**3GPP TSG RAN WG1 #108-e R1-220xxxx**

**e-Meeting, February 21th – March 3rd, 2022**

Source: moderator (vivo)

Title: Feature lead summary on [108-e-NR-CRs-04] Issue#5 Maintenance on SRS carrier switching

Agenda Item: 7.1

Document for: Discussion and Decision

1. Introduction

Following agreements reached in RAN1#106-e.

**Agreement**

For a target CC, when multiple aperiodic SRS resource sets for carrier switching are triggered by the same DCI and all the SRS resource sets will be transmitted according to the dropping rule, regarding UE behaviour on switching back to the source CC after transmitting one SRS resource set, further discuss the following alternatives:

* Alt 1) The behavior depends on the UE implementation
* Alt 2) UE stays in the target CC in the period between the SRS resource sets.
* Alt 3) If the time period between the SRS resource sets is smaller than the total required RF switching time to the source CC and back to the target CC and a higher priority UL transmission and/or DL reception is not scheduled on the source CC in the time period between the two SRS resources sets, the UE stays in the target CC in the period between the SRS resource sets; otherwise, the UE switches back to the source CC after transmitting each SRS resource set.
* Alt 4) UE switches back to source CC between the SRS resource sets

**Agreement**

For a target CC, In the case that multiple SRS resource sets are triggered by the same DCI, regarding the applicable timeline(s), further discuss the following alternatives:

* Alt 1) Individual timeline is applied to each triggered SRS resource set
  + “Individual timeline” means that for each SRS resource set, the deadline to consider DCI triggering the SRS resource set or other uplink signals is applied and decision is made independently amongst the SRS resource sets.
* Alt 2) The same timeline is applied to all the triggered SRS resource sets
  + “Same timeline” means that the deadline to consider DCI triggering the SRS resource sets or other uplink signals is applied considering the multiple SRS resource sets as a whole so that a single decision on collision handling is made for these SRS resource sets.

Following agreement reached in RAN1#107-e.

**Conclusion**

Regarding SRS carrier switching priority rules:

* For Rel-16, it is concluded that no modification in specifications should be made to clarify the current UE behaviour or to introduce a new UE behaviour regarding SRS carrier switching priority rules.
* For releases later than Rel-16, it is concluded to consider introducing a new UE capability for indicating simultaneous transmission while switching, and/or clarify the UE behaviour in the case of intra-band CA.
  + Note: If introduced, the new UE capability should always assume no simultaneous transmission while SRS carrier switching for the bands in the band combinations that are signalled to not support simultaneous transmission within *BandCombinationList-UplinkTxSwitch*.

**Agreement**

When multiple SRS resource sets for carrier switching are triggered by the same DCI, individual timeline is applied to each triggered SRS resource set (Alt 1 in RAN1 106-e agreement).

* FFS: whether spec change is needed

Based on the contributions listed in reference section, proposals for discussion/conclusion/agreement are provided in section 2.

1. Discussion
   1. Switching back to source CC

Proposal 2-1 : Support alt3. (from RAN1#106-e)

* If the time period between the SRS resource sets is smaller than the total required RF switching time to the source CC and back to the target CC and a higher priority UL transmission and/or DL reception is not scheduled on the source CC in the time period between the two SRS resources sets, the UE stays in the target CC in the period between the SRS resource sets; otherwise, the UE switches back to the source CC after transmitting each SRS resource set.

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| Company | views | comments |
| Apple | Do NOT support | Look at future is not desired as a UE behavior. We support Alt4 which in our view needs no (to minimal) spec change. |
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Conclusion for Rel-16:

* For a target CC, when multiple aperiodic SRS resource sets for carrier switching are triggered by the same DCI and all the SRS resource sets will be transmitted according to the dropping rule, regarding UE behaviour on switching back to the source CC after transmitting one SRS resource set:
  + If the time period between the SRS resource sets is smaller than the total required RF switching time to the source CC and back to the target CC and a higher priority UL transmission and/or DL reception is not scheduled on the source CC in the time period between the two SRS resources sets, the UE stays in the target CC in the period between the SRS resource sets; otherwise, the UE switches back to the source CC after transmitting each SRS resource set.

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| Company | views | comments |
| ZTE | Agree | Is this the same as Proposal 2-1 ? |
| Futurewei | Agree | We are ok to have this as conclusion of Rel-16 UE behavior |
| Apple | Do NOT support | Look at future is not desired as a UE behavior. We support Alt4 which in our view needs no (to minimal) spec change. |

* 1. Prioritization rule

Proposal 2-2: agree on prioritization rule for SRS carrier switching, following 2 options are proposed for consideration, if option 1 is agreed then corresponding TP is to be further discussed.

Option1:

For Rel-17, define joint prioritization rules for carriers that are in the same band as the source CC, taking as baseline the CR in R1-2103759.

Option2:

TP proposal below

----- unchanged part omitted-----

6.2.1.3 UE sounding procedure between component carriers

For a carrier of a serving cell *d* with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, denote as the corresponding carrier of a serving cell whose UL transmissions are temporarily suspended as signalled by higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier*. Define the set as the set of carriers of serving cells that each carrier meets one of the following conditions:

- is in the same band as , or and are both configured with *uplinkTxSwitching-r16*.

- is in the same TAG as .

where .

----- unchanged part omitted-----

For an SRS transmission starting in symbol of carrier and a conflicting transmission in carrier starting in symbol, where , the UE shall apply the prioritization / dropping rules in the remainder of this clause 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.

The following prioritization rules shall be applied in case of collision between a transmission of SRS over carrier and transmission of a physical signal/channel over a carrier of a serving cell in set :

- ~~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 on a carrier of a serving cell in set 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 on a carrier of a serving cell in set 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 a carrier of a serving cell in set ~~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 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 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 on a carrier of a serving cell in the set 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].

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| Company | comments |
| ZTE | Agree in principle. If the new UE capability for inter-band CA case is supported, the spec should be updated together. |
| Futurewei | Comparing options 1 and 2, the main difference is about whether same SCS is a condition and whether *uplinkTxSwitching-r16* is considered. To our understanding, same SCS is no longer needed for NR as difference SCS can be configured even with a single carrier for different BWP. About *uplinkTxSwitching-r16,* we are ok to include it as condition when the UE supports uplink TX switching. Overall, we agree with option 2. |
| Apple | Is this (Opt1 and/or Opt2) proposed for R16 ? If so we do NOT support and it is against the conclusion in 107-e (no need to open up the old discussion). If this is as part of R17, we only support together with new capability signaling for inter-band, and by removing *uplinkTxSwitching-r16* (which will be replaced with new R17 capability indication parameter, e.g. what is explained in Qualcomm’s contribution, R1-2202112, Sec. 5) |

* 1. UL/DL directional collision and priority

Proposal 2-3:

* Discuss ambiguity of application order between directional collision handling and priority check for SRS carrier switching.
  + Consider application order of transmission or reception from the UE side in timeline.

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| Company | comments |
| ZTE | We are open to discuss this new feature in Rel-17, i.e. support half duplex TDD CA and SRS carrier switching. If supported, we think directional collision handling should always be done first. |
| Futurewei | Agree with ZTE. This can be discussed for Rel-17 or later release. |
| Apple | We are open to further discuss this. In our view, similar to URLLC multiplexing vs cancellation issue, here first it should be determined which UL grants may survive. So, first apply SRS prioritization rules, next apply collision directional rules. |

* 1. UE capability

Proposed conclusion :

* RAN1 concludes that current ASN.1 does not include a capability to indicate “beyond UE’s indicated uplink CA capability”
  + Based on current specification, UEs not supporting simultaneous transmission in the target band and a third band (other than source and target bands) are allowed to drop transmissions in the third band (per RAN4 requirements)

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| Company | views | comments |
| ZTE | Agree |  |
| Futurewei | Not agree | We do not see such a conclusion is needed. |
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Proposal 2-4: Introduce a new UE capability, if agreed, down selection between option 1 and 2.

Option1 :

* Introduce a new Rel-17 UE FG to indicate if UL transmission in one band within a BandCombination impacts UL transmission in another band within the BandCombination for SRS carrier switching.

Option2:

1. For each “source-target” pair (as indicated by *srs-SwitchingTimesListNR*), the UE can indicate which other bands in the band combination are affected by the SRS switch. If this new indication is missing, the UE defaults to Rel-15 behavior.
2. If the UE indicates the new list of bands, the dropping rules / timelines apply to the bands indicated by the list (requires update in RAN1 specs).

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| Company | views | comments |
| ZTE | Slightly prefer option 1 | Just one question for option 2, why the capability should be introduced per ‘source-target’ pair ? what kind of usecase is ? e.g. for a source-target pair c2-c1, c3 is impacted, but for source-target pair c4-c1, c3 is not impacted, why ? In our view, whether c3 is impacted only replies on c1 regardless of the sourcce carrier. |
| Futurewei | We prefer option 2 | Option 2 is clearer and more future-proof. |
| Apple | Prefer Option 2 | In our view, Option 2 is a more detailed version of Option 1. We are fine to begin with a signaling procedure proposed by Qualcomm in R1-2202112, Sec. 5. |

* 1. Text Proposals

TP#1: TP for 38.214 section 6.2.1.3

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For an SRS resource set 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 clause taking into account:

----- unchanged part omitted-----

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| Company | views | comments |
| ZTE | Agree | This is for Rel-16 |
| Futurewei | Agree |  |
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TP#2: TP for 38.214 section 6.2.1.3

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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*, and also the uplink transmission on carrier *c3* if the UE is configured with *uplinkTxSwitching-r16* for uplink switching between uplink carrier *c2* and *c3*.

----- unchanged part omitted-----

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| Company | views | comments |
| ZTE | Agree |  |
| Futurewei | Agree |  |
| Apple | Don’t agree |  |

1. Reference:

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| [R1-2201064](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2201064.zip) | Maintenance on SRS carrier switching | vivo |
| Proposal 1: Support Alt 3 and no specification change is needed.  Proposal 2: It is better to make a conclusion to avoid ambiguities on UE implementation for carrier switching if Alt 3 is supported. | | |
| [R1-2201450](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2201450.zip) | Discussion on SRS carrier switching | ZTE |
| Proposal 1: Adopt the following text proposal for Rel-16 38.214 [4] 6.2.1.3 UE sounding procedure between component carriers For an SRS resource set 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 clause taking into account:  **Proposal 2:** Make the following as a conclusion for Rel-16.   * For a target CC, when multiple aperiodic SRS resource sets for carrier switching are triggered by the same DCI and all the SRS resource sets will be transmitted according to the dropping rule, regarding UE behaviour on switching back to the source CC after transmitting one SRS resource set:   + If the time period between the SRS resource sets is smaller than the total required RF switching time to the source CC and back to the target CC and a higher priority UL transmission and/or DL reception is not scheduled on the source CC in the time period between the two SRS resources sets, the UE stays in the target CC in the period between the SRS resource sets; otherwise, the UE switches back to the source CC after transmitting each SRS resource set. | | |
| [R1-2201681](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2201681.zip) | Discussion on SRS carrier switching | Intel Corporation |
| Proposal 1:  Adopt the following text change for SRS carrier switching timeline operation in 38.214.  …  For an SRS resource set transmission ~~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 clause taking into account:  Proposal 2:   * When multiple aperiodic SRS resource sets for carrier switching are triggered by the same DCI, support Alt. 3 regarding UE behavior between two SRS resource sets. | | |
| [R1-2201986](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2201986.zip) | Discussion on ambiguity for SRS carrier switching. | Samsung |
| Proposal 1: Need discussion related to ambiguity according to the application order between directional collision handling and priority check for SRS carrier switching.  Proposal 2: As a simple method to solve the ambiguity, we can consider that the application order follows the order of transmission or reception from the UE side in timeline. | | |
| [R1-2202112](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2202112.zip) | Discussion on SRS carrier switching | Qualcomm Incorporated |
| Proposal 1: For Rel-17, define joint prioritization rules for carriers that are in the same band as the source CC, taking as baseline the CR in R1-2103759.  Proposal 3: RAN1 concludes that current ASN.1 does not include a capability to indicate “beyond UE’s indicated uplink CA capability”   * Based on current specification, UEs not supporting simultaneous transmission in the target band and a third band (other than source and target bands) are allowed to drop transmissions in the third band (per RAN4 requirements)   Proposal 4: If a new capability for cases other than intra-band CA is to be introduced in Rel-17, the design should be as follows:   1. For each “source-target” pair (as indicated by *srs-SwitchingTimesListNR*), the UE can indicate which other bands in the band combination are affected by the SRS switch. If this new indication is missing, the UE defaults to Rel-15 behavior. 2. If the UE indicates the new list of bands, the dropping rules / timelines apply to the bands indicated by the list (requires update in RAN1 specs). | | |
| [R1-2200973](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2200973.zip) | Discussion on the remaining issues of UL Tx switching | Huawei, HiSilicon |
| **Proposal 2:** Adopt the TP in Appendix A.2 for uplink suspension of SRS carrier switching in TS 38.214 clause 6.2.1.3.  **<Unchanged parts are omitted – 38.214>** 6.2.1.3 UE sounding procedure between component carriers 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*, and also the uplink transmission on carrier *c3* if the UE is configured with *uplinkTxSwitching-r16* for uplink switching between uplink carrier *c2* and *c3*.  **<Unchanged parts are omitted – 38.214>**  **Proposal 3:** Adopt the TP in Appendix A.3 for prioritization rules of SRS carrier switching in TS 38.214 clause 6.2.1.3.  **<Unchanged parts are omitted – 38.214>** 6.2.1.3 UE sounding procedure between component carriers For a carrier of a serving cell *d* with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, denote as the corresponding carrier of a serving cell whose UL transmissions are temporarily suspended as signalled by higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier*. Define the set as the set of carriers of serving cells that each carrier meets one of the following conditions:  - is in the same band as , or and are both configured with *uplinkTxSwitching-r16*.  - is in the same TAG as .  where .  **<Unchanged parts are omitted – 38.214>**  For an SRS transmission starting in symbol of carrier and a conflicting transmission in carrier starting in symbol, where , the UE shall apply the prioritization / dropping rules in the remainder of this clause 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.  The following prioritization rules shall be applied in case of collision between a transmission of SRS over carrier and transmission of a physical signal/channel over a carrier of a serving cell in set :  - 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 on a carrier of a serving cell in set 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].  - 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 on a carrier of a serving cell in set 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].  - 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 a carrier of a serving cell in set 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 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].  - the UE shall drop PUSCH transmission carrying aperiodic CSI comprising only CQI/PMI/L1-RSRP/L1-SINR on a carrier of a serving cell in the set 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].  **<Unchanged parts are omitted – 38.214>**  **Proposal 4:** For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink, if a uplink transmission is scheduled after a SRS carrier switching occurrence and the time interval between the first symbol of the uplink transmission and the last symbol of SRS transmission is less than or equal to an interval of 13 symbols plus the RF retuning time required by SRS carrier switching, then the last symbol of PDCCH scheduling the uplink transmission should be no later than at symbol L, where the time interval between symbol L and the first symbol of SRS transmission is larger than symbols plus the RF retuning time.   * In case of different SCS between the uplink transmission and the SRS transmission, the 13 symbols are with respect to the smaller SCS. | | |
| [R1-2201181](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_108-e/Docs/R1-2201181.zip) | Discussion on other Rel-17 UE features | ZTE |
| **Proposal 2:** Introduce a new Rel-17 UE FG to indicate if UL transmission in one band within a BandCombination impacts UL transmission in another band within the BandCombination for SRS carrier switching. | | |