

## EE-343 Transmission Lines and Waveguides (3-1)

<b>1. Course Information</b>	
Course Number and Title:	EE-343 Transmission Lines and Waveguides
Credits:	4 (3+1)
Instructors-in-charge:	
Course type:	Lecture + Lab
Required or Elective:	Required
Course pre-requisites:	EE-241 Electromagnetic Field Theory, Math-241 Multivariable Calculus
Degree and Semester:	
Semester and Year:	

<b>2. Course Schedule</b>	
Lecture:	3 hrs/week, Two classes per week
Lab:	3 hrs/week, One session per week
Discussion:	1 hrs/week
Office and Office Hours:	1 <sup>st</sup> floor, Iftikhar Block, next to Seminar Hall 2, Wednesday, 1100 – 1150 hr

<b>3. Course Assessment</b>			
Exams:	Mid-term and Final Examination		
Homework:	3× Assignments / CEP		
Quizzes:	4× Quizzes		
Project Report:	1× Semester Project Report		
Lab Reports:	15× Lab reports		
Grading:	Theory: (75%)	Quizzes:	10%
		Assignments / CEP	10%
		Midterm:	30%
		Final Exam:	50%

<b>4. Textbook and Reference Book</b>	
Textbooks:	<b>Microwave Engineering (4<sup>th</sup> Edition)</b> by D. M. Pozar, John Wiley and Sons, ISBN: 978-0-470-63155-3
Reference Books:	<ol style="list-style-type: none"> <li>1. <b>Foundation for Microwave Engineering (2<sup>nd</sup> edition)</b> by R. E. Collin, McGraw-Hill Science, 2001, ISBN: 978-0070118119</li> <li>2. <b>Field and Wave Electromagnetics (2<sup>nd</sup> edition)</b> by David K. Cheng, Addison Wesley Publishing Co., 1989, ISBN: 0-201-01239-1</li> <li>3. Elements of Electromagnetics, by Matthew N O Sadiku; 7<sup>th</sup> Edition, Publisher: Oxford University Press, USA.</li> </ol>

## 5. Course Description

Transmission lines and waveguides are integral parts of wireless communication systems. The objective of the course is to introduce theoretical foundations and basic design parameters of transmission lines and waveguides. Moreover, the design techniques of microwave modules such as impedance matching networks, filters, power dividers and hybrid couplers are emphasized. Modern Software Ansys HFSS 2015 and Advanced Design System ADS 2016 are used for simulations.

## 6. Course Objectives

On the successful completion of the course, the student will be able to:

1. Understand basic parameters of transmission lines and waveguides.
2. Apply Maxwell's equations to find the expressions of fields in waveguides.
3. Design microwave components such as matching networks, resonators, filters, hybrid couplers, and dividers.
4. Use modern simulation tools to design different types of microwave modules.

7. Course Contents (48 class lectures – 16 weeks)				
Topic	CLO	Chap	Week	
<b>Transmission Lines:</b>	1	2	1	
<ul style="list-style-type: none"> <li>• Introduction to Transmission line equations and solutions,</li> <li>• Char. Impedance.</li> </ul>				
<ul style="list-style-type: none"> <li>• Reflection coefficient</li> <li>• Transmission coefficient</li> <li>• Standing wave and Standing-wave ratio.</li> </ul>	1	2	2	
<ul style="list-style-type: none"> <li>• Terminated lines</li> <li>• Introduction to the Smith chart</li> </ul>	1	2	3	
<ul style="list-style-type: none"> <li>• Coaxial line,</li> <li>• Quarter wave transformer,</li> <li>• Microstrip lines.</li> </ul>	1	2	4	
<b>Waveguides:</b>	2	3	5	
<ul style="list-style-type: none"> <li>• General solution of wave equations in the waveguides</li> <li>• Rectangular waveguide,</li> </ul>				
<ul style="list-style-type: none"> <li>• Wave solutions in parallel plate wave guide,</li> <li>• rectangular waveguide</li> </ul>	2	3	6	
<ul style="list-style-type: none"> <li>• Excitation of modes,</li> <li>• TE and TM modes in rectangular &amp; circular waveguides,</li> <li>• Surface waves on grounded dielectric.</li> </ul>	2	3	7	
<b>Network Analysis:</b>	3	4	8	
<ul style="list-style-type: none"> <li>• The S-parameters and S-matrix,</li> <li>• Impedance and Admittance matrices.</li> <li>• Inter-conversion of matrices</li> </ul>				
<b>Mid Term Week</b>				
<b>Impedance Matching:</b>	3	4	9	
<ul style="list-style-type: none"> <li>• Matching with lumped components using Smith chart</li> <li>• Single stub matching</li> </ul>				

<b><u>Microwave Components:</u></b> <ul style="list-style-type: none"> <li>• Transmission line resonators Rectangular cavity resonator</li> </ul>	3	5	10
•	3	5	11
<ul style="list-style-type: none"> <li>• Circular cavity resonator,</li> <li>• Q of a cavity resonator,</li> <li>• Re-entrant cavities</li> </ul>	3	6	12
<ul style="list-style-type: none"> <li>• Power dividers,</li> <li>• Microwave hybrid couplers,</li> <li>• Waveguide tees,</li> <li>• Directional couplers,</li> </ul>	3	6	13
<b><u>Microwave Filters:</u></b> <ul style="list-style-type: none"> <li>• Periodic structures</li> <li>• Filter design by insertion loss method,</li> <li>• Filter transformations and implementation</li> </ul>	3	7	14
<b><u>Microwave Tube Devices</u></b> <ul style="list-style-type: none"> <li>• Reflex Klystron</li> <li>• Klystron amplifier, Magnetron TWT</li> </ul>	3	8	15
<b><u>Microwave Semiconductor Devices and Amplifier:</u></b> <ul style="list-style-type: none"> <li>• Introduction to microwave diodes and transistors,</li> <li>• Two port gains, Stability,</li> <li>• Single stage low noise amplifier</li> </ul>	3	11, 12	16

<b>8. Lab Experiments</b>	
<b>Lab 1</b>	Introduction to Microwave Lab Equipment
<b>Lab 2</b>	Introduction to Advanced Design System 2016 Software and RLC Resonant Circuits
<b>Lab 3</b>	Design and Analysis of 50 $\Omega$ Microstrip and Coaxial Transmission Lines Terminated at Short, Open and Matched Loads
<b>Lab 4</b>	Intro to Smith Chart and Impedance Matching of a Resistive Load Using Quarter-wave Transformer
<b>Lab 5</b>	Design and Analysis of Rectangular Waveguide for X-band Applications
<b>Lab 6</b>	Power Measurements Using LabVolt System
<b>Lab 7</b>	T and $\pi$ -Shaped Resistive Attenuator Using ADS + Attenuator on LabVolt system
<b>Lab 8</b>	Impedance Matching Using L-shaped Lumped Component Networks
<b>Lab 9</b>	Impedance Matching Using Open and Short Microstrip Stubs
<b>Lab 10</b>	Wilkinson and T-Junction Power Dividers Using Microstrip Lines at 2 GHz
<b>Lab 11</b>	Quadrature and Ring Hybrid Coupler using Microstrip Lines at 2 GHz
<b>Lab 12</b>	Lowpass and High-Pass Filter Design Using Lumps Components and Microstrip Lines
<b>Lab 13</b>	Bandpass Filter Design Using Lumped Components and Coupled Microstrip Lines
<b>Lab 14</b>	Switching Network Design Using PIN diodes and Its Applications
<b>Lab 15</b>	Final Lab

**9. Course Learning Outcomes and mapping with Program Outcomes  
(Mapping CLO to PLO)**

Course Learning Outcome (CLOs)		PLOs	Learning Level
<b>CLO 1</b>	Describe the basics of wave propagation and parameters of transmission lines and waveguides using wave equations.	1	C2
<b>CLO 2</b>	Solve problems related to transmission lines and waveguides by selecting appropriate solution methods.	2	C5
<b>CLO 3</b>	Theoretically analyze N-port networks and design of passive microwave networks.	3	C3
<b>CLO 4</b>	Design and characterize different types of passive microwave components using fundamental principles of microwave engineering.	5	P4
<b>CLO 5</b>	Demonstrate proficiently the detailed design process for different microwave components.	10	A3

**10. Mapping of CLOs to Program Learning Outcomes**

PLOs / CLOs	CLO 1	CLO 2	CLO 3	CLO 4	CLO 5
<b>PLO1</b> (Engineering Knowledge)	<b>C2</b>				
<b>PLO2</b> (Problem Analysis)		<b>C5</b>			
<b>PLO3</b> (Design/ Development of Solutions)			<b>C3</b>		
<b>PLO4</b> (Investigation)					
<b>PLO5</b> (Modern Tool Usage)				<b>P4</b>	
<b>PLO6</b> (The Engineer and Society)					
<b>PLO7</b> (Environment and Sustainability)					
<b>PLO8</b> (Professional Ethics)					
<b>PLO9</b> (Individual and Teamwork)					
<b>PLO10</b> (Communication)					<b>A3</b>
<b>PLO11</b> (Project Management)					
<b>PLO12</b> (Lifelong Learning)					

**11. Program Learning Outcomes**

<b>PLO 1</b>	<b>Engineering Knowledge</b>
	An ability to apply knowledge of mathematics, science, engineering fundamentals and an engineering specialization to the solution of complex engineering problems.
<b>PLO 2</b>	<b>Problem Analysis</b>
	An ability to identify, formulate, research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences and engineering sciences.
<b>PLO 3</b>	<b>Design/Development of Solutions</b>

	An ability to design solutions for complex engineering problems and design systems, components or processes that meet specified needs with appropriate consideration for public health and safety, cultural, societal, and environmental considerations.
PLO 4	<b>Investigation</b>
	An ability to investigate complex engineering problems in a methodical way including literature survey, design and conduct of experiments, analysis and interpretation of experimental data, and synthesis of information to derive valid conclusions.
PLO 5	<b>Modern Tool Usage</b>
	An ability to create, select and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modeling, to complex engineering activities, with an understanding of the limitations.
PLO 6	<b>The Engineer and Society</b>
	An ability to apply reasoning informed by contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to professional engineering practice and solution to complex engineering problems.
PLO 7	<b>Environment and Sustainability</b>
	An ability to understand the impact of professional engineering solutions in societal and environmental contexts and demonstrate knowledge of and need for sustainable development.
PLO 8	<b>Professional Ethics</b>
	Apply ethical principles and commit to professional ethics and responsibilities and norms of engineering practice.
PLO 9	<b>Individual and Teamwork</b>
	An ability to work effectively, as an individual or in a team, on multifaceted and /or multidisciplinary settings.
PLO 10	<b>Communication</b>
	An ability to communicate effectively, orally as well as in writing, on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PLO 11	<b>Project Management</b>
	An ability to demonstrate management skills and apply engineering principles to one's own work, as a member and/or leader in a team, to manage projects in a multidisciplinary environment.
PLO 12	<b>Lifelong Learning</b>
	An ability to recognize importance of and pursue lifelong learning in the broader context of innovation and technological developments.