**3GPP TSG RAN WG1 #112bis-e R1-23xxxxx**

**E-meeting, April 17th – April 26th, 2023**

**Agenda Item: 5**

**Source: Moderator (China Telecom)**

**Title: [112bis-e-LS-03] FL summary of email discussion on reply LS for Rel-18 Tx switching**

**Document for: Discussion**

1. Introduction

This contribution is a summary of the following email discussion in response to RAN4 LS in R1-2302266 for Rel-18 Tx switching.

[112bis-e-LS-03] Email discussion for response to RAN4 LS in [R1-2302266](file:///C%3A%5CUsers%5Cyouns%5COneDrive%5CDocuments%5C3GPP%5CRAN1%20tdocs%5CTSGR1_112b-e%5CDocs%5CR1-2302266.zip) by April 21 – Jianchi (China Telecom).

1. Summary of contributions in RAN1#112bis-e

In contributions [2-13], following proposals were made.

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| Huawei, HiSilicon, [2, 13] | ***Observation 1:*** *In Rel-16, when a UE receives two DCI’s before T0-Toffset, only one UL Tx switching is triggered for both the UL transmission scheduled by two DCIs if the UL transmissions on the two bands are at least partially overlapped in time domain, otherwise two UL Tx switching are performed.****Observation 2:*** *In Rel-17, it has been supported that the two Tx chains are switched simultaneously for one triggered UL Tx switching.****Proposal:*** *Confirm that Rel-16 and Rel-17 mechanism of Tx switching can be directly reused in Rel-18 UL Tx switching among 3 or 4 bands.** *For dual UL, two UL transmissions that overlap in time triggers only one UL Tx switching.*
* *If the two Tx chains are switched for one triggered UL Tx switching, the UE should be capable to switch both Tx chain simultaneously.*
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| vivo, [3] | Answer: Yes, it is possible that two Tx chains are switched concurrently between two different band pairs and with overlapping switching period. |
| CATT, [4] | **Observation 1:** From the perspective of RAN1, RAN4’s question of ‘two Tx chains are switched concurrently between two different band pairs’ only refer to the case a UE is triggered to perform TX switching for two different band pairs before the start of earlier UL transmissions of ‘switch-to’ band.**Proposal 1:** From RAN1 perspective, when the two Tx chains are switched concurrently between two different band pairs, the switching periods for Tx switching between different band pairs are overlapping and start with the same symbol. |
| ZTE, [5] | ***Proposal 1:*** *If the two Tx chains are triggered to switch between two different band pairs (e.g., band A + band C->band B + band D), and when the two UL transmissions (including both CG PUSCH and DG PUSCH) after TX switching are at least partially overlapped in time domain, UE perform it as one TX switching involving more than 2 bands.** *If the later PUSCH transmission in the two UL transmissions after TX switching is DG PUSCH, UE expects that the DCI scheduling the later PUSCH transmission is no later than the following:*
	+ *Alt.1: T0,1- max {Toffset1, Toffset2}*
		- *Alt.2: the earlier time between {T0,1- Toffset1, T0,2- Toffset2}*
	+ *T0,1 and T0,2 are the start of the earlier transmission and later transmission in the two UL transmissions after TX switching, respectively. Toffset1 and Toffset2 are the corresponding processing time of the earlier UL transmissions and later UL transmission, respectively.*

*Otherwise, UE performs it as two separate Tx switching.* |
| Intel, [6] | **Proposal 1*** From RAN1 perspective, it is possible that the two Tx chains are switched concurrently between two different band pairs and with overlapping switching period.
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| Xiaomi, [7] | **Answer:**Generally speaking, RAN1 thinks it is possible that the two Tx chains are switched concurrently between different band pairs. In RAN1#111 e-meeting, RAN1 achieved the following agreement, which supports UL Tx switching between any two switching cases belonging to 3 bands case and 4 bands case respectively.

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| **Agreement**For dual UL, if UE supports concurrent transmission on all band pairs and supports up to 2 ports UL transmission on all the bands in the band combination, all possible switching cases with 1T-1T and 2T are assumed* In case of 3 bands, 6 switching cases ({2T,0T,0T}, {0T,2T,0T}, {0T,0T,2T}, {1T, 1T, 0T}, {1T, 0T, 1T}, {0T, 1T, 1T}) are assumed
* In case of 4 bands, 10 switching cases ({2T,0T,0T,0T}, {0T,2T,0T,0T}, {0T,0T,2T,0T}, {0T,0T,0T,2T}, {1T,1T,0T,0T}, {1T,0T,1T,0T}, {1T,0T,0T,1T}, {0T,1T,1T,0T}, {0T,1T,0T,1T}, {0T,0T,1T,1T}) are assumed
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Based on the above agreement, the two examples raised by RAN4 have been already supported:* Example #1: In the case of 3-band Tx switching, the switching is performed from 1T+1T on band A and B to 2T on band C. To be specific, RAN1 supports UL Tx switching between {1T, 1T, 0T} and {0T, 0T, 2T}, {1T, 0T, 1T} and {0T, 2T, 0T}, {0T, 1T, 1T} and {2T, 0T, 0T}, which aligns with RAN4’s example.
* Example #2: In the case of 4-band Tx switching, the switching is performed from 1T+1T on band A and B to 1T+1T on band C and D. To be specific, RAN1 supports UL Tx switching between {1T,1T,0T,0T} and {0T,0T,1T,1T}, {1T,0T,1T,0T} and {0T,1T,0T,1T}, {1T,0T,0T,1T} and {1T,0T,0T,1T}, which aligns with RAN4’s example.

Regarding whether the switching period is overlapping or not, RAN1 only specifies the switching period length and the located carrier. The time location of switching period in time domain is up to UE implementation. Therefore, it is possible that the two Tx chains are switched concurrently between two different band pairs and with overlapping switching period. |
| Spreadtrum, [8] | 1. ***RAN1 replies to RAN4 that it is possible that the two Tx chains are switched concurrently between two different band pairs and with overlapping switching period.***
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| Apple, [9] | **Reply to the question:** From RAN1 perspective, for the cases involving switching of the two Tx chains between two different bands (example#1: A(1Tx)+B(1Tx) -> C(2Tx) and example#2: A(1Tx)+B(1Tx) -> C(1Tx)+D(1Tx)), there can be two possibilities:* If a single switching instance is determined for the switching of the two Tx chains, then a single switching period (maximum among the band pairs) is applied, i.e. there is no overlapping switching period. Within that single switching period, whether the two Tx chains switch concurrently between the two different bands pairs or not is a UE implementation.
* If two switching instances are determined for the switching of the two Tx chains, then two corresponding switching periods are applied. The overlap of the two switching periods should not be possible and consequently, the two Tx chains are not switched concurrently between the two different band pairs
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| Qualcomm, [10] | **Observation: the two switching cases in the RAN4 LS are allowed from RAN1 perspective.****Proposal: For the following exemplary switch, the switching gap is summation of the per band pair switching period** * **For the Example #1: In the case of 3-band Tx switching, the switching is performed from 1T+1T on band A and B to 2T on band C, the switching gap is summation of {Tswitch\_A\_C, Tswitch\_B\_C}**
* **For Example #2: In the case of 4-band Tx switching, the switching is performed from 1T+1T on band A and B to 1T+1T on band C and D, the switching gap is summation of {max(Tswitch\_A\_C, Tswitch\_B\_C), max(Tswitch\_A\_D, Tswitch\_B\_D).**
* **Tswitch\_X\_Y is the UE reported switching period for band pair X, Y**
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| OPPO, [11] | ***Proposal 1: To add the following inputs to the reply LS to [1].*** * ***There is no RAN1 agreement that explicitly addresses the possibility of concurrent switching and overlapping switching periods.***
* ***It is worthwhile to note that, although there was assumption of overlapping switching periods in the past RAN1 discussion, the RAN4 LS in R4-2217741 may help to build up that assumption.***
* ***The possibility of concurrent switching and overlapping switching periods may differ among band pairs.***
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| NTT DOCOMO, [12] | **Proposal 1:****RAN1 first needs to agree on following clarifications to reply RAN4 LS*** **When a UE is triggered to perform TX switching between a band pair, and the start of the UL transmission after TX switching is T0, UE uses grants received before T0-Toffset to determine how to perform switching, where Toffset is the UE processing procedure time defined for the uplink transmission triggering.**
	+ **To determine the Toffset which is composed of N2andTswitch*,* the minimum SCS among the downlink carriers where DCI triggers the UL transmission for Tx switching is used as *µDL* and the minimum SCS among the UL carriers after Tx switching is used as *µUL* to determine N2,additionally, the minimum SCS among the UL carriers involved in Tx switching is used as *µUL* to determine Tswitch**
	+ **If the two Tx chains are triggered to switch between two different band pairs (e.g., band A + band C->band B + band D), and when the two UL transmissions after TX switching are at least partially overlapped in time domain, UE perform it as one TX switching involving more than 2 bands**

**Proposal 2:****RAN1 replies to RAN4 question with following feedbacks.*** **In example #1, it is RAN1 understanding that there should be only one UL Tx switching to perform 2T transmission on band C after 1T+1T transmissions on band A and B. The switching period in this case is determined based on maximum of {switching period for band pair A-C, switching period for band pair B-C}.**
* **In example #2, it is RAN1 understanding that whether there is only one Tx switching for two Tx chains or there are two Tx switchings (one switching for each Tx chain) is dependent on the trigger timing (T0, Toffset) and overlap in time domain between two 1T transmissions after two Tx chain switching(s), and RAN1 made following agreement.**
	+ **[When a UE is triggered to perform TX switching between a band pair, and the start of the UL transmission after TX switching is T0, UE uses grants received before T0-Toffset to determine how to perform switching, where Toffset is the UE processing procedure time defined for the uplink transmission triggering.]**
		- **[To determine the Toffset which is composed of N2andTswitch*,* the minimum SCS among the downlink carriers where DCI triggers the UL transmission for Tx switching is used as *µDL* and the minimum SCS among the UL carriers after Tx switching is used as *µUL* to determine N2,additionally, the minimum SCS among the UL carriers involved in Tx switching is used as *µUL* to determine Tswitch]**
		- **[If the two Tx chains are triggered to switch between two different band pairs (e.g., band A + band C->band B + band D), and when the two UL transmissions after TX switching are at least partially overlapped in time domain, UE perform it as one TX switching involving more than 2 bands]**
* **There is another example “Example #3: In the case of 3-band Tx switching, the switching is performed from 2T on band A to 1T+1T on band B and C”, and in example #3, it is RAN1 understanding that whether there is only one Tx switching for two Tx chains or there are two Tx switchings (one switching for each Tx chain) is dependent on the trigger timing (T0, Toffset) and overlap in time domain between two 1T transmissions after two Tx chain switching(s) same as in example #2.**
* **It is also RAN1 understanding that whether UE actually performs concurrent switching on two Tx chains or performs sequential switching on two Tx chains is up to UE implementation as long as switchings on two Tx chains are completed within reported switching period duration in case of one UL Tx switching.**
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1. Discussion

In [1], RAN4 asked the following question to RAN1.

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| **In addition, RAN4 would like to ask RAN1 one question:** From RAN1 perspective, is it possible that the two Tx chains are switched concurrently between two different band pairs and with overlapping switching period? Two examples are given below:* Example #1: In the case of 3-band Tx switching, the switching is performed from 1T+1T on band A and B to 2T on band C.
* Example #2: In the case of 4-band Tx switching, the switching is performed from 1T+1T on band A and B to 1T+1T on band C and D.
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**Moderator comments:** Based on contributions, at least there is common understanding in RAN1 that two example scenarios #1 and #2 mentioned in RAN4 LS are supported from RAN1 perspective. In addition, [12] proposed to add one more example scenario #3 for the completeness to reply to RAN4 question. Moderator would like to ask companies to provide views on proposed clarification on example scenarios related to RAN4 question.

### **Proposal 1**

### **1st round**

In the reply LS to RAN4, RAN1 confirms following three example scenarios related to RAN4 question are supported from RAN1 perspective.

* Example #1: In the case of 3-band Tx switching, the switching is performed from 1T+1T on band A and B to 2T on band C.
* Example #2: In the case of 4-band Tx switching, the switching is performed from 1T+1T on band A and B to 1T+1T on band C and D.
* Example #3: In the case of 3-band Tx switching, the switching is performed from 2T on band A to 1T+1T on band B and C.

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| Company | Comments |
| Xiaomi | We are OK to incorporate example#3 for completeness. |
| Apple | We don’t see the need to include additional examples. In our view, RAN4 provided examples to RAN1 just for our better understanding of the issue.  |
| NTT DOCOMO | We agree with Proposal 1 that all 3 example scenarios are supported from RAN1 perspective according to RAN1 discussion/agreements so far.We are proposing to add Example #3 for completeness as this scenario also relates to the question. Actually, we checked with RAN4 FL via offline and they confirmed Example #3 is also related to the question and hence they prefer to include example #3 in our reply. |
| MediaTek | We don’t see a need to include examples in the response. The reply to RAN4 question could be as follows:“*Yes, from RAN1 specifications perspective, it is possible that the two Tx chains are switched concurrently between two different band pairs and with overlapping switching period*”. |
| Vivo | it is ok to support example#3. |
| ZTE | We are ok to include the example#3 in the reply LS. |
| Ericsson | We are OK to include Example#3 in reply LS. Considering DCM explanations, not only there is no harm to include Example#3, but it is helpful as well.  |
| Qualcomm | We are ok to include the additional example and the above wording. |
| Nokia, NSB | We are OK to just confirm the RAN4 view along the lines suggested by MediaTek, or convey all the three examples as outlined by the moderator. |
| LGE | We have no strong view on whether to include examples in the reply. However, as commented by MediaTek, we think it is sufficient to reply only the possibility of concurrent switching of two Tx chains between two different band pairs and with overlapping switching period.  |
| OPPO | Though we are fine to confirm with 3 examples, our understanding is that the RAN4 LS does not ask for such confirmation.  |

### **2nd round**

**Moderator comments:** It seems majority companies are fine to include example#3. As explained by DOCOMO, there is no harm to include example#3, while it would be helpful to RAN4 for better understanding. I hope Apple and MediaTek can accept it. So proposal 1 is kept as it is.

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| Company | Comments |
| Apple2 | Although, we still don’t think it is needed to add more examples, but we can accept majority’s view to include example#3 |
| CATT | We are ok to include example#3 in reply LS.  |
| MediaTek | We still have issue with the direction of this discussion, it is going beyond answering RAN4 questions.  |

**Moderator comments:** Regarding RAN4’s question “is it possible that the two Tx chains are switched concurrently between two different band pairs and with overlapping switching period?”. It seems it is related to the issue on ambiguity between one Tx switching and two Tx switchings which has been discussed extensively in past RAN1 meetings. The latest proposal in [14] is as follows.

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| * When a UE is triggered to perform TX switching between a band pair, and the start of the UL transmission after TX switching is T0, UE uses grants received before T0-Toffset to determine how to perform switching, where Toffset is the UE processing procedure time defined for the uplink transmission triggering.
	+ - To determine the Toffset which is composed of N2andTswitch*,* the minimum SCS among the downlink carriers where DCI triggers the UL transmission for Tx switching is used as *µDL* and the minimum SCS among the UL carriers after Tx switching is used as *µUL* to determine N2,additionally, the minimum SCS among the UL carriers involved in Tx switching is used as *µUL* to determine Tswitch
		- If the two Tx chains are triggered to switch between two different band pairs (e.g., band A + band C->band B + band D), and when the two UL transmissions after TX switching are at least partially overlapped in time domain, UE perform it as one TX switching involving more than 2 bands
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**Moderator comments:** According to the discussion in [14], whether there is only one Tx switching for two Tx chains or there are two Tx switchings (one switching for each Tx chain) is dependent on the timeline and overlap in time domain between two 1T transmissions after two Tx chain switching(s), while the timeline may also include a couple of factors such as T0, Toffset, CG or DG, maximum or summation of the switching periods based on the contributions summarized in section 2. As per the following guidance from Chair, the discussion on potential RAN1 specification impact will be handled in agenda item 9.18, while we will focus on the answer to RAN4 question in agenda item 5.

The discussion on potential RAN1 specification impact to be handled under the email discussion(s) on draft CR(s) for Rel-18 MC-Enh in agenda item 9.18. For the RAN4 questions to RAN1, to be handle in agenda item 5.

**Moderator comments:** Then, looking back at the RAN4 question, RAN4 is asking the possibility of concurrent switching of two Tx chains between two different band pairs. For Example #1, it seems companies acknowledge that there is only one Tx switching, since 2 Tx chains are on the same band after Tx switching. For Example #2, whether there is one Tx switching or two Tx switchings will be discussed in agenda item 9.18. It seems companies acknowledge that one Tx switching is regarded as long as conditions are met, e.g., timeline, overlap in time domain. Example #3 is similar with Example #2. If there is one Tx switching, UE can perform concurrent switching of two Tx chains. Some companies may argue that if there is sufficient time between end of the transmission on switch-from bands (A and B) and start of the transmission on switch-to band (C), it may be possible UE implementation to perform switching on one Tx chain first and then perform switching on another Tx chain. But it does not preclude the possibility of concurrent switching of two Tx chains asked by RAN4.

Regarding the “with overlapping switching period” in RAN4 question, from moderator understanding, it refers to switching periods for different band pairs reported by UE. If there is only one Tx switching, the effective switching period is derived based on the following LS from RAN4. The concurrent switching of two Tx chains between two different band pairs can be performed during an effective switching period derived by switching periods for different band pairs reported by UE.

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| **LS** **R1-2300029/** **R4-2220548****Issue 2: Ambiguity issue when two Tx chains are switched between two different band pairs**For Rel-18 UL Tx switching among 4 bands, when switching from 1T+1T on band A and B to 1T+1T on band C and D is performed, and it is not clear whether UE performs Tx switching {from band A to C + B to D} or {from band A to D + B to C}, RAN4 agreed that:* As baseline UE assumption, no need to resolve the ambiguity issue of the switching pattern for each Tx chain and determine the switching gap based on the worst case by default, i.e., neither of the two Tx chains is expected to be used for transmission during the maximum of the four switching periods, i.e., max {Tswitch\_A-C, Tswitch\_B-D, Tswitch\_A-D, Tswitch\_B-C}.

Note: Tswitch\_A-C, Tswitch\_B-D, Tswitch\_A-D, Tswitch\_B-C are the switching periods reported by the UE for band pair A&C, B&D,A&D and B&C, respectively. |

**Moderator comments:** Note that RAN4 is discussing advanced UE capability that UE is capable of uplink transmission during the time period of longer switching period minus shorter switching period for the band pair with shorter switching period [15]. Then ,whether the concurrent switching of two Tx chains between two different band pairs can be performed during overlapping switching periods for different band pairs reported by UE, e.g., advanced UE capability, is up to RAN4.

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| **Issue 1-4-3 in [15]:**Time mask for one transmitter switching between band X and band Z, and between band Y and band Z, where UE is capable of uplink transmission on band Y during time period of {switching period #1 - switching period #2}, i.e., the UE indicates [*TBD-1*] in the capability [*TBD tx-on-non-affected-band*] |

### **Proposal 2**

### **1st round**

In the reply LS to RAN4, the answer to RAN4 question is as follows:

* RAN1 confirms that it is possible that the two Tx chains are switched concurrently between two different band pairs for the following three examples.
	+ Example #1: In the case of 3-band Tx switching, the switching is performed from 1T+1T on band A and B to 2T on band C.
	+ Example #2: In the case of 4-band Tx switching, the switching is performed from 1T+1T on band A and B to 1T+1T on band C and D.
	+ Example #3: In the case of 3-band Tx switching, the switching is performed from 2T on band A to 1T+1T on band B and C.
* It is RAN1 understanding it is possible that the concurrent switching of two Tx chains between two different band pairs can be performed during an effective switching period derived by switching periods for different band pairs reported by UE according to RAN4 LS [R1-2300029/R4-2220548].
	+ Whether the concurrent switching of two Tx chains between two different band pairs can be performed during overlapping switching periods for different band pairs reported by UE, e.g., subject to different UE capability, is up to RAN4.
* The conditions of concurrent switching of two Tx chains between two different band pairs are still under discussion in RAN1.

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| Company | Comments |
| Xiaomi | Support. What RAN1 needs to is to directly reply the questions from RAN4. The detailed discussion happening in RAN1 is no necessarily to be provided in the LS to RAN4. |
| Apple | A few comments on the proposal* + First, as commented in proposal 1, we suggest removing Example#3
	+ Second, it is not fully clear what “effective switching period” means here. At least in our understanding, this refers to the case of single switching instance, in which case, a single switching period is applied.
	+ Third, not sure about the sub-bullet. If the intention here is talk about the case of two switching instances, then in our view, there should not be concurrent switching. We would be okay to remove this sub-bullet
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| NTT DOCOMO | We are fine with moderator’s proposal that detailed conditions for the case with one UL Tx switching period (single switching instance in Apple’s wording) for both of two Tx chains are discussed separately in AI 9.18 while reply LS to RAN4 answers to the question with assuming such single switching instance case.* Regarding Apple’s second and third comments: As described above, we have same understanding with second comment that the proposal is focusing on single switching instance case. Regarding third comment, our understanding on sub-bullet of second main bullet is that this is also about single switching instance case and it is about the issue 1-4-3 in [15] (as figure that moderator captured above) where UE with advanced capability may or may not be able to perform transmission on one Tx chain associated with band pair requiring shorter switching period during the (longer) switching period which is required for another band pair associated with another Tx chain. We also think current wording of the sub-bullet is a bit confusing and FL’s intention may not be clearly reflected.

It seems all companies consider concurrent switching of two Tx chains is “possible”, and Proposal 2 saying “can be performed” would be ok in that sense. However, according to the contributions, we think companies have different views on whether performing concurrent switching of two Tx chains is “required (i.e., necessary)” at least in some case or not. If RAN1 answer is just “it is possible and can be performed”, we are not sure if the answer is sufficient for RAN4. If just “possible” or not is sufficient for RAN4, we are fine with the proposed answer. However, the clarification on whether it is “required” or not may have impact on switching gap duration determination. In our understanding, if RAN1 can agree that it is “required” to perform concurrent switching of two Tx chains in particular cases, it is aligned with RAN4 agreement on switching gap duration determination in case of Tx switching between different band pairs (i.e., the switching gap duration in the case is determined as maximum of reported switching periods for possible switching band pairs). However, if RAN1 cannot agree on it and it is “possible” but not “required” to perform concurrent switching of two Tx chains even in those particular cases, we should inform it to RAN4 and the switching gap duration determination in case of Tx switching between different band pairs needs to be re-discussed (e.g., as Qualcomm proposed, it should be summation instead of maximum if sequential switching of two Tx chains within one switching period is allowed). |
| MediaTek | RAN1 should focus on answering the question from RAN4 without deliberation on the reasons “why RAN4 asked this question”.RAN4 question is very clear: “***From RAN1 perspective, is it possible that the two Tx chains are switched concurrently between two different band pairs and with overlapping switching period?***”Thus, the discussion should be on answering the above question, Yes or No. The reply to RAN4 question should be as follows: “***Yes, from RAN1 specifications perspective, it is possible that the two Tx chains are switched concurrently between two different band pairs and with overlapping switching period***”. |
| vivo | RAN4 LS was initiated by the discussion in R4-2303693 of whether two separate TX switching as depicted in the figure below should be **always allowed** for the two TX chains when switching is triggered between two band pairs, and whether **a longer switching gap**(e.g. a switching gap with a length of the ‘no transmission block’ in the figure, which can be longer than switching period 1 and switching period 2) must be guaranteed for accommodate to such TX switching operation. RAN4 didn’t reach a conclusion and anticipated that further agreements from RAN1/2 will facilitate further discussion.**Way forward:*** Further discuss whether and how to cover the following scenario based on the RAN1/2 further agreement.

As pointed out by several companies, whether the two TX chain can be switched concurrently is also related to the issue on ambiguity between one Tx switching and two Tx switching. When UE determines to perform one TX switching, there will be only one switching period. **At least for this case, there is no need to have longer switching gap, and UE should complete the switching in the switch perioding defined by RAN4 LS [R1-2300029/R4-2220548]**. It is necessary to clarify the conditions under which one TX switching should be performed as it will help to facilitate the discussion in RAN4. But as DCM commented, just saying ‘it is possible’ but not clarifying ‘when is required’ may not help in resolving this issue as initially hoped.Additionally, according to the chairman's instructions, the discussion on 9.18 is now focusing on reviewing draft CR and RRC list, there are currently no plans to discuss this issue. To stay within the scope, it is recommended that the conditions for one TX switching be clarified in this agenda. If the conditions can be agreed, the corresponding spec change can be handled in 9.18 separately. And the other details such as the timeline can be further later.In our understanding, it is ‘required’ that example#1 should be performed as one TX switching as the two band pairs share the same target band. While for example#2/3, if when the two UL transmissions after TX switching are at least partially overlapped in time domain, UE should perform it as one TX switching involving more than 2 bands. Otherwise, there will be unnecessary resource waste and interruption.Our 2nd comment i*s* about ‘can be performed during an effective switching period’, our understanding is that UE should complete the switching in the derived switching period. If the group can quickly converge on the proposal on one or two TX switching from previous meeting (‘[**When a UE is triggered****to perform TX switching between a band pair, and the start of the UL transmission after TX switching is T0**….]’), we think it would be beneficial to include the proposal as part of the reply LS to provide a full picture on how RAN1 understands concurrent switching (i.e. conditions of one TX switching). If not possible, we suggest at least the following revisions to clarify when it is necessary from RAN1’s view to perform concurrent switching:* RAN1 confirms ~~that it is possible~~ that the two Tx chains are switched concurrently between two different band pairs for the following three examples when UE determines to perform only one TX switching involving more than 2 bands
	+ Example #1: In the case of 3-band Tx switching, the switching is performed from 1T+1T on band A and B to 2T on band C.
	+ Example #2: In the case of 4-band Tx switching, the switching is performed from 1T+1T on band A and B to 1T+1T on band C and D.
	+ Example #3: In the case of 3-band Tx switching, the switching is performed from 2T on band A to 1T+1T on band B and C.
* For Example#1: it is RAN1 understanding that there should be only one UL Tx switching involving 3 bands
* For Example #2: it is RAN1 understanding that UE performs only one TX switching involving 4 bands if the two UL transmissions after TX switching are at least partially overlapped in time domain.
* For Example#3: it is RAN1 understanding that UE performs only one TX switching involving 3 bands if the two UL transmissions after TX switching are at least partially overlapped in time domain.
* It is RAN1 understanding it is possible that the concurrent switching of two Tx chains between two different band pairs ~~can~~ should be ~~performed~~ completed during an ~~effective~~ switching period derived by switching periods for different band pairs reported by UE according to RAN4 LS [R1-2300029/R4-2220548]
	+ Whether the concurrent switching of two Tx chains between two different band pairs can be performed during overlapping switching periods for different band pairs reported by UE, e.g., subject to different UE capability, is up to RAN4.
* The ~~conditions~~ details(e.g. timeline including T0 and Toffset) of concurrent switching of two Tx chains between two different band pairs are still under discussion in RAN1.
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| ZTE | We are generally fine with the moderator’s proposal. Meanwhile, we also sympathize with NTT and vivo that it would be helpful if RAN1 can provide more info for RAN4 regarding the determination of one or two switching periods. Basically, we share similar view as vivo:* For example#1: Only one Tx switching instance is needed;
* For example#2 and example#3: Only one Tx switching instance is needed if the two 1-port transmissions after switching period are overlapped.
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| Ericsson | We are also fine with Moderator proposal. Similarly to others, we also think DCM raises valid points and if input from RAN1, can help RAN4 discussion we are supportive of including those information in the LS. |
| Qualcomm | Thanks for the FL’s proposal but we have following comments* For 1st bullet, we suggest removing “concurrently” as whether the switching is sequentially or concurrently highly replies on the UE implementation. UE may or may not switch “concurrently” for certain band pairs combination.
* For 2nd bullet, we don’t think RAN4 LS [R1-2300029/R4-2220548] (below) could derive the possibility of concurrent switching or not, as the LS clearly say this is ambiguous. We suggest removing this bullet as RAN4 is with better knowledge than us on how they get the following conclusion.

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| **Issue 2: Ambiguity issue when two Tx chains are switched between two different band pairs**For Rel-18 UL Tx switching among 4 bands, when switching from 1T+1T on band A and B to 1T+1T on band C and D is performed, and it is not clear whether UE performs Tx switching {from band A to C + B to D} or {from band A to D + B to C}, RAN4 agreed that:* As baseline UE assumption, no need to resolve the ambiguity issue of the switching pattern for each Tx chain and determine the switching gap based on the worst case by default, i.e., neither of the two Tx chains is expected to be used for transmission during the maximum of the four switching periods, i.e., max {Tswitch\_A-C, Tswitch\_B-D, Tswitch\_A-D, Tswitch\_B-C}.

Note: Tswitch\_A-C, Tswitch\_B-D, Tswitch\_A-D, Tswitch\_B-C are the switching periods reported by the UE for band pair A&C, B&D,A&D and B&C, respectively. |

* For the last bullet, we agree with Apple and others that the ongoing discussion is on 1 or 2 switching instance(s) which is not relevant to the concurrent or sequential switching.
 |
| Nokia, NSB | We’d be fine with the original moderator proposal, but if it is controversial, maybe the simple answer suggested by MediaTek could be more easily agreeable. |
| LGE | Among three main bullets in this proposal, it seems only the 1st main bullet is directly related to the question from RAN4. Not sure if the 2nd and 3rd main bullets are the information required by RAN4. |
| OPPO | We have a bit concern on translating the tone of “it is possible for a Tx switch to behave like what” into “the Tx switch shall/should behave like what in a specific example”. If UE behavior has to be quite specific under a given condition, this behavior needs to be in RAN1 specification, which however is not the case in R18 CR for MC.  |

### **2nd round**

**Moderator comments:**

@DOCOMO, for the last comment about “possible” or “required”, I understand it would be better if we can provide deterministic answer to RAN4 instead of “possibility”. However, as you mentioned that, it is related to the summation of switching periods proposed by Qualcomm. In my understanding, RAN4 is discussing the summation of switching periods for different band pairs as optional UE capability. It’s better up to RAN4 to make decision. Regarding whether “possible” is sufficient for RAN4, I discussed with my RAN4 colleague (moderator in RAN4), the answer of “possible” would also be helpful for RAN4 discussion.

@vivo, as explained above, I agree with you it would be great if we would handle everything. But different companies have different understandings. Chair’s guidance is “The discussion on potential RAN1 specification impact to be handled under the email discussion(s) on draft CR(s) for Rel-18 MC-Enh in agenda item 9.18”. We have to be realistic. At least Qualcomm has different understanding on the switching period even for single Tx switching instance.

@Qualcomm, we cannot remove “concurrently”, since RAN4 is asking the possibility of concurrent switching of two Tx chains. In my understanding, RAN4 is discussing the summation of switching periods for different band pairs as optional UE capability, which means the baseline assumption is concurrent switching according to RAN4 LS [R1-2300029/R4-2220548]. We cannot remove the 2nd main bullet either. 1st main bullet only answers the question of possibility of concurrent switching, but does not answer the question of overlapping switching period, which is the intension of 2nd main bullet. I understand that UE may have different capability. As explained above, we are talking about the possibility of concurrent switching. If there is the case that UE can perform concurrent switching, then the possibility exists. But it is does not preclude UE can report longer switching period and perform sequential switching.

@LGE, as explained to Qualcomm, 1st main bullet answers the question of possibility of concurrent switching, while 2nd main bullet answers how to handle the switching period when concurrent switching is performed. Since we provide the answer of possibility to RAN4 while detailed information still needs discussion in RAN1as pointed out by other companies which is related to the possibility, e.g., the ambiguity issue between one Tx switching and two Tx switchings.

@all, I agree with companies that it would be better to convey more information to RAN4. I also agree that it would be great if we can handle the ambiguity issue between one Tx switching and two Tx switchings in this agenda item. However, RAN4 is asking the possibility of concurrent switching of two Tx chains. First of all, we have to answer RAN4 question. It is not a good practice to mix everything together. I think from RAN4 perspective, it’s better to receive RAN1 feedback than nothing. Some revisions are made based on companies’ comments.

* “one Tx switching instance” is added in the main bullet.
* Regarding “effective switching period”, if it is confusing, we can change it to “a single switching period” as suggested by Apple.
* As for the sub-bullet of the second main bullet, it is about the issue 1-4-3 in [15] where UE with advanced capability as explained by DOCOMO. If it is confusing, we can delete it.
* “conditions” is changed to “details” in the last main bullet suggested by vivo.

**Moderator comments:** It seems RAN1 and RAN4 may have different understanding of concurrent Tx switching, and companies may have different understanding of concurrent Tx switching, either. I would like to check companies’ understanding. There are two cases:

Case #1: Two Tx chains are switched between two different band pairs simultaneously for one Tx switching instance during a single switching period derived by switching periods for different band pairs reported by UE.

Case #2: Two Tx chains are switched between two different band pairs sequentially for one Tx switching instance during a single switching period derived by switching periods for different band pairs reported by UE.

RAN4 is considering case #2 as kind of concurrent Tx switching. Companies are encouraged to provide comments whether both case #1 and case #2 can be regarded as concurrent Tx switching or it’s up to RAN4 to decide.

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| Company | Comments |
| ZTE | From RAN1 perspective, the key issue is the number and length of the switching period. As long as it is one switching period and the length of the switching is clear, it doesn’t matter whether UE performs the Tx switching simultaneously or sequentially.From this perspective, we tend to believe that this issue is better to be left to RAN4. |
| Apple2 | We tend to share similar view as ZTE. We need to agreed on RAN1 under what conditions, there is single switching period and under what conditions there are two switching periods. Then exactly how UE performs switching within those switching periods is UE implementation. |
| CATT | Our understanding is that Two Tx chains are switched between two different band pairs for one TX switching during a single switching period derived by switching periods for different band pairs reported by UE. Whether UE performs the two TX chains switching simultaneously or sequentially during a single switching period is up to UE implementation. Since RAN4 has defined the switching period of two TX chains switching as the maximum of the four switching periods, i.e. max{ Tswitch\_A-C, Tswitch\_B-D, Tswitch\_A-D, Tswitch\_B-C } to ensure sufficient switching time to accommodate the worst case.  |
| vivo | Similar view as ZTE, if UE can complete switching of two TX chains in one single switching period determined according to [R1-2300029/R4-2220548], it does not matter whether UE performs the Tx switching simultaneously or sequentially.What NW can see is, 1) switching period reported for each band pairs. What NW can assume is that 2) the TX switching will be done within a switching gap that is equal to the largest switching period determined according to [R1-2300029/R4-2220548] is needed to avoid UL interruption due to switching.  |
| Huawei, HiSilicon | As long as no additional UL interruption compared to the existing agreements, it is up to UE implementation to choose simultaneous or sequential retuning of Tx chain. Since no new UL interruption, then no need to introduce new UE capability as least from RAN1 perspective. |
| NTT DOCOMO | Thanks moderator for the comments and checking with RAN4 FL!Regarding case #1 and #2, we think both should be allowed as up to UE implementation at least when there is a sufficient time gap between end of transmission before switching and start of transmission after switching. But when there is no sufficient time gap between end of transmission before switching and start of transmission after switching i.e., “concurrent Tx switching” should be performed within the reported switching period according to RAN4 agreement in LS [R1-2300029/R4-2220548], we are not sure whether Case #2 is possible. For example, assuming that UE reports switching period as 140us for band pair A-B and 140 us for band pair A-C, when the UE performs “concurrent Tx switching” from 2T on A to 1T+1T on B+C, the allowed switching period would be max(140, 140) = 140 us if there is no sufficient gap between end of transmission on A and start of transmission on B+C (e.g., same start timing for B+C). In this case, UE may or may not be able to perform Case #2 within 140 us (as worst case, UE may require 140+140 = 280 us for Case #2) while Case #1 within 140 us should be possible. According to moderator’s explanation (and also our internal checking with our RAN4 colleague), as it is under RAN4 discussion that whether such UE implementation (based on Case #2) and corresponding switching period determination (such as summation instead of maximum or adding new switching period values) are allowed as optional or not, we are fine to leave this issue to RAN4. |
| Qualcomm | Thanks to FL for the explanation.As the majority agrees the three example cases are allowed from RAN1 perspective, we agree with others that most important issue is the within single switching period UE could complete the two different band pairs switch. Whether the switching is either simultaneous or sequenctial, it would be up to UE implementation. Our understanding “concurrent” equals to “simultaneous” as both of them means at the same time, which is also pointed out by vivo below. As FL mentioned above “It seems RAN1 and RAN4 may have different understanding of concurrent Tx switching”, to avoid ambiguty between RAN1 and RAN4, and explicitly allow both UE implementations, we would suggest to remove “concurrently” and clarify RAN1 considered two cases. Our detail proposal is in the next response. |

**Proposal 2-v2:**

In the reply LS to RAN4, the answer to RAN4 question is as follows:

* RAN1 confirms that it is possible that the two Tx chains are switched concurrently between two different band pairs for one Tx switching instance for the following three examples.
	+ Example #1: In the case of 3-band Tx switching, the switching is performed from 1T+1T on band A and B to 2T on band C.
	+ Example #2: In the case of 4-band Tx switching, the switching is performed from 1T+1T on band A and B to 1T+1T on band C and D.
	+ Example #3: In the case of 3-band Tx switching, the switching is performed from 2T on band A to 1T+1T on band B and C.
* It is RAN1 understanding it is possible that the concurrent switching of two Tx chains between two different band pairs can be performed during a single switching period derived by switching periods for different band pairs reported by UE according to RAN4 LS [R1-2300029/R4-2220548].
	+ [Whether two Tx chains are switched simultaneously or sequentially for one Tx switching instance during the single switching period is up to RAN4.]
* The details of concurrent switching of two Tx chains between two different band pairs are still under discussion in RAN1.

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| Company | Comments |
| ZTE | We are generally fine with this proposal. Regarding the last bullet, can we add some examples for it, otherwise RAN4 may assume RAN1 will take care all the remaining issues for concurrent switching of two Tx chains. However, from our perspective, RAN1 may only handle the potential timeline issue.* The details of concurrent switching of two Tx chains between two different band pairs are still under discussion in RAN1, e.g., timeline for triggering concurrent switching of two Tx chains within one switching period.
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| Apple2 | In principle, we are fine with proposal. However, for the sub-bullet in square brackets, in our view, it is up to UE implementation how they actual perform switching within a single switching period. So we would prefer to update the bullet to “ up to UE implementation” and remove square brackets.Also, we are fine with ZTEs updates |
| CATT | We suggest removing ‘possible’ for the second bullet. The current description seems like, in RAN1 understanding, it’s also allowed that a concurrent switching of two Tx chains between two different band pairs can be performed during two different single switching periods. But we don’t think it is a common understanding in RAN1.  |
| FL | CATT’s comments on removing ‘possible’ for the second bullet seems reasonable. I would like to ask companies to check whether the second main bullet and its sub-bullet can be revised as follows based on Apple and CATT’s comments.* It is RAN1 understanding that the concurrent switching of two Tx chains between two different band pairs can be performed during a single switching period derived by switching periods for different band pairs reported by UE according to RAN4 LS [R1-2300029/R4-2220548].
	+ Whether two Tx chains are switched simultaneously or sequentially for one Tx switching instance during the single switching period is up to UE implementation.
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| vivo | Thank you FL for the updates and reply. We may need some clarificationsOur understanding is that: ‘concurrent switching of two Tx chains’ is equivalent to ‘simultanous switching of two TX chains’, ‘One TX switching instance’ at least includes ‘simultanous switching of two TX chains’, but whether it includes ‘sequential switching of 2TX chains’ is up to RAN4, is this correct understanding? If yes, it seems that the ‘concurrent switching of two Tx chains’ in the last bullet should be changed to ‘One TX switching instance’, otherwise, it seems that we are expecting different conditions to be defined for sequential switching and simultaneous switching if sequential switching is confirmed to be supported in a single switching period by RAN4. As we commented above, whether sequential switching or simultaneous switching is performed by UE may be transparent, RAN1 only needs to define under what conditions, there is single switching period.We also support the revisions from ZTE and prefer to add ‘conditions’ in the last bullet since the ‘it is RAN1 understanding that UE performs only one TX switching….. if the two UL transmissions after TX switching are at least partially overlapped in time domain.’ in our proposal are removed and thus need FFS* RAN1 confirms that it is possible that the two Tx chains are switched concurrently between two different band pairs for one Tx switching instance for the following three examples.
	+ Example #1: In the case of 3-band Tx switching, the switching is performed from 1T+1T on band A and B to 2T on band C.
	+ Example #2: In the case of 4-band Tx switching, the switching is performed from 1T+1T on band A and B to 1T+1T on band C and D.
	+ Example #3: In the case of 3-band Tx switching, the switching is performed from 2T on band A to 1T+1T on band B and C.
* It is RAN1 understanding that the concurrent switching of two Tx chains between two different band pairs can be performed during a single switching period derived by switching periods for different band pairs reported by UE according to RAN4 LS [R1-2300029/R4-2220548].
	+ Whether two Tx chains are switched simultaneously or sequentially for one Tx switching instance during the single switching period is up to UE implementation.
* The details of ‘one TX switching instance’ of two Tx chains between two different band pairs are still under discussion in RAN1, e.g., timeline and conditions for triggering one TX switching instance of two Tx chains within one switching period.
 |
| Huawei, HiSilicon | We agree that the second main bullet is important and should be kept. Otherwise, it may mislead RAN4 that additional UL interruption can be allowed for a baseline UE (also applicable to the optional capability introduced by RAN4 for no UL interruption to the other band). The agreement in RAN4 LS R1-2300029 clearly set the maximum switching period required for a switching between band A+B and band C+D and it should be respected.Regarding the subbullet of the second main bullet, no additional UL interruption is very important since it costs performance loss. A change is suggested,* + On condition that no new additional UL interruption to be specified for all Rel-18 UL Tx switching UEs, whether two Tx chains are switched simultaneously or sequentially for one Tx switching instance during the single switching period is up to UE implementation.

For the third main bullet, it seems too broad and may be misinterpreted that such switching is completely new and has many issues to solve in RAN1. We suggest a change to clarify it as the conditions for a valid triggering of UL Tx switching with two Tx chains, which can include timeline, overlapping condition and other conditions for valid switching’s that are being raised in RAN1. * The conditions of a valid triggering ~~details~~ of concurrent switching of two Tx chains between two different band pairs are still under discussion in RAN1.
 |
| NTT DOCOMO | As in above our comment, we are basically fine with the moderator’s proposal to provide some answer without solving all details if it is helpful for RAN4 discussion. However, we think current proposal is still confusing. The proposal is saying that “concurrent switching is possible” in second main bullet, “whether two Tx chains are switched simultaneously or sequentially is up to UE implementation” in sub-bullet, and “details of concurrent switching are still under discussion in RAN1” in the last main bullet. So, it would be easy for companies in RAN4 to question that what is actually possible based on such RAN1 reply. Therefore, at least some wording updates would be necessary to avoid such potential confusion. Following is our suggested version based on moderator’s proposal.* RAN1 confirms that it is possible that the two Tx chains are switched concurrently between two different band pairs in one Tx switching instance for the following three examples.
	+ Example #1: In the case of 3-band Tx switching, the switching is performed from 1T+1T on band A and B to 2T on band C.
	+ Example #2: In the case of 4-band Tx switching, the switching is performed from 1T+1T on band A and B to 1T+1T on band C and D.
	+ Example #3: In the case of 3-band Tx switching, the switching is performed from 2T on band A to 1T+1T on band B and C.
* It is RAN1 understanding that the concurrent switching of two Tx chains between two different band pairs can be performed during a single switching period derived by switching periods for different band pairs reported by UE according to RAN4 LS [R1-2300029/R4-2220548].
	+ It is RAN1 understanding that there are following two possible cases of concurrent Tx switching of two Tx chains in one Tx switching instance, and whether case #2 is possible with switching period determination based on RAN4 agreement in LS [R1-2300029/R4-2220548] or not is up to RAN4.
		- Case #1: Two Tx chains are switched between two different band pairs **simultaneously** for one Tx switching instance during a single switching period derived by switching periods for different band pairs reported by UE.
		- Case #2: Two Tx chains are switched between two different band pairs **sequentially** for one Tx switching instance during a single switching period derived by switching periods for different band pairs reported by UE.

RAN1 is discussing some details on example scenarios, including under which conditions one Tx switching instance is provided for concurrent Tx switching of two Tx chains. |
| MediaTek | We are not fine with the proposed reply. As we mentioned in our initial response, RAN1 should focus on answering the question from RAN4 without deliberation on the reasons “why RAN4 asked this question”.Thus, the discussion should be on answering the above question, Yes or No. The reply to RAN4 question should be as follows: “***Yes, from RAN1 specifications perspective, it is possible that the two Tx chains are switched concurrently between two different band pairs and with overlapping switching period***”. |
| Qualcomm | In general, we think the sub-bullets under second major bullet clearly clarify the switch cases in our mind and the term “concurrent” is not accurate or needed. Among above proposals, we prefer DoCoMo’s version with removing “concurrent” which is explained in our above response.* RAN1 confirms that it is possible that the two Tx chains are switched ~~concurrently~~ between two different band pairs in one Tx switching instance for the following three examples.
	+ Example #1: In the case of 3-band Tx switching, the switching is performed from 1T+1T on band A and B to 2T on band C.
	+ Example #2: In the case of 4-band Tx switching, the switching is performed from 1T+1T on band A and B to 1T+1T on band C and D.
	+ Example #3: In the case of 3-band Tx switching, the switching is performed from 2T on band A to 1T+1T on band B and C.
* It is RAN1 understanding that the ~~concurrent~~ switching of two Tx chains between two different band pairs can be performed during a single switching period derived by switching periods for different band pairs reported by UE according to RAN4 LS [R1-2300029/R4-2220548].
	+ It is RAN1 understanding that there are following two possible cases of ~~concurrent~~ Tx switching of two Tx chains in one Tx switching instance, and whether case #2 is possible with switching period determination based on RAN4 agreement in LS [R1-2300029/R4-2220548] or not is up to RAN4.
		- Case #1: Two Tx chains are switched between two different band pairs **simultaneously** for one Tx switching instance during a single switching period derived by switching periods for different band pairs reported by UE.
		- Case #2: Two Tx chains are switched between two different band pairs **sequentially** for one Tx switching instance during a single switching period derived by switching periods for different band pairs reported by UE.

RAN1 is discussing some details on example scenarios, including under which conditions one Tx switching instance is provided for ~~concurrent~~ Tx switching of two Tx chains. |
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1. Reference
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3. R1-2302386 Discussion on UL Tx switching across 3 or 4 bands in Rel-18 Huawei, HiSilicon
4. R1-2302446 Draft LS reply on Rel-18 Multi-carrier enhancement for NR vivo
5. R1-2302639 Discussion on RAN4 LS on Rel-18 Multi-carrier enhancement for NR CATT
6. R1-2302754 [Draft] Reply LS on Rel-18 Multi-carrier enhancement for NR ZTE
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8. R1-2302955 [Draft] Reply LS on Rel-18 Multi-carrier enhancement for NR xiaomi
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10. R1-2303462 Draft reply LS to RAN4 on Rel-18 multi-carrier enhancements for NR Apple
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12. R1-2303629 Discussion on RAN4 LS for multi-carrier enhancement OPPO
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14. R1-2303856 Draft reply LS on UL Tx switching across 3 or 4 bands in Rel-18 Huawei, HiSilicon
15. R1-2302221 Summary#3 of discussion on multi-carrier UL Tx switching scheme Moderators (NTT DOCOMO, INC.)
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