Digital Signal Processing, Data Acquisition and Analysis

Course No. 197

FOR WHOM INTENDED (1) Testing laboratory personnel who want to expand their analysis capabilities, perhaps in the interest of improving their test designs; (2) analysis personnel responsible for the interpretation of data acquired in the laboratory; (3) test requestors/designers who want to know what tools are available and what to expect from them.

BRIEF COURSE DESCRIPTION (See course outline, over.) The objective of the first portion of the course (also available separately as Course 196, Digital Data Acquisition) is to provide participants with the knowledge required to specify, evaluate and use a wide variety of digital data acquisition systems in laboratory and field applications. Basic principles of sampling and digitizing theory are presented and reinforced with practical examples from everyday testing operations.

Hardware discussions concentrate on performance capabilities and practical problems that arise in laboratory and field applications. Heavy emphasis is placed on new technologies and system concepts that will be available in the near future. The aim is to prepare participants to design and procure state-of-the art systems that will satisfy their technical requirements efficiently and economically.

Literature describing the latest available hardware will be used as examples of good (and bad) practice. Particular emphasis will be placed on critical evaluation of commercially-available hardware and software systems.

The objective of the second part of the course is to provide participants with a working knowledge of the tools available for analysis of data acquired by digital data acquisition systems for a variety of laboratory and field applications. Basic analysis principals and methods are presented and reinforced with practical examples from everyday testing operations. The interaction between test design, data acquisition and analysis is emphasized.

The lectures and discussions are designed to promote understanding of the concepts involved through “mechanical feel” rather than mathematics. Participants are encouraged to offer problems from their own activities for discussion and solution by the class.

The course is presented as a series of highly interactive lecture /discussion sessions. Problems for individual and group solution are interspersed throughout the course to act as training aids and to evaluate class progress. Special-interest discussions are encouraged outside of the regular course sessions.

DIPLOMA PROGRAMS This course will satisfy the course 196 and 197 requirements of TTi’s Data Acquisition and Analysis Specialist (DAS) diploma program. It may be used as an elective for any TTi Specialist Diploma Program.

RELATED COURSES The data acquisition portion (part I) of Course 197 is available separately in Course 196, Digital Data Acquisition. Course 197-3, Digital Signal Processing and Data Analysis, is also available; it corresponds to part II of this outline. Either Course 197, 197-3 or 196 may be presented at your facility.

COMPLETE OnDEMAND COURSES Both Course 196 and 196 are available as Internet Complete OnDemand Courses. Together they feature more than twenty hours of video along with more in-depth reading material. All chapters of courses 196 and 196 are also available as OnDemand Internet Short Topics. See the on-line course outlines for details.

PREREQUISITES A good understanding of the engineering problem to be analyzed is expected. An understanding of basic computer and data acquisition principles will be useful.

TEXT Each student will receive 180 days access to the on-line electronic course workbook. Renewals and printed textbooks are available for an additional fee.

COURSE HOURS, CERTIFICATE AND CEUS Class hours/days for on-site courses can vary from 14–35 hours over 2–5 days as requested by our clients. Upon successful course completion, each participant receives a certificate of completion and one Continuing Education Unit (CEU) for every ten class hours.

NOT AFFILIATED WITH ANY VENDOR. TTi sells no hardware or firmware. Before buying data acquisition or analysis equipment, take this course. Equipment manufacturers’ field sales people may lack time to teach fundamentals. TTi training helps you to negotiate for the equipment you really need.

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Course Outline No. 197

Part I

Overview of the Measurement Process—The System Approach
- The role and function of digital data acquisition.
- Testing and experiment types—what capabilities are required?
- Accuracy, Dynamic Range, Headroom

Basic Concepts
- Basic calculations
- The Fourier Transform as a "Black Box"
- Data presentation in time and spectral domain

Sampling and Digitization Theory
- Data acquisition speed and accuracy/resolution considerations
- Aliasing
- Noise and other data corruption problems

Data Acquisition Hardware
- Signal Conditioning
- Amplifiers
  - Common-mode rejection
    - Transducer wiring practice
- Anti-alias filters
  - Estimating aliasing errors for different filter types
  - Filter/Sample-rate tradeoffs
- Sample-and-hold amplifiers
- Multiplexers
- Analog-to-digital converters
  - Flash, Successive-approximation, Multi-pass, Sigma-Delta, Integrating

The Computer System
- Candidate computer systems–tradeoffs
- Interface concepts—speed, implementation ease and robustness
- Data storage—speed, volume considerations

Types of Digital Acquisition Systems
- Applications, Special considerations, Performance and limitations of available system architectures

Data Analysis
- Engineering-Unit Conversions
- Data Interpolation
- Correction of Anti-Alias filter distortion

Evaluating Data Acquisition Systems
- Simple tests to evaluate system accuracy/capability

Specifying a system
- How do you specify a system to get what you want?

Part II

Introductions and Overview

Review of Basic Concepts
- The time and frequency domains
- Time histories and time series analysis
- Sampling theory; acquiring good data
- Linear systems; transform concepts • Spectra

"Static" (Load/Deflection) Test Analysis
- Basic curve fitting
  - Least squares techniques, linear regression, polynomial regression • Spline fitting
- Yield point determination

Oscillating-Signal Analysis
- Basic characterization • Decibels
- Data smoothing, averaging, trend removal...
- Random signals • Probability distribution • Correlation

Spectral Domain Operations
- Calculating and displaying the spectrum
  - The Fourier Transform
    - What it does (and doesn't) do
    - Fast Fourier Transform (FFT)
    - Basic relationships and rules • Spectral "arithmetic"
  - "1/N" Octave analysis
  - Spectral graphing formats
- Engineering applications
  - Power Spectral Density (PSD)
  - Transfer functions • Forced-response analysis

Data Filtering
- Filtering in the spectral domain
- Time-domain filtering
  - FIR, IIR filters
- When to use time-domain and spectral-domain filters

Signal Integration and Differentiation
- Practical problems with real data

Transient Data Analysis: Spectral Analysis
- Shock Response Spectra

Continuous-Data Analysis
- Finite measurement-length effects
  - Gibb's Phenomenon...Ringing
  - Windowing, window types/uses/advantages and disadvantages

Data Averaging
- Time block averaging • Spectral averaging, PSD
- Average transfer-function calculation • Coherence

Special Topics
- Anti-alias filter-correction techniques
- The "Ideal" filter
- Data interpolation: Averaging and derivative techniques
  - Spectral extension
  - Data Acquisition System Calibration

Using the tools • Class problems

Student Topic/Problem Discussion

Summary, Discussion

Final quiz

Award of Certificates for Successful Completion

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