Telemetry Systems

Course No. 171

FOR WHOM INTENDED This course is intended for personnel involved in engineering applications of telemetry, in either commercial or defense/space organizations. Applications include telemetry as applied to control and monitoring of space vehicles as well as telecommunications, automotive testing, in-plant industrial system control and electrical power transmission telemetry systems.

BRIEF COURSE DESCRIPTION The course starts with an introduction to telemetry systems, carrier signal modulation and telemetry standards.

The presentation continues with background information on topics encountered in telemetry systems such as: dB, sensors, filtering, signal waveforms and Fourier analysis.

Telemetry modulation techniques, frequency modulation (FM) and Pulse-Amplitude modulation (PAM) are covered next. After a discussion of digital signals, binary arithmetic and data formats, Analog/ Digital and Digital/Analog conversion is covered. Building on this knowledge, the instructor then presents Pulse-Code modulation (PCM), including sub- and super-commutation techniques. Student exercises on sample rates, sample plans and PCM Ground Station operation reinforce knowledge.

Next comes a discussion of Data Bus standards such as ARINC-429, MIL-STD-1553 and IRIG-106, Chapter 8, followed by bit encoding formats, including NRZ-L, Bi-Phase-L, RNRZ-L, Viterbi, Reed-Solomon, convolution and interleaving.

Special PCM formatting such as embedded asynchronous and embedded video techniques are discussed before covering time codes. The instructor then discusses Range Telecommunications issues such as multi-sourced data and architecture.

Next comes an overview of available computer systems, interfaces, networking options and parameter databases. Data compression and storage are considered next, including analog and digital tape recording and multiplexers. The course concludes with discussions of RF transmission theory, an overview of telemetry vendors and future trends in telemetry. CCSDS and packet telemetry may be covered, if requested.

CERTIFICATE PROGRAMS This course is an elective for TTI's Instrumentation Test Specialist Certificate Program and may be used as an elective for any other TTI Certificate Program.

PREREQUISITES There are no definite prerequisites, but TTI's courses "Instrumentation for Electrical Test and Measurement," and "Digital Signal Processing" would be helpful.

TEXT Each student will receive a course workbook including most of the viewgraphs used in the presentation, also a CD-ROM with copies of the various standards discussed in the class.

COURSE HOURS, CERTIFICATE AND CEUs Open courses meet seven hours per day. Upcoming presentation dates can be found on our current open course schedule. Class hours/days for on-site courses can vary from 14–35 hours over 2–5 days as requested by our clients. At successful course completion, each participant receives a certificate of completion and one Continuing Education Unit (CEU) for every ten class hours.

For schedules, general information and registration forms, see TTi's web site.

Course Outline

Introduction to Telemetry Systems: System Types, Basic RF telemetry, Components, System Configuration • Near-Earth and Deep Space • Standards
Understanding dB: Decibels, Power Ratio, Voltage Ratio, dB Reference Levels
Sensors: Mechanisms and Measurands • Sensor Types • Linearity • Mounting
Filtering: Analog vs. Digital filtering • Bandwidth • Filter characteristics
Signal Waveforms and Fourier Analysis: Time and Frequency Domain
Signal Sampling: Acquisition, Shannon/Nyquist Theorem, Aliasing
Frequency Modulation (FM) and Pulse Amplitude Modulation (PAM):
Carrier Modulation • Amplitude and Frequency Modulation (AM and FM)
FM: Ground Station, Frequencies, Techniques, Modulation, Guard Bands, Mixing, Sampling • PAM Ground Station • Miscellaneous Encoding
Digital Signals, Binary Arithmetic and Analog/Digital Conversion
Numbering Systems • Data formats: Fixed vs. Floating Point • Parity Math • Gray Code • Binary Coded Digital (BCD) • Endians • A/D, D/A Conversion
Pulse Code Modulation (PCM): PCM Encoder • Airborne Instrumentation
CAIS Sources • PCM Ground Station • Bit Sync • Clock Phase • Decommutator Frame Sync Pattern • Sample Rates vs. Bit Rate, Exercise • Sub-Commutation Frame Encoding • Formats • Super-Commutation • Super-Sub-Commutation Sub-Sub Commutation • Discrete Inputs • Sample Plans, Exercise
Parity Bits • Receiving System Setup • Receiver Settings • Bit Sync Settings Decom settings • Auto Polarity • Module and D/A I/O • PCM Exercise
Data Bus: ARINC-429 • MIL-STD-1553 • IRIG-106, Chapter 8 • Future
Bit Encoding: Digital Data Formats: NRZ-L • BiØ-L • RNRZ-L • Viterbi • Common Codes • Flywheeling • Bit Syncs • Noise in the Data Stream • Viterbi and Reed-Solomon Encoding • Convolution Encoding Examples • Interleaving
Advanced PCM: Embedded Asynchronous, Embedded Video, Variable Word Length Fragmented Words, Format Changes, Independent Subframes, Tagged Data, Burst Mode, Data Class 1 & 2, Sample/Hold, Encryption, PCM/FM
Time Codes: System Timing Info • Internal vs. External Time • Typical Codes • Resolution • IRIG-B, Serial Code • Nomenclature • Embedded Time • Accuracy
Range Telecommunications: Multi-Sourced Data • Architecture • Carrier Types IP Data Transfer • Merging File (Data) Sets • Best Source Selectors
The Computer and the Telemetry System: Architectures, Attributes • Data Words • Data Transfer Mechanisms • PC-Computers, Hardware • Getting Data to Disk • Buffer Servicing—CVT vs. Data Driven • Bus Standards • PC Systems, Software • Latency • Portability and Ruggedness • Buses: ISA, PCMCIA (PC Card), PCI, PCI-Express, VME, USB, FireWire (IEEE 1394), SCSI, Fibre Channel, SATA • RAID and Networked Storage • Ethernet: Rates, Components, Physical Medium • Fiber • Software Protocols • UDP vs. TCP • Data Flow Down • Display Devices • Graphics Display Engines • Parameter Databases • TMATS
System Processing, Testing, and Specifying: Needs for a Processing Engine
IRIG Time Testing • Data Driven vs CVT Testing • System Specifications
Data Compression and Storage: ZFN • Analog Recorders • Digital Technologies • Digital Tape • Multiplexers • IRIG Chapter 10 • Recording Media, Duration • Digital Media Sizing Exercise • IRIG Testing • Analog, Digital Tape Exercises
RF Transmission: UHF Bands • Future Frequencies • Digital Signal Transmission • Bandwidth, Output Power • Multi-Path Transmission • Modulation Techniques • FM vs. PSK • Antennas • Receivers • Bit Error Rate • BER Testing • JTRS
Mission Planning and Data Mining: Work Breakdown Structure • Mission Support Process • Data Mining, Tool Requirements • Three Solutions
Telemetry Vendors • Recommended Reading • Future Trends
CCSDS (optional/appendix): Packet Telemetry • Layering of Telemetry Data • Data Flow Chart • Conceptual Ground Station • Hierarchy • CCSDS Overhead
Summary, Final Quiz, Award of Certificates for Successful Completion

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