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Contents

Foreword

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1 Scope

The present document provides a general description of the physical layer of NR radio interface. The present document also describes the document structure of the 3GPP physical layer specifications, i.e. TS 38.200 series.

2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications"

[2] 3GPP TS 38.202: "NR; Services provided by the physical layer"

[3] 3GPP TS 38.211: "NR; Physical channels and modulation"

[4] 3GPP TS 38.212: "NR; Multiplexing and channel coding"

[5] 3GPP TS 38.213: "NR; Physical layer procedures for control"

[6] 3GPP TS 38.214: "NR; Physical layer procedures for data"

[7] 3GPP TS 38.215: "NR; Physical layer measurements"

3 Definitions, symbols and abbreviations

3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

Definition format

***<defined term>**: <definition>.*

example: text used to clarify abstract rules by applying them literally.

3.2 Symbols

For the purposes of the present document, the following symbols apply:

Symbol format

<symbol> <Explanation>

3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

BPSK	Binary Phase Shift Keying
CP	Cyclic Prefix
DFT-s-OFDM	Discrete Fourier Transform-spread-Orthogonal Frequency Division Multiplexing
DU	Distributed Unit
E-UTRA	Evolved Universal Terrestrial Radio Access

FDD	Frequency Division Duplex
FEC	Forward Error Correction
HARQ	Hybrid Automatic Repeat Request
IAB	Integrated access and backhaul
LDPC	Low Density Parity Check
MAC	Medium Access Control
MIMO	Multiple Input Multiple Output
MT	Mobile Termination
OFDM	Orthogonal Frequency Division Multiplexing
PBCH	Physical Broadcast Channel
PDCCH	Physical Downlink Control Channel
PDSCH	Physical Downlink Shared Channel
PRACH	Physical Random Access Channel
PSBCH	Physical Sidelink Broadcast Channel
PSCCH	Physical Sidelink Control Channel
PSFCH	Physical Sidelink Feedback Channel
PSSCH	Physical Sidelink Shared Channel
PUCCH	Physical Uplink Control Channel
PUSCH	Physical Uplink Shared Channel
QAM	Quadrature Amplitude Modulation
QPSK	Quadrature Phase Shift Keying
RLC	Radio Link Control
RRC	Radio Resource Control
SAP	Service Access Point
SRS	Sounding reference signal
TDD	Time Division Duplex
UE	User Equipment

4 General description of layer 1

4.1 Relation to other layers

4.1.1 General protocol architecture

The radio interface described in this specification covers the interface between the User Equipment (UE) and gNB, between gNBs, between IAB-node DU and IAB-node MT/UE, and between UEs. The radio interface is composed of the Layer 1, 2 and 3. The TS 38.200 series describes the Layer 1 (Physical Layer) specifications. Layers 2 and 3 are described in the 38.300 series.

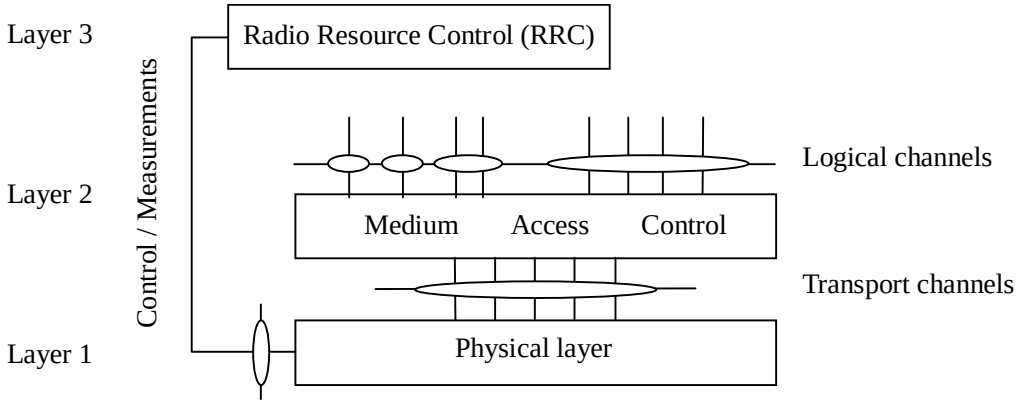

Figure 1: Radio interface protocol architecture around the physical layer

Figure 1 shows the NR radio interface protocol architecture around the physical layer (Layer 1). The physical layer interfaces the Medium Access Control (MAC) sub-layer of Layer 2 and the Radio Resource Control (RRC) Layer of Layer 3. The circles between different layer/sub-layers indicate Service Access Points (SAPs). The physical layer offers

a transport channel to MAC. The transport channel is characterized by how the information is transferred over the radio interface. MAC offers different logical channels to the Radio Link Control (RLC) sub-layer of Layer 2. A logical channel is characterized by the type of information transferred.

4.1.2 Service provided to higher layers

The physical layer offers data transport services to higher layers. The access to these services is through the use of a transport channel via the MAC sub-layer. Details are specified in [2].

4.2 General description of layer 1

4.2.1 Multiple access

The multiple access scheme for the NR physical layer is based on Orthogonal Frequency Division Multiplexing (OFDM) with a cyclic prefix (CP). For uplink, Discrete Fourier Transform-spread-OFDM (DFT-s-OFDM) with a CP is also supported. To support transmission in paired and unpaired spectrum, both Frequency Division Duplex (FDD) and Time Division Duplex (TDD) are enabled.

The Layer 1 is defined in a bandwidth agnostic way based on resource blocks, allowing the NR Layer 1 to adapt to various spectrum allocations. A resource block spans 12 sub-carriers with a given sub-carrier spacing.

The radio frame has a duration of 10ms and consists of 10 sub-frames with a sub-frame duration of 1ms. A sub-frame is formed by one or multiple adjacent slots, each having 14 adjacent symbols. Further details on the frame structure are specified in [2].

4.2.2 Physical channels and modulation

The physical channels defined in the downlink are:

- the Physical Downlink Shared Channel (PDSCH),
- the Physical Downlink Control Channel (PDCCH),
- the Physical Broadcast Channel (PBCH),

The physical channels defined in the uplink are:

- the Physical Random Access Channel (PRACH),
- the Physical Uplink Shared Channel (PUSCH),
- and the Physical Uplink Control Channel (PUCCH).

The physical channels defined in the sidelink are:

- the Physical Sidelink Broadcast Channel (PSBCH),
- the Physical Sidelink Control Channel (PSCCH),
- the Physical Sidelink Feedback Channel (PSFCH),
- and the Physical Sidelink Shared Channel (PSSCH).

In addition, signals are defined as reference signals, primary and secondary synchronization signals.

The modulation schemes supported are

- in the downlink, QPSK, 16QAM, 64QAM, and 256QAM,
- in the uplink, QPSK, 16QAM, 64QAM and 256QAM for OFDM with a CP and $\pi/2$-BPSK, QPSK, 16QAM, 64QAM and 256QAM for DFT-s-OFDM with a CP

4.2.3 Channel coding

The channel coding scheme for transport blocks is quasi-cyclic LDPC codes with 2 base graphs and 8 sets of parity check matrices for each base graph, respectively. One base graph is used for code blocks larger than certain sizes or with initial transmission code rate higher than thresholds; otherwise, the other base graph is used. Before the LDPC coding, for large transport blocks, the transport block is segmented into multiple code blocks with equal size. The channel coding scheme for PBCH and control information is Polar coding based on nested sequences. Puncturing, shortening and repetition are used for rate matching. Further details of channel coding schemes are specified in [4].

4.2.4 Physical layer procedures

There are several Physical layer procedures involved. Such procedures covered by the physical layer are;

- Cell search
- Power control
- Uplink synchronisation and Uplink timing control
- Random access related procedures
- HARQ related procedures
- Beam management and CSI related procedures
- Sidelink related procedures
- Channel access procedures

Through the control of physical layer resources in the frequency domain as well as in the time and power domains, implicit support of interference coordination is provided in NR.

4.2.5 Physical layer measurements

Radio characteristics are measured by the UE and the network and reported to higher layers. These include, e.g. measurements for intra- and inter-frequency handover, inter RAT handover, timing measurements, and measurements for RRM.

Measurements for inter-RAT handover are defined in support of handover to E-UTRA.

5 Document structure of physical layer specification

5.1 Overview

The physical layer specification consists of a general document (TS 38.201), and seven documents (TS 38.202, 38.211 through 38.215, and 37.213). The relation between the physical layer specifications in the context of the higher layers is shown in Figure 2.