS in the way that the **P**MOS would operate at the same absolute values (but in reversed polarity) of Drain-Current, Drain-Source Voltage and Gate-Source Voltage, as the given the **N**MOS. Keep in mind that both transistors should have similar ***r o*** (as represented by the slope of their output characteristics, ***Id (Vds, Vgs)***). Plot the Output V/A Characteristics of the PMOS (***Id*** as function of ***Vds*** and parameter ***Vgs***), and also its Transfer V/A Characteristics (***Id*** as function of ***Vgs*** and parameter ***Vds***). What is the Threshold Voltage of the PMOS transistor ? How large (in kOhms) is the achived value of the ***r o*** *of the PMOS at the bias point as seen in LT-Spice ?*

3) Use the transistors from task '**1**)' and taks '**2**)' to design a common source amplifier with NMOS as input and PMOS as current source load *(as explained in Exercise # 4)*. Use ideal voltage sources for biasing of NMOS and for PMOS. Use supply voltage ***Vdd = 2*Vds*** *(twice the value of* ***Vds****)*. Plot the Amplifier Voltage-Gain versus Frequency (*AC simulation*) and find out the achieved -***3dB*** corner frequency.

4) Add a source resistance ***RS*** = 500Ω and load resistance ***RL*** = 180kΩ to the amplifier. Plot the Voltage-Gain versus Frequency (*AC simulation*) and find out the achieved -***3dB*** corner frequency. Run also transient simulation with input signal amplitude of 10mV and frequency 1MHz.

5) In the Circuit of point '***4)***' add capacitor in parallel with the load resistor and perform Parametric Simulation to evaluate the gain with capacitances of 100fF, 200fF, 500fF, 1pF and 2pF.

6) Design the Bias Circuitry of the entire amplifier using Current Mirrors for the amplifier in task '**3**)', using some of the circuit configuration examples discussed during the Exercises (e.g. Execise # 5).