2023

ELECTRONIC SCIENCE

Paper : ELCGE 31

(Electronics)

Full Marks : 50

The figures in the margin indicate full marks.
Candidates are required to give their answers in their own words as far as practicable.

Answer ***any five*** questions.

1. (a) Define effective mass and minority carrier lifetime.
   (b) Where does the Fermi level lie for intrinsic silicon? Justify your answer.
   (c) What do you mean by direct and indirect band gap semiconductors? Which one of them favours light emission and why?
   (d) What is a degenerate semiconductor? 2+3+3+2

2. (a) Sketch typical charge distribution, electric-field distribution and potential distribution in a p-n junction diode with abrupt doping profile.
   (b) Which diode, made of Si or Ge, will show higher reverse saturation current and why?
   (c) What do you mean by diffusion capacitance and diffusion length?
   (d) What will happen to the reverse saturation current if the temperature of the junction is increased?
   (e) What is Zener breakdown? 2+2+2+2+2

3. (a) Define the (i) emitter injection ratio or emitter efficiency, and (ii) base transportation factor of a transistor.
   (b) What is Early effect of a transistor? How can it account for the input characteristics of a transistor in *CB* mode?
   (c) What are I_{CBO} and I_{CEO}? Give the relationship between them. How does I_{CBO} vary with temperature?
   (d) Draw and design a *CE* collector-feedback bias circuit of an *npn* transistor to establish a quiescent operating point at $I_{CQ} = 1$ mA and $V_{CEQ} = 8$ V. Given that, $\beta = 100$, $V_{CC} = 12$ V and $V_{BE} = 0.3$ V. 2+2+3+3

4. (a) Explain why biasing and bias stabilization are needed in a transistor circuit? What is meant by 'thermal runaway' of a transistor? How can 'thermal runaway' be avoided in a transistor circuit?

Please Turn Over

(b) Draw the r_e-model of a transistor operating in CE mode. Show that, $r_e = \frac{26mV}{I_E}$.

(c) In the small-signal transistor amplifier in fig. 1, $h_{ie} = 2\ \Omega$, $h_{fe} = 50$; h_{re} and h_{oe} are negligible. Draw the h-parameter equivalent circuit for the amplifier and determine : (i) Z_i, (ii) Z_0, and (iii) A_v. 4+3+3

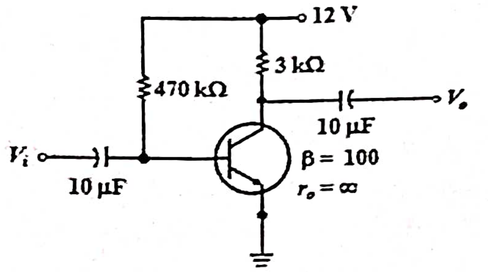

Fig. 1

5. (a) Draw a metal-oxide-semiconductor (MOS) structure and explain how inversion occurs in such a system.

(b) Draw the high frequency and low frequency capacitance-voltage characteristics of such a MOS device and explain why the capacitance values differ. 6+4

6. (a) Draw a neat diagram for the metal-oxide-semiconductor field effect transistor (MOSFET) and label its different areas.

(b) Draw the transfer and output characteristics of a MOSFET and explain the nature of such characteristics.

(c) Explain the purpose of scaling down of geometric dimensions in a MOSFET. What are the rules for constant field scaling? 2+5+3

7. (a) What is the value of R_f in case of a non-inverting op-amp circuit if the gain is 5.5 and R_i is 10 kΩ? The symbols have their usual meaning. $Af = 1 + \frac{Rf}{Ri}$

(b) Explain how op-amp is used as :

(i) a phase shifter

(ii) a scale changer.

(c) Explain how negative feedback reduces frequency distortion in feedback amplifiers. 3+(2+2)+3

8. (a) Calculate the octal equivalent of the decimal number 417.

(b) Minimize the following Boolean function :

F(A, B, C, D) = Σm (0, 1, 3, 5, 7, 8, 9, 11, 13, 15).

(c) Draw the circuit diagram of a D-Latch using NAND gates. Give its excitation table and K-Map representation.

(d) Explain the working of a Ripple counter and give its timing diagram. 2+2+3+3