3GPP TSG RAN WG1 Meeting #105-e R1-210xxxx

**e-Meeting, May 10th – 27th, 2021**

Source: Moderator (ZTE)

Title: Summary of [105-e-NR-7.1CRs-12] Issue#26 SRS carrier switching

Agenda Item: 7.1

**Document for: Discussion and Decision**

# Introduction

The document provides a summary for the email discussion thread [105-e-NR-7.1CRs-12] Issue#26 SRS carrier switching for Rel-16 only.

[105-e-NR-7.1CRs-12] Issue#26: SRS carrier switching – Chuangxin (ZTE) by May 25

For Rel-16 only

In order to make use of the email thread for discussion efficiently, two check points are planned as follows.

* 1st check point: 5/20 (UTC 23:59 pm).
	+ Try to get some consensus for proposals
* 2nd check point: 5/24 (UTC 23:59 pm).
	+ Try to get some consensus for specification change

# Discussion

Based on the contribution [1-5], the issues can be summarized as the following questions.

### Question 1: Whether priority rules are used for source CC

Contribution [1][4][5] raised the issue that whether priority rules are used between SRS in target CC and the source CC configured by higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier*.There are two interpretations on whether SRS carrier switching priority rules should be used for source CC:

* Alt 1: Yes, the prioritization rules apply to the source CC
	+ For companies supporting Alt 1, please also share your comments if the following highlighted sentence should be removed from the current 38.214. That’s because, based on the prioritization rules, the UL signals in source CC may not be suspended when the UL signals have higher priority than SRS in target CC.

|  |
| --- |
| A UE can be configured with SRS resource(s) on a carrier *c1* with slot formats comprised of DL and UL symbols and not configured for PUSCH/PUCCH transmission. For carrier *c1*, the UE is configured with higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier* the switching from carrier *c2* which is configured for PUSCH/PUCCH transmission. During SRS transmission on carrier *c1* (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR*), the UE temporarily suspends the uplink transmission on carrier *c2*.  |

* Alt 2: No, the source CC is always suspended as described in the above highlighted part.

Please companies share your comments and preference on the two interpretations

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| --- | --- |
| **Company** | **Comment** |
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### Question 2: Whether/which UL CCs other than source CC should be used in priority rules

Contribution [1][3][4][5] suggested the priority rule should be used between SRS in target CC and the UL CC set with the same band as the source CC configured by higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier*. The suggestion is similar as LTE, i.e. define the UL CC set *S*(*d*)*=* {*s*0(*d*)… *s*N-1(*d*)} as the set of carriers of serving cells that meet all the following conditions, where *d* is the target CC, and *s0(d)* is the source CC.

- {*s*0(*d*)… *s*N-1(*d*)} are in the same band as *s*0(*d*).

- {*s*0(*d*)… *s*N-1(*d*)} are in the same TAG as *s*0(d).

Contribution [2] seemed to prefer that the priority rules should be used between SRS in target CC and all potential UL CCs including CCs in different bands from the target CC as long as the UL CCs make UE transmission beyond its UL CA capability.

Contribution [1] pointed out that 38.133 (the relevant description is listed in section 5.1 in Appendix for convenience) defines an interruption period during which the UE MAY skip transmission for CCs other than source and target. So RAN4 specification handles the interruption operation between the SRS in target CC and UL signals in other CCs which are in different bands from the source CC.

In summary, there are following interpretations to define whether/which UL CCs other than source CC should be used for SRS carrier switching priority rules

* Option 1: The UL CCs in the same band as the source CC
	+ Please proponents also share whether LTE-similar description as shown in the above yellow part is OK or not. If not, please share your solution.
* Option 2: The UL CCs can be any carriers which result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability
* Option 3: Not support any other UL CCs for priority rules
	+ Please proponents if any share the reason why other UL CCs for priority rules are not needed

Please companies share your comments and preference on the two interpretations

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| --- | --- |
| **Company** | **Comment** |
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### Question 3: Whether/how extend timelines for multiple UL CCs

In RAN1#104bis-e meeting, a CR R1-2104043 was agreed to determine timelines for SRS in target carrier *c1* and the source carrier *c2* as shown in section 5.2 in Appendix. If UL CCs other than source CC should also be used in priority rule, the agreed SRS carrier switching timelines should be naturally extended from the configured source CC to multiple UL CCs (which UL CCs will depend on the outcome of Question 2).

Contribution [2] has the following proposals:

**Proposal 1 from [2]**: For the case that aperiodic SRS transmission on the target cell has higher priority than overlapping UL transmissions on other carriers, and the simultaneous transmission is beyond UE’s capability:

* UE does not expect that the gap between the last symbol of DCI indicating A-SRS on target CC and the first symbol of the earliest low priority UL transmission, among a group of overlapping UL transmissions with a priority lower than A-SRS, to be less than $T\_{proc}^{max}$, with $T\_{proc}^{max}=max\{T\_{proc}^{1}, …,T\_{proc}^{i}, …\}$

where $T\_{proc}^{i}$ is based on *N2*, which itself is determined based on the UE processing capability on the i-th low priority carrier, and the minimum of (*µDL*, *µith-UL*), where the *µDL* corresponds to the SCS of the PDCCH scheduling A-SRS, and *µith-UL* corresponds to the SCS of the uplink channel on the i-th low priority carrier.

**Proposal 2 from [2]**: For the case that UE is scheduled by a DCI, or a set of DCIs, to transmit a high priority UL transmission on a serving cell overlapping with a low priority SRS transmission on a carrier without configured PUSCH/PUCCH, and simultaneous transmission is beyond UE’s capability:

* UE does not expect the gap between the first symbol of the earliest low priority SRS transmission on the target cell and a last symbol of the last DCI among all DCIs indicating high priority transmissions on another carriers, to be less than $T\_{proc}^{max}$, with $T\_{proc}^{max}=max\{T\_{proc}^{1}, …,T\_{proc}^{i}, …\}$

where $T\_{proc}^{i}$ is based on SRS-SwitchingTime + *N2*, and *N2* is determined based on the UE processing capability on the target carrier, and the minimum of (*µith-DL*, *µUL*), where the *µith-DL* corresponds to the SCS of the PDCCH scheduling a high priority UL transmission on the i-th high priority carrier, and *µUL* corresponds to the SCS of the SRS on the target cell. SRS-SwitchingTime represents the UL or DL RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR,*

Contribution [4] [5] propose keeping the wording of the agreed CR R1-2104043 to determine SRS carrier switching timelines, and redefine *c2* to make that *c2* can be an UL CC other than the source CC.

In short, there are two ways to extend the timelines for SRS carrier switching.

* Solution 1: Based on the proposal 1 and 2 from contribution [2]
* Solution 2: Keeping the wording of the agreed CR R1-2104043 to determine SRS carrier switching timeline , and redefine *c2* to make that *c2* can be an UL CC other than the source CC

Please companies share your comments and preference on the two interpretations

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| --- | --- |
| **Company** | **Comment** |
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# Outcome of email discussion

# List of contributions

1. R1-2104647 Discussion on SRS carrier switching Qualcomm Incorporated
2. R1-2105074 Timeline Considerations for SRS Carrier Switching and Dropping Procedure Apple Inc.
3. Correction on prioritization rules of SRS carrier switching
4. R1-2104580 Discussion on SRS carrier switching ZTE
5. R1-2104581 Draft CR on SRS carrier switching ZTE

# Appendix

## SRS carrier switching in 38.133

##### 8.2.1.2.12 Interruptions at NR SRS carrier based switching

SRS transmission can be configured on a carrier not configured for PUCCH/PUSCH transmission. When a UE needs to transmit periodic, semi-persistent or aperiodic SRS on a carrier of a serving cell not configured for PUCCH/PUSCH transmission, the UE can perform carrier based switching to one or more carriers not configured for PUCCH/PUSCH transmission from a carrier with PUCCH/PUSCH transmission or from a carrier not configured for PUCCH/PUSCH transmission prior to transmitting SRS, provided that:

- switching is from a configured carrier to an active UL BWP of another activated carrier;

- the carrier of SCells not configured for PUCCH/PUSCH transmission to which SRS carrier based switching is performed is indicated by DCI SRS request field for aperiodic SRS transmission, or indicated by MAC-CE for semi-persistent SRS transmission, or configured via RRC for periodic SRS transmission;

- the serving cell, from which SRS carrier based switching is performed and whose UL transmission may therefore be interrupted, is indicated by srs-SwitchFromServCellIndex and srs-SwitchFromCarrier in TS38.331 [2];

- the SRS switching is not colliding with any other transmission with higher priority defined in TS 38.214 [26].

- the SRS switching is not colliding with any measurements in SCG.

- for UE, which does not support simultaneous reception and transmission for inter-band TDD CA specified in TS 38.331 [2], and is compliant to the requirements for inter-band CA with uplink in one NR band and without simultaneous Rx/Tx specified in TS 38.101-3 [20], the SRS transmission are not simultaneously scheduled with DL SSB/CSI-RS for L3 or L1 measurements transmission on other carriers.

The UE shall not perform SRS carrier based switching if the above conditions cannot be met.

When SRS carrier based switching is performed between carriers, the UE is allowed interruptions on any active serving cell in SCG if UE is not capable of Per-FR gap, or on active serving cell(s) in SCG in FR1 if UE is capable of Per-FR gap, during the switching to the carrier of a serving cell in FR1 not configured for PUCCH/PUSCH transmission,

- with up to X1 slot as specified in Table 8.2.1.2.12-1.

When SRS carrier based switching is performed between carriers, the UE is allowed interruptions on any active serving cell in SCG if UE is not capable of Per-FR gap, or on active serving cell(s) in SCG in FR2 if UE is capable of Per-FR gap, during the switching to the carrier of a serving cell in FR2 not configured for PUCCH/PUSCH transmission,

- with up to X2 slot as specified in Table 8.2.1.2.12-2.

When SRS carrier based switching is performed between carriers, the UE is allowed interruptions on any active serving cell in SCG if UE is not capable of Per-FR gap, or on active serving cell(s) in SCG in FR1 if UE is capable of Per-FR gap, during the switching from the carrier of a serving cell in FR1 not configured for PUCCH/PUSCH transmission,

- with up to X1 slot as specified in Table 8.2.1.2.12-1.

When SRS carrier based switching is performed between carriers, the UE is allowed interruptions on any active serving cell in SCG if UE is not capable of Per-FR gap, or on active serving cell(s) in SCG in FR2 if UE is capable of Per-FR gap, during the switching from the carrier of a serving cell in FR2 not configured for PUCCH/PUSCH transmission,

- with up to X2 slot as specified in Table 8.2.1.2.12-2.

Table 8.2.1.2.12-1: Interruption length X1 (slot)

|  |  |  |  |
| --- | --- | --- | --- |
|  | NR Slot length | SRS carrier | Interruption length X1 (slots) |
| C:\Users\10207298.ZTE\AppData\Local\Temp\ksohtml3028\wps3.png | (ms) of victim cell | switching time (us)Note 1 | Sub carrier spacing for agressor cell (kHz) |
|  |  |  | 15 | 30 |
| 0 | 1 | ≤ 200 | 2 | 2 |
|  |  | 300, 500 | 2 | 2 |
|  |  | 900 | 3 | 3 |
| 1 | 0.5 | ≤ 200 | 3 | 2 |
|  |  | 300, 500 | 3 | 3 |
|  |  | 900 | 4 | 4 |
| 2 | 0.25 | ≤ 200 | 4 | 3 |
|  |  | 300, 500 | 5 | 4 |
|  |  | 900 | 7 | 6 |
| 3 | 0.125 | ≤ 200 | 7 | 5 |
|  |  | 300, 500 | 9 | 7 |
|  |  | 900 | 12 | 10 |
| Note1: NR SRS carrier switching time is UE capability indicated by higher layer parameter *SRS-SwitchingTimeNR*. |

Table 8.2.1.2.12-2: Interruption length X2 (slot)

|  |  |  |  |
| --- | --- | --- | --- |
|  | NR Slot | SRS carrier | Interruption length X2 (slots) |
| C:\Users\10207298.ZTE\AppData\Local\Temp\ksohtml3028\wps4.png | length (ms) of victim cell | switching time (us) Note | Sub carrier spacing for agressor cell (kHz) |
|  |  |  | 60 | 120 |
| 0 | 1 | ≤ 200 | 2 | 2 |
| 1 | 0.5 | ≤ 200 | 2 | 2 |
| 2 | 0.25 | ≤ 200 | 3 | 3 |
| 3 | 0.125 | ≤ 200 | 4 | 4 |
| Note1: NR SRS carrier switching time is UE capability indicated by higher layer parameter *SRS-SwitchingTimeNR*. |

For intra-band SRS carrier switching in FR1 or FR2, interruptions in Table 8.2.1.2.12-1 and in Table 8.2.1.2.12-2 based on SRS carrier switching time ≤ 200us shall apply. For inter-band SRS carrier switching in FR1 or between FR1 and FR2, interruptions in Table 8.2.1.2.12-1 and in Table 8.2.1.2.12-2 shall apply.

## Endorsed CR R1-2104043 (TS38.214, Rel-16) in RAN1#104bis-e

**<Unchanged parts are omitted>**

##### 6.2.1.3 UE sounding procedure between component carriers

For an SRS transmission starting in symbol $N\_{c\_{1}}$ of carrier $c\_{1}$ and a conflicting transmission in carrier $c\_{2}$ starting in symbol$ N\_{c\_{2}}$, the UE shall apply the prioritization / dropping rules in the remainder of this subclause taking into account:

* DCI(s) for which the time interval between the last symbol of PDCCH and $N\_{c\_{1}}$ is at least$ N\_{2} $symbols and an additional time duration $T\_{SRS\_{CS}}$, and the time interval between the last symbol of PDCCH and $N\_{c\_{2}}$ is at least $ N\_{2}$ symbols*;* and
* semi-persistent CSI reports or SRS considered active at least $N\_{2}$ symbols and an additional time duration $T\_{SRS\_{CS}}$ before $N\_{c\_{1}}$, and considered active at least $N\_{2}$ symbols before $N\_{c\_{2}}$.

where $T\_{SRS\_{CS}}=max⁡\{switchingTimeUL,switchingTimeDL\}$, and the time interval unit of OFDM symbol is counted based on the smaller subcarrier spacing across $c\_{1}, c\_{2}$ and their corresponding scheduling cells.

For a carrier of a serving cell with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, the UE shall not transmit SRS whenever SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the carrier of the serving cell and PUSCH/PUCCH transmission carrying HARQ-ACK/positive SR/RI/CRI/SSBRI and/or PRACH happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].

For a carrier of a serving cell with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, the UE shall not transmit a periodic/semi-persistent SRS whenever periodic/semi-persistent SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the carrier of the serving cell and PUSCH transmission carrying aperiodic CSI happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].

For a carrier of a serving cell with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, the UE shall drop PUCCH/PUSCH transmission carrying periodic/semi-persistent CSI comprising only CQI/PMI/L1-RSRP/L1-SINR, and/or SRS transmission on another serving cell configured for PUSCH/PUCCH transmission whenever the transmission and SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the serving cell happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].

For a carrier of a serving cell with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, the UE shall drop PUSCH transmission carrying aperiodic CSI comprising only CQI/PMI/L1-RSRP/L1-SINR whenever the transmission and aperiodic SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133]) as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the carrier of the serving cell happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].

For an aperiodic SRS triggered in DCI format 2\_3 and if the UE is configured with higher layer parameter *srs-TPC-PDCCH-Group* set to 'typeA', and given by *SRS-CarrierSwitching,* without PUSCH/PUCCH transmission, the order of the triggered SRS transmission on the serving cells follow the order of the serving cells in the indicated set of serving cells configured by higher layers, where the UE in each serving cell transmits the configured one or two SRS resource set(s) with higher layer parameter *usage* set to 'antennaSwitching' and higher layer parameter *resourceType* in *SRS-ResourceSet* set to 'aperiodic'.

For an aperiodic SRS triggered in DCI format 2\_3 and if the UE is configured with higher layer parameter *srs-TPC-PDCCH-Group* set to 'typeB' without PUSCH/PUCCH transmission, the order of the triggered SRS transmission on the serving cells follow the order of the serving cells with aperiodic SRS triggered in the DCI, and the UE in each serving cell transmits the configured one or two SRS resource set(s) with higher layer parameter *usage* set to 'antennaSwitching' and higher layer parameter *resourceType* in *SRS-ResourceSet* set to 'aperiodic'.

If the UE is not configured for PUSCH/PUCCH transmission on carrier *c1* with slot formats comprised of DL and UL symbols, and if the UE is not capable of simultaneous reception and transmission on carrier *c1*and serving cell *c2*, the UE is not expected to be configured or indicated with SRS resource(s) such that SRS transmission on carrier *c1* (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR*) would collide with the REs corresponding to the SS/PBCH blocks configured for the UE or the slots belonging to a control resource set indicated by *MIB* or *SIB1* on serving cell *c2*.

For *n*-th (*n ≥* 1) aperiodic SRS transmission on a cell *c*, upon detection of a positive SRS request on a grant, the UE shall commence this SRS transmission on the configured symbol and slot provided

- it is no earlier than the summation of

- the maximum time duration between the two durations spanned by N OFDM symbols of the numerology of cell *c* and the cell carrying the grant respectively, and

- the UL or DL RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR,*

- it does not collide with any previous SRS transmissions, or interruption due to UL or DL RF retuning time.

otherwise, *n*-th SRS transmission is dropped, where N is the reported capability as the minimum time interval in unit of symbols, between the DCI triggering and aperiodic SRS transmission.

In case of inter-band carrier aggregation, a UE can simultaneously transmit SRS and PUCCH/PUSCH across component carriers in different bands subject to the UE's capability.

In case of inter-band carrier aggregation, a UE can simultaneously transmit PRACH and SRS across component carriers in different bands subject to UE's capability.

**<Unchanged parts are omitted>**