Signal Analysis and Measurement Techniques in MATLAB

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Senior Application Engineer
Agenda

- Perform interactive signal processing
  - Make key signal measurements
  - Perform time and frequency domain analysis

- Design, visualize, and optimize filters
  - Digital IIR and FIR filters
  - Interactive design tools

- Develop algorithms for signal processing
  - Signal transforms, multi-rate operations
  - Statistical functions, linear prediction

- Acquiring data from stand alone instruments
  - Demo: Acquiring data from an oscilloscope

- Q&A
Demo: Access, visualize, and analyze signals

Time-Domain

Frequency-Domain
Signal Analysis and Measurement Workflow

- **Files**
- **Software**
- **Hardware**
- **Signal Analysis & Measurement**
- **Algorithm Development**
- **Application Development**
- **Reporting and Documentation**
- **Outputs for Design**
- **Deployment**

Diagram showing the workflow:

1. Files
2. Software (Code & Applications)
3. Hardware
4. Signal Analysis & Measurement
5. Algorithm Development
6. Application Development
7. Reporting and Documentation
8. Outputs for Design
9. Deployment
Signal Analysis and Measurement in MATLAB

Explore & Discover

Signal Analysis & Measurement

Algorithm Development

Application Development

Automate

Access
Files
Software
Hardware

Share
Reporting and Documentation
Outputs for Design
Deployment

Files
Software
Hardware

Code & Applications

MATLAB 
.NET Excel
C/C++
Java .dll
What is MATLAB?

- Interactive development environment
- Technical computing language
- Data analysis and visualization
- Algorithm development and application deployment
Signal Processing Toolbox

- Industry-standard algorithms for signal processing
  - Waveform and pulse generation
  - Power spectral density estimation
  - Signal transforms – FFT, DFT, STFT
  - Digital FIR and IIR filter design
  - Analog filter design
  - Dispersion and Bi-level waveform Measurements
  - Statistical processing and windowing
  - Linear prediction and parametric time-series modeling
Signal Analysis, Processing, and Algorithms

- Perform interactive signal processing
  - Make key signal measurements
  - Perform time and frequency analysis

- Design, visualize, and optimize filters
  - Digital IIR and FIR filters
  - Interactive design and analysis tools

- Develop algorithms for signal processing
  - Signal transforms, multi-rate operations
  - Statistical functions, linear prediction

- Utilize MATLAB Apps
  - Signal Analysis (sptool)
  - Filter Design and Analysis (fdatool)
  - Window Design and Analysis (wintool)
Demo: Access, analyze, and process radio signals

- Frequency-Domain Analysis
- Filtering
- Demodulation and Time-Domain Visualization
Spectrum Analyzer

Signal analysis in the frequency domain

- Measure the spectral power density of streaming signals

- Spectral analysis settings as found on commercial real-time spectrum analyzers:
  - Center frequency, frequency span
  - Resolution bandwidth (RBW)
  - Windowing
  - Max/Min-hold, averaging

- Measure peaks with the peak finder tool
Time Scope

New features for visualizing signals varying in time

Cursor Measurements

- Drag horizontal and vertical cursors anywhere on screen
- Track waveforms with vertical cursors
  - Single- or cross-channel
- Standard oscilloscope readout
  - V1, V2, ΔV
  - T1, T2, ΔT
  - 1 / ΔT
  - ΔV / ΔT
Demo: 
Performing Signal Measurements on Clock Data

Rise and Fall Time

Pulse Width

State Level
Expanding the Capabilities of MATLAB

- MathWorks add-on tools for:
  - Statistics and curve fitting
  - *Signal processing*
  - Image processing
  - Wavelets
  - System identification and control system analysis
  - Neural networks and fuzzy logic
  - Optimization
  - Model-based calibration and more …

- Partner products for:
  - Additional interfaces
  - Domain-specific analysis
  - Niche applications
Signal Analysis and Measurement in MATLAB

Access
- Files
  - Software
    - Code & Applications
- Hardware

Explore & Discover
- Signal Analysis & Measurement
- Algorithm Development
  - For k=1:max
    - x = fft(dat)
    - y = 20*log1
- Application Development

Share
- Reporting and Documentation
  - PDF, .doc, .html
- Outputs for Design
- Deployment
  - MATLAB, .NET, C/C++, Java, .dll

Automate
MATLAB Connects to Your Hardware Devices

Instrument Control Toolbox
Instruments and RS-232 serial devices

Data Acquisition Toolbox
Plug-in data acquisition devices and sound cards

Image Acquisition Toolbox
Image capture devices

Vehicle Network Toolbox
CAN bus devices using CAN and XCP protocols

MATLAB
Interfaces for communicating with everything
Instrument Control Toolbox

Enables MATLAB to configure, control, and transfer data with instruments such as oscilloscopes, pulse generators, and signal analyzers

- Integrate instruments into MATLAB applications and Simulink models
- Interactive tool for detecting and controlling instruments
- Automatic code generation for faster and easier implementation
- Support for IVI, VXI plug&play, and MATLAB instrument drivers
- Support for common communication protocols
Acquiring Data Using the Test and Measurement Tool

**Features:**

- Export directly to Figure Window
- Export to MATLAB workspace
Test and Measurement Tool Features

**Features:**
- View driver properties
- View driver functions
- Create device objects
- Create interface objects
- View connected hardware
Session Log

Features:
- Automatically creates MATLAB code from activity within the tool
- Comments the code
- Can be saved for use in application
## Instrument Control Toolbox: Communication Protocols

### GPIB Boards
- Agilent Technologies
- CONTEC
- Keithley
- National Instruments
- Capital Equipment Corporation (CEC)
- IOTech
- Measurement Computing
- ICS Electronics

### VISA Interface (includes Serial, GPIB, VXI, GPIB-VXI, TCP/IP, USB)
- Agilent
- Rohde & Schwarz
- National Instruments
- Tektronix

### Network Interfaces and Other Protocols
- TCP/IP, UDP, Bluetooth, I2C

### Serial Port (core functionality in MATLAB)
- RS-232, RS-422, RS-485
- Expanded capability with Instrument Control Toolbox

For a full listing, visit: [www.mathworks.com/products/instrument](http://www.mathworks.com/products/instrument)
Instrument Control Toolbox: Instrument Drivers

- Industry-standard instrument standards
  - LAN eXtensions for Instrumentation (LXI)
  - Interchangeable Virtual Instrument (IVI™) drivers
  - VXI plug&play™ drivers

- Several hundred supported instruments
  - Drivers available through the instrument vendor

- Instrument drivers do not require knowledge of low-level commands

```plaintext
fwrite(obj, 'TRIG:MAI:EDGE:SLO RIS');
set(obj, 'TriggerSlope', 'Rising');
```
**Instrument Control Toolbox: Instrument Drivers**

- Automatically create MATLAB instrument driver for vendor’s driver
- Customize MATLAB driver to extend or enhance vendor’s driver
- Create custom MATLAB driver for *any* instrument

![MATLAB Instrument Driver](image1.png) ![Vendor Instrument Driver](image2.png)

**MATLAB Instrument Driver**

**Vendor Instrument Driver**

(IVI or VXI plug & play)
Instrument Control Toolbox: Supported Hardware

- Instruments from Agilent, Anritsu, LeCroy, Rohde & Schwarz, Tabor, Tektronix, and others

- Instruments and devices supporting common communication protocols (GPIB, VISA, TCP/IP, UDP, and serial, Bluetooth)

- **Serial devices** – Any device with a RS-232, RS-422, or RS-485 interface (EEGs, gas chronometers, mass spectrometers, etc.)

- Instruments using industry-standard instrument drivers (IVI, VXIplug&play, LXI)

Data Acquisition Toolbox
Acquire and output data from data acquisition boards

- Immediately analyze live or acquired data in MATLAB and Simulink
- Configure hardware without leaving MATLAB
- Incorporate custom analysis into PC-based digital oscilloscope
- Ability to do “one-shot” or continuous acquisition
- Support multiple data acquisition devices and vendors
Demonstration: 
*Soundcard Audio Spectral Analysis*

- Acquires and analyzes live data from data acquisition hardware in the MATLAB environment.

- Utilizes Data Acquisition Toolbox for device configuration and acquisition.

- Utilizes the sound card already available in most PC desktops/laptops as the acquisition device.
Data Acquisition Toolbox:
Supported Hardware

- Agilent*
- ADLINK*
- Advantech
- CONTEC*
- Data Translation*
- g.tec*
- IOTech*
- Keithley
- Measurement Computing (MCC)
- National Instruments
- Ono Sokki*
- United Electronic Industries*
- VXI Technology

- Any PC compatible sound card (AI, AO)

* Denotes that the hardware manufacturer made the investment to provide this support

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## Public Trainings in the next Few Months

<table>
<thead>
<tr>
<th>Course</th>
<th>Dates</th>
<th>Location</th>
</tr>
</thead>
<tbody>
<tr>
<td>Statistical Methods in MATLAB</td>
<td>02 Sep - 03 Sep</td>
<td>Bangalore</td>
</tr>
<tr>
<td>MATLAB Based Optimization Techniques</td>
<td>04 Sep</td>
<td>Bangalore</td>
</tr>
<tr>
<td>MATLAB Fundamentals</td>
<td>23 Sep - 25 Sep</td>
<td>Gurgaon (New Delhi)</td>
</tr>
<tr>
<td>Simulink for System and Algorithm Modeling</td>
<td>26 Sep - 27 Sep</td>
<td>Gurgaon (New Delhi)</td>
</tr>
<tr>
<td>MATLAB Fundamentals</td>
<td>07 Oct - 09 Oct</td>
<td>Pune</td>
</tr>
<tr>
<td>Simulink for System and Algorithm Modeling</td>
<td>10 Oct - 11 Oct</td>
<td>Pune</td>
</tr>
<tr>
<td>MATLAB for Building Graphical User Interfaces</td>
<td>21 Nov</td>
<td>Bangalore</td>
</tr>
<tr>
<td>Generating HDL Code from Simulink</td>
<td>28 Nov-29 Nov,2013</td>
<td>Bangalore</td>
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Summary

- MATLAB, Signal Processing Toolbox and DSP System Toolbox makes signal analysis, measurements, and algorithm design easy.

- Control and acquire data from test and measurement equipment using interactive tools in MATLAB.

- Acquiring and analyzing data from the same environment saves time and enables live analysis of data.