MATLAB EXPO 2017
KOREA
4월 27일, 서울
등록 하기 matlabexpo.co.kr
5G 무선통신 시스템 설계
: WLAN/LTE/5G

김종남
Application Engineer
Agenda

- Innovations in Mobile Communications
- Waveform Generation and End-to-end Simulation
  - WLAN, LTE, 5G (FBMC, UFMC)
- RF Instrument & Software-Defined Radio Connectivity
  - Transmission/Reception of LTE/WLAN Signals with SDRs
- Summary
Evolution of Air Interface Technologies

4G

3GPP
LTE, LTE-A

Rel-8
Dec 2008

Rel-9
Dec 2009

Rel-10
Mar 2011

Rel-11
Mar 2013

Rel-12
Mar 2015

Rel-13
Mar 2016

5G ?

Requirements
Higher data rates
More flexible spectrum use
Spatial resource
Low delay & link adaptability
Reliable service everywhere

5G standardization

Proposed enabling technologies
Massive MIMO
Small Cell, HetNet
New Modulations
New Frequency bands

IEEE 802.11 WLAN standards

802.11a
5 GHz
11 Mbps
1999

802.11b
2.4 GHz
11 Mbps
1999

802.11g
2.4 GHz
11 Mbps
2003

802.11n
2.4 & 5 GHz
600 Mbps
2009

802.11ac
5 GHz
7 Gbps
2013

3GPP
LTE, LTE-A

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Dec 2008

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5 GHz
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2013
Workflow/Use-cases of wireless designers

Signal Generation

End-to-End Simulations

Signal Detection

Packet detected

Packet successfully decoded!

VHT-SIGA Decoded

Measurements

HW & Radio Connectivity

RF Signal Generator

Zynq SDR
Did you know MATLAB/Simulink can help you with …

**Design and Verification**
*Simulate baseband and RF systems*
*Including LTE & WLAN standards*

**Over-the-air testing**
*Validate models with SDR and RF instruments*

**Prototyping and Implementation**
*Deploy algorithms onto target system*
WLAN systems

:Waveform Generation & End-to-end Simulation
WLAN 802.11ac Transceiver

Demo

Transmitter
- Test Waveform Generation

Channel
- Fading Channel

Receiver
- Synchronisation & OFDM Demodulation
  - Channel Estimation & Equalisation

Test Waveform Generation

Synchronisation & OFDM Demodulation

Channel Estimation & Equalisation

Fading Channel

VHT Frame
What is WLAN System Toolbox?

Physical layer (PHY) modeling
Standard-compliant functions for the design, simulation, analysis, and testing of wireless LAN communications systems

Transmitter & Receiver
L-SIG, HT-SIG, VHT-SIG-A, VHT-SIG-B
OFDM, MIMO Equalization, STBC Combining
Packet detection, symbol timing correction
Coarse and fine frequency offset estimation
Preamble signal decoders for L-SIG, HT-SIG, VHT-SIG-A, VHT-SIG-B fields

Propagation Channel
T Gn  T Gac

Measurements
Packet Error Rate  EVM
Spectral Emissions

Features
Open, customizable MATLAB code
C-code generation with MATLAB Coder
LTE/LTE-A system
Waveform Generation & End-to-end Simulation
LTE/LTE-A Transceiver

Transmitter
- Test Waveform Generation

Channel
- Fading Channel

Receiver
- Synchronisation & OFDM Demodulation
- Channel Estimation & Equalisation

Demo

MATLAB code snippet:
```matlab
function [txWaveform, rxWaveform, txBits, rxBits, txCW, rxCW] =...
    lteTxChRx(enb, PDSCH, MCS1, channel, SNRdB)

% Apply transmitter operations
[txWaveform, txBits, txCW] = lteTx(enb, PDSCH, MCS1);
% Apply Channel modelling
rxWaveform = lteCh(txWaveform, enb, channel, SNRdB);
% Apply receiver operations
[rxBits, rxCW] = lteRx(rxWaveform, enb, PDSCH);
```
LTE System Toolbox

- LTE and LTE-Advanced (Rel-8 through Rel-12)
- Scope
  - FDD/TDD
  - Uplink/Downlink
  - Transmitter/Receiver
- ~200 functions for physical layer (PHY) modeling
- Signal generation for LTE & UMTS
- ACLR/EVM measurement
- Conformance Tests
5G New Modulations: FBMC, UFMC
:Waveform Generation & End-to-end Simulation
5G Waveforms: New Modulation Schemes

- For 5G system both efficiency and robust synchronization are paramount
- Majority of candidates: Non-Orthogonal waveforms
- Members of “filtered” OFDM designs:
  1. FBMC: Filter-Bank Multi-Carrier
  2. UFMC: Universal Filtered Multi-Carrier
  3. GFDM: Generalized Frequency Division Multiplexing
Filter-Bank Multi-Carrier (FBMC)

- Introduce per-subcarrier filtering to reduce the side-lobes
- Arises from the staggered-multi-tone modulation (SMT) framework
- Couple of implementation options:
  - Frequency spreading (extended iFFT/FFT)
  - Poly-phase network (more efficient, commonly employed)

Disadvantages:
- Non-orthogonal, overlapped symbols
- A more complicated receiver structure, esp. for MIMO
Universal Filtered Multi-carrier (UFMC)

- Filtering applied per sub-bands (not per sub-carrier as in FBMC)
  - Filtering parameterized by side-lobe attenuation
  - Reduced filter length (compared to FBMC)
  - Good for short bursts, suited for uplink with multiple users

- Orthogonal in the complex plane
  - use complex QAM symbols, reapply MIMO schemes

- Receive complexity
  - Similar to OFDM, use per subcarrier equalization
5G Challenges and Our solutions

- **New Modulation Schemes**
  - Performance characteristics of FBMC, UFMC, etc.

- **More Antennas**
  - Beamforming and precoding algorithms
  - Antenna arrays and Massive MIMO

- **New Frequency Bands**
  - RF system architectures design in mmWave frequencies
  - Advanced Antenna, RF and DSP Co-Design
  - Channel modeling from real-world measurement data

- **Real Hardware Verification and Prototyping**
  - Hardware testbed to verify designs with live radio signals in realistic scenarios with standard compliant signals such as LTE and Wi-Fi
  - Quick prototyping on FPGA
Connectivity to RF instruments & SDR
: Over-the-air testing and Verification with Radio/Hardware
Over-the-air testing

Input bits

Voice
Video
Text

Source Coding

Channel Coding & Modulation

Antenna Array (MIMO)

Multi-carrier Transmitter

Transmitter

Over-the-air Transmission & Reception

Large-scale fading (path loss …)

Small-scale fading (Multipath, Doppler effects)

Interference

Noise

Receiver

De-Modulation & Channel Decoding

Equalizer

Channel estimation

Time & Frequency offset detection/ Compensation

Output bits

Source Decoding

Voic...
Physical connectivity to radio hardware
Hardware & Radio Connectivity

Generate custom waveforms
Transmit with SDR devices or RF instruments
Capture signals with SDR or instruments
Recover original data

Range of supported hardware
- RF Signal Generator
- Spectrum Analyzer
- Zynq Radio SDR
- USRP SDR
Supported SDRs & RF instruments

- RF Signal Generator
- Zynq Radio SDR
- USRP SDR
- Transmitter
- Receiver
- RF Spectrum Analyzer
- Zynq Radio SDR
- USRP SDR
- RTL SDR
Summary: With Today’s MATLAB you can …

Design and Verification
*Simulate baseband and RF systems*

- 5G, WLAN, LTE and custom waveform generation
- Measurements (EVM, BER, PER, …) & analysis of received waveforms
- Transmitter-Channel-Receiver end-to-end simulation

Over-the-air testing
*Validate models with SDR and RF instruments*

- Connect LTE/WLAN signals to USRP or Zync Radio
- Live experiments with Video/music/audio as input signals
- Measurements (EVM, BER, PER, …) & analysis of over-the-air received waveforms