# ELECTRONICS AND TELECOMMUNICATION ENGINEERING

## PAPER - I

**Some useful data:**

Electron charge: $1.6 \times 10^{-19}$ Coulomb

Free space permeability: $4\pi \times 10^{-7}$ H/m

Free space permittivity: 8.85 pF/m

Velocity of light in free spaces: $3 \times 10^{8}$ m/s

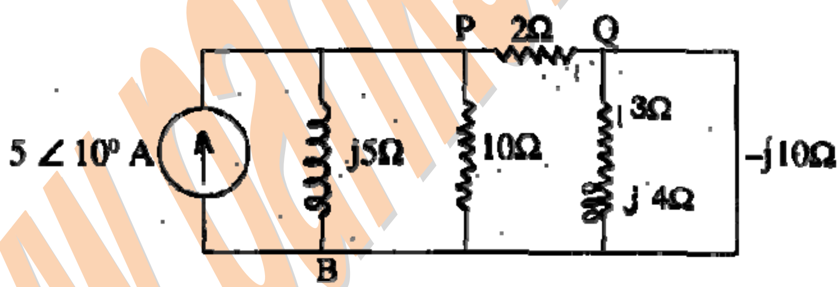
1. (a) The parameters of a certain transistor are $\alpha = 0.99$ and $I_{CBO} = 100$ nA, while $I_B = 20\ \mu$A. The transistor, connected in CE configuration, is in amplifying mode. Find $I_{CEO}$ , $I_C$ and $I_E$ . All symbols carry their usual meanings.

(b) Uniform charge densities $2\mu$ C/m$^2$ and $-2\mu$C/m$^2$ exist in x-y planes, infinite in extent and located at z=3 m and z=19 m respectively. The region $3 \le z \le 19$ is a dielectric of relative permittivity 9.0. Determine the displacement density, the electric field and polarisation vectors in the space between the planes.

(c) The voltage v and charge q on a certain non-linear capacitor are related as $q = kv^{1/3}$ where k is a constant. Determine the energy stored in the capacitor and express it (i) in terms of q and k and (ii) in terms of v and k.

(d) Represent a half sinusoidal pulse $g(t) = \sin \pi t,\ 0 \le t \le 1$ by an expression involving sine waves and step functions; and using this representation, write the Laplace transform of the given pulse.

(e) Find the power loss in the 10 ohm resistor in the circuit of Fig 1 (e).




(i) Determine the admittance parameters of the network of Fig 1 (f) and draw its $\pi$-equivalent circuit.

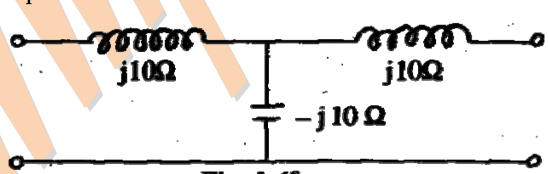



Fig. 1 (f)

(g) In an open-circuited loss line of length L, show that the ratio of the output voltage to the input voltage is maximum when

$$\frac{\sinh 2\alpha L}{\sin 2\beta L} = \frac{\beta}{\alpha}$$

where $\alpha$ and $\beta$ are respectively the attenuation and phase-shift constants of the line.

(h) A piezo-electric transducer of 1.5 $cm^2$ area and 0.11 cm thickness and having a 2 pC/N sensitivity is connected to a charge amplifier (an ideal operational amplifier) having a 20 pF feedback capacitor. Calculate the peak-to-peak swing of the amplifier output voltage when die transducer is subjected to a force of 0.017 sin 1000 t Newton.

2. (a) Synthesize two different R-C networks of the Cauer type for the following impedance function

$$2\frac{(s+2)(s+4)}{(s+1)(s+3)}\Omega \text{ taking 's' in } \sec^{-1}.$$

(b) In the circuit of Fig 2 (b), mutual inductance exists between the two coils, the coupling coefficient being k; Find the value of k, if the power loss in R is equal to 32 W. Also calculate the power loss if the terminals of one of the coils are interchanged.

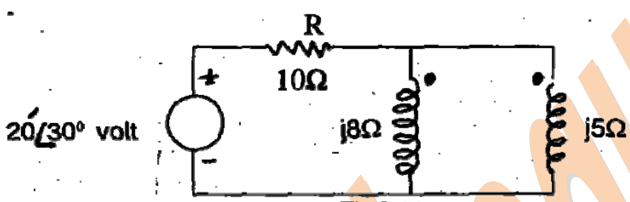



Fig 2 (b)

3. (a) A 5.0 mA sinusoidal current source with a 10 kΩ source resistance supplies power to a tank circuit which has L = 10.5 mH and C = 105 nF. The self-resistance of the coil is 100 Ω. Calculate the

(i) resonance frequency (in Hz). (ii) Q of the coil at the resonance frequency (iii) bandwidth of the entire circuit (iv) voltage across the coil, and (v) current through the capacitor.

The voltage and current are to be determined at the resonance frequency.

(b) For a parallel plane waveguide, infinite in extent and a spacing of 20 cm between the plates, calculate the

(i) phase velocity for TEM mode at all wavelengths (ii) cutoff wavelength for dominant TE mode (iii) phase velocity for dominant mode at 80% of cutoff wavelength, and (iv) the reflection angle for the above frequency of operation.

4. (a) A series R-L-C circuit with no initial energy is connected across a 50 V d-c supply at t = 0. Given R = 100 Ω, L = 2H and C = 200 μF, find the current i(t) in the circuit. Calculate the value of current for t = 120 ms and also the voltages across R, L id C and energy stored in L and C, all for t = 120 ms.

(b) A voltage source of 10 V, 50 Ω internal resistance and $3 \times 10^5$ rad/sec frequency supplies power to a lossless transmission line of 1 km length, of 100 Ω characteristic impedance (pure resistance) and having a 200 Ω termination. Calculate the power supplied to the 200 Ωs load and the transmission line. Consider the phase velocity to be equal to that in free space.

5. (a) Derive an expression for the radiation pattern of a linear array of five isotropic antennas, spaced half a wavelength apart, carrying currents in the ratio 1:2:2:2:1 and with progressive phase shift of 180°. Determine the directions of nulls. Also calculate the pattern values for 30°, 45°, 60°, 75° and 90° and show it by an approximate sketch.

(b) (i) Derive an expression for the capacitance per unit length of a coaxial cable. The outer radius of inner conductor is $r_1$ and the inner radius of outer conductor is $r_2$.

(ii) In a given case if $r_2=4r_1$, what will be the radius within which 75% of the total energy will be stored?

6. (a) A plane electromagnetic wave travelling in the +z direction in free space (z < 0) is normally incident on a good conductor (z > 0), the interface being at z =0. The electric field just prior to the interface is 2.0 in $3\pi\ 10^6$ t $\hat{y}$ mV/m. Determine the magnetic field component inside the conductor, given that the conductivity of the conductor is 61.7 MΩ/m while the permeability is equal to that of the free space. Show all steps clearly.

(b) Give the circuit configuration of the Wien bridge for the measurement of frequency indicating the adjustable elements and the positions of the source and detector. Drive the balance condition. Also explain the balancing procedure and typical practical arrangements, how the frequency is determined and the problems, if any associated with the bridge.

7. (a) In the measurement of a non-electrical quantity, the transducer and the associated amplifier produce an output voltage in the θ to 10 V range, the highest significant frequency component being 100 Hz. It is to be converted into digital form with a resolution of better than 0.01%. Find the

(i) minimum sampling rate (ii) minimum number of bits (iii) analogue value of the least significant bit (iv) aperture time requirement (v) dynamic range of the ADC in decibels, and (vi) ruts value of quantisation noise.

(b) In the circuit of Fig 7(b), the value of the inductance is so chosen that when it is tuned with a 4 μF capacitor, it resonates at 250 Hz. Determine the current i(t), voltages across the diode ($V_D$), inductor ($V_L$) and capacitor ($V_C$) and also the energy stored in the inductor ($W_L$) and the capacitor ($W_C$). All the above values are to be found and tabulated in four vertical columns for t = 0, 2, 4, 6 ms. The battery supply of 5 volts is switched on at t = 0. Assume the diode and the voltage source to be ideal and that there is no initial stored energy in C and L.

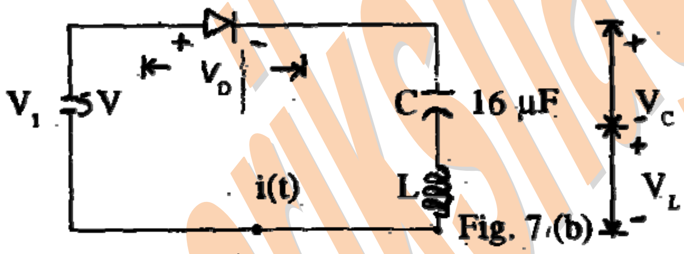
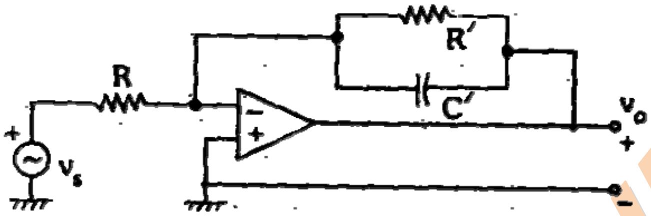


Fig. 7 (b)

# ELECTRONICS AND TELECOMMUNICATION ENGINEERING

## PAPER - II

1. (a) The circuit shown represents a low-pass d.c. coupled amplifier. Assuming an ideal OPAMP, find (i) the high frequency 3-dB point $f_H$ , (ii) the low frequency gain, $A_v = v_0/v_s$



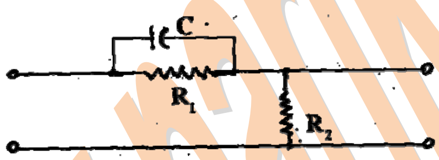

(b) What is the advantage of using Gray code? Enumerate the steps required for the conversion of binary number into its Gray code equivalent. Convert the binary number 1001011 to Gray code.

(c) Determine the gain margin and phase margin for the system in which

$$GH(j\omega) = \frac{1}{(j\omega+1)^3}$$

(d) Sketch the desirable range of location of the poles of the transfer function of a system if the system's damping ratio is to lie between 0.4 and 0.6 and its natural frequency is to lie between 3 and 5 rad/sec.

(e) Derive an expression for the maximum phase-lead which can be provided by the following network.




(f) The equation of and amplitude modulated wave is given as

$$v = 100\left[1 + 0.2\cos\left(2\pi \times 10^3 t\right)\right]\cos\left(2\pi \times 10^6 t\right)$$

Find all frequencies present and their respective amplitudes: Also determine the value of modulation index.

(g) For a binary symmetric channel, the error probability $P_e(0) = P_e(1) = p$ and errors are statistically independent. Show that the channel capacity is

C = s [1 + p log p + (1 – p) log (1 – P)]

where s is the signalling speed.

(h) Calculate the value of the minimum detectable power in a radar receiver if its noise figure is 12 dB and its bandwidth is 2.5 MHz. Assume the antenna noise temperature to be $300^o$ K.

(i) A pulse compression radar transmits an encoded pulse having a frequency chirp from 990 MHz to 1010 MHz centered around 1 GHz. What should be the range resolution capability of this radar?

(j) For a 1 cm × 2 cm rectangular waveguide, calculate the following:

(i) Group velocity and phase velocity (ii) Cut-off frequency (iii) Characteristic impedance (iv) Possible modes of propagation. Assume $f_0 = 10$ GHz.

## SECTION A

*(Attempt any two questions.)*

2. (a) Draw the circuit of a Wien Bridge Oscillator using a single operational amplifier. Derive the condition for sustained oscillations. State how: (i) a continuous variation of frequency is achieved; (ii) a change in frequency range is achieved; and (iii) the amplitude of oscillations is stabilized.

(b) A square wave whose peak to peak value is 1 V extends ± 0.5 V with respect to ground. The half period is 0.1 sec. This voltage is impressed upon an RC differentiator with time constant 0.2 sec. What are steady state maximum and minimum values of output voltage?

3. (a) Draw the circuit of transistorized cascode amplifier and determine its h-parameters in terms of those of the component transistors. What are the special advantages of this configuration (b) Why is it desirable to incorporate current limiting circuitry in a voltage regulator? Draw the circuit of a typical series pass regulator with built-in overload current limiting feature and describe its functioning.

4. (a) What are the advantages of dual-slope A/D converter? Give a schematic diagram of such a converter and explain its operation with the help of timing waveforms. How can this converter be made direct reading?

(b) Draw K-maps for the functions

$f_\alpha = AB + BD + \overline{A}\overline{B}C$ and $f_\beta = \overline{A}B + B\overline{D}$ and hence derive the K-maps for the functions $f_1 = f_\alpha \cdot f_\beta$ and $f_2 = f_\alpha + f_\beta$

Simplify the maps for $f_1$ and $f_2$ and give the resulting expressions in sum of products form.

5. (a) Design a binary half adder using only basic gates. Make a full adder using two half adders and any other basic gates. Write down Boolean functions for the half adder and express the Boolean function for the full adder in terms of those of the half adder and any other basic logic operations.

(b) Determine the state diagram and state table for a ingle input single output circuit which detects a 01 sequence. The sequence sets Z = 1, which is reset only by a 00 input sequence. For all other cases, Z = 0. Design the circuit using SR flip flops.

## SECTION B

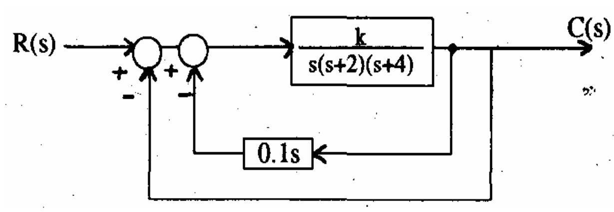
*(Attempt any two questions)*

6. (a) Sketch the root-locus of a unity feedback system with an open-loop transfer function

$$G(s) = \frac{k}{\left[s(s+2)(s+4)\right]}$$

For what range of k will the system have damped oscillatory response? What is the highest value of k that can be used before continuous oscillations occur?

(b) Consider the third order position control system with velocity feedback shown below. Determine the value of k so that the dominant poles of the transfer function of the closed lop system have a damping ratio of 0.5. What will be the response of the system to a unit step input for this value of k?




7. (a) Draw the block diagram of the Armstrong FM system and explain the generation of FM signals. Why is it called indirect method and what are its advantages ?

   (b) What is the function of the synchronising circuits in a TV receiver ? Draw and explain the working of a synch separator circuit with the help of waveforms. How are horizontal and vertical synch pulses separated?

8. (a) Two radars have the same peak power of 100 kW. One has a pulse width of 2μ secs and off period of 500 μ secs. The second one has a pulse width of 4 secs and off period of 400 μ secs. Which is better suited for long range reception ? Explain your answer clearly.

   (b) Define and explain the terms: Self information, Entropy and Mutual information.

   A code is composed of dots and dashes. Assume that the dash is 3 times as long as the dot and has one-third the probability of occurrence. Calculate

   (i) the information in a dot and that in a dash; (ii) the average information in the dot-dash code; and (iii) the average rate of, information transmission, assuming that a dot lasts 10 m secs and the same time interval is allowed between symbols.

9. (a) Draw a neat diagram of a two cavity Klystron. Show all voltages with proper polarities. Explain the phenomenon of bunching with the help of the Applegate diagram.

   (b) A two cavity Klystron amplifier has the following parameters:

   $V_0$ d. c. acceleration voltage = 1000 V

   f. frequency of operation = 3 GHz

   Grid gap spacing in either cavity = 1 mm

   Spacing between two cavities = 4 cm

   Find the :

   (i) Gap transit angle, (ii) Beam coupling coefficient (iii) Input gap voltage $V_1$ to give maximum output voltage $V_2$ and the (iv) Bunching parameter.