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

Prerequisites

MATLAB® Fundamentals and knowledge of digital communications systems

Day 1 of 2	
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 Parallel 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

Day 2 of 2	
Multi-Carrier Communications Systems for Multipath Channels	**Objective:** Understanding motivation for multi-carrier 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 multi-carrier 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 RTL-SDRs 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 multi-carrier communications system using a USRP Demonstration of a 2x2 OFDM-MIMO over-the-air system using USRPs