**3GPP TSG RAN WG1 #112bis-e R1-23xxxxx**

**e-Meeting, April 17th – April 26th, 2023**

**Source: Moderator (MediaTek)**

**Title: [112bis-e-R17-Others-01] Email discussion on other Rel-17 maintenance**

**Agenda item: 7.2**

**Document for:** **Discussion and Decision**

Introduction

This document intends to provide discussion summary on the following **3 issues** in RAN1#112-bis-e meeting:

1. two contributions [1, 2, MTK], one discussion paper and one CR, are submitted to clarify the relation between SUL indicator and *pusch-Config*/*pucch-Config* for DCI 0\_0
2. two contributions [3, 4, MTK], one discussion paper and one CR, propose to add periodicities of n80 and n160 to *periodicityAndPattern* in *RateMatchPattern* to avoid unnecessary resource waste when NCD-SSB is configured
3. one contribution [5, Qualcomm] proposes introducing new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset” to address the ambiguity of applicability for *aperiodicTriggeringOffset-r16/r17* with various SCS combinations and FR2-2

As guided by the Chairman, for the **3 issues** listed above, this contribution provides summary of the submitted contributions (Section 4.1, 4.2, 4.3), discussion points (Section 2.1, 2.2, 2.3), and possible RAN1 consensus during this meeting (Section 3.1, 3.2, 3.3, TBD).

[112bis-e-R17-Others-01] Email discussion on other Rel-17 maintenance by April 21 – James (MediaTek)

R1-2303363 On the relation between SUL indicator and pusch-Config/pucch-Config for DCI 0\_0 MediaTek Inc.

R1-2303364 [R17] Draft 38.212 CR on SUL indicator and pusch-Config/pucch-Config for DCI 0\_0 MediaTek Inc.

R1-2303365 On rate match pattern periodicity MediaTek Inc.

R1-2303366 Draft CR for 38.214 on rate match pattern periodicity MediaTek Inc.

R1-2303565 Clarification on A-CSI-RS triggering offset Qualcomm Incorporated

Discussion points (phase 1 until 18-Apr)

## For [1, 2, MTK] related to SUL indicator and pusch/pucch-Config for DCI 0\_0

In [1, MTK], it is mentioned that

1. from current spec 38.212 V17.5.0 7.3.1.1.1, the determination of PUSCH transmission scheduled by DCI 0\_0 on NUL (normal uplink) or SUL shown in Table 1 (prioritizing PUCCH carrier for PUSCH transmission) seems not matching the RAN1 #90bis agreement that the default location of the PUSCH is the same carrier as used by PUCCH. During RAN1 #112, this issue was discussed under R15 CR agenda (Section 7.1) and companies have diverse view on current R15 spec (some companies think it’s reasonable while some think it’s not supported).

Agreement: (RAN1 #90bis)

* UE specific RRC signalling (re-)configures the location of the PUCCH, either on the SUL carrier or on a non-SUL UL carrier in a SUL band combination
	+ The default location of the PUSCH is the same carrier as used by PUCCH



**Table 1: PUSCH transmission behavior on NUL (normal uplink) or SUL scheduled by DCI 0\_0 implied in current spec**

**38.212 V17.5.0** 7.3.1.1.1:



For 1), as companies can not have aligned understanding under R15 CR discussion (agenda 7.1) during RAN1 #112, it is proposed in [1] to revisit this issue in R17 (agenda 7.2) during RAN1 #112-bis-e, with the following proposal:

**Proposal 1: RAN1 to** **draw the following conclusion for R17:**

* **If an UL cell has NUL and SUL carrier, and *pusch-config* is configured, then the UL carrier configured with *pucch-config* should also be configured with *pusch-config***

**and sent an LS to RAN2 to clarify it in R17 38.331 spec.**

Besides, there is one remaining issue not discussed during RAN1 #112:

1. Only one carrier of NUL/SUL configured with *pusch-Config* but no carriers configured with *pucch-Config* (E.g. only cell-specific *pucch-ConfigCommon* is configured, as *pucch-Config* is an optional IE)

For 2), it is proposed in [1] to adopt a R17 38.212 CR to clarify this scenario:

**Proposal 2: Adopt the R17 CR (detailed CR text in Section 4.1 of this document) to 38.212 V17.5.0 7.3.1.1.1 about SUL indicator and *pusch-Config*/*pucch-Config* for DCI 0\_0.**

The following discussions points are devised to discuss the Proposals 1 & 2 above:

#### Discussion point 2.1-1:

**Do you support the proposal 1 from [1, MTK] to draw the following RAN1 conclusion for R17?**

* **If an UL cell has NUL and SUL carrier, and *pusch-config* is configured, then the UL carrier configured with *pucch-config* should also be configured with *pusch-config***

**If your answer is “No”, Please assist to elaborate (if possible) you understanding on how the RAN1 #90bis agreement for SUL:**

**“UE specific RRC signalling … the default location of the PUSCH is the same carrier as used by PUCCH”**

**is reflected in current spec (38.212 V17.5.0 7.3.1.1.1)?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comment** |
| MTK | Yes | We think a RAN1 agreement should be reflected in spec. Although RAN1 can not achieve consensus for R15/R16 in last meeting, we think a amendment in R17 is still helpful. |
| Qualcomm | Suggest conclusion | We have the same understanding that the UL carrier configured with pucch-config should also be configured with pusch-config. Instead of specification changes, we would suggest drawing a conclusion on this. This makes sure that RAN1 has this understanding even in legacy releases. |
| Nokia, NSB | [Yes] | Square-bracketing the answer, as to our understanding this is the Rel-15 behaviour, not something starting from Rel-17 onwards. I.e. we’d suggest removing “R17” from the conclusion**RAN1 to draw the following conclusion ~~for R17:~~*** **If an UL cell has NUL and SUL carrier, and *pusch-config* is configured, then the UL carrier configured with *pucch-config* should also be configured with *pusch-config***
 |
| ZTE | Yes | We are ok to capture this previous RAN1 agreements. |
| Samsung | Yes | We are okay with drawing the conclusion. |
| Huawei, HiSilicon |  | OK with a conclusion. A small suggestion,* **If an UL cell has NUL and SUL carrier, and *pusch-config* is configured, then the UL carrier configured with *pucch-config, if any,* should also be configured with *pusch-config***
 |
| Ericsson | Suggest conclusion | We are OK with conclusion. Agree with Nokia to remove “Rel-17”, and HW addition of “if any”. |
| MTK (moderator) | Summary for Discussion point 2.1-1 | It seems all companies are fine with a RAN1 conclusion as follows:**RAN1 to draw the following conclusion:****If an UL cell has NUL and SUL carrier, and *pusch-config* is configured, then the UL carrier configured with *pucch-config*, if any, should also be configured with *pusch-config***Support: MTK, Qualcomm, Nokia, ZTE, Samsung, Huawei, Ericsson (7)Moderator hence suggests to take the RAN1 conclusion above if no objections appear in the next 24 hours. |
|  |  |  |

#### Discussion point 2.1-2:

**If you answer to Discussion point 2.1-1 is “Yes”, are you fine with RAN1 to send an LS to RAN2 to capture the RAN1 conclusion in R17 38.331 spec?**

**If your answer is “Not fine”, Please assist to elaborate on your reason and suggested way forward (Ex. capture it in RAN1 spec instead) if possible.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Fine or Not fine** | **Comment** |
| MTK | Fine | Normally a RRC configuration constraint is described in 38.331, so we propose to send an LS to RAN2. We can also be fine to capture it in RAN1 spec (Ex. 212) if companies think this way is better. |
| Qualcomm | Suggest conclusion | Same comment as the last discussion point – Instead of specification changes, we would suggest drawing a conclusion on this. This makes sure that RAN1 has this understanding even in legacy releases. |
| Nokia, NSB | No objection | We have a slight concern that a Rel-17 CR to 38.331 could be understood as a change of functionality. That said, we can accept an LS to RAN2 suggesting RAN2 to discuss a possibility to clarify this point in the spec. |
| ZTE |  | We are open to send a LS to RAN2. |
| Samsung | Not fine | We think it is sufficient to draw the above conclusion without any spec changes.  |
| Ericsson | Prefer not | Drawing conclusion should be enough. Basically we have a conclusion on mis-configuration. Sending LS to RAN2 causes additional work for RAN2 that we should be mindful, specially when there is no impact on RAN2 spec. RAN1 conclusions are available to all WGs. |
| MTK (moderator) | Summary for Discussion point 2.1-2 | A quick summary for companies’ stands below:* Fine to send an LS to RAN2 to capture the RAN1 conclusion in R17 38.331 spec
	+ MTK, ZTE (2)
* No need to send an LS to RAN2:
	+ Qualcomm, Nokia, Samsung, Ericsson (4)

Moderator hence suggests NOT to send an LS to RAN2.**This discussion point can be closed.** |

#### (1st and 2nd round) Discussion point 2.1-3:

**Do you support the proposal 2 from [1, MTK] to adopt the R17 CR (detailed CR text in Section 4.1 of this document) to 38.212 V17.5.0 7.3.1.1.1 to address the following scenario:**

* **Only one carrier of NUL/SUL configured with *pusch-Config* but no carriers configured with *pucch-Config* (E.g. only cell-specific *pucch-ConfigCommon* is configured, as *pucch-Config* is an optional IE)**

**🡪 PUSCH transmission should happen on the carrier configured with *pusch-Config***

**(Note that the proposed CR is to cover a scenario for the branch “if the UL/SUL indicator is present”, so the current spec under the branch “if the UL/SUL indicator is not present” does not apply)**

**If your answer is “No”, Please assist to elaborate on your reason, how UE should behave when “UL/SUL indicator is present” and “*pucch-Config* is not configured”, and suggested revision/way forward, if possible.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comment** |
| MTK | Yes | Due to the reason that *pucch-Config* is an optional IE, we think the UE behavior of * Only one carrier of NUL/SUL configured with *pusch-Config* but no carriers configured with *pucch-Config*

should be specified in spec.  |
| Qualcomm |  | We thought FL’s proposal is already clear from the spec. Perhaps we can first check if there is any different understanding.  |
| Nokia, NSB | Motivation not clear | This would appear to be an introduction of a new condition that did not exist before and the need for that case is still unclear. Yes, the RRC allows for configuring PUSCH-config for one of the two uplinks and not configure PUCCH-config for either of the two, but we don’t quite see why this would be a configuration that the network needs the UE support for, when no suc case existed in the past. |
| ZTE | No | The CR tries to address the potential issue “*If the UL/SUL indicator is present in DCI format 0\_0 and the higher layer parameter pusch-Config is configured on only one carrier of UL or SUL, and the higher layer parameter pucch-Config is not configured on UL and SUL*”, however we don’t think it is an essential issue because the UL/SUL indicator is already there. If there is any misunderstanding, the network can always indicate the carrier with *pusch-Config* for PUSCH transmission*.*  |
| Samsung |  | We share a similar view with Nokia.  |
| Huawei, HiSilicon | Yes | A similar clarification and correction was done to DCI 0\_1. It should be corrected for DCI 0\_0.@ZTE, the motivation is similar to the proposal in discussion point 2.1-1, which is to clarify that the PUSCH cannot be scheduled by gNB on a carrier without pusch-config when the other carrier within the same cell has been configured with pusch-config. |
| Ericsson | No | We share same view as Nokia. |
| MTK (moderator) | Summary for Discussion point 2.1-3 | A quick summary for companies’ stands below:* Support to adopt the R17 CR from [1, MTK]
	+ MTK, Huawei (2)
* Not support to adopt the R17 CR:
	+ Not see why this would be a configuration NW needs UE to support: Nokia, Samsung, Ericsson (3)
	+ The UL/SUL indicator can be used by NW to resolve this issue: ZTE (1)
	+ The proposed CR indicates the same UE behavior as current spec: Qualcomm (1)

From moderator’s understanding, the proponent intends to clarify a scenario that can happen (as *pucch-Config* is an optional IE) but the corresponding UE behavior is not clearly specified in current spec* However, companies seem to have diverse understanding on current spec. To moderator, the proposed CR from MTK seems like an intuitive one if the scenario is supported, as one company (Qualcomm) thinks current spec is already interpreted that way.

Per current status, moderator hence suggests NOT to adopt the proposed CR.**Companies can still provide comments in 2nd round discussion to clarify their understanding before the email thread is closed, and moderator would capture them into the final moderator summary.** |
|  |  |  |

## For [3, 4, MTK] related to rate matching periodicity with NCD-SSB

In [3, MTK], it is mentioned that the maximum periodicity of *RateMatchPattern* is only 40ms which is less than the configurable periodicities of 80ms and 160ms for NCD-SSB. Considering trade-off between signaling overhead and specification completeness, it is proposed to add periodicities of n80 and n160 to *RateMatchPattern* to avoid unnecessary resource waste when NCD-SSB is configured with a periodicity of 80ms or 160ms at least for 15kHz and 30kHz SCS.

Proposal 1: Add periodicities of n80 and n160 to *periodicityAndPattern* in *RateMatchPattern*.

* Send LS to RAN2
* The companion draft 38.214 CR is provided in R1-2303366 [4]

Detailed spec quote and proposed CR text from [3, 4, MTK] can be found in Section 4.2 of this document. The following discussions points are devised to discuss the Proposals 1 above:

#### Discussion point 2.2-1:

**Do you support the proposal from [3, MTK] to “add periodicities of n80 and n160 to *periodicityAndPattern* in *RateMatchPattern*” (an LS to RAN2 is needed) to avoid unnecessary resource waste when NCD-SSB is configured with a periodicity of 80ms or 160ms?**

**If your answer is “No”, please assist to elaborate on the reasoning of your answer if possible.**

**If you have other views, please also elaborate.**

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| --- | --- | --- |
| **Company** | **Yes or No** | **Comment** |
| MTK | Yes | We think the proposal assists to avoid unnecessary resource waste when NCD-SSB is configured with a periodicity of 80ms or 160ms. |
| Ericsson | Rel-17: NoRel-18: Maybe | We do not think this is an essential correction for Rel-17, but we think it can be considered as a small optimization in Rel-18, and in that case, it should be discussed whether the best approach is to introduce new rate matching pattern periodicities or to introduce a new rate matching pattern which is exactly SSB. |
| Qualcomm |  | Since the overhead difference between periodicities of 40ms vs 80ms/160ms is not high, the proposal would be a nice-to-have feature. We are open to discuss this, but if RAN1 decides to support the new longer periodicities, not only RRC parameters, but also UE capabilities need to be considered. |
| Nokia, NSB | Rel-17: No, this is not an essential correction.Rel-18: Still, this is new functionality (would belong to TEI18), not a correction. | While it is true that being able to rate-match the UEs not using NCD-SSB around NCB-SSB with all periodicities would be a nice-to-have feature, the possible introduction of NCD-SSB to the system needs to work with the existing UE base. The incentive of implementing additional optional feature for the regular UEs to reduce the penalty of the NCD-SSB (if ever deployed at all, and if so, with periodicity of 80 or 160 ms) can be assumed to be low. And due to this the likelihood for networks implementing this can be assumed to be even lower just for a saving of a fraction of percent for those UEs while the system gain would be an order of magnitude smaller. So we view this more as specification “for completeness of the specification itself rather than specification for implementation.Agree with Qualcomm that additional UE capability would be a must, if this is agreed to, but the motivation for doing so doesn’t seem to be that clear. |
| ZTE | Open | We are open with this proposal. However, shouldn’t we introduce a corresponding UE feature for this longer periodicity? Otherwise, how can the gNB tell which UE supports this longer periodicity or not? |
| MTK (moderator) | Summary for Discussion point 2.2-1 | A quick summary for companies’ stands below:* Fine to “add periodicities of n80 and n160 to *periodicityAndPattern* in *RateMatchPattern*” **in R17**
	+ MTK, Qualcomm, ZTE (3)
		- New UE capability needed
* Not fine for R17, but may be fine for R18:
	+ Nokia, Ericsson (2)
		- A nice-to-have feature but not essential correction for Rel-17
		- Can be discussed in R18 (say TEI or RedCap related agenda)

Moderator hence suggests NOT to adopt the proposed CR in Rel-171. Proponent can try to propose it in R18 per companies’ input

**This discussion point can be closed.** |

#### Discussion point 2.2-2:

**If you answer to Discussion point 2.2-1 is “Yes”, are you fine with the proposed draft 38.214 CR provided in R1-2303366 [4, MTK] (CR text from [4, MTK] can be found in Section 4.2 of this document)?**

**If your answer is “Not fine”, please assist to elaborate on your reason and suggested revision if possible.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Fine or Not fine** | **Comment** |
| MTK | Fine |  |
| Ericsson | Rel-17: NoRel-18: Maybe | We do not think this is an essential correction for Rel-17, but we think it can be considered as a small optimization in Rel-18, and in that case, it should be discussed whether the best approach is to introduce new rate matching pattern periodicities or to introduce a new rate matching pattern which is exactly SSB. |
| Qualcomm |  | If RAN1 decides to introduce the new periodicities, corresponding UE capabilities are necessary. |
| Nokia, NSB | Not at this time | This would be a TEI18 item to compete with other TEI18 items, not a correction under “Others”. Agree with Qualcomm that a UE capability for the new values would be necessary. |
| ZTE |  | If UE capability is introduced, then the CR may need updates.  |
| Huawei |  | Although we agree with the potential benefits, for R17, the change may require ASN.1 impact – both RRC and UE capabilities.  |
| MTK (moderator) | Summary for Discussion point 2.2-2 | Same summary as Discussion point 2.2-1.**This discussion point can be closed.** |

## For [5, Qualcomm] related to value range of A-CSI-RS triggering offset

In [5], it is mentioned that TS 38.331 specifies three RRC parameters for aperiodic CSI-RS triggering offset, *aperiodicTriggeringOffset*, *aperiodicTriggeringOffset-r16*, and *aperiodiTriggeringOffset-r17*, as follows.

|  |  |
| --- | --- |
| NZP-CSI-RS-ResourceSet ::= SEQUENCE {[…] aperiodicTriggeringOffset INTEGER(0..6) OPTIONAL, -- Need S[…] aperiodicTriggeringOffset-r16 INTEGER(0..31) OPTIONAL -- Need S[…] aperiodicTriggeringOffset-r17 INTEGER (0..124) OPTIONAL, -- Need S[…]}

|  |
| --- |
| ***aperiodicTriggeringOffset, aperiodicTriggeringOffset-r16, aperiodicTriggeringOffset-r17***Offset X between the slot containing the DCI that triggers a set of aperiodic NZP CSI-RS resources and the slot in which the CSI-RS resource set is transmitted. For *aperiodicTriggeringOffset*, the value 0 corresponds to 0 slots, value 1 corresponds to 1 slot, value 2 corresponds to 2 slots, value 3 corresponds to 3 slots, value 4 corresponds to 4 slots, value 5 corresponds to 16 slots, value 6 corresponds to 24 slots. For *aperiodicTriggeringOffset-r16* and *aperiodicTriggeringOffset-r17*, the value indicates the number of slots. *aperiodicTriggeringOffset-r17* is applicable to SCS 480 kHz and 960 kHz, and only the values of integer multiples of 4 are valid, i.e. 0, 4, 8, and so on. The network configures only one of the fields. When neither field is included, the UE applies the value 0. |

 |

(The related RAN1 38.214 specification for aperiodic CSI-RS triggering with an offset is detailed in Section 4.3 of this document.)

For the aperiodic CSI-RS triggering offset, **two issues are identified**:

**Issue 1: Extended value range for aperiodic CSI-RS triggering offset requires UE to support *crossSlotScheduling-r16***

Two separate agreements related to value range of aperiodic CSI-RS triggering offset in Rel-16 from

* “cross-slot scheduling for UE power saving” in RAN1#100bis and
* “aperiodic CSI-RS when the triggering PDCCH and the CSI-RS have different numerologies” in RAN1 #100

are shown below:

|  |
| --- |
| Agreements: (RAN1#100bis)[…]* Aperiodic CSI-RS triggering offset value range is extended from {0, 1, 2, 3, 4, 16, 24} to {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24}

[…] |
| Agreements: (RAN1#100)When µPDCCH < µCSI-RS, X∈{0, 1, …, 31} |

However, TS 38.306 specifies a single UE capability to address the extended value range for aperiodic CSI-RS triggering offset. That is *crossSlotScheduling-r16* as follows.

| ***crossSlotScheduling-r16***Indicates whether UE supports dynamic indication of applicable minimum scheduling restriction by DCI format 0\_1 and 1\_1, and the minimum scheduling offset for PDSCH and aperiodic CSI-RS triggering offset (K0), and PUSCH (K2), and the extended value range for aperiodic CSI-RS triggering offset. Support of this feature is reported for licensed and unlicensed bands, respectively. When this field is reported, either of *non-SharedSpectrumChAccess-r16* or *sharedSpectrumChAccess-r16* shall be reported, at least. | UE | No | No | No |
| --- | --- | --- | --- | --- |

**Observation**:

* It is unclear what “the extended value range for aperiodic CSI-RS triggering offset” means and which RAN1 agreement it maps to (the one from RAN1#100bis or the one from RAN1 #100). It should be noted that the RAN1 #100 agreement is only for cross-carrier A-CSI-RS triggering with PDCCH of lower SCS to A-CSI-RS of higher SCS.
* It is unclear whether/how *crossSlotScheduling-r16* is required to be supported for extended value range for aperiodic CSI-RS triggering offset for FR2-2

**Issue 2: R16 parameter (or R17 parameter) seems applicable to the UEs that do not support the extended value range for aperiodic CSI-RS offset**

**Observation**: It seems not clear for which UE the parameter *aperiodicTriggeringOffset-r16* is configurable.

* For example, it is possible to interpret the spec such that a UE not supporting extended value range for aperiodic CSI-RS triggering offset (e.g., a UE not indicating support of *crossSlotScheduling-r16*) can be provided the aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* as long as the value is from {0, 1, 2, 3, 4, 16, 24}.
* Similarly, one may read the spec such that a UE not supporting FR2-2 can be provided the aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* as long as the value is from the value range the UE supports (e.g., {0, 1, 2, 3, 4, 16, 24} or {0, 1, …, 31}.

To resolve the above two issues, it is proposed in [5, Qualcomm] to introduce a new Rel-17 UE capability that indicates supported value range, RRC parameter, and {$μ\_{PDCCH}, μ\_{CSIRS}$}.

**Proposal A:**

* Introduce new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset for $μ\_{CSIRS}\leq 3$”
	+ Per-FS
	+ UE indicates support for one or multiple from the following:
		- Value range {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{PDCCH}=μ\_{CSIRS}\leq 3$
		- Value range {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{CSIRS}<μ\_{PDCCH}\leq 3$
		- Value range {0, 1, …, 31} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{PDCCH}<μ\_{CSIRS}\leq 3$
* Introduce new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset for $μ\_{CSIRS}=5 or μ\_{CSIRS}=6$”
	+ Per-FS
	+ UE indicates support for one or multiple from the following:
		- Value range {0, 4, 8, 12, …, 60, 64, 96} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for $μ\_{PDCCH}=μ\_{CSIRS}$ and $μ\_{CSIRS}=5$ or $μ\_{CSIRS}=6$
		- Value range {0, 4, 8, 12, …, 60, 64, 96} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for $μ\_{CSIRS}<μ\_{PDCCH}$ and $μ\_{CSIRS}=5$ or $μ\_{CSIRS}=6$
		- Value range {0, 4, 8, …, 124} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for $μ\_{PDCCH}<μ\_{CSIRS}$ and $μ\_{CSIRS}=5$ or $μ\_{CSIRS}=6$

The following discussions points are devised to discuss the Proposals A above:

#### Discussion point 2.3-1:

**Do you support the proposal A from [5, Qualcomm] to introduce new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset for** $\{μ\_{CSIRS}\leq 3$**} and {**$μ\_{CSIRS}=5 or μ\_{CSIRS}=6$**”} to resolve Issue 1 and Issue 2 listed above?**

**If your answer is “No”, please assist to elaborate on the reasoning of your answer if possible, and how the identified ambiguity (observation) in Issue 1 and Issue 2 described above can be addressed by current spec.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comment** |
| MTK | Yes | The proposal seems to resolve Issue 1 and Issue 2 nicely. |
| Qualcomm | Yes | The issues are quite clear. We think introducing new UE capabilities is the reasonable approach to address them. |
| Nokia, NSB | Support doing something to fix the issue. | We agree that the extended range for *aperiodicTriggeringOffset-r16* linkage to UE capability is not clear and it should be clarified. Furthermore we believe that the lifting of “if all the associated trigger states do not have the higher layer parameter *qcl-Type* set to 'typeD' in the corresponding TCI states, the CSI-RS triggering offset is fixed to zero.” limitation for configuring a CSI triggering offset should have been dropped in Rel-16. So we’d suggest adding a bullet* When the *aperiodicTriggeringOffset-r16* or *-r17* is configured, the configured value is applied regardless of whether or not all the associated trigger states do not have the higher layer parameter *qcl-Type* set to 'typeD' in the corresponding TCI states

However, we don’t agree that the UE capability is “support for one or multiple”, but for the 1st part:1. Value range {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{PDCCH}=μ\_{CSIRS}\leq 3$
2. Value range {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{CSIRS}<μ\_{PDCCH}\leq 3$
3. Value range {0, 1, …, 31} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{PDCCH}<μ\_{CSIRS}\leq 3$

We’d suggest that the combinations are limited: The UE supports either none, 1, 1&2 or 1&2&3.The same would apply also for the second part. |
| Ericsson2 |  | Some initial comments from us below. One aspect to consider is that for *crossSlotScheduling-r16* the only interpretation for extended value range for offset would be *aperiodicTriggeringOffset-r16* since the r16 feature could not anyway account for the support of future release parameter (*aperiodicTriggeringOffset-r17*).Regarding Issue 1, we do not think “*Extended value range for aperiodic CSI-RS triggering offset requires UE to support crossSlotScheduling-r16*”. Since the original RRC parameter (*aperiodicTriggeringOffset-r16)* was introduced for cross-carrier A-CSI-RS triggering, a UE indicating *crossCarrierA-CSI-trigDiffSCS-r16* would also support the *aperiodicTriggeringOffset-r16* is reasonable*.* Would there be an issue with such interpretation?Regarding issue 2, a UE supporting *crossSlotScheduling*-r16 or *crossCarrierA-CSI-trigDiffSCS-r16* can be configured with *aperiodicTriggeringOffset-r16*. Would there be an issue with such interpretation?Below text is captured in 38.331. Thus, it seems not possible to provide *aperiodicTriggeringOffset-r17* to a UE not supporting FR2-2. Perhaps proponent can clarify whether/how it would be possible?*aperiodicTriggeringOffset-r17* is applicable to SCS 480 kHz and 960 kHz, and only the values of integer multiples of 4 are valid, i.e. 0, 4, 8, and so on. |
| ZTE | No | We are fine with the intention to clarify this issue. However, we don’t think new UE capability is needed. The proposal can be updated as following.**Proposed conclusion*** Clarify “extended value range for aperiodic CSI-RS triggering offset for $μ\_{CSIRS}\leq 3$” as following
	+ - Value range {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{PDCCH}=μ\_{CSIRS}\leq 3$
		- Value range {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{CSIRS}<μ\_{PDCCH}\leq 3$
		- Value range {0, 1, …, 31} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{PDCCH}<μ\_{CSIRS}\leq 3$
* Clarify “extended value range for aperiodic CSI-RS triggering offset for $μ\_{CSIRS}=5 or μ\_{CSIRS}=6$” as following
	+ - Value range {0, 4, 8, 12, …, 60, 64, 96} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for $μ\_{PDCCH}=μ\_{CSIRS}$ and $μ\_{CSIRS}=5$ or $μ\_{CSIRS}=6$
		- Value range {0, 4, 8, 12, …, 60, 64, 96} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for $μ\_{CSIRS}<μ\_{PDCCH}$ and $μ\_{CSIRS}=5$ or $μ\_{CSIRS}=6$
		- Value range {0, 4, 8, …, 124} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for $μ\_{PDCCH}<μ\_{CSIRS}$ and $μ\_{CSIRS}=5$ or $μ\_{CSIRS}=6$

Based on our understanding, * if UE supports cross-slot scheduling, it can support {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24}
* if UE supports cross-carrier triggering for A-CSI-RS, it can support {0, 1, …, 31}
 |
| Qualcomm | Replies to comments | @Nokia:Thanks for the flexibility. If we need to limit the combinations of the UE capability, we would rather prefer “none, 3-only, 1-only, 1&2, 1&2&3”. We would like to enable indication of support 3 only - the reason is that 3 is mainly for A-CSI-RS triggering for cross-numerology (from low-to-high) while 1&2 are for A-CSI-RS triggering with cross-slot scheduling.However, given the maximum number of combinations is up to 8 (including none), the signalling reduction by limiting the combination is not much significant. So, we wonder whether full flexibility (any combination of 1 / 2 / 3 or none) would be acceptable?@EricssonIt makes sense to assume that *crossSlotScheduling-r16* does not indicate support of extended value range for A-CSI-RS triggering offset by *aperiodicTriggeringOffset-r17*. However, in this case there is no corresponding UE capability for *aperiodicTriggeringOffset-r17*. In our understanding, it is anyway necessary to address the capability for *aperiodicTriggeringOffset-r17*.Regarding whether the existing UE capability *crossCarrierA-CSI-trigDiffSCS-r16* indicates support of extended value range for *aperiodicTriggeringOffset-r16*, this is not preferable for us. The agreement for cross-numerology A-CSI-RS triggering offset in Rel-16 was to support {0, 1, …, 31} only when SCS of PDCCH is lower than SCS of CSI-RS, which is unclear from the description on *crossCarrierA-CSI-trigDiffSCS-r16* where a UE can indicate support of cross-numerology A-CSI-RS triggering from low-to-high SCS, high-to-low SCS, or both. Clarifying this (extended value ranges only for low-to-high) for Rel-16 would be too much as a maintenance.Regarding *aperiodicTriggeringOffset-r17* is applicable to SCS 480kHz and 960kHz, yes, this is captured in 38.331. Nevertheless, we consider the explicit UE capability signalling for this makes sense and the capability structure can follow the proposed Rel-17 new capability for *aperiodicTriggeringOffset-r16*.@ZTEWe do have a problem to say per-UE capability *crossSlotScheduling-r16* indicates support of extended value ranges for A-CSI-RS triggering offset for all the bands/band-combinations with low-to-high SCS, high-to-low SCS, same SCS. For other aspects, please see replies to Ericsson above. Essentially, the current capability formulation is quite weird and hence causes issue for implementing R16 cross-numerology A-CSI-RS triggering (or R16 UE power saving or R17 FR2-2). |
| Huawei, HiSilicon2 |  | For the issue 1, we think the extended value range of *aperiodicTriggeringOffset* is one of the components of cross slot scheduling introduced in r16 for power saving purpose. No need to split it from the ***crossSlotScheduling-r16.*** For the further extension value range due to mixed numerologies, gNB can determine the capability from the ***crossCarrierA-CSI-trigDiffSCS-r16***. So, there is no ambiguity between gNB and UE which value range should be used for r16 UE.For FR2-2, we do not think additional UE capability is required either. The design of FR2-2 is striving to have as many commonalities as FR2-1 as possible. So RAN1 only introduce UE feature significant different from existing design. The value range of *aperiodicTriggeringOffset-r17* is directly generated from those for 120kHz by multiplying 4, in order to keep similar absolute processing delay. So, we assume the capability of ***crossSlotScheduling-r16/crossCarrierA-CSI-trigDiffSCS-r16*** can be reused. The support of 480/960kHz SCS are reported with ***dl-FR2-2-SCS-480kHz-r17*** and ***dl-FR2-2-SCS-960kHz-r17*** in general.Considering the above, we do not think it is necessary to introduce specific UE capability for *aperiodicTriggeringOffset* in rel-16 and rel-17. |
| Qualcomm | Reply to comment | @HuaweiExtended value range for A-CSI-RS triggering offset was agreed for two independent purpose for two different WIs:

|  |
| --- |
| Agreements (for UE power saving, at RAN1#100bis):[…]* Aperiodic CSI-RS triggering offset value range is extended from {0, 1, 2, 3, 4, 16, 24} to {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24}

[…] |

|  |
| --- |
| Agreements (for CA/DC enhancements, at RAN1#100):When µPDCCH < µCSI-RS, X∈{0, 1, …, 31} |

The “extended value range for A-CSI-RS triggering offset” is a component of per-UE capability *crossSlotScheduling-r16*. There is a per-BC capability for cross-numerology A-CSI-RS triggering, *crossCarrierA-CSI-trigDiffSCS-r16*, which does not contain extended value range for A-CSI-RS triggering offset. The “extended value range for A-CSI-RS triggering offset” is a component of per-UE capability *crossSlotScheduling-r16*. There is a per-BC capability for cross-numerology A-CSI-RS triggering, *crossCarrierA-CSI-trigDiffSCS-r16*, which does not contain a component of “extended value range for A-CSI-RS triggering offset”. Then, for a UE supporting *crossCarrierA-CSI-trigDiffSCS-r16* for low-to-high SCS (but not supporting *crossSlotScheduling-r16*), how can we avoid ambiguity of the value range of *aperiodicTriggeringOffset* for the UE?Regarding Rel-17 parameter and the value range for A-CSI-RS triggering for {low-to-high SCS, high-to-low SCS, and same SCS}, could you elaborate which UE capability indicates support for that? |
| MTK (moderator) | Summary for Discussion point 2.3-1 | A quick summary for companies’ stands below:* Fine to introduce new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset”
	+ MTK, Qualcomm, Nokia (3)
		- Nokia: Need to limit the UE capability combinations
* Not fine to introduce new Rel-17 UE capability:
	+ ZTE, Huawei (2)
		- UE should support all the proposed UE capabilities in R17 already
* Need further clarification on the proposed UE capability:
	+ Ericsson (1)

It seems we may need a 2nd round discussion as there are some new arguments made from the proponent:Considering the following RRC parameters, RAN1 agreements, and only one UE capability to indicate “extended value range for aperiodic CSI-RS triggering offset”, two ambiguities 1) and 2) seem to exist in current spec:

|  |
| --- |
| aperiodicTriggeringOffset INTEGER(0..6) aperiodicTriggeringOffset-r16 INTEGER(0..31) aperiodicTriggeringOffset-r17 INTEGER (0..124) |
| Agreements (for UE power saving, at RAN1#100bis):* Aperiodic CSI-RS triggering offset value range is extended from {0, 1, 2, 3, 4, 16, 24} to {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24}
 |
| Agreements (for CA/DC enhancements, at RAN1#100):When µPDCCH < µCSI-RS, X∈{0, 1, …, 31} |
| ***crossSlotScheduling-r16*** (per UE capability)Indicates whether UE supports dynamic indication of applicable minimum scheduling restriction by DCI format 0\_1 and 1\_1, and the minimum scheduling offset for PDSCH and aperiodic CSI-RS triggering offset (K0), and PUSCH (K2), and the extended value range for aperiodic CSI-RS triggering offset. … |

1. The “extended value range for A-CSI-RS triggering offset” is a component of per-UE capability *crossSlotScheduling-r16*. There is a per-BC capability for cross-numerology A-CSI-RS triggering, *crossCarrierA-CSI-trigDiffSCS-r16*, which does not contain extended value range for A-CSI-RS triggering offset. For a UE supporting *crossCarrierA-CSI-trigDiffSCS-r16* for low-to-high SCS (but not supporting *crossSlotScheduling-r16*), it is not clear what value range of *aperiodicTriggeringOffset-r16* should be supported by the UE.
2. Regarding Rel-17 parameter and the value range for A-CSI-RS triggering for {low-to-high SCS, high-to-low SCS, and same SCS}, it is not clear which UE capability indicates support of the corresponding value range of *aperiodicTriggeringOffset-r17*.

**Please continue the discussion under (2nd round) Discussion point 2.3-1-2**.  |

#### (2nd round) Discussion point 2.3-1-2:

**Do you support the proposal A-1 below to introduce new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset for** $\{μ\_{CSIRS}\leq 3$**} and {**$μ\_{CSIRS}=5 or μ\_{CSIRS}=6$**”} to resolve the following two ambiguities?**

1. **The “extended value range for A-CSI-RS triggering offset” is a component of per-UE capability *crossSlotScheduling-r16*. There is a per-BC capability for cross-numerology A-CSI-RS triggering, *crossCarrierA-CSI-trigDiffSCS-r16*, which does not contain extended value range for A-CSI-RS triggering offset. For a UE supporting *crossCarrierA-CSI-trigDiffSCS-r16* for low-to-high SCS (but not supporting *crossSlotScheduling-r16*), it is not clear what value range of *aperiodicTriggeringOffset-r16* should be supported by the UE.**
2. **Regarding Rel-17 parameter and the value range for A-CSI-RS triggering for {low-to-high SCS, high-to-low SCS, and same SCS}, it is not clear which UE capability indicates support of the corresponding value range of *aperiodicTriggeringOffset-r17*.**

**Proposal A-1:**

* **Introduce new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset for** $μ\_{CSIRS}\leq 3$**”**
	+ **Per-FS**
	+ **UE indicates support for “none, 3-only, 1-only, 1&2, 1&2&3” from the following:**
		1. **Value range {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for** $μ\_{PDCCH}=μ\_{CSIRS}\leq 3$
		2. **Value range {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for** $μ\_{CSIRS}<μ\_{PDCCH}\leq 3$
		3. **Value range {0, 1, …, 31} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for** $μ\_{PDCCH}<μ\_{CSIRS}\leq 3$
	+ **When the *aperiodicTriggeringOffset-r16* or *aperiodicTriggeringOffset-r17* is configured, the configured value is applied regardless of whether or not all the associated trigger states do not have the higher layer parameter *qcl-Type* set to 'typeD' in the corresponding TCI states**
* **Introduce new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset for** $μ\_{CSIRS}=5 or μ\_{CSIRS}=6$**”**
	+ **Per-FS**
	+ **UE indicates support for “none, 3-only, 1-only, 1&2, 1&2&3” from the following:**
		1. **Value range {0, 4, 8, 12, …, 60, 64, 96} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for** $μ\_{PDCCH}=μ\_{CSIRS}$ **and** $μ\_{CSIRS}=5$ **or** $μ\_{CSIRS}=6$
		2. **Value range {0, 4, 8, 12, …, 60, 64, 96} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for** $μ\_{CSIRS}<μ\_{PDCCH}$ **and** $μ\_{CSIRS}=5$ **or** $μ\_{CSIRS}=6$
		3. **Value range {0, 4, 8, …, 124} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for** $μ\_{PDCCH}<μ\_{CSIRS}$ **and** $μ\_{CSIRS}=5$ **or** $μ\_{CSIRS}=6$
	+ **When the *aperiodicTriggeringOffset-r16* or *aperiodicTriggeringOffset-r17* is configured, the configured value is applied regardless of whether or not all the associated trigger states do not have the higher layer parameter *qcl-Type* set to 'typeD' in the corresponding TCI states**

**If your answer is “No”, please assist to elaborate on the reasoning of your answer if possible, and how the identified ambiguity of 1) and 2) described above can be addressed by current spec.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes or No** | **Comment** |
| MTK | Yes | We can accept Proposal A-1, considering the following RRC parameters, RAN1 agreements, and only one UE capability to indicate “extended value range for aperiodic CSI-RS triggering offset” in current spec.

|  |
| --- |
| aperiodicTriggeringOffset INTEGER(0..6) aperiodicTriggeringOffset-r16 INTEGER(0..31) aperiodicTriggeringOffset-r17 INTEGER (0..124) |
| Agreements (for UE power saving, at RAN1#100bis):* Aperiodic CSI-RS triggering offset value range is extended from {0, 1, 2, 3, 4, 16, 24} to {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24}
 |
| Agreements (for CA/DC enhancements, at RAN1#100):When µPDCCH < µCSI-RS, X∈{0, 1, …, 31} |
| ***crossSlotScheduling-r16*** (per UE capability)Indicates whether UE supports dynamic indication of applicable minimum scheduling restriction by DCI format 0\_1 and 1\_1, and the minimum scheduling offset for PDSCH and aperiodic CSI-RS triggering offset (K0), and PUSCH (K2), and the extended value range for aperiodic CSI-RS triggering offset. … |

 |
| ZTE |  | To further clarify our understanding of this issue.Our understanding about the value ranges for A-CSI-RS triggering for $μ\_{CSIRS}\leq 3$ is as following. It seems the spec and UE capability are clear. We are not sure what the issue is. Did we miss anything here?

|  |  |  |
| --- | --- | --- |
| UE capability for:cross-carrier A-CSI-RS triggering | UE capability for:cross-slot scheduling | value range |
| low-to-high | support | {0, 1, …, 31} |
| same SCS | support | {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} |
| high to low | support | {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} |
| low-to-high | not support | {0, 1, …, 31} |
| same SCS | not support | {0, 1, 2, 3, 4, 16, 24} |
| high to low | not support | {0, 1, 2, 3, 4, 16, 24} |

If there is any potential confusion for $μ\_{CSIRS}=5 or μ\_{CSIRS}=6$**,** we propose to discuss it under FR2-2 maintenance.  |
| Qualcomm | Yes | Agree with MTK. Unless this is resolved, the Rel-16 feature cross-numerology A-CSI-RS triggering with different SCS with extended value range for A-CSI-RS triggering offset cannot be supported, although we are supporting various CA configurations with different numerologies in market.@ZTE:As we have pointed out, we do not find “extended value range for A-CSI-RS triggering offset for low-to-high SCS” in the existing Rel-16 UE capability *crossCarrierA-CSI-trigDiffSCS-r16*. Changing Rel-16 spec / UE capability is not a good approach as we are now in Rel-18 timeframe.For $μ\_{CSIRS}=5 or μ\_{CSIRS}=6$, it is an issue that the UE capability to indicate support of extended value ranges itself does not exist. We think it is preferred to take the unified approach to resolve both cases $μ\_{CSIRS}\leq 3$ and $μ\_{CSIRS}=5 or μ\_{CSIRS}=6$. |
| Huawei, HiSilicon |  | We shared the similar view as ZTE on the table of value range mapping for SCS not larger than 120kHz. For 480kHz and 960kHz, there are capabilities for UE to report support of 480kHz SCS and 960kHz, i.e. ***dl-FR2-2-SCS-480kHz-r17*** and ***dl-FR2-2-SCS-960kHz-r17***. If you check UE feature for FR2-2, only FGs which is significantly changed from those in other FRs are introduced. So similar mapping table can be provided as below.

|  |  |  |  |
| --- | --- | --- | --- |
| crossCarrierA-CSI-trigDiffSCS-r16 | crossSlotScheduling-r16 | dl-FR2-2-SCS-480kHz-r17 or dl-FR2-2-SCS-960kHz-r17 | value range |
| low-to-high | support | support | {0, 4, 8, …, 124} |
| same SCS | support | support | {0, 4, 8, 12, …, 60, 64, 96} |
| high to low | support | support | {0, 4, 8, 12, …, 60, 64, 96} |
| low-to-high | not support | support | {0, 4, 8, …, 124} |
| same SCS | not support | support | {0, 4, 8, 12, …, 60, 64, 96} |
| high to low | not support | support | {0, 4, 8, 12, …, 60, 64, 96} |

As for the last two rows highlighted, there is no differentiation for UE with/without UE capability of *crossSlotScheduling-r16* when extending the value range of *aperiodicTriggeringOffset* during WI discussion*.* Thus, we assume same value range should be used irrespective of the report of crossSlotScheduling-r16. If necessary, we can ask for clarification in FR2-2 maintenance. |
| Ericsson3 |  | We are open to clarifications via capability. Some additional comments/questions below. * + 1. Regarding 3rd sub-bullets of the two main bullets, 3rd bullet proposal seems to imply RAN1 spec changes are needed, for example, to the below sentence from existing spec 38.214. Can it be clarified if this is intention of the proposal?

If the UE is not configured with *minimumSchedulingOffsetK0* for any DL BWP and *minimumSchedulingOffsetK2* for any UL BWP and if all the associated trigger states do not have the higher layer parameter *qcl-Type* set to 'typeD' in the corresponding TCI states, the CSI-RS triggering offset is fixed to zero.* + 1. Regarding 3rd sub-bullets, given below text from 38.331, can it be clarified which parameter “-r16” or “-r17” applies to which numerologies (FR2-2 and non-FR2-2 numerologies).

*aperiodicTriggeringOffset-r17* is applicable to SCS 480 kHz and 960 kHz, and only the values of integer multiples of 4 are valid, i.e. 0, 4, 8, and so on.* + 1. Regarding the capabilities, per-FS granularity seems excessive. Per BC indication seems sufficient since it is simply a UE being able to support an RRC parameter - UE can still indicate support or not for each of the different SCS cases. Can it also be clarified why UE indicates new capability with ‘none’ as the setting?
		2. For SCS of 480/960 kHz, we would be OK to leave it to FR2-2 maintenance discussion.
 |
| ZTE |  | responses to previous comments @QualcommMaybe we have different understandings. Based on our understanding, if something is specified in the spec but without detailed UE capability, then it means it should be supported by the UE by default. For this particular issue, the value range forµPDCCH < µCSIRS has been specified in the following spec. In this sense, if there is no specific UE FG for this range, then it should be supported by default if UE reports *crossCarrierA-CSI-trigDiffSCS-r16* indicating low-to-high.*The CSI-RS triggering offset has the values of {0, 1, …, 31} slots for* $μ\_{CSIRS}\leq 3$ *or {0, 4, 8, …, 124} slots for* $μ\_{CSIRS}=5$ *and* $μ\_{CSIRS}=6$ *when the µPDCCH < µCSIRS and {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for* $μ\_{CSIRS}\leq 3$ *or {0, 4, 8, 12, …, 60, 64, 96} slots for* $μ\_{CSIRS}=5$ *and* $μ\_{CSIRS}=6$ *when the µPDCCH > µCSIRS..* |
| MTK (moderator) | Temporary summary for Discussion point 2.3-1-2 | It seems for now companies’ stands are still not changed from 1st round discussion:* Fine to introduce new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset”
	+ MTK, Qualcomm, Nokia (3)
* Not fine to introduce new Rel-17 UE capability:
	+ ZTE, Huawei (2)
* Need further clarification on the proposed UE capability: (may be fine with per BC)
	+ Ericsson (1)

**Main argument from Qualcomm**:* “Extended value range for A-CSI-RS triggering offset for low-to-high SCS” is not included in the description of existing Rel-16 UE capability *crossCarrierA-CSI-trigDiffSCS-r16* and it should be clarified.

**Main argument from ZTE/Huawei**: (with expected UE behavior tabulated in their comment)* If something is specified in the spec but without detailed UE capability, then it should be supported by the UE by default. For this extended value range of A-CSI-RS triggering offset, it should be supported by default if UE reports *crossCarrierA-CSI-trigDiffSCS-r16* indicating low-to-high.

@all companies: **Please continue to discuss/comment** on the argument from both sides to **see whether a consensus can be achieved**. Also **welcomed to provide comment on Ericsson’s queries**.@Ericsson: For your comments:1. The intention of adding the 3rd sub-bullet is to address previous Nokia’s comment:
	* Furthermore we believe that the lifting of “if all the associated trigger states do not have the higher layer parameter *qcl-Type* set to 'typeD' in the corresponding TCI states, the CSI-RS triggering offset is fixed to zero.” limitation for configuring a CSI triggering offset should have been dropped in Rel-16. So we’d suggest adding a bullet.
2. My current understanding is “-r16” applies to FR2-2 and non-FR2-2, and “-r17” only applies to FR2-2, but I also feel current spec is not written in a crystal clear way.
3. Indication of “none” is proposed previous by Qualcomm during negotiation with Nokia. I think the intention is to allow UE to support only R15 value range. As for per FS or per BC, we can discuss it later if this new capability is acceptable to all companies.
4. Also ok for us.
 |
| Nokia, NSB | Yes | We’d be OK with the capability indication and capability grouping as formulated in A-1  |
| Qualcomm |  | **Regarding the 3rd sub-bullet (proposed by Nokia, asked by Ericsson)**Thanks, Ericsson3 for pointing it out. Indeed, the 3rd sub-bullet would require RAN1 spec change (though originally we are striving for avoiding spec change and putting all the clarifications in UE capability description..). We should be careful to avoid NBC issue in this case.In addition, the 3rd sub-bullet would bring another issue: whether the UE indicating support of this new Rel-17 UE capability is allowed to indicate support of lifting the restriction or not. We think this should be possible. Let us bring up one example. Suppose a UE supports DL CA band combination {FDD-15kHz + TDD-30kHz + FR2-120kHz}. The UE wants to support extended value range for A-CSI-RS triggering from FDD to FR2 (or TDD to FR2). With lifting the restriction, the UE would need to support extended value range, in addition to support of non-zero offset, from FDD to TDD in FR1. Strictly speaking, this is no longer simple clarification – rather is a new feature. We are not sure whether this is testable, when extended value range for A-CSI-RS triggering offset from FDD/TDD to FR2 is ready.In addition, it is a bit unclear for same SCS and high-to-low, in which case the restriction needs to be lifted. This should only be for low-to-high. Considering these, we now prefer to discuss “lifting the restriction” separately from the proposal on clarification for extended value range. If we have to incorporate this “lifting the restriction” in this discussion, we suggest ask proponent (Nokia) whether the following is OK:Opt.1: * Consider separate UE capability for the “lifting the restriction” from the UE capability clarifying the extended value range

Opt.2: * UE indicating the new Rel-17 UE capability clarifying the extended value range can indicate support/not-support the “lifting the restriction”

Note that in either case, “lifting the restriction” is limited to low-to-high in our understanding.**Regarding per-FS vs per-BC (comment from Ericsson3)**This also depends on whether we should incorporate the “lifting the restriction” in this UE capability. Would be better first to discuss the “lifting the restriction” part.If we do not incorporate “lifting the restriction” in this capability, if we go with per-BC, we prefer to allow a UE to indicate any combination(s) of 1, 2, and/or 3, for a given BC. |
| ZTE |  | As we have clarified in the previous round of discussion. The spec is clear, and we are not convinced that new UE capability is needed at least for $μ\_{CSIRS}\leq 3$**.**The legacy network has already implemented based on the existing spec, in which the UE will support extended triggering offset for A-CSI-RS in case of low-to-high cross-carrier triggering. If the new UE capability is introduced, it introduces different UE types (i.e., UE supporting crossCarrierA-CSI-trigDiffSCS with indicating low-to-high but not supporting extended triggering offset). To us, this is an NBC change and the new UE capability (if introduced) is an incapability. |
| Qualcomm |  | @ ZTEIn our understanding, potential backward compatibility issue by introducing the new UE capability from a network point of view is, only if the network configures FR1-FR2 CA with A-CSI-RS triggering from FR1 to FR2 using the extended value range for a UE who does not support *crossSlotScheduling-r16*. Therefore, we consider there is no real backward compatibility issue at least for network side. Please let us know otherwise.  |
| Huawei, HiSilicon |  | We shared similar view as ZTE and concern about backward compatibility issue. Assuming the FR2-2 issue will be treated separately, then the remaining part of proposal is just trying to change the existing R16 UE capability, which is far beyond the release was frozen.  |

Resulted RAN1 conclusion/agreement (phase 2)

## For [1, 2, MTK] related to SUL indicator and pusch/pucch-Config for DCI 0\_0

TBD based on outcome/situation of phase 1 discussion.

## For [3, 4, MTK] related to rate matching periodicity with NCD-SSB

TBD based on outcome/situation of phase 1 discussion.

## For [5, Qualcomm] related to value range of A-CSI-RS triggering offset

TBD based on outcome/situation of phase 1 discussion.

Summary of contribution inputs

## For [1, 2, MTK] related to SUL indicator and pusch/pucch-Config for DCI 0\_0

In [1, MTK], it is mentioned that from current spec 38.212 [6] V17.5.0 7.3.1.1.1, the determination of PUSCH transmission scheduled by DCI 0\_0 on NUL (normal uplink) or SUL seems not matching the RAN1 #90bis agreement that the default location of the PUSCH is the same carrier as used by PUCCH.

Agreement: (RAN1 #90bis)

* UE specific RRC signalling (re-)configures the location of the PUCCH, either on the SUL carrier or on a non-SUL UL carrier in a SUL band combination
	+ The default location of the PUSCH is the same carrier as used by PUCCH

Besides, there is one remaining issue not discussed during RAN1 #112:

* Only one carrier of NUL/SUL configured with *pusch-Config* but no carriers configured with *pucch-Config* (E.g. only cell-specific *pucch-ConfigCommon* is configured)

For the not matching RAN1 #90bis agreement part, the following two observations and one proposal are drawn:

**Observation 1: In 38.212 V17.5.0 7.3.1.1.1, there is related spec on the relation between SUL indicator and *pusch-Config*/*pucch-Config* for DCI 0\_0. Current spec implies the PUSCH transmission behavior on NUL (normal uplink) or SUL shown in Table 1 (prioritizing PUCCH carrier for PUSCH transmission). During RAN1 #112, this issue was discussed under R15 CR agenda (Section 7.1) and companies have diverse view on current R15 spec (some companies think it’s reasonable while some think it’s not supported).**

**Observation 2: In RAN1 #90bis, it was agreed that for UE specific RRC configuration of SUL/non-SUL UL carrier, “the default location of the PUSCH is the same carrier as used by PUCCH”.**

**Proposal 1: RAN1 to draw the following conclusion for R17:**

* **If an UL cell has NUL and SUL carrier, and *pusch-config* is configured, then the UL carrier configured with *pucch-config* should also be configured with *pusch-config***

**and sent an LS to RAN2 to clarify it in R17 38.331 spec.**



**Table 1: PUSCH transmission behavior on NUL (normal uplink) or SUL scheduled by DCI 0\_0 implied in current spec**

For the part of remaining issue not discussed during RAN1 #112, the following observation and proposal are drawn:

**Observation 3: There is one remaining issue not discussed during RAN1 #112:**

* **Only one carrier of NUL/SUL configured with *pusch-Config* but no carriers configured with *pucch-Config* (E.g. only cell-specific *pucch-ConfigCommon* is configured)**

**Looking again at the RAN1 #90bis agreement, it only regulates the UE-specific RRC configuration. Hence, for the scenario mentioned above, it seems more reasonable to transmit PUSCH on the carrier configured with *pusch-Config*.**

**Proposal 2: Adopt the following R17 CR to 38.212 V17.5.0 7.3.1.1.1 about SUL indicator and *pusch-Config*/*pucch-Config* for DCI 0\_0, to reflect the inference in Observation 3:**

**7.3.1.1 DCI formats for scheduling of PUSCH**

**7.3.1.1.1 Format 0\_0**

**…**

**- UL/SUL indicator – 1 bit for UEs configured with *supplementaryUplink* in *ServingCellConfig* in the cell as defined in Table 7.3.1.1.1-1 and the number of bits for DCI format 1\_0 before padding is larger than the number of bits for DCI format 0\_0 before padding; 0 bit otherwise. The UL/SUL indicator, if present, locates in the last bit position of DCI format 0\_0, after the padding bit(s).**

**- If the UL/SUL indicator is present in DCI format 0\_0 and the higher layer parameter *pusch-Config* is not configured on UL and SUL the UE ignores the UL/SUL indicator field in DCI format 0\_0, and the corresponding PUSCH scheduled by the DCI format 0\_0 is for the UL or SUL for which high layer parameter *pucch-Config* is configured;**

**- If the UL/SUL indicator is present in DCI format 0\_0 and the higher layer parameter *pusch-Config* is configured on only one carrier of UL or SUL, and the higher layer parameter *pucch-Config* is not configured on UL and SUL, the UE ignores the UL/SUL indicator field in DCI format 0\_0, and the corresponding PUSCH scheduled by the DCI format 0\_0 is for the UL or SUL for which high layer parameter *pusch-Config* is configured;**

**…**

## For [3, 4, MTK] related to rate matching periodicity with NCD-SSB

In [3, MTK], it is mentioned that the maximum periodicity of *RateMatchPattern* is only 40ms which is less than the configurable periodicities of 80ms and 160ms for NCD-SSB. Considering trade-off between signaling overhead and specification completeness, it is proposed to add periodicities of n80 and n160 to *RateMatchPattern* to avoid unnecessary resource waste when NCD-SSB is configured with a periodicity of 80ms or 160ms at least for 15kHz and 30kHz SCS.

Proposal 1: Add periodicities of n80 and n160 to *periodicityAndPattern* in *RateMatchPattern*.

* Send LS to RAN2
* The companion draft 38.214 CR is provided in R1-2303366 [4]

38.331:

|  |
| --- |
| *NonCellDefiningSSB* information elementNonCellDefiningSSB-r17 ::= SEQUENCE { absoluteFrequencySSB-r17 ARFCN-ValueNR, ssb-Periodicity-r17 ENUMERATED { ms5, ms10, ms20, ms40, **ms80, ms160**, spare2, spare1 } OPTIONAL, -- Need S ssb-TimeOffset-r17 ENUMERATED { ms5, ms10, ms15, ms20, ms40, ms80, spare2, spare1 } OPTIONAL, -- Need S ...} |

RateMatchPattern ::= SEQUENCE {

 rateMatchPatternId RateMatchPatternId,

 patternType CHOICE {

 bitmaps SEQUENCE {

 resourceBlocks BIT STRING (SIZE (275)),

 symbolsInResourceBlock CHOICE {

 oneSlot BIT STRING (SIZE (14)),

 twoSlots BIT STRING (SIZE (28))

 },

 periodicityAndPattern CHOICE {

 n2 BIT STRING (SIZE (2)),

 n4 BIT STRING (SIZE (4)),

 n5 BIT STRING (SIZE (5)),

 n8 BIT STRING (SIZE (8)),

 n10 BIT STRING (SIZE (10)),

 n20 BIT STRING (SIZE (20)),

 n40 BIT STRING (SIZE (40))

 }

38.214:

|  |
| --- |
| Clause 5.1.4.1 of TS 38.214The periodicityAndPattern can be {1, 2, 4, 5, 8, 10, 20 or 40} units long, but maximum of 40 msec. |

**Companion draft 38.214 CR from R1-2303366 [4]:**

**5.1.4.1 PDSCH resource mapping with RB symbol level granularity**

The procedures for PDSCH scheduled by PDCCH with DCI format 1\_1 described in this clause equally apply to PDSCH scheduled by PDCCH with DCI format 1\_2, by applying only the parameters of *rateMatchPatternGroup1DCI-1-2*, *rateMatchPatternGroup2DCI-1-2* instead of *rateMatchPatternGroup1* and *rateMatchPatternGroup2*. …

A UE may be configured with any of the following higher layer parameters indicating REs declared as not available for PDSCH:

- … A *RateMatchPattern* may contain:

- … a UE may be configured with a time-domain pattern (higher layer parameter *periodicityAndPattern* given by *RateMatchPattern*), where each bit of *periodicityAndPattern* corresponds to a unit equal to a duration of the symbol level bitmap, and a bit value equal to 1 indicates that the pair is present in the unit. The *periodicityAndPattern* can be {1, 2, 4, 5, 8, 10, 20,40, 80, or 160} units long, but maximum of 160 msec. The first symbol of *periodicityAndPattern* every 160 msec/P periods is a first symbol in frame $n\_{f}$ mod 16 = 0, where P is the duration of *periodicityAndPattern* in units of msec. When *periodicityAndPattern* is not configured for a pair, for a symbol level bitmap spanning two slots, the bits of the first and second slots correspond respectively to even and odd slots of a radio frame, and for a symbol level bitmap spanning one slot, the bits of the slot correspond to every slot of a radio frame. ...

<Unchanged texts omitted>

## For [5, Qualcomm] related to value range of A-CSI-RS triggering offset

In [5], it is mentioned that TS 38.331 specifies three RRC parameters for aperiodic CSI-RS triggering offset, *aperiodicTriggeringOffset*, *aperiodicTriggeringOffset-r16*, and *aperiodiTriggeringOffset-r17*, as follows.

|  |  |
| --- | --- |
| NZP-CSI-RS-ResourceSet ::= SEQUENCE {[…] aperiodicTriggeringOffset INTEGER(0..6) OPTIONAL, -- Need S[…] aperiodicTriggeringOffset-r16 INTEGER(0..31) OPTIONAL -- Need S[…] aperiodicTriggeringOffset-r17 INTEGER (0..124) OPTIONAL, -- Need S[…]}

|  |
| --- |
| ***aperiodicTriggeringOffset, aperiodicTriggeringOffset-r16, aperiodicTriggeringOffset-r17***Offset X between the slot containing the DCI that triggers a set of aperiodic NZP CSI-RS resources and the slot in which the CSI-RS resource set is transmitted. For *aperiodicTriggeringOffset*, the value 0 corresponds to 0 slots, value 1 corresponds to 1 slot, value 2 corresponds to 2 slots, value 3 corresponds to 3 slots, value 4 corresponds to 4 slots, value 5 corresponds to 16 slots, value 6 corresponds to 24 slots. For *aperiodicTriggeringOffset-r16* and *aperiodicTriggeringOffset-r17*, the value indicates the number of slots. *aperiodicTriggeringOffset-r17* is applicable to SCS 480 kHz and 960 kHz, and only the values of integer multiples of 4 are valid, i.e. 0, 4, 8, and so on. The network configures only one of the fields. When neither field is included, the UE applies the value 0. |

 |

The RAN1 specification for aperiodic CSI-RS triggering with an offset is specified in TS38.214 are as follows.

|  |
| --- |
| 5.2.1.5.1 Aperiodic CSI Reporting/Aperiodic CSI-RS when the triggering PDCCH and the CSI-RS have the same numerology[…]When aperiodic CSI-RS is used with aperiodic reporting, the CSI-RS offset is configured per resource set by the higher layer parameter *aperiodicTriggeringOffset* or *aperiodicTriggeringOffset-r16* or *aperiodicTriggeringOffset-r17*. The CSI-RS triggering offset has the values of {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} slots for $μ\_{CSIRS}\leq 3$ or {0, 4, 8, 12, …, 60, 64, 96} slots for $μ\_{CSIRS}=5$ and $μ\_{CSIRS}=6$, where $μ\_{CSIRS}$ is the subcarrier spacing configurations for CSI-RS. […]5.2.1.5.1a Aperiodic CSI Reporting/Aperiodic CSI-RS when the triggering PDCCH and the CSI-RS have different numerologies[…]Aperiodic CSI-RS timing:- When the aperiodic CSI-RS is used with aperiodic CSI reporting, the CSI-RS triggering offset *X* is configured per resource set by the higher layer parameter *aperiodicTriggeringOffset* or *aperiodicTriggeringOffset-r16* or *aperiodicTriggeringOffset-r17,* including the case that the UE is not configured with *minimumSchedulingOffsetK0* for any DL BWP or *minimumSchedulingOffsetK2* for any UL BWP and all the associated trigger states do not have the higher layer parameter *qcl-Type* set to 'typeD' in the corresponding TCI states. The CSI-RS triggering offset has the values of {0, 1, …, 31} slots for $μ\_{CSIRS}\leq 3$ or {0, 4, 8, …, 124} slots for $μ\_{CSIRS}=5$ and $μ\_{CSIRS}=6$ when the µPDCCH < µCSIRS and {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for $μ\_{CSIRS}\leq 3$ or {0, 4, 8, 12, …, 60, 64, 96} slots for $μ\_{CSIRS}=5$ and $μ\_{CSIRS}=6$ when the µPDCCH > µCSIRS.. The aperiodic CSI-RS is transmitted in a slot , if UE is configured with *ca-SlotOffset* for at least one of the triggered and triggering cell, and *Ks* = , otherwise, and where […] |

For the above specifications, **two issues are identified with proposed solutions**.

**Issue 1: Extended value range for aperiodic CSI-RS triggering offset requires UE to support *crossSlotScheduling-r16***

Two separate agreements related to value range of aperiodic CSI-RS triggering offset in Rel-16 from

* “cross-slot scheduling for UE power saving” in RAN1#100bis and
* “aperiodic CSI-RS when the triggering PDCCH and the CSI-RS have different numerologies” in RAN1 #100

are shown below:

|  |
| --- |
| Agreements: (RAN1#100bis)[…]* Aperiodic CSI-RS triggering offset value range is extended from {0, 1, 2, 3, 4, 16, 24} to {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24}

[…] |
| Agreements: (RAN1#100)When µPDCCH < µCSI-RS, X∈{0, 1, …, 31} |

However, TS 38.306 specifies a single UE capability to address the extended value range for aperiodic CSI-RS triggering offset. That is *crossSlotScheduling-r16* and specified as follows.

| ***crossSlotScheduling-r16***Indicates whether UE supports dynamic indication of applicable minimum scheduling restriction by DCI format 0\_1 and 1\_1, and the minimum scheduling offset for PDSCH and aperiodic CSI-RS triggering offset (K0), and PUSCH (K2), and the extended value range for aperiodic CSI-RS triggering offset. Support of this feature is reported for licensed and unlicensed bands, respectively. When this field is reported, either of *non-SharedSpectrumChAccess-r16* or *sharedSpectrumChAccess-r16* shall be reported, at least. | UE | No | No | No |
| --- | --- | --- | --- | --- |

**Observation**:

* It is unclear what “the extended value range for aperiodic CSI-RS triggering offset” means and which RAN1 agreement it maps to (the one from RAN1#100bis or the one from RAN1 #100). It should be noted that the RAN1 #100 agreement is only for cross-carrier A-CSI-RS triggering with PDCCH of lower SCS to A-CSI-RS of higher SCS.
* It is unclear whether/how *crossSlotScheduling-r16* is required to be supported for extended value range for aperiodic CSI-RS triggering offset for FR2-2

**Issue 2: R16 parameter (or R17 parameter) seems applicable to the UEs that do not support the extended value range for aperiodic CSI-RS offset**

**Observation**: The possible values for *aperiodicTriggeringOffset-r16* with µPDCCH >= µCSIRS and with µPDCCH < µCSIRS for $μ\_{CSIRS}\leq 3$ are clear from the spec. However, it is not clear for which UE the parameter *aperiodicTriggeringOffset-r16* is configurable.

* For example, it is possible to interpret the spec such that a UE not supporting extended value range for aperiodic CSI-RS triggering offset (e.g., a UE not indicating support of *crossSlotScheduling-r16*) can be provided the aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* as long as the value is from {0, 1, 2, 3, 4, 16, 24}.
* Similarly, one may read the spec such that a UE not supporting FR2-2 can be provided the aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* as long as the value is from the value range the UE supports (e.g., {0, 1, 2, 3, 4, 16, 24} or {0, 1, …, 31}.

To resolve the above two issues, it is proposed to introduce a new Rel-17 UE capability that indicates supported value range, RRC parameter, and {$μ\_{PDCCH}, μ\_{CSIRS}$}.

**Proposal:**

* Introduce new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset for $μ\_{CSIRS}\leq 3$”
	+ Per-FS
	+ UE indicates support for one or multiple from the following:
		- Value range {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{PDCCH}=μ\_{CSIRS}\leq 3$
		- Value range {0, 1, 2, 3, 4, 5, 6, …, 15, 16, 24} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{CSIRS}<μ\_{PDCCH}\leq 3$
		- Value range {0, 1, …, 31} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r16* for $μ\_{PDCCH}<μ\_{CSIRS}\leq 3$
* Introduce new Rel-17 UE capability for “extended value range for aperiodic CSI-RS triggering offset for $μ\_{CSIRS}=5 or μ\_{CSIRS}=6$”
	+ Per-FS
	+ UE indicates support for one or multiple from the following:
		- Value range {0, 4, 8, 12, …, 60, 64, 96} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for $μ\_{PDCCH}=μ\_{CSIRS}$ and $μ\_{CSIRS}=5$ or $μ\_{CSIRS}=6$
		- Value range {0, 4, 8, 12, …, 60, 64, 96} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for $μ\_{CSIRS}<μ\_{PDCCH}$ and $μ\_{CSIRS}=5$ or $μ\_{CSIRS}=6$
		- Value range {0, 4, 8, …, 124} for aperiodic CSI-RS triggering offset by *aperiodicTriggeringOffset-r17* for $μ\_{PDCCH}<μ\_{CSIRS}$ and $μ\_{CSIRS}=5$ or $μ\_{CSIRS}=6$

References

[1] R1-2303363, “On the relation between SUL indicator and pusch-Config/pucch-Config for DCI 0\_0”, MediaTek, RAN1 #112bis-e

[2] R1-2303364, “[R17] Draft 38.212 CR on SUL indicator and pusch-Config/pucch-Config for DCI 0\_0”, MediaTek, RAN1 #112bis-e

[3] R1-2303365, “On rate match pattern periodicity”, MediaTek, RAN1 #112bis-e

[4] R1-2303366, “Draft CR for 38.214 on rate match pattern periodicity”, MediaTek, RAN1 #112bis-e

[5] R1-2303565, “Clarification on A-CSI-RS triggering offset”, Qualcomm Incorporated, RAN1 #112bis-e

[6] 3GPP TS 38.212 V17.5.0, “NR; Multiplexing and channel coding”