Course ID
RF-PUBSAFE
Course Duration
5 days

Course Title
RF Propagation, Analysis, and Design for Land Mobile and Public Safety Radio Systems

Related Courses

- Review of Select Topics Included in IEEE WCET Exam: RF Propagation, Analysis, and Design (WCET1, 4 days)
- RF Propagation Models, Fading Characteristics, and Link Budget Analysis (RFPROP, 3 days)
- Antennas: Characteristics, Deployment, and the Future (ANTENNA, 1 day)
- RF Systems: Principles, Design, and Deployment (RFSYS, 3 days)
- RF for Technicians: A Fast-Track Workshop (RF-TECH, 4 days)
- RF Safety (RFSAFETY, ½-1 day)
- Traffic Engineering Models for Network Design (TRAFFIC, 3 days)
- Traffic Engineering for Voice and Data Networks (TELETRAF, 2-3 days)
- Cell Planning and Site Development (CELLPLAN, 3 days)
- GSM: A Technology Overview (GSM-B, 1 day)
- Direct Sequence Spread Spectrum Techniques and CDMA-Based Technologies (CDMA, 2 days)
- iDEN™: A Technology Overview (IDENO, 1 day)
- Microwave and Fixed Line-of-Sight Link Design Principles (MICROWAVE2, 2 days)
- TETRA: Network Architecture, Operation, and Design (TETRA, 3 days)
- HF/VHF: An Overview (HF-VHF, 1 day)
- Satellite Communications Principles and Design: A-to-Z of Modern Commercial and Military Satellite Systems (SATCOM, 2 days)
- WiMAX: The Technology (WIMAX-TECH, 2 days)
- Wireless Technologies: A Comparative Study (COMPARISON, 2-4 days)

Aimed At

This course is aimed at technical personnel who need to understand RF Systems from a Public Safety or Land Mobile Radio (LMR) perspective. It will be beneficial to those involved in analyzing, designing, or supporting public safety RF systems or the acquisition of equipment used in such systems.

Group Size

5-25

Prerequisites

Participants should have a technical background with some prior on-the-job experience with RF.

Course in a Nutshell

This five-day hands-on course is intended to provide a detailed understanding of the technical aspects of RF system design, analysis and deployment. Taught as an intensive workshop, the course relies heavily on instructor/class interaction, simulations and exercises that aid the student to develop an intuitive understanding of both the theoretical concepts and their practical application. To be able to participate in the hands-on activities, a scientific calculator and laptop for running Excel spreadsheets (with the analysis pack) are required.

The technologies used for Line-of-Sight (LOS) and Non-Line-of-Sight (NLOS) radio, from HF to EHF, are discussed in this course, as is the sizing of facilities, both air interface and backhaul, to satisfy the service objectives. Each module of this course builds upon the previous modules, helping you acquire the competencies you need in a carefully thought-out, step-by-step manner. The discussion of theoretical concepts will be complemented by multiple calculation exercises as well as exercises and simulations using spreadsheets provided by us. All in all, the course will provide you with an in-depth and practical knowledge of RF in the context of public safety radio or LMR systems.

Customize It!

The course can be adapted to the needs of those who lack prior RF experience. Shorter versions of this course, that cover the subject in less depth or omit some of the lab-work, are also available.

Learn How To

- Identify different E-M propagation modes based on frequency
- Describe different Land Mobile Radio (LMR) 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/m, µV and dBm/cm2
- Compare digital voice compression techniques based on performance
- 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
- Describe the P25 modulation schemes for transitioning from analog to digital
- Determine the bit rate of a channel based on bandwidth, modulation scheme and FEC overhead
- Compare 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: Adaptive Arrays
- Perform a cascade analysis for terrestrial radio systems
- Perform link budgets for both Line-of-Sight (LOS) and Non-Line-of Sight (NLOS) 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 Land Mobile Radio (LMR) Systems
- Radio Wave Characteristics
  - The Electro-magnetic 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 Variants
  - Basic Digital Modulation Schemes: ASK, PSK, FSK
  - Project 25 Modulation Schemes: C4FM and CQPSK
  - Getting More Bits per Baud using QAM
  - Error Correction Techniques
- Physical Layers and Multiple Access Techniques
  - Basic Access Techniques: FDMA and TDMA
  - OFDM and OFDMA
  - Spread Spectrum and CDMA
- 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

- Link Budget Analysis Techniques
  - Noise and Noise Sources (Internal and External)
  - Link Budget Considerations
  - Budgeting the Radio Link
- Line-of-Sight Radio Propagation
  - Defining Line-of-Sight
  - Line-of-Sight Path Loss Analysis
- The Non-Line-of-Sight Propagation Environment
  - Non-Line-of-Sight Propagation Mechanisms
  - Impairments due to Time Dispersal in NLOS Environments
  - Modeling NLOS Outdoor Propagation Loss
  - Modeling NLOS Indoor Propagation Loss
- Fundamentals of Traffic Engineering
  - A Brief Review of Statistics and Probability
  - Fundamental Traffic Terms and Concepts
  - Traffic Patterns: Smooth, Random and Peaked
  - Modeling Traffic: Loss (Blocking) Systems
  - Modeling Traffic: Queuing (Delay) Systems
  - Defining Service Objectives
- Wrap-up: Course Recap and Evaluations

Exercises Performed in This Course:

- Wavelength/frequency conversion
- Using decibels: Powers levels, gains and adding ratios
- Converting among different signal level references
- 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
- 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 reflection coefficient
- 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 terrestrial receive system
- Converting NFdb to Noise Temperature
- Performing LOS link budget using manufacturer's equipment 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
- Calculating traffic intensity in Erlangs and CCS
- Use Poisson, Erlang B and Erlang C models to determine the GoS
- Calculating link utilization based on server capacity and traffic generated
- Determining delay probability using Little and Erlang C models

How You Will Learn

- A seasoned instructor with wide experience in a variety of RF and wireless systems will present this course in workshop format.
- Along with the lecture, we will use a large number of hands-on (calculator or MS Excel-based) exercises to clarify the important concepts. The course can be optionally taught as an interactive lecture with less lab work.
- If you already know something about the RF technology, we will build on that knowledge base. We'll compare and contrast what's familiar with what's new, making the new ideas easier to learn as well as more relevant.
- If your background is less technical, we will use examples and analogies to reduce the complexity of the subject matter.
- 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.

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