**3GPP TSG-RAN WG4 Meeting # 98-bis-e R4-2106156**

**Electronic Meeting, 12th – 20th April, 2021**

**Agenda item:** 8.15.2

**Source:** Moderator (Ericsson)

**Title:** Email discussion summary for [98-bis-e][314] NR\_DL1024QAM\_BSRF

**Document for:** Information

# Introduction

This thread deals with BS requirements for 1024QAM. General considerations and UE requirements are dealt with in another thread. Two main issues need to be discussed for BS; the dynamic range requirement and EVM. For the dynamic range requirement, based on contributions there appears to be consensus. For the EVM, different opinions are presented regarding whether to agree the same value as LTE or study some aspects further further.

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

* 1st round: Agree dynamic range requirement. Exchange views on EVM
* 2nd round: Agree what needs to be done to move forward for EVM (i.e. agree EVM or agree which issues need to be addressed). Agree work split.

# Topic #1: BS RF requirements

This topic covers all BS RF requirements, including dynamic range and EVM. Also, the moderator proposal for work split for the BS requirements is covered.

## Companies’ contributions summary

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| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2104726 | CATT | **Moderator note: Submitted to 8.15.1 but included here for reference as it also relates to BS EVM.****Observation 1: Regarding crossover SNR between 1024QAM and 256QAM for Rank 1, the crossover SNR is shown as in table 2.1-2.*** + The crossover SNR with 3%/4% TX/RX EVM in TDL-A is ~35.7dB.
	+ As TX/RX EVM decreases, crossover SNR also decreases
	+ For the same TX/RX EVM, the crossover SNR in TDL-D is lower than that in TDL-A.

**Observation 2: Regarding EVM for Rank 1 between 1024QAM and 256QAM, the performance gain is shown as in table 2.1-3.** * + As TX/RX EVM decreases, throughput gain of 1024QAM compared to 256QAM increases, if TX/RX EVM decreases to 3%/3%, the throughput gain of 1024QAM compared to 256QAM in TDL-A is increased by ~19.8%.
	+ For the same TX/RX EVM, the throughput gain of 1024QAM compared to 256QAM in TDL-D is larger than that in TDL-A.

**Proposal: It is proposed to approve the simulation assumptions in Table 2.1-1 for further EVM evaluations.** |
| R4-2104728 | CATT | **Proposal 1: EVM requirement should be determined based on link level simulation and implementation for NR.****Proposal 2: To set 0dB RE power control dynamic range for 1024QAM.** |
| R4-2104989 | NEC | **Proposal**: **BS RF requirements for NR FR1 DL 1024QAM should be placed on EVM requirements and the required EVM value should be 2.5 %.** |
| R4-2106309 | Nokia | **Proposal 1: It is proposed to introduce RE power control dynamic range for 1024QAM modulation scheme as presented in table 1.****Proposal 2: Further studies are needed if E-UTRA EVM requirement for 1024QAM modulation scheme can be reused, taking into account SU.** |
| R4-2106475 | CATT | **Moderators note: These proposals are related to the conformance specification. There are no conformance TUs in this meeting and the discussion is proposed to be delayed to the conformance stage. However, proposals 3 and 4 on power back-off may have some relevance to the discussion on the core EVM requirement and so are taken up in this thread.****Proposal 1: EVM test requirement for 1024QAM should equal to the EVM requirement for 1024QAM in TS 38.104 + 1%.****Proposal 2: To define the following test model for 1024 QAM*** + - **NR-FR1-TM2b with single 1024QAM PRB allocation**
		- **NR-FR1-TM3.1b with all 1024QAM PRBs allocation.**

**Proposal 3: To support up to three rated output power declaration for 1024QAM capable BS.****Proposal 4: RAN4 should allow reasonable power back off for 1024QAM.** |
| R4-2106488 | Huawei | **Proposal 1:** 0 dB RE power control dynamic range should be reused for 1024-QAM**Proposal 2:** The required TX EVM should be carefully evaluated before introduction in RAN4 specification.**Moderators note: In particular, phase noise, CFR, TX non-linearity and degradations in the digital part are mentioned by Huawei for consideration in the paper.** |
| R4-2106594 | ZTE | **Proposal 1: at least following factor should be taken into account for FR1 NR 1024QAM.**1. I/Q compression and decompression due to larger channel bandwidth and higher MIMO layers;
2. Transmit chain non-linearity, mainly referring to PA non-linearity due to larger channel channel bandwidth;
3. Phase noise due to higher frequency range supported for NR compared with LTE.
 |
| R4-2106687 | Ericsson | **Proposal 1: Set RE power control dynamic range to be 0 dB (up and down) for 1024 QAM****Proposal 2: Set Minimum required EVM of 2.5% for 1024 QAM FR1** **Proposal 3: for work split considerations for impacted TS**

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| --- | --- |
| TS No. | Sourcing Company |
| 38.104 |  |
| 38.141-1 | Ericsson |
| 38.141-2 | Ericsson |

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## Open issues summary

### Sub-topic 1-1

Sub-topic description: RE power control dynamic range requirement

Open issues and candidate options before e-meeting: Requirement definition

**Issue 1-1: Power control dynamic range**

* Proposals
	+ Option 1: 0 dB RE power control dynamic range should be reused for 1024-QAM
	+ Option 2: No other option at the start of the discussion
* Recommended WF
	+ Please indicate whether your company disagrees with option 1, stating why in case you disagree

### Sub-topic 1-2

Sub-topic description: There is a need to determine BS EVM for 1024QAM. Some companies have proposed to assume 2.5% EVM (i.e. same as LTE), whilst others have indicated some issues for investigation. Since there are 2 companies proposing to adopt 2.5% EVM and 4 companies proposing further consideration, it seems that consensus on 2.5% is not currently achievable without further discussion and so thread is proposed to focus on identifying which issues need to be elaborated and discussed to resolve the EVM. The outcome of the discussion should be a WF which at minimum lists the identified issues.

A further aspect identified for discussion in the thread is to decide on whether for 1024QAM further power back-off should be assumed compared to 256QAM. Although power-back off will eventually be captured in the conformance specifications, the assumption of power back-off or not may have some relevance to deciding the core EVM requirement.

**Issue 1-2-1: Issues to consider to decide EVM**

* Proposals
	+ Companies are requested to present views on whether each of these issues is relevant to discuss/evaluate further to decide EVM. Please indicate a reason for your view in each case. Also add other issues to this list if you view something is missing (together with an explanation why)
		- Wider bandwidths
		- 30kHz SCS (as well as 15kHz SCS)
		- Spectral Utilization
		- Phase noise
		- CFR (Crest Factor Reduction)
		- TX linearity (in particular PA non-linearity)
		- Effects in the digital domain
		- I/Q compression
* Recommended WF
	+ TBA

**Issue 1-2-2: Whether to assume additional power back-off for 1024QAM**

* Proposals
	+ - Option 1: Consider additional power back-off for 1024QAM, to be declared by vendor
		- Option 2: Do not allow for additional power back-off compared to 256QAM value
		- Option 3: No need to consider this now; leave for the conformance phase
* Recommended WF
	+ TBA

### Sub-topic 1-3

Sub-topic description: Work split

**Issue 3-1: Work split**

* Proposals
	+ The following proposal has been presented by Ericsson (Rapporteur)

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| TS No. | Sourcing Company |
| 38.104 |  |
| 38.141-1 | Ericsson |
| 38.141-2 | Ericsson |

* Recommended WF
	+ Please indicate whether your company volunteers for a role in drafting the requirements. Based on the volunteering companies, the Rapporteur may update the work split.

## Companies views’ collection for 1st round

### Open issues

Sub topic 1-1

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXX |  |
| Huawei | **Issue 1-1: Power control dynamic range**Agree with option 1 |
| CATT | Option 1. |
| Qualcomm | Agree with option 1 as well.  |
| ZTE | Fine with option 1 |
| Nokia | We are fine with option 1. |
| Ericsson | Support Option 1 |
| NEC | Support option 1 |

Sub topic 1-2

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| **Company** | **Comments** |
| XXX |  |
| Huawei | Issue 1-2-1: Issues to consider to decide EVMAgree all listed aspects need to be taken into account. In addition we also propose to evaluate the required EVM by link level simulation. Maybe it is discussed in the thread 139.Issue 1-2-2: Whether to assume additional power back-off for 1024QAMAgree with Option 1 |
| CATT | **Issue 1-2-1: Issues to consider to decide EVM**We think the general contributors for TX EVM include effects in the digital domain, TX linearity (in particular PA non-linearity), phase noise, and IQ imbalance. If BS supports CFR (Crest Factor Reduction) to reduce PAPR, the CFR will be one of EVM contributors. I/Q compression need to be supported by NR BS due to wider bandwidths, so I/Q compression need to be considered as one of EVM contributors. **Issue 1-2-2: Whether to assume additional power back-off for 1024QAM**Option 1. |
| Qualcomm | We agree that adopting the EVM requirements directly from LTE might not be a good WF. Further studying of the aspects listed in Issue 1-2-1 are necessary. Link level simulations might be considered as well to derive the requirement.  |
| ZTE | Issue 1-2-1: Issues to consider to decide EVMAgree all aspects mentioned should be taken into account. Issue 1-2-2: Whether to assume additional power back-off for 1024QAMOption 1 |
| Nokia | Issue 1-2-1: We are fine to further investigate if LTE EVM requirement can be fully reused. Issue 1-2-2: We are fine to introduce additional power back off declaration for 1024QAM similar as it is done for LTE. |
| Ericsson | Issue 1-2-1: Although BS TX EVM can be adopted already for 2.5% similar to LTE it would be ok for us also to study areas where they may be some differences compared between LTE and NR.  For wider bandwidth aspect that companies bring up, its relevant to study the 100 MHz CBW compared to 20 MHz (largest in LTE).  Phase noise would not be an impact at frequencies in FR1 and therefore we feel it’s not needed for study in 1024 QAM discussions. Therefore we propose to focus the parameters to study. Issue 1-2-2: It’s preference for Option 3.  If power back off is needed we do not foresee a larger back off compared to 256 QAM.  Currently in NR conformance this is anyhow vendor declared back off and probably would also be similar approach for 1024 QAM.  |
| NEC | Issue 1-2-1: Ok to study the impact on listed issues. Issue 1-2-2: Option 3. Support to introduce additional back-off, but should be discussed in the conformance phase. |

Sub topic 1-3

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| **Company** | **Comments** |
| XXX | Huawei volunteers to take 38.104 spec.CATT would be interested in taking part in CR drafting. Anyone of 38.104/38.141-1/38.141-2 would be fine for us.ZTE would be also interested in taking part in CR drafting.Nokia volunteers to take AAS specs 37.145-1 and 37.145-2 where updates are also needed. |

CRs/TPs comments collection

No CRs or TPs.

## 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.*

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|  | **Status summary**  |
| **Sub-topic #1** | *Tentative agreements:*0 dB RE power control dynamic range should be reused for 1024-QAMThe following parameters were identified as needing more consideration for EVM. In the first round, no company indicated that the parameters below should not be considered:* Wider bandwidths
* 30kHz SCS (as well as 15kHz SCS)
* Spectral Utilization
* CFR (Crest Factor Reduction)
* TX linearity (in particular PA non-linearity)
* Effects in the digital domain
* I/Q compression

*Candidate options:*For EVM, one company questioned whether consideration of phase noise is really relevant for below 6GHz. Also, two companies indicated that link level simulations may be needed.Regarding power back-off, most companies indicated that they think power back-off is needed. Detailed implementation will be in the conformance phase. However, it is a bit ambiguous whether there is consensus that back-off can be taken as an assumption now. (Whether backoff can be assumed may be relevant to the EVM discussion)5 companies have volunteered to assist with specification drafting. Impacted specifications include 38.104, 38.141-1, 38.141-2, 37.104, 37.141, 37.105, 37.145-1, 37.145-2. Nokia indicated a preference for 37.145-1/2.*Recommendations for 2nd round:** Further discuss and clarify whether Phase Noise should be studied to decide EVM
* Further discuss and clarify parameters for link level simulations relating to EVM
* Clarify whether there is any objection to assuming that power back-off will be enabled in the conformance specification when deciding EVM
	+ Details of how to implement the power back-off in the specification will be discussed during the conformance phase
* The rapporteur is requested to provide a proposal on specification drafting based on indications of interested companies
 |

### CRs/TPs

No CRs or TPs

## Discussion on 2nd round (if applicable)

**2nd round Issue 1: Phase noise for EVM**

* Proposals
	+ Phase noise should be considered when assessing the EVM requirement
	+ There is no need to consider phase noise for FR1 when deciding EVM
* Recommended WF
	+ Please indicate your company view and explain why phase noise is important also for FR1 (or not)

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| **Company** | **Comments** |
| Qualcomm | We believe it is important to consider the impact of the phase noise when deriving EVM requirements, especially for dense constellations such as 1024 QAM, where random rotation of the received signal constellation due to phase noise may lead to symbol detection errors. Such impact will be existent for FR1 and gets more important for FR2 where we have higher SCS, so we believe studying of the phase noise’s impact on EVM for FR1 should be considered.  |
| Huawei | We also think phase noise should be considered. The reasons is that phase noise is indeed one of the aspects to be considered for EVM budget. And NR will use higher frequency band than LTE in FR1, e.g. 4.9 GHz |
| Nokia | Compare to FR2, for FR1 we don’t see necessary to take into account phase noise as part of the study. |
| Ericsson | There is no need to consider PN for FR1. We can further discuss the list of RF impairments required to be considered as part of the simulation parameters and how they shall be modelled. It would be difficult to agree on a common PN model for parameter alignment before simulations. In FR1, the PN impact would be minimal, and even with residual impairment simple CPE/ICI compensation would sufficiently mitigate the impairment due to PN.  |
| Huawei | Reply to Nokia and Ericsson, phase noise is not considered in the link simulation might be ok for FR1. The phase noise should be considered in the overall EVM budget. |

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| CATT | We agree Phase noise might be not so necessary for FR1 compared to FR2. But we are open for further discussion. |
| CATT | Need to do investigation on the PN impact on 1024QAM performance.  |

**2nd round Issue 2: Link level simulations EVM**

* Proposals
	+ Please propose simulation parameters
* Recommended WF

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| **Company** | **Comments** |
| Qualcomm | As a preliminary step we can consider the link level parameters listed in Annex A in 38.808 |
| Huawei | We believe link level simulation EVM will be needed for evaluation the required EVM and can be useful for defining EVM limits. Parameters in CATT R4-2104726 can be used as starting point for discussion. |
| Ericsson | We do not agree for parameters in 38.808, this study is for 52.6 -71 GHz range which is not applicable for this work in NR FR1. For CATT R4-2104726 we would like to consider wider CBW (not 20 MHz as proposed) due to companies view that the need for link level simulations is due to wider CBW compared to LTE. |
| Moderator | Given the comments so far, can we agree the following in the WF ?* Use parameters in R4-2104726 as a basis for link level parameters, but use a wider bandwidth.

Does anyone want to propose a bandwidth to consider ? |

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**2nd round Issue 3: Power back-off**

* Proposals
	+ Option 1: Agree that power back-off for 1024QAM (independent of 256QAM backoff) will be enabled. Details of how to specify are for the conformance phase
	+ Option 2: Object to making any decision on whether power backoff will be allowed before the conformance phase.
* Recommended WF
	+ Option 1 recommended. Please indicate if you object and explain the reasoning

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| **Company** | **Comments** |
| Qualcomm | We agree with option 1.  |
| Huawei | In existing specification, even for 256 QAM, power back-off is allowed and is a declared parameters. Hence it is nature that power back-off should be allowed. But we do not think it should be linked to 256 QAM back off.  |
| Nokia | We agree with option 1 – to introduce power back-off for 1024QAM. Agree wit Huawei, this is separate declaration not link to 256QAM (similar as it was introduced for in LTE where there is declaration for 256QAM and 1024QAM). |
| Moderator | In response to Huawei’s comment, I have updated option 1 to say “independent of” 256QAM. The intention of the option is actually not to link the power back-off to 256QAM. The intention is to capture that any power back-off for 1024QAM is independent of 256QAM.Qualcomm/Huawei (and others) please indicate if you disagree with this new wording. Feel free to add another option if needed.In case any company actually does want to link the 1024 back-off to 256QAM back-off, please add another option.(This is a moderator comment not expressing a technical preference but aimed at clarifying what is proposed to be agreed) |
| Moderator | Given comments so far and the update, can we agree the modified option 1 in the WF ? |
| NEC | We agree with the modified option 1. |
| CATT | Option1  |
| Huawei | Agree with modified option1 |

**2nd round Issue 4: Work split**

* Proposals
	+ The Rapporteur is requested to propose a work split between interested companies covering 37.104, 37.141, 37.105, 37.145-1, 37.145-2, 38.104, 38.141-1, 38.141-2
	+ Other companies please comment on the work split once proposed
* Recommended WF

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| --- | --- |
| Spec number | Responsible |
| 38.101-1 | Huawei |
| 38.104 | Huawei |
| 38.141-1 | ZTE |
| 38.141-2 | Ericsson |
| 37.145-1 | CATT |
| 37.145-2 | Nokia |

CATT: No need for changes to 37.104 and 37.105

# Topic #2: Applicability of 1024QAM in BS specification

This topic covers the question of whether 1024QAM requirements should be applicable to the wide area and medium range BS classes.

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2106487 | Huawei, HiSilicon, CMCC, China Unicom | **Proposal 1:** it is proposed that 1024-QAM RF requirements is not defined for Macro BS. And 1024-QAM is only defined for small cell scenarios. |

## Open issues summary

### Sub-topic 2-1

Sub-topic description: Applicability of 1024QAM in BS specs

Open issues and candidate options before e-meeting: Whether to apply the requirements to the wide area BS class

**Issue 2-1: Applicability of 1024QAM BS class**

* Proposals
	+ Option 1: Do not define 1024QAM RF requirements for the wide area BS class
	+ Option 2: Do not define 1024QAM RF requirements for the wide area and medium range BS classes
	+ Option 3: Define 1024QAM RF requirements for all BS classes
* Recommended WF
	+ Please indicate your company preference. Please outline the reasons for your preference, and in particular for option 3 why you think the requirement should be applied for wide area, or why/what further investigation is needed.

## Companies views’ collection for 1st round

### Open issues

Sub topic 2-1

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| **Company** | **Comments** |
| Huawei | Option 1 or Option 2. As discussed in our paper R4-2106487 and R4-2106488, 1024-QAM can not provide notable performance gain for Macro scenario, instead some power back-off will be need which causes performance degradation. Hence we propose to not to define 1024 QAM for Macro BS. |
| CATT  | Further evaluations might be needed. Currently prefer Option 1.  |
| Qualcomm | More analysis needs to confirm this. For now we lean towards Option 1. |
| ZTE | Open for further discussion and evaluation if needed. |
| Nokia | For LTE, 1024QAM was introduce for all BS classes, as this is optional feature based on vendor declaration. We don’t see a reason why we would limit this in NR FR1 to specific BS classes only if it is not restricted for LTE when additional power back-off is possible to be declared.  |
| SoftBank | We prefer option 3 since this proposal is another addition of “5G could be less than 4G”. We do not like to introduce an item which could be a blocking factor when we try to replace LTE-A with NR. |
| Verizon | Option 3! We would see the 1024 QAM for all BS classes (for different applications), instead of for small cells only.  |
| CMCC | RAN4 needs to evaluate the performance gain for wide area BS class. If there is a technical justification that there is no performance gain (1024QAM) for the wide area BS, we can accept option 1. |
| Ericsson | We support Option 3. 1024QAM will increase spectrum efficiency in particular at low load and/or when channel conditions are good. We don’t see why it would be useful for 4G in macro cells but now in 5G would not bring a gain. At this time before studies are completed, we believe it’s too early to eliminate scenarios/deployments which BS classes can be applicable. |
| Docomo | We prefer Option 3. 1024QAM has been defined for all BS classes in LTE. We don’t see a reason why it narrow down from LTE specification. |
| NEC | Option 1 or option 2 if justified. No need to support 1024QAM if it does not provide performance gain. |

### CRs/TPs comments collection

No CRs or TPs

## 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.*

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|  | **Status summary**  |
| **Sub-topic #1** | *Tentative agreements:*None*Candidate options:*Original options*Recommendations for 2nd round:*Continue discussion |

### CRs/TPs

No CRs or TPs

## Discussion on 2nd round (if applicable)

**2nd round Issue 1: Applicable BS classes**

* Proposals
	+ Option 1: Do not define 1024QAM RF requirements for the wide area BS class
	+ Option 2: Do not define 1024QAM RF requirements for the wide area and medium range BS classes
	+ Option 3: Define 1024QAM RF requirements for all BS classes
* Pleas continue discussions

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| --- | --- |
| **Company** | **Comments** |
| Qualcomm | We support option 1. If no gains are expected in medium range BS, we can adopt both options 1 and 2.  |
| KDDI | We share the view with other operators. We believe the NR specs should be aligned with the LTE specs. |
| Huawei | We support option 1. For Macro BS, the coverage is more important than others. The power back-off needed for 1024 QAM will depredate the performance actually. To the operators who want to include 1024 QAM for Macro BS, our question is what is level of power back-off is acceptable for Macro scenario?  |
| Nokia | As commented in 1st round, we don’t see technical arguments to restrict BS classes for 1024QAM compare to LTE. It is also align with operators requests.  |
| Ericsson | We support Option 3 as commented in 1st round. |
| ZTE | Based on the TU budget for this WID, we still have lots of meeting cycles left, maybe it’s not so urgent to draw the conclusion at this meeting. |
| Verizon | Same as 1st round, we support Option 3.  |
| NEC | We support option 3 if performance gain is observed, otherwise support option 1 or 2.We can revisit this issue after reviewing the simulation results based on the agreed simulation parameters in topic #1. |
| CATT | We prefer option 1. But it’s not urgent to make the decision before the gain is clear. |
| Docomo | Same as 1st round, we prefer Option 3. As some companies commented, it is not urgent to conclude this issue. |
| Huawei | As presented in our paper R4-2106487, simulation results show 1024-QAM can not provide notable performance gain for Macro scenario. We think system simulation is needed to show whether there is a performance gain for support 1024-QAM for Macro scenarios. |

# Recommendations for Tdocs

## 1st round

**New tdocs**

|  |  |  |
| --- | --- | --- |
| **Title** | **Source** | **Comments** |
| WF on BS RF requirements for 1024QAM | Moderator (Ericsson) | The WF will capture the agreements made in the 1st and 2nd rounds as documented in the discussion summary. For the 1st round, the text highlighted in yellow is proposed to be included into the WF. |

## 2nd round

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Tdoc number** | **Title** | **Source** | **Recommendation**  | **Comments** |
| R4-2106121 | WF on BS requirements for 1024QAM | Moderator (Ericsson) | Agreeable |  |