**3GPP TSG-RAN WG4 Meeting # 107 R4-2310010**

**Incheon, KR, May 22nd – May 26th , 2023**

**Agenda item:** 8.5.4

**Source:** Moderator (vivo)

**Title:** Topic summary for [107][127] FR1\_enh2\_part2

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

# Topic #1: Issues for 4Tx

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2307090**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307090.zip) | Nokia, Nokia Shanghai Bell | Consideration of scaling factor into configured transmitted power**Observation 1:** At least some companies have a common understanding that the upper limit of the output power of PUSCH is affected by combinations of some parameters like TPMI configuration, scaling factor and/or *ul-FullPowerTransmission*.**Observation 2:** Even now, a range of PCMAX,f,c is adjusted to reflect UE’s expected achievable output power by ΔPPowerClass, and/or some other impairments, depending on configured features, e.g., *powerBoostPi2BPS*K, or SRS antenna switching etc.**Observation 3:** ΔPPowerClass and associated text to explain have provided readers with expected UE behaviour/performance, e.g., applicable MPR, A-MPR table during SRS antenna switching, etc. **Observation 4:** TS38.101-1 doesn’t reflect what TS38.213 expects in terms of configured transmitted power range.**Observation 5:** TS38.101-1 allows higher power more than TS38.213 expects. This inconsistency makes it impossible for readers to uniquely interpret what the expected UE behaviour/performance.**Observation 6:** Without considering the impact of port configuration on configured transmitted power, UE behaviours in terms of power (and also applicable MPR/A-MPR conditions) is not clear.**Observation 7:** Uncertainty of expected achievable UE power (and MPR/A-MPR) may lead to inefficient allocation of resources.**Observation 8:** ΔPPowerClass alone may not work to adjust achievable output power of PUSCH associated with TPMI configuration and scaling factor.**Proposal:** Followings are incorporated into configured transmitted power formulas for PUSCH transmission.* if 0 dB ≤ ΔPPowerClass, PPowerClass - Max (ΔP*s* , ΔPPowerClass)
* if 0 dB > ΔPPowerClass, PPowerClass - ΔP*s* - ΔPPowerClass
* Note that ΔP*s* is 10\*log(1/s), where *s* is a scaling factor.
* Note that 0 dB > ΔPPowerClass happens when power boosting feature is enabled.
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| [**R4-2307143**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307143.zip) | Huawei, HiSilicon | On UE RF requirements for 4TxFor above issues, we stand pat on our position and don't think further consideration is needed unless consensus among companies reached for the raised issues with further clarification.***Proposal 1: The entry for ULFPTx Mode2 with 4 Tx ports transmission in Table 6.2D.1-3 in TS 38.101-1 shall be added concerning 2x23dBm+2x26dBm UE and 4x26dBm UE.******Observation 1: 2x23dBm+2x26dBm UE would report G4 in ul-FullPwrMode2-TPMIGroup-r16. Based on this feedback, gNB shall recognize this UE as the one with two 26dBm ports and two less-power ports******Observation 2: 4x26dBm UE would report G6 in ul-FullPwrMode2-TPMIGroup-r16. Based on this feedback, gNB shall recognize this UE as the one with four 26dBm ports.******Proposal 2: The entry for ULFPTx Mode2 with 4 Tx ports transmission and 2-layer transmission in Table 6.2D.1-3 in TS 38.101-1 shall be added as below：***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ULFPTx Mode | Transmission scheme | DCI format  | Modulation | Number of layers | Number of Tx Port | TPMI index |
| Mode-2 | Codebook based uplink | DCI format 0\_1 | CP-OFDM | 2 | 4 | 1 or 0, 1, 2, 3, 4 ,5NOTE |
| NOTE: TPMI index selected shall be based upon the full power TPMI reported by the UE [8, TS 38.213]. |

***Proposal 3: The entry for ULFPTx Mode2 with 4 Tx ports transmission and 1-layer transmission in Table 6.2D.1-3 in TS 38.101-1 shall be added as below：***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **ULFPTx Mode** | **Transmission scheme** | **DCI format**  | **Modulation** | **Number of layers** | **Number of Tx Port** | **TPMI index** |
| Mode-2 | Codebook based uplink | DCI format 0\_1 | DFT-s-OFDM, CP-OFDM | 1 | 4 | 4, 5, 6 ,7 or 4, 5, 6 ,7, 8, 9, 10, 11NOTE |
| NOTE: TPMI index selected shall be based upon the full power TPMI reported by the UE [8, TS 38.213]. |

***Proposal 4: The entry for ULFPTx Mode1 with 4 Tx ports transmission and 2-layer transmission in Table 6.2D.1-3 in TS 38.101-1 shall be added as below：***

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **ULFPTx Mode** | **Transmission scheme** | **DCI format**  | **Modulation** | **Number of layers** | **Number of Tx Port** | **TPMI index** |
| Mode-1 | Codebook based uplink | DCI format 0\_1 | CP-OFDM | 2 | 4 | 6NOTE |
| NOTE: TPMI index selected shall be based upon the full power TPMI reported by the UE [8, TS 38.213]. |

***Proposal 5: Some relaxation should be considered for PCMAX tolerance for UE supporting 4Tx.***  |
| [**R4-2307251**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307251.zip) | Qualcomm Technologies Int | 4 Tx RF issues**Proposal 1: Allow the 2 X23 + 2 X 26 dBm and 4 X 26 dBm Tx architectures to use the precoder matrix given below for UL MIMO 4-layer transmission.**$$\frac{1}{2}\left[\begin{matrix}1&0&0&0\\0&1&0&0\\0&0&1&0\\0&0&0&1\end{matrix}\right]$$**Proposal 2: Allow the 2 X23 + 2 X 26 dBm and 4 X 26 dBm Tx architectures to use the precoder matrix given below for 1-layer ULFPTx mode 1 operation.****Proposal 3: Allow the use of the EVM formula given below to obtain the total EVM for Tx architectures 2 X23 dBm + 2 X 26 dBm and 4 X 26 dBm when support for Tx diversity is declared.** $$EVM=\frac{\sum\_{i=1}^{4}P\_{i}EVM\_{i}}{\sum\_{i=1}^{4}P\_{i}}$$**Proposal 4: Verify full power rank 2 UL operation for 4 X 23 dBm Tx architecture in mode 1 and mode 2 operation.****Proposal 5: Verify full power rank 2 UL operation for 2 X 23 + 2 X 26 dBm Tx architecture in mode 1 and mode 2 operation.****Proposal 6: Verify full power rank 2 UL operation for 4 X 26 dBm Tx architecture in mode 1 and mode 2 operation.** |
| [**R4-2307483**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307483.zip) | LG Electronics | 4Tx UE RF requirements**Different achievable maximum output power with different antenna configurations****Proposal 1: Consider a same PA pair as baseline when configured with 2 antenna ports for both 2x23dBm+2x26dBm and 4x26dBm****Proposal 2: Further discuss whether PC1.5 applies to both 2x23dBm+2x26dBm and 4x26dBm no matter what the achievable maximum output power is higher than PC1.5 when configured with 4 antenna ports.****Full power rank 2 configurations****Observation 1: If PC1.5 is assumed as UE power class for both PA configurations of 2x23dBm+2x26dBm and 4x26dBm, the full power rank 2 is possible with a TPMI index of 0.****Relation between configured transmitted power and TPMI configuration****Proposal 3: Keep the current RAN4 spec, that Pcmax would not be impacted by TPMI.****PCMAX tolerance for PC1.5 UL-MIMO based on 4Tx****Proposal 4: Consider Table 4 as a starting point of PCMAX tolerance for 4Tx-based UL-MIMO/TxDiversity.**Table 4: PCMAX,*c* tolerance for 4 Tx UL-MIMO

|  |  |  |
| --- | --- | --- |
| PCMAX,*c*(dBm) | ToleranceTLOW(PCMAX\_L,*c*) (dB) | ToleranceTHIGH(PCMAX\_H,*c*) (dB) |
| 26 ≤ PCMAX,*c* ≤ 29 | 3.0 | 2.0 |
| 25 ≤ PCMAX,*c* < 26 | 5.0 | 2.0 |
| 24 ≤ PCMAX,*c* < 25 | 5.0 | 3.0 |
| 23 ≤ PCMAX,*c* < 24 | 5.0 | 4.0 |
| 19 ≤ PCMAX,*c* < 23 | 5.0 |
| 14 ≤ PCMAX,*c* < 19 | 6.0 |
| -40 ≤ PCMAX,*c* < 14 | 7.0 |

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| [**R4-2308238**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308238.zip) | vivo | Further discussion on 4Tx UE RF requirements**Observation 1:** Power scaling introduced in 38.213 as in Rel-15 has never been considered for verification. **Observation 2:** For the power scaling (factor s) introduced in 38.213 since Rel-16 for Full tx power feature for some Modes and TPMIs, no verification is done from Rel-16, since only the full power is design target. **Observation 3:** The fallback introduced by ΔPPowerClass has never been considered for verification.**Observation 4:** The implementation specific restriction on achievable power class in certain condition is similar to the Full Tx power cases from release-16, and the considerations are similar.**Proposal 1:** No need to verify the non-full power cases in 4Tx UE RF requirements.**Proposal 2:** Not to introduce rank = 2 full power tests. If more configuration(s) be considered for ULFPTx mode(s) for test configuration and requirements, Mode 1 with TPMI = 6 for 2-layer seems to be a candidate.**Proposal 3:** Extend the UL-MIMO coherence requirements for 4Tx requirements, and reuse the current requirements for any antenna connectors combination.  |
| [**R4-2308966**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308966.zip) | OPPO | R18 4Tx FWA**Proposal 1: No specify the power scaling related requirements in RAN4 spec. And when NW configures these non-full power TPMIs the RAN1 power scaling mechanism will be followed.****Observation 1: The fall back here actually means different antenna port configurations.****Observation 2: Same power class was assumed for UE with 2Tx be configured with single antenna port. And there is no separate power class reporting scheme to indicate different power classes under different antenna port configurations.****Proposal 2: For PC1.5 UE with 4x23dBm PAs, when it is configured with 2 antenna ports or 1 antenna port, PC1.5 requirements apply.****Proposal 3: Only Mode 1 needs to be considered to verify the 4x23dBm PA configurations.** |
| [**R4-2307144**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307144.zip) | Huawei, HiSilicon, vivo, Samsung, LG Electronics | Big CR to TS 38.101-1 4Tx requirements (phase 1) |

***Moderator’s Note****: The following two tdocs are in Agenda 4.1 ([107][101] Upto\_R16\_UERF\_maintenance), but also referenced here since discussion is related. Decision would not be made here but in [101].*

|  |  |  |
| --- | --- | --- |
| [**R4-2308248**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308248.zip)**\*****(Submitted: In Agneda4.1)** | vivo | Discussion on power scaling factor s and impact to RAN4**Observation 1:** The power scaling in RAN1 is due to RAN1’s understanding of UE implementation restriction and actually not that desirable. **Observation 2:** The power scaling fact s is applied to $\hat{P}\_{PUSCH,b,f,c}\left(i,j,q\_{d},l\right)$.**Observation 3:** The power scaling s does not directly change Pcmax or {}.**Observation 4:** Currently the power scaling factor does not impact power headroom definition and calculation.**Observation 5:** In case PH is positive, the PH reported would be the same to actual achievable PH even in case of power scaling is not equal to 1.**Observation 6:** In case PH is negative, the PH reported may haven an offset to actual achievable PH in case of power scaling not equal to 1. However, this may have quite limited impact to the whole system.**Observation 7:** The PH calculation with no consideration of power scaling factors s, may bring some unclear understandings of PH calculation, though the impact may not be large.**Observation 8:** The understanding of Pcmax may indeed be impacted by the power scaling factor s. Based on the observations, the following two proposals are provided:**Proposal 1:** Send a LS to RAN1 to ask RAN1’s view on this issue.**Proposal 2:** Not to change RAN4 spec until more feedback from RAN1. Any future revision of Pcmax related concept relating to this feature may also need communication with RAN1 to avoid undesirable impacts to RAN1. |
| [**R4-2308249**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308249.zip)**\*****(Submitted: In Agneda4.1)** | vivo | [Draft] LS on power scaling factor s and PHR in 38.213 |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1 Stage-2 Test Configurations

*Sub-topic description:*

Moderator’s note: Stage-2 UE reference architectures:

* 2x23dBm+2x26dBm
* 4x26dBm UE

*Open issues and candidate options before meeting:*

**Issue 1-1-1: Full power Mode 1, 2-layer**

* Proposals
	+ Option 1: Include this configuration, details as following:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **ULFPTx Mode** | **Transmission scheme** | **DCI format**  | **Modulation** | **Number of layers** | **Number of Tx Port** | **TPMI index** |
| Mode-1 | Codebook based uplink | DCI format 0\_1 | CP-OFDM | 2 | 4 | 6~~NOTE~~ |
| ~~NOTE: TPMI index selected shall be based upon the full power TPMI reported by the UE [8, TS 38.213].~~ |

*Moderator’s note:*

1. *This note is suggested deleted since it is mandatory for mode 1 4 Tx port and no need to report.*
2. *This configuration would be applied to both Stage-1 and Stage-2 reference architectures (4x23, 2x23+2x26, 4x26);*
	* Option 2: Include this configuration, TPMI TBD
	* Option 3: Not include this configuration,
* Recommended WF
	+ TBA

**Issue 1-1-2: Full power Mode 2, 1-layer**

* Proposals
	+ Option 1: Include this configuration, details as following:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| **ULFPTx Mode** | **Transmission scheme** | **DCI format**  | **Modulation** | **Number of layers** | **Number of Tx Port** | **TPMI index** |
| Mode-2 | Codebook based uplink | DCI format 0\_1 | DFT-s-OFDM, CP-OFDM | 1 | 4 | 4, 5, 6 ,7 or 4, 5, 6 ,7, 8, 9, 10, 11NOTE |
| NOTE: TPMI index selected shall be based upon the full power TPMI reported by the UE [8, TS 38.213]. |

*Moderator’s note:*

1. *These configurations would applied to Stage-2 reference architectures (2x23+2x26, 4x26).*
2. *Mode 2 cannot support full PC1.5 assuming Stage-1 reference architecture 4x23.*
	* Option 2: Include this configuration, TPMI TBD
	* Option 3: Not include this configuration,
* Recommended WF
	+ TBA

**Issue 1-1-3: Full power Mode 2, 2-layer**

* Proposals
	+ Option 1: Include this configuration, details as following:

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| ULFPTx Mode | Transmission scheme | DCI format  | Modulation | Number of layers | Number of Tx Port | TPMI index |
| Mode-2 | Codebook based uplink | DCI format 0\_1 | CP-OFDM | 2 | 4 | 1 or 0, 1, 2, 3, 4 ,5NOTE |
| NOTE: TPMI index selected shall be based upon the full power TPMI reported by the UE [8, TS 38.213]. |

*Moderator’s note:*

1. *These configurations would applied to Stage-2 reference architectures (2x23+2x26, 4x26).*
2. *Mode 2 cannot support full PC1.5 assuming Stage-1 reference architecture 4x23.*
	* Option 2: Include this configuration, TPMI TBD
	* Option 3: Not include this configuration,
* Recommended WF
	+ TBA

**Issue 1-1-4: Applicability of Stage-2 UE architecture’s conformance to Stage-1 test configurations.**

* Proposals
	+ Option 1: Confirm stage-2 reference architectures can also satisfy the stage-1 test configurations (rank = 4 and 1-layer ULFPTx mode 1)
	+ Option 2: Others
* Recommended WF
	+ TBA

**Issue 1-1-5: Power class for Stage-2 configurations.**

* Proposals
	+ Option 1: Further discuss whether power class 1.5 or new power class applies to both 2x23dBm+2x26dBm and 4x26dBm
	+ Option 2: Others
* Recommended WF
	+ TBA

**Issue 1-1-6: Verification of full power rank 2 UL operation**

* Proposals
	+ Option 1: Verify full power rank2 UL operation for
		- 4 X 23 Tx architecture in mode 1 and mode 2 operation
		- 2 X 23 + 2 X 26 Tx architecture in mode 1 and mode 2 operation
		- 4 X 26 Tx architecture in mode 1 and mode 2 operation
	+ Option 2: Others
* Recommended WF
	+ TBA

### Sub-topic 1-2 Other requirements

*Sub-topic description*

*Open issues and candidate options before meeting:*

**Issue 1-2-1: UL-MIMO coherence for 4Tx**

* Proposals
	+ Option 1: Extend the UL-MIMO coherence requirements for 4Tx requirements. (As in [**R4-2308238**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308238.zip))
	+ Option 2: Others
* Recommended WF
	+ TBA

**Issue 1-2-2: PCMAX,c tolerance for 4Tx**

* Proposals
	+ Option 1: Use the following table as a as a starting point of PCMAX tolerance for 4Tx-based UL-MIMO / TxDiversity.
* Table 4: PCMAX,*c* tolerance for 4 Tx UL-MIMO

|  |  |  |
| --- | --- | --- |
| PCMAX,*c*(dBm) | ToleranceTLOW(PCMAX\_L,*c*) (dB) | ToleranceTHIGH(PCMAX\_H,*c*) (dB) |
| 26 ≤ PCMAX,*c* ≤ 29 | 3.0 | 2.0 |
| 25 ≤ PCMAX,*c* < 26 | 5.0 | 2.0 |
| 24 ≤ PCMAX,*c* < 25 | 5.0 | 3.0 |
| 23 ≤ PCMAX,*c* < 24 | 5.0 | 4.0 |
| 19 ≤ PCMAX,*c* < 23 | 5.0 |
| 14 ≤ PCMAX,*c* < 19 | 6.0 |
| -40 ≤ PCMAX,*c* < 14 | 7.0 |

* + Option 2: TBA
* Recommended WF
	+ TBA

**Issue 1-2-3: EVM**

* Proposals
	+ Option 1: Allow the use of the EVM formula given below to obtain the total EVM for Stage-2 Tx architectures (2x23 dBm + 2x26 dBm and 4x26 dBm)
	+ Option 2: Others
* Recommended WF
	+ TBA

### Sub-topic 1-3 Power Scaling and other non-full power cases

*Sub-topic description*

This is not an issue specific for 4Tx, but for all the cases when power scaling is needed for legacy case and also Full Power transmission Mode when the full power can not be applied for some TPMI configurations. Here are some of the status:

1. According to RAN1, there are power scaling Rel-15 and in certain TPMI configurations for ULFPTx modes to reduce the maximum output power;
2. The UL-MIMO maximum power requirements do not verify the power scaling behavior;
3. The configurated transmitted power definition also do not consider the power scaling;
4. The PHR calculation do not consider power scaling.

*Open issues and candidate options before meeting:*

**Issue 1-3-1: Whether non-full power cases is need to be verified or not?**

* Proposals
	+ Option 1: Yes
	+ Option 2: No
	+ Option 3: Others
* Recommended WF
	+ TBA

**Issue 1-3-2: Whether configuration transmitted power formulas need be revised by power scaling or not?**

* Proposals
	+ Option 1: Yes

One draft scheme is as following ([**R4-2307090**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307090.zip))

* if 0 dB ≤ ΔPPowerClass, PPowerClass - Max (ΔP*s* , ΔPPowerClass)
* if 0 dB > ΔPPowerClass, PPowerClass - ΔP*s* - ΔPPowerClass
* Note that ΔP*s* is 10\*log(1/s), where *s* is a scaling factor.
* Note that 0 dB > ΔPPowerClass happens when power boosting feature is enabled.
	+ Option 2: No
		- Keep the Pcmax part in RAN4 as it is.
	+ Option 3: Others
* Recommended WF
	+ TBA

**Issue 1-3-3: Whether sending LS to ask RAN1’s view about the possible confusion or misalignment of PHR calculation related to power scaling issue?**

* Proposals
	+ Option 1: Yes
		- Discussion paper and draft reply LS reference to two maintenance Tdocs ([**R4-2308248**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308248.zip)& [**R4-2308249**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308249.zip))
	+ Option 2: Others
* Recommended WF
	+ TBA