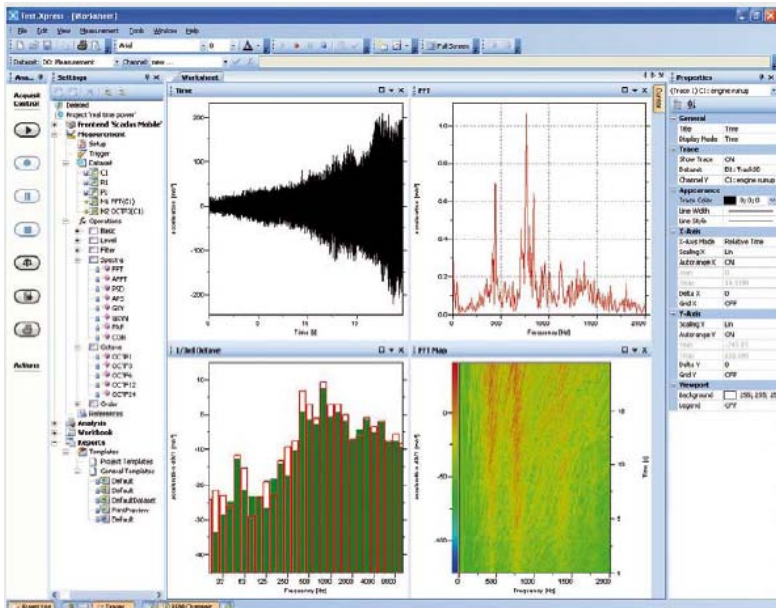
THE CENTER FOR PROFESSIONAL STUDIES



Digital Signal Processing in Noise and Vibration Testing

Digital Signal Processing (DSP) is the core technology behind today's noise and vibration testing. The techniques used and the associated assumptions along with their strengths and weaknesses will be presented in lecture format, and then re-enforced through active participation of the attendees.

- First, the basics of Digital Signal Processing and applicable engineering fundamentals are discussed to gain a common understanding of the application and general principles are reviewed. The methods capabilities as well as its limitations will also be discussed.

- Next, participants will focus on state of the art topics and explore the latest and most advanced aspects of digital signal processing.

- Lastly, participants will be shown how to run the model and interpret output results on LMS software products. A thorough understanding of what these results mean and how to use them to improve the product design will be discussed.

Course Syllabus

I IDENTIFYING INFORMATION

Course: Digital Signal Processing in Noise and Vibration Testing
Prerequisite: None
Time Frame: 40 total contact hours
Instructor: Charles Van Karsen
Associate Chair, Director of Undergraduate Studies
Mechanical Engineering and Engineering Mechanics
Michigan Technological University
BS in Mechanical Engineering
MS in Mechanical Engineering
23 years at MTU teaching and doing research
12 years as a practicing engineer in the Machine Tool, Automotive and Software industries
Mobile: (906) 370-7573
E-mail: cdvankar@mtu.edu

II REFERENCE MATERIALS

1. Smith, Steven, "The Scientist and Engineer's Guide to Digital Signal Processing"
2. Broesch, James, "Digital Signal Processing Demystified", High Text Publications 1997

III COURSE GOALS AND OBJECTIVES

1. Understand Fundamentals of DSP and its use in Noise and Vibration Enhancement
2. Understand how to correctly implement and use the results of an FFT
3. Interpretation of common Frequency Domain Measurements
4. Understand the fundamentals and applications of Digital Filters
5. Application and interpretation of Order Tracking analysis

IV METHODOLOGY

This course is an introduction to the Digital Signal Processing techniques that are used in the measurement and processing of noise and vibration data. Each module will introduce new material that the student will be allowed to experience for himself with the associate In-class Tutorials.

Lectures

Each detailed subject will be presented in a lecture format outlining the theory and standardized accepted methodology. A printed copy of the lecture material will be provided for the student's personal in-class use and as a reference material.

Specific Industry Examples

Real life examples will be covered that explain the application of the theory to various industries such as automotive, aerospace, home appliance. This will give the students a clear understanding of how and why these techniques are utilized in different industries and the value they add to noise and vibration enhancement.

In-Class Assignments

The student will conduct several hands-on tutorials to reinforce the theoretical concepts. These tutorials will increase in complexity as the students further develop their skills in applying DSP techniques. The students will present their work to the group for review and discussion.

V COURSE OUTLINE & ASSIGNMENTS

Module 1 – DSP Overview

Importance of accurate data collection and processing
Time, Frequency and Laplace Domain Relationships
Time – Frequency Domain Comparison
Basic Components of the Digital Signal Process
Terminology, tools and rules

Module 2 - Analog to Digital Conversion

Sampling Theory
Sampling Examples
Aliasing
Prevention of Aliasing
Quantization
In-class Tutorial – Aliasing and Sampling

Module 3 - Time and Frequency Domain

Time and Frequency Domain
Fourier Series Examples
Fourier Integral
Integral Fourier Transform
Discrete Fourier Transform
Fast Fourier Transform
Discrete Fourier Transform Examples
Periodic vs Non-periodic data
Leakage
Zoom Transform
In-class Tutorial – Frequency Domain Measurements

Module 4 - Time Domain Weighting

Time Domain Weighting
Common Window Functions
Mathematics of Windows
Rectangular Window
Hanning Window
Flat Top Window
Comparison: Rectangular, Hanning, Flat Top
Additional Windows
Window Correction Factors
In-class Tutorial - Windowing / Leakage

Module 5 - Measurements Overview

- Acquiring Measurement Data
- Classifying Data
- Measurement Perspectives

Module 6 - Frequency Domain Measurements

- Linear Spectrums
- Auto Power Spectrums
- Cross Power Spectrums
- Frequency Response Functions
- Measuring the FRF
- Computing H (jw)
- Coherence
- In-class Tutorial – Frequency Spectrum vs. Auto Power Spectrum
- In-class Tutorial – Auto Power Spectrums vs. Power Spectral Density
- In-Class Practical Exercise: 'Guess the Signal"

Module 7 - Digital Filtering Theory

- Basic Assumptions
- FIR and IIR Filter Design
- Analysis
- Applying Filters

Module 8 - Basic Signature Analysis

- Stationary Operating Conditions
- Stationary and Repeatable Operating Condition
- Analyzing Signatures
- What is an Order?
- Sine Wave Interaction
- Amplitude Modulation
- Frequency Modulation
- Frequencies of the causes of Noise or Vibration of a Machine
- Non-Stationary Operating Conditions

Module 9 - Tachometer Signal Analysis

- Tachometer Probe Hardware
- Tachometer Sensor Mounting
- Tachometer Signal Examples
- Tachometer Signal Processing Parameters
- Tachometer Signal Processing and Acquisition

Module 10 - FFT Based Order Tracking

FFT Order Tracking Signal Processing
FFT Transform and Windowing
FFT Order Tracking Errors
RPM Estimate Correction
In-Class Tutorial – FFT Based Order Tracking

Module 11 - Re-sample Based Order Tracking

Analog Angle Domain Sampling Strategies
Re-sampling Based Order Tracking Signal Processing
Re-sampled DFT Transform and Windowing
Re-sampling Order Tracking Errors
Preferred Data Acquisition Procedure for Re-sampling Based Order Tracking
Result of Re-sampling to the Angle Domain
Re-sampling Based Order Track Results
In-Class Tutorial – Angle Domain Based Order Tracking