MPIRICAL
Innovating Telecoms Training

> Instructor explained every detail very effectively and was able to get good knowledge on 5G. Thank you.

Watch our course intro video.

5G Air Interface

Course Description

The 5G air interface is a key part of the 5G system which will facilitate Enhanced Mobile Broadband and Ultra Reliable Low Latency Communication, as well as the support of Massive MTC (Machine Type Communications). This course, updated to Release 17, focuses on 5G SA (Standalone) operation, as well as incorporating NSA (Non Standalone) operation. The course details aspects from the physical layer channel and reference signals, through to scheduling and analysis of NR RRC signalling utilized to configure the NR air interface.

Prerequisites: 5G System Engineering or equivalent knowledge.

4 day (LiveOnsite, LiveOnline)

24 hours learning (OnlineAnytime)

24 CPD Learning Credits

Level: 3 (Advanced)

This course will contain the following sections:

1. 5G NG-RAN

Topic areas covered include:

- 5G Releases:
  - NR Releases and Features:
    - 5G Phase 1 and 5G Phase 2.
    - Release 17 Enhancements.
  - NR Versions:
    - Specification Version Numbering.
- 5G RAN
  - RAN Architecture:
    - Standalone Architecture.
    - Non-Standalone Architecture.
  - C-RAN:
    - C-RAN Architecture for 5G.
    - Separation of gNB-CU.
    - F1 Protocol Stack Split.
  - NR Protocol Stack.
- 5G RAN QoS:
  - PDU Sessions and QoS Flows.
  - QoS Flow Parameters:
    - 5QI (5G QoS Identifier)
  - Example PDU Session and QFI (QoS Flow Identifier) Mapping.
- 5G RAN Identities:
  - Subscriber and Device Identities:
    - SUPI, SUCI, 5G GUTI, 5G-S-TMSI, PEI and RNTI's.
  - RAN Identities:
    - NCGI, NCI, PCI, TAI, TAI List, RANAC and NPN Identities.

2. 5G Physical Layer

Topic areas covered include:

- 5G Waveform and Numerology:
  - Waveforms:
    - CP-OFDM and DFT-s-OFDM.
  - Numerology:
    - OFDM Subcarriers.
    - Orthogonal Frequency Division Multiplexing.
  - Cyclic Prefix.
- 5G NR Duplexing:
  - FDD and TDD Duplexing Modes.
  - SDL (Supplementary Downlink).
  - SUL (Supplementary Uplink).
- 5G Frequency Bands:
  - Definition of Frequency Ranges:
    - FR1, FR2, FR2-1 and FR2-2.
  - 5G NR Bands:
    - Key 3GPP Specifications.
  - Baseband Processing Combination.
  - 5G Carrier Numbering:
    - NR-ARFCN.
    - Global Frequency Raster.
    - Band Raster.
- NR Frame Structure:
  - Overall Frame Structure:
    - FDD and TDD Frame.
  - Slots and Slot Length.
  - Slot and Symbol Timing:
    - Tc (Time Unit).
  - Slot Format Configuration.
- NR Physical Resource Block:
  - NR PRB Definition.
  - Resource Grid.

4 day (LiveOnsite, LiveOnline)

24 hours learning (OnlineAnytime)

24 CPD Learning Credits

LiveOnsite, LiveOnline, OnlineAnytime

5G Physical Layer (cont.)

- Channel Bandwidth:
  - Maximum Transmission Bandwidth:
    - Release 17 Additions.
  - Carrier BWP (Bandwidth Part).

3. 5G Massive MIMO and Beamforming

Topic areas covered include:

- Massive MIMO and Multi-Antennas:
  - Multi-Antennas Features.
  - Requirement for Massive MIMO.
- MIMO in 5G:
  - Summary of Transmission Path in 5G NR:
    - Codewords, Layers and Antenna Ports.
  - MIMO Spatial Multiplexing.
  - SU-MIMO vs MU-MIMO.
- Beamforming (Massive MIMO):
  - Spatial Multiplexing vs Beamforming.
  - Creating a Beam.
  - Null Forming.
- Massive MIMO Antennas:
  - Antenna Elements and Subarrays.
  - Grid of Beams.
  - MIMO in a Handset.
- NR Beam Management:
  - Beam Management Terminology.
  - Beam Sweeping.
- SSB Location:
  - Synchronization Signal Block:
    - PSS, SSS, PBCH and PBCH DMRS.
  - SS Burst and Burst Set.
  - SS Block Locations:
    - GSCN (Global Synchronization Channel Number).
  - Beam Measurement, Determination and Reporting.
- Beam Management Reference Signals:
  - Reference Signals:
    - CSI-RS and SSB.
  - Single and Multiple CSI-RS:
    - CRI (CSI-RS Resource Indicator).
  - Transmission Based on SRS.
  - Transmission Configuration and Quasi Co-Location.
- Transmission and Ports in NR:
  - Downlink Transmission.
  - Uplink Transmission.
  - Antenna Ports.

4. 5G Physical Layer and Channels Introduction

Topic areas covered include:

- NR Channels:
  - Channel Types.
  - Logical Channels.
  - Transport Channels:
    - Mapping Logical Channels into Transport Channels.
  - Physical Channels:
    - Mapping Transport Channels to Physical Channels.
  - Synchronization and Reference Signals.
- NR Physical Layer Processing:
  - Key Specifications.
  - Code Block Generation.
  - Code Block Group.
  - Processing Chain.

5. NR Downlink Physical Channels and Signals

Topic areas covered include:

- NR Downlink Synchronization Signals:
  - PCI (Physical Cell Identity).
  - PSS and SSS.
- NR Physical Broadcast Channel:
  - MIB (Master Information Block).
  - PBCH Payload.
  - PBCH Physical Layer Processing.
  - DMRS (Demodulation Reference Signals) for PBCH.
- NR Physical Downlink Control Channel:
  - PDCCH Physical Layer Processing.
  - PDCCH Features.
  - CORESET (Control Resource Set).
  - CORESET Configuration.
  - Other PDCCH Usages.

NR Downlink Physical Channels and Signals (cont.)

- NR Physical Downlink Shared Channel:
  - PDSCH Configuration.
  - PDSCH DMRS.
- Activity: NR RRC parameter analysis using Mpirical's NetX and ASN.1 decoder.

6. NR Uplink Physical Channels

Topic areas covered include:

- NR Physical Random Access Channel:
  - Preamble Sequence Generation.
  - Configuring RACH/PRACH.
  - NR PRACH Configuration Index.
  - Preamble Formats.
  - Preamble Sequence Length.
  - NR PRACH Format 0 Example.
  - NR PRACH Format - (FR2).
- NR Physical Uplink Shared Channel:
  - NR PUSCH Processing Chain.
  - Configuring NR PUSCH.
  - PUSCH DMRS.
- NR Physical Uplink Control Channel:
  - NR PUCCH Formats.
  - NR PUCCH Location Example.
  - NR PUCCH Configuration.
  - PUCCH Format 0 Example.
- Activity: Activity: NR RRC parameter analysis using Mpirical's NetX and ASN.1 decoder.

7. 5G Reference Signals

Topic areas covered include:

- 5G Physical Signals:
  - Reference Signal Types.
- DMRS:
  - PBCH DMRS.
  - PDSCH and PUSCH DMRS.
  - PUCCH DMRS.
- Channel State Information Reference Signals:
  - CSI-RS Types and Features.
  - CSI-RS Locations in a Slot.
  - CSI-IM Patterns.

5G Reference Signals (cont.)

  - CSI-RS Configuration.
  - CSI Timing.
- Sounding Reference Signal.
- Phase Tracking Reference Signal.
- Activity: NR RRC parameter analysis using Mpirical's NetX and ASN.1 decoder.

8. NR Layer 2 and Layer 3

Topic areas covered include:

- NR Radio Resource Control:
  - NR RRC States:
    - RRC_IDLE, RRC_CONNECTED and RRC_INACTIVE.
  - RRC Messages:
    - Release 16 and 17 additions.
  - RRC Critical and Non-Critical Extensions.
- NR Service Data Application Protocol:
  - SDAP in the RAN.
- SDAP Functions.
  - SDAP Headers.
  - SDAP Example.
  - RDI and RQI Indication:
    - Reflective QoS.
- NR Packet Data Convergence Protocol:
  - PDCP Services.
  - PDCP Functions.
  - PDCP Profiles.
  - PDCP Protocol Data Units.
  - PDCP Example.
- NR Radio Link Control:
  - RLC Modes.
  - RLC Protocol Data Units.
- NR Medium Access Control:
  - MAC Services and Functions.
  - MAC Control Elements.
  - NR RNTI Identities.
  - MAC Headers.
- Activity: NR RRC parameter analysis using Mpirical's NetX and ASN.1 decoder.

9. 5G Scheduling

Topic areas covered include:

- Scheduling NR Resources:
  - gNB Scheduler.
  - DCI (Downlink Control Information).
  - Resource Allocation:
    - Resource Allocation Type 0.
    - Resource Allocation Type 1.
    - Dynamic Switch.
- NR Downlink Resource Allocation:
  - DCI Format 1_1.
  - PDSCH Time Domain Resource Allocation.
  - PDSCH MCS Tables.
  - Downlink Configured Scheduling.
  - Discontinuous Reception.
- NR Uplink Resource Allocation:
  - DCI Format 0_1.
  - PUSCH Time Domain Resource Allocation.
  - PUSCH MCS Tables.
  - Uplink Configured Scheduling.
- NR Feedback:
  - Feedback Options.
  - BSR (Buffer Status Reporting).
  - PHR (Power Headroom Reporting).
  - HARQ.
  - SR (Scheduling Request).
  - CSI (Channel State Information).
  - CQ (Channel Quality Indicator).
- Inter-RAN Resource Coordination:
  - Resource Coordination Signalling.
  - Coordination Resource Bitmap.
- Activity: NR RRC parameter analysis using Mpirical's NetX and ASN.1 decoder.

10. 5G Access Procedures

Topic areas covered include:

- 5G Initial Access:
  - Network Access Procedure.
  - Scanning.
  - SSB Operation.
  - Downlink Synchronization.
- NR CORESET#0 Acquisition:
  - MIB/SIB1/RMSI.
  - Example of Mapping.

5G Access Procedures (cont.)

- NR System Information and Cell Selection:
  - System Information Block 1.
  - System Information Types.
  - Cell Selection.
- NR Random Access:
  - Random Access Triggers.
  - Contention Based Random Access Procedure.
  - RACH Configuration Common.
  - PRACH Power Control.
  - Contention Free Random Access Procedure.
- Preamble Options:
  - PRACH Preambles.
  - Preambles per SSB per PRACH Occasion.
  - SS/PBCH Index Mapping to PRACH Occasion.
- Random Access Response:
  - Random Access Response Window.
  - Random Access Response Message.
- 5G Network Registration:
  - RRC Setup.
  - 5G Registration Procedure.
  - Device Capabilities.
- Activity: Signalling analysis of NR RRC Setup and Registration using Mpirical's NetX and ASN.1 decoder.

11. EN-DC Operational Procedures

Topic areas covered include:

- Attaching and EN-DC Operation:
  - Configuration for EN-DC.
  - Initial E-UTRA Attach.
- E-UTRA Measurements for EN-DC:
  - E-UTRA Measurement Configuration Options.
  - LTE Measurement Events.
  - NR Measurement Configuration.
  - Identifying Suitable NR Cell.
- PSCell Addition:
  - SgNB Addition.
  - Reconfiguration with Sync.
  - PSCell Split SRB.
  - PSCell Split DRB.
  - Secondary Node Release.
- EN-DC Radio Link Failure:
  - RLF Configuration.
  - Failure Report.

12. 5G Connected Mode Procedures

Topic areas covered include:

- PDU Session Establishment:
  - Connected Mode Procedures.
  - PDU Session Establishment Request.
  - PDU Session Establishment Accept.
- NR Radio Link Failure:
  - RLF Configuration.
  - Out-of-Sync and In-Sync.
  - NR RRC Reestablishment Procedure.
- NR Beam Failure:
  - Beam Failure Parameters.
  - Beam Failure Detection.
  - Beam Failure Recovery.
- NR Power Control:
  - Downlink Power Allocation.
  - Uplink Power Control.
- Activity: Signalling analysis of NR RRC and PDU Session Establishment using Mpirical's NetX and ASN.1 decoder.

13. 5G Paging

Topic areas covered include:

- 5G Paging:
  - NR RRC States.
  - Network Paging Procedure.
  - Paging Identity.
  - RRC Setup Request (Responding to Page).
- Scheduling 5G Paging:
  - Paging Frame and Occasion.
  - DCI Paging.
  - Discontinuous Reception for Paging.
- RRC Inactive State and Paging:
  - I-RNTI.
  - RAN Notification Area.
  - RRC Resume Procedure.
  - Paging in the RRC Inactive.
- Activity: NR RRC parameter analysis using ASN.1 decoder.

14. 5G Measurements

Topic areas covered include:

- NR Measurement Quantities:
  - Types of Measurements.
  - SS-RSRP.
  - SS-RSRQ.
  - SS-SINR.
  - CSI-RSRP.
  - CSI-RSRQ.
  - CSI-SINR.
- NR Measurements Configuration Options:
  - Measurement Configuration.
  - Measurement Objects.
  - Report Configuration.
  - NR Measurement Events.
  - Periodic Measurements.
  - Measurement Identities.
  - NR Measurement Timing Configuration.
- NR Measurement Gap Configuration:
  - SSB Based Inter-Frequency Measurements.
  - Gap Pattern Parameters.
  - EN-DC Measurement Gap.
- Activity: NR RRC parameter analysis using Mpirical's NetX and ASN.1 decoder.

15. 5G Carrier Aggregation

Topic areas covered include:

- 5G Carrier Allocation Terminology.
  - Component Carriers.
  - Band Terminology.
  - PCell, SCell and PSCell Terminology.
  - NR CA Band Combinations and Bandwidth Classes.
- Configuring NR Carrier Aggregation:
  - Activation Options.
  - Configuring CA SCells.
  - MAC CA Activation.
  - MAC Buffer Status and Power Headroom Reports.
  - Releasing NR Carrier Aggregation.
- Activity: NR RRC parameter analysis using ASN.1 decoder.

16. NR Dual Connectivity

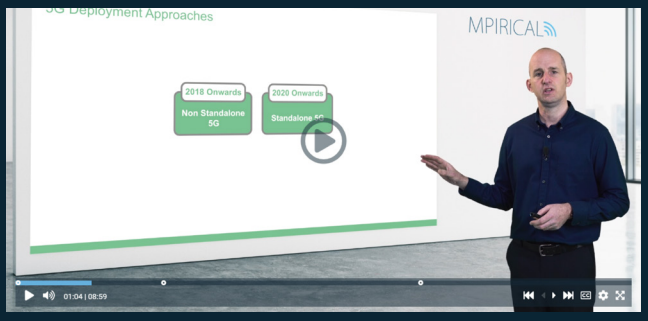
Topic areas covered include:

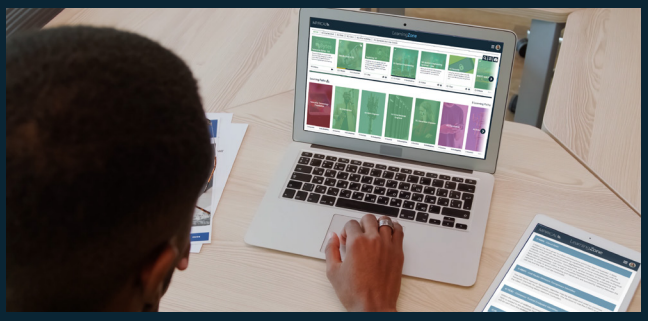
- NR Dual-Connectivity:
  - Concept and Terminology.
  - Signalling for NR-DC.
- NR-DC Operation:
  - NR-DC Secondary Node Addition.
  - NR-DC Bearer Configuration.
  - NR-DC Secondary Node Release.
- NR Dual Connectivity Mobility:
  - Change of Secondary Node.
- NR-DC Failure:
  - Configuring Radio Link Monitoring.
  - Secondary RAN Node Failure.
  - Master RAN Node Failure.
- Activity: NR RRC parameter analysis using ASN.1 decoder.

17. 5G Mobility

Topic areas covered include:

- NR Idle Mode Mobility:
  - Mobility Options.
  - NR Cell Reselection.
  - Registration Mobility Update.
- Priority Based Reselection:
  - Absolute Priorities.
  - Priority Reselection Scenarios.
- Handover Procedures:
  - X2 Handover Procedure.
  - RRC Connection Reconfiguration.
  - Path Switch Procedure.
  - N2 Handover Scenario.
- Minimizing Handover Failures:
  - Handover Failures.
  - Conditional Handover.
- Activity: Signalling analysis of RRC Measurement Report and Xn Handover using Mpirical's NetX and ASN.1 decoder.





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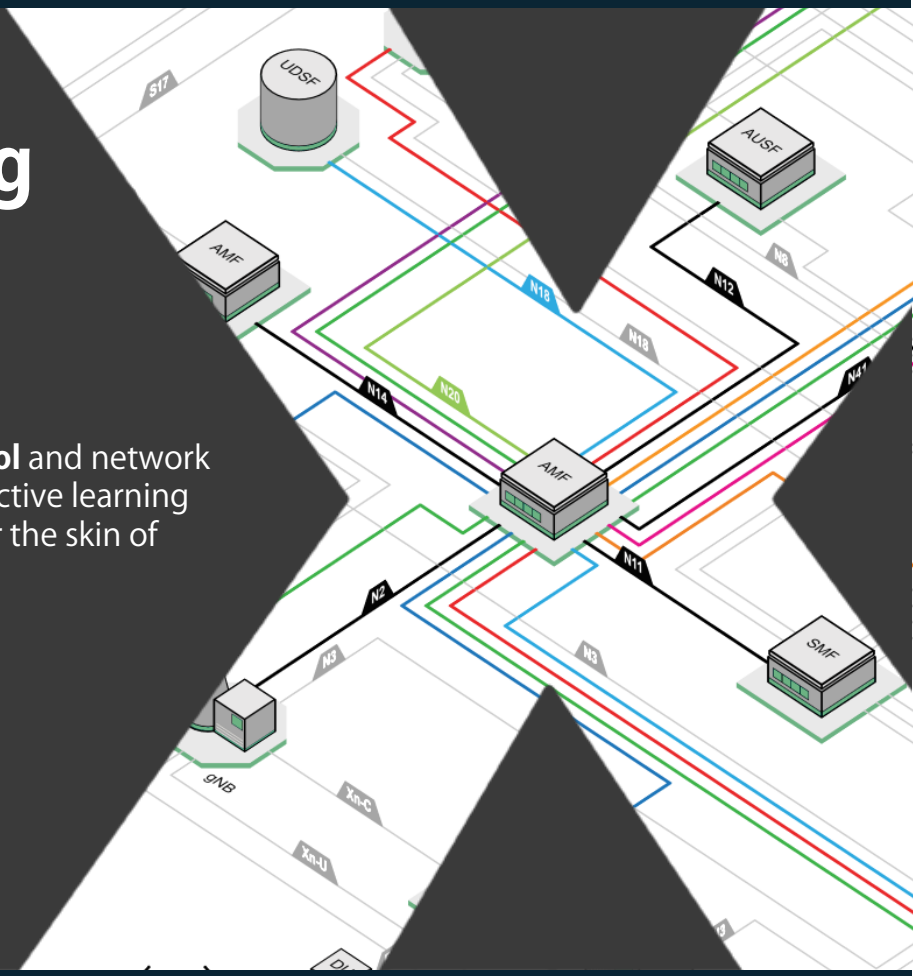

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