

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

- Find out the peak transconductance (g_m) for the MOSFET (TSMC Spice Model shared with you) at $V_{DS} = 5$ V. (Use SPICE)
 - What is the corresponding V_{GS} for the same? (Using SPICE)
 - Find out the intrinsic output resistance (r_o) for the same MOSFET for V_{GS} found in (b). (Use SPICE)
 - Draw the small signal equivalent circuit for the MOSFET when $V_{DS} = 3$ V and V_{GS} found above.
 - 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 .
 - 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 is infinite ($C_B = \infty$).
 - Find out the gain for the amplifier at 1 MHz and 1mHz in (e) if an additional load resistance $R_L = 10$ k Ω is connected at the output with a decoupling capacitor of 1 μ F.
- 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 $\phi_B = 0.4$ V and $\gamma = 0.7$ 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].

- Using the small signal ac equivalent model in 1(d) and assuming $C_{GS} = 1$ nF
 - Find out the frequency when the current gain becomes unity with $C_{GD} = 0$.
 - Re-calculate (a) when $C_{GD} = 0.2$ nF.
- The drain and gate of a n-MOS is shorted. What is the small signal ac-equivalent description of the circuit. [Explore book and see some of the usage of this configuration of a MOSFET].
- Optional Work:
Use SPICE and extract C_{GS} and C_{GD} for the MOSFET used in (1) at 1MHz and 1GHz.