Course ID
SATCOM5D
Course Duration
5 days

Course Title
Satellite Communications: Earth Station Design and Analysis

Related Courses

- Satellite Communications Principles and Design: A-to-Z of Modern Commercial and Military Satellite Systems (SATCOM, 2 days)
- Satellite Network Design Workshop: VSAT Design, Installation, and Program Management (SATSHOP, 1 day)

Aimed At

Participants with some background in telecommunications whose work requires a comprehensive workshop on satellite communications.

Group Size

5-25

Prerequisites

Technical background and general exposure to telecommunications networks.

Course in a Nutshell

Satellites are a key part of the global communications infrastructure, including technically advanced and developing countries alike. It's the only telephony and broadband wide-area network technology that's available everywhere, from the concrete jungles to the rain forests.

In this comprehensive, five-day workshop on satellite communications, you will acquire an in-depth understanding of the technical aspects of earth station design, link budget analysis, and deployment. Each module of this course builds upon the previous modules, culminating in complete performance analysis of a satellite network based on equipment specifications, system configuration, and satellite parameters. Using calculator exercises and Excel spreadsheets, the course will make sure that you have a detailed, practical, and hands-on understanding of all of the important aspects of SATCOM design.

Customize It!

- Depending on your degree of current knowledge of SATCOM systems, we can omit certain topics, resulting in a shorter course.
- The course can similarly be expanded to accommodate additional topics of interest or to include more detailed discussion of or added exercises related to certain topics.
- It can also be tailored to the needs of your system, commercial or military.

Learn How To

- Develop a system design based on communications requirements and limitations.
- Select system components, based on their specifications, to satisfy system requirements.
- Perform detailed EIRP and G/T analysis.
- Establish proper signal levels for optimum performance.
- Select the proper access technique based on system requirements and network topology.
- Perform availability analysis based on required fade margin, equipment reliability, and sparing strategy.
- Perform detailed end-to-end link budget analysis based on system limitations and equipment parameters.
- Troubleshoot problems common to satellite deployments.

Course Outline

Module I—Digital Communications for Geosynchronous Satellites

- Introduction and Overview
  - Guided and Unguided Transmission Media
  - Telecommunications Component Functions
  - Some Transport and Switching Terminology
- Digital vs. Analog
  - Digital/Analog Comparison
  - Analog Multiplexing
- Line Codes: Bit Rate, Baud Rate and Bandwidth
  - Harry Nyquist and Claude Shannon
  - Bandwidth and Bit rate at Baseband
  - Line Code Variations
- Voice Encoding Techniques: Bandwidth vs. Latency
  - Waveform Encoding
    - Pulse Code Modulation (PCM)
    - Adaptive Differential PCM
  - Source Coding
    - Linear Predictive Coding
    - Code-book Excited Linear Prediction (CELP)
  - Voice Coding Issues over Satellites
- Digital Communications Protocols
  - Overview of Protocol Layers
  - Physical Layer Aggregation and Switching Protocols
    - Standards-based TDM: T-carriers and E-carriers
    - Proprietary TDM: Aggregate Rate Multiplexing
    - Digital Cross-Connect Switching (DCS)
    - Digital Circuit Multiplication Equipment (DCME)
  - Data Link Layer Protocols and Equipment
    - Frame Relay FRADs and Switches
    - ATM and Negative Latency
    - Ethernet: Not just for LANs

    - Network Layer Devices and Functions
- Network Timing and Synchronization
    - Timing Terminology and Concepts
    - Stratum Levels and Timing Architectures

Module II—Geosynchronous Satellites

- Satellite Communications Overview
    - A Brief History of Satellite Communications
    - Overview of Earth Station Sub-systems
- Satellite Network Management
    - Control and Monitor Systems
    - SNMP for Network Management
    - The Role of Proxy Agents
- Geosynchronous Satellites: Strengths and Weaknesses
    - Common Satellite Deployments
    - Problems Caused by Long Path Delays
        - Need for Echo Cancellation
        - Perceptible Delay in Conversation
        - Talk Collisions over Double-hops
        - Reduction in Throughput When Using Protocols That Require Acknowledgement and Re-transmission
    - Problems Caused by Relative Satellite Motion
        - Doppler Shift of High-speed Data Streams
        - Tracking Requirements due to Satellite Inclination
- Comparison of Satellite Types
    - Orbital Variations
    - Payload Types
    - Operating Frequencies
- Overview of Satellite Access Techniques
    - FDMA for Digital and Analog Access
    - TDMA and F/TDMA for Digital Access
    - ALOHA and Slotted ALOHA
    - CDMA
- Comparing Satellite Access Techniques
- Satellite Topologies and Access Techniques

Module III—RF Basics for Satellite and Earth Station

- A Quick Review of Decibels
    - Logarithms and Their Functions
    - Using Decibels for Small and Large Ratios and Values
    - When NOT to use Decibels
- The Electromagnetic Spectrum
    - Frequency vs. Wavelength
    - Band Designations
    - Radar Bands Common to Satellite Communications
- Transmission Lines and Filters

  - Waveguide vs. Coax
  - Filter Parameters
- Overview of System Components
  - Basics of Radio Amplifiers
  - Filter Types and Functions
  - Types of Oscillators (Sources)
  - Mixers and Multipliers
  - Combiners and Splitters
- Bent-pipe Payload: A closer Look
  - Transponder Block Diagram
  - Basic Uplink/Downlink Components

Module IV—Earth Station Equipment: Parameters and Impairments

- Earth Station Uplink Equipment
  - Upconverter Types and Characteristics
  - Typical Upconverter Specifications
  - Amplifier Types and Characteristics
  - Amplifier Impairments Due to Non-linearity
    - Intermodulation Distortion
    - Spectral Regrowth
  - Typical Amplifier Specifications
  - Post-Amplifier Combining Techniques
    - Wide-band Signal Combining
    - Frequency-specific Signal Combining
- Antennas and Tracking Systems
  - Antenna Types
  - Antenna Patterns and Gain Calculations
  - Antenna Polarization Techniques
    - Linear Polarization Concept
    - Circular Polarization Concept
    - Comparison of Linear and Circular Polarization
  - Typical Antenna specifications
  - Antenna Tracking Systems
    - Step-tracking Systems
    - Mono-pulse Tracking Systems
- Earth Station Downlink Equipment
  - The Low Noise Amplifier: The Heart of the Receive System
    - LNA Types
    - LNA Characteristics
    - Typical LNA Specifications
  - Downconverter Characteristics
- Basics of Digital Modulation
    - Modulation Scheme Constellations
    - Noise and Errors and Free Distance
    - C/N and E_b/N_0 Calculations
- Pre-modulation Processing and Error Correction
    - Digital Energy Dispersal

        - Convolutional Encoding
        - Interleaving to Improve Data Recovery
        - High Level Modulation Schemes
        - Block Coding Techniques
    - Modem Variations
        - Coherent vs. Differential Demodulation
        - Offset QPSK for PAPR Improvement
    - Important Modem Characteristics and Specifications
- Thermal Noise and C/N
    - Quantifying Thermal Noise
    - Determining the C/N
    - Adding the Uplink C/N and the Downlink C/N

Module V—Earth Station Design

- Uplink Design Considerations
    - Earth Station EIRP
    - Earth Station Gains and Losses
    - Setting Uplink levels
- Downlink Design Considerations
    - Downlink Levels
    - Internal and External Noise Contributions
    - Noise Figure and Noise temperature
    - Performing a Cascade Analysis
    - G/T Contributing Factors
    - Performing a Detailed G/T Analysis
- Determining System Availability
    - Equipment Configuration
    - Sparing strategy
    - Equipment reliability
    - Link Availability and rain fade

Module VI—Link Analysis Techniques

- Overview of Link Analysis
    - Limiting Factors
    - Satellite Transponder Parameters
    - Earth Terminal Parameters
    - Operational Parameters
- Sources of Interference
    - Self-Interference
    - External Interference from Orbit
    - Terrestrial Sources of Interference
- Spreading Loss and Path Loss
    - Determining Distance to Satellite
    - Determining Power Flux Density at Satellite
    - Free Space Loss for Determining IRL at Satellite
    - Other Loss Contributions

        - Pointing Loss
        - Polarization Offset Loss
    - Bent-pipe Transponder Parameters
        - Transponder Footprint
        - Saturation Flux Density (SFD)
        - G/T
        - Saturation EIRP
        - Transponder Padding
        - Transponder Bandwidth
        - Satellite Inclination
    - Performing Link Budgets for Bent-pipe Satellites
        - Determining Total C/N on a Link
        - Determining EIRP for Bandwidth-limited Operation
        - Performing Detailed Uplink/Downlink Power Budgets
        - Putting It All Together: Link Budget Exercises
            - End-to-End Link budget for Mesh Topology (one direction)
            - End-to-End Link Budget for Spoke Network (both ways)
    - Wrap-up: Course Recap, Q/A, and Evaluations

How You Will Learn

- An engineer/instructor well versed in satellite communications will present this course in workshop format.
- Along with the lecture, we will use calculator exercises and Excel spreadsheets to make the class practical and job-relevant.
- If you already know something about SATCOM, we will build on that 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.

Revised *Nknm.f*