Course ID
RFMW3D
Course Duration
3 days

Course Title
RF and Microwave Training

Aimed At

RF and Microwave Training is aimed at the technical personnel who require an understanding of RF and microwave systems.

Prerequisites

An electrical engineering background and prior exposure to RF communications will be helpful to those taking *RF and Microwave Training*.

Related Courses

- RF for Land Mobile & Public Safety Radio (5 days)
- RF Systems (4 days)
- Radio Systems Analysis & Design (3 days)
- RF for Technicians (4 days)
- RF Propagation, Fading, Link Budget Analysis (2-3 days)
- Microwave & Fixed LOS Link Design (2 days)
- Microwave & Fixed LOS Link Design in Depth (4 days)
- Antennas (1-3 days)

Course in a Nutshell

In *RF and Microwave Training*, you will learn how radio waves propagate and fade, the models that describe RF propagation and fading, how antennas work and are used, and the principles of RF and microwave systems design — with emphasis on the maritime environment. At the end of the course, you will have a solid foundation in the concepts, principles, methods, and considerations common to all RF systems as well as an understanding of microwave link design. Hands-on exercises on Link Budget Analysis using Excel are included.

Customization

This course will be tailored to the needs of your project team.

Course Outline

PART 1 – Microwave Link Budget Analysis and Estimation

- **RF and Microwave Training: Radio Frequency (RF) Transmission, Reception, and Propagation**

  - Glossary of common radio propagation terms and acronyms
  - Why do we need to study propagation?
  - Relationship of propagation phenomena to wireless network modeling and design
  - Theory of Radio Frequency (RF) propagation
  - Basic radio wave components: (E) and (H) fields
  - Sky wave, ground wave and sea level propagation
  - Line-of-Sight (LOS) and non-Line-of-Sight (non-LOS) propagation
  - Free space path loss models
  - Frequency and wavelength calculations
  - Basic modulation theory
  - Channel efficiency: Bits per second per hertz
  - Bit rate vs. symbol rate
  - Digital and analog modulation: Advantages and disadvantages

- **RF and Microwave Training: Wireless Multiple Access Methods, Applications, and Comparison**

  - FDMA
  - TDMA
  - CDMA
  - OFDMA

- **RF and Microwave Training: Wave Propagation Factors Affecting Radio Waves – Loss Attenuation & Estimation**

  - Reflection
  - Refraction
  - Scattering
  - Diffraction
  - Earth's curvature
  - Fresnel zones
  - Absorption in terrestrial and sea environments

- **RF and Microwave Training: Antenna Configurations and Performance in the Context of RF Propagation Issues**

- Basic antennas: Isotropic and dipole radiators
- Concept of antenna gain and gain references
- Calculating and measuring antenna gain
- Effective Radiated Power (ERP)
- Antenna patterns
- How antennas achieve gain
- Reflector techniques, array techniques
- Families of antennas used in wireless: Architecture and characteristics
- Horizontal arrays: Yagis, log-periodics, etc.
- Implications of propagation driving antenna selection
- Multipath scattering in fixed and mobile clutter environment
- Beamwidths and tilt considerations for MW antennas
- Radiation patterns
- Antenna gains, patterns, and selection principles
- Practical excel calculators for antenna Gain estimation

- **RF and Microwave Training: ITU-R Propagation Models and Prediction Methods**

  - Propagation over smooth earth
  - Propagation over irregular terrain
  - Propagation over rough and smooth sea level
  - Diffraction over irregular terrain
  - Reflection over smooth terrain and building walls
  - Reflection over smooth sea surface
  - Scattering over rough sea level
  - Diffraction in microwave interference (site shielding)
  - Practical exercises including:
    - MW short- and long-range outdoor land-to-land propagation characteristics,
    - MW short- and long-range land-to-sea propagation characteristics,
    - RF and MW under-sea (sub-marine) propagation characteristics

- **RF and Microwave Training: 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
  - Cloud and fog attenuation
  - Other atmospheric attenuation

- **RF and Microwave Training: Link Budget Estimation**

  - Understanding the link budget equation
  - Line-of-sight (LOS) path loss models
  - Fresnel zone
  - Path loss and free space path loss
  - Antenna gain
  - Frequency considerations
  - Atmospheric, weather, and rain attenuation
  - Terrain factors
  - Multipath loss
  - Rician and Raleigh fading considerations
  - Cochannel interference
  - Transmission line loss
  - Exercise: Typical link budget calculation for a terrestrial MW link
  - Exercise: Typical link budget calculation for a sea communications MW link environment

PART 2 – Microwave Link Performance

- **RF and Microwave Training: Radio Performance: Propagation in a Variable Environment**

  - Multipath fading
    - Rician, Raleigh and Nakagami fading
    - Threshold crossing rate and average fade duration
    - Delay spread
    - Scatter function, WSSUS model and SCRM model
    - Doppler shift effects
    - Channel coherence time and coherence bandwidth
    - Multipath fading margin
  - Dealing with channel impairments
    - Forward Error Correction (FEC)
      - Definition of coding types and coding gain
      - Types of block codes with examples: CRC and Hamming codes
      - Space-time and space-frequency block coding
      - Convolutional coding and Viterbi decoding, with example
      - Interleaving and turbo codes
      - FEC coding gains and margins
    - Interleaving gain margin
    - Channel estimation and equalization
      - Linear versus non-linear equalization
      - Transversal filter

        - Zero-forcing equalization versus minimum mean-square error
        - Decision feedback equalization and training equalizer
        - Equalization gain margin
    - Antennas Diversity
        - Diversity types: Space, frequency, angle, polarization, hybrid
        - Diversity combining and improvements over non-diversity systems
        - Power Control

- **RF and Microwave Training: 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
    - Detailed analysis of a terrestrial RFI case

- **RF and Microwave Training: Throughput Estimation**
    - Channel Capacity
    - IP transmission
    - Throughput estimation

- **RF and Microwave Training: Performance Objectives**
    - ITU standards and recommendations
    - Real MW equipment parameters and characteristics
    - Availability and error rate objectives
    - Measurements of bit error rate, eye patterns, and jitter
    - Practical exercise using Excel

- **RF and Microwave Training: Course Recap and Q/A**

DCN ZgNt.f