Course ID
MICROWAVE4

Course Title
Microwave and Fixed Line-of-Sight Link Design Workshop

Course Duration
4 days

Related Courses

- Wireless Network Structure, Operation, and Technologies (WIRELESSNET, 3 days)
- RF Propagation Models, Fading Characteristics, and Link Budget Analysis (RFPROP, 3 days)
- WiMax: The Technology (WIMAX-TECH, 2 days)
- Technologies: A Comparative Study (COMPARISON, 2-4 days)
- GSM: Network Architecture, Operation, and Design (GSM-I, 5 days)
- iDEN™: Network Architecture, Operation, and Design (IDEN, 4 days)
- cdmaOne/IS95 (IS95, 2 days)
- Traffic Engineering Models for Network Design (TRAFFIC, 3 days)
- Microwave and Fixed Line-of-Sight Link Design Principles (MICROWAVE2, 2 days)

Aimed At

The standard presentation of this course assumes a bachelor of science in Electrical Engineering, Mathematics, Physics, or a related subject along with an appropriate background in communications.

Group Size

5-25

Prerequisites

None

Course in a Nutshell

Microwave links are a key part of the world's communications infrastructure. The tremendous growth in wireless services is made possible today through the use of microwaves for backhaul in wireless and mobile networks and for point-to-multipoint networks. For anyone involved with telecommunication and information technology, understanding this technology is of fundamental importance.

In this course you will learn both the technology and applications of line-of-sight microwaves. We will review elements of microwave link design, including digital radio and RF channel characteristics. You will also learn aspects of microwave link control, management, testing, standards, and practical deployment issues. This comprehensive review will give you the tools necessary to design and analyze any microwave link.

Customize It!

- *Are you a transmission or wireless engineer* who would like to "fill in the holes" and catch up with the state-of-the-art of microwave systems? Let us know so we can focus on the areas that interest you the most.

- *Are you a microwave communications system installer* who would like to learn the concepts and theory that underlie your craft? We can focus on the tools and techniques that will help you become more "tech savvy".
- *Are you a manager, executive, or sales person* whose work involves microwave communication systems? If so, we can emphasize those parts of the course that deal with the markets and applications pertinent to your project or product.
- *Add a workshop day at the end of the course*, for a total of five days: Get some hands-on practice on a computer-based microwave simulation and modeling tool to help you with design, procurement, and installation of a microwave system. We can help you get ready! Please ask us about the "combo discount".

Learn How To

- Understand the conceptual and theoretical underpinnings of this field
- Describe in detail how this technology works
- Identify the appropriate applications for microwave line-of-sight (LOS) links, from cellular backhaul to WiMax
- List the key components of digital radio and LOS links and describe how they fit together
- Plot a path profile and ensure sufficient clearance over obstacles in the path
- Predict multipath fading and calculate path reliability
- Analyze and design a microwave system

Course Outline

- Introduction
  - Microwave and other radio systems: Microwave versus copper cable, fiber optics, and leased services
  - Microwave frequency bands
  - Regulatory matters: Rules, regulations and recommendations; radio licenses and permits. Regulatory agencies (FCC or your national body)
- Characteristics of Voice, Data, and Video
  - Combining various signals
  - Channelizing the radio spectrum: Frequency, time, and code division multiple access (FDMA, TDMA, CDMA)
- History of Analog Microwave Radio
  - Frequency Division Multiplex (FDM) techniques and hierarchies
  - L Carrier and ITU frequency plans
- Digital Transmission Systems
  - Sampling theory
  - Time Division Multiplex (TDM) techniques and hierarchies
  - North American and ITU digital hierarchies
  - Plesiochronous Digital Hierarchy (PDH)
  - Synchronous networks (SDH/SONET)
- Digital Power Spectra and Bandwidths
  - Bandwidth definitions and requirements

- Nyquist and other shaping
- Regulatory masks
- Baseband data signals
- Filtering and rolloff factors

- Digital Modulation
  - Amplitude, frequency, and phase shift keying (ASK, FSK, PSK)
  - Binary versus M-ary modulation
  - QPSK, Offset QPSK, and π/4 QPSK
  - Minimum Shift Keying (MSK)
  - QAM and Trellis Coded Modulation (TCM)
  - Orthogonal FDM (OFDM)
- Line of Sight Transmission
  - Free space loss
  - Effect of terrain
  - Reflection and diffraction
  - Fresnel zones and path profiles
  - Clearance requirements
- Effects of Climate
  - Refraction and variations in radio refractivity (N factor)
  - Snell's law and the effective earth radius (K factor)
  - Rain attenuation; specific rain rate and effective path length; ITU rain attenuation model
  - Other atmospheric attenuation
  - Prediction of outage using computer models
- Fading
  - Multipath fading
  - Reflection and diffraction causes
  - Rayleigh, Rician, and log-normal statistics of fading
  - Multipath propagation models; Barnett-Vigants observations; ITU models
  - Diurnal and seasonal variations
- Effect of Fading on Digital Radio
  - Flat versus frequency selective fading
  - Minimum versus non-minimum phase fading
  - M and W curves
  - Flat, dispersive, and composite fade margins
  - Calculation of estimated outage using computer models
- Equalization
  - Linear versus non-linear equalization
  - Transversal filter
  - Zero-forcing equalization versus minimum mean-square error
  - Decision feedback equalization and training equalizer
- Antennas and Diversity
  - Antennas types and parameters: Gain, directivity, radiation pattern, polarization, beamwidth
  - Waveguide types and characteristics: Rectangular, circular

- Diversity types: Space, frequency, angle, polarization, hybrid
- Diversity combining and improvements over non-diversity systems

- Forward Error Correction
  - Definition of coding types and coding gain
  - Types of block codes with examples: CRC and Hamming codes
  - Convolutional coding and Viterbi decoding, with example
  - Interleaving and turbo codes
- Radio Frequency Interference (RFI) Coordination
  - Interference analysis for co-channel and adjacent-channel
  - Carrier-to-Interference (C/I) ratio
  - Threshold-to-interference (T/I) ratio
  - Manual and computer-aided design for intra- and inter-system interference
  - Frequency planning
  - Satellite and other external interference
  - Detailed analysis of a terrestrial RFI case
- Performance Objectives
  - Single link, tandem link, and end-to-end objectives
  - U.S. and ITU standards and recommendations
  - Availability and error rate objectives
  - Measurements of bit error rate, eye patterns, and jitter
- Acceptance Testing and Performance Monitoring
  - Factory tests; BER testing
  - Use of spectrum and link analyzers
  - Propagation instrumentation
  - On-line performance measurement
  - Fade margin testing
  - Fault isolation and performance monitoring
- Path Engineering
  - Manual and computer-aided design
  - Site selection, mapping, path profile generation and analysis
  - Reflection point analysis
  - Selection of components to meet performance objectives
  - Software examples; hands-on exercise designing paths; analysis of problem path
  - Use of digitized terrain data from USGS Digital Elevation Models for path profiles
- Wrap-up: Course Recap, Q/A, and Evaluations

How You Will Learn

- A seasoned instructor will present this course in interactive lecture format.
- Along with lecture, we use exercises, case studies, and interesting group activities to enrich the instruction and drive home the essential points.
- You will be given software and taught how to use this software to facilitate the design of line-of-sight microwave.
- If you already know something about the technology, we will build on that. We'll compare and contrast what's familiar with what's new, making new ideas easier to learn as well as more relevant.
- If your background is less technical, we will use meaningful and ingenious examples and analogies to simplify the complex 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.

Revised *Oct. 4, 2006*