B.E. (ETCE) Part-III 5th Semester Final Examination, 2011-12

Transmission Lines and Waveguides
(ET-504)

Time : 3 Hours

Full Marks : 70

Answer **Question no.1 and any FOUR** from the rest

(Smith Chart will be provided on request)

1. Select the most appropriate alternative (any Seven). 2×7=14

(a) There will be no reflection in transmission line if it is terminated by an impedance
(i) equal to Z_0 (ii) equal to 2 Z_0 (iii) equal to $Z_0 / 2$ (iv) equal to zero

(b) The propagation constant of a transmission line equals
(i) $(R + j\omega L) / (G + j\omega C)$ (ii) $\sqrt{(R + j\omega L)(G + j\omega C)}$ (iii) $\sqrt{(R + j\omega L)/(G + j\omega C)}$
(iv) $\sqrt{1/LC}$ (v) $(R + j\omega L)(G + j\omega C)$

(c) Primary constants of a line are
(i) R, L, G, C (ii) Z_0, γ, α, β (iii) ρ, SWR, Z_{in} (iv) Both (i) and (ii)
(v) none of the above

(d) In Smith chart problems, clockwise movement along constant-S circles indicates
(i) travel towards load (ii) travel towards generator (iii) none of the above

(e) Impedance matching over wide frequency range can be obtained by the use of
(i) double stubs (ii) single stubs (iii) quarter wave transformer

(f) Electromagnetic waves travelling in a rectangular wave guide have velocity
(i) less than velocity of light (ii) higher than velocity of light
(iii) equal to velocity of light (iv) None of these

(g) A matched wave guide load can be constructed by
(i) perfectly conducting metallic strip with a taper
(ii) an absorbing material strip with a taper
(iii) a perfectly conducting rectangular block located at the correct phase position

(h) The dominant mode in a rectangular wave guide is
(i) TE_{10} (ii) TE_{01} (iii) TM_{01} (iv) TEM

(i) When electromagnetic waves are propagated in wave guide
(i) they travel along the broader walls of the guide
(ii) they travel by successive reflections from the side walls
(iii) they travel through the dielectric without touching the walls
(iv) they travel along the four walls of the wave guide

2. (a) What is the cause of occurrence of ac resistance in a transmission line? Explain with necessary diagram. Prove mathematically that it is proportional to square root of frequency and inversely proportional to square root of conductivity for a round conductor.

(b) Consider a length l of a coaxial line of inner radius a and outer radius b ($b > a$). By applying Gauss's law derive the expression for the capacitance per unit length as $C = 2\pi\varepsilon / \ln\frac{b}{a}$.

(c) Experimental measurements yielded the following results in a transmission line at 1000 Hz: The input impedance with load end open $Z_{OC} = 900 \angle -40^0$ ohms, and with load end shorted $Z_{SC} = 400 \angle -20^0$ ohms. Determine the characteristic impedance of the line in terms of resistance and reactance. 6+5+3=14

3. (a) What is TEM wave? State the impossibility of TEM wave in wave guides.

(b) Define wave impedance. For TM waves in a rectangular waveguide the wave impedance is given by $Z_Z(TM) = \frac{\bar{\beta}}{\omega\varepsilon}$ where $\bar{\beta}$ is the phase constant in the guide. Making use of the expression for $\bar{\beta}$ derive that $Z_Z(TM) = \eta\sqrt{1-(f_C^2/f^2)}$ where f_C is the cut-off frequency and η is the intrinsic impedance of unbounded medium. Plot Z_Z versus frequency. From this expression state the reasons for transmission of power down the waveguide for frequencies above cut-off frequency and no transmission of power for frequencies below cut-off frequency. 7+7=14

4. (a) Clearly draw a schematic diagram of rectangular waveguide with dimensions. Write the boundary conditions for the x, y, z components of electric and magnetic fields applicable to the walls assuming perfect conductor.

(b) A transmission line has a characteristic impedance of 300 ohms and terminated in a load Z_L = 150 + j150 ohms. Find the following, using the Smith chart. (i) VSWR, (ii) reflection coefficient magnitude and phase, (iii) input impedance at a distance of 0.10λ from the load, (iv) input admittance at 0.10λ from the load and (v) position of first voltage minimum from the load. Label all the points legibly. Describe the procedure in obtaining your results. 4+10=14

5. (a) Write the expression of propagation constant $\bar{\gamma}$ in case of parallel plate transmission line in terms of its dimension and mode number. From this find the expressions for phase constant, guided wavelength, and phase velocity in terms of cut-off frequency and signal frequency for TE, TM waves. Find these parameters for TEM waves. Prove that the phase velocity in a guided medium is greater than the light velocity in unguided medium.

(b) The separation between parallel plates of a parallel plate waveguide is 3 cm. It is filled with a dielectric with relative permittivity of 4. The signal frequency is 6 GHz. For TE_{10} and TM_{10} modes calculate : (i) cut-off frequency, (ii) cut-off wavelength (iii) guide wavelength λg and (iv) phase velocity v_{ph}. 10+4=14

6. (a) Explain clearly with the aid of a schematic diagram how a directional coupler can be used to separate incident wave and reflected wave from a wave.

(b) By using Smith chart find the load impedance at the end of a λ/8 line if the sending-end impedance is 50 + j7 Ω. Assume Z_0 = 100 Ω. Describe the procedure of plotting. Verify the result analytically.

(c) Find the resonant frequency of an air-filled resonant cavity with dimensions a = 5 cm, b = 4 cm, and c = 10 cm for TE_{101} mode. 5+6+3=14

7. (a) Neatly sketch standing wave patterns over a distance of 3λ for voltage and current along an open circuited and short circuited line. Define voltage reflection coefficient. Is it the same as current reflection coefficient? Explain.

(b) A generator of 1 volt supplies power to a 1000 km long wire transmission line terminated in its characteristic impedance. If the primary line constants per km are R = 10.4 Ω, L = 0.0037 H, C = 0.00835 μF, G = 0.8 μS, determine Z_0, γ, α, β and phase velocity Vp. Also find out the currents at the sending and receiving ends and power delivered at the receiving end. (Assume signal frequency to be 1 kHz and generator internal impedance zero). Show all the complex calculations. 5+9=14

8. (a) Define standing wave ratio (SWR). Write the general transmission line equations in exponential form for a loss-less line. From this derive the expressions for the resultant (of the incident and reflected) voltage and resultant current at a distance l from the load in terms of load reflection coefficient ρ and its phase θ. From this expression show that the magnitude of the resultant of the incident and reflected voltages oscillates back and forth between maximum values of $|V^+|(1+\rho)$ and minimum values of $|V^+|(1-\rho)$, where V^+ is the incident voltage. From this also show that $VSWR = (1+\rho)/(1-\rho)$, $Z_{max} = Z_0 \times S$ and $Z_{min} = Z_0/S$.

(b) Draw the voltage and current standing wave pattern on a line terminated in a load impedance equal to $3Z_0$. 10+4=14