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Wireless Communications Systems Design with MATLAB and USRP Software-Defined Radios

SciEngineer's training courses are designed to help organizations and individuals close skills gaps, keep up-to-date with the industry-accepted best practices and achieve the greatest value from MathWorks® and COMSOL® Products.

Wireless Communications Systems Design with MATLAB and USRP Software-Defined Radios

This two-day course shows how to design and simulate singleand multi-carrier digital communications systems using MATLAB. Multi-antenna and turbo-coded communication systems are introduced, and different channel impairments and their modeling are demonstrated. Components from LTE and IEEE 802.11 systems will be used as examples. The instructor will demonstrate a radio-in-the-loop system using real-time hardware (RTL-SDR and USRP).

Prerequisites

MATLAB Fundamentals and knowledge of digital communications systems

DURATION

2 Days

LEVEL

Medium

TOPICS

Day 1

- Communication over a Noiseless Channel
- Noisy Channels, Channel Coding, and Error Rates
- Timing and Frequency Errors and Multipath Channels

Day 2

- Multicarrier Communications Systems for Multipath Channels
- Using Multiple Antennas for Robustness and Capacity Gains
- Building a Radio-in-the-Loop System

Communication over a Noiseless Channel

OBJECTIVE: Modeling an ideal single-carrier communications system and becoming familiar with System objects.

- Sampling theorem and aliasing
- Using complex baseband versus real passband simulation
- Creating a random bit stream
- Discovering System objects and their benefits
- Modulating a bit stream using QPSK
- Applying pulse-shaping to the transmitted signal
- Using eye diagrams and spectral analysis
- Modeling a QPSK receiver for a noiseless channel
- Computing bit error rate

Noisy Channels, Channel Coding, and Error Rates

OBJECTIVE: Modeling an AWGN channel. Using convolutional, LDPC, and turbo codes to reduce bit error rate. Error correcting codes from DVB-S.2 and LTE systems are used as examples. Accelerating simulations using multiple cores.

- Modeling an AWGN channel
- Using channel coding and decoding: convolutional, LDPC, and turbo codes
- Decoding using Trellis diagram and Viterbi algorithm
- Using Parallel Computing Toolbox to accelerate Monte Carlo simulations
- Discussion of alternative acceleration methods: GPUs, MATLAB Distributed Computing Server™, Cloud Center

Timing and Frequency Errors and Multipath Channels

OBJECTIVE: Modeling frequency offset, timing jitter errors, and mitigation using frequency and timing synchronization techniques. Modeling flat fading, multipath channels, and mitigation using equalizers.

- Modeling phase and timing offsets
- Mitigating frequency offset using a PLL
- Mitigating timing jitter using Gardner timing synchronization
- Modeling flat fading channels
- Using training sequences for channel estimation
- Modeling frequency selective fading channels
- Using Viterbi equalizers for time-invariant channels and LMS linear equalizers for time-varying channels
- Demonstration of a real-time demodulation of single-carrier broadcast using RTL-SDR

Multicarrier Communications Systems for Multipath Channels

OBJECTIVE: Understanding motivation for multicarrier communications systems for frequency selective channels. Modeling an OFDM transceiver with a cyclic prefix and windowing. System parameter values from IEEE 802.11ac and LTE will be used.

- Motivation for multicarrier communications
- Introduction to Orthogonal Frequency Division Multiplexing (OFDM)
- OFDM symbol generation using the IFFT
- Inter-block interference prevention using a cyclic prefix
- Reduction of out-of-band emissions using windowing
- Advantages and disadvantages of OFDM
- Timing and frequency recovery methods for OFDM
- Channel estimation using pilot symbols
- Frequency domain equalization

Using Multiple Antennas for Robustness and Capacity Gains

OBJECTIVE: Understanding alternative multiple antenna communications system. Modeling beamforming, diversity, and spatial multiplexing systems. Constructing a MIMO-OFDM system for wideband communications. MIMO modes of IEEE 802.11ac and LTE will be discussed.

- Advantages and types of multi-antenna systems
- Transmit and receive beamforming
- Receive diversity techniques
- Transmit diversity using orthogonal space-time block codes
- Narrowband multiple input-multiple output (MIMO) channel model
- MIMO channel estimation
- Spatial multiplexing using ZF and MMSE equalization
- Wideband communications using an MIMO-OFDM system

Building a Radio-in-the-Loop System

OBJECTIVE: Understanding the radio-in-the-loop development workflow. Using RTLSDRs and USRPs as radio-in-the-loop development platforms.

- Overview of the radio-in-the-loop workflow
- MathWorks communications hardware support (RTL-SDR, USRP, Zynq®-Based Radio)
- Hardware alternative comparison (pros/cons table)
- Different RIL transmit and receive modes (single burst, looped, streamed)
- Creation of an end-to-end single-antenna multicarrier communications system using a USRP
- Demonstration of a 2x2 OFDM-MIMO over-the-air system using USRPs

Expand your knowledge