**3GPP TSG-RAN WG1 Meeting #102-eR1-2007308**

**e-Meeting, August 17th – 28th, 2020**

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| *CR-Form-v12.0* |
| **CHANGE REQUEST** |
|  |
|  | **36.211** | **CR** | **0545** | **rev** | **-** | **Current version:** | **16.2.0** |  |
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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:***  | Multi-TB scheduling and PUR spanning PUSCH transmission in LTE-MTC |
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| ***Source to WG:*** | Moderator (Ericsson) |
| ***Source to TSG:*** |  |
|  |  |
| ***Work item code:*** | LTE\_eMTC5-Core |  | ***Date:*** | 2020-08-26 |
|  |  |  |  |  |
| ***Category:*** | F |  | ***Release:*** | Rel-16 |
|  | *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 canbe 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-12 (Release 12)**Rel-13 (Release 13)Rel-14 (Release 14)Rel-15 (Release 15)Rel-16 (Release 16)* |
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| ***Reason for change:*** | The statement about how long time an UL sub-PRB transmission spans in LTE-MTC has not been updated to take the Rel-16 features UL multi-TB scheduling and preconfigured uplink resources (PUR) into account.This issue was discussed in RAN1 email discussion [102-e-LTE-eMTC5-04] captured as Issue #3 in [R1-2007305](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2007305.zip). |
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| ***Summary of change:*** | Take multi-TB and PUR aspects into account in the statement about the time spanned by an UL sub-PRB transmission in LTE-MTC. |
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| ***Consequences if not approved:*** | Unclear or incorrect UE behavior for UL sub-PRB transmission in LTE-MTC with the Rel-16 features for UL multi-TB scheduling and PUR |
|  |  |
| ***Clauses affected:*** | 5.3.4 |
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|  | **Y** | **N** |  |  |
| ***Other specs*** |  | **X** |  Other core specifications  |  |
| ***affected:*** |  | **X** |  Test specifications |  |
| ***(show related CRs)*** |  | **X** |  O&M Specifications |  |
|  |  |
| ***Other comments:*** |  |
|  |  |
| ***This CR's revision history:*** |  |

### 5.3.4 Mapping to physical resources

For each antenna port  used for transmission of the PUSCH in a subframe 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 5.1.1.1 in 3GPP TS 36.213 [4], and mapped in sequence starting with  to physical resource blocks on antenna port  and assigned for transmission of PUSCH. The relation between the index  and the antenna port number  is given by Table 5.2.1-1. The mapping to resource elements  corresponding to the physical resource blocks assigned for transmission shall fulfil the following criteria:

- not used for transmission of reference signals, and

- not part of the last SC-FDMA symbol in a subframe, if the UE transmits SRS in the same subframe in the same serving cell, and

- not part of the last SC-FDMA symbol in a subframe configured with cell-specific SRS for non-BL/CE UEs and BL/CE UEs in CEModeA, if the PUSCH transmission partly or fully overlaps with the cell-specific SRS bandwidth, and

- not part of an SC-FDMA symbol reserved for possible trigger type 1 SRS transmission as specified in [4] in a UE-specific aperiodic SRS subframe in the same serving cell, and

- not part of an SC-FDMA symbol reserved for possible trigger type 0 SRS transmission as specified in [4] in a UE-specific periodic SRS subframe in the same serving cell when the UE is configured with multiple TAGs

- not part of the first SC-FDMA symbol in a subframe if the associated DCI indicates PUSCH starting position '01', '10', or '11' and does not indicate PUSCH mode 2.

- not part of the first SC-FDMA symbol in the second slot in a subframe if the associated DCI indicates PUSCH starting position '01', '10', or '11' and PUSCH mode 2.

- not part of the last SC-FDMA symbol in a subframe if the associated DCI indicates PUSCH ending symbol '1' and does not indicate PUSCH mode 3.

- not part of the second slot in a subframe if the associated DCI indicates PUSCH ending symbol '0' and PUSCH mode 3.

- not part of SC-FDMA symbols 5 to 13 in a subframe if the associated DCI indicates PUSCH ending symbol '1' and PUSCH mode 3.

The mapping to resource elements  shall be in increasing order of first the index , then the index . The mapping starts with the first slot in an uplink subframe, except for slot-PUSCH, subslot-PUSCH transmission, or PUSCH mode 2.

In case of PUSCH transmissions using sub-PRB allocations for BL/CE UEs, the mapping starts over in every valid uplink subframe composing an UL resource unit.

In case of slot-PUSCH, the mapping shall start at  in the slot assigned for transmission.

In case of PUSCH mode 2, the mapping shall start at in the second slot of the subframe assigned for transmission.

In case of subslot-PUSCH, the mapping shall start at symbol  where the start of the mapping is dependent on the uplink subslot number in the subframe assigned for transmission and the *DMRS-pattern* field in the related uplink DCI format [3] according to Table 5.3.4-1 where starting symbol index "4" for subslot #5 is applied if the UE has indicated the capability *ul-pattern-ddd-r15*.

Table 5.3.4-1: Starting symbol index for subslot-PUSCH transmission

|  |  |
| --- | --- |
| *DMRS-pattern* field in uplink-related DCI format [3] | Uplink subslot number |
| #0 | #1 | #2 | #3 | #4 | #5 |
| 00 | 1 | 4 | 6 | 1 | 3 | 5 |
| 01 | 0 | 3 | 5 | 0 | 2 | 4 |
| 10 | – | 3 | – | 0 | 2 | – |
| 11 | – | 3 | – | – | 2 | – |

In case of a semi-persistently scheduled subslot-PUSCH, and semi-persistent scheduling (i.e. higher layer parameter *sps-ConfigUL-STTI* is configured, see 3GPP TS 36.331 [9]) with a configured periodicity of 1 subslot (i.e. *semiPersistSchedIntervalUL-STTI* set to *sTTI1*), the mapping shall start at symbol  depending on the *DMRS-pattern* field in the related uplink DCI format [3] according to Table 5.3.4-2.

In case of a semi-persistently scheduled subslot-PUSCH and semi-persistent scheduling (the higher layer parameter *sps-ConfigUL-sTTI-r15* is configured, see 3GPP TS 36.331 [9]) with repetitions enabled (the higher layer parameter *totalNumberPUSCH-SPS-STTI-UL-Repetitions* is configured), the mapping shall start at symbol  depending on the *DMRS-pattern* field in the related uplink DCI format [3] according to Table 5.3.4-2.

Table 5.3.4-2: Starting symbol index for subslot-PUSCH transmission in case of semi-persistent scheduling with a configured periodicity of 1 subslot

|  |  |
| --- | --- |
| *DMRS-pattern* field in uplink-related DCI format [3] | Uplink subslot number |
| #0 | #1 | #2 | #3 | #4 | #5 |
| 00 | 1 | 4 | 6 | 1 | 3 | 5 |
| 10 | 1 | 3 | 6 | 0 | 3 | 5 |

In case of subslot-PUSCH and semi-persistent scheduling with a configured periodicity longer than 1 subslot the mapping shall start at symbol  according to the first row of Table 5.3.4-2 (i.e. equivalent to a signalling of *DMRS-pattern* field set to '00').

For the UpPTS, the mapping shall start at symbol  and if *dmrsLess-UpPts* is set to true the mapping shall end at symbol  in the second slot of a special subframe, otherwise, the mapping shall end at symbol  in the second slot of a special subframe.

For BL/CE UEs, the PUSCH transmission is restricted as follows:

- For CEModeA, if the PUSCH is associated with C-RNTI or SPS C-RNTI and the higher layer parameter *ce-pusch-maxBandwidth-config* is set to 5 MHz, the maximum number of allocatable PRBs for PUSCH is 24 PRBs. The allocatable PRBs include the PRBs belonging to the narrowbands defined in clause 5.2.4 and the odd PRB at the center of the uplink system bandwidth in case of odd total number of uplink PRBs. If a resource assignment or frequency hopping would result in a PUSCH resource allocation outside the allocatable PRBs then the PUSCH transmission in that subframe is dropped.

- For all other cases, the maximum number of allocatable PRBs for PUSCH is 6 PRBs restricted to one of the narrowbands defined in clause 5.2.4.

For BL/CE UEs in CEModeB, resource elements in the last SC-FDMA symbol in a subframe configured with cell-specific SRS shall be counted in the PUSCH mapping but not used for transmission of the PUSCH.

For BL/CE UEs, if one or more SC-FDMA symbol(s) are left empty due to guard period for narrowband or wideband retuning, the affected SC-FDMA symbol(s) shall be counted in the PUSCH mapping but not used for transmission of the PUSCH.

For a UE configured with SRS carrier switching, if the first symbol in a subframe overlaps with an SRS transmission (including any interruption due to uplink or downlink RF retuning time) in a carrier without PUSCH/PUCCH, the resource elements in the first SC-FDMA symbol shall be counted in the PUSCH mapping but not used for transmission of PUSCH.

For a UE configured with SRS carrier switching, if the last symbol in a subframe is counted in the PUSCH mapping and the last symbol in the subframe overlaps with an SRS transmission (including any interruption due to uplink or downlink RF retuning time) in a carrier without PUSCH/PUCCH, the resource elements in the last SC-FDMA symbol shall be counted in the PUSCH mapping but not used for transmission of PUSCH.

For a UE configured with SRS carrier switching, if the last symbol in a subframe is not counted in the PUSCH mapping and the second-to-last symbol in the subframe overlaps with an SRS transmission (including any interruption due to uplink or downlink RF retuning time) in a carrier without PUSCH/PUCCH, the resource elements in the second-to-last SC-FDMA symbol shall be counted in the PUSCH mapping but not used for transmission of PUSCH.

For a UE configured with PUSCH Mode 1, if DCI indicates PUSCH mode 1 enabled and the corresponding transmission of PUSCH starts in the second slot of a subframe, the resource elements in the first slot of the subframe shall be counted in the PUSCH mapping but not used for transmission of PUSCH.

For a UE configured with autonomous uplink,

- if the UE indicates PUSCH ending symbol '1' in uplink control information, or *endingSymbolAUL* is set to '12', the resource elements in the last SC-FDMA symbol shall be counted in the PUSCH mapping but not used for transmission of PUSCH;

- if the UE indicates PUSCH starting symbol '1' in uplink control information, the resource elements in the first SC-FDMA symbol shall be counted in the PUSCH mapping but not used for transmission of PUSCH.

If uplink frequency-hopping is disabled or the resource blocks allocated for PUSCH transmission are not contiguous in frequency, the set of physical resource blocks to be used for transmission is given by  where  is obtained from the uplink scheduling grant as described in clause 8.1 in 3GPP TS 36.213 [4].

If uplink frequency-hopping with type 1 PUSCH hopping is enabled, the set of physical resource blocks to be used for transmission is given by clause 8.4.1 in 3GPP TS 36.213 [4].

If uplink frequency-hopping with predefined hopping pattern is enabled, the set of physical resource blocks to be used for transmission in slot  is given by the scheduling grant together with a predefined pattern according to



where  is obtained from the scheduling grant as described in clause 8.1 in 3GPP TS 36.213 [4]. The parameter *pusch-HoppingOffset*,, is provided by higher layers. The size  of each sub-band is given by,



where the number of sub-bands  is given by higher layers. The function  determines whether mirroring is used or not. The parameter *Hopping-mode* provided by higher layers determines if hopping is "inter-subframe" or "intra and inter-subframe".

The hopping function and the function are given by





where  and the pseudo-random sequence  is given by clause 7.2 and CURRENT\_TX\_NB indicates the transmission number for the transport block transmitted in slot as defined in [8]. The pseudo-random sequence generator shall be initialised with  for frame structure type 1 and  for frame structure type 2 at the start of each frame.

For BL/CE UEs, the PRB resources for PUSCH transmission in the first subframe are obtained from the DCI as described in clauses 5.3.3.1.10 and 5.3.3.1.11 in [3]. Each of the PUSCH codewords is transmitted with repetitions, where is the number of transport blocks defined in clause 8.0 of 3GPP TS 36.213 [4]. The PUSCH transmission spans consecutive subframes, including subframes that are not BL/CE UL subframes where the UE postpones the PUSCH transmission if .

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

- In a subframe that is fully reserved as defined in clause 8.0 in [4], the PUSCH 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 PUSCH mapping but not used for transmission of the PUSCH.

- In case the UE is a BL/CE UE configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15* or *subPRB-Allocation* in *PUR-PUSCH-Config*, the PUSCH transmission spans consecutive subframes including subframes that are not BL/CE UL subframes where the UE postpones the PUSCH transmission, where is the number of scheduled TBs if *ce-PUSCH-MultiTB-Config* is enabled and multiple TBs are scheduled, otherwise .

- For BL/CE UE in CEModeA,

- If PUSCH is transmitted using preconfigured uplink resources,

- PUSCH frequency hopping is enabled when the higher layer parameter *pur-PUSCH-FreqHopping* is set, otherwise frequency hopping is disabled.

- Else, if PUSCH scheduled by DCI format 6-0A is associated with PUR C-RNTI,

- PUSCH frequency hopping is enabled when the higher layer parameter *pur-PUSCH-FreqHopping* is set and the frequency hopping flag in DCI format 6-0A indicates frequency hopping, otherwise frequency hopping is disabled.

- Else,

- PUSCH frequency hopping is enabled when the higher-layer parameter *pusch-HoppingConfig* is set and the frequency hopping flag in DCI format 6-0A indicates frequency hopping, otherwise frequency hopping is disabled.

- For BL/CE UE in CEModeB,

- If PUSCH is transmitted using preconfigured uplink resources,

- PUSCH frequency hopping is enabled when the higher layer parameter *pur-PUSCH-FreqHopping* is set, otherwise frequency hopping is disabled.

- Else, if PUSCH scheduled by DCI format 6-0B is associated with PUR C-RNTI,

- PUSCH frequency hopping is enabled when the higher layer parameter *pur-PUSCH-FreqHopping* is set, otherwise frequency hopping is disabled.

- Else,

- PUSCH frequency hopping is enabled when the higher-layer parameter *pusch-HoppingConfig* is set, otherwise frequency hopping is disabled.

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

- If a BL/CE UE is configured with higher layer parameter *ce-PUSCH-FlexibleStartPRB-AllocConfig*, the UE is not expected to have the frequency hopping enabled for PUSCH with the resource allocation including the center PRB not belonging to any narrowband.

- If frequency hopping is enabled for PUSCH and the UE is not configured with CEModeA and higher layer parameter *ce-PUSCH-FlexibleStartPRB-AllocConfig*,

- PUSCH is transmitted in uplink subframe  within the  consecutive subframes using the same number of consecutive PRBs as in the previous subframe starting from 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 UL subframe intended for carrying the PUSCH and  and  are cell-specific higher-layer parameters. For the  consecutive subframes, the UE shall not transmit PUSCH in subframe  if it is not a BL/CE UL subframe.

- If frequency hopping is enabled for PUSCH and the UE is configured with CEModeA and higher layer parameter *ce-PUSCH-FlexibleStartPRB-AllocConfig*,

- Except when the PUSCH resource allocation includes the center PRB not belonging to any narrowband, PUSCH is transmitted in uplink subframe  within the  consecutive subframes using the same number of consecutive PRBs as in the previous subframe, where is the narrowband index that starting PRB located in the absolute subframe number of the first UL subframe , defined as

- If 0 or with ,

- If with

 where is the number of edge PRB(s) not belonging to narrowbands in one side of system bandwidth , is the number of narrowbands, the starting PRB index and the length of the allocated resources are defined in clause 8.1.1 of [4]. After hopping, the narrowband  in subframe  is defined as



 where  and  are cell-specific higher-layer parameters. For the  consecutive subframes, the UE shall not transmit PUSCH in subframe  if it is not a BL/CE UL subframe. After hopping, the resource blocks have the same relative location of starting PRB in as in narrowband .

- If frequency hopping is enabled for PUSCH and the UE is configured with higher layer parameter *ce-PUSCH-FlexibleStartPRB-AllocConfig*,

- If a frequency hopping leads to a split resource allocation, where some PRB(s) is (are) on one edge and some PRB(s) is (are) on the other edge of the system bandwidth, the PUSCH transmission is dropped in that subframe.

- If a frequency hopping leads to a resource allocation, where some PRB(s) is (are) not belonging to any narrowband, the PUSCH transmission is dropped in that subframe.

For BL/CE UEs, for PUSCH transmission corresponding to the random access response grant and its retransmission, frequency hopping of the PUSCH 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-UlHoppingConfigCommonModeA*;

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

For BL/CE UEs in CEModeB, for PUSCH transmission not associated with Temporary C-RNTI, for frame structure type 1, after a transmission duration of  time units (which may include subframes that are not BL/CE UL subframes), a gap of  time units shall be inserted, according to the UE capability *ue-CE-NeedULGaps*, as specified in 3GPP TS 36.331 [9]. BL/CE UL subframes within the gap of  time units shall be counted for the PUSCH resource mapping but not used for transmission of the PUSCH.

For BL/CE UEs, for PUSCH transmission associated with Temporary C-RNTI for frame structure type 1, and if PRACH CE level 2 or 3 is used for the last PRACH attempt, after a transmission duration of  time units (which may include subframes that are not BL/CE UL subframes), a gap of  time units shall be inserted. BL/CE UL subframes within the gap of  time units shall be counted for the PUSCH resource mapping but not used for transmission of the PUSCH.

For UEs configured with *PUSCH-EnhancementsConfig*, the number of PUSCH subframe repetitions  and the PRB resources for PUSCH transmission in the first subframe are obtained from the DCI as described in clause 5.3.3.1.1C in [3]. The PUSCH transmission spans  consecutive subframes, including DL subframes where the UE postpones the PUSCH transmission in the case of frame structure type 2. PUSCH frequency hopping is enabled when the higher-layer parameters *pusch-HoppingOffsetPUSCH-Enh* and *interval-ULHoppingPUSCH-Enh* are set and the frequency hopping flag in DCI format 0C indicates frequency hopping, otherwise frequency hopping is disabled. If frequency hopping is not enabled for PUSCH, the PUSCH repetitions are located at the same PRB resources as in the first subframe. If frequency hopping is enabled for PUSCH, PUSCH is transmitted in uplink subframe  within the  consecutive subframes using the PRB resources starting at PRB index 

where  is the absolute subframe number of the first UL subframe carrying the PUSCH and  is given by the higher-layer parameter *interval-ULHoppingPUSCH-Enh* and  is given by the higher-layer parameter *pusch-HoppingOffsetPUSCH-Enh*.