Advances in Wireless Communications: Standard Compliant Models and Software Defined Radio

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Advances in Wireless Communications

Standard compliant models:
• Baseband Algorithms
• Waveform Generation & Analysis

MATLAB & LTE System Toolbox™

• RF Signal Generation & Capture
• Hardware Implementation

SDR Hardware

HW Support Package

Over-the-Air
LTE System Toolbox – PHY Modelling

Transmitted resource grid

power

frequency (subcarrier)

time (OFDM symbol)
LTE System Toolbox – PHY Modelling

Received resource grid

power

frequency (subcarrier) time (OFDM symbol)
LTE: Long Term Evolution

- Part of the 3GPP standards (GSM, UMTS, LTE)
- One of the technologies marketed as 4G
LTE Physical Layer Processing Chain

**TRANSMITTER**
- Channel coding
- Scrambling & modulation
- Layer mapper
- Precoding

**OFDM**
- Resource mapper
- Modulation

**RECEIVER**
- Synch.
- OFDM demodulation
- Channel estimation
- Equalisation

**LTE Transmitter** → **Propagation channel** → **LTE Receiver**
What is the LTE System Toolbox?

- Standard-compliant physical layer models:
  Supports LTE releases 8 to 11.

- Scope:
  - FDD / TDD
  - Uplink / Downlink
  - Transmitter / Receiver

- ~200 functions for physical layer (PHY) modelling

- Link-level simulation
Typical Use Cases for LTE System Toolbox

Golden Reference for Verification
Does my design work as it should?

Signal Generation/Analysis
Test with live data

End-To-End Simulation
How do design choices affect system performance?
Does my system conform to the standard?

Signal Information Recovery
Decode real-world signals
Main Benefits of the Toolbox

- Comprehensive
  - Comprehensive set of PHY models
  - Large number of preset, extensible examples

- Open environment
  - MATLAB-based
  - Link to test and measurement instruments (ICT)

- Versatile
  - Quick access to LTE waveforms for verification
  - Detailed behavior for LTE experts
From Design to Implementation with MATLAB and Simulink

- Baseband Algorithms
- Waveform Generation & Analysis

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Hardware Support Packages are...

“Downloadable add-ons that enable you to use a MathWorks product with specific third-party hardware”
What is Software Defined Radio?

“A software-defined radio (SDR) is a wireless communication system whose functionality can be configured using software or programmable hardware.”
SDR System

Analog Front End → Digital Front End → Baseband Processing

Commercial-off-the-shelf hardware

FMC

Tunable RF Card
(Ex: 400-4000 MHz)

Ethernet

FPGA Board

Host Computer
Available SDR Support Packages

- Xilinx FPGA-Based Radio
  - Virtex-6 ML605, Spartan-6 SP605
  - ADI FMCOMMS1, Epiq FMC-1Rx

- USRP Radio
  - N210, USRP2

- RTL-SDR Radio

See demo station!
Capability 1: SDR Peripheral

- Execute fixed radio functions on FPGA
- Tunable pre-defined radio parameters
- Easy out-of-the-box experience
Capability 2: SDR Target

- Generate code to implement custom radio functionality on FPGA
- Customized using HDL Coder
From Simulation to Real Signals

**TRANSMITTER**
- channel coding
- scrambling & modulation
- layer mapper
- precoding
- resource mapper
- OFDM modulation

**RECEIVER**
- decode
- equalisation
- channel estimation
- OFDM demodulation
- synch.

Over the air
Designing a QPSK Receiver using SDR Hardware

- Floating point design
- Fixed point design
  - Simulate with SDR hardware
  - Generate HDL using HDL Coder
  - Test implementation on hardware using real signals

Design Complete!
Algorithm design, prototype and verify

QPSK Receiver: IO Peripheral Using SDR Hardware
Algorithm design, prototype and verify

QPSK Receiver: Target SDR Hardware
From Design to Implementation with MATLAB and Simulink

- Baseband Algorithms
- Waveform Generation & Analysis

**MATLAB**

&

LTE System Toolbox™

**SDR Hardware**

- RF Signal Generation & Capture
- Hardware Implementation

Over-the-Air

HW Support Package

[Image: Diagram showing the process from design to implementation with MATLAB and Simulink, including baseband algorithms, waveform generation & analysis, RF signal generation & capture, and hardware implementation.]
Thank you

- Questions?