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# 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.

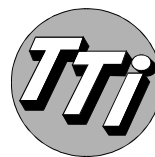
**COMPLETE OnDEMAND COURSES** Both Course 196 and 196 are available as Internet Complete OnDemand Courses. Together they feature more than twenty hours of video along with more in-depth reading material. All chapters of courses 196 and 196 are also available as OnDemand Internet Short Topics. See the 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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# Digital Signal Processing, Data Acquisition and Analysis

## 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

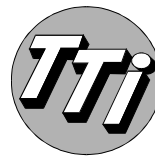
Transient Data Analysis: Spectral Analysis  
Shock Response Spectra

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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