

UNIVERSITY OF SWAZILAND

FACULTY OF SCIENCE

DEPARTMENT OF PHYSICS

MAIN EXAMINATION 2006

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 6 PAGES, INCLUDING THIS PAGE.

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

QUESTION 1

- (a) With the aid of a diagram, describe the principle of operation of a pnp (bipolar junction) transistor in the forward-active mode. (10 marks)
- (b) The characteristics of a typical bipolar junction transistor (npn) are given in Fig. 1.1.

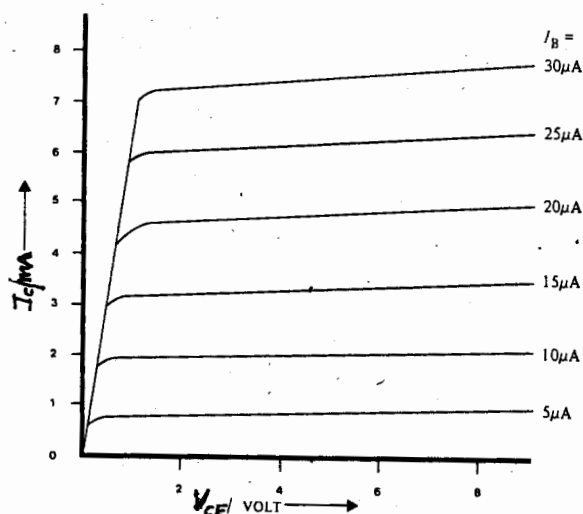


Fig. 1.1

- (i) Draw the loadline for supply voltage $V_{CC} = 8\text{ V}$ and collector resistor $R_C = 1\text{ k}\Omega$. (First: Determine the intercepts of the loadline). (4 marks)
- (ii) Choose the best operating point Q for an amplifier which uses this transistor, and then estimate the quiescent values of I_B , V_{CE} and I_C . Justify your choice. (3 marks)
- (c) The amplifier stage of Fig. 1.2 utilises an npn transistor in the C-E connection. If $I_E = 3\text{ mA}$, $V_{CE} = 8\text{ V}$, $V_E = 6\text{ V}$, calculate values of the following: R_C , R_E and V_B . (Assume that $V_{BE} = 0.6\text{ V}$)

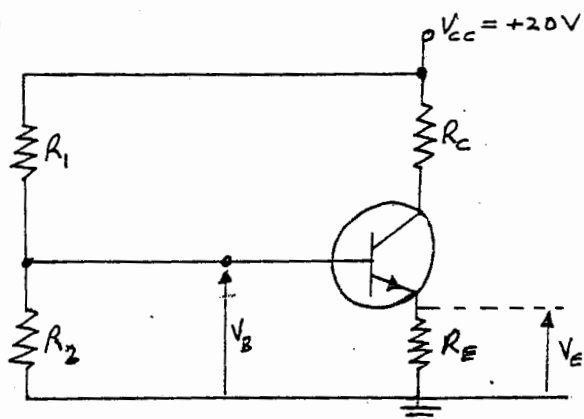


Fig. 1.2

QUESTION 2

- (a) A 9.1 V, 1.3 W Zener diode has a minimum current requirement of 20 mA and is to be used in a voltage regulator circuit. The supply voltage is $20\text{ V} \pm 10\%$ and the constant load current is 30 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 22 V. (5 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 r.m.s. with a step-down transformer having a turns ratio T of $1/3$. Calculate
- (i) the peak value of the secondary voltage and (3 marks)
 - (ii) the average value of the voltage across R_L . (2 marks)
- (c) A $100\text{ }\mu\text{F}$ capacitor is used to smooth the output of a half-wave rectifier. The peak voltage at the transformer secondary is 56 V (50 Hz) and the average current through the load is 15 mA.
- (i) Calculate the peak value of the ripple voltage (4 marks)
 - (ii) Calculate the average output voltage. (2 marks)

QUESTION 3

- (a) Draw and label a diagram that illustrates how you would obtain the drain and transfer characteristics of an n-channel JFET. (3 marks)
- (b) Sketch and label typical drain and transfer characteristic curves. (4 marks)
- (c) Use the curves to:
 - (i) explain the use of a JFET as a voltage controlled resistor; (3 marks)
 - (ii) explain how you would determine the mutual conductance. (4 marks)
- (d) When the gate-source voltage of a JFET is held at a constant value it is found that a change in the drain-source voltage of 2 V produces a change of 0.5 mA in the drain current. Calculate the drain resistance, r_d of the FET. (5 marks)
- (e) Consider the JFET amplifier in Fig. 3.1.

$$\begin{aligned}
 V_{DD} &= 15 \text{ V} \\
 R_D &= 4.7 \text{ k}\Omega \\
 g_m &= 10 \text{ mA/V} \\
 R_s &= 1 \text{ k}\Omega
 \end{aligned}$$

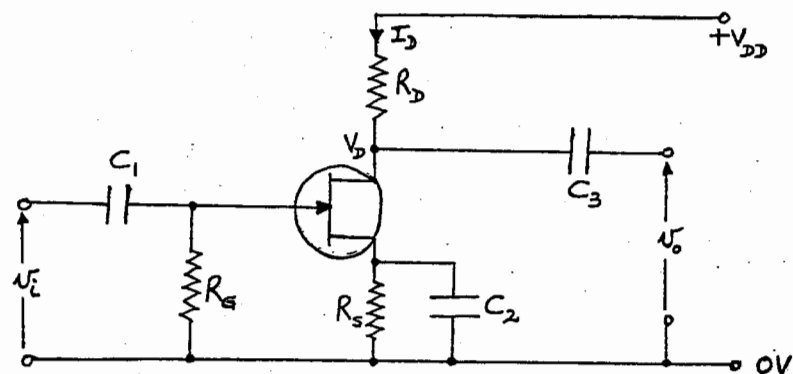


Fig. 3.1

- (i) If the self-bias value of $V_{GS} = -1.0$ volt, what is the bias value of the drain current, I_D ? (2 marks)
- (ii) Calculate the quiescent value of V_D . (2 marks)
- (iii) Calculate the voltage gain of the amplifier. (2 marks)

QUESTION 4

- (a) In the United States the ac power-line voltage is nominally 115 V rms. This voltage is connected to the primary of a transformer with a turns ratio of 1/50. What is the peak-to-peak secondary voltage? (4 marks)
- (b) For the half-wave rectifier of Fig. 4.1 with $R_L = 10 \text{ k}\Omega$,
- What are the dc output current and voltage? (5 marks)
 - If R_L in Fig. 4.1 is 100Ω , what is the average dc output voltage? (2 marks)
 - What would be the dc output voltage if the rectifier is used with a capacitor filter of $10 \mu\text{F}$? (6 marks)

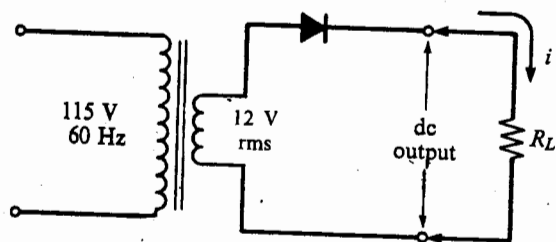


Fig. 4.1

- (c) In the Zener diode regulator shown in Fig. 4.2, $V_z = 5.1 \text{ V}$, and the Zener diode has a maximum power rating $P_{\text{maz}} = 500 \text{ mW}$. Find the required value of R_s if $V = 10 \text{ V}$, $R_L = 100 \Omega$ and the power dissipation is to be no more than 150 mW . (8 marks)

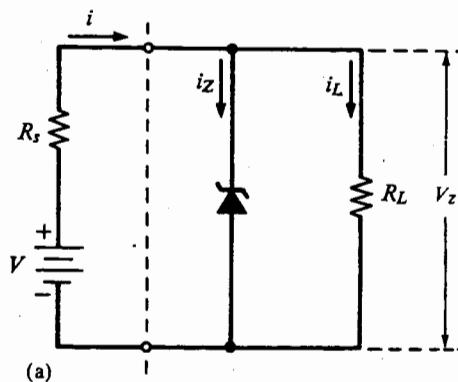


Fig. 4.2

QUESTION 5

- (a) Explain how you would fabricate a p-channel JFET. (7 marks)
- (b) With the aid of a diagram(s) and characteristics, discuss the principle of operation of the p-channel JFET. (8 marks)
- (c) (i) Draw the small signal model of a JFET common source amplifier; (3 marks)
- (ii) With the aid of the diagram, show that the gain of the amplifier is given by (4 marks)

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

- (d) In a JFET source follower, the FET used has a transconductance g_m of $15 \text{ m}\Omega^{-1}$. The source resistor $R_s = 5 \text{ k}\Omega$. Find the voltage gain A_v and the output resistance. (3 marks)