

Fundamentals of Radio Frequency (RF) Circuits

Course Number: 2145

Course Objectives:

Provide engineers, involved in the development of radio systems:

- 1) Basic understanding of the principles of RF circuit design
- 2) Acquaintance with the main components and circuits used in this field
- 3) Understanding of the characteristics of main circuits and sub systems

Day1

The Characteristics of RF signals

Frequency, wavelength, phase, power
Representation of a signal by a phasor
Representation of a signal by Inphase and Quadrature (IQ) components
The time domain and the frequency domain
Fourier series, Transform and Analysis
The db, and dbm units and their use

RF basic components: ideal and "real life" behavior

Resistor, Capacitor, inductor
Parasitic and their impact
Resonance, Quality factor and Bandwidth

Energy transfer, matching, the smith chart

Antennas

The physics of antennas
Gain, bandwidth, directivity, polarization, Antenna radiation plots
Antenna types: Isotropic, Dipole, Monopole, Helix,
Antenna arrays and beam forming.

Simple Passive RF circuits

Attenuators
Combiners
Splitters
Type of filters: Low pass, High pass and band path
Simple filters and their characteristics
BW, 3db BW, roll-off, ultimate attenuation, spurious
The distinction between Lumped and distributed components
Example of implementation of a distributed filter.

Noise and Linearity

Noise: Thermal Noise, Noise Figure, other sources of noise
Linearity of active circuits, harmonics and intermodulation
3rd order intermodulation, "two tone test" the concept of Intercept Point,
Input and output IP3. Linearity and its impact on ACPR

Characteristics of commonly used RF components (1)

- Ceramic, Helical, SAW and crystal filters
- Small signal Amplifier
- High power amplifier
- Power detector
- Mixer

Day 2

Characteristics of commonly used RF components (2)

- Phase detector
- Oscillator, Crystal Oscillator, Voltage controlled Oscillator
- OCXO, DTCXO
- IQ modulator

Frequency Synthesis

The PLL – structure and main characteristics, Types of frequency synthesizer, Fractional-N, DDS.

RF Chains.

Cascading Gain, Noise figure and Linearity,

Receivers

Heterodyne receiver architecture
The receiver main characteristics: Sensitivity, Linearity (IIP3), Dynamic range, Selectivity, Image rejection, Blocking.
Modern digital receiver architectures, Zero IF, integration with DSP baseband processing.

Power amplifiers

Basic characteristics, linearity: 1 db compression point, output IP3, impact of higher order intermodulation, power amplifier efficiency, basic classes (A, AB, C, D and E).
Linearization techniques of power amplifiers:
Pre –Distortion (analog and digital), Feed Forward, Cartesian Feedback, Envelop Elimination and restoration

Transmitters

Transmitter architectures, Heterodyne, integration with DSP baseband processing.
Characteristics of the transmitter: output power, linearity: harmonics, OIP3, ACPR, EVM, Emission Mask

Basic RF Test Equipment and their Use

- The Signal Generator
- The Spectrum analyzer
- The Network Analyzer