EX/IT/IEE/T/113/2017(S)

JADAVPUR UNIVERSITY

B. INFORMATION TECHNOLOGY

1st Year, 1st Semester Supplementary Exam. - 2017

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

General instructions (read carefully)

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 problem, 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) Name two intrinsic semi-conductor materials. If an element, to which Group of the Periodic Table does it belong ?

ii) With what material (any two) should an intrinsic semi-conductor material be doped to get an n-type semi-conductor ? To which Group of the Periodic Table do these dopants belong ?

iii) Define the "Law of electrical neutrality", in a situation where a semi-conductor material is doped with both n and p-type impurity materials.

iv) Explain mathematically what the effect of temperature is on the reverse saturation current in a semi-conductor diode.

v) What are the two different junction capacitances in a semi-conductor diode ? Relate them to their presence either in forward or reverse bias of the junction.

vi) Mention two important parameters of a Zener diode, as found in the data sheets.

vii) What is the ratio and realistic values of the width of the base of a BJT with respect to the total width of the BJT, during the fabrication process ?

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

ix) For what application is the common collector (CC) configuration of a BJT mostly used. Why ?

x) What should ideally be the location of the Quiescent (Q) point on the load line of a BJT ? Why is it so ?

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

xii) Which two principles of an ideal op-amp are extensively used for circuit analysis ? From which two ideal op-amp characteristics are these principles derived ?

xiii) What is the slew rate of an op-amp ? What is its typical value in IC 741 ?

xiv) What gives rise to input offset voltage in a practical op-amp ?

xv) Which feedback is used in oscillators ? Why ?

2.i) Derive the formula for finding the hole concentration in an n-type semi-conductor material. (4)

ii) Consider a gallium arsenide sample at T = 300 K with doping concentrations of $N_a = 0$ and $N_d = 10^{16}$ / cm^3. Assume complete ionization. Take values of electron and hole mobilities to be 8500 cm^2 / V-s and 400 cm^2 / V-s respectively. Intrinsic carrier concentration of the semi-conductor at 300 K is 1.8 X 10^6 / cm^3.

Calculate the minority carrier hole concentration and the drift current density, if the applied electric field is E = 10 V / cm. (6)

iii) a) A semi-conductor diode has a forward voltage of 0.25 V at current 10 mA at room temperature (300 K). Find the reverse saturation current.

b) Assuming diode ideality factor $\eta = 1$, calculate the bias voltage needed for diode current of 1 mA and 100 mA, at the same temperature.

What can you deduce about the change in forward current with corresponding change in forward voltage in the given semi-conductor diode from the given data ? [Hint : V_D is 0.25 V at current I_D = 10 mA (given); compare with values of V_D as obtained above for I_D of 1 mA and 100 mA].

c) Estimate the value of the reverse saturation current and forward current at 0.25 V at 30^0 C above room temperature.

What can you deduce about the values of the reverse saturation currents obtained for different temperature values [as obtained in a) and c)]. (2 + 4 + 4)

3. i) Explain, using block diagram, a regulated dc power supply starting from an a.c. mains input of 230 V, 50 Hz. Explain the function of each of the four blocks vis-à-vis what each block receives at its input and what it delivers at its output. Draw rough sketches of the input and output waveforms at each stage. (2 + 4)

ii) A major application of a Zener diode is as a voltage regulator. What does it regulate in terms of change of which parameters (any three) ? (3)

iii) What are the different modes of operation of a BJT in terms of different biasing combinations (either forward or reverse) at its two junctions ?

In which of these modes it operates as an amplifier and as a switch ? (3 + 2)

iv) Draw and explain the input characteristics of a BJT in common base (CB) configuration for different values of collector base voltage, V_{CB}. (6)

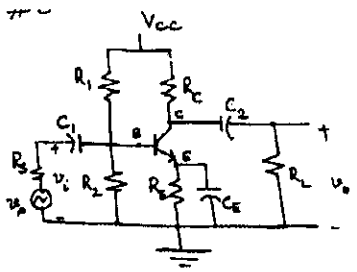
4. i) Draw and explain the output characteristics of a BJT in common emitter (CE) configuration for different values of input current. Mention realistic values of input and output currents and output voltage values along the axis. Mark the different regions of operation. (8)

ii) What are the different dc biasing circuits in a BJT ? Which one of them is most preferred and why ? (2 + 2)

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 ? (4 +2)

iv) Explain the reason for the upward slope of the output characteristic curve in common emitter (CE) configuration. (2)

5. i) For the BJT common emitter (CE) voltage (potential) divider bias circuit shown, draw the a.c. equivalent circuit using the r_e transistor model. Calculate the input impedance, Z_i and voltage gain, A_v for such a circuit. (10)



ii) Draw the drain and transfer characteristics of an n-channel depletion mode MOSFET identifying clearly the ohmic (triode) region, saturation region and cut-off region. Give representative values of the parameters used to draw the characteristic. (10)

6. i) Plot the curve depicting voltage gain of an amplifier vs frequency, indicating clearly the "cut-off frequencies" and "bandwidth". Define these parameters. (4)

ii) The output power of an amplifier is 50 mW when the signal frequency is 5 KHz. It falls to 25 mW when the frequency is increased to 20 KHz. Calculate the output power change in decibels. (2)

iii) Define "threshold voltage" and "pinch-off" of an n-channel enhancement mode MOSFET with suitable diagrams. (4)

iv) What is the basic building block of an op-amp ? Draw the circuit and explain its operation in brief. What is the prime condition that has to be satisfied for the proper working of the amplifier ?(4 + 1 +1)

v) What does the acronym CMRR stand for ? Express CMRR both in absolute and logarithmic terms. Should the value of CMRR be high or low ? Justify your answer. (1 + 2 + 1)

7. i) List the characteristics of an ideal OP-AMP (any six). (3)

ii) Show how subtraction operation can be carried out using op-amp. Derive the output voltage in terms of input voltages. (2 + 2)

iii) Draw the circuit of a Hartley oscillator using op-amp and explain its operation. What is the frequency, f_o at which such an oscillator will oscillate ? At this frequency what will be the gain of the op-amp ? (6 + 1 + 1)

iv) Draw the symbol of an SCR. Draw typical forward and reverse characteristics of an SCR, marking all relevant device parameters and "regions" of operation. (1 + 4)

8. Write short notes on **(any five)** (5 X 4)

i) Piecewise linear model of a diode.
ii) Load line and Quiescent (Q) point of a diode.
iii) Current amplification in a BJT in common base (CB) configuration vis-à-vis in common emitter (CE) configuration.
iv) N channel JFET.
v) Saturation in an op-amp.
vi) Barkhausen criteria.
vii) AC phase control using an SCR.
viii) Turning off an SCR.

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