Enhancing Test & Measurement capabilities using MATLAB® Software

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The application has many capabilities to help you with recording and analyzing these signals. You can match each capability number in this image with the number in the description below.
Overview

- Keysight Overview
- MATLAB for Keysight – MathWorks partnership
- Typical Application / Task with MATLAB
- Custom Signal Generation with MATLAB
- Custom Signal Analysis with MATLAB
- Remote Programming Interface
- References
MATLAB Software Overview

What is MATLAB?

- A well known data analysis software environment and programming language created by MathWorks and available through Keysight

- Keysight’s software platform for creating customized measurements and analysis routines with Keysight instruments

- Available for sale now with Keysight instruments
A Brief History of Keysight

1939–1998: The Hewlett-Packard years
A company founded on electronic measurement innovation.

1999–2013: The Agilent Technologies years
Spun off from HP, Agilent became the World’s Premier Measurement Company
In September 2013, announced the spin off its electronic measurement business

2014: Keysight begins operations
Focused 100% on electronic measurement industry
| Communications | Industrial, computer, semiconductor | Aerospace/defense |
Test Eco System

- **Dynamic Signal Analyzer**
  - One Box tester
  - Network Analyzer
  - TDR Scope
  - RF Switch Probe
  - Analog MUX Cable

- **RF/MW Source**
- **Digital Pattern/pulse**
- **Multi-channel DAC**
- **Function Gen**
- **Arbitrary Waveform Generator**
- **Precision V/I Sources**

- **DUT**
  - Input (RF Switch Analog MUX Cable)
  - Output (RF Switch Probe Analog MUX Cable)
  - DC Power
  - DC Power Analyzer

- **EDA s/w tools**
  - ADS
  - EMDS
  - System Vue
  - Genesys

- **RF/MW Signal Analyzer**
- **Oscilloscope**
- **Logic Analyzer**
- **Digitizer**
- **Counter**
- **Multimeter**

*Keysight Technologies*
Typical Applications / Tasks with MATLAB
Typical Applications/Tasks with MATLAB

Proprietary System Design and Test
- Development and testing of proprietary communications systems, RADAR, etc. (many times from the government) where off-the-shelf solutions cannot be used.

Wireless System Design and Test
- Development and testing of new & existing wireless systems when off-the-shelf solutions from Keysight do not exist.

Algorithm Development and Testing
- Anytime a user is researching, designing, prototyping, or testing a new algorithm.
Typical Applications/Tasks with MATLAB

3-D data Visualization
• Anytime a user needs to gain insight into their measurements and analysis by visualizing signals in three dimensions (like amplitude vs. frequency vs. time).

Application Development
• Anytime a user needs to develop a GUI-based application for any of the applications/tasks described.

Test Automation
• Anytime a user needs to automate a measurement with one or more instruments for any of the applications/tasks described.
## Signal Generation Hardware
- RF/MW signal generators
- Arbitrary waveform generators

## Signal Generation Software
- Embedded software (firmware)
- Signal Studio software
  - Standard-specific
  - Pulse Building, etc.

## Signal Analysis Hardware
- RF/MW signal analyzers
- Oscilloscopes

## Signal Analysis Software
- 89601A VSA
- Measurement Apps
  - VXA
  - Standard-/task-specific

## MATLAB
Works with signal generation and analysis hardware
- Extends the capabilities of Keysight instruments
- Enables customized measurements and analysis routines
Custom Signal Generation with MATLAB
Custom Signal Creation

Keysight’s wide variety of signal generators & Arbitrary Waveform generators along with MATLAB can meet various testing requirements

• Creating Custom signals from mathematical definitions
• Create multi-tone signals, pulsed radar, and multi-carrier waveforms.
• Generation of custom UWB and SATCOM signals using MATLAB
• Perform digital pre-distortion to reduce effects of spectral re-growth.
Custom Signal Creation

Keysight’s wide variety of signal generators & Arbitrary Waveform generators along with MATLAB can meet various testing requirements

- Generate arbitrary waveforms (multi-tone signals, pulsed radar signals, and multi-carrier modulated waveforms).
- Creating and generating IQ data.
- Creating channel and multipath effects in a waveform obtained from a simulated receiver module.
- Perform waveform pre-distortion and amplitude correction to generate a waveform that results in a flat amplitude response.
Custom waveform creation for the M8190A AWG

**Highlight:** Arbitrary waveform generation using the AXIe M8190A AWG

**Hardware/Software:**
- Agilent M8190A arbitrary waveform generator
- Agilent 90000-X oscilloscope (optional)
- N6171A MATLAB software

**Demonstration:**
- Generation of custom UWB and SatCom signals using MATLAB
- GUI application for creation of signals on traditional and AXIe form factor AWGs
- Envelope detection and using Hilbert transforms and User Defined MATLAB functions on the oscilloscope
Custom Signal Analysis with MATLAB
Developing Custom Tools for Signal Analysis

• Fast (Deep) Capture in IQ Analyzer Mode
• RTR (Real Time Recording) of Signal
• Advanced S-Parameter analysis
• Multichannel analysis on 8 channel Phase coherent Digitizer
• Advanced signal analysis on Oscilloscope.
MATLAB Demo: Fast (Deep) Capture in IQ Analyzer Mode

- Application example focuses on:
  - Fast (deep) capture in IQ analyzer mode
  - Capture more time (25x)
  - Maintain faster sample rate and effective bandwidth as time base is slowed to capture more time
  - Get better measurement and analysis results when needed

- Customer wants to record high frequency DUT signal for a considerable amount of time for either playback or analysis
MATLAB Demo: Fast (Deep) Capture in IQ Analyzer Mode

Hardware/Software Required:
- Agilent X-Series Analyzer (UXA, PXA, MXA, EXA, CXA)
- Developed and demonstrated with N6171A MATLAB software

Application Capabilities:
- Configure and perform fast capture and Standard capture of IQ data up to 510 MHz bandwidth and 512 Msamples of data
- Either visualize or save IQ data to file for further processing
- View MATLAB function implementing fast capture
- Automatically choose between Standard and Deep Capture
- Turn on the preamp, set the IF Path and IF Gain and such.
RTR Option: Specific Capabilities

1. Define Center Frequency (Hz)
2. Define Frequency Span (Hz)
3. Define Acquisition Time (s)
4. Infinite Persistence.
5. Data Source: two modes – Live Data acquisition mode or Saved data mode.
6. Start Recording
7. Playback
8. Slider control
9. Time Stamp: This box displays the time stamp (AM/PM format) of creation of each density frame.
10. Save Recording.
11. Advanced Settings: To optimize memory management and data save rates, an option to enter how often density data (in terms of number of frames) is stored to a .MAT file while recording is provided by the ‘MAT File Save Size’ box. The default value is set to 100 to deal with instruments with limited memory.

Two operating modes:
- Live data acquisition mode – Connects to the firmware, configure the instrument based on the values set in the GUI, and perform data capture
- Saved data mode – Record the data in a MATLAB data file, and analyze it later in MATLAB on the instrument or remote PC
Deep Capture Tool using UXA
(Keith Leitch – Keysight)

Customer Requirements:

- Capturing I/Q Data from an X-Series signal analyzer,
- Capturing up to 510 MHz bandwidth and 512 Msamples
- Automatically choose between Standard and Deep Capture
- Turn on the preamp, set the IF Path and IF Gain and such.
- Save a captured .MAT waveform and then play it back in 89601B VSA.
Deep Capture and Upload Tool

Features of the Tool Allow the User to:

- Vary Block size and IF Bandwidth
- Determine Time for capture
- Choose Carrier Frequency
- Set Power Amplitude
- Scale automatically or manually
- Impair data
  - Amplitude Fading
  - Doppler Frequency Shifting
- Save I/Q Data as .mat file
- Visualize Data in Time and Frequency Domain Before and after impairments
Customer Requirements:

- View the power spectrum density (PSD) of the acquired signal (Hi-speed serial data)
- View the Spectrogram (time-frequency power distribution)
- Find the first 5 dominant components in the frequency domain (audio signals)
- Calculate the occupied bandwidth, total harmonic distortion, SNR, spurious free dynamic range (SFDR) values of the signal being acquired
MATLAB Application for Frequency Domain Analysis of Oscilloscope waveforms

Hardware/Software Requirements:

• Any signal source
• Keysight Oscilloscope (Infinium or InfiniiVision)
• MATLAB Software Option-062

Application Capabilities:

• Visualize the power spectrum density (PSD)
• Visualize a spectrogram
• Select up to two channels simultaneously
• Place customizable cursors
• Measurement options: Channel, Distortion
• Custom processing of time domain data before visualization in the frequency domain
• Remotely control and configure the oscilloscope directly from the MATLAB application
Automating S-Parameter Measurements

Example: Characterizing an ISM-band low-noise amplifier

Highlight:

- MATLAB used to automate S-parameter measurements
- Extraction of measurement data for device characterization and modeling of RF networks

Hardware/Software:

- Agilent PNA Network Analyzer
- N6171A-M03 MATLAB software

Demonstration:

- MATLAB GUI to automate measurements
- Instrument Control Toolbox to control PNA, set up measurement and bring in measurement results into MATLAB
- RF Toolbox used to model and analyze networks of RF components, based on measured S-Parameters
Automating S-Parameter Measurements

Example: Characterizing an ISM-band low-noise amplifier

Creating Time Profile

- Device performance variation with time can be plotted to analyze the overall time dependent performance of the device.

Creating Temperature Profile

- Device performance variation with temperature can be plotted to analyze the overall temperature dependent performance of the device.

Demonstration:

- These data can be used for designing suitable heat sink & making the suitable design margins to meet the exacting working conditions.
Remote Programming of Instruments
Instrument Control Toolbox

- Communicate with and control test and measurement instruments. Connect MATLAB directly to instruments such as:
  - Function generators
  - Signal analyzers
  - Modular instruments (PXI, AXIe)
  - Oscilloscopes
  - Power supplies, etc.

- Connect using
  - Low level SCPI commands through interfaces such as:
    - Serial
    - GPIB
    - TCP/IP and HiSLIP
    - VISA
  - High-level APIs such as:
    - IVI
    - VXI plug&play drivers
    - MATLAB instrument driver
Test and Measurement Tool displays the resources (hardware, drivers, interfaces, etc.) accessible to the toolboxes that support the tool, and enables you to configure and communicate with those resources.
Typical Workflows Enabled by Instrument Control Toolbox

- Generate waveforms in MATLAB to send to an instrument
- Read time and frequency domain traces into MATLAB for analysis and visualization
- Build custom analysis and visualization routines to extend instrument capabilities
- Build automated test systems to verify hardware designs
- Build test systems based on LXI, PXI, and AXIe standards
References
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90-day Paid Access
Themes of data analysis, visualization, and programming are explored throughout this comprehensive introduction to MATLAB. Once enrolled, you have 90 days to complete this in-depth self-paced course at your own pace.
MATLAB Resources for Keysight Instruments

MATLAB Software for Keysight Signal Generators and Analyzers (N6171A)
Learn more at www.keysight.com/find/matlab

MATLAB Software for Keysight Oscilloscopes
Learn more at www.keysight.com/find/matlab_oscilloscopes

Visit these MATLAB resource pages to:
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