**3GPP TSG-RAN WG1 Meeting #117 R1-24xxxxx**

**Fukuoka, Japan, May 20 – 24, 2024**

**Agenda Item: 5**

**Source: Huawei, HiSilicon**

**Title: Summary of discussion on 3T6R and 4T6R antenna switching SRS**

**Document for: Discussion and Decision**

# Introduction

This contribution summarizes the discussion on RAN4 LS [1] regarding 3T6R and 4T6R antenna switching, based on inputs [2-10].

# Discussion

For 3T6R, RAN4 sent LS [1] asking RAN1 to consider 3T6R, but RAN1 also has a conclusion that no consensus on 3T6R antenna switching in Rel-19 as below,

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| **Conclusion**  There is no consensus in RAN1 to support antenna switching for 3TX UE in Rel-19 |

Therefore, please provide your views over the following options.

* **Option 1: Support antenna switching of 3T6R.**
* **Option 2: Antenna switching of 3T6R is not supported.**

**Note: If companies cannot achieve agreement on any option, then the previous conclusion is kept that there’s no consensus to support antenna switching for 3T6R.**

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| Companies | Comments |
| Samsung | Option 2. We have explicit conclusion as above. |
| ZTE | Support option 1. Antenna switching is an important feature in TDD for DL CSI acquisition. Besides, 3T6R is easy to specify but supporting two 4-port SRS resources and the 4th port is muted for each resource. |
| Ericsson | We support Option 1. There are gains with 3T6R compared to 2T6R and could be supported for UE with ≥3 Tx, with 3 Tx SRS transmission. 3 Tx SRS antenna switching could be discussed in the 3 Tx agenda item. |
| Huawei, HiSilicon | Support option 2. RAN1 has explicit conclusion, no need to discuss it again. |
| Nokia | We support Option 1. We share view with Ericsson and ZTE. We don’t think the specification impact is high. |
| InterDigital | Support Option 1. Antenna switching is a basic functionality of a UE, and it should be supported. |
| vivo | We can be open to support option 1, however we don’t want to see the situation using this agreement as argument for other topics currently being discussed. |
| Apple | We are okay to have Option 1, i.e., revert the conclusion. But it is purely from RAN1 perspective. There is no need to do this because RAN4 LS. |
| QC | Support option 1. |
| LG | Support option 1. There is ongoing discussion in Rel-19 MIMO, too. In our view, the specification effort to support 3T6R is very small, e.g., just reuse already agreed CB based 3-port SRS resource. |
| Fujitsu | Support Option 1. |

For 4T6R, the similar situation as 3T6R, where the RAN4 asked RAN1 to consider it, but RAN1 have discussed it in Rel-17 and not support. Based on the Tdocs, there are following options for further discuss.

Please provide your views over the following options.

* + **Option 1: Support antenna switching 4T6R by configuring a 4-port SRS resource and a 2-port SRS resource for SRS antenna switching.**
* **FFS on guard symbol(s) between the two SRS resources.**
  + **Option 2: Support antenna switching 4T6R by configuring two 4-port SRS resources for SRS antenna switching, where 2 ports in the second resource are transmitted.**
* **FFS on guard symbol(s) between the two SRS resources.**
  + **Option 3: Support antenna switching 4T6R by configuring 3 2-port SRS resources for SRS antenna switching, without guard symbol between the first and second SRS resources.**
* **FFS on guard symbol(s) between the second and third SRS resources.**
  + **Option 4: Antenna switching 4T6R is not supported.**

**Note: If companies cannot achieve agreement on any option, then it implies a conclusion that there’s no consensus to support antenna switching for 4T6R.**

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| Companies | Comments |
| Samsung | Option 4. We have explicit conclusion in Rel-17, and no corresponding specification. |
| ZTE | Support option 4. 4T6R was discussed during Rel-17, but it was too controversial to achieve an agreement. As long as 3T6R can be supported, the 4T6R UE can use 3T6R to perform antenna switching, and only two SRS resources/symbols are needed. |
| Ericsson | Support Option 4. We have same understanding as ZTE: There are no gains with 4T6R compared to 3T6R. |
| Huawei, HiSilicon | Support option 4. It has been discussed in RAN1 with explicit conclusion. |
| Nokia | Support Option 3. We see benefit of using option 3 in terms of latency and coverage. |
| InterDigital | Do not support Option 4. Other options are all fine, however similar view as Nokia that Option 3 gives the best performance. |
| Vivo | Support option 4. |
| Apple | We prefer Option 4. 4T6R is not within the scope of RAN plenary approved RAN1 package. |
| QC | Support option 1. |
| LG | Support option 4, we are not sure we can bring-up the past Rel-17 thing in this stage. |
| Fujitsu | Support Option 4. |

# Conclusion

TBD

# References

1. R1-2403834 LS on 3T6R and 4T6R antenna switching SRS RAN4, Huawei
2. R1-2404064 Draft reply LS on 3T6R and 4T6R antenna switching SRS Samsung
3. R1-2404142 Discussion on LS on 3T6R and 4T6R antenna switching SRS vivo
4. R1-2404245 Discussion on 3T6R and 4T6R antenna switching SRS ZTE
5. R1-2404246 Draft reply LS on 3T6R and 4T6R antenna switching SRS ZTE
6. R1-2405063 Discussion of RAN4 LS on 3T6R and 4T6R antenna switching SRS Nokia
7. R1-2404825 Discussion on LS on 3T6R and 4T6R antenna switching SRS OPPO
8. R1-2405131 Discussion of RAN4 LS on 3T6R and 4T6R antenna switching SRS Qualcomm Incorporated
9. R1-2405331 Discussion on 3T6R and 4T6R antenna switching SRS Huawei, HiSilicon
10. R1-2405302 Discussion on RAN4 LS on 3T6R and 4T6R SRS antenna switching Ericsson

# Appendix: Summary of proposals of companies

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| Sourcing | Proposals |
| [2] Samsung | During the discussion on Rel-19 MIMO in RAN1#116, RAN1 concluded the following that there will be no further discussion on SRS antenna switching for 3TX UE which includes 3T6R as well.  Also, as captured in RAN4 LS as above, since RAN1 also concluded not to introduce SRS antenna switching with 4T6R, there is no RAN1 specification supporting the case of 4T6R. Hence, specifying requirement on the case which is not specified in RAN1 specification does not make sense.  Based on above reasons, RAN1 cannot consider introducing 4T6R and 3T6R SRS antenna switching in Rel-19. |
| [3] Vivo | RAN1 to first agree on whether to consider the request from RAN4 on introducing 3T6R and 4T6R antenna switching, if yes, then details on SRS configuration and UE capabilities can be discussed.  If consensus can be reached in RAN1 to support 3T6R SRS antenna switching, following the legacy principle and agreement on 3-port SRS transmission, an SRS resource set with usage ‘antennaswitching’ can be configured with two 4-port SRS resources where 4th port of each resource is muted.  To support 4T6R SRS antenna switching, further discussion in RAN1 is needed on how to configure SRS resources in the SRS set. There could be two options:  Option1: configure two 4-port SRS resources in the set, where all 4 ports from the first resource is transmitted, and only 2 ports from the second resource is transmitted by switching two antennas.  Option2: configure one 4-port SRS resource and one 2-port SRS resource in the set, where all 4 ports from the first resource is transmitted, and 2 ports from the second resource is transmitted by switching two antennas. |
| [4][5] ZTE | Then for 3T6R UE, the DL CSI acquisition can only be achieved by degraded antenna switching, e.g., 1T6R or 2T6R. For 1T6R or 2T6R, six 1-port SRS resources and three 2 port SRS resources need to be configured, respectively. While if 3T6R is supported, only two 3-port SRS resources need to be configured. In comparison, 1T6R and 2T6R will cost four more and one more SRS symbols than 3T6R, respectively.  ***Proposal 1:*** *Support 3T6R antenna switching in Rel-19.*  ***Proposal 2:*** *For 3T6R antenna switching, two 4-port SRS resources are configured, and the 4th SRS port is always muted in each SRS resource.*  Generally, both Alt 1 and Alt 2 aim to fully utilize the UL transmission capability of the 4Tx UE. Nevertheless, at least two SRS resources/symbols are needed for either Alt 1 or Alt 2. If 3T6R is supported, the 4T6R UE can achieve DL CSI acquisition by degraded 3T6R antenna switching, then neither Alt 1 or Alt 2 is needed. The 3T6R antenna switching only requires two SRS resources/symbols, and it does not suffer from the drawbacks of 4T6R.  ***Observation 1:*** *4T6R antenna switching cannot save the number of SRS symbols compared to 3T6R antenna switching.*  ***Proposal 3:*** *Do NOT support 4T6R antenna switching in Rel-19.* |
| [6] Nokia | In Rel-19, RAN1 is working for introduction of 3TX UE operation. 3T6R SRS antenna switching operation can be discussed in the agenda. Because RAN agreed to support 3TX SRS by muting the last port of 4TX SRS, we think 3T6R can be easily supported by extending the legacy framework of 4T8R to 3T4R.  **Proposal 1: Support 3T6R SRS antenna switching with the operation of 4T8R by replacing 4TX SRS to 3TX SRS.**  **Proposal 2: Support SRS antenna switching of 2T6R without guard symbol (Alt 2-2) for 4T6R capable UE.** |
| [7] OPPO | In order to facilitate RAN4 discussion on RF requirements for 6 Rx UE and address the issue of SRS antenna switching for 6 Rx UE, RAN1 is considering the introduction of 4T6R and 3T6R SRS antenna switching in Rel-19. If 3T6R is not supported, then needs to fallback to 2T6R. This, however, increases SRS sounding overhead, e.g., more sounding OFDM symbols and gaps.  ***Proposal 1: Introduce 4T6R and 3T6R SRS antenna switching in Rel-19.*** |
| [8] Qualcomm | To support 3T6R, it is quite straightforward. Using 2 OFDM symbol each sound 3 antennas, 3T6R can be supported.  To support 4T6R, it is slightly more complicated. As illustrated by following figure, NW can configure two SRS resources on two OFDM symbols with a switching gap in between. The first 4-port SRS resource sounds 4 Rx antennas, the second 2-port SRS resource sounds 2 Rx antennas.  **Proposal 1:** **Support 4T6R and 3T6R SRS antenna switching in Rel-19.**   * **3T6R is supported with two TDMed 4-port SRS resources each transmit 3-port SRS with the last port muted.** * **4T6R is supported with a 4-port SRS resource TDMed with a 2-port SRS resource.** |
| [9] Huawei, HiSilicon | ***Proposal 1: If 4T6R SRS antenna switching is supported, the following SRS configurations can be considered，***   * ***Configuration of AS SRS resource set with three 2-port SRS resources, i.e., 2+2+2.*** * ***At least guard period between the first two resources is not needed.*** |
| [10] Ericsson | **Observation 1: 3T6R antenna switching has smaller overhead compared 2T6R antenna switching.**  **Observation 2:** **3T6R antenna switching configured with repetition or frequency hopping achieves higher SRS power compared to 2T6R antenna switching for the same overhead.**  **Proposal 1: If time is available in the Rel-19 work for 3 Tx, support 3T6R antenna switching.**  **Observation 3: 4T6R antenna switching with unequal number of SRS ports per OFDM symbol (Alt1) achieves lower SRS power per port compared to 3T6R antenna switching for the same overhead.**  **Observation 4: 4T6R antenna switching with equal number of and partially overlapping SRS ports per symbol (Alt2) requires a more complex antenna-switching pattern but cannot achieve higher SRS power per port compared to 3T6R antenna switching configured with repetition, for the same overhead.**  **Proposal 2:** **Do not support 4T6R antenna switching in Rel-19 and inform RAN4 in an LS reply.** |