3GPP TSG RAN WG1 #106bis-e R1-21xxxxx

**e-Meeting, October 11th – 19th, 2021**

**Agenda item: 5.1**

**Source: Moderator (China Telecom)**

**Title: [106bis-e-NR-R17-TxSwitching-01] Summary of email discussion on Rel-17 uplink Tx switching**

**Document for: Discussion**

# Introduction

In RAN #89 e-meeting, a new Rel-17 WID of “RF requirements enhancement for NR frequency range 1 (FR1)” [1] was approved and was revised in RAN #91 e-meeting [2], including following objectives.

* Specify UE requirements to enable Tx switching between different cases across carriers based on SUL and NR inter-band uplink CA for UE supporting maximum two concurrent transmissions
  + Specify UE requirements to enable Tx switching between cases
    - The scenarios include
      * For Tx switching based on SUL band combination, or uplink CA band combination

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|  | **Number of Tx chains in WID (carrier 1 + carrier 2)** |
| Case 2 | 0T+2T |
| Case 3 | 2T+0T |

* + - * For Tx switching based on uplink CA band combination

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|  | **Number of Tx chains in WID (carrier 1 + carrier 2)** |
| Case 1 | 1T+1T |
| Case 2 | 0T+2T |
| Case 3 | 2T+0T |

* + - Specify the following RAN4 requirements for above scenarios
      * Length of switching period
      * Time mask RF requirements
      * Uplink interruption and downlink interruption (RRM) requirements, if needed
    - Minimize the impacts on RAN1
      * Update RAN1 uplink switching for carrier aggregation and supplementary uplink
    - Minimize the impacts on RAN2
      * Update the RRC signaling to indicate the switching period location and length
      * Update the UE capabilities
  + Specify UE requirements to enable Tx switching between cases, where 1 carrier on band A and 2 contiguous aggregated carriers on band B, and band A is for SUL or non-SUL and band B is a non-SUL band
    - The scenarios include
      * For Tx switching based on SUL band combination, or uplink CA band combination

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|  | **Number of Tx chains in WID (band A + band B)** |
| Case 1 | 1T+1T |
| Case 2 | 0T+2T |

and

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|  | **Number of Tx chains in WID (band A + band B)** |
| Case 2 | 0T+2T |
| Case 3 | 2T+0T |

* + - * For Tx switching based on uplink CA band combination

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* + - Specify the following RAN4 requirements for above scenarios
      * Length of switching period
      * Time mask RF requirements
      * Uplink interruption and downlink interruption (RRM) requirements, if needed
    - Minimize the impacts on RAN1
      * Update RAN1 uplink switching for carrier aggregation and supplementary uplink
    - Minimize the impacts on RAN2
      * Update the RRC signaling to indicate the switching period location and length
      * Update the UE capabilities

Note 1: Only addressing the case of co-located and synchronized network deployment for the two UL carriers.

Note 2: Only addressing the case of single TAG for the two UL carriers for SUL and for UL CA.

Note 3: The UE is configured with two different uplink carrier frequencies.

This contribution is a summary of the following email discussion:

[106bis-e-NR-R17-TxSwitching-01] Email discussion on RAN1 Aspects for RF requirements for NR frequency range 1 (FR1) – Jianchi (China Telecom)

* 1st check point: October 14
* Final check point: October 19

# Email discussion (1st round)

## Determination of the state of Tx chains for 2Tx-2Tx switching

In RAN1#106-e, it was discussed how to handle the case that the state of Tx chains after Tx switching is not unique for UL CA option 2 for 2Tx-2Tx chains and the following agreement was achieved.

**Agreements: Down select one of the following options in RAN1#106b-e:**

* **Option 1:** For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, then
  + 1Tx on carrier 1 and 1Tx on carrier 2 is assumed if the carrier is configured with *uplinkTxSwitchingPeriodLocation* as true.
  + the state of Tx chains supporting 2Tx transmission is assumed on the carrier if the carrier is configured with *uplinkTxSwitchingPeriodLocation* as false.
* **Option 2:** For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, then the state of Tx chains supporting 2Tx transmission on the carrier is assumed.
* **Option 3:** For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, then 1Tx on carrier 1 and 1Tx on carrier 2 is assumed.

**Companies’ views [3] - [9] on each option are summarized in the table blow.**

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|  | **Option 1** | **Option 2** | **Option 3** |
| **Huawei, HiSilicon (R1-2108743)** | The network can flexibly adjust the UE behavior according to the actual situation, without requiring a new RRC parameter. | The network cannot adjust the UE behavior according to the actual situation. | |
| **ZTE (R1-2108839)** | coupling the default state with *uplinkTxSwitchingPeriodLocation* is not necessary from our perspective.  Which carrier is more important is typically decided by operator, not decided by the parameter *uplinkTxSwitchingPeriodLocation*. | since UE supports both 1-port and 2-port transmission on carrier2 and carrier1 under Case2 and Case3, respectively, to avoid unnecessary switching between 1-port and 2-port transmission, it is more appropriate to predefine the target case as Case2 and Case3. | |
| **vivo (R1-2108949)** | to couple the Tx state with the presence of uplink switching gap does not provide meaningful gain in practice but put constraint for gNB when configuring the presence of uplink switching gap between carriers | Option 2 could maximum the utilization of UL MIMO (i.e. 2Tx) on one carrier in the slot immediately after the Tx switching, but it would cause additional delay or resource overhead if 1Tx PUSCH or PUCCH is scheduled on the other carrier immediately after the Tx switching (as 0Tx is assumed). | Option 3 is more balanced between the two carriers and therefore preferred |
| **OPPO (R1-2109050)** | Whether the carrier is configured with *uplinkTxSwitchingPeriodLocation* as true or false is usually depending on the available UL resources, rather than on the importance of the carrier(s). | For a UE can support 2Tx-2Tx, gNB usually prefers to boost the data rate via utilizing the maximum capability of UE. Thus, gNB is likely to continue transmit 2-port PUSCH in this carrier/band, or switch back to another carrier/band to transmit 2-port PUSCH. Thus, Option 2 is the most efficient in most typical cases. | It is beneficial the case where gNB schedules UE with 1-port transmission switching between two carriers/bands. It should not be the typical case for a UE supporting 2Tx-2Tx UL Tx switching. |
| **China Telecom (R1-2109246)** | if a UE is configured with 2Tx-2Tx UL Tx switching, it means that this UE can be scheduled with 2Tx transmission on any of the two carrier with high probability. | | |
| **CMCC (R1-2109269)** | the “signaling” solution looks like the best one but it is already ruled out for Rel-17. Then the second-best solution is to exam the actual Tx switching application scenarios on major operators’ network and take decision accordingly. If for most of the time/scenarios, 2Tx is the righteous choice, then assuming 2Tx will be most efficient. | | |
| **Qualcomm (R1-2110163)** | the UL switching period is configured typically with the carrier with more UL slots, which doesn’t mean the carrier is less important | Option 2 somewhat incompatible with the feature of PUCCH carrier switching because it can result in a state switch for every successive PUCCH transmission when there is no PUSCH. | Option 3 tries to prioritize 1Tx on each band which is friendly to Pcell. |
| **Summary** | **Supported by Huawei, HiSilicon** | **Supported by ZTE, China Telecom, OPPO, CMCC** | **Supported by Qualcomm, vivo** |

In addition, R1-2108949 proposed option 4, configured between Option 2 and Option3 by a new RRC parameter.

* **Option 4:** For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, introduce a new RRC parameter to configure between 1) and 2)
  + 1) The state of Tx chains supporting 2Tx transmission on the carrier is assumed.
  + 2) 1Tx on carrier 1 and 1Tx on carrier 2 is assumed.

R1-2109246 proposed the details for 2Tx-2Tx switching between two uplink carriers and 2Tx-2Tx switching between two uplink bands.

* For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, then the state of Tx chains supporting 2Tx transmission on the carrier is assumed, i.e.,
  + If the current state of Tx chains is 0Tx on carrier 1 and 2Tx on carrier 2, and if the next UL transmission is 1-port transmission on carrier 1, the state of Tx chains after Tx switching is 2Tx on carrier 1 and 0Tx on carrier 2.
  + If the current state of Tx chains is 2Tx on carrier 1 and 0Tx on carrier 2, and if the next UL transmission is 1-port transmission on carrier 2, the state of Tx chains after Tx switching is 0Tx on carrier 1 and 2Tx on carrier 2.
* For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on at least one carrier on a band and the state of Tx chains after the UL Tx switching is not unique, then the state of Tx chains supporting 2Tx transmission on the band is assumed, i.e.,
  + If the current state of Tx chains is 0Tx on band A and 2Tx on band B, and if the next UL transmission is 1-port transmission on band A, the state of Tx chains after Tx switching is 2Tx on band A and 0Tx on band B.
  + If the current state of Tx chains is 2Tx on band A and 0Tx on band B, and if the next UL transmission is 1-port transmission on at least one carrier on band B, the state of Tx chains after Tx switching is 0Tx on band A and 2Tx on band B.

**FL comments:** It seems companies acknowledge that either option can work. Option 1 has the flexibility to configure the state of Tx chains but it has to couple with *uplinkTxSwitchingPeriodLocation*, and it seems most companies has concerns on the coupling. It is mentioned by companies that for UE configured with 2Tx-2Tx UL Tx switching, it means that this UE can be scheduled with 2Tx transmission on any of the two carrier with high probability, thus, Option 2 is the most efficient in most typical cases. Option 3 may avoid the switching gap in some cases, it is friendly to Pcell and more balanced between the two carriers, but it may not be the typical case for a UE supporting 2Tx-2Tx UL Tx switching. Based on companies’ views and analysis on each option, FL suggests to consider option 4 proposed by vivo, which keeps flexibility while it is not coupled with *uplinkTxSwitchingPeriodLocation*.

**Proposal:**

* For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, introduce a new RRC parameter to configure between 1) and 2)
  + 1) The state of Tx chains supporting 2Tx transmission on the carrier is assumed.
  + 2) 1Tx on carrier 1 and 1Tx on carrier 2 is assumed.

Companies are encouraged to provide comments on the above proposal.

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| **Company** | **Views** |
| vivo | Support. |
| Huawei, HiSilicon | Not our preference, we are fine with FL proposal if it is a majority view. |
| ZTE | Our first preference is Option 2. But we can also support FL proposal above (introducing new RRC parameter) for to break this deadlock of discussion.  Note that both operators joining this discussion view Option 2 as the most favourable one. If companies can’t coverage on Option 4, we would suggest to go with Option 2. |
| Intel | We are supportive to FL proposal |
| Qualcomm | Given either of Option 2 or 3 is workable, we are ok to FL’s proposal if the majority can compromise on this. |
| CMCC | Both option 2 and 4 are fine to us. |

## Differentiation between 1Tx-2Tx switching and 2Tx-2Tx switching

In RAN1#106-e, it was discussed whether to use existing RRC parameter or introduce a new RRC parameter to differentiate 1Tx-2Tx switching and 2Tx-2Tx switching. The following agreement has been achieved.

**Agreements: Down select one of the following options in RAN1 #106bis-e**

**Option 1:**

* For a UE configured with UL Tx switching via *uplinkTxSwitching*, the maximum number of antenna ports among all configured P-SRS/A-SRS and activated SP-SRS resources is used to determine the operation mode, i.e. either 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.
* 2Tx-2Tx switching mode: when the maximum number is 2 for all uplinks configured with *uplinkTxSwitching*
* 1Tx-2Tx switching mode: when the maximum number is 1 for any one uplink configured with *uplinkTxSwitching*
* the switching gap duration for a triggered uplink switching is equal to the switching time capability value reported for the switching mode
  + Note: If the switching time capability value for 1Tx-2Tx switching mode is not reported by the UE, the value reported for 2Tx-2Tx switching mode is applied.
* If any of the above SRS resources is configured with usage “noncodebook”, then the max number of 2 antenna ports are counted for the SRS resources during the determination of operation mode.
  + FFS how to determine the number of antenna ports for SRS resources.

**Option 2:**

* For a UE configured with UL Tx switching via *uplinkTxSwitching*, a new RRC parameter is used to indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.

**Companies’ views [3] - [9] on each option are summarized in the table blow.**

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|  | **Option 1** | **Option 2** |
| **Huawei, HiSilicon (R1-2108743)** | The counting of maximum number of antenna ports has no impact on the effective non-codebook operation, but only on the determination of operation mode which is used to determine the proper gap that a UE needs. | When new parameters are introduced, problems may arise. If a new RRC parameter is introduced, then it may end up with conflicting RRC parameters, for example, 2Tx-2Tx are configured to the UE by existing MIMO parameter, but the new RRC parameter indicates 1Tx-2Tx mode. |
| **ZTE (R1-2108839)** | network and UE has to consider the SRS for “noncodebook” as 2Tx.  The current spec supports non-codebook based 1Tx PUSCH transmission with configuration of one single port SRS resource but the above proposal seems to preclude such operation. It’s also confusing to say 2 antenna ports are counted in this case even 1-port SRS is configured.  we need to clarify whether configured SRS resources in inactive BWPs/cell should be counted as well. In any case, it is too complicated to require UE and network to sync up counting in different protocol layers. | If a new RRC parameter is introduced, network and UE can directly determine whether the SRS for “noncodebook” should be 1Tx or 2Tx. |
| **vivo (R1-2108949)** | Between the two options, the key controversy is how to count the UE Tx state (i.e. 1Tx or 2Tx) when an SRS resource with usage “non-codebook” is configured for a carrier. It is understood that for non-codebook based UL transmission, it is up to UE implementation to use either 1Tx or 2Tx. We think such UE implementation flexibility should be maintained in the UL Tx switching feature, which is allowed by Option1, since the worst case is assumed by gNB.  our understanding is that 2 antenna ports are assumed only for the purpose of determining UE Tx switching mode, it does not affect the UE implementation on using 1Tx or 2Tx for the real transmission. | In Option 2, the UE implementation (1Tx or 2Tx) for non-codebook based UL transmission is controlled by the NW, which is different from the case without UL Tx switching, therefore not desirable. |
| **OPPO (R1-2109050)** | Option 1 is more complicated compared to Option 2. That is to say, Option 1 may lead to more implementation complexity for UE. Moreover, Option 1 will make the specification obscure and not friendly to the readers. | There might be some concern on the introduction of new RRC parameter in Option 2. The additional signaling overhead of one RRC parameter is neglectable. |
| **Qualcomm (R1-2110163)** | When the SRS resource is configured with non-codebook, both 1-port and 2-ports are allowed while the exact port number would be configured by network. From current option 1, our feeling is the proponents want to preclude the 1 port case.  The current option 1 may have smaller time period as number of antenna ports could be changed/configured with MAC-CE. | Option 2 to introduce a new RRC IE in principle as this is the most efficient way.  The frequency for switching mode determination. Our understanding is this should be at least a RRC message circle, and therefore a new RRC IE as in Option 2 could serve this purpose very well. |
| **Summary** | **Supported by Huawei, HiSilicon, vivo** | **Supported by ZTE, OPPO, Qualcomm** |

**FL comments:** It seems companies have different understandings. The key points are summarized based on FL understanding below.

1) For option 1, 2 antenna ports are assumed only for the purpose of the determination of operation mode (1Tx-2Tx switching or 2Tx-2Tx switching). It has no impact on the effective non-codebook operation and it does not affect the UE implementation on using 1Tx or 2Tx for the real transmission.

2) Option 1 may lead to more implementation complexity for UE.

3) For option 2, the UE implementation (1Tx or 2Tx) for non-codebook based UL transmission is controlled by the NW, which is different from the case without UL Tx switching.

4) For option 2, if a new RRC parameter is introduced, then it may end up with conflicting RRC parameters, for example, 2Tx-2Tx are configured to the UE by existing MIMO parameter, but the new RRC parameter indicates 1Tx-2Tx mode.

Before moving forward, it is necessary to align the understandings. Companies are encouraged to provide views on the above summary.

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| **Company** | **Views** |
| vivo | For single port SRS configured with usage “non-codebook”, UE is allowed by implementation to use 1Tx or 2Tx (e.g. transparent TxD), our understanding is that such UE implementation flexibility can be maintained by Option 1. However, in Option 2, UE has to follow the RRC configuration therefore such flexibility is lost. |
| Huawei, HiSilicon | We support Option 1.  Option 2 has two drawbacks, firstly, a new RRC parameter can conflict with existing RRC parameters, a clarification like Option 1 is inevitable.  Secondly, the existing freedom of UE implementation (1Tx or 2Tx) for non-codebook based UL transmission should be kept, i.e. it is up to UE implementation to use either 1Tx or 2Tx for non-codebook UL transmission. However, Option 2 adds unnecessary restriction to UE implementation. |
| ZTE | We support Option 2.  For 1) and 2): Option 1 will make the spec cumbersome. It unnecessarily introduces one kind of “virtual port” for determining switching mode. Also, the handling for SP-SRS may be complicated especially considering the timeline between SP-SRS activation and Tx switching. What’s the UE behaviour if the triggering command of Tx switching if before the activation time of SP-SRS and the triggered PUSCH/PUCCH is after the activation time of SP-SRS? If Option1 is adopted, we have to address these kind of timeline issues.  For 3): By definition of 1Tx-2Tx switching, the UE should only use 1Tx in carrier 1. This is true for all transmission modes including codebook and non-codebook transmission. In order to perform Tx switching operation, network needs to know which Tx state of the UE is. There is 1Tx state even in 2Tx-2Tx switching. Regardless of which option, it should not be up to UE implementation to assume which Tx state it should be. Otherwise, there is no way to sync-up between network and UE.  Meanwhile, network can check UE’s capability report on non-codebook-based UL transmission and 1-2Tx or 2Tx-2Tx to select the most appropriate configuration. For example, if UE only indicates 2Tx-2Tx but not indicate 1Tx-2Tx, then network of course can only select 2Tx-2Tx.  For 4): This is totally an implementation issue. Network of course won’t generate conflicting configurations for its UE.  Furthermore, there is also compatibility problem for Option1. The UE should be able to perform 1Tx-2Tx switching under the gNB which only supports 1Tx-2Tx operation e.g. Rel-16 gNB or Rel-17 gNB supporting only 1Tx-2Tx operation. Option1 always assumes 2Tx-2Tx operation for non-codebook based transmission. This makes it incompatible with non-codebook based transmission under Rel-16 1Tx-2Tx switching. |
| Qualcomm | Please kindly find our response below.  1) – Yes.  2) – Yes.  3) – No. It would not change the UE implementation flexibility. More specifically,   * The gNB cannot configure 1Tx-2Tx mode where the assumed 1Tx CC is also configured with non-codebook based MIMO   4) – No. The configuration should be without ambiguity. The gNB should be guarantee no conflict configuration with either option above.  In response to vivo and Huawei’s comments on TxD, the limitation is due to only 1Tx on one of the carriers, which is not introduced by Option 2. The RRC configuration simply unambiguously clarifies the UE state, it does not change it.  We recall we had similar discussion on how to handle TxD in Rel-16 when we reached some consensus that TxD is not supported together with UL Tx switching. As TxD is still ongoing, we would suggest making the conclusion that TxD is not supported together with UL Tx switching. |

## 1-port transmission via DCI format 0\_1 for UL CA option 2

This issue was intensively discussed in Rel-16. Many compromised proposals were discussed but unfortunately no consensus was reached. The latest proposed conclusion in RAN1#106-e is as follows:

**Proposed Conclusion:**

* For Rel-17 Tx switching between two uplink carriers, no additional specification impact to support 1-port transmission via DCI format 0\_1 for UL CA option 2 when nrofSRS-Ports is configured as 2 antenna ports on carrier 1 or carrier 2 and the state of Tx chains is 1 Tx on carrier 1 and 1Tx on carrier 2.

R1-2110163 proposed the following.

* For Rel-17 Tx switching between Band A and Band B, no additional specification impact to support 1-port transmission via DCI format 0\_1 for UL CA option 2 when maximum *nrofSRS-Ports* among the carriers on Band B is configured as 2 antenna ports and the state of Tx chains is 1 Tx on Band A and 1Tx on Band B.

R1-2109050 proposed the followings.

* Alt.1: No further discussion in Rel-17
* Alt.2: Make a simple conclusion as below
  + For Rel-17 Tx switching, no additional specification enhancement to support 1-port transmission via DCI format 0\_1

FL would like to check if companies can live with any of the above alternatives.

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| **Company** | **Views** |
| Huawei, HiSilicon | Alt.1.  It is not new proposal and too much time has been wasted on discussions of the new MIMO scheme since Rel-16. Given multiple companies’ sustaining disagreement on the repeated proposal, we really don’t see any other option on the table other than Alt. 1. |
| ZTE | To cover both the 2-carrier case and the 3-carrier case, we can change the carrier 1 and carrier 2 to Band A and Band B, respectively. The following proposal may be more aligned with the previous proposal discussed in RAN1#106-e meeting.   * **For Rel-17 Tx switching between Band A and Band B, no additional specification impact to support 1-port transmission via DCI format 0\_1 for UL CA option 2 when nrofSRS-Ports is configured as 2 antenna ports on Band B and the state of Tx chains is 1 Tx on Band A and 1Tx on Band B.** |
| Qualcomm | No. We can’t accept either of the alternatives above from R1-2109050.  We are supportive of the above proposal from R1-2110163 which is the extension of the proposed conclusion by FL to cover Rel-17 two band switching.  Rel-17 allows 2 ports scheduling for both bands, which makes the status determination more complicated than Rel-16. This port number categorization is thus with higher importance and necessity. The conclusion would help to reduce the potential scheduling ambiguity. We propose the group to agree on the conclusion for Rel-17. |

## Back-to-back switching with SRS switching

In RAN1#106-e, following two options were discussed, but no consensus were reached.

**Option 1:**

* When SRS carrier switching is configured, a maximum of 3 switches (2 for SRS and 1 for UL Tx switching) are supported in 14 consecutive symbols corresponding to the SCS of SRS.

Note: it is applicable to both Rel-16 UL Tx switching and Rel-17 UL Tx switching.

**Option 2:**

* 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.

Note: it is applicable to both Rel-16 UL Tx switching and Rel-17 UL Tx switching.

Companies are encouraged to continue the discussion.

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| **Company** | **Views** |
| Huawei, HiSilicon | We support Option 2.  This method not only relief UE burden from too frequent RF retunings but also allows a gNB to schedule the succeeding slot so that no UL throughput loss for network operation, the cost is the DCI should be sent to the UE sufficiently earlier. With the help of earlier arrival of scheduling DCI, if a UE prefer to implement two switchings/RF retunings in this case, then it is still up to UE to do it. But it provides the availability to avoid frequent RF retunings. For example, if the switching time from CC3 to CC1 is the sum of two reported switching gaps, UE can choose the best implementation, either direct switching or two-step switching.  Option 1 puts too much unnecessary restriction to gNB scheduling, resulting UL throughput loss. |
| ZTE | As we discussed in last RAN1 meeting, we may need to first clarify whether Option2 can be applied to Rel-16 UE and whether there is any NBC issue.  Also, there is one remaining issue from last RAN1 meeting that hasn’t been finalized yet. We copied it below.  --------------------------  3. This proposal may unnecessarily put restrictions for the PUSCH scheduling when in fact, the additional timeline requirement is not necessary. Take the following figure as an example (three switches in total). If the UE is firstly in case 2 (2Tx @ CC 2), UE first switches to CC 3 to transmit SRS and switches back to CC2 and then switch to CC1 to transmit PUSCH1. Since there are only 3 switching here, there is no need to add any additional timeline requirement for this UE in this case.    -------------------------- |
| Qualcomm | We support Option 1.  On Option 2, we raised two technical concerns in the last meeting as follows, which unfortunately were not solved yet.  1. UE capability: UE is assumed to have the following capability: a) SRS carrier switching between CC2 and CC3, and b) UL Tx switching between CC1 and CC2. Now it seems UE needs support an additional c) UL Tx switching capability between CC1 and CC3. To support proposal 9, UE seems need to support and report capability c) and related parameters (e.g. switching time, switching options and, etc.).  2. In case that UE is capable of direct switching from CC3 to CC1, the feasible switching time from CC3 to CC1 also needs to be studied. The switching time capability is indicated for a given pair of cells, and it is not transitive. If the UE indicated it needs a certain gap duration to switch between a pair of cells for a particular purpose, it cannot be assumed that the UE needs the same gap duration to switch between a different pair of cells or for a different purpose.  Furthermore, even in case UE can report the switching capability between CC3 and CC1, we don’t see sufficient justification to change the current default UE behaviour, which is RF retuning to source carrier after SRS transmission on target carrier. |

## CA based SRS carrier switching

In RAN1#106-e, following TP was discussed in [106-e-NR-Maintenance-Others-02].

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| **<Unchanged parts are omitted – 38.214>**  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>** |

R1-2110163 had following proposals.

* **Proposal:** 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:** 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:** 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

Companies are encouraged to provide views on the above TP and proposals in R1-2110163.

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| **Company** | **Views** |
| Huawei, HiSilicon | We support the above TP.  The TP is technically correct and have no technical concern according to the discussion of multiple meetings. We hope it could be accepted.  Regarding the first proposal in R1-2110163, it seems the same as we proposed last meeting in R1-2106516, copied below. If the proposal has the same meaning, we support it, and prefer to discuss its any CR directly.  *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 s0(d) 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 S(d)= {s0(d)… sN-1(d)} as the set of carriers of serving cells that meet all the following conditions:*  *- si(d) is in the same band as s0(d), or s0(d) and si(d) are both configured with uplinkTxSwitching-r16.*  *- si(d) is in the same TAG as s0(d).*  *where .*  Regarding the second proposal in R1-2110163, it is about introduction of RAN4 requirement, not sure if RAN1 could make a decision for RAN4.  Regarding the third proposal, more clarifications are suggested. In current framework of SRS carrier switching, there are two-step procedures, i.e. prioritization rules to handle collision between UL transmission before determining any SRS transmission, and after determining a SRS transmission, the suspending rule. The first option in the third proposal seems about “after determining a SRS transmission”, while the second option seems about “before determining a SRS transmission”. To be more compatible with current framework, we feel the second option is better. But need more details and clarification from the proponent. |
| ZTE | We are ok to use the above TP as the starting point. |
| Qualcomm | During the email discussion in RAN1 #104b-emeeting, companies agreed that we could wait for the conclusion of email thread [104b-e-NR-7.1CRs -02] which is trying to solve similar ambiguity issue. However, the CR discussion did not get through until last meeting and not expected to be discussed in this meeting. In this sense we can’t agree the above TP as it’s a broken solution.  We think there would be two alternative approaches:   * Alternative 1: wait for SRS CR discussion and then make further discussion based on the outcome of SRS CR discussion. * Alternative 2: discuss and try to solve the issue without waiting for SRS CR discussion. The above proposal could be starting point.   As far as it would be a complete solution, we are fine with either alternative in the Rel-17 time frame. |

## TP

R1-2108743 provided TP for the uplink switching between two bands for SUL and the uplink switching between two bands for UL CA option 1.

R1-2108839 provided TP for 2Tx-2Tx switching between two uplink carriers for UL CA, 1Tx-2Tx/2Tx-2Tx switching between 1 carrier on Band A and 2 contiguous carriers on Band B for UL CA.

**FL comments:**

* Regarding the TP for2Tx-2Tx switching between two uplink carriers for UL CA, based on the discussion in the past RAN1 meetings, it seems the key point is whether a new RRC parameter is introduced to differentiate Rel-16 Tx switching or Rel-17 Tx switching. Since the discussion on differentiation between 1Tx-2Tx switching and 2Tx-2Tx switching is ongoing, we need to hold on the discussion on TP.
* Regarding the TP for uplink switching between two bands, it seems the TPs provided by R1-2108743 and R1-2108839 are quite divergent. The main point is whether the current spec description is revised to cover both uplink switching between two uplink carriers and uplink switching between two bands as in R1-2108743 or to introduce separate spec description for uplink switching between two bands as in R1-2108839.

**Companies are encouraged to answer the following question.**

**Question:** Regarding the TP for uplink switching between two bands, which option is preferred?

* **Option 1:** The current spec description is revised to cover both uplink switching between two uplink carriers and uplink switching between two bands in the same paragraphs.
* **Option 2:** Introduce separate paragraphs for spec description for uplink switching between two bands.
* **Option 3:** It’s up to Editor how to capture the agreements on uplink switching between two bands.

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| **Company** | **Views** |
| Huawei, HiSilicon | Based on all contribution papers, there is no different view on the TP for SUL. Since the TP for SUL is very simple and straightforward, we suggest to agree it now.  We never prefer to mix the SUL TP with the TP of UL CA, because they belongs to different sub-clauses in spec. We don’t see any technical reason to mix them together.  Regarding the remaining TPs, agree with FL that whether a new RRC parameter is needed should be discussed first.  We prefer to reuse the existing spec text as much as possible. We still don’t understand why redundant and repeated spec text is necessary. May proponent could clarify it. |
| ZTE | We support Option 2.  If no RRC parameter is introduced to different Rel-16 and Rel-17 UL Tx switching, Option1 will make the specification of UL Tx switching difficult to read. It is difficult/impossible to differentiate which bullet is for Rel-16 and which is for Rel-17. |
| Qualcomm | We propose to agree on the basic principles before we make decision on which above options would be the best approach.  In general, we think the proposal should use the newly approved RRC IEs, and potential approved UE capabilities. One example is the switching time for 2Tx-2Tx and 1Tx-2Tx. Given RAN2 is discussing the UE features at the same time, we propose to discuss some principles of UE capability. Below are our initial considerations:  - Differentiation of Rel-16 and Rel-17 capabilities. Given Rel-17 allows 2 Tx on both carriers/bands, we think it would be helpful to differentiate Rel-16 and Rel-17 switching capabilities. Furthermore, the differentiation should be implemented to both SUL and CA, as Rel-17 introduces new switching capabilities like 2Tx-2Tx, 3 carriers for intra-band CA, and etc.  - UE capability for 3 carriers. It may not need to introduce a new UE capability as UE could report corresponding CA bandwidth class and UL MIMO layers in the UL featureSetPerCCs for 2 continuous CCs on band B in the legacy way. However, it would be good if it would be limited to no more than 2 bands being configured with UL. With this limitation, feature per band combination would be acceptable. |

## UL-CA power-limited handling

R1-2110163 mentioned RAN4 identified an issue of SCell dropping in UL-CA when the power is limited, and send an LS to RAN1 asking a couple of questions on how to address the issue. R1-2110163 proposed the following proposal.

**Proposal:**

* Introduce a higher-layer parameter for relative power offset to reflect the priority difference for concurrent UL transmissions in case of power-limited
* For UL-CA power-limited handling, the UE allocates transmission powers to the concurrent transmissions taking into account the total available power and the relative power offset

**FL comments:** It seems not relevant to Tx switching and depends on the outcome of [106bis-e-NR-AI5-LSs-Prep].

# Email discussion (2nd round)

## Determination of the state of Tx chains for 2Tx-2Tx switching

**FL comments:** It seems the following proposal can be acceptable by everyone. Please refrain from any further comments.

**Proposal 1:**

* For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, introduce a new RRC parameter to configure between 1) and 2)
  + 1) The state of Tx chains supporting 2Tx transmission on the carrier is assumed.
  + 2) 1Tx on carrier 1 and 1Tx on carrier 2 is assumed.

## Differentiation between 1Tx-2Tx switching and 2Tx-2Tx switching

**FL comments:** It seems companies still have different understandings. From my understanding, the main difference between option 1 and option 2 is that some of the information can be implicitly derived from the existing RRC parameters for option 1. It has no impact on the effective non-codebook operation. Regarding UE implementation on using 1Tx or 2Tx, it does not mean the state of chain for Tx switching, while it means UE can use 1Tx or 2Tx for 1 layer transmission based on implementation. From my perspective, for option 2, the details should be clarified as commented by vivo and Huawei.

**Companies are encouraged to provide details of option 2.**

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| **Company** | **Views** |
| OPPO | We think Option 2 is a clean solution. In fact, there is a sub-bullet “*If any of the above SRS resources is configured with usage “noncodebook”, then the max number of 2 antenna ports are counted for the SRS resources during the determination of operation mode*.” In Option 1. It means in Option 2, 2 ports are always assumed for non-codebook PUSCH. If Huawei/vivo wants to keep the flexibility, we can also add the corresponding restriction in Option 2. |
| ZTE | It seems that companies may misunderstand the intention of this proposal. At the very beginning, since the Tx switching delay may be different between 1Tx-2Tx switching (where only 1 antenna can be switched between two carriers) and 2Tx-2Tx switching (where two antennas can be switched between two or three carriers), one method is needed to indicate the switching delay. Option1 is based on the SRS configuration and requires complicated mechanism to imply the switching delay. However, Option2 tries to introduce a new RRC parameter to indicate the switching delay, which is a clean solution.  In fact, Option 2 doesn’t imply any restriction on non-codebook operation of UL Tx switching as long as UE can perform the switching mechanism according to the tables we discussed in previous RAN1 meetings and finish Tx switching within the due switching delay.  Specification doesn’t have any restriction on the application of non-codebook transmission together with UL Tx switching since Rel-16. The same principle can be used for Rel-17 UL Tx switching.  We suggest the following proposal.  ***Proposal:***   * *For a UE configured with UL Tx switching via uplinkTxSwitching, a new RRC parameter is used to indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.*   *Note: This RRC parameter is used to differentiate the table (mapping between UL transmission ports and Tx chain) and switching delay for 1Tx-2Tx vs 2Tx-2Tx for UE, and it doesn’t imply any restriction on application of non-codebook transmission together with UL Tx switching.*  We hope the proponents of Option1 can address our concerns of Option1 as we mentioned in the 1st round of discussion. |
| Huawei, HiSilicon | In response to ZTE’s comment, could you please elaborate your potential timeline issue between SP-SRS and UL Tx switching? We don’t see an issue based on your comments. If it were an issue, how comes a new RRC parameter can resolve it?  Regarding your comments “*The UE should be able to perform 1Tx-2Tx switching under the gNB which only supports 1Tx-2Tx operation e.g. Rel-16 gNB or Rel-17 gNB supporting only 1Tx-2Tx operation. Option1 always assumes 2Tx-2Tx operation for non-codebook based transmission.*”, it is clear that a gNB will not configure non-codebook/codebook on the first carrier to a UE if the gNB only supports 1Tx-2Tx. Therefore, it is not ture that Option 1 always assumes 2Tx-2Tx operation for this case.  Regarding your comment that UE implementation should be restricted with 1Tx only for non-codebook UL MIMO, we disagree as explained before.  Since no response to our previous comment, we have to repeat our comment here again “a new RRC parameter can conflict with existing RRC parameters, a clarification like Option 1 is inevitable.” From this perspective, Option 2 requires a consensus on Option 1 first.    In response to QC’s comment that “We recall we had similar discussion on how to handle TxD in Rel-16 when we reached some consensus that TxD is not supported together with UL Tx switching. As TxD is still ongoing, we would suggest making the conclusion that TxD is not supported together with UL Tx switching.”, your comment is not in line with existing RAN1 agreements, where TxD is up to UE implementation since Rel-15.  From this perspective, Option 2 is not in line with the RAN1 agreement about TxD. |
| Qualcomm | We share similar views as FL on the 1Tx or 2Tx for single layer transmission, which should be an implementation issue.  In response to vivo and Huawei, when one carrier only has one Tx, UE can only transmit with 1 port, which is **not** the difference between above two options. Per our understanding, the two above modes only matter the switching time.  To make progress, we propose to add following sub-bullet. Hope it can resolve the concern.   * Option 2: For a UE configured with UL Tx switching via *uplinkTxSwitching*, a new RRC parameter is used to indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.   + 1Tx-2Tx mode is not expected to be configured where the assumed 1Tx CC is also configured with non-codebook based MIMO |
| vivo | Thanks for the discussion and clarifications!  We understand the main intention of the RRC configuration (a introduced in Option 2) is to clearly determine the switching time that gNB and UE assumes. However, the switching state table between 1Tx-2Tx and 2Tx-2Tx are also different, for example, UL non-codebook transmission on CC1 is possible if 2Tx-2Tx table is selected, while it is not possible for 1Tx-2Tx table if UE uses 2Tx for UL non-codebook transmission by implementation. To address the concern, we think the sub-bullets proposed ZTE and QC are both meaningful so it would be good to put them together under Option 2 for better clarity. And in this case, the Option 1 and updated Option 2 becomes equivalent, the only difference is whether explicit RRC configuration or implicit rule is used to align between gNB and UE. We would be fine with either way.   * Updated Option 2: For a UE configured with UL Tx switching via *uplinkTxSwitching*, a new RRC parameter is used to indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.   + 1Tx-2Tx mode is not expected to be configured where the assumed 1Tx CC is also configured with non-codebook based MIMO   + *Note: This RRC parameter is used to differentiate the table (mapping between UL transmission ports and Tx chain) and switching delay for 1Tx-2Tx vs 2Tx-2Tx for UE, and it doesn’t imply any restriction on application of non-codebook transmission together with UL Tx switching.* |

## 1-port transmission via DCI format 0\_1 for UL CA option 2

**FL comments:** Can we take the following as a conclusion?

**Proposal 2:**

**Conclusion:**

* For Rel-17 Tx switching between Band A and Band B, no additional specification impact to support 1-port transmission via DCI format 0\_1 for UL CA option 2 when maximum *nrofSRS-Ports* among the carriers on Band B is configured as 2 antenna ports and the state of Tx chains is 1 Tx on Band A and 1Tx on Band B.

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| **Company** | **Views** |
| ZTE | We support the above conclusion. |
| Huawei, HiSilicon | Since the discussion has last more than 16 months, we don’t prefer any further discussion. As a compromise, we can accept  **Conclusion:**   * For Rel-17 Tx switching between Band A and Band B, no additional specification impact to support 1-port transmission via DCI format 0\_1 for UL CA option 2 ~~when maximum~~*~~nrofSRS-Ports~~*~~among the carriers on Band B is configured as 2 antenna ports and the state of Tx chains is 1 Tx on Band A and 1Tx on Band B~~.   If it is not acceptable, we request a conclusion to say no consensus on this issue or no consensus to further discuss it, which pretty reflects the real RAN1 situation. |
| Qualcomm | We support FL’s proposal. |

## Back-to-back switching with SRS switching

**FL comments:** Continue discussion.

**Option 1:**

* When SRS carrier switching is configured, a maximum of 3 switches (2 for SRS and 1 for UL Tx switching) are supported in 14 consecutive symbols corresponding to the SCS of SRS.

Note: it is applicable to both Rel-16 UL Tx switching and Rel-17 UL Tx switching.

**Option 2:**

* 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.

Note: it is applicable to both Rel-16 UL Tx switching and Rel-17 UL Tx switching.

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| **Company** | **Views** |
| Huawei, HiSilicon | @QC, just remind that your two concerns had been replied last meeting, which can be found in summary R1-2108643, and also copied below.  “regarding your question on new RRC IE/switching capability, our response has been provided in the previous round, as copied below, please have a check. We guess that all potential switching gaps in your mind are smaller than the sum.  “*For the gap, we feel it is the sum of two gaps, so new capability is not needed. With this size of gap, it is up to UE implementation to have two steps of switchings. Do you need any different value of gap for it?*”  Regarding your follow-up comment on “the size of gap”, it is not optimized in term of gap size, but its benefits are 1) relief the burden of UE implementation 2) No need of new UE capability, the sum value is large sufficient to let UEs choose the best implementation, either direct switching or two-step switching;”  @ZTE, regarding your first comment about NBC issue, our proposal is only to require a modest stringent timeline for gNB scheduling, from our perspective, it is OK. Regarding your second comment about the remaining issue last meeting, we had replied it last meeting, in summary R1-2108643, as copied below,  “ in your figure, there are four switchings, CC1 to CC2 for SRS, then CC2 to CC3 for SRS, then CC3 to CC2 then to CC1 for PUSCH. This case illustrated in the figure is precluded by proposal 8. We feel it is popular scheduling scheme in a network. Do you prefer to preclude it?.” |
| Qualcomm | We support Option 1.  Based on the input of first round, our feeling is Option 2 still has some technical issues (e.g. UE capability, and etc.), but Option 1 is technically correct. In this case, we would kindly ask the group to approve Option 1 to make progress.  Furthermore, we think the note in both of the options is not necessary as the issue only happens when SRS carrier switching and UL Tx switching are configured within a short time period. As SRS carrier switching together UL Tx switching is with little possibility to be specified in Rel-16, adding this to Rel-16 might cause unnecessary burden to editors and specification readers.  In response to Huawei’s 1st round input on switching time, we copied our response in last meeting “*The point is that the switching time capability is indicated for a given pair of cells and it is not transitive. If the UE indicated it needs a certain gap duration to switch between a pair of cells for a particular purpose, it cannot be assumed that the UE needs the same gap duration to switch between a different pair of cells or for a different purpose.”.* If UE is required to perform this new direct switch, switching time should be checked per band combination and likely need to be reported along with the direct switching capability.  On the capability response from Huawei - “*For example, if the switching time from CC3 to CC1 is the sum of two reported switching gaps, UE can choose the best implementation, either direct switching or two-step switching.*”. Our understanding is the current switching behaviour (a.k.a. two-step switching) would likely remain as direct switching may or may not be supported by UE.  With all the respect, given Option 1 is technical correct, we want to kindly ask a question, if UE remains the same switching behaviour but need to introduce a new switching time, why we need Option 2? |
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## CA based SRS carrier switching

**FL comments:** From my understanding, currently the way we can go is to agree the following TP (only one company has concern) or hold on the discussion.

**Proposal 3:** Adopt the following TP to TS 38.214.

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| **<Unchanged parts are omitted – 38.214>**  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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| **Company** | **Views** |
| ZTE | OK |
| Huawei, HiSilicon | Support |
| Qualcomm | We have to rise our concern again as the above CR can NOT provide a complete solution.  We support to solve this issue and actually we were the 1st company to rise this issue in RAN1.  However, we have concern to only approve the above CR without others. In which case, some technical issues remain and no way to implement these combined features. The technical concerns were brought for several times. For example, if C3 is configured with UCI, it should be with higher priority than SRS of C1. We can’t find this statement in the current specification.  Again, we are willing to discuss and solve this issue with a **complete solution**. We are fine with either alternative in the Rel-17 time frame:   * Alternative 1: wait for SRS CR discussion and then make further discussion based on the outcome of SRS CR discussion. * Alternative 2: discuss and try to solve the issue without waiting for SRS CR discussion. The above proposal could be starting point. |

## TP

**FL comments:** Regarding the TP for uplink switching between two bands, it seems no concern has been raised for SUL. For UL CA, considering it’s controversial, let’s leave it to Editor how to capture the agreements.

**Proposal 4:** Adopt the following TP to TS 38.214.

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| **<Unchanged parts are omitted – 38.214>**  6.1.6.2 Uplink switching for supplementary uplink  For a UE indicating a capability for uplink switching with *BandCombination-UplinkTxSwitch* for a band combination, and if it is for that band combination configured in a serving cell with two uplink carriers with higher layer parameter *supplementaryUplink*:  - If the UE is configured with uplink switching with parameter *uplinkTxSwitching*,  - If the UE is to transmit any uplink channel or signal on a different uplink on a different band from the preceding transmission occasion based on DCI(s) received before or based on a higher layer configuration(s), then the UE assumes that an uplink switching is triggered in a duration of switching gap , where is the start time of the first symbol of the transmission occasion of the uplink channel or signal and is the preparation procedure time of the transmission occasion of the uplink channel or signal given in clause 5.3, clause 5.4, clause 6.2.1, clause 6.4 and in clause 9 of [6, TS 38.213], respectively. During the switching gap , the UE is not expected to transmit on any of the two uplinks.  - In all other cases the UE is expected to transmit normally all uplink transmissions without interruptions.  **<Unchanged parts are omitted – 38.214>** |

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| **Company** | **Views** |
| OPPO | Support |
| ZTE | Regarding the TP for SUL, we think the situation is the same as UL CA.  1) The 2Tx-2Tx is newly added for SUL in Rel-17, maybe a RRC parameter is needed to differentiate 1Tx-2Tx and 2Tx-2Tx. The current TP looks confusing since the Rel-16 UL Tx switching and Rel-17 UL Tx switching is not well differentiated.  2) The switching delay for 1Tx-2Tx and 2Tx-2Tx may be different, the current TP doesn’t reflect this.  Another issue is that, the current TP only mentions two uplinks, it is not clear whether the 3-carrier case is covered or not.  Overall, we think more discussion is needed (e.g., RRC parameters, UE capabilities) before finalizing the detailed TP. |
| Huawei, HiSilicon | In response to ZTE, the TP for SUL has been discussed for multiple meetings, we never received any reasoning why a new RRC parameter is needed and why the TP cannot cover both Rel-16 and Rel-17 UE behaviours.  Since it has been discussed for long time, we are afraid that “maybe” and “may” is not a valid argument. We don’t see any concrete issue for it.  The change in the TP is surely motivated only by the intra-band Band B case. The current spec is describing a UE behaviour between two uplinks associated with UL Tx switching, the two uplinks can be any two uplinks among the three uplinks in the intra-band Band B case. To capture the agreement for Band B case, only clarification of different B is needed, as the proposed TP.  We really don’t see any technical reason to delay the progress. |
| Qualcomm | Sorry, we do have concern on the above proposal.  We provided our views in first round already as “*Differentiation of Rel-16 and Rel-17 capabilities. Given Rel-17 allows 2 Tx on both carriers/bands, we think it would be helpful to differentiate Rel-16 and Rel-17 switching capabilities. Furthermore,* ***the differentiation should be implemented to both SUL and CA****, as Rel-17 introduces new switching capabilities like 2Tx-2Tx, 3 carriers for intra-band CA, and etc*.”  We want kindly ask proponent one question, with above wording, how a Rel-16 only capable UE behaves if there is a 2-port scheduling on SUL carrier? Isn’t it an error case?  In general, we think we should make consensus on some basic principles before deep diving into the TPs. |
| Huawei, HiSilicon | In response to Qualcomm, could you please provide a TP for SUL and show what could be the additional text change in addition to adding redundant new RRC parameters? We don’t see any additional text needed. |

# Email discussion (3rd round)

## Differentiation between 1Tx-2Tx switching and 2Tx-2Tx switching

**FL comments:** Based on the agreements, we need to make down selection on the following two options. After 2 rounds of discussion, from my understanding, as long as the issues are addressed, either option can work properly. Finally the only difference would be whether to reuse existing RRC parameter or introduce a new RRC parameter. Option 2 is updated based on the comments.

**Option 1:**

* For a UE configured with UL Tx switching via *uplinkTxSwitching*, the maximum number of antenna ports among all configured P-SRS/A-SRS and activated SP-SRS resources is used to determine the operation mode, i.e. either 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.
* 2Tx-2Tx switching mode: when the maximum number is 2 for all uplinks configured with *uplinkTxSwitching*
* 1Tx-2Tx switching mode: when the maximum number is 1 for any one uplink configured with *uplinkTxSwitching*
* the switching gap duration for a triggered uplink switching is equal to the switching time capability value reported for the switching mode
  + Note: If the switching time capability value for 1Tx-2Tx switching mode is not reported by the UE, the value reported for 2Tx-2Tx switching mode is applied.
* If any of the above SRS resources is configured with usage “noncodebook”, then the max number of 2 antenna ports are counted for the SRS resources during the determination of operation mode.
  + FFS how to determine the number of antenna ports for SRS resources.

**Option 2:**

* For a UE configured with UL Tx switching via *uplinkTxSwitching*, a new RRC parameter is used to indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.
* Note 1: gNB would not configure 1Tx-2Tx mode where the assumed 1Tx CC is also configured with non-codebook based MIMO.
* Note 2: The new RRC configuration would not conflict with other active RRC configurations on Tx states.
* Note 3: This RRC parameter is used to differentiate the table (mapping between UL transmission ports and Tx chain) and switching delay for 1Tx-2Tx vs 2Tx-2Tx for UE, and it doesn’t imply any restriction on application of non-codebook transmission together with UL Tx switching.

Any further comments?

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| **Company** | **Views** |
| Huawei, HiSilicon | Our question in previous round seems not answered yet.  Additionally, it is unclear in Note2 of Option 2 that what active RRC configuration is involved and how to determine a conflict. As commented before, it is inevitable to have the similar text as Option1 to clarify Note2.  This redundant RRC parameter only increases signaling overhead and possible conflicts.  Therefore, Option 2 is far from good enough. |
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## 1-port transmission via DCI format 0\_1 for UL CA option 2

**FL comments:** As most companies are fine with the following proposed conclusion, I would like to check again if it acceptable.

**Proposal 2:**

**Conclusion:**

* For Rel-17 Tx switching between Band A and Band B, no additional specification impact to support 1-port transmission via DCI format 0\_1 for UL CA option 2 when maximum *nrofSRS-Ports* among the carriers on Band B is configured as 2 antenna ports and the state of Tx chains is 1 Tx on Band A and 1Tx on Band B.

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| **Company** | **Views** |
| Huawei, HiSilicon | As commented before, the when sub-clause is redundant and unnecessary, our comment does not receive any reply.  Therefore, the proposal can be revised as,  **Proposal 2-rev:**  **Conclusion:**  For Rel-17 Tx switching between Band A and Band B, no additional specification impact to support 1-port transmission via DCI format 0\_1 for UL CA option 2 ~~when maximum~~*~~nrofSRS-Ports~~*~~among the carriers on Band B is configured as 2 antenna ports and the state of Tx chains is 1 Tx on Band A and 1Tx on Band B~~. |
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# Agreements at RAN1#106-e

**Agreements:**

* **For SUL and UL CA option 1, if 1Tx-2Tx UL Tx switching or 2Tx-2Tx UL Tx switching between 1 carrier on band A and 2 carriers on band B is configured, the switching period is only applicable when the UL transmissions are switched between band A and band B.**

**Agreements:**

* **For inter-band UL CA, if 1Tx-2Tx UL Tx switching between 1 carrier on band A and 2 carriers on band B is configured is configured:**
* **For option 2 of mapping between UL transmission ports and Tx chain**
  + **The switching period is only applicable in the following cases:**
    - **If the current state of Tx chains is 1 Tx on band A and 1Tx on band B, the next UL transmission has a 2-port transmission on at least one carrier on band B.**
    - **If the current state of Tx chains is 0 Tx on band A and 2Tx on band B, the next UL transmission has a 1-port transmission on the carrier on band A.**
  + **For other cases, the state of Tx chains of last UL transmission is assumed.**

**Agreements:**

* **For inter-band UL CA, if 2Tx-2Tx UL Tx switching between 1 carrier on band A and 2 carriers on band B is configured:**
* **For option 2 of mapping between UL transmission ports and Tx chain**
  + **The switching period is only applicable in the following cases:**
    - **If the current state of Tx chains is 1Tx on band A and 1Tx on band B, the next UL transmission has a 2-port transmission on the carrier on band A or at least one carrier on band B.**
    - **If the current state of Tx chains is 0Tx on band A and 2Tx on band B, the next UL transmission has a 1-port or 2-port transmission on the carrier on band A.**
    - **If the current state of Tx chains is 2Tx on band A and 0Tx on band B, the next UL transmission has a 1-port or 2-port transmission on at least one carrier on band B.**
  + **For other cases, the state of Tx chains of last UL transmission is assumed.**

**Agreements: Down select one of the following options in RAN1#106b-e:**

* **Option 1:** For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, then
  + 1Tx on carrier 1 and 1Tx on carrier 2 is assumed if the carrier is configured with *uplinkTxSwitchingPeriodLocation* as true.
  + the state of Tx chains supporting 2Tx transmission is assumed on the carrier if the carrier is configured with *uplinkTxSwitchingPeriodLocation* as false.
* **Option 2:** For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, then the state of Tx chains supporting 2Tx transmission on the carrier is assumed.
* **Option 3:** For UL-CA Option2, if UL Tx switching is triggered for 1-port transmission on a carrier and the state of Tx chains after the UL Tx switching is not unique, then 1Tx on carrier 1 and 1Tx on carrier 2 is assumed.

**Agreements: Down select one of the following options in RAN1 #106bis-e**

**Option 1:**

* **For a UE configured with UL Tx switching via *uplinkTxSwitching*, the maximum number of antenna ports among all configured P-SRS/A-SRS and activated SP-SRS resources is used to determine the operation mode, i.e. either 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.**
* **2Tx-2Tx switching mode: when the maximum number is 2 for all uplinks configured with *uplinkTxSwitching***
* **1Tx-2Tx switching mode: when the maximum number is 1 for any one uplink configured with *uplinkTxSwitching***
* **the switching gap duration for a triggered uplink switching is equal to the switching time capability value reported for the switching mode**
  + **Note: If the switching time capability value for 1Tx-2Tx switching mode is not reported by the UE, the value reported for 2Tx-2Tx switching mode is applied.**
* **If any of the above SRS resources is configured with usage “noncodebook”, then the max number of 2 antenna ports are counted for the SRS resources during the determination of operation mode.**
  + **FFS how to determine the number of antenna ports for SRS resources.**

**Option 2:**

* **For a UE configured with UL Tx switching via *uplinkTxSwitching*, a new RRC parameter is used to indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.**

# Agreements at RAN1#105-e

**Agreements:**

* For a UE configured with higher layer parameter *supplementaryUplink* and with 2Tx-2Tx UL Tx switching between two uplink carriers, the mechanism of uplink switching specified in S6.1.6.3 of TS 38.214 is reused.

**Agreements:**

* For a UE configured with UL CA Option 1 and with 2Tx-2Tx UL Tx switching between two uplink carriers, the mechanism of uplink switching specified in S6.1.6.2 of TS 38.214 is reused with the following add-on.
* When the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission is a 2-port transmission on another uplink carrier, then the UE is not expected to transmit for the duration of NTx1-Tx2 on any of the two carriers.

**Agreements:**

* For inter-band UL CA, if 2Tx-2Tx UL Tx switching between two uplink carriers is configured:
* For option 2 of mapping between UL transmission ports and Tx chain
  + The switching period is only applicable in the following cases:
    - If the current state of Tx chains is 1Tx on carrier 1 and 1Tx on carrier 2, the next UL transmission has a 2-port transmission on either carrier 1 or carrier 2.
    - If the current state of Tx chains is 0Tx on carrier 1 and 2Tx on carrier 2, the next UL transmission has a 1-port or 2-port transmission on carrier 1.
    - If the current state of Tx chains is 2Tx on carrier 1 and 0Tx on carrier 2, the next UL transmission has a 1-port or 2-port transmission on carrier 2.
  + For other cases, the state of Tx chains of last UL transmission is assumed.
* Note: For SUL, UL CA option 1 and UL CA option 2, in RAN1 understanding, no spec change to power configuration and power control.

**Agreement:**

* For a UE configured with 2Tx-2Tx UL Tx switching between two uplink carriers and configured with UL CA Option 2, if the state of Tx chains after UL Tx switching is not unique, a rule to determine the state of Tx chains after Tx switching is to be specified.
  + FFS: The state of Tx chains with the most of Tx chains on the most important uplink carrier is assumed, e.g. the carrier with *uplinkTxSwitchingPeriodLocation* configured as false.

# Agreements at RAN1#104b-e

**Agreements:**

* **For Rel-17 2Tx-2Tx switching between two uplink carriers, the mapping between UL transmission ports and Tx chain for SUL and UL CA Option 1 is defined as follows.**

|  |  |  |
| --- | --- | --- |
|  | Number of **Tx chains** in WID (carrier 1 + carrier 2) | Number of **antenna ports** for UL transmission (carrier 1 + carrier 2) |
| Case 2 | 0T+2T | 0P+2P, 0P+1P |
| Case 3 | 2T+0T | 2P+0P, 1P+0P |

**Agreements:**

* **For Rel-17 2Tx-2Tx switching between two uplink carriers, the mapping between UL transmission ports and Tx chain for UL CA Option 2 is defined as follows.**

|  |  |  |
| --- | --- | --- |
|  | Number of **Tx chains** in WID (carrier 1 + carrier 2) | Number of **antenna ports** for UL transmission (carrier 1 + carrier 2) |
| Case 1 | 1T+1T | 1P+0P, 1P+1P, 0P+1P |
| Case 2 | 0T+2T | 0P+2P, 0P+1P |
| Case 3 | 2T+0T | 2P+0P, 1P+0P |

**Conclusion:**

* For uplink Tx switching between 1 carrier on Band A and 2 contiguous carriers on Band B,
  + If the state of Tx chains is 1Tx on Band A and 1Tx on Band B, 1Tx is available simultaneously on both uplink carriers on band B for a UE.
  + If the state of Tx chains is 0Tx on Band A and 2Tx on Band B, 2Tx are available simultaneously on both uplink carriers on band B for a UE.

**Agreement:**

* Send LS to RAN4 asking following question:
  + Question: For UL Tx switching in a band pair of a band combination, whether or not the switching time reported by a UE for 2Tx-2Tx switching can be different from that reported by the UE for 1Tx-2Tx switching.

**Agreement:**

For Rel-17 1Tx-2Tx switching between 1 carrier on Band A and 2 contiguous carriers on Band B, the mapping between UL transmission ports and Tx chain for SUL and UL CA Option 1 is defined as follows.

|  |  |  |
| --- | --- | --- |
|  | Number of **Tx chains** in WID (band A + band B) | Number of **antenna ports** for UL transmission (band A (carrier 1) + band B (carrier 2 + carrier 3)) |
| Case 1 | 1T+1T | 1P+(0P+0P) |
| Case 2 | 0T+2T | 0P+(2P+0P), 0P+(0P+2P), 0P+(2P+2P), 0P+(1P+0P), 0P+(0P+1P), 0P+(1P+1P), 0P+(1P+2P), 0P+(2P+1P) |

**Agreement:**

For Rel-17 2Tx-2Tx switching between 1 carrier on Band A and 2 contiguous carriers on Band B, the mapping between UL transmission ports and Tx chain for SUL and UL CA Option 1 is defined as follows.

|  |  |  |
| --- | --- | --- |
|  | Number of **Tx chains** in WID (band A + band B) | Number of **antenna ports** for UL transmission (band A (carrier 1) + band B (carrier 2 + carrier 3)) |
| Case 2 | 0T+2T | 0P+(2P+0P), 0P+(0P+2P), 0P+(2P+2P), 0P+(1P+0P), 0P+(0P+1P), 0P+(1P+1P), 0P+(1P+2P), 0P+(2P+1P) |
| Case 3 | 2T+0T | 2P+(0P+0P), 1P+(0P+0P) |

**Agreement:**

For Rel-17 1Tx-2Tx switching between 1 carrier on Band A and 2 contiguous carriers on Band B, the mapping between UL transmission ports and Tx chain for UL CA Option 2 is defined as follows.

|  |  |  |
| --- | --- | --- |
|  | Number of **Tx chains** in WID (band A + band B) | Number of **antenna ports** for UL transmission (band A (carrier 1) + band B (carrier 2 + carrier 3)) |
| Case 1 | 1T+1T | 1P+(0P+0P), 1P+(1P+0P), 1P+(0P+1P), 1P+(1P+1P), 0P+(1P+0P), 0P+(0P+1P), 0P+(1P+1P) |
| Case 2 | 0T+2T | 0P+(2P+0P), 0P+(0P+2P), 0P+(2P+2P), 0P+(1P+0P), 0P+(0P+1P), 0P+(1P+1P), 0P+(1P+2P), 0P+(2P+1P) |

**Agreement:**

For Rel-17 2Tx-2Tx switching between 1 carrier on Band A and 2 contiguous carriers on Band B, the mapping between UL transmission ports and Tx chain for UL CA Option 2 is defined as follows.

|  |  |  |
| --- | --- | --- |
|  | Number of **Tx chains** in WID (band A + band B) | Number of **antenna ports** for UL transmission (band A (carrier 1) + band B (carrier 2 + carrier 3)) |
| Case 1 | 1T+1T | 1P+(0P+0P), 1P+(1P+0P), 1P+(0P+1P), 1P+(1P+1P), 0P+(1P+0P), 0P+(0P+1P), 0P+(1P+1P) |
| Case 2 | 0T+2T | 0P+(2P+0P), 0P+(0P+2P), 0P+(2P+2P), 0P+(1P+0P), 0P+(0P+1P), 0P+(1P+1P), 0P+(1P+2P), 0P+(2P+1P) |
| Case 3 | 2T+0T | 2P+(0P+0P), 1P+(0P+0P) |

**Conclusion:**

* For uplink Tx switching between 1 carrier on Band A and 2 contiguous carriers on Band B, whether Tx switching between 2Tx on Band A and 1Tx on Band A+1Tx on Band B for UL CA option 1 and SUL is included in WID could be clarified by RAN plenary or RAN4.

# References

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