3GPP TSG RAN WG1 #108-e R1-22xxxxx

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

**Agenda item: 5.1**

**Source: Moderator (China Telecom)**

**Title: [108-e-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

|  |  |
| --- | --- |
|  | **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

|  |  |
| --- | --- |
|  | **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

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

and

|  |  |
| --- | --- |
|  | **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

|  |  |
| --- | --- |
|  | **Number of Tx chains in WID (band A + band B)** |
| 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

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.

Editors’ CR on introduction of Rel-17 uplink Tx switching has been approved in RAN#94e [3]. This contribution is a summary of the following email discussion:

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

* 1st check point: February 25
* Final check point: March 3

# Email discussion

## RRC parameters

**FL comments:** As per Chair’s guidance, RAN1 will send the updated RRC parameters to RAN2 at the end of Week 1. Therefore, we have to finalize all issues relevant to RRC parameters as early as possible.

## 1st round (deadline: UTC 9:00am 22nd February)

In RAN1#107-e, the new RRC parameter to indicate the state of chains for UL CA option 2 was included in the agreed LS to RAN2 [4].

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **WI code** | **Sub-feature group** | **Parameter name in the spec** | **New or existing?** | **Description** | **Value range** | **Default value aspect** | **UE-specific or Cell-specific** | **Comment** |
| NR\_RF\_FR1\_enh-Core | Uplink Tx switching enhancements | *uplinkTxSwitchingdualULTxState* | new | For UL-CA option 2 and 2Tx-2Tx switching, indicate the state of chain if the state of Tx chains after the UL Tx switching is not unique. | [{1T, 2T}] | [2T] | UE-specific | **Agreement:**   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. |

In RAN2#116b-e, RAN2 discussed the running CR for this RRC parameter in [6].

|  |
| --- |
| uplinkTxSwitching-DualUL-TxState-r17 ENUMERATED {oneT, twoT} OPTIONAL -- Cond 2Tx |
| ***uplinkTxSwitching-DualUL-TxState***  Indicates which state of Tx chains is assumed after the UL Tx switching triggered by 1-port transmission on a carrier as specified in TS 38.214 [19] in case of 2Tx-2Tx switching is configured and *uplinkTxSwitchingOption* is set to *dualUL*. Value *oneT* indicates 1Tx is assumed to be supported on the carriers on each band, value *twoT* indicates 2Tx is assumed to be supported on that carrier. |

**FL comments:** Although there are some square brackets for the value range and default value for this RRC parameter, RAN2 has clearly captured this RRC parameter in the running CR. It seems no further update is needed for this RRC parameter from RAN1 perspective. Any comments?

|  |  |
| --- | --- |
| **Company** | **Comments** |
| New H3C | We agree with FL’s view on no further updated is needed. |
|  |  |
|  |  |

In RAN1#107-e, it was agreed to introduce a new RRC parameter to indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode. Due to lack of time, it was not included in the agreed LS to RAN2 in [4]. It was summarized in [5] for further discussion.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **WI code** | **Sub-feature group** | **Parameter name in the spec** | **New or existing?** | **Description** | **Value range** | **Default value aspect** | **UE-specific or Cell-specific** | **Comment** |
| NR\_RF\_FR1\_enh-Core | Uplink Tx switching enhancements | *uplinkTxSwitching-2T-Mode* | new | For a UE capable of 2Tx-2Tx switching and configured with *uplinkTxSwitching*, indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode in which the switching gap duration for a triggered uplink switching [xx 38.214] is equal to the switching time capability value reported for the switching mode. If 1Tx-2Tx mode is derived by the RRC parameter, then there is one uplink (or one uplink band in case of intra-band) configured with *uplinkTxSwitching*, on which the maximum number of antenna ports among all configured P-SRS/A-SRS and activated SP-SRS resources should be 1 and non-codebook based UL MIMO is not configured. |  |  | UE-specific | **Agreement:**   For a UE capable of 2Tx-2Tx switching and configured with UL Tx switching via uplinkTxSwitching, to differentiate the switching delay for 1Tx-2Tx switching from that for 2Tx-2Tx switching, a new RRC parameter is used to indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.  ‐ If 1Tx-2Tx mode is derived by the new RRC parameter, then there is on one uplink (or one uplink band in case of intra-band) configured with uplinkTxSwitching, on which the maximum number of antenna ports among all configured P-SRS/A-SRS and activated SP-SRS resources should be 1 and non-codebook based UL MIMO is not configured. RAN1 assume the uplink is configured with RRC parameter “carrier1” by RAN2.  ‐ The default value of the new RRC parameter is 1Tx-2Tx switching mode.  ‐ In a configured switching mode, the switching gap duration for a triggered uplink switching is equal to the switching time capability value reported for the switching mode.  ‐ Note: This RRC parameter doesn’t imply any restriction on application of non-codebook transmission together with UL Tx switching. |

In RAN2#116b-e, RAN2 discussed the running CR for this RRC parameter in [6].

|  |
| --- |
| uplinkTxSwitching-2T-Mode-r17 ENUMERATED {enabled} OPTIONAL, -- Cond 2Tx |
| ***uplinkTxSwitching-2T-Mode***  Indicates 2Tx-2Tx UL Tx switching is configured for inter-band UL CA or SUL as specified in TS 38.214 [19].  If this field is absent and *uplinkTxSwitching* is configured, it is interpreted that 1Tx-2Tx UL Tx switching is configured as specified in TS 38.214 [19]. In this case, on the carrier configured with *uplinkTxSwitching* and with *uplinkTxSwitchingCarrier* set to *carrier1* the maximum number of antenna ports among all configured P-SRS/A-SRS and activated SP-SRS resources should be 1 and non-codebook based UL MIMO is not configured. |

**FL comments:** Since RAN2 has discussed this RRC parameter in the running CR, we can align the name and description of the RRC parameter. Companies are encouraged to provide views on the above RRC parameter.

|  |  |
| --- | --- |
| **Company** | **Comments** |
|  |  |
|  |  |
|  |  |

## CA based SRS carrier switching

## 1st round (deadline: UTC 23:59 22nd February)

[11] has the following proposal:

To specify SRS carrier switch together with UL Tx switch in Rel-17, we prefer Alternative 1 but ok with Alternative 2 if this is majority view:

* 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 below proposals could be starting point.
  + 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.
  + 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.
  + 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.

[12] proposes to adopt the following TP for uplink suspension of SRS carrier switching in TS 38.214 clause 6.2.1.3.

|  |
| --- |
| **<Unchanged parts are omitted – 38.214>** 6.2.1.3 UE sounding procedure between component carriers A UE can be configured with SRS resource(s) on a carrier *c1* with slot formats comprised of DL and UL symbols and not configured for PUSCH/PUCCH transmission. For carrier *c1*, the UE is configured with higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier* the switching from carrier *c2* which is configured for PUSCH/PUCCH transmission. During SRS transmission on carrier *c1* (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR*), the UE temporarily suspends the uplink transmission on carrier *c2*, and also the uplink transmission on carrier *c3* if the UE is configured with *uplinkTxSwitching-r16* for uplink switching between uplink carrier *c2* and *c3*.  **<Unchanged parts are omitted – 38.214>** |

[12] proposes to adopt the following TP for prioritization rules of SRS carrier switching in TS 38.214 clause 6.2.1.3.

|  |
| --- |
| **<Unchanged parts are omitted – 38.214>** 6.2.1.3 UE sounding procedure between component carriers For a carrier of a serving cell *d* with slot formats comprised of DL and UL symbols, not configured for PUSCH/PUCCH transmission, denote as the corresponding carrier of a serving cell whose UL transmissions are temporarily suspended as signalled by higher layer parameter *srs-SwitchFromServCellIndex* and *srs-SwitchFromCarrier*. Define the set as the set of carriers of serving cells that each carrier meets one of the following conditions:  - is in the same band as , or and are both configured with *uplinkTxSwitching-r16*.  - is in the same TAG as .  where .  **<Unchanged parts are omitted – 38.214>**  For an SRS transmission starting in symbol of carrier and a conflicting transmission in carrier starting in symbol, where , the UE shall apply the prioritization / dropping rules in the remainder of this clause taking into account:  - DCI(s) for which the time interval between the last symbol of PDCCH and is at leastsymbols and an additional time duration , and the time interval between the last symbol of PDCCH and is at least symbols*;* and  - semi-persistent CSI reports or SRS considered active at least symbols and an additional time duration before , and considered active at least symbols before .  where , and the time interval unit of OFDM symbol is counted based on the smaller subcarrier spacing across and their corresponding scheduling cells.  The following prioritization rules shall be applied in case of collision between a transmission of SRS over carrier and transmission of a physical signal/channel over a carrier of a serving cell in set :  - the UE shall not transmit SRS whenever SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the carrier of the serving cell and PUSCH/PUCCH transmission carrying HARQ-ACK/positive SR/RI/CRI/SSBRI and/or PRACH on a carrier of a serving cell in set happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].  - the UE shall not transmit a periodic/semi-persistent SRS whenever periodic/semi-persistent SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the carrier of the serving cell and PUSCH transmission carrying aperiodic CSI on a carrier of a serving cell in set happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].  - the UE shall drop PUCCH/PUSCH transmission carrying periodic/semi-persistent CSI comprising only CQI/PMI/L1-RSRP/L1-SINR, and/or SRS transmission on a carrier of a serving cell in set configured for PUSCH/PUCCH transmission whenever the transmission and SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the carrier of the serving cell happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].  - the UE shall drop PUSCH transmission carrying aperiodic CSI comprising only CQI/PMI/L1-RSRP/L1-SINR on a carrier of a serving cell in the set whenever the transmission and aperiodic SRS transmission (including any interruption due to uplink or downlink RF retuning time [11, TS 38.133] as defined by higher layer parameters *switchingTimeUL* and *switchingTimeDL* of *SRS-SwitchingTimeNR)* on the carrier of the serving cell happen to overlap in the same symbol and that can result in uplink transmissions beyond the UE's indicated uplink carrier aggregation capability included in [13, TS 38.306].  **<Unchanged parts are omitted – 38.214>** |

**FL comments:** This issues has been discussed for a long time. I would like to check if companies are fine to discuss this issue based on TPs proposed in [12]. Otherwise, let’s postpone this discussion after the outcome of SRS CR discussion in [108-e-NR-CRs-04].

|  |  |
| --- | --- |
| **Company** | **Comments** |
| New H3C | We would like to defer this discussion after the outcome of SRS CR discussion in [108-e-NR-CRs-04]. |
|  |  |
|  |  |

## Back-to-back switching with SRS carrier switching

## 1st round (deadline: UTC 23:59 22nd February)

[11] has the following proposal:

* 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.

[12] has the following proposal:

* 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.

Companies are encouraged to provide comments on the above proposals by [11] and [12].

|  |  |
| --- | --- |
| **Company** | **Comments** |
| New H3C | In our understanding, R17 WID can’t specifically support SRS carrier switching feature in Rel-17 TX switching.  I wonder whether we need discuss about this issue at current stage (R17 is close to the end) |
|  |  |
|  |  |

## TP for the UL Tx switching

## 1st round (deadline: UTC 23:59 22nd February)

[8] - [12] propose TPs for UL Tx switching based on [3].

**FL comments:** My suggestion is that in this round of discussion, we focus on the major issue, i.e., the structure of the TP, based on editor draft CR (Mihai’s version v4r3) in RAN1#107-e. We can discuss other issues such as how to capture the RRC parameter, UE capability related issue and wording refinement later.

|  |
| --- |
| **<Unchanged parts are omitted – 38.214>** 6.1.6 Uplink switching 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 *uplinkTxSwitchingPeriod2T2T* if *uplinkTxSwitching-2T-Mode* is configured, and *uplinkTxSwitchingPeriod* otherwise:  - If a UE indicated a capability for uplink switching with *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.  [If *uplinkTxSwitching-2T-Mode* is not configured, then there is expected to be one uplink configured with *uplinkTxSwitching* for the UE, on which the maximum number of antenna ports among all configured periodic/aperiodic SRS and activated semi-persistent SRS resources should be 1 and non-codebook based transmission is not configured.]  [For a UE indicating a capability for uplink switching with *uplinkTxSwitchingPeriod2T2T* in *BandCombination-UplinkTxSwitch* for a band combination, the *maxNumberMIMO-LayersCB-PUSCH* of each band is expected to be greater than *oneLayer* in that band combination.]  If an uplink switching is triggered for an uplink transmission starting at *T0*, after *T0-Toffset*, the UE is not expected to cancel the uplink switching, or to trigger any other new uplink switching occurring before *T0* for any other uplink transmission that is scheduled after *T0-Toffset*, where *Toffset* is the UE processing procedure time defined for the uplink transmission triggering the switch given in clause 5.3, clause 5.4, clause 6.2.1, clause 6.4 and in clause 9 of [6, TS 38.213].  The UE does not expect to perform more than one uplink switching in a slot with *µUL* = max(*µUL, 1, µUL, 2*), where the *µUL, 1* corresponds to the subcarrier spacing of the active UL BWP of one uplink carrier before the switching gap and the *µUL, 2* corresponds to the subcarrier spacing of the active UL BWP of the other uplink carrier after the switching gap.  **<Unchanged parts are omitted – 38.214>** 6.1.6.2 Uplink switching for carrier aggregation For a UE indicating a capability for uplink switching with *BandCombination-UplinkTxSwitch* or *uplinkTxSwitchingPeriod2T2T* for a band combination, and if it is for that band combination configured with uplink carrier aggregation:  - If the UE is configured with uplink switching with parameter *uplinkTxSwitching*, when the UE is to transmit in the uplink based on DCI(s) received before or based on a higher layer configuration(s):  - When the UE is to transmit a 2-port transmission on one uplink carrier on one band and if the preceding uplink transmission is a 1-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - When the UE is to transmit a 1-port transmission on one uplink carrier on one band and if the preceding uplink transmission is a 2-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - [If *uplinkTxSwitching-2T-Mode* is configured, when the UE is to transmit a 2-port transmission on one uplink carrier on one band and if the preceding uplink transmission is a 2-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of of on any of the carriers.]  - For the UE configured with *uplinkTxSwitchingOption* set to 'switchedUL', when the UE is to transmit a 1-port transmission on one uplink carrier on one band and if the preceding uplink transmission was a 1-port transmission on another uplink carrier on another band, then the UE is not expected to transmit for the duration of on any of the carriers.  - For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 2-port transmission on one uplink carrier on one band and if the preceding uplink transmission was a 1-port transmission on a carrier on the same band and the UE is under the operation state in which 2-port transmission cannot be supported in the same band, then the UE is not expected to transmit for the duration of on any of the carriers.  - For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL',  - when the UE is to transmit a 1-port or 2-port transmission on one uplink carrier on one band and if the preceding uplink transmission was a 1-port transmission on another uplink carrier on another band and the UE is under the operation state in which 2-port transmission can be supported on the same uplink carrier, then the UE is not expected to transmit for the duration of on any of the carriers.  - If the UE is configured with *OneT* with *uplinkTxSwitching-DualUL-TxState*, when the UE is under the operation state in which 2-port transmission can be supported on one carrier on one band followed by no transmission on this carrier and 1-port transmission on the other carrier on another band the UE shall consider this as if 1-port transmission was transmitted on both uplinks, otherwise the UE shall consider this as if 2-port transmission took place on the transmitting carrier.  - 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 on one band, and any transmission on another uplink carrier on another band.  - In all other cases the UE is expected to transmit normally all uplink transmissions without interruptions.   6.1.6.3 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>** |

Companies are encouraged to provide comments on the above TP.

|  |  |
| --- | --- |
| **Company** | **Comments** |
| New H3C | We are fin with abovd TP. |
|  |  |
|  |  |

# Agreements at RAN1#107-e

**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.

**Agreement:**

* For a UE capable of 2Tx-2Tx switching and configured with UL Tx switching via *uplinkTxSwitching*, to differentiate the switching delay for 1Tx-2Tx switching from that for 2Tx-2Tx switching, a new RRC parameter is used to indicate 1Tx-2Tx switching mode or 2Tx-2Tx switching mode.
* If 1Tx-2Tx mode is derived by the new RRC parameter, then there is one uplink (or one uplink band in case of intra-band) configured with *uplinkTxSwitching*, on which the maximum number of antenna ports among all configured P-SRS/A-SRS and activated SP-SRS resources should be 1 and non-codebook based UL MIMO is not configured. RAN1 assume the uplink is configured with RRC parameter “carrier1” by RAN2*.*
* The default value of the new RRC parameter is 1Tx-2Tx switching mode.
* In a configured switching mode, the switching gap duration for a triggered uplink switching is equal to the switching time capability value reported for the switching mode.
* Note: This RRC parameter doesn’t imply any restriction on application of non-codebook transmission together with UL Tx switching.

# Agreements at RAN1#106b-e

**Agreement:**

* 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.

# 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

1. RP-202088, New WID proposal: RF requirements enhancement for NR frequency range 1 (FR1) in Rel-17, Huawei, HiSilicon, China Telecom, RAN #89e, Sep. 2020.
2. RP-210899, Revised WID: RF requirements enhancement for NR frequency range 1 (FR1), Huawei, HiSilicon, RAN #91e, Mar. 2021.
3. RP-212983, Introduction of UL Tx Switching enhancements, RAN1, RAN#94e, December 6th – 17th, 2021.
4. R1-2112977, LS on updated Rel-17 LTE and NR higher-layers parameter list, RAN1, Ericsson, November 11th – 19th, 2021.
5. R1-2200702, Collection of updated higher layers parameter list for Rel-17 NR, Moderator (Ericsson), 17th – 25th January 2022.
6. R2-2201873, RRC configuration to support R17 UL Tx switching enhancement, Huawei, HiSilicon, China Telecom, CATT, RAN2#116b-e, January 17th – 25th, 2022.
7. R1-2200973, Discussion on the remaining issues of UL Tx switching, Huawei, HiSilicon, February 21st – March 3rd, 2022.
8. R1-2201062, Remaining issues on Rel-17 Tx switching enhancements, vivo, February 21st – March 3rd, 2022.
9. R1-2201154, Maintenance of Rel-17 UL Tx switching, ZTE, February 21st – March 3rd, 2022.
10. R1-2201238, Discussion on Rel-17 Tx switching enhancement, OPPO, February 21st – March 3rd, 2022.
11. R1-2202110, Remaining issues of Rel-17 UL Tx switching, Qualcomm Incorporated, February 21st – March 3rd, 2022.
12. R1-2202491, Discussions on the remaining issues for UL Tx switching, Discussion on the remaining issues of UL Tx switching, Huawei, HiSilicon, February 21st – March 3rd, 2022.