I.E.S-(Conv.)-1980

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

PAPER - I

Time allowed: 3 hours *Maximum marks: 200*

Candidates should attempt question No. 1 which is compulsory, and any four of the remaining questions

The number of marks carried by each question is indicated at the end of the questions.

Answer must be written in English.

1. (a) Give reasons for the following :

(i) A conductor consisting of a thin-walled tube will have much less resistance at very high frequencies (e.g. several MHz) than a solid wire of the same DC resistance.

(ii) the reciprocal of Q of a capacitor is approximately equal to its power-factor.

(iii) If a long cylindrical magnetic core is slipped inside two single layer air-cored coils located coaxially so that it is common to both the coils, their mutual-inductance is increased more than their self-inductances.

(iv) Any material cannot be classified as conductor, semi-conductor or insulator without reference to its temperature of operation.

(v) In a high-gain junction transistor, the collector region has the highest resistivity and the emitter region has the lowest resistivity, the base region resistivity being in between.

(vi) A transmission line short-circuited at one end serves as resonant circuit at a frequency for which the line-length is an odd number of quarter-wavelength.

(vii) Vertical polarization is superior to horizontal polarization for communication between transmitting and receiving antennas that are both very close to ground in terms of the wavelength of the signal.

(viii) The directive-gain of a non-resonant antenna is usually at least twice as great as that of a resonant antenna of the same length, whereas the power-gain of the two is of the same order of magnitude.

(ix) Permanent magnet moving-coil meter is much superior to moving-iron meter for measuring DC voltages and currents.

(x) A digital frequency-counter is far more accurate than a wavemeter for high frequency measurement.

30

(b) Draw neat diagrams to illustrate the following and briefly explain their important features:

(i) Structure of a semi-conductor crystal.

(ii) Structure of a high frequency silicon planar transistor.

(iii) Experimental set-up to prove the reciprocity theorem in networks.

(iv) Height versus electron-density plot for the iono-sphere.

(v) Circuit schematic for measuring Q of a radio coil.

(vi) LVDT for displacement measurement.

30

2. (a) (i) Draw the complete equivalent circuit of a capacitor and explain the significance of the different components used therein.

(ii) What is meant by apparent capacitance of the capacitor? Ina capacitor of value 0.001μF, the equivalent series inductance is 0.1μH. At what frequency does the apparent capacitance differ from the true capacitance by 10%?

(b) Bring out the important differences between the following devices:

(i) Air-cored capacitor and PN junction capacitor.

(ii) air cored inductor and ferrite-cored inductor.

(iii) Rectifier diode and switching diode.

(iv) Junction transistor and field effect transistor.

20

3. (a) (i) What is meant by an intrinsic semiconductor? Determine the conductivity and resistivity of an intrinsic sample of silicon at normal room temperature (i.e. 300^{o}K).

[Assume :

Electron mobility, $\mu_n = 1350$ cm^2/volt sec

Hole mobility, $\mu_p = 480$ cm^2/volt sec

Intrinsic electron density in silicon at 300^{o}K = 1.52×10^{10}

Charge of electron or hole = 1.6×10^{-19} coulomb]

(ii) Explain the significance of space-charge layer at a PN junction.

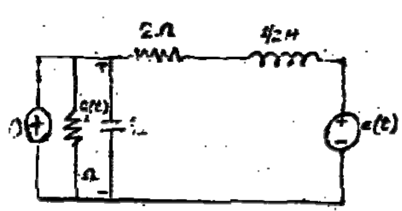
15

(b) (i) Sketch the output V-I characteristics of an NPN transistor in common-emitter operation and indicate there on the different regions of importance. Explain how you would use these characteristics to determine h_{FE}, I_{CBO} and BV_{CBO} of the transistor.

(ii) A silicon junction transistor operating at I_E = 1 mA, V_{CE} = 3V, has base-collector capacitance of 2 pf and base-emitter capacitance of 18 pf. Determine the current gain-bandwidth product ($=f_T$) of this transistor.
[Assume kT/q = 26 mV at normal room temperature]

4. (a) (i) State the superposition theorem and indicate how initial conditions are taken into account in applying this theorem.

(ii) Given i(t) = u(t) and e(t) = $5e^{-t}$ in the net-work shown in fig. 1, determine $e_2(t)$.



Q. 4 (a) (i)

(b) (i) A neon lamp that ionizes at 75 V is connected across a capacitor of 1μf. A resistance R is connected in series with the combination. Determine the value of R required to enable the lamp to glow 20 seconds after a DC voltage of 100 V is applied across the entire circuit.

(ii) A 100 V source whose frequency is variable is impressed across a series RLC circuit with R = 50Ω, L = 0.5 H, C = 50μf. Determine the resonant frequency of the circuit, the current at resonance and the Q factor.

20

5. (a) (i) Bring out the important differences between ground-wave propagation, space-wave propagation and iono-spheric propagation of radio waves, highlighting the application areas of each of them.

(ii) Explain what you understand by the following :

(A) Atmospheric noise

(B) Skip distance in a short-wave communication link

(C) Radio horizon.

15

(b) (i) Describe an experimental set-up for the measurement of impedance of a coaxial transmission line.

(ii) In a transmission line 100m long, terminates so that only the incident wave is present and the power at the load end is 1.2 dB less than at the generator end. Determine the attenuation constant (α) of the line.

20

6. (a) (i) Bring out the important differences between an amplifier rectifier type and rectifier-amplifier type electronic voltmeter.

(ii) Design an electronic voltmeter for the following specifications:

Input voltage range : 0-10 V

Input frequency range : 100 Hz-1 MHz

Output indicator : 0-100μA, DC meter

Assume that a semiconductor diode with forward resistance $<10\Omega$ and reverse resistance $<5M\Omega$ is available along with R's and C's for this application. Draw a circuit diagram.

(b) Give the basic principles of operation of the following instruments:

(i) Maxwell's bridge,

(ii) Digital voltmeter.

7. (a) (i) Write down the different transducers useful for measuring temperature and providing an electrical signal, and compare their relative performance.

(ii) Draw the circuit schematic for an electronic thermometer and explain its operation.

15

(b) Describe experimental techniques to determine the following in the laboratory:

(i) Current-gain of a transistor.

(ii) Open-loop gain of an operational amplifier.

(iii) Directivity of an antenna.

(iv) Selectivity of a broadcast receiver.

ELECTRONICS AND TELECOMMUNICATION ENGINEERING

PAPER - II

SECTION A

1. (a) Draw an FET amplifier with the load resistance = 100 KΩ, and $Rg_1 = Rg_2 = 1$ MΩ. Calculate the gain of the amplifier, if r_{DS} = 100 KΩ and g_m = 2 mΩ. What are the advantages of this amplifier?

(b) A transistor is used as an amplifier in a CB configuration, with the load resistance=40 KΩ, and the source resistance=200Ω. Find the voltage and the power gain of the amplifier, given that :

$h_{ib} = 50\Omega$; $h_{bo} = 0.2\ \mu\Omega$

$h_{rb} = c\times10^{-4}$; $h_{fb} = -0.99$

(c) A two-stage RC-coupled transistor amplifier is provided with a negative feedback, having a feedback of 1/100. Draw the amplifier circuit. If the gain of the amplifier without feedback is 60 db and it has a distortion of 10% in the output, then calculate the gain and the distortion of the amplifier with feedback.

2. (a) Draw the transistorized circuit of a bi-stable multivibrator. Show the waveforms at collectors and bases when a short pulse is given at the input. Explain how the speed of the circuit is improved.

(b) Show how a number of flip-flops may be used as a shift-register.

(c) Explain the working of a Miller Sweep generator. Draw a circuit using a pentode tube and suitable component valves to give a saw-tooth amplitude of 100V in 100μ sec approximately. Is the slope of the output wave independent of tube characteristics? Calculate the value of the charging capacitor.

3. (a) Using Karnaugh's map, simplify the Boolean functions :

(i) $\overline{ABC}D + \overline{ABCD} + \bar{A}B\bar{C}D + \bar{A}BCD + AB\overline{CD} + AB\bar{C}D$

(ii) $\overline{ABCD} + \overline{ABC}D + \overline{AB}CD + \overline{AB}CD + \overline{AB}C\,\overline{D} + \overline{AB}C\bar{D}$

(b) Draw the equivalent resistance-capacitance-transistor logic circuits for the simplified functions of 3(a).

(c) Explain how Binary multiplication and division are performed in a Digital computer using Adder and Shift register only. Draw a suitable block diagram of the Multiplier.

4. (a) Explain the function of a Synchro-differential system and obtain its transfer function.

(b) Plot the asymptotic Bode diagram for the open-loop transfer function:

$$G(s) = \frac{5(s+2)}{s(s+1)(4s^2+s+1)}$$

How is this plot used in determining the stability of the system?

(c) Show schematically how the speed of a shunt-field DC motor may be varied continuously by using SCR's and AC power supply. Explain briefly how the firing angle in SCR's is controlled for changing the armature voltage.

5. (a) The open-loop transfer function of a servo system is given as

$$y_o(s) = \frac{A}{s\tau(s\tau+1)}$$

Draw an approximate Nyquist plot of the function with the normalized variable $\omega\tau$ and A = 1. Explain how the Nyquist criterion of stability is now used, showing gain and phase margins. Is the system stable for all values of A, when the feedback loop is connected?

(b) Given an illustrative example of a second order servo system using derivative and position feedback. Obtain the input-output relation, and show that the step response of the system will have large overshoot and ringing with the damping ratio less than 0.15. Is it possible to decrease the overshoot without increasing the response time. If so, how?

(c) Draw an Analog computer set-up to simulate the above servo system of 5(b).

SECTION B

6. (a) In a discrete random system with inter-symbol influences, show that the Joint Entropy is given by

H(X,Y) = H(X) + H(Y/X).

(b) In a Binary symmetric channel, the symbols 1/0 are transmitted with equal probability at a rate of 10^4 per sec. The error rate in the channel P_e = 1/16. Calculate the rate of transmission R over the channel.

(c) Draw the modulator and demodulator circuits for PSK transmission of digital signals. Compare its error rate performance with that of FSK transmission.

7. (a) A television transmitter antenna has a height of 169 metres and the receiving antenna has a height of 16 m. What is the maximum distance through which the TV signal could be received by space propagation? What is the Radio Horizon in this case ?

(b) Draw the standard envelope for the picture-modulated carrier of a TV signal. Show how the ‘Synch’ signals are extracted and used for local synchronization in the receiver.

(c) Explain the term “Equisignal glidepath” as used in the Instrument Landing System. Give a neat diagram to indicate the positions of different units of ILS.

8. (a) Show the radiation pattern of a rhombic antenna used for the frequency band of 10-20 MHz. Give the design equations and curves necessary for designing such an antenna. What is Directive gain of a Rhombic antenna?

(b) The final stage of a HF transmitter uses a plate-modulate class-C amplifier and a class-B modulated amplifier. If the carrier power is 1 kW, calculate the DC input power required for the modulate and modulator amplifiers for m = 0 and 1. Assume the efficiencies of the amplifiers to be 80% and 60% respectively.

(c) What if VFT ? show a scheme for transmission of 24 telegraph channels simultaneously over a single telephone line. What is a static modulator?

9. (a) A 30 m parabolic antenna is used for the ground station of a satellite communication system in the 4/6 GHz band. Show its feed system and calculate its gain and beam width.

(b) In a synchronous communication satellite system the uplink operates at 6 GHz with the antenna elevation of 5^o. The transmitted power is 1 kW and the antenna gains of the transmitter and receiver are 60 db and 0 db respectively. Calculate the received power at the input of the satellite receiver.

(c) a receiver is fed from a 50 Ω antenna and the overall noise temperature is shown to be 290^oK. Calculate the Noise figure and the equivalent noise resistance of the receiver.

10. (a) Explain, from fundamental principles, why an waveguide behaves as a high-pass filter.

(b) A rectangular waveguide measures 34.5 cm internally and has a 10 GHz signal propagated in it. Calculate the cut off wavelength, the guide wavelength and the characteristic wave impedance for the $TE_{1,0}$ mode.

(c) Draw the block diagram of a typical Repeater of an LOS MW radio-relay system operating in the 4GHz band. Estimate the distance between the repeaters and the fade margin required from practical considerations.