**3GPP TSG RAN WG1 #115 R1-231nnnn**

**Chicago, USA, November 13th – November 17th, 2023**

**Agenda item:** 8.16.16

**Source:** Moderator (NTT DOCOMO, INC.)

**Title:** Summary on UE features for TEIs

**Document for:** Discussion and Decision

# **Introduction**

This document summarizes contributions submitted to AI 8.16.16 regarding UE features for TEIs.

According to the updated UE features list agreed in RAN1#114bis [1], there are following feature groups for TEI18.

* FGs for additional periodicity of the scheduling request
	+ 55-1 additionalSR-Periodicities-r18
* FGs for 1-symbol PRS
	+ 55-2a 1-symbol PRS for MG-based measurement in RRC\_CONNECTED state
	+ 55-2b 1-symbol PRS for outside MG in RRC\_CONNECTED state
	+ 55-2c 1-symbol PRS in RRC\_INACTIVE state
	+ 55-2d 1-symbol PRS for PDC
* FGs for multi-PUSCH scheduling with single DCI
	+ 55-3 Multiple PUSCHs scheduling by single DCI for non-consecutive slots in FR1
* FGs for HARQ multiplexing for PDSCH scheduling after UL grant on PUSCH
	+ 55-4a Multiplexing Type-1 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH
	+ 55-4b Multiplexing Type-2 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH
	+ 55-4c Multiplexing Type-3 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH
	+ 55-4d Determining a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant
	+ 55-4e Determining different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant
* FGs for pathloss RS updates for Type 1 CG-PUSCH
	+ 55-5 Enable MAC CE based pathloss RS updates for Type 1 CG-PUSCH
* FGs for span-based PDCCH monitoring with additional restrictions
	+ 55-6 (2, 2) span-based PDCCH monitoring with additional restriction(s)
	+ 55-6a Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells
	+ 55-6b Mix of Rel-16 PDCCH monitoring capability and Rel. 15 PDCCH monitoring capability on different carriers
	+ 55-6c Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers
	+ 55-6d Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span for MCG and for SCG when configured for NR-DC operation with Rel-16 PDCCH monitoring on all the serving cells
	+ 55-6e Number of carriers for CCE/BD scaling for MCG and for SCG when configured for NR-DC operation with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers
	+ 55-6f Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells with restriction for non-aligned span case
	+ 55-6g Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers with restriction for non-aligned span case
	+ 55-6h PDCCH repetition for Rel-16 PDCCH monitoring
* FGs for multi-DCI based multi-TRP
	+ 55-7 Two QCL TypeD for CORESET monitoring in multi-DCI based multi-TRP

# **FGs for HARQ multiplexing** **for PDSCH scheduling after UL grant on PUSCH**

In [1], FGs for HARQ multiplexing for PDSCH scheduling after UL grant on PUSCH are captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 55. TEI18 | 55-4a | Multiplexing Type-1 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-1 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where ACK/NACK is generated for the HARQ-ACK codebook including HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-11, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-1 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot. | Optional with capability signaling |
| 55. TEI18 | 55-4b | Multiplexing Type-2 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-2 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-10, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-2 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot. | Optional with capability signaling |
| 55. TEI18 | 55-4c | Multiplexing Type-3 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-3 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission | 4-1, 10-16, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-3 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot. | Optional with capability signaling |
| 55. TEI18 | 55-4d | Determining a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining a different PUCCH resource in a slot from the PUCCH resource indicated by the last DCI format before a UL grant in the slot, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | One of {FG 55-4a, 55-4b, 55-4c} | Yes | N/A | UE does not support to determine a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4e | Determining different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining different codebook size in a PUCCH slot from the size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | One of {FG 55-4a, 55-4b, 55-4c} | Yes | N/A | UE does not support to determine different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |

Following inputs are provided in contributions for the RAN1#115 meeting.

|  |  |  |
| --- | --- | --- |
| [2] | Nokia, Nokia Shanghai Bell | **Proposal for FGs 55-4a/b/c:** * Pre-requisites:
	+ Remove FG4-1. Unnecessary to list 4-1 as it is mandatory without capability and must be supported by all UEs anyway.
	+ Confirm “one of {5-17, 11-5, 11-6}” as without at least one of these the FGs 55-4a/b/c can’t be used.
	+ FG55-4a: Confirm FG4-11.
	+ FG55-4b: Confirm FG4-10.
	+ FG55-4c: Confirm FG10-16.
* Reporting granularity: Confirm “per band” and add a note: “Note: The UE indicates this capability on the downlink bands where the DCI scheduling the PDSCH can be received after the DCI scheduling the PUSCH”
* Confirm “N/A” for need for FDD/TDD differentiation
* Confirm “N/A” for need for FR1/FR2 differentiation
* Confirm “N/A” for Capability interpretation for mixture of FDD/TDD and/or FR1/FR2
* Remove square brackets from the Note “UE does not expect to determine a different ~~[~~PUCCH resource~~]~~ in a slot from the ~~[~~PUCCH resource~~]~~ determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot.”

**Proposal for FGs 55-4d/e** * Consequence if the feature is not supported by the UE: Remove the field as unnecessary
* Reporting granularity: Confirm “per band” and add a note: “Note: The UE indicates this capability on the downlink bands where the DCI scheduling the PDSCH can be received after the DCI scheduling the PUSCH and the UE supports determining different codebook size for this case”
* Confirm “N/A” for need for FDD/TDD differentiation
* Confirm “N/A” for need for FR1/FR2 differentiation
* Confirm “N/A” for Capability interpretation for mixture of FDD/TDD and/or FR1/FR2
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| [3] | ZTE | In RAN1#113, the TEI on HARQ multiplexing on PUSCH was approved with reaching the following agreements.

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| --- |
| **Agreement*** If UCI multiplexing of different priorities is not enabled, the restriction on scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions except the first repetition
* UE generates Type-1 HARQ-ACK codebook according to the existing specification with the modification of setting the actual ‘ACK/NACK’ value corresponding to PDSCH(s) scheduled after the UL grant.
* UE generates Type-2/3 HARQ-ACK codebook according to the existing specification.
	+ For Type-2 CB, UL DAI is used for generating HARQ CB.
* This feature is subject to separate UE capabilities for type-1, type-2, and type-3 codebooks.
* RRC parameter(s) to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on a PUSCH repetition except the first repetition are introduced in Rel-18.
* Note: the number of PUSCH repetitions can be scheduled/configured by gNB.
* Note: same principle of current specification which UL DAI in UL grant is applied to each PUSCH repetition is reused.
* The timeline specified in TS 38.213 Clause 9.2.5 are satisfied, i.e. between the last PDSCH and PUCCH, between the last PDCCH among UL grant /DL grant(s) and the earliest PUCCH or PUSCH

* Additional UE capabilities are introduced to support the following functions (UE will be configured by gNB to use the following features via RRC)
	+ HARQ-ACK codebook size change on a PUCCH slot
	+ PUCCH resource change on a PUCCH slot
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Based on the agreements and the agreed corresponding UE FGs, our views on the remaining issues are summarized below.* **Prerequisite FGs**
	+ FG 55-4a: the prerequisite FGs are FG 4-11 (Type 1 HARQ-ACK codebook), one of {FG 5-17 (DG PUSCH repetition A), FG 11-5 (DG PUSCH repetition B)}
		- We are ok to combine with repetition type B, though this was discussed and intent to repetition type A.
	+ FG 55-4b: the prerequisite FGs are FG 4-10 (Type 2 HARQ-ACK codebook), one of {FG 5-17 (DG PUSCH repetition A), FG 11-5 (DG PUSCH repetition B)}
	+ FG 55-4c: the prerequisite FGs are FG 10-16 (Type 3 HARQ-ACK codebook), one of {FG 5-17 (DG PUSCH repetition A), FG 11-5 (DG PUSCH repetition B)}
	+ FG 55-4d/e: the prerequisite FGs are one of {FG 55-4a, FG 55-4b, FG 55-4c}
* **Reporting granularity**
	+ The reporting granularity for the UE FGs for type-1, type-2, and type-3 codebooks could be the same as the prerequisite FG, i.e., per UE, per UE and per band, respectively.
	+ Note the reporting granularity of FG 5-17 is per UE.
* **FR or TDD/FDD differentiation**
	+ Though the targeting scenario is mainly for TDD, we are ok to also apply this to FDD, and no need to do any differentiation.
* **Whether to differentiate the PUCCH resource between a different resource in the time domain and a different resource in the frequency domain**
	+ Although it may sound reasonable that the HARQ-ACK multiplexing timeline may change only when the time domain resource of the PUCCH resource is changed, it is desirable to do such micro optimization. Otherwise we may need to further differentiate whether the starting symbol of the PUCCH resource is changed while not the duration of the PUCCH resource.

With above, we have the following proposal. ***Proposal 1: Adopt the following changes on UE FGs for the TEI on HARQ multiplexing on PUSCH.**** *The prerequisite FGs are updated as,*
	+ *~~4-1,~~ 4-11, one of {5-17, 11-5~~, 11-6~~} for FG-55-4a*
	+ *~~4-1,~~ 4-10, one of {5-17, 11-5~~, 11-6~~} for FG-55-4b*
	+ *4-1, 10-16, one of {5-17, 11-5~~, 11-6~~} for FG-55-4c*
	+ *~~4-1, 4-10~~ one of {FG 55-4a, FG 55-4b, FG 55-4c} for FG-55-4c/d*
* *The reporting granularity is*
	+ *Per UE for FG-55-4a/b*
	+ *Per band for FG-55-4c/d/e*
* *Do NOT further differentiate the UE capability depending on whether the time domain of a PUCCH resource is changed, i.e., updating the following text in ‘Note’ column as follows.*
	+ *‘UE does not expect to determine a different ~~[~~PUCCH resource~~]~~ in a slot from the ~~[~~PUCCH resource~~]~~ determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot.’*
 |
| [5] | Samsung | For the feature group 55-4a, 55-4b and 55-4c in [3], a more accurate description could be “Multiplexing Type-1/2/3 HARQ-ACK codebook in a PUSCH for PDSCHs scheduled after a UL grant”. For “Consequence if the feature is not supported by the UE”, the description of “PDSCH scheduling after a UL grant.” should be changed to “a PDSCH scheduled after the UL grant scheduling the PUSCH.” to be more accurate.In addition, for the feature group 55-4a, 55-4b and 55-4c, if there is no HARQ-ACK information determined in a slot before the UL grant, the case where a UE detects a DL DCI format coming after the UL DCI format scheduling a PUSCH repetition and the DL DCI format indicates a PUCCH transmission overlapping with the PUSCH repetition should be defined as error case. Because this case requires different HARQ-ACK codebook size change.**Proposal 2:** Adopt the following update for UE FG 55-4a, 55-4b and 55-4c.

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| --- | --- | --- | --- |
| **Index** | **Feature group** | **Consequence if the feature is not supported by the UE** | **Note** |
| 55-4a | Multiplexing Type-1 HARQ-ACK codebook in a PUSCH for PDSCH ~~scheduling~~ scheduled after UL grant ~~on PUSCH~~ | UE does not support to multiplex Type-1 HARQ-ACK codebook ~~on non-initial~~ in a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for a PDSCH ~~scheduling~~ scheduled after ~~a~~ the UL grant scheduling the PUSCH. | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot.UE does not expect to detect a DL DCI format coming after a UL grant and the DL DCI format indicates a PUCCH transmission overlapping with the PUSCH repetition and there is no PUCCH with HARQ-ACK overlapping with the PUSCH repetition before detecting the DL DCI format. |
| 55-4b | Multiplexing Type-2 HARQ-ACK codebook in a PUSCH for PDSCH ~~scheduling~~ scheduled after UL grant ~~on PUSCH~~ | UE does not support to multiplex Type-2 HARQ-ACK codebook ~~on non-initial~~ in a PUSCH repetition when the Type-~~1~~ 2 codebook includes HARQ-ACK information for a PDSCH ~~scheduling~~ scheduled after ~~a~~ the UL grant scheduling the PUSCH. | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot.UE does not expect to detect a DL DCI format coming after a UL grant and the DL DCI format indicates a PUCCH transmission overlapping with the PUSCH repetition and there is no PUCCH with HARQ-ACK overlapping with the PUSCH repetition before detecting the DL DCI format. |
| 55-4c | Multiplexing Type-3 HARQ-ACK codebook in a PUSCH for PDSCH ~~scheduling~~ scheduled after UL grant ~~on PUSCH~~ | UE does not support to multiplex Type-3 HARQ-ACK codebook ~~on non-initial~~ in a PUSCH repetition when the Type-~~1~~ 3 codebook includes HARQ-ACK information for a PDSCH ~~scheduling~~ scheduled after ~~a~~ the UL grant scheduling the PUSCH. | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot.UE does not expect to detect a DL DCI format coming after a UL grant and the DL DCI format indicates a PUCCH transmission overlapping with the PUSCH repetition and there is no PUCCH with HARQ-ACK overlapping with the PUSCH repetition before detecting the DL DCI format. |

For the feature group 55-4d, different UE capabilities should be considered for frequency domain and time domain or PUCCH resource change in frequency domain can be considered as the basic UE capability as in FG 55-4a, 55-4b and 55-4c.When a DL assignment comes after an UL grant for a UE, the UE determines the HARQ-ACK codebook and a PUCCH resource based on the HARQ-ACK codebook size and the PRI indication in the last DCI format for DL assignment before the UL grant. After that, the UE multiplexes the HARQ-ACK in a PUSCH overlapping with the PUCCH, if any. If PUCCH time domain resource is different from the PUCCH that UE determines before the UL grant, UE may multiplex the HARQ-ACK in another PUSCH. As a result, it would take additional time for the UE to re-determine the PUSCH and the REs for both the HARQ-ACK and the data in the PUSCH. An example is given in Figure 1 for illustration. UE first determines to multiplex HARQ-ACK in PUCCH#1 before receiving the UL DCI#1 and UL DCI#2, and then UE determines to multiplex HARQ-ACK in PUSCH#1 after receiving the UL DCI#1 and UL DCI#2. If the UE receives DL DCI 2a as shown in case a), UE needs to re-determine the PUSCH for multiplexing based on the PUCCH resource indicated by DL DCI 2a. On the other hand, if UE receives DL DCI 2b as shown in case b) indicating the same PUCCH time domain resource as PUCCH#1, the UE does not need to re-determine the PUSCH for HARQ-ACK multiplexing. The additional timeline is not required for this case.  case a) case b) Figure 1**Proposal 3:** Down-select from the following two alternatives for FG 55-4d.Alt 1) Support separate UE features for FG 55-4d and adopt the following update.Alt 2) FG 55-4d only considers the PUCCH resource change in time domain and adopt the following FG 55-4d-1 for FG 55-4d.

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| --- | --- | --- | --- |
| **Index** | **Feature group** | **Components** | **Consequence if the feature is not supported by the UE** |
| 55-4d-1 | Determining a different PUCCH resource in time domain to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining a different PUCCH resource in time domain in a slot from the PUCCH resource indicated by the last DCI format before a UL grant in the slot, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | UE does not support to be indicated a different PUCCH resource in time domain to transmit HARQ-ACK for PDSCH scheduled after UL grant by the DL grant scheduling the PDSCH. |
| 55-4d-2 | Determining a different PUCCH resource in frequency domain to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining a different PUCCH resource in frequency domain in a slot from the PUCCH resource indicated by the last DCI format before a UL grant in the slot, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | UE does not support to be indicated a different PUCCH resource in frequency domain to transmit HARQ-ACK for PDSCH scheduled after UL grant by the DL grant scheduling the PDSCH. |

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| [6] | Qualcomm Incorporated | We make the following proposal to address the remaining aspect of this UE feature.**Proposal**: Indicate FGs 55-4a to 55-4e with per band granularity.  |
| [7] | Huawei, HiSilicon | **Prerequisite of each UE features**To support FG 55-4a/b/c, UE requires HARQ-ACK codebook generation FGs and PUSCH repetition FGs as prerequisite features. For HARQ codebook generation, FG 4-11/4-10/10-16 corresponding to Type 1/2/3 codebooks respectively are considered. Since both Type-A and Type-B PUSCH repetitions are supported and the number of PUSCH repetitions can be scheduled or configured by the gNB, at least one of the FGs from {5-17, 11-5} should be supported as well. ***Proposal 1: The prerequisites of FG 55-4a/b/c are FG 4-11/4-10/10-16 corresponding to Type 1/2/3 codebook respectively, and at least one of the FGs from {5-17, 11-5}.*****Granularity of UE features**The granularity of prerequisite features is listed below.Table 1. Reporting Granularity for Prerequisites

|  |  |
| --- | --- |
| **FG** | **Granularity** |
| 4-11 | Per UE |
| 4-10 | Per UE |
| 10-16 | Per Band |
| 5-17 | Per UE |
| 11-5 | Per FS |

Following the LS [2] from RAN2, it would be simpler to define UE capabilities in the same or finer granularity than its prerequisite, to avoid ambiguity. Considering the granularity of each prerequisite in Table 1, therefore, following granularity is proposed,***Proposal 2: The reporting granularity of 55-4a/b/c/d/e should be the smallest granularity among all the prerequisites, i.e. per FS.*****Note for FG 55-4a/4b/4c**Following the agreement reached in RAN1 #114bis, two notes are added to FG 55-4a/b/c. For the second note, whether different “PUCCH resource” or different “PUCCH time domain resource” is used requires further discussion.

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| **Agreement*** The column of “Prerequisite feature groups” in FGs 55-4d and 55-4e is “one of {FG 55-4a, 55-4b, 55-4c}”
* Remove “FFS dependency between 55-4d/55-4e” from FGs 55-4a, 55-4b, and 55-4c
* Add following notes to FG 55-4a/b/c
	+ UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.
	+ UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot.
 |

It could be understood that a UE determines a PUCCH resource based on PDSCH-to-HARQ\_feedback timing indicator, PRI and the payload size of the HARQ information. Different PUCCH resources might occupy different frequency domain and same time domain resources, however, once the PRI changes, the UE needs to re-determine the PUCCH resource even if the changed resource is located at the same frequency domain as before or not. Thus, the bracket of PUCCH resource should be removed.***Proposal 3: For the second note of FG 55-4a/b/c, the bracket of [PUCCH resource] is removed.*****Others highlight part**The FGs 55-4a/b/c/d/e can be applied FDD as well, and no TDD/FDD differentiation.The FGs 55-4a/b/c/d/e can be applied to both FR1 and FR2.***Proposal 4: Endorse UE feature list in the Appendix for TEI-18 on HARQ-ACK multiplexing.***

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 55. TEI18 | 55-4a | Multiplexing Type-1 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-1 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where ACK/NACK is generated for the HARQ-ACK codebook including HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | ~~4-1,~~ 4-11, one of {5-17, 11-5, ~~11-6~~} | Yes | N/A | UE does not support to multiplex Type-1 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per ~~Band~~ FS | N/A | N/A | N/A | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different ~~[~~PUCCH resource~~]~~ in a slot from the ~~[~~PUCCH resource~~]~~ determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot. | Optional with capability signaling |
| 55. TEI18 | 55-4b | Multiplexing Type-2 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-2 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | ~~4-1,~~ 4-10, one of {5-17, 11-5, ~~11-6~~} | Yes | N/A | UE does not support to multiplex Type-2 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per ~~Band~~ FS | N/A | N/A | N/A | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different ~~[~~PUCCH resource~~]~~ in a slot from the ~~[~~PUCCH resource~~]~~ determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot. | Optional with capability signaling |
| 55. TEI18 | 55-4c | Multiplexing Type-3 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-3 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission | ~~4-1,~~ 10-16, one of {5-17, 11-5, ~~11-6~~} | Yes | N/A | UE does not support to multiplex Type-3 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per ~~Band~~ FS | N/A | N/A | N/A | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different ~~[~~PUCCH resource~~]~~ in a slot from the ~~[~~PUCCH resource~~]~~ determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot. | Optional with capability signaling |
| 55. TEI18 | 55-4d | Determining a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining a different PUCCH resource in a slot from the PUCCH resource indicated by the last DCI format before a UL grant in the slot, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | One of {FG 55-4a, 55-4b, 55-4c} | Yes | N/A | UE does not support to determine a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per ~~Band~~ FS | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4e | Determining different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining different codebook size in a PUCCH slot from the size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | One of {FG 55-4a, 55-4b, 55-4c} | Yes | N/A | UE does not support to determine different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per ~~Band~~ FS | N/A | N/A | N/A |  | Optional with capability signaling |

 |
| [8] | Ericsson | 2.1 On condition for the codebook sizeThe discussions for the corresponding UE features have become complicated and includes contradicting descriptions. The major underlying reason for such a complications is the condition on same or different codebook size.Definitely the restriction on the same codebook size is not motivated from network point of view, since the typical case of operation is that there are more DL opportunities to schedule before UL grant that after UL grant before start of repetition. Hence, this restriction makes the feature almost useless from network point of view.On the other hand, it is not clear the how the restriction on same of different codebook size has any benefit and reduces UE’s complexity. Indeed, it forces the UE to adopt different logic and procedures for this case as compared to the normal UE procedures for codebook generation. That in practice means that after any UL grant the UE has to execute the new logic/procedure.And how does the new logic work?* For example for Type-2 codebook, UE determines the size of codebook size based on detected PDSCHs and UL DAI. Then, UE needs to make a comparison and evaluate whether the generated codebook is valid or not based on its size. Considering the chance of DL miss-detection UE may assume error case in case of mis-match and after comparison.
* Another example for Type-2 codebook is that the UE determines the size of codebook size based on detected PDSCHs and UL DAI and stops detecting PDSCHs when the size matched the size of codebook size before the UL grant, or the UE performs padding to match the size if needed.

The argument that the gNB should ensure the same codebook size, is not a reasonable argument due to DL miss-detection and contradicts with the whole principal on codebook generation.The important factor is to follow the UL DAI for codebook generation before or after UL DAI.Moreover, FG 55-4a/b/c include a note that the codebook size before and after UL DAI should be the same. However, they are considered as pre-requisite of the FG 55-4e where its description suggests completely the opposite.Therefore, this restriction not only is technically wrong but also increases UE complexity and make the feature useless from network point of view.1. The condition on same codebook size is technically incorrect.
2. The condition on same codebook size increases UE complexity.
3. The condition on same codebook size makes the feature useless to be enabled.
4. The important factor is following the UL DAI for codebook generation before or after UL DAI, and not requiring the same codebook size before or after UL DAI
5. The condition on same codebook size has caused contradictions in corresponding UE features descriptions.

Therefore, we believe that this in an incorrect approach and should be corrected both in the agreement (see our companion contribution [3]) and the corresponding UE features. Therefore, we propose the followings for the UE features:1. Remove FG55-4e.
2. Remove the note on codebook size in FG 55-4a/b/c.
3. Update the UE features as in Table 1.

2.2 On condition for the PUCCH resourceAnother condition for the UE features is the condition on the same PUCCH resource. Similar to the previous discussion, it is not clear the how the restriction on PUCCH resource has any benefit and reduces UE’s complexity. Indeed, it forces the UE to adopt different logic and procedures for this case as compared to the normal UE procedures for PUCCH resource determination.Per normal procedures, based on the codebook size and indicated PRI, the UE determines the PUCCH resource for carrying HARQ-ACK. That in practice means that after any UL grant the UE has to execute the new logic/procedure.And how does the new logic work?* Does the UE determine PUCCH resources before and after and make comparison? What if there is a mismatch at the outcome of comparison due to DL misdetection?

When it comes to PUCCH resource, there is one element that can indeed reduce the UE complexity, and that skipping multiplexing timeline calculation as the following:If in a PUCCH slot that UE has determined a PUCCH resource for HARQ-ACK information corresponding to the PDSCHs before UL grant and UE determines a PUCCH resource for HARQ-ACK information corresponding to the PDSCHs after UL grant, the UE can skip new timeline calculation if these two PUCCH resources start at the same time in the PUCCH slot.We believe that is an important aspect that simplifies UE’s complexity and worth to be indicated as capability.1. The condition on same PUCCH resource increases UE complexity.
2. Reusing multiplexing timeline for a PUCCH slot with HARQ-ACK before UL grant and after UL grant reduces UE complexity.

Therefore, we believe that this in an incorrect approach and should be corrected both in the agreement (see our companion contribution [3]) and the corresponding UE features. Therefore, we propose the followings for the UE features:1. Remove the note on PUCCH resource in FG 55-4a/b/c.
2. Update FG55-4d such that the UE can reuse the multiplexing timeline for a PUCCH slot before UL grant, if the PUCCH after UL grant occurs in the same slot. The condition is the same starting time of the PUCCH resources before and after UL grant.

**Summary**Based on the above discussion and observations, we capture our view as changes and propose the following:1. Adopt the changes in red as shown in Table 1.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 55. TEI18 | 55-4a | Multiplexing Type-1 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-1 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where ACK/NACK is generated for the HARQ-ACK codebook including HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-11, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-1 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A | ~~UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.~~~~UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot.~~ | Optional with capability signaling |
| 55. TEI18 | 55-4b | Multiplexing Type-2 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-2 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-10, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-2 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A | ~~UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.~~~~UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot.~~ | Optional with capability signaling |
| 55. TEI18 | 55-4c | Multiplexing Type-3 HARQ-ACK codebook for PDSCH scheduling after UL grant on PUSCH | 1. UE multiplexes Type-3 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission | 4-1, 10-16, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-3 HARQ-ACK codebook on non-initial a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for PDSCH scheduling after a UL grant. | Per Band | N/A | N/A | N/A | ~~UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.~~~~UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot.~~ | Optional with capability signaling |
| 55. TEI18 | 55-4d | Determining ~~a different~~ PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. ~~Support determining a different PUCCH resource in a slot from the PUCCH resource indicated by the last DCI format before a UL grant in the slot, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot.~~
2. Support determining a PUCCH resource in a slot that starts in a same time in the slot as the PUCCH resource determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot
 | One of {FG 55-4a, 55-4b, 55-4c} | Yes | N/A | UE does not support to determine a different PUCCH resource to transmit HARQ-ACK for PDSCH scheduled after UL grant. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| ~~55. TEI18~~ | ~~55-4e~~ | ~~Determining different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant~~ | ~~1. Support determining different codebook size in a PUCCH slot from the size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot.~~ | ~~One of {FG 55-4a, 55-4b, 55-4c}~~ | ~~Yes~~ | ~~N/A~~ | ~~UE does not support to determine different codebook size to transmit HARQ-ACK for PDSCH scheduled after UL grant.~~ | ~~Per Band~~ | ~~N/A~~ | ~~N/A~~ | ~~N/A~~ |  | ~~Optional with capability signaling~~ |

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## **Discussion**

### **Proposal 2-1:**

* **Prerequisite of FG 55-4a is confirmed as: 4-11, one of {5-17, 11-5}**
* **Prerequisite of FG 55-4b is confirmed as: 4-10, one of {5-17, 11-5}**
* **Prerequisite of FG 55-4c is confirmed as: 10-16, one of {5-17, 11-5}**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | Summary of companies view* 55-4a
	+ 4-11, one of {5-17, 11-5, 11-6}: Nokia/NSB
	+ 4-11, one of {5-17, 11-5}: ZTE, HW/HiSi
* 55-4b
	+ 4-10, one of {5-17, 11-5, 11-6}: Nokia/NSB
	+ 4-10, one of {5-17, 11-5}: ZTE, HW/HiSi
* 55-4c
	+ 10-16, one of {5-17, 11-5, 11-6}: Nokia/NSB
	+ 10-16, one of {5-17, 11-5}: ZTE, HW/HiSi

**Reference*** FG 4-10: Dynamic HARQ-ACK codebook, per UE, Mandatory with capability signaling which shall be set to '1'
* FG 4-11: Semi-static HARQ-ACK codebook, per UE, Mandatory with capability signaling
* FG 5-17: PUSCH repetitions over multiple slots, per UE, Mandatory with capability signaling
* FG 10-16: One-shot HARQ ACK feedback, per band, Optional with capability signalling
* FG 11-5: PUSCH repetition Type B, per FS, Optional with capability signalling
* FG 11-6: PUSCH repetition Type A, per UE, Optional with capability signalling
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### **Question 2-2:**

* **Companies are encouraged to provide view on the reporting type of FGs 55-4a/55-4b/55-4c/55-4d/55-4e**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | Summary of companies view* 55-4a
	+ Per UE: ZTE
	+ Per band: Nokia/NSB, E///, QC
	+ Per FS: HW/HiSi
* 55-4b
	+ Per UE: ZTE
	+ Per band: Nokia/NSB, E///, QC
	+ Per FS: HW/HiSi
* 55-4c
	+ Per band: Nokia/NSB, ZTE, E///, QC
	+ Per FS: HW/HiSi
* 55-4d
	+ Per band: Nokia/NSB, ZTE, E///, QC
	+ Per FS: HW/HiSi
* 55-4e
	+ Per band: Nokia/NSB, ZTE, QC
	+ Per FS: HW/HiSi
* Add note: Nokia/NSB
	+ FGs 55-4a/55-4b/55-4c: The UE indicates this capability on the downlink bands where the DCI scheduling the PDSCH can be received after the DCI scheduling the PUSCH
	+ FGs 55-4d: The UE indicates this capability on the downlink bands where the DCI scheduling the PDSCH can be received after the DCI scheduling the PUSCH and the UE supports determining different PUCCH resource for this case
	+ FGs 55-4e: The UE indicates this capability on the downlink bands where the DCI scheduling the PDSCH can be received after the DCI scheduling the PUSCH and the UE supports determining different codebook size for this case: Nokia/NSB

According to the guidance from RAN2, the reporting type should not be coarser than that of prerequisite FG. This issue can be discussed after the prerequisite FGs are decided. |
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### **Question 2-3:**

* **Is it necessary to separate FG 55-4d as following FGs?**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 55. TEI18 | 55-4d-1 | Determining a different PUCCH resource in time domain to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining a different PUCCH resource in a slot from the PUCCH resource in time domain indicated by the last DCI format before a UL grant in the slot, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | One of {FG 55-4a, 55-4b, 55-4c} | Yes | N/A | UE does not support to ~~determine~~ be indicated a different PUCCH resource in time domain to transmit HARQ-ACK for PDSCH scheduled after UL grant by the DL grant scheduling the PDSCH. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |
| 55. TEI18 | 55-4d-2 | Determining a different PUCCH resource in frequency domain to transmit HARQ-ACK for PDSCH scheduled after UL grant | 1. Support determining a different PUCCH resource in a slot from the PUCCH resource in frequency domain indicated by the last DCI format before a UL grant in the slot, to include HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling a PUSCH transmission with repetitions and the HARQ-ACK information are multiplexed on a repetition of the PUSCH transmission other than a first repetition in the same slot. | One of {FG 55-4a, 55-4b, 55-4c} | Yes | N/A | UE does not support to be indicated a different PUCCH resource in frequency domain to transmit HARQ-ACK for PDSCH scheduled after UL grant by the DL grant scheduling the PDSCH. | Per Band | N/A | N/A | N/A |  | Optional with capability signaling |

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| --- | --- |
| Company | Comment |
| Moderator | This has been proposed by Samsung from last meeting. According to the discussion, majority companies don’t see the necessity to separate FG 55-4d.Summary of companies view* UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot
	+ Confirm: Nokia/NSB, ZTE, HW/HiSi
	+ Delete: E///
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### **Proposal 2-4:**

* **Component 1 in FG 55-4d is revised as: Support determining a PUCCH resource in a slot that starts in a same time in the slot as the PUCCH resource determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot**
* **Delete following notes from FG 55-4a/55-4b/55-4c**
	+ **UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot**
	+ **UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.**

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| --- | --- |
| Company | Comment |
| Moderator | This is proposed by Ericsson, which is also proposed in R1-2312245 under AI 8.17. This proposal tries to revert following agreement, which was made as a compromise among companies, especially for the UE capability parts. Moderator is not sure whether the agreement can be reverted since this proposal also changes the UE capability parts.

|  |
| --- |
| AgreementIf UCI multiplexing of different priorities is not enabled, the restriction on scheduling PDSCH after UL grant is removed for the case of PUSCH with repetitions except the first repetition* UE generates Type-1 HARQ-ACK codebook according to the existing specification with the modification of setting the actual ‘ACK/NACK’ value corresponding to PDSCH(s) scheduled after the UL grant.
* UE generates Type-2/3 HARQ-ACK codebook according to the existing specification.
	+ For Type-2 CB, UL DAI is used for generating HARQ CB.
* This feature is subject to separate UE capabilities for type-1, type-2, and type-3 codebooks.
* RRC parameter(s) to configure the function of scheduling PDSCH after a UL DCI format and multiplexing associated HARQ on a PUSCH repetition except the first repetition are introduced in Rel-18.
* Note: the number of PUSCH repetitions can be scheduled/configured by gNB.
* Note: same principle of current specification which UL DAI in UL grant is applied to each PUSCH repetition is reused.
* The timeline specified in TS 38.213 Clause 9.2.5 are satisfied, i.e. $T\_{proc,1}^{mux}$between the last PDSCH and PUCCH, $T\_{proc,2}^{mux}$ between the last PDCCH among UL grant /DL grant(s) and the earliest PUCCH or PUSCH
* Additional UE capabilities are introduced to support the following functions (UE will be configured by gNB to use the following features via RRC)
	+ HARQ-ACK codebook size change on a PUCCH slot
	+ PUCCH resource change on a PUCCH slot
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### **Proposal 2-5:**

* **FGs 55-4a, 55-4b, and 55-4c are updated as follows:**

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 55. TEI18 | 55-4a | Multiplexing Type-1 HARQ-ACK codebook in a PUSCH for PDSCH ~~scheduling~~ scheduled after UL grant ~~on PUSCH~~ | 1. UE multiplexes Type-1 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where ACK/NACK is generated for the HARQ-ACK codebook including HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-11, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-1 HARQ-ACK codebook ~~on non-initial~~ in a PUSCH repetition when the Type-1 codebook includes HARQ-ACK information for a PDSCH ~~scheduling~~ scheduled after ~~a~~ the UL grant scheduling the PUSCH. | Per Band | N/A | N/A | N/A | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot. | Optional with capability signaling |
| 55. TEI18 | 55-4b | Multiplexing Type-2 HARQ-ACK codebook in a PUSCH for PDSCH ~~scheduling~~ scheduled after UL grant ~~on PUSCH~~ | 1. UE multiplexes Type-2 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission.  | 4-1, 4-10, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-2 HARQ-ACK codebook ~~on non-initial~~ in a PUSCH repetition when the Type-~~1~~2 codebook includes HARQ-ACK information for a PDSCH ~~scheduling~~ scheduled after ~~a~~ the UL grant scheduling the PUSCH. | Per Band | N/A | N/A | N/A | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot. | Optional with capability signaling |
| 55. TEI18 | 55-4c | Multiplexing Type-3 HARQ-ACK codebook in a PUSCH for PDSCH ~~scheduling~~ scheduled after UL grant ~~on PUSCH~~ | 1. UE multiplexes Type-3 HARQ-ACK codebook on a repetition of a PUSCH transmission other than a first repetition, where the HARQ-ACK codebook includes HARQ-ACK information associated with PDSCH reception(s) scheduled after the UL grant scheduling the PUSCH transmission | 4-1, 10-16, one of {5-17, 11-5, 11-6} | Yes | N/A | UE does not support to multiplex Type-3 HARQ-ACK codebook ~~on non-initial~~ in a PUSCH repetition when the Type-~~1~~3 codebook includes HARQ-ACK information for a PDSCH ~~scheduling~~ scheduled after ~~a~~ the UL grant scheduling the PUSCH. | Per Band | N/A | N/A | N/A | UE does not expect to determine a different codebook size in a PUCCH slot from the codebook size determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in a slot overlapping with the PUCCH slot.UE does not expect to determine a different [PUCCH resource] in a slot from the [PUCCH resource] determined based on HARQ-ACK information associated with PDSCH reception(s) scheduled before a UL grant that schedules a PUSCH in that slot. | Optional with capability signaling |

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | This is proposed by Samsung. Companies are invited to provide view whether this revision is necessary or not. |
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# **FGs for span-based PDCCH monitoring with additional restrictions**

In [1], FGs for span-based PDCCH monitoring with additional restrictions are captured as below.

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| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 55. TEI18 | 55-6 | (2, 2) span-based PDCCH monitoring with additional restriction(s) | Support of (2, 2) span-based PDCCH monitoring as per FG11-2 with the following additional restriction(s)There is at least one OFDM symbol gap between two PDCCH monitoring occasions |  | Yes  | N/A |  | Per FS | N/A | N/A |  | This capability is signalled for SCS 15 kHz and 30 kHzThis capability is reported for processing capability #1 and for processing capability #2 respectively | Optional with capability signalling |
| 55. TEI18 | 55-6a | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells | 1.Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells- Candidate value for the component: {2, 3, …, 16)2.Supported span arrangement for CA-Candidate value for the component: {aligned spans only, aligned spans and non-aligned spans} | FG11-2 for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  |  | Optional with capability signalling |
| 55. TEI18 | 55-6b | Mix of Rel-16 PDCCH monitoring capability and Rel. 15 PDCCH monitoring capability on different carriers | Support Rel-15 monitoring capability and Rel-16 PDCCH monitoring capability on different serving cells | FG11-2 for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  |  | Optional with capability signalling |
| 55. TEI18 | 55-6c | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | 1.Supported combination(s) of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16)- Candidate values for pdcch-BlindDetectionCA-R15 is 1 to 15- Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 152. Supported span arrangement for CA- Candidate value for the component: {aligned spans only, aligned spans and non-aligned spans} | FG11-2b for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6b for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  |  | Optional with capability signalling |
| 55. TEI18 | 55-6d | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span for MCG and for SCG when configured for NR-DC operation with Rel-16 PDCCH monitoring on all the serving cells | Supported combination of (pdcch-BlindDetectionMCG-UE-r16, pdcch-BlindDetectionSCG-UE-r16) | FG11-2 for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  |  | Optional with capability signalling |
| 55. TEI18 | 55-6e | Number of carriers for CCE/BD scaling for MCG and for SCG when configured for NR-DC operation with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | Supported combination(s) of (pdcch-BlindDetectionMCG-UE-r15, pdcch-BlindDetectionSCG-UE-r15, pdcch-BlindDetectionMCG-UE-r16, pdcch-BlindDetectionSCG-UE-r16) | FG11-2b for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6b for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  |  | Optional with capability signalling |
| 55. TEI18 | 55-6f | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells with restriction for non-aligned span case | 1.Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells-Candidate value for the component: {2, 3, …, 16}2.UE supports aligned span and non-aligned spanIn case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot | FG11-2 for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  |  | Optional with capability signalling |
| 55. TEI18 | 55-6g | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers with restriction for non-aligned span case | 1.Supported combination(s) of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16)-Candidate values for pdcch-BlindDetectionCA-R15 is 1 to 15-Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 152.UE supports aligned span and non-aligned spanIn case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot | FG11-2b for (7, 3) or (4, 4) span based PDCCH monitoring;FG55-6b for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  |  | Optional with capability signalling |
| 55. TEI18 | 55-6h | PDCCH repetition for Rel-16 PDCCH monitoring | 1. Support of PDCCH repetition with Rel-16 PDCCH monitoring capability as defined in FG 11-2 family.2. Supported mode of PDCCH repetition3. X per CC4. X across all CCs | FG23-2-1, and;FG11-2 for (7, 3) or (4, 4) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  |  | Optional with capability signalling |

Following inputs are provided in contributions for the RAN1#115 meeting.

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| [4] | Intel Corporation | In the previous meeting FG 55-6h was introduced for UE that support FG55-6 and FG23-2-1e. The FG was intended to enable the support of FG23-2-1e for UE that may not support (2,2) span based PDCCH monitoring in FG11-2. The following is agreed FG information.

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| 55. TEI18 | 55-6h | PDCCH repetition for Rel-16 PDCCH monitoring | 1. Support of PDCCH repetition with Rel-16 PDCCH monitoring capability as defined in FG 11-2 family.2. Supported mode of PDCCH repetition3. X per CC4. X across all CCs | FG23-2-1, and;FG11-2 for (7, 3) or (4, 4) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  |  | Optional with capability signalling |

The information contents of 55-6h was copied over from FG23-2-1e. However, the definition of X which was captured as part of notes of FG23-2-1 was not captured in 55-6h. Therefore, as it stands the definition of X is missing for FG55-6h. We suggest adding the notes that provide the definition for X into FG55-6h. **Proposal 1:**Add Notes from FG23-2-1e to FG55-6h.

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| 55. TEI18 | 55-6h | PDCCH repetition for Rel-16 PDCCH monitoring | 1. Support of PDCCH repetition with Rel-16 PDCCH monitoring capability as defined in FG 11-2 family.2. Supported mode of PDCCH repetition3. X per CC4. X across all CCs | FG23-2-1, and;FG11-2 for (7, 3) or (4, 4) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | NOTE: - Components 3 and 4 are reported only if UE supports inter-span PDCCH repetition. - The limit X is associated with the total number of linked candidates of which the first candidate is received and the second one has not been received at any given span, where "received" and "not been received" is w.r.t. the end of the corresponding span of PDCCH candidate. - The limit X is indicated as a total count assuming count 1 for AL=1; 2 for AL=2; 4 for AL=4 or 8 or 16. - Candidate value "no limit" does not imply BD limit can be exceeded.  | Optional with capability signalling |

For FG 55-6 and its related FGs, FG55-6a/b/c/d/e/f/g all have been defined as per FS type. The description of the feature group and the type information from [1] is provided in the following table.

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| **FG Index** | **Feature Group** | **Type** |
| 55-6 | (2, 2) span-based PDCCH monitoring with additional restriction(s) | Per FS |
| 55-6a | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells | Per FS |
| 55-6b | Mix of Rel-16 PDCCH monitoring capability and Rel. 15 PDCCH monitoring capability on different carriers | Per FS |
| 55-6c | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | Per FS |
| 55-6d | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span for MCG and for SCG when configured for NR-DC operation with Rel-16 PDCCH monitoring on all the serving cells | Per FS |
| 55-6e | Number of carriers for CCE/BD scaling for MCG and for SCG when configured for NR-DC operation with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | Per FS |
| 55-6f | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells with restriction for non-aligned span case | Per FS |
| 55-6g | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers with restriction for non-aligned span case | Per FS |
| 55-6h | PDCCH repetition for Rel-16 PDCCH monitoring | Per FS |

From our understanding, FG 55-6a/b/c/d/e/f/g are basically copies of FG11-2a/b/c/e/d/f/g. For Rel-16, FG11-2a/c/d/e/f/g were all defined as per BC and not as per FS. From TS38.331, it is clear that these features were included in *CA-ParametersNR*, which is used for per BC features. Moreover, many of the feature descriptions, e.g. FG55-6d, provide descriptions about MCG and SCG capabilities, which is not possible to define per band per band combination (i.e. per FS). Therefore, we believe it is wrong to classify FG55-6c/d/e/f/g as per FS and they should have been classified as per BC.**Proposal 2:*** Change FG55-6a, 55-6c, 55-6d, 55-6e, 55-6f, 55-6g from per FS to per BC.

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| **FG Index** | **Feature Group** | **Type** |
| 55-6 | (2, 2) span-based PDCCH monitoring with additional restriction(s) | Per FS |
| 55-6a | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells | ~~Per FS~~Per BC |
| 55-6b | Mix of Rel-16 PDCCH monitoring capability and Rel. 15 PDCCH monitoring capability on different carriers | Per FS |
| 55-6c | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | ~~Per FS~~Per BC |
| 55-6d | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span for MCG and for SCG when configured for NR-DC operation with Rel-16 PDCCH monitoring on all the serving cells | ~~Per FS~~Per BC |
| 55-6e | Number of carriers for CCE/BD scaling for MCG and for SCG when configured for NR-DC operation with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | ~~Per FS~~Per BC |
| 55-6f | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells with restriction for non-aligned span case | ~~Per FS~~Per BC |
| 55-6g | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers with restriction for non-aligned span case | ~~Per FS~~Per BC |
| 55-6h | PDCCH repetition for Rel-16 PDCCH monitoring | Per FS |

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| [5] | Samsung | In RAN1 #114b, FG55-6a~h were agreed, and they have one-to-one mapping to FG11-2a~11-2g and FG23-12-1e. Also, FG55-6 which is pre-requisite of FG55-6a~h is a counterpart of FG11-2 which is pre-requisite of FG11-2a~11-2g and FG23-12-1e. If a UE indicating support of FG55-6 does not indicate support of FG11-2, then there is no issue to further discuss. However, since the only modification in FG55-6 compared with FG11-2 is relaxation of (2,2), it is reasonable to assume that the UE indicating support of FG55-6 would still indicate support of FG11-2 with span patterns (4,3) and/or (7,3). In this case, this UE may indicate one or more of FG55-6a~h as well as one or more of FG11-2a~11-2g and FG23-12-1e, and this can create ambiguity regarding which one should be used. This is mainly because Rel-16/17 gNB’s would not understand FG55-6 and 55-6x while a UE would not clearly know which version of gNB release it is connected to. Let’s consider component 1 of FG11-2a and FG55-6a as an example. The number reported in this component is used to determine the total BD limit in CA when only span-based monitoring is configured in all serving cells, and gNB and UE need to have common understanding on this value. Hence, interpretation needs to be established if the UE reports different values in these FGs. One straightforward way to resolve ambiguity is not to allow a UE to indicate both FG11-2x and 55-6x. Let’s again consider FG11-2a and 55-6a as an example. In this case, it is reasonable to assume the UE indicates FG11-2a instead of FG55-6a if it indicates FG11-2 since only FG11-2a would be understood in earlier gNB. This means that FG55-6a becomes only meaningful when FG11-2 as well as FG11-2a is not indicated. Hence, one possible solution is to introduce these restrictions (The UE signaling 55-6a shall not signal 11-2a) and remove FG11-2 from pre-requisite of 55-6x. The above approach effectively limits usability of FG55-6x, and an alternative to this would be to introduce interpretation when both are indicated such that the value in FG55-6x is used if the configured span pattern only satisfies relaxed (2,2) described in FG55-6 while not satisfying any of (2,2), (4,3), (7,3). Although this interpretation may be considered to be natural given the current structure of FG11-2x and FG55-6x, we think it is beneficial to clarify. On top of this, there also is a non-trivial aspect to address. Again, using component 1 of FG11-2a and FG55-6a as an example, the value of this component essentially affects all serving cells in CA while configured span pattern is per serving cell (at least in an unaligned case). In that sense, we also need to consider a case in which configured span pattern of some serving cells satisfy relaxed (2,2) while some serving cells do not. Accordingly, we propose to clarify that the value in FG55-6x is used if the configured span pattern of any serving cell satisfies relaxed (2,2).**Proposal 4:** Add a note ‘When a UE reports both FG11-2x and this, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG55-6’ in FG55-6x.Another issue to discuss is that reporting granularity of FG11-2a~11-2g except for FG11-2b is per-BC while reporting granularity of FG55-6a~g is per-FS. Per-BC here is more natural since the components in those 11-2x affects all serving cells together, but the fact that granularity of FG55-6 is already per-FS while it is pre-requisite of 55-6x makes a situation a bit tricky. With per-FS granularity of FG55-6a~h, there will be ambiguity if a UE signals different values for different bands in a BC. Hence, the UE shall indicate the same value for all serving cells. More precisely, the UE shall indicate the same value for the same position in all *FeatureSetsPerBands* in the indicated *FeatureSetCombination*. Based on this we propose two alts.**Proposal 5:**Alt1): Change granularity of FG55-6a~g except for FG55-6b to per-BCAlt2): Add a note ‘A UE shall indicate the same value for the same position in all *FeatureSetsPerBands* in the indicated *FeatureSetCombination* in FG55-6a~g except for FG55-6b.The proposed changes corresponding to Alt2 are reflected below with red fonts.

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| 55. TEI18 | 55-6a | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells | 1.Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells- Candidate value for the component: {2, 3, …, 16)2.Supported span arrangement for CA-Candidate value for the component: {aligned spans only, aligned spans and non-aligned spans} | FG11-2 for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | When a UE reports both FG11-2a and this, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG55-6.A UE shall indicate the same value for the same position in all *FeatureSetsPerBands* in the indicated *FeatureSetCombination.* | Optional with capability signalling |
|  | 55-6b | Mix of Rel-16 PDCCH monitoring capability and Rel. 15 PDCCH monitoring capability on different carriers | Support Rel-15 monitoring capability and Rel-16 PDCCH monitoring capability on different serving cells | FG11-2 for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | When a UE reports both FG11-2b and this, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG55-6. | Optional with capability signalling |
|  | 55-6c | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | 1.Supported combination(s) of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16)- Candidate values for pdcch-BlindDetectionCA-R15 is 1 to 15- Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 152. Supported span arrangement for CA- Candidate value for the component: {aligned spans only, aligned spans and non-aligned spans} | FG11-2b for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6b for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | When a UE reports both FG11-2c and this, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG55-6.A UE shall indicate the same value for the same position in all *FeatureSetsPerBands* in the indicated *FeatureSetCombination.* | Optional with capability signalling |
|  | 55-6d | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span for MCG and for SCG when configured for NR-DC operation with Rel-16 PDCCH monitoring on all the serving cells | Supported combination of (pdcch-BlindDetectionMCG-UE-r16, pdcch-BlindDetectionSCG-UE-r16) | FG11-2 for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | When a UE reports both FG11-2d and this, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG55-6.A UE shall indicate the same value for the same position in all *FeatureSetsPerBands* in the indicated *FeatureSetCombination.* | Optional with capability signalling |
|  | 55-6e | Number of carriers for CCE/BD scaling for MCG and for SCG when configured for NR-DC operation with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers | Supported combination(s) of (pdcch-BlindDetectionMCG-UE-r15, pdcch-BlindDetectionSCG-UE-r15, pdcch-BlindDetectionMCG-UE-r16, pdcch-BlindDetectionSCG-UE-r16) | FG11-2b for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6b for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | When a UE reports both FG11-2e and this, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG55-6.A UE shall indicate the same value for the same position in all *FeatureSetsPerBands* in the indicated *FeatureSetCombination.* | Optional with capability signalling |
|  | 55-6f | Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells with restriction for non-aligned span case | 1.Capability on the number of CCs for monitoring a maximum number of BDs and non-overlapped CCEs per span when configured with DL CA with Rel-16 PDCCH monitoring capability on all the serving cells-Candidate value for the component: {2, 3, …, 16}2.UE supports aligned span and non-aligned spanIn case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot | FG11-2 for (7, 3) or (4, 3) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | When a UE reports both FG11-2f and this, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG55-6.A UE shall indicate the same value for the same position in all *FeatureSetsPerBands* in the indicated *FeatureSetCombination.* | Optional with capability signalling |
|  | 55-6g | Number of carriers for CCE/BD scaling with DL CA with mix of Rel. 16 and Rel. 15 PDCCH monitoring capabilities on different carriers with restriction for non-aligned span case | 1.Supported combination(s) of (pdcch-BlindDetectionCA-R15, pdcch-BlindDetectionCA-R16)-Candidate values for pdcch-BlindDetectionCA-R15 is 1 to 15-Candidate values for pdcch-BlindDetectionCA-R16 is 1 to 152.UE supports aligned span and non-aligned spanIn case of non-aligned span when the configured number of cells with Rel-16 PDCCH monitoring is larger than the UE reported value, PDCCH monitoring occasion(s) should be configured only on same symbol(s) every slot | FG11-2b for (7, 3) or (4, 4) span based PDCCH monitoring;FG55-6b for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | When a UE reports both FG11-2g and this, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG55-6.A UE shall indicate the same value for the same position in all *FeatureSetsPerBands* in the indicated *FeatureSetCombination.* | Optional with capability signalling |
|  | 55-6h | PDCCH repetition for Rel-16 PDCCH monitoring | 1. Support of PDCCH repetition with Rel-16 PDCCH monitoring capability as defined in FG 11-2 family.2. Supported mode of PDCCH repetition3. X per CC4. X across all CCs | FG23-2-1, and;FG11-2 for (7, 3) or (4, 4) span based PDCCH monitoring;FG55-6 for (2, 2) span based PDCCH monitoring with additional restriction(s) | Yes  | N/A |  | Per FS | N/A | N/A |  | When a UE reports both FG23-12-1e and this, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG55-6. | Optional with capability signalling |

There is another issue to be addressed. As mentioned earlier, a set with one or more elements of (2,2), (4,3), (7,3) is reported for each SCS and processing type in 11-2. Such a set notion should be clearly defined since the set (multiple $\left(X,Y\right)$ combinations below) is used to determine the maximum number of PDCCH processing as described below in 38.213.

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| --- |
| If a UE indicates a capability to monitor PDCCH according to multiple $\left(X,Y\right)$ combinations and a configuration of search space sets to the UE for PDCCH monitoring on a cell results to a separation of every two consecutive PDCCH monitoring spans that is equal to or larger than the value of $X$ for one or more of the multiple combinations $\left(X,Y\right)$, the UE monitors PDCCH on the cell according to the combination $\left(X,Y\right)$, from the one or more combinations $\left(X,Y\right)$, that is associated with the largest maximum number of $M\_{PDCCH}^{max,\left(X,Y\right),μ}$ and $C\_{PDCCH}^{max,\left(X,Y\right),μ}$ defined in Table 10.1-2A and Table 10.1-3A. The UE expects to monitor PDCCH according to the same combination $\left(X,Y\right)$ in every slot on the active DL BWP of a cell. |

When the UE indicates 11-2 with one or more elements of (2,2), (4,3), (7,3) and if the UE also supports 55-6, then it indicates support of relaxed (2,2) in addition to the set reported in 11-2. In this case, a new definition of the set of (2,2), (4,3), (7,3) needs to be established by taking the union of the set in 11-2 and {(2,2)} in 55-6. Such union operation is done per SCS and per processing type for each FS in which support of both 11-2 and 55-6 are indicated.**Proposal 6:** Add a note ‘When a UE reports both FG11-2 and this, the union of supported span patterns in FG11-2 and this establishes the multiple combinations (X,Y) used to determine per-span BD/CCE limit as described in Clause 10 of TS38.213.’ in FG55-6.The proposed changes corresponding to alt2 are reflected below with red fonts.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 55. TEI18 | 55-6 | (2, 2) span-based PDCCH monitoring with additional restriction(s) | Support of (2, 2) span-based PDCCH monitoring as per FG11-2 with the following additional restriction(s)There is at least one OFDM symbol gap between two PDCCH monitoring occasions |  | Yes  | N/A |  | Per FS | N/A | N/A |  | This capability is signalled for SCS 15 kHz and 30 kHzThis capability is reported for processing capability #1 and for processing capability #2 respectivelyWhen a UE reports both FG11-2 and this, the union of supported span patterns in FG11-2 and this establishes the multiple combinations (X,Y) used to determine per-span BD/CCE limit as described in Clause 10 of TS38.213. | Optional with capability signalling |

 |

## **Discussion**

### **Proposal 3-1:**

* **Add following note in FG 55-6h**
	+ **Components 3 and 4 are reported only if UE supports inter-span PDCCH repetition.**
	+ **The limit X is associated with the total number of linked candidates of which the first candidate is received and the second one has not been received at any given span, where "received" and "not been received" is w.r.t. the end of the corresponding span of PDCCH candidate.**
	+ **The limit X is indicated as a total count assuming count 1 for AL=1; 2 for AL=2; 4 for AL=4 or 8 or 16.**
	+ **Candidate value "no limit" does not imply BD limit can be exceeded**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | Proposed by Intel |
|  |  |
|  |  |

### **Proposal 3-2:**

* **Alt1: Revise the reporting type of FG 55-6a/55-6c/55-6d/55-6e/55-6f/55-6g from per FS to per BC**
* **Alt2: Add a note in FG 55-6a/55-6c/55-6d/55-6e/55-6f/55-6g: A UE shall indicate the same value for the same position in all *FeatureSetsPerBands* in the indicated *FeatureSetCombination***

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| --- | --- |
| Company | Comment |
| Moderator | Proposed by Intel and Samsung |
|  |  |
|  |  |

### **Proposal 3-3:**

* **Add a note “When a UE reports both FG 11-2a/11-2b/11-2c/11-2d/11-2e/11-2f/11-2g/23-2-1e and this FG, the value reported in this FG is used if the configured span pattern of any serving cell satisfies FG 55-6” in FG 55-6a/55-6b/55-6c/55-6d/55-6e/55-6f/55-6g/55-6h**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | Proposed by Samsung |
|  |  |
|  |  |

### **Proposal 3-4:**

* **Add a note in FG 55-6: When a UE reports both FG11-2 and this FG, the union of supported span patterns in FG 11-2 and this FG establishes the multiple combinations (X,Y) used to determine per-span BD/CCE limit as described in Clause 10 of TS38.213.**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | Proposed by Samsung |
|  |  |
|  |  |

# **FGs for multi-DCI based multi-TRP**

In [2], FGs for multi-DCI based multi-TRP are captured as below.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Features | Index | Feature group | Components | Prerequisite feature groups | Need for the gNB to know if the feature is supported | Applicable to the capability signalling exchange between UEs (Sidelink WI only)”. | **Consequence if the feature is not supported by the UE** | **Type****(the ‘type’ definition from UE features should be based on the granularity of 1) Per UE or 2) Per Band or 3) Per BC or 4) Per FS or 5) Per FSPC)** | Need of FDD/TDD differentiation | Need of FR1/FR2 differentiation | Capability interpretation for mixture of FDD/TDD and/or FR1/FR2 | Note | Mandatory/Optional |
| 55. TEI18 | 55-7 | Two QCL TypeD for CORESET monitoring in multi-DCI based multi-TRP | Support of determining two QCL-TypeD for time-domain overlapping CORESETs in the same CC or for intra-band CA associated with coresetPoolIndex value 0 and 1 | 16-2a | Yes  | N/A |  | Per FSPC | N/A | FR2 only | N/A |  | Optional with capability signalling |

Following inputs are provided in contributions for the RAN1#115 meeting.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| [5] | Samsung | We would like to suggest adding a note.* + - * + Since QCL prioritization rule considers time domain overlapping for intra-band CA case as well, as a note, it is better to be clarified for the case when if a UE is not configured with two *coresetPoolIndex*es at least in a CC in a certain band. The UE can consider that all CORESETs in the CC are associated with *coresetPoolIndex* 0.

**Proposal 1:** Support FG 55-7 for endorsed Rel-18 TEI on QCL prioritization rule for multi-DCI based multi-TRP.The proposed change is reflected below with red fonts.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| 55. TEI18 | 55-7 | Two QCL TypeD for CORESET monitoring in multi-DCI based multi-TRP | Support of determining two QCL-TypeD for time-domain overlapping CORESETs in the same CC or for intra-band CA associated with coresetPoolIndex value 0 and 1 | 16-2a | Yes  | N/A |  | Per FSPC | N/A | FR2 only | N/A | Note: In case of intra-band CA, if a UE is not configured with two different coresetPoolIndexes in a certain CC, then all CORESETs in the CC are considered as being associated with coresetPoolindex 0. | Optional with capability signalling |

 |

## **Discussion**

### **Proposal 4-1:**

* **Add note in FG 55-7: Note: In case of intra-band CA, if a UE is not configured with two different coresetPoolIndexes in a certain CC, then all CORESETs in the CC are considered as being associated with coresetPoolindex 0.**

|  |  |
| --- | --- |
| Company | Comment |
| Moderator | This was discussed in the last RAN1 meeting when introducing FG 55-7. During the online discussion, no companies showed concern to delete the note, and hence, FG 55-7 was agreed without the note. Proponent is requested to explain why this is proposed again while they didn’t show the concern to delete it. |
|  |  |
|  |  |

# **Conclusions**

To be updated

# **References**

[1] R1-2310635 Updated RAN1 UE features list for Rel-18 NR after RAN1#114bis Moderators (AT&T, NTT DOCOMO, INC.)

[2] R1-2310904 On UE features for TEI18 Nokia, Nokia Shanghai Bell

[3] R1-2311029 Discussion on UE feature for Rel-18 TEI ZTE

[4] R1-2311140 Discussion on UE features for TEI Intel Corporation

[5] R1-2311881 UE features for endorsed Rel-18 TEI Samsung

[6] R1-2312073 UE features for endorsed TEI proposals. Qualcomm Incorporated

[7] R1-2312227 UE features for endorsed Rel-18 TEI on HARQ multiplexing on PUSCH Huawei, HiSilicon

[8] R1-2312244 On UE features for HARQ-ACK multiplexing on PUSCH TEI Ericsson