3GPP TSG-RAN WG1 Meeting #118 Tdoc R1-2407210

Maastricht, NL, August 19th – 23rd, 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:

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| 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.
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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. |

The status after RAN1#117 was summarized with two main observations [3]:

* Regardless of whether ‘per resource’ or ‘split power’ power control is assumed, it seems to be the common understanding for an SRS resource set with usage ‘nonCodebook’ that the UE splits the total transmit power for SRS equally among SRS resources in a symbol.
	+ It was confirmed in offline discussions there was no support for Alt 3), where the UE always scales the per-resource power for simultaneously transmitted SRS resources by the number of SRS resources in the set, N.
* While the power per resource is equivalent, what is reported in the PHR is unclear.  If $\hat{P}\_{SRS,b,f,c}\left(i,q\_{s},l\right) $is interpreted as the power for one SRS resource of N simultaneously transmitted resources, the PHR will be N times higher ($10log\_{10}N$ dB) than if $\hat{P}\_{SRS,b,f,c}\left(i,q\_{s},l\right) $is interpreted as the total transmitted power for all SRS resources.  However, if the gNB is aware of UE’s interpretation of if $\hat{P}\_{SRS,b,f,c}\left(i,q\_{s},l\right)$, it can correctly determine the available power in the UE.

In order to clarify the power control behavior and determination of power headroom, the following was agreed:

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| Consider the following approaches in RAN1#118, taking into account implications for power headroom reporting:**Approach 1**The UE determines the SRS transmission power $P\_{SRS,b,f,c}(i,q\_{s},l)$ as the combined power of simultaneously transmitted SRS resources with usage ‘nonCodebook’**Approach 2**The UE determines the SRS transmission power $P\_{SRS,b,f,c}(i,q\_{s},l)$ as the power of one SRS resource for simultaneously transmitted SRS resources with usage ‘nonCodebook’ |

In this contribution, we summarize the continuation of the discussion in RAN1#118 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, 5 discussion papers [4]-[8] and a draft CR [9] were submitted on this topic. A high level summary of these discussion papers paraphrasing the arguments for the two approaches with the supporting companies is given below.

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|  | **Supporting arguments** |
| **Approach 1**Supported by: Ericsson, Nokia, Samsung | * SRS transmission occasion is defined by time, and so is split equally across all ports in the occasion.[6]
* Consistent with power computation for e.g. multi-layer PUSCH, easy to determine available PUSCH power from SRS measurements, and uses the (total) UE configured maximum output power PCMAX,f,c(i) in SRS power control to compute available total SRS power.[8]
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| **Approach 2**Supported by: Apple, Huawei/Hi Silicon, ZTE/Sanechips | * SRS power control is determined using SRS resource bandwidth, and so $P\_{SRS,b,f,c}\left(i,q\_{s},l\right)$ is the power of one SRS resource. [4]
* In Approach 1, SRS bandwidth must be calculated over all resources in a set and using time, which is not backward compatible.[5]
* Same Tx power is not reached for Approach 1 when SRS resources are in different symbols. [7]
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The situation at present is therefore quite similar to the outcome of RAN1#117, without consensus for one Approach. While companies have elaborated their argumentation and there are more contributions this meeting, in Moderator’s expectation, it is unlikely after these 4 meetings of discussion that agreement can be reached on if Approach 1 vs. Approach 2 are supported by current specifications.

1. Even considering new arguments into RAN1#118, it is unlikely after these 4 meetings of discussion that agreement can be reached on if Approach 1 vs. Approach 2 are supported by current specifications.

Then regarding the impact interpreting the specs differently according to Approach 1 or 2, in [8], it is argued:

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| Observation 2 If the network assumes Approach 1 vs. 2 is used to determine the SRS target power, the amount of power the network should assume is available for PUSCH from a measurement of SRS is different by a factor of N, where N is the number of simultaneously transmitted SRS resources.Observation 3 If the network assumes Approach 1 vs. 2 is used to determine the SRS target power, the amount of power the network should assume is available for SRS from a type 1 PHR is different by a factor of N, where N is the number of simultaneously transmitted SRS resources. |

A similar view is expressed in [5], where PHR seems to require clarification, since a power splitting rule is introduced and used for PHR:

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| * Regarding Approach 2, in principle, this option is much aligned with legacy UL power control mechanism. While total Tx power extends the upper bound, we may consider to introduce a rule, e.g., equally splitting across the overlapping SRS resources, which can be used for PHR calculation as well.
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On the other hand, in [4], it is felt that support for Approach 2 in the specification is already clear:

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| Thus, for the scenario where multiple SRS resources with usage ‘nonCodebook’ are transmitted simultaneously, the SRS transmission power $P\_{SRS,b,f,c}\left(i,q\_{s},l\right)$ should be the power of one SRS resource. This is also aligned with the current spec that the total power is split between SRS ports of the resource, therefore no spec change is needed. |

It is further argued in [4] that power headroom (at least Type 3) is irrelevant to the scenarios we are discussing:

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| Observation 1: Type 3 power headroom reporting is irrelevant with the scenario where multiple SRS resources with usage ‘nonCodebook’ are transmitted simultaneously. |

To give Moderator’s perspective on these last two points: Firstly, companies are clearly interpreting the specs differently, some for Approach 1 and some for Approach 2, and we are stuck on doing so as observed above. Then regarding PHRs, it is true that a Type 3 PHR does not support where PUSCH transmission is configured on a cell, and so Type 3 PHR as currently implemented is not compatible with non-codebook based operation. However, the network should be able to use e.g. Type 1 PHR to determine available SRS power, as observed by [8] above.

1. It should be resolved if using Approach 1 or 2 has significant impact on the reported power headroom and relation between SRS and PUSCH power

In the following we address these two issues on reported PHR and SRS vs. PUSCH power, explaining Moderator’s understanding and asking Questions 2.1 and 2.2 to check this understanding.

For the power headroom issue, if X dB headroom is available for PUSCH, X dB headroom should be available for SRS. However, whether X is for one SRS resource or for the combined power of all SRS resources depends on if Approach 1 or Approach 2 is used by the UE. Question 2.1 attempts to align understanding of how power headroom relates to Approaches 1) and 2).

Alts a) and b) below are motivated by the understanding that power headroom is calculated by the target power, which for example for PUSCH in PHR Type 1 is the text in { } in the following (from 38.213 section 7.7.1), and where the approximate equality notation means that $P\_{PUSCH,b,f,c}(i,j,q\_{d},l)$ is equal to the target power when there is no power limitation.

$$PH\_{type1,b,f,c}\left(i,j,q\_{d},l\right)=P\_{CMAX,f,c}\left(i\right)-\{P\_{O\\_PUSCH,b,f,c}\left(j\right)+10log\_{10}(2^{μ}∙M\_{RB,b,fc}^{PUSCH}\left(i\right))+α\_{b,f,c}\left(j\right)∙PL\_{b,f,c}\left(q\_{d}\right)+Δ\_{TF,b,f,c}\left(i\right)+f\_{b,f,c}(i,l)\}≅P\_{CMAX,f,c}\left(i\right)-P\_{PUSCH,b,f,c}(i,j,q\_{d},l)$$

In Approach 1, the target power for SRS ($P\_{SRS,b,f,c}(i,q\_{s},l)$ when not power limited) is equal to the combined power of all SRS resources. However, in Approach 2, the target power $P\_{SRS,b,f,c}(i,q\_{s},l)$ is the power of one SRS resource, which means the total power is different by a factor of N, for N simultaneously transmitted SRS resources. Therefore, for Approach 1, a Type 1 PHR can be used directly for SRS, while for Approach 2, the PHR needs to be adjusted by $10log\_{10}N$ dB. If one were to assume that the power headroom for SRS with Approach 2 is the same as for PUSCH, i.e., there is no need to adjust a Type 1 PHR to find SRS headroom, this seems inconsistent to us with Approach 2. However, that is listed as Alt c), to confirm this understanding.

In the following, we set the power control targets equal to simplify explanation of the PHR behavior. If different power control settings are used for PUSCH and SRS, the network would take these differences into account, but would still be able to infer SRS power from a Type 1 PHR.

**Question 2.1: Please identify if you support Alt a), b), or c). If you don’t support any of them, please suggest another alternative. Note that Alt c) is not consistent with Approach 2 in our understanding, but is included here for completeness. If you support Alt c), please explain how it can be made consistent with Approach 2). Also, please provide your rationale for your preferred Alt in the comments field.**

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| **Which one of the following alternatives should the network assume for determining power headroom for SRS from a Type 1 PHR?****Assume the power control settings are such that the same target power is determined for PUSCH and SRS and the UE reports X dB Type 1 power headroom.****Alt a) Approach 1 is used by the UE and each of N simultaneously transmitted SRS resources can be increased by X dB, i.e.** $X=P\_{CMAX,f,c}-P\_{All\\_SRS\\_Resources}=P\_{CMAX,f,c}-P\_{SRS,b,f,c}(i,q\_{s},l)$**Alt b) Approach 2 is used by the UE and one resource of N simultaneously transmitted SRS resources can be increased by X dB (with the other resources not part of the PH calculation), i.e.** $X=P\_{CMAX,f,c}-(P\_{All\\_ SRS\\_Resources}-10log\_{10}N)= P\_{CMAX,f,c}-P\_{SRS,b,f,c}(i,q\_{s},l). $**Alt c) Approach 2 is used by the UE and each of N simultaneously transmitted SRS resources can be increased by X dB, i.e.** $X=P\_{CMAX,f,c}-P\_{All\\_SRS\\_Resources}=P\_{CMAX,f,c}-P\_{SRS,b,f,c}(i,q\_{s},l)$**Where** $P\_{All\\_SRS\\_Resources}$ **is the combined power of the N simultaneous SRS resources and** $P\_{CMAX,f,c}$ **and** $P\_{SRS,b,f,c}\left(i,q\_{s},l\right)$ **are as defined in 38.213 sections 7.1.1 and 7.3.1.** |
| **Company** | **Alt a), b), or c)** | **Comments** |
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We next consider where the amount of PUSCH power that would be received is inferred from a measurement of SRS. If the power control settings are such that the same target power is determined for PUSCH and SRS, and assuming the target powers are below Pcmax, then $P\_{SRS,b,f,c}\left(i,q\_{s},l\right)$=$P\_{PUSCH,b,f,c}(i,j,q\_{d},l)$. However, since in Approach 2 SRS is power controlled per resource, the total SRS power is N times higher than if the power control targets all SRS resources in Approach 1. This means that the received power of SRS would need to be adjusted for Approach 2 by a factor of $10log\_{10}N$ to determine the PUSCH power. If the network is aware of if Approach 1 vs. 2 is used in the UE, the same power target for SRS and PUSCH can be achieved by e.g. adjusting the P0 power control parameter when Approach 2 is used.

**Question 2.2: Please identify if you support Alt a), b), or c). If you don’t support any of them, please suggest another alternative. Note that Alt c) is not consistent with Approach 2 in our understanding, but is included here for completeness. If you support Alt c), please explain how it can be made consistent with Approach 2). Also please provide your rationale for your preferred Alt in the comments field.**

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| **Which one of the following alternatives should the network assume for determining PUSCH power given a measurement of SRS power?****Assume the power control settings are such that the same target power is determined for PUSCH and SRS and the UE is not power limited, and therefore** $P\_{SRS,b,f,c}\left(i,q\_{s},l\right)$**=**$P\_{PUSCH,b,f,c}(i,j,q\_{d},l)$ **(as defined in 38.213 sections 7.3.1 and 7.1.1).****Alt a) Approach 1 is used by the UE and if gNB receives N simultaneously transmitted SRS resources with combined power of Y dBm, PUSCH would be transmitted at Y dBm, i.e.** $Y=P\_{SRS,b,f,c}\left(i,q\_{s},l\right)=P\_{PUSCH,b,f,c}(i,j,q\_{d},l)$**Alt b) Approach 2 is used by the UE and if gNB receives N simultaneously transmitted SRS resources with combined power of Y dBm, PUSCH would be transmitted at** $Y-10log\_{10}N$ **dBm, i.e.** $Y=P\_{SRS,b,f,c}\left(i,q\_{s},l\right)+10log\_{10}N=P\_{PUSCH,b,f,c}(i,j,q\_{d},l) +10log\_{10}N$**Alt c) Approach 2 is used by the UE and if gNB receives N simultaneously transmitted SRS resources with combined power of Y dBm, PUSCH would be transmitted at Y dBm, i.e.** $Y=P\_{SRS,b,f,c}\left(i,q\_{s},l\right)=P\_{PUSCH,b,f,c}(i,j,q\_{d},l)$ |
| **Company** | **Alt a), b), or c)** | **Comments** |
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Potential specification changes were provided by [8] in this meeting for the two Approaches. Early comments on specification changes may facilitate understanding of the detailed operation and level of spec impact, and so we take them up now.

The following was proposed for Approach 1) for Rel-18. The changes were motivated with the following:

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| Since Approach 1 assumes that $P\_{SRS,b,f,c} (i,q\_{s},l)$ is the total SRS transmission power, regardless of the number of simultaneous SRS resources, it is not possible for the total target power of all SRS resources to exceed $P\_{CMAX,f,c}$, and the available power for PUSCH is the same as the available power for SRS (given the same power control settings and TPC). This means that it is only necessary to clarify the power split among SRS ports and resources. Presuming that the power split is to align with TDM’d SRS and non-codebook based PUSCH, one way implement split total power control in 38.213 section 7.3 can be as follows:…This clarifies that ‘configured antenna ports’ are the SRS ports of an SRS resource of an SRS resource set for the case where TDM is used. For the general case, ‘configured antenna ports’ is all SRS ports of all simultaneously transmitted SRS resource(s) in a set. Note that the constraint that all SRS resources are in an SRS resource set avoids the need to limit the change to resources sets with usage ‘nonCodebook’ since the only case where simultaneous SRS resource transmission in a set is allowed is for non-codebook based operation.  |

**Changes to support Approach 1 in 38.213 v. 18.3:**

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| 7.3 Sounding reference signalsFor 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 an SRS resource set in a symbol for SRS transmission.  |

**Question 2.3:**

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| **Please provide your view on the text proposal for Approach 1 above and any suggestions for improvement.** |
| **Company** | **Comments** |
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For Approach 2), changes were proposed for sections 7.3, 7.3.1, and 7.5 The changes for 7.3 and 7.3.1 were motivated with the following:

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| Since Approach 2 assumes that $P\_{SRS,b,f,c} (i,q\_{s},l)$ is the transmission power for one SRS resource, it is possible for the total target power of all SRS resources to exceed $P\_{CMAX,f,c}$. Therefore, for Approach 2 it is necessary to clarify what ‘configured antenna ports’ are in the multiple SRS resource case (as for Approach 1) and that the power is the power of each SRS resource in a transmission occasion (i.e. SRS power control is ‘per resource’). This can be accomplished with the following changes to section 7.3 and 7.3.1 of 38.213: |

The proposed text for these sections was (again for Rel-18):

**Changes to support Approach 2 in 38.213 v. 18.3:**

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| 7.3 Sounding reference signalsFor 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~~ SRS ports of each SRS resource of an SRS resource set in a symbol for SRS transmission. 7.3.1 UE behaviourIf a UE transmits SRS based on a configuration by *SRS-ResourceSet* on active UL BWP $b$ of carrier $f$ of serving cell $c$ using SRS power control adjustment state with index $l$, the UE determines the SRS transmission power $P\_{SRS,b,f,c}(i,q\_{s},l)$ of each SRS resource in SRS transmission occasion $i$ as  [dBm]where,- $P\_{CMAX,f,c}(i)$ is the UE configured maximum output power defined in [8, TS 38.101-1], [8-2, TS 38.101-2], [TS 38.101-3] and [8-5, TS 38.101-5] for carrier $f$ of serving cell $c$ in SRS transmission occasion $i$ |

The changes to 38.213 section 7.5 were motivated in [8] with:

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| With $P\_{SRS,b,f,c} (i,q\_{s},l)$ being the transmission power for one SRS resource, it is necessary to handle the case where the total power of the simultaneously transmitted SRS resources exceeds $P\_{CMAX,f,c}$. Proposals to handle this aspect have generally been to use the ‘Prioritizations for transmission power reductions’ section 7.5 of 38.213. This section adjusts the power of simultaneous transmissions of PUSCH, PUCCH, PRACH, and/or SRS serving cells or on a candidate cell via the parameter $P\_{CMAX}(i)$. In our understanding, this parameter is the maximum combined power of all cells and carriers, whereas $P\_{CMAX,f,c}$ is the power for each carrier and cell. Since we are concerned with exceeding the power on a cell/carrier, changes to this section should address how the total SRS power compares to $P\_{CMAX,f,c}$ rather than $P\_{CMAX}(i)$.  |

And the proposal was:

**Changes to support Approach 2 in 38.213 v. 18.3:**

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| 7.5 Prioritizations for transmission power reductionsFor single cell operation with two uplink carriers or for operation with carrier aggregation, if a total UE transmit power for PUSCH or PUCCH or PRACH or SRS transmissions on serving cells in a frequency range in a respective transmission occasion $i$ would exceed $\hat{P}\_{CMAX}(i)$, where $\hat{P}\_{CMAX}(i)$ is the linear value of $P\_{CMAX}(i)$ in transmission occasion $i$ as defined in [8-1, TS 38.101-1] for FR1 and [8-2, TS 38.101-2] for FR2, the UE allocates power to PUSCH/PUCCH/PRACH/SRS transmissions according to the following priority order (in descending order) so that the total UE transmit power for transmissions on serving cells in the frequency range is smaller than or equal to $\hat{P}\_{CMAX}(i)$ for that frequency range in every symbol of transmission occasion $i$. 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.…In case of same priority order and for operation with carrier aggregation, the UE prioritizes power allocation for transmissions on the primary cell of the MCG or the SCG over transmissions on a secondary cell. In case of same priority order and for operation with two UL carriers, the UE prioritizes power allocation for transmissions on the carrier where the UE is configured to transmit PUCCH. If PUCCH is not configured for any of the two UL carriers, the UE prioritizes power allocation for transmissions on the non-supplementary UL carrier. For the simultaneous transmissions of SRS resources in an SRS resource set with the higher layer parameter *usage* configured as ‘*non-Codebook*’, if the total UE transmit power for the transmissions on a carrier $f$ of serving cell $c$ in SRS transmission occasion $i$ would exceed $P\_{CMAX,f,c}(i)$, where $P\_{CMAX,f,c}(i)$ is the UE configured maximum output power defined in [8, TS 38.101-1], [8-2, TS 38.101-2], [TS 38.101-3] and [8-5, TS 38.101-5], the UE allocates equal power to the SRS resource transmissions so that the total UE transmit power is smaller than or equal to $P\_{CMAX,f,c}(i)$. |

**Question 2.4:**

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| **Please provide your view on the text proposal for Approach 2 above and any suggestions for improvement.** |
| **Company** | **Comments** |
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# 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

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4. Huawei, HiSilicon, “R1-2405874, Discussion on transmission power for simultaneously transmitted SRS resources”, 3GPP TSG RAN1#118, Maastricht, NL, August 19-23, 2024.
5. ZTE Corporation, Sanechips, “R1-2406462, Discussion on SRS Tx power and power headroom reporting”, 3GPP TSG RAN1#118, Maastricht, NL, August 19-23, 2024.
6. Samsung, “R1-2406618, Discussion on SRS transmission occasion”, 3GPP TSG RAN1#118, Maastricht, NL, August 19-23, 2024.
7. Apple, “R1-2406821, On SRS open loop power control with overlapping SRS resources”, 3GPP TSG RAN1#118, Maastricht, NL, August 19-23, 2024.
8. Ericsson, Nokia, “R1-2407177, SRS Tx Occasion and Power Scaling”, 3GPP TSG RAN1#118, Maastricht, NL, August 19-23, 2024.
9. Ericsson, Nokia, “R1-2407176, Draft CR on Multi-Resource SRS Port Power Scaling”, 3GPP TSG RAN1#118, Maastricht, NL, August 19-23, 2024.

# 6 Contact info

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

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