UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION	**:**	**2009/2010**
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

(a) Consider a bipolar junction transistor with a current gain h_{FE} of 200. The transistor is used as an amplifier connected in the common-emitter configuration. The leakeage current is 20 μA at 30° C and increases to 480 μA at 50° C. The steady current at the base of the transistor is 40 μA.

Calculate the percentage change in collector current when the junction temperature increases from 30° C to 50° C. (7 marks)

(b) An npn silicon transistor has the output characteristics shown in Fig. 1.1. It is used to design a voltage amplifier. The supply voltage, V_{CC} is 12 V and the collector resistance, R_C is 3 kΩ. With the aid of the enlarged graph on page 7, and the loadline concept, estimate the values of the parameters given below, under quiescent conditions:

(i) The base and collector current (6 marks)
(ii) The voltage drop across R_C. (2 marks)

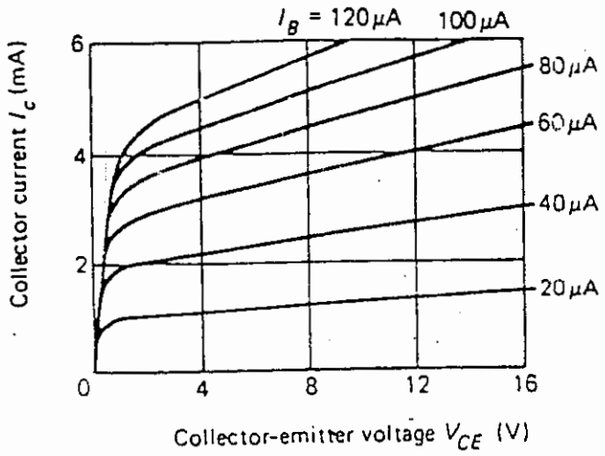

Fig.1.1

(c) (i) Draw a small signal model of a common-source amplifier. Include the output resistance, $1/h_{oe}$ in the model. (2 marks)

(ii) Derive the exact expressions of the current gain and voltage gain. (6 marks)

(iii) Calculate the current gain if the output conductance, h_{oe} is 2×10^{-5} siemen. (2 marks)

QUESTION 2

(a) Imagine an ac mains supply that provides a nominal voltage of 240 V rms. The primary of a step-down transformer with a turns ratio of 1/20 is connected to the mains supply. Determine the peak voltage at the secondary of the transformer. (4 marks)

(b) Fig. 2.1 shows a basic Zener diode voltage regulator. With the aid of a diagram(s) discuss the principle of operation of the regulator.

State the conditions that should be satisfied to ensure that the regulator gives a constant output voltage and that the diode is not damaged. (10 marks)

(c) Consider the Zener diode voltage regulator shown in Fig. 2.1. The minimum current required through the diode is 15 mA and the constant load current is 20 mA.

(i) Calculate the series resistance. (3 marks)

(ii) How much power would be dissipated in the Zener diode when the supply voltage is 18 V? (8 marks)

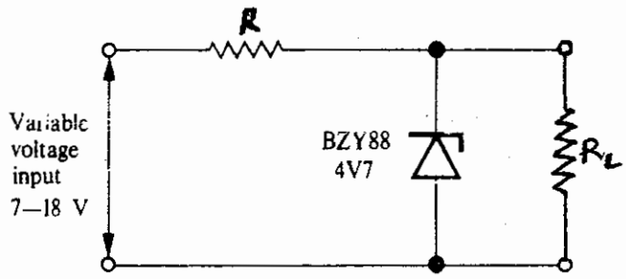

Fig. 2.1

QUESTION 3

(a) Define each of the following terms pertaining to a junction field effect transistor (JFET) and explain briefly how they can be measured with reference to appropriate sketches of graphs:

(i) mutual conductance (4 marks)

(ii) drain conductance (4 marks)

(b) Explain how an n-channel JFET works. Use a diagram and the I_D-V_{DS} characteristics of the transistor to illustrate your point. (8 marks)

(c) (i) Draw a small signal equivalent circuit of the common-source amplifier shown in Fig. 3.1.

(3 marks)

(ii) Show that the voltage gain of the common-source amplifier is expressed, approximately, as

$$A_v \approx -g_m R_D$$

where the symbols g_m and R_D have the usual meaning. (6 marks)

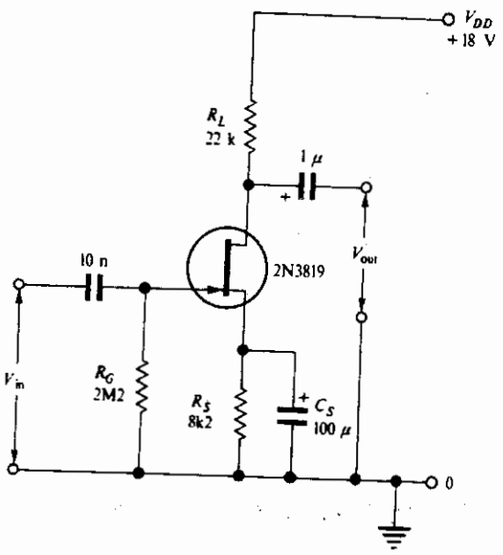

Fig. 3.1

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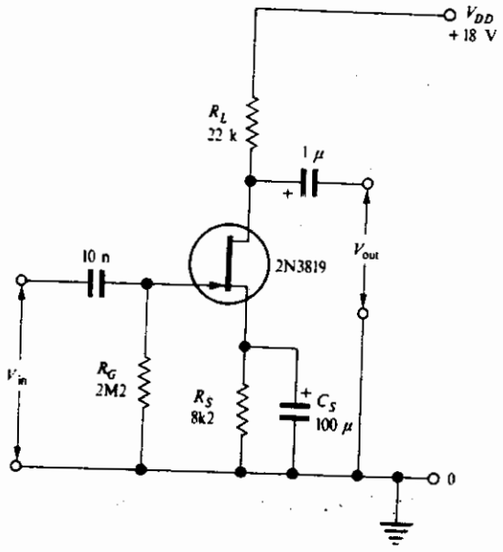

Fig. 3.1

QUESTION 4

(a) With the aid of a circuit diagram, explain how a full-wave rectifier that utilises a centre-tap transformer works. Sketch the output of the rectifier with reference to the transformer secondary voltage. (9 marks)

(b) A bridge rectifier with a smoothing capacitor operates from a 60 Hz mains supply. A load resistance of 1 kΩ is connected across the output terminals. The peak value of the output voltage is 24 V and the ripple voltage is 4 V.

(i) Sketch a graph of the output voltage against time with reference to the secondary voltage and label both axes. (4 marks)

(ii) Determine the capacitance of the capacitor. (6 marks)

(c) Fig. 4.1 shows a half-wave rectifier circuit with a smoothing capacitor. The average current through the load is 10 mA. The period of oscillation of the secondary voltage is 20 ms and its amplitude is 50 V.

Calculate the average voltage across the load resistor when the period of oscillation of the secondary voltage is 20 ms. (6 marks)

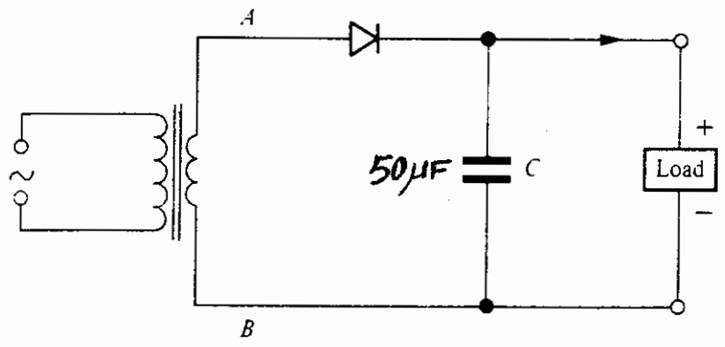

Fig. 4.1

QUESTION 5

(a) With reference to the circuit shown in Fig. 5.1, calculate values of the following d.c. voltages V_B, V_C and V_{CE} and the direct currents I_B and I_E. Assume that the current, I_{BB} flowing in the potential divider network (made up of resistors R_1 and R_2) is much greater than the base current I_B. Assume that $V_{BE} = 0.6$ V and that $h_{FE} = 200$. (15 marks)

(b) An npn transistor used as a voltage amplifier in the common-emitter configuration has hybrid parameters $h_{fe} = 120$ and $h_{ie} = 1$ kΩ. Assume that the load resistance R_C is 1.2 kΩ and that the output voltage has a peak-to-peak voltage of 2 V. Estimate the magnitude of the input voltage.

(4 marks)

(c) The drain current in a junction field effect transistor (JFET) varies by ± 0.5 mA when the signal voltage at the input has a peak-to-peak value of 1 V. Calculate the mutual conductance of the transistor. (2 marks)

(d) Sketch typical drain and mutual characteristics of a p-channel JFET. Label them. (4 marks)

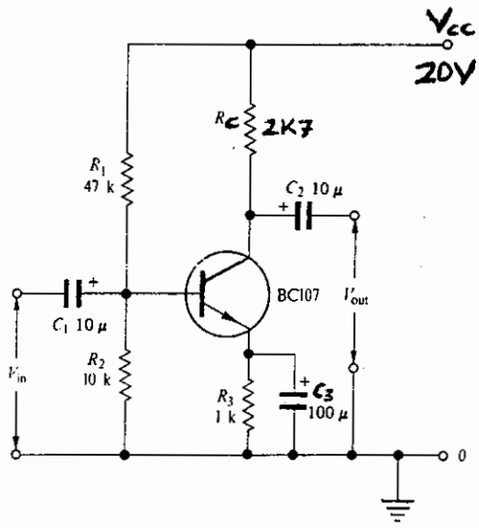

Fig. 5.1

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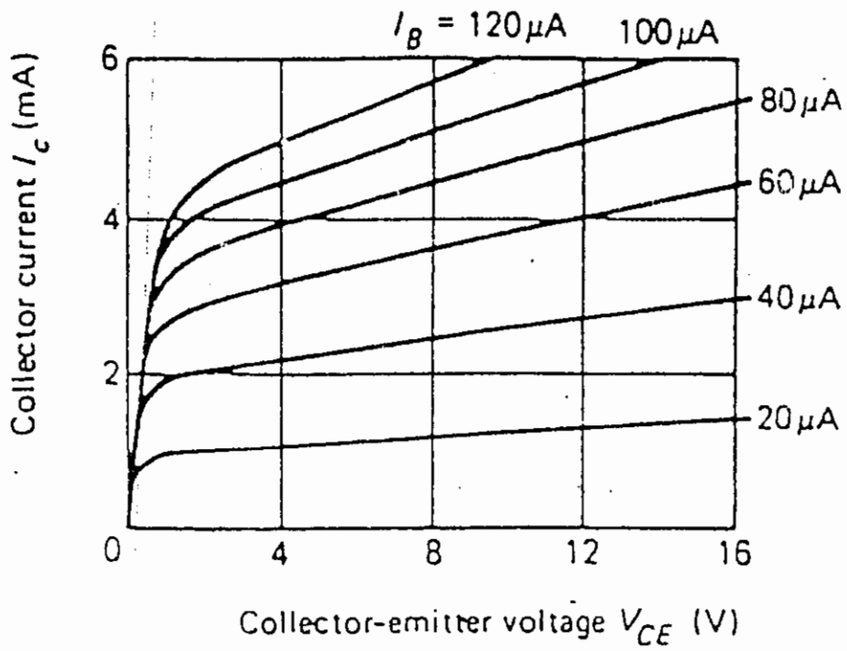

Fig. 1.1 (enlarged)