Acquiring Data from Sensors and Instruments Using MATLAB

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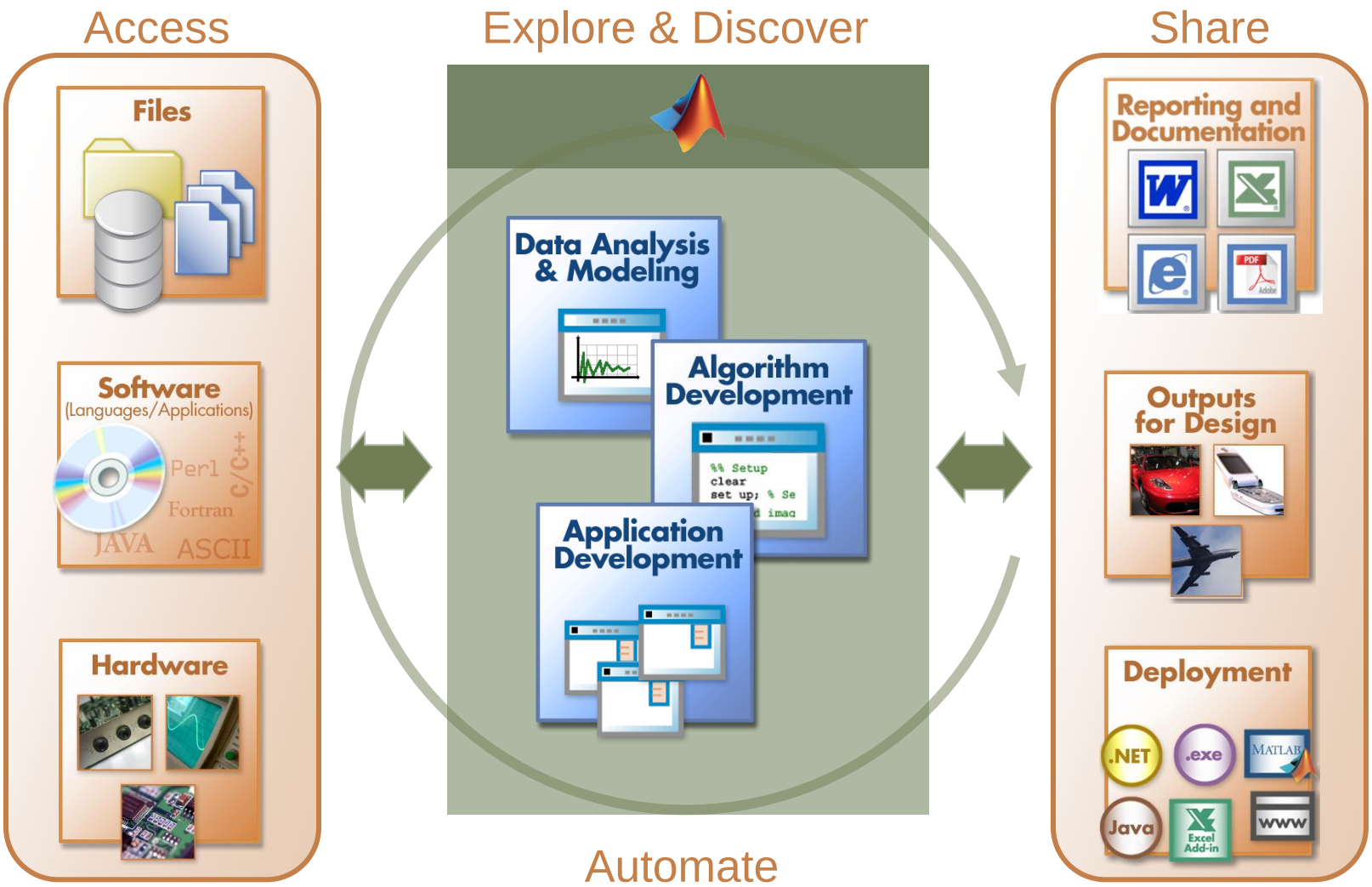
Agenda

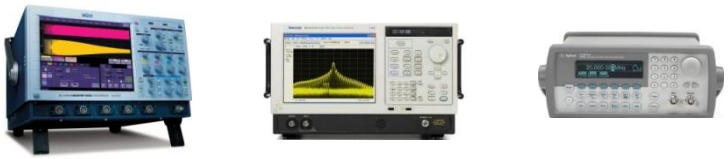
- Why acquire data with MATLAB?
- Overview of data access options from MATLAB
- Analyzing audio data
  - Demo: Analyzing the frequency spectrum of live audio signal
- Working with Sensors
  - Demo: Acquiring data from a thermocouple
  - Demo: Acquiring data from an IEPE accelerometer
  - Demo: Acquiring data from a Bluetooth sensor
- Acquiring data from stand alone instruments
  - Demo: Acquiring data from an oscilloscope
- Summary
- Q&A

Technical Computing Workflow



MATLAB Connects to Your Hardware

Data Acquisition Toolbox
Plug in data acquisition boards and modules



Instrument Control Toolbox
Instruments and RS-232 devices

Image Acquisition Toolbox™
Image capture devices

Vehicle Network Toolbox
CAN bus interface devices

MATLAB
Interfaces for communicating with everything

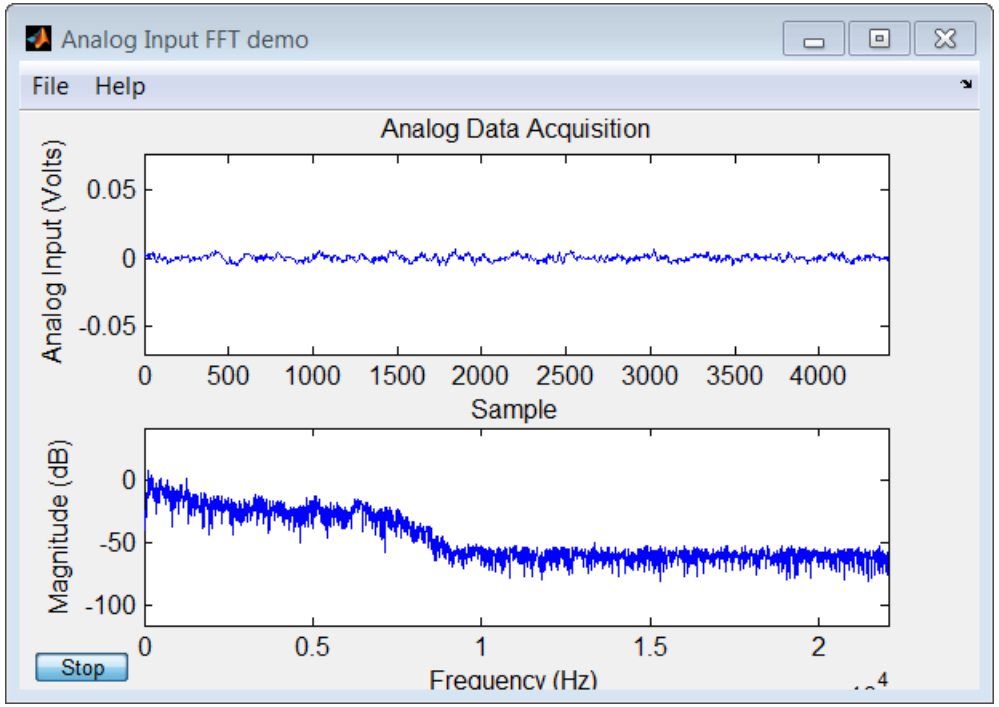
Data Acquisition Toolbox™: Supported Hardware

- Agilent Technologies
- Keithley
  - ISA, PCI, PCMCIA
- Measurement Computing Corporation
  - USB, PC/104, ISA, PCMCIA, Parallel port
- National Instruments
  - Hardware supported by NI-DAQ, NI-DAQmx drivers over AT, PCI, PCI Express, FireWire, PXI, SCXI, PCMCIA, parallel port, USB, CompactDAQ
- **Any Windows compatible sound cards (AI, AO)**
- IOtech
  - DaqBoard, DaqBook, DaqLab, DaqScan, Personal Daq/3000, and WaveBook Series
- Data Translation
  - All USB and PCI boards
- CONTEC
  - Various boards through CONTEC ML-DAQ adaptor
- Advantech

For a complete list, visit www.mathworks.com/products/daq/supportedio.html

Demo: Acquiring and analyzing data from sound cards

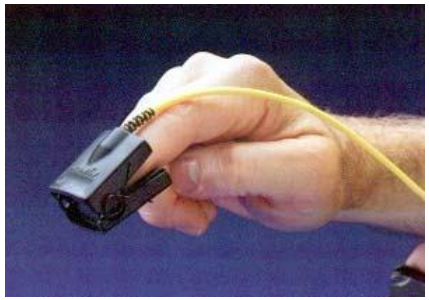
- Windows sound card
- Frequency Analysis
- Live Data
- Graphical User Interface



Analyzing sensor data from MATLAB

Physical Quantity

Sensor / Transducer



Voltage

Hardware

Data

Computer

Measurement Types
- Temperature
- Pressure
- Flow
- Acceleration
- Rotation
- Strain
- …

Using Sensors and actuators from MATLAB

- Common Sensor Types
  - Thermocouple, RTD, thermistor
  - Strain Gauge
  - Accelerometer
  - Photodiode
  - Flow Rate Sensor
  - Liquid Level sensor
  - Pressure Sensor
- Process Control Uses
  - 4 to 20 mA transmitters and receivers
  - Feedback Loop to control a process variable (temperature)

Common Tasks:

Browse connected DAQ hardware

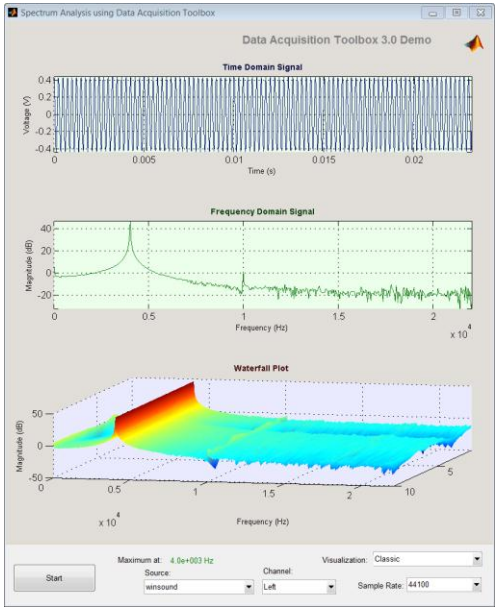
Set up Acquisition Parameters

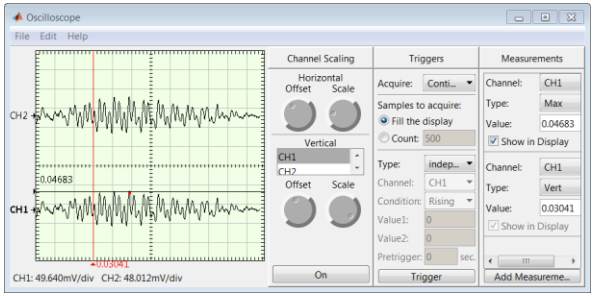
Collect data in foreground or background

Analyze and visualize the data

Data Acquisition Toolbox

- What kind of hardware can I use?
  - Supports for a variety of data acquisition boards and USB modules
- Key Features
  - Support for analog input, analog output, counters, timers, and digital I/O
  - Direct access to voltage, current, IEPE accelerometer, and thermocouple measurements
  - Live acquisition of measured data directly into MATLAB or Simulink
  - Hardware and software triggers for control of data acquisition
  - Device-independent software interface



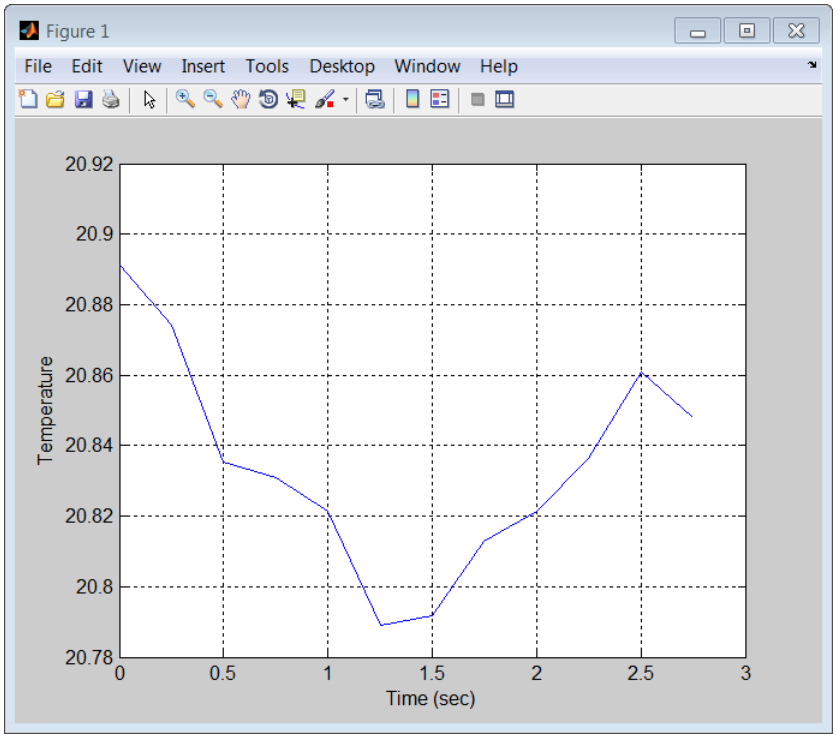


What's new in R2011b for Data Acquisition Toolbox?

- Two interfaces to connect to DAQ hardware
  - Legacy interface
  - Session-based interface (NI-only)
- Support the following on most NI hardware
  - IEPE accelerometer measurements
  - Bridge-based sensors measurements
  - Thermocouple and RTD measurements
  - Counter/Timer operations

Acquiring data from thermocouples

- No data conversion
- Collect data in units of choice
- Background or Foreground Acquisition

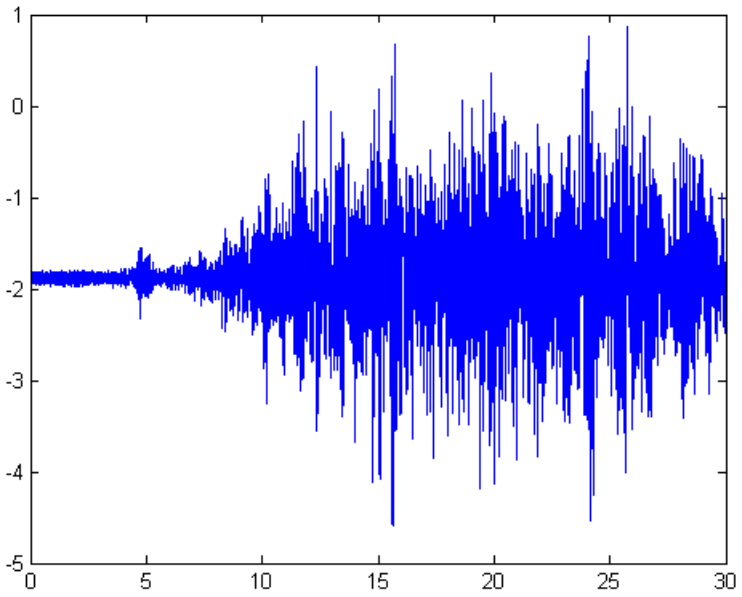


Working with IEPE sensors

- Industry Standard for accelerometers
  - **I**ntegrated **E**lectronics **P**iezo **E**lectric (IEPE)
  - Converts charge output to voltage
- Requires constant current source
  - NI IEPE DAQ hardware supplies the current on same wire as the sensor output

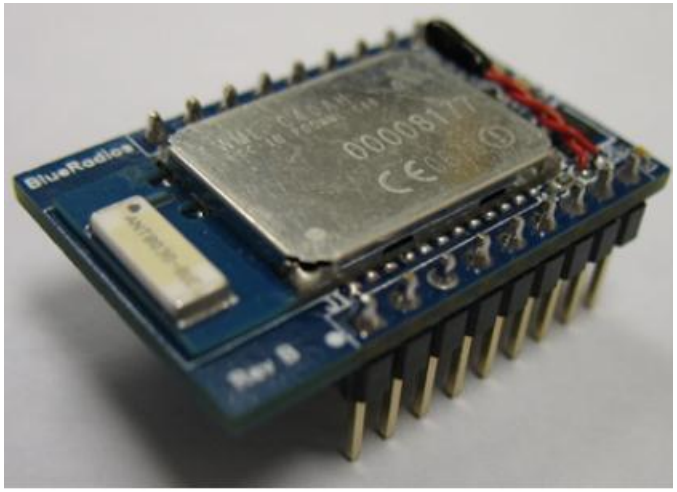
Acquiring IEPE accelerometer data

Model Number 352C22	ICP® ACCELEROMETER		
Performance	**ENGLISH**	**SI**	
Sensitivity (±15 %)	10 mV/g	1.0 mV/(m/s²)	
Measurement Range	±500 g pk	±4900 m/s² pk	
Frequency Range (±5 %)	1.0 to 10000 Hz	1.0 to 10000 Hz	
Frequency Range (±10 %)	0.7 to 13000 Hz	0.7 to 13000 Hz	
Frequency Range (±3 dB)	0.3 to 20000 Hz	0.3 to 20000 Hz	
Resonant Frequency	≥50 kHz	≥50 kHz	
Broadband Resolution (1 to 10000 Hz)	0.002 g rms	0.02 m/s² rms	[1]
Non-Linearity	≤1 %	≤1 %	[2]
Transverse Sensitivity	≤5 %	≤5 %	
Environmental			
Overload Limit (Shock)	±10000 g pk	±98000 m/s² pk	
Temperature Range (Operating)	-65 to +250 °F	-54 to +121 °C	
Temperature Response	See Graph	See Graph	[1]
Electrical			
	18 to 30 VDC	18 to 30 VDC	
	2 to 20 mA	2 to 20 mA	
	≤300 ohm	≤300 ohm	
	7 to 11 VDC	7 to 11 VDC	



Acquiring data from a Bluetooth temperature sensor

- Communication with Wireless Bluetooth Temperature Sensor
- Retrieve data
- Plot result




```
instrreset;
b = Bluetooth('BlueRadiosMS8BC5', 1); % create Bluetooth interface object
b.Terminator={'CR/LF','CR'}; % set read and write terminators
fopen(b); % open conenction
fprintf(b, 'ATMTR'); % send command to retrieve temperature
for i = 1:4
   data = fscanf(b);
end
      data % display data string returned
      data3 = parsetemp(data); % remove temperature value from string
fclose(b)
delete(b)
clear b
```

Key Capabilities & Benefits (DAT)

Capabilities	Benefits
Connect to a wide variety of DAQ hardware using a common set of commands	**Freedom to choose the hardware that is right for the task** Easier to maintain code and leverage previously written code fro new projects with different hardware
Access to hardware capable of specialized measurements such as IEPE accelerometer, thermocouple and Bridge	**Simplifies measurement test setup since the signal conditioning is in the hardware** Connect the sensor and acquire the data in the desired engineering units (g, degrees K etc.) without conversions or lookup tables
Access to counter/timer measurements	**Full access to the capability of the DAQ card** Simplifies applications involving counting, pulse width and frequency measurements
Enables live analysis of acquired data	**Simplified background data acquisition** Analyze data as you collect it. Reduce collection of bad data

Instrument Control Toolbox

- What are the key features of Instrument Control Toolbox?
  - IVI, VXIplug&play, and native MATLAB instrument driver support
  - GPIB and VISA (GPIB, GPIB-VXI, VXI, USB, TCP/IP, and serial) support
  - TCP/IP, UDP, and Bluetooth serial protocol support
  - Interactive tool for identifying, configuring, and communicating with instruments
  - Simulink® blocks for sending and receiving live data between instruments and Simulink models
  - Functions for reading and writing binary and ASCII data to and from instruments
  - Synchronous and asynchronous (blocking and nonblocking) read-and-write operations

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, VXI*plug&play*, LXI)



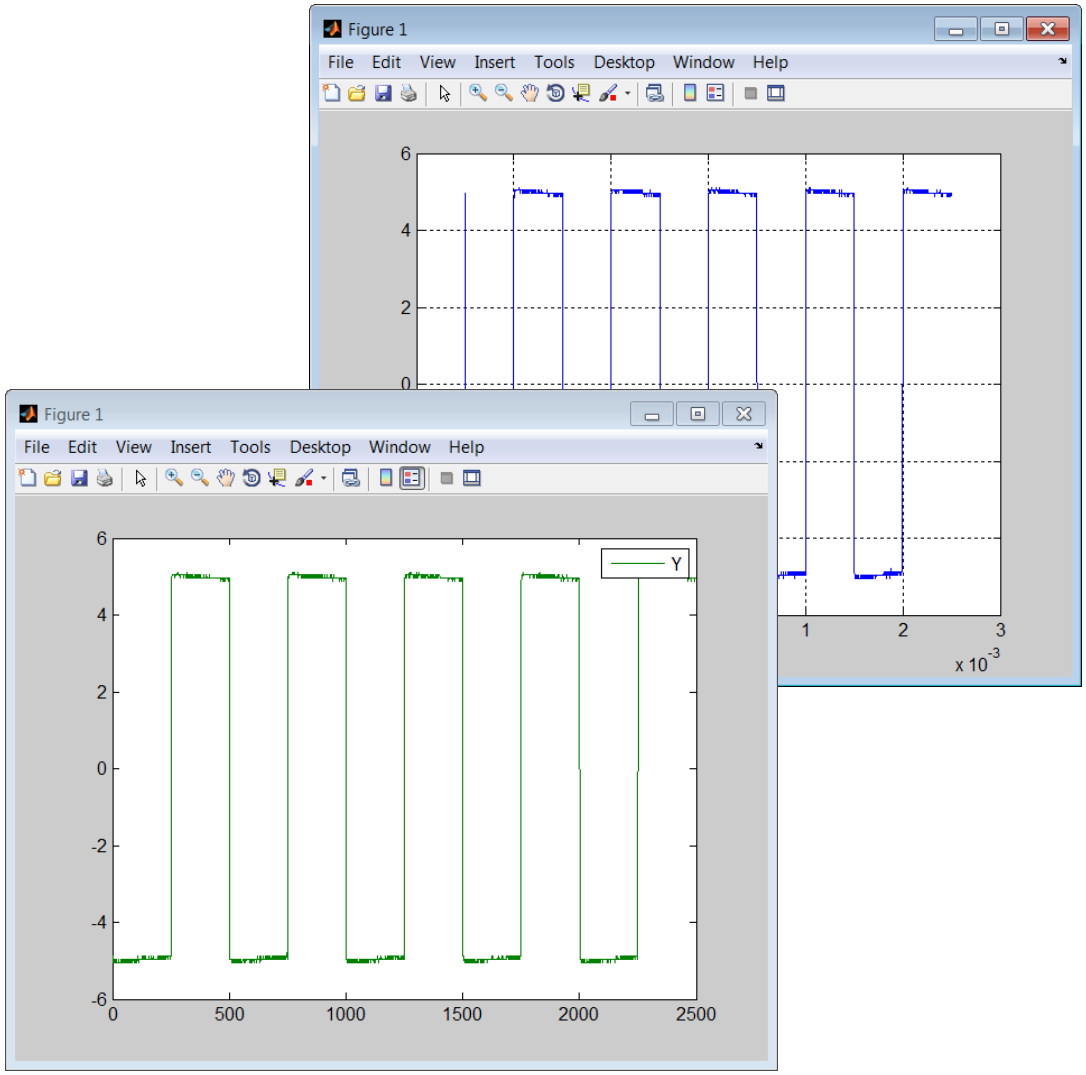
For a complete list, visit http://www.mathworks.com/products/instrument/hardware/index.html

Acquiring Data Using the Test and Measurement Tool

Features:

Export directly to Figure Window

Export to MATLAB workspace



Test and Measurement Tool Features

Features:

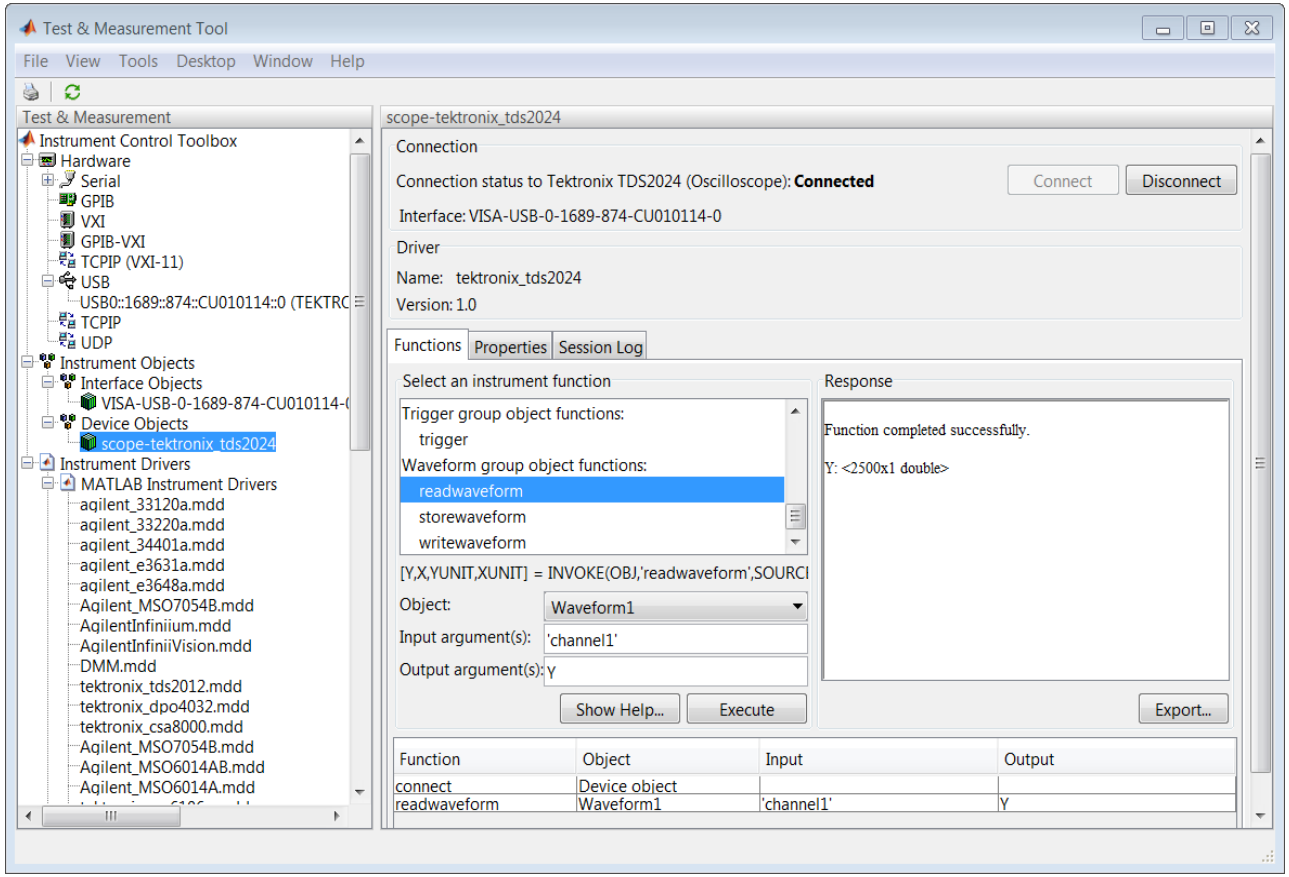
View driver properties

View driver functions

Create device objects

Create interface objects

View connected hardware



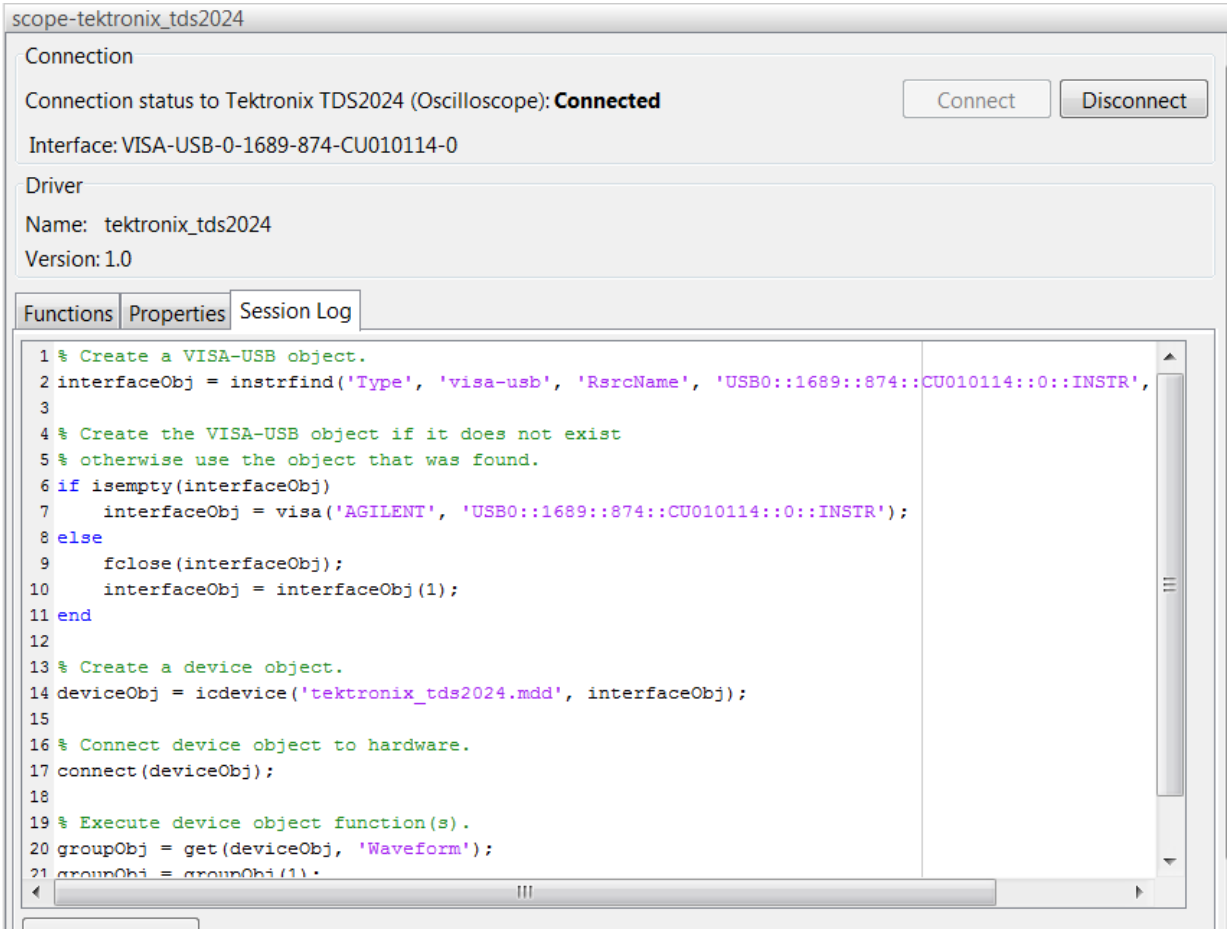
Session Log

Features:

Automatically creates MATLAB code from activity within the tool

Comments the code

Can be saved for use in application



What's new in R2011b for Instrument Control Toolbox

- Bluetooth support
  - Serial Port Profile (SPP)
- Quick Control Oscilloscope
  - Quick Control Oscilloscope objects
  - Based on IVI driver technology, but no knowledge required for end user

```
sc = oscilloscope();
sc.Resource = 'myScope';
sc.connect()
data = getWaveform(sc);
plot(data)
```

Key Capabilities & Benefits (ICT)

Capabilities	Benefits
Control and acquire data from instruments using IVI, VXIplug&play and MATLAB instrument drivers	**Verify designs and build test systems** Instrument Control Toolbox and MATLAB as a platform for design verification. Develop models in MATLAB or Simulink and test them with data generated or collected from test equipment. Verify that prototypes meets specs and build larger test systems.
Connect to instruments and devices over GPIB, TCP/IP, VISA, USB and Serial and Bluetooth	**Easily connect to hardware without leaving MATLAB** Analyzing data, visualizing data and developing custom measurements all in the single environment saves time.
Connect to remote software applications using TCP/IP	**Enables analysis of data collected from a remote source**

Summary

- Acquire Data from sensors and Instruments
  - Data Acquisition Toolbox
  - Instrument Control Toolbox
  - Image Acquisition Toolbox
  - Vehicle Network Toolbox
- Without leaving MATLAB you can acquire, analyze and visualize your data
- Acquiring and analyzing data from the same environment saves time and enables live analysis of data

Resources

- Data sheets, user stories, demos, technical literature, documentation
  - **www.mathworks.com/products**
- View this and other archived webinars
  - **www.mathworks.com/products/daq**
- View more data acquisition demos
  - **http://www.mathworks.com/products/daq/demos.html**
- View more instrument control demos
  - **http://www.mathworks.com/products/instrument/demos.html**
- View supported hardware
  - Data Acquisition Toolbox
  - Instrument Control Toolbox
  - Image Acquisition Toolbox
  - Vehicle Network Toolbox