UNIVERSITY OF SWAZILAND

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FACULTY OF SCIENCE AND ELECTRONIC ENGINEERING

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2013/2014

TITLE OF PAPER	**:**	**ELECTRONICS I**
COURSE NUMBER	**:**	**P311**
TIME ALLOWED	**:**	**THREE HOURS**
INSTRUCTIONS	**:**	**ANSWER ANY FOUR OUT OF FIVE QUESTIONS**
		EACH QUESTION CARRIES 25 MARKS
		MARKS FOR DIFFERENT SECTIONS ARE SHOWN IN THE RIGHT-HAND MARGIN.

THIS PAPER HAS 7 PAGES, INCLUDING THIS PAGE.

DO NOT OPEN THE PAPER UNTIL PERMISSION HAS BEEN GIVEN BY THE INVIGILATOR.

QUESTION 1

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(a) Suppose that you were required to plot the drain and transfer characteristics of an n-channel JFET. Sketch the diagram of a circuit you would connect to measure these characteristics and label it. (3 marks)

(b) Sketch and label typical drain and transfer characteristics of any n-channel JFET. (4 marks)

(c) With the aid of the drain and/or transfer characteristics:

(i) explain why the JFET can be used as a voltage controlled resistor; (3 marks)

(ii) explain how you would determine the transconductance from the transfer characteristics. (4 marks)

(d) When the gate-source voltage, V_{GS} of a JFET is kept constant, a change in the drain-source voltage of 2 V leads to a corresponding change in the drain current of 0.5 mA. Use this information to calculate the drain resistance, r_d of the JFET. (5 marks)

(e) The circuit in Fig. 1 represents a common-source amplifier. The mutual conductance of the JFET is 10 mS.

(i) Calculate the voltage gain of the amplifier. (2 marks)

(ii) Calculate I_D and V_D, when V_{GS} = -1.0 V (4 marks)

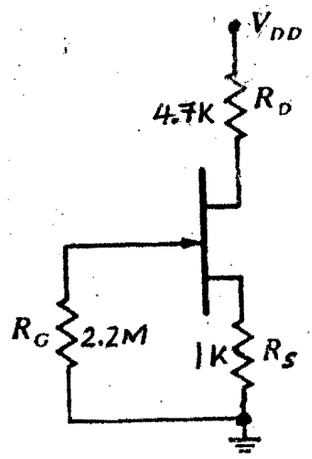

Fig. 1

QUESTION 2

(a) Describe the operation of an npn transistor when it is connected in the forward-active mode. Use a suitable diagram for illustration. (10 marks)

(b) The characteristics of a typical bipolar junction transistor (npn) are given in Fig. 2.

(i) Draw the loadline on the enlarged characteristics shown on page 7, when the supply voltage, $V_{CC} = 8$ V and the collector resistor, $R_C = 1$ kΩ. (4 marks)

(ii) Select a suitable quiescent point on one of the characteristics and estimate the quiescent values of I_B, I_C and V_{CE}.

(3 marks)

(c) Consider the circuit shown in Fig. 3. Calculate V_B, R_C *and* R_E using the following voltages and current:

$V_{CE} = 9$ V
$V_E = 6$ V
$V_{BE} = 0.6$ V
$I_E = 3$ mA

(8 marks)

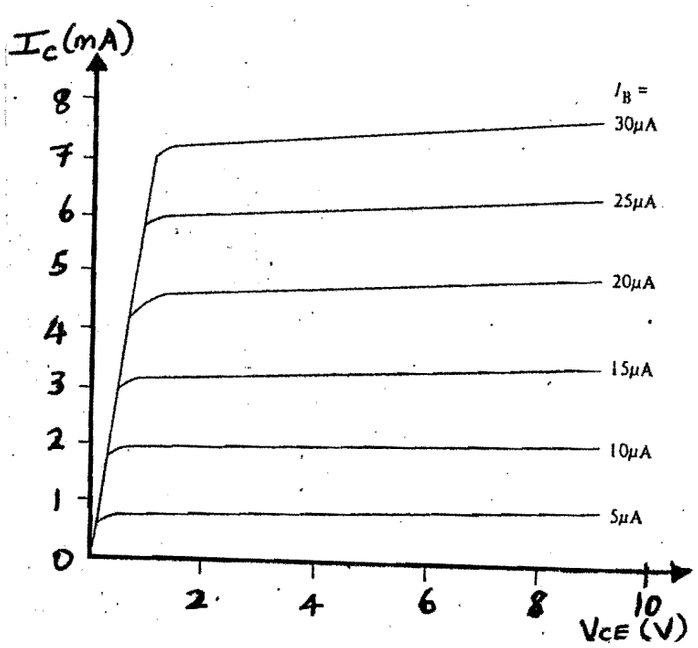

Fig. 2

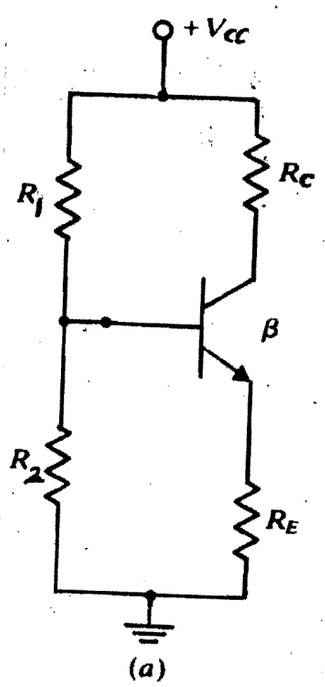

Fig. 3

QUESTION 3

(a) A 0.1 mF capacitor is used to filter the output of a half-wave rectifier. The transformer secondary voltage has a frequency of 50 Hz and an amplitude of 56 V. The average current through the load is 20 mA. Calculate the following:

(i) the peak value of the ripple voltage; (4 marks)

(ii) the average voltage across the load resistor, R_L. (2 marks)

(b) A half-wave rectifier circuit consists of a diode and a load resistor R_L. It operates on an a.c. mains supply of 240 V_{rms}. The turns ratio of the step-down transformer is 0.25. Calculate the following:

(i) the amplitude of the secondary voltage of the transformer; and (3 marks)

(ii) the average voltage across R_L. (2 marks)

(c) A Zener diode with the specifications listed below is used in a voltage regulator circuit.

Knee current = 20 mA
Zener voltage = 9.1 V
Maximum power rating of the Zener diode = 1.3 W

The voltage at the input of the regulator circuit is 20 V ± 10% and the load current, I_L = 30 mA.

(i) Sketch the circuit diagram of the voltage regulator circuit and label it; (2 marks)

(ii) Calculate the series resistance; (7 marks)

(iii) Calculate the power dissipated in the diode when the supply voltage is 22 V. (5 marks)

QUESTION 4

(a) Sketch the energy-band diagrams for the following materials. Label the diagrams and interpret the meaning of each diagram:

(i) intrinsic silicon; (5 marks)

(ii) n-type silicon. (5 marks)

(b) A silicon diode has a reverse saturation current of 10 nA when the junction temperature is 27 ^{0}C. The maximum current rating of this diode is 5 A.

(i) Calculate the forward current and forward voltage when the incremental resistance of the diode, $r_d = 100\ \Omega$. (7 marks)

(ii) If the diode is forward biased and the voltage across it is 0.5 V, what will be the forward current? (3 marks)

(iii) How high will the junction temperature be when the forward current is 5A and the forward voltage is 0.7 V? (5 marks)

QUESTION 5

(a) Explain, briefly, how you would manufacture a p-channel junction field effect transistor. (7 marks)

(b) With the aid of a diagram(s) and characteristics, discuss the principle of operation of the p-channel junction field effect transistor. (8 marks)

(c) (i) Sketch the small signal equivalent circuit of a common-source amplifier. (3 marks)

(ii) Use the equivalent circuit to show that the gain of the common-source amplifier, A_v is given by

$$A_V \propto \frac{r_d R_D}{r_d + R_D},$$

where r_d and R_D have their usual meanings. (4 marks)

(d) The transistor used in a source follower circuit has a mutual conductance of 15 mS. The source resistor R_S = 5 kΩ. Calculate the voltage gain of the follower and its output resistance. (3 marks)

PLEASE SUBMIT THIS PAGE TOGETHER WITH YOUR ANSWER BOOK 61

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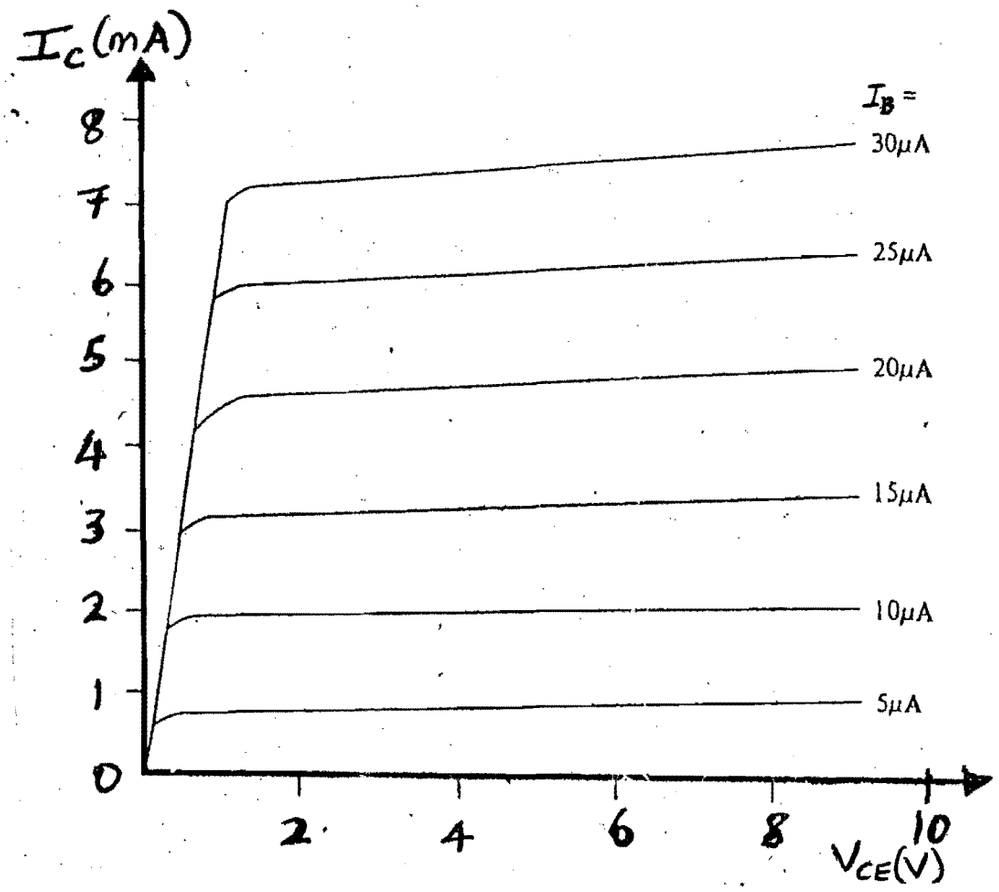

Fig. 2 (enlarged)