Course Title:

Wireless Communications Systems Design with MATLAB

Course Purpose:

This two-day course shows how to design and simulate single- and 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.

Topics include:

- Communication over a Noiseless Channel
- Noisy Channels, Channel Coding, and Error Rates
- Timing and Frequency Errors and Multipath Channels
- Multicarrier Communications Systems for Multipath Channels
- Using Multiple Antennas for Robustness and Capacity Gains

Pre- requisites:

MATLAB Fundamentals and knowledge of digital communications systems

- ✓ 2 training days
- ✓ Hours: 09:00-17:00
- ✓ Total training hours: 16

Training Center Systematics - Contact information:

Phone number: 03-7660111 Ext: 6 **Email:** training@systematics.co.il

Website: http://www.systematics.co.il/mathworks

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Teaching method

The course combines lectures, demonstrations and practical exercises in MATLAB, using original training books from MathWorks. The course is in Hebrew but the training materials are in English.

Course Objective:

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

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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

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

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- 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

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