**3GPP TSG-RAN WG4 Meeting #94-e R4-20xxxxx**

**Electronic Meeting, Feb.24th – Mar.6th 2020**

**Agenda item:** 8.11.1

**Source:** Moderator (Samsung)

**Title:** Email discussion summary for RAN4#94e\_#16\_NR\_eMIMO\_UE\_RF

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion and provide some guidelines for email discussion if necessary.*

In Rel-16 work item enhancements on MIMO for NR, the following features are identified for potential RAN4 RF core requirement impact, which are listed as objectives in WID [RP-192271]:

|  |
| --- |
| - Specify core requirements associated with the items specified by RAN1 [RAN4]• Identify impact on RF requirements for the reduced PAPR pi/2-BPSK DMRS and, if needed, specify RF requirements • Identify impact on RF requirements for the uplink full power transmission and, if needed, specify RF requirements |

For the reduced PAPR pi/2-BPSK DMRS, WF on MPR assumptions was email approved in RAN4#93, as R4-1916209, for triggering MPR evaluation on waveforms with pi/2 BPSK data and pi/2 DMRS for both FR1 and FR2. Based on companies’ evaluation, RAN4 will discuss the necessity and values for enhanced MPR requirement.

For the uplink full power transmission, WF was approved in RAN4#93, as R4-1916007, in which various aspects for defining corresponding RF requirements are listed for further discussion, including:

* General scope and assumption;
* Test configuration and requirement applicability for full power transmission MOP test;
* Unwanted emission for full power transmission for FR1;
* UE Power class capability.

*List of candidate target of email discussion for 1st round and 2nd round*

* 1st round: TBA
* 2nd round: TBA

As the rapporteur for eMIMO WI, we would like to suggest the following candidate target of 1st and 2nd round email discussion:

* 1st round: Collect more views on all topics, while the following clarification achieved:
	+ DMRS enhancement with pi/2 BPSK: decide FR1 Rel-15 requirement needs revisit or not, and FR2 enhancement can be out of the scope for discussion.
	+ Full power transmission: decide general scope and assumption
* 2nd round: Based on results from 1st round, proceed as much as possible.

# Topic #1: DMRS enhancement with PI/2 BPSK

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2000470 | Qualcomm Incorporated | Proposal 1: The MPR for edge, outer and inner RB allocations for Pi/2 BPSK with Pi/2 BPSK DMRS waveforms for FR1 PC3 operation are as indicated in table 1

|  |  |
| --- | --- |
| **Modulation** | **MPR (dB)** |
| **Edge RB allocations** | **Outer RB allocations** | **Inner RB allocations** |
| **DFT-s-OFDM** | Pi/2 BPSK | ≤ 3.51 | ≤ 1.21 | ≤ 0.21 |
| ≤ 0.52 | ≤ 0.52 | 02 |
| Pi/2 BPSK w Pi/2 BPSK DMRS | ≤ 1.01 | ≤ 0.01 | ≤ 0.01 |
| ≤ 0.02 | ≤ 0.02 | 02 |
| QPSK | ≤ 1 | 0 |
| 16 QAM | ≤ 2 | ≤ 1 |
| 64 QAM | ≤ 2.5 |
| 256 QAM | ≤ 4.5 |
| **CP-OFDM** | QPSK | ≤ 3 | ≤ 1.5 |
| 16 QAM | ≤ 3 | ≤ 2 |
| 64 QAM | ≤ 3.5 |
| 256 QAM | ≤ 6.5 |
| **NOTE 1: Applicable for UE operating in TDD mode with Pi/2 BPSK modulation and UE indicates support for UE capability powerBoosting-pi2BPSK and if the IE powerBoostPi2BPSK is set to 1 and 40 % or less slots in radio frame are used for UL transmission for bands n40, n41, n77, n78 and n79. The reference power of 0 dB MPR is 26 dBm.****NOTE 2: Applicable for UE operating in FDD mode, or in TDD mode in bands other than n40, n41, n77, n78 and n79 with Pi/2 BPSK modulation and if the IE powerBoostPi2BPSK is set to 0 and if more than 40 % of slots in radio frame are used for UL transmission for bands n40, n41, n77, n78 and n79.** |

Proposal 2: The MPR for edge, outer and inner RB allocations for Pi/2 BPSK with Pi/2 BPSK DMRS waveforms for FR1 PC2 operation are as indicated in table 2

| Modulation | MPR (dB) |
| --- | --- |
| Edge RB allocations | Outer RB allocations | Inner RB allocations |
| DFT-s-OFDM | Pi/2 BPSK | ≤ 3.5 | ≤ 0.5 | 0 |
| Pi/2 BPSK w Pi/2 BPSK DMRS | ≤ 1.0 | ≤ 0.0 | 0 |
| QPSK | ≤ 3.5 | ≤ 1 | 0 |
| 16 QAM | ≤ 3.5 | ≤ 2 | ≤ 1 |
| 64 QAM | ≤ 3.5 | ≤ 2.5 |
| 256 QAM | ≤ 4.5 |
| CP-OFDM | QPSK | ≤ 3.5 | ≤ 3 | ≤ 1.5 |
| 16 QAM | ≤ 3.5 | ≤ 3 | ≤ 2 |
| 64 QAM | ≤ 3.5 |
| 256 QAM | ≤ 6.5 |

 |
| R4-2000517 | Nokia, Nokia Shanghai Bell | FR1: We can observe that * More output power is available when amount of shaping is increased but it is not certain that this manifests as increased bitrate in base station receiver as spectrum starts to heavily distorted especially in case of shaping w/ [-0.3 1 0.3].
* Up to 3 dB more power could be achieved compared current MPR scheme (no power boosting assumed) for all three scenarios
* Even in case of no shaping inner allocation output power could be increased 2.5-3 dB.

FR2: We can observe that * Up to 1.5 dB more power could be achieved compared current MPR scheme however this is mostly due to relaxed specification not new DMRS
* Number of waveforms capable of achieving this 1.5 dB improvement in output power is increased when shaping is increased but it is not certain that this manifests as increased bitrate in base station receiver as spectrum starts to heavily distorted especially in case of shaping w/ [-0.3 1 0.3].
 |
| R4-2002036 | Huawei, HiSilicon | Observation 1: MPR can be improved a little bit for Pi/2 BPSK DMRS with FDSS compared to ZC DMRS with FDSS, but not too muchObservation 2: The MPR improvement even with newly designed DMRS sequence cannot reach the power boosting level defined in Rel-15 specObservation 3: The Rel-15 power boosting requirements for Pi/2 BPSK are over optimistically definedProposal 1: Rel-15 power boosting requirement for Pi/2 BPSK should be revisited firstly, then to consider whether MPR improvement based on Pi/2 BPSK DMRS should be defined in Rel-16Observation 4: Same requirements are applied for both pulse-shaped Pi/2 BPSK and non-pulse-shaped pi/2 BPSK for FR2Proposal 2: The DMRS evaluation should be focused on FR1. |

## Open issues summary

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

### Sub-topic 1-1: FR1 MPR Improvement

*Sub-topic description:*

*Open issues and candidate options before e-meeting:*

**Issue 1-1-1: Rel-15 FR1 requirement for Pi/2 BPSK**

* Proposals
	+ Option 1: Rel-15 FR1 requirement for Pi/2 BPSK should be revisited firstly.
	+ Option 2: No revisit is needed.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 1-1-2: Rel-16 FR1 MPR improvement for Pi/2 BPSK DMRS**

* Proposals
	+ Option 1: Qualcomm’s proposed MPR values.
	+ Option 2: Only consider MPR values if Rel-15 requirement is revisited.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 1-2: FR2 MPR Improvement

*Sub-topic description*

*Open issues and candidate options before e-meeting:*

**Issue 1-2-1: FR2 MPR values for Pi/2 BPSK w Pi/2 BPSK DMRS**

* Proposals
	+ Option 1: Current FR2 MPR tables remain unchanged.
	+ Option 2: FFS, due to up to 1.5 dB more power achievable (however this is mostly due to relaxed specification not new DMRS).
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXXIntel | **Issue 1-1-1: Rel-15 FR1 requirement for Pi/2 BPSK** Option 2 – No revisit**Issue 1-1-2: Rel-16 FR1 MPR improvement for Pi/2 BPSK DMRS** Intel has provided MPR values in last meeting, R4-1913466. Need to consider it as well**Issue 1-2-1: FR2 MPR values for Pi/2 BPSK w Pi/2 BPSK DMRS**Intel has provided MPR values in last meeting, R4-1913466. Need to consider it as well |

### CRs/TPs comments collection

*[Moderator] N/A since no CRs/TPs submitted.*

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic#1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: Uplink Tx Full Power transmission

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2000315 | Samsung | Observation 1: Due to Rel-15 UL-MIMO rank2 verification with CP-OFDM waveform which is non-zero MPR assuming at least 1.5dB MPR for FR1 and at least 3.5dB MPR for FR2 compared with full power transmission rank 1 TPMI2 verification with DFT-s-OFDM waveform which is zero MPR, at least full power transmission with mode 1 TPMI2 configuration still need to be verified with DFT-s-OFDM waveform.Observation 2: For the mode 2 UE which only has 2 antenna ports, the only one TMPI could be indicated directly instead of random selection of one full TPMI UE reported.Observation 3: Based on different assumption and different requirements between FR1 and FR2, TPMI0 for FR1 and TPMI2 for FR2 can be considered as the typical TPMIs respectively.Observation 4: RAN4 need to clarify the appropriate chapter to capture FR1 and FR2 MOP requirements for full power transmission, either in section 6.2 or 6.2D. Observation 5: From the verification and regulation perspective the measurement of UL full power transmission characteristics such as emission requirements and other requirements is reasonable.Proposal 1: Generally the specific MOP requirements for full power transmission in Rel-16 eMIMO could remain the same as that of Rel-15, only test configurations introduced based on supported mode should be captured in the specification according to the following table for transmission supporting up to 2 antenna ports.Table 1 Test configurations for transmission supporting 2 antenna ports

|  |  |  |
| --- | --- | --- |
|  | 1 port, rank1 | 2 ports, rank1 |
| Mode 1 | No test | TPMI2 (Note 1) |
| Mode 2 | No test | If TPMI0 is full power TPMI, test TPMI0;Else, test TMPI1 |
| None “The other mode” | No test | For FR1: TMPI0;For FR2: TPMI2 |
| Note 1: Only DFT-s-OFDM waveform need to be tested if Rel-15 UL-MIMO rank2 is supported and verified. |

 |
| R4-2000469 | Qualcomm Incorporated | Proposal 1: In mode 1, for rank 1 operation UE full power capability should be verified using TPMI 2 configuration. Proposal 2: In mode 2 in 2 port configuration the ability to obtain full TX power should be verified with the full power TPMIsProposal 3 : In mode 2 in 1 port configuration the full power transmission of a single layer simultaneously by a the UE over 2 antenna should be verifiedProposal 4: The individual outputs of all transmitting antennas shall be summed across frequency and compliance to the SEM specifications should be verified. |
| R4-2000751 | vivo | Observation 1: There is already two complete set of RF tests based on the configuration of maximum output power for UL-MIMO capable UE, one set for 1Tx and one set for 2Tx, and both of the two transmit chains were verified for typical configurations.Observation 2: This Mode2 1port test was absent at least from functional point of view. If this is to be tested and UL-MIMO is already supported, may be MOP is enough.Proposal 1: For UE that already supporting Rel-15 UL-MIMO, testing the whole set of Tx tests could be redundant for for new configurations of Full Tx power tests. It is preferred to do simplification, and preferably only MOP test is done. Proposal 2: Only one TPMI is used for each test if multiple TPMIs could satisfy Full Tx Power. |
| R4-2001230 | OPPO | Observation 1: Rel-15 UL MIMO is tested with TPMI [1 0; 0 1], basic requirements are tested with one antenna/PA activated.Observation 2: Mode 1 can be covered by UL MIMO and no new requirement is needed if UL MIMO is supported.Observation 3: For mode 2, e.g. UE with 23+26 PAs, the new test is needed only when UE reported PC3 in basic requirement otherwise no new requirement is needed.Observation 4: For “the other mode”, e.g. UE with 26+26 PAs, the new test is needed only when the PA activated in basic requirement test is different from the PA activated by “the other mode” TPMI. However, it is unknown to the outside which PA the UE is activated in basic requirement and “the other mode”. Randomly select one TPMI to test UE can never guarantee UE performance with “the other mode”. Proposal 1: − [1, 1] TPMI is used for Mode 1 when UE not supporting UL MIMO.− UE reported full power TPMI is used for Mode 2 when UE is tested with lower power class in basic requirements.− All supported full power TPMIs are tested for “the other mode” to guarantee UE performance or test the UE based on the announcement and use different PAs between basic test and “the other mode” test.Proposal 2: Test all the max power related emission requirements. |
| R4-2001322 | Ericsson | Observation 1: output power performance according to the power class important for single-port transmissions. Different PA architectures and virtualization strategies may or may not achieve full power for single layer transmission. Proposal 1: unwanted emissions must be verified for all modes of ULFPTxProposal 2: Fall-back (DCI 0\_0) should be tested for all modes, e.g. a UE advertising PC2 should be able to transmit according to PC2 also for single-port transmission. Proposal 3: the UE shall comply with requirements according to its power-class capability (ue-PowerClass) in fall-back regardless of FP mode.Proposal 4: consider adding a new power-class capability for two-layer transmissions per NR band (Rel-16). |
| R4-2002035 | Huawei, HiSilicon | Proposal 1: Test configurations can be further checked by RAN5 based on existing agreements reached in RAN4.Proposal 2: The verification of full power transmission is focused on two ports cases.Proposal 3: MOP is defined for all full power transmission modes.Proposal 4: Except for MOP, no other requirements need to be defined for UE supporting UL MIMO full power transmission.  |

## Open issues summary

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

### Sub-topic 2-1: General Scope and Assumption for Discussion

**Issue 2-1-1: General Assumption for UE Supported Mode**

* [Moderator]: In last meeting WF, it is captured as “Current assumption is UE can only support one mode”. However, clear definition of UE mode should be provided.
* Proposals:
	+ Option 1: confirm above assumption as RAN4 agreement
	+ Other options may be added based on companies’ further proposal.
* Recommended WF
	+ Suggest RAN4 clearly adopt Option 1 as agreement to simplify following discussion.

**Issue 2-1-2: Down-scoping by only considering up to 2 TX ports in Rel-16 eMIMO**

* [Moderator]: While the scenario with more than 2TX ports are considered in RAN1, by only considering 2TX ports could be beneficial to facilitate the Rel-16 eMIMO RAN4 discussion (which is generally the current status when RAN4 derived WFs in previous meetings).
* Proposals:
	+ Option 1: up to 2 TX ports in Rel-16 eMIMO;
	+ Option 2: No limitation is introduced in RAN4 Rel-16 eMIMO discussion.
* Recommended WF
	+ Suggest RAN4 agree on Option 1 to simplify following discussion.

**Issue 2-1-3: Down-scoping by only considering FR1 in Rel-16 eMIMO**

* [Moderator]: While RAN1 discussion does not differentiate FR1 and FR2 in full power transmission discussion, by only considering FR1 could be beneficial to facilitate the Rel-16 eMIMO RAN4 discussion (which is generally the current status when RAN4 derived WFs in previous meetings).
* Proposals:
	+ Option 1: Only consider FR1;
	+ Option 2: Both FR1 and FR2 should be considered.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-1-4: Down-scoping on possible physical implementation for Mode-0, 1, and 2 in Rel-16 eMIMO**

* [Moderator]: We observed that companies have different understanding on the possible physical implementations behind different modes. Clarification is needed.
* Proposals (at least for FR1):
	+ For Mode-1 UE, allowed physical implementation:
		- Option 1: 23dBm+23dBm UE claimed as PC2
		- Option 2: 23dBm+23dBm UE claimed as PC2, and 20dBm+20dBm UE claimed as PC3
	+ For Mode-2 UE, allowed physical implementation:
		- Option 1: 26dBm+23dBm UE claimed as PC2
		- Option 1a: 26dBm+23dBm UE claimed as PC2, and 23dBm+20dBm UE claimed as PC3
		- Option 2: 26dBm+23dBm UE claimed as PC2, and 23dBm+23dBm UE claimed as PC2 (Transparent TxD is used for 1 port SRS)
		- Option 2a: 26dBm+23dBm UE claimed as PC2 and 23dBm+20dBm UE claimed as PC3,
		and 23dBm+23dBm UE claimed as PC2 and 20dBm+20dBm UE claimed as PC3 (Transparent TxD is used for 1 port SRS)
	+ For Mode-0 UE (“the other mode”), allowed physical implementation:
		- Option 1: 23dBm+23dBm UE claimed as PC3
		- Option 2: 26dBm+26dBm UE claimed as PC2
		- Option 3: 23dBm+23dBm UE claimed as PC3 and 26dBm+26dBm UE claimed as PC2
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-1-5: Clarification on appropriate chapter for full power transmission MOP tests:**

* Proposals:
	+ Option 1: Specifying all MOP requirement for full power transmission in Section 6.2D, and all requirement for fallback DCI (i.e., DCI\_0\_0) in Section 6.2.
	+ Other options may be added based on companies’ further proposal.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 2-2: Test Configuration and Requirement Applicabilty for Full Power Transmission MOP Test

**Issue 2-2-1: For Mode 1 UE, requirement applicability:**

* Proposals: Companies are aligned to use TPMI [1,1] (i.e., TPMI2 for rank1, port2) for MOP test for Mode 1 UE, while concerns is raised for applicability rule:
	+ Option 1 (Last Meeting Agreement): No need to be tested if Rel-15 UL-MIMO rank2 is supported and verified.
	+ Option 2: Only DFT-s-OFDM waveform need to be verified if Rel-15 UL-MIMO rank2 is supported and verified.
	+ Option 3: Need to be verified no matter Rel-15 UL-MIMO rank2 is supported and verified.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion, especially on whether DFT-s-OFDM based waveform needs to be tested since this wave is not yet verified for UL-MIMO.

**Issue 2-2-2: For Mode 2 UE with 2 ports configuration, test configuration and requirement applicability:**

* Proposals: Companies are aligned to use full power TPMI(s) UE reported for Mode 2 UE with 2 ports, rank=1 configuration, while the detailed teste configuration and requirement applicability rule is under discussion with following options:
	+ Option 1: Select only one of full power TPMI(s);
	+ Option 2: Select only one of full power TPMI(s), if UE is tested with lower power class in basic requirement.
	+ Option 3: full power TPMI(s) with only one non-zero power port are excluded for full power transmission test.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion, especially for how to comprehend “Random selection of one TPMI is considered to limit the test case number.”

**Issue 2-2-3: For Mode 2 UE with 1 port configuration, test configuration and requirement applicability:**

* Proposals:
	+ Option 1: No test needed;
	+ Option 2: Full power transmission with 2 TX antenna connectors should be verified (sum over two antenna ports), i.e., either UE with transparent TxD (23+23dBm) or UE with full rated PA (26dBm) is allowed.
	+ Option 3: Full power transmission with 2 TX antenna connectors should be verified if full power is achieved by 2 TX antenna connectors (by UE declaration), i.e., only UE with transparent TxD (23+23dBm) to achieve full power transmission needs to be tested.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-2-4: For Mode 0 UE (“the other mode”) with 2 ports configuration, test configuration and requirement applicability**

* Proposals:
	+ Option 1: No test needed;
	+ Option 2: All supported full power TPMIs are tested;
	+ Option 3: Select only one of full power TPMI(s) for test;
	+ Option 3a: For UE support 2 ports, TPMI 0 for FR1 (and TPMI 2 for FR2 if applicable);
	+ Option 4: Based on the announcement and use different PAs between basic test and “the other mode” test.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 2-3: Unwanted Emissions for Full Power Transmission for FR1

**Issue 2-3-1: Whether unwanted emissions requirement are defined for full power transmission for FR1**

* Proposals:
	+ Option 1: Unwanted emissions must be verified for all modes of full power transmission
	+ Option 2: Unwanted emissions must be verified for all configurations of full power transmission, in which MOP requirement is defined and tested.
	+ Option 3: Except for MOP, no other requirement need to be defined
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

**Issue 2-3-2: How unwanted emissions requirement are tested for full power transmission for FR1**

* Proposals: For full power transmission with multiple TX antenna ports:
	+ Option 1: The individual outputs of all transmitting antennas shall be summed across frequency and compliance to the SEM specifications should be verified.
	+ Option 2: Requirement is specified and verified at each transmit antenna.
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

### Sub-topic 2-4: UE Power Class Capability

**Issue 2-4-1: New power class capability**

* Proposals:
	+ Option 1: adding a new power-class capability for two-layer transmissions per NR band (Rel-16).
* Recommended WF
	+ Companies’ views are collected in 1st round discussion.

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Intel | **Issue 2-1-1: General Assumption for UE Supported Mode**Option 1**Issue 2-1-2: Down-scoping by only considering up to 2 TX ports in Rel-16 eMIMO**Option 1**Issue 2-1-3: Down-scoping by only considering FR1 in Rel-16 eMIMO**FR2 has different situation. Since in FR2 when minimum peak EIRP was derived, antenna polarization gain was included. My understanding that rank 1, 2 ports full power transmission in FR2 has been supported already.**Issue 2-1-4: Down-scoping on possible physical implementation for Mode-0, 1, and 2 in Rel-16 eMIMO*** Proposals (at least for FR1):
	+ For Mode-1 UE, allowed physical implementation:
		- Option 2
	+ For Mode-2 UE, allowed physical implementation:
		- Option 1a
	+ For Mode-0 UE (“the other mode”), allowed physical implementation:
		- Option 3

**Issue 2-1-5: Clarification on appropriate chapter for full power transmission MOP tests:*** Proposals:
	+ Option 1

**Issue 2-2-1: For Mode 1 UE, requirement applicability:*** Proposals: Companies are aligned to use TPMI [1,1] (i.e., TPMI2 for rank1, port2) for MOP test for Mode 1 UE, while concerns is raised for applicability rule:
	+ Option 1 (Last Meeting Agreement): No need to be tested if Rel-15 UL-MIMO rank2 is supported and verified.

**Issue 2-2-2: For Mode 2 UE with 2 ports configuration, test configuration and requirement applicability:*** Proposals: Companies are aligned to use full power TPMI(s) UE reported for Mode 2 UE with 2 ports, rank=1 configuration, while the detailed teste configuration and requirement applicability rule is under discussion with following options:

Propose option 4: RAN4 defines all full power TPMI(s). Let Ran5 select one to reduce the testing time. That means RAN4 defines requirement only and does not select which TPMI should be tested.**Issue 2-2-3: For Mode 2 UE with 1 port configuration, test configuration and requirement applicability:*** Proposals:
	+ Option 3: Full power transmission with 2 TX antenna connectors should be verified if full power is achieved by 2 TX antenna connectors (by UE declaration), i.e., only UE with transparent TxD (23+23dBm) to achieve full power transmission needs to be tested.

**Issue 2-2-4: For Mode 0 UE (“the other mode”) with 2 ports configuration, test configuration and requirement applicability*** Proposals:
	+ Option 2: All supported full power TPMIs are tested;

**Issue 2-3-1: Whether unwanted emissions requirement are defined for full power transmission for FR1**Not clear what is the difference between option 1 and 2 in term of ‘all configurations’ and ‘all modes’. Unwanted emissions should be defined. **Issue 2-4-1: New power class capability**If a UE can support different power class in different configurations, like single port single PA, single port multiple PAs, UL MIMO, etc, it may needs. |
|  |  |

### CRs/TPs comments collection

*[Moderator] N/A since no CRs/TPs submitted.*

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary**  |
| **Sub-topic#1** | *Tentative agreements:**Candidate options:**Recommendations for 2nd round:* |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Appendix

## Full power transmission feature description from TS38.213 (R1-1913654)

|  |
| --- |
| 7.1       Physical uplink shared channelFor a PUSCH transmission on active UL BWP , as described in Subclause 12, of carrier  of serving cell , a UE first calculates a linear value  of the transmit power , with parameters as defined in Subclause 7.1.1. For a PUSCH transmission scheduled by a DCI format 0\_1 or configured by *ConfiguredGrantConfig* or *semiPersistentOnPUSCH*, if *txConfig* in *PUSCH-Config* is set to 'codebook', * if *ULFPTx* in *PUSCH-Config* is provided and *codebookSubset* in *PUSCH-Config* is set to *nonCoherent* or *partialAndNonCoherent*, the UE scales $\hat{P}\_{PUSCH,b,f,c}(i,j,q\_{d},l)$ by $s$ where:
	+ if *ULFPTxModes* in *PUSCH-Config* is set to Mode1, and each SRS resource in the *SRS-ResourceSet* with usage set to 'codebook' has more than one SRS port’, $s$ is the ratio of a number of antenna ports with non-zero PUSCH transmission power over the maximum number of SRS ports supported by the UE in one SRS resource
	+ if *ULFPTxModes* in *PUSCH-Config* is set to Mode2, $s=1$ for full power TPMIs reported by the UE [16, TS 38.306], and $s$ is the ratio of a number of antenna ports with non-zero PUSCH transmission power over a number of SRS ports for remaining TPMIs, where the number of SRS ports is associated with a SRS resource indicated by SRI if more than one SRS resources are configured in the *SRS-ResourceSet* with usage set to ‘codebook’, or the number of SRS ports is associated with the SRS resource if only one SRS resource is configured in the *SRS-ResourceSet* with usage set to ‘codebook’, and
	+ if *ULFPTxModes* in *PUSCH-Config* is not provided, $s=1$

-    else, if each SRS resource in the *SRS-ResourceSet* with *usage* set to 'codebook' has more than one SRS port, the UE scales the linear value by the ratio of the number of antenna ports with a non-zero PUSCH transmission power to the maximum number of SRS ports supported by the UE in one SRS resource. The UE splits the power equally across the antenna ports on which the UE transmits the PUSCH with non-zero power.  |

## RAN1 agrement on Full Power TX Mode

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Agreement**For mode 1, 2Tx non-coherent UE, the new codebook subset at least includes rank=1 TPMI=2 defined in Rel-15 which can be used for UL full power transmission**Agreement**For mode 1, 4Tx non-coherent UE, the new codebook subset at least includes, rank 1 TPMI= 13 defined in Rel-15 which can be used for UL full power transmission * FFS for the case that part of ports can deliver full power transmission

**Agreement**For mode 1, 4Tx non-coherent UE, the new codebook subset* at least includes, rank 2 TPMI=6 defined in Rel-15
* at least includes, rank 3 TPMI=1 defined in Rel-15

**Agreement**For mode 2, in case of non-coherent with 2 ports, support following TPMI indication for rank 1 which support UL full power transmission:* Rank 1: support {TPMI=0} and {TPMI=1}
* FFS: Details on UE capability signalling

**Conclusion**For mode 2, no additional rule for spatial filter update for SRS resources with different number ports**Agreement**For a capability 1 UE working with full power operations, for PUSCH power control, power scaling factor is fixed to 1**Agreement**For a UE working with Mode1 operation, for PUSCH power control, down-select or merge from the following alternatives in RAN1#98bis* Alt1: reuse Rel-15 power scaling mechanism.
* Alt2: power scaling factor is configured.
* Alt3: power scaling factor is determinded by #non-zero-PUSCH-port divided by #SRS-ports in the SRS resource indicated by SRI.
* Alt4: A UE can scale its transmit power by  to reach full power, where
	+ $K\left(ρ,m,ν\right)>1$ is a scale factor associated with  $ρ\in \{1,2,4\}$SRS ports corresponding to the PUSCH transmission and an optional mth TPMI with rank *v*.
		- If a TPMI is not associated with $K\left(ρ,m,ν\right)$, then  is determined without regard to *m* and *v*.
		- If $K\left(ρ,m,ν\right)$ is not configured by higher layers, a set of fixed values are defined for $K(ρ)$.
	+ $ρ\_{0}$is the number of non-zero PUSCH ports being transmitted
* Alt5: For the precoders in the new codebook subset for full power transmission, the power scaling factor is 1.

**Agreement**For a UE working with Mode2 operation, for PUSCH power control, down-select or merge from the following alternatives in RAN1#98bis* Alt1: power scaling factor is determinded by the reported TPMI precoders.
* Alt2: power scaling factor is configured.
* Alt3: power scaling factor is determinded by #non-zero-PUSCH-port divided by #SRS-ports in the SRS resource indicated by SRI.
* Alt4: A UE can scale its transmit power by $min⁡(1,K(ρ,m,ν)ρ\_{0}/ρ)$ to reach full power, where
	+ $K\left(ρ,m,ν\right)>1$ is a scale factor associated with $ρ\in \{1,2,4\}$ SRS ports corresponding to the PUSCH transmission and an optional mth TPMI with rank *v*.
		- If a TPMI is not associated with $K\left(ρ,m,ν\right)$, then $K\left(ρ,m,ν\right)$ is determined without regard to m and v.
		- If $K\left(ρ,m,ν\right)$ is not configured by higher layers, a set of fixed values are defined for $K(ρ)$.
	+ is the number of non-zero PUSCH ports being transmitted

**Agreement*** For 4 TX UEs, a maximum of 4 SRS resources are supported in Mode 2 for usage set to ‘codebook’ in a set
	+ Depending on UE capability, either up to 2 or 4 SRS resources are supported
* For 2 TX UEs, a maximum of 4 SRS resources are supported in Mode 2 for usage set to ‘codebook’ in a set
	+ Depending on UE capability, either up to 2 or 4 SRS resources are supported
* For mode 2 UEs, up to 2 different spatial relation info can be configured for all SRS resources with usage set to ‘codebook’

Note: it does not mean to support simultaneous transmission of multiple SRS resources *usage* is set to ‘codebook’Agreement from RAN1#98Bis**Agreement*** Support RRC configuration to operate in Mode1 or Mode2 subject to UE capability
	+ For UE capabilty-2 and-3, gNB can configure a UE to operate in Mode 1 or Mode 2 subject to UE capability
		- Note : if UE only supports Mode 1 gNB cannot configure this UE to operate in Mode 2, if UE only supports Mode 2 gNB cannot configure this UE to operate in Mode 1
	+ FFS: UE capability signaling discussion
	+ Note: capability-1 UE can be configured with RRC parameter “ULFPTx” to deliver UL full power has been agreed, exact parameter name is up to RAN2
* If gNB does not configure UE for Rel-16 full power UL transmission, Rel-16 UEs operate in Rel-15 behavior

**Agreement**For 2Tx in mode 1, * For rank=1, TPMI=2, TPMI=0, TPMI=1 are included in new codebook subset for non-coherent UEs with power scaling defined as in [38.213] Rel-15
* For rank=2, TPMI=0 is included in the new codebook subset

**Agreement**For Mode2, * Power scaling factor is equal to 1 for the reported TPMI precoders that supports full power Tx
* for the other TPMI precoders, if only one SRS resource is configured, the power scaling factor is determined by #non-zero-PUSCH-port divided by #SRS-ports
* for the other TPMI precoders, the power scaling factor is determined by #non-zero PUSCH port/#SRS ports in the SRS resource indicated by SRI

**Agreement**For Mode 1 4TX, for non-full power uplink transmission, antenna selection precoders are included in the new codebook subset following Rel-15 power scaling factor* FFS: Whether to include antenna selection precoders for full power uplink transmission

**Agreement**For full power uplink transmission Mode 1, 4TX partial-coherent, the new codebook subset includes* Rank1(CP-OFDM): TPMI = 12,13,14,15
* Rank1(DFT-s-OFDM): TPMI = 12,13,14,15
	+ FFS: TPMI=16, 17, 18, 19
* FFS: Whether clarification on which port pairs are coherent is needed

Agreement from RAN1#99**Agreement**The size of precoding information and number of layers field in DCI is determined by the maximum number of ports among the SRS resources in the SRS resource set with usage of codebook.* + If the number of ports for a configured SRS resource is less than the maximum SRS port number among the configured SRS resources, the most significant bit(s) shall be reserved.

**Agreement*** RRC parameters ULFPTx, ULFPTxModes are configured per UL BWP

**Agreement**For 2 ports, number of bits to indicate TPMI(s) which can deliver UL full power: * 2 bits (bitmap)
* Whether is this capability reporting is optional or not will be discussed as part of UE capability discussions

**Agreement**For 4 ports, number of bits to indicate TPMI(s) which can deliver UL full power:* + Non Coherent 2 bits
	+ Partial coherent 4 bits
		- Additional entries on top of existing entries may be added to table 1 and table 2
	+ Whether is this capability reporting is optional or not will be discussed as part of UE capability discussions

Table 1.

|  |  |
| --- | --- |
| 4Tx, nonCoherent | 4Tx, partial coherent (4bit) |
| G0 | G0 |
| G1 | G1 |
| G2 | G2 |
| G3 | G3 |
|  | G4 |
|  | G5 |
|  | G6 |
|  |  |

Definition of G0~G6 can be found in the table below.Table 2. |