Second Semester Examination
2022/2023 Academic Session

July / August 2023

EEE270 – Analogue Electronics II

Duration : 3 hours

Please check that this examination paper consists of **EIGHT (8)** pages of printed material including appendix before you begin the examination.

Instructions : This paper consists of **FIVE (5)** questions. Answer **ALL** questions. All questions carry the same marks.

1. Design a differential amplifier as shown in Figure 1. The gain, A_{DM} for the amplifier should be around 26 dB, and differential-mode output resistance, R_{od} of 20 kΩ. Given a value for $V_{DD} = V_{SS} = 10$ V. Assume $V_{TN} = 1$ V and $K_n = 25$ mA/V². Then, find:

   a) Transconductance, g_m (20 marks)
   b) Resistance, R_D and R_{SS} (45 marks)
   c) Current, I_D (20 marks)
   d) Estimation value of CMRR (dB) for this circuit (15 marks)

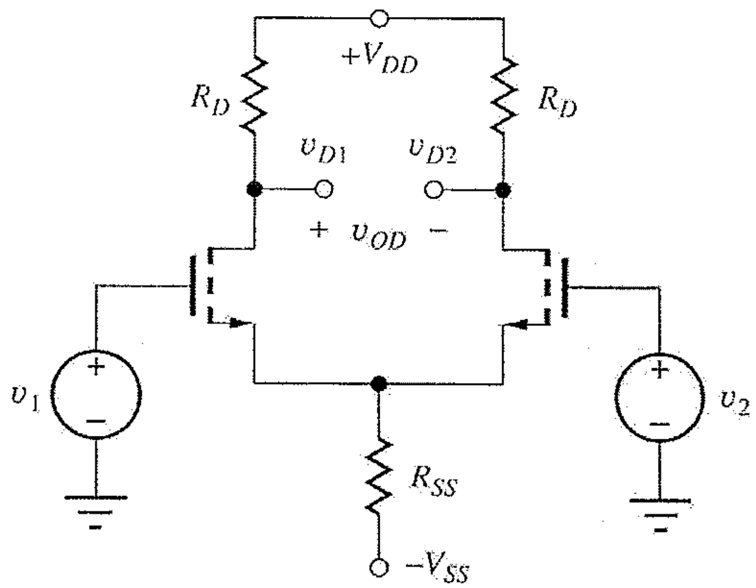

Figure 1

2. Analyze the circuit in Figure 2 below. Given values are: $V_{DD} = V_{SS} = 10$ V, $I_1 = 750$ μA, $I_2 = 2$ mA, $I_3 = 5$ mA. Assume $V_{TN} = 0.7$ V, $\lambda_n = 0.02$ V^{-1}, $K_n = 5$ mA/V^2, $V_{TP} = -0.7$ V, $\lambda_p = 0.015$ V^{-1}, $K_p = 2$ mA/V^2, $R_L = 2$ kΩ. Based on the given values, find:

a) Q-points (30 marks)

b) Differential mode voltage gain, A_{dm} (50 marks)

c) Output resistance, R_{out} (10 marks)

d) CMRR (resistance of current source I_1, $R_1 = 1.5$ MΩ) (10 marks)

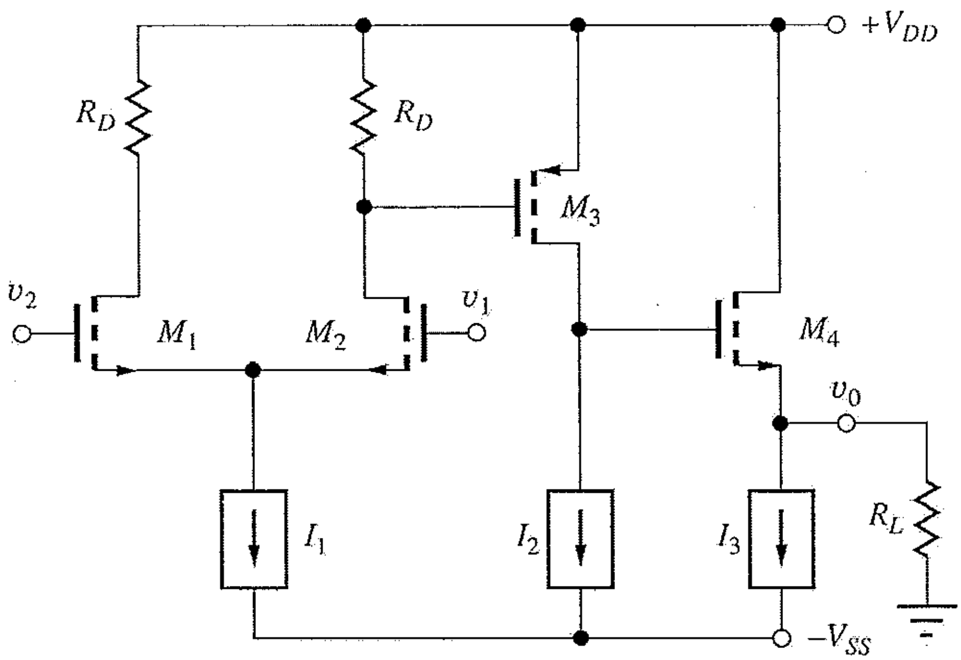

Figure 2

3. a) Find the output current, I_o and output resistance, R_{out} of the current source in Figure 3 (a) if V_{CC} = 12 V, R_1 = 100 kΩ, R_2 = 200 kΩ, R_E = 47 kΩ, β_o= 75, and Early Voltage, V_A = 50 V.

(50 marks)

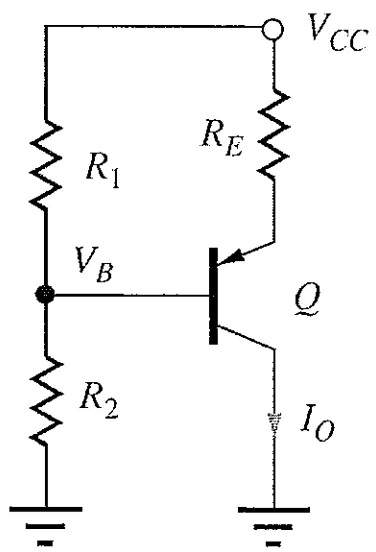

Figure 3 (a)

b) An amplifier with a dc gain of 60 dB has a single pole, high-frequency response with a 3-dB frequency of 100 kHz.

i. Give an expression for the gain function Av(s) (5 marks)

ii. Sketch Bode diagrams for the gain magnitude (10 marks)

iii. What is the gain-bandwidth product? (5 marks)

c) Find the midband gain, poles and zeros, and cut-off frequency for $A_H(s)$ transfer function below.

(30 marks)

$$A_H(s) = 50\frac{\left(1+\frac{s}{10^9}\right)}{\left(1+\frac{s}{10^6}\right)\left(1+\frac{s}{10^8}\right)}$$

4. a) For the common-source amplifier in Figure 4, draw,

i. ac small-signal circuit, and

ii. circuits for determining the time constant of each C_1, C_2 and C_3.

(44 marks)

b) Find the short circuit time constants for the amplifier.

(24 marks)

c) What is the lowest cut-off frequency of the amplifier if I_D= 1.5 mA and $V_{GS} - V_T$ = 0.5 V. Assume λ = 0.015/V.

(32 marks)

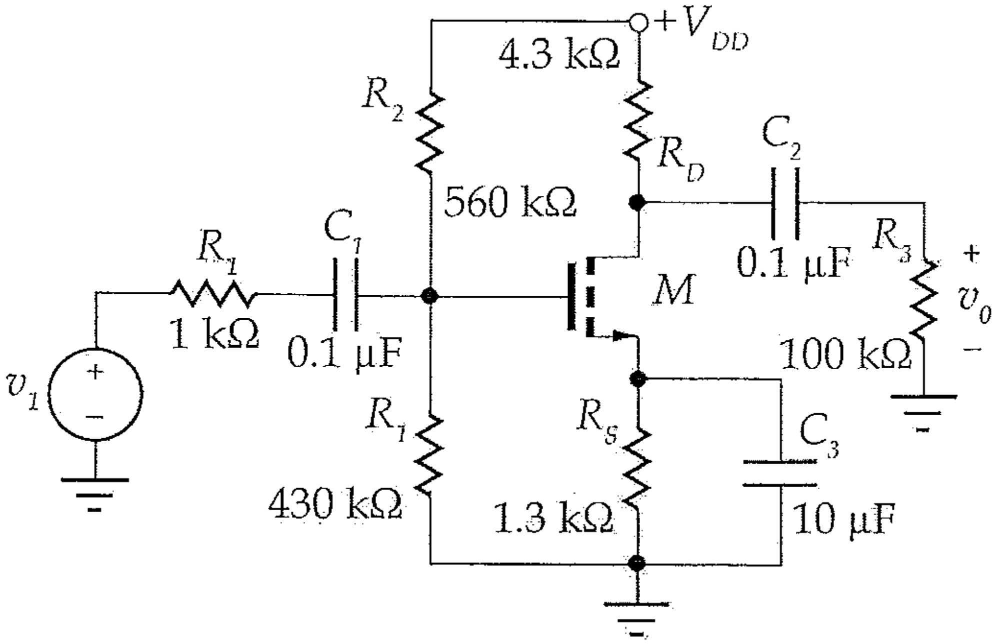

Figure 4

5. a)

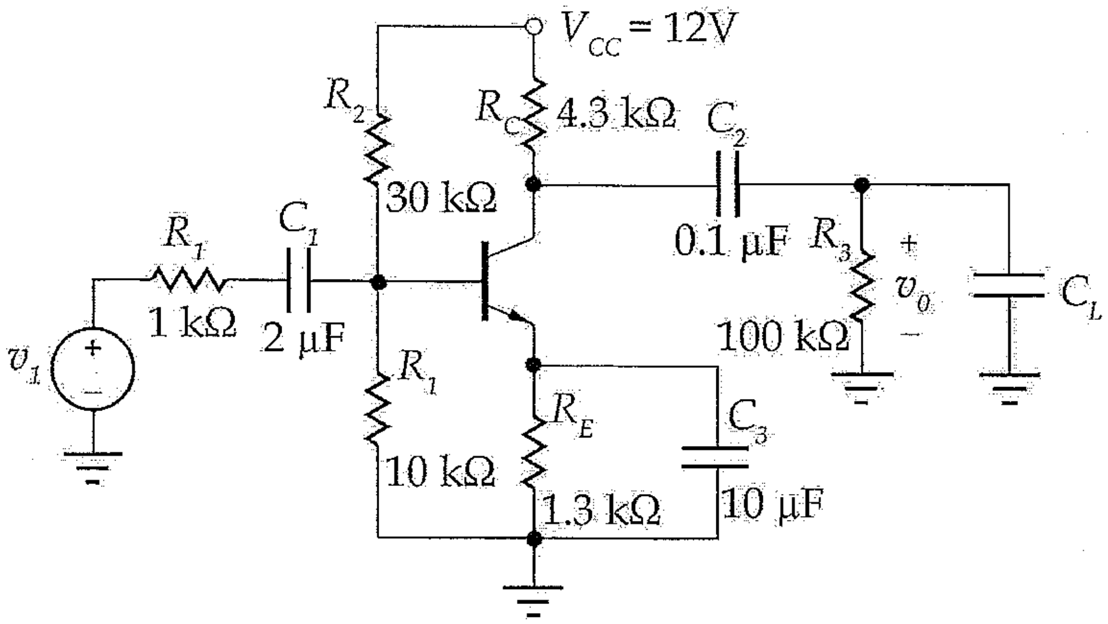

Figure 5 (a)

i. Find the midband gain and upper-cutoff frequency of the common-emitter amplifier shown in Figure 5 (a). Assuming β_0 = 100, f_T = 500 MHz, C_μ = 0.5 pF, r_x = 250 Ω, g_m= 64.0 mS and a Q-point of 1.60, 3.00 V.

(30 marks)

ii. Find additional poles and zeros of the common-emitter amplifier. Assume C_L=0, C_1=C_3=3.9 μF, C_2=0.082 μF.

(20 marks)

b) Figure 5 (b) shows an ideal voltage amplifier having a gain of -100 V/V with an impedance Z connected between its output and input terminals. Find the Miller equivalent circuit when Z is a 1 MΩ resistance. And use the equivalent circuit to determine V_0 / V_{sig}.

(50 marks)

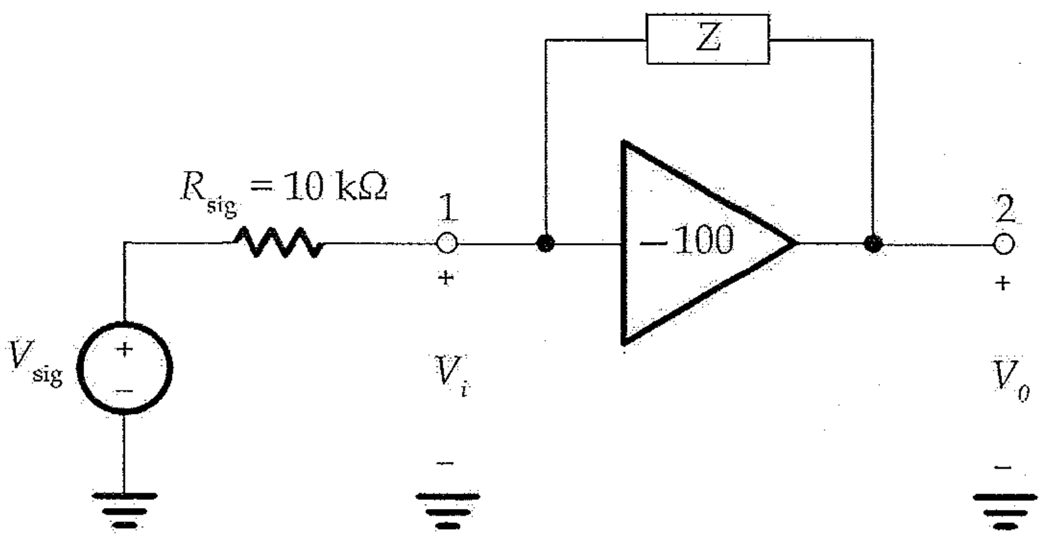

Figure 5 (b)

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APPENDIX

Question	Course Outcome (CO)	Programme Outcome (PO)
1	1	2
2	1	2
3	1	2
4	1	2
5	1	2