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UNIVERSITY OF SWAZILAND

MAIN EXAMINATION 2004/2005

FACULTY OF SCIENCE

DEPARTMENT OF ELECTRONIC ENGINEERING

TITLE OF PAPER: ELECTRONICS III - PAPER 1

COURSE NUMBER: E510

TIME ALLOWED: THREE HOURS

INSTRUCTIONS:

1. Answer any FOUR (4) of the following six questions.
2. Each question carries 25 marks.
3. Unless otherwise stated, $V_{BE(ON)} = 0.7$ V and $V_T = 0.026$ V.
4. If you think not enough data has been given in any question you may assume reasonable values.
5. In design, when necessary, use the following E24 range of values:

   10 11 12 13 15 16 18 20 22 24 27 30 33 36 39

   43 47 51 56 62 68 75 82 91

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THIS PAPER CONTAINS SEVEN (7) PAGES INCLUDING THIS PAGE

QUESTION ONE (25 marks)

(a) The transistors in Fig. Q.1b. are matched, but have finite β that cannot be ignored. Find expressions for I_{o1} and I_{o2} in terms of I_{ref} and comment on your answer.

(12 marks)

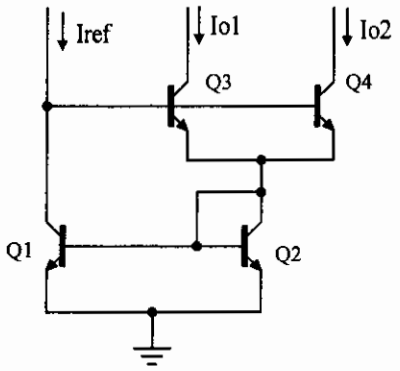


Fig. Q1a

(b) Design a constant current source to deliver a current of 1 mA to a load varying from 0 to 5 kΩ. Note that you must choose a power supply for your circuit and ensure that the transistors remain in forward active mode for the full range of load resistance. Assume that $V_{CEsat} = 0.2$ V

(8 marks)

(c) (i) A constant current source feeds a current to a resistor connected to the ground terminal of a circuit. Draw a suitable circuit for the current source. You are not required to specify any component values, but the polarity of power supply should be specified. *(3 marks)*

(ii) What are current sources or sinks used for in electronic circuits? *(2 marks)*

QUESTION TWO *(25 marks)*

Using ± 15 V dual power supplies specify all the circuit components required so that each transistor in Fig. Q.2 operates in the active mode with about 1 mA collector current. Using your component values predict the quiescent value of V_o in each circuit, and the V_{CE} of each transistor in the circuit.

(6+6+7+6 marks)

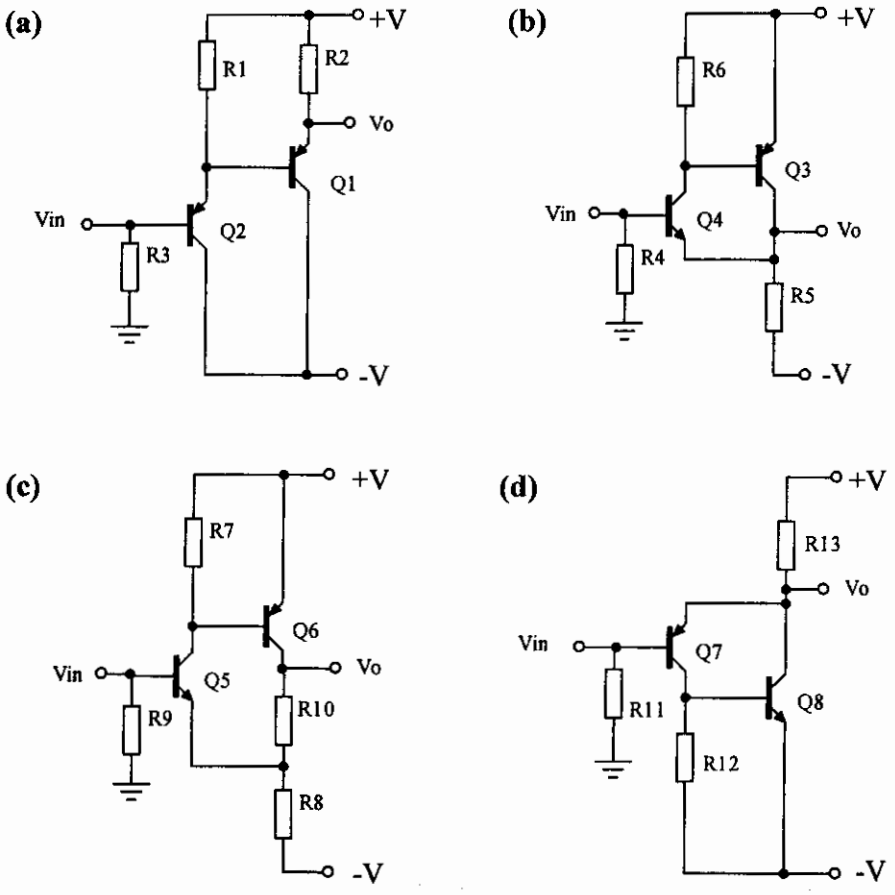


Fig. Q2

QUESTION THREE ***(25 marks)***

(a) If $\beta_F >> 1$, show that the voltage gain of the CE circuit in Fig. Q.3a is given by $A_v \approx -g_m R_2 /(1+g_m R_3)$. *(5 marks)*

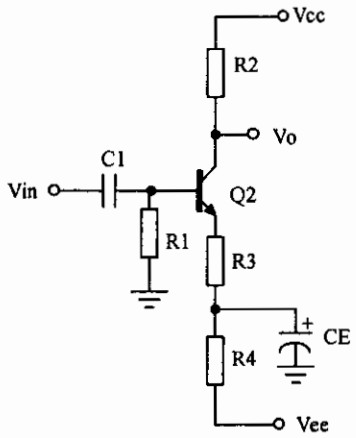
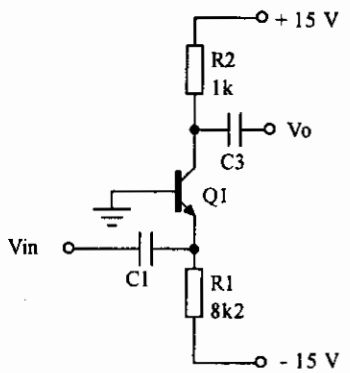


Fig. Q.3a

(b) Design a common-emitter amplifier based on Fig. Q.3a operating from ±15 V supplies with a voltage gain of 22. *(12 marks)*

(c) Calculate (i) the voltage gain v_o/v_{in} and (ii) the input impedance of the circuit of Fig. Q.3c Ignore the effect of the capacitors. *(8 marks)*



QUESTION FOUR ***(25 marks)***

(a) For the amplifier in Fig.Q.4a assume that all transistors are matched with $\beta = 200$.

(i) Show that the dc voltage at the bases of the transistors is nearly zero, even when Re = 0. *(3 marks)*

(ii) Calculate the single-ended and differential voltage gain (include the effects of the emitter degeneration resistors R_e). *(6 marks)*

(iii) Calculate the common mode voltage gain. *(4 marks)*

(iv) Calculate the CMRR in dB. *(2 marks)*

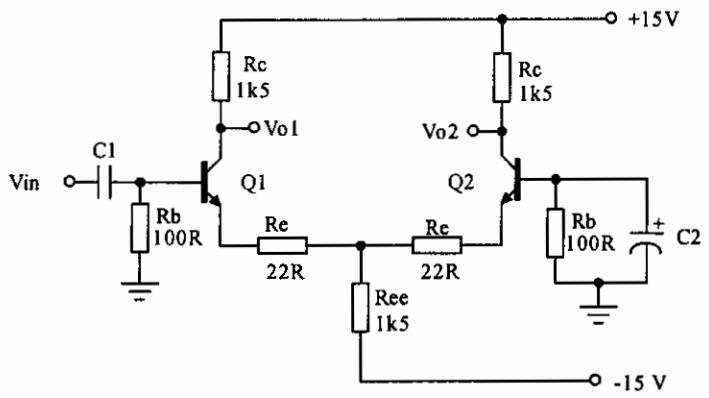


Fig. Q.4a

(b) The resistor R_{ee} in Fig. Q.4a is to be replaced with a current source without affecting the differential voltage gain.

(i) Design the current source. You may assume that several matched transistors with $\beta = 100$ and $V_A = 100$ V are available. *(5 marks)*

(ii) Which values you calculate in Q.4a are affected by the replacement of R_{ee} by your current source? Calculate the new values. *(5 marks)*

QUESTION FIVE ***(25 marks)***

(a) Consider the amplifier shown in Fig. Q.5a.

(i) What is the quiescent operating point of the transistor Q_1? *(2 marks)*

(ii) Why would such an operating point be used in practice? *(5 marks)*

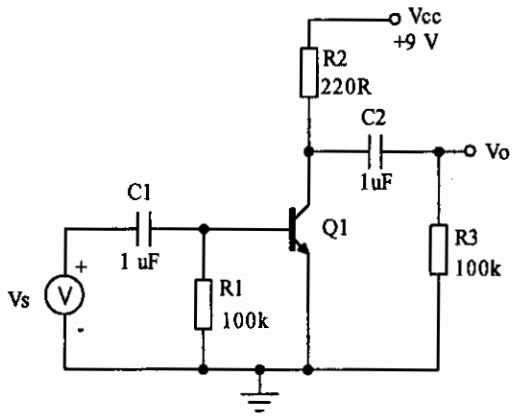


Fig. Q.5a

(b) The amplifier in Fig. Q.5a is modified as shown in Fig.Q.5b. Describe the output as the ac input signal frequency is varied from 50 kHz to 300 kHz.

(9 marks)

(c) What would be the effect of replacing the load resistor R_3 with a 10 kΩ resistor? Support your answer with relevant equivalent collector impedance derivations.

(9 marks)

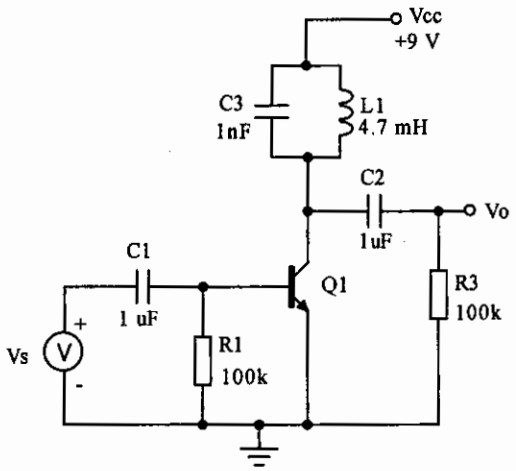


Fig. Q.5b

QUESTION SIX *(25 marks)*

(a) Derive the maximum efficiency of a Class B output stage. *(10 marks)*

(b) Calculate suitable values of the resistors in the Class AB output stage given in Fig. Q.6b. Assume that the maximum current in Q1 and Q2 is 100 times the current in Q3. The load resistance is 100 Ω. *(15 marks)*

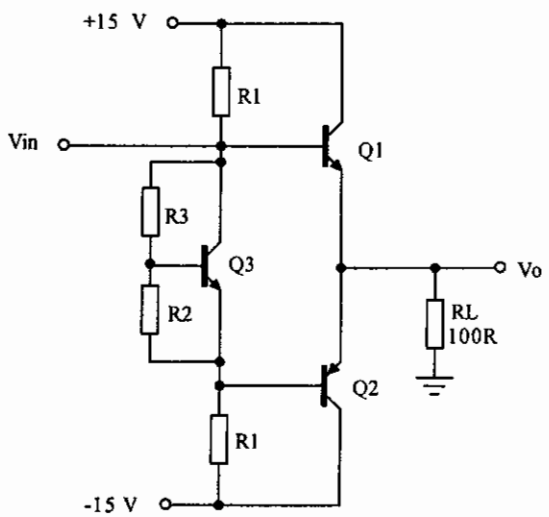


Fig. Q. 6b

END OF EXAMINATION PAPER