Assignment-1	EE204 - Analog Circuits	11th Jan 2018
Submission Deadline-17.00 19th Dec, 2018.	Submission Protocol: Drop hardcopy in the EE office	Comment: None

1. (a) Find out the peak transconductance (g_m) for the MOSFET (TSMC Spice Model shared with you) at V_{DS} = 5 V. (Use SPICE)
   (b) What is the corresponding V_{GS} for the same? (Using SPICE)
   (c) Find out the intrinsic output resistance (r_0) for the same MOSFET for V_{GS} found in (b). (Use SPICE)
   (d) Draw the small signal equivalent circuit for the MOSFET when V_{DS} = 3 V and V_{GS} found above.
   (d) Analytically design a regular class-A amplifier (without blocking and de-coupling capacitor) using the small signal equivalent circuit derived in (c) for an open circuit voltage gain of A_v = 2. Find out all the parameters for the circuit e.g. V_{DD}, V_{GG}, R_D. Find out the output impedance of the amplifier w/ and w/o R_D.
   (e) Re-design the same circuit in (d) using a single source V_{DD} = 5 V and using R_1-R_2 potential divider network. Assuming the input blocking capacitance in infinite (C_B = ∞).
   (f) Find out the gain for the amplifier at 1 MHz and 1mHz in (e) if an additional load resistance is connected at the output with a decoupling capacitor in 1 μF.
2. We have derived MOSFET small signal equivalent circuit in the class. We have assumed that source (S) is connected to the substrate (bulk B) and V_{BS} = 0 for a n-MOS. However, in principle we can apply a negative bias at bulk for n-MOS. Apply a V_{BS} changes the threshold for a MOSFET as:
   $$V_T = V_{T0} + \gamma\left(\sqrt{(2\phi_B + V_{SB})} - \sqrt{(2\phi_B)}\right)$$
   Typical value for φ_B = 0.4 V and γ = 0.7 $V^{-1/2}$. Using, the above expression for V_T, find out how the small signal equivalent circuit will modify. [Hint: I_{DS} now become a function of V_{BS} and transistor becomes a four terminal device. Look up the text book].
3. Using the small signal ac equivalent model in 1(d) and assuming C_{GS} = 1 nF
   (a) Find out the frequency when the current gain becomes unity with C_{GD} = 0.
   (b) Re-calculate (a) when C_{GD} = 0.2 nF.
4. The drain and gate of a n-MOS is shorted. What the equivalent small signal ac-equivalent description of the circuit. [Explore book and see some of the usage of this configuration of a MOSFET].
5. Optional Work:
   Use SPICE and extract C_{GS} and C_{GD} for the MOSFET used in (1) at 1MHz and 1GHz.