3GPP TSG-RAN WG1 Meeting #117 Tdoc R1-24nnnnn

Fukuoka City, Fukuoka, Japan, May 20th – 24th, 2024

Agenda Item: 7

Source: Moderator (Ericsson)

Title: Summary of NR Pre-Rel18 maintenance discussion for SRS power scaling and transmission occasion

Document for: Discussion, Decision

# 1 Introduction

In RAN1#116, how SRS antenna port power scaling is defined for an SRS transmission occasion was further discussed [2], following on from RAN1#115 [1]. In the resulting discussion, the moderator made the following proposals that were captured in the RAN1#116 Chair notes:

Study the following two options for RAN1#116bis:

* Modified Option2:
	+ equally split across all SRS ports in all the overlapping SRS resources in the same SRS resource set with usage ‘nonCodebook’~~all resources within a set~~ when they are fully overlapped in time.
* Option4: restrict it to ‘nonCodebook’ and the case when UE transmit power exceeds ** as below
	+ For simultaneous transmissions of SRS resources of a SRS resource set with higher layer parameter usage in SRS-ResourceSet set to ‘nonCodebook’, if the total UE transmit power for SRS transmission in a respective transmission occasion  would exceed , the UE should perform equal power scaling across the overlapping SRS resources.

In RAN1#116bis, while it was not possible to narrow down or merge these two options, conclusions were reached on the relative power of the SRS resources for non-codebook and beam management SRS usages:

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| **Conclusion**The transmit power of each of the simultaneously transmitted SRS resources for usage ‘nonCodebook’ is equal in the fully overlapping time/frequency case, regardless of whether calculated transmission power across all SRS resources is higher or lower than Pcmax.* No specification change

**Conclusion:**If total transmission power exceeds the maximum transmission power, for simultaneous transmission of SRS resources in different SRS resource sets for **beam management**, the transmission power of the SRS resources is left to UE implementation. |

In this contribution, we summarize the continuation of the discussion in RAN1#117 on SRS power scaling and the SRS transmission occasion.

Comments for the initial discussion are invited in section 2. Responses will be summarized after first round discussion in section 3.

Note that delegates participating in this topic are invited to provide their contact information in section 6 to facilitate offline discussions.

# 2 Discussion

In this meeting, a discussion paper [3] with a corresponding draft CR [4] were submitted on this topic.

Given the RAN1#116bis conclusion below on beam management, in Moderator’s understanding, the behavior of simultaneously transmitted SRS resources for beam management is clear. When total power is below Pcmax, the power of each resource is according to the power control settings of the set containing the resource. When the total power targeted by the power control is above Pcmax, the power of each resource is left to UE implementation. Therefore, what remains to be discussed is the power of multiple simultaneous SRS resources with set usage ‘nonCodebook’.

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| **Conclusion:**If total transmission power exceeds the maximum transmission power, for simultaneous transmission of SRS resources in different SRS resource sets for **beam management**, the transmission power of the SRS resources is left to UE implementation. |

1. What remains to be discussed in the context of SRS power scaling and transmission occasion maintenance is the power of multiple simultaneous SRS resources with set usage ‘nonCodebook’

Given the RAN1#116bis conclusion below, it is now clear that for SRSs configured in the same PRBs, the SRS resources in a set always have the same power, regardless of if the power control target would exceed Pcmax or not.

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| **Conclusion**The transmit power of each of the simultaneously transmitted SRS resources for usage ‘nonCodebook’ is equal in the fully overlapping time/frequency case, regardless of whether calculated transmission power across all SRS resources is higher or lower than Pcmax.* No specification change
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While the SRS resources’ powers are equal, it is not clear how they relate to the total power. In order to establish this relationship, we consider two alternatives discussed in [3]: where the total power is split by the number of SRS ports/resources in a symbol and 2) where the power per SRS resource is constant, regardless of the number of SRS ports/resources in a symbol. The first alternative is labeled as ‘split total power control’, which the second was labeled ‘per SRS resource power control’. In Moderator’s understanding, these two alternatives reflect the primary difference of opinion among companies. In the following, we summarize the discussion of these alternatives in [3].

With per SRS resource power control, in order to know the power per resource, the relationship between total and per resource power must be established. In [3], it is argued that without this information, the network will not be able to know if the available power is in a range of Pcmax/L to Pcmax when there are L SRS resources in a set. This further implies that it is difficult to use SRS power headroom reports in this range. Also, it was observed that it is difficult to determine power per PUSCH layer from measurements of SRS when per SRS resource power control is used.

1. If the relationship between total power and power per SRS resource is not specified, it may be difficult to know the total available power, use power headroom reports, and to infer the power of PUSCH layers from SRS measurements for non-codebook based operation.

An approach to define the power per resource in per SRS resource power control can be to set the power per resource using a fixed offset from the total power set by the power control. One natural way to do this would be to split the total target power by the number of SRS resources. That is, the power per resource is Pres=Ptot/L when the total power is Ptot and the number of resources is L. Again, this is true regardless of how many SRS resources are transmitted simultaneously, which implies that the power is scaled down by L even if there is only one SRS resource transmitted in a symbol. This means the gNB should not assume that changing the number of simultaneously transmitted SRS resources will change the SRS power per resource. As discussed in more detail in [3], non-codebook based PUSCH power control splits the total power equally among layers, which is opposite of the behavior for per SRS resource power control, where the power per resource is fixed, regardless of the number of simultaneously transmitted resources.

In Rel-18, it is possible to split ports of an 8 port SRS resource among different OFDM symbols. In this case, as can be seen from 38.213 section 7.3 below, the power is split equally among the ports in each symbol. Such a TDM’d SRS resource with a symbol carrying 4 of the 8 ports would be 3 dB higher power than a non-TDM’d SRS with a symbol carrying all eight ports. The behavior above of transmitting the same power regardless of how many SRS resources and ports are in a given symbol is the opposite of that of TDM’d SRS.

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| - if a UE is provided *nrofSRS-Ports-n8* = 'ports8tdm'for an SRS resource with 8 ports in an SRS resource set with usage 'codebook' or 'antennaSwitching', the UE splits a linear value $\hat{P}\_{SRS,b,f,c}(i,q\_{s},l)$ of the transmit power $P\_{SRS,b,f,c}(i,q\_{s},l)$ on active UL BWP $b$ of carrier $f$ of serving cell $c$ equally across the configured antenna ports on each symbol for SRS transmission.- else, a UE splits a linear value $\hat{P}\_{SRS,b,f,c}(i,q\_{s},l)$ of the transmit power $P\_{SRS,b,f,c}(i,q\_{s},l)$ on active UL BWP $b$ of carrier $f$ of serving cell $c$ equally across the configured antenna ports for SRS.  |

1. Splitting the total SRS power by the number of SRS resources in set, regardless of the number of SRS ports in an OFDM symbol mitigates the problem of inaccurate SRS power knowledge for per SRS resource power control. However, the gNB must still assume that there is no power increase from transmitting fewer SRS resources in a symbol, which is inconsistent with Rel-18 TDM’d SRS as well as Rel-15 non-codebook based PUSCH transmission.

Therefore, in Moderator’s view, it is a step forward to establish the relationship between the power per SRS resource and the total power. In that way, the network has some knowledge it can use for PUSCH resource allocation and to configure SRS. One alternative can be to align with the Rel-18 TDM’d SRS and with non-codebook based PUSCH, while another can be to split the power equally among all SRS resources in a set, regardless of the number of SRS resources in a symbol.

**Question 2.1: Please identify if you support Alt a) or Alt b). If you don’t support either, please suggest another alternative. Also please provide your rationale in the comments field.**

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| **Alt a) the power split of simultaneously transmitted SRS resources aligns with the behavior of TDM’d SRS and non-codebook based PUSCH****Alt b) the total PUSCH power is always split equally among all SRS resources in an SRS resource set, regardless of the number of SRS resources in a symbol.** |
| **Company** | **Alt a) or b)** | **Comments** |
| Google |  | We do not quite understand the discussion point. The two alternatives seem to be talking about different things: one for SRS power split, the other for PUSCH power split. |
| ZTE |  | To simply this discussion, we may only focus on SRS power determination (if not extending Pcmax). If so, our answer is that the formula is per SRS resources regardless of TDMed or not.  |
| Moderator |  | Thanks for the feedback. **@Google:** One of the points for Alt a) is if we should be able to determine the power of PUSCH layers for non-codebook or not (and the other is if varying the number of SRS ports in a symbol should change the power per SRS resource). Hope that clarifies.**@ZTE:** Last meeting, we clarified that the power is equal regardless of Pcmax. So should I understand you to be supportive of Alt b)? If not, how can it be improved? |
| Apple |  | We do not support neither. We need to clarify how SRS power control is performed in 38.213. It is reasonable to assume that it is based per SRS resource, but the power control related setting is configured per SRS resource set.Then, when power scaling is not needed, there is no need for any further clarification.When power scaling is needed, i.e., because the total power exceeds Pcmax, it is up to UE implementation.  |
| OPPO |  | We don’t support either option. In our understanding, the SRS power control in Rel-15 is per SRS resource basis. Either option would lead to NBC issue for Rel-15. If companies think there is any issue on Rel-15 mechanism, an enhancement can be discussed in current release (e.g. Rel-18) with corresponding UE capability. However, we don’t think the link adaptation is a big issue since gNB can estimate the total transmit power based on PHR (though it is for one resource) and can also correct the link adaptation based on OLLA. The two options would also degrades the SRS estimation performance due to lowered SRS transmit power.  |
| Samsung |  | In our understanding, overlapping SRS resources having same starting symbol and consecutive length should be regarded as the same SRS transmission occasion for transmit power control. So for NCB usage, if multiple SRS resources in a SRS resource set are overlapping, only one transmission power control value should be associated with all the SRS resources hence we don’t have to consider the case exceeding Pcmax, since it does not happen. In this case, when a P value is configured for the multiple SRS resources, so-called ‘split total power control’, i.e., the power P is split by the number of antenna ports for SRS, is a natural outcome  |
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The power for SRS varies according to the number of PRBs in the SRS. Since the RRC allows the number of PRBs per SRS resource to be different, it is in theory possible that the network would configure SRS resources in a set with *usage* nonCodebook to have different numbers of PRBs. This would lead to an unequal spOPPOlit of power among the SRS resources in a set, and was a reason why the RAN1#116b conclusion above was constrained to the ‘fully overlapping time/frequency case’. As was pointed out in RAN1#116 [5], FDM’d SRS resources have been discussed for Rel-15 e.g. in [6] issue 2.3.14, but explicit support for power scaling among FDMed SRS resources was not specified. Therefore, how UEs would behave with an unequal number of PRBs in simultaneously transmitted SRS resources likely remains unclear in Rel-18. Moreover, the motivation for unequal numbers of PRBs in simultaneous SRS resources is unclear for non-codebook based operation, since the PUSCH layers always occupy the same PRBs. It does not seem desirable to specify power control that only supports the case where simultaneous SRS resources occupy the same PRBs to solve the problem that a different number of PRBs is possible in the spec, but does not have defined behavior. In prior discussions, specifying that simultaneously transmitted SRS resources have the same number of PRBs did not seem possible, so one possible way forward is to make a conclusion that the relative power of SRS resources occupying different numbers of PRBs is left to UE implementation. Another way forward is to rely on the RAN1#116b conclusion above, with the common understanding that the relative power is left to UE implementation if SRS resources with different numbers of PRBs are transmitted simultaneously.

**Question 2.2: Please answer if you support either Option 1 or 2, elaborating your view in the comments.**

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| **Option 1.****Conclusion****The relative power of simultaneously transmitted SRS resources with set *usage* nonCodebook occupying different numbers of PRBs is left to UE implementation.****Option 2****The RAN1#116b conclusion for simultaneous SRS resources with set *usage* nonCodebook is sufficient; no new conclusion is needed to address where SRS resources occupy different numbers of PRBs.** |
| **Company** | **Opt 1 or 2** | **Comments** |
| Google |  | This case is prohibited in R15 spec.  |
| ZTE |  | If my memories serve me, in Rel-15, the number of PRBs of SRSs for CB in a set should be the same. |
| Moderator |  | My apologies, you are correct. Rel-15 (and Rel-18) has the following in 38.214 6.1.1.2: “The SRS resources transmitted simultaneously occupy the same RBs.”**No need for this discussion point, and it is closed.** |

If Alt a) from Question 2.1 is agreeable, one way to express it can be as follows [3][4]. Here, ‘configured antenna ports’ is disambiguated to be the SRS ports of one SRS resource in one SRS resource set for both the Rel-18 TDM’d SRS and the Rel-15 SRS. The Rel-15 SRS power splitting in the second bullet is further clarified to be the total number of SRS ports in one OFDM symbol. Note that there is no need to constrain the Rel-15 bullet to be non-codebook, since usages ‘codebook’ and ‘antenna switching’ do not allow simultaneously transmitted SRS resources, while simultaneous transmission for beam management is only with one SRS resource per SRS resource set. Note that while the text here is shown for Rel-18, Moderator would suggest a Rel-17 CR with the text below being the Rel-18 shadow.

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| For SRS, - if a UE is provided *nrofSRS-Ports-n8* = 'ports8tdm'for an SRS resource with 8 ports in an SRS resource set with usage 'codebook' or 'antennaSwitching', the UE splits a linear value $\hat{P}\_{SRS,b,f,c}(i,q\_{s},l)$ of the transmit power $P\_{SRS,b,f,c}(i,q\_{s},l)$ on active UL BWP $b$ of carrier $f$ of serving cell $c$ equally across the ~~configured antenna~~SRS ports of an SRS resource of an SRS resource set on each symbol for SRS transmission.- else, a UE splits a linear value $\hat{P}\_{SRS,b,f,c}(i,q\_{s},l)$ of the transmit power $P\_{SRS,b,f,c}(i,q\_{s},l)$ on active UL BWP $b$ of carrier $f$ of serving cell $c$ equally across ~~the configured antenna ports for SRS~~ all SRS ports of all SRS resources of a SRS resource set in a symbol for SRS transmission.  |

**Question 2.3:**

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| **Please provide your view on the text proposal above and any suggestions for improvement, assuming that Question 2.1 Alt a) is agreeable.** |
| **Company** | **Comments** |
| Google | If we want to modify spec, we can be fine to capture the same text as the conclusion agreed in last meeting or similar text as current 38.213. This returns to the original question, whether one SRS transmission occasion means one SRS resource or multiple SRS resources. It seems most of companies think one SRS transmission occasion means one SRS resource. The following text in 38.213 also suggests such understanding. **“If the UE transmits SRS on multiple SRS resources according the *XYZ* [6, TS 38.214], the UE allocates power so that all REs of the SRS transmission have same power.”**If necessary, probably similar wording as above can be considered for non-codebook.   |
| ZTE | Not support. In our views, the ‘configured antenna ports’ refers to ‘the number of SRS ports in a resource’. We do not believe that the current power control formula of SRS can be workable for a number of SRS resources, especially for the definition of ‘’. |
| Moderator | **@Google:** if other companies are now OK to capture last meeting’s conclusion in the spec, in my view that could clarify the behavior (both above and below Pcmax). For reference, that conclusion is again:**Conclusion**The transmit power of each of the simultaneously transmitted SRS resources for usage ‘nonCodebook’ is equal in the fully overlapping time/frequency case, regardless of whether calculated transmission power across all SRS resources is higher or lower than Pcmax.* No specification change

However: my point is that simply knowing that the power is equal according to last meeting’s conclusion does not relate it to the total power in the set, as discussed above. Alt b) was meant to tackle that with the presumption that a single, fixed, offset is used. I was hoping that fans of ‘per SRS resource’ power control might be OK with at least that. So, I’d like to focus first on resolving the behavior, but would welcome companies thoughts on capturing last meeting’s conclusion in the specs.**@ZTE:** Thanks for the comment. Since as you correctly point out, the number of PRBs must be the same for simultaneously transmitted SRS resources for non-codebook, then do I understand your concern to be that the number of PRBs can be different if the resources are not simultaneously transmitted? If we assume the # PRBs is the same for the non-simultaneous case, then (repeating a bit my response in Question 2.1, sorry for that) are you OK with Alt b)? |
| Apple | We do not support. Again, we first need to discuss if SRS power control in TS38.213 is per SRS resource, or something else.  |
| OPPO | We don’t think any CR is needed.  |
| Samsung  | In our view, the original text is already clearly expressing ‘split-total power control’, since ‘the configured antenna ports for SRS’ well indicate all of the antenna ports of the SRS resources corresponding to SRS transmission occasion *i*. Although the proposed texts look further clearly expressing ‘split-total power control’, we don’t think it is necessary to adopt.  |

If Alt b) is preferred, something like the following may be in order. As for Alt a), ‘configured ports’ is disambiguated to be the SRS ports of one SRS resource in one SRS resource set for both the Rel-18 TDM’d SRS and the Rel-15 SRS. The power is split equally among all SRS resources in an SRS resource set for Rel-15 *usage* nonCodebook. Note that while the text here is shown for Rel-18, Moderator would suggest a Rel-17 CR with the text below being the Rel-18 shadow.

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| For SRS, - if a UE is provided *nrofSRS-Ports-n8* = 'ports8tdm'for an SRS resource with 8 ports in an SRS resource set with usage 'codebook' or 'antennaSwitching', the UE splits a linear value $\hat{P}\_{SRS,b,f,c}(i,q\_{s},l)$ of the transmit power $P\_{SRS,b,f,c}(i,q\_{s},l)$ on active UL BWP $b$ of carrier $f$ of serving cell $c$ equally across the ~~configured antenna~~SRS ports of an SRS resource of an SRS resource set on each symbol for SRS transmission.- else, for an SRS resource set with *usage* 'nonCodebook', a UE splits a linear value $\hat{P}\_{SRS,b,f,c}(i,q\_{s},l)$ of the transmit power $P\_{SRS,b,f,c}(i,q\_{s},l)$ on active UL BWP $b$ of carrier $f$ of serving cell $c$ equally across ~~the configured antenna ports for SRS~~ all SRS ports of all SRS resources of an SRS resource set for SRS transmission. - else, a UE splits a linear value $\hat{P}\_{SRS,b,f,c}(i,q\_{s},l)$ of the transmit power $P\_{SRS,b,f,c}(i,q\_{s},l)$ on active UL BWP $b$ of carrier $f$ of serving cell $c$ equally across ~~the configured antenna ports for SRS~~ the SRS ports of an SRS resource of an SRS resource set for SRS transmission. |

**Question 2.4:**

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| **Please provide your view on the text proposal above and any suggestions for improvement, assuming that Question 2.1 Alt b) is agreeable.** |
| **Company** | **Comments** |
| Google | Please see our comments above |
| Apple | We do not support. Again, we first need to discuss if SRS power control in TS38.213 is per SRS resource, or something else.  |
| OPPO | We don’t think any CR is needed.  |
| Samsung | Same as our comments above |

# 3 Summary of discussion so far and way forward

## 3.1 First round summary

TBD

## 3.2 First round outcome

TBD

# 4 Conclusion

TBD

# 5 References

1. vivo, “R1-2311072, Discussion on SRS transmission occasion”, 3GPP TSG RAN1#115, Chicago, USA, November 13-17, 2023.
2. Moderator(vivo), “R1-2401842, Summary#2 of discussion on SRS transmission occasion and power scaling”, 3GPP TSG RAN1#116, Athens, Greece, February 26th – March 1st, 2024.
3. Ericsson, Nokia, “R1-2405118, SRS Tx occasion and power scaling”, 3GPP TSG RAN1#117, Fukuoka City, Fukuoka, Japan, May 20th – 24th, 2024.
4. Ericsson, Nokia, “R1-2405291, Correction on Multi-Resource SRS Port Power Scaling”, 3GPP TSG RAN1#117, Fukuoka City, Fukuoka, Japan, May 20th – 24th, 2024.
5. Oppo, “R1-2400577, Discussion on SRS transmission occasion and power scaling”, 3GPP TSG RAN1#116, Athens, Greece, February 26th – March 1st, 2024.
6. ZTE, Sanechips, “R1-1721567, Offline summary of UL power control – non-CA aspects”, 3GPP TSG RAN1#91, Reno, USA, November 27th – December 1st, 2017

# 6 Contact info

Please provide your contact information below in order to facilitate offline discussion.

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| **Company name** | **Delegate name** | **Email address** |
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