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TECHNICAL SPECIFICATION

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# Contents

# Foreword

This Technical Specification has been produced by the 3rd Generation Partnership Project (3GPP).

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# 1 Scope

The present document is a technical specification of the services provided by the physical layer of E-UTRA to upper layers.

# 2 References

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

- References are either specific (identified by date of publication, edition number, version number, etc.) or non specific.
- For a specific reference, subsequent revisions do not apply.
- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.


[1] Void

[2] Void

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

[4] Void

[5] Void

[6] Void

[7] Void

[8] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation".

[9] Void

[10] Void

[11] 3GPP TS 36.214: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical layer; Measurements".

[12] 3GPP TS 36.321: "Evolved Universal Terrestrial Radio Access (E-UTRA); Medium Access Control (MAC) protocol specification".

[13] 3GPP TS 36.306: "Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio access capabilities".

[14] 3GPP TS 23.303: "Technical Specification Group Services and System Aspects; Proximity-based services (ProSe)".

[15] Void

[16] 3GPP TS 23.285: "Technical Specification Group Services and System Aspects; Architecture enhancements for V2X services".

# 3 Definitions and abbreviations

## 3.1 Definitions

For the purposes of the present document, the terms and definitions given in TR 21.905 [3] 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 [3].

**Carrier frequency:** center frequency of the cell.

**Frequency layer:** set of cells with the same carrier frequency.

**NB-IoT:** NB-IoT allows access to network services via E-UTRA with a channel bandwidth limited to 200 kHz.

**Short Processing Time**: For 1 ms TTI length, the operation with short processing time in UL data transmission and DL data reception.

**Short TTI**: TTI length based on a slot or a subslot.

**Sidelink:** UE to UE interface for sidelink communication, V2X sidelink communication and sidelink discovery. The sidelink corresponds to the PC5 interface as defined in TS 23.303 [14].

**Sidelink communication**: AS functionality enabling ProSe Direct Communication as defined in TS 23.303 [14], between two or more nearby UEs, using E-UTRA technology but not traversing any network node. In this version, the terminology "sidelink communication" without "V2X" prefix only concerns PS unless explicitly stated otherwise.

**Sidelink discovery**: AS functionality enabling ProSe Direct Discovery as defined in TS 23.303 [14], using E-UTRA technology but not traversing any network node.

**V2X Sidelink communication**: AS functionality enabling V2X Communication as defined in TS 23.285 [16], between nearby UEs, using E-UTRA technology but not traversing any network node.

**Timing Advance Group:** See the definition in TS 36.321 [12].

## 3.2 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [3] 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 [3].

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

| | |
|---|---|
| ACK | Acknowledgement |
| ARQ | Automatic Repeat Request |
| BCCH | Broadcast Control Channel |
| BCH | Broadcast Channel |
| BL | Bandwidth reduced Low complexity |
| BLER | Block Error Rate |
| CG | Cell Group |
| CMAS | Commercial Mobile Alert System |
| CP | Cyclic Prefix |
| C-plane | Control Plane |
| CRC | Cyclic Redundancy Check |
| CSI | Channel State Information |
| DC | Dual Connectivity |
| DCCH | Dedicated Control Channel |
| DL | Downlink |
| DRX | Discontinuous Reception |
| DTCH | Dedicated Traffic Channel |
| DTX | Discontinuous Transmission |
| eNB | E-UTRAN NodeB |
| eIMTA | Enhanced Interference Management and Traffic Adaptation |

| | |
|---|---|
| EPDCCH | Enhanced physical downlink control channel |
| E-UTRA | Evolved UTRA |
| E-UTRAN | Evolved UTRAN |
| FDD | Frequency Division Duplex |
| FDM | Frequency Division Multiplexing |
| FS | Frame Structure |
| GERAN | GSM EDGE Radio Access Network |
| GSM | Global System for Mobile communication |
| HARQ | Hybrid ARQ |
| LAA | Licensed-Assisted Access |
| LTE | Long Term Evolution |
| MAC | Medium Access Control |
| MBMS | Multimedia Broadcast Multicast Service |
| MBSFN | Multimedia Broadcast multicast service Single Frequency Network |
| MCCH | Multicast Control Channel |
| MCH | Multicast Channel |
| MCS | Modulation and Coding Scheme |
| MIMO | Multiple Input Multiple Output |
| MTCH | Multicast Traffic Channel |
| MWUS | MTC Wake Up Signal |
| NACK | Negative Acknowledgement |
| NB-IoT | Narrow Band Internet of Things |
| NPBCH | Narrow Band Physical Broadcast Channel |
| NPDCCH | Narrow Band Physical Downlink Control Channel |
| NPDSCH | Narrow Band Physical Downlink Shared Channel |
| NPRACH | Narrow Band Physical Random Access Channel |
| NPUSCH | Narrow Band Physical Uplink Shared Channel |
| NWUS | Narrow Band Wake Up Signal |
| OFDM | Orthogonal Frequency Division Multiplexing |
| OFDMA | Orthogonal Frequency Division Multiple Access |
| PBCH | Physical broadcast channel |
| PDCCH | Physical downlink control channel |
| PDSCH | Physical downlink shared channel |
| PHY | Physical layer |
| PMCH | Physical multicast channel |
| PRACH | Physical random access channel |
| PRB | Physical Resource Block |
| ProSe | Proximity based Services |
| PSBCH | Physical Sidelink Broadcast CHannel |
| PSCCH | Physical Sidelink Control Channel |
| PSCell | Primary SCell |
| PSDCH | Physical Sidelink Discovery Channel |
| PSSCH | Physical Sidelink Shared CHannel |
| PUCCH | Physical uplink control channel |
| PUSCH | Physical uplink shared channel |
| QAM | Quadrature Amplitude Modulation |
| RACH | Random Access Channel |
| RF | Radio Frequency |
| RRC | Radio Resource Control |
| SAP | Service Access Point |
| SBCCH | Sidelink Broadcast Control CHannel |
| SC-FDMA | Single Carrier – Frequency Division Multiple Access |
| SCell | Secondary Cell |
| SC-PTM | Single Cell Point to Multipoint |
| SL-BCH | Sidelink Broadcast Channel |
| SL-DCH | Sidelink Discovery Channel |
| SL-SCH | Sidelink Shared Channel |
| SPDCCH | Short PDCCH |
| SPT | Short Processing Time |
| SPUCCH | Short PUCCH |
| SRS | Sounding Reference Symbol |
| STCH | Sidelink Traffic Channel |

| | |
|---|---|
| TAG | Timing Advance Group |
| TB | Transport Block |
| TDD | Time Division Duplex |
| TTI | Transmission Time Interval |
| UE | User Equipment |
| UL | Uplink |
| UMTS | Universal Mobile Telecommunication System |
| U-plane | User plane |
| UTRA | Universal Terrestrial Radio Access |
| UTRAN | Universal Terrestrial Radio Access Network |
| V2X | Vehicle-to-Everything |

# 4 Void

## 4.1 Void

## 4.2 Void

# 5 Services and functions of the physical layer

## 5.1 General

The physical layer offers data transport services to higher layers.

The access to these services is through the use of transport channels via the MAC sub-layer.

A transport block is defined as the data delivered by MAC layer to the physical layer and vice versa. Transport blocks are delivered once every TTI.

## 5.2 Overview of L1 functions

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. The physical layer is expected to perform the following functions in order to provide the data transport service:

- Error detection on the transport channel and indication to higher layers
- FEC encoding/decoding of the transport channel
- Hybrid ARQ soft-combining
- Rate matching of the coded transport channel to physical channels
- Mapping of the coded transport channel onto physical channels
- Power weighting of physical channels
- Modulation and demodulation of physical channels
- Frequency and time synchronisation
- Radio characteristics measurements and indication to higher layers
- Multiple Input Multiple Output (MIMO) antenna processing
- Transmit Diversity (TX diversity)

- Beamforming
- RF processing.

L1 functions are modelled for each transport channel in clauses 6.1, 6.2 and 6.3.

## 5.3 Void

# 6 Model of physical layer of the UE

The E-UTRA physical-layer model captures those characteristics of the E-UTRA physical-layer that are relevant from the point-of-view of higher layers. More specifically, the physical-layer model captures:

- The structure of higher-layer data being passed down to or up from the physical layer;
- The means by which higher layers can configure the physical layer;
- The different indications (error indications, channel-quality indications, etc.) that are provided by the physical layer to higher layers;
- Other (non-transport-channel-based) higher-layer peer-to-peer signalling supported by the physical layer.

## 6.1 Uplink model

### 6.1.1 Uplink Shared Channel

The physical-layer model for Uplink Shared Channel transmission is described based on the corresponding physical-layer-processing chain, see Figure 6.1.1-1. Processing steps that are relevant for the physical-layer model, e.g. in the sense that they are configurable by higher layers, are highlighted in blue. It should be noted that, in the cases of PUSCH and NPUSCH, the scheduling decision is fully done at the network side. The uplink transmission control in the UE then configures the uplink physical-layer processing, based on uplink transport-format and resource-assignment information received on the downlink.

- **Higher-layer data passed to/from the physical layer**
- One transport block of dynamic size delivered to the physical layer once every TTI.
- **CRC and transport-block-error indication**
- Transport-block-error indication delivered to higher layers.
- **FEC and rate matching**
- Channel coding rate is implicitly given by the combination of transport block size, modulation scheme and resource assignment;
- Physical layer model support of HARQ: in case of Incremental Redundancy, the corresponding Layer 2 Hybrid-ARQ process controls what redundancy version is to be used for the physical layer transmission for each TTI.
- **Interleaving**
- No control of interleaving by higher layers.
- **Data modulation**
- Modulation scheme is decided by MAC Scheduler (QPSK, 16QAM, 64QAM, and 256QAM; for BL UEs or UEs in enhanced coverage, supported modulation schemes are QPSK and 16QAM; for NB-IoT, supported modulation schemes are Pi/4-QPSK and Pi/2-BPSK for single-tone allocation, and QPSK for multi-tone allocation).
- **Mapping to physical resource**

- L2-controlled resource assignment.

- **Multi-antenna processing**

- MAC Scheduler partly configures mapping from assigned resource blocks to the available number of antenna ports.

- **Support of L1 control signalling**

- Transmission of ACK/NACK and CSI feedback related to DL data transmission

The model of Figure 6.1.1-1 also captures

- Transport via physical layer of Hybrid-ARQ related information associated with the PUSCH, to the peer HARQ process at the transmitter side;

- Transport via physical layer of corresponding HARQ acknowledgements to PUSCH transmitter side (except for NB-IoT UEs).

If a UE is configured with one or more SCells, the physical-layer-processing chain in Figure 6.1.1-1 is repeated for every UL Serving Cell.

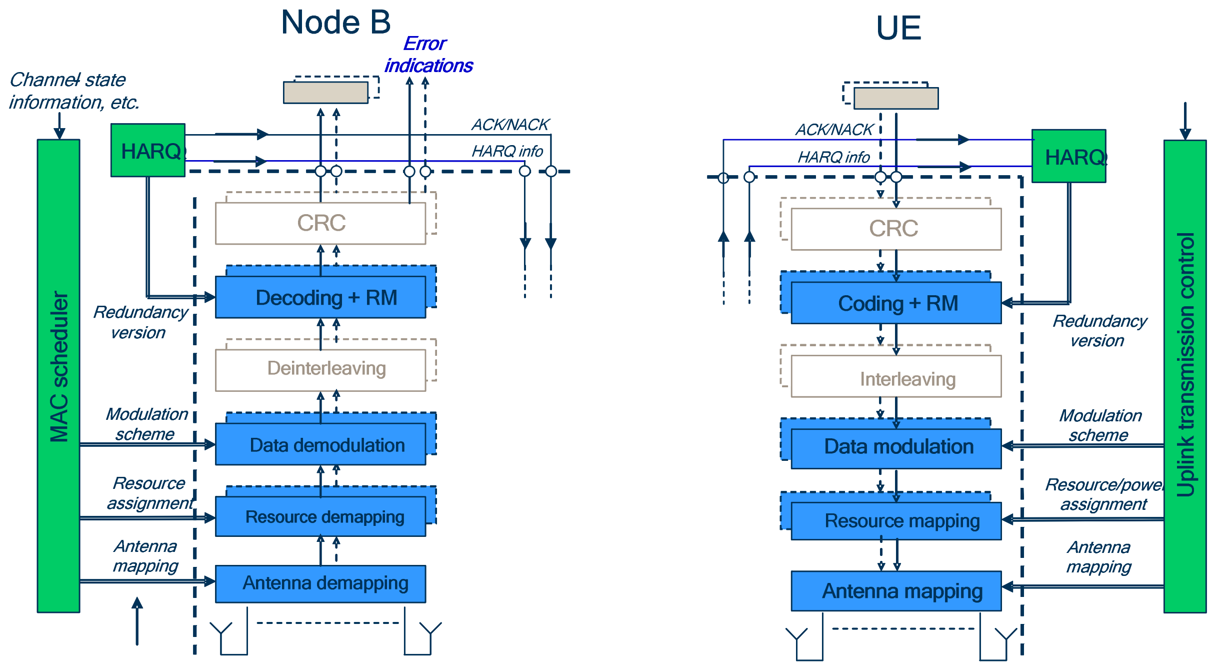


**Figure 6.1.1-1: Physical-layer model for UL-SCH transmission**

## 6.1.2 Random-access Channel

The physical-layer model for RACH transmission is characterized by a random access burst that consists of a cyclic prefix, a preamble, and a guard time during which nothing is transmitted.

The random access preambles are generated from Zadoff-Chu sequences with zero correlation zone (ZC-ZCZ), generated from one or several root Zadoff-Chu sequences. For NB-IoT, the random access preambles are generated from single-subcarrier frequency-hopping symbol groups. A symbol group consists of a cyclic prefix followed by five identical symbols, whose value is constant across symbol groups during each NPRACH transmission.

## 6.2 Downlink model

### 6.2.1 Downlink-Shared Channel

The physical-layer model for Downlink Shared Channel transmission is described based on the corresponding PDSCH or NPDSCH physical-layer-processing chain, see Figure 6.2.1-1. Processing steps that are relevant for the physical-layer model, e.g. in the sense that they are configurable by higher layers, are highlighted in blue on the figure.

- **Higher-layer data passed to/from the physical layer**
- N (up to two) transport blocks of dynamic size delivered to the physical layer once every TTI.
- **CRC and transport-block-error indication**
- Transport-block-error indication delivered to higher layers.
- **FEC and rate matching**
- Channel coding rate is implicitly given by the combination of transport block size, modulation scheme and resource assignment;
- Physical layer model support of HARQ: in case of Incremental Redundancy, the corresponding Layer 2 Hybrid-ARQ process controls what redundancy version is to be used for the physical layer transmission for each TTI.
- **Data modulation**
- Modulation scheme is decided by MAC Scheduler (QPSK, 16QAM, 64 QAM, 256QAM, and 1024QAM; for BL UEs or UEs in enhanced coverage, supported modulation schemes are QPSK and 16QAM, and 64QAM for CE mode A with no repetitions; for NB-IoT, only QPSK is supported).

**Multi-antenna processing**

- MAC Scheduler partly configures mapping from modulated code words (for each stream) to the available number of antenna ports.
- **Mapping to physical resource**
- L2-controlled resource assignment.
- **Support of L1 control signalling**
- Transmission of scheduler related control signals.
- **Support for Hybrid-ARQ-related signalling**

The model of Figure 6.2.1-1 also captures:

- Transport via physical layer of Hybrid-ARQ related information associated with the PDSCH, to the peer HARQ process at the receiver side;
- Transport via physical layer of corresponding HARQ acknowledgements to PDSCH transmitter side.

If a UE is configured with one or more SCells, the physical-layer-processing chain in Figure 6.2.1-1 is repeated for every DL Serving Cell.

NOTE: The signalling of transport-format and resource-allocation is not captured in the physical-layer model. At the transmitter side, this information can be directly derived from the configuration of the physical layer. The physical layer then transports this information over the radio interface to its peer physical layer, presumably multiplexed in one way or another with the HARQ-related information. On the receiver side, this information is, in contrast to the HARQ-related information, used directly within the physical layer for PDSCH demodulation, decoding etc., without passing through higher layers.

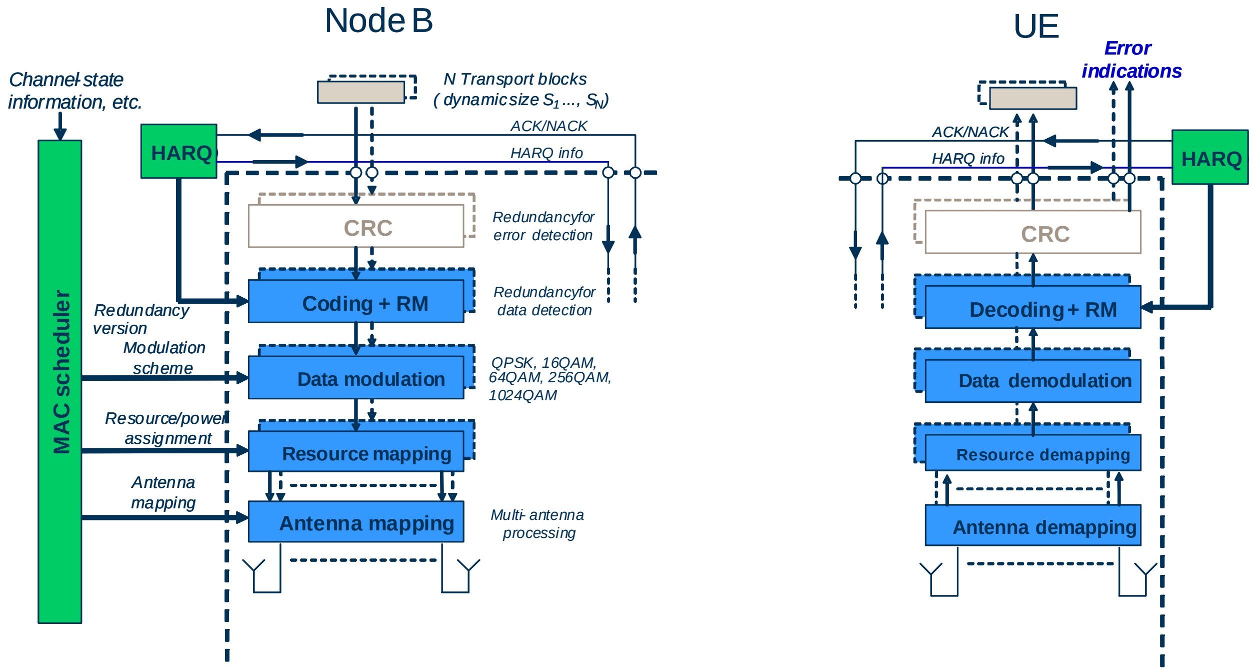


**Figure 6.2.1-1: Physical-layer model for DL-SCH transmission**

## 6.2.2 Broadcast Channel

The physical-layer model for BCH transmission is characterized by a fixed pre-defined transport format. The TTI (repetition rate) of the BCH is 40 ms except for NB-IoT and 640 ms for NB-IoT. The BCH physical-layer model is described based on the corresponding BCH physical-layer-processing chain, see Figure 6.2.2-1:

- **Higher-layer data passed to/from the physical layer**

- A single (fixed-size) transport block per TTI.

- **CRC and transport-block-error indication**

- Transport-block-error indication delivered to higher layers.

- **FEC and rate matching**

- Channel coding rate is implicitly given by the combination of transport block size, modulation scheme and resource assignment;

- No BCH Hybrid ARQ, i.e. no higher-layer control of redundancy version.

- **Data modulation**

- Fixed modulation scheme (QPSK), i.e. no higher-layer control.

- **Mapping to physical resource**

- Fixed pre-determined transport format and resource allocation, i.e. no higher-layer control.

- **Multi-antenna processing**

    - Fixed pre-determined processing, i.e. no higher-layer control.

- **Support for Hybrid-ARQ-related signalling**

- No Hybrid ARQ.

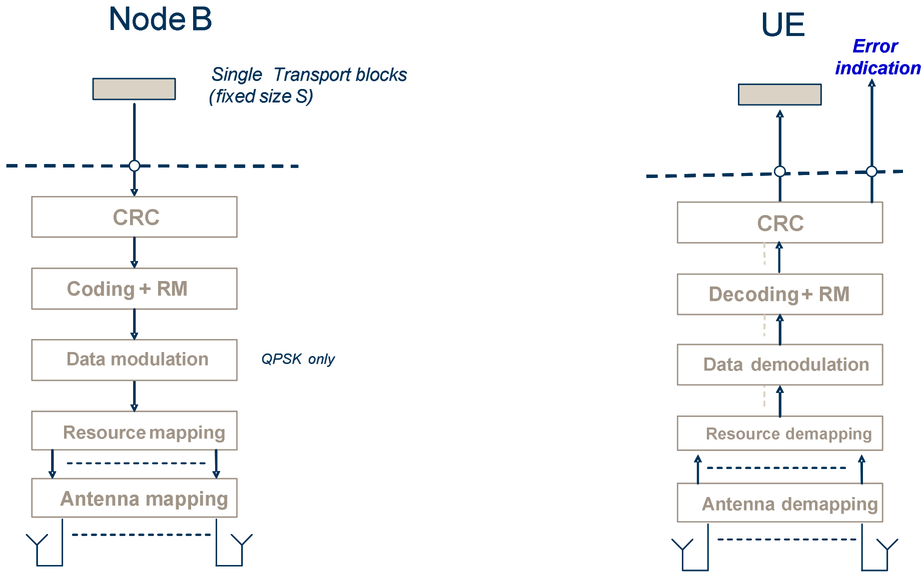


**Figure 6.2.2-1: Physical-layer model for BCH transmission**

NOTE: For NB-IoT, the BCH transport block of 40 bits is truncated to 34 bits by the NodeB when provided to the physical layer for BCH transmission. The BCH transport block of 34 bits is padded to 40 bits when delivered by the UE physical layer to the upper layer.

### 6.2.3 Paging Channel

The physical-layer model for PCH transmission is described based on the corresponding PCH physical-layer-processing chain, see Figure 6.2.3-1. Processing steps that are relevant for the physical-layer model, e.g. in the sense that they are configurable by higher layers, are highlighted in blue on the figure.

- **Higher-layer data passed to/from the physical layer**
- A single transport block per TTI.
- **CRC and transport-block-error indication**
- Transport-block-error indication delivered to higher layers.
- **FEC and rate matching**
- Channel coding rate is implicitly given by the combination of transport block size, modulation scheme and resource assignment;
- No PCH Hybrid ARQ, i.e. no higher-layer control of redundancy version.
- **Data modulation**
- Modulation scheme is decided by MAC Scheduler.
- **Mapping to physical resource**
- L2 controlled resource assignment;
- Possible support of dynamic transport format and resource allocation.
- **Multi-antenna processing**
- MAC Scheduler partly configures mapping from assigned resource blocks to the available number of antenna ports.
- **Support for Hybrid-ARQ-related signalling**

No Hybrid ARQ.

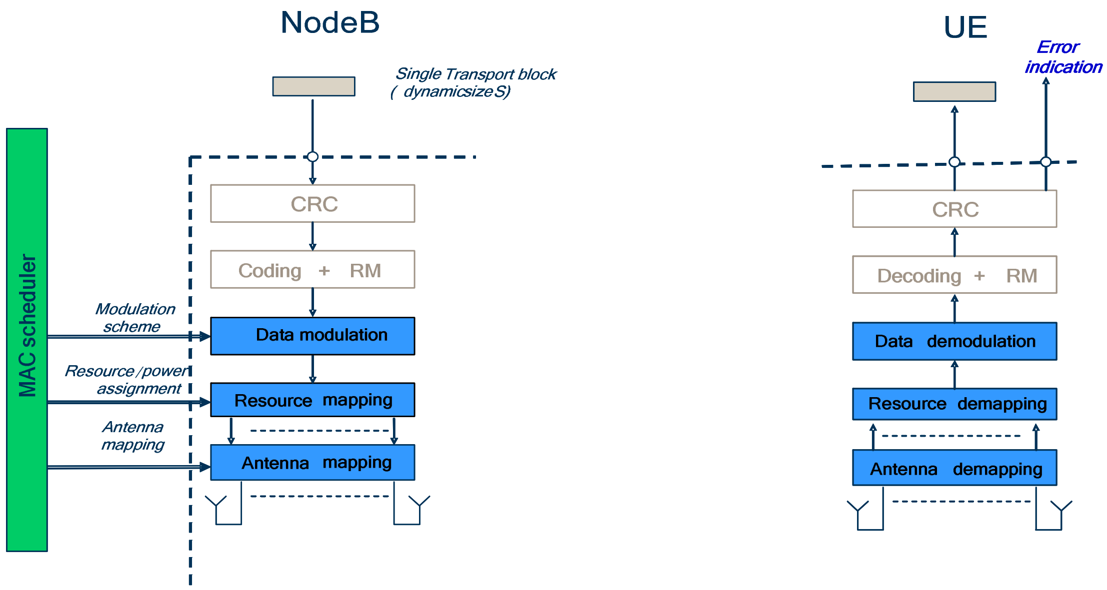


**Figure 6.2.3-1: Physical-layer model for PCH transmission**

## 6.2.4 Multicast Channel

The physical-layer model for MCH transmission is characterized by the support for multi-cell reception at the UE (a.k.a. "MBSFN" transmission). This implies that only semi-static configuration of the MCH transport format and resource assignment is possible. The MCH physical-layer model is described based on the corresponding MCH physical-layer-processing chain, see Figure 6.2.4-1. Processing steps that are relevant for the physical-layer model, e.g. in the sense that they are configurable by higher layers, are highlighted in blue.

- **Higher-layer data passed to/from the physical layer**

- One transport block delivered to physical layer once every TTI.

- **CRC and transport-block-error indication**

- Transport-block-error indication delivered to higher layers.

- **FEC and rate matching**

- Channel coding rate is implicitly given by the combination of transport block size, modulation scheme and resource assignment;

- No MCH Hybrid ARQ, i.e. no higher-layer control of redundancy version.

- **Data modulation**

- Modulation scheme is configured by RRC layer.

- **Mapping to physical resource**

- L2 controlled semi–static resource assignment.

- **Multi-antenna processing**

- MAC Scheduler partly configures mapping from assigned resource blocks (for each stream) to the available number of antenna ports.

- **Support for Hybrid-ARQ-related signalling**

- No Hybrid ARQ.

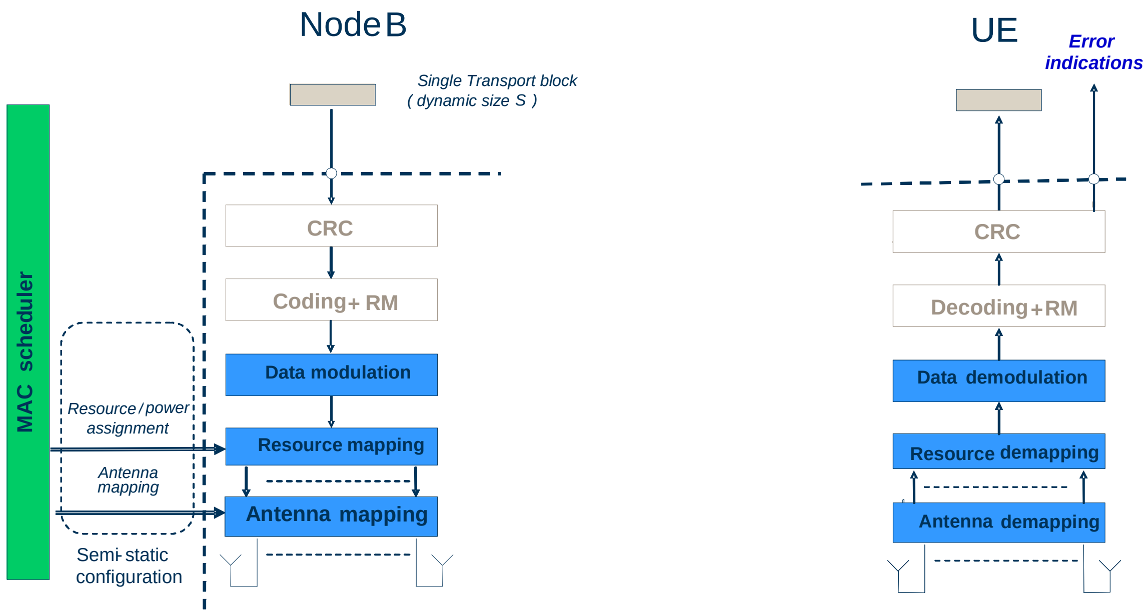


**Figure 6.2.4-1: Physical-layer model for MCH transmission**

# 6.3 Sidelink model

## 6.3.1 Sidelink Broadcast Channel

The physical-layer model for Sidelink Broadcast Channel transmission is characterized by a fixed pre-defined transport format. The TTI (repetition rate) of the SL-BCH not corresponding to V2X sidelink communication is 40ms whereas the TTI (repetition rate) of the SL-BCH corresponding to V2X sidelink communication is 160 ms, if a UE is configured to transmit on SL-BCH. The SL-BCH physical-layer model is described based on the corresponding SL-BCH physical-layer-processing chain, see Figure 6.3.1-1.

- **Higher-layer data passed to/from the physical layer**

- A single (fixed-size) transport block per TTI.

- **CRC and transport-block-error indication**

- Transport-block-error indication delivered to higher layers.

- **FEC and rate matching**

- Channel coding rate is implicitly given by the combination of transport block size, modulation scheme and resource assignment;

- No SL-BCH Hybrid ARQ, i.e. no higher-layer control of redundancy version.

- **Data modulation**

- Fixed modulation scheme (QPSK), i.e. no higher-layer control.

- **Mapping to physical resource**

- Fixed pre-determined transport format i.e. no higher-layer control.

- RRC controlled semi-static resource assignment.

- **Multi-antenna processing**

- Single antenna port is used.

- **Support for Hybrid-ARQ-related signalling**

- No Hybrid ARQ.

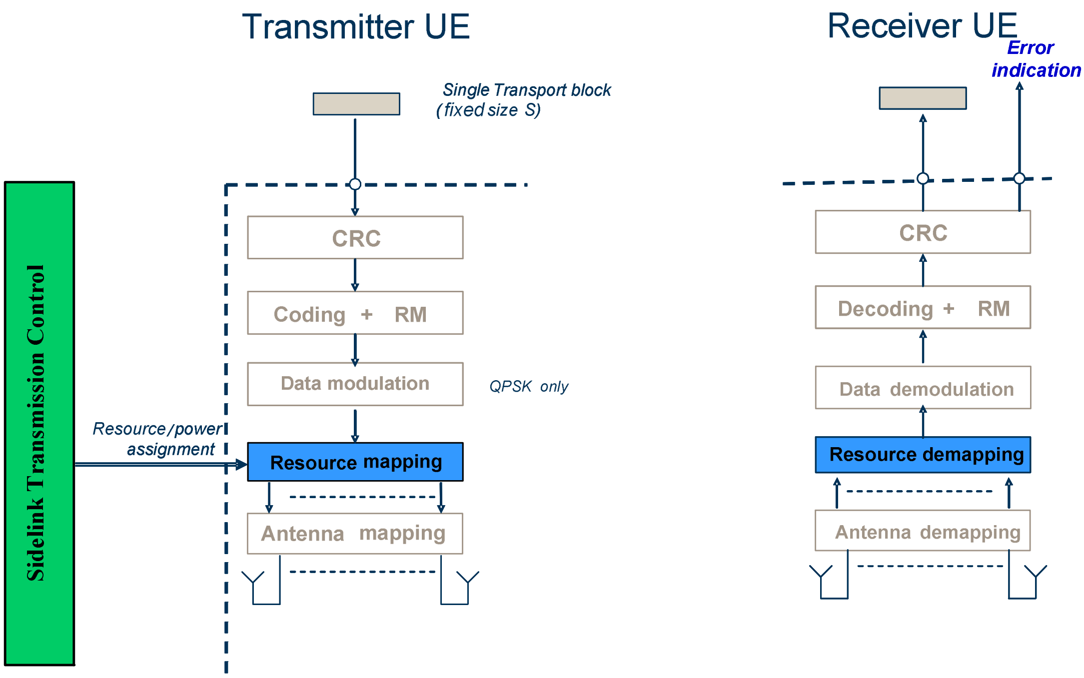


**Figure 6.3.1-1: Physical-layer model for SL-BCH transmission**

## 6.3.2 Sidelink Discovery Channel

The physical-layer model for Sidelink Discovery Channel transmission is characterized by a fixed pre-defined transport format. The SL-DCH physical-layer model is described based on the corresponding SL-DCH physical-layer-processing chain, see Figure 6.3.2-1. Processing steps that are relevant for the physical-layer model, e.g. in the sense that they are configurable by higher layers, are highlighted in blue. It should be noted that, in case scheduled resource allocation of SL-DCH, the scheduling decision is fully done by network side. The sidelink transmission control in the UE configures the sidelink physical-layer processing, based on sidelink transport-format and resource-assignment information received on the downlink. In case UE autonomous resource selection of SL-DCH, the scheduling decision is done by UE side. The sidelink transmission control in the UE configures the sidelink physical-layer processing, based on pre-defined sidelink transport-format and UE randomly selected resource-assignment.

- **Higher-layer data passed to/from the physical layer**

- A single (fixed-size) transport block per TTI.

- **CRC and transport-block-error indication**

- Transport-block-error indication delivered to higher layer.

- **FEC and rate matching**

- Channel coding rate is implicitly given by the combination of transport block size, modulation scheme and resource assignment;

- Support for soft combining, but no support for ACK/NACK feedback.

- **Data modulation**

- Fixed modulation scheme (QPSK), i.e. no higher-layer control.

- **Mapping to physical resource**

- RRC controlled semi-static resource assignment;

- **Multi-antenna processing**
- Single antenna port is used.

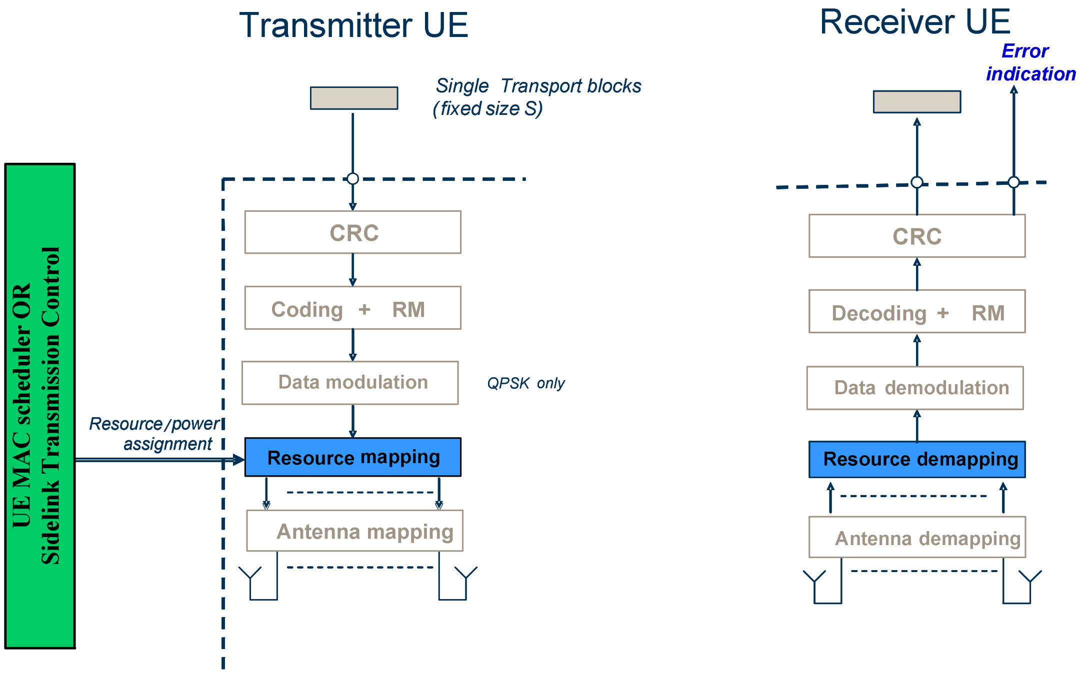


**Figure 6.3.2-1: Physical-layer model for SL-DCH transmission**

## 6.3.3 Sidelink Shared Channel

The physical-layer model for Sidelink Shared Channel transmission is described based on the corresponding SL-SCH physical-layer-processing chain, see Figure 6.3.3-1. Processing steps that are relevant for the physical-layer model, e.g. in the sense that they are configurable by higher layers, are highlighted in blue on the figure. It should be noted that, in case of scheduled resource allocation, the SL-SCH scheduling decision is done by network side. The sidelink transmission control in the UE configures the sidelink physical-layer processing, based on sidelink transport-format and resource-assignment information received on the downlink. In case of UE autonomous resource selection, the SL-SCH scheduling decision is done by UE side, and the MAC scheduler in the UE configures the sidelink physical-layer processing, based on the sidelink transport-format autonomously decided by the UE and autonomously selected resource-assignment.

- **Higher-layer data passed to/from the physical layer**
- One transport block of dynamic size delivered to the physical layer once every TTI.
- **CRC and transport-block-error indication**
- Transport-block-error indication delivered to higher layers.
- **FEC and rate matching**
- Channel coding rate is implicitly given by the combination of transport block size, modulation scheme and resource assignment;
- Support for soft combining, but no support for ACK/NACK feedback.
- **Data modulation**
- For scheduled resource allocation, modulation scheme is decided by higher layer signaling from eNB.

- For UE autonomous resource selection for sidelink communication, modulation scheme is decided by MAC scheduler (QPSK, 16QAM) in transmitter UE. For UE autonomous resource selection for V2X sidelink communication, modulation scheme is decided by MAC scheduler (QPSK, 16QAM, 64QAM) in transmitter UE.
- For UE autonomous resource selection for V2X sidelink communication, modulation scheme is decided by MAC scheduler in transmitter UE, according to the range defined by higher layer signalling from eNB or preconfiguration if configured.
- **Mapping to physical resource**
- L2-controlled resource assignment.
- **Multi-antenna processing**
- Single antenna port is used.

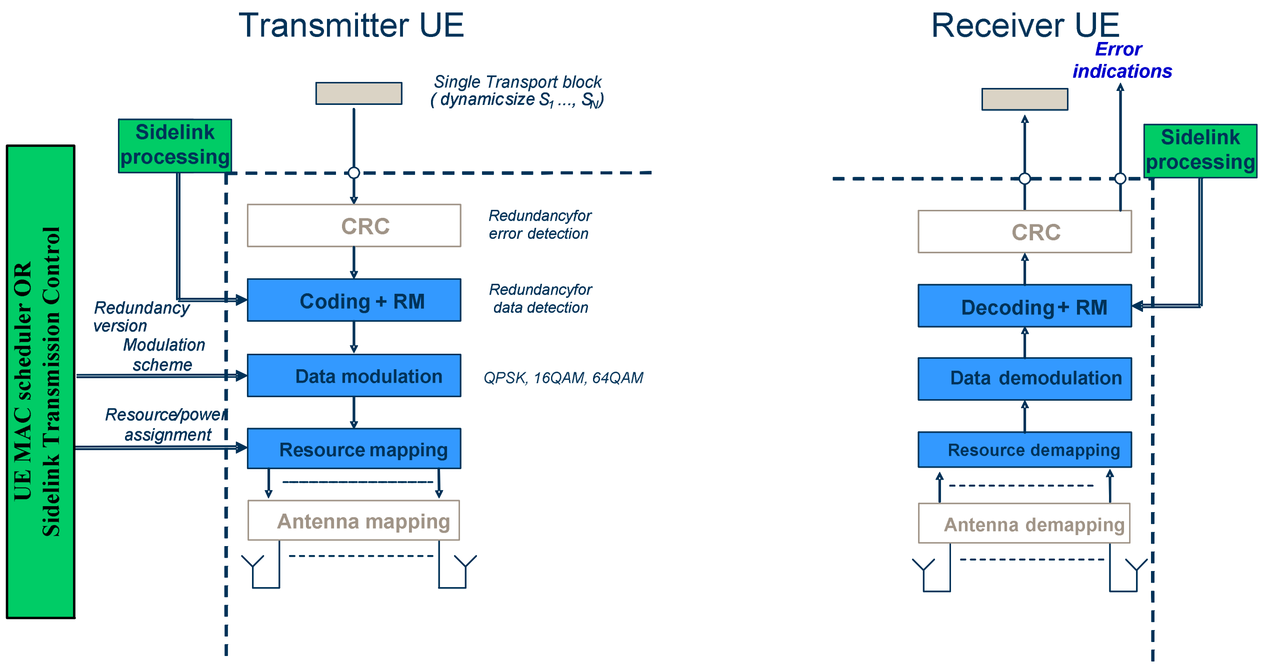


**Figure 6.3.3-1: Physical-layer model for SL-SCH transmission**

NOTE: For UE autonomous resource selection for V2X sidelink communication, the MAC scheduler in the transmitter UE decides whether to use 64QAM for data modulation based on UE capability, see TS 36.306 [13].

# 7 Void

# 8 Parallel transmission of simultaneous Physical Channels and SRS

This clause describes the requirements from the UE to send and receive on multiple Physical and Transport Channels and SRS simultaneously depending on the service capabilities and requirements.

## 8.1 Uplink

The table 8.1-1 describes the possible combinations of physical channels that can be sent in parallel in the uplink within the same subframe/slot/subslot. For NB-IoT, see Table 8.1-1a.

**Table 8.1-1: Uplink**

| | Physical Channel Combination | Transport Channel Combination | Mandatory dependent on UE radio access capabilities | Comment |
|---|---|---|---|---|
| 1 | *q* x PUSCH | UL-SCH | Mandatory | Note 1, Note 2, Note 6 |
| 2 | *k* x PRACH | RACH | Mandatory | Note 4 |
| 3 | *j* x *k* x PUCCH | N/A | Mandatory | CSI (not on SPUCCH) and Scheduling Requests are provided to Layer 2. Note 4, Note5, Note 6 |
| 4 | *q* x PUSCH + *j* x *k* x PUCCH | UL-SCH | Mandatory for UEs supporting simultaneous transmission of PUSCH and PUCCH | Note1, Note 2, Note 4, Note5, Note 6 |
| 5 | *k* x PRACH +*(q-k)* x PUSCH | RACH UL-SCH | Mandatory for UEs supporting multiple TAGs | Note 1, Note 2, Note 3, Note 4, Note 6 |
| 6 | *k* x PRACH + *j* x *k* x PUCCH | RACH | Mandatory for UEs supporting multiple TAGs | Note 3, Note 4, Note5, Note 6 |
| 7 | *k* x PRACH +*(q-k)* x PUSCH + *j* x *k* x PUCCH | RACH UL-SCH | Mandatory for UEs supporting simultaneous transmission of PUSCH and PUCCH and multiple TAGs | Note 1, Note 2, Note 3, Note 4, Note5, Note 6 |

Note 1: One PUSCH per UL CC.
Note 2: *q* is the number of UL CCs supported by the UE. *q* = 1 implies non-CA capable UE.
Note 3: PRACH and PUSCH/PUCCH/SPUCCH are from cells in different Timing Advance Groups, see TS 36.321 [12].
Note 4: *k* is the number of CGs supported by the UE. *k* = 1 implies non-DC capable UE. *k* = 2 implies DC capable UE, and one PUCCH/SPUCCH and one PRACH per CG.
Note 5: *j* is the number of PUCCH groups supported by the UE. *j* = 1 implies PUCCH/SPUCCH transmission is supported only on PCell. *j* = 2 implies PUCCH/SPUCCH transmission is supported on PCell and an SCell.
Note 6: Short TTI capable UEs shall support this Physical Channel Combination also for the subslot/slot equivalent of the mentioned channels (if existing).

**Table 8.1-1a: Uplink for NB-IoT**

| | Physical Channel Combination | Transport Channel Combination | Mandatory dependent on UE radio access capabilities | Comment |
|---|---|---|---|---|
| 1 | NPUSCH | UL-SCH | Mandatory | |
| 2 | NPRACH | RACH | Mandatory | |

The table 8.1-2 describes the possible combinations of SRS and physical channels that can be sent in parallel in uplink in the last symbol within the same subframe/slot/subslot by one UE. Table 8.1-2 is not applicable for NB-IoT.

**Table 8.1-2: Uplink in combinations with SRS**

| | Physical Channel and SRS Combination | Transport Channel Combination | Mandatory dependent on UE radio access capabilities | Comment |
|---|---|---|---|---|
| 1 | *q* x SRS | N/A | Mandatory | Note 2, Note 4 |
| 2 | *k* x PRACH +*(q-k)* x SRS | RACH | Mandatory for UEs supporting multiple TAGs | Note 2, Note 3, Note 4, Note 7 |
| 3 | *n* x PUSCH + *(q-n)* x SRS | UL-SCH | Mandatory for UEs supporting multiple TAGs | Note 1, Note 2, Note 4, Note 5, Note 6, Note 9 |
| 4 | *j* x *k* x PUCCH + *(q- j* x *k)* x SRS | N/A | Mandatory for UEs supporting multiple TAGs | Note 2, Note 4, Note 6, Note 7, Note 8, Note 9 |
| 5 | *n* x PUSCH + *j* x *k* x PUCCH + *(q-n)* x SRS | UL-SCH | Mandatory for UEs supporting simultaneous transmission of PUSCH and PUCCH and multiple TAGs | Note 1, Note 2, Note 4, Note 5, Note 6, Note 7, Note 8, Note 9 |
| 6 | *k* x PRACH + *n* x PUSCH + *(q-n-k)* x SRS | RACH<br>UL-SCH | Mandatory for UEs supporting multiple TAGs | Note 1, Note 2, Note 3, Note 4, Note 5, Note 6, Note 7, Note 9 |
| 7 | *k* x PRACH + *j* x *k* x PUCCH + *(q-(j+1)* x *k)* x SRS | RACH | Mandatory for UEs supporting multiple TAGs | Note 2, Note 3, Note 4, Note 6, Note 7, Note 8, Note 9 |
| 8 | *k* x PRACH + *n* x PUSCH + *j* x *k* x PUCCH + *(q-n-k)* x SRS | RACH<br>UL-SCH | Mandatory for UEs supporting simultaneous transmission of PUSCH and PUCCH and multiple TAGs | Note 1, Note 2, Note 3, Note 4, Note 5, Note 6, Note 7, Note 8, Note 9 |

Note 1: One PUSCH per UL CC.
Note 2: *q* is the number of UL CCs supported by the UE. *q* = 1 implies non-CA capable UE.
Note 3: PRACH and PUSCH/PUCCH/SPUCCH/SRS are from cells in different TAGs, see TS 36.321 [12].
Note 4: One SRS per UL CC.
Note 5: *n = 1, 2, …, q- k.*
Note 6: If UE is not configured with multiple TAGs, then SRS and PUSCH/PUCCH are not transmitted in parallel; otherwise, if UE is configured with multiple TAGs, then SRS and PUSCH/PUCCH are transmitted in parallel from different serving cells of the same TAG or different TAGs.
Note 7: *k* is the number of CGs supported by the UE. *k* = 1 implies non-DC capable UE. *k* = 2 implies DC capable UE, and one PUCCH/SPUCCH and one PRACH per CG.
Note 8: *j* is the number of PUCCH groups supported by the UE. *j* = 1 implies PUCCH/SPUCCH transmission is supported only on PCell. *j* = 2 implies PUCCH/SPUCCH transmission is supported on PCell and an SCell.
Note 9: Short TTI capable UEs shall support this Physical Channel Combination also for the subslot/slot equivalent of the mentioned channels (if existing).

# 8.2 Downlink

The tables describe the possible combinations of physical channels that can be received in parallel in the downlink in the same subframe by one UE. In one subframe, the UE shall be able to receive all TBs according to the indication on

PDCCH. Tables 8.2-1, 8.2-1a, 8.2-2 and 8.2-2a are applicable to LTE; Tables 8.2-1b and 8.2-2b are applicable to NB-IoT.

**Table 8.2-1: Downlink "Reception Types" except for NB-IoT UEs, BL UEs and UEs in enhanced coverage**

| "Reception Type" | Physical Channel(s) | Monitored RNTI | Associated Transport Channel |
|---|---|---|---|
| A | PBCH | N/A | BCH |
| B | PDCCH+PDSCH | SI-RNTI | DL-SCH |
| B1 | PDCCH+PDSCH | SI-RNTI (Note 11) | DL-SCH |
| C | PDCCH+PDSCH | P-RNTI | PCH |
| D | PDCCH+PDSCH | RA-RNTI (Note 3) | DL-SCH |
| | | Temporary C-RNTI (Note 3) (Note 4) | DL-SCH |
| | ((PDCCH+SPDCCH)/EPDCCH) +(PDSCH/slot/subslot PDSCH) | C-RNTI and Semi-Persistent Scheduling C-RNTI | DL-SCH |
| | ((PDCCH+SPDCCH)/EPDCCH) +(PDSCH+subslot/slot PDSCH) (Note 14) | C-RNTI and Semi-Persistent Scheduling C-RNTI | DL-SCH |
| D1 | ((PDCCH+SPDCCH)/EPDCCH) +(PDSCH/subslot/slot PDSCH) (Note 9) | C-RNTI | DL-SCH |
| | ((PDCCH+SPDCCH)/EPDCCH) +(PDSCH+subslot/slot PDSCH) (Note 9, Note 14) | C-RNTI | DL-SCH |
| D2 | PDCCH+PDSCH | SC-RNTI | DL-SCH |
| | | G-RNTI | DL-SCH |
| D3 | ((PDCCH+SPDCCH) /EPDCCH) +(PDSCH/subslot/slot PDSCH) | C-RNTI and Semi-Persistent Scheduling C-RNTI | DL-SCH |
| | ((PDCCH+SPDCCH)/EPDCCH) +(PDSCH+subslot/slot PDSCH) (Note 14) | C-RNTI and Semi-Persistent Scheduling C-RNTI | DL-SCH |
| | PDCCH+PDSCH | SC-RNTI | DL-SCH |
| | | G-RNTI | DL-SCH |
| E | PDCCH/EPDCCH (Note 1) | C-RNTI | N/A |
| F | PDCCH | Temporary C-RNTI (Note 5) | UL-SCH |
| | (PDCCH+SPDCCH)/EPDCCH | C-RNTI and Semi-Persistent Scheduling C-RNTI | UL-SCH |
| F1 | (PDCCH+SPDCCH)/EPDCCH (Note 9) | C-RNTI | UL-SCH |
| G | PDCCH | TPC-PUCCH-RNTI | N/A |
| H | PDCCH | TPC-PUSCH-RNTI | N/A |
| I | (PDCCH+SPDCCH)/EPDCCH | Semi-Persistent Scheduling C-RNTI (Note 6) | N/A |
| J | (PDCCH+SPDCCH)/EPDCCH | Semi-Persistent Scheduling C-RNTI (Note 7) | N/A |
| K | PDCCH | M-RNTI (Note 8) | N/A |
| K1 | PDCCH | SC-N-RNTI | N/A |
| K2 | PDCCH | M-RNTI | N/A |
| L | PMCH | N/A (Note 8) | MCH |
| M | PDCCH | eIMTA-RNTI | N/A |
| N | PDCCH/EPDCCH | SL-RNTI | SL-SCH |
| N1 | PDCCH/EPDCCH | SL-V-RNTI | SL-SCH |
| N2 | PDCCH/EPDCCH | SL Semi-Persistent Scheduling V-RNTI | SL-SCH |

| | | | |
|---|---|---|---|
| O | PDCCH | CC-RNTI | N/A |
| P | PDCCH | SRS-TPC-RNTI (Note 10) | N/A |
| Q | PDCCH/EPDCCH | UL Semi-Persistent Scheduling V-RNTI | UL-SCH |
| Q1 | PDCCH/EPDCCH | UL Semi-Persistent Scheduling V-RNTI (Note 12) | N/A |
| R | PDCCH/EPDCCH | SL Semi-Persistent Scheduling V-RNTI (Note 13) | N/A |

Note 1: PDCCH or EPDCCH is used to convey PDCCH order for Random Access.
Note 2: Void.
Note 3: RA-RNTI and Temporary C-RNTI are mutually exclusive and only applicable during Random Access procedure.
Note 4: Temporary C-RNTI is only applicable when no valid C-RNTI is available.
Note 5: Temporary C-RNTI is only applicable during contention-based Random Access procedure.
Note 6: Semi-Persistent Scheduling C-RNTI is used for DL Semi-Persistent Scheduling release.
Note 7: Semi-Persistent Scheduling C-RNTI is used for UL Semi-Persistent Scheduling release.
Note 8: In MBSFN subframes only
Note 9: DL-SCH reception corresponding to D1, and UL-SCH transmission corresponding to F1, are only applicable to SCells.
Note 10: SRS-TPC-RNTI is used to trigger group SRS and TPC for SRS-only SCells. Up to 2 SRS-TPC-RNTI can be concurrently configured.
Note 11: For MBMS-dedicated carrier, SI-RNTI may be assigned with two values which may be used in same subframe.
Note 12: Used for release of an UL Semi-Persistent Scheduling associated with UL Semi-Persistent Scheduling V-RNTI.
Note 13: Used for release of an SL Semi-Persistent Scheduling associated with SL Semi-Persistent Scheduling V-RNTI.
Note 14: For a UE indicating the capability of decoding PDSCH and subslot/slot PDSCH assigned with C-RNTI/SPS C-RNTI in the same subframe for a given carrier.

**Table 8.2-1a: Downlink "Reception Types" for BL UEs and UEs in enhanced coverage**

| "Reception Type" | Physical Channel(s) | Monitored RNTI | Associated Transport Channel |
|---|---|---|---|
| A | PBCH | N/A | BCH |
| B | MPDCCH (Note 1) | C-RNTI | N/A |
| B1 | MPDCCH (Note 8) | C-RNTI | N/A |
| C | MPDCCH | TPC-PUCCH-RNTI | N/A |
| D | MPDCCH | TPC-PUSCH-RNTI | N/A |
| D1 | MPDCCH (Note 7) | SC-RNTI | DL-SCH |
| | | G-RNTI | DL-SCH |
| E | MPDCCH | Semi-Persistent Scheduling C-RNTI (Note 2) | N/A |
| F | MPDCCH | Semi-Persistent Scheduling C-RNTI (Note 3) | N/A |
| G | MPDCCH (Note 4) | RA-RNTI | DL-SCH |
| | | Temporary C-RNTI | UL-SCH |
| | | Temporary C-RNTI | DL-SCH |
| | | P-RNTI | PCH |
| H | PDSCH (Note 5) | SI-RNTI | DL-SCH |
| | | P-RNTI | PCH |
| | | Temporary C-RNTI | DL-SCH |
| | | RA-RNTI | DL-SCH |
| H1 | PDSCH (Note 7) | SC-RNTI | DL-SCH |
| | | G-RNTI | DL-SCH |
| I | MPDCCH | Temporary C-RNTI (Note 6) | UL-SCH |
| | | C-RNTI and Semi-Persistent Scheduling C-RNTI | UL-SCH |
| J | MPDCCH | C-RNTI and Semi-Persistent Scheduling C-RNTI | DL-SCH |
| K | PDSCH (Note 5) | C-RNTI and Semi-Persistent Scheduling C-RNTI | DL-SCH |
| L | MWUS | N/A | N/A |

Note 1: MPDCCH is used to convey PDCCH order for Random Access.
Note 2: Semi-Persistent Scheduling C-RNTI is used for DL Semi-Persistent Scheduling release.
Note 3: Semi-Persistent Scheduling C-RNTI is used for UL Semi-Persistent Scheduling release.
Note 4: RA-RNTI, P-RNTI, and Temporary C-RNTI are not required to be simultaneously monitored.
Note 5: All RNTIs listed in the reception type are mutually exclusive.
Note 6: Temporary C-RNTI is only applicable during contention-based Random Access procedure.
Note 7: SC-RNTI and G-RNTI are not required to be simultaneously monitored.
Note 8: MPDCCH is used to convey uplink HARQ ACK feedback.

**Table 8.2-1b: Downlink "Reception Types" for NB-IoT UEs**

| "Reception Type" | Physical Channel(s) | Monitored RNTI | Associated Transport Channel |
|---|---|---|---|
| A | NPBCH | N/A | BCH |
| B | NPDCCH (Note 2) | C-RNTI | N/A |
| C | NPDCCH | P-RNTI | PCH |
| D | NPDCCH | RA-RNTI (Note 1) | DL-SCH |
| | | Temporary C-RNTI (Note 1) | |
| D1 | NPDCCH (Note 3) | SC-RNTI | DL-SCH |
| | | G-RNTI | DL-SCH |
| E | NPDSCH | N/A | DL-SCH |
| F | NPDCCH | C-RNTI | DL-SCH |
| G | NPDCCH | C-RNTI | UL-SCH |
| H | NWUS | N/A | N/A |
| I | NPDCCH | Semi-Persistent Scheduling C-RNTI (Note 4) | N/A |
| J | NPDCCH | Semi-Persistent Scheduling C-RNTI | UL-SCH |

Note 1: RA-RNTI and Temporary C-RNTI are mutually exclusive and only applicable during Random Access procedure.
Note 2: NPDCCH is used to convey PDCCH order for Random Access.
Note 3: SC-RNTI and G-RNTI are not required to be simultaneously monitored.
Note 4: Semi-Persistent Scheduling C-RNTI is used for releasing SR with SPS BSR.

**Table 8.2-2: Downlink "Reception Type" Combinations except for NB-IoT UEs, BL UEs and UEs in enhanced coverage**

The "Reception Type" used in this table refers to the "Reception Type" in Table 8.2-1.

| | PCell | PSCell | SCell | Non-serving cell |
|---|---|---|---|---|
| 1. RRC_IDLE | | | | |
| 1.1 All UEs | A + B + C + D | | | |
| | Remarks: The combination for Random Access procedure is only required, related to D. | | | |
| 1.2 UEs supporting MBMS | K + L | | | |
| 1.3 UEs supporting SC-PTM | K1 + D2 | | | |
| 2. RRC_CONNECTED | | | | |
| 2.1 All UEs | A + B + (D or E or G or I) + (F or H or J) + M | A + (D or E or G or I) + (F or H or J) + M | (E or D1) + F1 | |
| 2.2 UEs supporting FS2 | A + B + (D or E or G or I) + (F or H or J) + F + M + P | A + (D or E or G or I) + (F or H or J) + F + M | (E or D1) + F1 | |
| | Remarks: For TDD UL/DL configuration 6 with special subframe configuration 10 and TDD UL/DL configuration 0, two PDCCHs or EPDCCHs can be received in the same subframe for UL-SCH in two different uplink subframes. | | | |
| 2.2a UEs supporting FS3 | | | D1 + F1 + O | |
| | Remarks: For FS3, up to four PDCCHs or EPDCCHs can be received in the same subframe for LAA UL-SCH in different FS3 uplink subframes. | | | |
| 2.3 UEs supporting MBMS | ((E or G or I) + L + K) or (A + B + D) + (F or H or J) + M | ((E or G or I) + L + K) or (A + B + D) + (F or H or J) + M | (E + L + K) or (D1 + B) + F1 | (A + B) or (L + K) |
| | Remarks: The combination is the requirement when MBMS reception is on PCell and/or any other cell. *r* is the number of DL CCs on which the UE supports MBMS reception according to the MBMSInterestIndication. The number of L and the number of K ≤ *r*.<br>Remarks: It is not required to simultaneously receive EPDCCH and PMCH on the same cell. | | | |
| 2.3a UEs supporting FeMBMS | | | (D1 + B + K2) or (L + K2) + F1 | (A + B1 + K2) or (L + K2) |
| | Remarks: The combination is the requirement when MBMS reception is on PCell and/or any other cell. *r* is the number of DL CCs on which the UE supports MBMS reception according to the MBMSInterestIndication. The number of L and the number of K2 ≤ *r*.<br>Remarks: It is not required to simultaneously receive EPDCCH and PMCH on the same cell. | | | |
| 2.4 MBMS UEs supporting FS2 | ((E or G or I) + L + K) or (A + B + D) + 1x(F or H or J) + F + M + P | ((E or G or I) + L + K) or (A + B + D) + 1x(F or H or J) + F + M | (E + L + K) or (D1 + B) + F1 | (A + B) or (L + K) |
| | Remarks: For TDD UL/DL configuration 6 with special subframe configuration 10 and TDD UL/DL configuration 0, two PDCCHs or EPDCCHs can be received in the same subframe for UL-SCH in two different uplink subframes.<br>Remarks: The combination is the requirement when MBMS reception is on PCell and/or any other cell. *r* is the number of DL CCs on which the UE supports MBMS reception according to the MBMSInterestIndication. The number of L and the number of K ≤ *r*.<br>Remarks: It is not required to simultaneously receive EPDCCH and PMCH on the same cell. | | | |
| 2.5 UEs supporting ETWS and CMAS | A + B + C + (D or E or G or I) + (F or H or J) + M | A + (D or E or G or I) + (F or H or J) + M | (E or D1) + F1 | |
| 2.6 ETWS and CMAS UEs supporting FS2 | A + B + C + (D or E or G or I) + (F or H or J) + F + M + P | A + (D or E or G or I) + (F or H or J) + F + M | (E or D1) + F1 | |
| | Remarks: For TDD UL/DL configuration 6 with special subframe configuration 10 and TDD UL/DL configuration 0, two PDCCHs or EPDCCHs can be received in the same subframe for UL-SCH in two different uplink subframes. | | | |
| 2.7 UEs supporting sidelink communication | A + B + (D or E or G or I) + (F or H or J) + M + N | | | |
| 2.7a UEs supporting V2X sidelink communication | A + B + (D or E or G or I) + (F or H or J or Q or Q1) + M + N1 + (N2 or R) | | | |

| | | | | |
|---|---|---|---|---|
| 2.7b UEs supporting V2X sidelink communication | A + B + (D or E or G or I) + (F or H or J or Q or Q1) +M | | | |
| | Remarks: The 2.7 and 2.7a combination is the requirement when the UE is configured in scheduled resource allocation mode, and the 2.7b combination is the requirement when the UE is configured in autonomous resource selection mode. | | | |
| 2.8 UEs supporting SC-PTM | A + B + (D or (K1 + D2) or (K1 + D3) or E or G or I) + (F or H or J) + M | A + B + (D or (K1 + D2) or (K1 + D3) or E or G or I) + (F or H or J) + M | B + (D1 or (K1 + D2) or (K1 + D3) or E) + F1 | A + B + K1+ D2 |
| | Remarks: The combination is the requirement when SC-PTM reception is on PCell and/or any other cell. *r* is the number of DL CCs on which the UE supports SC-PTM reception according to the MBMSInterestIndication. The number of K1 and the number of D2 ≤ *r*. | | | |
| 2.9 SC-PTM UEs supporting FS2 | A + B + (D or (K1 + D2) or (K1 + D3) or E or G or I) + (F or H or J) + F + M + P | A + B + (D or (K1 + D2) or (K1 + D3) or E or G or I) + (F or H or J) + F + M | B + (D1 or (K1 + D2) or (K1 + D3) or E) + F1 | A + B + K1+ D2 |
| | Remarks: For TDD UL/DL configuration 6 with special subframe configuration 10 and TDD UL/DL configuration 0, two PDCCHs or EPDCCHs can be received in the same subframe for UL-SCH in two different uplink subframes.<br>Remarks: The combination is the requirement when SC-PTM reception is on PCell and/or any other cell. *r* is the number of DL CCs on which the UE supports SC-PTM reception according to the MBMSInterestIndication. The number of K1 and the number of D2 ≤ *r*. | | | |
| NOTE 1: *p* is the number of DL CCs supported by the UE. The number of D1 is ≤ (*p*-1). *q* is the number of UL CCs supported by the UE. For UE not supporting FS2, the number of F1 is ≤ (*q*-1). For UE supporting FS2, the number of F1 is ≤ 2x(*q*-1). *q* = *p* = 1 implies non-CA capable UE. Only 1xE is possible at any subframe over all serving cells. 1xM is included if UE supports eIMTA.<br>NOTE 2: The UE is only required to receive one PDSCH, pertaining to D or D1 or D2 (if the UE supports SC-PTM) or D3 (if the UE supports the parallel reception of unicast and SC-PTM), per DL CC.<br>NOTE 3: If a UE indicating category 0 is scheduled with PDSCH transmissions exceeding its processing capability as specified in TS 36.306 [13], the prioritization between these PDSCH transmissions is up to the UE implementation.<br>NOTE 4: Combination involving EPDCCH is optional and required only for UE supporting EPDCCH.<br>NOTE 5: Combination involving SPDCCH and/or subslot/slot PDSCH is optional and required only for UE supporting SPDCCH and/or subslot/slot PDSCH.<br>NOTE 6: For UEs supporting FS2, for TDD UL/DL configuration 0 not configured with special subframe configuration 10 and TDD UL/DL configuration 6 not configured with special subframe configuration 10, two PDCCHs or SPDCCHs can be received in a slot for UL-SCH with a slot duration in two different uplink slots.<br>NOTE 7: For UEs supporting FS2, for TDD UL/DL configuration 0 with special subframe configuration 10 and TDD UL/DL configuration 6 with special subframe configuration 10, three PDCCHs can be received in a slot for UL-SCH with a slot duration in three different uplink slots or two SPDCCHs can be received in a slot for UL-SCH with a slot duration in two different uplink slots. | | | | |

**Table 8.2-2a: Downlink "Reception Type" Combinations for BL UEs and UEs in enhanced coverage**

The "Reception Type" used in this table refers to the "Reception Type" in Table 8.2-1a.

| | PCell |
|---|---|
| 1. RRC_IDLE | |
| 1.1 All UEs | A or G or H |
| 1.2 UEs supporting SC-PTM | A or G or H or (D1 + H1) |
| 1.3 UEs supporting MWUS | A or G or H or L |
| 2. RRC_CONNECTED | |
| 2.1 All UEs | A or ((((J or E or B) + (I or F or B1)) or C or D) + K) or G or H |
| | Remarks: The combination for Random Access procedure is only required, related to G and H.<br>Remarks: B1 is only applicable for UEs supporting uplink HARQ ACK feedback. |
| 2.2 UEs supporting FS2 | A or ((((J or E or B) + (I or F or B1)) or C or D) + I + K) or G or H |
| | Remarks: For TDD UL/DL configuration 0, two MPDCCHs can be received in the same subframe for UL-SCH in two different uplink subframes, which is only applicable for UEs configured with CE mode A with no repetitions.<br>Remarks: The combination for Random Access procedure is only required, related to G and H.<br>Remarks: B1 is only applicable for UEs supporting uplink HARQ ACK feedback. |

NOTE: Any subset of the combinations specified in table 8.2-2 and 8.2-2a are also supported.

The "reception type" names in Table 8.2-2b refer to the "reception types" from Table 8.2-1b.

**Table 8.2-2b: Downlink "Reception Type" Combinations for NB-IoT UEs**

| | PCell |
|---|---|
| 1. RRC_IDLE | |
| 1.1 All UEs | A or C or D or E |
| | Remarks: The combination for Random Access procedure is only required, related to D. |
| 1.2 UEs supporting SC-PTM | A or C or D or E or D1 |
| 1.3 UEs supporting NWUS | A or C or D or E or H |
| 2. RRC_CONNECTED | |
| 2.1 All UEs | A or B or D or F or G or E |
| 2.2 UEs supporting SR with SPS BSR | A or B or D or F or G or E or I or J |

# 8.3 Sidelink

The table 8.3-1 describes the possible combinations of physical channels that can be sent in parallel from UE perspective in the sidelink within the same subframe. Table 8.3-2 describes the possible combinations of physical channels that can be received in parallel from UE perspective in the sidelink within the same subframe.

**Table 8.3-1: Sidelink transmission**

| | Physical Channel Combination | Transport Channel Combination | Mandatory dependent on UE radio access capabilities | Comment |
|---|---|---|---|---|
| 1 | PSDCH | SL-DCH | Mandatory for UE supporting sidelink discovery | The UE supporting sidelink discovery transmits sidelink discovery messages on the camped cell (idle) or PCell (connected). |
| 2 | PSBCH | SL-BCH | Mandatory for UE supporting sidelink communication or V2X sidelink communication | The UE supporting sidelink communication or V2X sidelink communication transmits MasterInformationBlock-SL messages in PSBCH on one preconfigured frequency. |
| 3 | PSSCH | SL-SCH | Mandatory for UE supporting sidelink communication or V2X sidelink communication | The UE supporting sidelink communication or V2X sidelink communication transmits sidelink data in PSSCH on one preconfigured frequency. |
| 4 | PSCCH | N/A | Mandatory for UE supporting sidelink communication or V2X sidelink communication | The UE supporting sidelink communication or V2X sidelink communication transmits sidelink control information in PSCCH on one preconfigured frequency. |
| NOTE: Depending on the UE capability, the UE may be able to perform simultaneous Uplink and Sidelink transmissions. If the UE is unable to perform simultaneous Uplink and Sidelink transmissions, transmissions are prioritized according to TS 36.321 [12].<br>NOTE: Depending on the UE capability, the UE may be able to perform simultaneous sidelink communication transmissions (PSBCH or PSSCH or PSCCH) and sidelink discovery transmission (PSDCH). If the UE is unable to perform simultaneous transmission of sidelink communication and discovery, transmissions are prioritized according to TS 36.321 [12]. | | | | |

**Table 8.3-2: Sidelink reception**

| | Physical Channel Combination | Transport Channel Combination | Mandatory dependent on UE radio access capabilities | Comment |
|---|---|---|---|---|
| 1 | PSDCH | SL-DCH | Mandatory for UE supporting sidelink discovery | |
| 2 | PSBCH | SL-BCH | Mandatory for UE supporting sidelink communication or V2X sidelink communication | |
| 3 | PSSCH | SL-SCH | Mandatory for UE supporting sidelink communication or V2X sidelink communication | |
| 4 | PSCCH | N/A | Mandatory for UE supporting sidelink communication or V2X sidelink communication | |
| NOTE: For sidelink communication, the UE shall be able to perform simultaneous Downlink and sidelink communication reception. For sidelink discovery, depending on the UE capability, the UE may be able to perform simultaneous Downlink and sidelink discovery receptions. If the UE is unable to perform simultaneous Downlink and sidelink discovery receptions, receptions are prioritized according to TS 36.321 [12]. For V2X sidelink communication, the UE shall be able to perform simultaneous Downlink and V2X sidelink communication reception.<br>NOTE: If the configured resources for reception of sidelink communication and sidelink discovery are overlapped, receptions are prioritized according to TS 36.321 [12]. | | | | |

# 9 Measurements provided by the physical layer

## 9.1 Void

## 9.2 UE Measurements

The list and detailed definition of UE measurements definition is provided in TS 36.214 [11].

## 9.3 E-UTRAN Measurements

The list and detailed definition of E-UTRAN measurements definition is provided in TS 36.214 [11].

# Annex A (informative): Change history

| Change history | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date** | **TSG #** | **TSG Doc.** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 11/2006 | RP-34 | RP-060795 | - | | | First version : presented at TSG-RAN #34 and TSG-RAN WG2 #56 (11/2006) | 0.0.0 |
| 05/2007 | RP-36 | RP-xyztu | | | | Update including physical layer modelling: submitted at TSG-RAN WG2 #58 (05/2006) | 0.0.1 |
| 06/2007 | RP-37 | R2-072502 | | | | Update including physical Services and functions of the Physical Layer: presented and TSG-RAN WG2 #58bis (06/2006) | 0.0.2 |
| 06/2007 | RP-37 | R2-072931 | | | | Update after presentation at TSG-RAN WG2 #58bis : physical channel channel terminology used | 0.1.0 |
| 09/2007 | RP-37 | RP-070686 | | | | Removal of editor's notes. Presented at TSG-RAN #37 for information | 1.0.0 |
| 10/2007 | R2-59bis | R2-074579 | | | | Agreements in RAN1 LS received at RAN2#59 have to be implemented in the specification (by RAN2#59bis): Parallel reception of Physical Broadcast Channel (PBCH) and DL-SCH in the same TTI is feasible; 2 new measurements were introduced for LTE, UE measurement "Reference Signal Received Quality (RSRQ)" and eNode B measurement "DL RS TX power". | 1.0.2 |
| 10/2007 | R2-59bis | R2-074584 | | | | Removal of incorrect Parallel reception of physical channels | 1.0.3 |
| 11/2007 | RP-38 | RP-070914 | | | | Submission to RAN for RAN#38 approval | 2.0.0 |
| 12/2007 | RP-38 | - | | | | Apprpved at TSG RAN-38 and placed under change control | 8.0.0 |
| 03/2009 | RP-43 | RP-090124 | 0002 | - | | Proposed CR on Parallel reception in LTE | 8.1.0 |
| | RP-43 | RP-090124 | 0004 | - | | Correction of out-of-date information | 8.1.0 |
| 06/2009 | RP-44 | RP-090509 | 0005 | 1 | | Correction of MBMS | 8.2.0 |
| | RP-44 | RP-090509 | 0006 | - | | Downlink reception types | 8.2.0 |
| | RP-44 | RP-090509 | 0009 | - | | Simultaneous reception of transport channels in the LTE | 8.2.0 |
| | RP-44 | RP-090509 | 0010 | - | | Clarification on the parallel receptions for PDSCHs | 8.2.0 |
| 12/2009 | RP-46 | RP-091341 | 0011 | - | | Addition of MBMS reception types | 9.0.0 |
| | RP-46 | RP-091346 | 0012 | - | | Remove FFSs from RAN2 specifications | 9.0.0 |
| | RP-46 | RP-091345 | 0014 | - | | Proposed CR to 36.302 on Introduction of CMAS | 9.0.0 |
| 03/2010 | RP-47 | RP-100308 | 0019 | 1 | | Correction to RSRP and RSRQ definition with Receiver Diversity to align with TS 36.214 | 9.1.0 |
| 06/2010 | RP-48 | RP-100556 | 0020 | - | | Correction to RSRQ definition to align with TS 36.214 | 9.2.0 |
| 12/2010 | RP-50 | RP-101226 | 0021 | 3 | | Introduction of CA to TS36.302 | 10.0.0 |
| 03/2011 | RP-51 | RP-110289 | 0022 | 1 | | Correction to parallel reception and transmission for CA | 10.1.0 |
| | RP-51 | RP-110270 | 0025 | - | | Corrections to TS36.302 on MBMS | 10.1.0 |
| | RP-51 | RP-110289 | 0026 | - | | Update and correction to TS36.302 for CA | 10.1.0 |
| 06/2011 | RP-52 | RP-110839 | 0028 | - | | DL Assignment in MBSFN Subframe | 10.2.0 |
| 12/2011 | RP-54 | RP-111716 | 0029 | - | | Corrections to channel model | 10.3.0 |
| 03/2012 | RP-55 | RP-120326 | 0030 | 1 | | Correction to the combination of physical uplink channels | 10.4.0 |
| 09/2012 | RP-57 | RP-121350 | 0031 | - | | Introduction of parallel PRACH and PUSCH/PUCCH/SRS transmission | 11.0.0 |
| 12/2012 | RP-58 | RP-121951 | 0036 | - | | Correction to parallel PRACH, SRS and PUSCH/PUCCH transmission | 11.1.0 |
| | RP-58 | RP-121956 | 0037 | - | | Introduction of EPDCCH in TS 36.302 | 11.1.0 |
| 03/2013 | RP-59 | RP-130245 | 0041 | - | | Correction to parallel SRS and PUSCH/PUCCH transmission | 11.2.0 |
| 06/2013 | RP-60 | RP-130808 | 0043 | - | | Clarification on EPDCCH reception in MBSFN subframes | 11.3.0 |
| | RP-60 | RP-130808 | 0044 | - | | Correction on downlink reception type combinations for UEs supporting multiple TAGs | 11.3.0 |
| | RP-60 | RP-130808 | 0045 | - | | Downlink Reception Type Combinations for MBMS capable UE | 11.3.0 |
| 09/2013 | RP-61 | RP-131311 | 0047 | - | | Miscellaneous correction to 36.302 | 11.4.0 |
| 03/2014 | RP-63 | RP-140355 | 0049 | - | | MBMS reception on any configured or configurable SCell | 11.5.0 |
| 06/2014 | RP-64 | RP-140884 | 0050 | - | | Introduction of the Downlink Reception Types for TDD eIMTA | 12.0.0 |
| | RP-64 | RP-140892 | 0051 | - | | Correction on simultaneous DL physical channels for idle UE | 12.0.0 |
| 09/2014 | RP-65 | RP-141506 | 0054 | 1 | | Updates for low complexity UEs, and the improvements for the representation of the reception requirements | 12.1.0 |
| 12/2014 | RP-66 | RP-142135 | 0056 | - | | Introduction of dual connectivity | 12.2.0 |
| 03/2015 | RP-67 | RP-150376 | 0059 | - | | Removal of unnecessary requirement to receive MIB on SCell | 12.3.0 |
| 06/2015 | RP-68 | RP-150921 | 0060 | - | | Introduction of ProSe | 12.4.0 |
| 09/2015 | RP-69 | RP-151443 | 0061 | 1 | | TS36.302 rapporteur's cleanup | 12.5.0 |
| 12/2015 | RP-70 | RP-152053 | 0062 | - | | Corrections to Sidelink in TS 36.302 | 12.6.0 |
| 12/2015 | RP-70 | RP-152071 | 0063 | - | | Introduction of PUCCH on SCell in CA | 13.0.0 |
| | RP-70 | RP-152080 | 0064 | 1 | | Introduction of SC-PTM | 13.0.0 |
| 03/2016 | RP-71 | RP-160470 | 0065 | 1 | | Correction on CA enhancement | 13.1.0 |

| Change history | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Date** | **TSG #** | **TSG Doc.** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| | RP-71 | RP-160453 | 0066 | 2 | | The introduction of eMTC features | 13.1.0 |
| 06/2016 | RP-72 | RP-161078 | 0070 | - | | Corrections on the data modulation of Downlink-Shared Channel | 13.2.0 |
| | RP-72 | RP-161080 | 0071 | 1 | | Correction for sidelink | 13.2.0 |
| | RP-72 | RP-161080 | 0072 | 1 | | Corrections on sidelink related description in TS36.302 | 13.2.0 |
| | RP-72 | RP-161080 | 0073 | - | | SC-PTM reception on non-Pcell | 13.2.0 |
| | RP-72 | RP-161080 | 0074 | - | | Improvements for the representation of eMTC features | 13.2.0 |
| | RP-72 | RP-161081 | 0076 | 1 | | Introduction of NB-IoT in 36.302 | 13.2.0 |
| 09/2016 | RP-73 | RP-161758 | 0078 | - | | Corrections to NB-IoT downlink reception type combinations | 13.3.0 |
| | RP-73 | RP-161753 | 0079 | 1 | | Introduction of LAA | 13.3.0 |
| | RP-73 | RP-161751 | 0082 | 1 | | Introduction of MBSFN measurements | 13.3.0 |
| | RP-73 | RP-161762 | 0083 | 1 | | Introduction of RS-SINR measurement to 36.302 | 13.3.0 |
| | RP-73 | RP-161755 | 0084 | - | | Miscellaneous corrections on DL reception types | 13.3.0 |
| 09/2016 | RP-73 | RP-161746 | 0077 | 2 | | Introducing V2V to TS 36.302 | 14.0.0 |
| | RP-73 | RP-161745 | 0080 | 1 | | Introduction of eLAA | 14.0.0 |
| 12/2016 | RP-74 | RP-162318 | 0086 | - | | Miscellaneous corrections to TS 36.302 | 14.1.0 |
| | RP-74 | RP-162328 | 0087 | 2 | | Corrections on V2V descriptions in TS 36.302 | 14.1.0 |
| | RP-74 | RP-162324 | 0090 | 1 | | Inroduce the new RNTIs for SRS Carrier Based Switching | 14.1.0 |
| | RP-74 | RP-162315 | 0091 | 1 | | Clarification on Reception Type for SC-PTM | 14.1.0 |
| 03/2017 | RP-75 | RP-170643 | 0092 | - | F | Correction on the definition of sidelink in 36.302 | 14.2.0 |
| | RP-75 | RP-170656 | 0094 | 1 | A | Correction for MAC SDU and PDU for BCH in NB-IoT | 14.2.0 |
| | RP-75 | RP-170655 | 0096 | - | A | Correction on channel bandwidth definition for NB-IoT | 14.2.0 |
| | RP-75 | RP-170637 | 0097 | 2 | B | Introduction of Rel-14 NB-IoTEnhancements | 14.2.0 |
| | RP-75 | RP-170636 | 0098 | 2 | B | Introduction of Rel-14 FeMTC | 14.2.0 |
| | RP-75 | RP-170633 | 0099 | 1 | B | Introduction of FeMBMS to 36.302 | 14.2.0 |
| | RP-75 | RP-170635 | 0103 | 1 | B | Introducing V2X to TS 36.302 | 14.2.0 |
| 06/2017 | RP-76 | RP-171223 | 0105 | 2 | F | Correction to SC-MCCH and SC-MTCH reception type | 14.3.0 |
| | RP-76 | RP-171234 | 0107 | 1 | F | Correction on the data modulation of Uplink Shared Channel | 14.3.0 |
| | RP-76 | RP-171244 | 0109 | 1 | A | Correction to downlink reception types for BL UEs and UEs in CE | 14.3.0 |
| | RP-76 | RP-171221 | 0112 | 1 | F | Correction to Downlink Reception Type Combinations for FeMBMS | 14.3.0 |
| 12/2017 | RP-78 | RP-172617 | 0114 | 2 | F | Correction to V2X descriptions in TS 36.302 | 14.4.0 |
| | RP-78 | RP-172616 | 0115 | 3 | F | Correction on downlink reception type combination for SC-PTM in feMTC | 14.4.0 |
| | RP-78 | RP-172624 | 0117 | 1 | A | Correction to description of uplink and downlink shared channel physical layer model for MTC and NB-IoT. | 14.4.0 |
| | RP-78 | RP-172615 | 1191 | 1 | F | Table 8.2-2 correction of the remarks for DL reception type of Sidelink and FeMBMS and move of EPDCCH remark to the bottom of the table | 14.4.0 |
| 06/2018 | RP-80 | RP-181218 | 1192 | 2 | B | Introduction of shortened TTI and processing time for LTE | 15.0.0 |
| | RP-80 | RP-181252 | 1193 | 1 | B | Introduction of Rel-15 NB-IoT enhancementsin 36.302 | 15.0.0 |
| | RP-80 | RP-181224 | 1194 | - | B | Introduction of Rel-15 eMTC enhancements in 36.302 | 15.0.0 |
| 12/2018 | RP-82 | RP-182671 | 1195 | 2 | F | Minor corrections to services provided by physical layer | 15.1.0 |
| | RP-82 | RP-182678 | 1196 | 2 | F | Correction on MCS for V2X sidelink communication in TS 36.302 | 15.1.0 |
| 03/2019 | RP-83 | RP-190549 | 1198 | 2 | F | Number of PDCCH/EPDCCH/SPDCCH received parallel | 15.2.0 |
| | RP-83 | RP-190552 | 1199 | 1 | F | Correction on PDCCH order | 15.2.0 |
| | RP-83 | RP-190549 | 1201 | - | A | Correction on PDCCH reception type combinations on CSS | 15.2.0 |
| 07/2020 | RP-88 | RP-201167 | 1206 | 1 | A | Correction on reception type combination for eMTC | 15.3.0 |
| | RP-88 | RP-201168 | 1208 | 2 | F | Adding Reception Type for uplink HARQ ACK feedback for Rel-15 eMTC | 15.3.0 |

# History

| Document history | | |
|---|---|---|
| V15.0.0 | July 2018 | Publication |
| V15.1.0 | April 2019 | Publication |
| V15.2.0 | May 2019 | Publication |
| V15.3.0 | July 2020 | Publication |
| | | |