3GPP TSG RAN WG1 #105-e R1-21xxxxx

**e-Meeting, May 10th – 27th, 2021**

**Agenda item: 5.1**

**Source: Moderator (China Telecom)**

**Title: [105-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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|   | **Number of Tx chains in WID (band A + band B)** |
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| 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.

An LS was sent by RAN4 [3]. This contribution is a summary of the following email discussion:

[105-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: 5/21
* 2nd check point: 5/25
* Final check: 5/27

# Email discussion (1st round)

## 2Tx-2Tx switching between two uplink carriers

The switching mechanism for 2Tx-2Tx switching between two uplink carriers was discussed for SUL, UL CA option 1 and option 2 in RAN1 #104b-e.

For SUL, it seems companies have common understanding that the mechanism of uplink switching specified in S6.1.6.3 of TS 38.214 can be reused.

**Proposal:**

* **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.**

Companies are encouraged to provide views on the above proposal.

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| **Company** | **Views** |
| CATT | We are fine with FL proposal. |
| Qualcomm | We are fine with FL proposal. |
| vivo | We are fine with FL proposal. |

For UL CA option 1, it is understood that some cases on top of the mechanism of uplink switching specified in S6.1.6.2 of TS 38.214 are necessary to be added. Following proposal was proposed.

**Proposal:**

* **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**$N\_{Tx1-Tx2}$ **on any of the two carriers.**

R1-2104245 provided TP for UL CA option 1.

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| 6.1.6.2 Uplink switching for carrier aggregation**<Unchanged parts are omitted – 38.214>**- For the UE configured with *uplinkTxSwitchingOption* set to 'switchedUL', when the UE is to transmit a 1-port transmission on one uplink carrier and if the preceding uplink transmission was a 1-port transmission on another uplink carrier, then the UE is not expected to transmit for the duration of $N\_{Tx1-Tx2}$ on any of the two carriers.- For the UE configured with *uplinkTxSwitchingOption* set to 'switchedUL', when the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission was a 2-port transmission on another uplink carrier, then the UE is not expected to transmit for the duration of $N\_{Tx1-Tx2}$ on any of the two carriers.- For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission was a 1-port transmission on the same uplink carrier and the UE is under the operation state in which 2-port transmission cannot be supported in the same uplink carrier, then the UE is not expected to transmit for the duration of $N\_{Tx1-Tx2}$ on any of the two carriers.**<Unchanged parts are omitted – 38.214>** |

R1-2104318 provided TP for UL CA option 1.

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| 6.1.6.2 Uplink switching for carrier aggregation**<Unchanged parts are omitted – 38.214>**- For the UE configured with *uplinkTxSwitchingOption* set to 'switchedUL' or configured with *[RRC\_R17\_CA Option1\_2carrier]*, when the UE is to transmit a 1-port transmission on one uplink carrier and if the preceding uplink transmission was a 1-port transmission on another uplink carrier, then the UE is not expected to transmit for the duration of $N\_{TX1-TX2}$ on any of the two carriers.- For the UE configured with *[RRC\_R17\_CA Option1\_2carrier] or [RRC\_R17\_CA Option2\_2carrier]*, when the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission was a 2-port transmission on another uplink carrier, then the UE is not expected to transmit for the duration of $N\_{TX1-TX2}$ on any of the two carriers.- For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission was a 1-port transmission on the same uplink carrier and the UE is under the operation state in which 2-port transmission cannot be supported in the same uplink carrier, then the UE is not expected to transmit for the duration of $N\_{TX1-TX2}$ on any of the two carriers.**<Unchanged parts are omitted – 38.214>** |

Companies are encouraged to provide views on the above proposal and two TPs.

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| **Company** | **Views** |
| CATT | We are fine with FL proposal and TP provided in R1-2104245 is a little bit preferred. |
| Qualcomm  | We are fine with FL proposal. TP of R1-2104318 is slightly preferred as option 2 also requires 2P+0P <-> 0P+2P.  |
| vivo | We are fine with FL proposal. TP of R1-2104245 is preferred.  |

For UL CA option 2, in RAN1 #104b-e the main controversial point was whether the note “No spec change to power configuration and power control” should kept or removed. Companies are encouraged to check whether we can achieve any consensus on one of the following alternatives about the note. If no consensus can be reached on any of the alternatives, FL would request GTW session to handle this issue.

**Proposal:**

* **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.**
	+ **Alt 1: Note: No spec change to power configuration and power control.**
	+ **Alt 2: Note: No spec change to power configuration and power control in RAN1.**
	+ **Alt 3: ~~Note: No spec change to power configuration and power control~~.**

Companies are encouraged to provide views on the above alternatives.

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| **Company** | **Views** |
| CATT | We are fine with FL proposal with Alt.2 for note of power configuration and power control.  |
| Qualcomm | We prefer FL’s Alt 3 as we fail to see why there should be an objection to the agreement without the note, and why only CA option 2 needs to make this clarification.  |
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R1-2104318 provided TP for UL CA option 2.

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| 6.1.6.2 Uplink switching for carrier aggregation**<Unchanged parts are omitted – 38.214>**- For the UE configured with *[RRC\_R17\_CA Option1\_2carrier] or [RRC\_R17\_CA Option2\_2carrier]*, when the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission was a 2-port transmission on another uplink carrier, then the UE is not expected to transmit for the duration of $N\_{TX1-TX2}$ on any of the two carriers.- For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission was a 1-port transmission on the same uplink carrier and the UE is under the operation state in which 2-port transmission cannot be supported in the same uplink carrier, then the UE is not expected to transmit for the duration of $N\_{TX1-TX2}$ on any of the two carriers.- For the UE configured with *uplinkTxSwitchingOption* set to 'dualUL', when the UE is to transmit a 1-port transmission on one uplink carrier and if the preceding uplink transmission was a 1-port transmission on another uplink carrier 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 $N\_{TX1-TX2}$ on any of the two carriers.- For the UE configured with *[RRC\_R17\_CA Option2\_2carrier]*, when the UE is to transmit a 1-port on one uplink carrier and if the preceding uplink transmission was a 1-port or 2-port transmission on another uplink carrier and the UE is under the operation state in which 2-port transmission can be supported on the another uplink carrier, then the UE switches to the operation state in which 2-port transmission can be supported on the uplink carrier and the UE is not expected to transmit for the duration of $N\_{TX1-TX2}$ on any of the two carriers.- For the UE configured with *[RRC\_R17\_CA Option2\_2carrier]*, when the UE is to transmit a 2-port transmission on one uplink carrier and if the preceding uplink transmission was a 1-port transmission on the same or another uplink carrier and the UE is under the operation state in which 2-port transmission cannot be supported in either carrier, then the UE is not expected to transmit for the duration of $N\_{TX1-TX2}$ on any of the two carriers.**<Unchanged parts are omitted – 38.214>** |

Companies are encouraged to provide views on the above TP.

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| **Company** | **Views** |
| CATT | We can firstly discuss about the applicable case of the switching period for UL CA option 2. After we have consensus on it, we can discuss about detail TP again. |
| Qualcomm | We agree with the main body of FL’s last proposal. We agree with the principle of the above text proposal.Although in our view the last two paragraphs could be merged and simplified by replacing them with:  |
|  | “ For the UE configured with *[RRC\_R17\_CA Option2\_2carrier]*, when the UE is to transmit a 2-port transmission on one uplink carrier when the UE is under the operation state in which 2-port transmission cannot be supported on that carrier, then the UE is not expected to transmit for the duration of $N\_{TX1-TX2}$ on any of the two carriers.”In any case, the following editorial change is suggested:“… state in which 2-port transmission can be supported on the ~~an~~other uplink carrier |

The state of Tx chains after Tx switching may not be unique in some cases. For instance, if the current state of Tx chains is 0T+2T and the next UL transmission is 1-port transmission on carrier 1, since 1P+0P can be mapped to either 1T+1T or 2T+0T, then what’s the state of Tx chains after Tx switching? Another example, if the current state of Tx chains is 2T+0T and the next UL transmission is 1-port transmission on carrier 2, since 0P+1P can be mapped to either 1T+1T or 0T+2T, then what’s the state of Tx chains after Tx switching?

In RAN1 #104b-e, three alternatives were discussed. R1-2104245 proposed another alternative.

* Alt 1: The state of Tx chains after Tx switching is predefined in the specifications.
* Alt 2: The state of Tx chains after Tx switching is indicated by Network.
* Alt 3: The state of Tx chains after Tx switching is determined by UE.
* Alt 4: The state of Tx chains with the most of Tx chains on the most important uplink carrier is assumed.
	+ FFS: which uplink carrier is the most important one, e.g. the one carrier with *uplinkTxSwitchingPeriodLocation* configured as false.

Companies are encouraged to provide views on the above alternatives.

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| **Company** | **Views** |
| CATT | We are fine with Alt.1. |
| Qualcomm | In R16, we define the state switching in the specification without explicit switching signalling. The RAN1 consensus is to implicitly inform UE to switch the UL Tx state by network scheduling and configuration. Before we make the selection of above alternatives, we make some initial analysis for the above 3 alternatives.* Alternative 1 doesn’t require additional explicit signaling which is with same principle of Rel-16. One possible implementation is to define a prioritized case or carrier when ambiguous scheduling happens. For example, we can always prioritize Case 1 which allows balanced transmission from both carriers. If the UE is at case 3 and scheduled for 0P+1P at the next slot, UE would switch to Case 1 when it’s prioritized in the specification. However, it would lose some flexibility as the prioritized Case is hard coded in the specification.
* Alternative 2 needs a new signaling to indicate which is the target case when ambiguity occurs. This would be the clearest way to tell the UE the switching target case.
* Alternative 3 leaves the decision to the scheduled UE. Frankly, we don’t understand how it works. For example, if UE is at case 3 and scheduled for 0P+1P at the next slot, what’s the switching target case? If UE selects one of Case 1 or Case 2, how the gNB know about this? If gNB doesn’t know the Tx chain status (Case number), how should the gNB know whether UE needs the switching gap or not for the next scheduling?
* Alternative 4 is a special example of Alternative 1 which is deprioritize the carrier with *UplinkTxSwitchingPeriodLocation*.

Both Alternative 1 and 2 should be workable to solve this ambiguous switching. We don’t have strong preference between them. For Alternative 3, we don’t know how it works but open to discuss if it’s workable.  |
| vivo | We are fine with Alt1 or Alt 3. To respond to QC about Alt 3, yes it leaves uncertainty at the gNB side, which means gNB has to schedule conservatively by assuming the worst case, i.e. a switching gap is required if there is such ambiguity.  |

## Uplink Tx switching between 1 carrier on Band A and 2 contiguous carriers on Band B

In RAN1 #104b-e, the following conclusion was reached.

**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.

Based on the conclusion, R1-2104245 and R1-2104652 proposed the basic principle of the switching mechanism for uplink Tx switching between two bands.

**Proposal: (R1-2104245)**

* **For inter-band UL-CA and SUL, if a UE is configured with UL Tx switching and additionally intra-band CA on Band B, the contiguous uplink carriers on a band B should be considered as a single uplink carrier for the purpose of UL Tx switching, i.e.**
	+ **with respect to the determination of uplink switching triggering, the presence of transmission occasion on any one uplink of the contiguous intra-band CA is equivalent to the presence of transmission occasion on any other uplink(s) of the contiguous intra-band CA.**
	+ **no uplink switching is triggered if the uplink where a transmission occasion is to be transmitted is different from the uplink of the preceding uplink transmission occasion but both uplinks belongs to the contiguous uplinks on band B.**

**Proposal: (R1-2104652)**

* **In evaluating the antenna ports for determination of UL Tx switching, the configuration of CC2 and CC3 are jointly considered and the maximum ports number among the scheduling for CC2 and CC3 on band B is used.**

R1-2104468, R1-2104737, R1-2104845, R1-2105452 proposed the detailed switching mechanism for SUL, UL CA option 1 and option 2. R1-2104245 provided TPs for SUL and UL CA option 1. R1-2104318 proposed the switching mechanism for UL CA and provided TPs for UL CA for 1Tx-2Tx and 2Tx-2Tx respectively.

Based on companies’ views, there can be following options for the discussion.

* Option 1: Discuss the switching mechanism for uplink Tx switching between two bands first and discuss corresponding TPs later.
	+ Option 1-1: Discuss the the basic principle of the switching mechanism for uplink Tx switching between two bands proposed by R1-2104245 and R1-2104652.
	+ Option 1-2: Discuss the detailed switching mechanism for SUL, UL CA option 1 and option 2 proposed by R1-2104468, R1-2104737, R1-2104845, R1-2105452
* Option 2: Discuss TPs provided by R1-2104245 and R1-2104318 directly.

From FL understanding, we may discuss TPs directly, but the TPs provided by R1-2104245 and R1-2104318 are quite divergent. In addition, TPs for uplink Tx switching between two bands may depend on TPs for uplink Tx switching between two carriers.

Companies are encouraged to provide views on the above options.

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| **Company** | **Views** |
| CATT | We are fine Option 1-2. Firstly of all, we have consensus on the switching mechanism for uplink Tx switching between two bands first and it is better to discuss about the detailed switching mechanism. |
| Qualcomm | We prefer option 1, which suggests getting consensus first before discussing the text proposal. Between Option 1-1 and Option 1-2, we slightly prefer option 1-1 as we need to decide how to evaluate the antenna port number for band B. This is the fundamental issue we need to solve first. Our understanding is the configuration of CC2 and CC3 are jointly considered and the maximum ports number among the scheduling for CC2 and CC3 on band B is used. If companies can get this consensus, we are also ok to discuss the detailed switching mechanism. |
| vivo | It seems Option 1-1 is better, we can discuss the problem step-by-step.  |

## Operation with downgraded MIMO setting and/or CA setting

R1-2104245 proposed that if UE support 2Tx-2Tx UL Tx switching, the UE can be configured and operated with downgraded MIMO setting of 1Tx-2Tx for UL Tx switching, and if UE support UL Tx switching with two contiguous carriers on Band B, the UE can be configured and operated with only one carrier on Band B as a downgraded UL Tx switching.

**Proposal:** Confirm the following,

* As usual, if UE support 2Tx-2Tx UL Tx switching, the UE can be configured and operated with downgraded MIMO setting of 1Tx-2Tx for UL Tx switching.
* As usual, if UE support UL Tx switching with two contiguous carriers on Band B, the UE can be configured and operated with only one carrier on Band B as a downgraded UL Tx switching.

Companies are encouraged to provide views on the above proposal.

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| **Company** | **Views** |
| CATT | We are fine with FL proposal. |
| Qualcomm | We are unsure if anything needs to be discussed or agreed. The “downgraded” setting is simply the Rel-16 operation. The UE indicates whether it supports Rel-16 UL Tx switching. If it does so, it can be configured with Rel-16 operation. Doesn’t seem any agreement is needed for this. Perhaps the intent is to discuss a capability pre-requisite relationship, i.e. whether Rel-16 UL Tx switching should be pre-requisite for Rel-17 UL Tx switching. We do not think there needs to be any pre-requisite but in any case, this should be discussed together with UE features at the end of the release. |
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## 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. In RAN1 #104b-e and RAN1 #105-e, some companies raised this issue in Rel-17 again. From FL perspective, it’s really difficult to continue the discussion. FL would like to give companies one more chance to check the following alternatives. If no consensus can be reached on any of the alternatives, FL suggest not to discuss it any further by email, and would request GTW session to handle this issue if possible.

Alt 1: supported by ZTE, Qualcomm

* For UL CA option 2, DCI format 0\_1 can be used to schedule a UL transmission on carrier 2 when nrofSRS-Ports is configured as 2 antenna ports and state of Tx chains is 1 Tx on carrier 1 and 1Tx on carrier 2.
	+ It’s up to implementation how DCI format 0\_1 to be used.

Alt 2: supported by Huawei, HiSilicon

* For UL CA option 2
	+ Rel-16 uplink full power transmission can be used for codebook based transmission with 2 SRS resources (with one 1-port SRS resource and one 2-port SRS resource) on carrier 2
	+ ­Note: No new uplink full power modes for UL CA Option2
	+ ­Note: If Rel-16 uplink full power mode is not supported by the UE capable of UL CA option 2and configured with one 2-port SRS resource for codebook based operation, 1-port PUSCH is scheduled only by DCI 0\_0
	+ ­Note: Rel-16 uplink full power mode is not required as a prerequisite feature for a UE capable of UL-CA Option2.

Alt 3: supported by Qualcomm

* Use the following rule to decide the Tx number(s) on a certain carrier,
* 2 Tx is used for these UL transmissions: PUSCH with TPMI=[$\frac{1}{\sqrt{2}}\left[\begin{array}{c}0\\1\end{array}\right]$ , $\frac{1}{\sqrt{2}}\left[\begin{array}{c}1\\1\end{array}\right]$], 2-port SRS, 2-port configured grant PUSCH, SRS carrier switching on the paired carrier
* 1 Tx is used for these UL transmissions: PUCCH, SR, PRACH, PUSCH scheduled by DCI 0\_0, single port configured grant PUSCH, PUSCH with TPMI=$\frac{1}{\sqrt{2}}\left[\begin{array}{c}1\\0\end{array}\right]$

Alt 4: supported by Huawei, HiSilicon, CATT, OPPO

* 1-port transmission via DCI format 0\_1 for UL CA option 2 is not considered for Rel-17 Tx switching.

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| **Company** | **Views** |
| CATT | We prefer to Alt.4 because it is out of scope in R17 WID. |
| Qualcomm | We support Alt. 1. This is surely in the scope as this is one of the key issues needs to be solved.In R16 UL Tx switching, we had some discussion, but no decision was made at that time due to diverged proposals. However, this is indeed an important issue to the product development and deployment. Clear definition of 1 or 2 ports would largely reduce the development and IoT test efforts between infrastructure vendors and chipset/UE vendors. |
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## Back-to-back switching with SRS switching

R1-2104652 mentioned that in Rel-16 UL Tx switching, UE is restricted to support one switch per one slot. However, the switching location could be anywhere inside the slot. For example, if the switch is triggered by SRS transmission, the switching location could be in the middle or even later part of the slot. Therefore, if there is an expected switch on the SRS transmission carrier, there would be two switches in 14 consecutive symbols even these two switches still belong to two slots. Now, when we consider SRS carrier switching and if the UL Tx switching is triggered by SRS carrier switching which means there would be 4 switches (2 for SRS and 2 for UL Tx switch) in 14 consecutive symbols! From UE implementation perspective, we definitely want to avoid this case as too many symbols are costed as switch gap.

UL

DL

DL

Tx Switch

CC1

UL

CC2

DL

DL

CC3

RF tuning

UL

4 switches within 14 consecutive symbols

SRS

RF tuning

SRS

Tx switch

Figure illustrative figure on 4 switches in 14 consecutive symbols

**Proposal:**

* **When SRS carrier switching configures – max of 3 switches (2 for SRS and 1 for UL Tx switching) in 14 consecutive symbols.**

Companies are encouraged to provide views on the above proposal.

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| **Company** | **Views** |
| CATT | The motivation isn’t clear to us. Maybe the proponent can explain more. |
| Qualcomm | This feature is with the pre-assumption that SRS carrier switch would be supported together with UL Tx switch in Rel-17.In Rel-16 UL Tx switching, UE is restricted to support one switch per slot. However, the switching location could be anywhere inside the slot. Therefore,, there would be two switch periods in 14 consecutive symbols even when the two switches belong to two slots. This has been illustrated in the figure. Furthermore, when we consider SRS carrier switching and if the switching is triggered by SRS carrier switching which means there would be 4 switches (2 for SRS and 2 for UL Tx switch) in 14 consecutive symbols! From UE implementation perspective, we definitely want to avoid this case. Our motivation is to avoid 4 switches in 14 consecutive symbols when UL Tx switch is tiggered by SRS carrier switch. |
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## Tx switching between case 1 and case 3 for UL CA option 1 and SUL

R1-2104598 proposed to discuss and clarify whether the switching between case 1 and case 3 for SUL and UL CA Option 1 is valid, for both 3 carriers case and 2 carriers case. As we have achieved the following conclusion in RAN1 #104b-e, the proponents can propose this issue to RAN plenary or RAN4. Then no further discussion in RAN1 is needed at present.

**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.

# 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.**

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|  | 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.**

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| --- | --- | --- |
|  | 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.

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