3GPP TSG RAN WG1 #104bis-e R1-21xxxxx

**e-Meeting, April 12th – 20th, 2021**

**Agenda item: 7.2.12**

**Source: Moderator (China Telecom)**

**Title: [104b-e-NR-Rel16-TxSwitching-01] Summary of email discussion on maintenance of Rel-16 uplink Tx switching**

**Document for: Discussion and Decision**

# Introduction

In [1], maintenance issues are summarized for Rel-16 uplink Tx switching. As per the guidance of Chairman, following issues are identified for email discussion/approval during RAN1 #104b e-meeting:

[104b-e-NR-Rel16-TxSwitching-01] Email discussion/approval regarding potential CRs for the following issues

* Issue#1: Correction on RRC parameter “uplinkTxSwitchRequest” in TS 38.214
* Issue#2: Clarification on SRS carrier switching
* Issue#3: Clarification on SRS antenna switching
  + Whether it is a valid case should be clarified first.
* Issue#4: Clarification on UCI mapping

till 4/16 – Jianchi (China Telecom)

This contribution is the summary of email discussion/approval on maintenance of Rel-16 uplink Tx switching.

# Email discussion (1st round)

## Issue #1: Correction on RRC parameter “*uplinkTxSwitchRequest*” in TS 38.214

R1-2102377 mentioned that the RRC parameter “*uplinkTxSwitchRequest*” is misused in section 6.1.6 in TS38.214.

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| 6.1.6 Uplink switching **< unchanged text omitted>**  The UE may omit uplink transmission during the uplink switching gap if the conditions defined in this clause are met and the UE is configured with *uplinkTxSwitching*. The switching gap is indicated by UE capability *uplinkTxSwitchingPeriod*:  - If a UE indicated a capability for uplink switching with *~~uplinkTxSwitchRequest~~* *BandCombination-UplinkTxSwitch* for a band combination, and if it is for that band combination  - Configured with a MCG using E-UTRA radio access and with a SCG using NR radio access (EN-DC), or  - Configured with uplink carrier aggregation, or  - Configured in a serving cell with two uplink carriers with higher layer parameter *supplementaryUplink*.  the conditions under which the switching gap may be present and the location of the switching gap are defined for each of the cases in clauses 6.1.6.1, 6.1.6.2, and 6.1.6.3 respectively.  **< unchanged text omitted>** |

Companies are encouraged to provide views on the above TP.

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| **Company** | **Comments** |
| Huawei, HiSilicon | OK. |
| ZTE | Seems fine.  Alternatively, if there is no other approved TP for 38.214, this can be captured in the chairman notes as an editorial change and ask editor to handle this. |
| CATT | We are fine with FL proposal |

## Issue #2: Clarification on SRS carrier switching

SRS carrier switching was intensively discussed in RAN1 #104e. Companies acknowledged that some clarification is needed, but no consensus has been achieved. R1-2102491, R1-2103149, R1-2103746 proposed to further discuss this issue in this meeting.

There are two UE behaviours for SRS carrier switching in the spec, i.e., dropping rule and suspension. R1-2102491 stated it is clear that the suspension is only applicable to the source carrier and target carrier. However, it is not clear whether the current dropping rule is applicable to the carrier other than source carrier and target carrier. R1-2102491 proposed the TP to clarify the UE behaviour.

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| **6.2.1.3 UE sounding procedure between component carriers** < -------------------- Other parts are omitted -------------------- >  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*. If the UE is configured with uplink switching with parameter *uplinkTxSwitching* for carrier *c2* and carrier *c3*, during 2-port 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 *c3*.  < -------------------- Other parts are omitted -------------------- > |

R1-2103746 proposed to clarify the UE behaviours for both dropping rule and suspension and proposed the TPs.

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| **<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>** |

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| **<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 meet all the following conditions:  - are in the same TAG as .  - are in the different band as , and are both configured with *uplinkTxSwitching-r16*.  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 happens to overlap in the same symbol.  - 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 happens to overlap in the same symbol.  - the UE shall drop PUCCH/PUSCH transmission carrying periodic 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 *d* happen to overlap in the same symbol.  - 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 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 *d* happen to overlap in the same symbol.  **<Unchanged parts are omitted>** |

R1-2103149 proposed the following proposals and provided the corresponding TPs.

Proposal 1: In the prioritization for SRS switching considers the state of carriers configured with UL Tx switching jointly. As an example, if SRS switching is configured between CC2 and CC3 then in the prioritization the state of CC1 also needs to be considered if CC1 and CC2 are configured with UL Tx switching.

Proposal 2: Define requirements allowing dropping transmissions on a CC due to SRS transmission on another CC, even if this CC is not configured with SRS switching, as long as the CC is configured with UL Tx switching.

Proposal 3: Choose one of the following options:

* During the SRS transmission on CC3 and the interruption time caused by RF tuning, UE is not expected to be scheduled or configured with other transmission requiring UL Tx switching
* Define rules on the order in which the UE state vs. dropping decisions are being made

Proposal 4: During SRS transmission, CC3 is always treated as two ports, even if one-port SRS resource is configured.

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| 6.1.6.2 Uplink switching for carrier aggregation **<Unchanged parts are omitted>**  - The UE is not expected to be scheduled or configured with uplink transmissions that result in simultaneous transmission on two antenna ports on one uplink carrier, and any transmission on another uplink carrier.  - If the UE is configured with *SRS-CarrierSwitching,* the UE is not expected to be scheduled or configured with any uplink transmission (including a preceding or succeeding duration ) overlapping with an SRS transmission on a serving cell not configured for PUSCH/PUCCH 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*), whenever the uplink transmission would be preceded or succeeded by a duration .- In all other cases the UE is expected to transmit normally all uplink transmissions without interruptions.  **<Unchanged parts are omitted>** |

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| **<Unchanged parts are omitted>** 6.2.1.3 UE sounding procedure between component carriers 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]. In evaluating whether the transmission can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability, the UE may assume uplink transmission occurring in all carriers configured for PUSCH/PUCCH transmission, except for the carrier indicated by *srs-SwitchFromCarrier*, and if that carrier is configured with parameter *uplinkTxSwitching*, also the other carrier configured with *uplinkTxSwitching*, for which the UE assumes the actual configured transmissions.  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]. In evaluating whether the transmission can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability, the UE may assume uplink transmission occurring in all carriers configured for PUSCH/PUCCH transmission, except for the carrier indicated by *srs-SwitchFromCarrier*, and if that carrier is configured with parameter *uplinkTxSwitching*, also the other carrier configured with *uplinkTxSwitching*, for which the UE assumes the actual configured transmissions.  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 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]. In evaluating whether the transmission can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability, the UE may assume uplink transmission occurring in all carriers configured for PUSCH/PUCCH transmission, except for the carrier indicated by *srs-SwitchFromCarrier*, and if that carrier is configured with parameter *uplinkTxSwitching*, also the other carrier configured with *uplinkTxSwitching*, for which the UE assumes the actual configured transmissions.  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]. In evaluating whether the transmission can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability, the UE may assume uplink transmission occurring in all carriers configured for PUSCH/PUCCH transmission, except for the carrier indicated by *srs-SwitchFromCarrier*, and if that carrier is configured with parameter *uplinkTxSwitching*, also the other carrier configured with *uplinkTxSwitching*, for which the UE assumes the actual configured transmissions.  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'.  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*. If the UE is configured with *uplinkTxSwitching-r16* for uplink switching between *c2* and a third carrier *c3*, the UE may temporarily suspend the uplink transmission on carrier *c3* during the 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*).  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*.  **<Unchanged parts are omitted>** |

Companies are encouraged to provide views on the proposals in R1-2103149 and proposed TPs in R1-2102491, R1-2103149 and R1-2103746.

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| **Company** | **Comments** |
| Huawei, HiSilicon | Regarding the first change about suspended uplink carrier, we prefer a concise TP like our TP proposed in R1-2103746.  Regarding the change about prioritization rules, the “switch-from” carrier is surely involved in prioritization rules together with the “switch-to” SRS carrier, **as shown in the latest LTE specification TS 36.213 for SRS carrier switching and shown in CR R1-1721095.** Therefore, we prefer to keep the same UE behaviour instead of excluding the “switch-from” carrier as the TP proposed in R1-2103149. Additionally, for the intra-band case where the same UE hardware PA shared between the “switch-from” carrier and the intra-band carrier, **the prioritization rules in LTE SRS carrier switching has been extended to the intra-band carrier as in R1-1721095**, and the following agreement,  RAN1#90:  ***Agreement in Principle:***  *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.*  Similar to the intra-band case, UE hardware are shared between the uplink carrier configured with ULTxswitching, the situation is the same regarding to the prioritization rules, i.e. the uplink carrier sharing the same UE hardware with “switch-from” carrier is also a victim carrier. Therefore, we propose our TP in R1-2103746 with the same text structure as the latest LTE spec for SRS carrier switching. |
| ZTE | We are supportive to clarify this issue. However, as we analysed in our contribution R1-2102491, there are two UE behaviours for SRS carrier switching in the spec, i.e., dropping rule and suspension. It is clear that the suspension is only applicable to the source carrier and target carrier. However, it is not clear whether the current dropping rule is applicable to the carrier other than source carrier and target carrier. Different understandings on this may lead to different TPs. For example,   * If the dropping rule (section 6.2.1.3 of TS38.214) can be applied to carriers other than the “source carrier” and “target carrier”, then it seems the current dropping rule can cover the current issue now. * However, if the dropping rule can NOT be applied to carriers other than the “source carrier” and “target carrier”, namely it can only be applied to “source carrier” and “target carrier”, then TP may be needed. Even in this case, the current spec seems to be conflict with each. Because dropping rule tends to compare the priority between transmissions on “source carrier” and “target carrier”, while suspension seems to say that transmission on “target carrier” is always prioritized and transmission on “source carrier” is always suspended.   We understand that this is not the place to update Rel-15 spec, but we would prefer to clarify this issue and reach common understanding at least for Rel-16 UL Tx switching for this issue here. |
| CATT | It seems that it is easy way to apply the dropping rule to carriers other than the “source carrier” and “target carrier”. |

## Issue #3: Clarification on SRS antenna switching

SRS antenna switching was discussed in RAN1 #104e. Companies have different understandings whether the proposed issue is a valid case.

UL

SRS

SRS and UL

DL

Y symbol

CC1 UL

CC2

DL

Potential conflict w/o clarification

R1-2103149 raised the issue that there is potential conflict due to SRS antenna switching illustrated in the above figure and have following proposal:

* In the Y-symbol gap between SRS transmissions defined by Table 6.2.1.2-1 in 38.214, the UE is assumed to operate with the same number of ports as before and after the gap.

Companies are encouraged to provide views on whether the above issue is a valid case.

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| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | No | As commented before, we hope the proponent could take our previous comments into consideration, copied below as well.  “Regarding issue#3, we don’t agree the case shown in Figure 2 in R1-2103149 is a valid case simply because it has been precluded by current specification either the text about “no more than 1 UL Tx switching per slot” or the text about switching gap much larger than Y=1 symbol. Additionally, the TP proposed in R1-2103149 seems not relevant to the figure and not necessary simply because the SRS resource set of SRS antenna switching has been already restricted with the same number of SRS ports. Without this TP, it has been the same number of ports anyway. Therefore, we don’t feel issue#3 should be discussed again in this meeting. We are open for it if a reasonable TP is provided in future meeting.” |
| ZTE |  | From our perspective, the SRS together with its switching gap are considered as a transmission as a whole. In this sense, this issue can be divided into two sub-cases.  Sub-case-1) 2-port SRS on CC2, UE is not expected to be configured/scheduled any UL transmission on CC1 that may be overlapping with this 2-port SRS together with its Y-symbol gap.  Sub-case-2) 1-port SRS on CC1, UE can be configured/scheduled 1-port UL transmission on CC1 that may be overlapping with this 2-port SRS together with its Y-symbol gap.  It seems one conclusion in the chairman notes could solve this issue, e.g.,  *If CC1 and CC2 are configured with UL Tx switching, UE is not expected to be configured/scheduled any UL transmission on CC1 that may be overlapping with 2-port SRS on CC2 together with its Y-symbol gap.* |
| CATT | No | It isn’t clear to us that why gNB need schedule UL transmission in CC 1 during Ygap in CC2. |

## Issue #4: Clarification on UCI mapping

R1-2103149 raised the issue that UE behaviour is not clear for UCI mapping in the case illustrated in the following figure:



R1-2103149 proposed two options to clarify the UE behaviour:

* Option 1: Error case
* Option 2: Do multiplexing first: multiplex the UCI in CC2, then drop CC2.

Companies are encouraged to provide views on the above issue and proposed options.

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| **Company** | **Comments** |
| Huawei, HiSilicon | Option 2. Because in current spec, as long as the timeline conditions for UCI multiplexing are met, UCI multiplexing is performed. The impact from UL Tx switching has been reflected by increased timeline conditions. If any conclusion would be made, the wording of Option 2 would be better to be rephrased a bit to describe the concerned case more precisely. |
| ZTE | If we understand this issue correctly, the issue is as following, a PUCCH was intended to be multiplexed in PUSCH on CC2. However, the PUSCH needs to be dropped (or partially cancelled) to accommodate the UL Tx switching gap on CC2. In this case, it is not clear whether the PUCCH should still multiplex on this PUSCH.  From our perspective, either option is ok. But it seems no spec change is needed. Maybe a clarification in the chairman notes is enough. |
| CATT | We want to clarify this issue. In our understanding, it is possible way that UL Tx switching gap is executed before UCI transmission in CC1 and then UCI needn’t be dropped. In this case, PUSCH in slot#9 needs to be dropped (or partially cancelled). |

# References

1. R1-2103502, Summary of Rel-16 uplink Tx switching, Moderator (China Telecom), RAN1#104bis-e, April 12th – 20th, 2021.
2. R1-2102377, Text Proposals for Tx Switching between Two Uplink Carriers, OPPO, RAN1#104bis-e, April 12th – 20th, 2021.
3. R1-2102491, Remaining Issues of Rel-16 UL Tx Switching, ZTE, RAN1#104bis-e, April 12th – 20th, 2021.
4. R1-2103149, Remaining issues for 1Tx-2Tx switching, Qualcomm Incorporated, RAN1#104bis-e, April 12th – 20th, 2021.
5. R1-2103746, Discussion on the remaining problems of supporting Tx switching between two uplink carriers, Huawei, HiSilicon, RAN1#104bis-e, April 12th – 20th, 2021.