SDR Solutions with NI Hardware and MathWorks Software

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Your Hosts

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Agenda

• History of MathWorks support for Ettus Research and NI platforms
• Current MathWorks support of NI SDR hardware
• Use cases
  - Streaming for data demodulation
  - Burst mode data capture for offline processing
  - Transmit beamforming
  - Ad hoc network creation
  - Power amplifier characterization
  - Signals intelligence with deep learning
• Future directions
Hardware Poll
USRP Support from Communications Toolbox

**Supported Radios**

*Ettus Research:*
- B200 and B200mini series
- X300 series
- N200 series
- N300 series

*NI:*
- USRP-294X and USRP-295X series
- USRP-292X and USRP-293X series

**Example Applications**

Real-time data capture
Burst mode data capture
Standards-based demodulation (e.g. FM, ADS-B, AIS)
MATLAB Workflow with NI Vector Signal Transceiver (VST)

- Generate waveforms in MATLAB
  - 5G, WLAN, Bluetooth, LTE, generic
- Upload to VST and transmit
- Run the signal through a device
- Capture the device output in the VST
- Perform offline analysis in MATLAB
Use Case – Streaming for Data Demodulation

1 0 1 1 1 0 0 0 1 1 0 0 0 0 1 1 0 0 1 0 1 0 0
0 0 0 1 1 0 0 0 0 1 1 0 0 1 0 1 0 0 1 0 1 0 1
1 0 0 0 0 1 1 0 0 1 0 1 0 0 1 0 1 0 1 1 1 0 0
1 1 0 0 1 0 1 0 0 1 0 1 0 1 1 1 0 0 0 0 1 1 1
1 0 1 0 0 1 0 1 0 1 1 1 0 0 0 0 1 1 1 0 0 0 1
0 1 0 1 0 1 1 1 0 0 0 1 1 1 0 0 1 1 0 0 0
1 1 1 0 0 0 1 1 1 0 0 0 1 1 0 0 0 1 1 0 1
0 0 0 1 1 1 0 0 0 1 1 0 0 0 1 1 0 1 0 1 1 0

QPSK Receiver

FM Broadcast Receiver with USRP(R) Hardware

Diagram showing the process of demodulation and synchronization in a QPSK receiver.
Use Case – Burst Mode Data Capture for Offline Processing

```
1 0 1 1 1 0 0 0 0 1 1 1 0 0 1 0 1 0 0 0 0 1 0 0 1 0 0 1 0 1 0 1
0 0 0 1 1 0 0 0 0 1 1 0 0 1 0 1 0 0 1 0 1 0 1
1 0 0 0 1 1 0 0 1 0 1 0 0 1 0 1 0 1 1 1 0 0
1 1 0 0 1 0 1 0 0 1 0 1 0 1 1 1 0 0 0 0 1 1 1
1 0 1 0 0 1 0 1 0 1 1 1 0 0 0 1 1 1 0 0 0 1
0 1 0 1 0 1 1 0 0 0 1 1 1 0 0 0 1 1 0 0
1 1 1 0 0 0 1 1 1 0 0 0 1 1 0 0 0 1 1 0 1
0 0 1 1 1 0 0 0 1 1 0 0 0 1 1 0 1 0 1 1 0
```
Use Case – Burst Mode Data Capture for Offline Processing

USRP Radio

Host PC
Software Poll
Use Case – Transmit Beamforming
Use Case – Transmit Beamforming
Use Case – Transmit Beamforming

Search Multi-User Transmit Beamforming USRP
Use Case – Set Up Your Own Ad Hoc Network

Search Packetized Modem MATLAB
Use Case – Power Amplifier Modeling with an NI PXIe VST

- Why?
Generic Hardware Setup

- Connect to NI PXIe box to
  - Send signals through a PA
  - Capture received signals
  - Take measurements
- Use captured signals to model the PA
- Perform HW-in-the-loop tests with PA and DPD
MathWorks Hardware Setup

Controller
PC

SMU
(Power Supply)

VST

PA

Controller PC

SMU (Power Supply)

VST

PA
Demo
Use Case – Signals Intelligence and Deep Learning

Signal Classification

Device Identification

Digital pre-distortion

Receiver design

Channel models and channel prediction

Autoencoder

Wireless network
Synthetic Data + Real-World Data = Better Deep Learning Models

- Generate synthetic data with impairments using MATLAB
- Gather real-world data over-the-air with NI SDR hardware
Model Development with Synthetic Signals

- Noise
- Multipath fading
- Frequency offset
- Sampling rate offset

Train:
- Synthesize labeled data
- Add impairments
- Train Network
- Trained Model

Test:
- New Signal
- Pre-Trained Model
- Classification
Wireless Modulation Classification with Deep Learning

- Generate synthetic modulated signals
- Apply channel impairments
- Train a CNN to classify modulation types
- Search “modulation classification MathWorks”
Over-the-air Test with NI SDR

- Generate OTA test signals using any source
- Connect MATLAB to NI SDR to receive signals
  - USRP-29xx or Ettus B2xx, N2xx, and X3xx
- Process real-time data in MATLAB
Future Directions

• NI will continue to incorporate the latest:
  • Data converters
  • Processing technologies
  • Data movement interfaces

• MathWorks will:
  • Stay current with UHD
  • Focus on performance
  • Plan more development for the N3xx radio

For more information, please visit:
• Virtual booth for more demonstrations of NI hardware with MathWorks software
• mathworks.com/hardware-support/ usrp
• ni.com/sdr
Application Poll
Thank you