**3GPP TSG RAN WG1 Meeting #102-e R1-2007051**

**E-meeting, August 17 - 28, 2020**

**Agenda Item: 7.2.6**

**Source: Huawei, HiSilicon**

**Title: Summary of [102-e-NR-eMIMO-09] Reply LS on feasibility of ULFPTx modes and transparent TxD for certain UE implementations**

**Document for: Discussion and Decision**

# Introduction

The full power transmission is under discussing in RAN4, an LS (R1-2005224/R4-2009171) send to RAN1 and asked the following three questions:

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| In RAN4 study of ULFPTx under eMIMO WI, enabling transparent Tx diversity (TxD) was agreed at least from Rel-16, and the applicability of transparent TxD is NOT related to UE supporting or not supporting Rel-16 ULFPTx. Two possible cases were identified in RAN4 to use transparent TxD to achieve the required transmission power, i.e. for a FR1 UE having two TX branches/antennae,* First case: Transparent TxD for UE configured with single SRS port (either with DCI\_0\_0 or single SRS port with DCI\_0\_1);
* Second case: Transparent TxD for UE configured with 2 SRS ports (FFS whether TxD is feasible in this case).

For the second case, two possible methods to transmit a multi-port SRS resource (i.e. 2Tx ports) with two PAs (PA1 and PA2) were considered, i.e. * Method-1: SRS port-1 maps to PA1, SRS port-2 maps to PA2
* Method-2: SRS port-1 maps to PA1+PA2, SRS port-2 maps to PA1+PA2

In order to make progress of corresponding discussion of transparent TxD related issues, RAN4 would like to get some clarification from RAN1 for the feasibility of the second case.**Question 1**: Whether the two mentioned methods are both feasible to transmit the full output power?**Question 2**: If answer is yes, which ULFPTx modes can be supported for these two methods?Furthermore, RAN4 discussed that the feasibility of different ULFPTx modes in FR2 UE. The ULFPTx mode-1 for FR2 UE has been confirmed to be feasible, while companies have different understandings for the other two modes (i.e., mode-1 and the other mode). RAN4 would like to get some clarification from RAN1 for the feasibility of the other two modes. **Question 3**: Whether the ULFPTx mode-2 and the other ULPFTx mode are feasible for FR2 UE? |

Based on the draft replied LSs from companies, the summary and draft proposals are provided.

# Summary of draft reply LSs

**Question 1: Whether the two mentioned methods are both feasible to transmit the full output power?**

**Replied as:**

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| **[1]** From RAN1 perspective, Method-1 was the general consideration while =designing codebook based operation in Rel-15 and subsequent ULFPTx feature in Rel-16. From RAN1 perspective, Method-2 is purely UE implementation and not visible in specification, thus from specification wise there is no differentiation between Method-1 and Method-2 in RAN1.**[2]** From RAN1 perspective, the two mentioned methods are both feasible to transmit the full output power. **[3]** Both methods are feasible to transmit full uplink output power. **[4]** The two mentioned methods are both feasible to transmit the full output power**[5]** Method 1 is feasible for all ULFPTx modes (subject to UE capability and PA architectures). Method 2 on the other hand can be feasible but not for all ULFPTx modes (cf. reply to Question 2 below). In addition, Method 1 is simpler of the two methods since it doesn’t rely on virtualizing (combing) multiple PAs.**[6]** From RAN1 perspective, method 1 is one-to-one PA-to-port mapping and method 2 is two-to-one PA-to-port mapping which can be referred to antenna virtualization and is up to UE implementation. So, if UE reports its capability of supporting ULFPTx based on either method 1 or 2, ULFPTx can be supported. Thus, both methods are feasible. [7] Method-1 is feasible to transmit UL full power when ULFPTx and 2 port SRS are configured, while Method-2 is not feasible in UEs in order to facilitate PA power reduction.[8] Yes. Both are feasible in RAN1’s view. The first method is based on sub-array antenna mapping structure, and the second method is based on full-connection antenna mapping structure, where the two antenna mapping structures are already modelled in TR36.897. |

Based on the draft reply from companies, 7 companies out of the total 8 answered with Method-2 is feasible. One company commented the drawback of Method-2 is not feasible for facilitating PA power reduction. Based on the situation, the draft proposal is provided as follows:

**Proposal 1: From RAN1 perspective, both Method-1 and Method-2 are feasible for UL full power transmission.**

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| Companies | Views |
| Apple | Support |
| vivo | As we mentioned in our tdoc that method-2 is purely implementation which is agnostic to RAN1 spec however RAN1 doesn’t have expertise to declare feasible or not feasible. We think some information on SRS is also beneficial for RAN4 to take into account while considering 2 methods. Thus, we would like to rephrase proposal 1 as “From RAN1 perspective, while designing full power transmission feature, there is no differentiation between 2 methods. Furthermore, when an UE is configured with 2-port SRS, both SRS ports are transmitted on same symbol(s). ” |
| ZTE | Support the Moderator’s proposal |
| LG | Support |
| Intel | From our view, Method-1 is feasible for UL full power transmission. It’s a simple and straight forward mapping.For Method-2, it is more implementation related.We share similar view with Ericsson in [7]. Method-2 would increase PAPR and therefore is not feasible from RAN1 perspective. |
| OPPO | Support |
| Spreadtrum | Support |
| CATT | Support |
| Huawei, HiSilicon | Support the proposal. Method-1 and Method-2 are the exactly antenna mapping structures we have discussed in LTE before and both captured in TS36.897, where one is sub-array structure and another is full connection structure. So, we do not see any problem with the two methods for UL full power transmission in RAN1.Then, to reply Intel, if following the logical, any rank-2/3/4 partial and coherent precoding is not feasible. It is not true. High-rank transmission with partial and full coherent precoders are always with multiple data streams in a PA. Then, for rank-1, Mentod-2 with Mode-2, there is no multiple layers in a PA, should be no issue, it is feasible for UL full power transmission. To vivo, we also agree that there is no difference for the two methods for the feasibility. We can add the sentence “From RAN1 perspective, while designing full power transmission feature, there is no differentiation between 2 methods” before the proposal, but we need to answer the question that feasible or not from RAN1 perspective. |
| Futurewei | Support |

**Email discussion conclusion 1:**

**Proposal 1: From RAN1 perspective, both Method-1 and Method-2 can be supported for UL full power transmission.**

**For method 2, the UE will need to transmit two SRS ports on each PA for two ports case in a symbol. If the UE is 2 layer capable, it will need to transmit 2 PUSCH layers on each PA in a symbol.   For method 1, each PA carries one SRS port and, in the case of non-coherent 2 layer transmission, one layer per PA; but for UEs that support coherent 2 layers PUSCH transmission, it needs to transmit two layers on each PA in a symbol.  RAN1 understand that multilayer transmission on a PA in a symbol could increase PAPR for PUSCH and multiple SRS port transmission on a PA in a symbol could increases PAPR for SRS, but RAN1 has not evaluated yet.**

**Question 2: If answer is yes, which ULFPTx modes can be supported for these two methods?**

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| **[1]** All UL full power transmission modes specified are feasible for Method-1. As mentioned in Answer 1, Method-1 was the general consideration for ULFPTx design in RAN1 and Method-2 is not visible in specification. SRS port-1 and SRS port-2 of an SRS resource are transmitted on same symbol(s), it is up to RAN4 to consider whether Method-2 is feasible for supporting ULFPTx. **[2]** From RAN1 perspective, the two mentioned methods are both feasible to transmit the full output power. * Regarding method-1, ULFPTx mode 0 (in the case that the two PAs are both full Tx power PA, like 23+23 dBm for PC3), ULFPTx mode 1 (by indicating the newly introduced TPMIs for the precoders with non-zero entries, e.g., for a UE with 20+20 dBm PAs for PC3) and ULFPTx mode 2 (by using UE capability reporting of full Tx power TPMI group(s), when the UE have one full power PA, e.g., for a UE with 23+20 dBm PAs for PC3) can be supported.
* Regarding method-2, ULFPTx mode 0 (in the case that two PAs are both full Tx power PA, like 23+23 dBm for PC3) and ULFPTx mode 2 (by using SRS port virtualization and UE capability reporting of full Tx power TPMI group(s), e.g., for a UE with 20+20 dBm PAs for PC3) can be supported.

**[3]** All ULFPTx modes (e.g. mode 0, 1, 2) can be supported with these two methods.**[4]** Depending on UE capability, UE with Method-1 or Method-2 may support one of {fullpower, fullpowerMode1, fullpowerMode2}**[5]** Method 1: all ULFPTx modes can be supported depending on UE PA architecture. * + Mode 0 can be supported if each PA is full-rated.
	+ Mode 1 can be supported since full power can be achieved with TPMI = 2, i.e., [1 1]/sqrt(2).
	+ Mode 2 can be supported if at least one PA is full-rated and the UE reports at least one full power TPMI (0 or 1), or the UE can be configured with a SRS resource with 1 port.

Method 2 * + Mode 0 can be supported if each SRS port can achieve full power.
	+ Mode 1: not usable, since if it is used, then both SRS ports (i.e. TPMI = 0,1) can achieve full power, which contradicts the fact that only TPMI = 2, i.e., [1 1]/sqrt(2) can achieve full power for mode 1.
	+ Mode 2:
		- For a SRS resource with 1 port, full power can be supported.
		- For a SRS resource with 2 ports, full power can be supported for the full power TPMI(s) reported by the UE.

In short, Method 1 can support all modes and Method 2 can support mode 0 and 2 but not mode 1.[6] The answer for Q2 is that it is depending on UE PA capability. For example, if UE is equipped with two full-rated PA (e.g. 23dBm for PC3), then both methods can support all ULFPTx modes.**[7]** Method-1 can be used for any Rel-16 ULFPTx mode.**[8]** The two methods can be used for UL full power Mode-1, Mode-2, and Mode-full power. For example, for power class-3, UE is with two PAs 20+20dBm, then Method-1 can be used for Mode-1, where [1 1] for full power transmission. Meanwhile, Method 2 can be used for Mode-2, where [1 0] for full power transmission. For another example, UE with two PAs 23+23dBm for power class-3, then Method-1 can be used for Mode-2 and Mode-full power, where [1 0] and [0 1] can be full power transmission as well.  |

Based on the draft replies from companies, [2][3][4][6][8] think UL full power transmission modes are feasible for both mapping methods, which may depend on the UE capability. [5] thinks the method-2 can be feasible for Mode-0 and Mode-2, but not Mode-1. [1] thinks Method-2 is transparent in RAN1 spec and the feasibility depends on RAN4. Some examples provided by companies show that Method-1 and Method-2 are feasible for modes. Then, the draft proposal is provided as follows:

**Proposal 2: From RAN1 perspective, Method-1 is feasible for any UL full power transmission modes, and Mothod-2 is feasible at least for Mode-2 and Mode-full power.**

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| Companies | Views |
| Apple | Support |
| vivo | For mode0 and mode2, since basic design principle in RAN1 was considering “full rated PA”, although from RAN1 perspective 2 methods are spec agnostic, RAN1 is not position to decide whether feasible or not feasible. Thus, we would like to rephrase proposal 2 as below:“From RAN1 perspective, both method 1 and method 2 are spec agonistic. RAN1 doesn’t see any issue with method 1 supporting UL full power transmission, method 2 might be possible with mode 0 and mode2 however RAN1 doesn’t have expertise on determining feasibility ” |
| ZTE | Support the Moderator’s proposal |
| LG | Support |
| Intel | We only support the part that Method-1 is feasible for all the UL full power transmission modes. |
| OPPO | Support |
| Spreadtrum | Support |
| CATT | Support |
| Huawei, HiSilicon | Support |
| FUTUREWEI | Support |

**Email discussion conclusion 2:**

**Proposal 2: From RAN1 perspective, Method-1 can be supported for any UL full power transmission modes, and Mothod-2 can be supported at least for Mode-2 and Mode-full power.**

Furthermore, RAN4 discussed that the feasibility of different ULFPTx modes in FR2 UE. The ULFPTx mode-1 for FR2 UE has been confirmed to be feasible, while companies have different understandings for the other two modes (i.e., mode-1 and the other mode). RAN4 would like to get some clarification from RAN1 for the feasibility of the other two modes.

**Question 3: Whether the ULFPTx mode-2 and the other ULPFTx mode are feasible for FR2 UE?**

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| **[1]** From RAN1 perspective, there is no differentiation between FR1 and FR2 while designing ULFPTx feature, however for one operation in mode-2 and the other ULFPTx mode the UE reports capability which is closely related to the PA output power. RAN1 is not sure whether such capability reporting is feasible for FR2. One of the UE features related to mode-2 is currently

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| 16-5c-2 | UL full power transmission fullpowerMode2– SRS resources |

being finalized in RAN1, where multiple SRS with different number of ports are configured to a UE, e.g. one resource with single SRS port and another resource with 2 SRS ports, ULFPTx mode-2 is feasible when gNB schedules PUSCH with DCI 0\_0 or DCI 0\_1 indicating SRI associated with single SRS port, which is equivalent to the First case of Transparent TxD.**[2]** Yes. From RAN1 perspective, the ULFPTx mode-2 and the other ULPFTx mode are feasible for FR2 UE.**[3]** Yes. It is feasible for FR2 UE to supports any ULFPTx mode. **[4]** Depending on UE capability, FR2 UE may support {fullpower} or {fullpowerMode2}.**[5]** Considering that mode 1 for FR2 UE has been confirmed to be feasible, there is no technical reason behind not allowing (or declaring infeasible) mode 0 or mode 2 in FR2, i.e., if a FR2 UE is allowed to support mode 1, then another FR2 UE, if it can, should be allowed to support mode 0 or mode 2. Hence, all modes should be feasible for FR2.[6] During the Rel-16 WI phase, RAN1 does not differentiate the ULFPTx modes according to the frequency range. Thus, in RAN1 perspective, all ULFPTx modes are feasible for FR2. [7] All Rel-16 ULFPTx modes are feasible for FR2 UEs from RAN1’s perspective.**[8]** The transmission Mode-2 and Mode-full power are also feasible for FR2 UEs. For one example, UE is with 20+20 dBm, each port can be virtualized from the two antennas by Method-2 above (full connection), then full power transmission can be achieved by port/beam selection with [1 0] or [0 1] in Mode-2 or Mode-full power. For another example, UE with 23+23dBm, then in Mode-2 and Mode-full power can provide full power transmission even one port/beam is blocked. For the third example, UE is with 20+20+20+20dBm for the same power class, the UL Tx can be virtualized as 2 ports in Mode-2, so that each port can be 23dBm power transmission.Actually, since Mode-2 and Mode-full power provide flexibility on port/beam selection for UL full power transmission, Mode-2 and Mode-full power are beneficial for the case of beam blockage in FR2, while the UL full transmit power will be on the non-blocked port/beam, but not waste the power on the blocked port/beam. |

Based on the replies from companies, most companies proposed that there are no difference between FR1 and FR2, all the modes are feasible for FR2. While [4] think depends on UE capability, Mode-2 and Mode-full power are feasible for FR2. The draft proposal based on the views are provided as follows:

**Proposal 3: UL full power modes {Mode-1, Mode-2 and Mode-full power} are feasible for FR2.**

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| Companies | Views |
| Apple | Support |
| vivo | RAN1 spec doesn’t differentiate FR1 and FR2, however mode0 and mode2 designs are based on “full rated PA”. Thus we would like add a sentence for better understanding.“Mode0 and Mode2 are designed considering UE is equipped with one or more full rated PAs.” |
| ZTE | Support the Moderator’s proposal |
| LG | Support |
| Intel | Support the Moderator’s proposal |
| OPPO | Support |
| Spreadtrum | Support |
| CATT | Support |
| Huawei, HiSilicon | SupportAgree that Mode-0 is for full related PAs, but Mode-2 is not only for full related PAs, as discussed in RAN1, Mode-2 can be based on port virtualization.  |
| FUTUREWEI | Support |

**Email discussion conclusion 3:**

**Proposal 3: UL full power modes {Mode-1, Mode-2 and Mode-full power} can be supported for FR2.**

# Conclusions

Based on the email discussion, we have the following conclusions in the email discussion:

**Proposal 1: From RAN1 perspective, both Method-1 and Method-2 can be supported for UL full power transmission.**

**For method 2, the UE will need to transmit two SRS ports on each PA for two ports case in a symbol. If the UE is 2 layer capable, it will need to transmit 2 PUSCH layers on each PA in a symbol.   For method 1, each PA carries one SRS port and, in the case of non-coherent 2 layer transmission, one layer per PA; but for UEs that support coherent 2 layers PUSCH transmission, it needs to transmit two layers on each PA in a symbol.  RAN1 understand that multilayer transmission on a PA in a symbol could increase PAPR for PUSCH and multiple SRS port transmission on a PA in a symbol could increases PAPR for SRS, but RAN1 has not evaluated yet.**

**Proposal 2: From RAN1 perspective, Method-1 can be supported for any UL full power transmission modes, and Mothod-2 can be supported at least for Mode-2 and Mode-full power.**

**Proposal 3: UL full power modes {Mode-1, Mode-2 and Mode-full power} can be supported for FR2.**

# References

1. [R1-2005325](file:///C%3A%5C%5CUsers%5C%5Cwanshic%5C%5COneDrive%20-%20Qualcomm%5C%5CDocuments%5C%5CStandards%5C%5C3GPP%20Standards%5C%5CMeeting%20Documents%5C%5CTSGR1_102%5C%5CDocs%5C%5CR1-2005325.zip)      Draft reply on LS on clarification of transparent diversity feasibility      vivo
2. [R1-2005491](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2005491.zip)      Draft reply LS on feasibility of ULFPTx modes and transparent TxD for certain UE implementations              ZTE
3. [R1-2005651](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2005651.zip)      Draft reply LS to RAN4 on feasibility of ULFPTx modes and transparent TxD for certain UE implementations        CATT
4. [R1-2005995](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2005995.zip)      Discussion on feasibility of ULFPTx modes and transparent TxD for certain UE implementations                      OPPO
5. [R1-2006080](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2006080.zip)      [Draft] Reply LS on clarification of transparent diversity feasibility      Samsung
6. [R1-2006591](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2006591.zip)      Draft reply LS on feasibility of ULFPTx modes and transparent TxD for certain UE implementations              LG Electronics
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8. [R1-2006938](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2006938.zip)      Draft reply LS on feasibility of UL FPT modes and transparent TxD for certain UE implementations              Huawei, HiSilicon
9. [R1-2005224](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_102%5CDocs%5CR1-2005224.zip)         LS on feasibility of ULFPTx modes and transparent TxD for certain UE implementations         RAN4, Huawei