**3GPP TSG RAN WG1 Meeting #104-e R1-20xxxxx**

**E-meeting, January 25 – February 5, 2021**

**Agenda Item: 7.2.5**

**Source: Moderator (Huawei)**

**Title:** **Feature lead summary#1 on PDCCH enhancements**

**Document for: Discussion and Decision**

# Introduction

This document summarizes the key issues for PDCCH enhancements discussed under agenda item 7.2.5 based on the views in [1][2][3][4][5], and aims to identify a set of critical issues for RAN1#104-e email discussion.

# Summary of issues raised for PDCCH enhancements

This section summarize the issues raised by companies on PDCCH enhancements, among which a set of issues can be identified for RAN1#104-e email discussions per the guidance from Chairman. Note that per the guidance from Chairman, only critical issues should be included and no more “nice to have” features.

Recommendation on the email threads and scope are given in section 2.1 and the summary of detailed issues are given in section 2.2.

## Recommendation for the scope of email threads

Based on the summary of issues in section 2.2, the following recommendation are made for the scope of email threads. More views are needed on whether to discuss issue A-3 and A-4.

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**Email discussion #1**

Email discussion/approval on remaining issues on DCI format:

* **Issue A-1**: Inconsistence between TS 38.213 and TS 38.331 in terms of the *dci-FormatsExt*

**Companies are encouraged to provide views on whether to include the following issues to the scope**.

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| Company | Issue A-2 | Issue A-3 | Issue A-4 | Comments |
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## Summary of detailed issues

**Issues raised on DCI format design**

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| **Issue #** | **Description** | **Source** | **Recommended handling** |
| A-1 | Correction on *dci-FormatsExt* in section 10.1 in TS 38.213 | Sharp (R1-2101535) | Included in the scope for email discussion  **Reason:**  *Critical correction, otherwise the spec is not correct* |
| A-2 | Restriction on SCS between PDCCH and PDSCH with the starting symbol of the PDCCH monitoring occasion as the reference of SLIV | Spreadtrum (R1-200792) | No discussion in RAN1#104-e  **Reason:**  *It was agreed not to use new SLIV reference for cross-carrier scheduling with different numerologies.* |
| A-3 | Whether the new SLIV reference (i.e. the starting symbol of the PDCCH monitoring occasion as the reference of SLIV) can be applied to Type 1 HARQ-ACK codebook | Samsung (R1-2101177) | More inputs from companies on whether to include or not.  **Reason:**  *It seems the current specification can work. However, if time permit can be discussed to achieve common understanding.* |
| A-4 | Ambiguity of subselection indication for DCI format 0\_1 and DCI format 0\_2 | Huawei/HiSilicon (R1-2102162) | More inputs from companies on whether to include or not.  **Reason:**  *It seems the current specification can work. However, if time permit can be discussed to achieve common understanding.* |

# DCI format scheduling Rel-16 URLLC

Based on the contributions from companies, the following issues related to DCI format design are discussed.

**Issue A-1**: Correction on *dci-FormatsExt* in section 10.1 in TS 38.213

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| *Sharp R1-2101535*  In Rel-16, DCI format 0\_2 and DCI format 1\_2 have been introduced for Rel-16 URLLC operation. A *dci-FormatsExt* is used to indicate whether a UE to monitor the DCI format 0\_2 and DCI format 1\_2 in the USS. To be more specific, in TS 38.331 [1] as below, the *dci-FormatsExt* is used to indicate whether a UE to monitor PDCCH candidates for the DCI format 0\_2 and DCI format 1\_2, or for the DCI format 0\_1, DCI format 1\_1, DCI format 0\_2, and DCI format 1\_2 in a USS.     |  | | --- | | ***dci-FormatsExt***  If this field is present, the field *dci-Formats* is ignored and *dci-FormatsExt* is used instead to indicate whether the UE monitors in this USS for DCI format 0\_2 and 1\_2 or formats 0\_1 and 1\_1 and 0\_2 and 1\_2 (see TS 38.212 [17], clause 7.3.1 and TS 38.213 [13], clause 10.1). |   On the other hand, in TS 38.213 [2] as below, it seems that the *dci-FormatsExt* can be also used to indicate a UE to monitor PDCCH candidates for the DCI format 0\_0 and DCI format 1\_0, or for DCI format 0\_1 and DCI format 1\_1, which are not allowed in the TS 38.331.   |  | | --- | | TS 38.213 V16.4.0 (2020-12)  10.1 UE procedure for determining physical downlink control channel assignment  - if search space set is a USS set, an indication by *dci-Formats* to monitor PDCCH candidates either for DCI format 0\_0 and DCI format 1\_0, or for DCI format 0\_1 and DCI format 1\_1, or an indication by *dci-FormatsExt* to monitor PDCCH candidates for DCI format 0\_0 and DCI format 1\_0, or for DCI format 0\_1 and DCI format 1\_1, or for DCI format 0\_2 and DCI format 1\_2, or, if a UE indicates a corresponding capability, for DCI format 0\_1, DCI format 1\_1, DCI format 0\_2, and DCI format 1\_2, or for DCI format 3\_0, or for DCI format 3\_1, or for DCI format 3\_0 and DCI format 3\_1 |   **Proposal:** Adopt the following TP relating to *dci-FormatsExt* in TS 38.213 to keep insistent with the description of the *dci-FormatsExt* in TS 38.331.   |  | | --- | | TP  TS 38.213 V16.4.0 (2020-12)  10.1 UE procedure for determining physical downlink control channel assignment  < Unchanged parts are omitted >  - if search space set is a USS set, an indication by *dci-Formats* to monitor PDCCH candidates either for DCI format 0\_0 and DCI format 1\_0, or for DCI format 0\_1 and DCI format 1\_1, or an indication by *dci-FormatsExt* to monitor PDCCH candidates for ~~DCI format 0\_0 and DCI format 1\_0, or for DCI format 0\_1 and DCI format 1\_1, or for~~ DCI format 0\_2 and DCI format 1\_2, or, if a UE indicates a corresponding capability, for DCI format 0\_1, DCI format 1\_1, DCI format 0\_2, and DCI format 1\_2, or for DCI format 3\_0, or for DCI format 3\_1, or for DCI format 3\_0 and DCI format 3\_1  < Unchanged parts are omitted > | |

**Feature lead view**: The issue is valid and needs to be addressed.

***Proposal A-1****: Endorse the text proposal in R1-2xxxxxx for TS 38.213 Section 10.1.*

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| 10.1 UE procedure for determining physical downlink control channel assignment  < Unchanged parts are omitted >  - if search space set is a USS set, an indication by *dci-Formats* to monitor PDCCH candidates either for DCI format 0\_0 and DCI format 1\_0, or for DCI format 0\_1 and DCI format 1\_1, or an indication by *dci-FormatsExt* to monitor PDCCH candidates for ~~DCI format 0\_0 and DCI format 1\_0, or for DCI format 0\_1 and DCI format 1\_1, or for~~ DCI format 0\_2 and DCI format 1\_2, or, if a UE indicates a corresponding capability, for DCI format 0\_1, DCI format 1\_1, DCI format 0\_2, and DCI format 1\_2, or for DCI format 3\_0, or for DCI format 3\_1, or for DCI format 3\_0 and DCI format 3\_1  < Unchanged parts are omitted > |

**Please provide your views on the above proposal A-1.**

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## Issue A-2: Restriction on SCS between PDCCH and PDSCH with the starting symbol of the PDCCH monitoring occasion as the reference of SLIV

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| *Spreadtrum R1-200792*  For time domain resource allocation for PDSCH for Rel-16 URLLC in DCI format 1\_2, the starting symbol of the PDCCH monitoring occasion in which the DL assignment is used as the reference point of the SLIV in time domain resource allocation table. Meanwhile, this reference is only applied to some of TDRA entries with K0=0 and PDSCH mapping type B. However, one issue is whether this PDCCH starting symbol can be used as the reference of SLIV when cross carrier scheduling is configured for one serving cell.  First, the SCS of PDCCH and PDSCH may be different when cross carrier scheduling, this may complex the definition of SLIV reference point. The starting symbol of PDCCH monitoring occasion cannot be added directly with start symbol and its length. At least, some specification changes are needed in order to contain this different numerology case.  Second, earliest possible starting point for the PDSCH is defined by the end of the PDCCH + Δ in cross carrier scheduling and PDCCH/PDSCH with different SCSs. For the case of lower SCS PDCCH scheduling a higher SCS PDSCH, the earliest possible starting point for the PDSCH is postponed to the next one or two slot. The limits of the starting point of PDSCH may increase the scheduling delay for URLLC traffic. From this point, we do not think the method of PDCCH starting symbol can provide any benefits compared with slot boundary for PDSCH time domain resource allocation.  Above all, we propose the starting symbol of the PDCCH monitoring occasion for PDSCH resource allocation only applies to same SCS between PDCCH and PDSCH, and adopt the TP below.  ***Proposal 1. Starting symbol of the PDCCH monitoring occasion for PDSCH resource allocation only applies to same SCS between PDCCH and PDSCH.*** |

**Feature lead view**:

The main concern given in R1-200792 is on utilization of the new SLIV reference for cross-carrier scheduling with different numerologies. According to agreement achieved in RAN1#99 meeting, the new reference of SLIV will not be used for the case of cross-carrier scheduling with different numerologies.

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Agreement

The new reference of SLIV is not expected to be configured for a serving cell configured to be scheduled with cross-carrier scheduling

* Applies only for the case of different numerologies

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In addition, the above agreement is already reflected in 38.214 section 5.1.2.1. Therefore, it seems correction here is not needed.

**Please provide your views on the issue A-2.**

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## Issue A-3: Whether the new SLIV reference (i.e. the starting symbol of the PDCCH monitoring occasion as the reference of SLIV) can be applied to Type 1 HARQ-ACK codebook

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| *Samsung R1-2101177*  Using PDCCH as PDSCH SLIV reference can help reducing TDRA bits in DCI format 1\_2, this is an important feature introduced in Rel-16 URLLC WI. PDSCH repetition is another important feature for URLLC and it can help increase the reliability of PDSCH transmission. When both features are used in Type-1 HAR-ACK codebook, the candidate PDSCHs in a slot can be impacted by both PDCCH monitoring occasions and the number of PDSCH repetitions. A simple example is given in Figure 1.    **Figure 1**  In the TDRA table, there is only one entry, i.e., SLIV1. In slot 0, there are two PDCCH monitoring occasions. SLIV2 is an extended SLIV using PDCCH as reference. In slot 1, there is one PDCCH monitoring occasion. Without considering PDSCH repetition, SLIV1 is the only possible SLIV in slot 1. If UE is configured with PDSCH repetition, for example, *pdsch-AggregationFactor =* 2 configured in PDSCH-Config, in this case SLIV2 can be a valid SLIV in slot 1 as well. If *pdsch-AggregationFactor* is configured in PDSCH-Config, PDCCH monitoring occasions in slot n-*pdsch-AggregationFactor*+1 should be used for determining the candidate PDSCHs scheduled by DCI format 1\_2 in slot n.  In Rel-16 IIOT, multiple SPS configurations are introduced and this feature is essential for URLLC because it can help reduce the latency as well as PDCCH signalling overhead. The number of PDSCH repetitions can also be configured in SPS-Config and there can be multiple SPS configurations with different values of *pdsch-AggregationFactor.* All the values of *pdsch-AggregationFactor* in all SPS-Config and PDSCH-Config should be considered for determining the candidate PDSCHs activated/scheduled by DCI format 1\_2.  Another impact is the periodicity of SPS PDSCH configuration. If PDSCH is determined using PDCCH as SLIV reference, the SPS PDSCH is determined using the PDCCH carrying the activating DCI as SLIV reference. The location of the activating DCI should also be taken into consideration when determining the candidate PDSCHs in Type-1 HARQ-ACK codebook.  In Rel-16 MIMO, dynamic indication of the number of PDSCH repetitions is introduced. If this feature is enabled using DCI format 1\_2, all the possible number of PDSCH repetitions should be considered when determining the candidate PDSCHs in Type-1 HARQ-ACK codebook.  Based on the above analysis, if UE is configured to use PDCCH as PDSCH SLIV reference and configured with Type-1 HARQ-ACK codebook, to ensure there are always HARQ-ACK bits for all possible PDSCH receptions following parameters need to be considered when determining the candidate PDSCHs in Type-1 HARQ-ACK codebook.   * the value of *pdsch-AggregationFactor* PDSCH-Config, * the values of *pdsch-AggregationFactor* in all SPS-Config * the values of periodicity of all the SPS PDSCH configurations * all the possible numbers of PDSCH repetitions that can be dynamic indicated by DCI format 1\_2   The size of Type-1 HARQ-ACK codebook would be increased if it is determined considering all the above parameters. An alternative solution is using slot boundary as PDSCH SLIV reference when UE is configured with Type-1 HARQ-ACK codebook. This solution is much easier compared with the former one.  ***Proposal: Slot boundary should be used as the reference of PDSCH SLIV if UE is configured with Type-1 HARQ-ACK codebook. The following 2 TPs should be adopted.***  TP #1   |  | | --- | | TS 38.214 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 *K0*, 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 *Ks*, where , if UE is configured with ca-SlotOffset for at least one of the scheduled and scheduling cell, and *Ks* = , otherwise, and where *n* is the slot with the scheduling DCI, and *K0* is based on the numerology of PDSCH, and  and are the subcarrier spacing configurations for PDSCH and PDCCH, respectively, and  - and are the and the, respectively, which are determined by higher-layer configured ca-SlotOffset, for the cell receiving the PDCCH respectively, and are the and the, 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 *S0* for starting symbol *S* is defined as:  - if configured with *pdsch-HARQ-ACK-Codebook = dynamic* and configured with *referenceOfSLIVForDCI-Format1-2-r16*, and when receiving PDSCH scheduled by DCI format 1\_2 with CRC scrambled by C-RNTI, MCS-C-RNTI, CS-RNTI with *K0=0*, and PDSCH mapping Type B, the starting symbol *S* is relative to the starting symbol *S0* 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 *S0=0.*  … |   TP #2   |  | | --- | | TS 38.213 9.1.2.1 Type-1 HARQ-ACK codebook in physical uplink control channel For a serving cell , an active DL BWP, and an active UL BWP, as described in Clause 12, the UE determines a set of occasions for candidate PDSCH receptions for which the UE can transmit corresponding HARQ-ACK information in a PUCCH in slot . If serving cell is deactivated, the UE uses as the active DL BWP for determining the set of occasions for candidate PDSCH receptions a DL BWP provided by *firstActiveDownlinkBWP-Id*. The determination is based:  a) on a set of slot timing values associated with the active UL BWP  a) If the UE is configured to monitor PDCCH for DCI format 1\_0 and is not configured to monitor PDCCH for either DCI format 1\_1 or DCI format 1\_2 on serving cell , is provided by the slot timing values {1, 2, 3, 4, 5, 6, 7, 8}  b) If the UE is configured to monitor PDCCH for DCI format 1\_1 and is not configured to monitor PDCCH for DCI format 1\_2 for serving cell , is provided by *dl-DataToUL-ACK*  c) If the UE is configured to monitor PDCCH for DCI format 1\_2 and is not configured to monitor PDCCH for DCI format 1\_1 for serving cell ,  is provided by *dl-DataToUL-ACK-ForDCIFormat1\_2*  d) If the UE is configured to monitor PDCCH for DCI format 1\_1 and DCI format 1\_2 for serving cell ,  is provided by the union of *dl-DataToUL-ACK* and *dl-DataToUL-ACK-ForDCIFormat1\_2*  b) on a set of row indexes of a table that is associated with the active DL BWP and defining respective sets of slot offsets , start and length indicators *SLIV*, and PDSCH mapping types for PDSCH reception as described in [6, TS 38.214], where the row indexes of the table are provided by the union of row indexes of time domain resource allocation tables for DCI formats the UE is configured to monitor PDCCH for serving cell  ~~a) if the UE is provided~~ *~~ReferenceofSLIV-ForDCIFormat1\_2~~*~~, for each row index with slot offset~~ ~~and PDSCH mapping Type B in a set of row indexes of a table for DCI format 1\_2 [6, TS 38.214], for each PDCCH monitoring occasion in a set of PDCCH monitoring occasions with different starting symbols within a slot where the UE monitors PDCCH for DCI format 1\_2 and with starting symbol , if for normal cyclic prefix and for extended cyclic prefix, add a new row index in the set of row indexes of the table by replacing the starting symbol of the row index by~~  … | |

**Feature lead view**: It seems the current specification can cover the cases mentioned in R1-2101177. However, if time permit the issue can be discussed to achieve common understanding in RAN1.

**Please provide your views on the issue A-2.**

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## Issue A-4: Ambiguity of subselection indication for DCI format 0\_1 and DCI format 0\_2

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| *Huawei/HiSilicon (R1-2102162)*  In the RAN1#103-e meeting, an issue about a possible ambiguity of the sub-selection indication for DCI format 0\_1 and DCI format 0\_2 was raised in by Sharp (R1-2008393). A method was proposed to apply the larger number of bits in the CSI request field between DCI format 0\_1 and DCI format 0\_2 for a sub-selection indication. In our view, the issue is valid and needs to be solved regardless of what specification changes to be adopted. The key point is to clarify which value is applied for sub-selection indication when there are two different values determined by RRC signaling *reportTriggerSize* and *reportTriggerSizeDCI-0-2-r16,* respectively. According to the current specification TS38.321 [3], the code point of CSI request in DCI format 0\_1 or DCI format 0\_2 indicates the position of the activated CSI triggering state in the list of *aperiodicTriggerStateList*. If the smaller number between *reportTriggerSize* and *reportTriggerSizeDCI-0-2-r16* is used for sub-selection indication, some code points in the CSI request field with larger size are not able to indicate the triggering state since the number of activated triggering states by sub-selection is less than the number of code points in CSI request. In this case, there is no ambiguity issue between the UE and gNB, but the code point of the CSI request field with the larger size is not fully used. Therefore, it is worthwhile to discuss and address this issue, and the text proposal in [2] can be the starting point.  ***Proposal 1: Discuss the issue “Ambiguity of subselection indication for DCI format 0\_1 and DCI format 0\_2” in RAN1#104-e meeting.***  *Sharp (R1-2008393)*  A higher layer parameter *CSI-AperiodicTriggerStateList* is used to configure a UE with a list of aperiodic CSI trigger states. The maximum number of the aperiodic CSI trigger states can be up to 128. The higher layer parameter *reportTriggerSize* is used to configure the DCI size of *CSI request* field of DCI format 0\_1 as (0 ~ 6 bits). As described in 5.2.1.5.1 in TS 38.214, when the number of configured aperiodic CSI triggering states in *CSI-AperiodicTriggerStateList* is greater than  for DCI format 0\_1, the UE would receive a subselection indication for selection of the aperiodic configured aperiodic triggering states.  Moreover, in NR URLLC, a new higher layer parameter *reportTriggerSize-ForDCIFormat0\_2* is used to configure the DCI size of *CSI request* field of DCI format 0\_2 as (0 ~ 6 bits). According to the TS 38.214 [1], aperiodic CSI-RS trigger procedure for DCI format 0\_1 is applied to that for DCI format 0\_2 by applying the higher layer parameter *reportTriggerSize-ForDCIFormat0\_2* instead of *reportTriggerSize*. That is, when the number of configured aperiodic CSI triggering states in *CSI-AperiodicTriggerStateList* is greater than for DCI format 0\_2, the UE would receive a subselection indication for selection of the aperiodic configured aperiodic triggering states.  For a UE monitoring both DCI format 0\_1 and DCI format 0\_2, there is a case where the number of configured CSI triggering states would be larger than the corresponding number indicated by the *reportTriggerSize* for DCI format 0\_1 and also be larger thanthe corresponding number indicatedthe *reportTriggerSize-ForDCIFormat0\_2* for DCI format 0\_2. Then according to 5.2.1.5.1 in TS 38.214, both DCI format 0\_1 and the DCI format 0\_2 would require a subselection indication. The issue has not been discussed in RAN1 yet. Furthermore, according to the TS 38.321 [2], there is only a single aperiodic CSI trigger state subselection MAC CE, which was introduced in Rel-15 for DCI format 0\_1. Therefore, it is straightforward that the single aperiodic CSI MAC CE is common and should be applied to both the DCI format 0\_1 and DCI format 0\_2 in the case that the number of configured CSI trigger states is greater than the number indicated by the *reportTriggerSize* for DCI format 0\_1 and greater than the number indicated by the *reportTriggerSize* for DCI format 0\_2.  **Proposal:** Adopt the following TP in TS 38.214 to precisely describe that a single subselection indication used for aperiodic CSI-RS trigger procedure is common for DCI format 0\_1 and DCI format 0\_2 in a case that the number of configured CSI trigger states is greater than the number indicated by the *reportTriggerSize* for DCI format 0\_1 and is greater than the number indicated by the *reportTriggerSize* for DCI format 0\_2.  TS 38.214 V16.3.0 (2020-09) 5.2.1.5.1 Aperiodic CSI Reporting/Aperiodic CSI-RS when the triggering PDCCH and the CSI-RS have the same numerology < Unchanged parts are omitted >  A trigger state is initiated using the *CSI request* field in DCI.  - When all the bits of *CSI request* field in DCI are set to zero, no CSI is requested.  - When the number of configured CSI triggering states in *CSI-AperiodicTriggerStateList* is greater than , where  is the number of bits in the DCI *CSI request* field, the UE receives a subselection indication, as described in clause 6.1.3.13 of [10, TS 38.321], used to map up to  trigger states to the codepoints of the *CSI request* field in DCI.  is configured by the higher layer parameter *reportTriggerSize* where . When the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the subselection indication, the corresponding action in [10, TS 38.321] and UE assumption on the mapping of the selected CSI trigger state(s) to the codepoint(s) of DCI CSI request field shall be applied starting from the first slot that is after slot where ** is the SCS configuration for the PUCCH. For the case that the number of configured CSI triggering states in *CSI-AperiodicTriggerStateList* is greater than , where  is a larger number of bits in the DCI *CSI request* field between DCI format 0\_1 and DCI format 0\_2, the UE receives a subselection indication used for both DCI format 0\_1 and DCI format 0\_2.  - When the number of CSI triggering states in *CSI-AperiodicTriggerStateList* is less than or equal to , the *CSI request* field in DCI directly indicates the triggering state. |

**Feature lead view**: There was discussion during preparation phase for this issue in RAN1#103-e and it was set as low priority due to many other more critical issues to be addressed. According to the definition in 38.321 and 38.213, it seems the current spec can work, but if time permit might be no harm to discuss and achieve common understanding in RAN1.

**Please provide your views on this issue.**

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# References

1. R1-2101535 Correction on inconsistence between TS 38.213 and TS 38.331 in terms of the *dci-FormatsExt* for NR URLLC Sharp
2. [R1-2101177](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007703.zip) Remaining issues on PDCCH as PDSCH SLIV reference Samsung
3. [R1-2101262](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007732.zip) Corrections on PDCCH enhancements Huawei, HiSilicon
4. [R1-2100792](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_103\Docs\R1-2007814.zip) Remaining issues of PDCCH enhancements for URLLC Spreadtrum Communications
5. [R1-2101536](file:///C:\Users\wanshic\OneDrive%20-%20Qualcomm\Documents\Standards\3GPP%20Standards\Meeting%20Documents\TSGR1_104\Docs\R1-2101536.zip) Remaining issue on PDSCH rate matching for DCI format 1\_0 for NR URLLC Sharp