**3GPP TSG RAN WG1 #109-e R1-2204856**

**e-Meeting, May 9th – 20th, 2022**

**Agenda Item: 8.16.16**

**Source: Moderator (AT&T)**

**Title: Summary of UE features for DL 1024QAM for NR FR1**

**Document for:** **Discussion/Decision**

# Introduction

This document presents the summary of email discussion/approval [109-e-R17-UE-features-1024QAM-01] during RAN1 #109-e. According to the Chairman’s Notes:

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| [109-e-R17-UE-features-1024QAM-01] Email discussion on UE features for DL 1024QAM for NR FR1 – Ralf (AT&T)* 1st check point for LS to RAN2: May 13
* Final check point for any remaining issues: May 20
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The following was discussed and/or agreed during RAN1 #109-e within the scope of [109-e-R17-UE-features-1024QAM-01]. All proposals are based on the latest RAN1 UE features list for Rel-17 NR in [1].

# Summary of Contributions Submitted to RAN1 #109-e

The following is the moderator’s summary of contributions submitted to RAN1 #109-e in this agenda item.

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| 36. NR\_DL1024QAM\_FR1 | 36-1 | 1024QAM for PDSCH for FR1 | Support 1024QAM for PDSCH for FR1 including 1024QAM modulation scheme as defined in TS 38.211, MCS and CQI feedback tables based on 1024QAM modulation order as defined in TS 38.214. | pdsch-256QAM-FR1 | Yes | N/A | No support of 1024 QAM for PDSCH | Per Band | N/A | Applicable only to FR1 | N/A | Note from WI objective: DL PDSCH 1024QAM for FR1 should be defined as a per-band UE capability | Optional with capability signalling |

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| Company | Summary |
| MediaTek Inc. [2] | In the WID, it clearly states that 1024QAM is applicable scenarios with up to 2 layer DL MIMO.

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| The objective is to specify downlink 1024QAM for NR PDSCH operation in FR1, together with related procedures, signalling and necessary RF requirements. The main objectives are:* Specify high order modulation for PDSCH [RAN1]
	+ Specify 1024QAM constellation as specified in E-UTRA for DL PDSCH
	+ Specify corresponding 5-bit MCS table with 1024QAM entries as defined in E-UTRA, with 5 bit DCI overhead for MCS indication
	+ Specify corresponding CQI feedback with 1024QAM entries as defined in E-UTRA, with no changes to the CQI field and table sizes
* Specify corresponding RRC signalling and UE capabilities [RAN2]
	+ Note: DL PDSCH 1024QAM for FR1 should be defined as a per-band UE capability
* Specify corresponding UE and BS RF core requirements [RAN4]
	+ UE and BS RF core requirements are specified for stationary wireless scenarios **with up to 2 layer DL MIMO**
	+ The cell size(s) and type of stationary wireless scenarios for which UE and BS RF core requirements are defined will be studied and decided by RAN4.
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However, it is not captured in the description of FG 36-1.

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| **Index** | **Feature group** | **Components** |
| 36-1 | 1024QAM for PDSCH for FR1 | Support 1024QAM for PDSCH for FR1 including 1024QAM modulation scheme as defined in TS 38.211, MCS and CQI feedback tables based on 1024QAM modulation order as defined in TS 38.214. |

We propose the following changes to capture this restriction. Without this clarification, it is not clear up to how many DL MIMO layers UE should support when it wants to report this FG 36-1 capability.Proposal 1: Make the following changes highlighted in red to Components of FG 36-1: * **Support 1024QAM for PDSCH with up to 2 MIMO layers for FR1 including 1024QAM modulation scheme as defined in TS 38.211, MCS and CQI feedback tables based on 1024QAM modulation order as defined in TS 38.214.**
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# Discussion/Approval Items during RAN1 #109-e — First Checkpoint

After review of contributions submitted to RAN1 #109-e in this agenda item, the following topics were identified by the moderator for discussion/approval during RAN1 #109-e.

**General comments**

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| Company | Comments/Questions/Suggestions |
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# Issue 1: FG 36-1

After review of contributions submitted to RAN1 #109-e in this agenda item, the following is proposed by the moderator. Companies submitted the following views on the moderator’s proposals.

**Proposal: Adopt the following changes highlighted in chromatic fonts, while keeping the yellow highlighting, if any, as shown**

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| 36. NR\_DL1024QAM\_FR1 | 36-1 | 1024QAM for PDSCH for FR1 | Support 1024QAM for PDSCH with up to 2 MIMO layers for FR1 including 1024QAM modulation scheme as defined in TS 38.211, MCS and CQI feedback tables based on 1024QAM modulation order as defined in TS 38.214. | pdsch-256QAM-FR1 | Yes | N/A | No support of 1024 QAM for PDSCH | Per Band | N/A | Applicable only to FR1 | N/A | Note from WI objective: DL PDSCH 1024QAM for FR1 should be defined as a per-band UE capability | Optional with capability signalling |

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| Company | Comments/Questions/Suggestions |
| MediaTek | @ZTE, thanks for reply but unfortunately, you’ve answered none of my questions. We don’t agree with your argument that 1024QAM is led by RAN4 and RAN4 should resolve the issues. Though 1024QAM is led by RAN4, again, FG36-1 has been generated/discussed by **RAN1** (and not RAN4). And as far as we know, no FGs related to 1024QAM have been defined in RAN4. In our contribution, we started with the statement about 2-layer restriction in WID. However, after receiving companies’ feedbacks in this email discussion, we agree with the majority view that WID does not restrict 1024QAM to 2 MIMO layers only. Accordingly, we have modified our proposal by taking that into account. So, please leave WID and RAN4 out of the discussion from now on, if possible. Again, FG36-1 was proposed and defined by RAN1 and should be taken care of by RAN1 in our opinion.Please focus on the issues we have identified. If you don’t agree they are valid issues, please point out why and/or provide alternative solutions to them. Otherwise, please focus on our modified proposal as follows. We are open for the value range of maximum DL MIMO layers. **Modified Proposal: Adopt the following changes in red to components of FG36-1:*** **Support 1024QAM for PDSCH with maximum *K* MIMO layers for FR1 including 1024QAM modulation scheme as defined in TS 38.211, MCS and CQI feedback tables based on 1024QAM modulation order as defined in TS 38.214 where *K* is indicated as one of {[1,] 2, 4, 8}.**
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# Discussion/Approval Items during RAN1 #109-e — Second Checkpoint

Based on the comments/questions/suggestions received by the first checkpoint, the following are the revised proposals and/or proposed agreements by the moderator. Companies submitted the following views on the moderator’s proposals.

***[Please submit all comments/questions/suggestions here, late comments/questions/suggestions submitted in Section 3 will not be considered]***

**General comments**

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| Company | Comments/Questions/Suggestions |
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# Issue 1: FG 36-1

**Proposal: Adopt the following changes highlighted in chromatic fonts, while keeping the yellow highlighting, if any, as shown**

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| 36. NR\_DL1024QAM\_FR1 | 36-1 | 1024QAM for PDSCH for FR1 | Support 1024QAM for PDSCH with maximum K MIMO layers for FR1 including 1024QAM modulation scheme as defined in TS 38.211, MCS and CQI feedback tables based on 1024QAM modulation order as defined in TS 38.214. | pdsch-256QAM-FR1 | Yes | N/A | No support of 1024 QAM for PDSCH | Per Band | N/A | Applicable only to FR1 | N/A | Candidate values for K :{ 2, 4, 8}Note from WI objective: DL PDSCH 1024QAM for FR1 should be defined as a per-band UE capability | Optional with capability signalling |

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| Company | Comments/Questions/Suggestions |
| MediaTek | Support the proposal.  |
| QC | Support. For candidate values, 6 Layers should be added as well for 6Rx or 8Rx device to reflect xt6R and xt8R SRS antennas switching introduced in Re-17. Candidate values for K :{ 2, 4, 6, 8} |
| Ericsson | Not support. Candidate Value K = 1 should be added. Existing FG allows such possibility (e.g. for Redcap UE), and that should be maintained with any FG updates. Regarding Qualcomm proposal to add max 6-layer PDSCH, we are not aware of any agreement on a capability for max 6 layers on the DL. It is appreciated if Qualcomm can share the relevant agreement/Rel-17 UE capability so we can check it further. For now, our proposal is as follows : ‘value1’ can be discussed further – e.g. ‘reserved’ if no other value is identified, etc. * Candidate values for K : {1,2,4,8, ‘value1’}

Since RAN2 has already implemented this FG in 38.306, perhaps exact details of how this update is reflected in RAN2 specs can be left to RAN2.  |
| ZTE, Sanechips | Thanks MTK for the follow-up comments and discussion.As to the complexity, we understand that there may be some additional complexity if 1024QAM is combined with higher MIMO layer. However, it is unclear to us whether these additional complexity deserves dedicated UE capability indication, and the cost of market fragmentation. It is noticed that UE can signaling scaling factor smaller than 1 for 1024QAM, it can relieve the complexity issue to some extend since if 1024QAM is used, another feasible to lower peak data rate is scheduling with smaller transmission layer. Also, for the introduction of 256QAM, there was no such discussion found yet.Despite all these points, we think we need to move on. So we are fine to include the maximum MIMO layer in 1024QAM for the sake of progress.For the inclusion of value of 1, we think it needs to be clarified whether Redcap UE supports 1024QM. |
| Samsung | We are fine with the proposal. For {1}, we tend to agree with ZTE’s view because it is understood that 1024QAM has been considered for high-capability UE. For {6}, we are fine with Ericsson’s proposal having the reserved value.  |
| Ericsson2 | Just to respond to ZTE, Sanechips, Samsung, while Redcap was one example, there can be other cases as well (low band). Since existing FG already allows such possibility, they should be maintained when making any FG updates. Therefore, K = 1 should be kept. * Candidate values for K : {1,2,4,8, ‘value1’}
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| Huawei, HiSilicon | We share similar view with ZTE, Sanechips, Samsung that we don’t see the reason for a Redcap UE to support 1024QAM. The candidate value {1} for K is not needed. |

# Discussion/Approval Items during RAN1 #109-e — Third Checkpoint

Based on the comments/questions/suggestions received by the second checkpoint, the following are the revised proposals and/or proposed agreements by the moderator. Companies submitted the following views on the moderator’s proposals.

***[Please submit all comments/questions/suggestions here, late comments/questions/suggestions submitted in Section 4 will not be considered]***

**General comments**

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| Company | Comments/Questions/Suggestions |
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# Issue 1: FG

**Proposal: Adopt the following changes highlighted in chromatic fonts, while keeping the yellow highlighting, if any, as shown**

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| Company | Comments/Questions/Suggestions |
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# Summary of Final Proposals for Agreements

This Section summarizes the final proposals for agreement in RAN1 #109-e by email. There are no tables for comments.

***[All comments must be directly made on the RAN1 email reflector]***

Companies can continue to update their comments in the previous Sections, however, these are no longer monitored by the moderator. Any such comments will be for archival purposes only and will not influence the outcome of this email discussion. Any objection to any of the proposals in this Section must be voiced directly on the RAN1 email reflector.

## Final Proposals for Agreement by the First Check Point

**Possible Agreement: Adopt the following changes highlighted in chromatic fonts, while keeping the yellow highlighting, if any, as shown**

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## Final Proposals for Agreement by the Second Check Point

**Possible Agreement: Adopt the following changes highlighted in chromatic fonts, while keeping the yellow highlighting, if any, as shown**

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# Conclusion

In addition to the agreements in Section 6, that were reached by email during RAN1 #109-e, the following was agreed by GTW during RAN1 #109-e:

# References

1. R1-2202929, Updated RAN1 UE features list for Rel-17 NR after RAN1 #108-e including remaining RAN1 issues, Moderators (AT&T, NTT DOCOMO, INC.)
2. R1-2204713, UE features DL 1024QAM for NR FR1, MediaTek Inc.