# Techno India NJR Institute of Technology

# Course File

# Session 2021-22

# Electromagnetic Waves (5EC4-02)

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# RAJASTHAN TECHNICAL UNIVERSITY, KOTA

**SYLLABUS**

**III Year - V Semester: B.Tech. (Electronics & Communication Engineering)**

## 5EC4-02: Electromagnetics Waves

**Credit: 3** **Max. Marks: 150(IA:30, ETE:120)**

**3L+0T+0P** **End Term Exam: 3 Hours**

| SN | Contents | Hours |
|---|---|---|
| 1 | Introduction: Objective, scope and outcome of the course. | 01 |
| 2 | Transmission Lines-Equations of Voltage and Current on TX line, Propagation constant and characteristic impedance, and reflection coefficient and VSWR, Impedance Transformation on Loss-less and Low loss Transmission line, Power transfer on TX line, Smith Chart, Admittance Smith Chart, Applications of transmission lines: Impedance Matching, use transmission line sections as circuit elements. | 08 |
| 3 | Maxwell's Equations-Basics of Vectors, Vector calculus, Basic laws of Electromagnetics,Maxwell's Equations, Boundary conditions at Media Interface. | 03 |
| 4 | Uniform Plane Wave Uniform plane wave, Propagation of wave, Wave polarization, Poincare's Sphere, Wave propagation in conducting medium, phase and group velocity, Power flow and Poynting vector, Surface current and power loss in a conductor. | 08 |
| 5 | Plane Waves at a Media Interface-Plane wave in arbitrary direction, Reflection and refraction at dielectric interface, Total internal reflection, wave polarization at media interface, Reflection from a conducting boundary. | 07 |
| 6 | Waveguides- Wave propagation in parallel plate waveguide, Analysis of waveguide general approach, Rectangular waveguide, Modal propagation in rectangular waveguide, Surface currents on the waveguide walls, Field visualization, Attenuation in waveguide. | 08 |
| 7 | Radiation-Solution for potential function, Radiation from the Hertz dipole, Power radiated by hertz dipole, Radiation Parameters of antenna, receiving antenna, Monopole and Dipole antenna | 07 |
| | **Total** | 42 |

## Course Overview:

Student will learn fundamentals of Electromagnetic waves from this 40-hour course. In this course, student will study the fundamental concepts and application of electromagnetic radiations. Also, they will studyvector calculus, coordinate systems, maxwell's equation and fundamentals of waveguide and antennas.

## Course Outcomes:

| CO.NO. | Cognitive Level | Course Outcome |
|---|---|---|
| 1 | Knowledge | Describe the concepts of coordinate system. |
| 2 | Analysis | Analyze the basic laws of electromagnetic field. |
| 3 | Synthesis | Explain the concepts of EMI & EMC. |

## Prerequisites:

1. Fundamentals of various orthogonal coordinate systems.
2. Must have completed the course on electrostatics and magnetostatics.
3. Student should be able to solve the problems of vector calculus.

## Course Outcome Mapping with Program Outcome:

| Course Outcome | Program Outcomes (PO's) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| CO. NO. | Domain Specific | | | | | Domain Independent | | | | | | |
| | PO1 | PO2 | PO3 | PO4 | PO5 | PO6 | PO7 | PO8 | PO9 | PO10 | PO11 | PO12 |
| CO1 | 2 | 1 | 1 | 0 | 0 | 2 | | | | | | |
| CO2 | 2 | 2 | 0 | 0 | 1 | 0 | | | | | | |
| CO3 | 1 | 2 | 3 | 1 | 1 | 2 | | | | | | |
| 1: Slight (Low) , 2: Moderate (Medium), 3: Substantial (High) | | | | | | | | | | | | |

## Course Coverage Module Wise:

| Lecture No. | Unit | Topic |
|---|---|---|
| 1 | **1** | **INTRODUCTION: Objective, scope and outcome of the course** |
| 2 | **2** | **TRANSMISSION LINES:-** Equations of Voltage and Current on TX line |
| 3 | 2 | Propagation constant and characteristic impedance |
| 4 | 2 | Reflection coefficient and VSWR |
| 5 | 2 | Impedance Transformation on Loss-less and Low loss Transmission line |
| 6 | 2 | Power transfer on TX line, Numerical |

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| | | |
|---|---|---|
| 7 | 2 | Smith Chart |
| 8 | 2 | Admittance Smith Chart |
| 9 | 2 | Applications of transmission lines: Impedance Matching, use transmission line sections as circuit elements. |
| 10 | **3** | **MAXWELL'S EQUATIONS-**Basics of Vectors, Vector calculus |
| 11 | 3 | Basic laws of electromagnetics, Maxwell's Equations |
| 12 | 3 | Boundary conditions at Media Interface |
| 13 | **4** | **UNIFORM PLANE WAVE:-** Propagation of wave |
| 14 | 4 | Wave polarization |
| 15 | 4 | Poincare's Sphere |
| 16 | 4 | Wave propagation in conducting medium |
| 17 | 4 | Phase and group velocity |
| 18 | 4 | Power flow and Poynting vector |
| 19 | 4 | Surface current |
| 20 | 4 | Power loss in a conductor |
| 21 | **5** | **PLANE WAVES AT A MEDIA INTERFACE** |
| 22 | 5 | Plane wave in arbitrary direction |
| 23 | 5 | Reflection and refraction at dielectric interface |
| 24 | 5 | Reflection and refraction at dielectric interface |
| 25 | 5 | Total internal reflection |
| 26 | 5 | wave polarization at media interface |
| 27 | 5 | Reflection from a conducting boundary |
| 28 | **6** | **WAVEGUIDES** |
| 29 | 6 | Wave propagation in parallel plate waveguide |
| 30 | 6 | Analysis of waveguide general approach |
| 31 | 6 | Rectangular waveguide |
| 32 | 6 | Modal propagation in rectangular waveguide |
| 33 | 6 | Surface currents on the waveguide walls |
| 34 | 6 | Field visualization |
| 35 | 6 | Attenuation in waveguide |
| 36 | **7** | **RADIATION FROM ANTENNA** |
| 37 | 7 | Radiation-Solution for potential function |
| 38 | 7 | Radiation from the Hertz dipole |
| 39 | 7 | Radiation Parameters of antenna |
| 40 | 7 | Receiving antenna |

**TEXT/REFERENCE BOOKS**


1. Electromagnetic Field Theory, Sadiku, Oxford.
2. Principles of Electromagnetics, Mahapatra, TMH.
3. Electromagnetic Field Theory and Transmission Lines, Rao, Wiley

## Teaching and Learning resources:

- **MOOC (NPTEL): -** https://nptel.ac.in/courses/117/101/117101056/

## Assessment Methodology:

1. Practical exam using lab instruments.
2. Two Midterm exams where student have to showcase subjective learning.
3. Final Exam (subjective paper) at the end of the semester.

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Roll No. Total No. of Pages : 3

5E1392

**B.Tech. V- Semester (Main) Examination, Nov. - 2019**
**PCC/PEC Electronics & Comm. Engg.**
**5EC 4-02 Electromagnetics Waves**

**Time : 3 Hours** **Maximum Marks : 120**
**Min. Passing Marks : 42**

***Instructions to Candidates:***

*Attempt **all ten** questions from **Part A**, **five** questions out of **eight** from **Part B** and **Four** questions out of **seven** from **Part C**.*

*Schematic diagrams must be shown wherever necessary. Any data you feel missing suitably be assumed and stated clearly. Units of quantities used/calculated must be stated clearly.*

## Part - A

(Answer should be given up to **25** words only)

**All** questions are **compulsory** **(10×2=20)**

1. If the cutoff frequency of an air-filled waveguide is 10 GHz and support $TE_{01}$ mode then what is its size?
2. Write the name of two impedance matching techniques used in Transmission lines.
3. Write the unit of pointing vector.
4. If cutoff frequency of $TE_{11}$ mode is 5 GHz then find the operating frequency of $TE_{23}$ mode.
5. If the length of a transmission line is less than $\lambda/4$ then draw its electrical equivalent circuit.
6. Write the Maxwell equation in differential form for electric field which determine the pattern of electric flux line.
7. Define the radiation resistance of an antenna.
8. What is the center of constant VSWR circle in Smith?
9. If the group velocity is $0.9\times10^3$ m/s then find the corresponding phase velocity.
10. Write the general expression of waveguide impedance when TM mode propagating inside waveguide.

## PART - B

(Analytical/Problem solving questions)

Attempt any **five** questions **(5×8=40)**

1. The cross section of a rectangular waveguide is 20×40 $cm^2$ then find the operating frequency of
   a) $TE_{02}$ and
   b) $TE_{32}$ mode.
2. Why TEM mode is not possible inside waveguide explain the reasons supporting with Maxwell's equations.
3. Explain any four antenna parameter and also write their units.
4. Define the characteristic impedance of a Transmission line and find its value at 50MHz. Assume the line primary parameters per unit length are R = 0.2 ohm, L = 0.2 Nanohenery, C = 0.5 nanofarad and G =10 Mho.
5. Draw the 2D and 3D radiation pattern of a dipole and mono pole antenna.
6. Design a single stub of a Transmission line which is terminated with a load of 20+j50 ohm and has characteristic impedance $Z_0$ = 100 ohm. Assume the signal frequency is 100 MHz.
7. Explain boundary conditions of electric and magnetic field. How these conditions are used?
8. Draw the electric and magnetic field pattern inside a waveguide at
   a) $TE_{10}$ and
   b) $TM_{21}$.

## PART - C

(Descriptive/Analytical/Problem Solving/Design Questions)

Attempt any **Four** questions **(4×15=60)**

1. Find the expression of input impedance of a Transmission line in terms of its characteristic impedance, load impedance and length of the line. Also find the value of it when the line length is
   a) $l = 2\lambda$ and $Z_L = 0$ ohm and
   b) $l = \lambda/4$ and $Z_L = Z_0$.
2. How EM signal radiated from a conductor? What are the conditions for it? Define the far field and near field around a radiating current element. Also find the interrelation between these two fields.

3. Explain the working of rectangular waveguide. What is the frequency range where these waveguide are most suitable? Find the minimum cutoff frequency of a waveguide, also find it for a waveguide whose cross section is $25 \times 50 cm^2$.

4. Explain the different losses in Transmission line and compare them
   a) in different type of Transmission line and
   b) at different frequency.

   How these losses can be reduced?

5. Define the reflection and transmission coefficient and find their value in following cases :
   a) A Transmission line (with $Z_0 = 100$) terminated with $Z_L = 200 + j\ 10$
   b) A Transmission line (with $Z_0 = 100$) terminated with $Z_L = j\ 100$
   c) A Transmission line (with $Z_0 = 100$) terminated with open circuit

6. Write *all* Maxwell equations in integral form for a dynamic EM field for vacuum *and a* lossy medium. Using these also develop the EM wave equation find prove that in vacuum the Wave are Transverse in nature.

7. Explain
   a) How microstrip lines are better than Waveguide at and above 60 GHz
   b) How Waveguides are better than microstrip lines between 1 to 30 GHz.