

भारतीय सूचना प्रौद्योगिकी संस्थान राँची
INDIAN INSTITUTE OF INFORMATION TECHNOLOGY, RANCHI
Jharkhand

Department of Electronics and Communication Engineering
B. Tech End Semester Examination – Spring Semester 2022-23

Roll No. 2021064021

Course Code: **EC 2002/EI 2002**
Date: 27.04.2023

Course Title: **Electromagnetic Theory**
Day: **Thursday**

Course Instructor: **Dr. Santosh Kumar Mahto**

Duration: 3 Hours

Max. Marks: 100

Instructions:

1. **Question no. 1 to 3 are compulsory.**
2. The figure in the right-hand margin indicates full marks.
3. Missing data, if any, may suitably be assumed.
4. Symbols have their usual meaning.

Section A: Answer all the questions.

- 1 (a) A load impedance $(200+j0)$ is to be matched to a 50Ω lossless transmission line using a quarter wave transformer (QWT). Calculate characteristics impedance of QWT. [2]
- (b) The characteristics impedance of lossless and distortion less transmission line is pure resistive. (True/false) [2]
- (c) Medium 1 has the electrical permittivity $\epsilon_1 = 1.5\epsilon_0$ F/m and occupies the region to left of $z = 0$ plane. Medium 2 has the electrical permittivity $\epsilon_2 = 2.5\epsilon_0$ F/m and occupies the region to the right of $z = 0$ plane. If E_1 in medium 1 is $E_1 = (2\hat{x} - 3\hat{y} + 1\hat{z})$ volt/m. Find the Electric field in medium 2. [2]
- (d) If attenuation constant (α) \ll phase constant (β), the line will be considered asline. [2]
- (e) A loss less transmission line has 75Ω characteristics impedance. The line is terminated in a load impedance of $50-j100\Omega$. The maximum voltage measured on the line is 100V. Find the maximum and minimum current. [2]
- (f) Impedance matching cannot achieved with a half wavelength transformer. (True /False) [2]
- (g) A lossless transmission line having 100Ω characteristics impedance and length $\lambda/4$ is short circuited at one end and connected to an ideal voltage source of 1V at the other end. The current drawn from the voltage source is
a. 0 b. 0.01A c. infinity d. None of these [2]
- (h) A two wire transmission line terminates in a television set. The VSWR measured on the line is 5.8. Calculate the percentage of power reflected from the television set. [2]
- (i) The electric field intensity of a plane wave propagating in a lossless non-magnetic medium is given by the following expression
$$E(z, t) = 5 \cos(2\pi \times 10^9 t - \beta z) \hat{x} + 3 \cos\left(2\pi \times 10^9 t - \beta z - \frac{\pi}{2}\right) \hat{y}.$$

The polarization of the wave is
i. Right hand circular, ii. Left hand circular
ii. Right hand elliptical iv. Linear [2]
- (j) A transmission line of 50Ω characteristic impedance is terminated with a 100Ω resistance. What is the minimum impedance measured on the line. [2]

- 2 (a) Derive the mathematical expression for determining input impedance (Z_{in}) at any point from the load end on the lossy and lossless line. [8]
 (b) Derive the expression to measure unknown impedance using transmission line. [8]
 (c) What is difference between Transmission line and waveguide? [4]
 3 (a) List and explain Maxwell's equation in point and integral form. [8]
 (b) Does TEM mode exist in rectangular waveguide? Explain. [3]
 (c) i. What different modes exist in the rectangular waveguide in microwave? [4]
 ii. What is dominant mode?
 iii. Find the dominant mode in rectangular waveguide.
 (d) What is the inconsistency of Ampere's law with continuity equation? Derive the modified Ampere's law by Maxwell for time varying field. [5]

Section B: Answer any two questions

- 4 (a) Derive the expression for constant resistance circles and constant reactance circle in the complex r -plane and determine centre and radius for constant resistance circles and constant reactance circles. Also, locate the following point in the smith chart. [10]
 a. Short circuit load
 b. Open circuit load
 c. Matched load
 (b) A lossless transmission line with $Z_0 = 50 \Omega$ is 30 m long and operates at 2MHz. The line is terminated with a load $Z_L = 60 + j40 \Omega$. If $u = 0.6c$ where c is velocity of light on the line, find [7]
 a. The reflection coefficient
 b. The standing wave ratio
 c. The input impedance
 With and without the Smith chart.
 (c) A material has conductivity of 2×10^{-2} mho/m and a relative permittivity of 81. Determine the frequency at which the conduction current in the medium is equal to the displacement current. [3]
 5 (a) What is meant by Uniform Plane Wave? Derive the expression for Uniform Plane Wave in the free space. [10]
 (b) What is polarization of wave? What are the types of polarization? Explain Left handed and Right handed circular polarization. [5]
 (c) Realize capacitance and inductance using short circuit and open circuit transmission line. [5]
 6 (a) State Divergence theorem and find the divergence of following given vector [5]
 a. $P = xyz a_x + x^3 z a_z$
 b. $Q = \rho \sin \theta a_\rho + \rho^3 z a_\theta + z \rho \cos \theta a_z$
 (b) Express the vector $B = \frac{10}{r} a_r + r \cos \theta a_\theta + a_\phi$ in Cartesian and cylindrical coordinates. [10]
 Find $B(-3, 4, 0)$ and $B(5, \pi/2, -2)$.
 (c) Show that the intrinsic impedance of the perfect dielectric $\eta = \frac{|E|}{|H|} = \sqrt{\frac{\mu}{\epsilon}}$ and show that its value in free space is 377Ω . [5]

All is well
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