Ex/IT/IEE/T/113/2019 (Old)

JADAVPUR UNIVERSITY

B. E. INFORMATION TECHNOLOGY

1st Year, 1st Semester (Old) Examinations – 2019

BASIC ELECTRONICS | **Time : 3 hours** | **Full Marks : 100**

Instructions

1. Special credit will be given to answers which are brief and to the point.
2. For any value related to any device parameter, which is not given in a question, assume suitable standard value for such parameter.
3. **Answer to every question should start on a new page.**
4. **Do not write answers to various parts of a question at different locations of your answer-script.**
5. The final answer (numerical values with unit) should be underlined or enclosed within a box.
6. Do not write on the front back cover of your answer booklet.

Question No. 1 is compulsory. Answer *any 4 (four)* from the rest.

Each question carries 20 marks. Question for each sub-part is mentioned at the right margin of a part question or set of part questions.

1. Answer *any 10 (ten)* of the following questions. Be specific and very brief in answering each question. (10 X 2)

i) What is the value of the energy gap between the valence and the conduction band in a semiconductor in terms of eV and J ?

ii) Name two intrinsic semiconductor materials - one single crystal, another compound.

iii) Why is there no net flow of current due to charge carriers in an open-circuit p-n junction, despite the presence of an electric field due to the barrier (or built-in) potential ?

iv) In what application is the Zener diode most commonly used ? What specifically is achieved in this application ?

v) Assuming ideal diode, derive the dc voltage in a half wave rectifier in terms of the peak voltage.

vi) Name two applications of a transistor. In which mode does it operate in each of these applications ?

vii) What is transistor h_{fe} ? What does the notation fe in h_{fe} stand for ?

viii) In a BJT in common base configuration, does the input current increase or decrease for a particular value of input voltage, with increase in output voltage ?

ix) If the Q point is shifted from the centre of the Load Line to too close to the saturation region, which swing (positive or negative) of the output signal will be clipped ? Why is it so ?

x) Proper biasing of the BJT ensures that the Q point once selected, does not shift due to change in values of which two parameters ?

xi) What are the main advantages (any two) of using a MOSFET rather than a BJT, in most applications ?

xii) What is the slew rate of an OP-AMP ? What is its typical value in IC 741 ?

xiii) What gives rise to input offset voltage in a practical OP-AMP ?

xiv) If the supply voltage of a practical OP-AMP (say IC 741C) is +/- 15V, what will be the maximum output voltage in a closed loop application ? What property (name only) restricts, if any, the output voltage to such values ?

xv) Which feedback is used in oscillators ? What is the other name for such a feedback ?

xvi) What is the advantage(s) of using an OP-AMP instead of a BJT in building a Hartley oscillator ?

2. i) Consider an intrinsic silicon (Si) bar of cross-section 5 cm^2 and length 2 cm at room temperature (300 K). An average electric field of 25 V / cm is applied across the ends of the Si bar.

a) Calculate
   i) Electron and hole components of current density
   ii) Resistivity of the bar

b) If now donor impurity to the extent of 1 part in 10^8 atoms of Si is added, find the minority carrier density.
   - Electron and hole mobility are 1400 cm^2 / V-s and 450 cm^2 / V-s respectively.
   - Intrinsic carrier concentration of Si at room temperature is 1.5×10^{10} / cm^3.
   - Number of Si atoms / cm^3 is 4.99×10^{22}. (3 X 2½)

ii) Consider a Si p-n junction at T = 300 K with doping densities $N_a = 10^{16}$ / cm^3 and $N_d = 10^{15}$ / cm^3. Calculate the space charge (depletion) width in the p-n junction. Assume a barrier potential of V_{bi} = 0.65 V.

Calculate x_n and x_p. How are they related to the doping concentration in n and p regions ?

Let a reverse bias voltage of V_R = 5 V be now applied across the p-n junction. Calculate the width of the space charge region in this case. (1½ + 4 + 2)

iii) The reverse saturation current for a p-n junction is measured as 40 nA at 25^0 C. Calculate the current at 20^0 C. (2)

iv) Draw the circuit schematic of a full wave bridge rectifier. (3)

3. i) Draw and explain the input characteristic of a BJT in common emitter configuration for different values of collector emitter voltage, V_{CE}. (5)

ii) Draw and explain the output characteristic of a BJT in common emitter configuration for different values of input current. Mention realistic values of input current and output current and voltage values along the axis. Show the different regions of operation and the input - output current relation in each region. (5 + 5)

iii) What are the functions of the coupling capacitors and the emitter bypass capacitor in a BJT used for amplification ? Are these capacitor values chosen to be high or low ? Why ? (3 + 2)

4. i) Analyze the reasons for the decrease in voltage gain of a BJT amplifier in the lower and upper frequency ranges, compared to the mid-frequency range, using representative values of the different capacitors contributing to the decrease in gain. Draw the small signal equivalent circuit using capacitors. (8)

ii) What is the significance of the cut-off frequency of an audio amplifier to be at 0.707 times (or -3 dB below) the mid-frequency gain ? (2)

ii) For a pnp BJT in common emitter configuration and with voltage divider bias, draw the circuit (showing v_s, v_i, and v_o among other parameters) and the ac equivalent circuit using the h-parameter transistor model. Calculate the input impedance, Z_i and overall voltage gain, A_{vs} of such a circuit. How is A_{vs} related to the voltage gain A_v of the circuit ? (5 + 4 + 1)

5. i) What are the different feedback amplifier topologies ? (Mention as "_ amplifier with _ feedback").

Describe in detail any one of the above using block diagram. (4 + 4)

ii) Draw the drain and transfer characteristics of an n-channel depletion type MOSFET identifying clearly the ohmic (triode) region, saturation region and cut-off region. Give representative values of the parameters used to draw the characteristic. (8)

iii) Define "threshold voltage" and I_{DSS} of an n-channel depletion mode MOSFET. (4)

6. i) List the characteristics of a practical OP-AMP (any six). Give representative values of these characteristics for an OP-AMP that is extensively used in the Laboratory and commercially. (3)

ii) Draw the Summer circuit using OP-AMP. Derive the closed loop voltage gain of such a circuit. (5)

iii) Enumerate any three advantages and any one disadvantage of using negative feedback amplifiers. (2)

iv) Draw the circuit of a Hartley oscillator using OP-AMP and explain its operation. Explain how Barkhausen criteria is complied with ?

What is the frequency, f_0 at which such an oscillator will oscillate ? What will be the gain of the OP-AMP at this frequency ? (8 + 2)

7. i) Draw the circuit symbol of an SCR. What is the other name of SCR ? (1 + 1)

ii) In what applications do you find use of SCRs (any four)? (2)

iii) By using two-transistor equivalent circuit, briefly describe the basic operation of an SCR. Draw typical forward and reverse characteristics of an SCR, marking all relevant device parameters and regions of operation. (6 + 4)

iv) How can we control the conduction angle of an SCR, by applying a Gate voltage ? Explain using a circuit with resistive load with a sinusoidal AC input. Draw appropriate voltage and current waveforms. (6)

8. Write short notes on ***<u>any 5 (five</u>***) (5 X 4)

i) Intrinsic and extrinsic semiconductors.
ii) Load Line and Quiescent (Q) point of a semi-conductor diode.
iii) Zener diode breakdown mechanisms.
iv) Frequency response (voltage gain vs frequency) of a BJT amplifier.
v) Pinch-off in an n-channel enhancement mode MOSFET.
vi) Saturation in a non-ideal OP-AMP.
vii) CMRR of an OP-AMP.
viii) Methods of turning OFF an SCR.

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