3GPP TSG RAN WG1 #100bis R1-20xxxxx

**e-Meeting, April 20th – 30th, 2020**

**Agenda item: 5.1**

**Source: Moderator (China Telecom)**

**Title: [100b-e-LS-TxSwitching-02] Email discussion/approval of the remaining issues for inter-band UL CA**

**Document for: Discussion and Decision**

# Introduction

In [1], open issues are summarized for uplink Tx switching from RAN1 perspective. As per the guidance of Chairman, following issues are identified for email discussion/approval during RAN1 #100bis e-meeting:

[100b-e-LS-TxSwitching-01] Email approval of the reply LS for [R1-2001522](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_100b%5CDocs%5CR1-2001522.zip) by 4/24 under AI 5.1 (CT/Apple, Jianchi/Chunhai)

* Discussion on potential RAN1 specification impact.
* Reply LS to RAN4

[100b-e-LS-TxSwitching-02] Email discussion/approval of the remaining issues for inter-band UL CA

* Mapping between UL transmission ports and Tx chain
* Switching mechanism
* Support of codebook based PUSCH transmission.

till 4/27, and the corresponding TPs if any by 4/30 (CT, Jianchi)

[100b-e-LS-TxSwitching-03] Email discussion/approval of the remaining issues for SUL, EN-DC and other general issues

* How to capture the additional time for PUSCH preparation procedure
* Whether additional preparation time is needed for other UL channels/signals
* UE behaviour in switching period
* Twisted-order scheduling/observation period
* For EN-DC, mapping between UL transmission ports and Tx chain, TDM pattern, switching mechanism, handling of transmission collision between 1Tx transmission in LTE and 2Tx transmission in NR.
* Whether more than two uplink carriers can be supported.

till 4/27, and the corresponding TPs if any by 4/30 (CT, Jianchi)

[100b-e-LS-TxSwitching-04] Email approval of TP capturing RAN1#100-e’s agreements regarding UL Tx switching (04/27-04/29) – Jianchi (CT)

This is email discussion thread #2 to discuss remaining issues for inter-band UL CA.

# Discussion on remaining issues for inter-band UL CA

## Issue #1: Mapping between UL transmission ports and Tx chain

**Proposal: Confirm the working assumption:**

**Working Assumption:**

* For inter-band UL CA, if option 2 is supported, the following sub-option 2-3 is defined.
	+ Minimize RAN1 impact
	+ No new RAN4 impact
	+ No new TDM pattern

Option 2-3

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

Companies are invited to provide views on whether the above work assumption can be confirmed.

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| **Companies** | **Comments** |
| China Telecom | Agree to confirm the working assumption. |
| OPPO | Ok to Confirm the working assumption. But I have a question: Why does gNB configure 0P+1P for case 2 when uplink Tx switching is configured? From my understanding, the antenna ports and uplink Tx switching are both configured by RRC. Thus what’s the difference between the two following configuration? 1. gNB does not configure uplink Tx switching and 1 port for carrier 22. gNB configures uplink Tx switching and 0P+1P for case 2From my understanding, the two cases will have similar or the same performance (depending on the switching time) If we add some restriction on the mapping between antenna ports and case 1/2, the design can be simplified. For example, we don’t need to consider 0P+1P in both Case 1 and Case 2 (some topic(s) in Issue#2) |
| ZTE | Agree to confirm the working assumption. We believe Option 2-3 only requires small amount of RAN1 spec changes, i.e. not more than Option 1 and other sub-options of Option 2. For option 2-3, since 0P+1P can be done in both cases, we only need to specify the following case changes:* 0P+2P triggers the case change from Case 1 to Case 2.
* Any transmission in carrier 1 (i.e. 1P+0P/1P+1P) triggers the case change from Case 2 to Case 1.

UE should assume to remain in the same state as previous UL transmission for all other cases. This can minimize the case switches. E.g. if PUCCH is configured in carrier 2 only, the UE does not need to do case switch just for the transmission of PUCCH without any uplink data. Another example is to allow 1-port PUSCH scheduled by “fallback DCI” 0\_0 in Case 2. This would reduce the number of case switches and hence the overhead of switching period. (This probably can address the question from OPPO.)We encourage companies to clarify if they have different understanding on Option 2-3 compared to our understanding described above. |
| LG | Agree to confirm the working assumption.  |
| CATT | In our view, there are at least two problems with option 2-3.1. A UE scheduled with 1P transmssion on carrier 2 cannot determine whether a switching period is needed without knowing the scheduling information on carrier 1. If 1P transmission is scheduled on carrier 1, UE has to swtich to case 1, otherwise UE can still at its current state. The decision would depend on two DCIs which is not desirable from our perspective.2. Specification impact of 2-3 is larger than option 2-1. In order to clearly describe option 2-3, two cases or states need to be defined in RAN1 specification. The definition itself may cause intensive debate. On the other hand, case definition is not needed for option 2-1.We have concerns on option 2-3. But for sake of progress, we can accept confirmation of the working assumption if that is the majority view. |
| Qualcomm | This depends on the outcome of [100b-e-LS-TxSwitching-01]. If DL interruptions are not supported, then we don’t agree with confirming the Working Assumption. |
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In RAN1 #99 and RAN1 #100e, following two options were extensively discussed.

* Option 1: If uplink Tx switching is configured, UE is not expected to be scheduled or configured with UL transmission on carrier 2 for case 1.

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

* Option 2: If uplink Tx switching is configured, UE can be scheduled or configured with UL transmission on both carrier 1 and carrier 2 for case 1.
	+ UE can be scheduled or configured with UL transmission on either carrier 1 or carrier 2.
	+ UE can be scheduled or configured with UL transmission on both carrier 1 and carrier 2 simultaneously.

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

In RAN1 #100e, a compromised proposal was raised and discussed.

**Proposal:**

* For inter-band UL CA, if UE reports via capability signaling to support uplink Tx switching, UE further reports via capability signaling which option (between Option 1 and Option 2) is supported.

Companies are invited to provide views on the above proposal.

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| **Companies** | **Accept or object** | **Comments** |
| China Telecom | Accept | We have debated on this issue for a long time. The above compromised proposal is reasonable to make progress. Otherwise we may fail to finalize the standardization in Rel-16 timeline. In addition, the above proposal has RAN2 impact, we need to make decision in this meeting and send LS to RAN2. |
| OPPO | Accept | We prefer option 1, but we can accept the proposal for compromise |
| ZTE | Accept | Agree with China Telecom that we have to make the decision in order to finalize UE capability which has RAN2 impact. Option1 may be simpler in terms of implementation. Compared with Option1, Option2 outperforms Option 1 according to analysis and simulation. Option2 supports 1P+1P simultaneous transmission. It also can reduce the number of Tx switches and hence reduce the overhead. Therefore, both Option1 and Option2 have pros and cons. In terms of specification impact, both options have similar RAN1 spec impact as it is only the condition of case definition of Case 1 is different. For example, the description of both Options can be covered as follows:Two cases are defined to represent two different operation states in a UE. Case 1: the UE can transmit 1-port transmission on Carrier1, * and/or the UE can transmit 1-port transmission on Carrier2 for the UE configured with [*TxSwitchingOption2*];
* and the UE cannot have any uplink transmission on Carrier2 for the UE configured with [*TxSwitchingOption1*].

Case 2: the UE can transmit 1-port or 2-port transmission on Carrier2 and the UE cannot have any uplink transmission on Carrier1.Then we can have simple and unified description to describe case changes for both options as shown in our TP in section 3 of R1-2001626[3]. We believe the same description can be used for SUL and EN-DC as well. Specifying both options would not introduce much extra specification work. Hence, proposal from the feature lead is a good compromise. It can be understood that companies have different implementation preference. We should not block either option. In addition, it is not reasonable to say we have to finalize all the details before agreeing to these options. Other details like uplink phase discussion can be applicable to both options. To be constructive, we hope companies can accept specifying both options and make it as a UE capability.  |
| LG | Accpet |  |
| CATT | Accept | We prefer option 1, but we can accept the proposal as a compromise. |
| Qualcomm | Accept | Option 1 is against the Work Item description. We would prefer not to have it. But as long as it is optional to support it, we would not object. |

Since we have debated on this issue for a long time, and the above proposal has RAN2 impact, we need to make decision in this meeting. If any company objects the above proposal, please answer follow questions.

* Q1: Do you want to finalize the standardization of UL CA based Tx switching in Rel-16 timeline?
* Q2: Please provide your constructive comments on how to finalize the standardization of UL CA based Tx switching in Rel-16 timeline.

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| **Companies** | **Q1** | **Q2** |
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## Issue #2: Switching mechanism

In RAN1 #100e, the following agreement was achieved:

* For inter-band UL CA, if UL switching period is configured by RRC
* ­The switching period is not always applicable on the carrier configured with switching period.
* The switching period is at least applicable between 1-port transmission in carrier 1 and 2-port transmission in carrier 2.

**Proposal: Confirm the working assumption:**

* **Working Assumption:** For inter-band UL CA, if uplink Tx switching is configured, the state of Tx chains of last UL transmission is assumed in case of no UL transmission.

Companies are invited to provide views on whether the above work assumption can be confirmed.

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| **Companies** | **Comments** |
| China Telecom | Agree to confirm the working assumption. |
| OPPO | Support to confirm the working assumption |
| ZTE | Agree to confirm the working assumption. This has the benefit of reducing unnecessary case changes. Setting up a default case would introduce unnecessary case changes even without any UL transmission. This is worse especially when there is downlink interruption during case switches. |
| **LG** | Agree to confirm WA. |
| **CATT** | Ok to confirm the working assumption. |
| Qualcomm | This depends on the outcome of [100b-e-LS-TxSwitching-01]. If DL interruptions are not supported, then we don’t agree with confirming the Working Assumption. |
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**Proposal:**

* Case1: UE can transmit 1-port transmission on carrier 1 (i.e. 1Tx on carrier 1 and 1Tx on carrier 2)
* Case2: UE can transmit 2-port transmission on carrier 2 and UE cannot have any uplink transmission in carrier 1 (i.e. 0Tx on carrier 1 and 2Tx on carrier 2).
* For inter-band UL CA, if uplink Tx switching is configured, the case state (i.e. state of Tx chains) of last UL transmission is assumed except in the following cases where the switching period is applicable before next uplink transmission:
* If the UE is under Case1, the next UL transmission has a 2-port transmission on carrier 2.
* If the UE is under Case2, the next UL transmission has a 1-port transmission on carrier 1.

Companies are invited to provide views on the above proposal.

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| **Companies** | **Accept or object** | **Comments** |
| China Telecom | Accept | In last meeting, we agreed that the state of Tx chains of last UL transmission is assumed in case of no UL transmission. In case of UL transmission, the presence of switching period and the state of Tx chains should be determined as well. The above proposal clarifies the presence of switching period and the state of Tx chains in case of UL transmission clearly. We support this proposal. |
| ZTE | Accept | Agree with the proposal. This proposal clarifies the condition of switching period based on the working assumption and agreements from RAN1#100e (which are described under #issue 2 in this document). It is beneficial to define cases using the wording of port instead of Tx since Tx is not defined in RAN1 spec.  |
| Qualcomm |  | This depends on the outcome of [100b-e-LS-TxSwitching-01]. If DL interruptions are not supported, then we don’t agree with the proposal. We agree with it otherwise. |
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**Proposal:**

* For inter-band UL CA, if uplink Tx switching is configured and if option 2 of mapping between UL transmission ports and Tx chain is supported, the state of Tx chains of last UL transmission is assumed in case of no UL transmission on carrier 1 and 1-port transmission on carrier 2 (0P+1P).

Companies are invited to provide views on the above proposal.

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| **Companies** | **Accept or object** | **Comments** |
| China Telecom | Accept | For option 2, since 0P+1P is supported for both case 1 and case 2, the state of Tx chains should be clarified in case of 0P+1P. In our view, 0P+1P does not trigger Tx switching, i.e. the state of Tx chains is kept unchanged. We support this proposal. |
| OPPO |  | I echo my question/comment from the discussion of Issue#1But I have a question: Why does gNB configure 0P+1P for case 2 when uplink Tx switching is configured? From my understanding, the antenna ports and uplink Tx switching are both configured by RRC. Thus what’s the difference between the two following configuration? 1. gNB does not configure uplink Tx switching and 1 port for carrier 22. gNB configures uplink Tx switching and 0P+1P for case 2From my understanding, the two cases will have similar or the same performance (depending on the switching time) If we add some restriction on the mapping between antenna ports and case 1/2, this issue can be avoided. By the way, if majority companies support FL’s proposal, we also can accept it.  |
| ZTE | Accept | Like what we mentioned in issue#1, 0P+1P should not trigger any case change. The above proposal aligns with this understanding. Please check our answer to issue#1 for the benefits of allowing 0P+1P in both cases. |
| CATT |  | This proposal seems to be covered by previous proposal.  |
| Qualcomm |  | This depends on the outcome of [100b-e-LS-TxSwitching-01]. If DL interruptions are not supported, then we don’t agree with the proposal. We agree with it otherwise. |

There are three options for the granularity of determination on the presence of the switching period:

* Option 1: The presence of the switching period is determined one time every transmission occasion.
* Option 2: The presence of the switching period is determined one time every slot.
* Option 2a: The presence of the switching period is determined one time every slot with smaller numerology.
* Option 2b: The presence of the switching period is determined one time every slot with larger numerology.
* Option 3: The presence of the switching period is determined one time every UL phase. An UL phase is defined as consecutive UL symbols in the TDD carrier which is capable of 2 ports transmission. The state of Tx chains is not changed during the UL phase.

Companies are invited to provide views on the above three options for the granularity of determination on the presence of the switching period.

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| **Companies** | **Which option is supported?** | **Comments** |
| China Telecom | Option 3 | UL CA based Tx switching can work with any of the above option. If Tx switching is determined one time very transmission occasion, frequent Tx switching may happen. UL phase is beneficial to avoid unnecessary Tx switching. |
| OPPO | Option 1 | It is up to gNB’s scheduling / configuration. From the perspective of UE, it can dynamically switch between Case 1 and Case 2 assuming the switching timing is guaranteed by the scheduling.  |
| ZTE | Option 3 | Setting up the UL phase can reduce unnecessary case switches and potential misalignment between network and UE on where the switching period is. This ensures performance gain and robustness. Also, it is easy for network and UE to implement this. RAN4 has agreed to support configuration on the carrier location of switching period in CA and SUL scenarios. During the switching period, UL transmission cannot be done in both carriers. It may not be clear what carrier location of switching period means. From our understanding, if the switching period is configured in carrier 1, it means the switching period should occur outside the uplink phase. i.e. corresponding to non-uplink symbols of carrier 2 since the switching period causes only uplink resources in carrier 1. With this understanding, it is more proper to define UL phase.  |
| Qualcomm | Option 3 | Option 3 minimizes interruptions and reduces UE complexity.  |
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## Issue #3: Support of codebook based PUSCH transmission for option 2

For UL CA option 2, for codebook based PUSCH transmission, the basic mechanism can be supported. PUCCH and PUSCH with 1-port transmission can be indicated by DCI format 0\_0 and DCI format 0\_1 can indicate PUSCH with 2-port transmission when *nrofSRS-Ports* is configured as 2 antenna ports.

However, *nrofSRS-Ports* is semi-statically configured while case 1 or case 2 can be dynamically changed. There is one problem that whether to indicate 1-port transmission using DCI format 0\_1 when *nrofSRS-Ports* is configured as 2 antenna ports.

Companies are invited to answer the following question:

* Whether DCI format 0\_1 can be used to indicate 1-port transmission when *nrofSRS-Ports* is configured as 2 antenna ports?

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| **Companies** | **Y/N** | **Comments** |
| China Telecom | Yes | 1-port transmission can be indicated by DCI format 0\_0. However, DCI format 0\_0 has other usage. The enhancement on DCI format 0\_1 to indicate 1-port transmission when *nrofSRS-Ports* is configured as 2 antenna ports can be considered. |
| OPPO | Yes | Rel-16 eMIMO has introduced the new functionality that an SRS resources for codebook based PUSCH can have SRS resources with different number of SRS ports. Therefore, there can be different values of *nrofSRS-Ports* for codebook based PUSCH. |
| ZTE | Yes | With this assumption, DCI Format 0\_1 can be used in 1-port UL transmission in carrier 2 when 2-port SRS is configured for codebook-based transmission. Otherwise, it is too restrictive if DCI Format 0\_1 cannot be used in carrier 2 under Case 1 given that DCI Format 0\_1 also provides other functionalities (e.g. SRS/CSI request, TPC command, dynamic BWP switching, etc.) that DCI Format 0\_0 cannot support. |
| LG | Yes | If the UE can be configured that higher layer parameter ul-FullPowerTransmission-r16 is set to fullpowerMode2, the SRI in DCI 0\_1 can be used to select 1-port or 2-port SRS resource to be used for PUSCH transmission.  |
| **CATT** | No | DCI format 0\_1 schedules UL transmission with either 1 Tx or 2 Txs according to the indicated TPMI. It does not matter that it is considered as 1-port transmission or 2-port transmission. The question is whether transmission using some specific TPMI is allowed under Case 1. The benefit seems to be reducing unnecessary switching. But in order to avoid switching, gNB may have to select a PMI that is not optimal to UL transmission leading to performance degradation. Considering current progress, we suggest to focus on other more important issues. |
| Qualcomm | Yes | Single port TPMI is supported for codebook-based UL MIMO. There is no reason not to support it for Tx switching also. |
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Following two options are proposed to indicate 1-port transmission using DCI format 0\_1 when *nrofSRS-Ports* is configured as 2 antenna ports:

* + Option 1: DCI Format 0\_1 can be used to indicate 1-port UL transmission on carrier 2 when 2-port SRS is configured for codebook-based transmission.
		- PUSCH transmission with TPMI=$\frac{1}{\sqrt{2}}\left[\begin{array}{c}1\\0\end{array}\right]$ is considered as 1 port transmission.
		- PUSCH transmission with all other TPMI, e.g., TPMI=$\frac{1}{\sqrt{2}}\left[\begin{array}{c}0\\1\end{array}\right]$ and TPMI=$\frac{1}{\sqrt{2}}\left[\begin{array}{c}1\\1\end{array}\right]$$\frac{1}{\sqrt{2}}\left[\begin{array}{c}1\\1\end{array}\right]$, are $\frac{1}{\sqrt{2}}\left[\begin{array}{c}1\\1\end{array}\right]$considered as 2 ports transmission.
	+ Option 2: gNB configures 2 SRS resources, 1-port SRS resource for Case 1 and 2-port SRS resource for Case 2.

Companies are invited to provide views on the above two options.

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| **Companies** | **Preferred option** | **Comments** |
| China Telecom | Either option is fine. Slightly prefer option 2 | Either option is fine. We slightly prefer option 2, since option 2 has less RAN1 impact. |
| OPPO | Option 2 | Option 2 has been introduced in Rel-16 eMIIMO. It can be reused here.The disadvantage is Option 1 is the restriction on the mapping of antenna ports and Tx chain, which discloses UE implementation.  |
| ZTE | Option 1 | We prefer Option 1 since it is cleaner. In any case, it is better to clarify in the spec whether PUSCH transmission using TPMI [1 ; 0] or [0 ; 1] is a 1 port or 2 port transmission. So we don’t think Option 2 has less RAN1 spec. In addition, most of the UEs support only one SRS resource in SRS set for codebook based PUSCH. It requires extra UE complexity to support 2 SRS resources just for the support of Tx switching. Having said that, we are also okay with Option 2 if this is a majority view. |
| LG | Option 2 | Option 2 can be supported by adopting the functionality in Rel-16 eMIMO ULFPTx Mode2.However, ULFPTx Mode 2 is supported at least for the non-Coherent UE and its codebookSubset does not include port combining TPMIs such as [1 1] T, [1 j] T, [1 -1] T, [1 -j]T. Also, it is still under discussion on the support of UL full power transmission in case of full coherent UE. So, reusing UL full power scheme as it is may not allow the 2port transmission with port combining TPMIs.  |
| Qualcomm | Option 1 | We fail to see the benefit of Option 1 for Tx switching. It unnecessarily increases SRS resource use. It is also against the SRS use for full power MIMO. For full power MIMO, the 1-port SRS is virtualized but that doesn’t work with Option 1.  |
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## Other issues

Companies are invited to provide views on other issues not covered above.

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| **Companies** | **Comments** |
| Qualcomm | There should be an agreement on the observation period, which should be limited to the first slot of the UL phase.  |
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13. R1-2002394, Discussion on RAN1 specification impact of DL interruption, CATT, RAN1 #100bis-e, Apr.2020.
14. R1-2002413, RAN1 aspects of UL Tx switching, Ericsson, RAN1 #100bis-e, Apr.2020.
15. R1-2002516, Discussion on 1Tx-2Tx switching impact in RAN1, Qualcomm Incorporated, RAN1 #100bis-e, Apr.2020.
16. R1-2002615, On UE Tx switching period delay and DL interruption, Nokia, Nokia Shanghai Bell, RAN1 #100bis-e, Apr.2020.
17. R1-2002661, Discussion on the remaining problems of supporting Tx switching between two uplink carriers, Huawei, HiSilicon, RAN1 #100bis-e, Apr.2020.

# Appendix

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| **Companies** | **Views** |
| **ZTE (R1-2001626)** | ***Proposal 3****: Support both option 1 and option 2. UE can report which option is supported based on UE capability.* ***Proposal 4****: Confirm the following working assumption.*

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| **Working Assumption:*** For inter-band UL CA, if option 2 is supported, the following sub-option 2-3 is defined.
	+ Minimize RAN1 impact
	+ No new RAN4 impact
	+ No new TDM pattern
* It can be revisited in future RAN1 meeting with taking into consideration any relevant RAN4 decisions on DL interruption for UL Tx switching.

Option 2-3

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

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There are at least the following four approaches to define the case switch granularity:1. Granularity = Transmission occasion;2. Granularity = Slot duration with smaller numerology;3. Granularity = Slot duration with higher numerology;4. Granularity = UL phase of carrier 2.***Proposal 5****: An UL phase is defined as consecutive UL symbols in the TDD carrier which is capable for 2 ports transmission.****Proposal 6****: PUSCH transmission based on TPMI C:\Users\10240317\AppData\Local\Temp\ksohtml\wps3E85.tmp.png is considered as 1-port transmission.* |
| **vivo (R1-2001643)** | **Proposal 2:** Consider supporting both option 1 and option 2 as UE capability.  |
| **OPPO (R1-2001743)** | ***Proposal 2: For case 1, our first preference is to support Option 1 (UE can only be scheduled UL transmission on carrier 1)***  ***As a compromise, we can accept to support Option 2 as an optional feature for a UE supporting Option 1******Proposal 3: In order to support Option 2, RAN1 should support a SRS resource set with 1-port SRS resource(s) and 2-port SRS resource(s) is configured for codebook based PUSCH (i.e., Reuse the scheme introduced in full power transmission)**** ***In case 1, 1-port SRS resource will be indicated by DCI for carrier 2***
* ***In case 2, 2-port SRS resource will be indicated by DCI for carrier 2***
* ***No spatial relation information is configured***
* ***Up to 2 SRS resources can be configured in the SRS resource (same restriction as Rel-15)***
* ***The power control scheme is the same as Rel-15***

***The power scaling factor is the ratio of the number of antenna ports with a non-zero PUSCH transmission power to the maximum number of SRS ports supported by the UE in one SRS resource.******Proposal 4: In Rel-16, a UE is not expected to be configured with Option 2 and non-codebook based PUSCH simultaneously.***  |
| **MediaTek (R1-2001821)** | **Proposal #4: Adopt Option 1 as UL Tx scheme for inter-band UL CA.** |
| **CATT (R1-2002059)** | **Proposal 1:*** + *For inter-band UL CA, UE can only be scheduled UL transmission on carrier 1 for Case 1. The switching period only exists when the scheduled UL transmissions are switched between carrier 1 and carrier 2.*
 |
| **China Telecom (R1-2002190)** | ***Proposal 4:**** For inter-band UL CA, if UE reports via capability signaling to support uplink Tx switching, UE further reports via capability signaling which option (between Option 1 and Option 2) is supported.
* Option 1: If uplink Tx switching is configured, UE is not expected to be scheduled or configured with UL transmission on carrier 2 for case 1.

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

* Option 2: If uplink Tx switching is configured, UE can be scheduled or configured with UL transmission on both carrier 1 and carrier 2 for case 1.
	+ UE can be scheduled or configured with UL transmission on either carrier 1 or carrier 2
	+ UE can be scheduled or configured with UL transmission on both carrier 1 and carrier 2 simultaneously

|  |  |  |
| --- | --- | --- |
|  | 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 |

***Proposal 5: Confirm the working assumption:**** For inter-band UL CA, if option 2 is supported, the following sub-option 2-3 is defined.
	+ Minimize RAN1 impact
	+ No new RAN4 impact
	+ No new TDM pattern

Option 2-3

|  |  |  |
| --- | --- | --- |
|  | 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 |

There can be three options for the granularity of Tx switching:* Option 1: The presence of the switching period is determined one time every transmission occasion.
* Option 2: The presence of the switching period is determined one time every slot.
* Option 2a: The presence of the switching period is determined one time every slot with smaller numerology.
* Option 2b: The presence of the switching period is determined one time every slot with larger numerology.
* Option 3: The presence of the switching period is determined one time every UL phase. An UL phase is defined as consecutive UL symbols in the TDD carrier which is capable of 2 ports transmission. The state of Tx chains is not changed during the UL phase.

***Proposal 6: For inter-band UL CA, UL phase is defined to avoid unnecessary Tx switching. An UL phase is defined as consecutive UL symbols in the TDD carrier which is capable of 2 ports transmission. The state of Tx chains is not changed during the UL phase.******Proposal 7: For UL CA option 2, for codebook based PUSCH transmission, DCI format 0\_1 can indicate 1-port UL transmission when 2-port SRS is configured. gNB can configure 2 SRS resources, 1-port SRS resource for Case 1 and 2-port SRS resource for Case 2.******Proposal 8: Confirm the working assumption:***For inter-band UL CA, if uplink Tx switching is configured, the state of Tx chains of last UL transmission is assumed in case of no UL transmission. |
| **Nokia (R1-2002222)** | **Maximum rate of switching:** For the Stand-alone NR with SUL, the agreement states that the need for switching is evaluated once for each UL transmission occasion (transmission occasion is defined in clause 7 of T 38.213). There seems to be no reason to define this differently for UL CA or for EN-DC.**Proposal:** For both EN-DC and NR-CA, the presence of the switching gap is determined one time every transmission occasion. **Proposal**: Adopt option 2: If uplinkTx switching is configured, the UE can be scheduled or configured with UL transmission on both carrier 1 and carrier 2 for case 1.* + UE can be scheduled or configured with UL transmission on either carrier 1 or carrier 2
	+ UE can be scheduled or configured with UL transmission on both carrier 1 and carrier 2 simultaneously
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| **Ericsson (R1-2002413)** | **Proposal 2*** **Option 2 (i.e., “UE can be scheduled UL transmission on both carrier 1 and carrier 2 for case 1 simultaneously”) should be supported for defining the condition and presence of switching periods for UL tx switching with CA case.**

**Proposal 3****If UE capability between Option 1 and Option 2 is introduced, the capability is defined as follows:*** **For an inter-band band-combination for which the UE indicates support for UL CA (i.e., “CA case”)**
	+ **Introduce additional UE capability to indicate the supported UE behavior when UL Tx switching is configured for the UE**
	+ **The supported UE behavior can be according to Option 1 or Option 2**
		- **Option 1: When configured for UL Tx switching, the UE is not expected to be scheduled or configured with UL transmission on both carrier 1 and carrier 2 simultaneously.**
		- **Option 2: When configured for UL Tx switching, the UE can be scheduled or configured with UL transmission on both carrier 1 and carrier 2 for case 1.**
			* **UE can be scheduled or configured with UL transmission on either carrier 1 or carrier 2**
			* **UE can be scheduled or configured with UL transmission on both carrier 1 and carrier 2 simultaneously**
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| **Qualcomm (R1-2002516)** | **Proposal 1 For inter-band UL CA, if uplink Tx switching is configured, UE can report via capability signaling which option (between Option 1 and Option 2) is supported.** **Proposal 2: In option 2,** * **2 Tx in CC2 (TDD) is used for these UL transmissions: PUSCH with TPMI=**$\frac{1}{\sqrt{2}}\left[\begin{array}{c}0\\1\end{array}\right]$**, PUSCH with TPMI=**$\frac{1}{\sqrt{2}}\left[\begin{array}{c}1\\1\end{array}\right]$**, 2-port SRS, 2-port configured grant PUSCH**
* **1 Tx in CC2 (TDD) is used for these UL transmissions: No grant, PUCCH, SR, PRACH, PUSCH with TPMI=**$\frac{1}{\sqrt{2}}\left[\begin{array}{c}1\\0\end{array}\right]$**, PUSCH scheduled by DCI 0\_0, single port configured grant PUSCH**

**Proposal 3: In option 2, the switching decision should only depend on the events in CC2 (TDD) with the following decision rule:*** **For any time period that overlaps with CC2 (TDD) UL:**
	+ **If 2 Tx in CC2 (TDD) is requested for any part of the observation period (as defined in Proposal 10) 🡪 Case 2**
	+ **Otherwise 🡪 Case 1**
* **For any time period that doesn’t overlap with CC2 (TDD) UL (i.e. CC1 (FDD) only)**
	+ **Always 🡪 Case 1**
	+ **In other words, at the end of a TDD UL period, always switch to Case 1, irrespective of history and irrespective of what grants may have been received**

**Proposal 4: To simplify the specification discussion, we make the following proposal on timeline.** * **Only allowing one switch for consecutive UL transmission of CC2**
* **Allowed switch boundaries are the start and the end of UL slot in CC2**
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| **Huawei (R1-2002661)** | ***Proposal 7****: For UL-CA with Tx switching, Option 1 is adopted:** *A UE, if supports, can be switched between Tx switching mode and normal UL-CA mode by RRC reconfiguration.*

To tackle such a mapping, a couple of potential solutions could be:* Explicit DCI indication, e.g. indicating whether 1T or 2T on carrier 2
* Inexplicit methods, such as:
	+ Reuse Rel-16 ULFP mode 2 as mentioned in [4].
	+ Scheduling restriction, e.g. UL phase as described in [5].

***Proposal 8****: To fully shape Option 2 for UL-CA with UL Tx switching, a package of potential spec impacts should be discussed and identified first before any conclusion of support of Option 2.* |