**3GPP TSG RAN WG1 Meeting #106-e R1-21xxxxx**

**E-Meeting, August 16th – August 27th, 2021**

**Agenda Item: 8.9.1**

**Source: Moderator (Huawei)**

**Title: Feature lead summary #1 on 106-e-LTE-Rel17\_NB\_IoT\_eMTC-01**

**Document for: Discussion and Decision**

# Introduction

The WID for Rel-17 enhancements for NB-IoT and LTE-MTC [1] includes an objective to support 16-QAM for unicast in UL and DL in NB-IoT.

* *Specify 16-QAM for unicast in UL and DL, including necessary changes to DL power allocation for NPDSCH and DL TBS. This is to be specified without a new NB-IoT UE category. For DL, increase in maximum TBS of e.g. 2x the Rel-16 maximum, and soft buffer size will be specified by modifying at least existing Category NB2. For UL, the maximum TBS is not increased. [NB-IoT] [RAN1, RAN4]*
	+ *Extend the NB-IoT channel quality reporting based on the framework of Rel-14—16, to support 16-QAM in DL. [NB-IoT] [RAN2, RAN1, RAN4]*

This documents provides the proposals and summary of discussions of the corresponding email discussion according to the inputs [2-10].

[106-e-LTE-Rel17\_NB\_IoT\_eMTC-01] Email discussion on support of 16-QAM for unicast in UL and DL for NB-IoT – Yubo (Huawei)

# Issues

## Applicability

### Issue 1: Applicability

The following are proposed:

|  |  |
| --- | --- |
| Sourcing | proposals |
| [2] | **Proposal 8: Support 16-QAM for NPDSCH in PUR procedure.** |
| [3] | **Proposal 9: Confirm the working assumption to support 16-QAM for NPUSCH in PUR procedure.****Proposal 10: For supporting 16-QAM in NPUSCH in PUR procedure, the field multiTone in npusch-MCS in PUR NPUSCH configuration is modified to include MCS 0-21.****Proposal 11: Support 16-QAM for NPDSCH in PUR procedure.** |
| [4] | **Proposal 1: Do not support DL 16-QAM during PUR procedure.****Proposal 6: Confirm the following working assumption:** * **Support 16-QAM for NPUSCH in PUR procedure.**

**Proposal 7: Include a configuration flag in *PUR-Config* to enable 16-QAM.** |
| [5] | ***Proposal 8: 16QAM could not be supported for NPDSCH in PUR procedure.*** |
| [6] | **Proposal 1: Support 16-QAM for NPUSCH/NPDSCH and UE can report CQI in*****PURConfigurationRequest.*** **Proposal 2: The details of related RRC IEs need FFS in RAN2.** |
| [7] | ***Proposal 1: Confirm the working assumption and propose not to support of 16-QAM for NPDSCH in PUR procedure.*** |
| [8] | **Observation 11 The “Support 16-QAM for NPUSCH in PUR procedure” is foreseen to be beneficial in some scenarios and straightforward to support, but for DL (i.e., FFS in the WA) the implications are different since it will require for example having to support channel quality reporting in idle-mode.****Proposal 8 Confirm the Working Assumption on the “Support 16-QAM for NPUSCH in PUR procedure”.** |

For the working assumption on support of 16-QAM for NPUSCH in PUR procedure, most companies support to confirm it, therefore, the following is proposed:

Proposal 1: Confirm the following working assumption:

Working Assumption

Support 16-QAM for NPUSCH in PUR procedure.

On the support of 16-QAM for NPDSCH in PUR procedure, companies (Huawei, HiSilicon, Nokia, NSB, MTK) propose to support 16-QAM for NPDSCH in PUR, and companies (QC, ZTE, Sanechips, Lenovo, Moto, Ericsson) propose to not support. As this has been discussed for several meeting, the following is proposed to close this topic:

Proposal 2 (conclusion): There’s no consensus to support 16-QAM for NPDSCH in PUR procedure.

With the support of 16-QAM for PUR NPUSCH, companies (Nokia, NSB, ) proposed the corresponding enhancement on the configuration of PUR, therefore, the following is proposed:

**Proposal 3: To support 16-QAM for NPUSCH in PUR procedure,**

* **The RRC IE *multiTone* in *npusch-MCS* in *pur-PhysicalConfig* is extended to indicate MCS from 0 to 21.**
* **One RRC IE is introduced in *pur-PhysicalConfig* to enable the use of 16-QAM.**

Please input your comments on the above proposals:

|  |  |
| --- | --- |
| Companies | Comments |
| Huawei, HiSilicon | We are generally fine with proposal 1, proposal 2 and proposal 3. For MCS indicating for PUR PUSCH, it can be up to RAN2 to decide whether to introduce a new IE or extend legacy IE. |
| Ericsson | * Proposal 1: Ok with confirming the WA.
* Proposal 2: OK.
* Proposal 3: In our view, we can come back to it in a future session in case the WA in proposal 1 becomes confirmed.
 |
| Lenovo,MotoM | We are fine with the proposal 1-3. |

## DCI

### Issue 2: DCI design

There are following proposals on power allocation

|  |  |
| --- | --- |
| Sourcing | proposals |
| [2] | **Proposal 1: The deployment is indicated by the legacy signaling *operationmodeInfo, i.e.,* no enhancement is needed on distinguishing the deployment.****Proposal 2: Confirm the working assumption for the indication of 16-QAM in uplink.****Working Assumption**For the indication of 16-QAM in uplink* The “Modulation and coding scheme” field in DCI Format N0 is utilized as in legacy for scheduling QPSK.
* One reserved state in the “Modulation and coding scheme” field in DCI Format N0 is utilized to indicate the use of 16QAM.
* The “Repetition number” field in DCI Format N0 is utilized to indicate the TBS indices (i.e., I\_TBS indices from 14 to 21) for 16-QAM in UL.

**Proposal 3: The reserved state to indicate the use of 16QAM in DCI format N0 and DCI format N1 should be “1111”.** |
| [3] | **Proposal 1: UE can determine the deployment mode from the MasterInformationBlock-NB or DL-CarrierConfigDedicated-NB field.****Proposal 2: Confirm the working assumption on indication of 16-QAM in uplink from RAN1#105-e.** |
| [5] | ***Proposal 2: If the most significant bit of ‘subcarrier indication’ filed is 1, the existing 4-bit MCS field indicates the TBS indices for 16QAM for UL, the QPSK TBS indices otherwise.*** |
| [6] | **Proposal 3: Set two TBS indices columns in the MCS-to-TBS mapping table for SA/GB and IB respectively.** |
| [7] | ***Proposal 5: For the DCI format N0 optimization, the joint coding of MCS, repetition number can be considered.*** |
| [8] | **Observation 1 For the “DCI Design for DL”, there is an FFS on “How UE distinguishes the deployment”). During RAN1# 105-e it was mentioned that using the parameter “operationModeInfo” was sufficient to make the distinction between deployment modes, however it was pointed out that it only applies to anchor carriers.****Proposal 1 The UE distinguishes the different ranges of TBS indices for “Stand-alone/Guard-band” and “In-band” deployments by re-using the legacy higher layer parameters “operationModeInfo” and “inbandCarrierInfo”.****Observation 8 The DCI design agreed for DL can be equally applied for UL, confirming the Working Assumption will allow to have symmetry between UL and DL in terms of DCI design principles.****Proposal 6 Confirm the Working Assumption on the DCI design for 16-QAM in UL:****For the indication of 16-QAM in uplink****- The “Modulation and coding scheme” field in DCI Format N0 is utilized as in legacy for scheduling QPSK.****- One reserved state in the “Modulation and coding scheme” field in DCI Format N0 is utilized to indicate the use of 16QAM.****- The “Repetition number” field in DCI Format N0 is utilized to indicate the TBS indices (i.e., I\_TBS indices from 14 to 21) for 16-QAM in UL.** |

Most companies support to confirm the working assumption on indication of 16-QAM in uplink, therefore, the following is proposed:

**Proposal 4: Confirm the working assumption:**

Working Assumption

For the indication of 16-QAM in uplink

* The “Modulation and coding scheme” field in DCI Format N0 is utilized as in legacy for scheduling QPSK.
* One reserved state in the “Modulation and coding scheme” field in DCI Format N0 is utilized to indicate the use of 16QAM.
* The “Repetition number” field in DCI Format N0 is utilized to indicate the TBS indices (i.e., I\_TBS indices from 14 to 21) for 16-QAM in UL.

On the FFS relating to distinguishing of deployments, companies proposed to reuse legacy signaling operationModeInfo in MIB and inbandCarrierInfo in SIB for the UE to distinguish the deployments. Therefore, the following is proposed:

**Proposal 5: For the UE configured with 16-QAM for NPDSCH, the deployment of the carrier is signaled by *operationModeInfo* in MIB or *inbandCarrierInfo* in SIB.**

Please input your preference and comments to the above proposal:

|  |  |
| --- | --- |
| Companies | Comments |
| Huawei, HiSilicon | We are fine with proposal 4 and proposal 5. |
| Ericsson | * Proposal 4: Ok with confirming the WA.
* Proposal 5: OK.
 |
| Lenovo, MotoM | We are fine with proposal 4 and 5 (?). For proposal 5, I am not sure the motivation of the proposal. The deployment of the carrier is signaled in ***operationModeInfo* in MIB or *inbandCarrierInfo* in SIB** from Rel.13, why do we need the new proposal?Do we want to clarify the **16-QAM for NPDSCH is supported in non-anchor carrier?** |

## Power allocation and power control

### Issue 3: downlink power allocation

There are following proposals on power allocation

|  |  |
| --- | --- |
| Sourcing | proposals |
| [2] | **Proposal 6: The working assumption for DL power allocation to support 16QAM for guard-band and standalone deployments should be confirmed.****Working Assumption**For downlink power allocation to support 16QAM:* For standalone and guard-band deployments:
	+ One power ratio is signaled optionally
		- NPDSCH EPRE to NRS EPRE in symbols without NRS
	+ The same transmit power is assumed across different symbols.
	+ If the signaling is not indicated, the legacy power allocation is used.
		- i.e., the ratio of NPDSCH EPRE to NRS EPRE is 0dB for one NRS antenna port, and -3dB for two NRS antenna ports
* UE specific signaling is used

**Proposal 7: Support Alt-2 for in-band deployments in the DL power allocation signaling.** |
| [3] | **Proposal 6: Confirm the working assumption on DL power allocation for stand-alone and guard-band deployments from RAN1#105-e.** **Proposal 7: For in-band deployment, select Alt 1 - the existing parameter nrs-CRS-PowerOffset is reused for same PCI case, and is signaled for different PCI case.**  |
| [4] | **Proposal 2:** **Confirm the following working assumption:**For downlink power allocation to support 16QAM:* **For standalone and guard-band deployments:**
	+ **One power ratio is signaled optionally**
		- **NPDSCH EPRE to NRS EPRE in symbols without NRS**
	+ **The same transmit power is assumed across different symbols.**
	+ **If the signalling is not indicated, the legacy power allocation is used.**
		- **i.e., the ratio of NPDSCH EPRE to NRS EPRE is 0dB for one NRS antenna port, and -3dB for two NRS antenna ports**
* **UE specific signalling is used**

**Proposal 3: For downlink power allocation to support 16QAM in in-band deployments, the following option is selected:*** + **Alt 2:**
		- **the power ratio between NPDSCH EPRE and NRS EPRE in symbols with CRS is signaled.**

**Proposal 4: For in-band deployments, the power ratio between NPDSCH EPRE and NRS EPRE in symbols with NRS is calculated assuming constant power across symbols with NRS and symbols without NRS or CRS.** |
| [5] | ***Proposal 3: For downlink power allocation, the working assumptions can be confirmed for standalone and guard-band deployments.******Proposal 4: For downlink power allocation, Alt 1 should be adopted for inband deployment.***  |
| [7] | ***Proposal 3: Confirm the working assumption for DL power allocation for standalone/guardband case.******Proposal 4: To indicate the DL power allocation for inband case, the existing parameter nrs-CRS-PowerOffset is reused for same PCI case, and is signaled for different PCI case.*** |
| [8] | **Proposal 4 Confirm the Working Assumption for the downlink power allocation to support 16-QAM in Stand-alone and Guard-band deployments.****Observation 6 For the downlink power allocation to support 16-QAM in “In-band deployments”, Alt-2 is not different in terms of complexity, specification impact and nature than what is under Working Assumption for Stand-alone and Guard-band deployments.****Observation 7 For the downlink power allocation to support 16-QAM in “In-band deployments”, Alt-2 is usable regardless of the PCI case. With Alt-2, all deployment modes will all use the same DL power allocation framework based on signalling power ratios.****Proposal 5 For the downlink power allocation to support 16-QAM in “In-band deployments”, Alt-2 is selected:****• The power ratio between NPDSCH EPRE and NRS EPRE in symbols with CRS is signaled.****• UE specific signaling is used** |

On the working assumption of power allocation for standalone and guardband deployments, most companies propose to confirm it. Therefore, the following is proposed:

**Proposal 6: Confirm the following working assumption:**

Working Assumption

For downlink power allocation to support 16QAM:

* For standalone and guard-band deployments:
	+ One power ratio is signaled optionally
		- NPDSCH EPRE to NRS EPRE in symbols without NRS
	+ The same transmit power is assumed across different symbols.
	+ If the signalling is not indicated, the legacy power allocation is used.
		- i.e., the ratio of NPDSCH EPRE to NRS EPRE is 0dB for one NRS antenna port, and -3dB for two NRS antenna ports
* UE specific signalling is used

For the inband deployment, companies (Nokia, NSB, ZTE, Sanechips, Lenovo, Moto) support Alt-1, and companies (Huawei, HiSilicon, QC, Ericsson) support alt-2.

One company (QC) raised a concern over Alt-1. As illustrated in the following figures, the CRS, NRS and NPDSCH are power boosted by 3dB compared to LTE PDSCH, i.e., the linear transmit power is 2. The calculated power is shown in Figure 1, which is different with the actual transmission power as shown in Figure 3.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Figure 1 Power allocation under Alt.1 (red: CRS, yellow: NPDSCH, green: NRS) – showing only a single symbol of each type**

|  |  |  |
| --- | --- | --- |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |
| 2 | 2 | 2 |

 | Figure 3 Correct power allocation over 2 PRBs, where the PDSCH in LTE PRB is “blanked” and the corresponding power is allocated to NB-IoT NPDSCH/NRS

|  |  |  |  |
| --- | --- | --- | --- |
| NB-IoT PRB | 2 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 2 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| “Blanked” LTE PRB | 2 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 2 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |
| 0 | 0 | 0 |

 |
| Figure 2 Nominal power allocation for an RB with PDSCH (red: CRS, orange: PDSCH)

|  |  |  |
| --- | --- | --- |
| 2 | 1 | 1 |
| 0.8 | 1 | 1 |
| 0.8 | 1 | 1 |
| 0.8 | 1 | 1 |
| 0.8 | 1 | 1 |
| 0.8 | 1 | 1 |
| 2 | 1 | 1 |
| 0.8 | 1 | 1 |
| 0.8 | 1 | 1 |
| 0.8 | 1 | 1 |
| 0.8 | 1 | 1 |
| 0.8 | 1 | 1 |

 |

Please input your comments to the above proposal and the concern over Alt-1:

|  |  |
| --- | --- |
| Companies | Comments |
| Huawei, HiSilicon | We are OK with proposal 6. For in-band deployment we support Alt-2, and we share similar concern with QC over Alt-1 for in-band DL power allocation. |
| Ericsson | Proposal 6: Ok with confirming the WA.For In-band, in our understanding some companies seem to think that Alt-2 does not include the assumption on “The same transmit power of different symbols is assumed” and for that reason they seem to be leaning towards Alt-1, however, the assumption made for “Stand-alone and Guard-band” where “The same transmit power is assumed across different symbols” applies for in-band deployments indeed the agreement for In-band deployments already states how the signalling for stand-alone and guard-band (assumption included) is applied in the in-band case: *“… the signaling for standalone and guard-band deployments … in this case applies to “symbols with NRS” and “symbols without NRS nor CRS”*”Thus, for the in-band case, we believe is sufficient to agree on the following:For the downlink power allocation to support 16-QAM in “In-band deployments”, Alt-2 is selected:* The power ratio between NPDSCH EPRE and NRS EPRE in symbols with CRS is signaled.
* UE specific signaling is used
 |
| Lenovo, MotoM | We still prefer Alt-1For NBIoT carrier (within 1PRB bandwidth), if different symbols have different receiving power, there will be some performance loss due to improper AGC for UE side. For QC’s concern, symbol 2 EPRE is signalled by higher layer, symbol 3 EPRE should be derived by assuming the same transmit power between 2 and 3. However, there will be different transmit power for symbol 1 and 2. It seems the design is not aligned.

|  |  |  |  |
| --- | --- | --- | --- |
| NB-IoT PRB | 2 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 2 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |
| 1.6 | 2 | 2 |

 |

### Issue 4: uplink power control

There are following proposals on uplink power control.

|  |  |
| --- | --- |
| Sourcing | proposals |
| [2] | **Proposal 9：A new term is introduce to support 16QAM in NPUSCH, which reuses the LTE term.*** **The uplink power control factor is calculated as**
 |
| [3] | **Proposal 8: A new uplink power control term is introduced in the uplink power control as follows** **and enabled via RRC configuration. If enabled, the parameter is given in a table based on MCS index. If not enabled, .** |
| [4] | **Proposal 8: For uplink power control, introduce the following specification changes:*** **Add a correction term in the power control equation.**
* **Add a configuration parameter *deltaMCS-Enabled***
* **Add the definition of BPRE as in LTE.**
 |
| [5] | ***Proposal 1: For uplink power control, a TPC command could be introduced in DCI format N0 to support 16QAM.**** ***Repetition number field can be repurpose to indicate TPC command if 16QAM MCS is scheduled.***
 |
| [7] | ***Proposal 6: Introduce parameter ΔTF to uplink power control enhancement in NBIoT.*** |
| [8] | **Observation 9 In LTE, the term ΔTF in the power control equation increases the power when the number of bits per RE is increased by a higher order modulation scheme, a similar element has been decided to be incorporated for 16-QAM in UL.****Observation 10 The LTE’s term ΔTF has some components that won’t apply for NB-IoT; hence its definition can be simplified as to make it meaningful for NB-IoT.****Proposal 7 For the term ΔTF into the uplink power control of NPUSCH using 16-QAM down-select one of the two approaches:**Alt-1: For 16-QAM in UL based on a simplified equation of legacy LTE, we define ΔTF as follows:**ΔTF = for *Ks* = 1.25 or ΔTF = 0 for *Ks* = 0.****Where *BPRE* =. is the highest code rate in the TBS/MCS table used for the Modulation Scheme, and is the number of bits per *M-ary* symbol of the Modulation Scheme.****Alt-2: We define a set of values from which ΔTF is obtained:****ΔTF is provided by a HL parameter referring to the following set of values {2dB, 4dB, 6dB, [7dB or 8dB]} “and if this field is absent then dB0 will be used”.** |

On the uplink power control, companies propose to introduce a new term in the power control equation, and there are following options for the determination of the new term:

* Reuse the LTE definition simplified for NB-IoT: for and for , where is given by higher layer parameter *deltaMCS-Enabled*, and where K is the code block size.
* is given in table based on MCS index if enabled, 0 otherwise.
* A TPC command is introduce to indicate the power offset for NPUSCH with 16-QAM.
* is configured by high layer parameter.
* ΔTF = for *Ks* = 1.25 or ΔTF = 0 for *Ks* = 0, where BPRE =. is the highest code rate in the TBS/MCS table used for the Modulation Scheme, and is the number of bits per M-ary symbol of the Modulation Scheme.

Therefore, the following is proposed:

**Proposal 7: A new term is introduced in the uplink power control to support 16-QAM, which is downselected from following options:**

* Option 1: Reuse the LTE definition simplified for NB-IoT: for and for , where is given by higher layer parameter *deltaMCS-Enabled*, and where K is the code block size.
* Option 2: is given in table based on MCS index if enabled, 0 otherwise.
* Option 3: A TPC command is introduce to indicate the power offset for NPUSCH with 16-QAM.
* Option 4: is configured by high layer parameter.
* Option 5: ΔTF = for *Ks* = 1.25 or ΔTF = 0 for *Ks* = 0, where BPRE =. is the highest code rate in the TBS/MCS table used for the Modulation Scheme, and is the number of bits per M-ary symbol of the Modulation Scheme.

Please input your preference and reasons on the down-selection:

|  |  |
| --- | --- |
| Companies | Comments |
| Huawei, HiSilicon | We are OK with proposal 7 and support option 1, since it is sufficient to follow the LTE principle and seems no need to introduce a different one. |
| Ericsson | Proposal 7:Question on Option 1, what is the actual result we are getting with option 1?For Option 5, it is not mentioned that it also re-uses the LTE’s definition, the only simplification is on *BPRE*, which is made dependent on the code rate and modulation scheme as follows: *BPRE* =. Then to determine ΔTF, we calculate first the TF for QPSK and then TF for 16-QAM as to obtain the difference between them (i.e., ΔTF):TFQPSK = = = 5.9379 dBTF16-QAM = = = 13.1924 dBΔTF = TF16-QAM - TFQPSK = 7.2545 dBFor Option 4, I believe the configured value is selected from a set containing at least a few of possible configurable values, in that case probably is better to add the following: “Option 4: is configured by high layer parameter, 0 otherwise. FFS: values in the set from which is chosen.” |
| Lenovo, MotoM | We are OK with proposal 7 and support option 1, since it is sufficient to follow the LTE principle and seems no need to introduce a different one. |

## Channel quality reporting

### Issue 5: Channel quality reporting

There are following proposals on power allocation

|  |  |
| --- | --- |
| Sourcing | proposals |
| [2] | **Proposal 4: The CQI reporting in Msg3 in connected mode should not be supported.****Proposal 5: Option 3 should be supported for CQI table for downlink 16-QAM CQI reporting.** |
| [3] | **Proposal 3: For 16-QAM CQI table, select one of the following options –*** **More than three candidate values for 16-QAM are added in the legacy table by replacing candidates with high repetition values (e.g. candidateRep-J to candidateRep-L).**
* **A new CQI table is defined for 16-QAM based on the eMTC table (CQI Tables in 36.213) as a starting point**

**Proposal 4: Define CSI reference resource to be used for 16-QAM CQI measurement.****Proposal 5: The CSI reference resource is given by a set of the last *R*CSI subframes used for NPDCCH monitoring by the BL/CE UE in the corresponding narrowband before *n*-*nCQI\_ref*.** |
| [5] | ***Observation 1: For Option 1 and 2, the limited number of CQI states with 16QAM cannot adequately match the variety of channel conditions.*** ***Observation 2: For Option 1 and 2, an overhead waste of report field will be caused since NPDCCH CQI entries cannot be applied in the CQI table when NPDSCH CQI report is triggered.*** ***Observation 3: For Option 1, the performance on NPDCCH CQI feedback will be impacted since some legacy entries for number of PDCCH repetitions are removed.******Observation 4:*** ***The channel quality for NPDSCH and NPDCCH can be reported separately based on different tables.******Observation 5: The existing MAC CE can be reused to report 4-bit CQI for NPDSCH if the UE receives a NPDSCH CQI command and 4-bit number of repetitions for NPDCCH if the UE receives a NPDCCH CQI command.*** ***Proposal 5: A separate 4-bit CQI table (similar to CQI tables in 36.213) should be defined for downlink 16QAM.******Proposal 6: CQI report in Msg3 is not supported for 16QAM in connected mode.******Proposal 7: There is no need to specify measurement reference resource for CQI report for NB-IoT 16QAM.*** |
| [6] | **Proposal 4: Support channel quality reporting in Msg3 in connected mode and the details need FFS in RAN2.****Proposal 5: A new 4-bit CQI table could be defined for 16-QAM.****Proposal 6: CQI for QPSK also needs to be included in the new CQI table.****Proposal 7: Introduce 8 CQI indices for 8 TBS indices for 16 QAM as Table 2.** |
| [7] | ***Proposal 2: Remove some of the legacy CQI reporting values and add more than 3 CQI reporting values for support 16QAM in DL or report the subset of CQI reporting values determined by channel condition.*** |
| [8] | **Observation 2 The legacy CQI mapping table in TS 36.133 clause 9.1.22.15 currently uses 13 out of 16 entries, hence the three unused fields could be utilized to incorporate the channel quality reporting for 16-QAM in DL.****Observation 3 For the TBS/MCS table for DL, the step-size between ITBS indices is in most cases smaller than 1dB, which is a level of granularity that might be unfeasible from a measurement quality perspective. Today the channel quality reporting is specified for each repetition level 1, 2, 4, 8, …, which means that in legacy the step size is 3dB.** **Observation 4 In Rel-17, the full range of ITBS indices (14 to 21 and 11 to 17 depending on the deployment mode) can be covered using only three candidate reports (i.e., candidateRep-M, candidateRep-N, or candidateRep-O) as to have a feasible level of granularity with step-sizes larger than 1dB.****Proposal 2 The three unused entries in the legacy CQI mapping Table in clause 9.1.22.15 of TS 36.133 (i.e., Table 9.1.22.15-1) are used for the CQI reporting of 16-QAM in DL.**

|  |  |  |
| --- | --- | --- |
| **Reported value** | **NPDCCH repetition level** | **16-QAM CQI index with NPDSCH transport block error probability not exceeding 0.1** |
| candidateRep-M | 1 | 0 |
| candidateRep-N | 1 | 1 |
| candidateRep-O | 1 | 2 |

|  |  |
| --- | --- |
| **CQI Index** | **ITBS index** |
|  | **Guard-band and Stand-alone deployments** | **In-band deployments** |
| 0 | [17] | [13] |
| 1 | [20] | [16] |
| 2 | [21] | [17] |

**Observation 5 For the DL channel quality report there is an “FFS on support in Msg3 in connected mode”, nonetheless TS 36.321 states “DL channel quality in Msg3 in RRC\_CONNECTED is not reported”.****Proposal 3 For the support of 16-QAM in DL the legacy is followed and the “DL channel quality in Msg3 in RRC\_CONNECTED is not reported”.** |
|  |  |

As most companies propose to not support channel quality report in Msg3 in connected mode, the following is proposed:

**Proposal 8 (conclusion): The channel quality report is not supported in Msg3 in connected mode in Rel-17.**

On the CQI table for downlink 16-QAM, 4 companies (Nokia, NSB, Lenovo, Moto) prefer option 1, 1 company (Ericsson) prefers option 2, and 7 companies (Huawei, HiSilicon, Nokia, NSB, ZTE, Sanechips, MTK) prefer option 3.

The concerns to support option 1 include: limited number of MCS entries for 16-QAM for efficient CQI reporting, “dB” step size granularity, increased size of legacy table, no backward compatible, and more UE complexity on hypothetical decoding of both NPDCCH and NPDSCH.

The concerns to support option 2 include: large SNR gap between NPDCCH repetition 1 and 16QAM TBS, more UE complexity on hypothetical decoding of both NPDCCH and NPDSCH, and limited number of MCS entries for 16-QAM for efficient CQI reporting.

The concerns to support option 3 include: no backward compatible, and additional signaling.

For the majority view (option 3), the concerns can be easily addressed by a Rel-17 RRC parameter. If it can be resolved, the following is proposed to move forward based on majority view:

**Proposal 9: For downlink 16-QAM, a new CQI table is defined based on the table 7.2.3-3 in TS 36.213 as a starting point.**

Please input your comments for the above proposals:

|  |  |
| --- | --- |
| Companies | Comments |
| Huawei, HiSilicon | We are OK with proposal 8 and proposal 9.  |
| Ericsson | * Proposal 8: Ok.
* Proposal 9: We are not ok with it, mainly because of the no backward compatibility from option 1 and option 3.
 |
| Lenovo, MotoM | We are OK with proposal 8For proposal 9, we have some concern because it is not aligned with the WIDIf we use new CQI table, I am not sure which part of the new CQI reporting follows the framework of CQI reporting in Rel.14-16.* Specify 16-QAM for unicast in UL and DL, including necessary changes to DL power allocation for NPDSCH and DL TBS. This is to be specified without a new NB-IoT UE category. For DL, increase in maximum TBS of e.g. 2x the Rel-16 maximum, and soft buffer size will be specified by modifying at least existing Category NB2. For UL, the maximum TBS is not increased. [NB-IoT] [RAN1, RAN4]
	+ Extend the NB-IoT channel quality reporting based on the framework of Rel-14—16, to support 16-QAM in DL. [NB-IoT] [RAN2, RAN1, RAN4]
 |

## Others

**Issue 6: Others**

There are also other proposals as below:

|  |  |
| --- | --- |
| Sourcing | proposals |
| [5] | ***Observation 6: For the large TBS case with QPSK, increasing the mapping RU number while keeping the repetition number reduced half improve performance more than 2 dB.******Proposal 9: For NB-IoT UE with 16QAM, double RU number should be considered to improve the performance for some QPSK entries with the repetition number reduced half.*** |
| [9] | **Observation 1: The PAPR of 16-QAM for DL NB-IoT is increased compared with QPSK.****Proposal 1: RAN1 to consider the reduction of 16-QAM PAPR for DL NB-IoT.** |
| [10] | **Observation 1 The WI on “Additional enhancements for NB-IoT and LTE-MTC” is coming to its end and there are two tasks that need to be started promptly (e.g., after RAN1# 106-e):****• An overall initial identification of specification impacts on a per agreement basis.****• Initiate the identification of the required RRC parameters per WI objective lead by RAN1 as to create the “Rel-17 RRC parameter list”.****Observation 2 In our view, the overall initial identification of specification impacts on a per agreement basis can be carried out in parallel with the RRC parameter list.** |

Please input any issue that can be considered for discussion in this meeting:

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| --- | --- |
| Companies | Comments |
| Ericsson | From other topics, we believe the following proposal in [3] is important to discuss: “Proposal 4: Define CSI reference resource to be used for 16-QAM CQI measurement.” |
|  |  |
|  |  |

# Summary

# References

1. RP-211340, “WID revision: Additional enhancements for NB-IoT and LTE-MTC”, Huawei, HiSilicon, RAN#92e, E-meeting, June 2021.
2. R1-2106558 Support of 16QAM for unicast in UL and DL in NB-IoT Huawei, HiSilicon
3. R1-2106654 Support of 16-QAM for NB-IoT Nokia, Nokia Shanghai Bell
4. R1-2106758 Support of 16-QAM for NB-IoT Qualcomm Incorporated
5. R1-2106847 Discussion on UL and DL 16QAM for NB-IoT ZTE, Sanechips
6. R1-2107508 Support 16QAM in NB-IOT MediaTek Inc.
7. R1-2107941 Support 16QAM for NBIoT Lenovo, Motorola Mobility
8. R1-2108116 Support of 16-QAM for unicast in UL and DL in NB-IoT Ericsson
9. R1-2107684 Discussion on DL PAPR for 16-QAM of NB-IoT Huawei, HiSilicon
10. R1-2108118 On Rel-17 RRC parameters and specification impacts for LTE-M and NB-IoT Ericsson