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)** |
| 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.

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. |
| OPPO | Support |
| ZTE | We would suggest to combine the first three proposals together just as what we discussed in last meeting for the following reasons.1. The table for SUL and CA Option1 is the same.2. Regarding the note “Note: No spec change to power configuration and power control” in the third proposal, although we think the note is not needed, if any company insists on discussing this note, it should be discussed whether this note is applicable to both SUL and CA Option1/Option2 together instead of just CA Option2 alone. |
| Huawei, HiSilicon | Support.We don’t see any necessity to combine different proposals as suggested by ZTE. The proposal directly addresses spec changes and whether the current spec text can be reused. Since SUL and UL CA have different sectors of spec texts, there is no need to combine any proposals. |

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.  |
| OPPO | Support the proposal. The second TP (R1-2104318) is preferred since CA Option 1 and Option 2 will need the same text. |
| ZTE | We would be ok if we can combine the first three proposals together with the corresponding TPs. Regarding the two TPs, they are almost the same except that TP in R1-2104245 assumes that RAN2 will reuse the old RRC parameter to differentiate CA Option1 and CA Option2 while our TP (R1-2104318) put the RRC parameter in brackets for now so that we can update it in case RAN2 defined different RRC parameters. Thus, we support our TP (R1-2104318). |
| Huawei, Hisilicon | We are fine with FL proposal. TP of R1-2104245 is preferred because the TP from R1-2104318 introduces additional RRC configuration which is associated with the same text as that without such new RRC configuration.@OPPO, Qualcomm, the TP from R1-2104245 also serves both UL CA Option 1 and Option 2 by removing the sentence “For the UE configured with *uplinkTxSwitchingOption* set to 'switchedUL',” However, it is not fully clear now how the switching triggering works for UL CA Option 2 yet, as discussed in the other FL proposal, so only Option 1 is addressed here. When it is clear enough, we can simply remove the sentence above to support UL CA Option 2, but it is only a discussion point how to capture UL CA Option 2 and not the focus here now. |

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.  |
| OPPO | The proposal seems only cover the following cases 2,3,5, but not cover the cases 1 and 4, which are supported in rel-16

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| No | Preceding uplink transmission | Next uplink transmission |  |
| 1 | 1-port on Carrier 1 and UE is under the operation state in which 2-port transmission can be supported on Carrier 1 | 1-port on Carrier 2 | Supported by Rel-16 mechanism |
| 2 | 1-port on Carrier 1 | 2-port on Carrier 2 | Supported by Rel-16 mechanism |
| 3 | 2-port on Carrier 1 | 1-port on Carrier 2 | Supported by Rel-16 mechanism |
| 4 | 1-port Carrier 1 and UE is under the operation state in which 2-port transmission cannot be supported on Carrier 1 | 2-port on Carrier 1 | Supported by Rel-16 mechanism |
| 5 | 2-port on Carrier 1 | 2-port on Carrier 2 | Not covered in Rel-16 |

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| ZTE | As discussed extensively in last meeting, we are not sure why the note is needed at all. The motivation of this note is not clear to us.@OPPO, it seems your case1 is covered by the following “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.”. Your case4 is covered by the following “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.”. |
| Huawei, HiSilicon | Support the proposal with note Alt 1. Alt 3 is not acceptable because the note was agreed in Rel-16 and no company explains why the existing mechanism of power control for Rel-16 UL Tx switching cannot be reused here.RAN1 spec impact should be minimized as WID requests. We don’t feel that more spec impact for power control is justified for UL-CA Option 2. |

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 |
| OPPO | Please see my comment for the previous proposal |
| ZTE | The TP can be agreed in principle and considered as the starting point. We are also open to Qualcomm’s suggestion. |
| Huawei, HiSilicon | Similar view as CATT, with too many open issues listed below by FL, it is premature to discuss a TP for UL-CA Option 2 now. |

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.  |
| ZTE | Alt.1 is sufficient. Alt.2 is more flexible, but a new RRC parameter is needed and not sure why this kind of flexibility can provide much gain. Alt.3 may lead to different understandings between UE and network.Based on our understanding, it seems that most companies prefer the following switching. Maybe we can directly agree the following.*For Rel-17 2Tx-2Tx switching between two uplink carriers for UL CA Option 2, if the UE is under case2 and it is to transmit a 1-port transmission on carrier1, the UE switches to case3; if the UE is under case3 and it is to transmit a 1-port transmission on carrier2, the UE switches to case2.* |
| Huawei, HiSilicon | Alt. 4. We agree with Qualcomm that Alt. 4 overlaps with Alt. 1 and can have more flexibility than Alt. 1 if the most important UL carrier is determined via RRC *UplinkTxSwitchingPeriodLocation*. Additionally, the Alt.4 have the flexibility as Alt. 2 but without introduction of any new RRC parameter as some company concerned.In short, **Alt.4 has both the advantages of Alt.1 and Alt. 2, but without requiring a new RRC parameter.**Regarding ZTE’s latest proposal, it seems basically an Alt. 1 with specific predefined state of Tx chain, but with less flexibility than Alt. 4.Based on the discussion above, to address the concern about new RRC parameter, we propose the revised Alt. 4,Proposal:* Alt 4-rev: 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.~~ is the one carrier with *uplinkTxSwitchingPeriodLocation* configured as false.

Besides, Alt 3 can work in the way as vivo described. |

## 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.  |
| OPPO | Open to either option. From my understanding, Proposal (R1-2104245) and Proposal (R1-2104652) are equivalent from the perspective of functionality, although they may lead to different spec wording.  |
| ZTE | We are ok with either Option 1-2 or Option2.From our perspective, the basic principle suggested by companies can be reflected in the detailed switching mechanism discussion or TP discussion. Even if we spend time defining some basic principles here, we still need to discuss the detailed mechanism or TP in the end. To save time, we suggest to directly discuss the detailed switching mechanism or TP.Regarding the TP provided by companies, although it looks quiet divergent, the essence of them are similar. We can also go with Option2 directly to save time. |
| Huawei, HiSilicon | Our TP (R1-2104245) provides a full picture of how much spec impacts are needed to capture our proposal in R1-2104245, it has very small spec impact if our proposal is agreed.We prefer Option 2 but are also OK with Option 1-2 if our TP is added to Option 1-2 as it has provided detailed switching mechanism. |

## 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. |
| OPPO | Support in principle. But we need to double check whether there is any inconsistency between R16 and R17 design. Thus, we can postpone this proposal until the R17 design details are clear.  |
| ZTE | From our perspective, this proposal is more like a UE feature discussion, which can be discussed at a later stage of Rel-17. |
| Huawei, HiSilicon | Support.Companies’ concerns seems to worry about the feasibility of operating a Rel-17 UE capable of Rel-17 UL Tx switching by a Rel-16 gNB capable of Rel-16 UL Tx switching. In our view, it should be feasible and should be a guideline for RAN1 design rather than leaving it to the late discussion phase of UE feature, otherwise an operator must upgrade all gNBs in order to accommodate Rel-17 UEs reporting only Rel-17 2Tx-2Tx UL Tx switching or Rel-17 Band-B UL Tx switching.More importantly, we don’t see any technical reason in the discussions not to confirm such feasibility nor any UE implementation obstacles. Especially, there is obviously no reason not to confirm the second bullet “*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.*”, without which the new Rel-17 UE will be dropped when it roams to an area where an operator does not deploy intra-band UL CA.In our understanding, there is no UE feature so far that precludes a gNB from configuring less carriers or lower dimension of UL MIMO for a UE, including the UE feature of Rel-16 UL Tx switching. **It is appreciated that if opposing companies could elaborate the reason why Rel-17 UL Tx switching is an exception.**In shorts, it is more than a discussion of UE feature, but also an important guideline for RAN1 design and should have been addressed as earlier as possible if any divergence. At least the second bullet should be confirmed.Regarding the first bullet, to address OPPO and Qualcomm’s concern, “for SUL and UL-CA Option1” can be added because the consistence seems achieved based on the discussions for them so far. |

## 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.

|  |  |
| --- | --- |
| **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. |
| OPPO | We prefer Alt.4. We don’t need to do any over-optimization |
| ZTE | In Rel-16, only carrier2 can be used for 2-port transmission. However, in Rel-17, the issue becomes more serious because both carrier1 and carrier 2 can be used for 2-port transmission for both CA and SUL. If one carrier is configured as 2-port carrier, then DCI format 0\_1/0\_2 can only be used to schedule 2-port PUSCH and transmission and only fallback DCI can be used to schedule 1-port PUSCH. In other words, in Case1, only fallback DCI can be used. This is too restrictive for network flexibility.We encourage companies to consider this issue and agree to address this issue in Rel-17. We support Alt.1, but we are also fine if companies prefer to discuss the detailed solutions later.  |
| Huawei, HiSilicon | Alt. 4. It is not new proposal and too much time has been wasted on the new MIMO scheme since Rel-16 discussions. |

## 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.

|  |  |
| --- | --- |
| **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. |
| ZTE | Based on our understanding, the SRS transmission is usually in the last several symbols of one certain slot. It would be ok to restrict up to 3 switches in 14 consecutive symbols. However, we may need to clarify the SCS for these 14 consecutive symbols. From our perspective, the SCS is determined by the SRS.*When SRS carrier switching configures – max of 3 switches (2 for SRS and 1 for UL Tx switching) in 14 consecutive symbols corresponding to the SCS of SRS.* |
| Huawei, HiSilicon | Thank Qualcomm for the proposal. A couple of clarifications are suggested.Firstly, the issue associated with SRS carrier switching is not specific to Rel-17 UL Tx switching but also applicable to Rel-16, so we suggest the discussion to be handled in Rel-16 email thread, or make it clear that any outcome of the discussion here is applicable to Rel-16 UL Tx switching.Secondly, please proponent clarify and confirm the proposal is only related to SRS carrier switching rather than to all general SRS transmissions. Because for general SRS transmission, a further restriction of 14 consecutive symbols was proposed by the same proponent in Rel-16 but not adopted by the group. We hope we are not repeating the discussion here unless anything new is found.Thirdly, since the SRS transmission in the figure is not restricted to only the last 6 symbols of a slot, it is appreciated if the proponent could clarify whether the issue is only specific to a UE capable of SRS transmissions at any symbol of a slot but not relevant to SRS transmission restricted at only the last 6 symbols of a slot.Fourthly, a case with small revision to the illustration figure seems not precluded by the proposal, could the proponent confirm the understanding? The case with small revision is that the UL transmission (blue) after SRS carrier switching is on CC2 (assuming UL slot here) rather than on CC1. In other words, if the gNB scheduling is restricted to schedule CC2 only in the succeeding symbols, the issue can be equivalently resolved? Fifthly, since it is motivated by “*want to avoid this case as too many symbols are costed as switch gap*”, please clarify whether the issue is only above overhead. Because the switching gap for SRS carrier switching can be as low as 30us, as the excerpt copied below, two gaps for SRS carrier switching plus two gaps of UL Tx switching can be only 30\*2+35\*2=130 us, whose overhead is much smaller than 140\*2 us that is required by a UE capable of 140us gap for SRS carrier switching.*switchingTimeUL ENUMERATED {n0us, n30us, n100us, n140us, n200us, n300us, n500us, n900us} OPTIONAL* |

## 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.**

|  |  |  |
| --- | --- | --- |
|  | 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. R4-2103234, LS on Rel-17 Tx switching enhancements, RAN4 #98e, Feb. 2021.
4. R1-2104137, Reply LS on Rel-17 uplink Tx switching, RAN1 #104b-e, Apr. 2021.
5. R1-2104245, Discussions on enhancements for UL Tx switching, Huawei, HiSilicon, May 2021.
6. R1-2104318, Discussion on Rel-17 UL Tx Switching, ZTE, May 2021.
7. R1-2104468, Discussion on R17 enhancements for UL TX switching, CATT, May 2021.
8. R1-2104598, Discussion on Rel-17 UL Tx Switching, CMCC, May 2021.
9. R1-2104652, Discussion on Rel-17 UL Tx switching, Qualcomm Incorporated, May 2021.
10. R1-2104737, Discussion on Rel-17 Tx switching enhancement, OPPO, May 2021.
11. R1-2104845, Discussion on Rel-17 uplink Tx switching, China Telecom, May 2021.
12. R1-2105452, Discussion on Rel-17 Tx switching enhancements, vivo, May 2021.