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Physical channels and modulation

(Release 18)

** 

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# Foreword

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

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

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z the third digit is incremented when editorial only changes have been incorporated in the document.

# 1 Scope

The present document describes the physical channels and signals for 5G-NR.

# 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 38.201: "NR; Physical Layer – General Description"

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

[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"

[8] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception"

[9] void

[10] 3GPP TS 38.306: "NR; User Equipment (UE) radio access capabilities"

[11] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification"

[12] 3GPP TS 38.133: "NR; Requirements for support of radio resource management"

[13] 3GPP TS 38.304: "NR; User Equipment (UE) procedures in Idle mode and RRC Inactive state"

[14] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone"

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

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

## 3.2 Symbols

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

 Resource element with frequency-domain index  and time-domain index  for antenna port  and subcarrier spacing configuration ; see clause 4.4.3

 Value of resource element  for antenna port and subcarrier spacing configuration ; see clause 4.4.3

 Amplitude scaling for a physical channel/signal

 PN sequence; see clause 5.2.1

 Subcarrier spacing

 Subcarrier spacing for random-access preambles

The ratio between  and ; see clause 4.1

 Subcarrier index relative to a reference

 OFDM symbol index relative to a reference

Subcarrier spacing configuration,

Number of coded bits to transmit on a physical channel [for codeword ]

Number of modulation symbols to transmit on a physical channel [for codeword ]

Number of modulation symbols to transmit per layer for a physical channel

Scheduled bandwidth for uplink transmission, expressed as a number of subcarriers

Scheduled bandwidth for uplink transmission, expressed as a number of resource blocks

Number of modulation symbols to transmit per antenna port for a physical channel

 Number of transmission layers

Size of bandwidth part ; see clause 4.4.4.4

Start of bandwidth part ; see clause 4.4.4.4

Cyclic prefix length; see clause 5.3.1

The size of the resource grid; see clauses 4.4.2 and 5.3

The start of the resource grid; see clause 4.4.2

The number of PT-RS groups; see clause 6.3.1.4

Physical layer cell identity; see clause 7.4.2.1

Physical-layer sidelink identity; see clause 8.4.2.1

Frequency-domain size of a control resource set; see clause 7.3.2.2

Number of resource-element groups in a CORESET; see clause 7.3.2.2

Number of samples per PT-RS group; see clause 6.3.1.4

Number of subcarriers per resource block, see clause 4.4.4.1

Number of slots per subframe for subcarrier spacing configuration , see clause 4.3.2

Number of slots per frame for subcarrier spacing configuration , see clause 4.3.2

Time duration of a control resource set; see clause 7.3.2.2

Length of the PUCCH transmission in OFDM symbols; see clause 6.3.2.1

Number of OFDM symbols per subframe for subcarrier spacing configuration ; see clause 4.3.1

Number of symbols per slot

Timing advance between downlink and uplink; see clause 4.3.1

A fixed offset used to calculate the timing advance; see clause 4.3.1

Network-controlled timing correction; see clause 4.3.1

UE-derived timing correction; see clause 4.3.1

Minimum time from reception to transmission for a half-duplex UE; see clause 4.3.2

System frame number (SFN)

Common resource block number for subcarrier spacing configuration , see clause 4.4.4.3

Hyper-frame number

Physical resource block number; see clause 4.4.4.4

Radio network temporary identifier

Slot number within a subframe for subcarrier spacing configuration ; see clause 4.3.2

Slot number within a frame for subcarrier spacing configuration ; see clause 4.3.2

Antenna port number

 Modulation order

 Number of antenna ports

Low-PAPR base sequence; see clause 5.2.2

Low-PAPR sequence; see clause 5.2.2

The time-continuous signal on antenna port and subcarrier spacing configuration for OFDM symbol  in a subframe; see clause 5.3.1

 Basic time unit for NR; see clause 4.1

 Radio frame duration; see clause 4.3.1

 Basic time unit for LTE

 Subframe duration; see clause 4.3.1

 Slot duration; see clause 4.3.2

 Timing advance between downlink and uplink; see clause 4.3.1

 Precoding matrix for spatial multiplexing

## 3.3 Abbreviations

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

BWP Bandwidth Part

CCE Control Channel Element

CORESET Control Resource Set

CRB Common Resource Block

CSI Channel-State Information

CSI-RS CSI Reference Signal

DCI Downlink Control Information

DM-RS Demodulation Reference Signal

FR1 Frequency Range 1 as defined in TS 38.104 [8]

FR2 Frequency Range 2 as defined in TS 38.104 [8]

IAB Integrated Access and Backhaul

IAB-MT IAB Mobile Termination

IE Information Element

NCR Network-Controlled repeater

NCR-MT NCR Mobile Termination

PBCH Physical Broadcast Channel

PDCCH Physical Downlink Control Channel

PDSCH Physical Downlink Shared Channel

PRACH Physical Random-Access Channel

PRB Physical Resource Block

PSS Primary Synchronization Signal

PT-RS Phase-tracking reference signal

PUCCH Physical Uplink Control Channel

PUSCH Physical Uplink Shared Channel

RAR Random Access Response

REG Resource-Element Group

RIM Remote Interference Management

RIM-RS Remote Interference Management Reference Signal

SRS Sounding Reference Signal

SSS Secondary Synchronization Signal

VRB Virtual Resource Block

# 4 Frame structure and physical resources

## 4.1 General

Throughout this specification, unless otherwise noted, the size of various fields in the time domain is expressed in time units  where Hz and . The constant  where ,  and .

Throughout this specification, unless otherwise noted, statements using the term "UE" in clauses 4, 5, 6, or 7 are equally applicable to the IAB-MT part of an IAB-node and the NCR-MT part of an NCR node.

## 4.2 Numerologies

Multiple OFDM numerologies are supported as given by Table 4.2-1 where and the cyclic prefix for a downlink or uplink bandwidth part are obtained from the higher-layer parameters *subcarrierSpacing* and *cyclicPrefix*, respectively.

Table 4.2-1: Supported transmission numerologies.

|  |  |  |
| --- | --- | --- |
|  |  | Cyclic prefix |
| 0 | 15 | Normal |
| 1 | 30 | Normal |
| 2 | 60 | Normal, Extended |
| 3 | 120 | Normal |
| 4 | 240 | Normal |
| 5 | 480 | Normal |
| 6 | 960 | Normal |

## 4.3 Frame structure

### 4.3.1 Frames and subframes

Downlink, uplink, and sidelink transmissions are organized into frames with  duration, each consisting of ten subframes of  duration. The number of consecutive OFDM symbols per subframe is . Each frame is divided into two equally-sized half-frames of five subframes each with half-frame 0 consisting of subframes 0 – 4 and half-frame 1 consisting of subframes 5 – 9.

There is one set of frames in the uplink and one set of frames in the downlink on a carrier.

Uplink frame number  for transmission from the UE shall start before the start of the corresponding downlink frame at the UE where

- and are given by clause 4.2 of [5, TS 38.213], except for msgA transmission on PUSCH where shall be used;

- given by clause 4.2 of [5, TS 38.213] is derived from the higher-layer parameters *ta-Common*, *ta-CommonDrift*, and *ta-CommonDriftVariant* if configured, otherwise ;

- given by clause 4.2 of [5, TS 38.213] is computed by the UE based on UE position and serving-satellite-ephemeris-related higher-layers parameters if configured, otherwise .



Figure 4.3.1-1: Uplink-downlink timing relation.

### 4.3.2 Slots

For subcarrier spacing configuration , slots are numbered in increasing order within a subframe and in increasing order within a frame. There are  consecutive OFDM symbols in a slot where  depends on the cyclic prefix as given by Tables 4.3.2-1 and 4.3.2-2. The start of slot in a subframe is aligned in time with the start of OFDM symbol  in the same subframe.

OFDM symbols in a slot in a downlink or uplink frame can be classified as 'downlink', 'flexible', or 'uplink'. Signaling of slot formats is described in clause 11.1 of [5, TS 38.213].

In a slot in a downlink frame, the UE shall assume that downlink transmissions only occur in 'downlink' or 'flexible' symbols.

In a slot in an uplink frame, the UE shall only transmit in 'uplink' or 'flexible' symbols.

A UE not capable of full-duplex communication and not supporting simultaneous transmission and reception as defined by parameter *simultaneousRxTxInterBandENDC, simultaneousRxTxInterBandCA or simultaneousRxTxSUL* [10, TS 38.306] among all cells within a group of cells is not expected to transmit in the uplink in one cell within the group of cells earlier than after the end of the last received downlink symbol in the same or different cell within the group of cells where is given by Table 4.3.2-3.

A UE not capable of full-duplex communication and not supporting simultaneous transmission and reception as defined by parameter *simultaneousRxTxInterBandENDC*, *simultaneousRxTxInterBandCA* *or simultaneousRxTxSUL* [10, TS 38.306] among all cells within a group of cells is not expected to receive in the downlink in one cell within the group of cells earlier than after the end of the last transmitted uplink symbol in the same or different cell within the group of cells where is given by Table 4.3.2-3.

For DAPS handover operation, a UE not capable of full-duplex communication is not expected to transmit in the uplink to a cell earlier than after the end of the last received downlink symbol in the different cell where is given by Table 4.3.2-3.

For DAPS handover operation, a UE not capable of full-duplex communication is not expected to receive in the downlink from a cell earlier than after the end of the last transmitted uplink symbol in the different cell where is given by Table 4.3.2-3.

A UE not capable of full-duplex communication is not expected to transmit in the uplink earlier than after the end of the last received downlink symbol in the same cell where is given by Table 4.3.2-3.

A UE not capable of full-duplex communication is not expected to receive in the downlink earlier than after the end of the last transmitted uplink symbol in the same cell where is given by Table 4.3.2-3.

Table 4.3.2-1: Number of OFDM symbols per slot, slots per frame, and slots per subframe for normal cyclic prefix.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 0 | 14 | 10 | 1 |
| 1 | 14 | 20 | 2 |
| 2 | 14 | 40 | 4 |
| 3 | 14 | 80 | 8 |
| 4 | 14 | 160 | 16 |
| 5 | 14 | 320 | 32 |
| 6 | 14 | 640 | 64 |

Table 4.3.2-2: Number of OFDM symbols per slot, slots per frame, and slots per subframe for extended cyclic prefix.

|  |  |  |  |
| --- | --- | --- | --- |
|  |  |  |  |
| 2 | 12 | 40 | 4 |

Table 4.3.2-3: Transition time and

|  |  |  |
| --- | --- | --- |
| **Transition time** | **FR1** | **FR2** |
|  | 25600 | 13792 |
|  | 25600 | 13792 |

## 4.4 Physical resources

### 4.4.1 Antenna ports

An antenna port is defined such that the channel over which a symbol on the antenna port is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed.

Two antenna ports are said to be quasi co-located if the large-scale properties of the channel over which a symbol on one antenna port is conveyed can be inferred from the channel over which a symbol on the other antenna port is conveyed. The large-scale properties include one or more of delay spread, Doppler spread, Doppler shift, average gain, average delay, and spatial Rx parameters.

### 4.4.2 Resource grid

For each numerology and carrier, a resource grid of  subcarriers and OFDM symbols is defined, starting at common resource block  indicated by higher-layer signalling. There is one set of resource grids per transmission direction (uplink, downlink, or sidelink) with the subscript set to DL, UL, and SL for downlink, uplink, and sidelink, respectively. When there is no risk for confusion, the subscript may be dropped. There is one resource grid for a given antenna port , subcarrier spacing configuration , and transmission direction (downlink, uplink, or sidelink).

For uplink and downlink, the carrier bandwidth for subcarrier spacing configuration is given by the higher-layer parameter *carrierBandwidth* in the *SCS-SpecificCarrier* IE. The starting position for subcarrier spacing configuration is given by the higher-layer parameter *offsetToCarrier* in the *SCS-SpecificCarrier* IE.

The frequency location of a subcarrier refers to the center frequency of that subcarrier.

For the downlink, the higher-layer parameter *txDirectCurrentLocation* in the *SCS-SpecificCarrier* IE indicates the location of the transmitter DC subcarrier in the downlink for each of the numerologies configured in the downlink. Values in the range 0 – 3299 represent the number of the DC subcarrier and the value 3300 indicates that the DC subcarrier is located outside the resource grid.

For the uplink, the higher-layer parameter *txDirectCurrentLocation* in the *UplinkTxDirectCurrentBWP* IE indicates the location of the transmitter DC subcarrier in the uplink for each of the configured bandwidth parts, including whether the DC subcarrier location is offset by 7.5 kHz relative to the center of the indicated subcarrier or not. Values in the range 0 – 3299 represent the number of the DC subcarrier, the value 3300 indicates that the DC subcarrier is located outside the resource grid, and the value 3301 indicates that the position of the DC subcarrier in the uplink is undetermined.

### 4.4.3 Resource elements

Each element in the resource grid for antenna port and subcarrier spacing configuration is called a resource element and is uniquely identified by where  is the index in the frequency domain and  refers to the symbol position in the time domain relative to some reference point. Resource element corresponds to a physical resource and the complex value . When there is no risk for confusion, or no particular antenna port or subcarrier spacing is specified, the indices and may be dropped, resulting in or .

### 4.4.4 Resource blocks

#### 4.4.4.1 General

A resource block is defined as consecutive subcarriers in the frequency domain.

#### 4.4.4.2 Point A

Point A serves as a common reference point for resource block grids and is obtained from:

- *offsetToPointA* for a PCell downlink where *offsetToPointA* represents the frequency offset between point A and the lowest subcarrier of the lowest resource block, which overlaps with the SS/PBCH block, or the SS/PBCH block after puncturing if applicable, used by the UE for initial cell selection, expressed in units of resource blocks assuming 15 kHz subcarrier spacing for FR1 and 60 kHz subcarrier spacing for FR2;

- for operation without shared spectrum channel access in FR1 and FR2-1, the lowest resource block has the subcarrier spacing provided by the higher layer parameter *subCarrierSpacingCommon*;

- for operation with shared spectrum channel access in FR1 or FR2, and for operation without shared spectrum channel access in FR2-2, the lowest resource block has the subcarrier spacing same as the SS/PBCH block used by the UE for initial cell selection;

- *absoluteFrequencyPointA* for all other cases where *absoluteFrequencyPointA* represents the frequency-location of point A expressed as in ARFCN.

#### 4.4.4.3 Common resource blocks

Common resource blocks are numbered from 0 and upwards in the frequency domain for subcarrier spacing configuration . The center of subcarrier 0 of common resource block 0 for subcarrier spacing configuration coincides with 'point A'.

The relation between the common resource block number in the frequency domain and resource elements  for subcarrier spacing configuration is given by



where  is defined relative to point A such that corresponds to the subcarrier centered around point A.

#### 4.4.4.4 Physical resource blocks

Physical resource blocks for subcarrier spacing configuration are defined within a bandwidth part and numbered from 0 to where is the number of the bandwidth part. The relation between the physical resource block in bandwidth part and the common resource block is given by

where is the common resource block where bandwidth part starts relative to common resource block 0. When there is no risk for confusion the index may be dropped.

#### 4.4.4.5 Virtual resource blocks

Virtual resource blocks are defined within a bandwidth part and numbered from 0 to where is the number of the bandwidth part.

#### 4.4.4.6 Interlaced resource blocks

Multiple interlaces of resource blocks are defined where interlace consists of common resource blocks , with being the number of interlaces given by Table 4.4.4.6-1. The relation between the interlaced resource block in bandwidth part and interlace and the common resource block is given by

where is the common resource block where bandwidth part starts relative to common resource block 0. When there is no risk for confusion the index may be dropped.

The UE expects that the number of common resource blocks in an interlace contained within bandwidth part is no less than 10.

Table 4.4.4.6-1: The number of resource block interlaces.

|  |  |
| --- | --- |
|  |  |
| 0 | 10 |
| 1 | 5 |

### 4.4.5 Bandwidth part

A bandwidth part is a subset of contiguous common resource blocks defined in clause 4.4.4.3 for a given numerology  in bandwidth part  on a given carrier. The starting position and the number of resource blocks in a bandwidth part shall fulfil and , respectively. Configuration of a bandwidth part is described in clause 12 of [5, TS 38.213].

A UE can be configured with up to four bandwidth parts in the downlink with a single downlink bandwidth part being active at a given time. The UE is not expected to receive PDSCH, PDCCH, or CSI-RS (except for RRM) outside an active bandwidth part.

A UE can be configured with up to four bandwidth parts in the uplink with a single uplink bandwidth part being active at a given time. If a UE is configured with a supplementary uplink, the UE can in addition be configured with up to four bandwidth parts in the supplementary uplink with a single supplementary uplink bandwidth part being active at a given time. The UE shall not transmit PUSCH or PUCCH outside an active bandwidth part. For an active cell, the UE shall not transmit SRS outside an active bandwidth part.

Unless otherwise noted, the description in this specification applies to each of the bandwidth parts. When there is no risk of confusion, the index may be dropped from , , , and .

### 4.4.6 Common MBS frequency resource

A common MBS frequency resource is a contiguous set of common resource blocks. The starting position of the common MBS frequency resource is defined relative to point A and the size of the common MBS frequency resource is given by . Resource blocks in a common MBS frequency resource are numbered in the same way as resource blocks in clause 4.4.4.4 with and replaced by and , respectively.

A UE is not expected to receive PDSCH or PDCCH associated with MBS transmissions scheduled with G-RNTI, G-CS-RNTI, MCCH-RNTI, or multicast-MCCH-RNTI outside the common MBS frequency resource.

## 4.5 Carrier aggregation

Transmissions in multiple cells can be aggregated. Unless otherwise noted, the description in this specification applies to each of the serving cells.

For carrier aggregation of cells with unaligned frame boundaries, the slot offset between a PCell/PScell and an SCell is determined by higher-layer parameter *ca-SlotOffset* for the SCell. The quantity is defined as the maximum of the lowest subcarrier spacing configuration among the subcarrier spacings given by the higher-layer parameters *scs-SpecificCarrierList* configured for PCell/PSCell and the SCell, respectively. The slot offset fulfills

- when the lowest subcarrier spacing configuration among the subcarrier spacings configured for the cell is for both cells or for both cells, the start of slot 0 for the cell whose point A has a lower frequency coincides with the start of slot for the other cell where if point A of the PCell/PSCell has a frequency lower than the frequency of point A for the SCell, otherwise ;

- otherwise, the start of slot 0 for the cell with the lower subcarrier spacing of the lowest subcarrier spacing given by the higher-layer parameters *scs-SpecificCarrierList* configured for the two cells, or the Pcell/PSCell if both cells have the same lowest subcarrier spacing given by the higher-layer parameters *scs-SpecificCarrierList* configured for the two cells, coincides with the start of slot for the other cell where if the lowest subcarreier spacing configuration given by *scs-SpecificCarrierList* of the PCell/PSCell is smaller than or equal to the lowest subcarrier spacing given by *scs-SpecificCarrierList* for the SCell, otherwise .

# 5 Generic functions

## 5.1 Modulation mapper

The modulation mapper takes binary digits, 0 or 1, as input and produces complex-valued modulation symbols as output.

### 5.1.1 π/2-BPSK

In case of π/2-BPSK modulation, bit  is mapped to complex-valued modulation symbol  according to



### 5.1.2 BPSK

In case of BPSK modulation, bit  is mapped to complex-valued modulation symbol  according to



### 5.1.3 QPSK

In case of QPSK modulation, pairs of bits, , are mapped to complex-valued modulation symbols  according to



### 5.1.4 16QAM

In case of 16QAM modulation, quadruplets of bits, , are mapped to complex-valued modulation symbols  according to



### 5.1.5 64QAM

In case of 64QAM modulation, hextuplets of bits, , are mapped to complex-valued modulation symbols  according to



### 5.1.6 256QAM

In case of 256QAM modulation, octuplets of bits, , are mapped to complex-valued modulation symbols  according to



### 5.1.7 1024QAM

In case of 1024QAM modulation, 10-tuplets of bits, , are mapped to complex-valued modulation symbols according to

## 5.2 Sequence generation

### 5.2.1 Pseudo-random sequence generation

Generic pseudo-random sequences are defined by a length-31 Gold sequence. The output sequence  of length, where, is defined by



where and the first m-sequence  shall be initialized with. The initialization of the second m-sequence, , is denoted by  with the value depending on the application of the sequence.

### 5.2.2 Low-PAPR sequence generation type 1

The low-PAPR sequence  is defined by a cyclic shift  of a base sequence  according to



where is the length of the sequence. Multiple sequences are defined from a single base sequence through different values of and .

Base sequences  are divided into groups, where  is the group number and  is the base sequence number within the group, such that each group contains one base sequence () of each length ,  and two base sequences () of each length , . The definition of the base sequence  depends on the sequence length .

#### 5.2.2.1 Base sequences of length 36 or larger

For, the base sequence  is given by



where



The length  is given by the largest prime number such that.

#### 5.2.2.2 Base sequences of length less than 36

For  the base sequence is given by



where the value of  is given by Tables 5.2.2.2-1 to 5.2.2.2-4.

For , the base sequence  is given by



Table 5.2.2.2-1: Definition of  for.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | |
| 0 | -3 | -1 | 3 | 3 | -1 | -3 |
| 1 | -3 | 3 | -1 | -1 | 3 | -3 |
| 2 | -3 | -3 | -3 | 3 | 1 | -3 |
| 3 | 1 | 1 | 1 | 3 | -1 | -3 |
| 4 | 1 | 1 | 1 | -3 | -1 | 3 |
| 5 | -3 | 1 | -1 | -3 | -3 | -3 |
| 6 | -3 | 1 | 3 | -3 | -3 | -3 |
| 7 | -3 | -1 | 1 | -3 | 1 | -1 |
| 8 | -3 | -1 | -3 | 1 | -3 | -3 |
| 9 | -3 | -3 | 1 | -3 | 3 | -3 |
| 10 | -3 | 1 | 3 | 1 | -3 | -3 |
| 11 | -3 | -1 | -3 | 1 | 1 | -3 |
| 12 | 1 | 1 | 3 | -1 | -3 | 3 |
| 13 | 1 | 1 | 3 | 3 | -1 | 3 |
| 14 | 1 | 1 | 1 | -3 | 3 | -1 |
| 15 | 1 | 1 | 1 | -1 | 3 | -3 |
| 16 | -3 | -1 | -1 | -1 | 3 | -1 |
| 17 | -3 | -3 | -1 | 1 | -1 | -3 |
| 18 | -3 | -3 | -3 | 1 | -3 | -1 |
| 19 | -3 | 1 | 1 | -3 | -1 | -3 |
| 20 | -3 | 3 | -3 | 1 | 1 | -3 |
| 21 | -3 | 1 | -3 | -3 | -3 | -1 |
| 22 | 1 | 1 | -3 | 3 | 1 | 3 |
| 23 | 1 | 1 | -3 | -3 | 1 | -3 |
| 24 | 1 | 1 | 3 | -1 | 3 | 3 |
| 25 | 1 | 1 | -3 | 1 | 3 | 3 |
| 26 | 1 | 1 | -1 | -1 | 3 | -1 |
| 27 | 1 | 1 | -1 | 3 | -1 | -1 |
| 28 | 1 | 1 | -1 | 3 | -3 | -1 |
| 29 | 1 | 1 | -3 | 1 | -1 | -1 |

Table 5.2.2.2-2: Definition of  for.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | | | | | | |
| 0 | -3 | 1 | -3 | -3 | -3 | 3 | -3 | -1 | 1 | 1 | 1 | -3 |
| 1 | -3 | 3 | 1 | -3 | 1 | 3 | -1 | -1 | 1 | 3 | 3 | 3 |
| 2 | -3 | 3 | 3 | 1 | -3 | 3 | -1 | 1 | 3 | -3 | 3 | -3 |
| 3 | -3 | -3 | -1 | 3 | 3 | 3 | -3 | 3 | -3 | 1 | -1 | -3 |
| 4 | -3 | -1 | -1 | 1 | 3 | 1 | 1 | -1 | 1 | -1 | -3 | 1 |
| 5 | -3 | -3 | 3 | 1 | -3 | -3 | -3 | -1 | 3 | -1 | 1 | 3 |
| 6 | 1 | -1 | 3 | -1 | -1 | -1 | -3 | -1 | 1 | 1 | 1 | -3 |
| 7 | -1 | -3 | 3 | -1 | -3 | -3 | -3 | -1 | 1 | -1 | 1 | -3 |
| 8 | -3 | -1 | 3 | 1 | -3 | -1 | -3 | 3 | 1 | 3 | 3 | 1 |
| 9 | -3 | -1 | -1 | -3 | -3 | -1 | -3 | 3 | 1 | 3 | -1 | -3 |
| 10 | -3 | 3 | -3 | 3 | 3 | -3 | -1 | -1 | 3 | 3 | 1 | -3 |
| 11 | -3 | -1 | -3 | -1 | -1 | -3 | 3 | 3 | -1 | -1 | 1 | -3 |
| 12 | -3 | -1 | 3 | -3 | -3 | -1 | -3 | 1 | -1 | -3 | 3 | 3 |
| 13 | -3 | 1 | -1 | -1 | 3 | 3 | -3 | -1 | -1 | -3 | -1 | -3 |
| 14 | 1 | 3 | -3 | 1 | 3 | 3 | 3 | 1 | -1 | 1 | -1 | 3 |
| 15 | -3 | 1 | 3 | -1 | -1 | -3 | -3 | -1 | -1 | 3 | 1 | -3 |
| 16 | -1 | -1 | -1 | -1 | 1 | -3 | -1 | 3 | 3 | -1 | -3 | 1 |
| 17 | -1 | 1 | 1 | -1 | 1 | 3 | 3 | -1 | -1 | -3 | 1 | -3 |
| 18 | -3 | 1 | 3 | 3 | -1 | -1 | -3 | 3 | 3 | -3 | 3 | -3 |
| 19 | -3 | -3 | 3 | -3 | -1 | 3 | 3 | 3 | -1 | -3 | 1 | -3 |
| 20 | 3 | 1 | 3 | 1 | 3 | -3 | -1 | 1 | 3 | 1 | -1 | -3 |
| 21 | -3 | 3 | 1 | 3 | -3 | 1 | 1 | 1 | 1 | 3 | -3 | 3 |
| 22 | -3 | 3 | 3 | 3 | -1 | -3 | -3 | -1 | -3 | 1 | 3 | -3 |
| 23 | 3 | -1 | -3 | 3 | -3 | -1 | 3 | 3 | 3 | -3 | -1 | -3 |
| 24 | -3 | -1 | 1 | -3 | 1 | 3 | 3 | 3 | -1 | -3 | 3 | 3 |
| 25 | -3 | 3 | 1 | -1 | 3 | 3 | -3 | 1 | -1 | 1 | -1 | 1 |
| 26 | -1 | 1 | 3 | -3 | 1 | -1 | 1 | -1 | -1 | -3 | 1 | -1 |
| 27 | -3 | -3 | 3 | 3 | 3 | -3 | -1 | 1 | -3 | 3 | 1 | -3 |
| 28 | 1 | -1 | 3 | 1 | 1 | -1 | -1 | -1 | 1 | 3 | -3 | 1 |
| 29 | -3 | 3 | -3 | 3 | -3 | -3 | 3 | -1 | -1 | 1 | 3 | -3 |

Table 5.2.2.2-3: Definition of  for 

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | | | | | | | | | | | | |
| 0 | -1 | 3 | -1 | -3 | 3 | 1 | -3 | -1 | 3 | -3 | -1 | -1 | 1 | 1 | 1 | -1 | -1 | -1 |
| 1 | 3 | -3 | 3 | -1 | 1 | 3 | -3 | -1 | -3 | -3 | -1 | -3 | 3 | 1 | -1 | 3 | -3 | 3 |
| 2 | -3 | 3 | 1 | -1 | -1 | 3 | -3 | -1 | 1 | 1 | 1 | 1 | 1 | -1 | 3 | -1 | -3 | -1 |
| 3 | -3 | -3 | 3 | 3 | 3 | 1 | -3 | 1 | 3 | 3 | 1 | -3 | -3 | 3 | -1 | -3 | -1 | 1 |
| 4 | 1 | 1 | -1 | -1 | -3 | -1 | 1 | -3 | -3 | -3 | 1 | -3 | -1 | -1 | 1 | -1 | 3 | 1 |
| 5 | 3 | -3 | 1 | 1 | 3 | -1 | 1 | -1 | -1 | -3 | 1 | 1 | -1 | 3 | 3 | -3 | 3 | -1 |
| 6 | -3 | 3 | -1 | 1 | 3 | 1 | -3 | -1 | 1 | 1 | -3 | 1 | 3 | 3 | -1 | -3 | -3 | -3 |
| 7 | 1 | 1 | -3 | 3 | 3 | 1 | 3 | -3 | 3 | -1 | 1 | 1 | -1 | 1 | -3 | -3 | -1 | 3 |
| 8 | -3 | 1 | -3 | -3 | 1 | -3 | -3 | 3 | 1 | -3 | -1 | -3 | -3 | -3 | -1 | 1 | 1 | 3 |
| 9 | 3 | -1 | 3 | 1 | -3 | -3 | -1 | 1 | -3 | -3 | 3 | 3 | 3 | 1 | 3 | -3 | 3 | -3 |
| 10 | -3 | -3 | -3 | 1 | -3 | 3 | 1 | 1 | 3 | -3 | -3 | 1 | 3 | -1 | 3 | -3 | -3 | 3 |
| 11 | -3 | -3 | 3 | 3 | 3 | -1 | -1 | -3 | -1 | -1 | -1 | 3 | 1 | -3 | -3 | -1 | 3 | -1 |
| 12 | -3 | -1 | -3 | -3 | 1 | 1 | -1 | -3 | -1 | -3 | -1 | -1 | 3 | 3 | -1 | 3 | 1 | 3 |
| 13 | 1 | 1 | -3 | -3 | -3 | -3 | 1 | 3 | -3 | 3 | 3 | 1 | -3 | -1 | 3 | -1 | -3 | 1 |
| 14 | -3 | 3 | -1 | -3 | -1 | -3 | 1 | 1 | -3 | -3 | -1 | -1 | 3 | -3 | 1 | 3 | 1 | 1 |
| 15 | 3 | 1 | -3 | 1 | -3 | 3 | 3 | -1 | -3 | -3 | -1 | -3 | -3 | 3 | -3 | -1 | 1 | 3 |
| 16 | -3 | -1 | -3 | -1 | -3 | 1 | 3 | -3 | -1 | 3 | 3 | 3 | 1 | -1 | -3 | 3 | -1 | -3 |
| 17 | -3 | -1 | 3 | 3 | -1 | 3 | -1 | -3 | -1 | 1 | -1 | -3 | -1 | -1 | -1 | 3 | 3 | 1 |
| 18 | -3 | 1 | -3 | -1 | -1 | 3 | 1 | -3 | -3 | -3 | -1 | -3 | -3 | 1 | 1 | 1 | -1 | -1 |
| 19 | 3 | 3 | 3 | -3 | -1 | -3 | -1 | 3 | -1 | 1 | -1 | -3 | 1 | -3 | -3 | -1 | 3 | 3 |
| 20 | -3 | 1 | 1 | -3 | 1 | 1 | 3 | -3 | -1 | -3 | -1 | 3 | -3 | 3 | -1 | -1 | -1 | -3 |
| 21 | 1 | -3 | -1 | -3 | 3 | 3 | -1 | -3 | 1 | -3 | -3 | -1 | -3 | -1 | 1 | 3 | 3 | 3 |
| 22 | -3 | -3 | 1 | -1 | -1 | 1 | 1 | -3 | -1 | 3 | 3 | 3 | 3 | -1 | 3 | 1 | 3 | 1 |
| 23 | 3 | -1 | -3 | 1 | -3 | -3 | -3 | 3 | 3 | -1 | 1 | -3 | -1 | 3 | 1 | 1 | 3 | 3 |
| 24 | 3 | -1 | -1 | 1 | -3 | -1 | -3 | -1 | -3 | -3 | -1 | -3 | 1 | 1 | 1 | -3 | -3 | 3 |
| 25 | -3 | -3 | 1 | -3 | 3 | 3 | 3 | -1 | 3 | 1 | 1 | -3 | -3 | -3 | 3 | -3 | -1 | -1 |
| 26 | -3 | -1 | -1 | -3 | 1 | -3 | 3 | -1 | -1 | -3 | 3 | 3 | -3 | -1 | 3 | -1 | -1 | -1 |
| 27 | -3 | -3 | 3 | 3 | -3 | 1 | 3 | -1 | -3 | 1 | -1 | -3 | 3 | -3 | -1 | -1 | -1 | 3 |
| 28 | -1 | -3 | 1 | -3 | -3 | -3 | 1 | 1 | 3 | 3 | -3 | 3 | 3 | -3 | -1 | 3 | -3 | 1 |
| 29 | -3 | 3 | 1 | -1 | -1 | -1 | -1 | 1 | -1 | 3 | 3 | -3 | -1 | 1 | 3 | -1 | 3 | -1 |

Table 5.2.2.2-4: Definition of  for 

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | -1 | -3 | 3 | -1 | 3 | 1 | 3 | -1 | 1 | -3 | -1 | -3 | -1 | 1 | 3 | -3 | -1 | -3 | 3 | 3 | 3 | -3 | -3 | -3 |
| 1 | -1 | -3 | 3 | 1 | 1 | -3 | 1 | -3 | -3 | 1 | -3 | -1 | -1 | 3 | -3 | 3 | 3 | 3 | -3 | 1 | 3 | 3 | -3 | -3 |
| 2 | -1 | -3 | -3 | 1 | -1 | -1 | -3 | 1 | 3 | -1 | -3 | -1 | -1 | -3 | 1 | 1 | 3 | 1 | -3 | -1 | -1 | 3 | -3 | -3 |
| 3 | 1 | -3 | 3 | -1 | -3 | -1 | 3 | 3 | 1 | -1 | 1 | 1 | 3 | -3 | -1 | -3 | -3 | -3 | -1 | 3 | -3 | -1 | -3 | -3 |
| 4 | -1 | 3 | -3 | -3 | -1 | 3 | -1 | -1 | 1 | 3 | 1 | 3 | -1 | -1 | -3 | 1 | 3 | 1 | -1 | -3 | 1 | -1 | -3 | -3 |
| 5 | -3 | -1 | 1 | -3 | -3 | 1 | 1 | -3 | 3 | -1 | -1 | -3 | 1 | 3 | 1 | -1 | -3 | -1 | -3 | 1 | -3 | -3 | -3 | -3 |
| 6 | -3 | 3 | 1 | 3 | -1 | 1 | -3 | 1 | -3 | 1 | -1 | -3 | -1 | -3 | -3 | -3 | -3 | -1 | -1 | -1 | 1 | 1 | -3 | -3 |
| 7 | -3 | 1 | 3 | -1 | 1 | -1 | 3 | -3 | 3 | -1 | -3 | -1 | -3 | 3 | -1 | -1 | -1 | -3 | -1 | -1 | -3 | 3 | 3 | -3 |
| 8 | -3 | 1 | -3 | 3 | -1 | -1 | -1 | -3 | 3 | 1 | -1 | -3 | -1 | 1 | 3 | -1 | 1 | -1 | 1 | -3 | -3 | -3 | -3 | -3 |
| 9 | 1 | 1 | -1 | -3 | -1 | 1 | 1 | -3 | 1 | -1 | 1 | -3 | 3 | -3 | -3 | 3 | -1 | -3 | 1 | 3 | -3 | 1 | -3 | -3 |
| 10 | -3 | -3 | -3 | -1 | 3 | -3 | 3 | 1 | 3 | 1 | -3 | -1 | -1 | -3 | 1 | 1 | 3 | 1 | -1 | -3 | 3 | 1 | 3 | -3 |
| 11 | -3 | 3 | -1 | 3 | 1 | -1 | -1 | -1 | 3 | 3 | 1 | 1 | 1 | 3 | 3 | 1 | -3 | -3 | -1 | 1 | -3 | 1 | 3 | -3 |
| 12 | 3 | -3 | 3 | -1 | -3 | 1 | 3 | 1 | -1 | -1 | -3 | -1 | 3 | -3 | 3 | -1 | -1 | 3 | 3 | -3 | -3 | 3 | -3 | -3 |
| 13 | -3 | 3 | -1 | 3 | -1 | 3 | 3 | 1 | 1 | -3 | 1 | 3 | -3 | 3 | -3 | -3 | -1 | 1 | 3 | -3 | -1 | -1 | -3 | -3 |
| 14 | -3 | 1 | -3 | -1 | -1 | 3 | 1 | 3 | -3 | 1 | -1 | 3 | 3 | -1 | -3 | 3 | -3 | -1 | -1 | -3 | -3 | -3 | 3 | -3 |
| 15 | -3 | -1 | -1 | -3 | 1 | -3 | -3 | -1 | -1 | 3 | -1 | 1 | -1 | 3 | 1 | -3 | -1 | 3 | 1 | 1 | -1 | -1 | -3 | -3 |
| 16 | -3 | -3 | 1 | -1 | 3 | 3 | -3 | -1 | 1 | -1 | -1 | 1 | 1 | -1 | -1 | 3 | -3 | 1 | -3 | 1 | -1 | -1 | -1 | -3 |
| 17 | 3 | -1 | 3 | -1 | 1 | -3 | 1 | 1 | -3 | -3 | 3 | -3 | -1 | -1 | -1 | -1 | -1 | -3 | -3 | -1 | 1 | 1 | -3 | -3 |
| 18 | -3 | 1 | -3 | 1 | -3 | -3 | 1 | -3 | 1 | -3 | -3 | -3 | -3 | -3 | 1 | -3 | -3 | 1 | 1 | -3 | 1 | 1 | -3 | -3 |
| 19 | -3 | -3 | 3 | 3 | 1 | -1 | -1 | -1 | 1 | -3 | -1 | 1 | -1 | 3 | -3 | -1 | -3 | -1 | -1 | 1 | -3 | 3 | -1 | -3 |
| 20 | -3 | -3 | -1 | -1 | -1 | -3 | 1 | -1 | -3 | -1 | 3 | -3 | 1 | -3 | 3 | -3 | 3 | 3 | 1 | -1 | -1 | 1 | -3 | -3 |
| 21 | 3 | -1 | 1 | -1 | 3 | -3 | 1 | 1 | 3 | -1 | -3 | 3 | 1 | -3 | 3 | -1 | -1 | -1 | -1 | 1 | -3 | -3 | -3 | -3 |
| 22 | -3 | 1 | -3 | 3 | -3 | 1 | -3 | 3 | 1 | -1 | -3 | -1 | -3 | -3 | -3 | -3 | 1 | 3 | -1 | 1 | 3 | 3 | 3 | -3 |
| 23 | -3 | -1 | 1 | -3 | -1 | -1 | 1 | 1 | 1 | 3 | 3 | -1 | 1 | -1 | 1 | -1 | -1 | -3 | -3 | -3 | 3 | 1 | -1 | -3 |
| 24 | -3 | 3 | -1 | -3 | -1 | -1 | -1 | 3 | -1 | -1 | 3 | -3 | -1 | 3 | -3 | 3 | -3 | -1 | 3 | 1 | 1 | -1 | -3 | -3 |
| 25 | -3 | 1 | -1 | -3 | -3 | -1 | 1 | -3 | -1 | -3 | 1 | 1 | -1 | 1 | 1 | 3 | 3 | 3 | -1 | 1 | -1 | 1 | -1 | -3 |
| 26 | -1 | 3 | -1 | -1 | 3 | 3 | -1 | -1 | -1 | 3 | -1 | -3 | 1 | 3 | 1 | 1 | -3 | -3 | -3 | -1 | -3 | -1 | -3 | -3 |
| 27 | 3 | -3 | -3 | -1 | 3 | 3 | -3 | -1 | 3 | 1 | 1 | 1 | 3 | -1 | 3 | -3 | -1 | 3 | -1 | 3 | 1 | -1 | -3 | -3 |
| 28 | -3 | 1 | -3 | 1 | -3 | 1 | 1 | 3 | 1 | -3 | -3 | -1 | 1 | 3 | -1 | -3 | 3 | 1 | -1 | -3 | -3 | -3 | -3 | -3 |
| 29 | 3 | -3 | -1 | 1 | 3 | -1 | -1 | -3 | -1 | 3 | -1 | -3 | -1 | -3 | 3 | -1 | 3 | 1 | 1 | -3 | 3 | -3 | -3 | -3 |

### 5.2.3 Low-PAPR sequence generation type 2

The low-PAPR sequence is defined by a base sequence according to

where is the length of the sequence.

Base sequences are divided into groups, where is the group number and is the base sequence number within the group, such that each group contains one base sequence () of length , . The sequence is defined by

where the definition of depends on the sequence length.

#### 5.2.3.1 Sequences of length 30 or larger

For , the sequence is obtained as the complex-valued modulations symbols resulting from π/2-BPSK modulation as defined in clause 5.1.1 applied to the binary sequence given by clause 5.2.1, initialized with .

#### 5.2.3.2 Sequences of length less than 30

For , the sequence is given by

where the value of is given by Table 5.2.3.2-1.

For , the sequence is obtained as the complex-valued modulations symbols resulting from π/2-BPSK modulation as defined in clause 5.1.1 applied to the binary sequence given by Tables 5.2.3.2-2 to 5.2.3.2-4.

Table 5.2.3.2-1: Definition of for .

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | |
| 0 | -1 | -7 | -3 | -5 | -1 | 3 |
| 1 | -1 | 3 | 7 | -3 | 7 | 3 |
| 2 | -1 | 3 | 1 | 5 | -1 | -5 |
| 3 | -7 | -3 | -7 | 5 | -7 | -3 |
| 4 | 7 | 5 | -1 | -7 | -3 | 1 |
| 5 | 3 | -3 | 1 | 5 | -1 | -1 |
| 6 | -7 | -3 | -7 | -3 | 7 | -5 |
| 7 | -7 | -3 | 1 | -5 | -1 | -5 |
| 8 | -7 | -3 | 3 | -3 | -7 | -3 |
| 9 | -7 | -7 | -1 | 1 | -5 | 1 |
| 10 | -7 | -3 | -7 | 5 | -1 | 5 |
| 11 | -7 | -7 | -3 | 1 | 5 | -1 |
| 12 | 5 | 7 | -3 | -5 | 5 | -5 |
| 13 | -3 | 7 | -5 | -1 | -5 | -1 |
| 14 | 5 | -7 | 7 | 1 | 5 | 1 |
| 15 | -7 | 3 | 1 | 5 | -1 | 3 |
| 16 | -7 | -5 | -1 | -7 | -5 | 5 |
| 17 | -7 | 1 | -3 | 3 | 7 | 5 |
| 18 | -7 | -7 | 3 | 5 | 1 | 5 |
| 19 | -7 | -3 | 3 | -1 | 3 | -5 |
| 20 | -7 | -5 | 5 | 3 | -7 | -1 |
| 21 | 1 | 5 | 1 | 5 | 3 | 7 |
| 22 | 1 | -3 | 1 | -5 | -1 | 3 |
| 23 | 1 | 7 | 1 | -5 | -7 | -1 |
| 24 | 1 | -1 | 3 | -1 | -7 | -3 |
| 25 | 1 | -1 | -5 | -1 | 3 | -3 |
| 26 | 1 | -1 | 3 | -1 | 3 | 7 |
| 27 | -5 | 3 | 7 | 5 | 3 | 7 |
| 28 | -7 | 1 | -3 | 1 | 5 | 1 |
| 29 | 1 | 5 | 3 | -7 | 5 | -3 |

Table 5.2.3.2-2: Definition of for .

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 3 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 |
| 4 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 |
| 5 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 6 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 |
| 7 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 8 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| 9 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 10 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| 11 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 12 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| 13 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 |
| 14 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 15 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| 16 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 |
| 17 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 |
| 18 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| 19 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 20 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 |
| 21 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 22 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 23 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 |
| 24 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 |
| 25 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 |
| 26 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 27 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 |
| 28 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 29 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |

Table 5.2.3.2-3: Definition of for .

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 |
| 3 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 |
| 4 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 |
| 5 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| 6 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 |
| 7 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 |
| 8 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 9 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| 10 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 |
| 11 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 12 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 |
| 13 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| 14 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 |
| 15 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| 16 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 |
| 17 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 |
| 18 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 19 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 |
| 20 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 |
| 21 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| 22 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 |
| 23 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 |
| 24 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| 25 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 |
| 26 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 |
| 27 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 28 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 |
| 29 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 |

Table 5.2.3.2-4: Definition of for

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | | | | | | | | | | | | | | | | | | |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 |
| 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |
| 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| 4 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |
| 5 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 1 |
| 6 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| 7 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 0 | 1 |
| 8 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 |
| 9 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 |
| 10 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 |
| 11 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 |
| 12 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 13 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 |
| 14 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 |
| 15 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 16 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 |
| 17 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 |
| 18 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| 19 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 |
| 20 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0 |
| 21 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 |
| 22 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 1 |
| 23 | 1 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 |
| 24 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 |
| 25 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| 26 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 |
| 27 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| 28 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |
| 29 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 1 |

## 5.3 OFDM baseband signal generation

### 5.3.1 OFDM baseband signal generation for all channels except PRACH and RIM-RS

The time-continuous signal  on antenna port and subcarrier spacing configuration for OFDM symbol  in a subframe for any physical channel or signal except PRACH is defined by

where at the start of the subframe,



and

-  is given by clause 4.2;

-  is the subcarrier spacing configuration;

- is the largest value among the subcarrier spacing configurations by *scs-SpecificCarrierList* for each of uplink and downlink and by *sl-SCS-SpecificCarrierList* for sidelink.

The starting position of OFDM symbol for subcarrier spacing configuration in a subframe is given by

In case of cyclic prefix extension of the first OFDM symbol allocated for PUSCH, SRS, PUCCH, PSCCH/PSSCH, PSFCH, or S-SS/PSBCH block transmission, the time-continuous signal for the interval preceding the first OFDM symbol for PUSCH, SRS, PUCCH, PSCCH/PSSCH, PSFCH, or S-SS/PSBCH block is given by

where refers to the signal in the previous subframe and

- for dynamically scheduled PUSCH, SRS, and PUCCH transmissions

where is given by Table 5.3.1-1 with for , for , and and given by the higher-layer parameters *cp-ExtensionC2* and *cp-ExtensionC3*, respectively, and given by clause 4.3.1. For contention-based random access, or in absence of higher-layer configuration of and , the value of shall be set to the largest integer fulfilling for each of the values of . *Text* is applied to the first UL transmission scheduled by the scheduling DCI.

- for a PUSCH transmission using configured grant

where is given by Table 5.3.1-2 with the index given by the procedure in [6, TS 38.214].

- for PSCCH/PSSCH, PSFCH, and S-SS/PSBCH block transmission

where and are given by Table 5.3.1-3 with the index given by the procedure in [5, TS 38.213] or [6, TS 38.214].

Table 5.3.1-1: The variables and for uplink cyclic prefix extension

|  |  |  |
| --- | --- | --- |
| index |  |  |
| 0 | - | - |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |

Table 5.3.1-2: The variable for uplink cyclic prefix extension with configured grants.

|  |  |
| --- | --- |
| index |  |
| 0 |  |
| 1 |  |
| 2 |  |
| 3 |  |
| 4 |  |
| 5 |  |
| 6 |  |

Table 5.3.1-3: The variables and for sidelink cyclic prefix extension

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Index |  | |  | |  | |
|  |  |  |  |  |  |
| 0 | - | - | - | - | - | - |
| 1 | 1 |  | 1 |  | 1 |  |
| 2 | 1 |  | 1 |  | 2 |  |
| 3 | 1 |  | 2 |  | 2 |  |
| 4 | 1 |  | 2 |  | - | - |
| 5 | 1 |  | 2 |  | - | - |
| 6 | 1 |  | 2 |  | - | - |
| 7 | - | - | 2 |  | - | - |
| 8 | - | - | 2 |  | - | - |

### 5.3.2 OFDM baseband signal generation for PRACH

The time-continuous signal  on antenna port for PRACH is defined by

where  and

-  is given by clause 6.3.3;

-  is the subcarrier spacing of the initial uplink bandwidth part during initial access. Otherwise,  is the subcarrier spacing of the active uplink bandwidth part;

- is the largest value among the subcarrier spacing configurations by the higher-layer parameter *scs-SpecificCarrierList*;

- is the lowest numbered resource block of the initial uplink bandwidth part and is derived by the higher-layer parameter *initialUplinkBWP* during initial access. Otherwise, is the lowest numbered resource block of the active uplink bandwidth part and is derived by the higher-layer parameter *BWP-Uplink*;



- is the frequency offset of the lowest PRACH transmission occasion in frequency domain with respect to physical resource block 0 of the active uplink bandwidth part. The quantity is given by the higher-layer parameter *msgA-RO-FrequencyStart* if configured and a type-2 random-access procedure is initiated as described in clause 8.1 of [5, TS 38.213], otherwise by *msg1-FrequencyStart* as described in clause 8.1 of [5 TS 38.213];

- is the PRACH transmission occasion index in frequency domain for a given PRACH transmission occasion in one time instance as given by clause 6.3.3.2;



- is the number of resource blocks occupied and is given by the parameter allocation expressed in number of RBs for PUSCH in Table 6.3.3.2-1.



- is the start CRB index of uplink RB set corresponding to the quantity . The UE assumes that the RB set is defined as when the UE is not provided *IntraCellGuardBandsPerSCS* for an UL carrier as described in Clause 7 of [6, TS 38.214]

- is the index of the RB set which contains the lowest PRACH transmission occasion in frequency domain indicated by . The UE may assume that is configured such that each PRACH transmission occasion is fully contained within an RB set.

-  and  are given by clause 6.3.3

- where

- for ,

- for kHz, is the number of times the interval overlaps with either time instance 0 or time instance  in a subframe

The starting position of the PRACH preamble in a subframe (for ) or in a 60 kHz slot (for kHz) is given by



where

- the subframe or 60 kHz slot is assumed to start at ;

- a timing advance value shall be assumed;

- and are given by clause 5.3.1;

- shall be assumed for kHz, otherwise the value of corresponds to kHz and the symbol position is given by



where

- is given by the parameter "starting symbol" in Tables 6.3.3.2-2 to 6.3.3.2-4;



- is the PRACH transmission occasion within the PRACH slot, numbered in increasing order from 0 to within a RACH slot where is given Tables 6.3.3.2-2 to 6.3.3.2-4 for and fixed to 1 for ;



- is given by Tables 6.3.3.2-2 to 6.3.3.2-4;



- is given by



- if kHz, then



- if kHz and either of "Number of PRACH slots within a subframe" in Tables 6.3.3.2-2 to 6.3.3.2-3 or "Number of PRACH slots within a 60 kHz slot" in Table 6.3.3.2-4 is equal to 1, then , otherwise

- if kHz and

- the "Number of PRACH slots within a 60 kHz slot" in Table 6.3.3.2-4 is equal to 1, then for kHz and for kHz, or

- the "Number of PRACH slots within a 60 kHz slot" in Table 6.3.3.2-4 is equal to 2, then for kHz and for kHz.

If the preamble format given by Tables 6.3.3.2-2 to 6.3.3.2-4 is A1/B1, A2/B2 or A3/B3, then

- if , then the PRACH preamble with the corresponding PRACH preamble format from B1, B2 and B3 is transmitted in the PRACH transmission occasion;

- otherwise the PRACH preamble with the corresponding PRACH preamble format from A1, A2 and A3 is transmitted in the PRACH transmission occasion

### 5.3.3 OFDM baseband signal generation for RIM-RS

The time-continuous signal on antenna port for RIM-RS is defined by

where

and

- where is the subcarrier spacing configuration for the RIM-RS;

- is the starting frequency offset of the RIM-RS as given by clause 7.4.1.6.4.3;

- is the length of the RIM-RS sequence where is the bandwidth of the RIM-RS in resource blocks;

- is the starting symbol given by clause 7.4.1.6.3;

- is given by clause 5.3.1 with ;

- is given by clause 5.3.1 with .

## 5.4 Modulation and upconversion

Modulation and upconversion to the carrier frequency  of the complex-valued OFDM baseband signal for antenna port , subcarrier spacing configuration , and OFDM symbol  in a subframe assumed to start at  is given by

- for PRACH

- for RIM-RS

where is the configured reference point for RIM-RS;

- for all other channels and signals



NOTE: For the uplink, the signal and the baseband signals part thereof should be filtered per UEimplementation, as required, to meet the minimum requirements as specified in [38.101-1] and [38.101-2] for the respective frequency range.

# 6 Uplink

## 6.1 Overview

### 6.1.1 Overview of physical channels

An uplink physical channel corresponds to a set of resource elements carrying information originating from higher layers. The following uplink physical channels are defined:

- Physical Uplink Shared Channel, PUSCH

- Physical Uplink Control Channel, PUCCH

- Physical Random Access Channel, PRACH

### 6.1.2 Overview of physical signals

An uplink physical signal is used by the physical layer but does not carry information originating from higher layers. The following uplink physical signals are defined:

- Demodulation reference signals, DM-RS

- Phase-tracking reference signals, PT-RS

- Sounding reference signal, SRS

## 6.2 Physical resources

The frame structure and physical resources the UE shall use when transmitting in the uplink transmissions are defined in Clause 4.

The following antenna ports are defined for the uplink:

- Antenna ports starting with 0 for demodulation reference signals for PUSCH

- Antenna ports starting with 1000 for SRS, PUSCH

- Antenna ports starting with 2000 for PUCCH

- Antenna port 4000 for PRACH

If PUSCH repetition Type B as described in clause 6.1 of [6, TS38.214] is applied to a physical channel, the UE transmission shall be such that the channel over which a symbol on the antenna port used for uplink transmission is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed if the two symbols correspond to the same actual repetition of a PUSCH transmission with repetition Type B.

If intra-slot frequency hopping is not enabled for a physical channel and PUSCH repetition Type B is not applied to the physical channel, the UE transmission shall be such that the channel over which a symbol on the antenna port used for uplink transmission is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed if the two symbols correspond to the same slot.

If intra-slot frequency hopping is enabled for a physical channel, the UE transmission shall be such that the channel over which a symbol on the antenna port used for uplink transmission is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed only if the two symbols correspond to the same frequency hop, regardless of whether the frequency hop distance is zero or not.

If DM-RS bundling is applied to PUSCH and/or PUCCH repetitions and/or transport-block processing over multiple slots as described in clause 6.1.7 of [6, 38.214], the UE transmission shall be such that the channel over which a symbol on the antenna port used for uplink transmission is conveyed can be inferred from the channel over which another symbol on the same antenna port is conveyed if the two symbols are transmitted within the same actual time-domain window.

## 6.3 Physical channels

### 6.3.1 Physical uplink shared channel

#### 6.3.1.1 Scrambling

Up to two codewords can be transmitted. In case of single-codeword transmission, .

For each codeword, the block of bits , where is the number of bits in codeword transmitted on the physical channel, shall be scrambled prior to modulation, resulting in a block of scrambled bits according to the following pseudo code

Set *i* = 0

while

if  // UCI placeholder bits



else

if  // UCI placeholder bits



else



end if

end if

*i* = *i* + 1

end while

where x and y are tags defined in [4, TS 38.212] and where the scrambling sequence is given by clause 5.2.1. The scrambling sequence generator shall be initialized with

where

- equals the higher-layer parameter *dataScramblingIdentityPUSCH* if configured and the RNTI equals the C-RNTI, MCS-C-RNTI, SP-CSI-RNTI or CS-RNTI, and the transmission is not scheduled using DCI format 0\_0 in a common search space;

- equals the higher-layer parameter *msgA-DataScramblingIndex* if configured and the PUSCH transmission is triggered by a Type-2 random access procedure as described in clause 8.1A of [5, TS 38.213];

- otherwise

- is the index of the random-access preamble transmitted for msgA as described in clause 5.1.3A of [11, TS 38.321]

and where equals the RA-RNTI for msgA and otherwise corresponds to the RNTI associated with the PUSCH transmission as described in clause 6.1 of [6, TS 38.214] and clause 8.3 of [5, TS 38.213].



#### 6.3.1.2 Modulation

For each codeword , the block of scrambled bits shall be modulated as described in clause 5.1 using one of the modulation schemes in Table 6.3.1.2-1, resulting in a block of complex-valued modulation symbols .

Table 6.3.1.2-1: Supported modulation schemes.

|  |  |  |  |
| --- | --- | --- | --- |
| **Transform precoding disabled** | | **Transform precoding enabled** | |
| **Modulation scheme** | **Modulation order** | **Modulation scheme** | **Modulation order** |
|  |  | π/2-BPSK | 1 |
| QPSK | 2 | QPSK | 2 |
| 16QAM | 4 | 16QAM | 4 |
| 64QAM | 6 | 64QAM | 6 |
| 256QAM | 8 | 256QAM | 8 |

#### 6.3.1.3 Layer mapping

The complex-valued modulation symbols for each of the codewords to be transmitted shall be mapped onto up to four layers according to Table 7.3.1.3-1. Complex-valued modulation symbols for codeword shall be mapped onto the layers , where is the number of layers and is the number of modulation symbols per layer.

#### 6.3.1.4 Transform precoding

If transform precoding is not enabled according to 6.1.3 of [6, TS38.214],  for each layer .

If transform precoding is enabled according to 6.1.3 of [6, TS38.214], and  depends on the configuration of phase-tracking reference signals.

If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are not being used, the block of complex-valued symbols for the single layer shall be divided into sets, each corresponding to one OFDM symbol and .

If the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are being used, the block of complex-valued symbols shall be divided into sets, each set corresponding to one OFDM symbol, and where set  contains  symbols and is mapped to the complex-valued symbols corresponding to OFDM symbol  prior to transform precoding, with and . The index of PT-RS samples in set , the number of samples per PT-RS group , and the number of PT-RS groups are defined in clause 6.4.1.2.2.2. The quantity  when OFDM symbol  contains one or more PT-RS samples, otherwise .

Transform precoding shall be applied according to



resulting in a block of complex-valued symbols . The variable, where  represents the bandwidth of the PUSCH in terms of resource blocks, and shall fulfil



where  is a set of non-negative integers.

#### 6.3.1.5 Precoding

The block of vectors shall be precoded according to

where , . The set of antenna ports shall be determined according to the procedure in [6, TS 38.214].

For non-codebook-based transmission, the precoding matrix equals the identity matrix.

For codebook-based transmission, the precoding matrix depends on the number of antenna ports used for the transmission:

- for single-layer transmission on a single antenna port, ;

- for transmissions using 2, or 4 antenna ports, is given by Tables 6.3.1.5-1 to 6.3.1.5-7;

- for transmissions using 8 antenna ports, is given by

where

- the subscripts and denote the row of the respective matrix;

- is given by Table 6.3.1.5-8;

- the intermediate precoding matrix is given by Tables 6.3.1.5-9 to 6.3.1.5-24, 6.3.1.5-29 to 6.3.1.5-36, and 6.3.1.5-39 to 6.3.1.5-47 with representing the all-zero matrix with rows and columns;

- the submatrices are given by Tables 6.3.1.5-25 to 6.3.1.5-28 and 6.3.1.5-37 to 6.3.1.5-38.

The TPMI index used in the tables above is obtained from the DCI scheduling the uplink transmission or the higher layer parameters according to the procedure in [6, TS 38.214].

When the higher-layer parameter *txConfig* is not configured, the precoding matrix .

Table 6.3.1.5-1: Precoding matrix for single-layer transmission using two antenna ports.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TPMI index | (ordered from left to right in increasing order of TPMI index) | | | | | | | |
| 0 – 5 |  |  |  |  |  |  | - | - |

Table 6.3.1.5-2: Precoding matrix for single-layer transmission using four antenna ports with transform precoding enabled.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TPMI index | (ordered from left to right in increasing order of TPMI index) | | | | | | | |
| 0 – 7 |  |  |  |  |  |  |  |  |
| 8 – 15 |  |  |  |  |  |  |  |  |
| 16 – 23 |  |  |  |  |  |  |  |  |
| 24 – 27 |  |  |  |  | - | - | - | - |

Table 6.3.1.5-3: Precoding matrix for single-layer transmission using four antenna ports with transform precoding disabled.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| TPMI index | (ordered from left to right in increasing order of TPMI index) | | | | | | | |
| 0 – 7 |  |  |  |  |  |  |  |  |
| 8 – 15 |  |  |  |  |  |  |  |  |
| 16 – 23 |  |  |  |  |  |  |  |  |
| 24 – 27 |  |  |  |  | - | - | - | - |

Table 6.3.1.5-4: Precoding matrix for two-layer transmission using two antenna ports with transform precoding disabled.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| TPMI index | (ordered from left to right in increasing order of TPMI index) | | | |
| 0 – 2 |  |  |  | - |

Table 6.3.1.5-5: Precoding matrix for two-layer transmission using four antenna ports with transform precoding disabled.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| TPMI index | (ordered from left to right in increasing order of TPMI index) | | | |
| 0 – 3 |  |  |  |  |
| 4 – 7 |  |  |  |  |
| 8 – 11 |  |  |  |  |
| 12 – 15 |  |  |  |  |
| 16 – 19 |  |  |  |  |
| 20 – 21 |  |  | - | - |

Table 6.3.1.5-6: Precoding matrix for three-layer transmission using four antenna ports with transform precoding disabled.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| TPMI index | (ordered from left to right in increasing order of TPMI index) | | | |
| 0 – 3 |  |  |  |  |
| 4 – 6 |  |  |  | - |

Table 6.3.1.5-7: Precoding matrix for four-layer transmission using four antenna ports with transform precoding disabled.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| TPMI index | (ordered from left to right in increasing order of TPMI index) | | | |
| 0 – 3 |  |  |  |  |
| 4 |  | - | - | - |

Table 6.3.1.5-8: The port mapping function for transmission using 8 antenna ports.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Higher-layer parameter *CodebookType*** | | | | | | | |
|  | **codebook1** | | **codebook2** | | **codebook3** | | **codebook4** | |
|  | **antenna port group** |  | **antenna port group** |  | **antenna port group** |  | **antenna port group** |  |
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 1 | 1 | 1 | 4 | 1 | 1 |
| 2 | 2 | 4 | 1 | 1 | 2 | 2 |
| 3 | 3 | 5 | 5 | 3 | 3 |
| 4 | 4 | 1 | 2 | 2 | 2 | 4 | 4 |
| 5 | 5 | 3 | 6 | 5 | 5 |
| 6 | 6 | 6 | 3 | 3 | 6 | 6 |
| 7 | 7 | 7 | 7 | 7 | 7 |

Table 6.3.1.5-9: Intermediate precoding matrix for *codebook1=ng1n4n1* and single-layer transmission using eight antenna ports.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | | | | | | | |
| 0 – 7 |  |  |  |  |  |  |  |  |
| 8 – 15 |  |  |  |  |  |  |  |  |

Table 6.3.1.5-10: Intermediate precoding matrix for *codebook1=ng1n4n1* and two-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | | | | | | | |
| 0 – 7 |  |  |  |  |  |  |  |  |
| 8 – 15 |  |  |  |  |  |  |  |  |
| 16 – 23 |  |  |  |  |  |  |  |  |
| 24 – 31 |  |  |  |  |  |  |  |  |

Table 6.3.1.5-11: Intermediate precoding matrix for *codebook1=ng1n4n1* and three-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | | | |
| 0 – 3 |  |  |  |  |
| 4 – 7 |  |  |  |  |
| 8 – 11 |  |  |  |  |
| 12 – 15 |  |  |  |  |
| 16 – 19 |  |  |  |  |
| 20 – 23 |  |  |  |  |

Table 6.3.1.5-12: Intermediate precoding matrix for *codebook1=ng1n4n1* and four-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | | | |
| 0 – 3 |  |  |  |  |
| 4 – 7 |  |  |  |  |
| 8 – 11 |  |  |  |  |
| 12 – 15 |  |  |  |  |
| 16 – 19 |  |  |  |  |
| 20 – 23 |  |  |  |  |

Table 6.3.1.5-13: Intermediate precoding matrix for *codebook1=ng1n4n1* and five-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |
| --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | |
| 0 – 1 |  |  |
| 2 – 3 |  |  |
| 4 – 5 |  |  |
| 6 – 7 |  |  |

Table 6.3.1.5-14: Intermediate precoding matrix for *codebook1=ng1n4n1* and six-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |
| --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | |
| 0 – 1 |  |  |
| 2 – 3 |  |  |
| 4 – 5 |  |  |
| 6 – 7 |  |  |

Table 6.3.1.5-15: Intermediate precoding matrix for *codebook1=ng1n4n1* and seven-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |
| --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | |
| 0 – 1 |  |  |
| 2 – 3 |  |  |

Table 6.3.1.5-16: Intermediate precoding matrix for *codebook1=ng1n4n1* and eight-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |
| --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | |
| 0 – 1 |  |  |
| 2 – 3 |  |  |

Table 6.3.1.5-17: Intermediate precoding matrix for *codebook1=ng1n2n2* and single-layer transmission using eight antenna ports.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix**  **(ordered from left to right in increasing order of TPMI index)** | | | | | | | |
| 0 – 7 |  |  |  |  |  |  |  |  |
| 8 – 15 |  |  |  |  |  |  |  |  |

Table 6.3.1.5-18: Intermediate precoding matrix for *codebook1=ng1n2n2* and two-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | | | | | | | |
| 0 – 7 |  |  |  |  |  |  |  |  |
| 8 – 15 |  |  |  |  |  |  |  |  |
| 16 – 23 |  |  |  |  |  |  |  |  |
| 24 – 31 |  |  |  |  |  |  |  |  |

Table 6.3.1.5-19: Intermediate precoding matrix for *codebook1=ng1n2n2* and three-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | | | |
| 0 – 3 |  |  |  |  |
| 4 – 7 |  |  |  |  |
| 8 – 11 |  |  |  |  |
| 12 – 15 |  |  |  |  |
| 16 – 19 |  |  |  |  |
| 20 – 23 |  |  |  |  |

Table 6.3.1.5-20: Intermediate precoding matrix for *codebook1=ng1n2n2* and four-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | | | |
| 0 – 3 |  |  |  |  |
| 4 – 7 |  |  |  |  |
| 8 – 11 |  |  |  |  |
| 12 – 15 |  |  |  |  |
| 16 – 19 |  |  |  |  |
| 20 – 23 |  |  |  |  |

Table 6.3.1.5-21: Intermediate precoding matrix for *codebook1=ng1n2n2* and five-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |
| --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | |
| 0 – 1 |  |  |
| 2 – 3 |  |  |
| 4 – 5 |  |  |
| 6 – 7 |  |  |

Table 6.3.1.5-22: Intermediate precoding matrix for *codebook1=ng1n2n2* and six-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |
| --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | |
| 0 – 1 |  |  |
| 2 – 3 |  |  |
| 4 – 5 |  |  |
| 6 – 7 |  |  |

Table 6.3.1.5-23: Intermediate precoding matrix for *codebook1=ng1n2n2* and seven-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |
| --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | |
| 0 – 1 |  |  |
| 2 – 3 |  |  |
| 4 – 5 |  |  |
| 6 – 7 |  |  |

Table 6.3.1.5-24: Intermediate precoding matrix for *codebook1=ng1n2n2* and eight-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |  |
| --- | --- | --- |
| **TPMI index** | **Intermediate precoder matrix (ordered from left to right in increasing order of TPMI index)** | |
| 0 – 1 |  |  |
| 2 – 3 |  |  |
| 4 – 5 |  |  |
| 6 – 7 |  |  |

Table 6.3.1.5-25: Submatrices for *codebook2* and used in Tables 6.3.1.5-29 to 6.3.1.5-31.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **(ordered from left to right in increasing order of )** | | | | | | | |
| 0 – 7 |  |  |  |  |  |  |  |  |
| 8 – 15 |  |  |  |  |  |  |  |  |

Table 6.3.1.5-26: Submatrices for *codebook2* and used in Tables 6.3.1.5-30 to 6.3.1.5-33.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **(ordered from left to right in increasing order of )** | | | |
| 0 – 3 |  |  |  |  |
| 4 – 7 |  |  |  |  |

Table 6.3.1.5-27: Submatrices for *codebook2* and used in Tables 6.3.1.5-31, 6.3.1.5-33, 6.3.1.5-34, and 6.3.1.5-35.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **(ordered from left to right in increasing order of )** | | | |
| 0 – 3 |  |  |  |  |

Table 6.3.1.5-28: Submatrices for *codebook2* and used in Tables 6.3.1.5-32, 6.3.1.5-35, and 6.3.1.5-36.

|  |  |  |
| --- | --- | --- |
|  | **(ordered from left to right in increasing order of )** | |
| 0 – 1 |  |  |

Table 6.3.1.5-29: Intermediate precoding matrix for *codebook2* and single-layer transmission using eight antenna ports.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 15 |  |
| 16 – 31 |  |
| 32 |  |

Table 6.3.1.5-30: Intermediate precoding matrix for *codebook2* and two-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 7 |  |
| 8 – 15 |  |
| 16 – 271 |  |

Table 6.3.1.5-31: Intermediate precoding matrix for *codebook2* and three-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 3 |  |
| 4 – 7 |  |
| 8 – 135 |  |
| 136 – 263 |  |

Table 6.3.1.5-32: Intermediate precoding matrix for *codebook2* and four-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 1 |  |
| 2 – 3 |  |
| 4 – 67 |  |

Table 6.3.1.5-33: Intermediate precoding matrix for *codebook2* and five-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 31 |  |

Table 6.3.1.5-34: Intermediate precoding matrix for *codebook2* and six-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 15 |  |

Table 6.3.1.5-35: Intermediate precoding matrix for *codebook2* and seven-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 7 |  |

Table 6.3.1.5-36: Intermediate precoding matrix for *codebook2* and eight-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 3 |  |

Table 6.3.1.5-37: Submatrices for *codebook3* and used in Tables 6.3.1.5-39 to 6.3.1.5-45.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **(ordered from left to right in increasing order of )** | | | |
| 0 – 3 |  |  |  |  |

Table 6.3.1.5-38: Submatrices for *codebook3* and used in Tables 6.3.1.5-40 to 6.3.1.5-46.

|  |  |  |
| --- | --- | --- |
|  | **(ordered from left to right in increasing order of )** | |
| 0 – 1 |  |  |

Table 6.3.1.5-39: Intermediate precoding matrix for *codebook3* and single-layer transmission using eight antenna ports.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 3 |  |
| 4 – 7 |  |
| 8 – 11 |  |
| 12 – 15 |  |
| 16 |  |

Table 6.3.1.5-40: Intermediate precoding matrix for *codebook3* and two-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 1 |  |
| 2 – 3 |  |
| 4 – 5 |  |
| 6 – 7 |  |
| 8 – 23 |  |
| 24 – 39 |  |
| 40 – 55 |  |
| 56 – 71 |  |
| 72 – 87 |  |
| 88 – 103 |  |
| 104 |  |

Table 6.3.1.5-41: Intermediate precoding matrix for *codebook3* and three-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 7 |  |
| 8 – 15 |  |
| 16 – 23 |  |
| 24 – 31 |  |
| 32 – 39 |  |
| 40 – 47 |  |
| 48 – 111 |  |
| 112 – 175 |  |
| 176 – 239 |  |
| 240 – 303 |  |
| 304 |  |

Table 6.3.1.5-42: Intermediate precoding matrix for *codebook3* and four-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 255 |  |
| 256 – 259 |  |
| 260 – 263 |  |
| 264 – 267 |  |
| 268 – 271 |  |
| 272 – 275 |  |
| 276 – 279 |  |

Table 6.3.1.5-43: Intermediate precoding matrix for *codebook3* and five-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 15 |  |
| 16 – 31 |  |
| 32 – 159 |  |

Table 6.3.1.5-44: Intermediate precoding matrix for *codebook3* and six-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 7 |  |
| 8 – 15 |  |
| 16 – 79 |  |

Table 6.3.1.5-45: Intermediate precoding matrix for *codebook3* and seven-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 31 |  |

Table 6.3.1.5-46: Intermediate precoding matrix for *codebook3* and eight-layer transmission using eight antenna ports with transform precoding disabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – 15 |  |

Table 6.3.1.5-47: Intermediate precoding matrix for *codebook4* and transmission using eight antenna ports. Up to 8 layers are supported with transform precoding disabled and up to one layer with transform precoding enabled.

|  |  |
| --- | --- |
| **TPMI index** | **Intermediate precoder matrix** |
| 0 – | where column of , denoted , has an element 1 on the row corresponding to the port on which layer is to be transmitted, and element 0 in all other rows, ,  , where if a layer is to be transmitted on port and otherwise, and for , where is defined by Table 5.2.2.2.5-4 of [6, TS 38.214].  TPMI indices to are mapped to values of , first by increasing values of the number of transmitted layers, and then by increasing values of for a given number of layers. |
| 255 |  |
| 256 |  |
| 257 |  |
| 258 |  |

#### 6.3.1.6 Mapping to virtual resource blocks

For each of the antenna ports used for transmission of the PUSCH, the block of complex-valued symbols  shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [5, TS 38.213] and mapped in sequence starting with  to resource elements in the virtual resource blocks assigned for transmission which meet all of the following criteria:

- they are in the virtual resource blocks assigned for transmission, and

- the corresponding resource elements in the corresponding physical resource blocks are not used for transmission of the associated DM-RS, PT-RS, or DM-RS intended for other co-scheduled UEs as described in clause 6.4.1.1.3

The mapping to resource elements allocated for PUSCH according to [6, TS 38.214] shall be in increasing order of first the index over the assigned virtual resource blocks, where is the first subcarrier in the lowest-numbered virtual resource block assigned for transmission, and then the index , with the starting position given by [6, TS 38.214].

#### 6.3.1.7 Mapping from virtual to physical resource blocks

Virtual resource blocks shall be mapped to physical resource blocks according to non-interleaved mapping.

For non-interleaved VRB-to-PRB mapping for uplink resource allocation types 0 and 1 [6, TS 38.214], virtual resource block is mapped to physical resource block except for PUSCH scheduled by RAR UL grant or PUSCH scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI in active uplink bandwidth part starting at , including all resource blocks of the initial uplink bandwidth part starting at , and having the same subcarrier spacing and cyclic prefix as the initial uplink bandwidth part, in which case virtual resource block is mapped to physical resource block .

For non-interleaved VRB-to-PRB mapping for uplink resource allocation type 2 [6, TS 38.214], virtual resource block is mapped to physical resource block .

### 6.3.2 Physical uplink control channel

#### 6.3.2.1 General

The physical uplink control channel supports multiple formats as shown in Table 6.3.2.1-1. In case intra-slot frequency hopping is configured for PUCCH formats 1, 3, or 4 according to clause 9.2.1 of [5, TS38.213], the number of symbols in the first hop is given by  where  is the length of the PUCCH transmission in OFDM symbols.

Table 6.3.2.1-1: PUCCH formats.

|  |  |  |
| --- | --- | --- |
| PUCCH format | Length in OFDM symbols | Number of bits |
| 0 | 1 – 2 | ≤2 |
| 1 | 4 – 14 | ≤2 |
| 2 | 1 – 2 | >2 |
| 3 | 4 – 14 | >2 |
| 4 | 4 – 14 | >2 |

#### 6.3.2.2 Sequence and cyclic shift hopping

PUCCH formats 0, 1, 3, and 4 use sequences given by clause 5.2.2 with where the sequence group and the sequence number depend on the sequence hopping in clause 6.3.2.2.1 and the cyclic shift depends on the cyclic shift hopping in clause 6.3.2.2.2.

##### 6.3.2.2.1 Group and sequence hopping

The sequence group and the sequence number within the group depends on the higher-layer parameter *pucch-GroupHopping*:

- if *pucch-GroupHopping* equals 'neither'



where  is given by the higher-layer parameter *hoppingId* if configured, otherwise .

- if *pucch-GroupHopping* equals 'enable'



where the pseudo-random sequence  is defined by clause 5.2.1 and shall be initialized at the beginning of each radio frame with  where  is given by the higher-layer parameter *hoppingId* if configured, otherwise .

- if *pucch-GroupHopping* equals 'disable'



where the pseudo-random sequence  is defined by clause 5.2.1 and shall be initialized at the beginning of each radio frame with where  is given by the higher-layer parameter *hoppingId* if configured, otherwise .

The frequency hopping index if intra-slot frequency hopping is disabled by the higher-layer parameter *intraSlotFrequencyHopping*. If frequency hopping is enabled by the higher-layer parameter *intraSlotFrequencyHopping*, for the first hop and for the second hop.



##### 6.3.2.2.2 Cyclic shift hopping

The cyclic shift varies as a function of the symbol and slot number according to

where

- is the slot number in the radio frame

- is the OFDM symbol number in the PUCCH transmission where corresponds to the first OFDM symbol of the PUCCH transmission,

- is the index of the OFDM symbol in the slot that corresponds to the first OFDM symbol of the PUCCH transmission in the slot given by [5, TS 38.213]

-  is given by [5, TS 38.213] for PUCCH format 0 and 1 while for PUCCH format 3 and 4 is defined in clause 6.4.1.3.3.1

-  except for PUCCH format 0 when it depends on the information to be transmitted according to clause 9.2 of [5, TS 38.213].

- is given by

- for PUCCH formats 0 and 1 if PUCCH shall use interlaced mapping according to any of the higher-layer parameters *useInterlacePUCCH-PUSCH* in *BWP-UplinkCommon* or *useInterlacePUCCH-PUSCH* in *BWP-UplinkDedicated*, where is the resource block number within the interlace;

- otherwise

The function  is given by

where the pseudo-random sequence  is defined by clause 5.2.1. The pseudo-random sequence generator shall be initialized with , where  is given by the higher-layer parameter *hoppingId* if configured, otherwise .

#### 6.3.2.3 PUCCH format 0

##### 6.3.2.3.1 Sequence generation

The sequence  shall be generated according to

where is given by clause 6.3.2.2 with  depending on the information to be transmitted according to clause 9.2 of [5, TS 38.213]. The quantity is given by clause 9.2.1 of [5, TS 38.213].

##### 6.3.2.3.2 Mapping to physical resources

The sequence  shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [5, TS 38.213] and mapped in sequence starting with  to resource elements assigned for transmission according to clause 9.2.1 of [5, TS 38.213] in increasing order of first the index  over the assigned physical resources spanning resource blocks, and then the index on antenna port .

For interlaced transmission, the mapping operation shall be repeated for each resource block in the interlace and in the active bandwidth part over the assigned physical resource blocks according to clause 9.2.1 of [5, TS 38.213], with the resource-block dependent sequence generated according to clause 6.3.2.2.

#### 6.3.2.4 PUCCH format 1

##### 6.3.2.4.1 Sequence modulation

The block of bits  shall be modulated as described in clause 5.1 using BPSK if  and QPSK if , resulting in a complex-valued symbol .   
The complex-valued symbol  shall be multiplied with a sequence according to

where is given by clause 6.3.2.2. The quantity is given by clause 9.2.1 of [5, TS 38.213].

The block of complex-valued symbols shall be block-wise spread with the orthogonal sequence  according to

where is given by Table 6.3.2.4.1-1. Intra-slot frequency hopping shall be assumed when the higher-layer parameter *intraSlotFrequencyHopping* is provided, regardless of whether the frequency-hop distance is zero or not, and interlaced mapping is not enabled, otherwise no intra-slot frequency hopping shall be assumed.

The orthogonal sequence  is given by Table 6.3.2.4.1-2 where  is the index of the orthogonal sequence to use according to clause 9.2.1 of [5, TS 38.213]. In case of a PUCCH transmission spanning multiple slots according to clause 9.2.6 of [5, TS38.213], the complex-valued symbol  is repeated for the subsequent slots.

Table 6.3.2.4.1-1: Number of PUCCH symbols and the corresponding .

|  |  |  |  |
| --- | --- | --- | --- |
| PUCCH length, |  | | |
| No intra-slot hopping | Intra-slot hopping | |
|  |  |
| 4 | 2 | 1 | 1 |
| 5 | 2 | 1 | 1 |
| 6 | 3 | 1 | 2 |
| 7 | 3 | 1 | 2 |
| 8 | 4 | 2 | 2 |
| 9 | 4 | 2 | 2 |
| 10 | 5 | 2 | 3 |
| 11 | 5 | 2 | 3 |
| 12 | 6 | 3 | 3 |
| 13 | 6 | 3 | 3 |
| 14 | 7 | 3 | 4 |

Table 6.3.2.4.1-2: Orthogonal sequences  for PUCCH format 1.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  |  | | | | | | |
|  |  |  |  |  |  |  |
| 1 | [0] | - | - | - | - | - | - |
| 2 | [0 0] | [0 1] | - | - | - | - | - |
| 3 | [0 0 0] | [0 1 2] | [0 2 1] | - | - | - | - |
| 4 | [0 0 0 0] | [0 2 0 2] | [0 0 2 2] | [0 2 2 0] | - | - | - |
| 5 | [0 0 0 0 0] | [0 1 2 3 4] | [0 2 4 1 3] | [0 3 1 4 2] | [0 4 3 2 1] | - | - |
| 6 | [0 0 0 0 0 0] | [0 1 2 3 4 5] | [0 2 4 0 2 4] | [0 3 0 3 0 3] | [0 4 2 0 4 2] | [0 5 4 3 2 1] | - |
| 7 | [0 0 0 0 0 0 0] | [0 1 2 3 4 5 6] | [0 2 4 6 1 3 5] | [0 3 6 2 5 1 4] | [0 4 1 5 2 6 3] | [0 5 3 1 6 4 2] | [0 6 5 4 3 2 1] |

##### 6.3.2.4.2 Mapping to physical resources

The sequence shall be multiplied with the amplitude scaling factor in order to conform to the transmit power specified in [5, TS 38.213] and mapped in sequence starting with to resource elements which meet all of the following criteria:

- they are in the resource blocks assigned for transmission,

- they are not used by the associated DM-RS

The mapping to resource elements not reserved for other purposes shall be in increasing order of first the index over the assigned physical resource blocks according to clause 9.2.1 of [5, TS 38.213], and then the index on antenna port .

For interlaced transmission, the mapping operation shall be repeated for each resource block in the interlace and in the active bandwidth part over the assigned physical resource blocks according to clause 9.2.1 of [5, TS 38.213], with the resource-block dependent sequence generated according to clause 6.3.2.2.

#### 6.3.2.5 PUCCH format 2

##### 6.3.2.5.1 Scrambling

The block of bits , where is the number of bits transmitted on the physical channel, shall be scrambled prior to modulation, resulting in a block of scrambled bits according to the following pseudo code

Set *i* = 0

while

if // UCI placeholder bits

else

end if

*i* = *i* + 1

end while

where y is the tag defined in [4, TS38.212] and the scrambling sequence is given by clause 5.2.1. The scrambling sequence generator shall be initialized with

where

- equals the higher-layer parameter *dataScramblingIdentityPUSCH* if configured,

- otherwise

and is given by the C-RNTI.

##### 6.3.2.5.2 Modulation

The block of scrambled bits shall be modulated as described in clause 5.1 using QPSK, resulting in a block of complex-valued modulation symbols where .

##### 6.3.2.5.2A Spreading

Spreading shall be applied according to

resulting in a block of complex-valued symbols .

If the higher layer parameter *interlace1* is not configured, and the higher-layer parameter *occ-Length* is configured,

- is given by the higher-layer parameter *occ-Length*;

- is given by Tables 6.3.2.5A-1 and 6.3.2.5A-2 where , the quantity is the index of the orthogonal sequence to use given by the higher-layer parameter *occ-Index*, and is the interlaced resource block number as defined in clause 4.4.4.6 within the interlace given by the higher-layer parameter *Interlace0*.

otherwise and

Table 6.3.2.5A-1: Orthogonal sequences for PUCCH format 2 when .

|  |  |
| --- | --- |
|  |  |
| 0 |  |
| 1 |  |

Table 6.3.2.5A-2: Orthogonal sequences for PUCCH format 2 when .

|  |  |
| --- | --- |
|  |  |
| 0 |  |
| 1 |  |
| 2 |  |
| 3 |  |

##### 6.3.2.5.3 Mapping to physical resources

The block of complex-valued symbols shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [5, TS 38.213] and mapped in sequence starting with to resource elements which meet all of the following criteria:

- they are in the resource blocks assigned for transmission,

- they are not used by the associated DM-RS.

The mapping to resource elements not reserved for other purposes shall be in increasing order of first the index  over the assigned physical resource blocks according to clause 9.2.1 of [5, TS 38.213], and then the index  on antenna port .

#### 6.3.2.6 PUCCH formats 3 and 4

##### 6.3.2.6.1 Scrambling

The block of bits , where is the number of bits transmitted on the physical channel, shall be scrambled prior to modulation, resulting in a block of scrambled bits according to the following pseudo code

Set *i* = 0

while

if // UCI placeholder bits

else

end if

*i* = *i* + 1

end while

where y is the tag defined in [4, TS38.212] and the scrambling sequence is given by clause 5.2.1. The scrambling sequence generator shall be initialized with

where

- equals the higher-layer parameter *dataScramblingIdentityPUSCH* if configured,

- otherwise

and is given by the C-RNTI.

##### 6.3.2.6.2 Modulation

The block of scrambled bits shall be modulated as described in clause 5.1 using QPSK unless π/2-BPSK is configured, resulting in a block of complex-valued modulation symbols where for QPSK and for π/2-BPSK.

##### 6.3.2.6.3 Block-wise spreading

For both PUCCH format 3 and 4, with representing the bandwidth of the PUCCH in terms of resource blocks according to clauses 9.2.3, 9.2.5.1 and 9.2.5.2 of [5, TS 38.213] and shall for non-interlaced mapping fulfil

where  is a set of non-negative integers and . For interlaced mapping, if a single interlace is configured and if two interlaces are configured.

For PUCCH format 3, if interlaced mapping is not configured, no block-wise spreading is applied and



where is given by clauses 9.2.3, 9.2.5.1 and 9.2.5.2 of [5, TS 38.213] and .

For PUCCH format 3 with interlaced mapping and PUCCH format 4, block-wise spreading shall be applied according to

where

- for PUCCH format 3 with interlaced mapping, if a single interlace is configured and , if two interlaces are configured;

- for PUCCH format 4, is given by the higher-layer parameter *occ-Length*;

and  is given by Tables 6.3.2.6.3-1 and 6.3.2.6.3-2 for where is the index of the orthogonal sequence to use according to clause 9.2.1 of [5, TS 38.213]. The quantity is given by the higher-layer parameter *occ-Length* if provided, otherwise .

Table 6.3.2.6.3-1: Orthogonal sequences  for PUCCH format 3 with interlaced mapping and PUCCH format 4 when .

|  |  |
| --- | --- |
|  |  |
| 0 |  |
| 1 |  |

Table 6.3.2.6.3-2: Orthogonal sequences  for PUCCH format 3 with interlaced mapping and PUCCH format 4 when .

|  |  |
| --- | --- |
|  |  |
| 0 |  |
| 1 |  |
| 2 |  |
| 3 |  |

##### 6.3.2.6.4 Transform precoding

The block of complex-valued symbols shall be transform precoded according to



resulting in a block of complex-valued symbols .

##### 6.3.2.6.5 Mapping to physical resources

The block of modulation symbols shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [5, TS 38.213] and mapped in sequence starting with to resource elements which meet all of the following criteria:

- they are in the resource blocks assigned for transmission,

- they are not used by the associated DM-RS

The mapping to resource elements not reserved for other purposes shall be in increasing order of first the index  over the assigned physical resource blocks according to clause 9.2.1 of [5, TS 38.213], and then the index  on antenna port .

In case of intra-slot frequency hopping according to clause 9.2.1 of [5, TS 38.213],  OFDM symbols shall be transmitted in the first hop and  symbols in the second hop where  is the total number of OFDM symbols used in one slot for PUCCH transmission.

### 6.3.3 Physical random-access channel

#### 6.3.3.1 Sequence generation

The set of random-access preambles  shall be generated according to



from which the frequency-domain representation shall be generated according to



where , , , or depending on the PRACH preamble format as given by Tables 6.3.3.1-1 and 6.3.3.1-2.

There are 64 preambles defined in each time-frequency PRACH occasion, enumerated in increasing order of first increasing cyclic shift  of a logical root sequence, and then in increasing order of the logical root sequence index, starting with the index obtained from the higher-layer parameter *prach-RootSequenceIndex* or *rootSequenceIndex-BFR* or by *msgA-PRACH-RootSequenceIndex* if configured and a type-2 random-access procedure is initiated as described in clause 8.1 of [5, TS 38.213]. Additional preamble sequences, in case 64 preambles cannot be generated from a single root Zadoff-Chu sequence, are obtained from the root sequences with the consecutive logical indexes until all the 64 sequences are found. The logical root sequence order is cyclic; the logical index 0 is consecutive to . The sequence number  is obtained from the logical root sequence index according to Tables 6.3.3.1-3 to 6.3.3.1-4B.

The cyclic shift  is given by



where  is given by Tables 6.3.3.1-5 to 6.3.3.1-7, the higher-layer parameter *msgA-RestrictedSetConfig*, if provided, determines the type of restricted sets (unrestricted, restricted type A, restricted type B); otherwise, the higher-layer parameter *restrictedSetConfig* determines the type of restricted sets (unrestricted, restricted type A, restricted type B), and Tables 6.3.3.1-1 and 6.3.3.1-2 indicate the type of restricted sets supported for the different preamble formats.

The variable  is given by



where  is the smallest non-negative integer that fulfils . The parameters for restricted sets of cyclic shifts depend on .

For restricted set type A, the parameters are given by:

- for 



- for 



For restricted set type B, the parameters are given by:

- for 



- for 



- for 



- for 



- for 



- for 



For all other values of , there are no cyclic shifts in the restricted set.

Table 6.3.3.1-1: PRACH preamble formats for  and kHz.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Format |  |  |  |  | Support for restricted sets |
| 0 | 839 | 1.25 kHz |  |  | Type A, Type B |
| 1 | 839 | 1.25 kHz |  |  | Type A, Type B |
| 2 | 839 | 1.25 kHz |  |  | Type A, Type B |
| 3 | 839 | 5 kHz |  |  | Type A, Type B |

Table 6.3.3.1-2: Preamble formats for and kHz where .

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Format |  | | |  |  |  | Support for restricted sets |
|  |  |  |
| A1 | 139 | 1151 | 571 |  |  |  | - |
| A2 | 139 | 1151 | 571 |  |  |  | - |
| A3 | 139 | 1151 | 571 |  |  |  | - |
| B1 | 139 | 1151 | 571 |  |  |  | - |
| B2 | 139 | 1151 | 571 |  |  |  | - |
| B3 | 139 | 1151 | 571 |  |  |  | - |
| B4 | 139 | 1151 | 571 |  |  |  | - |
| C0 | 139 | 1151 | 571 |  |  |  | - |
| C2 | 139 | 1151 | 571 |  |  |  |  |

Table 6.3.3.1-3: Mapping from *logical index*  to sequence number  for preamble formats with .

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sequence number in increasing order of | | | | | | | | | | | | | | | | | | | |
| 0 – 19 | 129 | 710 | 140 | 699 | 120 | 719 | 210 | 629 | 168 | 671 | 84 | 755 | 105 | 734 | 93 | 746 | 70 | 769 | 60 | 779 |
| 20 – 39 | 2 | 837 | 1 | 838 | 56 | 783 | 112 | 727 | 148 | 691 | 80 | 759 | 42 | 797 | 40 | 799 | 35 | 804 | 73 | 766 |
| 40 – 59 | 146 | 693 | 31 | 808 | 28 | 811 | 30 | 809 | 27 | 812 | 29 | 810 | 24 | 815 | 48 | 791 | 68 | 771 | 74 | 765 |
| 60 – 79 | 178 | 661 | 136 | 703 | 86 | 753 | 78 | 761 | 43 | 796 | 39 | 800 | 20 | 819 | 21 | 818 | 95 | 744 | 202 | 637 |
| 80 – 99 | 190 | 649 | 181 | 658 | 137 | 702 | 125 | 714 | 151 | 688 | 217 | 622 | 128 | 711 | 142 | 697 | 122 | 717 | 203 | 636 |
| 100 – 119 | 118 | 721 | 110 | 729 | 89 | 750 | 103 | 736 | 61 | 778 | 55 | 784 | 15 | 824 | 14 | 825 | 12 | 827 | 23 | 816 |
| 120 – 139 | 34 | 805 | 37 | 802 | 46 | 793 | 207 | 632 | 179 | 660 | 145 | 694 | 130 | 709 | 223 | 616 | 228 | 611 | 227 | 612 |
| 140 – 159 | 132 | 707 | 133 | 706 | 143 | 696 | 135 | 704 | 161 | 678 | 201 | 638 | 173 | 666 | 106 | 733 | 83 | 756 | 91 | 748 |
| 160 – 179 | 66 | 773 | 53 | 786 | 10 | 829 | 9 | 830 | 7 | 832 | 8 | 831 | 16 | 823 | 47 | 792 | 64 | 775 | 57 | 782 |
| 180 – 199 | 104 | 735 | 101 | 738 | 108 | 731 | 208 | 631 | 184 | 655 | 197 | 642 | 191 | 648 | 121 | 718 | 141 | 698 | 149 | 690 |
| 200 – 219 | 216 | 623 | 218 | 621 | 152 | 687 | 144 | 695 | 134 | 705 | 138 | 701 | 199 | 640 | 162 | 677 | 176 | 663 | 119 | 720 |
| 220 – 239 | 158 | 681 | 164 | 675 | 174 | 665 | 171 | 668 | 170 | 669 | 87 | 752 | 169 | 670 | 88 | 751 | 107 | 732 | 81 | 758 |
| 240 – 259 | 82 | 757 | 100 | 739 | 98 | 741 | 71 | 768 | 59 | 780 | 65 | 774 | 50 | 789 | 49 | 790 | 26 | 813 | 17 | 822 |
| 260 – 279 | 13 | 826 | 6 | 833 | 5 | 834 | 33 | 806 | 51 | 788 | 75 | 764 | 99 | 740 | 96 | 743 | 97 | 742 | 166 | 673 |
| 280 – 299 | 172 | 667 | 175 | 664 | 187 | 652 | 163 | 676 | 185 | 654 | 200 | 639 | 114 | 725 | 189 | 650 | 115 | 724 | 194 | 645 |
| 300 – 319 | 195 | 644 | 192 | 647 | 182 | 657 | 157 | 682 | 156 | 683 | 211 | 628 | 154 | 685 | 123 | 716 | 139 | 700 | 212 | 627 |
| 320 – 339 | 153 | 686 | 213 | 626 | 215 | 624 | 150 | 689 | 225 | 614 | 224 | 615 | 221 | 618 | 220 | 619 | 127 | 712 | 147 | 692 |
| 340 – 359 | 124 | 715 | 193 | 646 | 205 | 634 | 206 | 633 | 116 | 723 | 160 | 679 | 186 | 653 | 167 | 672 | 79 | 760 | 85 | 754 |
| 360 – 379 | 77 | 762 | 92 | 747 | 58 | 781 | 62 | 777 | 69 | 770 | 54 | 785 | 36 | 803 | 32 | 807 | 25 | 814 | 18 | 821 |
| 380 – 399 | 11 | 828 | 4 | 835 | 3 | 836 | 19 | 820 | 22 | 817 | 41 | 798 | 38 | 801 | 44 | 795 | 52 | 787 | 45 | 794 |
| 400 – 419 | 63 | 776 | 67 | 772 | 72 | 767 | 76 | 763 | 94 | 745 | 102 | 737 | 90 | 749 | 109 | 730 | 165 | 674 | 111 | 728 |
| 420 – 439 | 209 | 630 | 204 | 635 | 117 | 722 | 188 | 651 | 159 | 680 | 198 | 641 | 113 | 726 | 183 | 656 | 180 | 659 | 177 | 662 |
| 440 – 459 | 196 | 643 | 155 | 684 | 214 | 625 | 126 | 713 | 131 | 708 | 219 | 620 | 222 | 617 | 226 | 613 | 230 | 609 | 232 | 607 |
| 460 – 479 | 262 | 577 | 252 | 587 | 418 | 421 | 416 | 423 | 413 | 426 | 411 | 428 | 376 | 463 | 395 | 444 | 283 | 556 | 285 | 554 |
| 480 – 499 | 379 | 460 | 390 | 449 | 363 | 476 | 384 | 455 | 388 | 451 | 386 | 453 | 361 | 478 | 387 | 452 | 360 | 479 | 310 | 529 |
| 500 – 519 | 354 | 485 | 328 | 511 | 315 | 524 | 337 | 502 | 349 | 490 | 335 | 504 | 324 | 515 | 323 | 516 | 320 | 519 | 334 | 505 |
| 520 – 539 | 359 | 480 | 295 | 544 | 385 | 454 | 292 | 547 | 291 | 548 | 381 | 458 | 399 | 440 | 380 | 459 | 397 | 442 | 369 | 470 |
| 540 – 559 | 377 | 462 | 410 | 429 | 407 | 432 | 281 | 558 | 414 | 425 | 247 | 592 | 277 | 562 | 271 | 568 | 272 | 567 | 264 | 575 |
| 560 – 579 | 259 | 580 | 237 | 602 | 239 | 600 | 244 | 595 | 243 | 596 | 275 | 564 | 278 | 561 | 250 | 589 | 246 | 593 | 417 | 422 |
| 580 – 599 | 248 | 591 | 394 | 445 | 393 | 446 | 370 | 469 | 365 | 474 | 300 | 539 | 299 | 540 | 364 | 475 | 362 | 477 | 298 | 541 |
| 600 – 619 | 312 | 527 | 313 | 526 | 314 | 525 | 353 | 486 | 352 | 487 | 343 | 496 | 327 | 512 | 350 | 489 | 326 | 513 | 319 | 520 |
| 620 – 639 | 332 | 507 | 333 | 506 | 348 | 491 | 347 | 492 | 322 | 517 | 330 | 509 | 338 | 501 | 341 | 498 | 340 | 499 | 342 | 497 |
| 640 – 659 | 301 | 538 | 366 | 473 | 401 | 438 | 371 | 468 | 408 | 431 | 375 | 464 | 249 | 590 | 269 | 570 | 238 | 601 | 234 | 605 |
| 660 – 679 | 257 | 582 | 273 | 566 | 255 | 584 | 254 | 585 | 245 | 594 | 251 | 588 | 412 | 427 | 372 | 467 | 282 | 557 | 403 | 436 |
| 680 – 699 | 396 | 443 | 392 | 447 | 391 | 448 | 382 | 457 | 389 | 450 | 294 | 545 | 297 | 542 | 311 | 528 | 344 | 495 | 345 | 494 |
| 700 – 719 | 318 | 521 | 331 | 508 | 325 | 514 | 321 | 518 | 346 | 493 | 339 | 500 | 351 | 488 | 306 | 533 | 289 | 550 | 400 | 439 |
| 720 – 739 | 378 | 461 | 374 | 465 | 415 | 424 | 270 | 569 | 241 | 598 | 231 | 608 | 260 | 579 | 268 | 571 | 276 | 563 | 409 | 430 |
| 740 – 759 | 398 | 441 | 290 | 549 | 304 | 535 | 308 | 531 | 358 | 481 | 316 | 523 | 293 | 546 | 288 | 551 | 284 | 555 | 368 | 471 |
| 760 – 779 | 253 | 586 | 256 | 583 | 263 | 576 | 242 | 597 | 274 | 565 | 402 | 437 | 383 | 456 | 357 | 482 | 329 | 510 | 317 | 522 |
| 780 – 799 | 307 | 532 | 286 | 553 | 287 | 552 | 266 | 573 | 261 | 578 | 236 | 603 | 303 | 536 | 356 | 483 | 355 | 484 | 405 | 434 |
| 800 – 819 | 404 | 435 | 406 | 433 | 235 | 604 | 267 | 572 | 302 | 537 | 309 | 530 | 265 | 574 | 233 | 606 | 367 | 472 | 296 | 543 |
| 820 – 837 | 336 | 503 | 305 | 534 | 373 | 466 | 280 | 559 | 279 | 560 | 419 | 420 | 240 | 599 | 258 | 581 | 229 | 610 | - | - |

Table 6.3.3.1-4: Mapping from *logical index*  to sequence number  for preamble formats with .

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sequence number  in increasing order of | | | | | | | | | | | | | | | | | | | |
| 0 – 19 | 1 | 138 | 2 | 137 | 3 | 136 | 4 | 135 | 5 | 134 | 6 | 133 | 7 | 132 | 8 | 131 | 9 | 130 | 10 | 129 |
| 20 – 39 | 11 | 128 | 12 | 127 | 13 | 126 | 14 | 125 | 15 | 124 | 16 | 123 | 17 | 122 | 18 | 121 | 19 | 120 | 20 | 119 |
| 40 – 59 | 21 | 118 | 22 | 117 | 23 | 116 | 24 | 115 | 25 | 114 | 26 | 113 | 27 | 112 | 28 | 111 | 29 | 110 | 30 | 109 |
| 60 – 79 | 31 | 108 | 32 | 107 | 33 | 106 | 34 | 105 | 35 | 104 | 36 | 103 | 37 | 102 | 38 | 101 | 39 | 100 | 40 | 99 |
| 80 – 99 | 41 | 98 | 42 | 97 | 43 | 96 | 44 | 95 | 45 | 94 | 46 | 93 | 47 | 92 | 48 | 91 | 49 | 90 | 50 | 89 |
| 100 – 119 | 51 | 88 | 52 | 87 | 53 | 86 | 54 | 85 | 55 | 84 | 56 | 83 | 57 | 82 | 58 | 81 | 59 | 80 | 60 | 79 |
| 120 – 137 | 61 | 78 | 62 | 77 | 63 | 76 | 64 | 75 | 65 | 74 | 66 | 73 | 67 | 72 | 68 | 71 | 69 | 70 | - | - |
| 138 – 837 | N/A | | | | | | | | | | | | | | | | | | | |

Table 6.3.3.1-4A: Mapping from *logical index* to sequence number for preamble formats with .

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sequence number in increasing order of | | | | | | | | | | | | | | | | | | | |
| 0-19 | 1 | 1150 | 2 | 1149 | 3 | 1148 | 4 | 1147 | 5 | 1146 | 6 | 1145 | 7 | 1144 | 8 | 1143 | 9 | 1142 | 10 | 1141 |
| 20-39 | 11 | 1140 | 12 | 1139 | 13 | 1138 | 14 | 1137 | 15 | 1136 | 16 | 1135 | 17 | 1134 | 18 | 1133 | 19 | 1132 | 20 | 1131 |
| 40-59 | 21 | 1130 | 22 | 1129 | 23 | 1128 | 24 | 1127 | 25 | 1126 | 26 | 1125 | 27 | 1124 | 28 | 1123 | 29 | 1122 | 30 | 1121 |
| 60-79 | 31 | 1120 | 32 | 1119 | 33 | 1118 | 34 | 1117 | 35 | 1116 | 36 | 1115 | 37 | 1114 | 38 | 1113 | 39 | 1112 | 40 | 1111 |
| 80-99 | 41 | 1110 | 42 | 1109 | 43 | 1108 | 44 | 1107 | 45 | 1106 | 46 | 1105 | 47 | 1104 | 48 | 1103 | 49 | 1102 | 50 | 1101 |
| 100-119 | 51 | 1100 | 52 | 1099 | 53 | 1098 | 54 | 1097 | 55 | 1096 | 56 | 1095 | 57 | 1094 | 58 | 1093 | 59 | 1092 | 60 | 1091 |
| 120-139 | 61 | 1090 | 62 | 1089 | 63 | 1088 | 64 | 1087 | 65 | 1086 | 66 | 1085 | 67 | 1084 | 68 | 1083 | 69 | 1082 | 70 | 1081 |
| 140-159 | 71 | 1080 | 72 | 1079 | 73 | 1078 | 74 | 1077 | 75 | 1076 | 76 | 1075 | 77 | 1074 | 78 | 1073 | 79 | 1072 | 80 | 1071 |
| 160-179 | 81 | 1070 | 82 | 1069 | 83 | 1068 | 84 | 1067 | 85 | 1066 | 86 | 1065 | 87 | 1064 | 88 | 1063 | 89 | 1062 | 90 | 1061 |
| 180-199 | 91 | 1060 | 92 | 1059 | 93 | 1058 | 94 | 1057 | 95 | 1056 | 96 | 1055 | 97 | 1054 | 98 | 1053 | 99 | 1052 | 100 | 1051 |
| 200-219 | 101 | 1050 | 102 | 1049 | 103 | 1048 | 104 | 1047 | 105 | 1046 | 106 | 1045 | 107 | 1044 | 108 | 1043 | 109 | 1042 | 110 | 1041 |
| 220-239 | 111 | 1040 | 112 | 1039 | 113 | 1038 | 114 | 1037 | 115 | 1036 | 116 | 1035 | 117 | 1034 | 118 | 1033 | 119 | 1032 | 120 | 1031 |
| 240-259 | 121 | 1030 | 122 | 1029 | 123 | 1028 | 124 | 1027 | 125 | 1026 | 126 | 1025 | 127 | 1024 | 128 | 1023 | 129 | 1022 | 130 | 1021 |
| 260-279 | 131 | 1020 | 132 | 1019 | 133 | 1018 | 134 | 1017 | 135 | 1016 | 136 | 1015 | 137 | 1014 | 138 | 1013 | 139 | 1012 | 140 | 1011 |
| 280-299 | 141 | 1010 | 142 | 1009 | 143 | 1008 | 144 | 1007 | 145 | 1006 | 146 | 1005 | 147 | 1004 | 148 | 1003 | 149 | 1002 | 150 | 1001 |
| 300-319 | 151 | 1000 | 152 | 999 | 153 | 998 | 154 | 997 | 155 | 996 | 156 | 995 | 157 | 994 | 158 | 993 | 159 | 992 | 160 | 991 |
| 320-339 | 161 | 990 | 162 | 989 | 163 | 988 | 164 | 987 | 165 | 986 | 166 | 985 | 167 | 984 | 168 | 983 | 169 | 982 | 170 | 981 |
| 340-359 | 171 | 980 | 172 | 979 | 173 | 978 | 174 | 977 | 175 | 976 | 176 | 975 | 177 | 974 | 178 | 973 | 179 | 972 | 180 | 971 |
| 360-379 | 181 | 970 | 182 | 969 | 183 | 968 | 184 | 967 | 185 | 966 | 186 | 965 | 187 | 964 | 188 | 963 | 189 | 962 | 190 | 961 |
| 380-399 | 191 | 960 | 192 | 959 | 193 | 958 | 194 | 957 | 195 | 956 | 196 | 955 | 197 | 954 | 198 | 953 | 199 | 952 | 200 | 951 |
| 400-419 | 201 | 950 | 202 | 949 | 203 | 948 | 204 | 947 | 205 | 946 | 206 | 945 | 207 | 944 | 208 | 943 | 209 | 942 | 210 | 941 |
| 420-439 | 211 | 940 | 212 | 939 | 213 | 938 | 214 | 937 | 215 | 936 | 216 | 935 | 217 | 934 | 218 | 933 | 219 | 932 | 220 | 931 |
| 440-459 | 221 | 930 | 222 | 929 | 223 | 928 | 224 | 927 | 225 | 926 | 226 | 925 | 227 | 924 | 228 | 923 | 229 | 922 | 230 | 921 |
| 460-479 | 231 | 920 | 232 | 919 | 233 | 918 | 234 | 917 | 235 | 916 | 236 | 915 | 237 | 914 | 238 | 913 | 239 | 912 | 240 | 911 |
| 480-499 | 241 | 910 | 242 | 909 | 243 | 908 | 244 | 907 | 245 | 906 | 246 | 905 | 247 | 904 | 248 | 903 | 249 | 902 | 250 | 901 |
| 500-519 | 251 | 900 | 252 | 899 | 253 | 898 | 254 | 897 | 255 | 896 | 256 | 895 | 257 | 894 | 258 | 893 | 259 | 892 | 260 | 891 |
| 520-539 | 261 | 890 | 262 | 889 | 263 | 888 | 264 | 887 | 265 | 886 | 266 | 885 | 267 | 884 | 268 | 883 | 269 | 882 | 270 | 881 |
| 540-559 | 271 | 880 | 272 | 879 | 273 | 878 | 274 | 877 | 275 | 876 | 276 | 875 | 277 | 874 | 278 | 873 | 279 | 872 | 280 | 871 |
| 560-579 | 281 | 870 | 282 | 869 | 283 | 868 | 284 | 867 | 285 | 866 | 286 | 865 | 287 | 864 | 288 | 863 | 289 | 862 | 290 | 861 |
| 580-599 | 291 | 860 | 292 | 859 | 293 | 858 | 294 | 857 | 295 | 856 | 296 | 855 | 297 | 854 | 298 | 853 | 299 | 852 | 300 | 851 |
| 600-619 | 301 | 850 | 302 | 849 | 303 | 848 | 304 | 847 | 305 | 846 | 306 | 845 | 307 | 844 | 308 | 843 | 309 | 842 | 310 | 841 |
| 620-639 | 311 | 840 | 312 | 839 | 313 | 838 | 314 | 837 | 315 | 836 | 316 | 835 | 317 | 834 | 318 | 833 | 319 | 832 | 320 | 831 |
| 640-659 | 321 | 830 | 322 | 829 | 323 | 828 | 324 | 827 | 325 | 826 | 326 | 825 | 327 | 824 | 328 | 823 | 329 | 822 | 330 | 821 |
| 660-679 | 331 | 820 | 332 | 819 | 333 | 818 | 334 | 817 | 335 | 816 | 336 | 815 | 337 | 814 | 338 | 813 | 339 | 812 | 340 | 811 |
| 680-699 | 341 | 810 | 342 | 809 | 343 | 808 | 344 | 807 | 345 | 806 | 346 | 805 | 347 | 804 | 348 | 803 | 349 | 802 | 350 | 801 |
| 700-719 | 351 | 800 | 352 | 799 | 353 | 798 | 354 | 797 | 355 | 796 | 356 | 795 | 357 | 794 | 358 | 793 | 359 | 792 | 360 | 791 |
| 720-739 | 361 | 790 | 362 | 789 | 363 | 788 | 364 | 787 | 365 | 786 | 366 | 785 | 367 | 784 | 368 | 783 | 369 | 782 | 370 | 781 |
| 740-759 | 371 | 780 | 372 | 779 | 373 | 778 | 374 | 777 | 375 | 776 | 376 | 775 | 377 | 774 | 378 | 773 | 379 | 772 | 380 | 771 |
| 760-779 | 381 | 770 | 382 | 769 | 383 | 768 | 384 | 767 | 385 | 766 | 386 | 765 | 387 | 764 | 388 | 763 | 389 | 762 | 390 | 761 |
| 780-799 | 391 | 760 | 392 | 759 | 393 | 758 | 394 | 757 | 395 | 756 | 396 | 755 | 397 | 754 | 398 | 753 | 399 | 752 | 400 | 751 |
| 800-819 | 401 | 750 | 402 | 749 | 403 | 748 | 404 | 747 | 405 | 746 | 406 | 745 | 407 | 744 | 408 | 743 | 409 | 742 | 410 | 741 |
| 820-839 | 411 | 740 | 412 | 739 | 413 | 738 | 414 | 737 | 415 | 736 | 416 | 735 | 417 | 734 | 418 | 733 | 419 | 732 | 420 | 731 |
| 840-859 | 421 | 730 | 422 | 729 | 423 | 728 | 424 | 727 | 425 | 726 | 426 | 725 | 427 | 724 | 428 | 723 | 429 | 722 | 430 | 721 |
| 860-879 | 431 | 720 | 432 | 719 | 433 | 718 | 434 | 717 | 435 | 716 | 436 | 715 | 437 | 714 | 438 | 713 | 439 | 712 | 440 | 711 |
| 880-899 | 441 | 710 | 442 | 709 | 443 | 708 | 444 | 707 | 445 | 706 | 446 | 705 | 447 | 704 | 448 | 703 | 449 | 702 | 450 | 701 |
| 900-919 | 451 | 700 | 452 | 699 | 453 | 698 | 454 | 697 | 455 | 696 | 456 | 695 | 457 | 694 | 458 | 693 | 459 | 692 | 460 | 691 |
| 920-939 | 461 | 690 | 462 | 689 | 463 | 688 | 464 | 687 | 465 | 686 | 466 | 685 | 467 | 684 | 468 | 683 | 469 | 682 | 470 | 681 |
| 940-959 | 471 | 680 | 472 | 679 | 473 | 678 | 474 | 677 | 475 | 676 | 476 | 675 | 477 | 674 | 478 | 673 | 479 | 672 | 480 | 671 |
| 960-979 | 481 | 670 | 482 | 669 | 483 | 668 | 484 | 667 | 485 | 666 | 486 | 665 | 487 | 664 | 488 | 663 | 489 | 662 | 490 | 661 |
| 980-999 | 491 | 660 | 492 | 659 | 493 | 658 | 494 | 657 | 495 | 656 | 496 | 655 | 497 | 654 | 498 | 653 | 499 | 652 | 500 | 651 |
| 1000-1019 | 501 | 650 | 502 | 649 | 503 | 648 | 504 | 647 | 505 | 646 | 506 | 645 | 507 | 644 | 508 | 643 | 509 | 642 | 510 | 641 |
| 1020-1039 | 511 | 640 | 512 | 639 | 513 | 638 | 514 | 637 | 515 | 636 | 516 | 635 | 517 | 634 | 518 | 633 | 519 | 632 | 520 | 631 |
| 1040-1059 | 521 | 630 | 522 | 629 | 523 | 628 | 524 | 627 | 525 | 626 | 526 | 625 | 527 | 624 | 528 | 623 | 529 | 622 | 530 | 621 |
| 1060-1079 | 531 | 620 | 532 | 619 | 533 | 618 | 534 | 617 | 535 | 616 | 536 | 615 | 537 | 614 | 538 | 613 | 539 | 612 | 540 | 611 |
| 1080-1099 | 541 | 610 | 542 | 609 | 543 | 608 | 544 | 607 | 545 | 606 | 546 | 605 | 547 | 604 | 548 | 603 | 549 | 602 | 550 | 601 |
| 1100-1119 | 551 | 600 | 552 | 599 | 553 | 598 | 554 | 597 | 555 | 596 | 556 | 595 | 557 | 594 | 558 | 593 | 559 | 592 | 560 | 591 |
| 1120-1139 | 561 | 590 | 562 | 589 | 563 | 588 | 564 | 587 | 565 | 586 | 566 | 585 | 567 | 584 | 568 | 583 | 569 | 582 | 570 | 581 |
| 1140-1149 | 571 | 580 | 572 | 579 | 573 | 578 | 574 | 577 | 575 | 576 | - | - | - | - | - | - | - | - | - | - |

Table 6.3.3.1-4B: Mapping from *logical index* to sequence number for preamble formats with .

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Sequence number in increasing order of | | | | | | | | | | | | | | | | | | | |
| 0-19 | 1 | 570 | 2 | 569 | 3 | 568 | 4 | 567 | 5 | 566 | 6 | 565 | 7 | 564 | 8 | 563 | 9 | 562 | 10 | 561 |
| 20-39 | 11 | 560 | 12 | 559 | 13 | 558 | 14 | 557 | 15 | 556 | 16 | 555 | 17 | 554 | 18 | 553 | 19 | 552 | 20 | 551 |
| 40-59 | 21 | 550 | 22 | 549 | 23 | 548 | 24 | 547 | 25 | 546 | 26 | 545 | 27 | 544 | 28 | 543 | 29 | 542 | 30 | 541 |
| 60-79 | 31 | 540 | 32 | 539 | 33 | 538 | 34 | 537 | 35 | 536 | 36 | 535 | 37 | 534 | 38 | 533 | 39 | 532 | 40 | 531 |
| 80-99 | 41 | 530 | 42 | 529 | 43 | 528 | 44 | 527 | 45 | 526 | 46 | 525 | 47 | 524 | 48 | 523 | 49 | 522 | 50 | 521 |
| 100-119 | 51 | 520 | 52 | 519 | 53 | 518 | 54 | 517 | 55 | 516 | 56 | 515 | 57 | 514 | 58 | 513 | 59 | 512 | 60 | 511 |
| 120-139 | 61 | 510 | 62 | 509 | 63 | 508 | 64 | 507 | 65 | 506 | 66 | 505 | 67 | 504 | 68 | 503 | 69 | 502 | 70 | 501 |
| 140-159 | 71 | 500 | 72 | 499 | 73 | 498 | 74 | 497 | 75 | 496 | 76 | 495 | 77 | 494 | 78 | 493 | 79 | 492 | 80 | 491 |
| 160-179 | 81 | 490 | 82 | 489 | 83 | 488 | 84 | 487 | 85 | 486 | 86 | 485 | 87 | 484 | 88 | 483 | 89 | 482 | 90 | 481 |
| 180-199 | 91 | 480 | 92 | 479 | 93 | 478 | 94 | 477 | 95 | 476 | 96 | 475 | 97 | 474 | 98 | 473 | 99 | 472 | 100 | 471 |
| 200-219 | 101 | 470 | 102 | 469 | 103 | 468 | 104 | 467 | 105 | 466 | 106 | 465 | 107 | 464 | 108 | 463 | 109 | 462 | 110 | 461 |
| 220-239 | 111 | 460 | 112 | 459 | 113 | 458 | 114 | 457 | 115 | 456 | 116 | 455 | 117 | 454 | 118 | 453 | 119 | 452 | 120 | 451 |
| 240-259 | 121 | 450 | 122 | 449 | 123 | 448 | 124 | 447 | 125 | 446 | 126 | 445 | 127 | 444 | 128 | 443 | 129 | 442 | 130 | 441 |
| 260-279 | 131 | 440 | 132 | 439 | 133 | 438 | 134 | 437 | 135 | 436 | 136 | 435 | 137 | 434 | 138 | 433 | 139 | 432 | 140 | 431 |
| 280-299 | 141 | 430 | 142 | 429 | 143 | 428 | 144 | 427 | 145 | 426 | 146 | 425 | 147 | 424 | 148 | 423 | 149 | 422 | 150 | 421 |
| 300-319 | 151 | 420 | 152 | 419 | 153 | 418 | 154 | 417 | 155 | 416 | 156 | 415 | 157 | 414 | 158 | 413 | 159 | 412 | 160 | 411 |
| 320-339 | 161 | 410 | 162 | 409 | 163 | 408 | 164 | 407 | 165 | 406 | 166 | 405 | 167 | 404 | 168 | 403 | 169 | 402 | 170 | 401 |
| 340-359 | 171 | 400 | 172 | 399 | 173 | 398 | 174 | 397 | 175 | 396 | 176 | 395 | 177 | 394 | 178 | 393 | 179 | 392 | 180 | 391 |
| 360-379 | 181 | 390 | 182 | 389 | 183 | 388 | 184 | 387 | 185 | 386 | 186 | 385 | 187 | 384 | 188 | 383 | 189 | 382 | 190 | 381 |
| 380-399 | 191 | 380 | 192 | 379 | 193 | 378 | 194 | 377 | 195 | 376 | 196 | 375 | 197 | 374 | 198 | 373 | 199 | 372 | 200 | 371 |
| 400-419 | 201 | 370 | 202 | 369 | 203 | 368 | 204 | 367 | 205 | 366 | 206 | 365 | 207 | 364 | 208 | 363 | 209 | 362 | 210 | 361 |
| 420-439 | 211 | 360 | 212 | 359 | 213 | 358 | 214 | 357 | 215 | 356 | 216 | 355 | 217 | 354 | 218 | 353 | 219 | 352 | 220 | 351 |
| 440-459 | 221 | 350 | 222 | 349 | 223 | 348 | 224 | 347 | 225 | 346 | 226 | 345 | 227 | 344 | 228 | 343 | 229 | 342 | 230 | 341 |
| 460-479 | 231 | 340 | 232 | 339 | 233 | 338 | 234 | 337 | 235 | 336 | 236 | 335 | 237 | 334 | 238 | 333 | 239 | 332 | 240 | 331 |
| 480-499 | 241 | 330 | 242 | 329 | 243 | 328 | 244 | 327 | 245 | 326 | 246 | 325 | 247 | 324 | 248 | 323 | 249 | 322 | 250 | 321 |
| 500-519 | 251 | 320 | 252 | 319 | 253 | 318 | 254 | 317 | 255 | 316 | 256 | 315 | 257 | 314 | 258 | 313 | 259 | 312 | 260 | 311 |
| 520-539 | 261 | 310 | 262 | 309 | 263 | 308 | 264 | 307 | 265 | 306 | 266 | 305 | 267 | 304 | 268 | 303 | 269 | 302 | 270 | 301 |
| 540-559 | 271 | 300 | 272 | 299 | 273 | 298 | 274 | 297 | 275 | 296 | 276 | 295 | 277 | 294 | 278 | 293 | 279 | 292 | 280 | 291 |
| 560-569 | 281 | 290 | 282 | 289 | 283 | 288 | 284 | 287 | 285 | 286 | - | - | - | - | - | - | - | - | - | - |

Table 6.3.3.1-5:  for preamble formats with kHz.

|  |  |  |  |
| --- | --- | --- | --- |
| *zeroCorrelationZoneConfig*, *msgA-ZeroCorrelationZoneConfig* | value | | |
| Unrestricted set | Restricted set type A | Restricted set type B |
| 0 | 0 | 15 | 15 |
| 1 | 13 | 18 | 18 |
| 2 | 15 | 22 | 22 |
| 3 | 18 | 26 | 26 |
| 4 | 22 | 32 | 32 |
| 5 | 26 | 38 | 38 |
| 6 | 32 | 46 | 46 |
| 7 | 38 | 55 | 55 |
| 8 | 46 | 68 | 68 |
| 9 | 59 | 82 | 82 |
| 10 | 76 | 100 | 100 |
| 11 | 93 | 128 | 118 |
| 12 | 119 | 158 | 137 |
| 13 | 167 | 202 | - |
| 14 | 279 | 237 | - |
| 15 | 419 | - | - |

Table 6.3.3.1-6:  for preamble formats with kHz.

|  |  |  |  |
| --- | --- | --- | --- |
| *zeroCorrelationZoneConfig*, *msgA-ZeroCorrelationZoneConfig* | value | | |
| Unrestricted set | Restricted set type A | Restricted set type B |
| 0 | 0 | 36 | 36 |
| 1 | 13 | 57 | 57 |
| 2 | 26 | 72 | 60 |
| 3 | 33 | 81 | 63 |
| 4 | 38 | 89 | 65 |
| 5 | 41 | 94 | 68 |
| 6 | 49 | 103 | 71 |
| 7 | 55 | 112 | 77 |
| 8 | 64 | 121 | 81 |
| 9 | 76 | 132 | 85 |
| 10 | 93 | 137 | 97 |
| 11 | 119 | 152 | 109 |
| 12 | 139 | 173 | 122 |
| 13 | 209 | 195 | 137 |
| 14 | 279 | 216 | - |
| 15 | 419 | 237 | - |

Table 6.3.3.1-7:  for preamble formats with .

|  |  |  |  |
| --- | --- | --- | --- |
| *zeroCorrelationZoneConfig*, *msgA-ZeroCorrelationZoneConfig* | value | | |
|  |  |  |  |
| 0 | 0 | 0 | 0 |
| 1 | 2 | 8 | 17 |
| 2 | 4 | 10 | 21 |
| 3 | 6 | 12 | 25 |
| 4 | 8 | 15 | 30 |
| 5 | 10 | 17 | 35 |
| 6 | 12 | 21 | 44 |
| 7 | 13 | 25 | 52 |
| 8 | 15 | 31 | 63 |
| 9 | 17 | 40 | 82 |
| 10 | 19 | 51 | 104 |
| 11 | 23 | 63 | 127 |
| 12 | 27 | 81 | 164 |
| 13 | 34 | 114 | 230 |
| 14 | 46 | 190 | 383 |
| 15 | 69 | 285 | 575 |

#### 6.3.3.2 Mapping to physical resources

The preamble sequence shall be mapped to physical resources according to



where  is an amplitude scaling factor in order to conform to the transmit power specified in [5, TS38.213], and  is the antenna port. Baseband signal generation shall be done according to clause 5.3 using the parameters in Table 6.3.3.1-1 or Table 6.3.3.1-2 with  given by Table 6.3.3.2-1.

Random access preambles can only be transmitted in the time resources obtained from Tables 6.3.3.2-2 to 6.3.3.2-4 and depends on FR1 or FR2 and the spectrum type as defined in [8, TS38.104]. The PRACH configuration index in Tables 6.3.3.2-2 to 6.3.3.2-4 is

- for Table 6.3.3.2-3 given by the higher-layer parameter *prach-ConfigurationIndex,* or by *msgA-PRACH-ConfigurationIndex* if configured; and

- for Tables 6.3.3.2-2 and 6.3.3.2-4 given by the higher-layer parameter *prach-ConfigurationIndex,* or by *msgA-PRACH-ConfigurationIndex* if configured.

For the IAB-MT part of an IAB-node, the following applies:

- if the higher-layer parameter *prach-ConfigurationPeriodScaling-IAB* is configured, the variable used in of Tables 6.3.3.2-2 to 6.3.3.2-4 shall be replaced by , where and is given by the higher-layer parameter *prach-ConfigurationPeriodScaling-IAB* and the IAB-node does not expect to be larger than 64;

- if the higher-layer parameter *prach-ConfigurationFrameOffset-IAB* is configured, the variable used in of Tables 6.3.3.2-2 to 6.3.3.2-4 shall be replaced by where is given by the higher-layer parameter *prach-ConfigurationFrameOffset-IAB*, and ;

- if the higher-layer parameter *prach-ConfigurationSOffset-IAB* is configured, the subframe number from Tables 6.3.3.2-2 to 6.3.3.2-3 and the slot number from Table 6.3.3.2-4 shall be replaced by where is given by the higher-layer parameter *prach-ConfigurationSOffset-IAB*, and is the number of subframes in a frame when using Tables 6.3.3.2-2 to 6.3.3.2-3 and the number of slots in a frame for 60 kHz subcarrier spacing when using in Table 6.3.3.2-4.

Random access preambles can only be transmitted in the frequency resources given by either the higher-layer parameter *msg1-FrequencyStart* or *msgA-RO-FrequencyStart* if configured as described in clause 8.1 of [5 TS 38.213]. The PRACH frequency resources , where equals the higher-layer parameter *msg1-FDM* or *msgA-RO-FDM* if configured, are numbered in increasing order within the initial uplink bandwidth part during initial access, starting from the lowest frequency. Otherwise, are numbered in increasing order within the active uplink bandwidth part, starting from the lowest frequency.

For operation with shared spectrum channel access, for , a UE expects to be provided with higher-layer parameter *msg1-FrequencyStart* or *msgA-RO-FrequencyStart* if configured, and higher-layer parameter *msg1-FDM* or *msgA-RO-FDM* if configured, such that a random-access preamble is confined within a single RB set. The UE assumes that the RB set is defined as when the UE is not provided *intraCellGuardBandsPerSCS* for an UL carrier as described in Clause 7 of [6, TS 38.214].

For operation with shared spectrum channel access, for or and Type-2 random access, a UE expects to be provided with higher-layer parameter *msgA-RO-FDM* equals to one.

For the purpose of slot numbering in the tables, the following subcarrier spacing shall be assumed:

- 15 kHz for FR1

- 60 kHz for FR2.

For handover purposes to a target cell in paired or unpaired spectrum where the target cell uses , the UE may assume the absolute value of the time difference between radio frame in the current cell and radio frame in the target cell is less than if the association pattern period in clause 8.1 of [5, TS 38.213] is not equal to 10 ms.

For inter frequency handover purposes where the source cell is either in paired or unpaired spectrum and the target cell is in unpaired spectrum and uses , the UE may assume the absolute value of the time difference between radio frame in the current cell and radio frame in the target cell is less than

Table 6.3.3.2-1: Supported combinations of and , and the corresponding value of .

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | for PRACH | for PUSCH | , allocation expressed in number of RBs for PUSCH |  |
| 839 | 1.25 | 15 | 6 | 7 |
| 839 | 1.25 | 30 | 3 | 1 |
| 839 | 1.25 | 60 | 2 | 133 |
| 839 | 5 | 15 | 24 | 12 |
| 839 | 5 | 30 | 12 | 10 |
| 839 | 5 | 60 | 6 | 7 |
| 139 | 15 | 15 | 12 | 2 |
| 139 | 15 | 30 | 6 | 2 |
| 139 | 15 | 60 | 3 | 2 |
| 139 | 30 | 15 | 24 | 2 |
| 139 | 30 | 30 | 12 | 2 |
| 139 | 30 | 60 | 6 | 2 |
| 139 | 60 | 60 | 12 | 2 |
| 139 | 60 | 120 | 6 | 2 |
| 139 | 120 | 60 | 24 | 2 |
| 139 | 120 | 120 | 12 | 2 |
| 139 | 120 | 480 | 3 | 1 |
| 139 | 120 | 960 | 2 | 23 |
| 139 | 480 | 120 | 48 | 2 |
| 139 | 480 | 480 | 12 | 2 |
| 139 | 480 | 960 | 6 | 2 |
| 139 | 960 | 120 | 96 | 2 |
| 139 | 960 | 480 | 24 | 2 |
| 139 | 960 | 960 | 12 | 2 |
| 571 | 30 | 15 | 96 | 2 |
| 571 | 30 | 30 | 48 | 2 |
| 571 | 30 | 60 | 24 | 2 |
| 571 | 120 | 120 | 48 | 2 |
| 571 | 120 | 480 | 12 | 1 |
| 571 | 120 | 960 | 7 | 47 |
| 571 | 480 | 120 | 192 | 2 |
| 571 | 480 | 480 | 48 | 2 |
| 571 | 480 | 960 | 24 | 2 |
| 1151 | 15 | 15 | 96 | 1 |
| 1151 | 15 | 30 | 48 | 1 |
| 1151 | 15 | 60 | 24 | 1 |
| 1151 | 120 | 120 | 97 | 6 |
| 1151 | 120 | 480 | 25 | 23 |
| 1151 | 120 | 960 | 13 | 45 |

Table 6.3.3.2-2: Random access configurations for FR1 and paired spectrum/supplementary uplink.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PRACH Configuration  Index | Preamble format |  | | Subframe number | Starting symbol | Number of PRACH slots within a subframe | , number of time-domain PRACH occasions within a PRACH slot | , PRACH duration |
|  |  |
| 0 | 0 | 16 | 1 | 1 | 0 | - | - | 0 |
| 1 | 0 | 16 | 1 | 4 | 0 | - | - | 0 |
| 2 | 0 | 16 | 1 | 7 | 0 | - | - | 0 |
| 3 | 0 | 16 | 1 | 9 | 0 | - | - | 0 |
| 4 | 0 | 8 | 1 | 1 | 0 | - | - | 0 |
| 5 | 0 | 8 | 1 | 4 | 0 | - | - | 0 |
| 6 | 0 | 8 | 1 | 7 | 0 | - | - | 0 |
| 7 | 0 | 8 | 1 | 9 | 0 | - | - | 0 |
| 8 | 0 | 4 | 1 | 1 | 0 | - | - | 0 |
| 9 | 0 | 4 | 1 | 4 | 0 | - | - | 0 |
| 10 | 0 | 4 | 1 | 7 | 0 | - | - | 0 |
| 11 | 0 | 4 | 1 | 9 | 0 | - | - | 0 |
| 12 | 0 | 2 | 1 | 1 | 0 | - | - | 0 |
| 13 | 0 | 2 | 1 | 4 | 0 | - | - | 0 |
| 14 | 0 | 2 | 1 | 7 | 0 | - | - | 0 |
| 15 | 0 | 2 | 1 | 9 | 0 | - | - | 0 |
| 16 | 0 | 1 | 0 | 1 | 0 | - | - | 0 |
| 17 | 0 | 1 | 0 | 4 | 0 | - | - | 0 |
| 18 | 0 | 1 | 0 | 7 | 0 | - | - | 0 |
| 19 | 0 | 1 | 0 | 1,6 | 0 | - | - | 0 |
| 20 | 0 | 1 | 0 | 2,7 | 0 | - | - | 0 |
| 21 | 0 | 1 | 0 | 3,8 | 0 | - | - | 0 |
| 22 | 0 | 1 | 0 | 1,4,7 | 0 | - | - | 0 |
| 23 | 0 | 1 | 0 | 2,5,8 | 0 | - | - | 0 |
| 24 | 0 | 1 | 0 | 3, 6, 9 | 0 | - | - | 0 |
| 25 | 0 | 1 | 0 | 0,2,4,6,8 | 0 | - | - | 0 |
| 26 | 0 | 1 | 0 | 1,3,5,7,9 | 0 | - | - | 0 |
| 27 | 0 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | - | - | 0 |
| 28 | 1 | 16 | 1 | 1 | 0 | - | - | 0 |
| 29 | 1 | 16 | 1 | 4 | 0 | - | - | 0 |
| 30 | 1 | 16 | 1 | 7 | 0 | - | - | 0 |
| 31 | 1 | 16 | 1 | 9 | 0 | - | - | 0 |
| 32 | 1 | 8 | 1 | 1 | 0 | - | - | 0 |
| 33 | 1 | 8 | 1 | 4 | 0 | - | - | 0 |
| 34 | 1 | 8 | 1 | 7 | 0 | - | - | 0 |
| 35 | 1 | 8 | 1 | 9 | 0 | - | - | 0 |
| 36 | 1 | 4 | 1 | 1 | 0 | - | - | 0 |
| 37 | 1 | 4 | 1 | 4 | 0 | - | - | 0 |
| 38 | 1 | 4 | 1 | 7 | 0 | - | - | 0 |
| 39 | 1 | 4 | 1 | 9 | 0 | - | - | 0 |
| 40 | 1 | 2 | 1 | 1 | 0 | - | - | 0 |
| 41 | 1 | 2 | 1 | 4 | 0 | - | - | 0 |
| 42 | 1 | 2 | 1 | 7 | 0 | - | - | 0 |
| 43 | 1 | 2 | 1 | 9 | 0 | - | - | 0 |
| 44 | 1 | 1 | 0 | 1 | 0 | - | - | 0 |
| 45 | 1 | 1 | 0 | 4 | 0 | - | - | 0 |
| 46 | 1 | 1 | 0 | 7 | 0 | - | - | 0 |
| 47 | 1 | 1 | 0 | 1,6 | 0 | - | - | 0 |
| 48 | 1 | 1 | 0 | 2,7 | 0 | - | - | 0 |
| 49 | 1 | 1 | 0 | 3,8 | 0 | - | - | 0 |
| 50 | 1 | 1 | 0 | 1,4,7 | 0 | - | - | 0 |
| 51 | 1 | 1 | 0 | 2,5,8 | 0 | - | - | 0 |
| 52 | 1 | 1 | 0 | 3,6,9 | 0 | - | - | 0 |
| 53 | 2 | 16 | 1 | 1 | 0 | - | - | 0 |
| 54 | 2 | 8 | 1 | 1 | 0 | - | - | 0 |
| 55 | 2 | 4 | 0 | 1 | 0 | - | - | 0 |
| 56 | 2 | 2 | 0 | 1 | 0 | - | - | 0 |
| 57 | 2 | 2 | 0 | 5 | 0 | - | - | 0 |
| 58 | 2 | 1 | 0 | 1 | 0 | - | - | 0 |
| 59 | 2 | 1 | 0 | 5 | 0 | - | - | 0 |
| 60 | 3 | 16 | 1 | 1 | 0 | - | - | 0 |
| 61 | 3 | 16 | 1 | 4 | 0 | - | - | 0 |
| 62 | 3 | 16 | 1 | 7 | 0 | - | - | 0 |
| 63 | 3 | 16 | 1 | 9 | 0 | - | - | 0 |
| 64 | 3 | 8 | 1 | 1 | 0 | - | - | 0 |
| 65 | 3 | 8 | 1 | 4 | 0 | - | - | 0 |
| 66 | 3 | 8 | 1 | 7 | 0 | - | - | 0 |
| 67 | 3 | 4 | 1 | 1 | 0 | - | - | 0 |
| 68 | 3 | 4 | 1 | 4 | 0 | - | - | 0 |
| 69 | 3 | 4 | 1 | 7 | 0 | - | - | 0 |
| 70 | 3 | 4 | 1 | 9 | 0 | - | - | 0 |
| 71 | 3 | 2 | 1 | 1 | 0 | - | - | 0 |
| 72 | 3 | 2 | 1 | 4 | 0 | - | - | 0 |
| 73 | 3 | 2 | 1 | 7 | 0 | - | - | 0 |
| 74 | 3 | 2 | 1 | 9 | 0 | - | - | 0 |
| 75 | 3 | 1 | 0 | 1 | 0 | - | - | 0 |
| 76 | 3 | 1 | 0 | 4 | 0 | - | - | 0 |
| 77 | 3 | 1 | 0 | 7 | 0 | - | - | 0 |
| 78 | 3 | 1 | 0 | 1,6 | 0 | - | - | 0 |
| 79 | 3 | 1 | 0 | 2,7 | 0 | - | - | 0 |
| 80 | 3 | 1 | 0 | 3,8 | 0 | - | - | 0 |
| 81 | 3 | 1 | 0 | 1,4,7 | 0 | - | - | 0 |
| 82 | 3 | 1 | 0 | 2,5,8 | 0 | - | - | 0 |
| 83 | 3 | 1 | 0 | 3, 6, 9 | 0 | - | - | 0 |
| 84 | 3 | 1 | 0 | 0,2,4,6,8 | 0 | - | - | 0 |
| 85 | 3 | 1 | 0 | 1,3,5,7,9 | 0 | - | - | 0 |
| 86 | 3 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | - | - | 0 |
| 87 | A1 | 16 | 0 | 4,9 | 0 | 1 | 6 | 2 |
| 88 | A1 | 16 | 1 | 4 | 0 | 2 | 6 | 2 |
| 89 | A1 | 8 | 0 | 4,9 | 0 | 1 | 6 | 2 |
| 90 | A1 | 8 | 1 | 4 | 0 | 2 | 6 | 2 |
| 91 | A1 | 4 | 0 | 4,9 | 0 | 1 | 6 | 2 |
| 92 | A1 | 4 | 1 | 4,9 | 0 | 1 | 6 | 2 |
| 93 | A1 | 4 | 0 | 4 | 0 | 2 | 6 | 2 |
| 94 | A1 | 2 | 0 | 4,9 | 0 | 1 | 6 | 2 |
| 95 | A1 | 2 | 0 | 1 | 0 | 2 | 6 | 2 |
| 96 | A1 | 2 | 0 | 4 | 0 | 2 | 6 | 2 |
| 97 | A1 | 2 | 0 | 7 | 0 | 2 | 6 | 2 |
| 98 | A1 | 1 | 0 | 4 | 0 | 1 | 6 | 2 |
| 99 | A1 | 1 | 0 | 1,6 | 0 | 1 | 6 | 2 |
| 100 | A1 | 1 | 0 | 4,9 | 0 | 1 | 6 | 2 |
| 101 | A1 | 1 | 0 | 1 | 0 | 2 | 6 | 2 |
| 102 | A1 | 1 | 0 | 7 | 0 | 2 | 6 | 2 |
| 103 | A1 | 1 | 0 | 2,7 | 0 | 2 | 6 | 2 |
| 104 | A1 | 1 | 0 | 1,4,7 | 0 | 2 | 6 | 2 |
| 105 | A1 | 1 | 0 | 0,2,4,6,8 | 0 | 2 | 6 | 2 |
| 106 | A1 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | 2 | 6 | 2 |
| 107 | A1 | 1 | 0 | 1,3,5,7,9 | 0 | 2 | 6 | 2 |
| 108 | A1/B1 | 2 | 0 | 4,9 | 0 | 1 | 7 | 2 |
| 109 | A1/B1 | 2 | 0 | 4 | 0 | 2 | 7 | 2 |
| 110 | A1/B1 | 1 | 0 | 4 | 0 | 1 | 7 | 2 |
| 111 | A1/B1 | 1 | 0 | 1,6 | 0 | 1 | 7 | 2 |
| 112 | A1/B1 | 1 | 0 | 4,9 | 0 | 1 | 7 | 2 |
| 113 | A1/B1 | 1 | 0 | 1 | 0 | 2 | 7 | 2 |
| 114 | A1/B1 | 1 | 0 | 7 | 0 | 2 | 7 | 2 |
| 115 | A1/B1 | 1 | 0 | 1,4,7 | 0 | 2 | 7 | 2 |
| 116 | A1/B1 | 1 | 0 | 0,2,4,6,8 | 0 | 2 | 7 | 2 |
| 117 | A2 | 16 | 1 | 2,6,9 | 0 | 1 | 3 | 4 |
| 118 | A2 | 16 | 1 | 4 | 0 | 2 | 3 | 4 |
| 119 | A2 | 8 | 1 | 2,6,9 | 0 | 1 | 3 | 4 |
| 120 | A2 | 8 | 1 | 4 | 0 | 2 | 3 | 4 |
| 121 | A2 | 4 | 0 | 2,6,9 | 0 | 1 | 3 | 4 |
| 122 | A2 | 4 | 0 | 4 | 0 | 2 | 3 | 4 |
| 123 | A2 | 2 | 1 | 2,6,9 | 0 | 1 | 3 | 4 |
| 124 | A2 | 2 | 0 | 1 | 0 | 2 | 3 | 4 |
| 125 | A2 | 2 | 0 | 4 | 0 | 2 | 3 | 4 |
| 126 | A2 | 2 | 0 | 7 | 0 | 2 | 3 | 4 |
| 127 | A2 | 1 | 0 | 4 | 0 | 1 | 3 | 4 |
| 128 | A2 | 1 | 0 | 1,6 | 0 | 1 | 3 | 4 |
| 129 | A2 | 1 | 0 | 4,9 | 0 | 1 | 3 | 4 |
| 130 | A2 | 1 | 0 | 1 | 0 | 2 | 3 | 4 |
| 131 | A2 | 1 | 0 | 7 | 0 | 2 | 3 | 4 |
| 132 | A2 | 1 | 0 | 2,7 | 0 | 2 | 3 | 4 |
| 133 | A2 | 1 | 0 | 1,4,7 | 0 | 2 | 3 | 4 |
| 134 | A2 | 1 | 0 | 0,2,4,6,8 | 0 | 2 | 3 | 4 |
| 135 | A2 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | 2 | 3 | 4 |
| 136 | A2 | 1 | 0 | 1,3,5,7,9 | 0 | 2 | 3 | 4 |
| 137 | A2/B2 | 2 | 1 | 2,6,9 | 0 | 1 | 3 | 4 |
| 138 | A2/B2 | 2 | 0 | 4 | 0 | 2 | 3 | 4 |
| 139 | A2/B2 | 1 | 0 | 4 | 0 | 1 | 3 | 4 |
| 140 | A2/B2 | 1 | 0 | 1,6 | 0 | 1 | 3 | 4 |
| 141 | A2/B2 | 1 | 0 | 4,9 | 0 | 1 | 3 | 4 |
| 142 | A2/B2 | 1 | 0 | 1 | 0 | 2 | 3 | 4 |
| 143 | A2/B2 | 1 | 0 | 7 | 0 | 2 | 3 | 4 |
| 144 | A2/B2 | 1 | 0 | 1,4,7 | 0 | 2 | 3 | 4 |
| 145 | A2/B2 | 1 | 0 | 0,2,4,6,8 | 0 | 2 | 3 | 4 |
| 146 | A2/B2 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | 2 | 3 | 4 |
| 147 | A3 | 16 | 1 | 4,9 | 0 | 1 | 2 | 6 |
| 148 | A3 | 16 | 1 | 4 | 0 | 2 | 2 | 6 |
| 149 | A3 | 8 | 1 | 4,9 | 0 | 1 | 2 | 6 |
| 150 | A3 | 8 | 1 | 4 | 0 | 2 | 2 | 6 |
| 151 | A3 | 4 | 0 | 4,9 | 0 | 1 | 2 | 6 |
| 152 | A3 | 4 | 0 | 4 | 0 | 2 | 2 | 6 |
| 153 | A3 | 2 | 1 | 2,6,9 | 0 | 2 | 2 | 6 |
| 154 | A3 | 2 | 0 | 1 | 0 | 2 | 2 | 6 |
| 155 | A3 | 2 | 0 | 4 | 0 | 2 | 2 | 6 |
| 156 | A3 | 2 | 0 | 7 | 0 | 2 | 2 | 6 |
| 157 | A3 | 1 | 0 | 4 | 0 | 1 | 2 | 6 |
| 158 | A3 | 1 | 0 | 1,6 | 0 | 1 | 2 | 6 |
| 159 | A3 | 1 | 0 | 4,9 | 0 | 1 | 2 | 6 |
| 160 | A3 | 1 | 0 | 1 | 0 | 2 | 2 | 6 |
| 161 | A3 | 1 | 0 | 7 | 0 | 2 | 2 | 6 |
| 162 | A3 | 1 | 0 | 2,7 | 0 | 2 | 2 | 6 |
| 163 | A3 | 1 | 0 | 1,4,7 | 0 | 2 | 2 | 6 |
| 164 | A3 | 1 | 0 | 0,2,4,6,8 | 0 | 2 | 2 | 6 |
| 165 | A3 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | 2 | 2 | 6 |
| 166 | A3 | 1 | 0 | 1,3,5,7,9 | 0 | 2 | 2 | 6 |
| 167 | A3/B3 | 2 | 1 | 2,6,9 | 0 | 2 | 2 | 6 |
| 168 | A3/B3 | 2 | 0 | 4 | 0 | 2 | 2 | 6 |
| 169 | A3/B3 | 1 | 0 | 4 | 0 | 1 | 2 | 6 |
| 170 | A3/B3 | 1 | 0 | 1,6 | 0 | 1 | 2 | 6 |
| 171 | A3/B3 | 1 | 0 | 4,9 | 0 | 1 | 2 | 6 |
| 172 | A3/B3 | 1 | 0 | 1 | 0 | 2 | 2 | 6 |
| 173 | A3/B3 | 1 | 0 | 7 | 0 | 2 | 2 | 6 |
| 174 | A3/B3 | 1 | 0 | 1,4,7 | 0 | 2 | 2 | 6 |
| 175 | A3/B3 | 1 | 0 | 0,2,4,6,8 | 0 | 2 | 2 | 6 |
| 176 | A3/B3 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | 2 | 2 | 6 |
| 177 | B1 | 16 | 0 | 4,9 | 0 | 1 | 7 | 2 |
| 178 | B1 | 16 | 1 | 4 | 0 | 2 | 7 | 2 |
| 179 | B1 | 8 | 0 | 4,9 | 0 | 1 | 7 | 2 |
| 180 | B1 | 8 | 1 | 4 | 0 | 2 | 7 | 2 |
| 181 | B1 | 4 | 0 | 4,9 | 0 | 1 | 7 | 2 |
| 182 | B1 | 4 | 1 | 4,9 | 0 | 1 | 7 | 2 |
| 183 | B1 | 4 | 0 | 4 | 0 | 2 | 7 | 2 |
| 184 | B1 | 2 | 0 | 4,9 | 0 | 1 | 7 | 2 |
| 185 | B1 | 2 | 0 | 1 | 0 | 2 | 7 | 2 |
| 186 | B1 | 2 | 0 | 4 | 0 | 2 | 7 | 2 |
| 187 | B1 | 2 | 0 | 7 | 0 | 2 | 7 | 2 |
| 188 | B1 | 1 | 0 | 4 | 0 | 1 | 7 | 2 |
| 189 | B1 | 1 | 0 | 1,6 | 0 | 1 | 7 | 2 |
| 190 | B1 | 1 | 0 | 4,9 | 0 | 1 | 7 | 2 |
| 191 | B1 | 1 | 0 | 1 | 0 | 2 | 7 | 2 |
| 192 | B1 | 1 | 0 | 7 | 0 | 2 | 7 | 2 |
| 193 | B1 | 1 | 0 | 2,7 | 0 | 2 | 7 | 2 |
| 194 | B1 | 1 | 0 | 1,4,7 | 0 | 2 | 7 | 2 |
| 195 | B1 | 1 | 0 | 0,2,4,6,8 | 0 | 2 | 7 | 2 |
| 196 | B1 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | 2 | 7 | 2 |
| 197 | B1 | 1 | 0 | 1,3,5,7,9 | 0 | 2 | 7 | 2 |
| 198 | B4 | 16 | 0 | 4,9 | 0 | 2 | 1 | 12 |
| 199 | B4 | 16 | 1 | 4 | 0 | 2 | 1 | 12 |
| 200 | B4 | 8 | 0 | 4,9 | 0 | 2 | 1 | 12 |
| 201 | B4 | 8 | 1 | 4 | 0 | 2 | 1 | 12 |
| 202 | B4 | 4 | 0 | 4,9 | 0 | 2 | 1 | 12 |
| 203 | B4 | 4 | 0 | 4 | 0 | 2 | 1 | 12 |
| 204 | B4 | 4 | 1 | 4,9 | 0 | 2 | 1 | 12 |
| 205 | B4 | 2 | 0 | 4,9 | 0 | 2 | 1 | 12 |
| 206 | B4 | 2 | 0 | 1 | 0 | 2 | 1 | 12 |
| 207 | B4 | 2 | 0 | 4 | 0 | 2 | 1 | 12 |
| 208 | B4 | 2 | 0 | 7 | 0 | 2 | 1 | 12 |
| 209 | B4 | 1 | 0 | 1 | 0 | 2 | 1 | 12 |
| 210 | B4 | 1 | 0 | 4 | 0 | 2 | 1 | 12 |
| 211 | B4 | 1 | 0 | 7 | 0 | 2 | 1 | 12 |
| 212 | B4 | 1 | 0 | 1,6 | 0 | 2 | 1 | 12 |
| 213 | B4 | 1 | 0 | 2,7 | 0 | 2 | 1 | 12 |
| 214 | B4 | 1 | 0 | 4,9 | 0 | 2 | 1 | 12 |
| 215 | B4 | 1 | 0 | 1,4,7 | 0 | 2 | 1 | 12 |
| 216 | B4 | 1 | 0 | 0,2,4,6,8 | 0 | 2 | 1 | 12 |
| 217 | B4 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | 2 | 1 | 12 |
| 218 | B4 | 1 | 0 | 1,3,5,7,9 | 0 | 2 | 1 | 12 |
| 219 | C0 | 8 | 1 | 4 | 0 | 2 | 7 | 2 |
| 220 | C0 | 4 | 1 | 4,9 | 0 | 1 | 7 | 2 |
| 221 | C0 | 4 | 0 | 4 | 0 | 2 | 7 | 2 |
| 222 | C0 | 2 | 0 | 4,9 | 0 | 1 | 7 | 2 |
| 223 | C0 | 2 | 0 | 1 | 0 | 2 | 7 | 2 |
| 224 | C0 | 2 | 0 | 4 | 0 | 2 | 7 | 2 |
| 225 | C0 | 2 | 0 | 7 | 0 | 2 | 7 | 2 |
| 226 | C0 | 1 | 0 | 4 | 0 | 1 | 7 | 2 |
| 227 | C0 | 1 | 0 | 1,6 | 0 | 1 | 7 | 2 |
| 228 | C0 | 1 | 0 | 4,9 | 0 | 1 | 7 | 2 |
| 229 | C0 | 1 | 0 | 1 | 0 | 2 | 7 | 2 |
| 230 | C0 | 1 | 0 | 7 | 0 | 2 | 7 | 2 |
| 231 | C0 | 1 | 0 | 2,7 | 0 | 2 | 7 | 2 |
| 232 | C0 | 1 | 0 | 1,4,7 | 0 | 2 | 7 | 2 |
| 233 | C0 | 1 | 0 | 0,2,4,6,8 | 0 | 2 | 7 | 2 |
| 234 | C0 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | 2 | 7 | 2 |
| 235 | C0 | 1 | 0 | 1,3,5,7,9 | 0 | 2 | 7 | 2 |
| 236 | C2 | 16 | 1 | 4,9 | 0 | 1 | 2 | 6 |
| 237 | C2 | 16 | 1 | 4 | 0 | 2 | 2 | 6 |
| 238 | C2 | 8 | 1 | 4,9 | 0 | 1 | 2 | 6 |
| 239 | C2 | 8 | 1 | 4 | 0 | 2 | 2 | 6 |
| 240 | C2 | 4 | 0 | 4,9 | 0 | 1 | 2 | 6 |
| 241 | C2 | 4 | 0 | 4 | 0 | 2 | 2 | 6 |
| 242 | C2 | 2 | 1 | 2,6,9 | 0 | 2 | 2 | 6 |
| 243 | C2 | 2 | 0 | 1 | 0 | 2 | 2 | 6 |
| 244 | C2 | 2 | 0 | 4 | 0 | 2 | 2 | 6 |
| 245 | C2 | 2 | 0 | 7 | 0 | 2 | 2 | 6 |
| 246 | C2 | 1 | 0 | 4 | 0 | 1 | 2 | 6 |
| 247 | C2 | 1 | 0 | 1,6 | 0 | 1 | 2 | 6 |
| 248 | C2 | 1 | 0 | 4,9 | 0 | 1 | 2 | 6 |
| 249 | C2 | 1 | 0 | 1 | 0 | 2 | 2 | 6 |
| 250 | C2 | 1 | 0 | 7 | 0 | 2 | 2 | 6 |
| 251 | C2 | 1 | 0 | 2,7 | 0 | 2 | 2 | 6 |
| 252 | C2 | 1 | 0 | 1,4,7 | 0 | 2 | 2 | 6 |
| 253 | C2 | 1 | 0 | 0,2,4,6,8 | 0 | 2 | 2 | 6 |
| 254 | C2 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | 2 | 2 | 6 |
| 255 | C2 | 1 | 0 | 1,3,5,7,9 | 0 | 2 | 2 | 6 |

Table 6.3.3.2-3: Random access configurations for FR1 and unpaired spectrum.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PRACH Configuration  Index | Preamble format |  | | Subframe number | Starting symbol | Number of PRACH slots within a subframe | , number of time-domain PRACH occasions within a PRACH slot | , PRACH duration |
|  |  |
| 0 | 0 | 16 | 1 | 9 | 0 | - | - | 0 |
| 1 | 0 | 8 | 1 | 9 | 0 | - | - | 0 |
| 2 | 0 | 4 | 1 | 9 | 0 | - | - | 0 |
| 3 | 0 | 2 | 0 | 9 | 0 | - | - | 0 |
| 4 | 0 | 2 | 1 | 9 | 0 | - | - | 0 |
| 5 | 0 | 2 | 0 | 4 | 0 | - | - | 0 |
| 6 | 0 | 2 | 1 | 4 | 0 | - | - | 0 |
| 7 | 0 | 1 | 0 | 9 | 0 | - | - | 0 |
| 8 | 0 | 1 | 0 | 8 | 0 | - | - | 0 |
| 9 | 0 | 1 | 0 | 7 | 0 | - | - | 0 |
| 10 | 0 | 1 | 0 | 6 | 0 | - | - | 0 |
| 11 | 0 | 1 | 0 | 5 | 0 | - | - | 0 |
| 12 | 0 | 1 | 0 | 4 | 0 | - | - | 0 |
| 13 | 0 | 1 | 0 | 3 | 0 | - | - | 0 |
| 14 | 0 | 1 | 0 | 2 | 0 | - | - | 0 |
| 15 | 0 | 1 | 0 | 1,6 | 0 |  |  | 0 |
| 16 | 0 | 1 | 0 | 1,6 | 7 | - | - | 0 |
| 17 | 0 | 1 | 0 | 4,9 | 0 | - | - | 0 |
| 18 | 0 | 1 | 0 | 3,8 | 0 | - | - | 0 |
| 19 | 0 | 1 | 0 | 2,7 | 0 | - | - | 0 |
| 20 | 0 | 1 | 0 | 8,9 | 0 | - | - | 0 |
| 21 | 0 | 1 | 0 | 4,8,9 | 0 | - | - | 0 |
| 22 | 0 | 1 | 0 | 3,4,9 | 0 | - | - | 0 |
| 23 | 0 | 1 | 0 | 7,8,9 | 0 | - | - | 0 |
| 24 | 0 | 1 | 0 | 3,4,8,9 | 0 | - | - | 0 |
| 25 | 0 | 1 | 0 | 6,7,8,9 | 0 | - | - | 0 |
| 26 | 0 | 1 | 0 | 1,4,6,9 | 0 | - | - | 0 |
| 27 | 0 | 1 | 0 | 1,3,5,7,9 | 0 | - | - | 0 |
| 28 | 1 | 16 | 1 | 7 | 0 | - | - | 0 |
| 29 | 1 | 8 | 1 | 7 | 0 | - | - | 0 |
| 30 | 1 | 4 | 1 | 7 | 0 | - | - | 0 |
| 31 | 1 | 2 | 0 | 7 | 0 | - | - | 0 |
| 32 | 1 | 2 | 1 | 7 | 0 | - | - | 0 |
| 33 | 1 | 1 | 0 | 7 | 0 | - | - | 0 |
| 34 | 2 | 16 | 1 | 6 | 0 | - | - | 0 |
| 35 | 2 | 8 | 1 | 6 | 0 | - | - | 0 |
| 36 | 2 | 4 | 1 | 6 | 0 | - | - | 0 |
| 37 | 2 | 2 | 0 | 6 | 7 | - | - | 0 |
| 38 | 2 | 2 | 1 | 6 | 7 | - | - | 0 |
| 39 | 2 | 1 | 0 | 6 | 7 | - | - | 0 |
| 40 | 3 | 16 | 1 | 9 | 0 | - | - | 0 |
| 41 | 3 | 8 | 1 | 9 | 0 | - | - | 0 |
| 42 | 3 | 4 | 1 | 9 | 0 | - | - | 0 |
| 43 | 3 | 2 | 0 | 9 | 0 | - | - | 0 |
| 44 | 3 | 2 | 1 | 9 | 0 | - | - | 0 |
| 45 | 3 | 2 | 0 | 4 | 0 | - | - | 0 |
| 46 | 3 | 2 | 1 | 4 | 0 | - | - | 0 |
| 47 | 3 | 1 | 0 | 9 | 0 | - | - | 0 |
| 48 | 3 | 1 | 0 | 8 | 0 | - | - | 0 |
| 49 | 3 | 1 | 0 | 7 | 0 | - | - | 0 |
| 50 | 3 | 1 | 0 | 6 | 0 | - | - | 0 |
| 51 | 3 | 1 | 0 | 5 | 0 | - | - | 0 |
| 52 | 3 | 1 | 0 | 4 | 0 | - | - | 0 |
| 53 | 3 | 1 | 0 | 3 | 0 | - | - | 0 |
| 54 | 3 | 1 | 0 | 2 | 0 | - | - | 0 |
| 55 | 3 | 1 | 0 | 1,6 | 0 | - | - | 0 |
| 56 | 3 | 1 | 0 | 1,6 | 7 | - | - | 0 |
| 57 | 3 | 1 | 0 | 4,9 | 0 | - | - | 0 |
| 58 | 3 | 1 | 0 | 3,8 | 0 | - | - | 0 |
| 59 | 3 | 1 | 0 | 2,7 | 0 | - | - | 0 |
| 60 | 3 | 1 | 0 | 8,9 | 0 | - | - | 0 |
| 61 | 3 | 1 | 0 | 4,8,9 | 0 | - | - | 0 |
| 62 | 3 | 1 | 0 | 3,4,9 | 0 | - | - | 0 |
| 63 | 3 | 1 | 0 | 7,8,9 | 0 | - | - | 0 |
| 64 | 3 | 1 | 0 | 3,4,8,9 | 0 | - | - | 0 |
| 65 | 3 | 1 | 0 | 1,4,6,9 | 0 | - | - | 0 |
| 66 | 3 | 1 | 0 | 1,3,5,7,9 | 0 | - | - | 0 |
| 67 | A1 | 16 | 1 | 9 | 0 | 2 | 6 | 2 |
| 68 | A1 | 8 | 1 | 9 | 0 | 2 | 6 | 2 |
| 69 | A1 | 4 | 1 | 9 | 0 | 1 | 6 | 2 |
| 70 | A1 | 2 | 1 | 9 | 0 | 1 | 6 | 2 |
| 71 | A1 | 2 | 1 | 4,9 | 7 | 1 | 3 | 2 |
| 72 | A1 | 2 | 1 | 7,9 | 7 | 1 | 3 | 2 |
| 73 | A1 | 2 | 1 | 7,9 | 0 | 1 | 6 | 2 |
| 74 | A1 | 2 | 1 | 8,9 | 0 | 2 | 6 | 2 |
| 75 | A1 | 2 | 1 | 4,9 | 0 | 2 | 6 | 2 |
| 76 | A1 | 2 | 1 | 2,3,4,7,8,9 | 0 | 1 | 6 | 2 |
| 77 | A1 | 1 | 0 | 9 | 0 | 2 | 6 | 2 |
| 78 | A1 | 1 | 0 | 9 | 7 | 1 | 3 | 2 |
| 79 | A1 | 1 | 0 | 9 | 0 | 1 | 6 | 2 |
| 80 | A1 | 1 | 0 | 8,9 | 0 | 2 | 6 | 2 |
| 81 | A1 | 1 | 0 | 4,9 | 0 | 1 | 6 | 2 |
| 82 | A1 | 1 | 0 | 7,9 | 7 | 1 | 3 | 2 |
| 83 | A1 | 1 | 0 | 3,4,8,9 | 0 | 1 | 6 | 2 |
| 84 | A1 | 1 | 0 | 3,4,8,9 | 0 | 2 | 6 | 2 |
| 85 | A1 | 1 | 0 | 1,3,5,7,9 | 0 | 1 | 6 | 2 |
| 86 | A1 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 7 | 1 | 3 | 2 |
| 87 | A2 | 16 | 1 | 9 | 0 | 2 | 3 | 4 |
| 88 | A2 | 8 | 1 | 9 | 0 | 2 | 3 | 4 |
| 89 | A2 | 4 | 1 | 9 | 0 | 1 | 3 | 4 |
| 90 | A2 | 2 | 1 | 7,9 | 0 | 1 | 3 | 4 |
| 91 | A2 | 2 | 1 | 8,9 | 0 | 2 | 3 | 4 |
| 92 | A2 | 2 | 1 | 7,9 | 9 | 1 | 1 | 4 |
| 93 | A2 | 2 | 1 | 4,9 | 9 | 1 | 1 | 4 |
| 94 | A2 | 2 | 1 | 4,9 | 0 | 2 | 3 | 4 |
| 95 | A2 | 2 | 1 | 2,3,4,7,8,9 | 0 | 1 | 3 | 4 |
| 96 | A2 | 1 | 0 | 2 | 0 | 1 | 3 | 4 |
| 97 | A2 | 1 | 0 | 7 | 0 | 1 | 3 | 4 |
| 98 | A2 | 2 | 1 | 9 | 0 | 1 | 3 | 4 |
| 99 | A2 | 1 | 0 | 9 | 0 | 2 | 3 | 4 |
| 100 | A2 | 1 | 0 | 9 | 9 | 1 | 1 | 4 |
| 101 | A2 | 1 | 0 | 9 | 0 | 1 | 3 | 4 |
| 102 | A2 | 1 | 0 | 2,7 | 0 | 1 | 3 | 4 |
| 103 | A2 | 1 | 0 | 8,9 | 0 | 2 | 3 | 4 |
| 104 | A2 | 1 | 0 | 4,9 | 0 | 1 | 3 | 4 |
| 105 | A2 | 1 | 0 | 7,9 | 9 | 1 | 1 | 4 |
| 106 | A2 | 1 | 0 | 3,4,8,9 | 0 | 1 | 3 | 4 |
| 107 | A2 | 1 | 0 | 3,4,8,9 | 0 | 2 | 3 | 4 |
| 108 | A2 | 1 | 0 | 1,3,5,7,9 | 0 | 1 | 3 | 4 |
| 109 | A2 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 9 | 1 | 1 | 4 |
| 110 | A3 | 16 | 1 | 9 | 0 | 2 | 2 | 6 |
| 111 | A3 | 8 | 1 | 9 | 0 | 2 | 2 | 6 |
| 112 | A3 | 4 | 1 | 9 | 0 | 1 | 2 | 6 |
| 113 | A3 | 2 | 1 | 4,9 | 7 | 1 | 1 | 6 |
| 114 | A3 | 2 | 1 | 7,9 | 7 | 1 | 1 | 6 |
| 115 | A3 | 2 | 1 | 7,9 | 0 | 1 | 2 | 6 |
| 116 | A3 | 2 | 1 | 4,9 | 0 | 2 | 2 | 6 |
| 117 | A3 | 2 | 1 | 8,9 | 0 | 2 | 2 | 6 |
| 118 | A3 | 2 | 1 | 2,3,4,7,8,9 | 0 | 1 | 2 | 6 |
| 119 | A3 | 1 | 0 | 2 | 0 | 1 | 2 | 6 |
| 120 | A3 | 1 | 0 | 7 | 0 | 1 | 2 | 6 |
| 121 | A3 | 2 | 1 | 9 | 0 | 1 | 2 | 6 |
| 122 | A3 | 1 | 0 | 9 | 0 | 2 | 2 | 6 |
| 123 | A3 | 1 | 0 | 9 | 7 | 1 | 1 | 6 |
| 124 | A3 | 1 | 0 | 9 | 0 | 1 | 2 | 6 |
| 125 | A3 | 1 | 0 | 2,7 | 0 | 1 | 2 | 6 |
| 126 | A3 | 1 | 0 | 8,9 | 0 | 2 | 2 | 6 |
| 127 | A3 | 1 | 0 | 4,9 | 0 | 1 | 2 | 6 |
| 128 | A3 | 1 | 0 | 7,9 | 7 | 1 | 1 | 6 |
| 129 | A3 | 1 | 0 | 3,4,8,9 | 0 | 1 | 2 | 6 |
| 130 | A3 | 1 | 0 | 3,4,8,9 | 0 | 2 | 2 | 6 |
| 131 | A3 | 1 | 0 | 1,3,5,7,9 | 0 | 1 | 2 | 6 |
| 132 | A3 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 7 | 1 | 1 | 6 |
| 133 | B1 | 4 | 1 | 9 | 2 | 1 | 6 | 2 |
| 134 | B1 | 2 | 1 | 9 | 2 | 1 | 6 | 2 |
| 135 | B1 | 2 | 1 | 7,9 | 2 | 1 | 6 | 2 |
| 136 | B1 | 2 | 1 | 4,9 | 8 | 1 | 3 | 2 |
| 137 | B1 | 2 | 1 | 4,9 | 2 | 2 | 6 | 2 |
| 138 | B1 | 1 | 0 | 9 | 2 | 2 | 6 | 2 |
| 139 | B1 | 1 | 0 | 9 | 8 | 1 | 3 | 2 |
| 140 | B1 | 1 | 0 | 9 | 2 | 1 | 6 | 2 |
| 141 | B1 | 1 | 0 | 8,9 | 2 | 2 | 6 | 2 |
| 142 | B1 | 1 | 0 | 4,9 | 2 | 1 | 6 | 2 |
| 143 | B1 | 1 | 0 | 7,9 | 8 | 1 | 3 | 2 |
| 144 | B1 | 1 | 0 | 1,3,5,7,9 | 2 | 1 | 6 | 2 |
| 145 | B4 | 16 | 1 | 9 | 0 | 2 | 1 | 12 |
| 146 | B4 | 8 | 1 | 9 | 0 | 2 | 1 | 12 |
| 147 | B4 | 4 | 1 | 9 | 2 | 1 | 1 | 12 |
| 148 | B4 | 2 | 1 | 9 | 0 | 1 | 1 | 12 |
| 149 | B4 | 2 | 1 | 9 | 2 | 1 | 1 | 12 |
| 150 | B4 | 2 | 1 | 7,9 | 2 | 1 | 1 | 12 |
| 151 | B4 | 2 | 1 | 4,9 | 2 | 1 | 1 | 12 |
| 152 | B4 | 2 | 1 | 4,9 | 0 | 2 | 1 | 12 |
| 153 | B4 | 2 | 1 | 8,9 | 0 | 2 | 1 | 12 |
| 154 | B4 | 2 | 1 | 2,3,4,7,8,9 | 0 | 1 | 1 | 12 |
| 155 | B4 | 1 | 0 | 1 | 0 | 1 | 1 | 12 |
| 156 | B4 | 1 | 0 | 2 | 0 | 1 | 1 | 12 |
| 157 | B4 | 1 | 0 | 4 | 0 | 1 | 1 | 12 |
| 158 | B4 | 1 | 0 | 7 | 0 | 1 | 1 | 12 |
| 159 | B4 | 1 | 0 | 9 | 0 | 1 | 1 | 12 |
| 160 | B4 | 1 | 0 | 9 | 2 | 1 | 1 | 12 |
| 161 | B4 | 1 | 0 | 9 | 0 | 2 | 1 | 12 |
| 162 | B4 | 1 | 0 | 4,9 | 2 | 1 | 1 | 12 |
| 163 | B4 | 1 | 0 | 7,9 | 2 | 1 | 1 | 12 |
| 164 | B4 | 1 | 0 | 8,9 | 0 | 2 | 1 | 12 |
| 165 | B4 | 1 | 0 | 3,4,8,9 | 2 | 1 | 1 | 12 |
| 166 | B4 | 1 | 0 | 1,3,5,7,9 | 2 | 1 | 1 | 12 |
| 167 | B4 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 0 | 2 | 1 | 12 |
| 168 | B4 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 2 | 1 | 1 | 12 |
| 169 | C0 | 16 | 1 | 9 | 2 | 2 | 6 | 2 |
| 170 | C0 | 8 | 1 | 9 | 2 | 2 | 6 | 2 |
| 171 | C0 | 4 | 1 | 9 | 2 | 1 | 6 | 2 |
| 172 | C0 | 2 | 1 | 9 | 2 | 1 | 6 | 2 |
| 173 | C0 | 2 | 1 | 8,9 | 2 | 2 | 6 | 2 |
| 174 | C0 | 2 | 1 | 7,9 | 2 | 1 | 6 | 2 |
| 175 | C0 | 2 | 1 | 7,9 | 8 | 1 | 3 | 2 |
| 176 | C0 | 2 | 1 | 4,9 | 8 | 1 | 3 | 2 |
| 177 | C0 | 2 | 1 | 4,9 | 2 | 2 | 6 | 2 |
| 178 | C0 | 2 | 1 | 2,3,4,7,8,9 | 2 | 1 | 6 | 2 |
| 179 | C0 | 1 | 0 | 9 | 2 | 2 | 6 | 2 |
| 180 | C0 | 1 | 0 | 9 | 8 | 1 | 3 | 2 |
| 181 | C0 | 1 | 0 | 9 | 2 | 1 | 6 | 2 |
| 182 | C0 | 1 | 0 | 8,9 | 2 | 2 | 6 | 2 |
| 183 | C0 | 1 | 0 | 4,9 | 2 | 1 | 6 | 2 |
| 184 | C0 | 1 | 0 | 7,9 | 8 | 1 | 3 | 2 |
| 185 | C0 | 1 | 0 | 3,4,8,9 | 2 | 1 | 6 | 2 |
| 186 | C0 | 1 | 0 | 3,4,8,9 | 2 | 2 | 6 | 2 |
| 187 | C0 | 1 | 0 | 1,3,5,7,9 | 2 | 1 | 6 | 2 |
| 188 | C0 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 8 | 1 | 3 | 2 |
| 189 | C2 | 16 | 1 | 9 | 2 | 2 | 2 | 6 |
| 190 | C2 | 8 | 1 | 9 | 2 | 2 | 2 | 6 |
| 191 | C2 | 4 | 1 | 9 | 2 | 1 | 2 | 6 |
| 192 | C2 | 2 | 1 | 9 | 2 | 1 | 2 | 6 |
| 193 | C2 | 2 | 1 | 8,9 | 2 | 2 | 2 | 6 |
| 194 | C2 | 2 | 1 | 7,9 | 2 | 1 | 2 | 6 |
| 195 | C2 | 2 | 1 | 7,9 | 8 | 1 | 1 | 6 |
| 196 | C2 | 2 | 1 | 4,9 | 8 | 1 | 1 | 6 |
| 197 | C2 | 2 | 1 | 4,9 | 2 | 2 | 2 | 6 |
| 198 | C2 | 2 | 1 | 2,3,4,7,8,9 | 2 | 1 | 2 | 6 |
| 199 | C2 | 8 | 1 | 9 | 8 | 2 | 1 | 6 |
| 200 | C2 | 4 | 1 | 9 | 8 | 1 | 1 | 6 |
| 201 | C2 | 1 | 0 | 9 | 2 | 2 | 2 | 6 |
| 202 | C2 | 1 | 0 | 9 | 8 | 1 | 1 | 6 |
| 203 | C2 | 1 | 0 | 9 | 2 | 1 | 2 | 6 |
| 204 | C2 | 1 | 0 | 8,9 | 2 | 2 | 2 | 6 |
| 205 | C2 | 1 | 0 | 4,9 | 2 | 1 | 2 | 6 |
| 206 | C2 | 1 | 0 | 7,9 | 8 | 1 | 1 | 6 |
| 207 | C2 | 1 | 0 | 3,4,8,9 | 2 | 1 | 2 | 6 |
| 208 | C2 | 1 | 0 | 3,4,8,9 | 2 | 2 | 2 | 6 |
| 209 | C2 | 1 | 0 | 1,3,5,7,9 | 2 | 1 | 2 | 6 |
| 210 | C2 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 8 | 1 | 1 | 6 |
| 211 | A1/B1 | 2 | 1 | 9 | 2 | 1 | 6 | 2 |
| 212 | A1/B1 | 2 | 1 | 4,9 | 8 | 1 | 3 | 2 |
| 213 | A1/B1 | 2 | 1 | 7,9 | 8 | 1 | 3 | 2 |
| 214 | A1/B1 | 2 | 1 | 7,9 | 2 | 1 | 6 | 2 |
| 215 | A1/B1 | 2 | 1 | 4,9 | 2 | 2 | 6 | 2 |
| 216 | A1/B1 | 2 | 1 | 8,9 | 2 | 2 | 6 | 2 |
| 217 | A1/B1 | 1 | 0 | 9 | 2 | 2 | 6 | 2 |
| 218 | A1/B1 | 1 | 0 | 9 | 8 | 1 | 3 | 2 |
| 219 | A1/B1 | 1 | 0 | 9 | 2 | 1 | 6 | 2 |
| 220 | A1/B1 | 1 | 0 | 8,9 | 2 | 2 | 6 | 2 |
| 221 | A1/B1 | 1 | 0 | 4,9 | 2 | 1 | 6 | 2 |
| 222 | A1/B1 | 1 | 0 | 7,9 | 8 | 1 | 3 | 2 |
| 223 | A1/B1 | 1 | 0 | 3,4,8,9 | 2 | 2 | 6 | 2 |
| 224 | A1/B1 | 1 | 0 | 1,3,5,7,9 | 2 | 1 | 6 | 2 |
| 225 | A1/B1 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 8 | 1 | 3 | 2 |
| 226 | A2/B2 | 2 | 1 | 9 | 0 | 1 | 3 | 4 |
| 227 | A2/B2 | 2 | 1 | 4,9 | 6 | 1 | 2 | 4 |
| 228 | A2/B2 | 2 | 1 | 7,9 | 6 | 1 | 2 | 4 |
| 229 | A2/B2 | 2 | 1 | 4,9 | 0 | 2 | 3 | 4 |
| 230 | A2/B2 | 2 | 1 | 8,9 | 0 | 2 | 3 | 4 |
| 231 | A2/B2 | 1 | 0 | 9 | 0 | 2 | 3 | 4 |
| 232 | A2/B2 | 1 | 0 | 9 | 6 | 1 | 2 | 4 |
| 233 | A2/B2 | 1 | 0 | 9 | 0 | 1 | 3 | 4 |
| 234 | A2/B2 | 1 | 0 | 8,9 | 0 | 2 | 3 | 4 |
| 235 | A2/B2 | 1 | 0 | 4,9 | 0 | 1 | 3 | 4 |
| 236 | A2/B2 | 1 | 0 | 7,9 | 6 | 1 | 2 | 4 |
| 237 | A2/B2 | 1 | 0 | 3,4,8,9 | 0 | 1 | 3 | 4 |
| 238 | A2/B2 | 1 | 0 | 3,4,8,9 | 0 | 2 | 3 | 4 |
| 239 | A2/B2 | 1 | 0 | 1,3,5,7,9 | 0 | 1 | 3 | 4 |
| 240 | A2/B2 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 6 | 1 | 2 | 4 |
| 241 | A3/B3 | 2 | 1 | 9 | 0 | 1 | 2 | 6 |
| 242 | A3/B3 | 2 | 1 | 4,9 | 2 | 1 | 2 | 6 |
| 243 | A3/B3 | 2 | 1 | 7,9 | 0 | 1 | 2 | 6 |
| 244 | A3/B3 | 2 | 1 | 7,9 | 2 | 1 | 2 | 6 |
| 245 | A3/B3 | 2 | 1 | 4,9 | 0 | 2 | 2 | 6 |
| 246 | A3/B3 | 2 | 1 | 8,9 | 0 | 2 | 2 | 6 |
| 247 | A3/B3 | 1 | 0 | 9 | 0 | 2 | 2 | 6 |
| 248 | A3/B3 | 1 | 0 | 9 | 2 | 1 | 2 | 6 |
| 249 | A3/B3 | 1 | 0 | 9 | 0 | 1 | 2 | 6 |
| 250 | A3/B3 | 1 | 0 | 8,9 | 0 | 2 | 2 | 6 |
| 251 | A3/B3 | 1 | 0 | 4,9 | 0 | 1 | 2 | 6 |
| 252 | A3/B3 | 1 | 0 | 7,9 | 2 | 1 | 2 | 6 |
| 253 | A3/B3 | 1 | 0 | 3,4,8,9 | 0 | 2 | 2 | 6 |
| 254 | A3/B3 | 1 | 0 | 1,3,5,7,9 | 0 | 1 | 2 | 6 |
| 255 | A3/B3 | 1 | 0 | 0,1,2,3,4,5,6,7,8,9 | 2 | 1 | 2 | 6 |
| 256 | 0 | 16 | 1 | 7 | 0 | - | - | 0 |
| 257 | 0 | 8 | 1 | 7 | 0 | - | - | 0 |
| 258 | 0 | 4 | 1 | 7 | 0 | - | - | 0 |
| 259 | 0 | 2 | 0 | 7 | 0 | - | - | 0 |
| 260 | 0 | 2 | 1 | 7 | 0 | - | - | 0 |
| 261 | 0 | 2 | 0 | 2 | 0 | - | - | 0 |
| 262 | 0 | 2 | 1 | 2 | 0 | - | - | 0 |

Table 6.3.3.2-4: Random access configurations for FR2 and unpaired spectrum.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| PRACH Config.  Index | Preamble format |  | | Slot number | Starting symbol | Number of PRACH slots within a 60 kHz slot | , number of time-domain PRACH occasions within a PRACH slot | , PRACH duration |
|  |  |
| 0 | A1 | 16 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 6 | 2 |
| 1 | A1 | 16 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 6 | 2 |
| 2 | A1 | 8 | 1,2 | 9,19,29,39 | 0 | 2 | 6 | 2 |
| 3 | A1 | 8 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 6 | 2 |
| 4 | A1 | 8 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 6 | 2 |
| 5 | A1 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 6 | 2 |
| 6 | A1 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 6 | 2 |
| 7 | A1 | 4 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 6 | 2 |
| 8 | A1 | 2 | 1 | 7,15,23,31,39 | 0 | 2 | 6 | 2 |
| 9 | A1 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 6 | 2 |
| 10 | A1 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 6 | 2 |
| 11 | A1 | 2 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 6 | 2 |
| 12 | A1 | 1 | 0 | 19,39 | 7 | 1 | 3 | 2 |
| 13 | A1 | 1 | 0 | 3,5,7 | 0 | 1 | 6 | 2 |
| 14 | A1 | 1 | 0 | 24,29,34,39 | 7 | 1 | 3 | 2 |
| 15 | A1 | 1 | 0 | 9,19,29,39 | 7 | 2 | 3 | 2 |
| 16 | A1 | 1 | 0 | 17,19,37,39 | 0 | 1 | 6 | 2 |
| 17 | A1 | 1 | 0 | 9,19,29,39 | 0 | 2 | 6 | 2 |
| 18 | A1 | 1 | 0 | 4,9,14,19,24,29,34,39 | 0 | 1 | 6 | 2 |
| 19 | A1 | 1 | 0 | 4,9,14,19,24,29,34,39 | 7 | 1 | 3 | 2 |
| 20 | A1 | 1 | 0 | 3,5,7,9,11,13 | 7 | 1 | 3 | 2 |
| 21 | A1 | 1 | 0 | 23,27,31,35,39 | 7 | 1 | 3 | 2 |
| 22 | A1 | 1 | 0 | 7,15,23,31,39 | 0 | 1 | 6 | 2 |
| 23 | A1 | 1 | 0 | 23,27,31,35,39 | 0 | 1 | 6 | 2 |
| 24 | A1 | 1 | 0 | 13,14,15, 29,30,31,37,38,39 | 7 | 2 | 3 | 2 |
| 25 | A1 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 7 | 1 | 3 | 2 |
| 26 | A1 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 6 | 2 |
| 27 | A1 | 1 | 0 | 1,3,5,7,…,37,39 | 0 | 1 | 6 | 2 |
| 28 | A1 | 1 | 0 | 0,1,2,…,39 | 7 | 1 | 3 | 2 |
| 29 | A2 | 16 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 3 | 4 |
| 30 | A2 | 16 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 3 | 4 |
| 31 | A2 | 8 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 3 | 4 |
| 32 | A2 | 8 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 3 | 4 |
| 33 | A2 | 8 | 1,2 | 9,19,29,39 | 0 | 2 | 3 | 4 |
| 34 | A2 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 3 | 4 |
| 35 | A2 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 3 | 4 |
| 36 | A2 | 4 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 3 | 4 |
| 37 | A2 | 2 | 1 | 7,15,23,31,39 | 0 | 2 | 3 | 4 |
| 38 | A2 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 3 | 4 |
| 39 | A2 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 3 | 4 |
| 40 | A2 | 2 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 3 | 4 |
| 41 | A2 | 1 | 0 | 19,39 | 5 | 1 | 2 | 4 |
| 42 | A2 | 1 | 0 | 3,5,7 | 0 | 1 | 3 | 4 |
| 43 | A2 | 1 | 0 | 24,29,34,39 | 5 | 1 | 2 | 4 |
| 44 | A2 | 1 | 0 | 9,19,29,39 | 5 | 2 | 2 | 4 |
| 45 | A2 | 1 | 0 | 17,19,37,39 | 0 | 1 | 3 | 4 |
| 46 | A2 | 1 | 0 | 9, 19, 29, 39 | 0 | 2 | 3 | 4 |
| 47 | A2 | 1 | 0 | 7,15,23,31,39 | 0 | 1 | 3 | 4 |
| 48 | A2 | 1 | 0 | 23,27,31,35,39 | 5 | 1 | 2 | 4 |
| 49 | A2 | 1 | 0 | 23,27,31,35,39 | 0 | 1 | 3 | 4 |
| 50 | A2 | 1 | 0 | 3,5,7,9,11,13 | 5 | 1 | 2 | 4 |
| 51 | A2 | 1 | 0 | 3,5,7,9,11,13 | 0 | 1 | 3 | 4 |
| 52 | A2 | 1 | 0 | 4,9,14,19,24,29,34,39 | 5 | 1 | 2 | 4 |
| 53 | A2 | 1 | 0 | 4,9,14,19,24,29,34,39 | 0 | 1 | 3 | 4 |
| 54 | A2 | 1 | 0 | 13,14,15, 29,30,31,37,38,39 | 5 | 2 | 2 | 4 |
| 55 | A2 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 5 | 1 | 2 | 4 |
| 56 | A2 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 3 | 4 |
| 57 | A2 | 1 | 0 | 1,3,5,7,…,37,39 | 0 | 1 | 3 | 4 |
| 58 | A2 | 1 | 0 | 0,1,2,…,39 | 5 | 1 | 2 | 4 |
| 59 | A3 | 16 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 2 | 6 |
| 60 | A3 | 16 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 61 | A3 | 8 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 2 | 6 |
| 62 | A3 | 8 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 63 | A3 | 8 | 1,2 | 9,19,29,39 | 0 | 2 | 2 | 6 |
| 64 | A3 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 2 | 6 |
| 65 | A3 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 2 | 6 |
| 66 | A3 | 4 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 67 | A3 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 2 | 6 |
| 68 | A3 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 2 | 6 |
| 69 | A3 | 2 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 70 | A3 | 1 | 0 | 19,39 | 7 | 1 | 1 | 6 |
| 71 | A3 | 1 | 0 | 3,5,7 | 0 | 1 | 2 | 6 |
| 72 | A3 | 1 | 0 | 9,11,13 | 2 | 1 | 2 | 6 |
| 73 | A3 | 1 | 0 | 24,29,34,39 | 7 | 1 | 1 | 6 |
| 74 | A3 | 1 | 0 | 9,19,29,39 | 7 | 2 | 1 | 6 |
| 75 | A3 | 1 | 0 | 17,19,37,39 | 0 | 1 | 2 | 6 |
| 76 | A3 | 1 | 0 | 9,19,29,39 | 0 | 2 | 2 | 6 |
| 77 | A3 | 1 | 0 | 7,15,23,31,39 | 0 | 1 | 2 | 6 |
| 78 | A3 | 1 | 0 | 23,27,31,35,39 | 7 | 1 | 1 | 6 |
| 79 | A3 | 1 | 0 | 23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 80 | A3 | 1 | 0 | 3,5,7,9,11,13 | 0 | 1 | 2 | 6 |
| 81 | A3 | 1 | 0 | 3,5,7,9,11,13 | 7 | 1 | 1 | 6 |
| 82 | A3 | 1 | 0 | 4,9,14,19,24,29,34,39 | 0 | 1 | 2 | 6 |
| 83 | A3 | 1 | 0 | 4,9,14,19,24,29,34,39 | 7 | 1 | 1 | 6 |
| 84 | A3 | 1 | 0 | 13,14,15, 29,30,31,37,38,39 | 7 | 2 | 1 | 6 |
| 85 | A3 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 7 | 1 | 1 | 6 |
| 86 | A3 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 87 | A3 | 1 | 0 | 1,3,5,7,…,37,39 | 0 | 1 | 2 | 6 |
| 88 | A3 | 1 | 0 | 0,1,2,…,39 | 7 | 1 | 1 | 6 |
| 89 | B1 | 16 | 1 | 4,9,14,19,24,29,34,39 | 2 | 2 | 6 | 2 |
| 90 | B1 | 8 | 1 | 4,9,14,19,24,29,34,39 | 2 | 2 | 6 | 2 |
| 91 | B1 | 8 | 1,2 | 9,19,29,39 | 2 | 2 | 6 | 2 |
| 92 | B1 | 4 | 1 | 4,9,14,19,24,29,34,39 | 2 | 2 | 6 | 2 |
| 93 | B1 | 2 | 1 | 4,9,14,19,24,29,34,39 | 2 | 2 | 6 | 2 |
| 94 | B1 | 2 | 1 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 6 | 2 |
| 95 | B1 | 1 | 0 | 19,39 | 8 | 1 | 3 | 2 |
| 96 | B1 | 1 | 0 | 3,5,7 | 2 | 1 | 6 | 2 |
| 97 | B1 | 1 | 0 | 24,29,34,39 | 8 | 1 | 3 | 2 |
| 98 | B1 | 1 | 0 | 9,19,29,39 | 8 | 2 | 3 | 2 |
| 99 | B1 | 1 | 0 | 17,19,37,39 | 2 | 1 | 6 | 2 |
| 100 | B1 | 1 | 0 | 9,19,29,39 | 2 | 2 | 6 | 2 |
| 101 | B1 | 1 | 0 | 7,15,23,31,39 | 2 | 1 | 6 | 2 |
| 102 | B1 | 1 | 0 | 23,27,31,35,39 | 8 | 1 | 3 | 2 |
| 103 | B1 | 1 | 0 | 23,27,31,35,39 | 2 | 1 | 6 | 2 |
| 104 | B1 | 1 | 0 | 3,5,7,9,11,13 | 8 | 1 | 3 | 2 |
| 105 | B1 | 1 | 0 | 4,9,14,19,24,29,34,39 | 8 | 1 | 3 | 2 |
| 106 | B1 | 1 | 0 | 4,9,14,19,24,29,34,39 | 2 | 1 | 6 | 2 |
| 107 | B1 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 8 | 1 | 3 | 2 |
| 108 | B1 | 1 | 0 | 13,14,15, 29,30,31,37,38,39 | 8 | 2 | 3 | 2 |
| 109 | B1 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 6 | 2 |
| 110 | B1 | 1 | 0 | 1,3,5,7,…,37,39 | 2 | 1 | 6 | 2 |
| 111 | B1 | 1 | 0 | 0,1,2,…,39 | 8 | 1 | 3 | 2 |
| 112 | B4 | 16 | 1,2 | 4,9,14,19,24,29,34,39 | 0 | 2 | 1 | 12 |
| 113 | B4 | 16 | 1,2 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 1 | 12 |
| 114 | B4 | 8 | 1,2 | 4,9,14,19,24,29,34,39 | 0 | 2 | 1 | 12 |
| 115 | B4 | 8 | 1,2 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 1 | 12 |
| 116 | B4 | 8 | 1,2 | 9,19,29,39 | 0 | 2 | 1 | 12 |
| 117 | B4 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 1 | 12 |
| 118 | B4 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 1 | 12 |
| 119 | B4 | 4 | 1,2 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 1 | 12 |
| 120 | B4 | 2 | 1 | 7,15,23,31,39 | 2 | 2 | 1 | 12 |
| 121 | B4 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 1 | 12 |
| 122 | B4 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 1 | 12 |
| 123 | B4 | 2 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 1 | 12 |
| 124 | B4 | 1 | 0 | 19, 39 | 2 | 2 | 1 | 12 |
| 125 | B4 | 1 | 0 | 17, 19, 37, 39 | 0 | 1 | 1 | 12 |
| 126 | B4 | 1 | 0 | 24,29,34,39 | 2 | 1 | 1 | 12 |
| 127 | B4 | 1 | 0 | 9,19,29,39 | 2 | 2 | 1 | 12 |
| 128 | B4 | 1 | 0 | 9,19,29,39 | 0 | 2 | 1 | 12 |
| 129 | B4 | 1 | 0 | 7,15,23,31,39 | 0 | 1 | 1 | 12 |
| 130 | B4 | 1 | 0 | 7,15,23,31,39 | 0 | 2 | 1 | 12 |
| 131 | B4 | 1 | 0 | 23,27,31,35,39 | 0 | 1 | 1 | 12 |
| 132 | B4 | 1 | 0 | 23,27,31,35,39 | 2 | 2 | 1 | 12 |
| 133 | B4 | 1 | 0 | 9,11,13,15,17,19 | 0 | 1 | 1 | 12 |
| 134 | B4 | 1 | 0 | 3,5,7,9,11,13 | 2 | 1 | 1 | 12 |
| 135 | B4 | 1 | 0 | 4,9,14,19,24,29,34,39 | 0 | 1 | 1 | 12 |
| 136 | B4 | 1 | 0 | 4,9,14,19,24,29,34,39 | 2 | 2 | 1 | 12 |
| 137 | B4 | 1 | 0 | 13,14,15, 29,30,31,37,38,39 | 2 | 2 | 1 | 12 |
| 138 | B4 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 1 | 12 |
| 139 | B4 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 1 | 12 |
| 140 | B4 | 1 | 0 | 3, 5, 7, …, 23,25 | 2 | 1 | 1 | 12 |
| 141 | B4 | 1 | 0 | 3, 5, 7, …, 23,25 | 0 | 2 | 1 | 12 |
| 142 | B4 | 1 | 0 | 1,3,5,7,…,37,39 | 0 | 1 | 1 | 12 |
| 143 | B4 | 1 | 0 | 0, 1, 2,…, 39 | 2 | 1 | 1 | 12 |
| 144 | C0 | 16 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 7 | 2 |
| 145 | C0 | 16 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 7 | 2 |
| 146 | C0 | 8 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 7 | 2 |
| 147 | C0 | 8 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 7 | 2 |
| 148 | C0 | 8 | 1,2 | 9,19,29,39 | 0 | 2 | 7 | 2 |
| 149 | C0 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 7 | 2 |
| 150 | C0 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 7 | 2 |
| 151 | C0 | 4 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 7 | 2 |
| 152 | C0 | 2 | 1 | 7,15,23,31,39 | 0 | 2 | 7 | 2 |
| 153 | C0 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 7 | 2 |
| 154 | C0 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 7 | 2 |
| 155 | C0 | 2 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 7 | 2 |
| 156 | C0 | 1 | 0 | 19,39 | 8 | 1 | 3 | 2 |
| 157 | C0 | 1 | 0 | 3,5,7 | 0 | 1 | 7 | 2 |
| 158 | C0 | 1 | 0 | 24,29,34,39 | 8 | 1 | 3 | 2 |
| 159 | C0 | 1 | 0 | 9,19,29,39 | 8 | 2 | 3 | 2 |
| 160 | C0 | 1 | 0 | 17,19,37,39 | 0 | 1 | 7 | 2 |
| 161 | C0 | 1 | 0 | 9,19,29,39 | 0 | 2 | 7 | 2 |
| 162 | C0 | 1 | 0 | 23,27,31,35,39 | 8 | 1 | 3 | 2 |
| 163 | C0 | 1 | 0 | 7,15,23,31,39 | 0 | 1 | 7 | 2 |
| 164 | C0 | 1 | 0 | 23,27,31,35,39 | 0 | 1 | 7 | 2 |
| 165 | C0 | 1 | 0 | 3,5,7,9,11,13 | 8 | 1 | 3 | 2 |
| 166 | C0 | 1 | 0 | 4,9,14,19,24,29,34,39 | 8 | 1 | 3 | 2 |
| 167 | C0 | 1 | 0 | 4,9,14,19,24,29,34,39 | 0 | 1 | 7 | 2 |
| 168 | C0 | 1 | 0 | 13,14,15, 29,30,31,37,38,39 | 8 | 2 | 3 | 2 |
| 169 | C0 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 8 | 1 | 3 | 2 |
| 170 | C0 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 7 | 2 |
| 171 | C0 | 1 | 0 | 1,3,5,7,…,37,39 | 0 | 1 | 7 | 2 |
| 172 | C0 | 1 | 0 | 0,1,2,…,39 | 8 | 1 | 3 | 2 |
| 173 | C2 | 16 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 2 | 6 |
| 174 | C2 | 16 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 175 | C2 | 8 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 2 | 6 |
| 176 | C2 | 8 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 177 | C2 | 8 | 1,2 | 9,19,29,39 | 0 | 2 | 2 | 6 |
| 178 | C2 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 2 | 6 |
| 179 | C2 | 4 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 2 | 6 |
| 180 | C2 | 4 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 181 | C2 | 2 | 1 | 7,15,23,31,39 | 2 | 2 | 2 | 6 |
| 182 | C2 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 1 | 2 | 6 |
| 183 | C2 | 2 | 1 | 4,9,14,19,24,29,34,39 | 0 | 2 | 2 | 6 |
| 184 | C2 | 2 | 1 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 185 | C2 | 1 | 0 | 19,39 | 2 | 1 | 2 | 6 |
| 186 | C2 | 1 | 0 | 3,5,7 | 0 | 1 | 2 | 6 |
| 187 | C2 | 1 | 0 | 24,29,34,39 | 7 | 1 | 1 | 6 |
| 188 | C2 | 1 | 0 | 9,19,29,39 | 7 | 2 | 1 | 6 |
| 189 | C2 | 1 | 0 | 17,19,37,39 | 0 | 1 | 2 | 6 |
| 190 | C2 | 1 | 0 | 9,19,29,39 | 2 | 2 | 2 | 6 |
| 191 | C2 | 1 | 0 | 7,15,23,31,39 | 2 | 1 | 2 | 6 |
| 192 | C2 | 1 | 0 | 3,5,7,9,11,13 | 7 | 1 | 1 | 6 |
| 193 | C2 | 1 | 0 | 23,27,31,35,39 | 7 | 2 | 1 | 6 |
| 194 | C2 | 1 | 0 | 23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 195 | C2 | 1 | 0 | 4,9,14,19,24,29,34,39 | 7 | 2 | 1 | 6 |
| 196 | C2 | 1 | 0 | 4,9,14,19,24,29,34,39 | 2 | 1 | 2 | 6 |
| 197 | C2 | 1 | 0 | 13,14,15, 29,30,31,37,38,39 | 7 | 2 | 1 | 6 |
| 198 | C2 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 7 | 1 | 1 | 6 |
| 199 | C2 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 0 | 1 | 2 | 6 |
| 200 | C2 | 1 | 0 | 1,3,5,7,…,37,39 | 0 | 1 | 2 | 6 |
| 201 | C2 | 1 | 0 | 0,1,2,…,39 | 7 | 1 | 1 | 6 |
| 202 | A1/B1 | 16 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 6 | 2 |
| 203 | A1/B1 | 16 | 1 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 6 | 2 |
| 204 | A1/B1 | 8 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 6 | 2 |
| 205 | A1/B1 | 8 | 1 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 6 | 2 |
| 206 | A1/B1 | 4 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 6 | 2 |
| 207 | A1/B1 | 4 | 1 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 6 | 2 |
| 208 | A1/B1 | 2 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 6 | 2 |
| 209 | A1/B1 | 1 | 0 | 19,39 | 8 | 1 | 3 | 2 |
| 210 | A1/B1 | 1 | 0 | 9,19,29,39 | 8 | 1 | 3 | 2 |
| 211 | A1/B1 | 1 | 0 | 17,19,37,39 | 2 | 1 | 6 | 2 |
| 212 | A1/B1 | 1 | 0 | 9,19,29,39 | 2 | 2 | 6 | 2 |
| 213 | A1/B1 | 1 | 0 | 23,27,31,35,39 | 8 | 1 | 3 | 2 |
| 214 | A1/B1 | 1 | 0 | 7,15,23,31,39 | 2 | 1 | 6 | 2 |
| 215 | A1/B1 | 1 | 0 | 23,27,31,35,39 | 2 | 1 | 6 | 2 |
| 216 | A1/B1 | 1 | 0 | 4,9,14,19,24,29,34,39 | 8 | 1 | 3 | 2 |
| 217 | A1/B1 | 1 | 0 | 4,9,14,19,24,29,34,39 | 2 | 1 | 6 | 2 |
| 218 | A1/B1 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 6 | 2 |
| 219 | A1/B1 | 1 | 0 | 1,3,5,7,…,37,39 | 2 | 1 | 6 | 2 |
| 220 | A2/B2 | 16 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 3 | 4 |
| 221 | A2/B2 | 16 | 1 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 3 | 4 |
| 222 | A2/B2 | 8 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 3 | 4 |
| 223 | A2/B2 | 8 | 1 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 3 | 4 |
| 224 | A2/B2 | 4 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 3 | 4 |
| 225 | A2/B2 | 4 | 1 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 3 | 4 |
| 226 | A2/B2 | 2 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 3 | 4 |
| 227 | A2/B2 | 1 | 0 | 19,39 | 6 | 1 | 2 | 4 |
| 228 | A2/B2 | 1 | 0 | 9,19,29,39 | 6 | 1 | 2 | 4 |
| 229 | A2/B2 | 1 | 0 | 17,19,37,39 | 2 | 1 | 3 | 4 |
| 230 | A2/B2 | 1 | 0 | 9,19,29,39 | 2 | 2 | 3 | 4 |
| 231 | A2/B2 | 1 | 0 | 23,27,31,35,39 | 6 | 1 | 2 | 4 |
| 232 | A2/B2 | 1 | 0 | 7,15,23,31,39 | 2 | 1 | 3 | 4 |
| 233 | A2/B2 | 1 | 0 | 23,27,31,35,39 | 2 | 1 | 3 | 4 |
| 234 | A2/B2 | 1 | 0 | 4,9,14,19,24,29,34,39 | 6 | 1 | 2 | 4 |
| 235 | A2/B2 | 1 | 0 | 4,9,14,19,24,29,34,39 | 2 | 1 | 3 | 4 |
| 236 | A2/B2 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 3 | 4 |
| 237 | A2/B2 | 1 | 0 | 1,3,5,7,…,37,39 | 2 | 1 | 3 | 4 |
| 238 | A3/B3 | 16 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 2 | 6 |
| 239 | A3/B3 | 16 | 1 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 2 | 6 |
| 240 | A3/B3 | 8 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 2 | 6 |
| 241 | A3/B3 | 8 | 1 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 2 | 6 |
| 242 | A3/B3 | 4 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 2 | 6 |
| 243 | A3/B3 | 4 | 1 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 2 | 6 |
| 244 | A3/B3 | 2 | 1 | 4,9,14,19,24,29,34,39 | 2 | 1 | 2 | 6 |
| 245 | A3/B3 | 1 | 0 | 19,39 | 2 | 1 | 2 | 6 |
| 246 | A3/B3 | 1 | 0 | 9,19,29,39 | 2 | 1 | 2 | 6 |
| 247 | A3/B3 | 1 | 0 | 17,19,37,39 | 2 | 1 | 2 | 6 |
| 248 | A3/B3 | 1 | 0 | 9,19,29,39 | 2 | 2 | 2 | 6 |
| 249 | A3/B3 | 1 | 0 | 7,15,23,31,39 | 2 | 1 | 2 | 6 |
| 250 | A3/B3 | 1 | 0 | 23,27,31,35,39 | 2 | 1 | 2 | 6 |
| 251 | A3/B3 | 1 | 0 | 23,27,31,35,39 | 2 | 2 | 2 | 6 |
| 252 | A3/B3 | 1 | 0 | 4,9,14,19,24,29,34,39 | 2 | 1 | 2 | 6 |
| 253 | A3/B3 | 1 | 0 | 4,9,14,19,24,29,34,39 | 2 | 2 | 2 | 6 |
| 254 | A3/B3 | 1 | 0 | 3,7,11,15,19,23,27,31,35,39 | 2 | 1 | 2 | 6 |
| 255 | A3/B3 | 1 | 0 | 1,3,5,7,…,37,39 | 2 | 1 | 2 | 6 |

## 6.4 Physical signals

### 6.4.1 Reference signals

#### 6.4.1.1 Demodulation reference signal for PUSCH

##### 6.4.1.1.1 Sequence generation

6.4.1.1.1.1 Sequence generation when transform precoding is disabled

If transform precoding for PUSCH is not enabled, the sequence  shall be generated according to

.

where the pseudo-random sequence  is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialized with

where  is the OFDM symbol number within the slot, is the slot number within a frame, and

- are given by the higher-layer parameters *scramblingID0* and *scramblingID1*, respectively, in the *DMRS-UplinkConfig* IE if provided and the PUSCH is scheduled by DCI format 0\_1, 0\_2, or 0\_3, or by a PUSCH transmission with a configured grant;

- is given by the higher-layer parameter *scramblingID0* in the *DMRS-UplinkConfig* IE if provided and the PUSCH is scheduled by DCI format 0\_0 with the CRC scrambled by C-RNTI, MCS-C-RNTI, or CS-RNTI;

- are, for each msgA PUSCH configuration, given by the higher-layer parameters *msgA-ScramblingID0* and *msgA-ScramblingID1*, respectively, in the *msgA-DMRS-Config* IE if provided and the PUSCH transmission is triggered by a Type-2 random access procedure as described in clause 8.1A of [5, TS 38.213];

- otherwise;

- and are given by

- if the higher-layer parameter *dmrs-Uplink* in the *DMRS-UplinkConfig* IE is provided

where is the CDM group defined in clause 6.4.1.1.3.

- otherwise

The quantity is

- indicated by the DM-RS initialization field, if present, either in the DCI associated with the PUSCH transmission if DCI format 0\_1, 0\_2, or 0\_3, in [4, TS 38.212] is used;

- indicated by the higher layer parameter *dmrs-SeqInitialization*, if present, for a Type 1 PUSCH transmission with a configured grant;

- determined by the mapping between preamble(s) and a PUSCH occasion and the associated DMRS resource for a PUSCH transmission of Type-2 random access process in [5, TS 38.213];

- determined by the mapping between SS/PBCH block(s) and a PUSCH occasion and the associated DMRS resource for a configured-grant based PUSCH transmission in RRC\_INACTIVE state [5, TS 38.213];

- otherwise .

6.4.1.1.1.2 Sequence generation when transform precoding is enabled

If transform precoding for PUSCH is enabled, the reference-signal sequence  shall be generated according to



where with depends on the configuration:

- if the higher-layer parameter *dmrs-UplinkTransformPrecoding* is configured, π/2-BPSK modulation is used for PUSCH, and the PUSCH transmission is not a msg3 transmission, and the transmission is not scheduled using DCI format 0\_0 in a common search space, is given by clause 5.2.3 with given by

where unless given by the DCI according to clause 7.3.1.1.2 in [4, TS38.212] for a transmission scheduled by DCI format 0\_1, or given by the DCI according to clause 7.3.1.1.3 in [4, TS38.212] for a transmission scheduled by DCI format 0\_2 if the antenna ports field in the DCI format 0\_2 is not 0 bit, or given by the DCI according to clause 7.3.1.1.4 in [4, TS38.212] for a transmission scheduled by DCI format 0\_3, or given by the higher-layer parameter *antennaPort* for a PUSCH transmission scheduled by a type-1 configured grant; and

- are given by the higher-layer parameters *pi2BPSK-ScramblingID0* and *pi2BPSK-ScramblingID1*, respectively, in the *DMRS-UplinkConfig* IE if provided and the PUSCH is scheduled by DCI format 0\_1, or by DCI format 0\_2 if the antenna ports field in the DCI format 0\_2 is not 0 bit, or by DCI format 0\_3, or by a PUSCH transmission with a configured grant;

- is given by the higher-layer parameter *pi2BPSK-ScramblingID0* in the *DMRS-UplinkConfig* IE if provided and the PUSCH is scheduled by DCI format 0\_0 with the CRC scrambled by C-RNTI, MCS-C-RNTI, or CS-RNTI, or by DCI format 0\_2 if the antenna ports field in the DCI format 0\_2 is 0 bit;

- otherwise;

- otherwise, is given by clause 5.2.2 with .

The sequence group , where is given by

- if is configured by the higher-layer parameter *nPUSCH-Identity* in the *DMRS-UplinkConfig* IE, and

- the higher-layer parameter *dmrs-UplinkTransformPrecoding* is not configured or the higher-layer parameter *dmrs-UplinkTransformPrecoding* is configured and π/2-BPSK modulation is not used for PUSCH, and

- the PUSCH is neither scheduled by RAR UL grant nor scheduled by DCI format 0\_0 with CRC scrambled by TC-RNTI according to clause 8.3 in [5, TS 38.213];

- if the higher-layer parameter *dmrs-UplinkTransformPrecoding* is configured, π/2-BPSK modulation is used for PUSCH, the PUSCH transmission is not a msg3 transmission, and the transmission is not scheduled using DCI format 0\_0 in a common search space;

- otherwise

where and the sequence number are given by:



- if neither group, nor sequence hopping is enabled



- if group hopping is enabled and sequence hopping is disabled



where the pseudo-random sequence  is defined by clause 5.2.1 and shall be initialized with at the beginning of each radio frame



- if sequence hopping is enabled and group hopping is disabled



where the pseudo-random sequence  is defined by clause 5.2.1 and shall be initialized with at the beginning of each radio frame.



The hopping mode is controlled by higher-layer parameters:

- for PUSCH transmission scheduled by RAR UL grant or by DCI format 0\_0 with CRC scrambled by TC-RNTI, sequence hopping is disabled and group hopping is enabled or disabled by the higher-layer parameter *groupHoppingEnabledTransformPrecoding;*

- for all other transmissions, sequence hopping and group hopping are enabled or disabled by the respective higher-layer parameters *sequenceHopping* and *sequenceGroupHopping* if these parameters are provided, otherwise, the same hopping mode as for Msg3 shall be used.

The UE is not expected to handle the case of combined sequence hopping and group hopping.

The quantity above is the OFDM symbol number in the slot except for the case of double-symbol DMRS in which case is the OFDM symbol number in the slot of the first symbol of the double-symbol DMRS.

##### 6.4.1.1.2 (void)

##### 6.4.1.1.3 Precoding and mapping to physical resources

The sequence  shall be mapped to the intermediate quantity according to

- if transform precoding is not enabled,

- if the higher-layer parameter *enhanced-dmrs-Type* is configured

- otherwise

- if transform precoding is enabled

where , , and are given by Tables 6.4.1.1.3-1 and 6.4.1.1.3-2 and the configuration type is given by the higher-layer parameter *DMRS-UplinkConfig*, and both and correspond to . The intermediate quantity if Δ corresponds to any other antenna ports than*.*

The intermediate quantity shall be precoded, multiplied with the amplitude scaling factor in order to conform to the transmit power specified in [6, TS 38.214], and mapped to physical resources according to



where

- the precoding matrix is given by clause 6.3.1.5,

- the set of antenna ports  is given by clause 6.3.1.5, and

- the set of antenna ports is given by [6, TS 38.214];



and the following conditions are fulfilled:

- the resource elements are within the common resource blocks allocated for PUSCH transmission.

The reference point for is

- subcarrier 0 in common resource block 0 if transform precoding is not enabled, and

- subcarrier 0 of the lowest-numbered resource block of the scheduled PUSCH allocation if transform precoding is enabled.

The reference point for and the position  of the first DM-RS symbol depends on the mapping type:

- for PUSCH mapping type A:

-  is defined relative to the start of the slot if frequency hopping is disabled and relative to the start of each hop in case frequency hopping is enabled

-  is given by the higher-layer parameter *dmrs-TypeA-Position*

- for PUSCH mapping type B:

-  is defined relative to the start of the scheduled PUSCH resources if frequency hopping is disabled and relative to the start of each hop in case frequency hopping is enabled

- 

The position(s) of the DM-RS symbols is given by  and duration where

- is the duration between the first OFDM symbol of the slot and the last OFDM symbol of the scheduled PUSCH resources in the slot for PUSCH mapping type A according to Tables 6.4.1.1.3-3 and 6.4.1.1.3-4 if intra-slot frequency hopping is not used, or

- is the duration of scheduled PUSCH resources for PUSCH mapping type B according to Tables 6.4.1.1.3-3 and 6.4.1.1.3-4 if intra-slot frequency hopping is not used, or

- is the duration per hop according to Table 6.4.1.1.3-6 if intra-slot frequency hopping is used.

- if the higher-layer parameter *maxLength* in *DMRS-UplinkConfig* is not configured, or for a msgA transmission *msgA-MaxLength* in *msgA-DMRS-Config* is not configured, the tables shall be used according to single-symbol DM-RS

- if the higher-layer parameter *maxLength* in *DMRS-UplinkConfig* is equal to 'len2', the associated DCI or configured grant configuration determines whether single-symbol or double-symbol DM-RS shall be used

- if the higher-layer parameter *msgA-MaxLength* in *msgA-DMRS-Config* is equal to 'len2', double-symbol DM-RS shall be used

- if the higher-layer parameter *dmrs-AdditionalPosition* is not set to 'pos0' and intra-slot frequency hopping is enabled according to clause 7.3.1.1.2 in [4, TS 38.212] and by higher layer, Tables 6.4.1.1.3-6 shall be used assuming *dmrs-AdditionalPosition* is equal to 'pos1' for each hop.

For PUSCH mapping type A,

- the case *dmrs-AdditionalPosition* is equal to 'pos3' is only supported when *dmrs-TypeA-Position* is equal to 'pos2';

- symbols in Table 6.4.1.1.3-4 is only applicable when *dmrs-TypeA-Position* is equal to 'pos2'.

For msgA transmitted using PUSCH mapping type A,

- the case *msgA-DMRS-AdditionalPosition* is equal to 'pos3' is only supported when *dmrs-TypeA-Position* is equal to 'pos2';

- *'dmrs-AdditionalPosition*' in Tables 6.4.1.1.3-3 to 6.4.1.1.3-6 shall be replaced by *msgA-DMRS-AdditionalPosition;*

- only PUSCH DM-RS configuration type 1 is supported;

- only basic DM-RS multiplexing in Table 6.4.1.1.3-5 is supported.

For msgA transmitted using PUSCH mapping type B,

- '*dmrs-AdditionalPosition*' in Tables 6.4.1.1.3-3 to 6.4.1.1.3-6 shall be replaced by *msgA-DMRS-AdditionalPosition*;

- only PUSCH DM-RS configuration type 1 is supported;

- only basic DM-RS multiplexing in Table 6.4.1.1.3-5 is supported.

The time-domain index , and the supported antenna ports are given by Table 6.4.1.1.3-5.

Table 6.4.1.1.3-1: Parameters for PUSCH DM-RS configuration type 1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **CDM group** |  |  |  |
| 0 | 0 | 0 |  |  |
| 1 | 0 | 0 |  |  |
| 2 | 1 | 1 |  |  |
| 3 | 1 | 1 |  |  |
| 4 | 0 | 0 |  |  |
| 5 | 0 | 0 |  |  |
| 6 | 1 | 1 |  |  |
| 7 | 1 | 1 |  |  |
| 8 | 0 | 0 |  |  |
| 9 | 0 | 0 |  |  |
| 10 | 1 | 1 |  |  |
| 11 | 1 | 1 |  |  |
| 12 | 0 | 0 |  |  |
| 13 | 0 | 0 |  |  |
| 14 | 1 | 1 |  |  |
| 15 | 1 | 1 |  |  |

Table 6.4.1.1.3-2: Parameters for PUSCH DM-RS configuration type 2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **CDM group** |  |  |  |
| 0 | 0 | 0 |  |  |
| 1 | 0 | 0 |  |  |
| 2 | 1 | 2 |  |  |
| 3 | 1 | 2 |  |  |
| 4 | 2 | 4 |  |  |
| 5 | 2 | 4 |  |  |
| 6 | 0 | 0 |  |  |
| 7 | 0 | 0 |  |  |
| 8 | 1 | 2 |  |  |
| 9 | 1 | 2 |  |  |
| 10 | 2 | 4 |  |  |
| 11 | 2 | 4 |  |  |
| 12 | 0 | 0 |  |  |
| 13 | 0 | 0 |  |  |
| 14 | 1 | 2 |  |  |
| 15 | 1 | 2 |  |  |
| 16 | 2 | 4 |  |  |
| 17 | 2 | 4 |  |  |
| 18 | 0 | 0 |  |  |
| 19 | 0 | 0 |  |  |
| 20 | 1 | 2 |  |  |
| 21 | 1 | 2 |  |  |
| 22 | 2 | 4 |  |  |
| 23 | 2 | 4 |  |  |

Table 6.4.1.1.3-3: PUSCH DM-RS positions  within a slot for single-symbol DM-RS and intra-slot frequency hopping disabled.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| in symbols | DM-RS positions | | | | | | | |
| PUSCH mapping type A | | | | PUSCH mapping type B | | | |
| *dmrs-AdditionalPosition* | | | | *dmrs-AdditionalPosition* | | | |
| *pos0* | *pos1* | *pos2* | *pos3* | *pos0* | *pos1* | *pos2* | *pos3* |
| <4 | - | - | - | - |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  | , 4 | , 4 | , 4 |
| 6 |  |  |  |  |  | , 4 | , 4 | , 4 |
| 7 |  |  |  |  |  | , 4 | , 4 | , 4 |
| 8 |  | , 7 | , 7 | , 7 |  | , 6 | , 3, 6 | , 3, 6 |
| 9 |  | , 7 | , 7 | , 7 |  | , 6 | , 3, 6 | , 3, 6 |
| 10 |  | , 9 | , 6, 9 | , 6, 9 |  | , 8 | , 4, 8 | , 3, 6, 9 |
| 11 |  | , 9 | , 6, 9 | , 6, 9 |  | , 8 | , 4, 8 | , 3, 6, 9 |
| 12 |  | , 9 | , 6, 9 | , 5, 8, 11 |  | , 10 | , 5, 10 | , 3, 6, 9 |
| 13 |  | , 11 | , 7, 11 | , 5, 8, 11 |  | , 10 | , 5, 10 | , 3, 6, 9 |
| 14 |  | , 11 | , 7, 11 | , 5, 8, 11 |  | , 10 | , 5, 10 | , 3, 6, 9 |

Table 6.4.1.1.3-4: PUSCH DM-RS positions  within a slot for double-symbol DM-RS and intra-slot frequency hopping disabled.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **in symbols** | **DM-RS positions** | | | | | | | |
| **PUSCH mapping type A** | | | | **PUSCH mapping type B** | | | |
| ***dmrs-AdditionalPosition*** | | | | ***dmrs-AdditionalPosition*** | | | |
| ***pos0*** | ***pos1*** | ***pos2*** | ***pos3*** | ***pos0*** | ***pos1*** | ***pos2*** | ***pos3*** |
| <4 | - | - |  |  | - | - |  |  |
| 4 |  |  |  |  | - | - |  |  |
| 5 |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |  |  |
| 8 |  |  |  |  |  | , 5 |  |  |
| 9 |  |  |  |  |  | , 5 |  |  |
| 10 |  | , 8 |  |  |  | , 7 |  |  |
| 11 |  | , 8 |  |  |  | , 7 |  |  |
| 12 |  | , 8 |  |  |  | , 9 |  |  |
| 13 |  | , 10 |  |  |  | , 9 |  |  |
| 14 |  | , 10 |  |  |  | , 9 |  |  |

Table 6.4.1.1.3-5: PUSCH DM-RS time index .

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DM-RS multiplexing** | **DM-RS duration** |  | **Supported antenna ports** | |
| **Configuration type 1** | **Configuration type 2** |
| Basic | single-symbol DM-RS | 0 | 0 – 3 | 0 – 5 |
| double-symbol DM-RS | 0, 1 | 0 – 7 | 0 – 11 |
| Enhanced | single-symbol DM-RS | 0 | 0 – 3, 8 – 11 | 0 – 5, 12 – 17 |
| double-symbol DM-RS | 0, 1 | 0 – 15 | 0 – 23 |

Table 6.4.1.1.3-6: PUSCH DM-RS positions  within a slot for single-symbol DM-RS and intra-slot frequency hopping enabled.

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **in symbols** | **DM-RS positions** | | | | | | | | | | | |
| **PUSCH mapping type A** | | | | | | | | **PUSCH mapping type B** | | | |
|  | | | |  | | | |
| ***dmrs-AdditionalPosition*** | | | | ***dmrs-AdditionalPosition*** | | | | ***dmrs-AdditionalPosition*** | | | |
| ***pos0*** | | ***pos1*** | | ***pos0*** | | ***pos1*** | | ***pos0*** | | ***pos1*** | |
| **1st hop** | **2nd hop** | **1st hop** | **2nd hop** | **1st hop** | **2nd hop** | **1st hop** | **2nd hop** | **1st hop** | **2nd hop** | **1st hop** | **2nd hop** |
| ≤3 | - | - | - | - | - | - | - | - | 0 | 0 |  | 0 |
| 4 | 2 | 0 | 2 | 0 | 3 | 0 | 3 | 0 | 0 | 0 |  | 0 |
| 5, 6 | 2 | 0 | 2 | 0, 4 | 3 | 0 | 3 | 0, 4 | 0 | 0 |  | 0, 4 |
| 7 | 2 | 0 | 2, 6 | 0, 4 | 3 | 0 | 3 | 0, 4 | 0 | 0 |  | 0, 4 |

#### 6.4.1.2 Phase-tracking reference signals for PUSCH

##### 6.4.1.2.1 Sequence generation

###### 6.4.1.2.1.1 Sequence generation if transform precoding is not enabled

If transform precoding is not enabled, the precoded phase-tracking reference signal for subcarrier  on layer  is given by

where

- antenna ports or associated with PT-RS transmission are given by clause 6.2.3 of [6, TS 38.214]



- is given by clause 6.4.1.1.1.1



- at the position of the first DM-RS symbol in absence of PUSCH intra-slot frequency hopping

- at the position of the first DM-RS symbol in hop in presence of PUSCH intra-slot frequency hopping

###### 6.4.1.2.1.2 Sequence generation if transform precoding is enabled

If transform precoding is enabled, the phase-tracking reference signal  to be mapped in position before transform precoding, where depends on the number of PT-RS groups , the number of samples per PT-RS group , and according to Table 6.4.1.2.2.2-1, shall be generated according to

.

where the pseudo-random sequence  is defined in clause 5.2.1 and  is given by Table 6.4.1.2.1.2-1. The pseudo-random sequence generator shall be initialized with

where  is the lowest OFDM symbol number in the PUSCH allocation in slot that contains PT-RS according to clause 6.4.1.2.2.2 and is given by the higher-layer parameter *nPUSCH-Identity*.

Table 6.4.1.2.1.2-1: The orthogonal sequence .

|  |  |  |
| --- | --- | --- |
|  |  |  |
| 0 |  |  |
| 1 |  |  |
| 2 | - |  |
| 3 | - |  |

##### 6.4.1.2.2 Mapping to physical resources

###### 6.4.1.2.2.1 Precoding and mapping to physical resources if transform precoding is not enabled

The UE shall transmit phase-tracking reference signals only in the resource blocks used for the PUSCH, and only if the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are being used.

The PUSCH PT-RS shall be mapped to resource elements according to

when all the following conditions are fulfilled

-  is within the OFDM symbols allocated for the PUSCH transmission

- resource element  is not used for DM-RS

-  and correspond to

The quantities and are given by Tables 6.4.1.1.3-1 and 6.4.1.1.3-2, the configuration type is given by the higher-layer parameter *dmrs-Type* in the *DMRS-UplinkConfig* IE, and the precoding matrix is given by clause 6.3.1.5*.* The quantity  is an amplitude scaling factor to conform with the transmit power specified in clause 6.2.2 of [6, TS 38.214].

The set of time indices  defined relative to the start of the PUSCH allocation is defined by

1. set and 

2. if any symbol in the interval overlaps with a symbol used for DM-RS according to clause 6.4.1.1.3

- set

- set  to the symbol index of the DM-RS symbol in case of a single-symbol DM-RS or to the symbol index of the second DM-RS symbol in case of a double-symbol DM-RS

- repeat from step 2 as long as  is inside the PUSCH allocation

3. add  to the set of time indices for PT-RS

4. increment  by one

5. repeat from step 2 above as long as  is inside the PUSCH allocation

where  is defined in Table 6.2.3.1-1 of [6, TS 38.214].

For the purpose of PT-RS mapping, the resource blocks allocated for PUSCH transmission are numbered from 0 to  from the lowest scheduled resource block to the highest. The corresponding subcarriers in this set of resource blocks are numbered in increasing order starting from the lowest frequency from 0 to . The subcarriers to which the PT-RS shall be mapped are given by



where

-



-  is given by Table 6.4.1.2.2.1-1 for the DM-RS port associated with the PT-RS port according to clause 6.2.3 in [6, TS 38.214]. If the higher-layer parameter *resourceElementOffset* in *PTRS-UplinkConfig* is not configured, the column corresponding to 'offset00' shall be used.

- is the RNTI associated with the DCI scheduling the transmission using C-RNTI, CS-RNTI, MCS-C-RNTI, SP-CSI-RNTI, or is the CS-RNTI in case of configured grant

-  is the number of resource blocks scheduled

- is given by [6, TS 38.214].

Table 6.4.1.2.2.1-1: The parameter  .

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| DM-RS antenna port |  | | | | | | | |
| DM-RS Configuration type 1 | | | | DM-RS Configuration type 2 | | | |
| *resourceElementOffset* | | | | *resourceElementOffset* | | | |
| offset00 | offset01 | offset10 | offset11 | offset00 | offset01 | offset10 | offset11 |
| 0 | 0 | 2 | 6 | 8 | 0 | 1 | 6 | 7 |
| 1 | 2 | 4 | 8 | 10 | 1 | 6 | 7 | 0 |
| 2 | 1 | 3 | 7 | 9 | 2 | 3 | 8 | 9 |
| 3 | 3 | 5 | 9 | 11 | 3 | 8 | 9 | 2 |
| 4 | - | - | - | - | 4 | 5 | 10 | 11 |
| 5 | - | - | - | - | 5 | 10 | 11 | 4 |
| 8 | 4 | 6 | 10 | 0 | - | - | - | - |
| 9 | 6 | 8 | 0 | 2 | - | - | - | - |
| 10 | 5 | 7 | 11 | 1 | - | - | - | - |
| 11 | 7 | 9 | 1 | 3 | - | - | - | - |
| 12 | - | - | - | - | 6 | 7 | 0 | 1 |
| 13 | - | - | - | - | 7 | 0 | 1 | 6 |
| 14 | - | - | - | - | 8 | 9 | 2 | 3 |
| 15 | - | - | - | - | 9 | 2 | 3 | 8 |
| 16 | - | - | - | - | 10 | 11 | 4 | 5 |
| 17 | - | - | - | - | 11 | 4 | 5 | 10 |

###### 6.4.1.2.2.2 Mapping to physical resources if transform precoding is enabled

The UE shall transmit phase-tracking reference signals only in the resource blocks and OFDM symbols used for the PUSCH, and only if the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are being used.

The sequence  shall be multiplied by  and mapped to complex valued symbols in  where

-  are the complex-valued symbols in OFDM symbol  before transform precoding according to clause 6.3.1.4

- depends on the number of PT-RS groups , the number of samples per PT-RS group , and  according to Table 6.4.1.2.2.2-1

-  is the ratio between amplitude of one of the outermost constellation points for the modulation scheme used for PUSCH and one of the outermost constellation points for π/2-BPSK as defined in clause 6.2.3 of [TS 38.214]

The set of time indices  for which PT-RS shall be transmitted is defined relative to the start of the PUSCH allocation and is defined by

1. set  and 

2. if any symbol in the interval overlaps with a symbol used for DM-RS according to clause 6.4.1.1.3

- set

- set  to the symbol index of the DM-RS symbol in case of a single-symbol DM-RS and to the symbol index of the second DM-RS symbol in case of a double-symbol DM-RS

- repeat from step 2 as long as  is inside the PUSCH allocation

3. add  to the set of time indices for PT-RS

4. increment  by one

5. repeat from step 2 above as long as  is inside the PUSCH allocation

where is given by the higher-layer parameter *timeDensityTransformPrecoding* in the *PTRS-UplinkConfig* IE.

Table 6.4.1.2.2.2-1: PT-RS symbol mapping.

|  |  |  |
| --- | --- | --- |
| Number of  PT-RS groups | Number of samples per PT-RS group | Index of PT-RS samples in OFDM symbol  prior to transform precoding |
| 2 | 2 | where and |
| 2 | 4 | where |
| 4 | 2 | where and |
| 4 | 4 | where |
| 8 | 4 | where |

#### 6.4.1.3 Demodulation reference signal for PUCCH

##### 6.4.1.3.1 Demodulation reference signal for PUCCH format 1

###### 6.4.1.3.1.1 Sequence generation

The reference signal sequence is defined by

where is given by Table 6.4.1.3.1.1-1, by clause 9.2.1 of [5, TS 38.213], and the sequence is given by clause 5.2.2.

Intra-slot frequency hopping shall be assumed when the higher-layer parameter *intraSlotFrequencyHopping* is enabled, regardless of whether the frequency-hop distance is zero or not, otherwise no intra-slot frequency hopping shall be assumed.

The orthogonal sequence  is given by Table 6.3.2.4.1.-2 with the same index  as used in clause 6.3.2.4.1.

Table 6.4.1.3.1.1-1: Number of DM-RS symbols and the corresponding .

|  |  |  |  |
| --- | --- | --- | --- |
| PUCCH length, |  | | |
| No intra-slot hopping | Intra-slot hopping | |
|  |  |
| 4 | 2 | 1 | 1 |
| 5 | 3 | 1 | 2 |
| 6 | 3 | 2 | 1 |
| 7 | 4 | 2 | 2 |
| 8 | 4 | 2 | 2 |
| 9 | 5 | 2 | 3 |
| 10 | 5 | 3 | 2 |
| 11 | 6 | 3 | 3 |
| 12 | 6 | 3 | 3 |
| 13 | 7 | 3 | 4 |
| 14 | 7 | 4 | 3 |

###### 6.4.1.3.1.2 Mapping to physical resources

The sequence shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [5, 38.213] and mapped in sequence starting with  to resource elements in a slot on antenna port  according to

where corresponds to the first OFDM symbol of the PUCCH transmission and shall be within the resource blocks assigned for PUCCH transmission according to [5, TS 38.213].

For interlaced transmission, the mapping operation shall be repeated for each resource block in the interlace and in the active bandwidth part over the assigned physical resource blocks according to clause 9.2.1 of [5, TS 38.213], with the resource-block dependent sequence generated according to clause 6.3.2.2.

##### 6.4.1.3.2 Demodulation reference signal for PUCCH format 2

###### 6.4.1.3.2.1 Sequence generation

The reference-signal sequence shall be generated according to

where the pseudo-random sequence  is defined in clause 5.2. The pseudo-random sequence generator shall be initialized with

where  is the OFDM symbol number within the slot, is the slot number within the radio frame, and and are defind in clause 6.3.2.5.2A.

The quantity is given by the higher-layer parameter *scramblingID0* in the *DMRS-UplinkConfig* IE if provided and by otherwise*.* If a UE is configured with both *dmrs-UplinkForPUSCH-MappingTypeA* and *dmrs-UplinkForPUSCH-MappingTypeB*, *scramblingID0* is obtained from *dmrs-UplinkForPUSCH-MappingTypeB*.

###### 6.4.1.3.2.2 Mapping to physical resources

The sequence shall be multiplied with the amplitude scaling factor in order to conform to the transmit power specified in [5, 38.213] and mapped in sequence starting with to resource elements in a slot on antenna port  according to

where  is defined relative to subcarrier 0 of common resource block 0 and shall be within the resource blocks assigned for PUCCH transmission according to clause 9.2.1 of [5, TS 38.213].

##### 6.4.1.3.3 Demodulation reference signal for PUCCH formats 3 and 4

###### 6.4.1.3.3.1 Sequence generation

The reference-signal sequence shall be generated according to



where is given by clause 6.3.2.6.3 and depends on the configuration:

- if the higher-layer parameter *dmrs-UplinkTransformPrecodingPUCCH* is configured, and -BPSK is used for PUCCH, is given by clause 5.2.3 with and given by clause 6.4.1.3.2.1. The sequence group and the sequence number depend on the sequence hopping in clause 6.3.2.2.1.

- otherwise, for PUCCH format 3, PUCCH format 4 with =1, and PUCCH format 4 with >1 when -BPSK is not used for PUCCH, is given by clause 6.3.2.2 and the cyclic shift varies with the symbol number and slot number according to clause 6.3.2.2.2 with

- for PUCCH format 3 without interlaced mapping;

- obtained from Table 6.4.1.3.3.1-1 with the orthogonal sequence index given by clause 6.3.2.6.3 for PUCCH format 3 with interlaced mapping and PUCCH format 4.

Table 6.4.1.3.3.1-1: Cyclic shift index for PUCCH format 3 with interlaced mapping and PUCCH format 4.

|  |  |  |  |
| --- | --- | --- | --- |
| **Orthogonal sequence index** | **Cyclic shift index** | | |
|  |  |  |
| 0 | 0 | 0 | 0 |
| 1 | - | 6 | 6 |
| 2 | - | - | 3 |
| 3 | - | - | 9 |

###### 6.4.1.3.3.2 Mapping to physical resources

The sequence shall be multiplied with the amplitude scaling factor , , in order to conform to the transmit power specified in [5, 38.213] and mapped in sequence starting with  to resource elements on antenna port  according to



where

-  is defined relative to subcarrier 0 of the lowest-numbered resource block assigned for PUCCH transmission,

-  is given by Table 6.4.1.3.3.2-1 for the case with and without intra-slot frequency hopping and with and without additional DM-RS as described in clause 9.2.1 of [TS 38.213], where  corresponds to the first OFDM symbol of the PUCCH transmission.

The resource elements shall be within the resource blocks assigned for PUCCH transmission according to clause 9.2.1 of [5, TS 38.213].

Table 6.4.1.3.3.2-1: DM-RS positions for PUCCH format 3 and 4.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| PUCCH length | DM-RS position  within PUCCH span | | | |
| No additional DM-RS | | Additional DM-RS | |
| No hopping | Hopping | No hopping | Hopping |
| 4 | 1 | 0, 2 | 1 | 0, 2 |
| 5 | 0, 3 | | 0, 3 | |
| 6 | 1, 4 | | 1, 4 | |
| 7 | 1, 4 | | 1, 4 | |
| 8 | 1, 5 | | 1, 5 | |
| 9 | 1, 6 | | 1, 6 | |
| 10 | 2, 7 | | 1, 3, 6, 8 | |
| 11 | 2, 7 | | 1, 3, 6, 9 | |
| 12 | 2, 8 | | 1, 4, 7, 10 | |
| 13 | 2, 9 | | 1, 4, 7, 11 | |
| 14 | 3, 10 | | 1, 5, 8, 12 | |

#### 6.4.1.4 Sounding reference signal

##### 6.4.1.4.1 SRS resource

An SRS resource is configured by the *SRS-Resource* IE or the *SRS-PosResource* IE and consists of

- antenna ports , where the number of antenna ports is given by the higher layer parameter *nrofSRS-Ports* if configured, otherwise , and when the SRS resource is in a SRS resource set with higher-layer parameter *usage* in *SRS-ResourceSet* not set to 'nonCodebook', or determined according to [6, TS 38.214] when the SRS resource is in a SRS resource set with higher-layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook'.

- , the number of hops for SRS Tx hopping for an SRS resource configured by *SRS-PosResource* given by the higher layer parameter *SRShoppingNrofHops* if configured, otherwise .

- consecutive OFDM symbols given by the field *nrofSymbols* contained in the higher layer parameter *resourceMapping*. If ,is the number of consecutive OFDM symbol per hop.

- , the starting position in the time domain given by  where the offset counts symbols backwards from the end of the slot and is given by the field *startPosition* contained in the higher layer parameter *resourceMapping* and . If is the starting position of each hop in the time domain, determined by the field *startPosition* for each SRS transmission hop.

- , the frequency-domain starting position of the sounding reference signal.

##### 6.4.1.4.2 Sequence generation

The sounding reference signal sequence for an SRS resource, or if *SRShoppingNrofHops* for *SRS-PosResource* is provided, for a given hop within an SRS resource, shall be generated according to

where is given by clause 6.4.1.4.3, is given by clause 5.2.2 with and the transmission comb number is contained in the higher-layer parameter *transmissionComb*. The quantity is the OFDM symbol number within the SRS resource.

The quantity is given by

- if the higher-layer parameter *nrofSRS-Ports-n8* equals *ports8tdm*

- otherwise

The cyclic shift for antenna port is given as

where

where is contained in the higher layer parameter *transmissionComb*. The maximum number of cyclic shifts is given by Table 6.4.1.4.2-1.

The quantities and  are given by

- if the higher-layer parameter *nrofSRS-Ports-n8* equals *ports8tdm*

- otherwise

The quantity is given by

- if the higher-layer parameter *cyclicShiftHopping* is not configured:

- If the higher-layer parameter *cyclicShiftHopping* is configured:

where and is the th entry and the cardinality of the set

respectively, where is given by the higher-layer parameter *hoppingSubset* inthe *cyclicShiftHopping* IE if configured, otherwise . The higher-layer parameter *hoppingSubset* inthe *cyclicShiftHopping* IE includes a bitmap of bits with bits being set to 1, where the th bit being set to 1 corresponds to .

The pseudo-random sequence is defined by clause 5.2.1 and shall be initialized with at the beginning of each radio frame for which , where the cyclic-shift hopping identity is contained in the higher-layer parameter *cyclicShiftHopping*.

If the higher-layer parameter *hoppingFinerGranularity* is configured, , otherwise .

The sequence group and the sequence number in clause 5.2.2 depends on the higher-layer parameter *groupOrSequenceHopping* in the *SRS-Resource* IE or the *SRS-PosResource* IE*.* The SRS sequence identity is given by the higher layer parameter *sequenceId* in the *SRS-Resource* IE, in which case , or the *SRS-PosResource-r16* IE, in which case .

- if *groupOrSequenceHopping* equals 'neither', neither group, nor sequence hopping shall be used and



- if *groupOrSequenceHopping* equals 'groupHopping', group hopping but not sequence hopping shall be used and



where the pseudo-random sequence is defined by clause 5.2.1 and shall be initialized with at the beginning of each radio frame.

- if *groupOrSequenceHopping* equals 'sequenceHopping', sequence hopping but not group hopping shall be used and



where the pseudo-random sequence is defined by clause 5.2.1 and shall be initialized with at the beginning of each radio frame.

Table 6.4.1.4.2-1: Maximum number of cyclic shifts as a function of .

|  |  |
| --- | --- |
|  |  |
| 2 | 8 |
| 4 | 12 |
| 8 | 6 |

##### 6.4.1.4.3 Mapping to physical resources

Throughout this clause, when the higher layer parameter *SRShoppingNrofHops* is provided for *SRS-PosResource*, the sounding reference signal sequence definitions applies to a given hop.

When SRS is transmitted on a given SRS resource, the sequence for each OFDM symbol and for each of the antenna ports of the SRS resource shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [5, 38.213] and mapped in sequence starting with  to resource elements  in a slot for each of the antenna ports  according to

The length of the sounding reference signal sequence is given by

where is given by a selected row of Table 6.4.1.4.3-1 with  where  is given by the field *b-SRS* contained in the higher-layer parameter *freqHopping* if configured, otherwise . The row of the table is selected according to the index  given by the field *c-SRS* contained in the higher-layer parameter *freqHopping*. The quantity is given by the higher-layer parameter *FreqScalingFactor* if configured, otherwise . When *FreqScalingFactor* is configured, the UE expects the length of the SRS sequence to be a multiple of 6.

The frequency-domain starting position is defined by

where

and

and

- is given by the higher-layer parameter *StartRBIndex* if configured, otherwise ;

- is given by Table 6.4.1.4.3-3 with

if the higher-layer parameter *EnableStartRBHopping* is configured, otherwise .

- is given by the higher-layer parameter YYY.

- is the hop transmission counter in the time domain.

- is the initial hop index.

The quantity is given by

- if the higher-layer parameter *combOffsetHopping* is not configured:

- if the higher-layer parameter *combOffsetHopping* is configured:

where and is the th entry and the cardinality of the set

respectively, where is given by the higher-layer parameter *hoppingSubset* inthe *combOffsetHopping* IE if configured, otherwise . The higher-layer parameter *hoppingSubset* inthe *combOffsetHopping* IE includes a bitmap of bits with bits being set to 1, where the th bit being set to 1 corresponds to .

The pseudo-random sequence is defined by clause 5.2.1 and shall be initialized with at the beginning of each radio frame for which , where the comb offset hopping identity  is contained in the higher-layer parameter *combOffsetHopping*.

If the higher-layer parameter *hoppingWithRepetition* is set to *Repetition*, , otherwise .

If *SRShoppingNrofHops* is configured:

- The reference point for is the lowest subcarrier of the configured bandwidth for SRS with Tx hopping configured by the parameter XXX in *TxhoppingBandwidth*.

otherwise:

- If  the reference point for is subcarrier 0 in common resource block 0, otherwise the reference point is the lowest subcarrier of the BWP.

If the SRS is configured by the IE *SRS-PosResource*, the quantity is given by Table 6.4.1.4.3-2, otherwise .

The frequency domain shift value adjusts the SRS allocation with respect to the reference point grid and is contained in the higher-layer parameter *freqDomainShift* in the *SRS-Resource* IE or the *SRS-PosResource* IE. The transmission comb offset is contained in the higher-layer parameter *transmissionComb* in the *SRS-Resource* IE or the *SRS-PosResource* IE and is a frequency position index.

Frequency hopping of the sounding reference signal is configured by the parameter , given by the field *b-hop* contained in the higher-layer parameter *freqHopping* if configured, otherwise .

If , frequency hopping is disabled and the frequency position index remains constant (unless re-configured) and is defined by



for all OFDM symbols of the SRS resource. The quantity  is given by the higher-layer parameter *freqDomainPosition* if configured, otherwise , and the values of and for are given by the selected row of Table 6.4.1.4.3-1 corresponding to the configured value of .

If , frequency hopping is enabled and the frequency position indices are defined by

where is given by Table 6.4.1.4.3-1,



and where regardless of the value of . The quantity counts the number of SRS transmissions. For the case of an SRS resource configured as aperiodic by the higher-layer parameter *resourceType*, it is given by within the slot in which the symbol SRS resource is transmitted. The quantity is given by if the higher-layer parameter *nrofSRS-Ports-n8* equals ‘ports8tdm’, otherwise . The quantity is the repetition factor given by the field *repetitionFactor* if configured, otherwise .

For the case of an SRS resource configured as periodic or semi-persistent by the higher-layer parameter *resourceType*, the SRS counter is given by

for slots that satisfy . The periodicity  in slots and slot offset  are given in clause 6.4.1.4.4.

Table 6.4.1.4.3-1: SRS bandwidth configuration.

|  |  | |  | |  | |  | |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  |  |  |  |  |  |  |  |  |
| 0 | 4 | 1 | 4 | 1 | 4 | 1 | 4 | 1 |
| 1 | 8 | 1 | 4 | 2 | 4 | 1 | 4 | 1 |
| 2 | 12 | 1 | 4 | 3 | 4 | 1 | 4 | 1 |
| 3 | 16 | 1 | 4 | 4 | 4 | 1 | 4 | 1 |
| 4 | 16 | 1 | 8 | 2 | 4 | 2 | 4 | 1 |
| 5 | 20 | 1 | 4 | 5 | 4 | 1 | 4 | 1 |
| 6 | 24 | 1 | 4 | 6 | 4 | 1 | 4 | 1 |
| 7 | 24 | 1 | 12 | 2 | 4 | 3 | 4 | 1 |
| 8 | 28 | 1 | 4 | 7 | 4 | 1 | 4 | 1 |
| 9 | 32 | 1 | 16 | 2 | 8 | 2 | 4 | 2 |
| 10 | 36 | 1 | 12 | 3 | 4 | 3 | 4 | 1 |
| 11 | 40 | 1 | 20 | 2 | 4 | 5 | 4 | 1 |
| 12 | 48 | 1 | 16 | 3 | 8 | 2 | 4 | 2 |
| 13 | 48 | 1 | 24 | 2 | 12 | 2 | 4 | 3 |
| 14 | 52 | 1 | 4 | 13 | 4 | 1 | 4 | 1 |
| 15 | 56 | 1 | 28 | 2 | 4 | 7 | 4 | 1 |
| 16 | 60 | 1 | 20 | 3 | 4 | 5 | 4 | 1 |
| 17 | 64 | 1 | 32 | 2 | 16 | 2 | 4 | 4 |
| 18 | 72 | 1 | 24 | 3 | 12 | 2 | 4 | 3 |
| 19 | 72 | 1 | 36 | 2 | 12 | 3 | 4 | 3 |
| 20 | 76 | 1 | 4 | 19 | 4 | 1 | 4 | 1 |
| 21 | 80 | 1 | 40 | 2 | 20 | 2 | 4 | 5 |
| 22 | 88 | 1 | 44 | 2 | 4 | 11 | 4 | 1 |
| 23 | 96 | 1 | 32 | 3 | 16 | 2 | 4 | 4 |
| 24 | 96 | 1 | 48 | 2 | 24 | 2 | 4 | 6 |
| 25 | 104 | 1 | 52 | 2 | 4 | 13 | 4 | 1 |
| 26 | 112 | 1 | 56 | 2 | 28 | 2 | 4 | 7 |
| 27 | 120 | 1 | 60 | 2 | 20 | 3 | 4 | 5 |
| 28 | 120 | 1 | 40 | 3 | 8 | 5 | 4 | 2 |
| 29 | 120 | 1 | 24 | 5 | 12 | 2 | 4 | 3 |
| 30 | 128 | 1 | 64 | 2 | 32 | 2 | 4 | 8 |
| 31 | 128 | 1 | 64 | 2 | 16 | 4 | 4 | 4 |
| 32 | 128 | 1 | 16 | 8 | 8 | 2 | 4 | 2 |
| 33 | 132 | 1 | 44 | 3 | 4 | 11 | 4 | 1 |
| 34 | 136 | 1 | 68 | 2 | 4 | 17 | 4 | 1 |
| 35 | 144 | 1 | 72 | 2 | 36 | 2 | 4 | 9 |
| 36 | 144 | 1 | 48 | 3 | 24 | 2 | 12 | 2 |
| 37 | 144 | 1 | 48 | 3 | 16 | 3 | 4 | 4 |
| 38 | 144 | 1 | 16 | 9 | 8 | 2 | 4 | 2 |
| 39 | 152 | 1 | 76 | 2 | 4 | 19 | 4 | 1 |
| 40 | 160 | 1 | 80 | 2 | 40 | 2 | 4 | 10 |
| 41 | 160 | 1 | 80 | 2 | 20 | 4 | 4 | 5 |
| 42 | 160 | 1 | 32 | 5 | 16 | 2 | 4 | 4 |
| 43 | 168 | 1 | 84 | 2 | 28 | 3 | 4 | 7 |
| 44 | 176 | 1 | 88 | 2 | 44 | 2 | 4 | 11 |
| 45 | 184 | 1 | 92 | 2 | 4 | 23 | 4 | 1 |
| 46 | 192 | 1 | 96 | 2 | 48 | 2 | 4 | 12 |
| 47 | 192 | 1 | 96 | 2 | 24 | 4 | 4 | 6 |
| 48 | 192 | 1 | 64 | 3 | 16 | 4 | 4 | 4 |
| 49 | 192 | 1 | 24 | 8 | 8 | 3 | 4 | 2 |
| 50 | 208 | 1 | 104 | 2 | 52 | 2 | 4 | 13 |
| 51 | 216 | 1 | 108 | 2 | 36 | 3 | 4 | 9 |
| 52 | 224 | 1 | 112 | 2 | 56 | 2 | 4 | 14 |
| 53 | 240 | 1 | 120 | 2 | 60 | 2 | 4 | 15 |
| 54 | 240 | 1 | 80 | 3 | 20 | 4 | 4 | 5 |
| 55 | 240 | 1 | 48 | 5 | 16 | 3 | 8 | 2 |
| 56 | 240 | 1 | 24 | 10 | 12 | 2 | 4 | 3 |
| 57 | 256 | 1 | 128 | 2 | 64 | 2 | 4 | 16 |
| 58 | 256 | 1 | 128 | 2 | 32 | 4 | 4 | 8 |
| 59 | 256 | 1 | 16 | 16 | 8 | 2 | 4 | 2 |
| 60 | 264 | 1 | 132 | 2 | 44 | 3 | 4 | 11 |
| 61 | 272 | 1 | 136 | 2 | 68 | 2 | 4 | 17 |
| 62 | 272 | 1 | 68 | 4 | 4 | 17 | 4 | 1 |
| 63 | 272 | 1 | 16 | 17 | 8 | 2 | 4 | 2 |

Table 6.4.1.4.3-2: The offset for SRS as a function of and .

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | | | | |
|  |  |  |  |  |
| 2 | 0 | 0,1 | 0,1,0,1 | - | - |
| 4 | - | 0, 2 | 0, 2, 1, 3 | 0, 2, 1, 3, 0, 2, 1, 3 | 0, 2, 1, 3, 0, 2, 1, 3, 0, 2, 1, 3 |
| 8 | - | - | 0, 4, 2, 6 | 0, 4, 2, 6, 1, 5, 3, 7 | 0, 4, 2, 6, 1, 5, 3, 7, 0, 4, 2, 6 |

Table 6.4.1.4.3-3: The quantity as a function of .

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | |
|  |  |  |  |
| 0 | 0 | 0 | 0 |
| 1 | - | 1 | 2 |
| 2 | - | - | 1 |
| 3 | - | - | 3 |

##### 6.4.1.4.4 Sounding reference signal slot configuration

Throughout this clause, when the higher layer parameter *SRShoppingNrofHops* is provided for *SRS-PosResource*, the sounding reference signal slot configuration applies to a given hop.

For an SRS resource configured as periodic or semi-persistent by the higher-layer parameter *resourceType*, a periodicity  (in slots) and slot offset  are configured according to the higher-layer parameter *periodicityAndOffset-p* or *periodicityAndOffset-sp* in the *SRS-Resource* IE, or *periodicityAndOffset-p* or *periodicityAndOffset-sp* in the *SRS-PosResource* IE. Candidate slots in which the configured SRS resource may be used for SRS transmission are the slots satisfying

and, if the higher-layer parameter XXX if configured, also

where is given by the higher-layer parameter XXX and is the hyper-frame number.

SRS is transmitted as described in clause 6.2.1 of [6, TS 38.214].

# 7 Downlink

## 7.1 Overview

### 7.1.1 Overview of physical channels

A downlink physical channel corresponds to a set of resource elements carrying information originating from higher layers. The following downlink physical channels are defined:

- Physical Downlink Shared Channel, PDSCH

- Physical Broadcast Channel, PBCH

- Physical Downlink Control Channel, PDCCH.

### 7.1.2 Overview of physical signals

A downlink physical signal corresponds to a set of resource elements used by the physical layer but does not carry information originating from higher layers.

The following downlink physical signals are defined:

- Demodulation reference signals, DM-RS

- Phase-tracking reference signals, PT-RS

- Positioning reference signal, PRS

- Channel-state information reference signal, CSI-RS

- Primary synchronization signal, PSS

- Secondary synchronization signal, SSS

## 7.2 Physical resources

The frame structure and physical resources the UE shall assume when receiving downlink transmissions are defined in Clause 4.

The following antenna ports are defined for the downlink:

- Antenna ports starting with 1000 for PDSCH

- Antenna ports starting with 2000 for PDCCH

- Antenna ports starting with 3000 for channel-state information reference signals

- Antenna ports starting with 4000 for SS/PBCH block transmission

- Antenna ports starting with 5000 for positioning reference signals

The UE shall not assume that two antenna ports are quasi co-located with respect to any QCL type unless specified otherwise.

For DM-RS associated with a PDSCH, the channel over which a PDSCH symbol on one antenna port is conveyed can be inferred from the channel over which a DM-RS symbol on the same antenna port is conveyed only if the two symbols are within the same resource as the scheduled PDSCH, in the same slot, and in the same PRG as described in clause 5.1.2.3 of [6, TS 38.214].

For DM-RS associated with a PDCCH, the channel over which a PDCCH symbol on one antenna port is conveyed can be inferred from the channel over which a DM-RS symbol on the same antenna port is conveyed only if the two symbols are within resources for which the UE may assume the same precoding being used as described in clause 7.3.2.2.

For DM-RS associated with a PBCH, the channel over which a PBCH symbol on one antenna port is conveyed can be inferred from the channel over which a DM-RS symbol on the same antenna port is conveyed only if the two symbols are within a SS/PBCH block transmitted within the same slot, and with the same block index according to clause 7.4.3.1.

## 7.3 Physical channels

### 7.3.1 Physical downlink shared channel

#### 7.3.1.1 Scrambling

Up to two codewords  can be transmitted. In case of single-codeword transmission, .

For each codeword , the UE shall assume the block of bits , where is the number of bits in codeword  transmitted on the physical channel, are scrambled prior to modulation, resulting in a block of scrambled bits according to

where the scrambling sequence is given by clause 5.2.1. The scrambling sequence generator shall be initialized with

where

-  equals the higher-layer parameter *dataScramblingIdentityPDSCH* if configured and the RNTI equals the C-RNTI, MCS-C-RNTI, or CS-RNTI, and the transmission is not scheduled using DCI format 1\_0 in a common search space;

- equals the higher-layer parameter *dataScramblingIdentityPDSCH* if configured in a common MBS frequency resource and the RNTI equals the G-RNTI, G-CS-RNTI, MCCH-RNTI, or multicast-MCCH-RNTI, and the transmission is scheduled using DCI in a common search space configured in the common MBS frequency resource;

- equals

- the higher-layer parameter *dataScramblingIdentityPDSCH* if the codeword is scheduled using a CORESET with *CORESETPoolIndex* equal to 0;

- the higher-layer parameter *dataScramblingIdentityPDSCH2* if the codeword is scheduled using a CORESET with *CORESETPoolIndex* equal to 1;

if the higher-layer parameters *dataScramblingIdentityPDSCH* and *dataScramblingIdentityPDSCH2* are configured together with the higher-layer parameter *CORESETPoolIndex* containing two different values, and the RNTI equals the C-RNTI, MCS-C-RNTI, or CS-RNTI, and the transmission is not scheduled using DCI format 1\_0 in a common search space;

- otherwise

and where corresponds to the RNTI associated with the PDSCH transmission as described in clause 5.1 of [6, TS 38.214].



#### 7.3.1.2 Modulation

For each codeword , the UE shall assume the block of scrambled bits are modulated as described in clause 5.1 using one of the modulation schemes in Table 7.3.1.2-1, resulting in a block of complex-valued modulation symbols .

Table 7.3.1.2-1: Supported modulation schemes.

|  |  |
| --- | --- |
| Modulation scheme | Modulation order |
| QPSK | 2 |
| 16QAM | 4 |
| 64QAM | 6 |
| 256QAM | 8 |
| 1024QAM | 10 |

#### 7.3.1.3 Layer mapping

The UE shall assume that complex-valued modulation symbols for each of the codewords to be transmitted are mapped onto one or several layers according to Table 7.3.1.3-1. Complex-valued modulation symbols for codeword shall be mapped onto the layers , where is the number of layers and is the number of modulation symbols per layer.

Table 7.3.1.3-1: Codeword-to-layer mapping for spatial multiplexing.

|  |  |  |  |
| --- | --- | --- | --- |
| Number of layers | Number of codewords | Codeword-to-layer mapping | |
| 1 | 1 |  |  |
| 2 | 1 |  |  |
| 3 | 1 |  |  |
| 4 | 1 |  |  |
| 5 | 2 |  |  |
|  |
| 6 | 2 |  |  |
|  |
| 7 | 2 |  |  |
|  |
| 8 | 2 |  |  |
|  |

#### 7.3.1.4 Antenna port mapping

The block of vectors , shall be mapped to antenna ports according to



where , . The set of antenna ports  shall be determined according to the procedure in [4, TS 38.212].

#### 7.3.1.5 Mapping to virtual resource blocks

The UE shall, for each of the antenna ports used for transmission of the physical channel, assume the block of complex-valued symbols conform to the downlink power allocation specified in [6, TS 38.214] and are mapped in sequence starting with to resource elements in the virtual resource blocks assigned for transmission which meet all of the following criteria:

- they are in the virtual resource blocks assigned for transmission;

- the corresponding physical resource blocks are declared as available for PDSCH according to clause 5.1.4 of [6, TS 38.214];

- the corresponding resource elements in the corresponding physical resource blocks are

- not used for transmission of the associated DM-RS or DM-RS intended for other co-scheduled UEs as described in clause 7.4.1.1.2;

- not used for non-zero-power CSI-RS, which is according to clause 7.4.1.5 and not configured by *TRS-ResourceSet* IE, if the corresponding physical resource blocks are for a PDSCH scheduled by a PDCCH with the CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI, G-RNTI for multicast, G-CS-RNTI, or a PDSCH with SPS, except if the non-zero-power CSI-RS is a CSI-RS configured by the higher-layer parameter *CSI-RS-Resource-Mobility* in the *MeasObjectNR* IE or except if the non-zero-power CSI-RS is an aperiodic non-zero-power CSI-RS resource;

- not used for PT-RS according to clause 7.4.1.2;

- not declared as 'not available for PDSCH according to clause 5.1.4 of [6, TS 38.214].

The mapping to resource elements allocated for PDSCH according to [6, TS 38.214] and not reserved for other purposes shall be in increasing order of first the index over the assigned virtual resource blocks, where is the first subcarrier in the lowest-numbered virtual resource block assigned for transmission, and then the index .

#### 7.3.1.6 Mapping from virtual to physical resource blocks

The UE shall assume the virtual resource blocks are mapped to physical resource blocks according to the indicated mapping scheme, non-interleaved or interleaved mapping. If no mapping scheme is indicated, the UE shall assume non-interleaved mapping.

For non-interleaved VRB-to-PRB mapping, virtual resource block is mapped to physical resource block , except for PDSCH transmissions scheduled with DCI format 1\_0 in a common search space in which case virtual resource block is mapped to physical resource block where is the lowest-numbered physical resource block in the control resource set where the corresponding DCI was received. When two PDCCH candidates from two linked common search space sets as indicated by the higher-layer parameter *searchSpaceLinking* are detected, and the two linked common search space sets are associated with different control resource sets, the control resource set with the lowest number among the two linked control resource sets is used to determine .

For interleaved VRB-to-PRB mapping, the mapping process is defined by:

- Resource block bundles are defined as

- for PDSCH transmissions scheduled with DCI format 1\_0 with the CRC scrambled by SI-RNTI in Type0-PDCCH common search space in CORESET 0, the set of resource blocks in CORESET 0 are divided into resource-block bundles in increasing order of the resource-block number and bundle number where is the bundle size and is the size of CORESET 0.

- resource block bundle consists of resource blocks if and resource blocks otherwise,

- all other resource block bundles consists of resource blocks.

- for PDSCH transmissions scheduled with DCI format 1\_0 in any common search space in bandwidth part with starting position , other than Type0-PDCCH common search space in CORESET 0, the set of virtual resource blocks , where is the size of CORESET 0 if CORESET 0 is configured for the cell and the size of initial downlink bandwidth part if CORESET 0 is not configured for the cell, are divided into virtual resource-block bundles in increasing order of the virtual resource-block number and virtual bundle number and the set of physical resource blocks are divided into physical resource-block bundles in increasing order of the physical resource-block number and physical bundle number, where , is the bundle size, and is the lowest-numbered physical resource block in the control resource set where the corresponding DCI was received. When two PDCCH candidates from two linked search space sets as indicated by the higher-layer parameter *searchSpaceLinking* are detected, and the two linked search space sets are associated with different control resource sets, the control resource set with the lowest number among the two linked control resource sets is used to determine .

- resource block bundle 0 consists of resource blocks,

- resource block bundle consists of resource blocks if and resource blocks otherwise,

- all other resource block bundles consists of resource blocks.

- for all other PDSCH transmissions, the set of resource blocks in bandwidth part  with starting position are divided into resource-block bundles in increasing order of the resource-block number and bundle number where  is the bundle size for bandwidth part  provided by the higher-layer parameter *vrb-ToPRB-Interleaver* for DCI formats 1\_0, 1\_1, and 1\_3 in a UE-specific search space, or *vrb-ToPRB-InterleaverDCI-1-2* for DCI format 1\_2, and

- resource block bundle 0 consists of resource blocks,



- resource block bundle consists of resource blocks if and resource blocks otherwise,



- all other resource block bundles consists of resource blocks.



- Virtual resource blocks in the interval are mapped to physical resource blocks according to



- virtual resource block bundle is mapped to physical resource block bundle



- virtual resource block bundle  is mapped to physical resource block bundle  where



- The UE is not expected to be configured with simultaneously with a PRG size of 4 as defined in [6, TS 38.214]

The UE may assume that the same precoding in the frequency domain is used within a PRB bundle and the bundle size is determined by clause 5.1.2.3 in [6, TS 38.214]. The UE shall not make any assumption that the same precoding is used for different bundles of common resource blocks.

For PDSCH transmissions scheduled by DCI format 4\_1 or 4\_2, and using G-RNTI or G-CS-RNTI, the quantities and in this clause are replaced by and , respectively, and is the bundle size for the common MBS frequency resource provided by the higher-layer parameter vrb-ToPRB-Interleaver in pdsch-ConfigMulticast.

For PDSCH transmissions scheduled by DCI format 4\_0, and using G-RNTI for broadcast, MCCH-RNTI, or multicast-MCCH-RNTI, the quantities and in this clause are replaced by and , respectively, and *.*

### 7.3.2 Physical downlink control channel (PDCCH)

#### 7.3.2.1 Control-channel element (CCE)

A physical downlink control channel consists of one or more control-channel elements (CCEs) as indicated in Table 7.3.2.1-1.

Table 7.3.2.1-1: Supported PDCCH aggregation levels.

|  |  |
| --- | --- |
| Aggregation level | Number of CCEs |
| 1 | 1 |
| 2 | 2 |
| 4 | 4 |
| 8 | 8 |
| 16 | 16 |

#### 7.3.2.2 Control-resource set (CORESET)

A control-resource set consists of resource blocks in the frequency domain and symbols in the time domain.

A control-channel element consists of 6 resource-element groups (REGs) where a resource-element group equals one resource block during one OFDM symbol. Resource-element groups within a control-resource set are numbered in increasing order in a time-first manner, starting with 0 for the first OFDM symbol and the lowest-numbered resource block in the control resource set.

A UE can be configured with multiple control-resource sets. Each control-resource set is associated with one CCE-to-REG mapping only.

The CCE-to-REG mapping for a control-resource set can be interleaved or non-interleaved and is described by REG bundles:

- REG bundle  is defined as REGs where  is the REG bundle size, , and is the number of REGs in the CORESET

- CCE  consists of REG bundles where is an interleaver

For non-interleaved CCE-to-REG mapping, and .

For interleaved CCE-to-REG mapping, for and for . The interleaver is defined by

where .

The UE is not expected to handle configurations resulting in the quantity not being an integer.

For a CORESET configured by the *ControlResourceSet* IE:

- is given by the higher-layer parameter *frequencyDomainResources*;

- is given by the higher-layer parameter *duration*, where is supported only if the higher-layer parameter *dmrs-TypeA-Position* equals 3;

- interleaved or non-interleaved mapping is given by the higher-layer parameter *cce-REG-MappingType*;

- equals 6 for non-interleaved mapping and is given by the higher-layer parameter *reg-BundleSize* for interleaved mapping;

- is given by the higher-layer parameter *interleaverSize*;

- is given by the higher-layer parameter *shiftIndex* if provided, otherwise ;

- for both interleaved and non-interleaved mapping:

- if the higher-layer parameter *precoderGranularity* equals *sameAsREG-bundle* the UE may assume the same precoding being used within a REG bundle

- if the higher-layer parameter *precoderGranularity* equals *allContiguousRBs*,

- the UE may assume the same precoding being used across the all resource-element groups within the set of contiguous resource blocks in the CORESET;

- the UE may assume that no resource elements in the CORESET overlap with an SSB;

- if the UE is not provided with the higher-layer parameter *pdcchCandidateReception-WithCRSOverlap*, the UE may assume that no resource elements in the CORESET overlap with LTE cell-specific reference signals as indicated by the higher-layer parameter *lte-CRS-ToMatchAround*, *lte-CRS-PatternList1*, *lte-CRS-PatternList2*, *lte-CRS-PatternList3*, or *lte-CRS-PatternList4*.

For CORESET 0 configured by the *ControlResourceSetZero* IE:

- and are defined by clause 13 of [5, TS 38.213];

- the UE may assume interleaved mapping;

- ;

- ;

- ;

- the UE may assume normal cyclic prefix when CORESET 0 is configured by MIB or SIB1;

- the UE may assume the same precoding being used within a REG bundle.

For CORESET 0 on a carrier where the SS/PBCH block is detected at sync raster points defined in Tables 5.4.3.1-2 or 5.4.3.1-3 of [14, TS 38.101-1] and configured by the *ControlResourceSetZero* IE:

- and are defined by Table 13-0 in clause 13 of [5, TS 38.213];

- if on a carrier with a channel bandwidth of 3 MHz, the CORESET is obtained by applying the description above assuming interleaved mapping with ;

- if on a carrier with a channel bandwidth of 3 MHz, the CORESET is obtained by applying the description above assuming interleaved mapping with or non-interleaved mapping as defined by clause 13 of [5, TS 38.213], followed by puncturing the 9 highest-numbered resource blocks to obtain the 15 resource blocks forming CORESET 0;

- if on a carrier with a channel bandwidth of 5 MHz, the CORESET is obtained by applying the description above assuming interleaved mapping with , followed by puncturing the 4 highest-numbered resource blocks to obtain the 20 resource blocks forming CORESET 0;

- ;

- ;

- the UE may assume normal cyclic prefix when CORESET 0 is configured by MIB or SIB1;

- the UE may assume the same precoding being used within a REG bundle.

#### 7.3.2.3 Scrambling

The UE shall assume the block of bits , where is the number of bits transmitted on the physical channel, is scrambled prior to modulation, resulting in a block of scrambled bits according to

where the scrambling sequence  is given by clause 5.2.1. The scrambling sequence generator shall be initialized with



where

- for a UE-specific search space as defined in clause 10 of [5, TS 38.213], equals the higher-layer parameter *pdcch-DMRS-ScramblingID* if configured;



- for a PDCCH with the CRC scrambled by G-RNTI, G-CS-RNTI, MCCH-RNTI, or multicast-MCCH-RNTI in a common search space as defined in clause 10 of [5, TS 38.213], equals the higher-layer parameter *pdcch-DMRS-ScramblingID* if configured in a common MBS frequency resource;

- otherwise

and where

- is given by the C-RNTI for a PDCCH in a UE-specific search space if the higher-layer parameter *pdcch-DMRS-ScramblingID* is configured, and



- otherwise.



#### 7.3.2.4 PDCCH modulation

The UE shall assume the block of bits to be QPSK modulated as described in clause 5.1.3, resulting in a block of complex-valued modulation symbols .

#### 7.3.2.5 Mapping to physical resources

The UE shall assume the block of complex-valued symbols to be scaled by a factor  and mapped to resource elements used for the monitored PDCCH and not used for the associated PDCCH DMRS in increasing order of first , then . The antenna port .

### 7.3.3 Physical broadcast channel

#### 7.3.3.1 Scrambling

The UE shall assume the block of bits, where  is the number of bits transmitted on the physical broadcast channel, are scrambled prior to modulation, resulting in a block of scrambled bits according to

where the scrambling sequence  is given by clause 5.2. The scrambling sequence shall be initialized with at the start of each SS/PBCH block where

- for , is the two least significant bits of the candidate SS/PBCH block index

- for , is the three least significant bits of the candidate SS/PBCH block index

with being the maximum number of candidate SS/PBCH blocks in a half frame, as described in [5, TS 38.213].

#### 7.3.3.2 Modulation

The UE shall assume the block of bits are QPSK modulated as described in clause 5.1.3, resulting in a block of complex-valued modulation symbols .

#### 7.3.3.3 Mapping to physical resources

Mapping to physical resources is described in clause 7.4.3.

## 7.4 Physical signals

### 7.4.1 Reference signals

#### 7.4.1.1 Demodulation reference signals for PDSCH

##### 7.4.1.1.1 Sequence generation

The UE shall assume the sequence is defined by

.

where the pseudo-random sequence is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialized with

where is the OFDM symbol number within the slot, is the slot number within a frame, and

- are given by the higher-layer parameters *scramblingID0* and *scramblingID1*, respectively, in the *DMRS-DownlinkConfig* IE if provided and the PDSCH is scheduled by PDCCH using DCI format 1\_1, 1\_2, or 1\_3 with the CRC scrambled by C-RNTI, MCS-C-RNTI, or CS-RNTI;

- is given by the higher-layer parameter *scramblingID0* in the *DMRS-DownlinkConfig* IE if provided and the PDSCH is scheduled by PDCCH using DCI format 1\_0 with the CRC scrambled by C-RNTI, MCS-C-RNTI, or CS-RNTI;

- are given by the higher-layer parameters *scramblingID0* and *scramblingID1*, respectively, in the *DMRS-DownlinkConfig* IE if provided in a common MBS frequency resource for multicast and the PDSCH is scheduled by PDCCH using DCI format 4\_2 with the CRC scrambled by G-RNTI or G-CS-RNTI;

- is given by the higher-layer parameter *scramblingID0* in the *DMRS-DownlinkConfig* IE if provided in a common MBS frequency resource and the PDSCH is scheduled by PDCCH with the CRC scrambled by G-RNTI, G-CS-RNTI, MCCH-RNTI, or multicast-MCCH-RNTI;

- otherwise;

- given by

- if the higher-layer parameter *dmrs-Downlink* in the *DMRS-DownlinkConfig* IE is provided

where λ is the CDM group defined in clause 7.4.1.1.2.

- otherwise by

The quantity is given by the DM-RS sequence initialization field, if present, in the DCI associated with the PDSCH transmission if DCI format 1\_1, 1\_2, 1\_3, or 4\_2 in [4, TS 38.212] is used, otherwise .

##### 7.4.1.1.2 Mapping to physical resources

The UE shall assume the PDSCH DM-RS being mapped to physical resources according to configuration type 1 or configuration type 2 as given by the higher-layer parameter *dmrs-Type*.

The UE shall assume the sequence  is scaled by a factor to conform with the transmission power specified in [6, TS 38.214] and mapped to resource elements according to

- if the higher-layer parameter *enhanced-dmrs-Type* is configured

- otherwise

where , , and are given by Tables 7.4.1.1.2-1 and 7.4.1.1.2-2 and the following conditions are fulfilled:

- the resource elements are within the common resource blocks allocated for PDSCH transmission

The reference point for is

- subcarrier 0 of the lowest-numbered resource block in CORESET 0 if the corresponding PDCCH is associated with CORESET 0 and Type0-PDCCH common search space and is addressed to SI-RNTI;

- otherwise, subcarrier 0 in common resource block 0

The reference point for  and the position  of the first DM-RS symbol depends on the mapping type:

- for PDSCH mapping type A:

-  is defined relative to the start of the slot

- if the higher-layer parameter *dmrs-TypeA-Position* is equal to 'pos3' and  otherwise

- for PDSCH mapping type B:

-  is defined relative to the start of the scheduled PDSCH resources

- 

The position(s) of the DM-RS symbols is given by  and duration where

- for PDSCH mapping type A, is the duration between the first OFDM symbol of the slot and the last OFDM symbol of the scheduled PDSCH resources in the slot

- for PDSCH mapping type B, is the duration of the scheduled PDSCH resources

and according to Tables 7.4.1.1.2-3 and 7.4.1.1.2-4.

For PDSCH mapping type A

- the case *dmrs-AdditionalPosition* equals to 'pos3' is only supported when *dmrs-TypeA-Position* is equal to 'pos2';

- and symbols in Tables 7.4.1.1.2-3 and 7.4.1.1.2-4 respectively is only applicable when *dmrs-TypeA-Position* is equal to 'pos2';

- single-symbol DM-RS, except if all of the following conditions are fulfilled in which case :

- the higher-layer parameter *lte-CRS-ToMatchAround*, *lte-CRS-PatternList1*, *lte-CRS-PatternList2*, *lte-CRS-PatternList3*, or *lte-CRS-PatternList4* is configured; and

*-* the higher-layer parameter *dmrs-AdditionalPosition* is equal to 'pos1' and ; and

*-* the UE has indicated it is capable of *additionalDMRS-DL-Alt*

For PDSCH mapping type B

- if the PDSCH duration  OFDM symbols for normal cyclic prefix or OFDM symbols for extended cyclic prefix, and the front-loaded DM-RS of the PDSCH allocation collides with resources reserved for a search space set associated with a CORESET,  shall be incremented such that the first DM-RS symbol occurs immediately after the CORESET and until no collision with any CORESET occurs, and

- if the PDSCH duration is 2 symbols, the UE is not expected to receive a DM-RS symbol beyond the second symbol;

- if the PDSCH duration is 5 symbols and if one additional single-symbol DMRS is configured, the UE only expects the additional DM-RS to be transmitted on the 5th symbol when the front-loaded DM-RS symbol is in the 1st symbol of the PDSCH duration, otherwise the UE should expect that the additional DM-RS is not transmitted;

- if the PDSCH duration is 7 symbols for normal cyclic prefix or 6 symbols for extended cyclic prefix:

- if one additional single-symbol DM-RS is configured, the UE only expects the additional DM-RS to be transmitted on the 5th or 6th symbol when the front-loaded DM-RS symbol is in the 1st or 2nd symbol, respectively, of the PDSCH duration, otherwise the UE should expect that the additional DM-RS is not transmitted;

- if the PDSCH duration OFDM symbols, the UE is not expected to receive the front-loaded DM-RS beyond the 4th symbol;

- if the PDSCH duration is 12 or 13 symbols, the UE is not expected to receive DM-RS mapped to symbol 12 or later in the slot;

- for all values of the PDSCH duration other than 2, 5, and 7 symbols, the UE is not expected to receive DM-RS beyond the :th symbol;

- if the PDSCH duration is less than or equal to 4 OFDM symbols, only single-symbol DM-RS is supported.

- if the higher-layer parameter *lte-CRS-ToMatchAround*, *lte-CRS-PatternList1*, *lte-CRS-PatternList2*, *lte-CRS-PatternList3*, or *lte-CRS-PatternList4* is configured, the PDSCH duration symbols for normal cyclic prefix, the subcarrier spacing configuration , single-symbol DM-RS is configured, and at least one PDSCH DM-RS symbol in the PDSCH allocation collides with a symbol containing resource elements as indicated by the higher-layer parameter *lte-CRS-ToMatchAround*, *lte-CRS-PatternList1*, *lte-CRS-PatternList2*, *lte-CRS-PatternList3*, or *lte-CRS-PatternList4*, then shall be incremented by one in all slots.

The time-domain index and the supported antenna ports are given by Table 7.4.1.1.2-5 where

- single-symbol DM-RS is used if the higher-layer parameter *maxLength* in the *DMRS-DownlinkConfig* IE is not configured;

- single-symbol or double-symbol DM-RS is determined by the associated DCI if the higher-layer parameter *maxLength* in the *DMRS-DownlinkConfig* IE is equal to 'len2';

- basic or enhanced DM-RS multiplexing is controlled by the higher-layer parameter *enhanced-dmrs-Type.*

In absence of CSI-RS configuration, and unless otherwise configured, the UE may assume PDSCH DM-RS and SS/PBCH block to be quasi co-located with respect to Doppler shift, Doppler spread, average delay, delay spread, and, when applicable, spatial Rx parameters. Unless specified otherwise, the UE may assume that the PDSCH DM-RS within the same CDM group are quasi co-located with respect to Doppler shift, Doppler spread, average delay, delay spread, and spatial Rx (when applicable). The UE may assume that DMRS ports associated with a TCI state as described in clause 5.1.6.2 of [6, TS 38.214] of a PDSCH are QCL with QCL Type A, Type D (when applicable) and average gain.

The UE may assume that no DM-RS collides with the SS/PBCH block.

Table 7.4.1.1.2-1: Parameters for PDSCH DM-RS configuration type 1.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **CDM group** |  |  |  |
| 1000 | 0 | 0 |  |  |
| 1001 | 0 | 0 |  |  |
| 1002 | 1 | 1 |  |  |
| 1003 | 1 | 1 |  |  |
| 1004 | 0 | 0 |  |  |
| 1005 | 0 | 0 |  |  |
| 1006 | 1 | 1 |  |  |
| 1007 | 1 | 1 |  |  |
| 1008 | 0 | 0 |  |  |
| 1009 | 0 | 0 |  |  |
| 1010 | 1 | 1 |  |  |
| 1011 | 1 | 1 |  |  |
| 1012 | 0 | 0 |  |  |
| 1013 | 0 | 0 |  |  |
| 1014 | 1 | 1 |  |  |
| 1015 | 1 | 1 |  |  |

Table 7.4.1.1.2-2: Parameters for PDSCH DM-RS configuration type 2.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | **CDM group** |  |  |  |
| 0 | 0 | 0 |  |  |
| 1 | 0 | 0 |  |  |
| 2 | 1 | 2 |  |  |
| 3 | 1 | 2 |  |  |
| 4 | 2 | 4 |  |  |
| 5 | 2 | 4 |  |  |
| 6 | 0 | 0 |  |  |
| 7 | 0 | 0 |  |  |
| 8 | 1 | 2 |  |  |
| 9 | 1 | 2 |  |  |
| 10 | 2 | 4 |  |  |
| 11 | 2 | 4 |  |  |
| 12 | 0 | 0 |  |  |
| 13 | 0 | 0 |  |  |
| 14 | 1 | 2 |  |  |
| 15 | 1 | 2 |  |  |
| 16 | 2 | 4 |  |  |
| 17 | 2 | 4 |  |  |
| 18 | 0 | 0 |  |  |
| 19 | 0 | 0 |  |  |
| 20 | 1 | 2 |  |  |
| 21 | 1 | 2 |  |  |
| 22 | 2 | 4 |  |  |
| 23 | 2 | 4 |  |  |

Table 7.4.1.1.2-3: PDSCH DM-RS positions  for single-symbol DM-RS.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **in symbols** | **DM-RS positions** | | | | | | | |
| **PDSCH mapping type A** | | | | **PDSCH mapping type B** | | | |
| ***dmrs-AdditionalPosition*** | | | | ***dmrs-AdditionalPosition*** | | | |
| ***pos0*** | ***pos1*** | ***pos2*** | ***pos3*** | ***pos0*** | ***pos1*** | ***pos2*** | ***pos3*** |
| 2 | - | - | - | - |  |  |  |  |
| 3 |  |  |  |  |  |  |  |  |
| 4 |  |  |  |  |  |  |  |  |
| 5 |  |  |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |  |  |
| 8 |  | , 7 | , 7 | , 7 |  |  |  |  |
| 9 |  | , 7 | , 7 | , 7 |  |  |  |  |
| 10 |  | , 9 | , 6, 9 | , 6, 9 |  |  |  |  |
| 11 |  | , 9 | , 6, 9 | , 6, 9 |  |  |  |  |
| 12 |  | , 9 | , 6, 9 | , 5, 8, 11 |  |  |  |  |
| 13 |  | , | , 7, 11 | , 5, 8, 11 |  |  |  |  |
| 14 |  | , | , 7, 11 | , 5, 8, 11 | - | - | - | - |

Table 7.4.1.1.2-4: PDSCH DM-RS positions  for double-symbol DM-RS.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **in symbols** | **DM-RS positions** | | | | | |
| **PDSCH mapping type A** | | | **PDSCH mapping type B** | | |
| ***dmrs-AdditionalPosition*** | | | ***dmrs-AdditionalPosition*** | | |
| ***pos0*** | ***pos1*** | ***pos2*** | ***pos0*** | ***pos1*** | ***pos2*** |
| <4 |  |  |  | - | - |  |
| 4 |  |  |  | - | - |  |
| 5 |  |  |  |  |  |  |
| 6 |  |  |  |  |  |  |
| 7 |  |  |  |  |  |  |
| 8 |  |  |  |  |  |  |
| 9 |  |  |  |  |  |  |
| 10 |  | , 8 |  |  |  |  |
| 11 |  | , 8 |  |  |  |  |
| 12 |  | , 8 |  |  |  |  |
| 13 |  | , 10 |  |  |  |  |
| 14 |  | , 10 |  | - | - |  |

Table 7.4.1.1.2-5: PDSCH DM-RS time index and antenna ports .

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **DM-RS multiplexing** | **DM-RS duration** |  | **Supported antenna ports** | |
| **Configuration type 1** | **Configuration type 2** |
| Basic | single-symbol DM-RS | 0 | 1000 – 1003 | 1000 – 1005 |
| double-symbol DM-RS | 0, 1 | 1000 – 1007 | 1000 – 1011 |
| Enhanced | single-symbol DM-RS | 0 | 1000 – 1003, 1008 – 1011 | 1000 – 1005, 1012 – 1017 |
| double-symbol DM-RS | 0, 1 | 1000 – 1015 | 1000 – 1023 |

#### 7.4.1.2 Phase-tracking reference signals for PDSCH

##### 7.4.1.2.1 Sequence generation

The phase-tracking reference signal for subcarrier  is given by



where  is the demodulation reference signal given by clause 7.4.1.1.2 at position  and subcarrier 

##### 7.4.1.2.2 Mapping to physical resources

The UE shall assume phase-tracking reference signals being present only in the resource blocks used for the PDSCH, and only if the procedure in [6, TS 38.214] indicates phase-tracking reference signals being used.

If present, the UE shall assume the PDSCH PT-RS is scaled by a factor to conform with the transmission power specified in clause 4.1 of [6, TS 38.214] and mapped to resource elements according to

when all the following conditions are fulfilled

-  is within the OFDM symbols allocated for the PDSCH transmission

- resource element is not used for DM-RS, non-zero-power CSI-RS (except for those configured for mobility measurements or with *resourceType* in corresponding *CSI-ResourceConfig* configured as 'aperiodic'), zero-power CSI-RS, SS/PBCH block, a detected PDCCH according to clause 5.1.4.1 of [6, TS38.214], or is declared as 'not available' by clause 5.1.4 of [6, TS 38.214]

The set of time indices  defined relative to the start of the PDSCH allocation is defined by

1. set and 

2. if any symbol in the interval overlaps with a symbol used for DM-RS according to clause 7.4.1.1.2

- set

- set  to the symbol index of the DM-RS symbol in case of a single-symbol DM-RS and to the symbol index of the second DM-RS symbol in case of a double-symbol DM-RS

- repeat from step 2 as long as is inside the PDSCH allocation

3. add to the set of time indices for PT-RS

4. increment  by one

5. repeat from step 2 above as long as is inside the PDSCH allocation

where .

For the purpose of PT-RS mapping, the resource blocks allocated for PDSCH transmission are numbered from 0 to  from the lowest scheduled resource block to the highest. The corresponding subcarriers in this set of resource blocks are numbered in increasing order starting from the lowest frequency from 0 to . The subcarriers to which the UE shall assume the PT-RS is mapped are given by



where

-

- is given by Table 7.4.1.2.2-1 for the DM-RS port associated with the PT-RS port according to clause 5.1.6.3 in [6, TS 38.214]. If the higher-layer parameter *resourceElementOffset* in the *PTRS-DownlinkConfig* IE is not configured, the column corresponding to 'offset00' shall be used.



-  is the RNTI associated with the DCI scheduling the transmission

-  is the number of resource blocks scheduled

- is given by [6, TS 38.214].

Table 7.4.1.2.2-1: The parameter .

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| DM-RS antenna port |  | | | | | | | |
| DM-RS Configuration type 1 | | | | DM-RS Configuration type 2 | | | |
| *resourceElementOffset* | | | | *resourceElementOffset* | | | |
| offset00 | offset01 | offset10 | offset11 | offset00 | offset01 | offset10 | offset11 |
| 1000 | 0 | 2 | 6 | 8 | 0 | 1 | 6 | 7 |
| 1001 | 2 | 4 | 8 | 10 | 1 | 6 | 7 | 0 |
| 1002 | 1 | 3 | 7 | 9 | 2 | 3 | 8 | 9 |
| 1003 | 3 | 5 | 9 | 11 | 3 | 8 | 9 | 2 |
| 1004 | - | - | - | - | 4 | 5 | 10 | 11 |
| 1005 | - | - | - | - | 5 | 10 | 11 | 4 |
| 1008 | 4 | 6 | 10 | 0 | - | - | - | - |
| 1009 | 6 | 8 | 0 | 2 | - | - | - | - |
| 1010 | 5 | 7 | 11 | 1 | - | - | - | - |
| 1011 | 7 | 9 | 1 | 3 | - | - | - | - |
| 1012 | - | - | - | - | 6 | 7 | 0 | 1 |
| 1013 | - | - | - | - | 7 | 0 | 1 | 6 |
| 1014 | - | - | - | - | 8 | 9 | 2 | 3 |
| 1015 | - | - | - | - | 9 | 2 | 3 | 8 |
| 1016 | - | - | - | - | 10 | 11 | 4 | 5 |
| 1017 | - | - | - | - | 11 | 4 | 5 | 10 |

#### 7.4.1.3 Demodulation reference signals for PDCCH

##### 7.4.1.3.1 Sequence generation

The UE shall assume the reference-signal sequence for OFDM symbol is defined by

.

where the pseudo-random sequence is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialized with

where is the OFDM symbol number within the slot, is the slot number within a frame, and

- is given by the higher-layer parameter *pdcch-DMRS-ScramblingID* if provided;

- is given by the higher-layer parameter *pdcch-DMRS-ScramblingID* if configured for a common search space in a common MBS frequency resource;

- otherwise.

##### 7.4.1.3.2 Mapping to physical resources

The UE shall assume the sequence is mapped to resource elements according to



where the following conditions are fulfilled

- they are within the resource element groups constituting the PDCCH the UE attempts to decode if the higher-layer parameter *precoderGranularity* equals *sameAsREG-bundle*,

- all resource-element groups within the set of contiguous resource blocks in the CORESET where the UE attempts to decode the PDCCH if the higher-layer parameter *precoderGranularity* equals *allContiguousRBs*.

The reference point for is

- subcarrier 0 of the lowest-numbered resource block in the CORESET if the CORESET is configured by the PBCH or by the *controlResourceSetZero* field in the *PDCCH-ConfigCommon* IE,

- subcarrier 0 in common resource block 0 otherwise

The quantity is the OFDM symbol number within the slot.

The antenna port .

A UE not attempting to detect a PDCCH in a CORESET shall not make any assumptions on the presence or absence of DM-RS in the CORESET.

In absence of CSI-RS configuration, and unless otherwise configured, the UE may assume PDCCH DM-RS and SS/PBCH block to be quasi co-located with respect to Doppler shift, Doppler spread, average delay, delay spread, and, when applicable, spatial Rx parameters.

#### 7.4.1.4 Demodulation reference signals for PBCH

##### 7.4.1.4.1 Sequence generation

The UE shall assume the reference-signal sequence  for an SS/PBCH block is defined by



where  is given by clause 5.2. The scrambling sequence generator shall be initialized at the start of each SS/PBCH block occasion with



where

- for ,  where  is the number of the half-frame in which the PBCH is transmitted in a frame with  for the first half-frame in the frame and  for the second half-frame in the frame, and  is the two least significant bits of the candidate SS/PBCH block index as defined in [5, TS 38.213]

- for ,  where  is the three least significant bits of the candidate SS/PBCH block index as defined in [5, TS 38.213]

with being the maximum number of candidate SS/PBCH blocks in a half frame, as described in [5, TS 38.213].

##### 7.4.1.4.2 Mapping to physical resources

Mapping to physical resources is described in clause 7.4.3.

#### 7.4.1.5 CSI reference signals

##### 7.4.1.5.1 General

Zero-power (ZP) and non-zero-power (NZP) CSI-RS are defined

- for a non-zero-power CSI-RS configured by the *NZP-CSI-RS-Resource* IE or by the *CSI-RS-Resource-Mobility* field in the *CSI-RS-ResourceConfigMobility* IE or by the *TRS-ResourceSet* IE, the sequence shall be generated according to clause 7.4.1.5.2 and mapped to resource elements according to clause 7.4.1.5.3

- for a zero-power CSI-RS configured by the *ZP-CSI-RS-Resource* IE, the UE shall assume that the resource elements defined in clause 7.4.1.5.3 are not used for PDSCH transmission subject to clause 5.1.4.2 of [6, TS 38.214]. The UE performs the same measurement/reception on channels/signals except PDSCH regardless of whether they collide with ZP CSI-RS or not.

##### 7.4.1.5.2 Sequence generation

The UE shall assume the reference-signal sequence  is defined by



where the pseudo-random sequence  is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialised with

at the start of each OFDM symbol where is the slot number within a radio frame,  is the OFDM symbol number within a slot, and  equals the higher-layer parameter s*cramblingID* or *sequenceGenerationConfig*.

##### 7.4.1.5.3 Mapping to physical resources

For each CSI-RS configured, the UE shall assume the sequence  being mapped to resources elements according to



when the following conditions are fulfilled:

- the resource element is within the resource blocks occupied by the CSI-RS resource for which the UE is configured

The reference point for is subcarrier 0 in common resource block 0.

The value of is given by the higher-layer parameter *density* in the *CSI-RS-ResourceMapping* IE or the *CSI-RS-CellMobility* IE and the number of ports is given by the higher-layer parameter *nrofPorts*. For NZP CSI-RS configured by the *TRS-ResourceSet* IE, the density and number of ports .

The UE is not expected to receive CSI-RS and DM-RS on the same resource elements.

The UE shall assume  for a non-zero-power CSI-RS where  is selected such that the power offset specified by the higher-layer parameter *powerControlOffsetSS* in the *NZP-CSI-RS-Resource* IE or in the *TRS-ResourceSet* IE, if provided, is fulfilled.

The quantities , , , and  are given by Tables 7.4.1.5.3-1 to 7.4.1.5.3-5 where each in a given row of Table 7.4.1.5.3-1 corresponds to a CDM group of size 1 (no CDM) or size 2, 4, or 8. The CDM type is provided by the higher layer parameter *cdm-Type* in the *CSI-RS-ResourceMapping* IE. For NZP CSI-RS configured by the *TRS-ResourceSet* IE, the CDM type is 'noCDM'. The indices and index resource elements within a CDM group.

The time-domain locations and are provided by the higher-layer parameters *firstOFDMSymbolInTimeDomain* and *firstOFDMSymbolInTimeDomain2*, respectively, in the *CSI-RS-ResourceMapping* IE or the *CSI-RS-ResourceConfigMobility* IE and defined relative to the start of a slot. For NZP CSI-RS configured by *TRS-ResourceSet* IE, the time-domain location is provided by the higher-layer parameter *firstOFDMSymbolInTimeDomain* or *firstOFDMSymbolInTimeDomain*+4.

The frequency-domain location is given by a bitmap provided by the higher-layer parameter *frequencyDomainAllocation* in the *CSI-RS-ResourceMapping* IE, the *CSI-RS-ResourceConfigMobility* IE, or the *TRS-ResourceSet* IE, with the bitmap and value of in Table 7.4.1.5.3-1 given by

- , for row 1 of Table 7.4.1.5.3-1

- , for row 2 of Table 7.4.1.5.3-1

- , for row 4 of Table 7.4.1.5.3-1

- , for all other cases

where  is the bit number of the  bit in the bitmap set to one, repeated across every of the resource blocks configured for CSI-RS reception by the UE. The starting position and number of the resource blocks in which the UE shall assume that CSI-RS is transmitted are given by the higher-layer parameters *freqBand* and *density* in the *CSI-RS-ResourceMapping* IE for the bandwidth part given by the higher-layer parameter *BWP-Id* in the *CSI-ResourceConfig* IE or given by the higher-layer parameters *nrofPRBs* in the *CSI-RS-CellMobility* IE where the the *startPRB* given by *csi-rs-MeasurementBW* is relative to common resource block 0*.* For NZP CSI-RS configured by *TRS-ResourceSet* IE, the starting position and number of the resource blocks in which the CSI-RS can be transmitted are given by the higher-layer parameters *nrofRBs*, and *startingRB* in the *TRS-ResourceSet* IE, where *startingRB* is relative to common resource block 0 and the density .

The UE shall assume that a CSI-RS is transmitted using antenna ports  numbered according to



where  is the sequence index provided by Tables 7.4.1.5.3-2 to 7.4.1.5.3-5,  is the CDM group size, and  is the number of CSI-RS ports. The CDM group index  given in Table 7.4.1.5.3-1 corresponds to the time/frequency locations  for a given row of the table. The CDM groups are numbered in order of increasing frequency domain allocation first and then increasing time domain allocation.

For a CSI-RS resource configured as periodic or semi-persistent by the higher-layer parameter *resourceType*, configured by the higher-layer parameter *CSI-RS-CellMobility* or configured by the higher-layer parameter *TRS-ResourceSet-r17*, the UE shall assume that the CSI-RS is transmitted in slots satisfying



where the periodicity  (in slots) and slot offset  are obtained from the higher-layer parameter *CSI-ResourcePeriodicityAndOffset*, *slotConfig* or *periodicityAndOffset-r17*. The UE shall assume that CSI-RS is transmitted in a candidate slot as described in clause 11.1 of [5, TS 38.213], clause 10.4B of [5, TS 38.213].

The UE may assume that antenna ports within a CSI-RS resource are quasi co-located with QCL Type A, Type D (when applicable), and average gain.

Table 7.4.1.5.3-1: CSI-RS locations within a slot.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Row** | **Ports** | **Density** | ***cdm-Type*** |  | **CDM group index** |  |  |
| 1 | 1 | 3 | noCDM | , , | 0,0,0 | 0 | 0 |
| 2 | 1 | 1, 0.5 | noCDM | , | 0 | 0 | 0 |
| 3 | 2 | 1, 0.5 | fd-CDM2 | , | 0 | 0, 1 | 0 |
| 4 | 4 | 1 | fd-CDM2 | , | 0,1 | 0, 1 | 0 |
| 5 | 4 | 1 | fd-CDM2 | , | 0,1 | 0, 1 | 0 |
| 6 | 8 | 1 | fd-CDM2 | , , , | 0,1,2,3 | 0, 1 | 0 |
| 7 | 8 | 1 | fd-CDM2 | , ,, | 0,1,2,3 | 0, 1 | 0 |
| 8 | 8 | 1 | cdm4-FD2-TD2 | , | 0,1 | 0, 1 | 0, 1 |
| 9 | 12 | 1 | fd-CDM2 | , , , ,, | 0,1,2,3,4,5 | 0, 1 | 0 |
| 10 | 12 | 1 | cdm4-FD2-TD2 | , , | 0,1,2 | 0, 1 | 0, 1 |
| 11 | 16 | 1, 0.5 | fd-CDM2 | , , , ,, , , | 0,1,2,3,  4,5,6,7 | 0, 1 | 0 |
| 12 | 16 | 1, 0.5 | cdm4-FD2-TD2 | , , , | 0,1,2,3 | 0, 1 | 0, 1 |
| 13 | 24 | 1, 0.5 | fd-CDM2 | , , , , , ,, , , , , | 0,1,2,3,4,5,  6,7,8,9,10,11 | 0, 1 | 0 |
| 14 | 24 | 1, 0.5 | cdm4-FD2-TD2 | , , , , , | 0,1,2,3,4,5 | 0, 1 | 0, 1 |
| 15 | 24 | 1, 0.5 | cdm8-FD2-TD4 | , , | 0,1,2 | 0, 1 | 0, 1, 2, 3 |
| 16 | 32 | 1, 0.5 | fd-CDM2 | , , , ,, , , , , , , , , , , | 0,1,2,3,  4,5,6,7,  8,9,10,11,  12,13,14,15 | 0, 1 | 0 |
| 17 | 32 | 1, 0.5 | cdm4-FD2-TD2 | , , , , , , , | 0,1,2,3,4,5,6,7 | 0, 1 | 0, 1 |
| 18 | 32 | 1, 0.5 | cdm8-FD2-TD4 | , , , | 0,1,2,3 | 0,1 | 0,1, 2, 3 |

Table 7.4.1.5.3-2: The sequences  and  for *cdm-Type* equal to 'noCDM'.

|  |  |  |
| --- | --- | --- |
| Index |  |  |
| 0 | 1 | 1 |

Table 7.4.1.5.3-3: The sequences  and  for *cdm-Type* equal to 'fd-CDM2'.

|  |  |  |
| --- | --- | --- |
| Index |  |  |
| 0 |  | 1 |
| 1 |  | 1 |

Table 7.4.1.5.3-4: The sequences  and  for *cdm-Type* equal to 'cdm4-FD2-TD2'.

|  |  |  |
| --- | --- | --- |
| Index |  |  |
| 0 |  |  |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |

Table 7.4.1.5.3-5: The sequences  and  for *cdm-Type* equal to 'cdm8-FD2-TD4'.

|  |  |  |
| --- | --- | --- |
| Index |  |  |
| 0 |  |  |
| 1 |  |  |
| 2 |  |  |
| 3 |  |  |
| 4 |  |  |
| 5 |  |  |
| 6 |  |  |
| 7 |  |  |

#### 7.4.1.6 RIM reference signals

##### 7.4.1.6.1 General

RIM-RS can be used by an gNB to measure inter-cell interference and to provide information about the experienced interference to other gNBs. Up to two different types of RIM-RS can be configured where

- the first RIM-RS type can be used to convey information,

- the second RIM-RS type depends on configuration only.

##### 7.4.1.6.2 Sequence generation

The RIM-RS receiver shall assume the reference-signal sequence is defined by

where the pseudo-random sequence is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialised with

where

- is given by clause 7.4.1.6.4.4;

- where the pseudo-random sequence is given by clause 5.2.1, initialized with where the multiplier factor and the offset ;

- is the number of RIM-RS transmission periods since where

- is the time in seconds relative to of 00:00:00 on 1 January 1900, calculated as continuous time without leap second and traceable to a common time reference, and

- is the RIM-RS transmission periodicity in seconds assuming that the first RIM-RS transmission period starts at , and where is given by clause 7.4.1.6.4.2.

##### 7.4.1.6.3 Mapping to physical resources

The RIM-RS receiver shall assume the reference signal being mapped to physical resources according to

where is an amplitude scaling factor in order to control the RIM-RS transmission power and is the antenna port. Baseband signal generation shall be done according to clause 5.3.3.

The starting position for RIM-RS type in slot in a frame is given by

in slots satisfying

where

- counts the number of times the SFN periods within the RIM-RS transmission period;

- where is the symbol offset of the reference point after the starting boundary of the uplink-downlink switching period in which the RIM-RS is mapped to and is obtained as described in clause 7.4.1.6.4.2;

- is the total number of slots in a RIM-RS transmission period as defined in clause 7.4.1.6.4.2;

- is the slot offset of the uplink-downlink switching period with index with respect to the starting boundary of the RIM-RS transmission period and is defined in clause 7.4.1.6.4.2;

- is the RIM-RS transmission periodicity in units of uplink-downlink switching period as defined in clause 7.4.1.6.4.2.

##### 7.4.1.6.4 RIM-RS configuration

###### 7.4.1.6.4.1 General

A resource for RIM-RS transmission is defined by the indices , , and used as indices into configured lists of time, frequency, and sequence parameters, respectively.

All RIM-RS resources occupy the same number of resource blocks, . At most 32 RIM-RS resources can be configured within a 10 ms period.

###### 7.4.1.6.4.2 Time-domain parameters and mapping from to time-domain parameters

RIM-RS are transmitted periodically with the RIM-RS transmission period defined in units of the uplink-downlink switching period determined from one or two configured uplink-downlink periods.

- If a single uplink-downlink period is configured for RIM-RS purposes,

- is the RIM-RS transmission periodicity in terms of uplink-downlink switching periods given by

where ms;

- is the total number of slots in a RIM-RS transmission period;

- is the slot offset of the uplink-downlink switching period with index with respect to the starting boundary of the RIM-RS transmission period

- If two uplink-downlink periods are configured for RIM-RS purposes,

- is the RIM-RS transmission periodicity in terms of pairs of uplink-downlink switching periods and is given by

where each pair consists of a first period of ms and a second period of ms and where  divides 20 ms;

- is the total number of slots in a RIM-RS transmission period;

- is the slot offset of the uplink-downlink switching period with index with respect to the starting boundary of the RIM-RS transmission period

The intermediate quantity is given by

where

- and are the total number of setIDs for RIM-RS type 1 and RIM-RS type 2, respectively;

- is the number of candidate frequency resources configured in the network;

- is the number of candidate sequences assigned for RIM-RS type in the network;

- and are the number of consecutive uplink-downlink switching periods for RIM-RS type 1 and RIM-RS type 2, respectively. If near-far functionality is not configured, , otherwise and the first and second half of the consecutive uplink-downlink switching periods are for near functionality and far functionality, respectively.

The quantity is obtained from entry in a list of configured symbol offsets for RIM-RS .

###### 7.4.1.6.4.3 Frequency-domain parameters and mapping from to frequency-domain parameters

The frequency-domain parameter in clause 5.3.3 is the frequency offset relative to a configured reference point for RIM-RS and is obtained from entry in a list of configured frequency offsets expressed in units of resource blocks.

The number of candidate frequency resources configured in the network, , shall fulfil

If , the frequency difference between any pair of configured frequency offsets in the list is not smaller than .

The number of resource blocks for RIM-RS is given by

###### 7.4.1.6.4.4 Sequence parameters and mapping from to sequence parameters

The scrambling identity clause 7.4.1.6.2 is obtained from entry in a list of configured scrambling identities.

###### 7.4.1.6.4.5 Mapping between resource triplet and set ID

The resource indices , , and are determined from the index in the set ID according to

where

- is given by

- is the number of candidate frequency resources configured in the network;

- is the number of sequence candidates for the current RIM-RS resource given by

- is the starting time offset given by

- is given by

where is the number of candidate sequences assigned for RIM-RS type 1

- is the number of consecutive uplink-downlink periods for RIM-RS type as given by clause 7.4.1.6.4.2;

- .

The set ID is determined from the resource triplet according to

#### 7.4.1.7 Positioning reference signals

##### 7.4.1.7.1 General

A positioning frequency layer consists of one or more downlink PRS resource sets, each of which consists of one or more downlink PRS resources as described in [6, TS 38.214].

##### 7.4.1.7.2 Sequence generation

The UE shall assume the reference-signal sequence is defined by

where the pseudo-random sequence is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialised with

where is the slot number, the downlink PRS sequence ID is given by the higher-layer parameter *dl-PRS-SequenceID*, and is the OFDM symbol within the slot to which the sequence is mapped.

##### 7.4.1.7.3 Mapping to physical resources in a downlink PRS resource

For each downlink PRS resource configured, the UE shall assume the sequence  is scaled with a factor and mapped to resources elements according to

when the following conditions are fulfilled:

- the resource element is within the resource blocks occupied by the downlink PRS resource for which the UE is configured;

- the symbol is not used by any SS/PBCH block used by a serving cell for downlink PRS transmitted from the same serving cell or any SS/PBCH block from a non-serving cell whose time frequency location is provided to the UE by higher layers for downlink PRS transmitted from the same non-serving cell;

- the slot number satisfies the conditions in clause 7.4.1.7.4.

and where

- the antenna port

- is the first symbol of the downlink PRS within a slot and given by the higher-layer parameter *dl-PRS-ResourceSymbolOffset*;

- the size of the downlink PRS resource in the time domain is given by the higher-layer parameter *dl-PRS-NumSymbols*;

- the comb size is given by the higher-layer parameter *dl-PRS-CombSizeN-AndReOffset* for a downlink PRS resource configured for RTT-based propagation delay compensation, otherwise by the higher-layer parameter *dl-PRS-CombSizeN* such that the combination is one of {1, 2}, {2, 2},{4, 2}, {6, 2}, {12, 2}, {1, 4}, {4, 4}, {12, 4}, {1, 6}, {6, 6}, {12, 6}, {1, 12} and {12, 12}*;*

- the resource-element offset is obtained from the higher-layer parameter *dl-PRS-CombSizeN-AndReOffset*;

- the quantity is given by Table 7.4.1.7.3-1.

If the downlink PRS resource is configured for RTT based propagation delay compensation as described in clause 9 of [6, TS 38.214], the reference point for is subcarrier 0 in common resource block 0; Otherwise, the reference point for is the location of the point A of the positioning frequency layer, in which the downlink PRS resource is configured where point A is given by the higher-layer parameter *dl-PRS-PointA*.

Table 7.4.1.7.3-1: The frequency offset as a function of .

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Symbol number within the downlink PRS resource | | | | | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 |
| 2 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 |
| 4 | 0 | 2 | 1 | 3 | 0 | 2 | 1 | 3 | 0 | 2 | 1 | 3 |
| 6 | 0 | 3 | 1 | 4 | 2 | 5 | 0 | 3 | 1 | 4 | 2 | 5 |
| 12 | 0 | 6 | 3 | 9 | 1 | 7 | 4 | 10 | 2 | 8 | 5 | 11 |

##### 7.4.1.7.4 Mapping to slots in a downlink PRS resource set

For a downlink PRS resource in a downlink PRS resource set, the UE shall assume the downlink PRS resource being transmitted when the slot and frame numbers fulfil

and one of the following conditions are fulfilled:

- the higher-layer parameters *dl-PRS-MutingOption1* and *dl-PRS-MutingOption2* are not provided;

- the higher-layer parameter *dl-PRS-MutingOption1* is provided with bitmap but *dl-PRS-MutingOption2* with bitmap is not provided, and bit is set;

- the higher-layer parameter *dl-PRS-MutingOption2* is provided with bitmap but *dl-PRS-MutingOption1* with bitmap is not provided, and bit is set;

- the higher-layer parameters *dl-PRS-MutingOption1* with bitmap and *dl-PRS-MutingOption2* with are both provided, and both bit and are set.

where

- is bit in the bitmap given by the higher-layer parameter *dl-PRS-MutingOption1* where is the size of the bitmap;

- is bit in the bitmap given by the higher-layer parameter *dl-PRS-MutingOption2;*

- the periodicity and the slot offset are given by the higher-layer parameter *dl-PRS-Periodicity-and-ResourceSetSlotOffset;*

- the downlink PRS resource slot offset is given by the higher-layer parameter *dl-PRS-ResourceSlotOffset*;

- the repetition factor is given by the higher-layer parameter *dl-PRS-ResourceRepetitionFactor*;

- the muting repetition factor is given by the higher-layer parameter *dl-PRS-MutingBitRepetitionFactor*;

- the time gap is given by the higher-layer parameter *dl-PRS-ResourceTimeGap*;

For a downlink PRS resource in a downlink PRS resource set configured for RTT-based propagation delay compensation, the UE shall assume the downlink PRS resource being transmitted as described in clause 9 of [6, TS 38.214]; otherwise, the UE shall assume the downlink PRS resource being transmitted as described in clause 5.1.6.5 of [6, TS 38.214].

### 7.4.2 Synchronization signals

#### 7.4.2.1 Physical-layer cell identities

There are 1008 unique physical-layer cell identities given by



where and .

#### 7.4.2.2 Primary synchronization signal

##### 7.4.2.2.1 Sequence generation

The sequence  for the primary synchronization signal is defined by



where



and



##### 7.4.2.2.2 Mapping to physical resources

Mapping to physical resources is described in clause 7.4.3.

#### 7.4.2.3 Secondary synchronization signal

##### 7.4.2.3.1 Sequence generation

The sequence  for the secondary synchronization signal is defined by



where



and



##### 7.4.2.3.2 Mapping to physical resources

Mapping to physical resources is described in clause 7.4.3.

### 7.4.3 SS/PBCH block

#### 7.4.3.1 Time-frequency structure of an SS/PBCH block

In the time domain, an SS/PBCH block consists of 4 OFDM symbols, numbered in increasing order from 0 to 3 within the SS/PBCH block, where PSS, SSS, and PBCH with associated DM-RS are mapped to symbols as given by Table 7.4.3.1-1.

In the frequency domain, an SS/PBCH block consists of 240 contiguous subcarriers with the subcarriers numbered in increasing order from 0 to 239 within the SS/PBCH block. The quantities and represent the frequency and time indices, respectively, within one SS/PBCH block. The UE may assume that the complex-valued symbols corresponding to resource elements denoted as 'Set to 0' in Table 7.4.3.1-1 are set to zero. The quantity in Table 7.4.3.1-1 is given by . The quantity is the subcarrier offset from subcarrier 0 in common resource block to the lowest-numbered subcarrier of the SS/PBCH block, or the SS/PBCH block after puncturing if applicable, where is obtained from the higher-layer parameter *offsetToPointA*.

- For operation with shared spectrum channel access in FR2-2 and for operation without shared spectrum channel access, the 4 least significant bits of are given by the higher-layer parameter *ssb-SubcarrierOffset* and for FR1 the most significant bit of is given by in the PBCH payload as defined in clause 7.1.1 of [4, TS 38.212].

- For operation with shared spectrum channel access in FR1, the 4 least significant bits of are given by the higher-layer parameter *ssb-SubcarrierOffset* and the most significant bit of is given by in the PBCH payload as defined in clause 7.1.1 of [4, TS 38.212]. If , ; otherwise, .

If *ssb-SubcarrierOffset* is not provided, is derived from the frequency difference between the SS/PBCH block and Point A.

The UE may assume that the complex-valued symbols corresponding to resource elements that are part of a common resource block partially or fully overlapping with an SS/PBCH block, or an SS/PBCH block after puncturing if applicable, and not used for SS/PBCH transmission are set to zero in the OFDM symbols partially or fully overlapping with OFDM symbols where SS/PBCH is transmitted.

For an SS/PBCH block, the UE shall assume

- antenna port is used for transmission of PSS, SSS, PBCH and DM-RS for PBCH,

- the same cyclic prefix length and subcarrier spacing for the PSS, SSS, PBCH and DM-RS for PBCH,

- for SS/PBCH block type A, and with the quantities , and expressed in terms of 15 kHz subcarrier spacing, and

- for SS/PBCH block type B in FR2-1, and with the quantity expressed in terms of the subcarrier spacing provided by the higher-layer parameter *subCarrierSpacingCommon* and expressed in terms of 60 kHz subcarrier spacing;

- for SS/PBCH block type B in FR2-2, and with the quantity expressed in terms of the SS/PBCH block subcarrier spacing and expressed in terms of 60 kHz subcarrier spacing;

- the centre of subcarrier 0 of resource block coincides with the centre of subcarrier 0 of a common resource block with the subcarrier spacing

- provided by the higher-layer parameter *subCarrierSpacingCommon* for operation without shared spectrum channel access in FR1 and FR2-1; and

- same as the subcarrier spacing of the SS/PBCH block for operation without shared spectrum access in FR2-2 and for operation with shared spectrum channel access.

- This common resource block overlaps with subcarrier 0 of the lowest-numbered resource block of the SS/PBCH block, or the SS/PBCH block after puncturing if applicable.

The UE may assume that SS/PBCH blocks transmitted with the same block index on the same center frequency location are quasi co-located with respect to Doppler spread, Doppler shift, average gain, average delay, delay spread, and, when applicable, spatial Rx parameters. The UE shall not assume quasi co-location for any other SS/PBCH block transmissions other than what is specified in [5, TS 38.213].

For cell search on a carrier with a channel bandwidth of 3 MHz, the UE is not expected to receive subcarriers 0 to 47 and 192 to 239 in any of the 4 OFDM symbols of the SS/PBCH block, where the remaining 12 resource blocks form the SS/PBCH block after puncturing.

Table 7.4.3.1-1: Resources within an SS/PBCH block for PSS, SSS, PBCH, and DM-RS for PBCH.

|  |  |  |
| --- | --- | --- |
| Channel or signal | OFDM symbol number  relative to the start of an SS/PBCH block | Subcarrier number  relative to the start of an SS/PBCH block |
| PSS | 0 | 56, 57, …, 182 |
| SSS | 2 | 56, 57, …, 182 |
| Set to 0 | 0 | 0, 1, …, 55, 183, 184, …, 239 |
| 2 | 48, 49, …, 55, 183, 184, …, 191 |
| PBCH | 1, 3 | 0, 1, …, 239 |
| 2 | 0, 1, …, 47,  192, 193, …, 239 |
| DM-RS for PBCH | 1, 3 |  |
| 2 |  |

##### 7.4.3.1.1 Mapping of PSS within an SS/PBCH block

The UE shall assume the sequence of symbols constituting the primary synchronization signal to be scaled by a factor  to conform to the PSS power allocation specified in [5, TS 38.213] and mapped to resource elements in increasing order of  where  and  are given by Table 7.4.3.1-1 and represent the frequency and time indices, respectively, within one SS/PBCH block.

##### 7.4.3.1.2 Mapping of SSS within an SS/PBCH block

The UE shall assume the sequence of symbols  constituting the secondary synchronization signal to be scaled by a factor  and mapped to resource elements in increasing order of  where  and  are given by Table 7.4.3.1-1 and represent the frequency and time indices, respectively, within one SS/PBCH block.

##### 7.4.3.1.3 Mapping of PBCH and DM-RS within an SS/PBCH block

The UE shall assume the sequence of complex-valued symbols constituting the physical broadcast channel to be scaled by a factor  to conform to the PBCH power allocation specified in [5, TS 38.213] and mapped in sequence starting with  to resource elements which meet all the following criteria:

- they are not used for PBCH demodulation reference signals

The mapping to resource elements not reserved for PBCH DM-RS shall be in increasing order of first the index  and then the index , where  and  represent the frequency and time indices, respectively, within one SS/PBCH block and are given by Table 7.4.3.1-1.

The UE shall assume the sequence of complex-valued symbols  constituting the demodulation reference signals for the SS/PBCH block to be scaled by a factor of to conform to the PBCH power allocation specified in [5, TS 38.213] and to be mapped to resource elements in increasing order of first  and then  where  and  are given by Table 7.4.3.1-1 and represent the frequency and time indices, respectively, within one SS/PBCH block.

#### 7.4.3.2 Time location of an SS/PBCH block

The locations in the time domain where a UE shall monitor for a possible SS/PBCH block are described in clause 4.1 of [5, TS 38.213].

# 8 Sidelink

## 8.1 Overview

### 8.1.1 Overview of physical channels

A sidelink physical channel corresponds to a set of resource elements carrying information originating from higher layers. The following sidelink physical channels are defined:

- Physical Sidelink Shared Channel, PSSCH

- Physical Sidelink Broadcast Channel, PSBCH

- Physical Sidelink Control Channel, PSCCH

- Physical Sidelink Feedback Channel, PSFCH

### 8.1.2 Overview of physical signals

A sidelink physical signal corresponds to a set of resource elements used by the physical layer but does not carry information originating from higher layers.

The following sidelink physical signals are defined:

- Demodulation reference signals, DM-RS

- Channel-state information reference signal, CSI-RS

- Phase-tracking reference signals, PT-RS

- Sidelink primary synchronization signal, S-PSS

- Sidelink secondary synchronization signal, S-SSS

- Sidelink positioning reference signal, SL PRS

## 8.2 Physical resources

### 8.2.1 General

In a shared SL PRS resource pool, the OFDM symbol immediately preceding the symbols which are configured for use by PSFCH if PSFCH is configured in this slot, and the last symbol configured for sidelink in a slot, serve as guard symbol(s). In a dedicated SL PRS resource pool, the last symbol configured for sidelink in a slot serves as a guard symbol. Otherwise, the OFDM symbol immediately following the last symbol used for PSSCH, PSFCH, or S-SSB serves as a guard symbol.

The first OFDM symbol of a PSSCH and its associated PSCCH is duplicated as described in clauses 8.3.1.5 and 8.3.2.3. The first OFDM symbol of a PSFCH is duplicated as described in clause 8.3.4.2.2.

The OFDM symbol immediately preceding an SL PRS transmission in a dedicated SL PRS resource pool is generated as described in clause 8.4.1.6.3.

### 8.2.2 Numerologies

Multiple OFDM numerologies are supported as given by Table 8.2.2-1 where and the cyclic prefix for a sidelink bandwidth part are obtained from the higher-layer parameter *sl-BWP*.

Table 8.2.2-1: Supported transmission numerologies.

|  |  |  |
| --- | --- | --- |
|  | [kHz] | Cyclic prefix |
| 0 | 15 | Normal |
| 1 | 30 | Normal |
| 2 | 60 | Normal, Extended |
| 3 | 120 | Normal |

### 8.2.3 Frame structure

#### 8.2.3.1 Frames and subframes

The frame and subframe structure for sidelink transmission is defined in clause 4.3.1.

#### 8.2.3.2 Slots

The slot structure for sidelink transmission is defined in clause 4.3.2.

### 8.2.4 Antenna ports

An antenna port is defined in clause 4.4.1.

The following antenna ports are defined for the sidelink:

- Antenna ports starting with 1000 for PSSCH

- Antenna ports starting with 2000 for PSCCH

- Antenna ports starting with 3000 for CSI-RS

- Antenna ports starting with 4000 for S-SS/PSBCH block

- Antenna ports starting with 5000 for PSFCH

- Antenna ports starting with 6000 for SL PRS

For DM-RS associated with a PSBCH, the channel over which a PSBCH symbol on one antenna port is conveyed can be inferred from the channel over which a DM-RS symbol on the same antenna port is conveyed only if the two symbols are within a S-SS/PSBCH block transmitted within the same slot, and with the same block index according to clause 8.4.3.1.

For DM-RS associated with a PSSCH, the channel over which a PSSCH symbol on one antenna port is conveyed can be inferred from the channel over which a DM-RS symbol on the same antenna port is conveyed only if the two symbols are within the same frequency resource as the scheduled PSSCH and in the same slot.

For DM-RS associated with a PSCCH, the channel over which a PSCCH symbol on one antenna port is conveyed can be inferred from the channel over which a DM-RS symbol on the same antenna port is conveyed only if the two symbols are within the same frequency resource as the transmitted PSCCH and in the same slot.

### 8.2.5 Resource grid

The resource grid for sidelink transmission is defined in clause 4.4.2.

For sidelink, the carrier bandwidth and the starting position for subcarrier spacing configuration are obtained from the higher-layer parameter *sl-SCS-SpecificCarrierList*.

For the sidelink, the higher-layer parameter *sl-TxDirectCurrentLocation* indicates the location of the transmitter DC subcarrier in the sidelink for each of the configured bandwidth parts. Values in the range 0 – 3299 represent the number of the DC subcarrier, the value 3300 indicates that the DC subcarrier is located outside the resource grid, and the value 3301 indicates that the position of the DC subcarrier in the sidelink is undetermined. The DC subcarrier location offset relative to the center of the indicated subcarrier is given by if *frequencyShift7p5khzSL* is provided and by otherwise, where is given by the higher-layer parameter *valueN*.

### 8.2.6 Resource elements

Resource elements are defined in clause 4.4.3.

### 8.2.7 Resource blocks

Resource blocks are defined in clause 4.4.4.

Point A for sidelink transmission/reception is obtained from the higher-layer parameter *sl-AbsoluteFrequencyPointA*.

### 8.2.8 Bandwidth part

Configuration of the single bandwidth part for sidelink transmission is described in clause 16 of [5, TS 38.213].

## 8.3 Physical channels

### 8.3.1 Physical sidelink shared channel

#### 8.3.1.1 Scrambling

For the single codeword , the block of bits , where is the number of bits in codeword transmitted on the physical channel as defined in [4, TS 38.212], shall be scrambled prior to modulation.

Scrambling shall be done according to the following pseudo code

set

set

while

if // SCI placeholder bits

else

end if

*i* = *i* + 1

end while

where the scrambling sequence is given by clause 5.2.1 and

- for

-

- The scrambling sequence generator shall be initialized with

where and the quantity equals the decimal representation of the CRC on the PSCCH associated with the PSSCH according to with and given by clause 8.3.2 in [4, TS 38.212].

- for

-

- The scrambling sequence generator shall be initialized with

where and the quantity equals the decimal representation of the CRC on the PSCCH associated with the PSSCH according to with and given by clause 8.3.2 in [4, TS 38.212].

#### 8.3.1.2 Modulation

For the single codeword , the block of scrambled bits shall be modulated, resulting in a block of complex-valued modulation symbols where .

Modulation for shall be done as described in clause 5.1 using QPSK, where .

Modulation for shall be done as described in clause 5.1 using one of the modulation schemes in Table 8.3.1.2-1 where .

Table 8.3.1.2-1: Supported modulation schemes.

|  |  |
| --- | --- |
| **Modulation scheme** | **Modulation order** |
| QPSK | 2 |
| 16QAM | 4 |
| 64QAM | 6 |
| 256QAM | 8 |

#### 8.3.1.3 Layer mapping

Layer mapping shall be done according to clause 7.3.1.3 with the number of layers , resulting in , .

#### 8.3.1.4 Precoding

The block of vectors shall be precoded according to clasue 6.3.1.5 where the precoding matrix equals the identity matrix and .

#### 8.3.1.5 Mapping to virtual resource blocks

For each of the antenna ports used for transmission of the PSSCH, the block of complex-valued symbols shall be multiplied with the amplitude scaling factor in order to conform to the transmit power specified in [5, TS 38.213] and mapped to resource elements in the virtual resource blocks assigned for transmission, where is the first subcarrier in the lowest-numbered virtual resource block assigned for transmission.

The mapping operation shall be done in two steps:

- first, the complex-valued symbols corresponding to the bit for the 2nd-stage SCI in increasing order of first the index over the assigned virtual resource blocks and then the index , starting from the first PSSCH symbol carrying an associated DM-RS and meeting all of the following criteria:

- the corresponding resource elements in the corresponding physical resource blocks are not used for transmission of the associated DM-RS, PT-RS, or PSCCH;

- secondly, the complex-valued modulation symbols not corresponding to the 2nd -stage SCI shall be in increasing order of first the index over the assigned virtual resource blocks, and then the index with the starting position given by [6, TS 38.214] and meeting all of the following criteria:

- the resource elements are not used for 2nd-stage SCI in the first step;

- the resource elements are not in the symbols used for transmission of the associated SL PRS according to clause 8.2.4.1.1 of [6, TS 38.214];

- the corresponding resource elements in the corresponding physical resource blocks are not used for transmission of the associated DM-RS, PT-RS, CSI-RS, or PSCCH.

The resource elements used for the PSSCH in the first OFDM symbol in the mapping operation above, including any DM-RS, PT-RS, or CSI-RS occurring in the first OFDM symbol, shall be duplicated in the OFDM symbol immediately preceding the first OFDM symbol in the mapping.

#### 8.3.1.6 Mapping from virtual to physical resource blocks

Virtual resource blocks shall be mapped to physical resource blocks according to non-interleaved mapping.

For non-interleaved VRB-to-PRB mapping, virtual resource block is mapped to physical resource block .

### 8.3.2 Physical sidelink control channel

#### 8.3.2.1 Scrambling

The block of bits , where is the number of bits transmitted on the physical channel, shall be scrambled prior to modulation, resulting in a block of scrambled bits according to

where the scrambling sequence is given by clause 5.2.1. The scrambling sequence generator shall be initialized with

#### 8.3.2.2 Modulation

The block of scrambled bits shall be modulated as described in clause 5.1 using QPSK, resulting in a block of complex-valued modulation symbols where .

#### 8.3.2.3 Mapping to physical resources

The set of complex-valued modulation symbols shall be multiplied with the amplitude scaling factor in order to conform to the transmit power specified in [5, TS 38.213] and mapped in sequence starting with to resource elements assigned for transmission according to clause 16.4 of [5, TS 38.213], and not used for the demodulation reference signals associated with PSCCH, in increasing order of first the index over the assigned physical resources, and then the index on antenna port.

The resource elements used for the PSCCH in the first OFDM symbol in the mapping operation above, including any DM-RS, PT-RS, or CSI-RS occurring in the first OFDM symbol, shall be duplicated in the immediately preceding OFDM symbol.

### 8.3.3 Physical sidelink broadcast channel

#### 8.3.3.1 Scrambling

The block of bits, where is the number of bits transmitted on the physical sidelink broadcast channel, shall be scrambled prior to modulation, resulting in a block of scrambled bits according to

where the scrambling sequence is given by clause 5.2.1. The scrambling sequence generator shall be initialized with at the start of each S-SS/PSBCH block.

#### 8.3.3.2 Modulation

The block of bits shall be QPSK modulated as described in clause 5.1.3, resulting in a block of complex-valued modulation symbols where .

#### 8.3.3.3 Mapping to physical resources

Mapping to physical resources is described in clause 8.4.3.

### 8.3.4 Physical sidelink feedback channel

#### 8.3.4.1 General

#### 8.3.4.2 PSFCH format 0

##### 8.3.4.2.1 Sequence generation

The sequence shall be generated according to

where is given by clause 6.3.2.2 with the following exceptions:

- is given by clause 16.3 of [5, TS 38.213];

- is given by clause 16.3 of [5, TS 38.213];

- is given by

- if the higher-layer parameter *transmissionStructureForPSFCH* is configured and set to ‘*dedicated interlace’* and where is the resource block number within the interlace;

- otherwise

- ;

- is the index of the OFDM symbol in the slot that corresponds to the second OFDM symbol of the PSFCH transmission in the slot given by [5, TS 38.213];

- and with given by the higher-layer parameter *sl-PSFCH-HopID* if configured; otherwise, .

- with given by the higher-layer parameter *sl-PSFCH-HopID* if configured; otherwise, .

##### 8.3.4.2.2 Mapping to physical resources

The sequence shall be multiplied with the amplitude scaling factor in order to conform to the transmit power specified in [5, TS 38.213] and mapped in sequence starting with to resource elements assigned for transmission of the second PSFCH symbol according to clause 16.3 of [5, TS 38.213] in increasing order of the index over the assigned physical resources on antenna port.

The resource elements used for the PSFCH in the OFDM symbol in the mapping operation above shall be duplicated in the immediately preceding OFDM symbol.

## 8.4 Physical signals

### 8.4.1 Reference signals

#### 8.4.1.1 Demodulation reference signals for PSSCH

##### 8.4.1.1.1 Sequence generation

The sequence shall be generated according to

where the pseudo-random sequence is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialized with

where is the OFDM symbol number within the slot, is the slot number within a frame, and where the quantity equals the decimal representation of CRC on the PSCCH associated with the PSSCH according to with and given by clause 7.3.2 in [4, TS 38.212].

##### 8.4.1.1.2 Mapping to physical resources

The sequence shall be mapped to the intermediate quantity according to clause 6.4.1.1.3 using configuration type 1 without transform precoding, and where , , and are given by Table 8.4.1.1.2-2, and is specified in clause 8.4.1.1.1.

The patterns used for the PSSCH DM-RS is indicated in the SCI as described in clause 8.3.1.1 of [4, TS 38.212].

The intermediate quantity shall be precoded, multiplied with the amplitude scaling factor specified in clause 8.3.1.5, and mapped to physical resources according to

where

- the precoding matrix is given by clause 8.3.1.4,

- the set of antenna ports is given by clause 8.3.1.4, and

- the set of antenna ports is given by [6, TS 38.214];

and the following conditions are fulfilled:

- the resource elements are within the common resource blocks allocated for PSSCH transmission.

The quantity is defined relative to subcarrier 0 in common resource block 0 and the quantity is defined relative to the start of the scheduled resources for transmission of PSSCH and the associated PSCCH, including the OFDM symbol duplicated as described in clauses 8.3.1.5 and 8.3.2.3.

The position(s) of the DM-RS symbols is given by according to Table 8.4.1.1.2-1 where the number of PSSCH DM-RS is indicated in the SCI, and is the duration of the scheduled resources for transmission of PSSCH according to clause 8.1.2.1 of [6, TS 38.214] and the associated PSCCH, including the OFDM symbol duplicated as described in clauses 8.3.1.5 and 8.3.2.3.

Table 8.4.1.1.2-1: PSSCH DM-RS time-domain location.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| in symbols | DM-RS position | | | | | |
| PSCCH duration 2 symbols | | | PSCCH duration 3 symbols | | |
| Number of PSSCH DM-RS | | | Number of PSSCH DM-RS | | |
| 2 | 3 | 4 | 2 | 3 | 4 |
| 6 | 1, 5 |  |  | 1, 5 |  |  |
| 7 | 1, 5 |  |  | 1, 5 |  |  |
| 8 | 1, 5 |  |  | 1, 5 |  |  |
| 9 | 3, 8 | 1, 4, 7 |  | 4, 8 | 1, 4, 7 |  |
| 10 | 3, 8 | 1, 4, 7 |  | 4, 8 | 1, 4, 7 |  |
| 11 | 3, 10 | 1, 5, 9 | 1, 4, 7, 10 | 4, 10 | 1, 5, 9 | 1, 4, 7, 10 |
| 12 | 3, 10 | 1, 5, 9 | 1, 4, 7, 10 | 4, 10 | 1, 5, 9 | 1, 4, 7, 10 |
| 13 | 3, 10 | 1, 6, 11 | 1, 4, 7, 10 | 4, 10 | 1, 6, 11 | 1, 4, 7, 10 |

Table 8.4.1.1.2-2: Parameters for PSSCH DM-RS.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | CDM group |  |  | |  |
|  |  |  |  |  |  |
| 1000 | 0 | 0 | +1 | +1 | +1 |
| 1001 | 0 | 0 | +1 | -1 | +1 |

#### 8.4.1.2 Phase-tracking reference signals for PSSCH

##### 8.4.1.2.1 Sequence generation

The precoded sidelink phase-tracking reference signal for subcarrier on layer is given by

where

- antenna ports or associated with PT-RS transmission are given by clause 8.2.3 of [6, TS 38.214];

- is given by clause 8.4.1.1.1 at the position of the first PSSCH symbol carrying an associated DM-RS.

##### 8.4.1.2.2 Mapping to physical resources

The UE shall transmit phase-tracking reference signals only in the resource blocks used for the PSSCH, and only if the procedure in [6, TS 38.214] indicates that phase-tracking reference signals are being used.

The PSSCH PT-RS shall be mapped to resource elements according to

when all the following conditions are fulfilled

- is within the OFDM symbols allocated for the PSSCH transmission;

- resource element is not used for PSCCH, nor DM-RS associated with PSSCH;

- and correspond to

The precoding matrix is given by clause 8.3.1.4*.*

The set of time indices  defined relative to the start of the PSSCH allocation is defined by

1. set and

2. if any symbol in the interval overlaps with a symbol used for DM-RS according to clause 8.4.1.1.2

- set

- set to the symbol index of the DM-RS symbol

- repeat from step 2 as long as is inside the PSSCH allocation

3. add to the set of time indices for PT-RS

4. increment by one

5. repeat from step 2 above as long as is inside the PSSCH allocation

where is given by clause 8.4.3 of [6, TS 38.214].

For the purpose of PT-RS mapping, the resource blocks allocated for PSSCH transmission are numbered from 0 to from the lowest scheduled resource block to the highest. The corresponding subcarriers in this set of resource blocks are numbered in increasing order starting from the lowest frequency from 0 to . The subcarriers to which the PT-RS shall be mapped are given by

where

-

- is given by Table 8.4.1.2.2-1 for the DM-RS port associated with the PT-RS port according to clause 8.2.3 in [6, TS 38.214].

- is the number of resource blocks scheduled;

- is given by [6, TS 38.214];

- where the quantity equals the decimal representation of CRC on the PSCCH associated with the PSSCH according to with and given by clause 7.3.2 in [4, TS 38.212].

PSSCH PT-RS shall not be mapped to resource elements containing PSCCH or PSCCH DMRS by puncturing PSSCH PT-RS.

A UE is not expected to receive sidelink CSI-RS and PSSCH PT-RS on the same resource elements.

Table 8.4.1.2.2-1: The parameter .

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| DM-RS antenna port |  | | | |
|  | *resourceElementOffset* | | | |
|  | offset00 | offset01 | offset10 | offset11 |
| 0 | 0 | 2 | 6 | 8 |
| 1 | 2 | 4 | 8 | 10 |

#### 8.4.1.3 Demodulation reference signals for PSCCH

##### 8.4.1.3.1 Sequence generation

The sequence shall be generated according to

where the pseudo-random sequence is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialized with

where

- is the OFDM symbol number within the slot,

- is the slot number within a frame, and

- is given by the higher-layer parameter *sl-DMRS-ScrambleID*.

##### 8.4.1.3.2 Mapping to physical resources

The sequence shall be multiplied with the amplitude scaling factor in order to conform to the transmit power specified in [5, 38.213] and mapped in sequence starting with to resource elements in a slot on antenna port according to

where the following conditions are fulfilled

- they are within the resource elements constituting the PSCCH

The quantity is given by Table 8.4.1.3.2-1 and shall be randomly selected by the UE.

The reference point for is subcarrier 0 in common resource block 0.

The quantity is the OFDM symbol number within the slot.

Table 8.4.1.3.2-1: The quantity .

|  |  |  |  |
| --- | --- | --- | --- |
|  |  | | |
|  |  |  |
| 0 | 1 | 1 | 1 |
| 1 | 1 |  |  |
| 2 | 1 |  |  |

#### 8.4.1.4 Demodulation reference signals for PSBCH

##### 8.4.1.4.1 Sequence generation

The reference-signal sequence for an S-SS/PSBCH block is defined by

where is given by clause 5.2. The scrambling sequence generator shall be initialized at the start of each S-SS/PSBCH block occasion with

##### 8.4.1.4.2 Mapping to physical resources

Mapping to physical resources is described in clause 8.4.3.

#### 8.4.1.5 CSI reference signals

##### 8.4.1.5.1 General

##### 8.4.1.5.2 Sequence generation

The sequence shall be generated according to

where the pseudo-random sequence is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialised with

at the start of each OFDM symbol where is the slot number within a radio frame, is the OFDM symbol number within a slot, and where the quantity equals the decimal representation of CRC for the sidelink control information mapped to the PSCCH associated with the CSI-RS according to with and given by clause 7.3.2 in [4, TS 38.212].

##### 8.4.1.5.3 Mapping to physical resources

Mapping to resource elements shall be done according to clause 7.4.1.5.3 with the following exceptions:

- only 1 and 2 antenna ports are supported, ;

- only density is supported;

- zero-power CSI-RS is not supported;

- the quantity is an amplitude scaling factor to conform with the transmit power specified in clause 8.2.1 of [6, TS 38.214].

#### 8.4.1.6 Positioning reference signals

##### 8.4.1.6.1 General

A SL PRS resource refers to a time-frequency resource within a slot, used for SL PRS transmission.

##### 8.4.1.6.2 Sequence generation

The sequence is defined by

where the pseudo-random sequence is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialised with

where

- is the slot number within the radio frame

- is the OFDM symbol number within the slot to which the sequence is mapped

- is the sidelink PRS sequence ID, which, if not provided by higher layers, is obtained from the decimal representation of the CRC for the sidelink control information mapped to the PSCCH associated with the SL PRS according to with and given by clause 7.3.2 in [4, TS 38.212].

##### 8.4.1.6.3 Mapping to physical resources

The sequence shall be multiplied with the amplitude scaling factor in order to conform to the transmit power specified in [5, TS 38.213] and mapped to resources elements according to

when the following conditions are fulfilled:

- the resource element is within the common resource blocks occupied by the SL PRS resource

and where

- the comb size is provided by the higher layers

- the resource-element offset

- the frequency offset is given by Table 8.4.1.6.3-1

- the starting symbol is provided by higher layers for a dedicated SL PRS resource pool, or is determined such that the symbols {} are mapped to the last consecutive symbols in the slot that can be used for SL PRS for a shared SL PRS resource pool as described in clause 8.2.4.1.1 in [6, TS38.214]

- the number of symbols is provided by higher layers and limited to combinations fulfilling

- in a dedicated SL PRS resource pool: {1, 2}, {2, 2}, {2, 4}, {4, 4}, {6, 6}, and combinations with and where

- in a shared SL PRS resource pool:{1, 1}, {1, 2}, {2, 1}, {2, 2}, {2, 4}, {4, 1}, {4, 2}, {4, 4}

- the antenna port

The reference point for is subcarrier 0 in common resource block 0.

For transmission of an SL PRS in a dedicated SL PRS resource pool, the content of the OFDM symbol immediately preceding the SL PRS resource shall be generated and mapped to resource elements with

- the time-domain index

- the set of frequency-domain indices shall be identical to those of the last OFDM symbol in the SL PRS resource

Table 8.4.1.6.3-1: The frequency offset as a function of .

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Symbol number within the sidelink PRS resource** | | | | | | | | |
| **0** | **1** | **2** | **3** | **4** | **5** | **6** | **7** | **8** |
| 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 2 | 0 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 0 |
| 4 | 0 | 2 | 1 | 3 | 0 | 2 | 1 | 3 | 0 |
| 6 | 0 | 3 | 1 | 4 | 2 | 5 | 0 | 3 | 1 |

### 8.4.2 Synchronization signals

#### 8.4.2.1 Physical-layer sidelink synchronization identities

There are 672 unique physical-layer sidelink synchronization identities given by

where and . The sidelink synchronization identities are divided into two sets, id\_net consisting of and id\_oon consisting of .

#### 8.4.2.2 Sidelink primary synchronization signal

##### 8.4.2.2.1 Sequence generation

The sequence for the sidelink primary synchronization signal is defined by

where

and

##### 8.4.2.2.2 Mapping to physical resources

Mapping to physical resources is described in clause 8.4.3.

#### 8.4.2.3 Sidelink secondary synchronization signal

##### 8.4.2.3.1 Sequence generation

The sequence for the sidelink secondary synchronization signal is defined by

where

and

##### 8.4.2.3.2 Mapping to physical resources

Mapping to physical resources is described in clause 8.4.3.

### 8.4.3 S-SS/PSBCH block

#### 8.4.3.1 Time-frequency structure of an S-SS/PSBCH block

In the time domain, an S-SS/PSBCH block consists of OFDM symbols, numbered in increasing order from 0 to within the S-SS/PSBCH block, where S-PSS, S-SSS, and PSBCH with associated DM-RS are mapped to symbols as given by Table 8.4.3.1-1. The number of OFDM symbols in an S-SS/PSBCH block for normal cyclic prefix and for extended cyclic prefix. The first OFDM symbol in an S-SS/PSBCH block is the first OFDM symbol in the slot.

In the frequency domain, an S-SS/PSBCH block consists of 132 contiguous subcarriers with the subcarriers numbered in increasing order from 0 to 131 within the sidelink S-SS/PSBCH block. The quantities and represent the frequency and time indices, respectively, within one sidelink S-SS/PSBCH block.

For an S-SS/PSBCH block, the UE shall use

- antenna port 4000 for transmission of S-PSS, S-SSS, PSBCH and DM-RS for PSBCH;

- the same cyclic prefix length and subcarrier spacing for the S-PSS, S-SSS, PSBCH and DM-RS for PSBCH,

Table 8.4.3.1-1: Resources within an S-SS/PSBCH block for S-PSS, S-SSS, PSBCH, and DM-RS.

|  |  |  |
| --- | --- | --- |
| Channel or signal | OFDM symbol number  relative to the start of an S-SS/PSBCH block | Subcarrier number  relative to the start of an S-SS/PSBCH block |
| S-PSS | 1, 2 | 2, 3, …, 127, 128 |
| S-SSS | 3, 4 | 2, 3, …, 127, 128 |
| Set to zero | 1, 2, 3, 4 | 0, 1, 129, 130, 131 |
| PSBCH | 0, 5, 6, …, | 0, 1,…, 131 |
| DM-RS for PSBCH | 0, 5, 6, …, | 0, 4, 8, …., 128 |

##### 8.4.3.1.1 Mapping of S-PSS within an S-SS/PSBCH block

The sequence of symbols constituting the sidelink primary synchronization signal in one OFDM symbol shall be scaled by a factor to conform to the S-PSS power allocation specified in [5, TS 38.213] and mapped to resource elements in increasing order of in each of the symbols , where and are given by Table 8.4.3.1-1 and represent the frequency and time indices, respectively, within one S-SS/PSBCH block.

##### 8.4.3.1.2 Mapping of S-SSS within an S-SS/PSBCH block

The sequence of symbols constituting the sidelink secondary synchronization signal in one OFDM symbol shall be scaled by a factor to conform to the S-SSS power allocation specified in [5, TS 38.213] and mapped to resource elements in increasing order of in each of the symbols , where and are given by Table 8.4.3.1-1 and represent the frequency and time indices, respectively, within one S-SS/PSBCH block.

##### 8.4.3.1.3 Mapping of PSBCH and DM-RS within an S-SS/PSBCH block

The sequence of complex-valued symbols constituting the physical sidelink broadcast channel shall be scaled by a factor to conform to the PSBCH power allocation specified in [5, TS 38.213] and mapped in sequence starting with to resource elements which meet all the following criteria:

- they are not used for PSBCH demodulation reference signals

The mapping to resource elements not reserved for PSBCH DM-RS shall be in increasing order of first the index and then the index, where and represent the frequency and time indices, respectively, within one S-SS/PSBCH block and are given by Table 8.4.3.1-1.

The sequence of complex-valued symbols constituting the demodulation reference signals for the S-SS/PSBCH block shall be scaled by a factor of to conform to the PSBCH power allocation specified in [5, TS 38.213] and mapped to resource elements in increasing order of first and then where and are given by Table 8.4.3.1-1 and represent the frequency and time indices, respectively, within one S-SS/PSBCH block.

#### 8.4.3.2 Time location of an S-SS/PSBCH block

The locations in the time domain where a UE shall monitor for a possible S-SS/PSBCH block are described in clause 16.1 of [5, TS 38.213].

## 8.5 Timing

Transmission of a sidelink radio frame number from the UE shall start seconds before the start of the corresponding timing reference frame at the UE. The UE is not required to receive sidelink or downlink transmissions earlier than the value of , which is given in [12, TS 38.133], after the end of a sidelink transmission.

For sidelink transmissions:

If the UE has a serving cell fulfilling the S criterion according to clause 8.2 of [13, TS 38.304]

- The timing of reference radio frame equals that of downlink radio frame in the cell with the same uplink carrier frequency as the sidelink and

- is given by clause 4.3.1 of [TS 38.211],

Otherwise

- The timing of reference radio frame *i* and value are given by clause 12.2.2, 12.2.3, 12.2.4 or 12.2.5 of [12, TS 38.133].



Figure 8.5-1: Sidelink timing relation

The quantity equals to 0.

Annex A:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2017-04 | RAN1#89 | R1-1708219 |  |  |  | Draft skeleton | 0.0.0 |
| 2017-05 | AH\_1706 | R1-1711366 |  |  |  | Inclusion of agreements up to and including RAN1#89 | 0.0.1 |
| 2017-06 | AH\_1706 | R1-1711886 |  |  |  | Updated editor's version | 0.0.2 |
| 2017-06 | AH\_1706 | R1-1712004 |  |  |  | Clean version further to RAN1's endorsement | 0.1.0 |
| 2017-07 | AH\_1706 | R1-1712011 |  |  |  | Inclusion of agreements up to and including RAN1 NR AdHoc #2 | 0.1.1 |
| 2017-08 | AH\_1706 | R1-1712950 |  |  |  | Updated editor's version | 0.1.2 |
| 2017-08 | RAN1#90 | R1-1713296 |  |  |  | Updated editor's version | 0.1.3 |
| 2017-08 | RAN1#90 | R1-1714656 |  |  |  | Endorsed by RAN1#90 | 0.2.0 |
| 2017-08 | RAN1#90 | R1-1715321 |  |  |  | Inclusion of agreements from RAN1#90 | 0.2.1 |
| 2017-09 | RAN1#90 | R1-1715329 |  |  |  | Updated editor's version | 0.2.2 |
| 2017-09 | RAN#77 | RP-171994 |  |  |  | For information to plenary | 1.0.0 |
| 2017-09 | AH\_1709 | R1-1716927 |  |  |  | Inclusion of agreements from AdHoc#3 | 1.0.1 |
| 2017-09 | AH\_1709 | R1-1718318 |  |  |  | Updated editor's version | 1.0.2 |
| 2017-10 | RAN1#90b | R1-1719105 |  |  |  | Endorsed by RAN1#90bis | 1.1.0 |
| 2017-10 | RAN1#90b | R1-1719224 |  |  |  | Inclusion of agreements from RAN1#90bis | 1.1.1 |
| 2017-11 | RAN1#90b | R1-1719685 |  |  |  | Updated editor's version | 1.1.2 |
| 2017-11 | RAN1#90b | R1-1720850 |  |  |  | Updated editor's version | 1.1.3 |
| 2017-11 | RAN1#90b | R1-1721048 |  |  |  | Endorsed by RAN1#90bis | 1.2.0 |
| 2017-12 | RAN1#91 | R1-17xxxxx |  |  |  | Inclusion of agreements from RAN1#91 | 1.2.1 |
| 2017-12 | RAN1#91 | R1-1721341 |  |  |  | Endorsed by RAN1#91 | 1.3.0 |
| 2017-12 | RAN#78 | RP-172284 |  |  |  | For approval by plenary | 2.0.0 |
| 2017-12 | RAN#78 |  |  |  |  | Approved by plenary – Rel-15 spec under change control | 15.0.0 |
| 2018-03 | RAN#79 | RP-180200 | 0001 | - | F | CR capturing the Jan18 ad-hoc and RAN1#92 meeting agreements | 15.1.0 |
| 2018-06 | RAN#80 | RP-181172 | 0002 | 1 | F | CR to 38.211 capturing the RAN1#92bis and RAN1#93 meeting agreements | 15.2.0 |
| 2018-09 | RAN#81 | RP-181789 | 0003 | - | F | Corrections according to agreements from RAN1#94 | 15.3.0 |
| 2018-12 | RAN#82 | RP-182523 | 0004 | 1 | F | Combined CR of all essential corrections to 38.211 from RAN1#94bis and RAN1#95 | 15.4.0 |
| 2019-03 | RAN#83 | RP-190447 | 0005 | - | F | CR for PUCCH Format 1 | 15.5.0 |
| 2019-03 | RAN#83 | RP-190447 | 0006 | - | F | CR on PDSCH mapping to virtual resource blocks | 15.5.0 |
| 2019-03 | RAN#83 | RP-190447 | 0007 | 2 | F | Alignment of terminology across specifications | 15.5.0 |
| 2019-03 | RAN#83 | RP-190447 | 0008 | - | F | Correction on physical resource mapping for PUSCH with configured grant | 15.5.0 |
| 2019-03 | RAN#83 | RP-190773 | 0009 | 1 | F | Correction to frequency-domain starting position for SRS resource mapping | 15.5.0 |
| 2019-06 | RAN#84 | RP-191281 | 0010 | - | F | CR on PUCCH format 1 | 15.6.0 |
| 2019-06 | RAN#84 | RP-191281 | 0011 | - | F | Correction on reference name of UE capability of additional DMRS for co-existence with LTE CRS | 15.6.0 |
| 2019-06 | RAN#84 | RP-191281 | 0012 | - | F | Correction on mapping from virtual to physical resource blocks | 15.6.0 |
| 2019-06 | RAN#84 | RP-191281 | 0014 | 2 | F | Corrections to 38.211 including alignment of terminology across specifications | 15.6.0 |
| 2019-06 | RAN#84 | RP-191281 | 0015 | - | F | Clarification regarding non-full-duplex UE communication | 15.6.0 |
| 2019-06 | RAN#84 | RP-191281 | 0016 | - | F | Corrections on PUSCH scheduled by RAR UL grant and Msg3 PUSCH retransmission | 15.6.0 |
| 2019-09 | RAN#85 | RP-191940 | 0017 | - | F | Correction on PUSCH scrambling | 15.7.0 |
| 2019-09 | RAN#85 | RP-191940 | 0018 | - | F | Correction on PDSCH resource allocation scheduled by PDCCH in Type 0 common search space | 15.7.0 |
| 2019-09 | RAN#85 | RP-191940 | 0019 | - | F | Corrections to 38.211 including alignment of terminology across specifications in RAN1#98 | 15.7.0 |
| 2019-12 | RAN#86 | RP-192624 | 0022 | - | F | Corrections to 38.211 including alignment of terminology across specifications in RAN1#98bis and RAN1#99 | 15.8.0 |
| 2019-12 | RAN#86 | RP-192634 | 0020 | 1 | B | Introduction of remote interference management | 16.0.0 |
| 2019-12 | RAN#86 | RP-192635 | 0023 | - | B | Introduction of two-step RACH | 16.0.0 |
| 2019-12 | RAN#86 | RP-192636 | 0024 | - | B | Introduction of NR-based access to unlicensed spectrum | 16.0.0 |
| 2019-12 | RAN#86 | RP-192637 | 0025 | - | B | Introduction of integrated access and backhaul for NR | 16.0.0 |
| 2019-12 | RAN#86 | RP-192638 | 0026 | - | B | Introduction of V2X | 16.0.0 |
| 2019-12 | RAN#86 | RP-192639 | 0027 | - | B | Introduction of eURLLC support | 16.0.0 |
| 2019-12 | RAN#86 | RP-192641 | 0028 | - | B | Introduction of MIMO enhancements | 16.0.0 |
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| 2019-12 | RAN#86 | RP-192646 | 0030 | - | B | Introduction of enhanced support for dynamic spectrum sharing | 16.0.0 |
| 2019-12 | RAN#86 | RP-192646 | 0031 | - | B | Introduction of additional RACH configurations for TDD FR1 | 16.0.0 |
| 2019-12 | RAN#86 | RP-192645 | 0032 | - | B | Introduction of cross-carrier scheduling with different numerologies | 16.0.0 |
| 2020-03 | RAN#87-e | RP-200186 | 0033 | - | F | Corrections to integrated access and backhaul for NR | 16.1.0 |
| 2020-03 | RAN#87-e | RP-200192 | 0034 | - | F | Corrections to NR positioning support | 16.1.0 |
| 2020-03 | RAN#87-e | RP-200184 | 0035 | - | F | Corrections to two-step RACH | 16.1.0 |
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| 2020-03 | RAN#87-e | RP-200185 | 0037 | - | F | Corrections to NR-based access to unlicensed spectrum | 16.1.0 |
| 2020-03 | RAN#87-e | RP-200187 | 0038 | - | F | Corrections to V2X | 16.1.0 |
| 2020-03 | RAN#87-e | RP-200190 | 0039 | - | F | Corrections to MIMO enhancements | 16.1.0 |
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