3GPP TSG-RAN WG1 Meeting #108-e R1-2201737

e-Meeting, 21st February – 3rd March, 2022

Agenda Item: 8.2.3

Source: Moderator (Ericsson)

Title: FL Summary for [108-e-NR-52-71GHz-03] Email discussion/approval on enhancements for PUCCH formats 0/1/4

Document for: Discussion, Decision

# 1 Introduction

This document summarizes the contributions made under the “Enhancements for PUCCH Formats 0/1/4” agenda item of the Rel-17 work item "Extending current NR operation to 71 GHz."

The following email thread is assigned for discussion of this topic:

[108-e-NR-52-71GHz-03] Email discussion for maintenance on PUCCH formats 0/1/4 enhancements – Steve (Ericsson)

* 1st check point: February 25
* Final check point: March 3

# 2 Multiplexing of Coded Bits to PUCCH

The following table provides a summary of company proposals on this topic:

|  |  |
| --- | --- |
| Company | Company Proposals |
| Huawei [2] | **Proposal 2: Support the following TP#2 in clause 6.3.1.6 of TS 38.212.**

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| --- |
| **TP#2 for clause 6.3.1.6 of TS 38.212**< Unchanged parts are omitted >For PUCCH format 3, set $N\_{UCI}^{symbol}=12⋅N\_{PRB}^{PUCCH,3}/N\_{SF}^{PUCCH,3}$ , where  is the number of PRBs that is determined by the UE for PUCCH format 3 transmission according to Clause 9.2 of [5, TS 38.213], and $N\_{SF}^{PUCCH,3}$ is the spreading factor for PUCCH format 3 [4, TS 38.211].For PUCCH format 4, set $N\_{UCI}^{symbol}=12⋅N\_{PRB}^{PUCCH,4}/N\_{SF}^{PUCCH,4}$, where $N\_{PRB}^{PUCCH,4}$ is the number of PRBs that is determined by the UE for PUCCH format 4 transmission according to Clause 9.2 of [5, TS 38.213], and  is the spreading factor for PUCCH format 4.< Unchanged parts are omitted > |

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The moderator agrees that the correction identified by Huawei is needed to account for the fact that PF4 can now be configured with more than 1 RB. The moderator recommends the following more compact TP which aligns with the notation used in 38.211 (see Section 6.3.2.6).

## **[HIGH] Text Proposal #2 (Multiplexing of coded bits to PUCCH)**

>>> Text Proposal for 38.212, Section 6.3.1.6 >>>

\*\*\* Unchanged text omitted \*\*\*

For PUCCH formats 3 and 4, set $N\_{UCI}^{symbol}=12⋅N\_{PRB}^{PUCCH,s3}/N\_{SF}^{PUCCH,s3}$, where $N\_{SF}^{PUCCH,s3}$ is the number of PRBs that is determined by the UE for PUCCH ~~format 3~~ transmission according to Clause 9.2 of [5, TS 38.213], and $N\_{SF}^{PUCCH,s3}$ is the spreading factor for PUCCH ~~format 3~~ [4, TS 38.211] where $s\in \left\{3,4\right\}$.

~~For PUCCH format 4, set~~ $N\_{UCI}^{symbol}=12/N\_{SF}^{PUCCH,4}$~~, where~~ $N\_{SF}^{PUCCH,4}$ ~~is the spreading factor for PUCCH format 4.~~

\*\*\* Unchanged text omitted \*\*\*

>>> End Text Proposal >>>

## **[HIGH] Text Proposal #2a (Multiplexing of coded bits to PUCCH)**

>>> Text Proposal for 38.212, Section 6.3.1.6 >>>

\*\*\* Unchanged text omitted \*\*\*

For PUCCH formats 3 and 4, set $N\_{UCI}^{symbol}=12⋅N\_{PRB}^{PUCCH,s3}/N\_{SF}^{PUCCH,s3}$, where $N\_{SF}^{PUCCH,s3}$ is the number of PRBs that is determined by the UE for PUCCH ~~format 3~~ transmission according to Clause 9.2 of [5, TS 38.213], and $N\_{SF}^{PUCCH,s3}$ is the spreading factor for the corresponding PUCCH format ~~3~~ [4, TS 38.211] where $s\in \left\{3,4\right\}$.

~~For PUCCH format 4, set~~ $N\_{UCI}^{symbol}=12/N\_{SF}^{PUCCH,4}$~~, where~~ $N\_{SF}^{PUCCH,4}$ ~~is the spreading factor for PUCCH format 4.~~

\*\*\* Unchanged text omitted \*\*\*

>>> End Text Proposal >>>

Please provide your company view on Text Proposal #1.

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| --- | --- |
| **Company** | **View/Position** |
| Intel | We agree with the FL’s assessment and we are OK with TP#1.  |
| vivo | OK with TP. |
| LG Electronics | Ok with TP. |
| Apple | We are fine with the TP. |
| Nokia, NSB | We agree a correction is needed and support the TP by the moderator.  |
| ZTE, Sanechips | We are fine with the TP. |
| Lenovo | We are fine with the TP. |
| OPPO | We are OK with the TP. |
| Samsung | We are ok with the pirit of the TP. One suggestion on the wording, it needs to clarify $N\_{SF}^{PUCCH,s}$ is associated with the format s. For PUCCH formats 3 and 4, set $N\_{UCI}^{symbol}=12⋅N\_{PRB}^{PUCCH,s3}/N\_{SF}^{PUCCH,s3}$, where $N\_{SF}^{PUCCH,s3}$ is the number of PRBs that is determined by the UE for PUCCH ~~format 3~~ transmission according to Clause 9.2 of [5, TS 38.213], and $N\_{SF}^{PUCCH,s3}$ is the spreading factor for the corresponding PUCCH format ~~format 3~~ [4, TS 38.211] where $s\in \left\{3,4\right\}$. |
| InterDigital | We agree that this correction is needed. We slightly prefer Samsung’s TP than the suggest TP. |
| Qualcomm | We agree that correction is needed and slightly prefer Samsung’s TP |
| CATT | We are fine with the TP with samsung’s modification |
| NTT DOCOMO | We support TP with Samsung’s updates. |
| Moderator | Samsung's update seems reasonable, and Text Proposal #2a is added above capturing the suggestion. The moderator recommends that we try to agree on this.Please comment further only if you have concern with Text Proposal #2a |
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# 3 Mapping to Physical Resources

## 3.1 Mapping specified in 38.211

The following table provides a summary of company proposals on this topic:

|  |  |
| --- | --- |
| Company | Company Proposals |
| Huawei [2] | **Proposal 1: Support the following TP#1 in clause 6.3.2.4.2 and clause 6.3.2.6.5 of TS 38.211.**

|  |
| --- |
| **TP#1 for TS 38.211 Clause** **6.3.2.4.2 and Clause 6.3.2.6.5**< Unchanged parts are omitted >6.3.2.4.2 Mapping to physical resourcesThe sequence  shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [5, TS 38.213] and mapped in sequence starting with  to resource elements $\left(k,l\right)\_{p,μ}$ which meet all of the following criteria: - they are in the resource blocks assigned for transmission according to clause 9.2.1 of [5, TS 38.213],- they are not used by the associated DM-RS The mapping to resource elements $\left(k,l\right)\_{p,μ}$ not reserved for other purposes shall be in increasing order of first the index  over the assigned physical resource blocks spanning $M\_{RB}^{PUCCH,1}$ resource blocks, and then the index  on antenna port . < Unchanged parts are omitted >6.3.2.6.5 Mapping to physical resourcesThe block of modulation symbols $z\left(0\right),…,z(N\_{SF}^{PUCCH,s}M\_{symb}-1)$ shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [5, TS 38.213] and mapped in sequence starting with $z(0)$ to resource elements $(k,l)\_{p,μ}$ which meet all of the following criteria: - they are in the resource blocks assigned for transmission,- they are not used by the associated DM-RSThe mapping to resource elements $(k,l)\_{p,μ}$ not reserved for other purposes shall be in increasing order of first the index  over the assigned physical resource blocks spanning $M\_{RB}^{PUCCH,s}$ resource blocks according to clause 9.2.1 of [5, TS 38.213], and then the index  on antenna port .< Unchanged parts are omitted > |

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The moderator agrees that a correction is needed to at least Section 6.3.2.4.2 (for PF1) since the text says "over the assigned physical resource block" which does not account for the fact that PF1 can now be configured with more than one RB. This can easily be corrected by changing this to "over the assigned physical resource blocks according to clause 9.2.1 of [5, TS 38.213]". This same approach (referring to 38.213) is what is used in all sections of 38.211 that describe the mapping to physical resources, so good to keep that consistency. Otherwise the text for PF2/3 would need to be changed as well.

It is the moderator's view that the other corrections proposed by Huawei are not needed, since 38.213 already specifies that $M\_{RB}^{PUCCH,1}$ and $M\_{RB}^{PUCCH,4}$ can be either be greater than 1 or equal to 1 as highlighted in in the following clauses:

If the *format* indicates *PUCCH-format1*,the PUCCH format configured for a PUCCH resource is PUCCH format 1, where the PUCCH resource also includes an index for an initial cyclic shift provided by *initialCyclicShift*, a number of symbols for a PUCCH transmission provided by *nrofSymbols*, a first symbol for the PUCCH transmission provided by *startingSymbolIndex*, and an index for an orthogonal cover code by *timeDomainOCC*. For PUCCH transmission in FR2-2, the PUCCH resource can also include a number of PRBs $M\_{RB}^{PUCCH,1}$ provided by *nrofPRBs*; otherwise, $M\_{RB}^{PUCCH,1}=1$*.*

If the *format* indicates *PUCCH-format4*, the PUCCH format configured for a PUCCH resource is PUCCH format 4, where the PUCCH resource also includes a number of symbols for a PUCCH transmission provided by *nrofSymbols*, an orthogonal cover code length by *occ-Length*, an orthogonal cover code index by *occ-Index*, and a first symbol for the PUCCH transmission provided by *startingSymbolIndex*. For PUCCH transmission in FR2-2, the PUCCH resource can also include a number of PRBs $M\_{RB}^{PUCCH,4}$ provided by *nrofPRBs*; otherwise, $M\_{RB}^{PUCCH,1}=1$

Note: the typo in red is proposed to be corrected in Section 3.2 so that it refers to the number of RBs for PF4, not PF1 (please see text proposal in that section).

Based on this, the moderator's recommendation is to make only the following correction

### **[HIGH] Text Proposal #3-1 (Mapping to physical resources for PF1)**

>>> Text Proposal for 38.211, Section 6.3.2.4.2 >>>

\*\*\* Unchanged text omitted \*\*\*

6.3.2.4.2 Mapping to physical resources

The sequence  shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [5, TS 38.213] and mapped in sequence starting with  to resource elements $\left(k,l\right)\_{p,μ}$ which meet all of the following criteria:

- they are in the resource blocks assigned for transmission ~~according to clause 9.2.1 of [5, TS 38.213]~~,

- they are not used by the associated DM-RS

The mapping to resource elements $\left(k,l\right)\_{p,μ}$ not reserved for other purposes shall be in increasing order of first the index  over the assigned physical resource blocks according to clause 9.2.1 of [5, TS 38.213], and then the index  on antenna port .

For interlaced transmission, the mapping operation shall be repeated for each resource block in the interlace and in the active bandwidth part over the assigned physical resource blocks according to clause 9.2.1 of [5, TS 38.213], with the resource-block dependent sequence generated according to clause 6.3.2.2.

>>> End Text Proposal >>>

Please provide your company view on Text Proposal #3-1.

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| --- | --- |
| **Company** | **View/Position** |
| Intel | We agree with the FL’s assessment and we are OK with the recommended TP.  |
| vivo | OK with TP. |
| LG Electronics | Ok with TP. |
| Apple | We are fine with the TP. |
| Nokia, NSB | We support the TP |
| ZTE, Sanechips | We are fine with the TP. |
| Lenovo | We are Ok with the TP. |
| OPPO | We are OK with the TP. |
| Samsung | We are ok with the TP.  |
| InterDigital | We are fine with the TP.  |
| Qualcomm | We are fine with the TP |
| CATT | We are fine with the TP. |
| NTT DOCOMO | We are fine with the TP. |
| Moderator | Seems like there is consensus so far on Text Proposal #3-1. Please comment further only if you have concerns. |
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## 3.2 Mapping specified in 38.213

The following table provides a summary of company proposals on this topic:

|  |  |
| --- | --- |
| Company | Company Proposals |
| Huawei [2] | **Proposal 3: Support the following TP#3 in clause 9.2.1 of TS 38.213.**

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| --- |
| **TP#3 in clause 9.2.1 of TS 38.213**< Unchanged parts are omitted >If the *format* indicates *PUCCH-format4*, the PUCCH format configured for a PUCCH resource is PUCCH format 4, where the PUCCH resource also includes a number of symbols for a PUCCH transmission provided by *nrofSymbols*, an orthogonal cover code length by *occ-Length*, an orthogonal cover code index by *occ-Index*, and a first symbol for the PUCCH transmission provided by *startingSymbolIndex*. For PUCCH transmission in FR2-2, the PUCCH resource can also include a number of PRBs $M\_{RB}^{PUCCH,4}$ provided by *nrofPRBs*; otherwise, $M\_{RB}^{PUCCH,1}M\_{RB}^{PUCCH,4}=1$*.*< Unchanged parts are omitted > |

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The moderator agrees that the correction identified by Huawei is needed (clearly a typo).

### **[HIGH] Text Proposal #3-2 (Mapping to physical resources for PF4)**

>>> Text Proposal for 38.213, Section 9.2.1 >>>

\*\*\* Unchanged text omitted \*\*\*

If the *format* indicates *PUCCH-format4*, the PUCCH format configured for a PUCCH resource is PUCCH format 4, where the PUCCH resource also includes a number of symbols for a PUCCH transmission provided by *nrofSymbols*, an orthogonal cover code length by *occ-Length*, an orthogonal cover code index by *occ-Index*, and a first symbol for the PUCCH transmission provided by *startingSymbolIndex*. For PUCCH transmission in FR2-2, the PUCCH resource can also include a number of PRBs $M\_{RB}^{PUCCH,4}$ provided by *nrofPRBs*; otherwise, $M\_{RB}^{PUCCH,1}M\_{RB}^{PUCCH,4}=1$*.*

\*\*\* Unchanged text omitted \*\*\*

>>> End Text Proposal >>>

Please provide your company view on Text Proposal #3-2.

|  |  |
| --- | --- |
| **Company** | **View/Position** |
| Intel | We agree with the FL’s assessment and we are OK with TP#3-2.  |
| vivo | OK |
| LG Electronics | Ok with TP. |
| Apple | We are fine with the TP. |
| Nokia, NSB | We support the TP |
| ZTE, Sanechips | We are fine with the TP. |
| Lenovo | We are fine with the TP. |
| OPPO | We are OK with the TP. |
| Samsung | We are ok with the TP.  |
| InterDigital | We are fine with the TP.  |
| Qualcomm | We are fine with the TP |
| CATT | We are fine with the TP. |
| NTT DOCOMO | We are fine with the TP. |
| Moderator | Seems like there is consensus so far on Text Proposal #3-2. Please comment further only if you have concerns. |
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# 4 Potential Coverage Imbalance between PF2/3 and PF4

The following table provides a summary of company proposals on this topic:

|  |  |
| --- | --- |
| **Company** | **Company Proposals** |
| OPPO [4] | **Proposal 1: For PF2/3 in 60GHz band, the actual number of RBs used for a PUCCH transmission is equal to NRB, i.e., the actual number of RBs does not vary dynamically based on PUCCH payload.** |
| ZTE [5] | **Observation 1: If there is a need to deal with the problem of PSD limitation or coverage performance, increasing the configurable PRB numbers for PUCCH format 0/1/4 can be considered as a potential candidate method.** |
| Interdigital [3] | ***Observation 1:*** *Redesigning the number of RBs for PUCCH format 4 requires additional discussion of all related aspects should be revisited as well.****Observation 2:*** *Enhancement on PUCCH formats 2 and 3 is out of scope for NR 52-71.****Observation 3:*** *Potential coverage imbalance issue can be handled by gNB configuration with the flexibility given by the current specification.****Proposal 1:*** *It is preferred to keep the current design for PUCCH formats in NR 52-71* |
| Ericsson [6] | **Observation 1** Sufficient configuration flexibility exists amongst legacy PF2, PF3 and enhanced (multi-RB) PF4 to cover a broad range of deployment scenarios. It is not needed to revisit the max payload size for enhanced PF4. |
| Moderator | Two companies propose further enhancements of either the PF2/3 or PF4 designs to address a potential coverage imbalance. Two companies propose that the current design is left as is.Given that this issue has been de-prioritized for three meetings now due to lack of company support, the moderator's view is that there is not much chance to reach consensus on making any changes. However, let's give it another round and see if the situation has changed.**Q1**: Is there a need to address a potential coverage imbalance between PF2/3 and multi-RB PF4?**Q2**: If yes to Q1, how should the issue be addressed?* Alt-1: For PF2/3 in FR2-2 change the procedure for determining the number of RBs such that the number is fixed rather than varying dynamically based on payload size
* Alt-2: For PF4 in FR2-2, increase the maximum number of RBs (more than 16)
* Alt-3: For PF4 in FR2-2, change the maximum payload size (more than 115 bits)
 |
| Intel | Q1: no need to address any issue with potential covereage imbalance beteen PF2/3. Also this is out of scope from this AI. |
| vivo | Q1: same view as Intel. |
| LG Electronics | Q1: We share the same view with Intel. |
| Apple | Q1: identical view to the previous companies |
| Nokia, NSB | Q1: we see no need to address this. |
| ZTE, Sanechips | Q1: we admit that there is a issue on coverage imbalance between PF2/3 and multi-RB PF4 and it can also be handled. But we can be flexible if majority companies do not want to resolve it. |
| Lenovo | Q1: we don’t see a need to address this as it is out of the scope |
| OPPO | Q1: Yes. PF2/3 is generally used for larger UCI payloads, so the coverage performance should be guaranteed. Furthermore, as we pointed out in our contribution, the MIL loss ranges from 1.2dB to 13.5dB depending on the number of RBs compared with N\_RB=16, which is quite substantial.In addition, we find that it can’t be handled by gNB implementation. For example, for PF3, even if the lowest code rate, i.e. r=0.08, and Qm=1 are configured, the PUCCH resource configured for a UE can carry $M\_{RB}^{PUCCH}∙N\_{sc,ctrl}^{RB}∙N\_{symbol-UCI}^{PUCCH}∙Q\_{m}∙r=16∙12∙12∙1∙0.08=184$bits. If the number of UCI bits is 120, the number of RBs used for PF3 transmission will be decreased to 11 according to 38.213 Section 9.2.3. In this case, the coverage performance of PF3 will be degraded. Therefore, the potential coverage imbalance between PF2/3 and enhanced PF4 should be addressed to ensure the consistent coverage performance in FR2-2.Q2: We support Alt-1. Note that for enhanced PF4, we have made an agreement that the actual number of RBs used for a PUCCH transmission does not vary dynamically based on PUCCH payload. Thus, the similar agreement can be made for PF2/3 and the spec impact is little. For Alt-2 and Alt-3, we has made an agreement that the maximum configured number of RBs is 16 and the same maximum UCI paload limit as in R15/16(115 bits) is maintained for multi-RB PF4, which should not be reverted. |
| InterDigital | Q1: As we proposed in our contribution, no need to address the issue. We also agree that the possible solution may be out of scope if the solution includes any enhancement on PUCCH format 2/3.  |
| Qualcomm | We dont think there is time to address the issue, and we agree with Ericcsion that there is already enough configuration flexibility |
| NTT DOCOMO | Q1: We share the same view with Intel and no need to address this issue. |

# References

1. R1-2200403, "FL Summary for [107bis-e-R17-52-71GHz-03] Email discussion/approval on enhancements for PUCCH formats 0/1/4," Moderator (Ericsson), RAN1#107bis-e, January 2022.
2. R1-2200954 Remaining issues of PUCCH enhancement for 52-71GHz spectrum Huawei, HiSilicon
3. R1-2201034 Remaining issues for enhanced PUCCH formats 0/1/4 InterDigital, Inc.
4. R1-2201267 Discussion on remaining issue for enhancements for PUCCH format 0/1/4 OPPO
5. R1-2201390 Remaining issues on the PUCCH enhancements for 52.6 to 71GHz ZTE, Sanechips
6. R1-2201736 PUCCH enhancements Ericsson