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

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

**Agenda Item: 5**

**Source: Huawei, HiSilicon**

**Title: Summary on impact of SRS antenna switching for TDD-FDD band combinations**

**Document for: Discussion and Decision**

# **Introduction**

This contribution summarizes the discussion of following email discussion, regarding the LS from RAN4 [1], on the impact of SRS antenna switching for TDD-FDD band combinations. The companies’ proposals are summarized in Appendix.

[112bis-e-LS-02] Email discussion on potential RAN1 specification change with regards to the issue raised in R1-2302268 by April 19 – Yubo (Huawei).

* Note: If there is consensus to update RAN1 specifications, a follow up email discussion will be set up under agenda item 7.1 for a potential CR.

# **Discussion**

The issue identified in LS [1] is the impact to FDD DL receiving and UL transmitting in FDD+TDD combinations caused by SRS antenna switching, when UE share the same RF in these bands.

* The impact to FDD band downlink receiving was also captured in RAN4 LS R4-1708772.

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| In some UE architectures, some TDD and FDD bands share common RF front-end components. When TDD Tx is active on a UE in FDD+TDD CA among these bands, and TDD SRS antenna switching is executed, some FDD Rx will also switch antennas, which results in an abrupt phase and/or amplitude change on FDD Rx (a glitch in FDD Rx). The degree of phase and/or amplitude change is dependent on the delta in channel conditions between the two antennas. This abrupt phase change can cause a significant BLER and hence throughput loss on FDD Rx in the subframes colliding with TDD Tx SRS antenna switching. |

* The impact to TDD band uplink transmission was discussed in [6] for LTE. The antenna switching in TDD bands will result in antenna switching in FDD bands also, due to the sharing of RF.

Then based on the observations of RAN4, there is following conclusion from RAN4 [1].

Therefore, some clarifications for the expected scheduling restrictions for both UL and DL in the affected band in an EN-DC/NR CA band combination would be helpful enabling the SRS antenna switching feature.

## **Impact to UL transmission in FDD band**

From contributions [2-5], Vivo, Qualcomm, Huawei, HiSilicon propose to introduce a CR to clarify the scheduling restriction. Samsung proposes to further discuss whether the clarification is needed. QC also proposes a text proposal.

Since most companies propose to introduce a CR to clarify the scheduling restriction, and RAN4 also concluded that the clarification is helpful for the SRS antenna switching feature, the following is proposed:

**Proposal 1: Endorse a CR to resolve the impact to UL transmission in FDD band for EN-DC/NR CA in FDD-TDD band combinations.**

Please provide your comments regarding the above proposal:

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| Companies | Comments |
| vivo | Support the proposal |
| NTT DOCOMO | Support the proposal |
| MediaTek | We agree to clarify the restriction, but we do not agree the wording of the proposal above, as it seems to restrict to combinations involving TDD bands, and RAN1 spec and RAN2 UE capability in this case is not specific about duplex mode. Therefore, if we clarify a scheduling restriction in RAN1 specs we should purely link it to the higher layer UE capability (similar to how Qualcomm implemented that part in their TP).  |
| Qualcomm | Agree with MTK. |
| Nokia, NSB | We support clarifying the issue, e.g. along the lines of the Qualcomm CR. |
| Samsung | We are fine with clarifying this issue if there is no critical issue. Qualcomm’s TP can be a starting point.  |
| Huawei, HiSilicon | We support the proposal. |
| ZTE | We are fine with the proposal.  |
| Apple | Agree with MTK and QC |
| Mod | Based on the comment from MediaTek, the following is proposed, with the wording more general:**Proposal 1: Endorse a CR to resolve the impact to UL transmission for bands reported by *txSwitchWithAnotherBand* as described in R1-2302268.**For the CR, we can discuss after Mr. Chair approves the clarification. |
| CATT | Support the proposal. |
| Ericson | Would like further discussion before agreeing to clarification or endorsing a CR. 38.133 already describes interruptions for txSwitchWithAnotherBand. Is the intention to add new behavior beyond this? If not, why is 38.133 not enough?  |

## **Impact to DL receiving in FDD band**

Qualcomm proposes to not specify any UE behaviour for downlink impact in RAN1, proposes to capture it in RAN4 specs instead. And Huawei, HiSilicon propose to specify the scheduling restriction in RAN1 spec.

Please note that in RAN4 LS, it’s concluded that clarification of scheduling restriction for DL is also helpful.

*Therefore, some clarifications for the expected scheduling restrictions for both UL and DL in the affected band in an EN-DC/NR CA band combination* *would be helpful enabling the SRS antenna switching feature.*

Please provide your comments on the clarification of scheduling restriction for DL in affected band in EN-DC/NR CA band combinations.

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| Companies | Comments |
| vivo | We are fine to capture in RAN1 spec. we can discuss exact wording and applicable version of the spec |
| NTT DOCOMO | We are open to the place for capturing this aspect. There seems pros and cons for each direction, if we understand correctly:* Capturing in RAN1 spec indeed gives operation how the scheduling should be in very clear manner. Meanwhile, some flexibility on the scheduling may be lost given that the scheduler may want to schedule DL even considering the influence of AS SRS.
* Capturing in RAN4 spec may not be actual “restriction” imposed on the scheduler; it could rather be a suggestion that “such a DL may be affected by AS SRS…”. It may be able to keep scheduler flexibility somehow, while the result of such scheduling policy may be quite affected by AS-SRS.
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| MediaTek | We would like to understand better why there is a preference to capture in RAN4 spec instead of RAN1 spec. Is it because it is easier to refer to band combinations there? |
| Qualcomm | We prefer to capture this in the RAN4 spec, similar to other downlink interruptions (e.g. SCell activation, measurement gaps, SRS carrier switching). |
| Nokia, NSB | We prefer RAN4, where the text allows the UE reception to be interrupted if the UE needs, rather than make it a functional requirement in RAN1. |
| Samsung | We have similar view to Qualcomm. We prefer to capture the possible impact on DL in RAN4 spec.  |
| Huawei, HiSilicon | We support to have a clear clarification in RAN1 spec, as concluded in RAN4 LS. The problem with current RAN4 requirement is that the impact to receiving performance is not clear, e.g., when the interruption occurs at data symbols then it may just result in increased BLER, and it occurs at DMRS symbols, UE may not be able to decode it. Our intention is just to make it clear that UE does not need to decode it.If companies still have concern over further clarification, we propose something like below to refer to RAN4 requirement.For a UE configured with multiple component carriers, and for a first component carrier configured with uplink in a first band and a second component carrier configured with downlink in a second band that are signaled to be impacted according to higher layer parameter *txSwitchImpactToRx* the UE follows the requirement in 8.2.2.2.16 in 38.133 related to antenna switching. |
| ZTE | We are fine to let RAN4 handle it. Huawei’s CR for DL is also fine to us.  |
| Apple | We share similar view as QC. On HW/HiSi’s proposal above, although we agree with the intention, but in our view we don’t need to capture it in spec (8.2.2.2.16 in 38.133, and/or 6.3.3.6 in 38.101-1, etc already define UE behavior) |
| Mod | Please feedback whether the proposal from Huawei, HiSilicon is fine for you.@Apple, I understand your comment, from RAN4 LS, they have the conclusion that some clarification in RAN1 for DL is helpful for the SRS antenna switching feature, the above proposal has removed the UE behavior, which should resolves your concern. |
| CATT | Huawei’s CR is fine to us. |
| Ericsson | We have a similar view to Qualcomm: 38.133 should be enough. Moreover, we would prefer to not restrict gNB scheduling unnecessarily, and the current spec allows gNB to schedule with the understanding that interruptions may occur. |

# **Conclusion**

TBD

# **References**

1. R1-2302268 (R4-2303633), Huawei/Hisilicon, LS on clarification on impact of SRS antenna switching for TDD-FDD band combinations, From: RAN4, To: RAN1, RAN2.
2. R1-2302451 Discussion on impact of SRS antenna switching for TDD-FDD band combinations vivo
3. R1-2303095 Draft Reply LS on clarification on impact of SRS antenna switching for TDD-FDD band combinations Samsung
4. R1-2303558 Clarification on SRS antenna switching Qualcomm Incorporated
5. R1-2303861 Discussion on SRS antenna switching for TDD-FDD band combinations Huawei, HiSilicon
6. R1-1712769, Qualcomm Incorporated, Discussion on simultaneous PUSCH and SRS transmission from different antenna ports.

# **Appendix** **List of companies’ proposals**

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| Companies | Proposals |
| Vivo [2] | Proposal: for the UEs supporting SRS antenna switching and signaling corresponding *txSwitchImpactToRx* and *txSwitchWithAnotherBand* capabilities, introduce a CR to reflect restriction on simultaneous SRS and PUSCH transmission in NR spec 38.213. |
| Samsung [3] | In RAN1’s understanding, the UE can report the UE capability ‘srs-TxSwitch’ to indicate whether to support SRS antenna switching including following component parameters in TS 38.306:*[… copied description of srs-TxSwitch, srs-TxSwitch-v1610 from TS 38.306 is omitted]*Based on the above UE capability report, the gNB can acknowledge whether SRS antenna switching can affect DL reception or UL transmission in the band combination if the UE would report ‘txSwitchImpactToRx’ and ‘txSwitchWithAnotherBand’. Based on reported UE capability parameters, the gNB can avoid that problematic scheduling and will implement the scheduling restriction not to support SRS antenna switching and DL reception/UL transmission simultaneously if the UE reports ‘txSwitchImpactToRx’ and ‘txSwitchWithAnotherBand’ in the band combination. However, making the clarification for this scheduling restriction makes RAN1 specification clearer if there is no NBC issue. Therefore, RAN1 can further discuss whether this clarification is required for RAN1 specification and there are no NBC issues. |
| Qualcomm [4] | **Observation 1: In LTE, there is a clear mapping between SRS ports and PUSCH ports. In NR, this is not the case.****Proposal 1: RAN1 to adopt TP1 for TS 38.214.**

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| ============================<TP1, 38.214>============================6.2.1.2 UE sounding procedure for DL CSI acquisition**<Unchanged parts are omitted>**For a UE configured with multiple component carriers, and for a first component carrier configured with uplink in a first band and a second component carrier configured with uplink in a second band that are signalled to switch together according to higher layer parameter *txSwitchWithAnotherBand* the UE is not expected to follow inconsistent transmissions related to antenna switching.For a UE configured with multiple component carriers configured with uplink in intra-band CA, the UE is not expected to follow inconsistent transmissions related to antenna switching.For a UE configured with EN-DC, and for a first component carrier configured with uplink corresponding to in an E-UTRA band and a second component carrier configured with uplink in a NR band that are signalled to switch together according to higher layer parameter *txSwitchWithAnotherBand*, the UE is not expected to follow inconsistent transmissions related to antenna switching in E-UTRA and NR.For a UE configured with intra-band EN-DC, the UE is not expected to follow inconsistent transmissions related to antenna switching in E-UTRA and NR. |

**Proposal 2: RAN1 does not intend to specify any UE behavior related to *txSwitchImpactToRx*. It is RAN1’s understanding that *txSwitchImpactToRx* will result in a ‘glitch’ in downlink reception, which can be captured by RAN4 specifications.** |
| Huawei, HiSilicon [5] | ***Observation 1: For FDD-TDD band combinations, the SRS antenna switching in TDD band impacts on the uplink transmission and downlink receiving of the FDD band.******Observation 2: For LTE, a CR in RAN1 was approved and RAN2 introduced UE capabilities txAntennaSwitchDL and txAntennaSwitchUL to resolve the issues in FDD-TDD band combinations.******Observation 3: For NR, there is no clarification for the expected scheduling restrictions for both UL and DL in the affected band in EN-DC/NR CA FDD-TDD band combinations.******Proposal 1: Support the following restrictions for TDD-FDD combinations where some bands support Tx antenna switching:**** ***For each uplink band, the UE is not expected to transmit uplink channels/signals on different antenna ports with bands reported by*** ***txSwitchWithAnotherBand.***
* ***For each uplink band, the UE is not required to receive PDSCH on bands reported by txSwitchImpactToRx in symbols where antenna switching is performed.***
* ***The above is clarified in spec by CR.***
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