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.

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| 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** |
| QC | Alt 1. With respect to removing that text from the specification, we do not have a strong view. To us, it is just describing what RRC parameters determine the source and target CCs. |
| Apple | We think it is more aligned with RAN4 spec if we go with Alt1. Although we prefer to keep the text and modify it as “…the UE may temporarily suspend…” |
| ZTE | Alt 1  We think it is good either to remove the yellow part or modify it as Apple suggested. |
| Huawei, HiSilicon | Alt 1  In our view, the yellow text could serve as a general high level description of what would happen when UL traffic of victim CC(s) and SRS of aggressor CC overlap in time domain. The issue is that the details that are provided in the prioritization rules and the above yellow high level description seem to not to be aligned in two aspects: 1) In prioritization rules, UL traffic of victim CC(s) are not always dropped. In fact, SRS of the aggressor CC may be dropped; 2) Prioritization rules use “UE shall drop” while the above yellow text use “UE temporarily suspends”. To resolve these discrepancies, we suggest to change “UE temporarily suspends” to “UE may drop” in the above yellow text. |
| Nokia | Alt 1.  We don’t see the conflict with the prioritization rules and the yellow highlighted text. If the SRS is dropped, then the “during SRS transmission on carrier c1…” does not hold as there is no SRS transmission on c1 and hence there is no suspension on carrier c2 either. |
| Ericsson | Alt 1, with the ‘may temporarily suspend’ clarification from Apple. However it should be clear from the remainder of section 6.2.1.3 (e.g. on inter-band capability) that ‘may suspend’ is the case, so Apple’s change is for readability in my view. |
| Moderator | I suggest taking the following two bullets as the offline consensus:   * The prioritization rules of SRS carrier switching apply to the source CC. * Change the wording of 38.214 as “…the UE may temporarily suspend…”   @Nokia I think the change is OK to avoid any confusion even though it is not a big issue. Hope you are fine.  @HW ‘suspend’ and ‘drop’ are the same from my view, Hope you are also fine with the above small change, not a big issue.  If there is no concern on the offline consensus including for question 2 and 3, I will provide the text proposal accordingly. |
| vivo | Alt1, either removing the text in yellow or adding “may” as suggested by Apple is fine. |
| Samsung | Alt 1. Apple’s modification seems better. |
| Intel | Alt 1.  The prioritization rule should be applied to the source CC.  We think it is ok to have the wording change of “…the UE may temporarily suspend…” in 38.214. |
| Qualcomm | We would not be OK with adding “may”, it seems to imply that the UE can choose to suspend or not. The situation is that, when the SRS is transmitted in the target CC, the source CC is always interrupted (due to prioritization rules). The only question is whether the yellow text is redundant, not whether it is “may” or “shall”. |
| Moderator2 | Based on the discussion so far, I think the common understanding is that the yellow part is redundant and may cause confusion since priority rules clearly specify which one SRS or UL signals should be dropped. So I suggest taking the following as offline consensus.   * The prioritization rules of SRS carrier switching apply to the source CC. * Remove the following sentence from 38.214   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*. |
| Ericsson | Actually, I prefer to not drop the yellow text. I have a similar view as Huawei on its purpose as an overview of the carrier switching operation. And taking qualcomm’s point that \*when\* the SRS is transmitted in the switching-to carrier, the switching-from carrier is interrupted, then we see no problem with having it.  If we did drop the yellow text, then for me it is not clear what ‘conflicting’ means in the first sentence of the next paragraph, since there is then no mention of suspension in the first paragraph with the yellow text gone:  For an SRS transmission starting in symbol of carrier and a conflicting transmission in carrier starting in symbol, |
| Apple | We see correct concern raised by QC, and also agree with Ericsson to keep the text. Our suggestion is to change as “When SRS transmission on carrier *c1* is performed, during SRS transmission on *c1* (including any….” |

### 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** |
| QC | Option 1. We think “same band” and “same TAG’ is a good condition. |
| Apple | Option 2. Indeed 38.133 assumes that:   1. SRS based carrier switching is transmitted if “the SRS switching is not colliding with any other transmission with higher priority defined in TS 38.214”    1. Here RAN4 is referring to 38.214 for prioritization rules; on “any other transmission” RAN4 considers any active cell, based on perFR configurations … (details in 38.133) 2. When SRS carrier based switching is performed between carriers, low priority UL signals “on any active serving cell” (in the same FR as target CC only, if the UE supports Per-FR gap) are interrupted, where “interruption” in RAN4 is commonly understood as dropping. 3. RAN4 specifies interruptions for both inter-band and intra-band scenarios   Having said that, we think from RAN4’s spec, there is no difference between source CC and any other UL carrier (same FR with target for perFR). RAN1 already defined cancellation timeline between source and target, without referring to RAN4’s specification of “interruptions”. Same is applied for other UL carriers, inter-band or intra/band with source since based on RAN4’s spec they are all almost equally treated (“interruption” is applied to LP transmissions regardless of UL carrier is source CC or a 3rd CC). |
| ZTE | After checking, we think option 2 may be more reasonable as Apple’s explanation.  In 38.133, whether UL signals in other CCs interrupt or not are still based the priority rule referring to 38.214 as Apple pointed it out (see the first yellow part in section 5.1). In such case, it seems the priority rule between the target CC and UL CCs in different bands from the source CC is still needed.  @QC, Could you clarify it ? Or is it OK to go for option 2 ? |
| Huawei, HiSilicon | Option 1.  The yellow text is provided based on the agreement we made in RAN1#90bis that interruption and collision handling due to SRS switching is similar to those of LTE. Interruption/collision handling in LTE itself is partly based on the agreement made in RAN1 90 (both agreements are brought below). We think option 1 is better aligned with the agreement in RAN1#90bis and harmonizes LTE and NR specs. We do not see how we can infer from 5.1 in 38.133 and the text in 38.214 (“can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306]”), any clear prioritization rules concerning the case that the CCs are in the same band and the same TAG as the victim CC.  One approach may be to further discuss the need to clarify the interruption/collision rules for the cases that are not considered in the [1][3][4][5] independently of this discussion.  ***Agreement: (RAN1 90bis)***   * *Specify NR SRS switching among CCs similar to Rel-14 LTE SRS carrier-based switching design including*    + *Periodic/aperiodic/semi-persistent SRS on a CC without PUCCH/PUSCH configured*   + *TA (through PRACH) on TAG without PUSCH/PUCCH configured*   + *Power control separated from that of PUSCH*   + *Group common DCI for aperiodic SRS triggering and TPC*   + *DL/UL interruptions and collision handling due to SRS switching*   ***Agreement in Principle (RAN1 90):***  *Capture the following in 36.213:*   * *The “same PA” is implicitly identified by the following. Two “CC with the same PA” are those that:*   + *Are in the same band*   + *Are in the same TAG*   + *Have the same CP* * *Adopt the following solution for the cases of collision between SRS switching and victim CC:*   + *Extend collision rules to victim CC (i.e., the transmission of SRS depends on the information transmitted in the source CC and the victim CC).*   *CR to be prepared for RAN1#90bis.* |
| Nokia | The interruption on other carriers would seem to typically come from RAN4. We are generally fine with any of the options, but wonder if there is a necessity for RAN1 to specify this. |
| Ericsson | Option 1 is OK for us. To explain our motivation: for us, this is more to give gNB some additional scheduling flexibility, rather than that designs should be based on LTE (as it seems a bit late in NR for this consideration to be so relevant). |
| QC2  (copy from email reflector) | As described in our contribution, the rules in RAN1 and RAN4 are not really contradicting:  The RAN1 rules state which channels / signals the UE \***SHALL**\* drop. This reflects the fact that a given Tx chain is retuned to a different frequency and, therefore, it is impossible for the UE to transmit simultaneously in source and target CCs.   * + In our view, one special case is the case of intra-band CA, where two CCs will share a Tx chain and, therefore, it is impossible that the UE transmits in target CC and the intra-band CC simultaneously.   [Ali]: This is true but not the whole truth in our view :) As it is clear from RAN4 spec, and also aligned with our understanding from RAN1’s spec, SRS carrier based switching may interrupt any other low priority UL signals “on any active serving cell”.     * We disagree that the RAN4 “interruption” means dropping. It just means that the UE behavior during the interruption time does not have to meet any requirements, but a UE will meet the specifications if it doesn’t interrupt any other CC (i.e., it means that the UE \***may**\* drop a transmission / reception). In general, the RAN4 relaxation is due to the fact that reconfiguring the Tx chains may result in a *glitch* in other Tx/Rx chains, which may result in poor performance during this time. Thus, we think that the RAN4 relaxation is on top of the RAN1 specification.   + Actually, most UEs should be able to perform simultaneous transmission in target CC and other CCs, since the glitch is only going to happen (if any) during the retuning time, not during the active SRS transmission in the target CC.   [Ali]: there is nothing in RAN4 spec to “relax” interruption due to SRS carrier switching to just “glitch”. I don’t meant to say the impact on intra-band is always same as inter-band, but certainly it is not true either to say impact on inter-band is always as simple as “glitch". If we cannot agree on RAN4’s intention of “interruption” we are fine to send an LS to RAN4.    In summary:  - RAN1 spec captures the cases where the UE will never be able to transmit in both CCs simultaneously, and thus prioritization / dropping rules are defined. This includes source <-> target, and the intra-band CCs with source (if the CR under discussion is approved).  - RAN4 spec captures the case where the UE may suffer a glitch due to RF retuning, the UE may or may not be able to transmit/receive during this period  [Ali]: Please see above. |
| Moderator | QC’s elaboration in the email reflector is pasted in above.  Based on the above comments so far, I suggest take the following as offline consensus:  The priority rules of SRS carrier switching 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*. 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).  @Nokia Thanks for your flexibility. If we take option 1, there will be spec change as shown in contribution [3][4]. As QC’s explanation, RAN4 spec just captures the case where the UE may suffer a glitch due to RF retuning, the UE may or may not be able to transmit/receive during this period. It does not handle the cases where the UE will never be able to transmit in both CCs simultaneously.  @Ericsson, The yellow part in option 1 has considered the difference from LTE, i.e. remove the SCS and CP condition since NR supports multiple BWPs.  @Apple Please check if you are OK for option 1 |
| Apple2 | Copy our replies to the reflector (also commented inline above) |
| vivo | We agree with explanation from QC and fine with option1 |
| Samsung | For inter-band CA case, we think that the following specification (last part of 6.2.1.3) can explain already whether other CCs are interrupted or not:  (6.2.1.3 in 38.214)  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.  In the above statements, UL transmission from other CCs cannot be interrupted by SRS carrier switching **depending on UE’s capability**. Additional change for inter-band CA seems the optimization issue (gNB received UE’s capability (it should include inter-band CA related capabilities also) and can schedule inter-band UL CA based on the reported UE’s capability).  So, Option 1 is enough to clarify the SRS carrier switching. (Yellow part is ok) |
| Apple3 | @Samsung: “*In the above statements, UL transmission from other CCs cannot be interrupted by SRS carrier switching* ***depending on UE’s capability***.” We agree with you that based on current spec, simultaneous transmission between SRS and PUCCH/PUSCH across inter-band CCs, is subject to UE’s capability. I think QC says such capability indication is not needed for simultaneous transmission between SRS and an UL signal on CC inter-band with source CC, since they interpret RAN4’s “interruption” as “glitch” and thus in their view no cancellation/dropping is involved, which is against our understanding of RAN4 and RAN1’s specs, for example see what you copied from 348.214, if “interruption” on inter-band is simply a glitch, then no need to have “under UE capability” in RAN1…. |
| Intel | We think Option 2 is more reasonable. Since there is UE capability on uplink carrier aggregation, then all the CCs should be considered for prioritization handling. |
| Qualcomm | To reply to Apple:  there is nothing in RAN4 spec to “relax” interruption due to SRS carrier switching to just “glitch”. I don’t meant to say the impact on intra-band is always same as inter-band, but certainly it is not true either to say impact on inter-band is always as simple as “glitch". If we cannot agree on RAN4’s intention of “interruption” we are fine to send an LS to RAN4.  Well, let’s forget “glitch” or “not glitch”. Interruption means that the UE can do whatever it wants during that period (similar to e.g. measurement gaps). But, again, I think the RAN1 specs and the RAN4 specs are not in contradiction: RAN1 tells you to prioritize and drop, RAN4 gives you the possibility of further relaxation. |
| Apple4 | @Qualcomm: "But, again, I think the RAN1 specs and the RAN4 specs are not in contradiction: RAN1 tells you to prioritize and drop, RAN4 gives you the possibility of further relaxation.”  We didn’t say there is contradiction between RAN1 and RAN4. Indeed, in my view, you are saying there is such contradiction by saying "RAN4 gives you the possibility of further relaxation”, which is not supported/referenced anywhere in RAN4 either in RAN1. I had already provided text from RAN4 indicating interruption is applicable to all cells. Similarly in RAN1, as also mentioned by Samsung, inter-band simultaneous transmission is under UE’s UL-CA capability. If we take your “further relaxation” then there is no need for UE to indicate such capability, as simultaneous inter-band transmissions is relaxed (please see you own prior emails).  The simple question is this: For SRS carrier-based switching, are priority rules defined in RAN1 applicable to inter-band CCs? The answer is yes to us based on both RAN4 and RAN1 specs that I already copied before (see my prior replies). I know your understanding is different and you think "UE can do whatever it wants… RAN4 gives the possibility of further relaxation”, but please provide text reference from RAN4/RAN1 and/or let’s agree to send LS to RAN4 if we cannot agree on RAN4’s intention of “interruption”… We can all check with our colleagues in RAN4. |
| Moderator | Many thanks for the good technical discussion. It seems companies still have different understanding on RAN4 specification, sending an LS seems the only way to solve the problem.  Proposed offline consensus:  Send an LS to ask RAN4’s understanding on the following questions for SRS carrier switching   * In 38.133, it specifies when SRS carrier based switching is performed between carriers, the UE is allowed interruptions up to X1(or X2) slots on any active serving cell, during the switching to the carrier of a serving cell not configured for PUCCH/PUSCH transmission. RAN1 would like to ask RAN4 whether the interruption slots include the duration of the active SRS transmission in the target carrier of the serving cell not configured for PUCCH/PUSCH * On priority rules specified in 38.214 between SRS in the target carrier of the serving cell not configured for PUCCH/PUSCH and signals in UL carriers (UE will not transmit the lower priority signal), RAN1 agreed that the UL carriers at least include the source carrier which is configured by higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier.* However, RAN1 companies are not sure which one of the following options is RAN4’s understanding when RAN4 specifies the interruption slots in 38.133:   + Option 1: The UL CCs are in the same band as the source CC which is configured by higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier*   + Option 2: The UL CCs can be any carriers which result in uplink transmissions beyond the UE’s indicated uplink   So RAN1 kindly asks RAN4 to provide RAN4’s understanding. |
| Ericsson | LS is fine for us; support the offline consensus here. |
| vivo2 | Two options being discussed are purely RAN1 issues, we don’t think RAN4 can help us in this matter. No need to send LS to RAN4 |
| Apple | Thanks moderator for the LS. We suggest to add the word “capability” at the end of Option 2 which seems to be missing. Also, we suggest to ask RAN4’s intention on “interruption” for any of Options, e.g. whether or not it may include “not transmitting/not receiving” on the interrupted CCs.  @vivo, It is RAN4’s scope to determine once inter-band CCs’s are interrupted (as the term used by RAN4) due to SRS carrier switching, the interruption is something left to UE without capability report indication, or it involves dropping low priority transmission. For the latter case, we in RAN1 need to properly define the cancellation timeline. |
| Qualcomm | We are very confused by this conclusion. Does anybody have the understanding that Option 1 is the correct one? I thought we understand that Option 2 is the correct interpretation (with some caveats, e.g. in some cases only the CCs in the same FR can be interrupted).  Again, the question is not which CCs can be interrupted, but which CCs \*shall\* be interrupted and which CCs enter the prioritization.  Just to be clear, we are not OK with sending the LS.  Let us reply to Apple:  Apple>>for SRS carrier-based switching, are priority rules defined in RAN1 applicable to inter-band CCs?  QC>> No  Apple>>[…] but please provide text reference from RAN4/RAN1  QC>>  As you can see, the text between RAN1 spec and RAN4 spec is very different: RAN1 spec defines what the UE \*does\*, RAN4 specs what the UE \*is allowed\* to do (hence I use the term “relaxation”).  -RAN1 spec: the UE **temporarily suspends** the uplink transmission on carrier c2  - RAN4 spec: the UE **is allowed** interruptions […] **up to X1** slot    By the way, this “interruption” is not different from interruption from other sources, e.g. due to SCell activation. |
| Apple | *QC>>Again, the question is not which CCs can be interrupted, but which CCs \*shall\* be interrupted and which CCs enter the prioritization.*  In our view, if something is beyond UE’s capability it shall be dropped (it’s not like “maybe, can be,…”). You are saying priority rules and capability indications are not applied to inter-band CCs. And you are referring to RAN4’s spec of “UE is allowed of interruption”, to support your view for “*Interruption means that the UE can do whatever it wants during that period*”. It was already discussed that RAN4’s “allowed to interrupt” is applied to all cells (including “source CC”, including intra-band and intra-band CCs, where RAN1 already agreed to have cancellation timeline for source CC and nobody was referring to RAN4 at the time, taking “allowed to interrupt” as “*UE can do whatever it wants…*”). It was also already explained that RAN4’s intention of “interruption” is “no transmitting/no receiving”. When RAN4 spec is referred here, and we don’t have the same understanding of RAN4’s intention, why shouldn’t we send an LS?! |
| Qualcomm | *if something is beyond UE’s capability it shall be dropped*  What capability are you referring to? Could you explicitly indicate the IEs in 38.331?.  The main issue, in our view, is that the capability you are referring to (whether the UE can do simultaneous transmission in a CC other than the source/target CC while switching) does not exist. But still, this is not a big deal, since the UE \*may\* drop that transmission.  Again, if we send an LS to RAN4 as worded, we now what we will get – let me paste it here and let’s see if we agree:   * In 38.133, it specifies when SRS carrier based switching is performed between carriers, the UE is allowed interruptions up to X1(or X2) slots on any active serving cell, during the switching to the carrier of a serving cell not configured for PUCCH/PUSCH transmission. RAN1 would like to ask RAN4 whether the interruption slots include the duration of the active SRS transmission in the target carrier of the serving cell not configured for PUCCH/PUSCH   >> The interruption slots include the duration of the active SRS transmission   * On priority rules specified in 38.214 between SRS in the target carrier of the serving cell not configured for PUCCH/PUSCH and signals in UL carriers (UE will not transmit the lower priority signal), RAN1 agreed that the UL carriers at least include the source carrier which is configured by higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier.* However, RAN1 companies are not sure which one of the following options is RAN4’s understanding when RAN4 specifies the interruption slots in 38.133:   + Option 1: The UL CCs are in the same band as the source CC which is configured by higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier*   + Option 2: The UL CCs can be any carriers which result in uplink transmissions beyond the UE’s indicated uplink   >> The UL CCs include any other carrier regardless of the UE capability. |

### 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 , with

where 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 , with

where 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** |
| Qualcomm | We prefer to see first the outcome of question 2 (if question 2 is not agreed, then there are no “multiple CCs”) |
| Apple | We prefer Solution 1, but we also think the most important thing is to properly define the set of multiple CCs. Having said that, we can live with Solution 2 as well |
| Huawei, HiSilicon | We also think that it is better to discuss the timeline issue after reaching a consensus on prioritization rules in Quation1 and Question 2. |
| Nokia | This doesn’t look like a correction any longer, but discussion of new timing rules to Rel-15. We don’t see the need to revisit the SRS carrier switching induced gaps. |
| Ericsson | We prefer to come back to this question as well. |
| Samsung | We also prefer to discuss this issue after checking the outcome of question 2. |
| Intel | This issue can be discussed after Question 2 is resolved. |

# 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 Huawei, HiSilicon
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 of carrier and a conflicting transmission in carrier starting in symbol, 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 is at leastsymbols and an additional time duration , and the time interval between the last symbol of PDCCH and is at least symbols*;* and
* semi-persistent CSI reports or SRS considered active at least symbols and an additional time duration before , and considered active at least symbols before .

where , and the time interval unit of OFDM symbol is counted based on the smaller subcarrier spacing across 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>**