ELL735 (Analog Integrated Circuits) Minor Examination, 27th Sept 2022 (4:00-5:00 PM)
Dept. of Electrical Engineering, IIT Delhi
Note: Please assume missing parameters if any.

Full Marks = 100

Problem 1: (Marks = 5x5 =25) Choose the correct option (only one) & provide analysis. No analysis will lead to 0 score. Only correct option and correct analysis will lead to full score. No step marks will be awarded.

Problem 1.1: A common source amplifier is shown in Fig. 1.1. The small signal parameters of M1 are gm1, ro1. The small signal voltage gain is

a) -gm1.R
b) -gm1.ro1
c) -gm1 (ro1||R)
d) gm1(ro1||R)

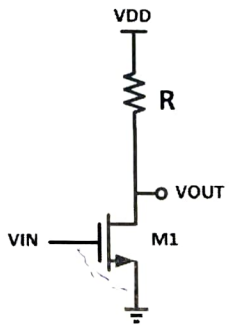

Fig. 1.1

Problem 1.2: The maximum and minimum swing of signal at the output of the amplifier in Fig. 1.1 is

a) VDD and Overdrive voltage of M1
b) VDD and VGS1
c) VDD – I*R and Overdrive voltage of M1
d) VDD – I*R and VGS1

Problem 1.3: In Fig. 1.3, an NMOS with aspect ratio of W/L has Vov= 0.2V, Vth= 0.4V and Id=100uA . Minimum VD to keep M1 and M2 in saturation is

a) 0.4V
b) 0.6V
c) 0.7V
d) 1.4V

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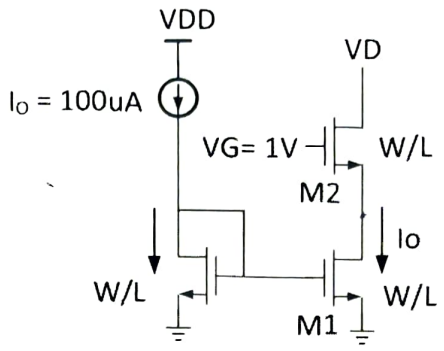

Fig. 1.3

Problem 1.4: A designer has tried all methods to optimize the noise performance of a common source amplifier with resistive load. To reduce the noise further he connects two of the stages in parallel node by node. Which of the following statement is true.

a) The output noise rms voltage spectral density becomes half.
b) The input referred noise rms voltage spectral density becomes half.
c) Both (a) and (b) are correct
d) The output noise current power spectral density becomes double.

Problem 1.5: A current mirror consists of two NMOS devices with W= 4um and L=1um. The Avt of the technology is 5mVum. The company manufactured 10^7 5G cellphone radio ICs which used this current mirror. Which of the following statement is true.

a) In 68% of the ICs, the Vth mismatch will be within +/- 2.5mV.
b) In 95% of the ICs, the Vth mismatch will be within +/- 5mV.
c) In 99.7% of the ICs, the Vth mismatch will be within +/- 7.5mV.
d) All of the above.

Problem 2: [Marks=7x5=35]

The circuit diagram of a common source amplifier is shown in Fig. 2 . The small signal parameters of M1 are gm1, ro1 and those of M2 are gm2, ro2. The threshold voltage of M1 and M2 are Vth1 and |Vth2| respectively. The thermal noise coefficient for both NMOS and PMOS is γ. Ignore flicker noise.

a) Evaluate the small signal voltage gain of the circuit
b) Evaluate the output impedance
c) Evaluate the input impedance
d) The maximum and minimum output voltage swing in terms of VGS1, VB, Vth1, |Vth2|.
e) Evaluate the output noise voltage PSD. Ignore flicker noise.
f) Evaluate the input referred noise voltage PSD.
g) If PMOS M2 is replaced with an ideal current source Id, plot small signal voltage gain vs Id.

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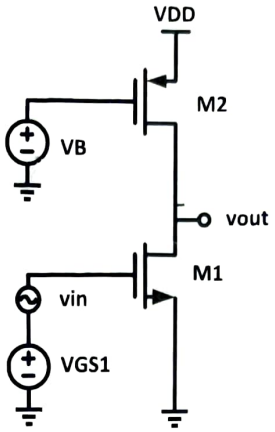

Fig. 2

Problem 3: [Marks=5+5+5+5=20]

The circuit diagram of a common source amplifier is shown in Fig. 3. The PMOS M2 is biased using a current mirror. The small signal parameters of M1 are gm1, ro1 and those of M2/M3 are gm2, ro2. Thermal noise co-efficient is γ. Ignore flicker noise.

a) Evaluate the expression for input referred noise voltage.
b) For better SNR, how would you choose gm1 (small or large) and gm2 (small or large)?
c) Given Ibias, how would you size M2/M3 for low noise [answer if small/large L, small/large W]? Explain why?
d) Given Ibias, how would you size M2/M3 to minimize current mismatch due to both Vth and β mismatch [answer if small/large L, small/large W]? Explain why?

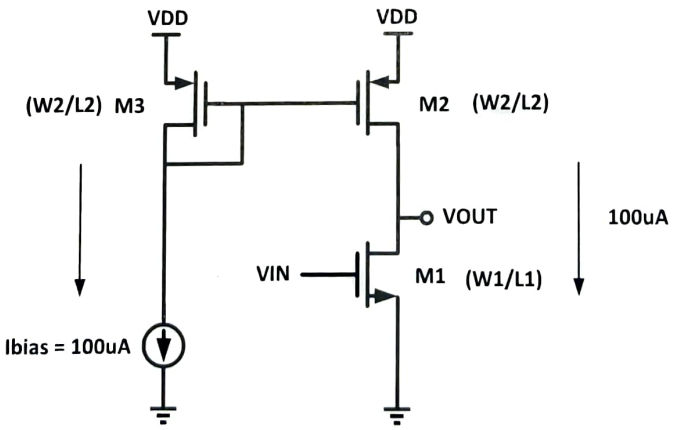

Fig. 3

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Problem 4: [Marks= 5 + 5+ 10=20]

A biasing scheme of low voltage cascode current source is shown in Fig. 4. The small signal parameters of M1 are gm1, ro1; those of M2 are gm2, ro2. Ignore body effect.

a) Find the output impedance Zout of the circuit in terms of small signal parameters of M1 and M2.
b) Evaluate the expression for minimum voltage VD at the output necessary to keep M1 and M2 transistors in saturation in terms of overdrives Vov1 and Vov2.
c) Evaluate the expression for minimum R value required to keep all transistors in saturation for this minimum voltage at the output. Express in terms of Io, W2/L2, Cox and μn.

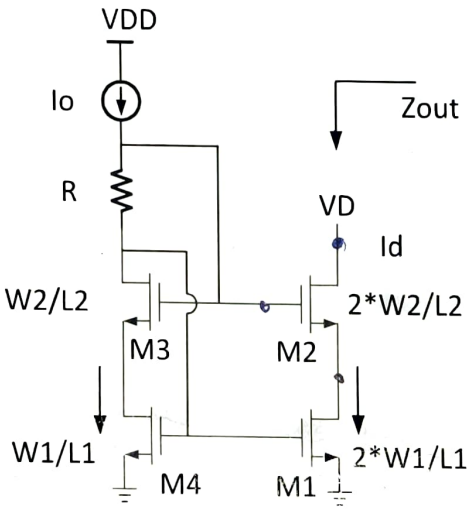

Fig. 4