RF Circuit Design (ECE321/ECE521)

Instructor: Dr. M. S. Hashmi
Credits: 4
Pre-requisites: Foundations of Electromagnetic Fields and Waves
Text Book: RF Circuit Design *Theory and Applications, 2nd edition* – R. Ludwig and G. Bogdanov, Pearson Economy
Reference Materials:

- Microwave Engineering, 3rd Edition – D. M. Pozar, Wiley
- Secrets of RF Circuit Design – Joseph Carr, McGraw Hill
- RF Circuit Design – R. Bowick, Newnes
- IEEE Xplore, and IEL

Post Conditions: On successful completion of this course, the students should:

- Learn various techniques employed for the design of RF Circuits
- Acquire hands-on skills to analyze and design simple RF components such as matching networks, coupler (different variants), power divider etc, used in the Radio Communication Circuits
- Gain skills in using at least one of the software tools ADS/CST/SystemVue, PCB Printing Machine, and RF Instruments such as Vector Network Analyzer, Spectrum Analyzer, and Power Sensor.

Brief Course Descriptions: This course is designed to train the students to RF circuits & systems design techniques for radio communications leading towards the recent research in the domain of advanced radio technology.

In the first half of the course, the students will be exposed to the fundamental concepts of passive and active circuits design at radio frequencies. These fundamental concepts require substantial understanding of transmission line theory and Smith chart and therefore this course will start with thorough discussion on these two topics. This also includes training the students on the commercial software tools such as Advanced Design System (ADS), CST Microwave Studio, and Keysight SystemVue. Tutorials on these tools will be provided. Eventually, the design assignments will train the students on advanced features of these tools.

In the second half of the course, students will be introduced to design aspects of components such as matching networks, couplers, and power dividers etc. As part of the course projects, the students will be required to carry out projects from conception to realization, develop the prototype using PCB machine, and then demonstrate the performance through measurements.

Break-up of Lectures:

Lecture (1-2): RF Behavior of Passive Components, Chip Components and Circuit Board Considerations, RF Circuit Manufacturing Process

Lecture (3-5): Transmission Line Analysis, Example of Transmission Lines, Equivalent Circuit Representation, Theoretical Foundation, Circuit Parameters for a Parallel-Plate Transmission Line, Summary of Different Transmission Line Configurations, General Transmission Line Equations,

Microstrip Transmission Lines, Terminated Lossless Transmission Line (Analytical Treatment, MATLAB Simulations), Special Termination Conditions (Analytical Treatment, MATLAB Simulations)

Lecture (6-7): The Smith Chart (From Reflection Coefficient to Load Impedance, Impedance Transformation, Admittance Transformation, Parallel Series Connection), Introduction to ADS (Simple Examples), ADS Design Guides (Smith Chart and its applications)

Lecture (8-11): Single- and Multi-port Networks (Interconnecting networks, Network properties and Applications, Scattering Parameters), Design and Analysis of multi-port network using ADS

Lecture (12-14): Impedance Matching and Tuning

Lecture (15-17): Passive RF Components (Coupler Design: analytical technique and ADS implementation; Power Combiner and Power Divider: analytical techniques and ADS implementation; Multi-band Component Design Techniques)

Lecture (18-20): RF Filter Design

Lecture (20-20): Multi-Frequency Design Techniques

Lecture (23): Vector Network Analyzer and Simple Calibration Approach

Lecture (21-26): Active RF Components (RF Field Effect Transistors, MOSFETs, HEMTs), Power Amplifier (Biasing and Matching Networks Design Techniques and ADS Implementation; Stability Considerations, Constant Gain, Constant VSWR Circles, Power Amplifier Topologies, Power Amplifier Operation Modes, Multi-band Matching Techniques for Power Amplifiers)

Assignments, Quizzes, and Evaluations: There will be several design assignments and surprise quizzes. In one of the assignments students will be required to go through pre-selected research papers and provide their own understanding and findings in the form of term paper (4-6 pages). There will be one mid-term and one-final exam.

Project: Each group will be given distinct projects. It will cover schematic design, layout, and momentum simulation of various components of the project. The list of possible projects will be announced in the class.

Evaluation Scheme: Design Assignments (20%), Class Test (15%), Project (30%), Mid-term Exam (20%), Final Exam (15%)