UNIVERSITI SAINS MALAYSIA

Semester I Examination
Academic Session 2007/2008

October/November 2007

EEE 510 – ADVANCED ANALOGUE CIRCUIT DESIGN

Time : 3 hours

INSTRUCTION TO CANDIDATE:

Please ensure that this examination paper contains **EIGHT (8)** printed pages and **SIX (6)** questions before answering.

Answer **FIVE (5)** questions.

Distribution of marks for each question is given accordingly.

All questions must be answered in English.

1. Figure1 shows a series-shunt amplifier with a feedback factor $\beta = 1$. The amplifier is designed so that $vo = 0$ for $vs = 0$, with small deviations in vo from 0V dc being minimized by negative feedback action. The technology utilized has $k'n = 2k'p = 120\frac{\mu A}{V^2}, |Vt| = 0.7V, and |V'A| = 24V$.

(a) Calculate g_m and r_o of each transistor. (10 marks)

(b) Find the values of A. Assume that the bias current sources are ideal. (10 marks)

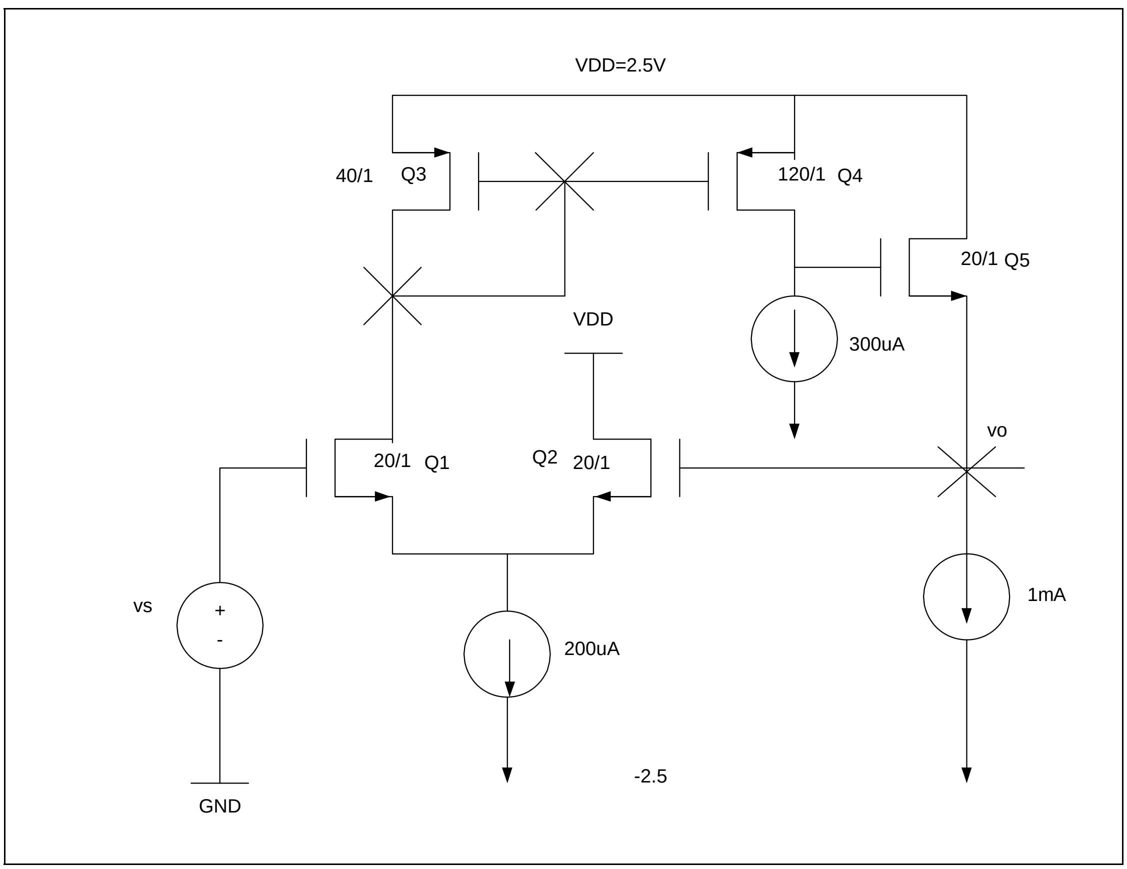

Figure 1

2. The MOSFET current source shown in the Figure 2 is required to deliver a DC current of 1mA with VGS = 0.8V. If the MOSFET has V_t = 0.55 V, V_A = 20V and the body trans-conductance factor $\chi = 0.2,$ find the value of R that results in a current-source output resistance of 200 $k\Omega$. Also determine the dc voltage VBIAS.

(20 marks)

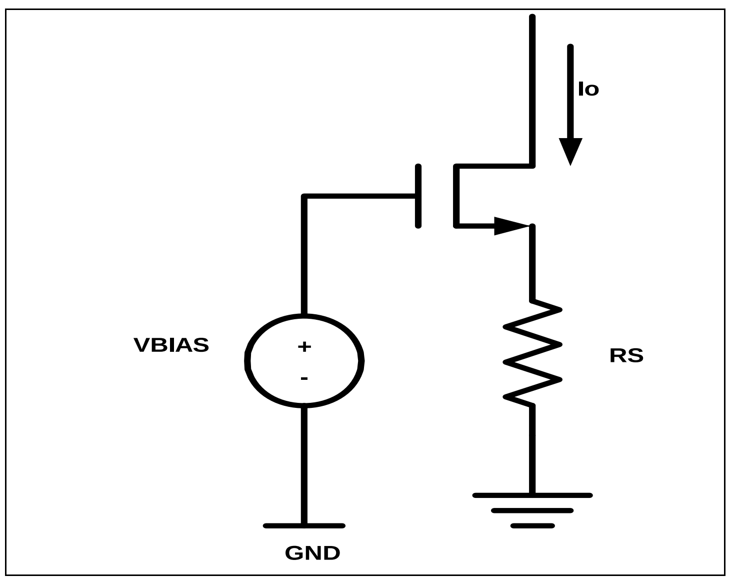

Figure 2

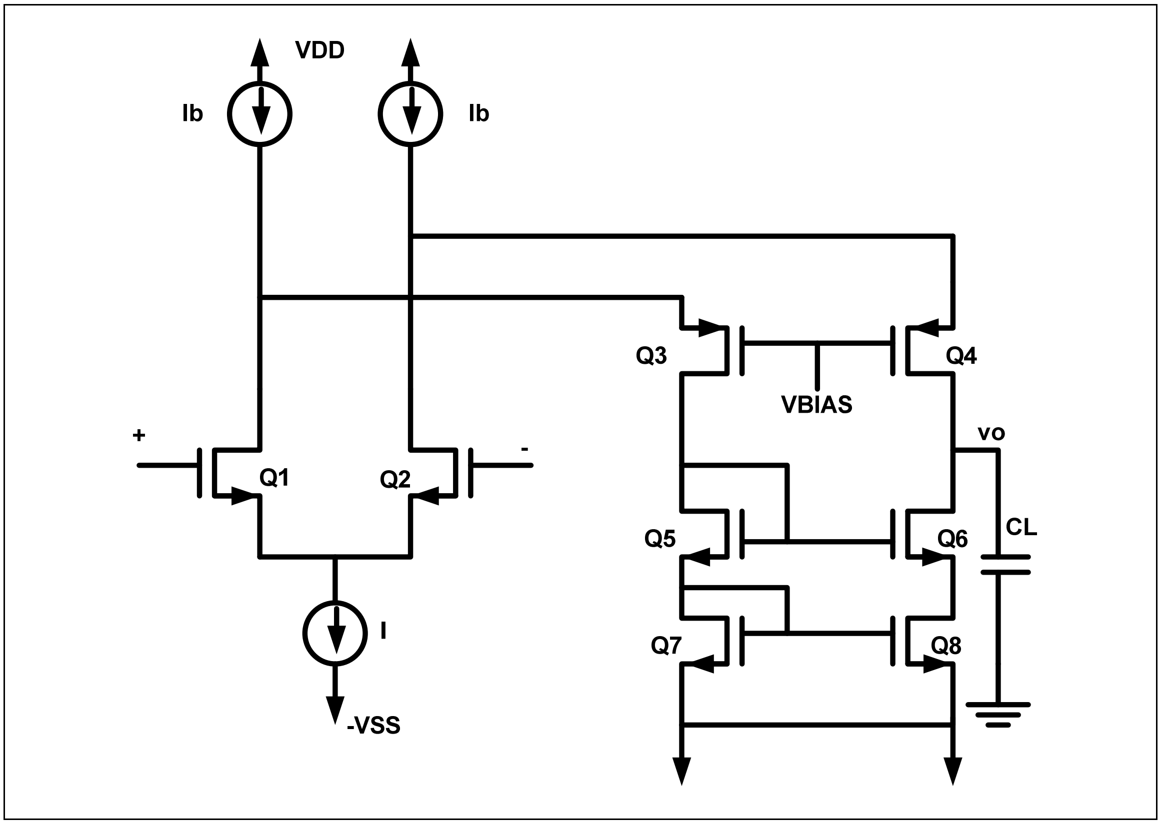

Figure 3

3. For the folded cascade in Figure 3, the op amp has bias currents I =125uA and I_B = 150uA and with all transistors operated at the overdrive voltages of 0.2V.

(a) Find W/L ratios for all devices. Assume that the technology available is characterized by k'n = 250 uA/V^2 and k'p = 90 uA/V^2.

(5 marks)

(b) What is the expression of the output resistance. (5 marks)

(c) Based on the specification given, if we were to add C_L of 350f to the output , what would be your amplifier gainbandwidth?

(5 marks)

(d) If VA is 10V, where do you anticipate the dominant pole?

(5 marks)

4. (a) What is the difinition of transition frequency, f_T? Explain how the f_T of a bipolar transistor can be measured and calculated. Neglect r_{ex} and $r\mu$. Show that

$$f_T = \frac{1}{2\pi} \frac{g_m}{C_\pi + C_\mu}$$

(8 marks)

(b) Derive the complete small-signal model (i.e. find g_m, g_{mb}, r_o,C_{sb}, C_{db}, C_{ox}, C_{gs} and draw the small-signal model with all these elements in it) for an NMOS transistor with I_D = 100 μA, V_{SB} = 1 V, V_{DS} = 2 V. Device parameters are ϕ_f = 0.3 V, W = 10 μm, L = 1 μm, γ = 0.5 $V^{1/2}$, k' = μnCox = 200 $\mu A/V^2$, λ = 0.02 V^{-1}, t_{ox} = 100 angstroms, ψ_o = 0.6 V, C_{sbo}=C_{dbo}=10 fF. Overlap capacitance from gate to source and gate to drain is 1fF. Assume C_{gb} = 5 fF.

(12 marks)

5. (a) Show that the transconductance of the amplifier circuit in Figure 4 can be represented by $\frac{1}{(1+\chi)R_S}$ when r_o >> R_S and R_S is large. χ is the body transconductance to the transistor's transconductance ratio.

(10 marks)

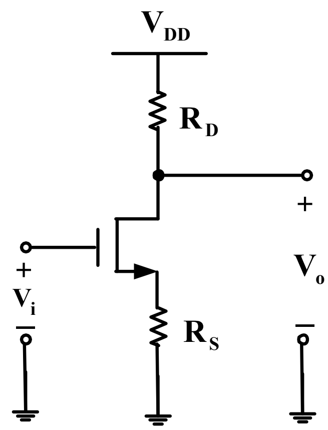

Figure 4

(b) For the circuit shown in Figure 5, the parameters are : $V_{DD} = 10\ \text{V}$, R_1=70.9 kΩ, R_2=29.1 kΩ, and R_D=5 kΩ. The transistor parameters are: V_t=1.5 V, $k = \frac{\mu_n C_{ox}}{2}\frac{W}{L} = 0.5\ \text{mA}/\text{V}^2$ and λ=0.01 V^{-1}. Assume R_{Si} = 4 kΩ. Determine the small-signal voltage gain and input and output resistances of the amplifier shown.

(10 marks)

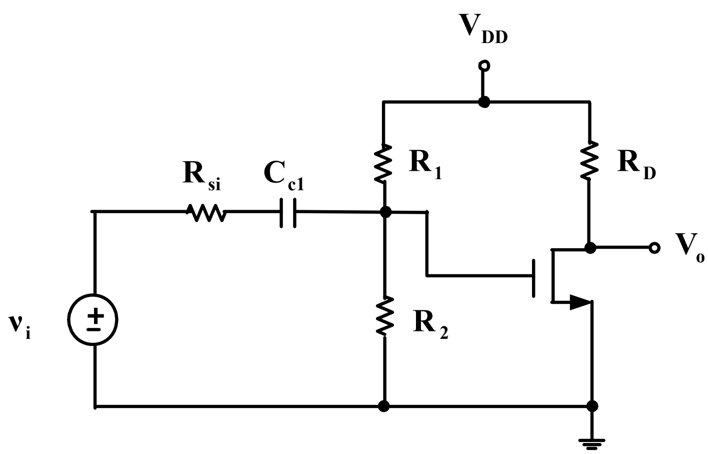

Figure 5

6. (a) Describe the advantages of using an amplifier of the Darglington configuration.

(5 marks)

(b) For each transistor in the circuit in Figure 6, the parameters are: β=125, V_{BE}=0.7 V, and $r_o = \infty$.

(i) Determine the Q-points of each transistor (i.e. I_{CQ1}, V_{CEQ1}, I_{CQ2}, V_{CEQ2})

(ii) Find the overall small-signal voltage gain

$$a_v = \frac{v_o}{v_s}$$

(iii) Determine the input resistance R_i and the output resistance R_o.

(15 marks)

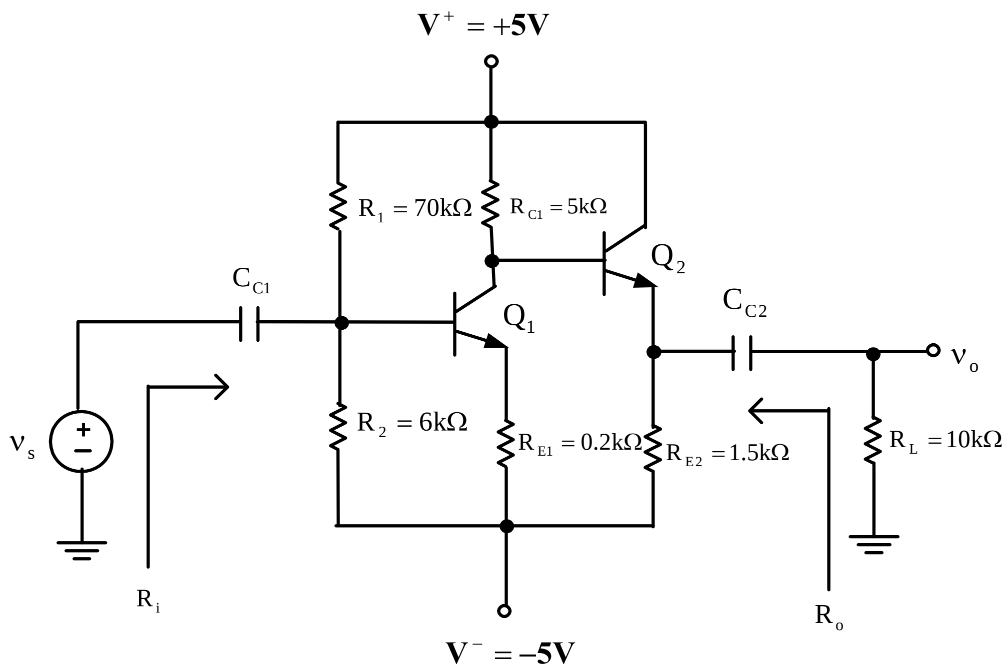

Figure 6

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