**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)

# Discussion

## Applicability

### Issue 1: Applicability

The following has been achieved in online discussion:

Agreement:

Confirm the following working assumption:

* Working Assumption
	+ Support 16-QAM for NPUSCH in PUR procedure.

For proposal 1,

@Ericsson, regarding the comments “such as data-to-pilot power ratios, and MCS ranges”, the data-to-pilot power ratios has been added in the proposal, however MCS range is not needed as NPDSCH in PUR is dynamically scheduled. “Two new optional IEs for DL and UL 16QAM are introduced in the PUR configuration”, not sure what “new optional IEs” mean, is it the enabler of 16-QAM?

@Nokia, @ZTE, it seems reasonable to me to leave the details to RAN2.

The proposal are updated as below:

Proposal 1: Support 16-QAM for NPDSCH in PUR procedure

* CSI report is not supported/expected during PUR procedure

**Proposal 2: To support 16-QAM for NPDSCH and NPUSCH in PUR procedure,**

* **16-QAM can be enabled/disabled by UE specific RRC signaling for NPDSCH and NPUSCH separately**
	+ **When 16-QAM is enabled for NPUSCH, TBS for PUR can be indicated by UE specific RRC signalling.**
	+ **When 16-QAM is enabled for NPDSCH, The power ratios between NRS and NPDSCH is indicated by UE specific RRC signaling**

Please input your comments on the above proposals:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson v020 | Given Proposal 2, we can be OK with Proposal 1.Proposal 1 is ok as it is.Proposal 2, we request the following update:**Proposal 2: To support 16-QAM for NPDSCH and NPUSCH in PUR procedure,*** **16-QAM can be enabled/disabled by UE specific RRC signaling for NPDSCH and NPUSCH separately**
	+ **When 16-QAM is enabled for NPUSCH, the TBS indices, RU indices and UL power control parameter are indicated in *PUR-Config-NB***
	+ **When 16-QAM is enabled for NPDSCH, the DL power allocation is indicated in *PUR-Config-NB***
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## DCI

### Issue 2: DCI design

The following have been achieved:

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.

Agreement

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

For proposal 3, @Ericsson, @ZTE, @Nokia, as there’s no real difference between comments, the proposal is updated according to majority view.

**Proposal 3: the agreement below is updated as**

Agreement

 **For the UE configured with 16-QAM for NPDSCH, the deployment of the carrier is signaled by *operationModeInfo* in MIB or *inbandCarrierInfo* in SIB/Msg4.**

Please input your comments regarding the above proposal:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson v020 | Yes, we are ok with Proposal 3 |
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## Power allocation and power control

### Issue 3: downlink power allocation

The following has been achieved:

**Confirm 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

**Working Assumption**

For downlink power allocation to support 16QAM:

* For inband deployments, a power ratio is signaled in addition to the signalling for standalone and guard-band deployments which in this case applies to “symbols with NRS” and “symbols without NRS nor CRS”.
	+ the power ratio between NPDSCH EPRE and NRS EPRE in symbols with CRS is signalled
	+ the signalling is UE specific

Note: “symbols with NRS” and “symbols without NRS nor CRS” have the same power.

### Issue 4: uplink power control

Regarding the options proposed for uplink power control,

* Option 1: Reuse the LTE definition simplified for NB-IoT: $∆\_{TF,c}\left(i\right)=10log\_{10}\left(\left(2^{BPRE∙K\_{s}}-1\right)\right)$ for $K\_{s}=1.25$ and $∆\_{TF,c}\left(i\right)=0$ for $K\_{s}=0$, where $K\_{s}$ is given by higher layer parameter *deltaMCS-Enabled*, and $BPRE=\frac{K}{N\_{RE}}$ where K is the code block size.
* Option 2: $∆\_{TF,c}$ 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: $∆\_{TF,c}$ is configured by high layer parameter.
* Option 5: ΔTF = $10log\_{10}\left(\frac{2^{\left(BPRE\_{16QAM}∙K\_{s}\right)}-1}{2^{\left(BPRE\_{QPSK}∙K\_{s}\right)}-1}\right)$ for *Ks* = 1.25 or ΔTF = 0 for *Ks* = 0, where BPRE =$ CodeRate\_{max}∙Q\_{m}$. $CodeRate\_{max}$ is the highest code rate in the TBS/MCS table used for the Modulation Scheme, and $Q\_{m}$ is the number of bits per M-ary symbol of the Modulation Scheme.

The following has been achieved:

Agreement

Down-select one option from Cat 1 as starting point

* Cat 1: Option 1, Option 2/Option 4, Option 5

FFS Cat 2: Option 3, for close-loop power control

* Option 1: Reuse the LTE definition simplified for NB-IoT: $∆\_{TF,c}\left(i\right)=10log\_{10}\left(\left(2^{BPRE∙K\_{s}}-1\right)\right)$ for $K\_{s}=1.25$ and $∆\_{TF,c}\left(i\right)=0$ for $K\_{s}=0$, where $K\_{s}$ is given by higher layer parameter *deltaMCS-Enabled*, and $BPRE=\frac{K}{N\_{RE}}$ where K is the code block size.
* Option 2: $∆\_{TF,c}$ 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: $∆\_{TF,c}$ is configured by high layer parameter.
* Option 5: ΔTF = $10log\_{10}\left(\frac{2^{\left(BPRE\_{16QAM}∙K\_{s}\right)}-1}{2^{\left(BPRE\_{QPSK}∙K\_{s}\right)}-1}\right)$ for *Ks* = 1.25 or ΔTF = 0 for *Ks* = 0, where BPRE =$ CodeRate\_{max}∙Q\_{m}$. $CodeRate\_{max}$ is the highest code rate in the TBS/MCS table used for the Modulation Scheme, and $Q\_{m}$ is the number of bits per M-ary symbol of the Modulation Scheme.

Please input your preference and reasons on the down-selection, and your comments on the FFS as well:

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| --- | --- |
| 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* =$ CodeRate\_{max}∙Q\_{m}$. 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 = $10log\_{10}\left(2^{\left(CodeRate\_{max}∙Q\_{m}(i)∙K\_{s}\right)}-1\right)$ = $10log\_{10}\left(2^{\left(0.92∙2∙1.25\right)}-1\right)$ = 5.9379 dBTF16-QAM = $10log\_{10}\left(2^{\left(CodeRate\_{max}∙Q\_{m}(i)∙K\_{s}\right)}-1\right)$ = $10log\_{10}\left(2^{\left(0.89∙4∙1.25\right)}-1\right)$ = 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: $∆\_{TF,c}$ is configured by high layer parameter, 0 otherwise. FFS: values in the set from which $∆\_{TF,c}$ 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. |
| ZTE,Sanechips | Agree with Proposal 7 and support option3. A TPC command can provide flexible power control. Because the CQI is report ed by MAC CE and NB-IoT UE is a kind of low cost UE, the complicated calculation for ΔTF is not appropriate for NB-IoT. |
| Nokia, NSB | We are fine with proposal 7. Our preference is option 2, which is a simplified version of option 1/5. |
| Qualcomm | We think Option 3 should be removed. The other options can be further discussed. |
| Ericsson v010 | We kindly request the proponent of Option 1 to provide the numeric value obtained from ΔTF.For Option 5, ΔTF = 7.2545 dB.An equation-based solution as Option 1 and Option 5 provides a single ΔTF value. Thus, we think that is probably better to have more flexibility through a ΔTF configured via HL (e.g., Option 4), where ΔTF is selected from among a set of possible values in a set. For example:ΔTF = {A*dB*, B*dB*, C*dB*, D*dB*} is provided by HL parameter, and if this field is absent then 0*dB* will be used. * FFS: A, B, C, D.

With the above approach, the resulting ΔTF from e.g., Option 1, Option 5 could be included in the set, which provides flexibility. |
| Nokia, NSB | We think that a single value per MCS level defined in specifications should be sufficient. There is no need to computer the value for each allocation nor have multiple higher-layer configured values. |
| Huawei, HiSilicon | The specific value is calculated based on $∆\_{TF,c}\left(i\right)=10log\_{10}\left(\left(2^{BPRE∙K\_{s}}-1\right)\right)$ for $K\_{s}=1.25$. And $∆\_{TF,c}\left(i\right)=0$ for $K\_{s}=0$. $K\_{s}$ is given by higher layer parameter *deltaMCS-Enabled*, and $BPRE=\frac{K}{N\_{RE}}$ where K is the code block size. $N\_{RE}$ is the number of REs for NPUSCH. |
| ZTE, Sanechips | A repurposed field with 4 bits can be used for TPC command. There are enough states to include all power offset determined by $∆\_{TF,c}$. We do not see any benefits to adopt the $∆\_{TF,c}$, instead of dynamic TPC control. |
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## Channel quality reporting

### Issue 5: Channel quality reporting

The following proposal has been achieved:

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.

Agreement

For CQI table for downlink 16-QAM, down-select between following options in RAN1#106-e:

* Option 1: More than three candidate values for 16-QAM are added in the legacy table.
	+ FFS: Which of the legacy entries are removed
* Option 2: Three candidate values for 16-QAM are added in the legacy table.
* Option 3: A new CQI table is defined for 16-QAM based on the eMTC table (CQI Tables in 36.213) as a starting point

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: not backward compatible, out of scope of WID, and additional signaling.

After the GTW session, more discussion is needed regarding the concerns listed above.

**Question 1: What’s your first preference between the three options?**

**Question 2: Your comments regarding the listed concerns for the preferred option?**

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| --- | --- |
| Companies | Comments |
| Ericsson v020 | Question 1: Option-2 as to have backward compatibility, no step-size granularity issues, and to stick to the WID.Question 2: For Option-1 • Incurs in a “dB” step-size granularity issue, since the step-size in most of the cases will be smaller than 1dB (in some cases as small ⁓ 0.45 dB). It is questionable the feasibility of the SINR measurement quality required to support such a fine granularity. • Requires increasing the size of legacy Table 9.1.22.15-1 since for Stand-alone/Guard-Band deployments 8 reports would be needed (i.e., I\_TBS indices from 14 to 21).• There is an FFS that considers removing legacy entries as to not have to increase the size of the legacy table, however in that case the side effect is ending up with a no backward compatible solution.For Option-3As mentioned earlier not backward compatible, out of scope of WID, and additional signaling. Since we are standardizing 16-QAM, one of the main concerns is having re-design the reports for QPSK, which won’t be as legacy any longer. |
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## Others

**Issue 6: Others**

Based on previous comments, there are two companies proposing to discuss the CSI reference. Therefore, the following is proposed for discussion:

**Proposal 10: Define CSI reference resource to be used for 16-QAM CQI measurement.**

Please input your comments to the above proposal or any other issue that can be considered for discussion in this meeting:

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| --- | --- |
| Companies | Comments |
| Ericsson v010 | We need to define reference symbols to estimate CQI, NRS seems to be suitable for this purpose in NB-IoT. |
| Nokia, NSB | We support this proposal. It can be based on NRS with similar definition as for eMTC. |
| MTK | Considering the limited resource, We think it’s better to follow legacy measurement framework (NRS based as well). Definite CSI reference resource might introduce extra latency compared to instant moving-average measurement.  |
| Huawei, HiSilicon | In channel quality reporting in R16, no reference resource is defined for measurement in the spec. We think there is no need to define this and can follow the legacy. |
| ZTE, Sanechips | In the frequency domain, the UE can only measure CQI based on one PRB where UE monitors NPDCCH and the associated NPDSCH. In the time domain, whether to use a single subframe or multiple subframes to measure CQI can be based on UE implementation. In addition, RAN1 has not defined measurement reference resource for channel quality report in Rel-14/16 NB-IoT. Thus, the measurement reference resource does not need to be specified for Rel-17 CQI report. |
|  |  |

# Round 2 Discussion

## Applicability

### Issue 1: Applicability

The following has been achieved in online discussion:

Agreement:

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, it seems several companies can accept 16-QAM for PUR NPDSCH, if no further enhancement for CQI during PUR procedure. The following is proposed:

Proposal 1: Support 16-QAM for NPDSCH in PUR procedure

* CSI report is not supported/expected during PUR procedure
* The power ratios between NRS and NPDSCH is pre-configured for NPDSCH in PUR procedure

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

**Proposal 2: To support 16-QAM for NPUSCH in PUR procedure,**

* **One RRC IE is introduced in *pur-PhysicalConfig* to enable the use of 16-QAM.**
	+ **When 16-QAM is enabled, the RRC IE *multiTone* in *npusch-MCS* in *pur-PhysicalConfig* indicates the TBS indices for 16-QAM.**

Please input your comments on the above proposals:

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| --- | --- |
| Companies | Comments |
| Ericsson v010 | * Proposal 1: Even if the CSI report were not supported, other DL related elements would have to be pre-configured such as data-to-pilot power ratios, and MCS ranges. If after truly pondering the importance of the DL use-case (recall 64 QAM in DL was not supported for PUR) versus the specification impacts, the interest still prevails, then aiming at being constructive we could accept proposal 1 subject to have an agreement stating that: “*Two new optional IEs for DL and UL 16QAM are introduced in the PUR configuration*”. The above as to be able to control DL and UL separately in PUR.

 * Proposal 2: It seems that extending the RRC IE *multiTone* is not needed, since the following approach will allow to save bits.

**To support 16-QAM for NPUSCH in PUR procedure,*** One RRC IE is introduced in *pur-PhysicalConfig* to enable the use of 16-QAM.
	+ When 16-QAM is enabled, the RRC IE *multiTone* in npusch-MCS in *pur-PhysicalConfig* indicates MCS from 14 to 21.
 |
| Nokia, NSB | We support Proposal 1.On Proposal 2, our original proposal was to only extend the multiTone field for UE capable of 16-QAM (i.e. no need to enable the use of 16-QAM separately). However, we have no strong view and can also accept Ericsson’s proposal to introduce two optional IEs. |
| MTK | We are ok with Proposa1 and prefer the modified proposal2 from Ericsson. |
| Huawei, HiSilicon | For proposal 2 the detailed signaling can be up to RAN2. We are also fine with proposal 1. |
| ZTE, Sanechips | For proposal1, we can compromise to accept this proposal unless there is no any further optimization.For proposal2, alternatively, a new 5bits field, e.g., ***multiTone-r17***, can also be used for enabling 16-QAM and corresponding MCS value. We think it is up to RAN2 decision.   |
| Moderator | On comments from Ericsson, for NPDSCH in PUR procedure, the MCS is not pre-configured but scheduled from DCI, so this new IE is not needed. Regarding the comments, proposals are updated as below:Proposal 1: Support 16-QAM for NPDSCH in PUR procedure* CSI report is not supported/expected during PUR procedure
* The power ratios between NRS and NPDSCH is pre-configured for NPDSCH in PUR procedure

**Proposal 2: To support 16-QAM for NPUSCH in PUR procedure,*** **One RRC IE is introduced in *pur-PhysicalConfig* to enable the use of 16-QAM.**
	+ **When 16-QAM is enabled, the RRC IE *multiTone* in npusch-MCS in *pur-PhysicalConfig* indicates the TBS indices for 16-QAM.**
 |
| Ericsson v016 | In my understanding there are elements of DL that somehow need to be pre-configured. If it is not the case, then why your proposal 1 includes the “power ratios … for NPDSCH in PUR procedure”??? That is why, if 16-QAM in UL and DL is to be supported in PUR, we can be ok with it subject to have “*Two new optional IEs for DL and UL 16QAM are introduced in the PUR configuration*”. The above as to be able to control DL and UL separately in PUR. |
| ZTE, Sanechips | Whether to introduce a new RRC IE or reuse the RRC IE is up to RAN2 decision.Modify the proposal 2 as following:1. **QAM for PUR can be enabled/disabled by UE specific RRC signalling.**
* **when 16-QAM for PUR is enabled, TBS for PUR can be indicated by UE specific RRC signalling**
 |
| Nokia, NSB | We are fine with Proposal 1.On Proposal 2, we have similar view / preference as ZTE that the ***multitone*** field can be used. But we have no strong preference here so we could also accept the proposal if that is the majority view. |

## DCI

### Issue 2: DCI design

The following have been achieved:

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.

Agreement

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

Regarding the comments that inbandCarrierInfo can also be in Msg3, maybe we can have a proposal to correct it as below:

**Proposal 3: the agreement below is updated as**

Agreement

 **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 comments regarding the above proposal:

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| --- | --- |
| Companies | Comments |
| Ericsson v016 | Due that “*operationModeInfo*” refers to “MIB”, proposal 3 looks asymmetrical. We do not see the problem in just adding “/msg4” as to have “*inbandCarrierInfo* in SIB/msg4”. |
| ZTE, Sanechips | We do not need to change the agreement. Just add a new agreement to capture msg4 is fine.**For the UE configured with 16-QAM for NPDSCH, the deployment of the carrier also can be signaled by *inbandCarrierInfo* in UE-specific RRC signalling.** |
| Nokia, NSB | We think it’s better to add clarification text as proposed by Ericsson rather than to delete “in SIB”. |

## Power allocation and power control

### Issue 3: downlink power allocation

The following has been achieved:

**Confirm 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 inband, there’s still following two alternatives:

* For inband deployments, a power ratio is signaled in addition to the signalling for standalone and guard-band deployments which in this case applies to “symbols with NRS” and “symbols without NRS nor CRS”. Down-select from the following options in RAN1#106-e:
	+ Alt 1:
		- The existing parameter nrs-CRS-PowerOffset is reused for same PCI case, and is signaled for different PCI case.
		- The same transmit power of different symbols is assumed as to derive from *nrs-CRS-PowerOffset* the NPDSCH EPRE in symbols with CRS.
	+ Alt 2:
		- the power ratio between NPDSCH EPRE and NRS EPRE in symbols with CRS is signaled

For inband, 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.

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| **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 |

 |

**Proposal 4: For downlink power allocation to support 16QAM:**

* **For inband deployments, a power ratio is signaled in addition to the signalling for standalone and guard-band deployments which in this case applies to “symbols with NRS” and “symbols without NRS nor CRS”. Down-select from the following options in RAN1#106-e:**
	+ **the power ratio between NPDSCH EPRE and NRS EPRE in symbols with CRS is signalled**
	+ **the signalling is UE specific**

Please input your comments to 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 |

 |
| ZTE, Sanechips | Agree with Proposal 6. For in-band deployment, we support Alt-1 to ensure that guardband/standalone and inband deployments have the same assumption with the same transmit power across different symbols. For the mentioned concern on Alt 1, increasing the ratio of NPDSCH EPRE to NRS EPRE in symbols without NRS(agreed) can increase the absolute NPDSCH EPRE of all OFDM symbols to meet decoding requirements.  |
| Nokia, NSB | We support proposal 6 |
| Qualcomm | Proposal 6 is OK.For in-band, let us reply to some of the comments:“However, there will be different transmit power for symbol 1 and 2. It seems the design is not aligned.”The transmit power in symbols 1 and 2 are indeed different if you only take into account the NBIOT PRB. If you add the other PRB we show in our contribution, the power is constant (that’s the whole point).“we support Alt-1 to ensure that guardband/standalone and inband deployments have the same assumption with the same transmit power across different symbols”The issue with inband is that the eNB cannot “blank” the CRS in the other PRBs, so if CRS is power boosted, NPDSCH needs to be correspondingly de-boosted to keep constant power across the wideband LTE carrier. |
| Moderator | As there’s no further response regarding QC’s elaboration, the concern that for LTE the transmit power between different symbols should be same and the CRS power should be constant within LTE bandwidth, the following is proposed:* For inband deployments, a power ratio is signaled in addition to the signalling for standalone and guard-band deployments which in this case applies to “symbols with NRS” and “symbols without NRS nor CRS”. Down-select from the following options in RAN1#106-e:
	+ the power ratio between NPDSCH EPRE and NRS EPRE in symbols with CRS is signalled
	+ the signalling is UE specific
 |
| Ericsson v016 | We are Ok with proposal 4, you just need to remove the text “Down-select from the options in RAN1#016-e:”  |
| ZTE, Sanechips | If there are multiple UEs(NB-IoT UE and LTE UE) are scheduled in the same subframe, the power for CRS boosting can be borrowed from LTE PDSCH power. In this case, the NPDSCH power does not need to be de-boosted. |

### Issue 4: uplink power control

Regarding the options proposed for uplink power control,

* Option 1: Reuse the LTE definition simplified for NB-IoT: $∆\_{TF,c}\left(i\right)=10log\_{10}\left(\left(2^{BPRE∙K\_{s}}-1\right)\right)$ for $K\_{s}=1.25$ and $∆\_{TF,c}\left(i\right)=0$ for $K\_{s}=0$, where $K\_{s}$ is given by higher layer parameter *deltaMCS-Enabled*, and $BPRE=\frac{K}{N\_{RE}}$ where K is the code block size.
* Option 2: $∆\_{TF,c}$ 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: $∆\_{TF,c}$ is configured by high layer parameter.
* Option 5: ΔTF = $10log\_{10}\left(\frac{2^{\left(BPRE\_{16QAM}∙K\_{s}\right)}-1}{2^{\left(BPRE\_{QPSK}∙K\_{s}\right)}-1}\right)$ for *Ks* = 1.25 or ΔTF = 0 for *Ks* = 0, where BPRE =$ CodeRate\_{max}∙Q\_{m}$. $CodeRate\_{max}$ is the highest code rate in the TBS/MCS table used for the Modulation Scheme, and $Q\_{m}$ is the number of bits per M-ary symbol of the Modulation Scheme.

The following has been achieved:

Agreement

Down-select one option from Cat 1 as starting point

* Cat 1: Option 1, Option 2/Option 4, Option 5

FFS Cat 2: Option 3, for close-loop power control

Please input your preference and reasons on the down-selection, and your comments on the FFS as well:

|  |  |
| --- | --- |
| 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* =$ CodeRate\_{max}∙Q\_{m}$. 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 = $10log\_{10}\left(2^{\left(CodeRate\_{max}∙Q\_{m}(i)∙K\_{s}\right)}-1\right)$ = $10log\_{10}\left(2^{\left(0.92∙2∙1.25\right)}-1\right)$ = 5.9379 dBTF16-QAM = $10log\_{10}\left(2^{\left(CodeRate\_{max}∙Q\_{m}(i)∙K\_{s}\right)}-1\right)$ = $10log\_{10}\left(2^{\left(0.89∙4∙1.25\right)}-1\right)$ = 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: $∆\_{TF,c}$ is configured by high layer parameter, 0 otherwise. FFS: values in the set from which $∆\_{TF,c}$ 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. |
| ZTE,Sanechips | Agree with Proposal 7 and support option3. A TPC command can provide flexible power control. Because the CQI is report ed by MAC CE and NB-IoT UE is a kind of low cost UE, the complicated calculation for ΔTF is not appropriate for NB-IoT. |
| Nokia, NSB | We are fine with proposal 7. Our preference is option 2, which is a simplified version of option 1/5. |
| Qualcomm | We think Option 3 should be removed. The other options can be further discussed. |
| Ericsson v010 | We kindly request the proponent of Option 1 to provide the numeric value obtained from ΔTF.For Option 5, ΔTF = 7.2545 dB.An equation-based solution as Option 1 and Option 5 provides a single ΔTF value. Thus, we think that is probably better to have more flexibility through a ΔTF configured via HL (e.g., Option 4), where ΔTF is selected from among a set of possible values in a set. For example:ΔTF = {A*dB*, B*dB*, C*dB*, D*dB*} is provided by HL parameter, and if this field is absent then 0*dB* will be used. * FFS: A, B, C, D.

With the above approach, the resulting ΔTF from e.g., Option 1, Option 5 could be included in the set, which provides flexibility. |
| Nokia, NSB | We think that a single value per MCS level defined in specifications should be sufficient. There is no need to computer the value for each allocation nor have multiple higher-layer configured values. |
| Huawei, HiSilicon | The specific value is calculated based on $∆\_{TF,c}\left(i\right)=10log\_{10}\left(\left(2^{BPRE∙K\_{s}}-1\right)\right)$ for $K\_{s}=1.25$. And $∆\_{TF,c}\left(i\right)=0$ for $K\_{s}=0$. $K\_{s}$ is given by higher layer parameter *deltaMCS-Enabled*, and $BPRE=\frac{K}{N\_{RE}}$ where K is the code block size. $N\_{RE}$ is the number of REs for NPUSCH. |
| ZTE, Sanechips | A repurposed field with 4 bits can be used for TPC command. There are enough states to include all power offset determined by $∆\_{TF,c}$. We do not see any benefits to adopt the $∆\_{TF,c}$, instead of dynamic TPC control. |

## Channel quality reporting

### Issue 5: Channel quality reporting

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]
 |
| MTK | For proposal 8, we follow majorities, ok with it. We are also ok with proposal9, regardging Lenovo,MotoM’ concern, the reporting is still a 4-bits table like legacy Release, from the view of framework, we think it doesn’t violate it.  |
| ZTE, Sanechips | Agree with Proposal 8 and 9. |
| Nokia, NSB | We support Proposal 9. For Proposal 8, although we feel that channel quality reporting in Msg3 would be beneficial, we are OK to proceed with majority view. |
|  |  |
|  |  |
|  |  |

## Others

**Issue 6: Others**

Based on previous comments, there are two companies proposing to discuss the CSI reference. Therefore, the following is proposed for discussion:

**Proposal 10: Define CSI reference resource to be used for 16-QAM CQI measurement.**

Please input your comments to the above proposal or any other issue that can be considered for discussion in this meeting:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson v010 | We need to define reference symbols to estimate CQI, NRS seems to be suitable for this purpose in NB-IoT. |
| Nokia, NSB | We support this proposal. It can be based on NRS with similar definition as for eMTC. |
| MTK | Considering the limited resource, We think it’s better to follow legacy measurement framework (NRS based as well). Definite CSI reference resource might introduce extra latency compared to instant moving-average measurement.  |
| Huawei, HiSilicon | In channel quality reporting in R16, no reference resource is defined for measurement in the spec. We think there is no need to define this and can follow the legacy. |
| ZTE, Sanechips | In the frequency domain, the UE can only measure CQI based on one PRB where UE monitors NPDCCH and the associated NPDSCH. In the time domain, whether to use a single subframe or multiple subframes to measure CQI can be based on UE implementation. In addition, RAN1 has not defined measurement reference resource for channel quality report in Rel-14/16 NB-IoT. Thus, the measurement reference resource does not need to be specified for Rel-17 CQI report. |
|  |  |

# 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