2023

ANALOG IC DESIGN

Full Marks : 100

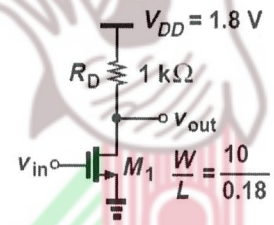
Time : Three hours

The figures in the margin indicate full marks for the questions.

*Answer **any five** questions.*

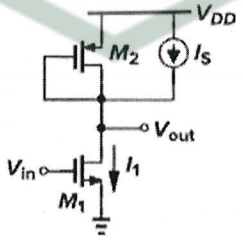
1. a) Draw and explain the low frequency small-signal model of an NMOS transistor? Discuss how channel length modulation and body bias effect are incorporated in it. 4+6

   b) Calculate the small signal voltage gain and output resistance for the CS stage given below. Given $I_D = 1mA$, $V_{th} = 0.5V$, $k_p = 100\mu\frac{A}{V^2}$ and $\lambda = 0.1\ V^{-1}$. 6



   c) Show how the parasitic capacitances C_{GS} and C_{GD} vary with V_{GS} when V_{DS} is kept constant. 4

2. a) In the amplifier circuit shown below, M_1 is biased to operate in saturation region and $I_S = \frac{3}{4} I_1$. Determine the size of each transistor for a voltage gain of 5 and calculate the ratio of their overdrive voltages. Assume $\lambda = 0$. 8

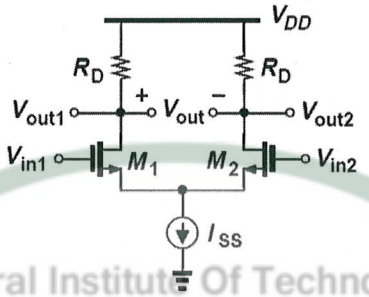


   b) Find the circuit transconductance of a CS stage with resistive load and source degeneration resistance and plot its variation with respect to input bias voltage. 4

   c) Draw the circuit diagram of a cascode amplifier biased with an ideal 8

current source. Evaluate its voltage gain when $\lambda \neq 0$ for both transistors.

3 a) For the circuit shown below, find the expression for V_{out} in terms of V_{in1}, V_{in} and I_{SS}. Show how transfer characteristics is changed when device transconductance is doubled keeping the tail current a constant. 10



b) Draw the circuit diagram and its small signal equivalent of a differential amplifier with single ended output. Using small signal analysis, find the expression for ac voltage gain when a differential input is applied. 10

4 a) Design a fully differential telescopic amplifier in 180nm technology node for a minimum output voltage swing of 3V and ac voltage gain of 3000. Given, power budget = 30mW, V_{DD}=3V, $V_{TN} = |V_{TP}| = 0.7$V, $\lambda_N = 0.1V^{-1}$ and $\lambda_P = 0.2V^{-1}$at L_{MIN}, $(k_P)_N = 60\mu AV^{-2}$, $(k_P)_P = 30\mu AV^{-2}$. 10

b) Draw and explain the working of a high swing cascode current mirror circuit. 5

c) Draw circuit diagram of folded cascode amplifier with NMOS input and determine its voltage gain by approximate analysis. Discuss any benefit provided by this topology. 5

5 a) What are the different sources of noise in MOSFET. Give expression for each one of them. 6

b) Compute the expression for input referred noise power spectral density in a fully differential amplifier. 6

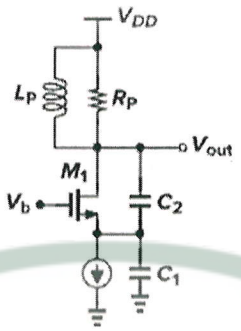
c) Give example for an amplifier with third order loop transfer function. Using Bode plot, show how this amplifier can become unstable when resistive feedback is introduced. Explain how such a circuit can be stabilized using dominant pole compensation method. 8

6 a) Using a neat circuit diagram and necessary derivation, show how the gain of a single stage can be boosted with the help of an auxiliary amplifier. 6

b) Draw the circuit diagram of any one band-gap reference (BGR) circuit and explain how it provides stability with respect to temperature variation. 10

c) Explain the necessity of start-up circuit in the design of BGR circuit and explain its working using a neat circuit diagram. 4

7 a) Find the condition under which the following circuit can function as an oscillator. 10



b) Explain the concept behind the working of a negative-Gm oscillator with the help of necessary circuit diagram. 5

c) Draw the circuit diagram and explain the working of a current-starved ring oscillator VCO. 5