462mcd2018

Master Course Description for EE-462 (ABET sheet)

Title: Microwave Engineering

Credits: 4

UW Course Catalog Description

Coordinator: Matt Reynolds, Associate Professor, Electrical and Computer Engineering

Goals: To expose students to microwave theory, analysis, simulations, and measurements.

Learning Objectives: At the end of this course, students will be able to:

- 1. Understand transmission line theory and S-parameters
- 2. *Understand* material properties such as permittivity and permeability
- 3. *Understand* how to obtain material properties using different techniques
- 4. *Understand* phenomena caused by high-speed circuits
- 5. *Understand* time- and frequency-domain techniques
- 6. Understand microwave waveguides
- 7. Understand measurement techniques

Textbook: D. Pozar, Microwave Engineering, 4th Ed., Wiley, 2012, ISBN 978-0-470-63155-3

References

- 1. Lab handouts
- 2. Lecture notes

Prerequisites by Topic:

- 1. Basic electromagnetic theory
- 2. Basic transmission line theory

Topics:

- 1. Review: Microwave transmission lines (1 week)
- Analysis of microwave circuits using S-parameters
- Microstrip TL
- 3. Electrical properties of materials (2 weeks)
- Physical properties
- TL formulation (forward problem)
- Estimation of dielectric constant from S11 and S21 (inverse problem)
- Reflection method and lumped element model
- Dielectric constant measurement and inversion techniques

- 5. Time-domain analysis of TL with complex loads (1 week)
- Unit step function signal response
- Finite rise-time signal response
- 7. Time-domain analysis of lossy TL and dispersion effects (1 week)
- 8. High-speed circuits and signal coupling effects (1 week)
- Forward and backward coupled signals on TL
- 10. Discontinuity in high-frequency and high-speed circuits (1 week)
- Parameter extractions
- 12. Review: TEM, TE, and TM modes on parallel plate waveguides (1 week)
- Phase and group velocities
- Conductor and dielectric loss
- 14. Waves on rectangular and circular waveguides (1 week)
- Derivation of fields in waveguides and wave mode structures
- Bessel differential equations and Bessel functions
- Loss in waveguides
- Dielectric waveguides and surface waves
- 16. Special topics (1 week)
- RF/Microwave in communication systems
- Angle of arrival
- Wave propagation in urban and suburban areas

Course Structure: Lectures are organized so that students can analyze and design microwave circuits assigned in each lab project. The first few weeks cover basic electromagnetic theory in transmission lines and waveguides. Different techniques such as ABCD- and S-parameter approaches are presented to analyze the microwave circuits. Each lab project is designed so that the students are able to apply the theory studied in class to practical problems.

Laboratory projects:

- 1. Lab 1 Time- and frequency-domain analysis of a TL model
- Implementation of inverse chirp-Z transform.
- 3. Lab 2 Dielectric constant estimation using transmission method
- Forward and inverse problem in EM
- Estimation of the dielectric constant from S11 and S21 measurements
- Error analysis and ill-posed problems
- 5. Lab 3 Dielectric constant estimation using reflection method
- Lumped element model and its approximation
- Estimation of the dielectric constant from S11 measurement
- Error analysis and ill-posed problem
- 7. Lab 4 Time- and frequency-domain analysis of unmatched TL
- Reflection from inductive, capacitive, and resistive loads
- Reflection from a non-uniform TL

- Data analysis using Laplace transform
- 9. Lab 5 Coupled noise analysis
- Forward and backward coupled noise
- Analysis using the circuit model
- 11. Final Projects: Some examples are:
- Design of a microwave stud finder
- Implementation of the TRL calibration method

Computer Resources: Ansys Electronics Desktop microwave design software

Laboratory Resources: Vector network analyzer (VNWA),TEK TDR for the time-domain measurements

Grading: 50% midterm and final exams, 50% lab projects and homework assignments

ABET Student Outcome Coverage: This course addresses the following outcomes:

H = high relevance, M = medium relevance, L = low relevance to course.

- (1) An ability to identify, formulate, and solve complex engineering problems by applying principles of engineering, science, and mathematics. **(H)** The majority of the lectures, homework and projects deal with the application of electromagnetic theory. Mathematical formulations are commonplace throughout the course.
- (2) An ability to develop and conduct appropriate experimentation, analyze and interpret data, and use engineering judgment to draw conclusions **(H)** The course materials are organized so that students will be able to analyze and test microwave devices. Each project will start with a detailed analysis. This course uses microwave equipment which must be calibrated carefully to obtain good results.

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