**3GPP TSG-WG1 Meeting #106bR1-21xxxxx**

**e-meeting, October 11 – 19, 2021**

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| *CR-Form-v12.1* | | | | | | | | |
| **DRAFT CHANGE REQUEST** | | | | | | | | |
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|  | **36.211** | **CR** | **xxxx** | **rev** | **-** | **Current version:** | **16.7.0** |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network | **X** | Core Network |  |

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| ***Title:*** | Introduction of additional enhancements for NB-IoT and LTE-MTC | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Ericsson | | | | | | | | | |
| ***Source to TSG:*** | RAN1 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NB\_IOTenh4\_LTE\_eMTC6-Core | | | | |  | ***Date:*** | | | 2021-10-01 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | **B** |  | | | | | ***Release:*** | | | Release 17 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-15 (Release 15) Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | Introduction of additional enhancements for NB-IoT and LTE-MTC | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | Updates according to RAN1 agreements for the following new features:  - 14-HARQ processes in DL, for HD-FDD Cat M1 UEs (5.4.3).  - 16-QAM for unicast in uplink and downlink (10.1.3.2, 10.2.3.2).  Editorial correction (6.4.1) | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | No support of additional enhancements for NB-IoT and LTE-MTC | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 5.4.3, 6.4.1, 10.1.3.2, 10.2.3.2 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  |  | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  |  | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  |  | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

### 5.4.3 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 Clause 5.1.2.1 in 3GPP TS 36.213 [4], and mapped in sequence starting with  to resource elements. PUCCH uses one or more resource block in each of the two slots in a subframe. Within the physical resource block(s) used for transmission, the mapping of  to resource elements  on antenna port  and not used for transmission of reference signals shall be in increasing order of first , then  and finally the slot number, starting with the first slot in the subframe. The relation between the index  and the antenna port number  is given by Table 5.2.1-1.

For non-BL/CE UEs, except for PUCCH format 4, the physical resource blocks to be used for transmission of PUCCH in slot  are given by



For BL/CE UEs, PUCCH is transmitted with  repetitions.

- The BL/CE UE is not expected to transmit with when *ce-enable14HARQ* is configured.

The PUCCH transmission spans  consecutive subframes, including subframes that are not BL/CE UL subframes where the UE postpones the PUCCH transmission if [or if the BL/CE UE is configured with *ce-HARQ-ACK-delay-type* indicating Alt-1].

- The quantity  is given

- by the higher layer parameter *pucch-NumRepetitionCE-Format1* for PUCCH format 1/1a and *pucch-NumRepetitionCE-Format2* for PUCCH format 2/2a/2b, if configured. Otherwise

- by the higher-layer parameter *pucch-NumRepetitionCE-Msg4-Level0-r13, pucch-NumRepetitionCE-Msg4-Level1-r13, pucch-NumRepetitionCE-Msg4-Level2-r13* or *pucch-NumRepetitionCE-Msg4-Level3-r13*.

- If uplink resource reservation is enabled for the UE as specified in [9], then in case of PUCCH transmission with  associated with C-RNTI or SPS C-RNTI using UE-specific MPDCCH search space including PUCCH transmission without a corresponding MPDCCH,

- In a subframe that is fully reserved as defined in clause 8.0 in [4], the PUCCH transmission is postponed until the next BL/CE uplink subframe that is not fully reserved.

- In a subframe that is partially reserved, the reserved SC-FDMA symbols shall be counted in the PUCCH mapping but not used for transmission of the PUCCH.

The physical resource blocks to be used for transmission of PUCCH in subframe  within the  consecutive subframes are given by



where  is the absolute subframe number of the first uplink subframe intended for PUCCH.

The variable  depends on the PUCCH format.

- Formats 1, 1a and 1b:



- Formats 2, 2a and 2b:



- Format 3:



- Format 5 (non-BL/CE UEs only):



For non-BL/CE UEs, for PUCCH format 4, the physical resource blocks to be used for transmission of PUCCH in slot  are given by



where  is obtained from [4].

Mapping of modulation symbols for the physical uplink control channel for PUCCH formats 1 – 3 is illustrated in Figure 5.4.3-1.

In case of simultaneous transmission of sounding reference signal and PUCCH format 1, 1a, 1b, 3, 4 or 5 when there is one serving cell configured, the shortened PUCCH format shall be used where the last SC-FDMA symbol in the second slot of a subframe shall be left empty.

In case of guard period for narrowband or wideband retuning for BL/CE UEs, if an SC-FDMA symbol is left empty due to guard period, the SC-FDMA symbol shall be counted in the PUCCH mapping but not used for transmission of the PUCCH. The SC-FDMA symbol affected by the guard period can be the first SC-FDMA symbol in the first slot of a subframe and/or the last SC-FDMA symbol in the second slot of a subframe.



Figure 5.4.3-1: Mapping to physical resource blocks for PUCCH formats 1 – 3 for non-BL/CE UEs.

### 6.4.1 Physical downlink shared channel for BL/CE UEs

For BL/CE UEs, the following additions and exceptions hold in addition to those in clause 6.4:

- The maximum number of allocatable PRBs for PDSCH is restricted as follows:

- If the PDSCH is associated with C-RNTI or SPS C-RNTI and the higher layer parameter *ce-pdsch-maxBandwidth-config* is set,

- if the higher layer parameter *ce-pdsch-maxBandwidth-config* is set to 20 MHz, the maximum number of allocatable PRBs for PDSCH is 96 PRBs restricted to the narrowbands defined in clause 6.2.7;

- if the higher layer parameter *ce-pdsch-maxBandwidth-config* is set to 5 MHz, the maximum number of allocatable PRBs for PDSCH is 24 PRBs restricted to no more than four of the narrowbands defined in clause 6.2.7.

- If the PDSCH is associated with G-RNTI and the higher layer parameter *pdsch-MaxBandwidth-SC-MTCH* is set to 24 PRBs, the maximum number of allocatable PRBs for PDSCH is 24 PRBs restricted to no more than four of the narrowbands defined in clause 6.2.7.

- For all other cases, the maximum number of allocatable PRBs for PDSCH is 6 PRBs restricted to one of the narrowbands defined in clause 6.2.7.

- Resource elements occupied by CSI reference signals shall be counted in the PDSCH mapping but not used for transmission of the PDSCH.

- Resource elements belonging to synchronization signals, the core part of PBCH, PBCH repetitions, or resource elements reserved for reference signals in the mapping operation of PBCH but not used for transmission of reference signals, shall be counted in the PDSCH mapping but not used for transmission of the PDSCH.

- PRB pairs occupied by RSS shall be counted in the PDSCH mapping but not used for transmission of the PDSCH.

- For BL/CE UEs in CEModeB configured in transmission mode 9, in MBSFN subframe(s), resource elements that correspond to the positions of cell-specific reference signals as in subframe #0 shall not be counted in the PDSCH mapping and not used for transmission of the PDSCH.

- Resource elements belonging to PRBs in which PRS is transmitted (including PRS muted subframes) shall be counted in the PDSCH mapping but not used for transmission of the PDSCH.

- If the higher layer parameter *ce-punctured-subcarriers-DL* is configured, and the DCI associated with the PDSCH uses C-RNTI or SPS C-RNTI, and transmit diversity according to clause 6.3.4.3 is used,

- In the mapping to resource elements, when the complex-valued symbols  and , where  is an even number, are mapped to resource elements  and  in the same OFDM symbol with , then if *ce-punctured-subcarriers-DL* indicates that any of  and  shall be counted but not used for transmission, the UE shall assume that both  and  are counted but not used for transmission.

- If PDSCH transmission in the LTE control region is configured by higher layer parameter *transmissionInControlChRegion*, after the initial mapping of the PDSCH to resource elements starting from in the first slot to the last OFDM symbol available for downlink transmission in the subframe has been performed, the mapping shall continue with resource elements not reserved for cell-specific reference signals in increasing order of first the index over the assigned physical resource blocks and then the index starting from in the first slot to in the first slot, where is given by clause 7.1.6.4 of 3GPP TS 36.213 [4].

For BL/CE UEs, if the PDSCH is not carrying SIB1-BR the PRB resources for PDSCH transmission in the first subframe are obtained from the DCI as described in clauses 5.3.3.1.12, 5.3.3.1.13, and 5.5.1.3.14 in [3], or provided by higher layers. Each of the PDSCH codewords is transmitted with  repetitions, where is the number of transport blocks defined in clause 7.1.11 of 3GPP TS 36.213 [4]. The PDSCH transmission spans consecutive subframes, including subframes that are not BL/CE DL subframes where the PDSCH transmission is postponed.

- If downlink resource reservation is enabled for the UE as specified in [9], and the Resource reservation field in the DCI is set to 1, then in case of PDSCH transmission associated with C-RNTI or SPS C-RNTI using UE-specific MPDCCH search space including PDSCH transmission without a corresponding MPDCCH,

- In a subframe that is fully reserved as defined in clause 7.1 in [4], the PDSCH transmission is postponed until the next BL/CE downlink subframe that is not fully reserved.

- In a subframe that is partially reserved, the reserved resource elements shall be counted in the PDSCH mapping but not used for transmission of the PDSCH.

- If frequency hopping is not enabled for PDSCH, all PDSCH repetitions are located at the same PRB resources, and

- if frequency hopping is enabled for PDSCH, the PDSCH shall be transmitted in subframe  within the  consecutive downlink subframes using the PRB resources of the narrowband  with the same RIV as that of narrowband . The narrowband  is defined as



where  is the absolute subframe number of the first downlink subframe intended for PDSCH and ,  and  are cell-specific higher-layer parameters. For PDSCH carrying SI other than SIB1-BR and for PDSCH associated with P-RNTI, if *interval-DlHoppingConfigCommonModeB* is signalled in SIB1-BR, then the frequency hopping granularity  is set to *interval-DlHoppingConfigCommonModeB*; otherwise,  is set to *interval-DlHoppingConfigCommonModeA* signalled in SIB1-BR.

For BL/CE UE in CEModeA, frequency hopping of PDSCH associated with C-RNTI or SPS C-RNTI is enabled when higher layer parameter *mpdcch-pdsch-HoppingConfig* is set and the frequency hopping flag in DCI format 6-1A indicates frequency hopping, otherwise, frequency hopping of is not enabled. For BL/CE UE in CEModeB, frequency hopping of PDSCH associated with C-RNTI or SPS C-RNTI is enabled when higher layer parameter *mpdcch-pdsch-HoppingConfig* is set, otherwise, frequency hopping of is not enabled.

The UE shall not expect PDSCH in subframe  if it is not a BL/CE DL subframe.

For BL/CE UEs, if the PDSCH carries SIB1-BR, the PDSCH transmission is repeated periodically in every period of 8 radio frames, where a period starts with a radio frame with  where ** is the system frame number. The PDSCH is transmitted  times in each period of 8 frames, Let  be the set of narrowbands, excluding narrowbands overlapping with the 72 center subcarriers for , and ordered in increasing order of narrowband index. The PDSCH transmission cycles through the set  of narrowbands in increasing order of **, starting with ** for the first subframe, according to

**

where  is the number of narrowbands in the set .

The set of frames and subframes used for SIB1-BR transmission in each period are given by Tables 6.4.1-1 and 6.4.1-2.

Table 6.4.1-1: The set of frames and subframes for SIB1-BR for .

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Frame structure type 1 | | Frame structure type 2 | |
|  |  |  |  |
| 4 | 0 | 0 | 4 | 1 | 5 |
| 1 | 1 | 4 | 1 | 5 |

Table 6.4.1-2: The set of frames and subframes for SIB1-BR for .

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Frame structure type 1 | | Frame structure type 2 | |
|  |  |  |  |
| 4 | 0 | 0 | 4 | 1 | 5 |
| 1 | 1 | 4 | 1 | 0 |
| 8 | 0 | 0, 1 | 4 | 0, 1 | 5 |
| 1 | 0, 1 | 9 | 0, 1 | 0 |
| 16 | 0 | 0, 1 | 4, 9 | 0, 1 | 0, 5 |
| 1 | 0, 1 | 0, 9 | 0, 1 | 0, 5 |

BL/CE UEs may assume the same precoding matrix being used for a PRB across a block of  consecutive subframes when UE-specific reference signals are transmitted together with the PDSCH, where the subframe number of the first subframe in each block of  consecutive subframes, denoted as , satisfies .

For PDSCH transmission associated with SI-RNTI or P-RNTI to BL/CE UEs, frequency hopping of the PDSCH is enabled when higher layer parameter *si-HoppingConfigCommon* is set.

For PDSCH transmission associated with PUR-RNTI to BL/CE UEs using UE-specific MPDCCH search space, frequency hopping of the PDSCH is enabled when higher layer parameter *pur-PDSCH-FreqHopping* is set.

For PDSCH transmission associated with RA-RNTI or temporary C-RNTI to BL/CE UEs, frequency hopping of the PDSCH is enabled when higher layer parameter *rar-HoppingConfig* is set. Further

- if PRACH CE level 0 or 1 is used for the last PRACH attempt,  is set to the higher layer parameter *interval-DlHoppingConfigCommonModeA*;

- if PRACH CE level 2 or 3 is used for the last PRACH attempt,  is set to the higher layer parameter *interval-DlHoppingConfigCommonModeB*.

For PDSCH transmission associated with SC-RNTI to BL/CE UEs, frequency hopping of the PDSCH is enabled when higher layer parameter *mpdcch-pdsch-HoppingConfig-SC-MCCH* is set. Further

- if *mpdcch-pdsch-HoppingConfig-SC-MCCH* is set to CEModeA,  is set to the higher layer parameter *interval-DlHoppingConfigCommonModeA*;

- if *mpdcch-pdsch-HoppingConfig-SC-MCCH* is set to CEModeB,  is set to the higher layer parameter *interval-DlHoppingConfigCommonModeB.*

For PDSCH transmission associated with G-RNTI to BL/CE UEs,

- if the higher layer parameter *mpdcch-pdsch-CEmodeConfig-SC-MTCH* is set to CEModeA,

- if the higher layer parameter *mpdcch-pdsch-HoppingConfig-SC-MTCH* is set and the frequency hopping flag in DCI format 6-1A indicates frequency hopping, then frequency hopping of the PDSCH is enabled and  is set to the higher layer parameter *interval-DlHoppingConfigCommonModeA*, otherwise frequency hopping is not enabled;

- if the higher layer parameter *mpdcch-pdsch-CEmodeConfig-SC-MTCH* is set to CEModeB,

- if the higher layer parameter *mpdcch-pdsch-HoppingConfig-SC-MTCH* is set, then frequency hopping of the PDSCH is enabled and  is set to the higher layer parameter *interval-DlHoppingConfigCommonModeB*, otherwise frequency hopping is not enabled*.*

10.1.3 Narrowband physical uplink shared channel

The narrowband physical uplink shared channel supports two formats:

- NPUSCH format 1, used to carry the UL-SCH

- NPUSCH format 2, used to carry uplink control information

10.1.3.1 Scrambling

Scrambling shall be done according to clause 5.3.1. The scrambling sequence generator shall be initialised with  where  is the first slot of the transmission of the codeword. In case of NPUSCH repetitions, the scrambling sequence shall be reinitialised according to the above formula after every  transmissions of the codeword with  and  set to the first slot and the frame, respectively, used for the transmission of the repetition. The quantity  is given by clause 10.1.3.6.

10.1.3.2 Modulation

Modulation shall be done according to clause 5.3.2 resulting in a block of modulated symbols . Table 10.1.3.2-1 specifies the modulation mappings applicable for the narrowband physical uplink shared channel.

The block of modulated symbols shall be multiplied with a code resulting in a block of modulation symbols according to

where

- in case a positive scheduling request according to [4] is to be transmitted using NPUSCH format 2

- otherwise

**Table 10.1.3.2-1: NPUSCH modulation schemes**

|  |  |  |
| --- | --- | --- |
| **NPUSCH format** |  | **Modulation scheme** |
| 1 | 1 | BPSK, QPSK |
| >1 | QPSK, 16QAM |
| 2 | 1 | BPSK |

10.1.3.3 Layer mapping

Layer mapping shall be done according to clause 5.3.2A with  using instead of .

10.1.3.4 Transform precoding

Transform precoding shall be done according to clause 5.3.3 with  and  replaced by .

10.1.3.5 Precoding

Precoding shall be done according to clause 5.3.3A assuming a single antenna port.

10.1.3.6 Mapping to physical resources

Each NPUSCH codeword can be mapped to one or more than one resource units, , as given by clause 16.5.1.2 of 3GPP TS 36.213 [4], each of which shall be transmitted  times.

The block of complex-valued symbols  shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [4], and mapped in sequence starting with  to subcarriers assigned for transmission of NPUSCH. The mapping to resource elements  corresponding to the subcarriers assigned for transmission and not used for transmission of reference signals, shall be in increasing order of first the index , then the index, starting with the first slot in the assigned resource unit.

After mapping to slots, the  slots shall be repeated  additional times, before continuing the mapping of  to the following slot, where





For NPUSCH Format 1 and 2 on frame structure type 2 with ,

- the NPUSCH transmission is carried out in the first set of  slots spanning over two contiguous uplink subframes not overlapping with any uplink subframe configured as invalid;

- for TDD configuration 1 and 4, if the starting position for the NPUSCH is indicated as the second of the two contiguous uplink subframes, the NPUSCH transmission is postponed until the start of two consecutive uplink subframes.

If a mapping to  slots or a repetition of the mapping contains a resource element which overlaps with

- any configured NPRACH resource according to *nprach-ParametersList* in *SystemInformationBlockType2-NB*, or

- any configured NPRACH resource according to *nprach-ParametersList* given by *ul-ConfigList* in *SystemInformationBlockType22-NB* and if the UE indicates *multiCarrier-NPRACH* as supported, or

- any configured NPRACH resource according to *nprach-ParametersList* given by *ul-ConfigListMixed* in *SystemInformationBlockType22-NB* and if the UE indicates *multiCarrier-NPRACH* and *mixedOperationMode* as supported, or

- any configured NPRACH resource according to *nprach-ParametersListFmt2* in *SystemInformationBlockType2-NB* and if the UE indicates *nprach-Format2* as supported, or

- any configured NPRACH resource according to *nprach-ParametersListFmt2* given by *ul-ConfigList* in *SystemInformationBlockType23-NB* and if the UE indicates *multiCarrier-NPRACH* and *nprach-Format2* as supported, or

- any configured NPRACH resource according to *nprach-ParametersListFmt2* given by *ul-ConfigListMixed* in *SystemInformationBlockType23-NB* and if the UE indicates*multiCarrier-NPRACH, mixedOperationMode* and *nprach-Format2* as supported, or

- any configured NPRACH resource according to *nprach-ParametersListTDD* in *SystemInformationBlockType2-NB*, or

- any configured NPRACH resource according to *nprach-ParametersListTDD* in *SystemInformationBlockType22-NB* and if the UE indicates *multiCarrier-NPRACH* as supported, or

- any configured NPRACH resource configured for Early Data Transmissionand if the NPUSCH transmission is during an Early Data Transmission procedure [12, Clause 7.3b],

then,

- for  the NPUSCH transmission in overlapped slots is postponed until the next  slots not overlapping with any configured NPRACH resource.

- for  the NPUSCH transmission in overlapped  slots is postponed until the next  slots starting with the first slot satisfying and not overlapping with any configured NPRACH resource.

NPRACH gaps as defined in clause 10.1.6.1 are not part of the NPRACH resource. For frame structure type 2, the valid uplink subframes which are not used for NPRACH transmission when it is not possible to map G symbol groups back-to-back are not part of the NPRACH resource. The mapping of  is then repeated until  slots have been transmitted. After transmissions and/or postponements due to NPRACH of  time units, for frame structure type 1, a gap of  time units shall be inserted where the NPUSCH transmission is postponed. The portion of a postponement due to NPRACH which coincides with a gap is counted as part of the gap.

When higher layer parameter *npusch-AllSymbols* is set to false, resource elements in SC-FDMA symbols overlapping with a symbol configured with SRS according to *srs-SubframeConfig* shall be counted in the NPUSCH mapping but not used for transmission of the NPUSCH. When higher layer parameter *npusch-AllSymbols* is set to true, all symbols are transmitted.

If higher layer parameter *resourceReservationConfigUL* is configured, then in case of NPUSCH format 1 transmission associated with C-RNTI or SPS C-RNTI using UE-specific NPDCCH search space with the Resource reservation field in the DCI set to 1 including NPUSCH format 1 transmission without a corresponding NPDCCH, or in case of NPUSCH format 2 transmission associated with C-RNTI using UE-specific NPDCCH search space,

- In a subframe for  or a slot for that is overlapping with any fully reserved uplink subframe as defined in clause 16.5 in [4],

- for , the NPUSCH transmission is postponed until the next NB-IoT uplink subframe that is not fully reserved.

- for , the NPUSCH transmission in the slot is postponed until the next slot spanning over two contiguous uplink subframes not overlapping with any uplink subframe that is fully reserved.

- In a subframe for  or a slot for that is not overlapping with any fully reserved uplink subframe, any SC-FDMA symbols overlapping with reserved symbols shall be counted in the NPUSCH mapping but not used for transmission of the NPUSCH.

### 10.2.3 Narrowband physical downlink shared channel

#### 10.2.3.1 Scrambling

Scrambling shall be done according to clause 6.3.1. If the NPDSCH is carrying the BCCH, the scrambling sequence generator shall be initialised with . Otherwise, the scrambling sequence generator shall be initialised with  whereis the first slot of the transmission of the codeword.

In case of NPDSCH repetitions and the NPDSCH carrying the BCCH, the scrambling sequence generator shall be reinitialized according to the expression above for each repetition.

In case of NPDSCH repetitions and the NPDSCH is not carrying the BCCH, the scrambling sequence generator shall be reinitialized according to the expression above after every transmission of the codeword withand set to the first slot and the frame, respectively, used for the transmission of the repetition.

#### 10.2.3.2 Modulation

Modulation shall be done according to clause 6.3.2 using one of the modulation schemes in Table 10.2.3-1

Table 10.2.3-1: Modulation schemes

|  |  |
| --- | --- |
| Physical channel | Modulation schemes |
| NPDSCH | QPSK, 16QAM |

#### 10.2.3.3 Layer mapping and precoding

Layer mapping and precoding shall be done according to clause 6.6.3 using the same set of antenna ports as the NPBCH.

#### 10.2.3.4 Mapping to resource elements

Each NPDSCH codeword can be mapped to one or more than one subframes, , as given by clause 16.4.1.3 of 3GPP TS 36.213 [4], each of which shall be transmitted times.

For each of the antenna ports used for transmission of the physical channel, the block of complex-valued symbols  shall be mapped to resource elements  which meet all of the following criteria in the current subframe:

- the subframe is not used for transmission of NPBCH, NPSS, or NSSS, and

- except in a special subframe when , they are assumed by the UE not to be used for NRS, and

- they are not overlapping with resource elements used for CRS as defined in clause 6 (if any), and

- the index  in the first slot in a subframe fulfils  where is given by clause 16.4.1.4 of 3GPP TS 36.213 [4], and

- in addition, for frame structure type 2

- in a special subframe, if , they are in DwPTS

- in a special subframe, if , they are not NRS locations in subframes which are not special subframes.

The mapping of  in sequence starting with  to resource elements  on antenna port  meeting the criteria above shall be in increasing order of first the index  and then the index, starting with the first slot and ending with the second slot in a subframe. For NPDSCH not carrying BCCH, after mapping to a subframe, the subframe shall be repeated for additional subframes, before continuing the mapping of  to the following subframe.

The resource elements in a special subframe that are not part of DwPTS are counted but not used in the mapping if . When , the resource elements in a special subframe assumed by the UE for NRSs are counted but not used in the mapping if .

For frame structure type 1,

- for NPDSCH associated with C-RNTI when *interferenceRandomisationConfig* is used according to [9],or

- for NPDSCH associated with RA-RNTI, TC-RNTI or P-RNTI and transmitted in an NB-IoT carrier configured by *SystemInformationBlockType22-NB*, or

- for NPDSCH associated with C-RNTI in an NB-IoT carrier configured by *SystemInformationBlockType22-NB* when *RadioResourceConfigDedicted-NB* is not configured by higher layer, or

- for NPDSCH associated with PUR-RNTI/G-RNTI/ SC-RNTI, or

for frame structure type 2,

- for NPDSCH not carrying the BCCH,

define  as the block of complex-valued symbols mapped to subframe number and radio frame number . Each complex-valued symbol  shall be multiplied with before its transmission, with



where the scrambling sequence is given by clause 7.2 and shall be initialized at the start of each subframe with .

The mapping of  is then repeated until subframes have been transmitted. For frame structure type 2, the resource elements in a special subframe that are not part of DwPTS are counted but not used in the repetition. When , the resource elements in a special subframe assumed by the UE for NRSs are counted but not used in the repetition.

For NPDSCH carrying BCCH, the is mapped to  subframes in sequence and then repeated until subframes have been transmitted, where

- for mapping NPDSCH carrying *SystemInformationBlockType1-NB* to subframe #3 for frame structure type 1;

- otherwise.

The NPDSCH transmission can be configured by higher layers with transmission gaps where the NPDSCH transmission is postponed. There are no gaps in the NPDSCH transmission if where  is given by the higher layer parameter *dl-GapThreshold* and  is given by [4]. The gap starting frame and subframe is given by  where the gap periodicity,, is given by the higher layer parameter *dl-GapPeriodicity*. The gap duration in number of subframes is given by , where  is given by the higher layer parameter *dl-GapDurationCoeff*. For NPDSCH carrying the BCCH there are no gaps in the transmission.

The UE shall not expect NPDSCH in subframe  if it is not a NB-IoT downlink subframe, except for transmissions of NPDSCH carrying *SystemInformationBlockType1-NB* in

- subframes 3 and 4 for frame structure type 1; and

- subframes 0, 4, and 5 for frame structure type 2.

In case of NPDSCH transmissions, in subframes that are not NB-IoT downlink subframes, the NPDSCH transmission is postponed until the next NB-IoT downlink subframe.

If higher layer parameter *resourceReservationConfigDL* is configured, then in case of NPDSCH transmission associated with C-RNTI using UE-specific NPDCCH search space with the Resource reservation field in the DCI set to 1,

- In a subframe that is fully reserved as defined in clause 16.4 in [4], the NPDSCH transmission is postponed until the next NB-IoT downlink subframe that is not fully reserved.

- In a subframe that is partially reserved, the reserved OFDM symbols shall be counted in the NPDSCH mapping but not used for transmission of the NPDSCH.