Training Program:

Satellite Communications: Earth Station Design & Analysis

COURSE OVERVIEW:

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 (which are included with the course), we will make sure that you have a detailed, practical, and hands-on understanding of all of the important aspects of SATCOM design.

COURSE OBJECTIVES:

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.

COURSE OUTLINE

Module I—Digital Communications for Geosynchronous Satellites

- Digital vs. Analog
- Network Components and Topologies
- Switching Terminology
- Digital/Analog Comparison
- 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
- Continuously Variable Slope Delta Modulation
- 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
- 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
- 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
- Overview of Satellite Access Techniques
- FDMA for Digital and Analog Access
- TDMA and F/TDMA for Digital Access

Module III—Earth Station Equipment

- 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
- Radio Building Blocks
- Basics of Radio Amplifiers
- Filter Types and Functions
- Type of Oscillators (Sources)
- Mixers and Multipliers
- 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
- Transmission Line Characteristics
- 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
- Modems and Error Correction
- Modulation: Digital and Analog
- Basics of Digital Modulation
- Modulation Scheme Constellations
- Noise and Errors and Free Distance
- C/N and Eb/N0 Calculations
- Error Correction Techniques
- Block Coding
- Convolutional Coding
- Modem Variations
- Coherent vs. Differential Demodulation
- Offset QPSK for PAPR Improvement
- Timing Considerations for Satellite Links
- Loop Timing Systems
- Master/Slave Timing Systems
- Doppler Buffers for High Data Rates
- Important Modem Characteristics and Specifications
- Thermal Noise and C/N

- Quantifying Noise
- Determining the C/N
- Adding the Uplink C/N and the Downlink C/N
- Power and M&C Systems
- System Components and Alarm Types
- Critical and Technical Power Systems

Module IV—Earth Station Design

- A Comparison of Access Techniques
- Dedicated Carrier Access
- Demand Assigned Multiple Access
    - ✓ FDMA
    - ✓ TDMA
    - ✓ F/TDMA
- Access Technique Selection Criteria
- Cost Analysis: FDMA vs. TDMA
- Hub-spoke vs. Mesh Networks
- Uplink Design Considerations
- Antenna gain and efficiency
- 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 V—Link Analysis Techniques

- Overview of Link Analysis
- Limiting Factors
- Satellite Transponder Parameters
- Earth Terminal Parameters
- Operational Parameters
- Spreading Loss and Path Loss
- Determining Distance to Satellite
- Determining Power Flux Density at Satellite
- Free Space Loss
- Other Loss Contributions
- Pointing Loss
- Polarization Offset Loss
- Satellite Transponder Parameters
- Saturation Flux Density
- G/T
- Saturation EIRP
- Transponder Padding
- Transponder Bandwidth
- Transponder Footprint
- 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
- Ka-band and Processing Satellites
- Processing Satellites: Pros and Cons
- Link Budgets for Processing Satellite
- Ka-band and the Future of Geosynchronous Satellites
- Wrap-up: Course Recap, Q/A, and Evaluations