Course ID
**RF4D**
Course Duration
**4 days**

Course Title
# Radio Systems Analysis and Design Workshop

**Related Courses**

- 2G to 4G+: Technologies, Drivers, and Business Case (2GTO4G, 4-5 days)
- Review of Select Topics Included in IEEE WCET Exam: RF Propagation, Analysis, and Design (WCET1, 4 days)
- Satellite Communications: Earth Station Design and Analysis (SATCOM5D, 5 days)
- RF Propagation, Analysis, and Design for Land Mobile and Public Safety Radio Systems (RF-PUBSAFE, 5 days)
- RF Propagation, Fading, and Link Budget Analysis (RFPROP, 2-3 days)
- Antennas: Characteristics, Deployment, and the Future (ANTENNA, 1-3 days)
- Microwave and Fixed Line-of-Sight Link Design (MICROWAVE, 2 days)
- HF Communications: An Overview (HF, 1-2 days)

**Aimed At**

RF engineers and technicians whose job requires an in-depth, hands-on introduction to RF systems analysis and design.

**Group Size**

5-25

**Prerequisites**

While there are no formal prerequisites, a technical background and some exposure to RF systems is assumed.

**Course in a Nutshell**

This is an intense hands-on course designed to provide you with an in-depth understanding of the technical aspects of RF systems design, analysis and deployment. Technologies used for Line-of-Sight (LOS) and Non-Line-of-Sight (NLOS) radio, from HF to EHF, are discussed. The focus of the course is the evolution of Cellular radio from GSM to LTE. Throughout this course, the student will gain in-depth knowledge of RF through the use of multiple calculation exercises as well as exercises and simulations using provided spreadsheets. Each module of this course builds upon the previous modules, enhancing the student's understanding of the topic areas.

**Customize It!**

We can customize this course to your project requirements including the types of technologies and spectrum bands you work with.

**Learn How To**

- Identify different E-M propagation modes based on frequency
- Describe different Land Mobile Radio Systems
- Define the relationship between bandwidth and Baud rate
- Use decibels for gains, losses and power levels
- Perform conversions among different signal level references: dBm, dBµV/mµV, dBm/cm2
- Describe the various components of a radio and their functions
- Describe various amplifier types and impairments
- Quantify the relationship between noise and bandwidth
- Compare analog and digital modulation techniques
- Determine the bit rate of a channel based on bandwidth, modulation scheme and FEC overhead
- Describe multiple access using FDMA, TDMA, CDMA and OFDMA
- Determine Near-field and Far-field regions of an antenna
- Compare VSWR, Return Loss, Reflected Power and Mismatch Loss
- Describe multiple antenna systems: MIMO and Adaptive Arrays
- Perform a cascade analysis for terrestrial radio systems
- Perform link budgets for both Line-of-Sight and Non-Line-of Sight links
- Determine LOS distance based on the radio horizon
- Perform a path loss analysis using a simple physical model
- Compare several empirical path loss models for NLOS
- Describe how Delay Spread and Doppler Spread effect small–scale fading
- Perform a path loss analysis for a NLOS environment
- Determine blocking and delay probability using basic traffic models

**Course Outline**

- Introduction to Wireless Technologies
  - A Brief History of Wireless Communications
  - The Continuing Evolution of Wireless Technologies
  - Modern Wireless Technologies
  - Overview of Cellular Radio Systems and Components
  - Evolution of Cellular Networks
- Radio Wave Characteristics
  - Using the TI-30 Scientific Calculator
  - The Electromagnetic Spectrum
  - Propagation Modes of Radio Waves
  - Radio Spectrum: Licensed and License Exempt
- Fundamental Radio Concepts

- Basics of Information Transfer for Radio
- Working with Decibels: Gains, Losses, Power, Conversions
- Voice Compression Techniques for Digital Radio
- Basic Radio System Components
- Wireless Impairments: Internal Noise and Distortion

- Digital Modulation and Error Correction Techniques
  - Analog Modulation: AM and FM
  - Basic Digital Modulation Schemes: ASK, FSK, PSK
  - Processing for Digital Modulation
  - Getting More Bits per Baud
  - Modern Error Correction Techniques

- Physical Layers and Multiple Access Techniques
  - Basic Access Techniques: FDMA and TDMA
  - GPRS Evolution to Packet Switching
  - Spread Spectrum and CDMA
  - High Speed CDMA-based Technologies: 1XEV-DO and HSPA
  - OFDM and OFDMA
  - LTE: The Next Evolutionary Step in Cellular Radio
  - LTE Advanced for Greater Throughput

- Introduction to GSM: Air Interface, Core Network and Operation
  - GSM History and Deployment status
  - GSM System Architecture
  - The GSM Air Interface (MS-BSS)
  - Network Switching Subsystem (NSS): The Core Network
  - NSS Components
  - GSM Mobility Management

- Basics of Antennas and Antenna Systems
  - E-M Field Radiation: Intentional and Unintentional
  - Basic Antenna Types and Uses
  - Basic Antenna Characteristics
  - Antenna Field Regions
  - Care and Feeding of Antennas
  - Antenna Diversity Techniques
  - Advanced Antenna Systems: Adaptive Arrays and MIMO

- Link Budget Analysis Techniques
  - Noise and Noise Sources
  - Link Budget Considerations
  - Budgeting the Radio Link

- Line-of-Sight Radio Propagation
  - Defining Line-of-Sight: Fresnel Zone Clearance
  - Earth's Curvature and the Radio Horizon
  - Reflection, Refraction and Scattering in LOS Propagation
  - Line-of-Sight Path Loss Analysis

- The Non-Line-of-Sight Propagation Environment
  - Non-Line-of-Sight Propagation Mechanisms
  - Coherence Time and Coherence Bandwidth
  - Impairments Due to Time Dispersal of a Radio Signal
  - Dealing with Problems Due to Time Dispersal
  - Modeling Propagation Loss in a NLOS Environment
- Wrap-up
  - Course Recap and Q/A
  - Evaluations

**Exercises and Simulations Performed in This Course:**

- Wavelength/frequency conversion
- Using decibels: Power levels, gains and adding ratios
- Converting among different signal level references
- Amplifier back-off vs. efficiency
- Determining the thermal noise seen by an antenna
- Receiver noise contribution; Noise Figure
- Determining the bit rate of a channel
- Determining theoretical symbol error rate
- OFDM and orthogonality simulation
- CDMA and processing gain simulation
- Determining aperture antenna gain
- Antenna pattern evaluation; beam-width and front-to-back ratio
- Determining antenna reactive and radiative near fields
- Converting between VSWR and Return Loss
- Comparing % reflected power and return loss measurements
- Phase combining simulation
- Performing a simple RF power budget
- Converting gain and NFdB to linear ratios
- Performing cascade analysis of a cellular radio receive system
- Performing LOS link budget using manuf. equip. specifications
- Determine LOS and NLOS margin based on service objectives
- Determining LOS radio horizon
- Determining Fresnel zone clearance
- Performing a free-space path loss analysis
- Determining link reliability based on rain fade margin
- Estimating diffraction gain for obstacle in radio path
- Determining the coherence bandwidth for a given environment
- Estimating the RMS delay spread of an open area
- Determining the coherence time for a given Doppler spread
- Estimating NLOS path loss using the Log Distance formula
- Comparing expected loss for several models in a given environment

**How You Will Learn**

- A highly qualified subject matter expert instructor, experienced in a range of RF and wireless technologies, will present this course in workshop mode.
- Along with the lecture, we will use scientific calculator and Excel based exercises to practice the techniques taught.
- You will receive a printed Participant Handbook which will help you remember and retain what you learned in class and apply it on your job.

*Revised* *3Gk-f*