PAPER CODE NO.	EXAMINER:	Professor S Hall	
ELEC 271	DEPARTMENT:	**EE&E**	TEL. NO: 44529

SECOND SEMESTER EXAMINATIONS 2017/18

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.

The use of a calculator IS allowed.

Additional Information:

Amplifier properties attached

1. a) Draw small-signal ac equivalent circuits of bipolar and MOSFET transistors at mid-frequencies, as defined between the two -3 dB points. Compare and contrast the ac parameters for transconductance and output resistance for application in analogue circuits. **5**

Part 2: Amplifier properties

b) Sketch a typical frequency response curve (Bode plot of voltage gain versus frequency) of an ac-coupled common-emitter voltage amplifier. Explain the form of the curve, indicating clearly the reasons for the low and high frequency roll-off. **5**

Part 7: Amplifier frequency response - Bandwidth of voltage amplifier

c) Figure Q1c) shows a transistor amplifier circuit in which the quiescent DC collector current is 1 mA. Assuming that parameter r_{ce} and resistor R_E are large enough to be neglected, draw the equivalent circuit and calculate the voltage gain, v_o/v_i. State an application for this amplifier. The collector resistor, R_C = 2 kΩ. **5**

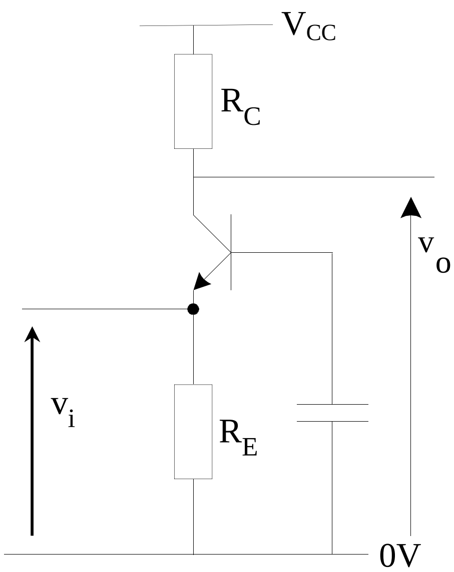

Figure Q1c)

Part 2: Amplifier properties

d) Figure Q1d) shows a simplified diagram of a cascode amplifier. Consider it as a two-stage amplifier and hence show, using the amplifier properties provided at the end of this paper, that the voltage gain is approximately given by; **5**

$$A_V = -g_m \times R_C \, .$$

What is the main application for this amplifier?

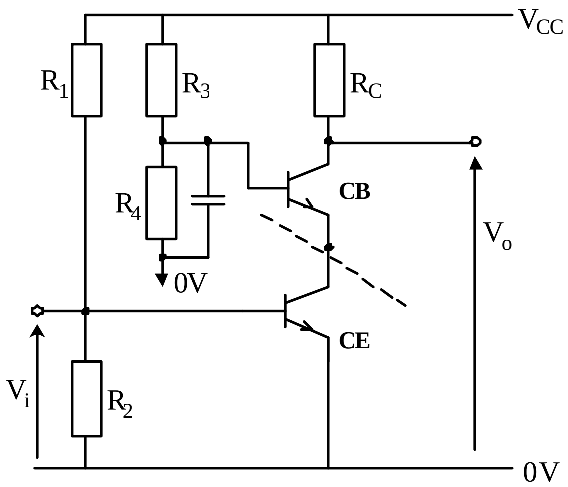

Figure Q1d)

Part 7: Amplifier frequency response - Bandwidth of voltage amplifier

e) The triangular element in the circuit shown in the Figure Q1e) represents an ideal trans-resistance amplifier with a gain of 100 kΩ. Work out the value of the voltage gain, v_o / v_g if R_g = 5 kΩ and R_L = 10 kΩ. Part 12: Generic amplifiers **4**

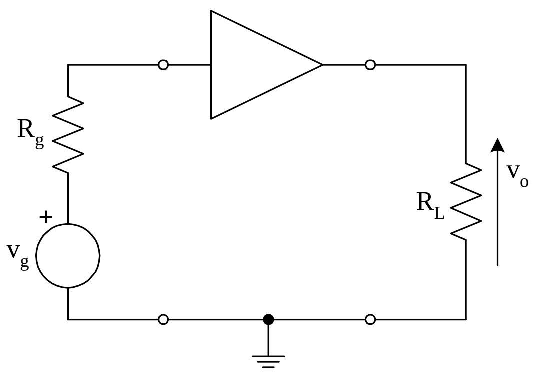

Figure Q1e)

f) Figure Q1f) shows the ac equivalent circuit of a common-source amplifier where R_t is the ac load. The low-frequency roll-off is to be set by the capacitor C_S. Design the amplifier to have a low-frequency roll-off, f_L = 100 Hz. You may assume that R_S is much greater than the impedance of C_S at the frequency of 100 Hz. (g_m = 1 mA/V) **6**

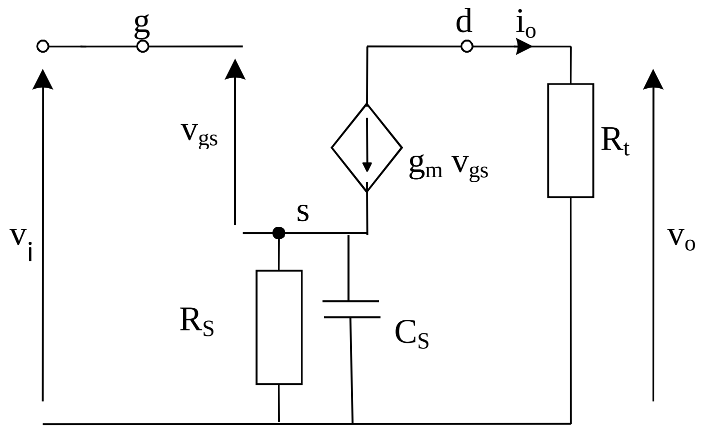

Figure Q1f)

Part 7: Amplifier frequency response - Bandwidth of voltage amplifier

g) The op-amp in Figure Q1g) is ideal. For the condition $R_1 = R_2$, show that the output voltage, V_o is given by, $V_o = V_{g1} + V_{g2}$. **5**

How would you modify the circuit to obtain a gain of 10?

State all assumptions used in your analysis. Part 16: Op-amp circuits

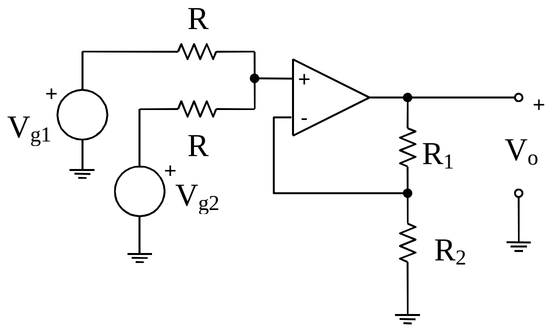

Figure Q1g)

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h) Explain the meaning of the terms, 'voltage offset' and 'offset current', in relation to operational amplifiers. How would you alleviate these problems for the case of the inverting operational amplifier circuit? **5**

Part 21: Op-amp problems

Total

40

2. You are required to design a common emitter voltage amplifier (find values for the resistors) to meet the following specification and criteria: a collector current of I_C = 1 mA, DC voltage rail, V_{CC} = 10 V and $V_{BE}(on)$ = 0.6 V.

a) Sketch the schematic circuit and calculate the four resistor values, R_C, R_E, R_{B1} and R_{B2} to meet the required specification, according to the following guidelines: **12**

i) Allow 10% of V_{CC} across $R_{E,}$

ii) about 0.5 V_{CC} at the collector node,

iii) the current in the base bias resistors should be ten times greater than the DC base current, where the DC current gain is 200.

Comment on each guideline.

b) The voltage gain of your amplifier is required to be greater than 50. Write down an expression for the voltage gain (see attached Amplifier Properties sheet) and hence find the minimum value of load resistor, R_L that could be used, to satisfy this requirement. **8**

Part 2: Design example I

Total
20

3. Figure Q3 shows a differential amplifier with current source biasing.

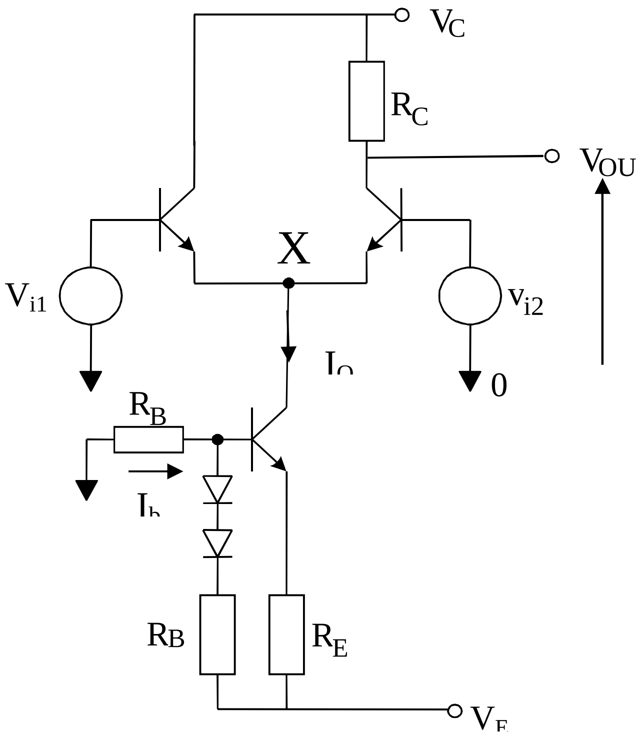


Figure Q3

a) Explain the good features of this design. **4**

b) Design the circuit (estimate values for the resistors) to meet the following specification: I_O = 1 mA and the DC level at V_{OUT} = 0 V. **10**

Hints: Allow 2 V across R_E, the current in the bias circuit, $I_b = 0.1\times I_O$ and the forward-bias diode drop is 0.6 V. You may assume ideal transistors with high DC current gain, with V_{CC} = 10 V, and V_{EE} = −10 V.

c) Explain why point ‘X’ can be considered an ac ground for differential signals and hence draw an ac equivalent circuit for the differential amplifier. Use the equivalent circuit to estimate the differential gain. **6**

Parts 3 & 4: Differential amplifier and current source biasing

Total

20

4. a) List the advantages and disadvantages for the use of negative feedback in electronic systems. **5**

Part 11: Intro to Feedback

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; **5**

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

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

Part 13: Feedback Theory

c) Figure Q4 shows the circuit of an amplifier with feedback, partially prepared for ac. analysis by removing the large bias resistors, coupling capacitors and shorting out the DC supply.

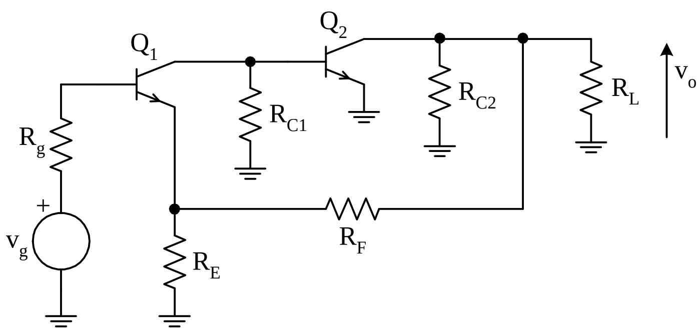


Figure Q4

i) Identify the feedback topology and hence the amplifier type. **3**

ii) Represent the circuit as a negative feedback system and hence estimate the appropriate gain, assuming that the open-loop gain of the amplifier is large. State any approximations and assumptions used in your analysis. **7**

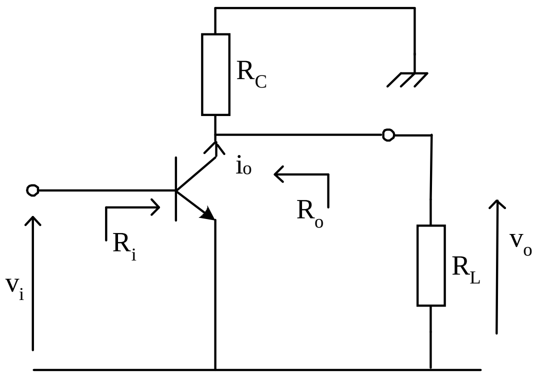
R_F = 25 kΩ, and R_E = 2.2 kΩ.

Part 14: Application of Feedback to amplifiers

Total 20

ELEC271 / Amplifier properties

Common Emitter

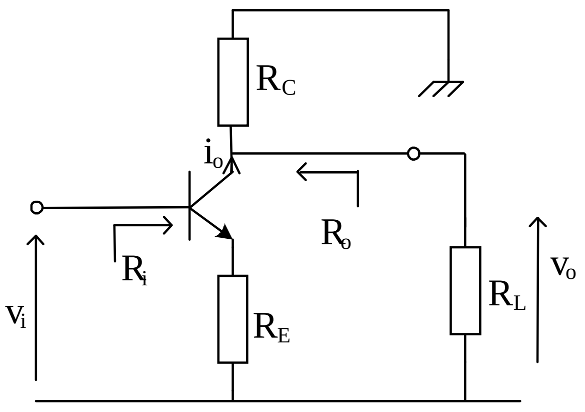


$R_i = r_{be}$

$R_o = R_C$

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

Common emitter with emitter degradation

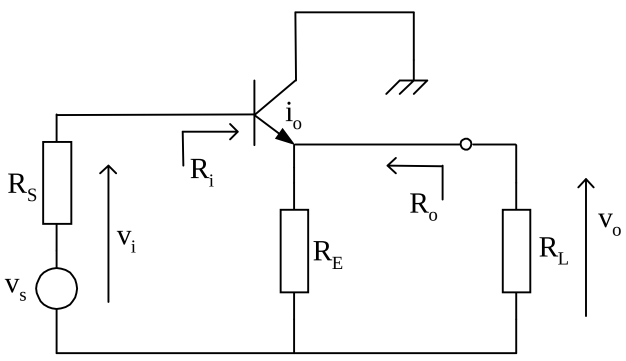


$$R_i = r_{be} + (1+\beta_o) R_E$$

$R_o = R_C$

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

Common collector (Emitter follower)

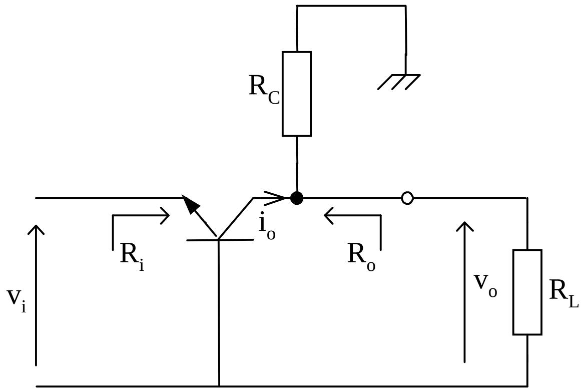


$$R_i = r_{be} + (1+\beta_o) R_E \,//\, R_L$$

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

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

Common base



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

$$A_V = g_m R_C // R_L$$