UNIVERSITY OF SWAZILAND   106

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

SUPPLEMENTARY EXAMINATION 2011

TITLE OF PAPER   :   ELECTRONICS I

COURSE NUMBER   :   P311

TIME ALLOWED   :   THREE HOURS

INSTRUCTIONS   :   ANSWER <u>ANY FOUR</u> 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.

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INVIGILATOR.

1

(a)   An ac power-line supplies $240V_{rms}$ to the primary of a transformer with a secondary:primary turns ratio of 30. Calculate the peak voltage across the secondary of the transformer.   (4 marks)

(b)   Figure 1.1 shows a Zener diode regulator. The maximum power rating of the Zener diode is 250 mW and the Zener voltage is 9.1 V.

Calculate the value of R_s required to ensure that the power dissipated in the Zener diode is to be less than 100 mW when the supply voltage, V is 12 V and the load resistance, R_L is 100 Ω.   (8 marks)

(c)   Consider the half-wave rectifier shown in Figure 1.2.

   (i)   Calculate the average current through R_L.   (3 marks)

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

   (iii)   What would be the average voltage when R_L = 100 Ω?   (2 marks)

   (iv)   What would be the average voltage when the rectifier is used with a smoothing capacitor equal to 100 μF?   (6 marks)
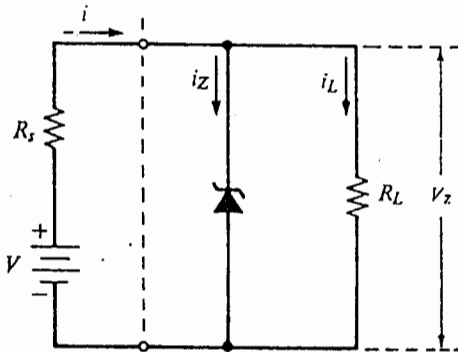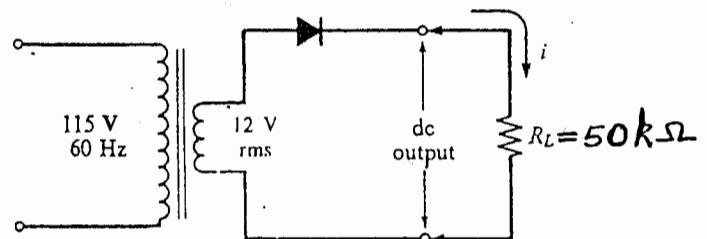

Figure 1.1

Figure 1.2

2

QUESTION 2

(a)   Describe the principle of operation of a pnp (bipolar junction) transistor connected in the forward-active mode. Use a schematic diagram for illustration.   (10 marks)

(b)   Consider the common-emitter amplifier shown in Fig. 2.1. If $I_E = 2\ mA$, $V_{CE} = 12\ V$, $V_E = 5V$ and $V_{BE} = 0.65V$, calculate values of R_E, R_C and V_B.
(8 marks)

(c)   The characteristics of a typical bipolar junction transistor (npn) are given in Fig. 2.2.

   (i)   Draw the loadline for supply voltage $V_{CC} = 8\ V$ and collector resistor $R_C = 500\Omega$.   (4 marks)

   (ii)   Choose an operating point on the characteristics and estimate the quiescent values of I_B, V_{CE} and I_C. Justify your choice of the operating point.
(3 marks)

Note: You are requested to complete the table provided on page 7 of this paper and submit it together with your answer book(s).
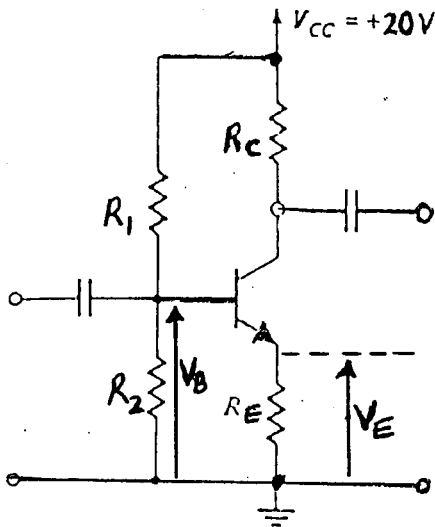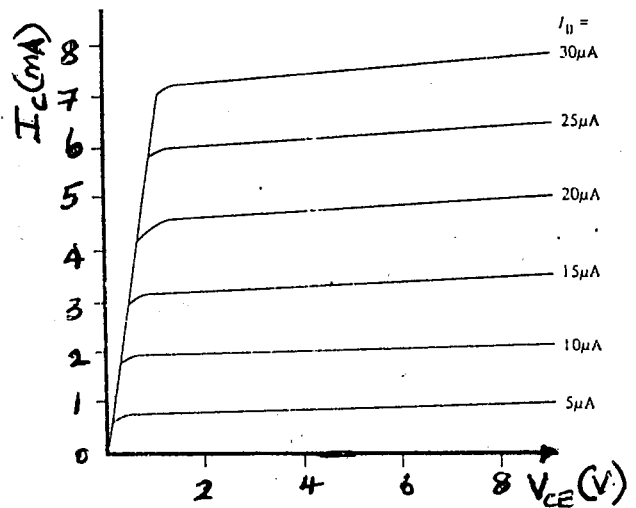

Fig. 2.1

Fig. 2.2

3

QUESTION 3

(a)   With the aid of a diagram as well as the drain and mutual characteristics, explain how a p-channel JFET works.

(8 marks)

(b)   Use appropriate diagrams to explain how you would manufacture a p-channel JFET from a p- or n-type material.   (7 marks)

(c)   (i)   Draw the small signal model of a JFET common source amplifier. (3 marks)
        (ii)   Show that the gain of this amplifier is

$$A_v = -g_m \left[\frac{1}{R_D} + \frac{1}{r_d} \right]^{-1}.$$

(4 marks)

(d)   In a JFET source follower, the transistor used has a mutual conductance equal to 10 mS. The resistor connected between the source and common is 5kΩ. Calculate the voltage gain of the follower.   (3 marks)

4

QUESTION 4

(a) A 10 μF capacitor is used to reduce the ripple voltage at the output of a half-wave rectifier. The amplitude of the voltage at the transformer secondary is 25 V (50 Hz) and on average the current through the load is 5 mA..

  (i)   Calculate the peak-to-peak value of the ripple voltage   (4 marks)
  (ii) Calculate the average output voltage.   (2 marks)

(b) A voltage regulator circuit utilises a 4.1 V, 500 mW Zener diode. The minimum current requirement of the diode is10 mA. The supply voltage is 15V± 10% and the constant current through the load is 20 mA.

  (i)   Draw 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 18 V.

                                                                     (5 marks)

(c) 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}. with a step-down transformer that has a turns ratio T of 1/3. Calculate

  (i)   the peak value of the secondary voltage and   (3 marks)
  (ii) the d.c. voltage across R_L.   (2 marks)

5

QUESTION 5

(a) (i)   Explain how you would obtain the transfer and drain characteristics of an n-channel JFET. Use a suitable diagram to support your explanation. (3 marks)

(ii)   Sketch and label typical transfer and drain characteristics . (4 marks)

(iii)   Use the characteristics explain how the use of a JFET as a voltage controlled resistor and how you would determine the mutual conductance. (7 marks)

(b)   Consider a JFET connected in the common-source mode. If the gate-source voltage is kept constant and a change in the drain-source voltage of 4 V produces a corresponding change of 1 mA in the drain current, what would be the drain resistance, r_d of the FET.

(5 marks)

(c)   Consider the JFET amplifier in Fig. 5.1. The transconductance, g_m of the transistor used is 20 mΩ^{-1}.

(i)   What would be the values of I_D and V_D when V_{GS} is -1.5V? (4 marks)
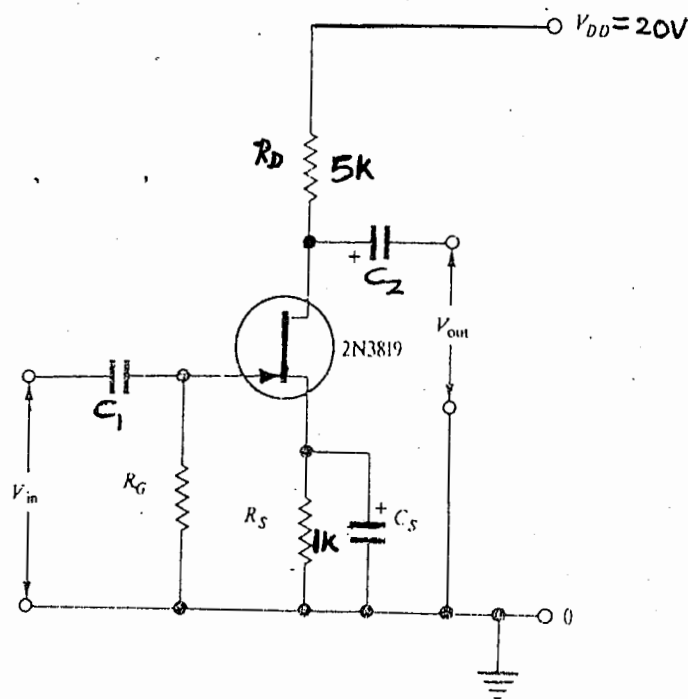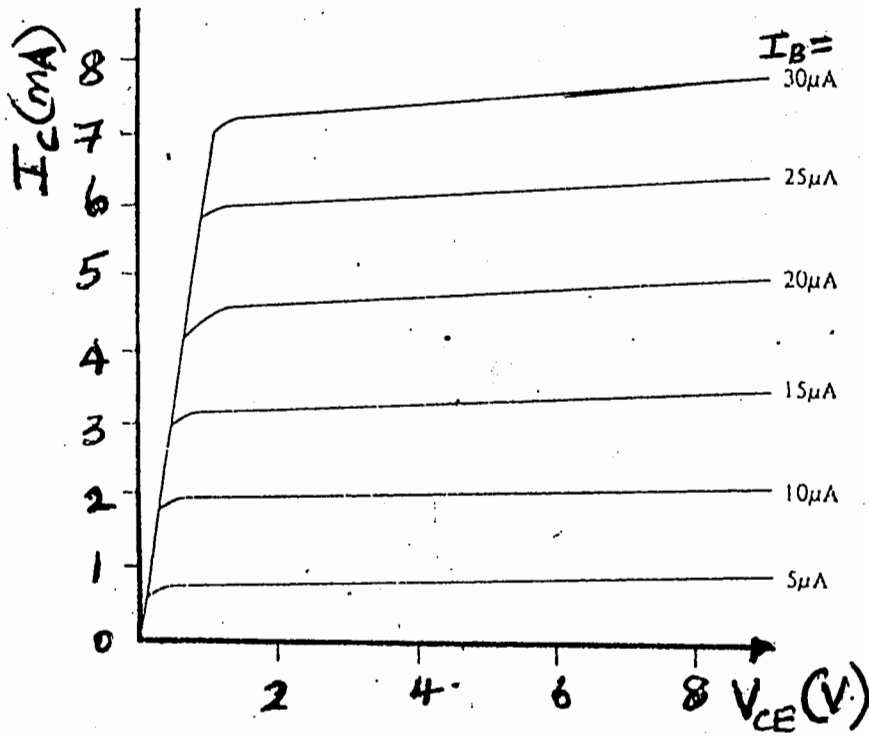(ii)   Find the voltage gain of the amplifier. (2 marks)

Fig. 5.1

6

USE THE GRAPH BELOW TO ANSWER QUESTION 2(c)

The graph should be handed in together with your answer book(s).