3GPP TSG RAN WG1 #110bis-e R1-22xxxxx

**E-meeting, October 10th – 19th, 2022**

**Agenda item: 8.17**

**Source: Moderator (China Telecom)**

**Title: FL summary of email discussion on remaining issues of Rel-17 UL Tx switching**

**Document for: Discussion**

# Introduction

This contribution is a summary of the following email discussion.

[110bis-e-R17-Others-02] Email discussion on remaining issues of Rel-17 UL Tx switching by October 14 – Jianchi (China Telecom)

* Check on October 12 whether there is consensus for specification change.

# Discussion

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

**Qualcomm [R1-2209966]** points out that, in Rel-16 UL Tx switching, UE is restricted to support one switch per one slot. However, the switching location could be anywhere inside the slot. For example, if the switch is triggered by SRS transmission, the switching location could be in the middle or even later part of the slot. Therefore, if there is an expected switch on the SRS transmission carrier, there would be two switches in 14 consecutive symbols even if these two switches still belong to two slots. When we consider SRS carrier switching and if the UL Tx switching is triggered by SRS carrier switching which means there would be 4 switches (2 for SRS and 2 for UL Tx switch) in 14 consecutive symbols.

UL

DL

DL

Tx Switch

CC1

UL

CC2

DL

DL

CC3

RF tuning

UL

4 switches within 14 consecutive symbols

SRS

RF tuning

SRS

Tx switch

**Qualcomm [R1-2209966]** has the following proposal:

**Proposal: When SRS carrier switching is configured, a maximum of 3 switches (2 for SRS and 1 for UL Tx switching) are supported in 14 consecutive symbols.**

In RAN1#110, **Huawei [R1-2205771]** had the following proposal to address this issue:

***Proposal 2:*** *For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink, if a uplink transmission is scheduled after a SRS carrier switching occurrence and the time interval between the first symbol of the uplink transmission and the last symbol of SRS transmission is less than or equal to an interval of 13 symbols plus the RF retuning time required by SRS carrier switching, then the last symbol of PDCCH scheduling the uplink transmission should be no later than at symbol L, where the time interval between symbol L and the first symbol of SRS transmission is larger than* $ N\_{2} $*symbols plus the RF retuning time.*

* *In case of different SCS between the uplink transmission and the SRS transmission, the 13 symbols are with respect to the smaller SCS.*

**Huawei [R1-2207648]** proposed the following changes to TS 38.214.

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| **< Unchanged parts are omitted >**6.1.6 Uplink switchingThe UE may omit uplink transmission during the uplink switching gap $N\_{Tx1-Tx2}$if the conditions defined in this clause are met and the UE is configured with *uplinkTxSwitching*. The switching gap $N\_{Tx1-Tx2}$is indicated by UE capability *uplinkTxSwitchingPeriod2T2T* if *uplinkTxSwitching-2T-Mode* is configured, and *uplinkTxSwitchingPeriod* otherwise: - If a UE indicated a capability for uplink switching with *BandCombination-UplinkTxSwitch* for a band combination, and if it is for that band combination- Configured with a MCG using E-UTRA radio access and with a SCG using NR radio access (EN-DC), or- Configured with uplink carrier aggregation, or- Configured in a serving cell with two uplink carriers with higher layer parameter *supplementaryUplink*. the conditions under which the switching gap may be present and the location of the switching gap are defined for each of the cases in clauses 6.1.6.1, 6.1.6.2, and 6.1.6.3 respectively.If an uplink switching is triggered for an uplink transmission starting at *T0*, after *T0-Toffset*, the UE is not expected to cancel the uplink switching, or to trigger any other new uplink switching occurring before *T0* for any other uplink transmission that is scheduled after *T0-Toffset*, where *Toffset* is the UE processing procedure time defined for the uplink transmission triggering the switch given in clause 5.3, clause 5.4, clause 6.2.1, clause 6.4 and in clause 9 of [6, TS 38.213].The UE does not expect to perform more than one uplink switching in a slot with *µUL* = max(*µUL, 1, µUL, 2*), where the *µUL, 1* corresponds to the subcarrier spacing of the active UL BWP of one uplink carrier before the switching gap and the *µUL, 2* corresponds to the subcarrier spacing of the active UL BWP of the other uplink carrier after the switching gap.If the UE is configured with *uplinkTxSwitching-r16* for uplink switching between uplink carrier *c2* and *c3*, and it is also configured with SRS resource(s) on a carrier *c1* and the switching from carrier *c2* according to sub-clause 6.2.1.3, and if an uplink transmission is scheduled on carrier *c3* after a SRS transmission on carrier *c1* and the time interval between the first symbol of the uplink transmission on carrier *c3* and the last symbol of SRS transmission on carrier *c1* is less than or equal to an interval of 13 symbols plus the RF retuning time required by the SRS transmission, then the last symbol of PDCCH scheduling the uplink transmission on carrier *c3* should be no later than at symbol L, where the time interval between symbol L and the first symbol of SRS transmission on carrier *c1* is larger than $ N\_{2} $ symbols plus the RF retuning time, where the SCS for 13 symbols is the smaller SCS between carrier *c1* and *c3*.**<Unchanged parts are omitted>** |

**FL comments:** This issue was discussed in past RAN1 meetings since Rel-16. From FL understanding, it’s hard to achieve consensus to select one from R1-2209966 and R1-2205771. One compromised solution is UE can report one of them.

**Alt 1:**

**For UE supporting Rel-17 Tx switching, UE reports one or both of the following options.**

* **Option 1:** When SRS carrier switching is configured, a maximum of 3 switches (2 for SRS and 1 for UL Tx switching) are supported in 14 consecutive symbols.
* **Option 2:** For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink, if a uplink transmission is scheduled after a SRS carrier switching occurrence and the time interval between the first symbol of the uplink transmission and the last symbol of SRS transmission is less than or equal to an interval of 13 symbols plus the RF retuning time required by SRS carrier switching, then the last symbol of PDCCH scheduling the uplink transmission should be no later than at symbol L, where the time interval between symbol L and the first symbol of SRS transmission is larger than$ N\_{2} $symbols plus the RF retuning time.
	+ In case of different SCS between the uplink transmission and the SRS transmission, the 13 symbols are with respect to the smaller SCS.

**FL comments:** Another alternative is to restrict the maximum number of switching gap due to Tx switching in one slot to 1, and restrict the maximum number of SRS carrier switching in one slot to 1.

**Alt 2:**

* UE is not expected to be scheduled more than one switching gap due to uplink Tx switching in one slot.
* UE is not expected to be scheduled more than one SRS carrier switching, including both RF tuning before and after SRS carrier switching, in one slot.

Companies are encouraged to check the above alternatives.

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| **Company** | **Comments** |
| ZTE | Thanks for the FL summary. This issue has been online discussed in last RAN1 meeting without any outcome. We would suggest not to repeating the discussion again in this meeting. Some detailed comments from our side:Option2 will cause unnecessary additional scheduling delay and complicate the network scheduling even if it is not needed. For example, if there are only two/three switchings in one slot (1/2 for SRS switching and 1 for UL Tx switching), UE should be able to handle this kind of switching. However, if Option2 is adopted, it will cause additional scheduling delay for this example.Regarding Option1, we understand the intention of this proposal. However, we have concern on introducing this restriction at this late stage. If we really want to have something, we think we should at least to allow a maximum of 4 switches (2 for SRS switching and 2 for UL Tx switching) in 14 consecutive symbols to ensure UE can switch back to the previous carrier for PUSCH/PUCCH transmission.Overall, we are negative on this proposal and prefer not to repeat the discussion. |
| New H3C | We agree with ZTE’s comment on no repeating discussion this issue without any consensus. |
| Qualcomm | Thanks to FL for the promoted proposal.Our first preference is Alt. 1 - Option1 as this could reduce the unnecessary switches within a short time period.However, we understand the current situation. As a compromise, we could support Alt 2 if other company is fine with this, even though this is not equivalent to our former proposal.We propose some minor revision as follows.**Revised Alt 2:*** If both SRS carrier switching and UL Tx switching configured,
* UE is not expected to be scheduled more than one switching gap due to uplink Tx switching in one slot.
* UE is not expected to be scheduled more than one SRS carrier switching, including both RF tuning before and after SRS carrier switching, in one slot.
* In case of different SCS between the uplink transmission and the SRS transmission, the one slot is with respect to the smaller SCS.
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| Huawei, HiSilicon | Thanks to FL for the proposal.It is not clear for us why Option 1 is needed, but to make progress and have clearer scheduling restrictions for these features, we can compromise to accept the following combined proposal (combination of revised alt 2 and Option 2),**Proposal-rev1**:For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink, * UE is not expected to be scheduled more than one switching gap due to uplink Tx switching in one slot. UE is not expected to be scheduled more than one SRS carrier switching, including both RF tuning before and after SRS carrier switching in one slot.
	+ In case of different SCS between the uplink transmission and the SRS transmission, the one slot is with respect to the smaller SCS.
* For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink, if a uplink transmission is scheduled after a SRS carrier switching occurrence and the time interval between the first symbol of the uplink transmission and the last symbol of SRS transmission is less than or equal to an interval of 13 symbols plus the RF retuning time required by SRS carrier switching, then the last symbol of PDCCH scheduling the uplink transmission should be no later than at symbol L, where the time interval between symbol L and the first symbol of SRS transmission is larger than$ N\_{2} $symbols plus the RF retuning time.
	+ In case of different SCS between the uplink transmission and the SRS transmission, the 13 symbols are with respect to the smaller SCS.
* Introduce Rel-17 UE capabilities for UEs who don’t require the above two scheduling restrictions, respectively.
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| vivo | We can accept alt 2 proposed by FL with the condition that “For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink” and introduction of corresponding UE capability suggested by Huawei. Or not to repeat the discussion. |
| FL | Companies are encouraged to check whether there is any concern on the following **Revised Alt 2-v2 or Proposal-rev1** proposed by Huawei.**Revised Alt 2-v2:*** For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink
	+ UE is not expected to be scheduled more than one switching gap due to uplink Tx switching in one slot. UE is not expected to be scheduled more than one SRS carrier switching, including both RF tuning before and after SRS carrier switching, in one slot.
		- In case of different SCS between the uplink transmission and the SRS transmission, the one slot is with respect to the smaller SCS.
	+ Introduce Rel-17 UE capability for UEs who don’t require the above scheduling restrictions.

**Proposal-rev1**:For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink, * UE is not expected to be scheduled more than one switching gap due to uplink Tx switching in one slot. UE is not expected to be scheduled more than one SRS carrier switching, including both RF tuning before and after SRS carrier switching in one slot.
	+ In case of different SCS between the uplink transmission and the SRS transmission, the one slot is with respect to the smaller SCS.
* For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink, if a uplink transmission is scheduled after a SRS carrier switching occurrence and the time interval between the first symbol of the uplink transmission and the last symbol of SRS transmission is less than or equal to an interval of 13 symbols plus the RF retuning time required by SRS carrier switching, then the last symbol of PDCCH scheduling the uplink transmission should be no later than at symbol L, where the time interval between symbol L and the first symbol of SRS transmission is larger than$ N\_{2} $symbols plus the RF retuning time.
	+ In case of different SCS between the uplink transmission and the SRS transmission, the 13 symbols are with respect to the smaller SCS.
* Introduce Rel-17 UE capabilities for UEs who don’t require the above two scheduling restrictions, respectively.
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| Qualcomm | Thanks for the FL’s promotion and responses from companies.As we commented above, our preference is Alt. 1 – Option 1 which could solve our concern on frequent switches (e.g. 4 switches or more) within 14 symbols. What we could accept is either revised-Alt 2-v3 or revised FL’s Alt. 1 with UE capability below. We make slight updates to avoid ambiguity on “uplink” for Alt.2, and some updates on Alt 1 – Option 1.Again, we could accept one of below two Alternatives as compromise, not a mixed version.**Revised Alt 2-v3:*** For a UE configured with UL Tx switching on two uplink bands and configured with SRS carrier switching for a third uplink band
	+ UE is not expected to be scheduled more than one switching gap due to uplink Tx switching in one slot. UE is not expected to be scheduled more than one SRS carrier switching, including both RF tuning before and after SRS carrier switching, in one slot.
		- In case of different SCS between the uplink transmission and the SRS transmission, the one slot is with respect to the smaller SCS.
	+ Introduce Rel-17 UE capability for UEs who don’t require the above scheduling restrictions.

**Revised-Alt 1:**For a UE configured with UL Tx switching on two uplink bands and configured with SRS carrier switching for a third uplink band* UE is not expected to be scheduled or configured with more than 3 switches, which are one SRS carrier switching, including both RF tuning before and after SRS carrier switching and one UL Tx switching, within 14 consecutive symbols.
	+ In case of different SCS between the uplink transmission and the SRS transmission, the one slot is with respect to the smaller SCS.
* For a UE configured with UL Tx switching on two uplinks and configured with SRS carrier switching for a third uplink, if a uplink transmission is scheduled after a SRS carrier switching occurrence and the time interval between the first symbol of the uplink transmission and the last symbol of SRS transmission is less than or equal to an interval of 13 symbols plus the RF retuning time required by SRS carrier switching, then the last symbol of PDCCH scheduling the uplink transmission should be no later than at symbol L, where the time interval between symbol L and the first symbol of SRS transmission is larger than$ N\_{2} $symbols plus the RF retuning time.
	+ In case of different SCS between the uplink transmission and the SRS transmission, the 13 symbols are with respect to the smaller SCS.

Introduce Rel-17 UE capabilities for UEs who don’t require the above two scheduling restrictions, respectively. |
| ZTE | Again, we are not in favour of either solution for the following reasons. Regarding Revised Alt 2-v2:* + 1. For sentence “*UE is not expected to be scheduled more than one SRS carrier switching, including both RF tuning before and after SRS carrier switching, in one slot.*” it seems to say that even if there is no UL Tx switching in one slot, UE is still not expected to be scheduled more than one SRS carrier switching. This is not related to UL Tx switching, we don’t need to have such limitation. If companies want to introduce any limitation, it should be introduced only for the slot where UL Tx switching is happening.
		2. In the previous Rel-16 spec “*The UE does not expect to perform more than one uplink switching in a slot with µUL = max(µUL, 1, µUL, 2), where the µUL, 1 corresponds to the subcarrier spacing of the active UL BWP of one uplink carrier before the switching gap and the µUL, 2 corresponds to the subcarrier spacing of the active UL BWP of the other uplink carrier after the switching gap.*”, this is based on the max{u1, u2}. The current wording “the one slot is with respect to the smaller SCS” in the above proposal is not clear which SCS is adopted.
		3. The basic UE behavior should be no limitation on these. If a UE capability is needed, the UE capability should be introduced for UEs having the above limitations.

Regarding Revised-Alt 1:According to proponents’ comments, either of two solutions can address the potential concern. Mixing two solutions together is not constructive from our perspective. We have provided our concern/comments for both solutions in the 1st round and 2nd round of discussion, we won’t repeat here. We can’t accept the mixed solution. |
| New H3C | We slightly prefer revised Alt2-v2 from FL to conclude this issue or draw no consensus conclusion for RAN1. |
| vivo | **Revised Alt 2-v4:*** For a UE configured with UL Tx switching on two uplink bands and configured with SRS carrier switching for a third uplink band
	+ UE is not expected to be scheduled more than one switching gap due to uplink Tx switching in one slot. UE is not expected to be scheduled more than one SRS carrier switching, including both RF tuning before and after SRS carrier switching, in ~~one~~ the same slot.
		- In case of different SCS between the uplink transmission and the SRS transmission, the one slot is with respect to the smaller SCS.
	+ Introduce Rel-17 UE capability for UEs who don’t require the above scheduling restrictions.

Thanks for FL summary. Sorry for late response. Regarding the first concern from ZTE, we suggest the above **Revised Alt 2-v4.** Hope this can help. |
| Huawei, HiSilicon | The proposals are only about scheduling restrictions and have impact on gNB implementation. The first bullet from QC’s revised Alt1 has too much impacts on gNB implementation but its value to relax potential UE burden is unclear to us. Therefore, we suggest to replace the bullet with revised Alt 2, i.e. our proposal-rev1 as a compromise.The reason to have the second bullet in our proposal-rev1 is explained in our paper R1-2205771. The second bullet is helpful for a UE to implement an UL Tx switching that is right after SRS carrier switching occurrence which is the only issue in the concerned scenario.Therefore, we can only live with our proposal-rev1. |

# References

1. R1-2209966, Remaining Issues of Rel-17 UL Tx switching, Qualcomm Incorporated, RAN1#110bis-e, October 10th – 19th, 2022.
2. R1-2205771, Discussion on remaining issues for supporting Tx switching between two uplink carriers, Huawei, HiSilicon, RAN1#110, August 22nd – 26th, 2022.
3. R1-2207648, Correction on back-to-back switching with SRS switching, Huawei, HiSilicon, RAN1#110, August 22nd – 26th, 2022.