Total number of printed pages: 2

BTech(UG)/8/UECE814B

2024

ANALOG IC DESIGN

Full Marks : 100

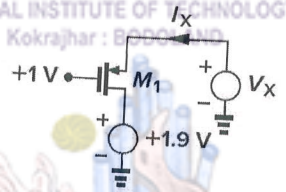
Time : Three hours

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

*Answer **any five** questions.*

1. a) Discuss in detail each circuit element in the small signal model of a MOSFET and explain how the value of each parameter in it is calculated. 10

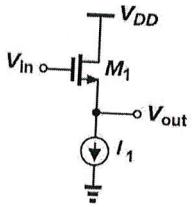
   b) For the circuit given below, write the expression for I_X and transconductance and plot them as V_X is varied from 0 to 3V. 5+5



2 a) A diode connected MOSFET act as a two terminal device. Determine its resistance using small equivalent model. Discuss how this resistance differs between NMOS and PMOS when used as a load resistance in a CS stage with NMOS input transistor. 4

   b) Evaluate the expression for circuit transconductance and voltage gain for a CS amplifier with degenerating resistance R_S and load resistance R_D. 6

   c) For the source follower circuit below, (W/L)1=20/0.5, $I_1 = 200\mu A$, $V_{t0} = 0.5V$, $2\phi_F = 0.7V$, $V_{DD} = 1.2V$, $\mu_n C_{ox} = 50\mu A/V^2$, and $\gamma = 0.4V^{-1/2}$. Calculate the value of Vout when Vin=1.2V. If I_1 is implemented using a single NMOS transistor, determine its minimum sizing so that it is saturated for the same input voltage. 5+5



3 a) Draw the circuit diagram of a NMOS-PMOS folded cascode amplifier. Show that its output resistance is relatively lower than that of an ordinary cascode amplifier. Discuss any one advantage of folded cascode 3+3

configuration.

b) Show that a fully differential amplifier with resistive load can be analyzed using superposition principle where the effect of differential inputs is evaluated separately. Determine the small signal voltage gain of this circuit. 8

c) Determine what happen to the expression for voltage gain of a fully differential amplifier with resistive load if one of the devices has a transconductance twice that of the other. 6

4 a) Compare the performance of a high swing cascode current mirror circuit with that of an ordinary cascode current mirror circuit. 6

b) Draw the circuit of a 5-transistor OpAmp with PMOS input and single ended output. Derive its voltage gain and maximum output voltage swing. 8

c) Discuss the negative effect of introducing unity feedback in a telescopic OpAmp with single ended output. 6

5 a) Design a telescopic OpAmp with single ended output for a 180nm technology node with voltage gain of 3000 and peak-to-peak output voltage swing of 1.5V. Given VDD=3V, Maximum power budget=10mW, $\mu_n C_{ox} = 60\mu$ A/V^2, $\mu_p C_{ox} = 30\mu$ A//V^2, $V_{TN} = |V_{TP}|$ =0.7V and $\lambda_P = 2\lambda_N$ =0.2/V. 10

b) Explain how the gain of a cascode amplifier can be boosted using a folded cascode auxiliary amplifier by evaluating the voltage gain of the resulting circuit. Discuss this circuit's advantage over the circuit where a CS stage is used as an auxiliary amplifier. 6+4

6 a) What are the types of noise generated in a MOSFET operating in saturation mode? Give expression for each. Evaluate the value of mean-square value of input referred noise voltage in a fully differential telescopic amplifier. Determine the contributions from each of the nine devices stating the proper reason involved. 4+6

b) Show that an amplifier with forward path transfer function $A(s) = \frac{A_0}{(1+s/\omega_C)^3}$ and a resistive feedback path transfer function β is not stable if $A_0\beta = 100$ and $\omega_C = 10$MHz. Discuss with details a method to stabilize this system. 4+6

7 a) Discuss how input referred noise is calculated in a multi-stage amplifier? 5

b) Calculate the temperature sensitivity of a forward biased diode voltage carrying a constant current of say 5μA through it. For the given current, assume a diode voltage of 0.65V at a temperature of 300K. 5

c) Draw the circuit diagram of a band gap reference circuit and explain how PTAT and CTAT voltages are generated and canceled. 10
