RF Circuits Design and CAD

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Time: **Place:**

Overview

The aim of module is to provide students with a basic understanding of the RF design problem through a combination of lectures on background theory and practical design examplkes, especially the use of advanced CAD tools and techniques for design and analysis.

Lecture 1 – Amplifier design basics; matching, stability, bias networks.

1.1 The evolution of the RF design procedure and the advantage of modern CAD tool
1.2 The overall procedure of RF design with CAD
1.3 Design an amplifier with a simple case study through CAD – circuit simulation, matching optimizing, and test its performance.
1.4 Transfer the design from the 'ideal' case into the 'real' case
1.5 the bias circuit should have minimal effects on the high frequency performance.

Lecture 2 – Stability performance of circuit

2.1 Stability Analysis – general introduction
2.2 the tradeoff between bandwidth, matching, and the stability
2.3 Input and output port stability characteristic.

Lecture 3 – Measurement of scattering parameters: two-port measurement systems

3.1 The basic understanding of transmission parameters
3.2 What is the main components inside the network analyzer
3.3 Measurement components - the signal source, signal splitter, receiver, detecter.

Lecture 4 – Calibration Concepts

4.1 One port error correction model and its calculation method of network analyzer.
4.2 Two port error correction model and its calculation method of network analyzer.
4.3 The error correction procedure for real devices – insertable and non-insertable devices.

Lecture 5 – Amplifier broadband design concept

5.1 Ideal amplifier & amplifier with additional matching network
5.2 The input and output gain circles: matching designed for a wide range of frequencies.
5.3 Additional matching network to achieve constant gain wide range of frequencies
5.4 Circuit design to achieve broadband matching with constant gain

Lecture 6 – Noise Figure: definition and measurement

6.1 Noise Paramenters: definition, measurement and modelling
6.2 Definition of noise and noise figure (NF).
6.3 NF measurement: using Y factor method.

Lecture 7 – Low noise amplifier design.

7.1 NF in multiple stage RF circuit design: the NF of first stage is most important.

7.2 Circuit model for noise added in devices: noise figure is depended on the source impedance and load matching state.
7.3 Noise circles: a tradeoff between gain and matching.

Lecture 8 – Transistor characterization: CAD equivalent circuit modelling, figures of merit.

8.1 Introduction
8.2 Commonly used types of transistor: FETs, JTs.
8.3 CAD modelling concept: measure s parameters, then represent measured data in terms of signal equivalent circuit model.

Lecture 9 – CAD model extraction and degeneration

9.1 CAD model extraction procedure: measure s parameters -> strip off y-parasitics and convert to z-parameters ->strip of z-parasitics and convert to y-parameters -> extract intrinsic circuit elements.
9.2 CAD model degeneration: by doing so a simpler circuit with same topology can be analyzed.

Lecture 10 – Non-Linear behaviour: transistor models and power amplifier design

10.1 Load line analysis: aid in determining load resistance to gain highest power and against from nonlinear region.
10.2 The basic understanding of amplifier working at class A/B/C/D/F operation and the harmonic matching technique – generally by adding a resonance circuit to terminate the odd or even signal components into open or short circuits.
10.3 Load pull contour: tool that guide in the load resistance determination.
10.4 Linear VS nonlinear design process: nonlinear models should be considered for full design, while linear design is suitable for small signal under one bias condition.
10.5 Measurement system for nonlinear performance: network analyzer/power meters.

Background Reading and Resource List:

Microwave and Wireless Simplified, T.S. Laverghetta (Artech House 1998)
Microwave Transistor Amplifiers. Analysis and Design, G. Gonzalez (Prentice Hall 1997, 2nd Edition)
Microwave Circuit Design, G.D. Vendelin, A.M. Pavio and U.L. Rohde (Wiley 1990)
Microwave Engineering, D. M. Pozar (Wiley 1998, 2nd Edition)

Instructors

Jiangtao Su received the B.E.and M.E. degrees in electronic engineering from Ocean University of China, QingDao, China in 2002 and 2005, and Pd.D. degree in electrical and electronic engineering from Cardiff University, Cardiff, UK in 2011 respectively.

In 2010, he joined Mesuro.Ltd , UK as a scientific engineer until December 2015. Since 2016, he has been with the School of the Electronic Information, HangDian University, China, where he is a specially appointed researcher. His current research interests include nonlinear device characterization and modelling, large-signal nonlinear measurement, and mmWave circuits design.