PAPER CODE NO. **ELEC 271**	EXAMINER:	Prof. S. Hall	
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UNIVERSITY OF LIVERPOOL

Second Semester Examinations 2016-17

ELECTRONIC CIRCUITS AND SYSTEMS

TIME ALLOWED: THREE HOURS

INSTRUCTIONS TO CANDIDATES

The numbers in the right hand margin represent an approximate guide to the marks available for that question (or part of a question). Total marks available are 100.

Question 1 carries 40 marks. All other questions carry 20 marks.

Answer ALL Questions.

Additional Information Attached:

Amplifier Properties

1. a) Explain what is meant by the term 'small signal equivalent circuit'. How is it used in electronics design? **5**

Part 1: Transistor model

b) Figure Q1b shows a transistor amplifier circuit in which the quiescent DC collector current is 1 mA. Assuming that r_{ce} may be neglected, calculate the voltage gain v_o/v_i. What is the application for this circuit? **5**

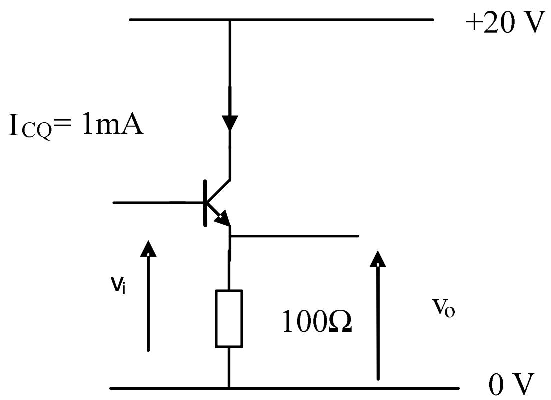


Figure Q1b

Part 2: Amplifier properties

c) Consider a MOSFET common-source amplifier where the bias resistors can be ignored. Draw the ac equivalent circuit of the MOSFET device with zero load resistor and hence show that the gain-bandwidth product is given approximately by, **5**

$$f_T = \frac{g_m}{2\pi C}$$

Where g_m is the transconductance and C is the sum of gate-source and gate-drain capacitance. State any approximations employed.

Part8: Field-effect transistors

d) Explain physically, the Miller Effect. How does it influence the amplifier performance? Suggest a circuit configuration that does not suffer from Miller Effect and explain why. **5**

Part 7: Amplifier frequency response - Bandwidth of voltage amplifier

e) The triangular element in the circuit shown in figure Q1e) represents an ideal current amplifier with a **5** gain of 50. Work out the value of the voltage gain if R_g = 5 kΩ and R_L = 10 kΩ. Part 12: Generic amplifiers

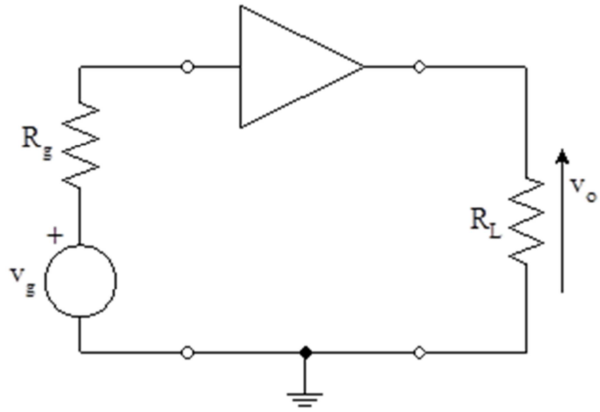


Figure Q1e

f) Draw an appropriate equivalent circuit for the amplifier shown in Figure Q1f, and hence derive the following expression for the loop gain: Part 17: Finding the loop gain **5**

$$T = A_{ol}\frac{r_d}{r_o + r_d}$$

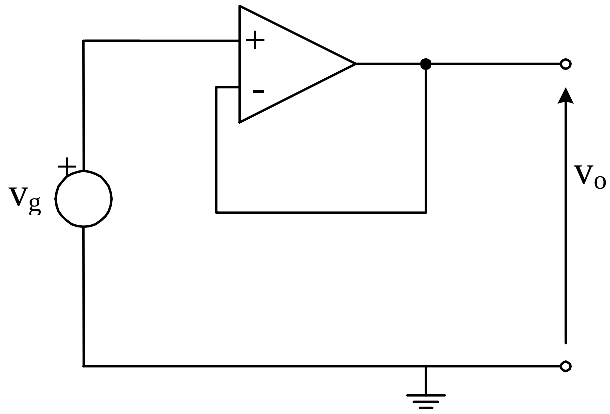


Figure Q1f

The parameter r_d is the amplifier input resistance, r_o its output resistance and A_{ol} is its open-loop gain.

g) Figure Q1g shows an inverting operational amplifier circuit. Identify the feedback topology used in the circuit. Describe briefly the effect that the feedback will have on the input resistance R_i and output resistance R_o of the circuit. Part 16: VSP **5**

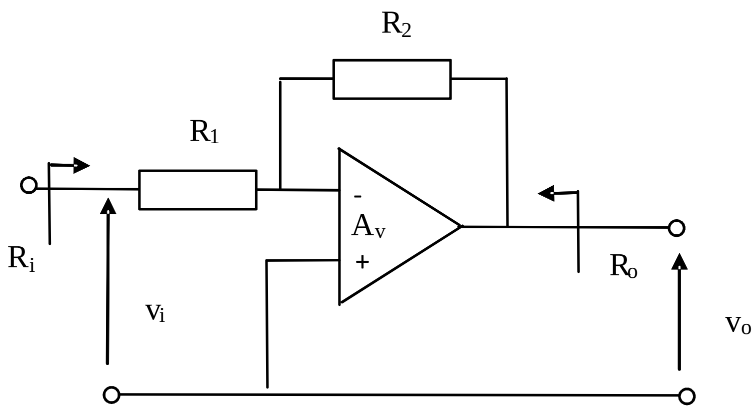


Figure Q1g

h) Referring to Figure Q1h, estimate the voltage at the collector of transistor Q1 and hence the collector current of transistor Q3. What is the function of the circuit block represented by transistors Q_1 and Q_2? **5**

What types of output sensing and input summing are being used in this amplifier?

V_{CC} = 10 V, V_{EE} = -10 V and DC current gain, β is large for all transistors.

Case study of the Motorola MC1350 op-amp

And Part 14: Application of Feedback to amplifiers

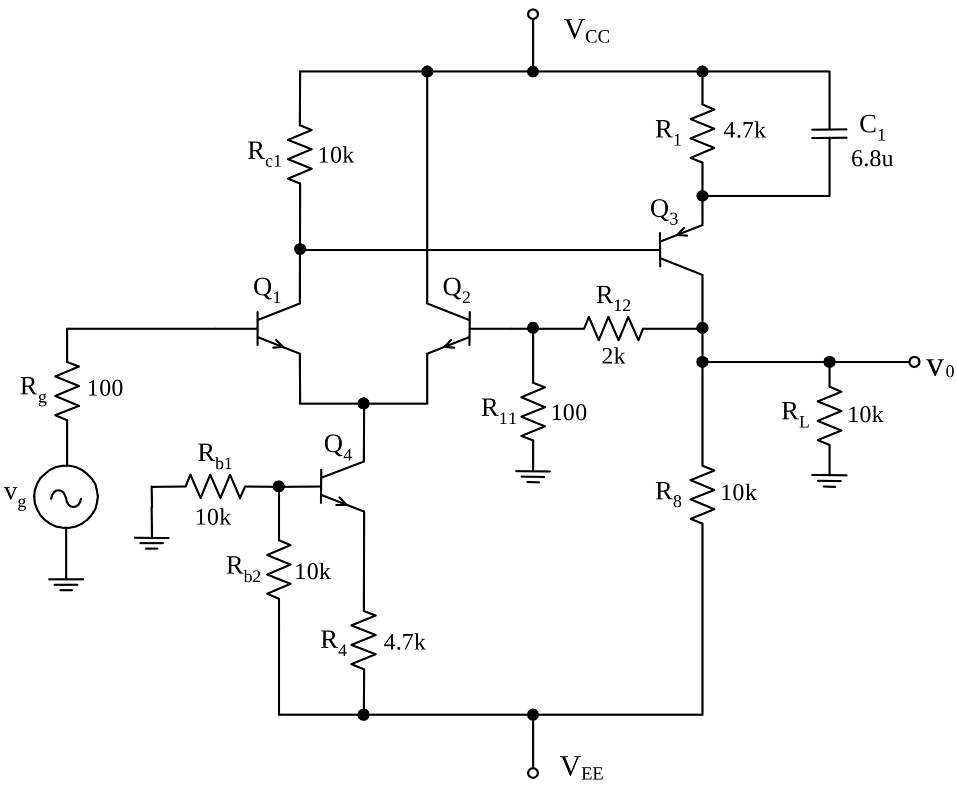


Figure Q1h

Total 40

2 Figure Q2 shows a two-stage voltage amplifier with bias components, coupling and DC blocking capacitors omitted for clarity.

Part 2 + Design examples + Part 12: Feedback

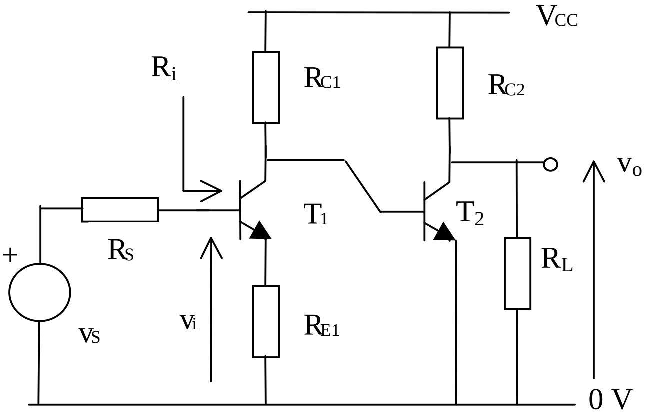


Figure Q2

You are required to design the amplifier to achieve an input resistance, R_i = 100 kΩ and an overall voltage gain equal to or greater than 200, into a resistor output load, R_L. The common-emitter stage (T_2) has bias current equal to 0.5 mA.

V_{CC} = 20 V, β_o = 200, R_S = 20 kΩ and the DC levels of the first and second stage outputs need to be set at half the supply voltage. Allow 10% of V_{CC} across R_E.

Proceed as follows:

a) i) Use the chain rule to show that the system voltage gain is given as: **2**

$$A_{Vs} = A_{V1} A_{V2} \frac{R_i}{R_i + R_S}$$

ii) Work out the bias current (I_{C1}) and emitter resistor value to meet the input specification. Hence find the value of the collector resistor of the first stage. **6**

iii) Work out the gain of the first stage and hence find the required gain of the 2nd stage to meet the specification. Find also a value for R_{C2}. **4**

iv) Find a minimum value of the load to achieve the required gain. **4**

b) Comment on the ‘quality’ of your voltage amplifier and suggest how it could be improved. **4**

Total **20**

3 a) Figure Q3 shows the circuit of a basic operational amplifier made up of individual stages that have been identified as 1 to 5. Briefly describe the purpose of each of these stages. **5**

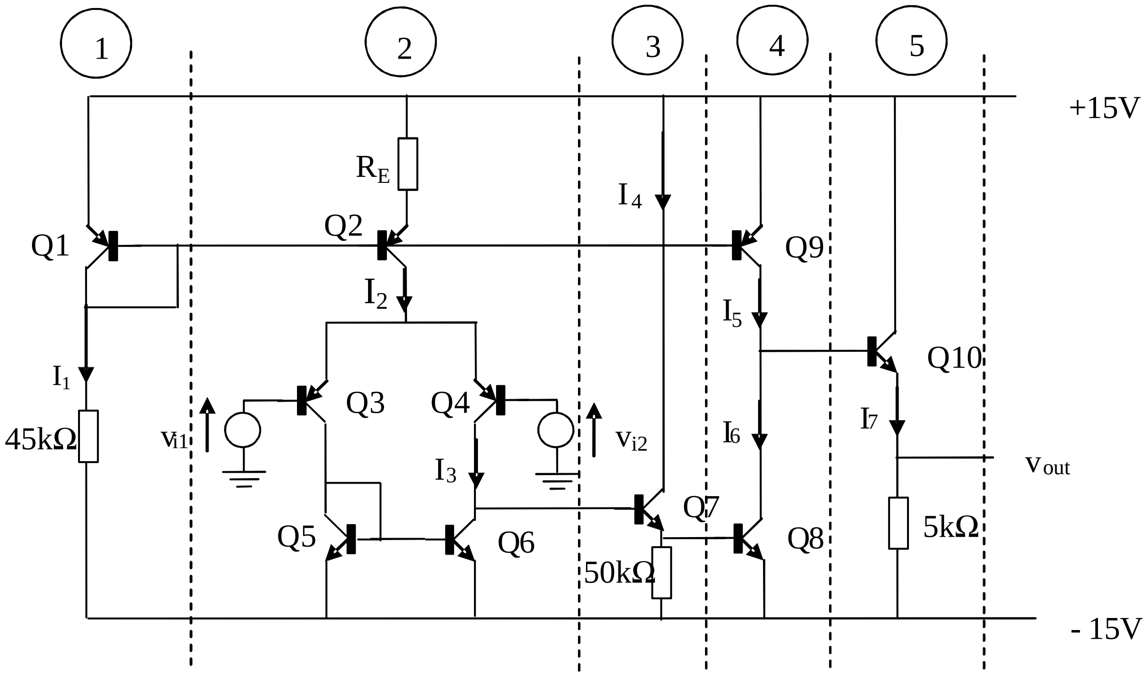


Figure Q3

b) **If I_2 = 0.2 mA**, make reasonable approximations to estimate the total DC current drawn by the circuit from the ±15V DC voltage supply when the amplifier is biased so that the DC value of V_{out} = 0 V and the ac input signals are zero. **5**

Expt.5 + associated lecture and notes on vital

Question 3 continues overleaf

Question 3 continued.

c) Assuming that the voltage gains of the two common collector stages 3 and 5 are both unity, make reasonable approximations to estimate the overall small signal voltage gain of the amplifier, A_V, where: **10**

$$A_V = \frac{v_{out}}{v_{i1} - v_{i2}}$$

Assume that all the transistors have an ac current gain, β_o = 100 and large DC current gain. The Early voltage, V_A = 100 V and transistor output resistance can be taken as

$r_o = \dfrac{V_A}{I_C}$ where I_C is the bias current. You should use the attached equation sheet.

Total 20

4 a) List the advantages and disadvantages of using negative feedback in electronic systems. Part 12 **4**

b) Draw a block diagram of an amplifier with feedback, labelling clearly the open loop gain A_{ol} and feedback fraction, β. Show that the gain with feedback is given by **6**

$$A_f = \frac{A_{ol}}{1 + A_{ol}\beta}.$$

Under what conditions is the closed loop gain insensitive to variations in the open loop gain? Part 13

c) Identify the feedback topology of the amplifier shown in Figure Q6c and hence the amplifier type. Represent the circuit as a negative feedback system and hence estimate the appropriate gain. **10**

State approximations used in your analysis.

Part 14

Total **20**

Figure shown overleaf

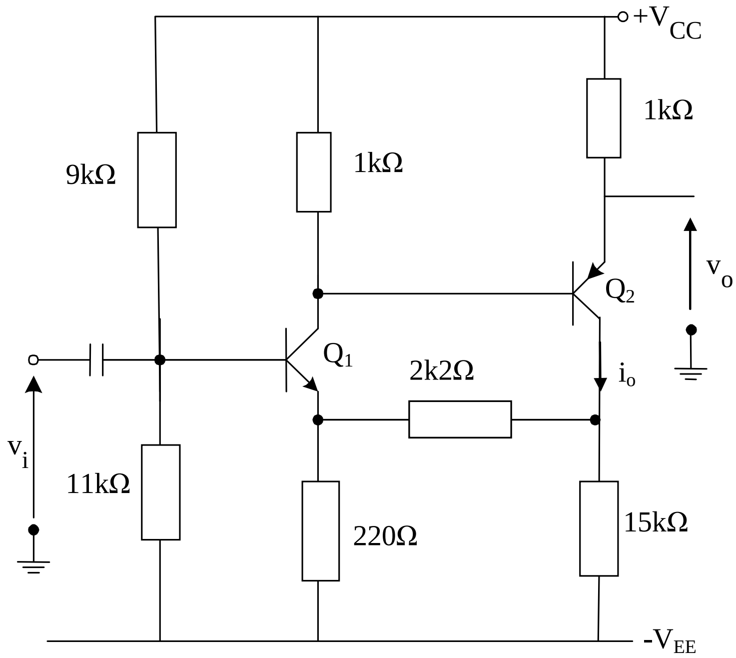
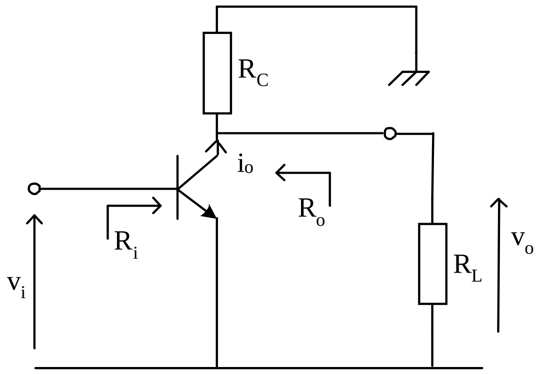


Figure Q6c

ELEC271 / Amplifier properties

Common Emitter

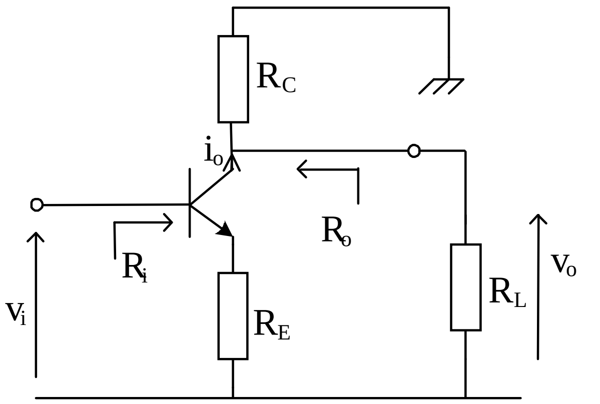


$R_i = r_{be}$

$R_o = R_C$

$$A_V = \frac{v_o}{v_i} = -g_m R_C \,//\, R_L$$

Common emitter with emitter degradation

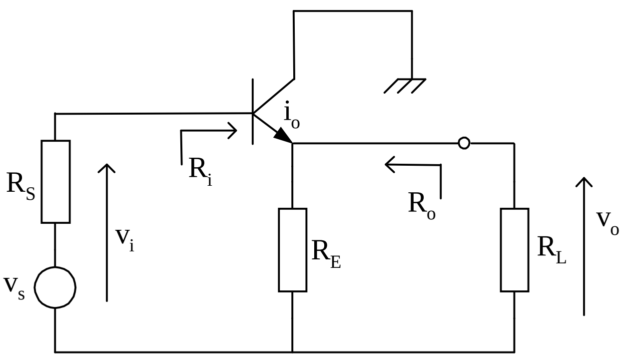


$$R_i = r_{be} + (1+\beta_o) R_E$$

$R_o = R_C$

$$A_V = -\frac{g_m R_C \,//\, R_L}{1 + g_m R_E}$$

Common collector (Emitter follower)

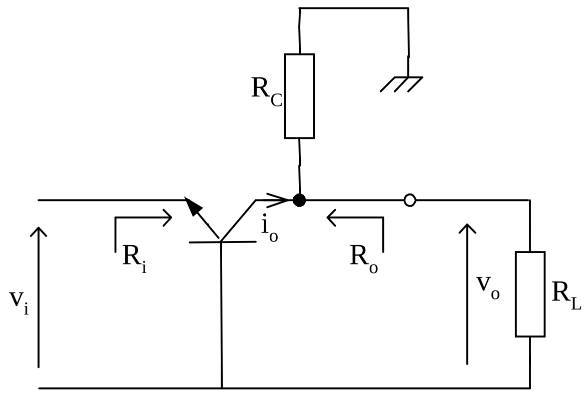


$$R_i = r_{be} + (1+\beta_o) R_E \,//\, R_L$$

$$R_o = \frac{r_{be} + R_S}{1+\beta_o} \,//\, R_E$$

$$A_V = \frac{g_m R_E \,//\, R_L}{1 + g_m R_E \,//\, R_L}$$

Common base



$$R_i = \frac{r_{be}}{1+\beta_o} \approx 1/g_m = r_e$$

$R_o = R_C$

$$A_V = g_m R_C \,//\, R_L$$