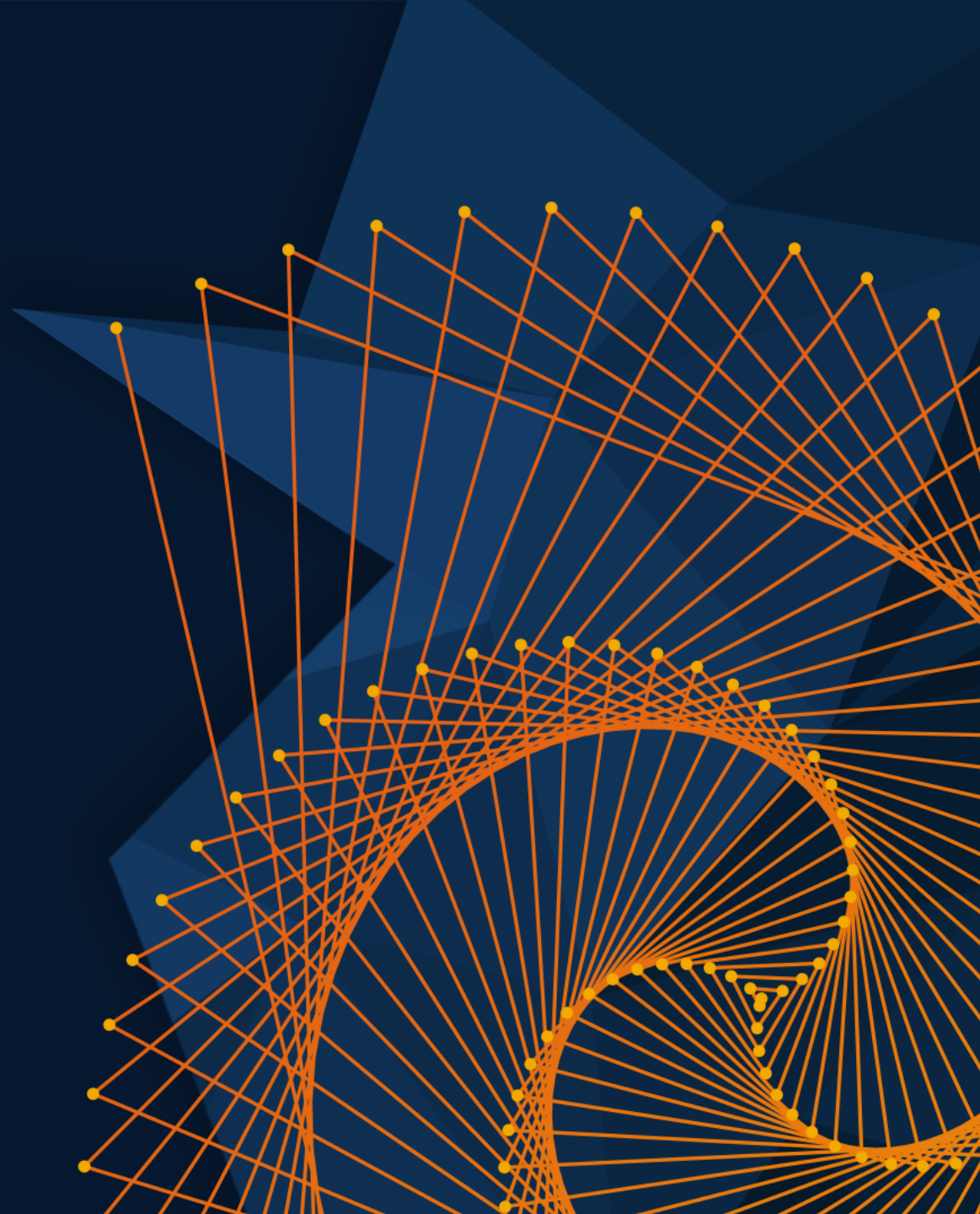
MATLAB EXPO

무선 시스템 설계를 위해 MATLAB을 USRP에 연동하는 데모

정승혁, 매스웍스코리아



MathWorks

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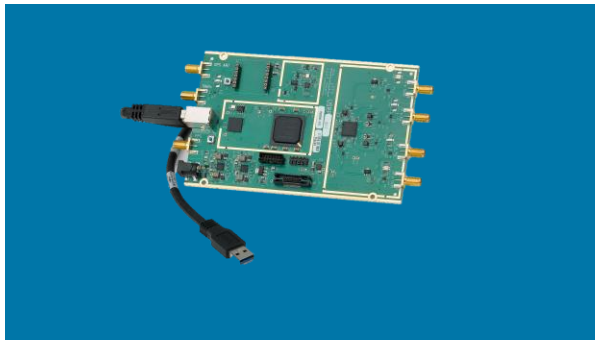
Wireless Testing Solutions in MATLAB



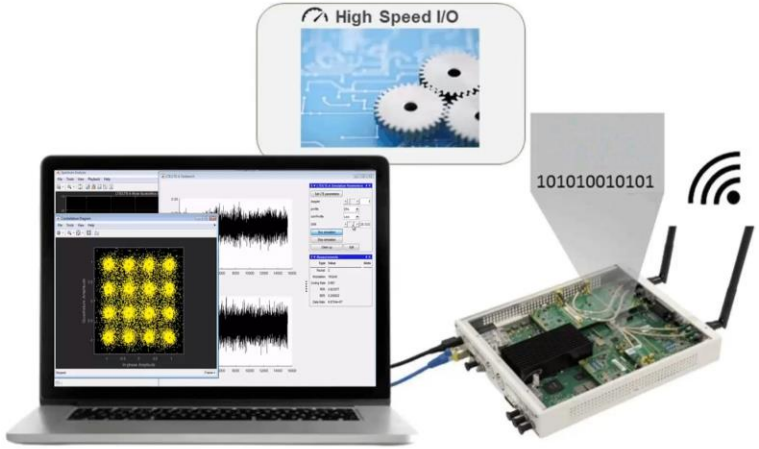
MATLAB Solutions	Wireless Testbench	Comms Toolbox SDR HSPs	Instrument Control Toolbox
Max Supported Rate	250 Msps	20 Msps	XX Gsps
Radio I/O	✓	✓	✓
FPGA Targeting	✓	✘	✘
Supported Radio Price ($)	8K to 35K	Up to 4K	$$$$$

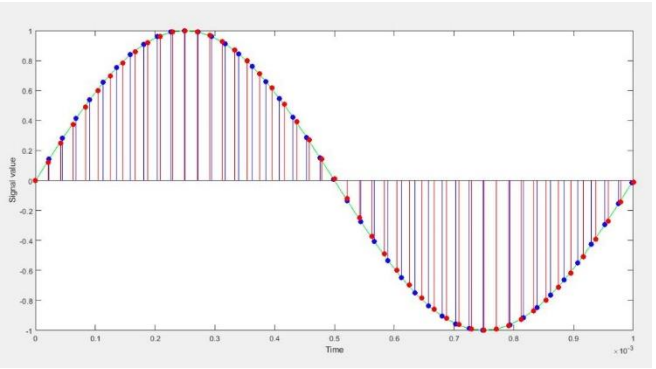
Supported Workflows by Wireless Testbench

Workflows Supported		
Workflow 1: Radio I/O	Transmit and capture wideband signals at up to 250 Msps	*Transmit/Capture using up to 2GB/4GB of on-board storage* ✓*17s of 5G data @30.72 MSPS* ✓6.5s of WLAN data @80 MSPS ✓*2s at full N321 device rate (250MSPS)*
Workflow 2: Intelligent Capture	Intelligent data capture with FPGA-based detectors and re-sampler	*Reduce data requirements by intelligently capturing only waveforms of interest by prebuilt detectors* ✓*Correlates the input signal with a known preamble sequence* ✓*Supports correlating filters of up to 1024 taps at all sample rates* ✓*Detect and capture a signal using signal energy as the trigger* ✓Farrow-based rate conversion
Workflow 3: Targeting	USRP Targeting	*Integrate custom IP blocks with RF Network-on-Chip (RFNoC™)* ✓Radio customization ✓Rapid prototyping ✓Easy to use

Workflow 1: Radio I/O

- Transmit/capture at full device rates (up to 250 MSPS)
- Capture using up to 2GB (4GB on X410) of on-board storage
  - >17s of 5G data @30.72 MSPS
  - > 6.5s of WLAN data @80 MSPS
  - > 2s at full N321 device rate (250MSPS)
- Capture to host via high-speed streaming
- Capture to file or workspace
- Select arbitrary sample rates
  - Farrow-based rate conversion
  - E.g. select 40Msps for WLAN signal capture on N310
- Generate and transmit waveforms with Wireless Waveform Generator app

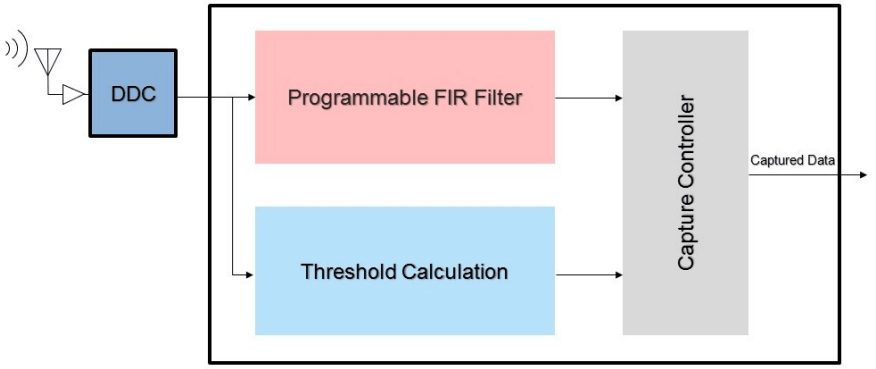


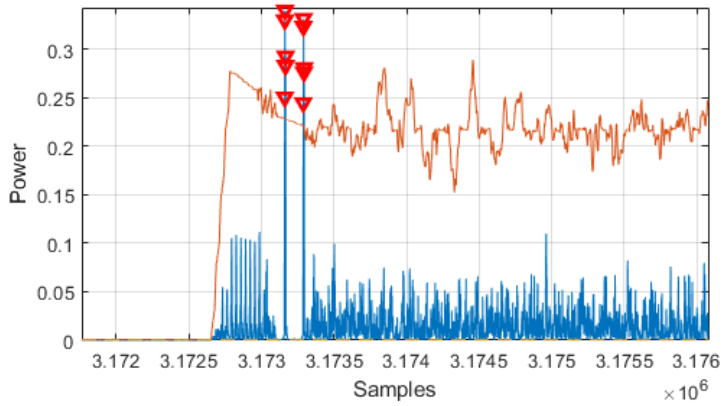


Workflow 2: Intelligent Capture

- Use FPGA-based preamble detection to capture only the signal of interest
- Transmit/capture at full device rates (up to 250 MSPS)
- Preamble sequences of up to 1024 taps
- Select arbitrary sample rates with farrow-based rate conversion
- Detect and capture a signal using signal energy as the trigger
- Transmit test waveforms in parallel to detection

```
pd = preambleDetector("MyRadio");
pd.SampleRate = 40e6;
pd.Preamble = WLANPreamble;
data = capture(pd,milliseconds(100))
```

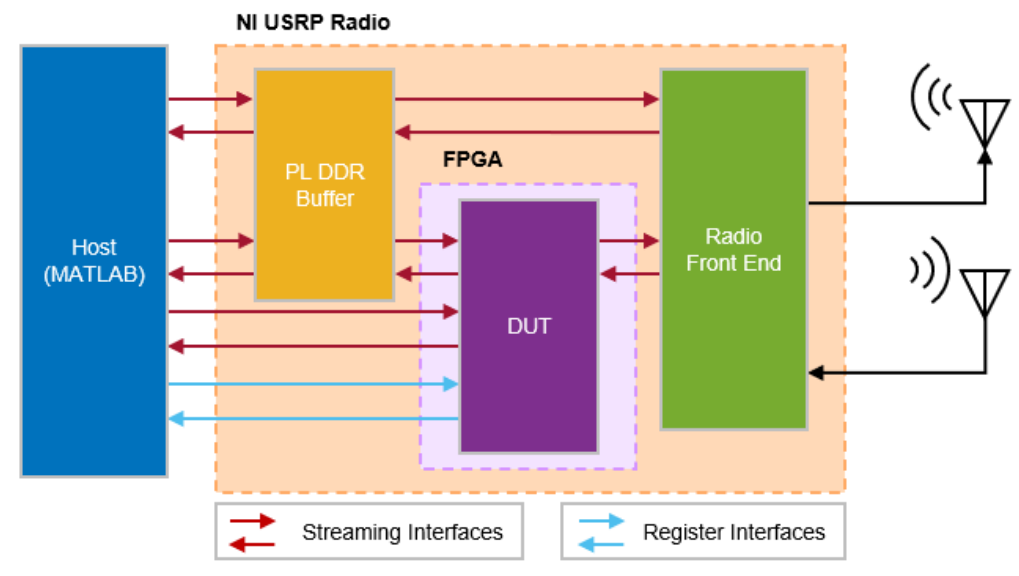


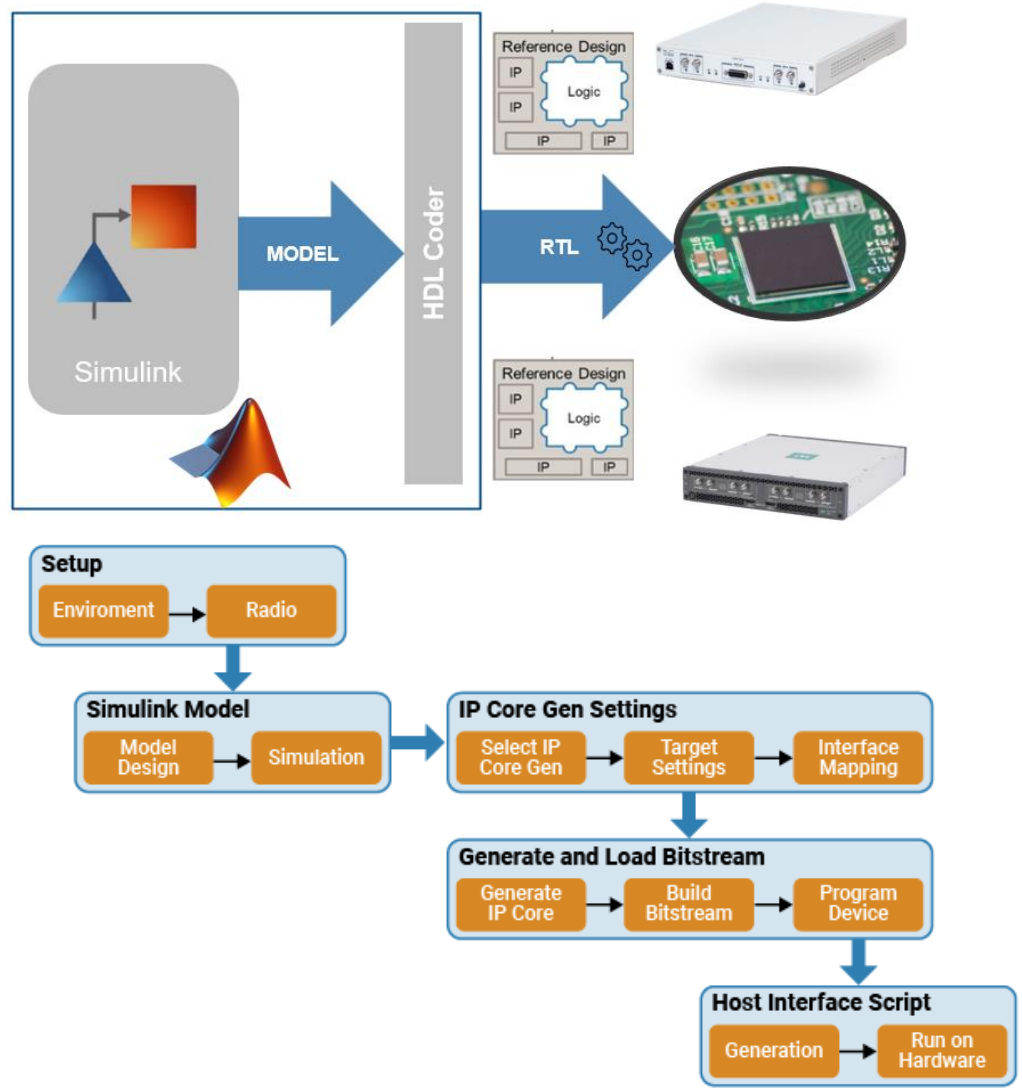


Workflow 3: USRP Targeting

R2024a

- **Follows standard HDL Coder workflow**
- **Generate bitstream and control from MATLAB**
- **Steps**
  1. Select Platform and parameters
  2. Map DUT(user logic) IOs (data & register)
  3. Generate HDL and wrap it as IP core (single click)
  4. Generate Bitstream with User DUT (single click)
  5. Generate MATLAB script to control DUT (single click)





[Getting Started with NI USRP Targeting Workflow]

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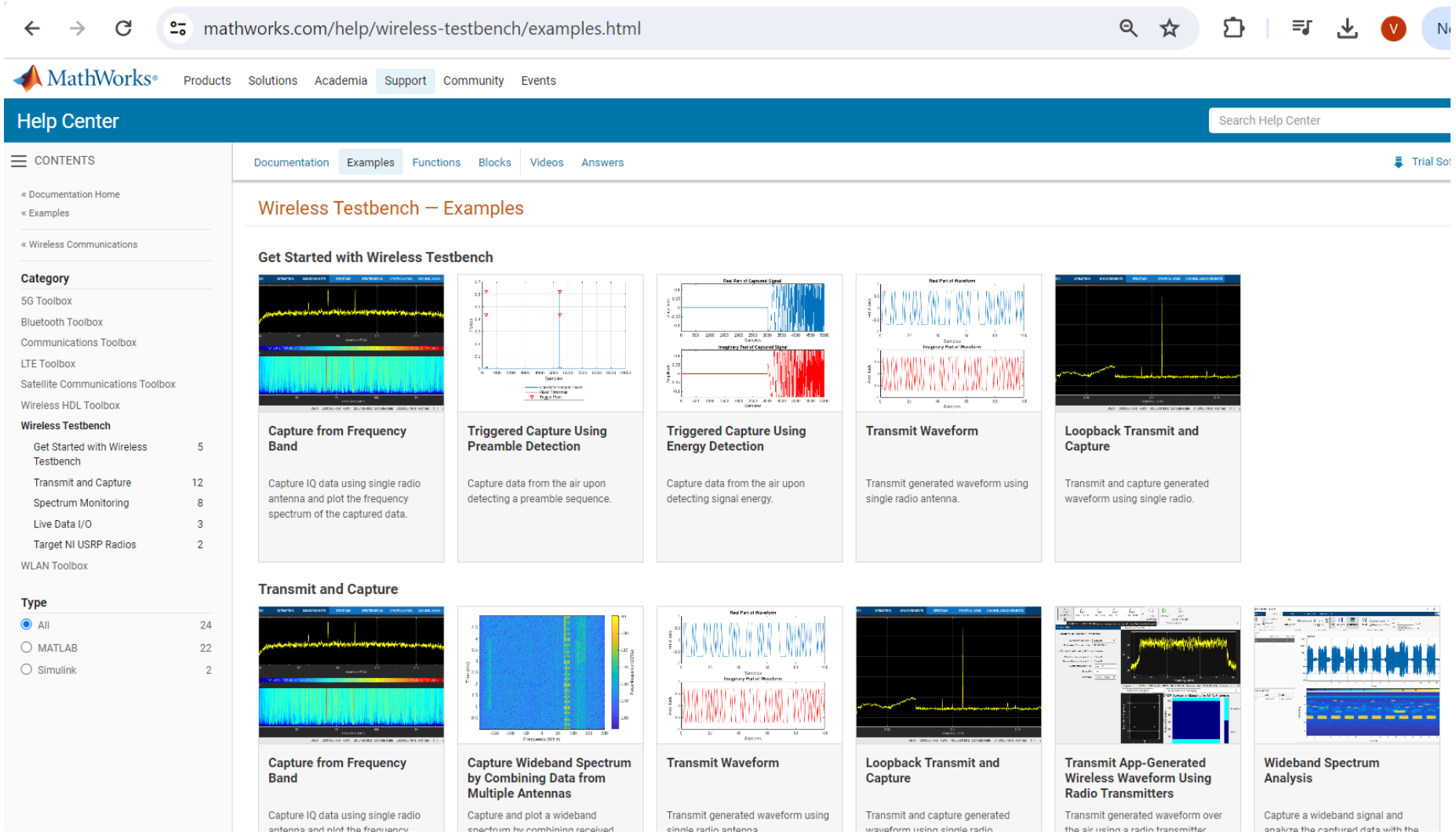
Wireless Testbench: Examples

https://www.mathworks.com/help/wireless-testbench/examples.html



Wireless Testbench: Examples

Capability	Examples	Description
Transmit and Capture	Capture wideband spectrum	✓ Capture a wideband spectrum using multiple antennas ✓ Use the multiband combiner ✓ Capture up to 800 MHz of bandwidth
	Capture signals for AI training	✓ Scans a wide bandwidth to determine 5G NR and LTE signal ✓ Captures and labels the bandwidth of the associated carrier waveforms ✓ Captures unknown signals
Spectrum Monitoring	Triggered Capture using Preamble Detection	✓ Use USRP to capture data from the air using preamble detection. ✓ Use the transmit capabilities of the radio to loop back a test waveform
	Triggered Capture Using Energy Detection	✓ Use USRP to capture data from the air using energy detection. ✓ Use the transmit capabilities of the radio to loopback a test waveform
Live Data I/O	OFDM Transmitter and Receiver	✓ Run a complete end-to-end OFDM transmission system ✓ Use a single-input single-output (SISO) channel. ✓ Mimics standardized transmission schemes like 5G NR
USRP Targeting	Multiport Packet-Based USRP Targeting	✓ Deploy a multi-port packet-based algorithm on USRP ✓ Use Simulink® to model an algorithm ✓ Generate bitstream and MATLAB scripting interface

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Wireless Testbench: Supported SDR Hardware

N300

N310

N320

N321

X300

X310

X410 (RFSoC)

Ettus Research™
A National Instruments Company

USRP

Supported SDR Hardware: Specifications

N310

- Channels: up to 4x4 per device
- 100 MHz bandwidth/channel
- 10 MHz – 6 GHz
- Large user-programmable FPGA, Zynq-7100
- Configurable sample rates: 122.88, 125, and 153.6 MS/s
- 16-bit ADC, 14-bit DAC

X310

- Channels: up to 2X2 per device
- 160MHz bandwidth per channel
- Frequency range: DC - 6 GHz
- Xilinx Kintex-7 XC7K410T FPGA
- 16-bit ADC, 14-bit DAC

N32X

- 2x2 MIMO
- 200 MHz BW per channel
- 3 MHz – 6 GHz range
- Zynq XC7Z100-2FFG900I
- 200/245.76/250 MHz sample rates
- 16-bit ADC, 14-bit DAC

X410

- 1 MHz to 7.2 GHz frequency range (tunable up to 8GHz)
- Up to 400 MHz of instantaneous bandwidth per channel
- 4 RX, 4 TX in half-wide RU form factor
- Xilinx Zynq Ultrascale+ ZU28DR RFSoC
- 12-bit ADC, 14-bit DAC
- IQ Sample Clock rates up to 500 MS/s

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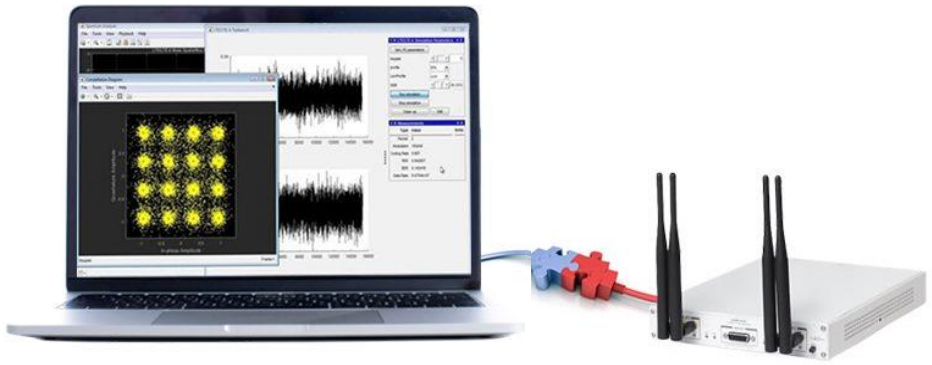
Wireless Testbench: R2024a



Test wideband wireless systems and perform spectrum monitoring

Transmit and capture wideband signals at up to 250 MSPS

Transmit/Capture using up to 2GB/4GB of on-board storage

- ✓ *17s of 5G data @30.72 MSPS*
- ✓ 6.5s of WLAN data @80 MSPS
- ✓ *2s at full N321 device rate (250MSPS)*
- ✓ *Capture to host via high-speed streaming*

Intelligent data capture using FPGA-based detectors

Reduce data by intelligently capturing only waveforms of interest

- ✓ *Correlates the input signal with a known preamble sequence*
- ✓ *Detect and capture a signal using signal energy as the trigger*
- ✓ *Farrow-based rate conversion*

USRP Targeting

Integrate custom IP blocks with RF Network-on-Chip (RFNoC™)

- ✓ *Radio customization*
- ✓ *Rapid prototyping*
- ✓ *Easy to use*

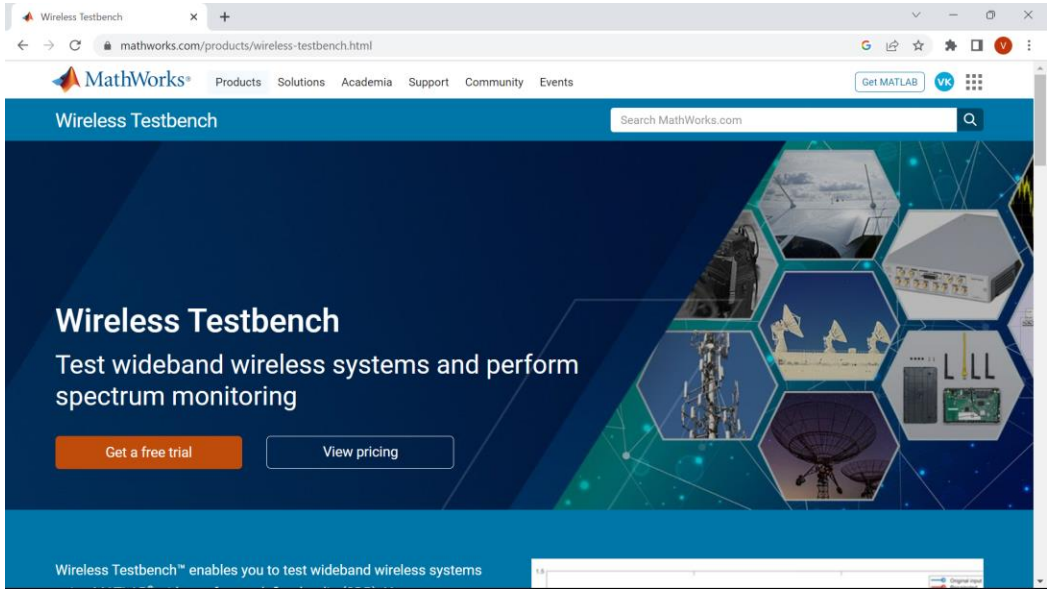
Wireless Testbench: Simple Radio Set Up

Features

- Rapidly set up the wireless test environment
- Easy installation of third-party dependencies
- Radio setup wizard to configure the radio

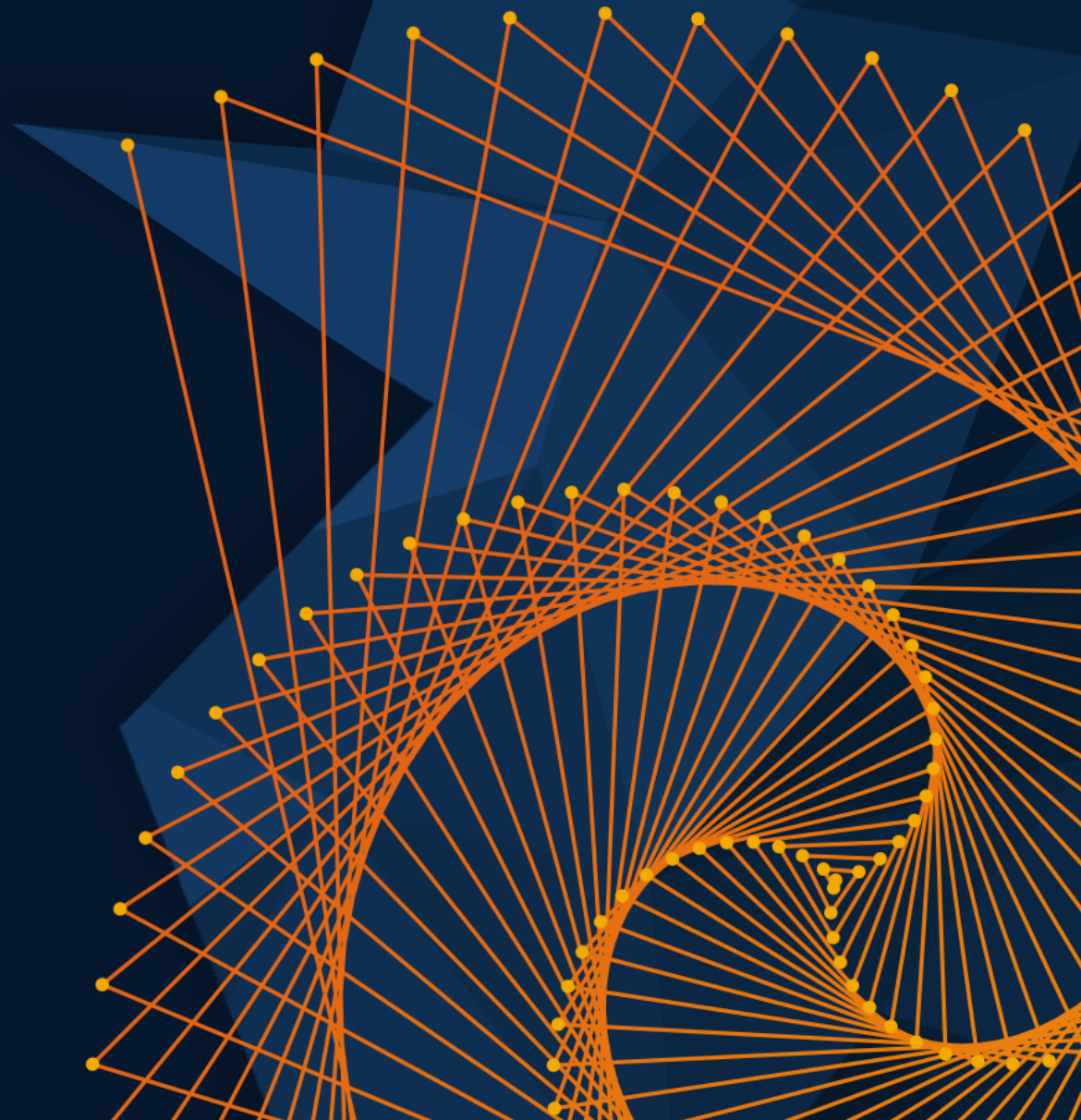
Summary and Key Takeaways

https://www.mathworks.com/products/wireless-testbench.html



- **Wireless Testbench Workflows:**
  - High-speed data transmit capture capability up to 250 MSPS
  - Intelligent signal detection using a preamble detector
- **Wireless Testbench Examples:**
  - High-speed data transmission and capture
  - Spectrum Monitoring
  - USRP Targeting
- **Wireless Testbench hardware support:**
  - USRP N3XX, X3XX, X410
- **Wireless Testbench Features:**
  - Transmit and capture wideband signals
  - Intelligent data capture using FPGA-based detectors
  - Integrate custom IP blocks with RF Network-on-Chip
- **Required Products:**
  - MATLAB, Signal Processing Toolbox, DSP System Toolbox, Communications Toolbox
  - HDL Coder (for HDL Code Generation)

MATLAB EXPO



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