PROGRAMMA RF SYSTEMS 2018/19

The target of the course is to introduce the radio front-end of a communication system with reference to its main macro elements (subsystems). The first part of the course is devoted to the analysis of the various block composing the receiving and the transmitting units of a typical RF front-end from the operating point of view. Using behavioral models characterizing these blocks, the budget equation of the radio front-end is introduced. The solution of the budget equation is then illustrated, assuming a suitable trade-off among the various figures-of-merit of the systems. To this purpose, simulations tools at system level are introduced and their use for the system optimization is illustrated.
The course includes some topics that are taught using the flipped and blended classroom approaches.

Specific topics (1st part):

- Introduction to microwave communication systems. Fundamentals of frequency conversion: the super-heterodyne radio receiver. Block diagram of the RF front-end in receivers and transmitters. Basic blocks: Antenna, Amplifier (low noise and power), Mixer, Local Oscillator. Recalls on signals in communication systems: carrier and complex (baseband) modulation.
- Introduction to antennas: guided and radiated electromagnetic waves. System aspects of antennas. Fundamental parameters: directivity, radiation pattern, gain, effective area, efficiency, radiation impedance.
- The radio link: Friis equation (link budget)
- Noise in RF front-end. Definition of the noise temperature. Noise in frequency conversion (SSB and DSB). Evaluation of the equivalent noise temperature of the receiver. Comparison with the direct conversion receiver. Noise generated at antenna output.
- Linear and non-linear distortion: definitions and characterization. Transfer function: no-distortion condition for amplitude and group delay. Weak non-linearity in 2-port networks: 1dB compression point and 3th order intercept point. Techniques for improving linearity in RF Transmitter (linearizers)
- Classification and characteristic parameters of microwave amplifiers. Physical meaning of Transducer gain. Behavioral modelling of amplifiers.
- Models and characterization of mixers and oscillators.
- Figure of merits of the complete RF front-end. Computation techniques: system simulation with commercial software

The second part of the course is devoted to the introduction of the technologies adopted at RF and microwave frequencies. The concept of distributed network is first presented, highlighting the main differences with classical lumped-element circuits. Then suitable techniques for the analysis and design of distributed circuits are discussed (also based on CAD) and their application to some of the sub-systems introduced in the first part of the course is discussed. Finally, an overview of the fabrication technologies used for RF circuit is presented with reference to both discrete and integrated solutions.
Specific topics (2nd part):

- Matrix characterization of *n*-port networks. Classical Z and Y matrices and limits of their use in high frequency circuits. Definition of power waves. Scattering matrix: definitions and properties.
- Introduction to microwave circuits. Main differences with lumped-element circuits. Interconnections and their effects. Discontinuities: meaning and representation. Analysis with CAD techniques.
- Impedance matching: basic concepts (matching and maximum power transfer). Matching with lumped elements (L network). Single stub and double stub tuners.
- Coupled transmission lines: analysis with the conventional lumped model; even and odd mode parameters. Directional couplers and combiners.

- Introduction to the design of narrow band microwave amplifiers. Maximization of transducer gain and stability issues. Evaluation of optimum loads with the Smith Chart. CAD techniques for non-linear analysis of amplifiers: the Harmonic Balance method.
- Microwave Oscillators: topological configuration and evaluation of optimum load with the Smith Chart. The dielectric oscillators: scheme and dimensioning criteria.
- Overview of semiconductor active devices at microwave frequencies. Basics on fabrication technologies of RF and microwave circuits

Bibliography

David M. Pozar: Microwave Engineering. Editor: John Wiley & Sons
Michel Steer: Microwave and RF Design, A System Approach. Editor: Scitech
Kai Chang: RF and Microwave Wireless Systems. Editor: John Wiley & Sons
P. Kenington: High-linearity RF amplifier design. Editor: Artech House

Slides prepared by the teacher http://home.deib.polimi.it/macchiar/indice_file/Page584.html