3GPP TSG RAN WG1 Meeting #108-e R1-2201201

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

**Source: Moderator (ZTE)**

Title: FL summary #1 on SRS enhancements

Agenda Item: 8.1.3

Document for: Discussion and Decision

# Introduction

In RAN#94-e, Rel-17 feMIMO WI has been declared as compete given the core technical functionalities have been delivered till RAN1#107-e. In this contribution, we summarize companies’ views on maintenance of the SRS enhancements submitted to RAN1#108-e [1]-[19].

# Flexibility enhancements

## SRS triggering offset

### 2.1.1 Collision handling

One FFS point from RAN1#104e’s agreement on available slot definition is “rules to handle the case of multiple SRS resource sets with overlapping symbols and/or triggered by a same DCI”. Companies’ detailed views are given in the table below.

Table 2-1

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| --- |
| **Issue 2.1: Collision handling** |
| Views | Companies | Priority rules |
| Introduce dropping rule when collision happens among aperiodic SRS resource sets | Ericsson, Intel, Nokia/NSB, vivo, CATT, Lenovo/MotM, NTT DOCOMO, Spreadtrum (UE optional feature) | * Rule 1 – Based on usage: Intel, CMCC, Nokia/NSB, Ericsson, vivo, NTT DOCOMO
* Rule 2 – Based on set ID and CC ID: Intel, Ericsson, vivo, CATT, Spreadtrum,
* Rule 3 – Based on order of the triggering DCI: Lenovo/MotM, vivo
 |
| Introduce dropping rule when overlapping happens between a aperiodic SRS resource in a CC and a PUSCH/PUCCH/PRACH in another CC and result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability | CATT | CATT: If the SRS overlaps with PUSCH/PUCCH transmission carrying HARQ-ACK/positive SR/RI/CRI/SSBRI and/or PRACH, the SRS in the overlapped symbols are dropped; Otherwise, the PUSCH/PUCCH is dropped. |
| Do not introduce new dropping rule | Samsung, LG |  |

Based on majority view from companies’ input, the following proposal is given.

***FL Proposal 2-1:*** *Introduce dropping rule when collision happens among multiple aperiodic SRS resource sets in a same CC or different CCs.*

* *Adopt the following priority rules (with priority level from high to low)*
	+ *Usage > CC ID > Set ID*
		- *For usages, priority order is AS > CB > NCB > BM*
		- *For CC ID/set ID, lower ID has higher priority than higher ID*
* *The new dropping rule is a UE optional feature*
	+ *UE will take collision as error case if UE does not support this feature*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | The issue of AP SRS collision can be avoided by gNB implementation. Thus, this new rule is not needed.Moreover, as some companies commented in previous meeting(s), it is not justified to define the priority based on usage since in different scenarios, the priority of different usage will be different. We also have some additional questions for clarification: 1. One question for the intention of “*UE will take collision as error case if UE does not support this feature*”. Does it mean that UE will not transmit any SRS in this case? Or does it allow UE to transmit some of the overlapped SRS?
2. Let consider Set 1 (SRS1, SRS 2) and Set 2 (SRS 3, SRS 4) for this proposal. If only SRS1 and SRS 2 have one overlapped symbol, will UE drop the whole SRS 1(assume it is with low priority), or only drop the SRS 1 transmission in the overlapped symbol, or drop the whole Set 1?
 |
| DOCOMO | Support FL Proposal 2-1 |
|  |  |

### 2.1.2 Other remaining issues

Table 2-2

|  |  |
| --- | --- |
| Company | Issue |
| Intel | **Issue 2.2:** The available slot operation for aperiodic SRS is also applicable to DCI format 2\_3. |
| OPPO | **Issue 2.3:** For a given triggered SRS resource, if the number (X) of configured “t” values is less than the number (Y) of codepoints that can be indicated by the new DCI field, when one of the largest (Y-X) codepoints is indicated by the new DCI field, the slot for the transmission of this triggered SRS resource is determined by Rel-15/16 mechanism. |
| Qualcomm | **Issue 2.4:** UE drops the triggered A-SRS if the available slot offset is not reached within a specific span of time. |

***FL Proposal 2-2:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | For issue 2.3, the issue should be addressed. We are open to the final solution  |
|  |  |
|  |  |

## Flexible antenna switching

Multiple companies discuss the issue of indicating the number of antennas to support more flexible antenna switching via dynamic signaling. Their views are summarized in the following table.

Table 2-3

|  |
| --- |
| **Issue 2.5: Update Tx/Rx antennas for SRS antenna switch in dynamic signaling** |
| Views | Companies | Further details |
| Support indicating the number of Tx/Rx antennas for SRS antenna switching via MAC CE or DCI | Lenovo/MotM, Intel, Xiaomi, Samsung, Nokia/NSB, Spreadtrum | MAC CE:* Supported by Xiaomi, Samsung, Nokia/NSB, Spreadtrum
* Against by Intel

DCI:* Intel
 |
| Support UE reporting of the preferred antenna switching configuration | Yes: Xiaomi (MAC CE)No: Intel |  |

***FL proposal 2-3:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | First of all, we need to clarify whether changing the number of SRS ports dynamically will change the real number of Tx/Rx antennas for reception or transmission of other channel/signalsSecondly, with recommend from UE side, this feature is not useful. Thus, if we support some dynamic indication of antenna switching, a mechanism allowing UE recommendation should be designed togetherThirdly, MAC CE is sufficient. Don’t support DCI.  |
| DOCOMO | We are wondering if there should be a linkage between this topic and UE feature issue, i.e., whether to support downgrading configuration for antenna switching. From our perspective, if any downgrading configuration is not supported for architecture with more than 4 Rx, then the discussion is related only to UEs implementing 4 or less number of Rx. For such UEs, since the number of Rx is not very large, the flexibility discussed above seems not very essential. Also without this feature, Rel-15 and Rel-16 has just worked well in our understanding. Therefore, we do not see the need to introduce this during this CR phase. On the other hand, if we see more than 4 Rx architecture with downgrading configurations, the benefit seems to be much clearer, which we think may be worth being introduced even at this stage. In this case, we prefer to draw an agreement for the support of downgrading configurations for Rx more than 4 during WI discussion.  |
|  |  |

## Update of the association between trigger states and resource sets

Several companies discuss the issue of using MAC CE to update the association between SRS trigger states and SRS resource sets. Companies’ views are summarized in the following table

Table 2-4

|  |
| --- |
| **Issue 2.6: Update of the association between trigger states and resource sets** |
| Views | Companies |
| Support to update the association between SRS trigger states and SRS resource sets via MAC CE | Lenovo/MotM, Nokia/NSB |

***FL proposal 2-4:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | We don’t see clear benefit.  |
| DOCOMO | Fine with introducing MAC CE update of the association between SRS trigger states and SRS resource sets.  |
|  |  |

## Remaining issues for flexible DCI format

Table 2-5

|  |
| --- |
| **Issue 2.7: Interpretation of TPC command and BWP indicator in DCI 0\_1/0\_2 triggering SRS without data and without CSI** |
| Issues | Companies |
| For SRS triggered by DCI format 0\_1/0\_2 without scheduling PUSCH and without CSI Request, the existing TPC command carried by the DCI is used for the triggered SRS transmission. | Intel |
| When SRS is triggered by DCI format 0\_1/0\_2 without scheduling PUSCH and without CSI Request, the existing BWP indicator field carried by the DCI could be used to switch the BWP for the triggered aperiodic SRS transmission. | Intel, Futurewei |
| **Issue 2.8: Extension to CSI report quantity set as “none”** |
| Issues | Companies |
| Support DCI format 0\_1 and 0\_2 to trigger aperiodic SRS without data but with a non-zero "CSI request" where the associated "reportQuantity" in CSI-ReportConfig set to "none" for all CSI report(s) triggered by "CSI request" in this DCI format 0\_1 or 0\_2 | CATT |

***FL proposal 2-5:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Repurpose of DCI is not needed.For Issue 2.8, if the proposal is agreed, new UE feature and new RRC parameter should be supported accordingly.  |
|  |  |
|  |  |

## TPs

This section captures companies’ TPs to correct errors, improve readability or reflect missing agreements for endorsed RAN1 specifications.

***TP 2-1 (from Futurewei):*** *For the text in clause 6.2.1, TS 38.214 v17.0.0 on AP SRS triggering*

|  |
| --- |
| **<**Unchanged text is omitted>- If the UE receives the DCI triggering aperiodic SRS in slot *n* and at least one resource set is configured with parameter *availableSlotOffset* across all configured BWPs in a component carrier except when SRS is configured with the higher layer parameter *SRS-PosResource*, - If ca-SlotOffset is configured, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in the (*t* + 1)-th available slot counting from slot ~~if ca-SlotOffset is configured,~~ - Otherwise ~~otherwise~~ the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in the (t + 1)-th available slot counting from slot , where*- k* is configured via higher layer parameter *slotOffset* for each triggered SRS resources set and is based on the subcarrier spacing of the triggered SRS transmission, *µSRS* and *µPDCCH* are the subcarrier spacing configurations for triggered SRS and PDCCH carrying the triggering command, respectively;**<**Unchanged text is omitted>- If the UE receives the DCI triggering aperiodic SRS in slot *n* and at least one resource set is configured with parameter *availableSlotOffset* across all configured BWPs in a component carrier for the triggered aperiodic SRS transmission except when SRS is configured with the higher layer parameter *SRS-PosResource*, …**<**Unchanged text is omitted> |

Companies’ views on TP 2-1 are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Ok with the TP |
| DOCOMO | For ca-SlotOffset related part, we agree the TP makes the spec clearer. Thus we are fine with that TP. For the latter part, we agree to clarify “a component carrier” is for the triggered A-SRS. It seems the TP above captures this aspect properly.  |
|  |  |

***TP 2-2 (from OPPO):*** *Adopt the following TP (highlighted by Yellow) for TS 38.214 to align RAN1 and RAN2 specifications.*

|  |
| --- |
| TP for TS 38.214 (based on CR R1-2112949)Section 6.2.1<omitted text>The following SRS parameters are semi-statically configurable by higher layer parameter *SRS-Resource* or *SRS-PosResource*.- *srs-ResourceId* or *SRS-PosResourceId* determines SRS resource configuration identity.- Number of SRS ports, as defined by the higher layer parameter *nrofSRS-Ports* and described in clause 6.4.1.4 of [4, TS 38.211]. If not configured, *nrofSRS-Ports* is 1.*-* Time domain behaviour of SRS resource configuration as indicated by the higher layer parameter *resourceType*, which may be periodic, semi-persistent, aperiodic SRS transmission as defined in clause 6.4.1.4 of [4, TS 38.211].- Slot level periodicity and slot level offset as defined by the higher layer parameters *periodicityAndOffset-p* or *periodicityAndOffset-sp* for an SRS resource of type periodic or semi-persistent. The UE is not expected to be configured with SRS resources in the same SRS resource set *SRS-ResourceSet* or *SRS-PosResourceSet* with different slot level periodicities. For an *SRS-ResourceSet* configured with higher layer parameter *resourceType* set to 'aperiodic', a slot level offset is defined by the higher layer parameter *slotOffset.* For an *SRS-ResourceSet* configured with higher layer parameter *resourceType* set to 'aperiodic', a list of zero up to four different available slot offset values from the reference slot *n* + *k* to the slot where the aperiodic SRS resource set is transmitted where *n* is the slot with triggering DCI and *k* is *SlotOffset* is defined by the higher layer parameter *~~AvailableSlotOffset~~**availableSlotOffsetList.* The parameter *~~AvailableSlotOffset~~**availableSlotOffsetList* can be configured up to 4 different values*.* For an *SRS-PosResourceSet* configured with higher layer parameter r*esourceType* set to 'aperiodic', the slot level offset is defined by the higher layer parameter *slotOffset* for each SRS resource.- Number of OFDM symbols in the SRS resource, starting OFDM symbol of the SRS resource within a slot including repetition factor R as defined by the higher layer parameter *resourceMapping* and described in clause 6.4.1.4 of [4, TS 38.211]. If *R* is not configured, then *R* is equal to the number of OFDM symbols in the SRS resource.- SRS bandwidth and , as defined by the higher layer parameter *freqHopping* and described in clause 6.4.1.4 of [4, TS 38.211]. If not configured, then= 0.- Frequency hopping bandwidth , as defined by the higher layer parameter *freqHopping* and described in clause 6.4.1.4 of [4, TS 38.211]. If not configured, then = 0.- ~~Defining~~ partial frequency sounding factor PF and start RB index *k*F for partial frequency sounding as defined by the higher layer parameters *freqScalingFactor* *~~FreqScalingFactor~~* ~~P~~~~F~~ ~~and~~ *~~StartRBIndex k~~*~~F~~~~, respectively~~, and described in Clause 6.4.1.4 of [4, TS 38.211]. If not configured, then *P*F = 1 and *k*F,= 0.- Defining start RB index hopping for partial frequency sounding in different SRS frequency hopping periods for aperiodic/periodic/semi-persistent SRS based on the hopping pattern *k*hopping as described in clause 6.4.1.4.3 in [4, TS 38.211. If not configured, then start RB hopping is not enabled and *k*hopping is fixed to be 0 for all SRS symbols. <omitted text>For a UE configured with one or more SRS resource configuration(s), and when the higher layer parameter *resourceType* in *SRS-Resource* or *SRS-PosResource* is set to 'aperiodic':- the UE receives a configuration of SRS resource sets,- the UE receives a downlink DCI, a group common DCI, or an uplink DCI based command where a codepoint of the DCI may trigger one or more SRS resource set(s). For SRS in a resource set with usage set to 'codebook' or 'antennaSwitching', the minimal time interval between the last symbol of the PDCCH triggering the aperiodic SRS transmission and the first symbol of SRS resource is *N2*  symbols and an additional time duration *Tswitch*. Otherwise, the minimal time interval between the last symbol of the PDCCH triggering the aperiodic SRS transmission and the first symbol of SRS resource is *N2* +14 symbols and an additional time duration *Tswitch*. The minimal time interval unit of OFDM symbol is counted based on the minimum subcarrier spacing given by min(*µPDCCH, µUL*) where *µUL* is given by min(*µUL,carrier1, µUL,carrier2, µSRS*) when the UE is configured with the higher layer parameter *uplinkTxSwitchingOption* set to 'dualUL' for uplink carrier aggregation, and by *µSRS*otherwise. *µSRS* and *µPDCCH*are the subcarrier spacing configurations for triggered SRS and PDCCH carrying the triggering command respectively. - *Tswitch*, *µUL,carrier1* and *µUL,carrier2* are defined in clause 6.4.- When UE reporting *[Triggering SRS* only in DCI 0\_1/0\_2*],* the UE can be indicated with DCI 0\_1 and 0\_2 to trigger aperiodic SRS without data and without CSI as described in clause 7.3.1.1 of TS38.212. Otherwise, except for DCI format 0\_1/0\_2 with CRC scrambled by SP-CSI-RNTI, a UE is not expected to receive a DCI format 0\_1/0\_2 with UL-SCH indicator of "0" and CSI request of all zero(s) as described in clause 7.3.1.1 of [5, TS 38.212].- If the UE receives the DCI triggering aperiodic SRS in slot *n* and at least one resource set is configured with parameter *~~availableSlotOffset~~ availableSlotOffsetList* across all configured BWPs in a component carrier except when SRS is configured with the higher layer parameter *SRS-PosResource*, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in the (*t* + 1)-th available slot counting from slot if *ca-SlotOffset* is configured, otherwise the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in the (*t* + 1)-th available slot counting from slot , where<omitted text>*t* is configured via higher layer parameter *~~availableSlotOffset~~ availableSlotOffsetList* with up to four different valuesfor each triggered SRS resources set and is based on the subcarrier spacing of the triggered SRS transmission. When one or more SRS resource sets across all configured BWPs in a component carrier are configured, and at least one resource set is configured with *~~availableSlotOffset~~* *availableSlotOffsetList* parameter of more than one values, the indicated value out of *~~availableSlotOffset~~ availableSlotOffsetList* is indicated by SOI field in DCI scheduling PUSCH/PDSCH and DCI 0\_1/0\_2 without data and without CSI request described in [5, TS 38.212]. The UE shall apply indicated value of *availableSlotOffset* set specificallyfor those sets with configured *~~availableSlotOffset~~ availableSlotOffsetList* parameter. When one or more SRS resource sets across all configured BWPs in a component carrier are configured and at least one resource set is configured with *~~availableSlotOffset~~ availableSlotOffsetList* parameter, and the *~~availableSlotOffset~~ availableSlotOffsetList* parameter for each SRS resource set has only one value, the UE shall apply the configured value of *~~availableSlotOffset~~ availableSlotOffsetList* specificallyfor those sets with configured *~~availableSlotOffset~~ availableSlotOffsetList* parameter. For SRS resource set configured with *~~availableSlotOffset~~* parameter, each of resource set is configured with *K* values for ~~of~~ *~~availableSlotOffset~~* *availableSlotOffsetList* parameter. For SRS resource set configured without *~~availableSlotOffset~~ availableSlotOffsetList* parameter, *t* = 0 is applied for each of resource set. - If the UE receives the DCI triggering aperiodic SRS in slot *n* and none of the resource sets is configured with parameter *~~availableSlotOffset~~ availableSlotOffsetList* across all configured BWPs in a component carrier, and if the UE is configured with *ca-SlotOffset* for at least one of the triggered and triggering cell, except when SRS is configured with the higher layer parameter *SRS-PosResource*, the UE transmits aperiodic SRS in each of the triggered SRS resource set(s) in slot , otherwise, the UE transmits aperiodic SRS in each of the triggered resource set(s) in slot , where  |

Companies’ views on TP 2-2 are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Support |
| DOCOMO | While we appreciate OPPO’s careful check on the exact parameter names, we think the status in RAN2 (CR for 38.331 has not yet endorsed) should also be considered. Therefore, we think it could be better to wait for RAN2 progress a little bit more to discuss those parameter name alignments. Note that our understanding on RAN2 status is as follows:* R2-2202000 has not been endorsed yet.
* The latest running CR proposed by rapporteur is R2-2203032 which has not yet endorsed either.
 |
|  |  |

***TP 2-3 (from CATT):*** *Adopt the following TP for TS38.214 on AP-SRS*

|  |
| --- |
| ----------------Start of TP for TS38.214---------------------6.2.1 UE sounding procedure……- Slot level periodicity and slot level offset as defined by the higher layer parameters *periodicityAndOffset-p* or *periodicityAndOffset-sp* for an SRS resource of type periodic or semi-persistent. The UE is not expected to be configured with SRS resources in the same SRS resource set *SRS-ResourceSet* or *SRS-PosResourceSet* with different slot level periodicities. For an *SRS-ResourceSet* configured with higher layer parameter *resourceType* set to 'aperiodic', a slot level offset is defined by the higher layer parameter *slotOffset.* For an *SRS-ResourceSet* configured with higher layer parameter *resourceType* set to 'aperiodic', a list of zero up to four available slot offset values from the reference slot *n* + *k* to the slot where the aperiodic SRS resource set is transmitted where *n* is the slot with triggering DCI and *k* is *SlotOffset* is defined by the higher layer parameter *AvailableSlotOffset.* The parameter *AvailableSlotOffset* can be configured up to 4 values*.* For an *SRS-PosResourceSet* configured with higher layer parameter r*esourceType* set to 'aperiodic', the slot level offset is defined by the higher layer parameter *slotOffset* for each SRS resource.……*- t* is configured via higher layer parameter *availableSlotOffset* with up to four valuesfor each triggered SRS resources set and is based on the subcarrier spacing of the triggered SRS transmission. When one or more SRS resource sets across all configured BWPs in a component carrier are configured, and at least one resource set is configured with *availableSlotOffset* parameter of more than one values, the indicated value of *availableSlotOffset* is indicated by SOI field in DCI scheduling PUSCH/PDSCH and DCI 0\_1/0\_2 without data and without CSI request described in [5, TS 38.212]. The UE shall apply indicated value of *availableSlotOffset* set specificallyfor those sets with configured *availableSlotOffset* parameter. When one or more SRS resource sets across all configured BWPs in a component carrier are configured and at least one resource set is configured with *availableSlotOffset* parameter, and the *availableSlotOffset* parameter for each SRS resource set has only one value, the UE shall apply the configured value of *availableSlotOffset* specificallyfor those sets with configured *availableSlotOffset* parameter. For SRS resource set configured with *availableSlotOffset* parameter, each of resource set is configured with *K* values of *availableSlotOffset* parameter. For SRS resource set configured without *availableSlotOffset* parameter, *t* = 0 is applied for each of resource set.……----------------End of TP for TS38.214--------------------- |

Companies’ views on TP 2-3 are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| DOCOMO | Looks ok, while no update could also be fine.  |
|  |  |
|  |  |

# Antenna switching up to 8Rx

## Remaining issues for resource set configurations

Several companies propose to support more antenna switching configurations as summarized in the following table.

Table 3-1

|  |
| --- |
| **Issue 3.1: Support more antenna switching configurations** |
| Companies | Views |
| Nokia/NSB | Support the following periodic or semi-persistent antenna switching configurations* 1T8R with all numerology options
	+ A total of six resources transmitted in different symbols of two slots and where the SRS port of each SRS resource in the given two sets is associated with a different UE antenna port.
* 1T6R
	+ Up to 60 KHz numerologies: a total of eight resources transmitted in different symbols and where the SRS port of each SRS resource in the given set is associated with a different UE antenna port.
	+ With 120 KHz numerology: a total of eight resources transmitted in different symbols of two slots and where the SRS port of each SRS resource in the given two sets is associated with a different UE antenna port.
 |
| CATT | Support N = 1 for aperiodic SRS configuration for 1T4R |

***FL Proposal 3-1:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| DOCOMO | For the proposal from Nokia, generally we are not sure why more SRS resources than the number of Rx antenna ports have to be specified. CATT’s proposal would be fine for us.  |
|  |  |
|  |  |

## Guard period

### 3.2.1 Presence of GP

Companies discuss possible enhancements on the presence of guard symbols for antenna switching SRS. The proposed alternatives and companies’ positions are summarized as follows.

Table 3-2

|  |
| --- |
| **Issue 3.2: Presence of guard symbols** |
| Alternatives | Companies |
| Alt 1-0: Guard symbols are always-on, which is same as Rel-15 | Intel, Xiaomi |
| Alt 1-1: Guard symbols are configurable subject to UE capability | CMCC, CATT, NTT DOCOMO, LG |

***FL Proposal 3-2:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Support Alt 1-0 which is aligned with RAN4 LS. Without new input from RAN4, RAN1 should stick to the existing design. |
| DOCOMO | Our preference has been captured correctly. Support Alt 1-1.  |
|  |  |

### 3.2.2 Remaining issue of inter-set GP

One FFS point for inter-set GP is how/whether to handle the case where the interval between SRS resource sets is larger than Y.

Table 3-3

|  |
| --- |
| **Issue 3.3: How/whether to handle the case where the interval between SRS resource sets is larger than Y** |
| Alternatives | Companies |
| Alt 1: UL/DL signals are allowed to be transmitted in the interval between SRS resource sets for antenna switching when the interval is larger than Y symbols, i.e., no scheduling restriction | CMCC, Huawei/HiSilicon |
| Alt 2: If the interval between two SRS resource sets for antenna switching is larger than Y symbols, Y consecutive symbols in the interval is reserved for scheduling restriction.* Supported by Nokia/NSB, CATT, NTT DOCOMO, vivo
 | Alt 2-1: If the interval between two SRS resource sets for antenna switching is larger than Y symbols, the position of guard period for scheduling restriction is the last Y symbols of the interval. | Nokia/NSB, CATT, NTT DOCOMO |
| Alt 2-2: If the interval between two SRS resource sets for antenna switching is larger than Y symbols, the position of guard period for scheduling restriction is the first Y symbols of the interval | Nokia/NSB, CATT |
| Alt 2-3: If the interval between two SRS resource sets for antenna switching is larger than Y symbols, the position of guard period for scheduling restriction is configured by signaling | vivo |
| Alt 3: Any DL/UL signal is not expected to be transmitted in the interval between two SRS resource sets | Qualcomm |

***FL Proposal 3-3:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Support either of Alt.2-1 and Alt2.-2.For Alt.1, if no scheduling restriction is introduced, UE may have no sufficient time for antenna switching when gNB indicates some scheduling.For Alt.3, it is too restricted for gNB configuration and scheduling |
| DOCOMO | We do not believe Alt-3 is consistent with RAN4’s intention described in R1-2200895. Since RAN4, who defines the needed guard periods, has clarified that other resources than Y-symbol is available from their point of view, there would be no justification to limit the usage of such resources from RAN1 point of view. We are fine with either Alt 2-1 or 2-2. Alt 2-3 is also fine, while specifying the configurability will require more specification efforts, which may not be preferable at this stage. Alt 1 is also fine if possible, but we think RAN4 said Y-symbol should be assigned for antenna switching, which may need to be captured in RAN1 specification explicitly.  |
|  |  |

## TPs

This section captures companies’ TPs to correct errors, improve readability or reflect missing agreements for endorsed RAN1 specifications.

***TP 3-1 (from CMCC):*** *For the enhancement on antenna switching up to 8Rx, the TP suggestion for TS 38.214 in Section 6.2 is as the following*

|  |
| --- |
| **<**Unchanged text is omitted>- For 1T8R, zero or one or two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* set to 'periodic 'or 'semi-persistent' if the UE is not indicating a capability for [maximum 2 semi-persistent and maximum 1 periodic SRS resource sets], or up to two SRS resource sets configured with 'semi-persistent' and up to one SRS resource set configured with 'periodic' if the UE is indicating a capability for [maximum 2 semi-persistent and maximum 1 periodic SRS resource sets], where the two SRS resource sets configured with 'semi-persistent' are not activated at the same time. Each SRS resource set with eight SRS resources transmitted in different symbols, and where the SRS port of each SRS resource in each set is associated with a different UE antenna port. and**<**Unchanged text is omitted> |

Companies’ views on TP 3-1 are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Agree with the motivation and can accept the TP. However, a better way is to use keep the consistency for the style of the description for each configuration. e.g., similar to “1T6R”, there are 3 paragraphs for periodic, semi-persistent and aperiodic, respectively.  |
| DOCOMO | Support the proposal  |
|  |  |

***TP 3-2 (From Huawei/HiSilicon):*** *We have the following text proposal for TS 38.214 V17.0.0*

|  |
| --- |
| < Start of the text proposal >6.2.1.2 UE sounding procedure for DL CSI acquisition< Unchanged parts are omitted >- For 1T=1R, or 2T=2R, or 4T=4R, up to two SRS resource sets each with one SRS resource, where the number of SRS ports for each resource is equal to 1, 2, or 4. If the UE is indicating a capability for [maximum 2 semi-persistent and maximum 1 periodic SRS resource sets],two SRS resource sets configured with *resourceType* in *SRS-ResourceSet* set to '*semi-persistent*' and one SRS resource set configured with *resourceType* in *SRS-ResourceSet* set to '*periodic*' also can be configured, where each SRS resource set has one SRS resource, the number of SRS ports for each resource is equal to 1, 2, or 4, and the two SRS resource sets configured with 'semi-persistent' are not activated at the same time, or< End of the text proposal > |

Companies’ views on TP 3-2 are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Support this part “each SRS resource set has one SRS resource, the number of SRS ports for each resource is equal to 1, 2, or 4, and”For other parts, we prefer to keep the current version |
| DOCOMO | It seems ok.  |
|  |  |

# Coverage and capacity enhancements

## TPs for increase repetition

This section captures companies’ TPs to correct errors, improve readability or reflect missing agreements for endorsed RAN1 specifications.

***TP 4-1 (from Apple):*** *Consider the following TP to TS38.211 to include SRS repetition with {10, 14} consecutive OFDM symbols*

|  |
| --- |
| 6.4.1.4 Sounding reference signal6.4.1.4.1 SRS resourceAn SRS resource is configured by the *SRS-Resource* IE or the *SRS-PosResource* IE and consists of- antenna ports , where the number of antenna ports is given by the higher layer parameter *nrofSRS-Ports* if configured, otherwise , and when the SRS resource is in a SRS resource set with higher-layer parameter *usage* in *SRS-ResourceSet* not set to 'nonCodebook', or determined according to [6, TS 38.214] when the SRS resource is in a SRS resource set with higher-layer parameter *usage* in *SRS-ResourceSet* set to 'nonCodebook'- consecutive OFDM symbols given by the field *nrofSymbols* contained in the higher layer parameter *resourceMapping*- , the starting position in the time domain given by  where the offset counts symbols backwards from the end of the slot and is given by the field *startPosition* contained in the higher layer parameter *resourceMapping* and - , the frequency-domain starting position of the sounding reference signal |

Companies’ views on TP 4-1 are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Support |
| DOCOMO | Seems ok. Perhaps could also be considered to write values in ascending order.  |
|  |  |

***TP 4-2 (from CATT):*** *The repetition factor R for Rel-17 SRS coverage and capacity enhancement and SRS transmission with frequency hopping when > 4, R > 2 need to be captured in current specification and the following TP for TS38.214 is adopted.*

|  |
| --- |
| ----------------Start of TP for TS38.214---------------------6.2.1.1 UE SRS frequency hopping procedureFor a given SRS resource, the UE is configured with repetition factor R∈{1,2,4} and R∈{1,2,3,4,5,6,7,8,10,12,14} by higher layer parameter *resourceMapping* and *resourceMapping-r17,* respectively,in *SRS-Resource* where *R*≤*Ns*. When frequency hopping within an SRS resource in each slot is not configured (*R=Ns*), each of the antenna ports of the SRS resource in each slot is mapped in all the  symbols to the same set of subcarriers in the same set of PRBs. When frequency hopping within an SRS resource in each slot is configured without repetition (*R=1*), according to the SRS hopping parameters , and defined in clause 6.4.1.4 of [4, TS 38.211], each of the antenna ports of the SRS resource in each slot is mapped to different sets of subcarriers in each OFDM symbol, where the same transmission comb value is assumed for different sets of subcarriers. When both frequency hopping and repetition within an SRS resource in each slot are configured (*Ns*> *4, R* > *2*), each of the antenna ports of the SRS resource in each slot is mapped to the same set of subcarriers within each pair of R adjacent OFDM symbols, and frequency hopping across the pairs is according to the SRS hopping parameters , and ,where should be divisible by .For operation with shared spectrum channel access, the UE does not expect that multiple hops of an SRS resource transmission are in different RB sets.A UE may be configured adjacent symbol aperiodic SRS resource with intra-slot frequency hopping within a bandwidth part, where the full hopping bandwidth is sounded with an equal-size subband across  symbols when frequency hopping is configured with *R=1*. A UE may be configured adjacent symbols aperiodic SRS resource with intra-slot frequency hopping within a bandwidth part, where the full hopping bandwidth is sounded with an equal-size subband across pairs of *R* adjacent OFDM symbols, when frequency hopping is configured with *R2* and should be divisible by . Each of the antenna ports of the SRS resource is mapped to the same set of subcarriers within each pair of R adjacent OFDM symbols of the resource.A UE may be configured symbol periodic or semi-persistent SRS resource with inter-slot hopping within a bandwidth part, where the SRS resource occupies the same symbol location in each slot. A UE may be configured symbol periodic or semi-persistent SRS resource with intra-slot and inter-slot hopping within a bandwidth part, where the N-symbol SRS resource occupies the same symbol location(s) in each slot. For , when frequency hopping is configured with *R2*, intra-slot and inter-slot hopping is supported with each of the antenna ports of the SRS resource mapped to different sets of subcarriers across pairs of *R* adjacent OFDM symbol(s) of the resource in each slot, where should be divisible by *R*. Each of the antenna ports of the SRS resource is mapped to the same set of subcarriers within each pair of *R* adjacent OFDM symbols of the resource in each slot. For *Ns= R*, when frequency hopping is configured, inter-slot frequency hopping is supported with each of the antenna ports of the SRS resource mapped to the same set of subcarriers in *R* adjacent OFDM symbol(s) of the resource in each slot.----------------End of TP for TS38.214--------------------- |

Companies’ views on TP 4-2 are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Support in principle with some comments:1. (*Ns*> *4, R* > *2*) *should be (Ns >=4, R>=2) since Ns =4, R=2 are legacy values and should be captured in the spec*
2. *“resourceMapping-r17”* The spec usually doesn’t differentiate different parameters only by suffix like “-r17”
 |
| DOCOMO | For the first part, since neither Rel-15 nor Rel-16 do not capture this, we think the same handling should also be applied in Rel-17, that is, it seems not necessary to capture N values. If deemed necessary, “and R∈{1,2,3,4,5,6,7,8,10,12,14}” should be “and N~~R~~∈{1,2,3,4,5,6,7,8,10,12,14}The other parts look fine.  |
|  |  |

## RB-level partial frequency sounding (RPFS)

This section summarizes companies’ views on remaining issues for RPFS.

### 4.1.1 Applicable case

Some companies discuss whether to restrict RPFS applicable to FH enabled case only. Companies’ views are summarized as follows.

Table 4-1

|  |
| --- |
| **Issue 4.1: Whether RPFS is applicable to non-FH case** |
| Views | Companies |
| RPFS is applicable for frequency hopping case only | Intel, Qualcomm, OPPO, vivo |
| RPFS is applicable for both frequency hopping and non-frequency hopping cases | Ericsson, Huawei/HiSilicon, Futurewei, CATT, NTT DOCOMO |
| Support of RPFS for non-FH case is an optional UE feature for UEs supporting RPFS | ZTE |

***FL Proposal 4-1:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| DOCOMO | Our position has been correctly captured. In general, since P\_F is configurable, we do not see the strong need to not allow RPFS for non-FH case in the specification. Just to configure R\_F=1 in case of non-FH case would just fine. Since we see it beneficial even when non-FH is configured, we appreciate it if the spec does not disallow this explicitly. The third choice can be indeed considered as a potential middle ground, while not our best preference.  |
|  |  |
|  |  |

### 4.1.2 Capturing the restriction on sequence length

We have agreed that SRS sequence shorter than the minimum length supported in the current specification is not pursued as in previous agreements. However it hasn’t been reflected in the current specification. Companies discuss how to specify this restriction, and their views are summarized as follows.

Table 4-2

|  |
| --- |
| **Issue 4.2: How to capture the restriction on sequence length** |
| Alternatives | Companies |
| Introduce restriction in TS 38.214 on the length of SRS sequence when RPFS or comb 8 is configured* Supported by Ericsson, ZTE, Samsung, NTT DOCOMO
 | Alt 1: UE expects the length of the SRS sequence to be a multiple of 6. | ZTE, Samsung |
| Alt 2: The UE only expects to be configured with partial frequency sounding factor which generates one of sequence lengths given by | NTT DOCOMO |

***FL Proposal 4-2:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | We prefer Alt.1 |
| DOCOMO | we think another way (similar to Alt 1) is to capture “UE does not expect to be configured with R\_F which generates the sequence other than 38.211 5.1.2 defines” since RAN1 may specify SRS sequence other than multiple of 6 in the future. By having such text, we can ensure a bit better forward compatibility in the spec.  |
|  |  |

### 4.1.3 Maximum number of CSs

Some companies discuss the issue of maximum number of CSs for RPFS. At least when sequence length is 6, the current specification does not work well to use RPFS and Comb 2 or 4 for 4 ports. Companies’ proposals to address this issue are summarized as follows.

Table 4-3

|  |
| --- |
| **Issue 4.3: To address the issue of Max CS for RPFS** |
| Views | Companies |
| Alt 1: Clarify in TS 38.211 that for comb-2 and comb-4 if the length of SRS sequence is 6. | ZTE |
| Alt 2: If is configured to be 2 or 4, the maximum number of cyclic shifts should be based on the SRS sequence length, for example, a function of and , and when and , , otherwise . | NEC |

***FL Proposal 4-3:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| DOCOMO | Ok with both alternatives.  |
| NEC | Support Alt 2. We see severe issue on determination of maximum number of cyclic shift in current specification (details shown in our document [[R1-2201898](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_108-e/Docs/R1-2201898.zip)]), which will significantly reduce the SRS capacity and can not support 4-port SRS, as orthogonality can not be guaranteed. Especially for , based on current specification, is determined to be 8, and actually orthogonality can be well supported if the SRS sequence length is a multiple of 8, but with the introduction of , in most cases, the SRS sequence length is not a multiple of 8 (only a multiple of 6, in this case if is still determined to be 8, only up to 2 orthogonal ports can be achieved). |
| ZTE | We support both alternatives to address the issue of supporting 4 ports for RPFS. * We agree with NEC’s comment on comb-2 above.
* Further, for comb-4, when the sequence length is 6, we still cannot get 4 ports in one comb offset as the CS interval has to be 3 based on the current spec.

So both comb 2 and comb 4 need to be addressed. We support the following proposal:*When P\_F = 2 or 4,** *if P\_F is 2 and K\_TC = 2, otherwise .*
 |

### 4.1.4 Other remaining issues

Table 4-4

|  |
| --- |
| **Issue 4.4: Dynamic signaling to determine PF and kF** |
| Views | Companies |
| Use MAC CE or DCI to update P\_F and/or k\_F | CATT, Lenovo/MotM |
| Do not support to use MAC CE or DCI | Samsung, vivo |
| **Issue 4.5: Whether to support start RB location hopping within a legacy FH period** |
| Views | Companies |
| Support start RB location hopping on SRS occasion(s) within one hopping period | CATT |

***FL Proposal 4-4:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
|  |  |
|  |  |
|  |  |

### 4.1.5 TPs

This section captures companies’ TPs to correct errors, improve readability or reflect missing agreements for endorsed RAN1 specifications.

***TP 4-3 (from ZTE):*** *Adopt the following TP to correct an error on SRS resource mapping formula in section 6.4.1.4.3 of TS 38.211.*

|  |
| --- |
| 6.4.1.4.3 Mapping to physical resources<Unchanged parts are omitted>The length of the sounding reference signal sequence is given bywhere is given by a selected row of Table 6.4.1.4.3-1 with  where  is given by the field *b-SRS* contained in the higher-layer parameter *freqHopping* if configured, otherwise . The row of the table is selected according to the index  given by the field *c-SRS* contained in the higher-layer parameter *freqHopping*. The quantity is given by the higher-layer parameter *FreqScalingFactor* if configured, otherwise .The frequency-domain starting position is defined bywhere and- is given by the higher-layer parameter *StartRBIndex* if configured, otherwise ; - is given by Table 6.4.1.4.3-3 with if the higher-layer parameter *EnableStartRBHopping* is configured, otherwise .<Unchanged parts are omitted> |

Companies’ views on TP 4-3 are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Ok with the TP |
| DOCOMO | We are ok with the TP, while it seems not essential (rather it seems just replacing parameters but keeping the same technical meaning).  |
| ZTE | We would like to clarify this issue a bit.The current Rel-17 specification is . But this changes the start subcarrier index of the legacy FH hopping pattern as the sequence length is for RPFS instead of for Rel-15/16. RPFS shouldn’t change the legacy frequency hopping pattern. That is, to calculate , we should use , which is same as legacy FH, instead of . Therefore, should be This is an error to correct for RPFS, otherwise the spec is broken. |
|  |  |

***TP 4-4 (from OPPO):*** *Adopt the following TP (highlighted by Yellow) for TS 38.211 to align RAN1 and RAN2 specifications.*

|  |
| --- |
| 6.4.1.4.3 Mapping to physical resourcesWhen SRS is transmitted on a given SRS resource, the sequence for each OFDM symbol and for each of the antenna ports of the SRS resource shall be multiplied with the amplitude scaling factor  in order to conform to the transmit power specified in [5, 38.213] and mapped in sequence starting with  to resource elements  in a slot for each of the antenna ports  according toThe length of the sounding reference signal sequence is given bywhere is given by a selected row of Table 6.4.1.4.3-1 with  where  is given by the field *b-SRS* contained in the higher-layer parameter *freqHopping* if configured, otherwise . The row of the table is selected according to the index  given by the field *c-SRS* contained in the higher-layer parameter *freqHopping*. The quantity is given by the higher-layer parameter *~~FreqScalingFactor~~ freqScalingFactor* if configured, otherwise .The frequency-domain starting position is defined bywhere and- is given by the higher-layer parameter *~~StartRBIndex~~**freqScalingFactor* if configured, otherwise ; - is given by Table 6.4.1.4.3-3 with if the higher-layer parameter *~~EnableStartRBHopping~~* *enableStartRBHopping* is configured, otherwise .Editor’s note: the applicability of RPFS to the non-FH case is to be discussed in RAN1 |

Companies’ views on TP 4-4 are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Support |
| DOCOMO | Fine with the TP.  |
|  |  |

## Comb-8

### 4.2.1 WA on the support of 4 ports when Max CS = 6

Companies’ views on the WA for the support of 4 ports when Max CS = 6 are summarized as follows.

Table 4-5

|  |
| --- |
| **Issue 4.6: On the following WA**To support 4 ports with Max CS = 6, * Port 0 and Port 2 locate in n\_CS and (n\_CS+3) mod 6 in comb offset k\_TC, respectively.
* Port 1 and Port 3 locate in n\_CS and (n\_CS+3) mod 6 in comb offset (k\_TC + 4) mod 8, respectively.
* Note: n\_CS and k\_TC are the configured CS and comb offset values.
* Note: This working assumption can be revisited if Max CS = 12 is agreed.
 |
| Alternatives | Companies |
| Confirm the WA | Samsung, Nokia/NSB, vivo, Lenovo/MotM |
| Revise the WA to support different cyclic shift values for Ports 0/2 and Ports 1/3* Port 0 and Port 2 locate in n\_CS and (n\_CS+3) mod 6 in comb offset k\_TC, respectively.
* Port 1 and Port 3 locate in (n\_CS+1) mod 6 and (n\_CS+3+1) mod 6 in comb offset (k\_TC + 4) mod 8, respectively.
 | NEC |

***FL Proposal 4-5:*** *TBD*

Companies’ further views are collected as follows.

|  |  |
| --- | --- |
| Companies | Views |
| OPPO | Confirm the WA |
| DOCOMO | Ok with confirming the WA.  |
| NEC | We propose to update the cyclic shift values for Port 1/3 on different REs, which can reduce the PAPR with marginal spec effort (simulation result as shown in our document [[R1-2201898](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_108-e/Docs/R1-2201898.zip)]. And the PAPR issue has been discussed for long time in Rel-16), and actually, different SRS ports with different cyclic shift values also conforms to legacy structure for 4-port SRS in Rel-15/16 (different SRS ports correspond to different cyclic shift values in following formula). |

# Conclusion

The following proposals are recommended at least for the first GTW discussion.

# Appendix

## Previous agreements

Table 6-1

|  |
| --- |
| **RAN1#102e****Agreement**Enhance the determination of aperiodic SRS triggering offset, with at least one of the following alternatives* + Alt 1: Delay the SRS transmission to an available slot later than the triggering offset defined in current specification, including possible re-definition of the triggering offset
	+ Alt 2: Indicate triggering offset in DCI explicitly or implicitly
	+ Alt 3: Update triggering offset in MAC CE
	+ Further consideration aspects may include the cost v.s. the total combinations PDCCH and SRS locations for gNB to choose, DCI overhead, multi-UE SRS multiplexing, CA aspect, whether to have multiple opportunities to transmit SRS, etc.

**Agreement**Study the following two alternatives in the scope to enhance at least one DCI format for aperiodic SRS triggering * + Alt 1: Use UE-specific DCI, e.g., extending DCI 0\_1 without uplink data and without CSI
	+ Alt 2: Use group-common DCI, e.g., extending DCI 2\_3 for cases other than carrier switching
	+ Further consideration aspects may include simultaneous or CC-specific SRS triggering for multiple CCs, dynamic indication of SRS frequency resources, etc..

**Agreement**For SRS overhead reduction, study reusing same resources among multiple usages, at least for “codebook” and “antenna switching”. Study aspects include* + Whether implementation approach based on legacy SRS configuration is sufficient
		- If not, and if there are benefits other than RRC overhead reduction, study further on the case that antenna switching and PUSCH have different number of Tx antennas, whether UL BWP for different SRS usages is the same or different, whether and how to ensure UE to use same virtualization, the set of applicable usages, UE implementation complexity and overhead, etc..

**Agreement**For SRS antenna switching up to 8Rx, study the configuration of {1T6R, 1T8R, 2T6R, 2T8R, 4T6R, 4T8R}.* + Study points may include CSI latency, performance considering aspects like insertion loss, use cases, antenna structure, UE power saving, SRS resource configuration, etc..

**Agreement**For SRS coverage/capacity enhancements, evaluate and, if needed, specify one or more from three categories based on the following definition. * + Class 1 (Time bundling): Utilize relationship among two or more occasions of one or more SRS resources in one or more slots to enable joint processing within time domain.
		- Study aspects include the issue of phase discontinuity, interruption of SRS transmission by other UL signals, etc..
	+ Class 2 (Increase repetition): Change the legacy SRS pattern in one resource and one occasion from time domain by increasing SRS symbols for repetition.
		- Study aspects include to use TD-OCC to compensate the negative impact on SRS capacity, inter-cell interference randomization, whether these SRS symbols are in one slot or consecutive slots, etc..
	+ Class 3 (Partial frequency sounding): Support more flexibility on SRS frequency resources to allow SRS transmission on partial frequency resources within the legacy SRS frequency resources.
		- Study aspects include the partial frequency resources are with RB level or subcarrier level (e.g., larger comb, partial bandwidth), PAPR issue, etc..

**RAN1#103e****Agreement**A given aperiodic SRS resource set is transmitted in the (t+1)-th available slot counting from a reference slot, where t is indicated from DCI, or RRC (if only one value of t is configured in RRC), and the candidate values of t at least include 0. Adopt at least one of the following options for the reference slot.* Opt. 1: Reference slot is the slot with the triggering DCI.
* Opt. 2: Reference slot is the slot indicated by the legacy triggering offset.
* FFS the detailed definition of “available slot” considering UE processing complexity and timeline to determine available slot, potential co-existence with collision handling, etc., e.g.,
	+ Based on only RRC configuration, “available slot” is the slot satisfying: there are UL or flexible symbol(s) for the time-domain location(s) for all the SRS resources in the resource set and it satisfies the minimum timing requirement between triggering PDCCH and all the SRS resources in the resource set
* FFS explicit or implicit indication of t
* FFS whether updating candidate triggering offsets in MAC CE may be beneficial

**Agreement**Support at least DCI 0\_1 and 0\_2 to trigger aperiodic SRS without data and without CSI.* FFS whether/how to re-purpose the unused fields, e.g., the triggering offset(s) and the frequency resources for triggering A-SRS on one or more component carriers, SFI-index, etc.
* FFS UL/DL DCI with data for aperiodic SRS
* FFS group common DCI

**Agreement**In Rel-17 SRS coverage and capacity enhancement, support at least one scheme from Class 2 and Class 3, and deprioritize Class 1.* Note: Extensions of Rel-15/16 frequency hopping are included in Classes 2 and 3, e.g. where UE hops once per symbol within a Rel-17 SRS resource.

**Agreement**Candidate schemes for Class 2:* Scheme 2-0: Increase the number of repetition symbols in one slot
* Scheme 2-1: Inter-slot repetition on consecutive symbols or non-consecutive symbols across slots
* Scheme 2-2: Repetition with TD-OCC
* Scheme 2-3: Repetition with CS hopping

Candidate schemes for Class 3:* Scheme 3-1: RB-level partial frequency sounding
* Scheme 3-2: Subcarrier-level partial frequency sounding
* Scheme 3-3: Subband-level partial frequency sounding
* Scheme 3-4: Partial-frequency sounding schemes assisted with CSI-RS, where SRS is transmitted in a subset of RBs of the original SRS frequency resource
* Scheme 3-5: Dynamic change of SRS bandwidth with RB-level subband size scaling
* Note: Consider issues like gNB receiver complexity, PAPR, etc., with above schemes
* Note: Joint operation between Class 2 and Class 3 schemes can be considered

**Agreement**For antenna switching up to 8Rx, support SRS resource configurations for {1T6R, 1T8R, 2T6R, 2T8R, [4T6R], 4T8R}.**RAN1#104e****Agreement**For Rel-17 SRS capacity and coverage enhancement, support the following* Increase the maximum number of repetition symbols in one slot and one SRS resource to S
	+ Support at least one S value from {8, 10, 12, 14}
		- FFS other candidate values
* Support to transmit SRS only in  contiguous RBs in one OFDM symbol, where  indicates the number of RBs configured by BSRS and CSRS
	+ Support at least one PF value from {2, [3], 4, 8}
		- FFS other candidate values, e.g., non-integer values for PF
	+ Note: SRS sequence shorter than the minimum length supported in the current specification is not pursued.
	+ No new sequence including length is introduced
	+ FFS it is applicable to frequency hopping and non-frequency hopping
	+ FFS detailed signaling mechanism to determine PF and the location of the  RBs
* Support Comb 8
	+ Note: SRS sequence shorter than the minimum length supported in the current specification is not pursued.
* FFS whether and if needed, how to use harmonized approach to define the three supported schemes
* Note: other schemes for SRS capacity and coverage enhancements are not supported in Rel-17.

**Agreement*** For aperiodic antenna switching SRS, support to configure N <=N\_max resource sets, where totally K resources are distributed in the N resource sets flexibly based on RRC configuration.
	+ For 1T6R, K=6, N\_max = [4], and each resource has 1 port.
	+ For 1T8R, K=8, N\_max = [4], and each resource has 1 port.
	+ For 2T6R, K=3, N\_max = [3], and each resource has 2 ports.
	+ For 2T8R, K=4, N\_max = [4], and each resource has 2 ports.
	+ (Working Assumption) For 4T8R, K=2, N\_max = [2], and each resource has 4 ports.
	+ FFS the number of supported candidate values of N for each xTyR.
* FFS extension to increase N\_max for 1T4R, 2T4R, T=R and 1T2R cases for aperiodic, periodic and semi-persistent SRS resources
* FFS the number of resources and resource sets for semi-persistent and periodic antenna switching SRS
* Note: SRS could be transmitted over the last 6 OFDM symbols, or over any OFDM symbols within the slot subject to UE capability.

**Agreement**Further study whether and if needed, how to achieve further enhancements on aperiodic SRS triggering and resource management based on repurposing unused fields in DCI format 0\_1/0\_2 without data and without CSI. Consider the following examples* CAT A: Time-domain parameters
	+ A-1: Indication of available slot position, i.e., the t values
	+ A-2: Indication of slot offset
	+ A-3: Indication of SRS symbol-level offset
	+ A-4: Indication of time-domain behavior for SRS transmission over multiple OFDM symbols, e.g., repetition, hopping, and/or splitting
* CAT B: Frequency-domain parameters
	+ B-1: Indication of a group of CCs for SRS transmission
	+ B-2: Indication of frequency domain resource in a BWP for SRS transmission
	+ B-3: Indication of whether DL/UL BWP is applied for SRS transmission
* CAT C: Power control parameters
	+ C-1: Re-purpose ‘TPC command for PUSCH’ as ‘TPC command for SRS’
		- FFS impact on power control, impact from triggering a group of CCs for SRS
	+ C-2: Indication of open loop power control parameter e.g., p0.
* CAT D: Spatial-domain parameters, i.e., indication of SRS port and beamforming
* CAT E: Extend the number of DCI codepoints for aperiodic SRS trigger states
* Other examples are not precluded

**Agreement**A list of t values is configured in RRC for each SRS resource set. Adopt at least one of the following for DCI indication of t.* In DCI format 0\_1/0\_2 without data and without CSI request,
	+ Alt 1-1: Reuse the same scheme used for DCI format 0\_1/0\_2/1-1/1-2 that schedules a PDSCH or PUSCH
	+ Alt 1-2: Re-purpose unused DCI field to indicate t
	+ Alt 1-3: t is indicated by a configurable DCI field, where the DCI field may contain bits from unused fields and additional bits configured by gNB
		- FFS design details with other potential field(s)
	+ FFS: whether t can be slot offset
* In DCI format 0\_1/0\_2/1-1/1-2 that schedules a PDSCH or PUSCH
	+ Alt 2-1: t is indicated by adding a new configurable DCI field
	+ Alt 2-2: t is indicated without adding DCI payload
* Note: The size of DCI payload does not change dynamically
* Note: RAN1 should strive for unified solution for different DCI formats.
* FFS: The number of RRC configured t values per SRS resource set and DCI bit field size.

**Agreement**Confirm the following working assumption with modificationsAn “available slot” is a slot satisfying there are UL or flexible symbol(s) for the time-domain location(s) for all the SRS resources in the resource set and it satisfies UE capability on the minimum timing requirement between triggering PDCCH and all the SRS resources in the resource set.* From the first symbol carrying the SRS request DCI and the last symbol of the triggered SRS resource set, UE does not expect to receive SFI indication, UL cancellation indication or dynamic scheduling of DL channel/signal(s) on flexible symbol(s) that may change the determination of “available slot”.
* Note: Collision handling between the triggered SRS and any other UL channel/signal is performed after the determination of available slot.
* FFS: Rules to handle the case of multiple SRS resource sets with overlapping symbols and/or triggered by a same DCI

**RAN1#104bis-e****Agreement**For increased repetition in Rel-17, support the following N\_symbol (number of OFDM symbols in one SRS resource) and R (repetition factor) values* N\_symbol = 8, R = {1, 2, 4, 8}
* N\_symbol = 12, R = {1, 2, [3], 4, 6, 12}
* FFS the following configurations
	+ N\_symbol = 10, R = {1, 2, 5, 10}
	+ N\_symbol = 14, R = {1, 2, 7, 14}
* FFS options to reduce SRS BW for R>1

**Agreement**On aperiodic SRS configuration for antenna switching with > 4Rx, support the following N\_max values* 1T6R: N\_max = 3
* 1T8R: N\_max = 4
* 2T6R: N\_max = 3
* 2T8R: N\_max = 4
* [4T8R: N\_max = 2]
* The support of N\_max value does not imply the support of N value that is smaller than N\_max. This is FFS.
* FFS whether further enhancement for single-DCI or multi-DCI based MTRP is needed

**Agreement**For RB-level partial frequency sounding (RPFS) in Rel-17* The start RB index of the RBs in the RBs is , where kF = {0, …, PF-1}
	+ FFS support start RB location (Noffset) hopping in different SRS occasions, symbols or frequency hopping periods, and if supported, detailed hopping pattern
* Support to determine PF and Noffset at least via RRC configuration per SRS resource.
	+ FFS whether to introduce DCI and/or MAC CE in addition

**Working Assumption**For DCI indication of “t” in Rel-17 SRS triggering offset enhancement* For both DCI that schedules a PDSCH/PUSCH and DCI 0\_1/0\_2 without data and without CSI request
	+ t is indicated by adding a new configurable DCI field (up to 2 bits)
		- Applies only when there are multiple candidate values of t configured
	+ No further enhancement to indicate “t” for DCI 0\_1/0\_2 without data and without CSI request at least when the new DCI field is configured

**Agreement**On supported values of N for Rel-17 aperiodic SRS antenna switching with >4Rx, down-select at least one of the following alternatives in RAN1#105e* Alt 1: All the non-zero integer values <= N\_max are supported for N
* Alt 2: Support N=N\_max only
* Alt 3: Support specific N values <= N\_max
* FFS whether different alternatives may be selected for the same xTyR configuration subject to the UE capability on maximum number of symbols that can be used for SRS in a slot
* FFS: whether different alternatives may be selected for different xTyR configuration

**Agreement**Study the maximum number of cyclic shifts for Comb-8 in Rel-17, with the following alternatives as starting points* Alt 1: The maximum number of CSs for Comb-8 is 6
* Alt 2: The maximum number of CSs for Comb-8 is 12, and introduce a rule to restrict applicable CSs when SRS sequence is shorter than the maximum number of CSs

**Agreement*** Up to 4 “t” values can be configured per SRS resource set.

**Agreement*** For RPFS in Rel-17, support PF = {2, 4}.
* FFS 3, 8, 12, 16 or fractional numbers
* Support at least one of the following alternatives (to be decided in RAN1#105-e)
	+ Alt 1: is an integer value
	+ Alt 2: is an integer value with minimum value 4
	+ Alt 3: is a multiple of 4
	+ Alt 4: Round to a multiple of 4 in case of Alt 1 or Alt 2

**Agreement**On aperiodic SRS configuration for antenna switching with 4T8R, support N\_max = 2**Agreement**For RPFS SRS in Rel-17, adopt one of the following alternatives for sequence generation, where no new sequence length other than the ones supported in the current spec is introduced (to be decided in RAN1#105-e)* Alt 1: Generate length- ZC sequence
* Alt 2: Truncate from legacy length- sequence according to the location of RPFS SRS

**Agreement**For antenna switching, support one of the following * Alt 1: Support maximum one SRS resource set for periodic SRS and maximum one SRS resource set for semi-persistent SRS
* Alt 2: Support up to two semi-persistent SRS resource sets in addition to a periodic SRS resource set
	+ Note: the two SP-SRS resource sets are not activated at the same time.
* FFS whether further enhancement for single-DCI or multi-DCI based MTRP is needed
* FFS whether configurations on SRS repetitions have impact
* FFS relevant UE capability design

**RAN1#106-e****Agreement**Confirm the following WA:For DCI indication of “t” in Rel-17 SRS triggering offset enhancement* For both DCI that schedules a PDSCH/PUSCH and DCI 0\_1/0\_2 without data and without CSI request
	+ t is indicated by adding a new configurable DCI field (up to 2 bits)
		- Applies only when there are multiple   candidate values of t configured
	+ No further enhancement to indicate “t” for DCI 0\_1/0\_2 without data and without CSI request at least when the new DCI field is configured

**Agreement**Support start RB location (Noffset) hopping in different SRS frequency hopping periods for RPFS and at least periodic/semi-persistent SRS, where Noffset is the start RB index of the RBs in the RBs.* For a given SRS transmission occasion, , where khopping is same for all SRS occasions within a legacy FH period but changes across legacy FH periods, kF and PF are at least configured by RRC signaling (kF = {0, 1, …, PF-1}).
* Support at least one pattern for khopping in time domain, FFS detailed pattern
* Note: the legacy FH period is the period to sound the full SRS hopping bandwidth across the different subbands of RBs each.
* This start RB location hopping is enabled or disabled by RRC signaling.
* FFS whether MAC CE or DCI can be additionally used
* When this start RB location hopping is disabled, khopping is fixed to be 0 for all SRS symbols
* This start RB location hopping is UE optional.
* FFS whether start RB location hopping is also applicable on SRS occasion(s) within one FH period (e.g., when R>1) and/or on aperiodic SRS, if so, how

**Agreement**For aperiodic xTyR antenna switching SRS, where xTyR is from {1T6R, 1T8R, 2T6R, 2T8R, 4T8R}, support all the non-zero integer values N<=N\_max except N=1 for 1T8R * For each xTyR configuration, UE does not expect multiple SRS resource sets are configured or triggered in one slot
* UE does not expect that the OFDM symbols contained in one SRS resource set exceed UE capability on which OFDM symbols can be used for SRS taking guard period into account

**Agreement**Support Opt. 2: Reference slot is the slot indicated by the legacy triggering offset.* If DCI is transmitted in slot n, and k is the legacy triggering offset, reference slot is slot n+k.
* Note: the legacy triggering offset can be 0, if slotOffset is absent.

**Conclusion**MAC CE for t value update in Rel-17 is not supported.**Agreement**For antenna switching SRS, support maximum one SRS resource set for periodic SRS and maximum 2 SRS resource sets for semi-persistent SRS.* Note: the two SP-SRS resource sets are not activated at the same time
* For xTyR where y>4, if UE does NOT support this feature, support maximum one SRS resource set for periodic SRS and maximum one SRS resource set for semi-persistent SRS
* Applies for all supported xTyR where y<=8
* For each xTyR antenna switching (except for 4T6R if supported), each periodic or semi-persistent resource set contains y/x resources.

This feature is UE optional: For UEs that do not support this feature, follow Rel-15 on the number of resource sets for periodic and semi-persistent SRS**Agreement*** Support 4T6R SRS antenna switching in Rel-17.

**Agreement**For RPFS SRS sequence generation, support * Alt 1: Generate length- ZC sequence.

**Agreement**For SRS increased repetitions in Rel-17, support the following configurations, and no other values are supported.* (N\_symbol, R) = {(8, 1), (8, 2), (8, 4), (8, 8), (12, 1), (12, 2), (12, 3), (12, 4), (12, 6), (12, 12), (10, 1), (10, 2), (10, 5), (10,10), (14, 1), (14, 2), (14, 7), (14, 14)}
* Note: N\_symbol SRS symbols are adjacent in a slot.

**Agreement*** On the presence of guard symbols in Rel-17 for SRS antenna switching, down-select one of the following
	+ Alt 1-0: Guard symbols are always-on, which is same as Rel-15
	+ Alt 1-1: Guard symbols are configurable subject to UE capability
* On whether to introduce guard symbols between SRS resource sets for antenna switching, down-select one of the following
	+ Alt 2-0: Do not introduce guard symbols between SRS resource sets, i.e., guard symbols only appears between SRS resources in a resource set
	+ Alt 2-1: Introduce guard symbols between two sets mapped to consecutive slots
* Note: Rel-15 guard period symbols are supported if none of the above enhancements is agreed

**Agreement**For Comb-8 SRS in Rel-17, down-select one of the following in RAN1#106bis-e* Alt 1: The maximum number of CSs for Comb-8 is 6
* Alt 2: The maximum number of CSs for Comb-8 is 12, and introduce a rule to restrict applicable CSs when SRS sequence is shorter than the maximum number of CSs

**RAN1#106bis-e****Agreement**For two SRS resource sets of an xTyR antenna switching located in two consecutive slots, if UE is capable of transmitting SRS in all symbols in one slot, a minimum gap period of Y symbols exists between the last OFDM symbol occupied by the SRS resource set in the first slot and the first OFDM symbol occupied by the SRS resource set in the second slot* The value of Y is same as the inter-resource GP defined in Rel-15
* FFS: Whether or not the minimum GP exists can be RRC configurable subject to UE capability
* Whether this inter-set GP is needed for 4T6R can be discussed later per the decision on 4T6R configuration.
* FFS: How/Whether to handle the case where the interval between SRS resource sets is larger than Y

**Agreement**For the detailed pattern of when start RB location hopping across legacy FH periods is enabled, support the following* For PF = 2, = {0, 1}
* For PF = 4, = {0, 2, 1, 3}
* Note: means for the (n+1)-th legacy FH period, where n = {0, 1, 2, 3, …}

**Agreement**Bit width of SOI depends on the maximum number of “t” values configured for any of the aperiodic SRS resource sets (FFS: across all CCs or across a CC/BWP)* The SOI field is 0 bit if the maximum number of ‘t’ values is one
* If at least one resource set has “t” configured
	+ For the resource sets with “t” value configured, each of them is configured with K values of “t”, where 1<=K<=4
	+ t=0 applies for the resource set(s) without “t” configured in RRC
* If none of the resource sets is configured with “t” values, follow Rel-15 approach to determine slot offset

**Agreement**For comb-8 SRS in Rel-17, the maximum number of CSs is 6.* FFS: Whether a maximum number of 12 CSs is supported

**Agreement**For extension of aperiodic antenna switching SRS configurations for <=4Rx, support N=4 for 1T4R and N=2 for 1T2R/2T4R.* The above extension is UE optional

**Agreement**On SRS configuration for 4T6R, select at least one from the following three alternatives in RAN1#107e* Alt 1: 4 + 2
* Alt 2: 2+2+2
	+ Alt 2-1:
		- No guard symbols exist between the 1st and the 2nd transmission. Y guard symbol(s) exist between 2nd and 3rd transmission, where Y is same as the value defined in the current specification for different SCSs
	+ Alt 2-2:
		- For SCS=15, 30 and 60KHz: No guard symbols exist
		- For SCS=120 KHz: No guard symbols exist between the 1st  and the 2nd transmission, and 1 guard symbol exists between the 2nd and 3rd transmission
* Clarification on the notation: means totally K resources are needed, where the k-th resource contains ports, 1<=k<=K

**RAN1#107-e****Agreement**When ca-SlotOffset is configured, reference slot to use the Rel-17 mechanism for determining the SRS offset is slot 107a, otherwise reference slot is 107b where are determined by *ca-SlotOffset* configurations of the PDCCH carrier and SRS carrier.**Agreement**For a CC with t value configured, SOI bit width depends on the maximum number of t values configured for all the resource sets across all configured BWPs in a CC for SRS transmission.* For the CCs without any t value configured, follow Rel-15/16 mechanism to determine the SRS slot offset, where SOI bit width is 0

**Working assumption**To support 4 ports with Max CS = 6, * Port 0 and Port 2 locate in n\_CS and (n\_CS+3) mod 6 in comb offset k\_TC, respectively.
* Port 1 and Port 3 locate in n\_CS and (n\_CS+3) mod 6 in comb offset (k\_TC + 4) mod 8, respectively.
* Note: n\_CS and k\_TC are the configured CS and comb offset values.
* Note: This working assumption can be revisited if Max CS = 12 is agreed.

**Agreement**For aperiodic SRS, support same start RB location hopping approach as for P/SP SRS if there are multiple frequency hopping period in the slot**Conclusion**In Rel-17, SRS 4T6R is not supported**Conclusion**No consensus to have further restriction on the number of RBs for RPFS in Rel-17.* No introduction of new sequence length

**Conclusion**There is no consensus in RAN1 to support Max CS = 12 for comb-8 in Rel-17. |

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | R1-2200934 | Remaining issues on SRS enhancement in Rel-17 | Huawei, HiSilicon |
| [2] | R1-2200995 | Enhancements on SRS flexibility, coverage and capacity | FUTUREWEI |
| [3] | R1-2201083 | Maintenance on SRS enhancement | vivo |
| [4] | R1-2201190 | Remaining issues on SRS enhancements | ZTE |
| [5] | R1-2201228 | Enhancements on SRS flexibility, coverage and capacity | OPPO |
| [6] | R1-2201333 | Discussion on remaining issues on SRS Enhancements for Rel-17 | CATT |
| [7] | R1-2201430 | Enhancements on SRS | Lenovo, Motorola Mobility |
| [8] | R1-2201468 | Remaining issues on SRS enhancement | NTT DOCOMO, INC. |
| [9] | R1-2201539 | Considerations on SRS enhancements | Spreadtrum Communications |
| [10] | R1-2201572 | Enhancements on SRS flexibility, coverage and capacity | LG Electronics |
| [11] | R1-2201630 | Maintenance for feMIMO SRS | Ericsson |
| [12] | R1-2201687 | Remaining Details on SRS enhancements | Intel Corporation |
| [13] | R1-2201762 | Views on Rel-17 SRS enhancement | Apple |
| [14] | R1-2201849 | Remaining issues on SRS enhancement | CMCC |
| [15] | R1-2201898 | Discussion on remaining issues on SRS enhancement | NEC |
| [16] | R1-2201940 | Discussion on SRS enhancements | Xiaomi |
| [17] | R1-2202001 | Maintenance on Rel-17 SRS | Samsung |
| [18] | R1-2202127 | Enhancements on SRS flexibility, coverage and capacity | Qualcomm Incorporated |
| [19] | R1-2202321 | Maintenance of enhancements for SRS flexibility, coverage and capacity | Nokia, Nokia Shanghai Bell |