

# ETSI TS 138 214 V16.4.0 (2021-01)



**5G;  
NR;  
Physical layer procedures for data  
(3GPP TS 38.214 version 16.4.0 Release 16)**

<https://standards.iteh.ai/catalog/standards/sist/667ec231-67b0-432b-9d00-7c743efe1984/etsi-ts-138-214-v16-4-0-2021-01>



---

ReferenceRTS/TSGR-0138214vg40

---

---

Keywords5G

---

**ETSI**

650 Route des Lucioles  
F-06921 Sophia Antipolis Cedex - FRANCE

---

Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16

Siret N° 348 623 562 00017 - NAF 742 C  
Association à but non lucratif enregistrée à la  
Sous-Préfecture de Grasse (06) N° 7803/88

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

**Important notice**

<https://standards.iteh.ai/catalog/standards/sist/667ec231-67b0-432b-9d00-7c7a56198468/etsi-ts-138-214-v16-4-0-2021-01>  
The present document can be downloaded from:  
<http://www.etsi.org/standards-search>

The present document may be made available in electronic versions and/or in print. The content of any electronic and/or print versions of the present document shall not be modified without the prior written authorization of ETSI. In case of any existing or perceived difference in contents between such versions and/or in print, the prevailing version of an ETSI deliverable is the one made publicly available in PDF format at [www.etsi.org/deliver](http://www.etsi.org/deliver).

Users of the present document should be aware that the document may be subject to revision or change of status. Information on the current status of this and other ETSI documents is available at <https://portal.etsi.org/TB/ETSIDeliverableStatus.aspx>

If you find errors in the present document, please send your comment to one of the following services:  
<https://portal.etsi.org/People/CommitteeSupportStaff.aspx>

---

**Copyright Notification**

---

No part may be reproduced or utilized in any form or by any means, electronic or mechanical, including photocopying and microfilm except as authorized by written permission of ETSI.

The content of the PDF version shall not be modified without the written authorization of ETSI.

The copyright and the foregoing restriction extend to reproduction in all media.

© ETSI 2021.

All rights reserved.

**DECT™**, **PLUGTESTS™**, **UMTS™** and the ETSI logo are trademarks of ETSI registered for the benefit of its Members.

**3GPP™** and **LTE™** are trademarks of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners.

**oneM2M™** logo is a trademark of ETSI registered for the benefit of its Members and of the oneM2M Partners.

**GSM®** and the GSM logo are trademarks registered and owned by the GSM Association.

---

# Intellectual Property Rights

## Essential patents

IPRs essential or potentially essential to normative deliverables may have been declared to ETSI. The information pertaining to these essential IPRs, if any, is publicly available for **ETSI members and non-members**, and can be found in ETSI SR 000 314: *"Intellectual Property Rights (IPRs); Essential, or potentially Essential, IPRs notified to ETSI in respect of ETSI standards"*, which is available from the ETSI Secretariat. Latest updates are available on the ETSI Web server (<https://ipr.etsi.org/>).

Pursuant to the ETSI IPR Policy, no investigation, including IPR searches, has been carried out by ETSI. No guarantee can be given as to the existence of other IPRs not referenced in ETSI SR 000 314 (or the updates on the ETSI Web server) which are, or may be, or may become, essential to the present document.

## Trademarks

The present document may include trademarks and/or tradenames which are asserted and/or registered by their owners. ETSI claims no ownership of these except for any which are indicated as being the property of ETSI, and conveys no right to use or reproduce any trademark and/or tradename. Mention of those trademarks in the present document does not constitute an endorsement by ETSI of products, services or organizations associated with those trademarks.

---

# Legal Notice

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

The present document may refer to technical specifications or reports using their 3GPP identities. These shall be interpreted as being references to the corresponding ETSI deliverables.

The cross reference between 3GPP and ETSI identities can be found under <http://webapp.etsi.org/key/queryform.asp>.

<https://standards.iteh.ai/catalog/standards/sist/667ec231-67b0-432b-9d00-7c743cef1984/etsi-ts-138-214-v16-4-0-2021-01>

---

# Modal verbs terminology

In the present document "**shall**", "**shall not**", "**should**", "**should not**", "**may**", "**need not**", "**will**", "**will not**", "**can**" and "**cannot**" are to be interpreted as described in clause 3.2 of the [ETSI Drafting Rules](#) (Verbal forms for the expression of provisions).

"**must**" and "**must not**" are **NOT** allowed in ETSI deliverables except when used in direct citation.

# Contents

Intellectual Property Rights .....	2
Legal Notice .....	2
Modal verbs terminology.....	2
Foreword.....	6
1 Scope .....	7
2 References .....	7
3 Definitions, symbols and abbreviations .....	8
3.1 Definitions .....	8
3.2 Symbols.....	8
3.3 Abbreviations .....	8
4 Power control .....	9
4.1 Power allocation for downlink .....	9
5 Physical downlink shared channel related procedures .....	10
5.1 UE procedure for receiving the physical downlink shared channel .....	10
5.1.1 Transmission schemes .....	13
5.1.1.1 Transmission scheme 1 .....	13
5.1.2 Resource allocation.....	13
5.1.2.1 Resource allocation in time domain.....	13
5.1.2.1.1 Determination of the resource allocation table to be used for PDSCH.....	16
5.1.2.2 Resource allocation in frequency domain .....	20
5.1.2.2.1 Downlink resource allocation type 0.....	20
5.1.2.2.2 Downlink resource allocation type 1 .....	21
5.1.2.3 Physical resource block (PRB) bundling.....	22
5.1.3 Modulation order, target code rate, redundancy version and transport block size determination.....	24
5.1.3.1 Modulation order and target code rate determination .....	26
5.1.3.2 Transport block size determination .....	29
5.1.4 PDSCH resource mapping .....	32
5.1.4.1 PDSCH resource mapping with RB symbol level granularity .....	32
5.1.4.2 PDSCH resource mapping with RE level granularity .....	33
5.1.5 Antenna ports quasi co-location.....	35
5.1.6 UE procedure for receiving reference signals.....	38
5.1.6.1 CSI-RS reception procedure.....	38
5.1.6.1.1 CSI-RS for tracking.....	39
5.1.6.1.2 CSI-RS for L1-RSRP and L1-SINR computation .....	40
5.1.6.1.3 CSI-RS for mobility .....	40
5.1.6.2 DM-RS reception procedure .....	41
5.1.6.3 PT-RS reception procedure .....	43
5.1.6.4 SRS reception procedure for CLI.....	45
5.1.6.5 PRS reception procedure.....	45
5.1.7 Code block group based PDSCH transmission.....	49
5.1.7.1 UE procedure for grouping of code blocks to code block groups .....	49
5.1.7.2 UE procedure for receiving code block group based transmissions .....	49
5.2 UE procedure for reporting channel state information (CSI) .....	50
5.2.1 Channel state information framework.....	50
5.2.1.1 Reporting settings .....	50
5.2.1.2 Resource settings.....	50
5.2.1.3 (void).....	51
5.2.1.4 Reporting configurations.....	51
5.2.1.4.1 Resource Setting configuration .....	54
5.2.1.4.2 Report Quantity Configurations .....	55
5.2.1.4.3 L1-RSRP Reporting.....	57
5.2.1.4.4 L1-SINR Reporting .....	57
5.2.1.5 Triggering/activation of CSI Reports and CSI-RS .....	58

5.2.1.5.1	Aperiodic CSI Reporting/Aperiodic CSI-RS when the triggering PDCCH and the CSI-RS have the same numerology .....	58
5.2.1.5.1a	Aperiodic CSI Reporting/Aperiodic CSI-RS when the triggering PDCCH and the CSI-RS have different numerologies .....	61
5.2.1.5.2	Semi-persistent CSI/Semi-persistent CSI-RS .....	63
5.2.1.6	CSI processing criteria .....	64
5.2.2	Channel state information .....	65
5.2.2.1	Channel quality indicator (CQI) .....	65
5.2.2.1.1	(void) .....	68
5.2.2.2	Precoding matrix indicator (PMI) .....	68
5.2.2.2.1	Type I Single-Panel Codebook .....	68
5.2.2.2.2	Type I Multi-Panel Codebook .....	74
5.2.2.2.3	Type II Codebook .....	78
5.2.2.2.4	Type II Port Selection Codebook .....	85
5.2.2.2.5	Enhanced Type II Codebook .....	87
5.2.2.2.6	Enhanced Type II Port Selection Codebook .....	94
5.2.2.3	Reference signal (CSI-RS) .....	96
5.2.2.3.1	NZP CSI-RS .....	96
5.2.2.4	Channel State Information – Interference Measurement (CSI-IM) .....	97
5.2.2.5	CSI reference resource definition .....	98
5.2.3	CSI reporting using PUSCH .....	99
5.2.4	CSI reporting using PUCCH .....	102
5.2.5	Priority rules for CSI reports .....	103
5.3	UE PDSCH processing procedure time .....	104
5.3.1	Application delay of the minimum scheduling offset restriction .....	105
5.4	UE CSI computation time .....	106
5.5	UE PDSCH reception preparation time with cross carrier scheduling with different subcarrier spacings for PDCCH and PDSCH .....	107
6	Physical uplink shared channel related procedure .....	108
6.1	UE procedure for transmitting the physical uplink shared channel .....	108
6.1.1	Transmission schemes .....	109
6.1.1.1	Codebook based UL transmission .....	110
6.1.1.2	Non-Codebook based UL transmission .....	111
6.1.2	Resource allocation .....	112
6.1.2.1	Resource allocation in time domain .....	112
6.1.2.1.1	Determination of the resource allocation table to be used for PUSCH .....	116
6.1.2.2	Resource allocation in frequency domain .....	119
6.1.2.2.1	Uplink resource allocation type 0 .....	119
6.1.2.2.2	Uplink resource allocation type 1 .....	120
6.1.2.2.3	Uplink resource allocation type 2 .....	121
6.1.2.3	Resource allocation for uplink transmission with configured grant .....	122
6.1.3	UE procedure for applying transform precoding on PUSCH .....	125
6.1.4	Modulation order, redundancy version and transport block size determination .....	126
6.1.4.1	Modulation order and target code rate determination .....	127
6.1.4.2	Transport block size determination .....	131
6.1.5	Code block group based PUSCH transmission .....	132
6.1.5.1	UE procedure for grouping of code blocks to code block groups .....	132
6.1.5.2	UE procedure for transmitting code block group based transmissions .....	133
6.1.6	Uplink switching .....	133
6.1.6.1	Uplink switching for EN-DC .....	133
6.1.6.2	Uplink switching for carrier aggregation .....	134
6.1.6.3	Uplink switching for supplementary uplink .....	135
6.2	UE reference signal (RS) procedure .....	135
6.2.1	UE sounding procedure .....	135
6.2.1.1	UE SRS frequency hopping procedure .....	140
6.2.1.2	UE sounding procedure for DL CSI acquisition .....	141
6.2.1.3	UE sounding procedure between component carriers .....	142
6.2.1.4	UE sounding procedure for positioning purposes .....	143
6.2.2	UE DM-RS transmission procedure .....	143
6.2.3	UE PT-RS transmission procedure .....	145
6.2.3.1	UE PT-RS transmission procedure when transform precoding is not enabled .....	145

6.2.3.2	UE PT-RS transmission procedure when transform precoding is enabled.....	148
6.3	UE PUSCH frequency hopping procedure .....	148
6.3.1	Frequency hopping for PUSCH repetition Type A.....	148
6.3.2	Frequency hopping for PUSCH repetition Type B .....	149
6.4	UE PUSCH preparation procedure time.....	150
7	UE procedures for transmitting and receiving on a carrier with intra-cell guard bands.....	151
8	Physical sidelink shared channel related procedures.....	152
8.1	UE procedure for transmitting the physical sidelink shared channel .....	153
8.1.1	Transmission schemes .....	154
8.1.2	Resource allocation.....	154
8.1.2.1	Resource allocation in time domain .....	154
8.1.2.2	Resource allocation in frequency domain .....	155
8.1.3	Modulation order, target code rate, redundancy version and transport block size determination.....	155
8.1.3.1	Modulation order and target code rate determination .....	155
8.1.3.2	Transport block size determination .....	155
8.1.4	UE procedure for determining the subset of resources to be reported to higher layers in PSSCH resource selection in sidelink resource allocation mode 2 .....	156
8.1.5	UE procedure for determining slots and resource blocks for PSSCH transmission associated with an SCI format 1-A .....	159
8.1.6	Sidelink congestion control in sidelink resource allocation mode 2 .....	160
8.1.7	UE procedure for determining the number of logical slots for a reservation period.....	161
8.2	UE procedure for transmitting sidelink reference signals .....	161
8.2.1	CSI-RS transmission procedure.....	161
8.2.2	PSSCH DM-RS transmission procedure.....	161
8.2.3	PT-RS transmission procedure .....	162
8.3	UE procedure for receiving the physical sidelink shared channel .....	162
8.4	UE procedure for receiving reference signals .....	162
8.4.1	CSI-RS reception procedure .....	162
8.4.2	DM-RS reception procedure for RSRP computation.....	162
8.4.3	PT-RS reception procedure.....	162
8.5	UE procedure for reporting channel state information (CSI).....	163
8.5.1	Channel state information framework.....	163
8.5.1.1	Reporting configurations.....	163
8.5.1.2	Triggering of sidelink CSI reports .....	163
8.5.2	Channel state information.....	163
8.5.2.1	CSI reporting quantities .....	163
8.5.2.1.1	Channel quality indicator (CQI).....	163
8.5.2.2	Reference signal (CSI-RS).....	164
8.5.2.3	CSI reference resource definition.....	164
8.5.3	CSI reporting .....	165
8.6	UE PSSCH preparation procedure time .....	165
<b>Annex A (informative):</b>	<b>Change history .....</b>	<b>167</b>
History .....		172

---

# 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:

Version x.y.z

where:

- x the first digit:
  - 1 presented to TSG for information;
  - 2 presented to TSG for approval;
  - 3 or greater indicates TSG approved document under change control.
- y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.
- z the third digit is incremented when editorial only changes have been incorporated in the document.

**iTeh STANDARD PREVIEW**  
**(standards.iteh.ai)**

ETSI TS 138 214 V16.4.0 (2021-01)

<https://standards.iteh.ai/catalog/standards/sist/667ec231-67b0-432b-9d00-7c743efe1984/etsi-ts-138-214-v16-4-0-2021-01>

---

# 1 Scope

The present document specifies and establishes the characteristics of the physical layer procedures of data channels 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 38.211: "NR; Physical channels and modulation"
- [5] 3GPP TS 38.212: "NR; Multiplexing and channel coding"
- [6] 3GPP TS 38.213: "NR; Physical layer procedures for control"
- [7] 3GPP TS 38.215: "NR; Physical layer measurements"
- [8] 3GPP TS 38.101: "NR; User Equipment (UE) radio transmission and reception"
- [9] 3GPP TS 38.104: "NR; Base Station (BS) radio transmission and reception"
- [10] 3GPP TS 38.321: "NR; Medium Access Control (MAC) protocol specification"
- [11] 3GPP TS 38.133: "NR; Requirements for support of radio resource management"
- [12] 3GPP TS 38.331: "NR; Radio Resource Control (RRC); Protocol specification"
- [13] 3GPP TS 38.306: "NR; User Equipment (UE) radio access capabilities"
- [14] 3GPP TS 38.423: "NG-RAN; Xn Application Protocol (XnAP)"
- [15] 3GPP TS 36.211: "Evolved Universal Terrestrial Radio Access (E-UTRA); Physical channels and modulation"
- [16] 3GPP TS 37.213: "Physical layer procedures for shared spectrum channel access"
- [17] 3GPP TS 37.355: "LTE Positioning Protocol (LPP)"



## 3 Definitions, symbols and abbreviations

### 3.1 Definitions

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

### 3.2 Symbols

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

### 3.3 Abbreviations

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

BWP	Bandwidth part
CBG	Code block group
CLI	Cross Link Interference
CP	Cyclic prefix
CQI	Channel quality indicator
CPU	CSI processing unit
CRB	Common resource block
CRC	Cyclic redundancy check
CRI	CSI-RS Resource Indicator
CSI	Channel state information
CSI-RS	Channel state information reference signal
CSI-RSRP	CSI reference signal received power
CSI-RSRQ	CSI reference signal received quality
CSI-SINR	CSI signal-to-noise and interference ratio
CW	Codeword
DCI	Downlink control information
DL	Downlink
DM-RS	Dedicated demodulation reference signals
DRX	Discontinuous Reception
EPRE	Energy per resource element
IAB-MT	Integrated Access and Backhaul – Mobile Terminal
L1-RSRP	Layer 1 reference signal received power
LI	Layer Indicator
MCS	Modulation and coding scheme
PDCCH	Physical downlink control channel
PDSCH	Physical downlink shared channel
PSS	Primary Synchronisation signal
PUCCH	Physical uplink control channel
QCL	Quasi co-location
PMI	Precoding Matrix Indicator
PRB	Physical resource block
PRG	Precoding resource block group
PRS	Positioning reference signal
PT-RS	Phase-tracking reference signal
RB	Resource block
RBG	Resource block group
RI	Rank Indicator
RIV	Resource indicator value
RS	Reference signal
SCI	Sidelink control information
SLIV	Start and length indicator value

SR	Scheduling Request
SRS	Sounding reference signal
SS	Synchronisation signal
SSS	Secondary Synchronisation signal
SS-RSRP	SS reference signal received power
SS-RSRQ	SS reference signal received quality
SS-SINR	SS signal-to-noise and interference ratio
TB	Transport Block
TCI	Transmission Configuration Indicator
TDM	Time division multiplexing
UE	User equipment
UL	Uplink

## 4 Power control

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

### 4.1 Power allocation for downlink

The gNB determines the downlink transmit EPRE.

For the purpose of SS-RSRP, SS-RSRQ and SS-SINR measurements, the UE may assume downlink EPRE is constant across the bandwidth. For the purpose of SS-RSRP, SS-RSRQ and SS-SINR measurements, the UE may assume downlink EPRE is constant over SSS carried in different SS/PBCH blocks. For the purpose of SS-RSRP, SS-RSRQ and SS-SINR measurements, the UE may assume that the ratio of SSS EPRE to PBCH DM-RS EPRE is 0 dB.

For the purpose of CSI-RSRP, CSI-RSRQ and CSI-SINR measurements, the UE may assume downlink EPRE of a port of CSI-RS resource configuration is constant across the configured downlink bandwidth and constant across all configured OFDM symbols.

ETSI TS 138 214 V16.4.0 (2021-01)

The downlink SS/PBCH SSS EPRE can be derived from the SS/PBCH downlink transmit power given by the parameter *ss-PBCH-BlockPower* provided by higher layers. The downlink SSS transmit power is defined as the linear average over the power contributions (in [W]) of all resource elements that carry the SSS within the operating system bandwidth.

The downlink CSI-RS EPRE can be derived from the SS/PBCH block downlink transmit power given by the parameter *ss-PBCH-BlockPower* and CSI-RS power offset given by the parameter *powerControlOffsetSS* provided by higher layers. The downlink reference-signal transmit power is defined as the linear average over the power contributions (in [W]) of the resource elements that carry the configured CSI-RS within the operating system bandwidth.

For downlink DM-RS associated with PDSCH, the UE may assume the ratio of PDSCH EPRE to DM-RS EPRE ( $\beta_{\text{DMRS}}$  [dB]) is given by Table 4.1-1 according to the number of DM-RS CDM groups without data as described in

Clause 5.1.6.2. The DM-RS scaling factor  $\beta_{\text{PDSCH}}^{\text{DMRS}}$  specified in Clause 7.4.1.1.2 of [4, TS 38.211] is given by

$$\beta_{\text{PDSCH}}^{\text{DMRS}} = 10^{\frac{\beta_{\text{DMRS}}}{20}}.$$

**Table 4.1-1: The ratio of PDSCH EPRE to DM-RS EPRE**

Number of DM-RS CDM groups without data	DM-RS configuration type 1	DM-RS configuration type 2
1	0 dB	0 dB
2	-3 dB	-3 dB
3	-	-4.77 dB

When the UE is scheduled with one or two PT-RS ports associated with the PDSCH,

- if the UE is configured with the higher layer parameter *epr-Ratio*, the ratio of PT-RS EPRE to PDSCH EPRE per layer per RE for each PT-RS port ( $\rho_{PTRS}$ ) is given by Table 4.1-2 according to the *epr-Ratio*, the PT-RS scaling factor  $\beta_{PTRS}$  specified in clause 7.4.1.2.2 of [4, TS 38.211] is given by  $\beta_{PTRS} = 10^{\frac{\rho_{PTRS}}{20}}$ .
- otherwise, the UE shall assume *epr-Ratio* is set to state '0' in Table 4.1-2 if not configured.

**Table 4.1-2: PT-RS EPRE to PDSCH EPRE per layer per RE ( $\rho_{PTRS}$ )**

<i>epr-Ratio</i>	The number of PDSCH layers with DM-RS associated to the PT-RS port					
	1	2	3	4	5	6
0	0	3	4.77	6	7	7.78
1	0	0	0	0	0	0
2	reserved					
3	reserved					

For link recovery, as described in clause 6 of [6, TS 38.213] the ratio of the PDCCH EPRE to NZP CSI-RS EPRE is assumed as 0 dB.

## 5 Physical downlink shared channel related procedures

### 5.1 UE procedure for receiving the physical downlink shared channel

For downlink, a maximum of 16 HARQ processes per cell is supported by the UE. The number of processes the UE may assume will at most be used for the downlink is configured to the UE for each cell separately by higher layer parameter *nrofHARQ-ProcessesForPDSCH*, and when no configuration is provided the UE may assume a default number of 8 processes.

A UE shall upon detection of a PDCCH with a configured DCI format 1\_0, 1\_1 or 1\_2 decode the corresponding PDSCHs as indicated by that DCI. For any HARQ process ID(s) in a given scheduled cell, the UE is not expected to receive a PDSCH that overlaps in time with another PDSCH. The UE is not expected to receive another PDSCH for a given HARQ process until after the end of the expected transmission of HARQ-ACK for that HARQ process, where the timing is given by Clause 9.2.3 of [6]. In a given scheduled cell, the UE is not expected to receive a first PDSCH and a second PDSCH, starting later than the first PDSCH, with its corresponding HARQ-ACK assigned to be transmitted on a resource ending before the start of a different resource for the HARQ-ACK assigned to be transmitted for the first PDSCH, where the two resources are in different slots for the associated HARQ-ACK transmissions, each slot is composed of  $N_{sym}^{slot}$  symbols [4] or a number of symbols indicated by *subslotLengthForPUCCH* if provided, and the HARQ-ACK for the two PDSCHs are associated with the HARQ-ACK codebook of the same priority. In a given scheduled cell, the UE is not expected to receive a first PDSCH, and a second PDSCH, starting later than the first PDSCH, with its corresponding HARQ-ACK assigned to be transmitted on a resource ending before the start of a different resource for the HARQ-ACK assigned to be transmitted for the first PDSCH if the HARQ-ACK for the two PDSCHs are associated with HARQ-ACK codebooks of different priorities. For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start receiving a first PDSCH starting in symbol  $j$  by a PDCCH ending in symbol  $i$ , the UE is not expected to be scheduled to receive a PDSCH starting earlier than the end of the first PDSCH with a PDCCH that ends later than symbol  $i$ . In a given scheduled cell, for any PDSCH corresponding to SI-RNTI, the UE is not expected to decode a re-transmission of an earlier PDSCH with a starting symbol less than  $N$  symbols after the last symbol of that PDSCH, where the value of  $N$  depends on the PDSCH subcarrier spacing configuration  $\mu$ , with  $N=13$  for  $\mu=0$ ,  $N=13$  for  $\mu=1$ ,  $N=20$  for  $\mu=2$ , and  $N=24$  for  $\mu=3$ .

When receiving PDSCH scheduled with SI-RNTI or P-RNTI, the UE may assume that the DM-RS port of PDSCH is quasi co-located with the associated SS/PBCH block with respect to Doppler shift, Doppler spread, average delay, delay spread, spatial RX parameters when applicable.

When receiving PDSCH scheduled with RA-RNTI, or MSGB-RNTI, the UE may assume that the DM-RS port of PDSCH is quasi co-located with the SS/PBCH block or the CSI-RS resource the UE used for RACH association as

applicable, and transmission with respect to Doppler shift, Doppler spread, average delay, delay spread, spatial RX parameters when applicable. When receiving a PDSCH scheduled with RA-RNTI in response to a random access procedure triggered by a PDCCH order which triggers contention-free random access procedure for the SpCell [10, TS 38.321], the UE may assume that the DM-RS port of the received PDCCH order and the DM-RS ports of the corresponding PDSCH scheduled with RA-RNTI are quasi co-located with the same SS/PBCH block or CSI-RS with respect to Doppler shift, Doppler spread, average delay, delay spread, spatial RX parameters when applicable.

When receiving PDSCH in response to a PUSCH transmission scheduled by a RAR UL grant or corresponding PUSCH retransmission, or when receiving PDSCH in response to a PUSCH for Type-2 random access procedure, or a PUSCH scheduled by a fallback RAR UL grant or corresponding PUSCH retransmission, the UE may assume that the DM-RS port of PDSCH is quasi co-located with the SS/PBCH block the UE selected for RACH association and transmission with respect to Doppler shift, Doppler spread, average delay, delay spread, spatial RX parameters when applicable.

If the UE is not configured for PUSCH/PUCCH transmission for at least one serving cell configured with slot formats comprised of DL and UL symbols, and if the UE is not capable of simultaneous reception and transmission on serving cell  $c_1$  and serving cell  $c_2$ , the UE is not expected to receive PDSCH on serving cell  $c_1$  if the PDSCH overlaps in time with SRS transmission (including any interruption due to uplink or downlink RF retuning time [10]) on serving cell  $c_2$  not configured for PUSCH/PUCCH transmission.

The UE is not expected to decode a PDSCH in a serving cell scheduled by a PDCCH with C-RNTI, CS-RNTI or MCS-C-RNTI and one or multiple PDSCH(s) required to be received according to this Clause in the same serving cell without a corresponding PDCCH transmission if the PDSCHs partially or fully overlap in time except if the PDCCH scheduling the PDSCH ends at least 14 symbols before the earliest starting symbol of the PDSCH(s) without the corresponding PDCCH transmission, where the symbol duration is based on the smallest numerology between the scheduling PDCCH and the PDSCH, in which case the UE shall decode the PDSCH scheduled by the PDCCH.

The UE is not expected to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI if another PDSCH in the same cell scheduled with RA-RNTI or MSGB-RNTI partially or fully overlap in time.

The UE in RRC\_IDLE and RRC\_INACTIVE modes shall be able to decode two PDSCHs each scheduled with SI-RNTI, P-RNTI, RA-RNTI or TC-RNTI, with the two PDSCHs partially or fully overlapping in time in non-overlapping PRBs.

On a frequency range 1 cell, the UE shall be able to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI and, during a process of P-RNTI triggered SI acquisition, another PDSCH scheduled with SI-RNTI that partially or fully overlap in time in non-overlapping PRBs, unless the PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI requires Capability 2 processing time according to clause 5.3 in which case the UE may skip decoding of the scheduled PDSCH with C-RNTI, MCS-C-RNTI, or CS-RNTI.

On a frequency range 2 cell, the UE is not expected to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI if in the same cell, during a process of P-RNTI triggered SI acquisition, another PDSCH scheduled with SI-RNTI partially or fully overlap in time.

The UE is expected to decode a PDSCH scheduled with C-RNTI, MCS-C-RNTI, or CS-RNTI during a process of autonomous SI acquisition.

If the UE is configured by higher layers to decode a PDCCH with its CRC scrambled by a CS-RNTI, the UE shall receive PDSCH transmissions without corresponding PDCCH transmissions using the higher-layer-provided PDSCH configuration for those PDSCHs.

If a UE is configured by higher layer parameter *PDCCH-Config* that contains two different values of *coresetPoolIndex* in *ControlResourceSet*, the UE may expect to receive multiple PDCCHs scheduling fully/partially/non-overlapped PDSCHs in time and frequency domain. The UE may expect the reception of full/partially-overlapped PDSCHs in time only when PDCCHs that schedule two PDSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex*. For a *ControlResourceSet* without *coresetPoolIndex*, the UE may assume that the *ControlResourceSet* is assigned with *coresetPoolIndex* as 0. When the UE is scheduled with full/partially/non-overlapped PDSCHs in time and frequency domain, the full scheduling information for receiving a PDSCH is indicated and carried only by the corresponding PDCCH, the UE is expected to be scheduled with the same active BWP and the same SCS. When the UE is scheduled with full/partially-overlapped PDSCHs in time and frequency domain, the UE can be scheduled with at most two codewords simultaneously. When PDCCHs that schedule two PDSCHs are associated to different *ControlResourceSets* having different values of *coresetPoolIndex*, the following operations are allowed:

- For any two HARQ process IDs in a given scheduled cell, if the UE is scheduled to start receiving a first PDSCH starting in symbol  $j$  by a PDCCH associated with a value of *coresetPoolIndex* ending in symbol  $i$ , the UE can be scheduled to receive a PDSCH starting earlier than the end of the first PDSCH with a PDCCH associated with a different value of *coresetPoolIndex* that ends later than symbol  $i$ .
- In a given scheduled cell, the UE can receive a first PDSCH in slot  $i$ , with the corresponding HARQ-ACK assigned to be transmitted in slot  $j$ , and a second PDSCH associated with a value of *coresetPoolIndex* different from that of the first PDSCH starting later than the first PDSCH with its corresponding HARQ-ACK assigned to be transmitted in a slot before slot  $j$ .

If PDCCHs that schedule corresponding PDSCHs are associated to the same or different *ControlResourceSets* having the same value of *coresetPoolIndex*, the UE procedure for receiving the PDSCH upon detection of a PDCCH follows Clause 5.1.

A UE does not expect to be configured with *repetitionScheme* if the UE is configured with higher layer parameter *repetitionNumber*.

When a UE is configured by higher layer parameter *repetitionScheme* set to one of 'fdmSchemeA', 'fdmSchemeB', 'tdmSchemeA', if the UE is indicated with two TCI states in a codepoint of the DCI field '*Transmission Configuration Indication*' and DM-RS port(s) within one CDM group in the DCI field '*Antenna Port(s)*'.

- When two TCI states are indicated in a DCI and the UE is set to 'fdmSchemeA', the UE shall receive a single PDSCH transmission occasion of the TB with each TCI state associated to a non-overlapping frequency domain resource allocation as described in Clause 5.1.2.3.
- When two TCI states are indicated in a DCI and the UE is set to 'fdmSchemeB', the UE shall receive two PDSCH transmission occasions of the same TB with each TCI state associated to a PDSCH transmission occasion which has non-overlapping frequency domain resource allocation with respect to the other PDSCH transmission occasion as described in Clause 5.1.2.3.
- When two TCI states are indicated in a DCI and the UE is set to 'tdmSchemeA', the UE shall receive two PDSCH transmission occasions of the same TB with each TCI state associated to a PDSCH transmission occasion which has non-overlapping time domain resource allocation with respect to the other PDSCH transmission occasion and both PDSCH transmission occasions shall be received within a given slot as described in Clause 5.1.2.1.

When a UE is configured by the higher layer parameter *repetitionNumber* in *PDSCH-TimeDomainResourceAllocation*, the UE may expect to be indicated with one or two TCI states in a codepoint of the DCI field '*Transmission Configuration Indication*' together with the DCI field '*Time domain resource assignment*' indicating an entry which contains *repetitionNumber* in *PDSCH-TimeDomainResourceAllocation* and DM-RS port(s) within one CDM group in the DCI field '*Antenna Port(s)*'.

- When two TCI states are indicated in a DCI with '*Transmission Configuration Indication*' field, the UE may expect to receive multiple slot level PDSCH transmission occasions of the same TB with two TCI states used across multiple PDSCH transmission occasions in the *repetitionNumber* consecutive slots as defined in Clause 5.1.2.1.
- When one TCI state is indicated in a DCI with '*Transmission Configuration Indication*' field, the UE may expect to receive multiple slot level PDSCH transmission occasions of the same TB with one TCI state used across multiple PDSCH transmission occasions in the *repetitionNumber* consecutive slots as defined in Clause 5.1.2.1.

When a UE is not indicated with a DCI that DCI field '*Time domain resource assignment*' indicating an entry which contains *repetitionNumber* in *PDSCH-TimeDomainResourceAllocation*, and it is indicated with two TCI states in a codepoint of the DCI field '*Transmission Configuration Indication*' and DM-RS port(s) within two CDM groups in the DCI field '*Antenna Port(s)*', the UE may expect to receive a single PDSCH where the association between the DM-RS ports and the TCI states are as defined in Clause 5.1.6.2.

When a UE is not indicated with a DCI that DCI field '*Time domain resource assignment*' indicating an entry which contains *repetitionNumber* in *PDSCH-TimeDomainResourceAllocation*, and it is indicated with one TCI states in a codepoint of the DCI field '*Transmission Configuration Indication*', the UE procedure for receiving the PDSCH upon detection of a PDCCH follows Clause 5.1.

If more than one PDSCH on a serving cell each without a corresponding PDCCH transmission are in a slot, after resolving overlapping with symbols in the slot indicated as uplink by *tdd-UL-DL-ConfigurationCommon*, or by *tdd-UL-*



*DL-ConfigurationDedicated*, a UE receives one or more PDSCHs without corresponding PDCCH transmissions in the slot as specified below.

- Step 0: set  $j=0$ , where  $j$  is the number of selected PDSCH(s) for decoding.  $Q$  is the set of activated PDSCHs without corresponding PDCCH transmissions within the slot
- Step 1: A UE receives one PDSCH with the lowest configured *sps-ConfigIndex* within  $Q$ , set  $j=j+1$ . Designate the received PDSCH as survivor PDSCH.
- Step 2: The survivor PDSCH in step 1 and any other PDSCH(s) overlapping (even partially) with the survivor PDSCH in step 1 are excluded from  $Q$ .
- Step 3: Repeat step 1 and 2 until  $Q$  is empty or  $j$  is equal to the number of unicast PDSCHs in a slot supported by the UE

## 5.1.1 Transmission schemes

Only one transmission scheme is defined for the PDSCH, and is used for all PDSCH transmissions.

### 5.1.1.1 Transmission scheme 1

For transmission scheme 1 of the PDSCH, the UE may assume that a gNB transmission on the PDSCH would be performed with up to 8 transmission layers on antenna ports 1000-1011 as defined in Clause 7.3.1.4 of [4, TS 38.211], subject to the DM-RS reception procedures in Clause 5.1.6.2.

## 5.1.2 Resource allocation

### 5.1.2.1 Resource allocation in time domain

When the UE is scheduled to receive PDSCH by a DCI, the *Time domain resource assignment* field value  $m$  of the DCI provides a row index  $m + 1$  to an allocation table. The determination of the used resource allocation table is defined in Clause 5.1.2.1.1. The indexed row defines the slot offset  $K_0$ , the start and length indicator *SLIV*, or directly the start symbol  $S$  and the allocation length  $L$ , and the PDSCH mapping type to be assumed in the PDSCH reception.

Given the parameter values of the indexed row:

- The slot allocated for the PDSCH is  $K_s$ , where

$$K_s = \left\lfloor n \cdot \frac{2^{\mu_{\text{PDSCH}}}}{2^{\mu_{\text{PDCCH}}}} \right\rfloor + K_0 + \left\lfloor \left( \frac{N_{\text{slot,offset,PDCCH}}^{\text{CA}}}{2^{\mu_{\text{offset,PDCCH}}}} - \frac{N_{\text{slot,offset,PDSCH}}^{\text{CA}}}{2^{\mu_{\text{offset,PDSCH}}}} \right) \cdot 2^{\mu_{\text{PDSCH}}} \right\rfloor, \text{ if UE is configured with } ca-$$

*SlotOffset* for at least one of the scheduled and scheduling cell, and  $K_s = \left\lfloor n \cdot \frac{2^{\mu_{\text{PDSCH}}}}{2^{\mu_{\text{PDCCH}}}} \right\rfloor + K_0$ , otherwise, and

where  $n$  is the slot with the scheduling DCI, and  $K_0$  is based on the numerology of PDSCH, and  $\mu_{\text{PDSCH}}$  and  $\mu_{\text{PDCCH}}$  are the subcarrier spacing configurations for PDSCH and PDCCH, respectively, and

- $N_{\text{slot,offset,PDCCH}}^{\text{CA}}$  and  $\mu_{\text{offset,PDCCH}}$  are the  $N_{\text{slot,offset}}^{\text{CA}}$  and the  $\mu_{\text{offset}}$ , respectively, which are determined by higher-layer configured *ca-SlotOffset*, for the cell receiving the PDCCH respectively,  $N_{\text{slot,offset,PDSCH}}^{\text{CA}}$  and  $\mu_{\text{offset,PDSCH}}$  are the  $N_{\text{slot,offset}}^{\text{CA}}$  and the  $\mu_{\text{offset}}$ , respectively, which are determined by higher-layer configured *ca-SlotOffset* for the cell receiving the PDSCH, as defined in clause 4.5 of [4, TS 38.211].
- The reference point  $S_0$  for starting symbol  $S$  is defined as:
  - if configured with *referenceOfSLIVDCI-1-2*, and when receiving PDSCH scheduled by DCI format 1\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI with  $K_0=0$ , and PDSCH mapping Type B, the starting symbol  $S$  is relative to the starting symbol  $S_0$  of the PDCCH monitoring occasion where DCI format 1\_2 is detected;
  - otherwise, the starting symbol  $S$  is relative to the start of the slot using  $S_0=0$ .

- The number of consecutive symbols  $L$  counting from the starting symbol  $S$  allocated for the PDSCH are determined from the start and length indicator  $SLIV$ :

if  $(L-1) \leq 7$  then

$$SLIV = 14 \cdot (L-1) + S$$

else

$$SLIV = 14 \cdot (14-L+1) + (14-1-S)$$

where  $0 < L \leq 14-S$ , and

- the PDSCH mapping type is set to Type A or Type B as defined in Clause 7.4.1.1.2 of [4, TS 38.211].

The UE shall consider the  $S$  and  $L$  combinations defined in table 5.1.2.1-1 satisfying  $S_0 + S + L \leq 14$  for normal cyclic prefix and  $S_0 + S + L \leq 12$  for extended cyclic prefix as valid PDSCH allocations:

**Table 5.1.2.1-1: Valid  $S$  and  $L$  combinations**

PDSCH mapping type	Normal cyclic prefix			Extended cyclic prefix		
	$S$	$L$	$S+L$	$S$	$L$	$S+L$
Type A	{0,1,2,3} (Note 1)	{3,...,14}	{3,...,14}	{0,1,2,3} (Note 1)	{3,...,12}	{3,...,12}
Type B	{0,...,12}	{2,...,13}	{2,...,14}	{0,...,10}	{2,4,6}	{2,...,12}

Note 1:  $S = 3$  is applicable only if  $dmrs\text{-}TypeA\text{-}Position = 3$

**STANDARD PREVIEW**

When receiving PDSCH scheduled by DCI format 1\_1 or 1\_2 in PDCCH with CRC scrambled by C-RNTI, MCS-C-RNTI, or CS-RNTI with NDI=1, if the UE is configured with  $pdsch\text{-}AggregationFactor$  in  $pdsch\text{-}config$ , the same symbol allocation is applied across the  $pdsch\text{-}AggregationFactor$  consecutive slots. When receiving PDSCH scheduled by DCI format 1\_1 or 1\_2 in PDCCH with CRC scrambled by CS-RNTI with NDI=0, or PDSCH scheduled without corresponding PDCCH transmission using  $sps\text{-}Config$  and activated by DCI format 1\_1 or 1\_2, the same symbol allocation is applied across the  $pdsch\text{-}AggregationFactor$  in  $sps\text{-}Config$  if configured, or across the  $pdsch\text{-}AggregationFactor$  in  $pdsch\text{-}config$  otherwise, consecutive slots. The UE may expect that the TB is repeated within each symbol allocation among each of the  $pdsch\text{-}AggregationFactor$  consecutive slots and the PDSCH is limited to a single transmission layer. For PDSCH scheduled by DCI format 1\_1 or 1\_2 in PDCCH with CRC scrambled by CS-RNTI with NDI=0, or PDSCH scheduled without corresponding PDCCH transmission using  $sps\text{-}Config$  and activated by DCI format 1\_1 or 1\_2, the UE is not expected to be configured with the time duration for the reception of  $pdsch\text{-}AggregationFactor$  repetitions, in  $sps\text{-}Config$  if configured, or across the  $pdsch\text{-}AggregationFactor$  in  $pdsch\text{-}config$  otherwise, larger than the time duration derived by the periodicity  $P$  obtained from the corresponding  $sps\text{-}Config$ . The redundancy version to be applied on the  $n^{th}$  transmission occasion of the TB, where  $n = 0, 1, \dots, pdsch\text{-}AggregationFactor - 1$ , is determined according to table 5.1.2.1-2 and " $rv_{id}$  indicated by the DCI scheduling the PDSCH" in table 5.1.2.1-2 is assumed to be 0 for PDSCH scheduled without corresponding PDCCH transmission using  $sps\text{-}Config$  and activated by DCI format 1\_1 or 1\_2.

If a UE is configured with higher layer parameter  $repetitionNumber$  or if the UE is configured by  $repetitionScheme$  set to one of 'fdmSchemeA', 'fdmSchemeB' and 'tdmSchemeA', the UE does not expect to be configured with  $pdsch\text{-}AggregationFactor$ .

**Table 5.1.2.1-2: Applied redundancy version when  $pdsch\text{-}AggregationFactor$  is present**

$rv_{id}$ indicated by the DCI scheduling the PDSCH	$rv_{id}$ to be applied to $n^{th}$ transmission occasion			
	$n \bmod 4 = 0$	$n \bmod 4 = 1$	$n \bmod 4 = 2$	$n \bmod 4 = 3$
0	0	2	3	1
2	2	3	1	0
3	3	1	0	2
1	1	0	2	3

A PDSCH reception in a slot of a multi-slot PDSCH reception is omitted according to the conditions in Clause 11.1 of [6, TS38.213].