**3GPP TSG-RAN WG4 Meeting #94-e R4-200xxxx**

**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** |
| Huawei | Sub topic 1-1: **Issue 1-1-1: Rel-15 FR1 requirement for Pi/2 BPSK** Option 1: revisit the Rel-15 power boost requirement and it is worth noting that the DMRS in Rel-15 is ZC based sequence, which has larger PAPR compared to that defined in Rel-16.**Issue 1-1-2: Rel-16 FR1 MPR improvement for Pi/2 BPSK DMRS**Option 2: MPR could be better than Rel-15 requirements, but the precondition is to revise Rel-15 MPR requirement based on ZC DMRS evaluation. Sub topic 1-2:**Issue 1-2-1: FR2 MPR values for Pi/2 BPSK w Pi/2 BPSK DMRS**Only for FR1 in Rel-16….Others: |
|  Qualcomm | Sub topic 1-1: **Issue 1-1-1: Rel-15 FR1 requirement for Pi/2 BPSK** * + Option 2: No revisit is needed. An extra line item can be put in the existing MPR tables for Pi/2 BPSK DMRS w Pi/2 BPSK data

**Issue 1-1-2: Rel-16 FR1 MPR improvement for Pi/2 BPSK DMRS** * + Option 1: Qualcomm’s proposed MPR values.

Sub topic 1-2:**Issue 1-2-1: FR2 MPR values for Pi/2 BPSK w Pi/2 BPSK DMRS*** FFS for FR2
 |
| Intel | **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 |
| Apple | Issue 1-1-1: Option 2; pi/2 BPSK DMRS is a Rel-16 eMIMO feature and shall not have an impact on Rel-15. Issue 1-1-2: RAN4 should conduct a further study on FR1 MPR with pi/2 BPSK DMRS for the next meetingIssue 1-2-1: RAN4 should conduct a further study on FR2 MPR with pi/2 BPSK DMRS for the next meeting |

### 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#1-1**FR1 MPR Improvement | *General Summary of 1st Round Discussion:*  *- For issue 1-1-1, 4 Companies provided their comments while diverse views toward revisit Rel-15 FR1 requirement for pi/2 BPSK, i.e., 1 company propose revisit while 3 companies opposed; Moderator recommend RAN4 chair to resolve this issue 1-1-1 firstly.* *Tentative agreements: Candidate options:**Following possible options are listed for RAN4 chair’s judgment for 1st round decision:* *- Option 1: RAN4 agree no revisit on Rel-15 FR1 MPR requirement for pi/2 BPSK.*  *- Option 2: Re-evaluate Rel-15 FR1 MPR requirement for pi/2 BPSK.* *Recommendations for 2nd round:* *- Focus on MPR evaluations for Rel-16 pi/2 BPSK DMRS:  🡪 Available in 4 companies’ contribution (Intel in last meeting’s contribution R4-1913466), 🡪 Further discussion and analysis on other companies’ result could be provided;  🡪 Companies provide their suggested WF on how to resolve the big difference between companies.*  |
| **Sub-topic#1-2**FR2 MPR Improvement | *Summary of 1st Round Discussion:*  *- Two companies suggest FFS for FR2, 1 company think FR2 should be considered, while 1 company propose to exclude the discussion from FR2.* *Tentative agreements:* *- FFS FR2 MPR for Rel-16 Pi/2 BPSK DMRS**Candidate options:**Recommendations for 2nd round:* *- Interested companies further provide comments on FR2 MPR evaluation assumption for further analysis in next meeting, which should be captured in WF.*  |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| #1 | WF on MPR with Pi/2 BPSK DMRS | Qualcomm |

### CRs/TPs

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

## Discussion on 2nd round (if applicable)

*[Moderator] Detailed discussion will be triggered by WF drafting discussion on open issues.*

## 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 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** |
| vivo | Sub topic 2-1: Issue 2-1-1: There is still no conclusion in RAN1 on whether one UE can only support one mode. Thus it might difficult to settle this in RAN4. Issue 2-1-2: Agree option 1. (Up to 2Tx ports in Rel-16) Issue 2-1-3: Not clear whether it is meaningful for FR2 since most of the implementation background & restrictions were based on FR1, such as one port per antenna. If the meaning of FR2 cannot be justified, Option 1 would be preferred.Issue 2-1-4: Reference (typical) implementation can be discussed and used when defining test cases. However, implementation options do not need to be specified.Issue 2-1-5: Discussion on whether fallback is needed or not is preferred before the discussion on the spec location.Sub topic 2-2:Issue 2-2-1: Option 2 can be reasonable. Based on current situation it seems that there is currently no test point for UL-MIMO 2 layer test, which is not considered in last meeting’s WF. Issue 2-2-2: Current physical layer spec only support one full power TPMI. Base on this we do not need consider the case of multiple supported TPMIs, and actually no random selection is needed in this case. Last meeting’s WF did not fully consider this background and leave more room than needed, causing some possible confusion.Issue 2-2-3: Still option 1 is preferred. However, Tx diversity like verification is needed or not may still be discussed at least from functional point of view.Issue 2-2-4: Actually the term “full power TPMI” is for Mode 2 only and not suitable for Mode 0. If the term here be interpreted as TPMIs that could achieve full power, Option3 is preferred. Still not clear the intention of fixed TPMI in option 3a.Sub topic 2-3:Issue 2-3-1: It might be difficult to completely do not consider emission requirements here. However, we think there is some redundancy here and there may be room for simplification. In addition, not clear the difference of option 1 and option 2.Issue 2-3-2: There is similar discussion in maintenance part.Sub topic 2-4:Issue 2-4-1: No comments.….Others: |
| OPPO | Sub topic 2-1: Issue 2-1-1: Prefer Option 1, i.e. confirm current assumption “UE can only support one mode” when defining test configurations to make the discussion simple. The 23+23 UE can only report mode 1, 23+26 UE report mode 2, 26+26 UE report the other mode.Issue 2-1-2: Support option 1.Issue 2-1-3: Support option 1, even RAN1 did not distinguish FR1 and FR2 but the modes and capabilities actually were designed for FR1 like two full rated PAs, etc.Issue 2-1-4: The preferred optioned are as below to facilitate the test configuration definition. The reason we exclude 20+20 to achieve 23 is that this is the corner case, for PC3 UE it is suggested to only consider either 1PA 23 or 2 PA 23+23 configurations. And focus the eMIMO WI on PC2 UEs.o For Mode-1 UE, allowed physical implementation:  Option 1: 23dBm+23dBm UE claimed as PC2o For Mode-2 UE, allowed physical implementation: Option 1: 26dBm+23dBm UE claimed as PC2o For Mode-0 UE (“the other mode”), allowed physical implementation:  Option 2: 26dBm+26dBm UE claimed as PC2Issue 2-1-5: ok with option 1.Sub topic 2-2:Issue 2-2-1: ok with Option 2 to further test DFT-s-OFDM waveform if Rel-15 UL-MIMO rank2 is supported and verified, and no other configurations is needed.Issue 2-2-2: We suggest option 2, i.e. “Select only one of full power TPMI(s), if UE is tested with lower power class in basic requirement”. The reason behind is that actually for mode 2 UE if we assume UE PA configuration is 23+26, then the target is to test this 26dBm PA performance under [0 1] or [1 0] TPMI. However, this 26dBm PA configuration has already been tested under basic single antenna port requirements if it declares PC2 with single antenna port mode. This issue is tightly connected with “EN-DC power class and UL MIMO clarifications” topic in agenda 6.5.4.1. If the final outcome is that UE power class is corresponding to the single antenna port mode, i.e. 26dBm PA is tested in basic requirements, then the UL MIMO TPMI [0 1] or [1 0] is not needed anymore.Issue 2-2-3: Suggest option 1. The Tx diversity has been discussed in Rel-15 for a long time and cannot reach consensus on whether specifying it or not. The single antenna port with 26dBm PA can be covered by issue 2-2-2.Issue 2-2-4: Our suggestion is either Option 2 or Option 4. The main purpose is to check both 26dBm PAs output power and emissions. Since one 26dBm PA has already been tested by basic requirements, the main efforts should focus on the other 26dBm PA, that’s why Option 4 is suggest, however, if people think this kind of UE declaration based test is not reliable, then we are also ok with option 2, i.e. test both [0 1] and [1 0] TPMIs.Sub topic 2-3:Issue 2-3-1: Suggest option 2. Only the configurations defined in MOP needs to be tested with emissions.Issue 2-3-2: Suggest option 1.Sub topic 2-4:Issue 2-4-1: New power-class capability can be added, but it depends on the outcome of “EN-DC power class and UL MIMO clarifications” topic in agenda 6.5.4.1. If the conclusion there is the power class capability in Rel-15 is for single antenna port mode, then new power class can be added for UL MIMO, otherwise, new power class for single antenna port mode should be added. |
| SoftBank | Sub topic 2-3: Issue 2-3-1: Support Option 1. As described in our comment for Issue 2-3-2, the condition of defining the unwanted emissions requirements for general UL-MIMO is different from that for full power transmission. We should not treat the unwanted emissions requirements for general UL-MIMO and full power transmission the same. Issue 2-3-2: Support Option 1. As described in TR 36.807 Section 6.6B, the approach of "each transmit antenna" can be adopted only when the average transmission power per antenna in UL-MIMO transmission is reduced by 3 dB comparing with that of single antenna connector transmission. Full power transmission does not satisfy this condition so each transmit antenna approach cannot be applied.  |
| Huawei | Sub topic 2-1: **Issue 2-1-1: General Assumption for UE Supported Mode**There is no limitation in RAN1 that UE can only support one mode, which depends on UE implementation architecture. But for the test purpose, we may consider only verify one mode indicated by the UE. **Issue 2-1-2: Down-scoping by only considering up to 2 TX ports in Rel-16 eMIMO**Option 1, up to 2 TX ports in Rel-16 eMIMO**Issue 2-1-3: Down-scoping by only considering FR1 in Rel-16 eMIMO**Option 1: only FR1. FR2 only defines the min peak EIRP, which is measured with two polarization transmission assumption. **Issue 2-1-4: Down-scoping on possible physical implementation for Mode-0, 1, and 2 in Rel-16 eMIMO*** For Mode-1 UE, allowed physical implementation:

option 2 and UE with full rated transmission capability at each Tx can also claim as Mode-1 * For Mode-2 UE, allowed physical implementation:

option 1a and UE with full rated transmission capability for each Tx can also claim as Mode-2* 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:**Option1Sub topic 2-2:**Issue 2-2-1: For Mode 1 UE, requirement applicability:**Option1**Issue 2-2-2: For Mode 2 UE with 2 ports configuration, test configuration and requirement applicability:**Option1, up to RAN5 to select which TPMI should be tested.**Issue 2-2-3: For Mode 2 UE with 1 port configuration, test configuration and requirement applicability:**Option 1 **Issue 2-2-4: For Mode 0 UE (“the other mode”) with 2 ports configuration, test configuration and requirement applicability**Option 3Sub topic 2-3:**Issue 2-3-1: Whether unwanted emissions requirement are defined for full power transmission for FR1**Option 3, other requirements are already defined for UL MIMO in Rel-15 **Issue 2-3-2: How unwanted emissions requirement are tested for full power transmission for FR1**Option 3, only MOP is verified additionally for full power transmission capability based on the newly defined requirement. Unwanted emissions in RAN5 are already tested under maximum output power condition. Sub topic 2-4:**Issue 2-4-1: New power class capability**No need to introduce new power class for UL MIMO as we already had agreement that the power class should be the same for single antenna port mode. The ambiguity is for NSA mode, and our proposal is to introduce additional power class signalling for NR band in NSA combinations.  |
| LG Electronics | Sub topic 2-1: Issue 2-1-1: From RAN4 min. requirements perspective, we prefer option 1.Issue 2-1-2: prefer option 1.Issue 2-1-3: prefer option 1 even though RAN1 doesn’t distinguish FR1 and FR2.Issue 2-1-4: LGE has also same understanding as below preferred options to facilitate the test configuration definition. For PC3 UE, RAN4 only considers either 1PA 23dBm or 2 PA 23dBm+23dBm configurations. In Rel-16 eMIMO, we would like to focus on PC2 UEs.o For Mode-1 UE, allowed physical implementation:Option 1: 23dBm+23dBm UE claimed as PC2o For Mode-2 UE, allowed physical implementation:Option 1: 26dBm+23dBm UE claimed as PC2o For Mode-0 UE (“the other mode”), allowed physical implementation: Option 2: 26dBm+26dBm UE claimed as PC2Issue 2-1-5: prefer option 1. Sub topic 2-2:Issue 2-2-1: LGE also support option 2 to test DFT-s-OFDM waveform only if Rel-15 UL-MIMO rank2 is supported and verified, and no other configurations is needed.Issue 2-2-2: LGE prefers option 2 due to the fact that test can’t be duplicated under basic single antenna port requirements.Issue 2-2-3: LGE prefers option 1. Mode 2 with 1 port transmission is already verified in single port test.Issue 2-2-4: we think that either Option 2 or Option 3a is enough to verify emission within max. output power.Sub topic 2-3:Issue 2-3-1: LGE prefers option 2 for unwanted emission requirements with all configurations. RAN4 defines only MOP to be tested with emissions.Issue 2-3-2: LGE prefers option 1 and needs to check whether the emission level simply can be summed or not. For example, when testing EN-DC RSE, Txs should be transmitted simultaneously in air to be measured. However, for conducted spurious emission, there will be measurement at each single port. Sub topic 2-4:Issue 2-4-1: it may be needed to define new power-class capability to distinguish single antenna mode. |
|  Qualcomm | Sub topic 2-1: **Issue 2-1-1: General Assumption for UE Supported Mode*** + The decision as to whether a UE needs to support multiple modes or only 1 mode has not been decided yet in RAN1. Our preference is for the UE to have the signalling capability to indicate that it can support either one of the modes, multiple modes or none of the modes.

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

 **Issue 2-1-3: Down-scoping by only considering FR1 in Rel-16 eMIMO*** + Option 2: Both FR1 and FR2 should be considered. For FR2 some implementations may choose to simultaneously transmit on 2 TX chains. Down-scoping exclusively to FR1 would prevent FR2 UEs from using this framework.

**Issue 2-1-4: Down-scoping on possible physical implementation for Mode-0, 1, and 2 in Rel-16 eMIMO*** + Modes 0, 1 and 2 should all be possible modes of operation and there should be no down scoping of this feature. These modes should be applicable to other power classes as well and not be restricted to PC2 and PC3. It is difficult to predict future operation scenarios of the UE. So, it is best to retain all 3 modes and have them apply to as many power classes as possible in order to have the maximum applicability for the largest number of scenarios.

**Issue 2-1-5: Clarification on appropriate chapter for full power transmission MOP tests:*** + Option 1 seems to be the best way to present the specifications in both full power transmission and fallback DCI\_0\_0 mode in FR1.
	+ For FR2 section 6.2 may be a better place to introduce this framework because RAN5 always configures the UE with 2 SRS ports.

Sub topic 2-2:**Issue 2-2-1: For Mode 1 UE, requirement applicability:*** + Option 2: Only DFT-s-OFDM waveform need to be verified 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:*** + All full power TPMI(s) should be tested

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

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

Sub topic 2-3:**Issue 2-3-1: Whether unwanted emissions requirement are defined for full power transmission for FR1*** + Option 2: Unwanted emissions must be verified for all configurations of full power transmission, in which MOP requirement is defined and tested.

**Issue 2-3-2: How unwanted emissions requirement are tested for full power transmission for FR1*** + Option 1: The individual outputs of all transmitting antennas shall be summed across frequency and compliance to the SEM specifications should be verified.

 Sub topic 2-4:**Issue 2-4-1: New power class capability*** + New power class capability can be defined for a UE transmitting over multiple antennae per NR band. The new power class will be determined as the sum of power on all antennae.

….Others: |
| 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. |
| Apple | Issue 2-1-1: We prefer to understand what modes are under discussion, given the RAN1 agreement on UE capabilities associated with Full Power TxIssue 2-1-2: Option 1Issue 2-1-3: Option 1Issue 2-1-4: More discussion is needed on the optionsIssue 2-4-1: The Rel-16 eMIMO WID explicitly precludes changes to the power class by the Full Power Tx objective [[RP-192271](http://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_85/Docs/RP-192271.zip)]:Specify enhancement to allow full power transmission in case of uplink transmission with multiple power amplifiers (assume no change on UE power class)We do not support adding a new power class capability for this feature. |
| Samsung | Sub-topic 2-1: General Scope and Assumption- Issue 2-1-1: Support Option 1 (Prefer UE only support one mode, i.e., Mode-1, Mode-2 or Mode-0 (“the other mode”) as RAN4 agreement)- Issue 2-1-2: Support Option 1 (which helps to simplifying the discussion, and to our best knowledge commercial product plan will only consider up to 2TX ports in Rel-16 eMIMO)- Issue 2-1-3: Open to also take FR2 into account, while RAN4 need to consider existing agreement can also be applied to FR2. - Issue 2-1-4: at least for FR1: * + For Mode-1 UE, allowed physical implementation:
		- Option 2: 23dBm+23dBm UE claimed as PC2, and 20dBm+20dBm UE claimed as PC3
	+ For Mode-2 UE, allowed physical implementation:
		- Option 1a: 26dBm+23dBm UE claimed as PC2, and 23dBm+20dBm UE claimed as PC3
	+ For Mode-0 UE (“the other mode”), allowed physical implementation:
		- Option 3: 23dBm+23dBm UE claimed as PC3 and 26dBm+26dBm UE claimed as PC2

- Issue 2-1-5: Support Option 1 Sub-topic 2-2: Test Configuration and Requirement Applicability for Full Power Tx MOP Test- Issue 2-2-1: Option 2 (The issue of DFT-s-OFDM waveform not supported in UL-MIMO is not yet considered in previous WF.)- Issue 2-2-2: Option 2 (if only 26+23dBm UE claimed as PC2 (and 23+20dBm UE claimed as PC3) is considered for Mode-2 UE, the situation can be simpler, and the argument behind option 2 is reasonable since single TX port test has been done already with the same MOP requirement based on the full rated PA)- Issue 2-2-3: Option 1 is preferred. However option 2 is not fully against our view, but we need the clarification why both methods (transparent TxD or full rated PA) are allowed for Mode-2 with one TX port configured, but transparent TxD is not allowed (at least not tested) for Mode-1 with one TX port configured. - Issue 2-2-4: Option 3a, since for FR1 single TX is preferred while for FR2 TX from both polarization is also aligned with Rel-15 assumption for testing. Anyway, not prefer to test all possible TPMIs which can achieve full power TX. Sub-topic 2-3: Unwanted Emissions for Full Power Tx for FR1- Issue 2-3-1: Option 2 is acceptable, i.e., unwanted emission requirement will be tested in the all the configuration (certain mode, certain TPMI) in which MOP test is performed. - Issue 2-3-2: Option 1 is acceptable, while the conclusion should be aligned with Rel-15 maintenance part’s counterpart discussion. Sub-topic 2-4: UE Power Class Capability- Issue 2-4-1: Don’t have strong view, but it somehow depends on the general assumption discussion for allowed UE implementation in Rel-16 eMIMO WI.  |
| Ericsson | Issue 2-1-1: a fair assumption is that a UE supports one of the modes 1 and 2 since these represent specific architectures (“the other mode” assumed to be full power). Tests should be developed for all modes specified.Issue 2-1-2: Option 1, to have a chance of completion in Rel-16 (significant changes expected)Issue 2-1-3: FR1, difficult enough to complete this in Rel-16. Some test issues are actually more difficult for FR1 with its conducted testing.Issue 2-1-4:Mode 1: Option 2 (by TPMI2)Mode 2 can attain full power via virtualization or use of a full-power PA, full power TPMI can be indicated so can be Option 2bMode 0: we assume a 23 + 23 dBm could also achieve 26 dBm with two-layer transmission (but should not indicate PC2).General: the main aspect from a network perspective is the 20 + 20 dBm claimed as PC2, tests should ensure there is no performance degradation compared to UEs equipped with a full-power PC3 PA (maintaining phase between branches an issue for virtualization).Issue 2-1-5: requires further discussion (6.2 is single connector/port)Issue 2-2-1: Option 3, relative phase between Tx chains may not be maintained in the verification with TPMI2 (rank2 transmission a different case)Issue 2-2-2: in principle, the core requirement should apply for all full-power TPMI (for applicable UE capability)Issue 2-2-3: Option 2, UE declaration (in Option 2) is only useful in conformance testingIssue 2-2-4: neither Option 1 nor Option 4. Regarding declarations, we note that the network can not rely on declarations used in conformance testing, performance must be mapped to capability.Issue 2-3-1: strictly speaking, unwanted emissions requirements shall always be met (Option 1) but are often verified only in MOP tests (Option 2). Issue 2-3-2: Option 1, if verification per connector then established methods for multi-connector should be used, e.g. comparing the measured result + 3 dB (two connectors) to the limit subject to the total output power.Issue 2-4-1: obviously supportive of Option 1, noting this is only relevant for when ULFPTx in PUSCH-Config is not provided (i.e. Rel-15 case with 23 + 23 dBm architecture) and “the other mode” if this produces 26 dBm for two layers but only 23 dBm in fallback (not relevant for Mode 1 and Mode 2 with a full-power PA or full-power TPMI).General comment: for all modes: performance in fallback must be tested. Indication of a power class in *ue-PowerClass* (*UE-NR-Capability*) shall imply that the UE is capable of producing this power for all transmissions (virtualization allowed). |

### 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# 2-1** | *Issue 2-1-1: General Assumption for UE Supported Mode: “Current assumption is UE can only support one mode”** Option 1: confirm above assumption as RAN4 agreement, i.e., UE only support one mode from Mode-1, Mode-2 and Mode-0 (“the other mode”) (OPPO, LGE, Intel, Samsung)
* Option 2: still no conclusion in RAN1 (vivo, Qualcomm).
* Option 3: No limitation, but define test applicability that only one mode indicated by UE is verified. (Huawei)
* Option 4: UE supports one of the modes 1 and 2 since these represent specific architectures (“the other mode” assumed to be full power) (Ericsson)

*[Moderator] This issue is related to test applicability for full power TX requirement, e.g., if dual mode is supported whether or not UE need to test all possible mode which achieve full power transmission. However, some companies clearly propose that all modes which are supported by UE shall be tested.* *Based on the situation (no clear majority view considering option 2-4 means similar standard impact, i.e., no restriction for supporting both Mode-1 and Mode-2), moderator suggest more discussion on this topic considering following aspects:* * What is the benefit for a Mode-2 UE also claims its support for Mode-1?
* If UE can support both Mode-1 and Mode-2, what shall be testability rule? Candidate options could be (1) If UE support both Mode-1 and Mode-2, both mode shall be tested for full power transmission feature (Ericsson); (2) If UE support both Mode-1 and Mode-2, only one mode is verified (Huawei).

*Tentative agreements: N/A**Recommendations for 2nd round:** *Further discussion based on above questions mentioned by Moderator.*
 |
| *Issue 2-1-2: Down-scoping by only considering up to 2 TX ports in Rel-16 eMIMO** Option 1: up to 2 TX ports in Rel-16 eMIMO (vivo, OPPO, Huawei, LGE, Qualcomm, Intel, Apple, Samsung, Ericsson);
* Option 2: No limitation is introduced in RAN4 Rel-16 eMIMO discussion.

*[Moderator] Clear majority view for option 1.**Tentative agreements:* * *For full power transmission in Rel-16 eMIMO WI, RAN4 only specify requirement for UE supporting up to 2TX ports.*

*Recommendations for 2nd round: N/A* |
| *Issue 2-1-3: Down-scoping by only considering FR1 in Rel-16 eMIMO** Option 1: Only consider FR1 (OPPO, Huawei, LGE, Intel, Apple, Ericsson);
* Option 1a: full power transmission is already supported for FR2, so Rel-16 eMIMO just focus on FR1 (Intel)
* Option 2: Both FR1 and FR2 should be considered (Qualcomm).
* Option 2a: FFS FR2 since current discussion is based mostly on FR1 (vivo, Samsung)

*[Moderator] As some company proposed full power transmission could already be supported in FR2, while we are questioning the conclusion since some of Rel-15 product is said to not support TPMI2 (rank-1 codebook) due to not supporting coherent UL-MIMO as far as we know. However, some company also provided some arguments for option 1, and generally major view comes to Option 1.* *Tentative agreements: N/A**Recommendations for 2nd round:** *Further discussion based on above argument, and companies could further provide evidence for its necessity to consider FR2 or compromise to Option 1.*
 |
| *Issue 2-1-4: Down-scoping on possible physical implementation for Mode-0, 1, and 2 in Rel-16 eMIMO** Option 0: All possible implementation options shall not be precluded (vivo, Qualcomm).
* For Mode-1 UE, allowed physical implementation:
	+ Option 1: 23dBm+23dBm UE claimed as PC2 (OPPO, LGE)
	+ Option 2: 23dBm+23dBm UE claimed as PC2, and 20dBm+20dBm UE claimed as PC3 (Intel, Samsung, Ericsson)
	+ Option 3: above Option 2 and Mode-0 UE also can claim its support of Mode-1

(Huawei)* For Mode-2 UE, allowed physical implementation:
	+ Option 1: 26dBm+23dBm UE claimed as PC2 (OPPO, LGE)
	+ Option 1a: 26dBm+23dBm UE claimed as PC2, and 23dBm+20dBm UE claimed as PC3 (Intel, Samsung)
	+ 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) ([Ericsson])
	+ Option 3: above Option 1a and Mode-0 UE also can claim its support of Mode-2 (Huawei)
* For Mode-0 UE (“the other mode”), allowed physical implementation:
	+ Option 1: 23dBm+23dBm UE claimed as PC3
	+ Option 1a: 23dBm + 23dBm UE claimed as PC3, but PC2 by two layer UL-MIMO (Ericsson)
	+ Option 2: 26dBm+26dBm UE claimed as PC2 (OPPO, LGE)
	+ Option 3: 23dBm+23dBm UE claimed as PC3 and 26dBm+26dBm UE claimed as PC2 (Huawei, Intel, Samsung)

*[Moderator] As some company mentioned, the intention of proposing Issue 2-1-4 needs to be clarified. Moderator think clarification on possible implementation options helps the group to move forward on other topics. For instance, the issues like whether MOP is needed to be achieved in fallback mode (DCI\_0\_0), whether transparent TxD is allowed for Mode-2 UE configured with 1-Port precoder, etc.* *Tentative agreements: N/A**Recommendations for 2nd round: Considering this situation, we suggest companies to discuss at least by focusing two basic questions (which are behind the above options for all modes):* * *Although 20dBm PA give flexibility for UE implementation, is this 20dBm PA implementation a real design option for near future products? If not, Moderator suggest the group don’t consider the options with 20dBm PA in RAN4 scope, considering it is common practice in RAN4 to only define requirements based on real product implementation (not similar as some other working group).*
* *23dBm + 23dBm to claim its support for both Mode-1 and Mode-2 is allowed or not (similar to Issue 2-1-1)? If company support this, the benefits should be justified. Considering majority view, Moderator suggest company to consider compromise to majority view for simplified assumption.*

*If company feel uncomfortable for “down-scope possible implementation”, Moderator suggest that the conclusion from above discussion serves as “reference UE architecture for RAN4 requirement definition”.*  |
| *Issue 2-1-5: Clarification on appropriate chapter for full power transmission MOP tests (for FR1):** 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 for FR1. (OPPO, Huawei, LGE, Qualcomm, Intel, Samsung)
* Option 2: Need further discussion (vivo, Ericsson).

*[Moderator]Although major view prefer to have option 1, Moderator still suggest for further discussion since the difference may come from different view for fallback mode (for which we add Issue 2-1-6). One company also have proposal for FR2, while this discussion can be postponed until RAN4 concludes on Issue 2-1-3.* *Tentative agreements: N/A**Recommendations for 2nd round: Suggest companies to discuss at least by focusing on:** *Whether or not it is common understanding that Section 6.2 is only for single connector/port even after Mode-1 UE is introduced? If so, it could imply that 3dB degradation from claimed PC should be allowed for Mode-1 UE for requirement in Section 6.2, e.g., Mode-1 UE with 20dBm+20dBm PA claiming PC3, 3dB degradation should be allowed for requirement in 6.2, while Moderator believe that to many other companies, it is very weird that after Rel-16 enhancement, some UEs even can’t support PC3 23dBm MOP in 6.2 which is commonly regarded as “basic requirement” for all UE. Actually this is another reason we suggest the group to consider the possibility of 20dBm+20dBm implementation in Issue 2-1-4.*
 |
| *Issue 2-1-6 (Newly added Issue based on discussion progress): UE behavior for fallback DCI (DCI\_0\_0)* * Option 1: For all modes, when UE is scheduled by fallback DCI (DCI\_0\_0), MOP should be tested in which antenna virtualization shall be allowed. e.g., Mode-1 20dBm + 20dBm PC3 UE shall use antenna virtualization for fallback DCI (Ericsson)
* Option 2: Antenna virtualization is not allowed for fallback DCI, so 3dB degradation is allowed for Mode-1 UE and MOP is not achievable or tested. For Mode-2 and “the other mode”, MOP requirement in Section 6.2 could be referred for fallback DCI.
* Option 3: UE behaviour for fallback DCI is not needed to be discussed.

*Tentative agreements: N/A**Recommendations for 2nd round: Suggest companies to discuss above options.*  |
| **Sub-topic 2-2** | *Issue 2-2-1: For Mode 1 UE, requirement applicability** Option 1 (Last Meeting Agreement): No need to be tested if Rel-15 UL-MIMO rank2 is supported and verified. (Huawei, Intel)
* Option 2: Only DFT-s-OFDM waveform need to be verified if Rel-15 UL-MIMO rank2 is supported and verified. (vivo, OPPO, LGE, Qualcomm, Samsung)
* Option 3: Need to be verified no matter Rel-15 UL-MIMO rank2 is supported and verified (Ericsson).

*[Moderator] Majority view for Option 2.* *Tentative agreements:* * Only DFT-s-OFDM waveform need to be verified if Rel-15 UL-MIMO rank2 is supported and verified.

*Recommendations for 2nd round: Continue discussion if the above tentative agreement is not reached in 1st round.*  |
| *Issue 2-2-2: For Mode 2 UE with 2 ports configuration, test configuration and requirement applicability:** Option 1: Select only one of full power TPMI(s) (Huawei)
* Option 2: Select only one of full power TPMI(s), if UE is tested with lower power class in basic requirement (OPPO, LGE, Samsung).
* Option 3: full power TPMI(s) with only one non-zero power port are excluded for full power transmission test.
* Option 4: All full power TPMI(s) UE support should be tested. (Qualcomm, Ericsson)
* Option 5: 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. (Intel)

*[Moderator] No majority view observed.* *Tentative agreements: N/A**Recommendations for 2nd round: Continue discussion by focusing on:* * *If the reference implementation for Mode-2 can be simplified by just considering one full rated PA + one non-full rated PA, and only 2TX is assumed, this issue will be simplified since either TPMI0 or TPMI1 is the only full power TPMI.*
* *Suggest the group to compromise to Option 5 if down-scoping on reference implementation for Mode-2 is not achieved.*
 |
| *Issue 2-2-3: For Mode 2 UE with 1 port configuration, test configuration and requirement applicability:** Option 1: No test needed (vivo, OPPO, Huawei, LGE, Samsung);
* 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. (Qualcomm, Ericsson)
* 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. (Intel)

*[Moderator] Majority view observed for Option-1.* *Tentative agreements:* * *For Mode 2 UE with 1 port configuration, both MOP requirement and test are not needed.*

*Recommendations for 2nd round: If tentative agreement is not reached in 1st round, continue discussion.*  |
| *Issue 2-2-4: For Mode 0 UE (“the other mode”) with 2 ports configuration, test configuration and requirement applicability** Option 1: No test needed;
* Option 2: All supported full power TPMIs are tested; (OPPO, LGE, Qualcomm, Intel, Ericsson)
* Option 3: Select only one of full power TPMI(s) for test; (vivo, Huawei, Ericsson, Samsung)
* Option 3a: For UE support 2 ports, TPMI 0 for FR1 (and TPMI 2 for FR2 if applicable); (LGE, Samsung, Ericsson)
* Option 4: Based on the announcement and use different PAs between basic test and “the other mode” test. (OPPO)

*[Moderator] Considering the similarity between Option 3 and Option 3a, we don’t observe majority between Option 2 vs. Option 3/3a.* *Tentative agreements: N/A**Recommendations for 2nd round: Continue discussion. Considering the companies not prefer Option 2 could be due to test effort issue, is that possible to test TPMI2 for FR1 as a compromise considering the performance for TPMI 0/1 is already guaranteed if fallback DCI requirement is tested.*  |
| **Sub-topic 2-3** | *Issue 2-3-1: Whether unwanted emissions requirement are defined for full power transmission for FR1** Option 1: Unwanted emissions must be verified for all mode(s) of full power transmission which is supported by UE, and to select one configuration for each supported mode if multiple configurations are tested for MOP.
* Option 2: Unwanted emissions must be verified for all configurations of full power transmission, in which MOP requirement is defined and tested. (OPPO, LGE, Qualcomm, Samsung, Ericsson)
* Option 3: Except for MOP, no other requirement need to be defined (Huawei)

*[Moderator] Sorry for not fully clarify the intention by preparing the Option 1, while at least our original intention is not test all MOP configuration as Option 2 does. Pls. see above highlighted clarification. Based on that, we assume Softbank, vivo and Intel will give or change the preference. Seems majority view is Option-2, while at least only one company explicitly oppose Option-2.**Tentative agreements: Option-2 if majority view can be confirmed,* *Recommendations for 2nd round: Continue discussion if Option -2 is not agreed in 1st round.*  |
| *Issue 2-3-2: How unwanted emissions requirement are tested for full power transmission for FR1** Option 1: The individual outputs of all transmitting antennas shall be summed across frequency and compliance to the SEM specifications should be verified. (OPPO, Softbank, LGE, Qualcomm, Samsung, Ericsson)
* Option 2: Requirement is specified and verified at each transmit antenna.
* Option 3: only MOP is verified additionally for full power transmission capability based on the newly defined requirement. Unwanted emissions in RAN5 are already tested under maximum output power condition. (Huawei)

*[Moderator] Option-1 is majority view, however considering similar discussion in parallel discussion in Rel-15 maintenance, suggest to align the conclusion.* *Tentative agreements: Depends on Chair’s decision based on two email discussions’ outcome.* *Recommendations for 2nd round: Continue discussion if agreement is not achieved in 1st round.*  |
| **Sub-topic 2-4** | *Issue 2-4-1: New power class capability* * Option 1: adding a new power-class capability for two-layer transmissions per NR band (Rel-16) (LGE, Intel, Ericsson)
* Option 1a: New power class capability can be defined for a UE transmitting over multiple antennae per NR band. The new power class will be determined as the sum of power on all antennae. (Qualcomm)
* Option 1b: add new power class but how to add depends on the outcome of “EN-DC power class and UL MIMO clarifications” topic in agenda 6.5.4.1 (OPPO)
* Option 2: No need to introduce new power class (Huawei, Apple)

*[Moderator] Seems major view to Option 1 if companies supporting Option 1a and 1b can compromise to Option 1.* *Tentative agreement: Option 1 (as majority view if companies supporting Option 1a and 1b can compromise to Option 1 )**Recommendations for 2nd round: Continue discussion if agreement is not achieved in 1st round.* |

*Suggestion on WF/LS assignment*

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|  | **WF/LS t-doc Title**  | **Assigned Company,****WF or LS lead** |
| #1 | WF on Uplink Full Power Transmission | vivo |

### CRs/TPs

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

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| **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)

*[Moderator] As discussed with WF lead for Uplink Full Power transmission (vivo), companies’ views will be firstly collected in this email discussion summary here. Particularly, in this 2nd round discussion, Moderator would like to ask companies to provide view on:*

 *(a) Strong negative view on Tentative Agreement (Note: Tentative Agreement will only be proposed based on majority view, if any observed from 1st round discussion.)
 🡪 If no strong negative view received in 2nd round, it is suggested to capture this Tentative Agreement in WF.*

 *(b) Technical view collected based on Moderator’s suggestions in order to collect more comments to solve technical deadlock.*

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|  | **Status summary**  |
| **Sub-topic# 2-1** | *Issue 2-1-1: General Assumption for UE Supported Mode: “Current assumption is UE can only support one mode”** Option 1: confirm above assumption as RAN4 agreement, i.e., UE only support one mode from Mode-1, Mode-2 and Mode-0 (“the other mode”) (OPPO, LGE, Intel, Samsung)
* Option 2: still no conclusion in RAN1 (vivo, Qualcomm).
* Option 3: No limitation, but define test applicability that only one mode indicated by UE is verified. (Huawei)
* Option 4: UE supports one of the modes 1 and 2 since these represent specific architectures (“the other mode” assumed to be full power) (Ericsson)

*[Moderator in 1st Round] This issue is related to test applicability for full power TX requirement, e.g., if dual mode is supported whether or not UE need to test all possible mode which achieve full power transmission. However, some companies clearly propose that all modes which are supported by UE shall be tested.* *[Moderator in 2nd Round]Based on the situation, moderator suggest the following Tentative agreement by combing Option 1 and 4 (seems Ericsson’s view is aligned with Option, but just assume there will be no explicit capability signaling for “the other mode”) to ask companies’ view on below tentative agreement based on a majority view (5 companies for Option 1/4 vs. 3 companies for others):* *Tentative Agreement (based on majority view):* * *In Rel-16 eMIMO, UE shall not support both mode 1 and mode 2;*

*Recommendations for 2nd round:** *Further discussion on above tentative agreement; furthermore, companies are encourage to provide the NW-side benefits if UE can support both Mode-1 and Mode-2:*

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| Company | Preference in 2nd Round | Further Comments in 2nd Round |
| Samsung | Support Tentative Agreement | We don’t see the clear benefits by a specific UE implementation which already support Mode-2, but also to claim its support of Mode-1. The tentative agreement helps to simplify eMIMO discussion since no need to discuss on test applicability rule in the future meeting.  |
| Intel | Support tentative agreement | A UE may support both mode 1 and 2 by theory, but mode 2 has single PA (26dBm) to support full power transmission, while mode 1 full power transmission has to use the configuration of one layer two ports 23dBm + 23dBm reduced from 26dBm => 26dBm with CCD which shows frequency selective within the CBW -> potential issue in small RB transmissions. Don’t see advantage at least for this aspect. |
| OPPO | Support tentative agreement |  |

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| *Issue 2-1-2: Down-scoping by only considering up to 2 TX ports in Rel-16 eMIMO** Option 1: up to 2 TX ports in Rel-16 eMIMO (vivo, OPPO, Huawei, LGE, Qualcomm, Intel, Apple, Samsung, Ericsson);
* Option 2: No limitation is introduced in RAN4 Rel-16 eMIMO discussion.

*[Moderator in 1st Round] Clear majority view for option 1.**Tentative agreements (based on clear majority view):* * *For full power transmission in Rel-16 eMIMO WI, RAN4 only specify requirement for UE supporting up to 2TX ports.*

*Recommendations for 2nd round:* * *If objection on above tentative agreement, company is asked provide comments below:*

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| Company | Preference in 2nd Round | Further Comments in 2nd Round |
| OPPO | Support tentative agreement |  |
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| *Issue 2-1-3: Down-scoping by only considering FR1 in Rel-16 eMIMO** Option 1: Only consider FR1 (OPPO, Huawei, LGE, Intel, Apple, Ericsson);
* Option 1a: full power transmission is already supported for FR2, so Rel-16 eMIMO just focus on FR1 (Intel)
* Option 2: Both FR1 and FR2 should be considered (Qualcomm).
* Option 2a: FFS FR2 since current discussion is based mostly on FR1 (vivo, Samsung)

*[Moderator in 1st Round] As some company proposed full power transmission could already be supported in FR2, while we are questioning the conclusion since some of Rel-15 product is said to not support TPMI2 (rank-1 codebook) due to not supporting coherent UL-MIMO as far as we know. However, some company also provided some arguments for option 1, and generally major view comes to Option 1.* *Tentative agreements (based on compromising from all options):* * In Rel-16 eMIMO RAN4 discussion for full power transmission feature,
	+ At least define UE RF requirement for FR1;
	+ FFS the necessity of full power transmission feature for FR2.

*Recommendations for 2nd round:* * *Further discussion on above tentative agreement:*

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| Company | Preference in 2nd Round | Further Comments in 2nd round |
| Samsung | Support Tentative Agreement | In the next meeting, companies can further provide the view on the necessity of FP TX feature in FR2 based on Rel-15 status.  |
| Intel | Support tentative agreement |  |
| OPPO | Support tentative agreement |  |

 |
| *Issue 2-1-4: Down-scoping on possible physical implementation for Mode-0, 1, and 2 in Rel-16 eMIMO** Option 0: All possible implementation options shall not be precluded (vivo, Qualcomm).
* For Mode-1 UE, allowed physical implementation:
	+ Option 1: 23dBm+23dBm UE claimed as PC2 (OPPO, LGE)
	+ Option 2: 23dBm+23dBm UE claimed as PC2, and 20dBm+20dBm UE claimed as PC3 (Intel, Samsung, Ericsson)
	+ Option 3: above Option 2 and Mode-0 UE also can claim its support of Mode-1

(Huawei)* For Mode-2 UE, allowed physical implementation:
	+ Option 1: 26dBm+23dBm UE claimed as PC2 (OPPO, LGE)
	+ Option 1a: 26dBm+23dBm UE claimed as PC2, and 23dBm+20dBm UE claimed as PC3 (Intel, Samsung)
	+ 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) ([Ericsson])
	+ Option 3: above Option 1a and Mode-0 UE also can claim its support of Mode-2 (Huawei)
* For Mode-0 UE (“the other mode”), allowed physical implementation:
	+ Option 1: 23dBm+23dBm UE claimed as PC3
	+ Option 1a: 23dBm + 23dBm UE claimed as PC3, but PC2 by two layer UL-MIMO (Ericsson)
	+ Option 2: 26dBm+26dBm UE claimed as PC2 (OPPO, LGE)
	+ Option 3: 23dBm+23dBm UE claimed as PC3 and 26dBm+26dBm UE claimed as PC2 (Huawei, Intel, Samsung)

*[Moderator in 1st Round] As some company mentioned, the intention of proposing Issue 2-1-4 needs to be clarified. Moderator think clarification on possible implementation options helps the group to move forward on other topics. For instance, the issues like whether MOP is needed to be achieved in fallback mode (DCI\_0\_0), whether transparent TxD is allowed for Mode-2 UE configured with 1-Port precoder, etc.* *Tentative agreements: N/A**Recommendations for 2nd round: Considering this situation, Moderator suggest companies to discuss at least by focusing two basic questions (which are behind the above options for all modes):* * *Although 20dBm PA give flexibility for UE implementation, is this 20dBm PA implementation a real design option for near future products? If not, Moderator suggest the group don’t consider the options with 20dBm PA in RAN4 scope, considering it is common practice in RAN4 to only define requirements based on real product implementation (not similar as some other working group).*
* *23dBm + 23dBm to claim its support for both Mode-1 and Mode-2 is allowed or not (similar to Issue 2-1-1)? If company support this, the benefits should be justified. Considering majority view, Moderator suggest company to consider compromise to majority view for simplified assumption.*

*If company feel uncomfortable for “down-scope possible implementation”, Moderator suggest that the conclusion from above discussion serves as “reference UE architecture for RAN4 requirement definition”.* * *Further view collected:*

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| Company | Further Comments in 2nd round |
| Samsung | Based on the discussion till now, we are okay to exclude 20dBm PA at least from “reference UE architecture for RAN4 requirement”, considering we don’t see the real possible product implementation based on 20dBm PA. For Mode-2 UE, downscoping is possible if the tentative agreement for above Issue 2-1-1 is approved. We suggest only regard 23dBm+23dBm PC2 UE as Mode-1 UE. For Mode-2 UE, only one full rated PA + one non-full rated PA is allowed for RAN4 requirement.  |
| Intel | 1. 20dBm single PA transmission can be excluded from discussion for fallback transmission.
2. I assume 23dBm + 26dBm combination. Our comments have been provided in Issue 2-1-1
 |
| OPPO | 1. OK with excluding 20+20 configurations;
2. *Only consider 23dBm + 23dBm to claim its support for Mode-1*
 |

 |
| *Issue 2-1-5: Clarification on appropriate chapter for full power transmission MOP tests (for FR1):** 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 for FR1. (OPPO, Huawei, LGE, Qualcomm, Intel, Samsung)
* Option 2: Need further discussion (vivo, Ericsson).

*[Moderator in 1st Round]Although major view prefer to have option 1, Moderator still suggest for further discussion since the difference may come from different view for fallback mode (for which we add Issue 2-1-6). One company also have proposal for FR2, while this discussion can be postponed until RAN4 concludes on Issue 2-1-3.* *Tentative agreements: N/A**Recommendations for 2nd round: Suggest companies to discuss at least by focusing on:** *Whether or not it is common understanding that Section 6.2 in TS38.101-1 is only for single connector/port even after Mode-1 UE is introduced in Rel-16?*
* *Further view collected:*

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| Company | Further Comments in 2nd Round |
| Samsung | We don’t prefer to give big modification on Section 6.2 in TS38.101-1, so it is reasonable to keep Section 6.2 in TS38.101-1 only for single connector/port even after Mode-1 UE is introduced in Rel-16.  |
| OPPO | Prefer to keep Section 6.2 in TS38.101-1 only for single connector/portS |

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| *Issue 2-1-6 (Newly added Issue based on discussion progress): UE behavior for fallback DCI (DCI\_0\_0)* * Option 1: For all modes, when UE is scheduled by fallback DCI (DCI\_0\_0), MOP should be tested in which antenna virtualization shall be allowed. e.g., Mode-1 20dBm + 20dBm PC3 UE shall use antenna virtualization for fallback DCI (Ericsson)
* Option 2: Antenna virtualization is not allowed for fallback DCI, so 3dB degradation is allowed for Mode-1 UE and MOP is not achievable or tested. For Mode-2 and “the other mode”, MOP requirement in Section 6.2 could be referred for fallback DCI.
* Option 3: UE behaviour for fallback DCI is not needed to be discussed.

*[Moderator in 2nd round]: The issue is added based on 1st round discussion.* *Tentative agreements: N/A**Recommendations for 2nd round:* * *Suggest companies to provide preference for above options:*

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| Company | Preference in 2nd Round | Further Comments in 2nd Round |
| Samsung | Option 2 | If 20dBm PA is excluded, the only case for Mode-1 UE is just 23dBm+23dBm UE (claiming PC2), if so its fallback DCI only support 23dBm is a legacy problem from Rel-15. For Rel-15 full power transmission, at least NW can use TPMI2 to make Mode-1 UE on full power transmission mode already. For Mode-2 and “the other Mode”, UE should have not problem by applying requirement in 6.2 for fallback DCI.  |
| Intel | Option 1 | It makes more sense to have all modes supporting fallback DCI tested |
| OPPO | Option 3 | DCI 0-0 behavior is still discussing in Rel-15 power class topic, suggest the eMIMO only focus on the MIMO configurations and requirements. |

*.*  |
| **Sub-topic 2-2** | *Issue 2-2-1: For Mode 1 UE, requirement applicability** Option 1 (Last Meeting Agreement): No need to be tested if Rel-15 UL-MIMO rank2 is supported and verified. (Huawei, Intel)
* Option 2: Only DFT-s-OFDM waveform need to be verified if Rel-15 UL-MIMO rank2 is supported and verified. (vivo, OPPO, LGE, Qualcomm, Samsung)
* Option 3: Need to be verified no matter Rel-15 UL-MIMO rank2 is supported and verified (Ericsson).

*[Moderator in 1st Round] Majority view for Option 2.* *Tentative agreements (based on majority view):* * Only DFT-s-OFDM waveform need to be verified if Rel-15 UL-MIMO rank2 is supported and verified.

*Recommendations for 2nd round:* * *Suggest companies to give viewpoint on above tentative agreement:*

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| Company | Preference in 2nd Round | Further Comments in 2nd Round |
| Samsung | Support tentative agreement | Tentative agreement is just a technical revision based on last meeting’s agreement, due to the fact that DFT-s-OFDM waveform can’t be verified in Rel-15 UL-MIMO rank 2.  |
| Intel | Tentative agreement  | We can follow majority view |
| OPPO | Support tentative agreement |  |

 |
| *Issue 2-2-2: For Mode 2 UE with 2 ports configuration, test configuration and requirement applicability:** Option 1: Select only one of full power TPMI(s) (Huawei)
* Option 2: Select only one of full power TPMI(s), if UE is tested with lower power class in basic requirement (OPPO, LGE, Samsung).
* Option 3: full power TPMI(s) with only one non-zero power port are excluded for full power transmission test.
* Option 4: All full power TPMI(s) UE support should be tested. (Qualcomm, Ericsson)
* Option 5: 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. (Intel)

*[Moderator in 1st Round] No majority view observed.* *Tentative agreements: N/A**Recommendations for 2nd round: Continue discussion by focusing on:* * *If the reference implementation for Mode-2 can be simplified by just considering one full rated PA + one non-full rated PA, and only 2TX is assumed, this issue will be simplified since either TPMI0 or TPMI1 is the only full power TPMI.*
* *Companies’ view collected:*

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| Company | Preference in 2nd Round | Further Comments in 2nd Round |
| Samsung | TPMI0 or TPMI1 based on UE declaration | In Rel-16, only 2TX is assumed (based on tentative agreement without no objection in 1st round) and we suggest to only consider Mode-2 UE as one full rate PA + one non-full rated PA. If that is the case, the situation seems straightforward.  |
| Intel | Option 2 | Support Option 2 if 2Tx is assumed. |
| OPPO | Option 2 | The TPMI used actually can be based on UE declaration. |

 |
| *Issue 2-2-3: For Mode 2 UE with 1 port configuration, test configuration and requirement applicability:** Option 1: No test needed (vivo, OPPO, Huawei, LGE, Samsung);
* 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. (Qualcomm, Ericsson)
* 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. (Intel)

*[Moderator in 1st Round] Majority view observed for Option-1.* *Tentative agreements (based on majority view):* * *For Mode 2 UE with 1 port configuration, both MOP requirement and test are not specified in Rel-16.*

*Recommendations for 2nd round: Views on above tentative agreement based on majority view.*

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| Company | Preference in 2nd Round | Further Comments in 2nd Round |
| Samsung | Support tentative agreement  | Support tentative agreement based on majority view |
| Intel |  | Can moderator clarify what the definition of Mode 2 UE with 1 port configuration is? We do have the configuration for mode 2 with 23dBm + 26dBm, which supports one port full power of 26dBm PA.  |
| OPPO | Support tentative agreement |  |

 |
| *Issue 2-2-4: For Mode 0 UE (“the other mode”) with 2 ports configuration, test configuration and requirement applicability** Option 1: No test needed;
* Option 2: All supported full power TPMIs are tested; (OPPO, LGE, Qualcomm, Intel, Ericsson)
* Option 3: Select only one of full power TPMI(s) for test; (vivo, Huawei, Ericsson, Samsung)
* Option 3a: For UE support 2 ports, TPMI 0 for FR1 (and TPMI 2 for FR2 if applicable); (LGE, Samsung, Ericsson)
* Option 4: Based on the announcement and use different PAs between basic test and “the other mode” test. (OPPO)

*[Moderator in 1st Round] Considering the similarity between Option 3 and Option 3a, we don’t observe majority between Option 2 vs. Option 3/3a.* *Tentative agreements: N/A**Recommendations for 2nd round: Continue discussion:*

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| --- | --- |
| Company | Further Comments in 2nd Round |
| Samsung | Considering the companies not prefer Option 2 could be due to test effort issue, is that possible to test TPMI2 for FR1 as a compromise considering the performance for TPMI 0/1 is already guaranteed if fallback DCI requirement is tested. |
| Intel | Support option 2 as 1st choice. But option 3 is still ok due to test time concern.  |
| OPPO | Only option 2 can guarantee UE emissions. If the concern is about testing time then only one TPMI can be used. Details about how to choose the TPMI in option 3 is unclear, maybe the way option 4 choose the TMPI could be used. |

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| **Sub-topic 2-3** | *Issue 2-3-1: Whether unwanted emissions requirement are defined for full power transmission for FR1** Option 1: Unwanted emissions must be verified for all mode(s) of full power transmission which is supported by UE, and to select one configuration for each supported mode if multiple configurations are tested for MOP.
* Option 2: Unwanted emissions must be verified for all configurations of full power transmission, in which MOP requirement is defined and tested. (OPPO, LGE, Qualcomm, Samsung, Ericsson, [Softbank])
* Option 3: Except for MOP, no other requirement need to be defined (Huawei)

*[Moderator in 1st Round] Sorry for not fully clarify the intention by preparing the Option 1, while at least our original intention is not test all MOP configuration as Option 2 does. Pls. see above highlighted clarification. Based on that, we assume Softbank, vivo and Intel will give or change the preference. Seems majority view is Option-2, while at least only one company explicitly oppose Option-2.**Tentative agreements (based on majority views):* * Unwanted emissions must be verified for all configurations of full power transmission, in which MOP requirement is defined and tested.

*Recommendations for 2nd round: Companies are encouraged to provide their preference given the above Moderator’s explanation on Option-1. See the above tentative agreement (based on Option-2) based on majority view is agreeable or not:*

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| Company | Preference in 2nd Round | Further Comments in 2nd Round |
| Samsung | Support tentative agreement  | All configuration for MOP test needs test for emission requirement.  |
| Intel | Support tentative agreement | Emission limits must be met |
| OPPO | Support tentative agreement |  |

 |
| *Issue 2-3-2: How unwanted emissions requirement are tested for full power transmission for FR1** Option 1: The individual outputs of all transmitting antennas shall be summed across frequency and compliance to the SEM specifications should be verified. (OPPO, Softbank, LGE, Qualcomm, Samsung, Ericsson)
* Option 2: Requirement is specified and verified at each transmit antenna.
* Option 3: only MOP is verified additionally for full power transmission capability based on the newly defined requirement. Unwanted emissions in RAN5 are already tested under maximum output power condition. (Huawei)

*[Moderator in 1st Round] Option-1 is majority view, however considering similar discussion in parallel discussion in Rel-15 maintenance, suggest to align the conclusion.* *[Moderator in 2nd Round] Here we only consider full power transmission introduced in Rel-16, Moderator suggest to approve Option 1 as majority view, but limit the test method for Rel-16 and forward (i.e., no revisit on Rel-15).* *Tentative agreements (based on majority view):** For unwanted emission requirements to be tested for Rel-16 full power transmission,
	+ The individual outputs of all transmitting antennas shall be summed across frequency and compliance to the SEM specifications should be verified.
	+ No impact on Rel-15 test for unwanted emission requirement.

*Recommendations for 2nd round: Continue discussion if above tentative agreement is agreeable or not.*

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| Company | Preference in 2nd Round | Further Comments in 2nd Round |
| Samsung | Support tentative agreement  |   |
| OPPO | Support tentative agreement |  |

 |
| **Sub-topic 2-4** | *Issue 2-4-1: New power class capability* * Option 1: adding a new power-class capability for two-layer transmissions per NR band (Rel-16) (LGE, Intel, Ericsson)
* Option 1a: New power class capability can be defined for a UE transmitting over multiple antennae per NR band. The new power class will be determined as the sum of power on all antennae. (Qualcomm)
* Option 1b: add new power class but how to add depends on the outcome of “EN-DC power class and UL MIMO clarifications” topic in agenda 6.5.4.1 (OPPO)
* Option 2: No need to introduce new power class (Huawei, Apple)

*[Moderator in 1st Round] Seems major view to Option 1 if companies supporting Option 1a and 1b can compromise to Option 1.* *Tentative agreement (based on majority view if Option 1a/b can compromise to Option 1):* * Adding a new power-class capability for two-layer transmissions per NR band (Rel-16).

*Recommendations for 2nd round: Continue discussion if above tentative agreement is agreeable or not.*

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| --- | --- | --- |
| Company | Preference in 2nd Round | Further Comments in 2nd Round |
| Samsung | Would like to clarify more  | Would like to clarify more on new power class capability (for two-layer transmission per NR) and UE’s capability for Mode1/2 and “the other mode”.  |
| Intel |  | Our understanding is all mode 0/1/2 are part of UL-MIMO extension in practice. We think standalone mode 0/1/2 without supporting UL-MIMO could be rare. We can think about a unified approach for power-class capability of a UE to cover UL-MIMO and mode 0/1/2 together.  |
| OPPO | Option 1b | The new power class discussion is also happening in the Rel-15 power class discussion and it has not been agreed that the Rel-15 UE reported power class is based on single port or UL MIMO. Therefore, the discussion here need to wait for the Rel-15 conclusions in agenda 6.5.4.1 |

 |

## 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. |