**3GPP TSG RAN WG1 Meeting #108-e R1-22xxxxx**

**e-Meeting, February 21 – March 3, 2022**

**Agenda Item: 8.9.1**

**Source: Moderator (Huawei)**

**Title: Feature lead summary #1 on 108-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 [2-11].

[108-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)

* 1st check point: November 15
* Final check point: November 19

# Discussion

## Uplink power control

### Issue 1: uplink power control

The companies’ proposals are listed in the table below

|  |  |
| --- | --- |
| Sourcing | Proposals |
| [2] | **Proposal 2：The new power control term can be applied to NPUSCH with QPSK when configured with 16QAM.** |
| [3] | ***Observation 1: For legacy QPSK, there is no clear requirements to introduce the new term*** $∆\_{TF,c}$ ***for uplink power control in NB-IoT.*** ***Observation 2: For NPUSCH with QPSK and TBS 1-6, uplink power reduction caused by*** $∆\_{TF,c}$ ***will lead to a performance loss if*** $∆\_{TF,c}$ ***is applied to QPSK.******Proposal 1: An offset can be applied on*** $∆\_{TF,c}$ ***to reduce the power difference between QPSK and 16QAM.**** ***The offset could be indicated by higher layers.***
 |
| [4] | **Proposal 2: The new uplink power control term** $∆\_{TF,c}\left(i\right)$ **is also applied to QPSK when UE is configured with 16-QAM.**  |
| [5] | **Proposal 2: The new term** $Δ\_{TF}$ **also applies to QPSK, when configured with 16-QAM.** |
| [6] | ***Proposal 2: The new term*** $∆\_{TF,c}$ ***introduced for power control of NPUSCH applies to QPSK and 16QAM when configured with 16QAM.*** |
| [7] | **Proposal 2: The new term** $∆\_{TF,c}$ **should apply to both 16QAM and QPSK, no offset needed.** |
| [8] | **Observation 7 A new term (ΔTF) for 16-QAM in UL was introduced as to account for the larger number of bits per RE that this higher order modulation scheme introduces.****Observation 8 Due to the introduction of ΔTF, it was pointed out the possibility of introducing a way to prevent a large power difference between QPSK and 16-QAM.****Observation 9 Two proposals remained considered to alleviate the power difference between QPSK and 16-QAM: 1) “Introducing ΔTF for QPSK” and 2) “Introducing an Offset acting on ΔTF for 16-QAM”.****Observation 10 “Introducing ΔTF for QPSK” has as a side effect QPSK resulting in an UL power control behavior that will be different with and without 16-QAM configured.****Observation 11 Due that it was not possible to reach a consensus towards 1) or 2), at some point one company commented that “in terms of open loop such jump up to 6.5dB is very common, perhaps we could let it go”.****Observation 12 In our view, the WID’s objective was about introducing 16-QAM for NB-IoT and therefore we should not create side effects (i.e., different behaviors) from making modifications touching upon legacy modulation schemes.** **Observation 13 Based on observation 12, any solution intended to alleviate the power difference between QPSK and 16-QAM should be based on a solution acting on 16-QAM elements (i.e., offset acting on ΔTF), otherwise is preferred to deal with a power difference between QPSK and 16-QAM.****Proposal 3 If the power difference between QPSK and 16-QAM is to be alleviated, it should be based on a solution acting on 16-QAM elements (i.e., offset acting on ΔTF), otherwise is preferred to live with such a power difference between modulation schemes.** |

The following has been agreed in last meeting:

**Agreement**

**The following working assumption is confirmed.**

**For the new term** $∆\_{TF,c}$ **introduced for power control of NPUSCH,**

* 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.
* FFS: whether the new term applies to QPSK when configured with 16QAM, if it does not, whether an additional term is introduced to avoid jump between QPSK and 16QAM

On the FFS part, based on the comments, it will be down-selected from the following options:

* Option 1: The term $∆\_{TF,c}\left(i\right)$ can also be applied to NPUSCH with QPSK, when 16-QAM is configured.
* Option 2: An offset to $∆\_{TF,c}\left(i\right)$ is configured from a set of {[1dB], [2dB], [4dB], [6dB]}, when 16-QAM is configured.

For information, the $∆\_{TF,c}\left(i\right)$calculated are summarized in the following table:

|  |  |  |  |
| --- | --- | --- | --- |
| Modulation | $$I\_{TBS}$$ |  | $$I\_{RU}$$ |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| QPSK | 13 | TBS | 224 | 488 | 744 | 1032 | 1256 | 1544 | 2024 | 2536 |
| $$∆\_{TF,c}\left(i\right)$$ | 4.546765 | 5.238875 | 5.374201 | 5.708471 | 5.481782 | 5.686359 | 5.542038 | 5.562083 |
| 16QAM | 14 | TBS | 256 | 552 | 840 | 1128 | 1416 | 1736 | 2280 |  |

And the power control values for both options are listed as below, assuming 5RUs, and that the default P0 is 0dB, and the power of 16QAM NPUSCH for option 1 and option 2 is the same.

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| $$I\_{TBS}$$ | Modulation | TBS | $∆\_{TF,c} $: option 1 | P0 setting for option 1 | $∆\_{TF,c} $: option 2 | Offset for option 2 | P0 setting for option 2 |
| 1 | QPSK | 176 | -6.27282 | 0 | 0 | 0 | 6.5 |
| 3 | QPSK | 256 | -4.42746 | 0 | 0 | 0 | 6.5 |
| 4 | QPSK | 328 | -3.15198 | 0 | 0 | 0 | 6.5 |
| 5 | QPSK | 424 | -1.76735 | 0 | 0 | 0 | 6.5 |
| 6 | QPSK | 504 | -0.7883 | 0 | 0 | 0 | 6.5 |
| 7 | QPSK | 584 | 0.083221 | 0 | 0 | 0 | 6.5 |
| 8 | QPSK | 680 | 1.026534 | 0 | 0 | 0 | 6.5 |
| 9 | QPSK | 776 | 1.887086 | 0 | 0 | 0 | 6.5 |
| 10 | QPSK | 872 | 2.685284 | 0 | 0 | 0 | 6.5 |
| 11 | QPSK | 1000 | 3.676093 | 0 | 0 | 0 | 6.5 |
| 12 | QPSK | 1128 | 4.603156 | 0 | 0 | 0 | 6.5 |
| 13 | QPSK | 1256 | 5.481782 | 0 | 0 | 0 | 6.5 |
| 14 | 16QAM | 1416 | 6.528084 | 0 | 6.528084 | -6.5 | 6.5 |
| 15 | 16QAM | 1544 | 7.332797 | 0 | 7.332797 | -6.5 | 6.5 |
| 16 | 16QAM | 1608 | 7.726365 | 0 | 7.726365 | -6.5 | 6.5 |
| 17 | 16QAM | 1800 | 8.878457 | 0 | 8.878457 | -6.5 | 6.5 |
| 18 | 16QAM | 1992 | 9.996363 | 0 | 9.996363 | -6.5 | 6.5 |
| 19 | 16QAM | 2152 | 10.90802 | 0 | 10.90802 | -6.5 | 6.5 |
| 20 | 16QAM | 2344 | 11.98355 | 0 | 11.98355 | -6.5 | 6.5 |
| 21 | 16QAM | 2536 | 13.04336 | 0 | 13.04336 | -6.5 | 6.5 |

The company positions for the two options are as following:

* Option 1: The term $∆\_{TF,c}\left(i\right)$ can also be applied to NPUSCH with QPSK, when 16-QAM is configured.
	+ Huawei, HiSilicon, Nokia, NSB, Qualcomm, MediaTek,
* Option 2: An offset to $∆\_{TF,c}\left(i\right)$ is configured from a set of {[1dB], [2dB], [4dB], [6dB]}, when 16-QAM is configured.
	+ ZTE, Sanechips, Ericsson

As this issue has discussed for several meetings without consensus, please input your comments of following:

* technical concerns that the option not preferred could not work
* any update to the option not preferred so that it’s acceptable to you.

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | The technical concern we have with Option 1 is that we should not only see the issue from the perspective of UEs supporting 16-QAM, but also from the perspective of the co-existence of UEs supporting 16-QAM and UEs not supporting this feature. For those UEs configured with 16-QAM the QPSK transmissions will account for an extra parameter, which won’t be the case for the QPSK transmissions of UEs not supporting 16-QAM.Thus, if the power difference between QPSK and 16-QAM is to be alleviated, it should be based on a solution acting on 16-QAM elements (e.g., an offset acting on ΔTF as per Option 2), otherwise is preferred to live with such a power difference between modulation schemes. |
| Qualcomm | Regarding Ericsson’s concern, if it is desirable to keep the same power control between QPSK and 16-QAM UEs, the base station can disable this feature by setting $K\_{s}=0$. In any case, the power difference between QPSK and 16-QAM cannot be too large. |
| Lenovo, MotoM | Support Option 1.For NPUSCH uplink power control, the parameter P0 is UE-specific configured. So, if we want to address the UE uplink power fairness concern for UE with/wo 16QAM, different UEs can have different P0, which can be done by eNB implementation.For Option 2, what is the metric for eNB to determine the offset $∆\_{TF,c}\left(i\right)$ is configured as [1dB], [2dB], [4dB] or [6dB]? |
| MTK | Ok with Option1 |
| Ericsson v006 | To Lenovo:On the question about the “metric”, isn’t so that the same question applies to your proposal of using “P0”. If I’m not wrong in both cases it would be up to the eNodeB to determine the offset/P0. |
| Huawei, HiSilicon | Support option 1. The new uplink power control term is consistent with the legacy LTE principle based on MCS, then the same principle can be applied to QPSK as well to resolve this power jump issue without any additional RRC parameters impact. |
| ZTE, Sanechips | QPSK TBS 1-6 may be scheduled for NPUSCH due to channel degradation when 16QAM is enabled. In this case, high layer parameter can not adjust in time, UL power reduction caused by $∆\_{TF,c}$ will result in a performance loss if $∆\_{TF,c}$ is applied to QPSK. From our understanding, NB-IoT should ensure transmission reliability in low SNR, so it is not suitable to follow LTE approach. |
| Moderator | From the comments, it seems the concerns to both options can be resolved.The concerns to option 1 include impact of co-existing with legacy UEs and UL power reduction of low TBS entries, which could be resolved by setting $K\_{s}=0$ or proper setting of UE specific component P0.The concerns to option 2 include the metric to determine the offset to $∆\_{TF,c}\left(i\right)$, which in my understanding can be to have the same power between TBS entries 13 and 14, as listed in the table above.As there’s no middle ground between two options and this issue has been discussed for several meetings, it is proposed to stop this issue with following conclusion:Conclusion: there’s no consensus in RAN1on the following:whether the new term applies to QPSK when configured with 16QAM, if it does not, whether an additional term is introduced to avoid jump between QPSK and 16QAM |
| Nokia, NSB | We support option 1. This is a new power control mode, and we should have consistent behavior for both QPSK and 16-QAM in this power control mode. Our preference is that since the technical concerns for both options can be resolved, we should select the option with majority view. Otherwise there will be a big jump in the transmit power between QPSK and 16-QAM, which many companies have concerns with. |
| ZTE, Sanechips | Ks and P0 are seme-static configured, they can not adjust for TS 1-6 in time. Therefore, option 1 still can not ensure transmission reliability in low SNR. Additionally, consistent QPSK from Rel-16 to Rel-17 for NB-IoT is also important. Given the current situation, and both options can resolve the performance gap issue, we think maybe the following middle round can be considered:Both of the following two options are supported* Option 1: The term $∆\_{TF,c}\left(i\right)$ can also be applied to NPUSCH with QPSK, when 16-QAM is configured.
* Option 2: An offset to $∆\_{TF,c}\left(i\right)$ is configured from a set of {[1dB], [2dB], [4dB], [6dB]}, when 16-QAM is configured.

If the offset is configured, then the term $∆\_{TF,c}\left(i\right)$ would not be applied to NPUSCH with QPSK. If the offset is not configured, the term $∆\_{TF,c}\left(i\right)$ can be applied to NPUSCH with QPSK. |

## Channel quality reporting

### Issue 2: Configuration and switching of CQI table

The companies’ proposals are listed in the table below

|  |  |
| --- | --- |
| Sourcing | Proposals |
| [2] | **Proposal 1: The use of legacy table or the new CQI table is indicated by UE in MAC CE, if 16QAM is configured.** |
| [3] | ***Proposal 2: When DL 16QAM is configured, UE indicates the use of legacy or new CQI table via MAC CE.*** |
| [4] | **Proposal 1: On the use of legacy measurement reporting table, our preferences are –*** **1st preference: The eNB can configure, via higher-layer signalling, the CQI table to be used by the UE when configured with 16-QAM.**
* **2nd preference: If 16-QAM in DL is configured, then the UE should use the 16-QAM CQI table, otherwise the UE will use the legacy table.**
 |
| [5] | **Proposal 4: The UE uses the 16-QAM CQI table if it is configured with 16-QAM, otherwise it uses the QPSK table.** |
| [6] | ***Proposal 1: When 16QAM is configured, the new CQI table is used. UE determines the legacy or new CQI table based on Rmax, or eNB indicates the use of legacy or new CQI table via MAC CE or RRC configuration.*** |
| [7] | **Proposal 1: switching of CQI table should down selected from following two options.*** + **Option 1: UE indicates the use of legacy or new CQI table via MAC CE.**
	+ **Option 2: eNB indicates the use of legacy or new CQI table via MAC CE.**
 |
| [8] | Observation 1 Towards the end of RAN1# 107-e, the possibility of switching between the Rel-17 CQI table and the legacy CQI table was discussed.Observation 2 There were several proposals for performing the CQI Table switching such as using MAC CE, Rmax, RRC configuration, and “if 16QAM in DL is configured in msg4, then the UE should use the 16QAM CQI table, otherwise the UE will use the legacy table”.**Observation 3 During RAN1# 107-e, it was mentioned that the designed Rel-17 CQI table should be sufficient as to do not require a switching to the legacy table since UEs should be configured with a small Rmax value, and the radio conditions of such UEs cannot change so drastically as to require reports tied to a very large number of repetitions.**Observation 4 16-QAM was designed to be used with 1 repetition, if due to a change in the radio conditions were necessary to switch to QPSK, it seems that the Rel-17 CQI Table covers a reasonable margin of NPDCCH repetitions (up to 32 repetitions).Observation 5 We need to consider that going beyond the number of repetitions (> 32 repetitions) covered by the Rel-17 CQI table, may even result in an RLF for a UE configured with a small Rmax value.Observation 6 Thus, for a scenario requiring a large number of repetitions (i.e., > 32) a CQI table switching mechanism may result to be irrelevant, since in those scenarios a larger Rmax would need to be configured.Proposal 1 Based on the Rel-17 CQI table design which covers up to 32 repetitions for QPSK, introducing a table switching mechanism is no longer necessary. |

On configuration and switching of the CQI table, the company positions are summarized as below:

* + Option 1: UE indicates the use of legacy or new CQI table via MAC CE.
		- Huawei, HiSilicon, ZTE, Sanechips, MediaTek
	+ Option 2: eNB indicates the use of legacy or new CQI table via MAC CE.
		- MediaTek, Lenovo, Moto
	+ Option 3: eNB configures the use of legacy or new CQI table via RRC configuration
		- Nokia, NSB (1st), Lenovo, Moto
	+ Option 4: if Rmax<=16, the new CQI table is used, otherwise, the legacy CQI table is used.
		- Lenovo, Moto
	+ Option 5: the 16-QAM CQI table is used if DL 16-QAM is configured, otherwise the legacy CQI table is used
		- Nokia, NSB (2nd), Qualcomm, Ericsson

As the views are still very diverse, it is proposed to down-select from the two options with support of most number of companies, i.e., option 1 and option 5.

**Proposal 1: When 16QAM is configured, the new CQI table is used. On use of the legacy CQI table, it’s down-selected from following options:**

* + **Option 1: UE indicates the use of legacy or new CQI table via MAC CE.**
	+ **Option 5: the 16-QAM CQI table is used if DL 16-QAM is configured, otherwise the legacy CQI table is used**

Please input your preference regarding the two options.

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | Given the final design of the Rel-17 CQI table, we think that there is no need of introducing any CQI table switching mechanism. Hence, Option 5 is our preference which in our understanding does not need any specification statement since it is an inherent fact for the feature. |
| Qualcomm | Option 5 – it is very unclear why any of the other options are needed. |
| Lenovo, MotoM | Consider the status, we are OK to support option 5, no optimization is needed.For option 1, Is the additional 1-bit table selection indication always along with 4bit CQI reporting in MAC CE? Why not directly keep all entries of legacy table and extend the 16QAM CQI entries, report 5 bit at the beginning? Option 1 is not straightforward way (4+1 instead of 5). |
| MTK | Actually, 16QAM configured UE might encounter channel condition in which NPDCCH repetition is more than 32, option5 can’t accommodate this . Considering the fact Option1 extends reporting bits to 5 bits, option5 with 5 bits CQI table including all legacy and 16QAM extended entries might be the optimal solution. |
| Huawei, HiSilicon | We are OK with proposal 1 and support Option 1. Option 5 will lost the accuracy of CQI reporting in bad channel conditions/low SNR range wherein the UE needs to report a large number of repetitions. Furthermore, Option 1 can obtain scheduling flexibility. With the legacy CQI table, eNB does not need to reconfigure the UE to disable 16-QAM, which can save signaling overhead and thus power consumption.For the CQI report, the UE measures the SNR by the processing of the downlink (reference) signal, and then maps the measured SNR to the repetition number of NPDCCH or MCS of the NPDSCH to estimate the CQI. The use of legacy CQI table when 16QAM is configured does not introduce any additional UE complexity for CQI measurement and reporting. |
| ZTE, Sanechips | OK with option1. 16QAM feature is compatible with all QPSK MCS and number of repetitions. So 16QAM can remain always enabled to save RRC reconfiguration and facilitate modulation scheduling. When the channel quality becomes better or worse, the eNB can flexibly select the appropriate modulation mode to improve performance. Then, switching of CQI tables is needed. Option 1 is preferred. |
| Moderator | There are still similar number of companies supporting option 1 and option 5. However, the option of specifying a 5-bit CQI table is not preferred at this stage.As this has RAN2 impact, to finish this issue in this week, it is proposed to endorse the following proposal, which seems to be the common part and minimum essential enhancement needed:**Proposal 1: When 16QAM is configured, the new CQI table is used.** |
| Nokia, NSB | We are fine with the FL’s proposal. |
| ZTE, Sanechips | For sake of progress, we can accept the proposal with adding the following note:**Proposal 1: When 16QAM is configured, the new CQI table is used.****Note: RAN1 does not preclude that UE can indicate the use of legacy CQI table for 16-QAM and RAN2 can further discuss and decide.** |

## Text proposals

### EPRE for 16-QAM

In section 1 of [5], it is proposed to replace the description of constant power between symbols by equations, with the following text proposal

|  |
| --- |
| TP1 (TS 36.213)16.2.2 Downlink power allocation**[…]**If a UE is configured with higher layer parameters *npdsch-16QAM-Config* and *nrs-PowerRatio*,- if higher layer parameter *operationModeInfo* indicates '10' or '11',- the ratio of NPDSCH EPRE to NRS EPRE among NPDSCH REs (not applicable to NPDSCH REs with zero EPRE) is given by the parameter *nrs-PowerRatio* in symbols without NRS, and- the ratio of NPDSCH EPRE to NRS EPRE among NPDSCH REs in symbols with NRS is given by $\frac{}{}$, where $$ is given by the parameter *nrs-PowerRatio*, and $$ for a cell with two NRS antenna ports and $$ for a cell with one NRS antenna port- otherwise,- the ratio of NPDSCH EPRE to NRS EPRE among NPDSCH REs (not applicable to NPDSCH REs with zero EPRE) is given by the parameter *nrs-PowerRatio* in symbols without NRS and CRS, and- the ratio of NPDSCH EPRE to NRS EPRE among NPDSCH REs (not applicable to NPDSCH REs with zero EPRE) is given by the parameter *nrs-PowerRatioWithCRS* in symbols with CRS, and- the ratio of NPDSCH EPRE to NRS EPRE among NPDSCH REs in symbols with NRS is given by $\frac{}{}$, where $$ is given by the parameter *nrs-PowerRatio*, and $$ for a cell with two NRS antenna ports and $$ for a cell with one NRS antenna port. |

Please input your comments regarding the above text proposal:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | Math-wise the proposed TP seems to be correct, the only thing that needs to be amended is the following variable “$s=4$ for a cell with two NRS antenna ports and $s=5$ for a cell with one NRS antenna port”. |
| Qualcomm | Agree with the typo correction by Ericsson, it should be *s*. |
| Lenovo, MotoM | We are also OK to use the equation to illustrate the power ratio. However, there is no definition of *s* in the current spec, so we can directly use the ratio of NPDSCH EPRE to NRS EPRE among NPDSCH REs in symbols with NRS is given by $\frac{1}{5}(6−1)$ for a cell with one NRS antenna port and$ \frac{1}{4}(6−1)$ for a cell with two NRS antenna ports, where $$ is given by the parameter *nrs-PowerRatio.* |
| Huawei, HiSilicon | The spec already captures that the same transmit power should be assumed across different symbols, then the ratio of NPDSCH EPRE to NRS EPRE in symbols with NRS can be derived implicitly if the ratio of NPDSC EPRE to NRS EPRE in symbols without NRS is known. Thus, we think the ratio of NPDSCH EPRE to NRS EPRE in symbols with NRS are not required to show explicitly in the spec. The current spec text can work. |
| ZTE, Sanechips | Similar view with Huawei.  |
| Qualcomm | Just to clarify our view: the current text says “the UE can assume the power is constant across all symbols”. This text is highly inaccurate, in our view:1. What happens if there is no NPDSCH transmission? In this case, the power is clearly not constant.
2. There are many other ways to make the power constant (e.g. half the REs have twice the power, the other half have zero power).

In our understanding, it would be much more clear to specify exactly what is the EPRE, similar to what we did in the past: for LTE we have $ρ\_{a} ρ\_{b}$, even when the power is constant, for RSS we also have the equation that describes constant power. Even for QPSK NB-IoT, the 0dB (single port) and 3dB (dual port) EPRE express a constant power across symbols, but it was never written this way in the specifications. |
| Ericsson v012 | We support this TP, either upon fixing the typo we pointed out in our previous comment (i.e., replacing “$ρ$” by “s”) or without using “s” through putting directly the numeric value respectively. |
| Nokia, NSB | Our preference is to adopt the TP with appropriate correction since it can make the specifications clearer.  |
| ZTE, Sanechips | Thanks Qualcomm for the clarification. We are OK with the update from Lenovo, since it avoids introducing a new parameter.  |

### Configuration for PUR

In section 2 of [5], it is proposed that the configuration/behavior of 16-QAM for downlink is as following:

* If 16 QAM is enabled in PUR, and the DCI is mapped to the search space by PUR-RNTI, and MCS=’1111’, or
* If 16QAM is enabled in UE-specific RRC, and the DCI is mapped to the search space by C-RNTI and MCS = ‘1111’, then
	+ Use 16-QAM as the modulation order.

And it is proposed to endorse the following text proposal:

|  |
| --- |
| TP 3(TS 36.213):16.4.1.5 Modulation order and transport block size determinationTo determine the modulation order in the NPDSCH, the UE shall- if the UE is configured with higher layer parameter *npdsch-16QAM-Config* and the DCI is mapped onto the UE specific search space and the 4-bit "modulation and coding scheme" field () in the DCI is set to ‘1111’, or if the UE is configured with higher layer parameter *pur-DL-16QAM-Config* and the DCI is mapped onto the UE specific search space given by PUR-RNTI and the 4-bit "modulation and coding scheme" field () in the DCI is set to ‘1111’,- use modulation order, **=** 4- otherwise- use modulation order, **=** 2. |

In section 2.2 of [8], the same issue is discussed, and the following text proposal is proposed:

|  |
| --- |
| ------------------------------------------------------- Text Start -----------------------------------------------------------16.4.1.5 Modulation order and transport block size determinationTo determine the modulation order in the NPDSCH, the UE shall- if the UE is configured with higher layer parameter *npdsch-16QAM-Config* and the DCI is mapped onto the UE specific search space given by C-RNTI or if the UE is configured with higher layer parameter *pur-DL-16QAM-Config* and the DCI is mapped onto the UE specific search space given by PUR-RNTI, and the 4-bit "modulation and coding scheme" field () in the DCI is set to ‘1111’,- use modulation order, **=** 4- otherwise- use modulation order, **=** 2.------------------------------------------------------- Text End ----------------------------------------------------------- |

Please input your comments regarding the above two text proposals:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | Either of the two TPs above are ok. Perhaps we slightly prefer the one at the bottom due that it is a bit shorter, but if the one on the top were adopted it seems that we would need to add “given by C-RNTI” before the track changes start. |
| Qualcomm | Either TP works. |
| Lenovo, MotoM | If the concern of section 2.4 is addressed, that is, common understanding of the configuration of DL 16QAM in connected mode and idle mode has been achieved, we are OK to add the DL 16QAM in PUR in modulation determination.For the first TP, there is duplicated condition 5 in the IF conditionif 1 and 2 and 5 or if 3 4 and 5For the second TP, there may be some misunderstanding of condition 5 in the logicif 1 and 2 or if 3 and 4, and 5How about the following combination of the above two TP?To determine the modulation order in the NPDSCH, the UE shall-    if the UE is configured with higher layer parameter *npdsch-16QAM-Config* and the DCI is mapped onto the UE specific search space given by C-RNTI, or the UE is configured with higher layer parameter *pur-DL-16QAM-Config* and the DCI is mapped onto the UE specific search space given by PUR-RNTI,-    if the 4-bit "modulation and coding scheme" field () in the DCI is set to ‘1111’,-       use modulation order, = 4-    otherwise-       use modulation order, **=** 2-    otherwise-    use modulation order, **=** 2. |
| Ericsson v006 | Lenovo’s proposal seems in principle to be fine as well and a bit clearer. |
| Huawei, HiSilicon | We are fine both TPs and Lenovo’s updates seems more clear. |
| ZTE, Sanechips | We are OK with the update from Lenovo. |
| Qualcomm | We are OK with the update from Lenovo |
| Moderator | It seems the proposal from Lenovo is acceptable, which is copied as below with change marks for a TP:16.4.1.5 Modulation order and transport block size determinationTo determine the modulation order in the NPDSCH, the UE shall- if the UE is configured with higher layer parameter *npdsch-16QAM-Config* and the DCI is mapped onto the UE specific search space given by C-RNTI, or the UE is configured with higher layer parameter *pur-DL-16QAM-Config* and the DCI is mapped onto the UE specific search space given by PUR-RNTI,- If the 4-bit "modulation and coding scheme" field () in the DCI is set to ‘1111’,- use modulation order, **=** 4- otherwise- use modulation order, **=** 2.- otherwise- use modulation order, **=** 2. |
| Ericsson v012 | We support the TP cited above by the Moderator. |
| Nokia, NSB | We support the FL’s proposal. |

### Support of 16-QAM in TB processing of NPUSCH

In section 3.2.1, it is proposed to capture the missed part of 16-QAM in TB processing of NPUSCH, with the following text proposal:

|  |
| --- |
| --------------------------------------------------------- Text Start ---------------------------------------------------------6.3.2 Uplink shared channelFigure 6.3.2-1 shows the processing structure for the UL-SCH transport channel. Data arrives to the coding unit in the form of a maximum of one transport block over a number of resource units per UL cell. The number of resource units is scheduled according to [3]. The following coding steps can be identified:- CRC attachment- Channel coding- Rate matchingFigure 6.3.2-1: Transport block processing for UL-SCHThe CRC attachment, channel coding, and rate matching are performed according to clauses 5.2.2.1, 5.2.2.3, and 5.2.2.4, respectively, with the following differences: - In clause 5.1.4.1.2 in the calculation of  , *Qm* is 1 for π/2-BPSK, 2 for π/4-QPSK and 4 for 16QAM, and *rvidx* = 0 or 2. In addition, after rate matching interleaving is applied per resource unit according to clauses 5.2.2.7 and 5.2.2.8 without any control information in order to apply a time-first rather than frequency-first mapping, where the input sequence to 5.2.2.7 is the portion of *e* for a resource unit instead of *f*, and where  is the number of SC-FDMA symbols for NPUSCH in a UL resource unit as given in clause 10.1.2.3 of [2].------------------------------------------------------- Text End ----------------------------------------------------------- |

Please input your comments regarding the above text proposal:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | OK with the TP. It seems needed, since now 16QAM is supported. |
| Qualcomm | It is unclear why this change is needed. This clause defines the value of $Q\_{m}$ for those modulation schemes that are only supported in NB-IoT (and therefore are not present in the following text in 5.1.4.1.2):Set where *Qm* is equal to 2 for QPSK, 4 for 16QAM, 6 for 64QAM and 8 for 256QAM, and where16-QAM is already there, so there is no need to list it in “with the following differences”.Actually, the mentioning of pi/2 BPSK could be removed since it is supported in eMTC as well (and referred in 5.1.4.1.2 explicitly) – the text above is from latest Rel-13, where pi/2 BPSK was not supported for eMTC. |
| Lenovo, MotoM | It is better to keep the original text (although *2 for π/4-QPSK* is redundant from Rel.13) |
| Ericsson v006 | Thanks to Qualcomm for the comment, in that case we need to make the specification consistent and under the same argument given that “π/2-BPSK” is already in 5.1.4.1.2 then it should be removed since it does not fall anymore into category “*with the following differences*” either. |
| Huawei, HiSilicon | Share the same view as QC |
| ZTE, Sanechips | If there is no technical problem, Rel-13 modification is not expected and original text can be kept. |
| Ericsson v009 | To ZTE:The problem would be the inconsistency in the specifications, since based on clause 5.1.4.1.2 we wouldn’t be applying the same logic to “16QAM” and “π/2-BPSK”. |
| Moderator | It seems the proposed change is not needed. Please continue to discuss whether the change of legacy spec is needed. |
| Ericsson v012 | To avoid future misunderstandings, to apply the same logic/argument, and to make the specification consistent:Given that “π/2-BPSK” is already in 5.1.4.1.2 then it should be removed since it does not fall anymore into category “*with the following differences*”. |
| Nokia, NSB | We have no strong view. We think it’s OK to remove the “π/2-BPSK”. |
| ZTE, Sanechips | Thanks for the clarification. We can go with the majority.  |

### Uplink power control for PUR NPUSCH with 16QAM

In section 3.2.2.1 of [8], it is proposed to add the uplink power control for NPUSCH with 16-QAM, with following text proposal:

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| --- |
| ------------------------------------------------------- Text Start ----------------------------------------------------------16.2.1.1.1 UE behaviourThe setting of the UE Transmit power for a Narrowband Physical Uplink Shared Channel (NPUSCH) transmission is defined as follows. For FDD, if the UE is capable of enhanced random access power control [12], and it is configured by higher layers, and for TDD, enhanced random access power control shall be applied for a UE which started the random access procedure in the first or second configured NPRACH repetition level.------------------------------------------------------- Text Omitted -------------------------------------------------------- If NPUSCH (re)transmissions with 16QAM or NPUSCH (re)transmission corresponding to preconfigured uplink resource with 16QAM,- $Δ\_{TF,c}\left(i\right)=10log\_{10}\left(\left(2^{BPRE⋅K\_{s}}−1\right)\right)$ for and $∆\_{TF,c}(i)=0$ for where  is given by the parameter *deltaMCS-Enabled* provided by higher layers for serving cell , and- $BPRE=K/N\_{RE}$ where $K$ is the code block size and $N\_{RE}$ is the number of resource elements determined as $N\_{RE}=(N\_{symb}^{UL}−1)N\_{slots}^{UL}N\_{sc}^{RU}N\_{RU}$ where $N\_{symb}^{UL}$, $N\_{slots}^{UL}$, $N\_{sc}^{RU}$ are defined in [3], and $N\_{RU}$ is defined in section 16.5.1.1- otherwise $∆\_{TF,c}(i)=0$.------------------------------------------------------- Text End ----------------------------------------------------------- |

Please input your comments regarding the above text proposal:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | Ok with the TP. The new term in the UE’s transmit power control equation is also applicable for PUR, nonetheless since the statement “NPUSCH (re)transmissions with 16QAM” does not encompass PUR, then an explicit statement about PUR needs to be added. |
| Lenovo, MotoM | The CR is not necessary. “If NPUSCH (re)transmissions with 16QAM” includes NPUSCH (re)transmission with PUR |
| Ericsson v006 | I do not think “NPUSCH (re)transmissions with 16QAM” includes “NPUSCH (re)transmission corresponding to preconfigured uplink resource with 16QAM”.All over the place in the technical specifications we have been distinguishing ordinary “NPUSCH (re)transmissions” from “NPUSCH (re)transmission corresponding to preconfigured uplink resource” through such a differentiated wording. |
| Huawei, HiSilicon | Literally it seems it already includes the PUR PUSCH as commented by Lenovo. We may need to further check whether the spec has any differences. |
| ZTE, Sanechips | Before this TP, we may need the agreement to support the new term for PUR |
| Ericsson v009 | To ZTE:ΔTF was introduced into the UE’s transmit power control equation to account for the fact that 16-QAM uses 4-bits per M-ary symbol. PUR makes use of the UE’s transmit power control equation and can be configured to use 16-QAM which uses the new term ΔTF. Indeed, from TS 36.331, you can see that PUR-Config-NB refers to UplinkPowerControlDedicated which contains the new term ΔTF. |
| Moderator | On whether a new agreement is needed, it seems the PUR PUSCH with 16QAM also uses the power control as in the endorsed RRC parameter:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| NB\_IOTenh4\_LTE\_eMTC6 | ...　 | enable16QAM-ul in PUR-config-NB | … | According to the following agreement, the configurations are up to RAN2, including the MCS indices, RU indices and UL power control parameter: AgreementTo 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• The corresponding configurations and signaling details are up to RAN2 |

On whether “NPUSCH (re)transmissions with 16QAM” includes “NPUSCH (re)transmission corresponding to preconfigured uplink resource with 16QAM”, by checking the spec, in the same part as the text proposal, the NPUSCH (re)transmission also covers NPUSCH (re)transmission corresponding to preconfigured uplink resource:For NPUSCH (re)transmissions corresponding to the random access response grant if enhanced random access power control is not applied, and for all other NPUSCH transmissions except for NPUSCH (re)transmission corresponding to preconfigured uplink resource, when the number of repetitions of the allocated NPUSCH RUs is greater than 2: |
| Ericsson v012 | Firstly, it should be now clear from what I cited on “PUR-Config-NB” and “UplinkPowerControlDedicated” and also from the text-box that the Moderator cited that the new term applies for PUR.Secondly, on whether “NPUSCH (re)transmissions with 16QAM” includes “NPUSCH (re)transmission corresponding to preconfigured uplink resource with 16QAM”, in many places of the specification we have explicitly distinguished between those two. The main intention is to hint that for “the parameter *deltaMCS-Enabled* provided by higher layers” there are two cases and in one of those cases is in “PUR-Config-NB”. |
| ZTE, Sanechips | The issue1 is still in the discussion. If $∆\_{TF,c}\left(i\right)$ is also applied to QPSK, then the text also need additionally modified since it is not only for 16-QAM. Therefore, modifications can be made later based on the final conclusions of issue1. |

### The indices of MCS for PUR NPUSCH

In section 3.2.2.2 of [8], it is proposed to clarify how the indices of MCS for PUR NPUSCH is provided, with the following text proposal:

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| --- |
| ------------------------------------------------------- Text Start ----------------------------------------------------------16.5.1.2 Modulation order, redundancy version and transport block size determinationTo determine the modulation order, redundancy version and transport block size for the NPUSCH, the UE shall first- read the "modulation and coding scheme" field () in the DCI or configured by higher layers for NPUSCH transmission using preconfigured uplink resource, and- read the "redundancy version" field () in the DCI or initiate with $rv\_{DCI}=0$ for NPUSCH transmission using preconfigured uplink resource, and- read the "resource assignment" field () in the DCI or configured by higher layers for NPUSCH transmission using preconfigured uplink resource, and - compute the total number of allocated subcarriers (), number of resource units (), and repetition number () according to Clause 16.5.1.1.------------------------------------------------------- Text Omitted -------------------------------------------------------The UE shall use (,) and Table 16.5.1.2-2 to determine the TBS to use for the NPUSCH. is given in Table 16.5.1.2-1 if , or $I\_{TBS}=I\_{MCS}^{'}+14$ if NPUSCH with 16QAM except for NPUSCH transmission using preconfigured uplink resource in which case the corresponding indices are provided in *PUR-Config-NB*,  otherwise. $I\_{MCS}^{'}$ is the value of the "modulation and coding scheme for 16QAM" in the DCI.------------------------------------------------------- Text End ----------------------------------------------------------- |

Please input your comments regarding the above text proposal:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | Ok with the TP, since it is not captured from where the information is obtained in the case of NPUSCH transmission using preconfigured uplink resources. |
| Lenovo, MotoM | OK with the TP in general. Can we directly use $I\_{TBS}$ instead of the corresponding indices.or $I\_{TBS}=I\_{MCS}^{'}+14$ if NPUSCH with 16QAM except for NPUSCH transmission using preconfigured uplink resource in which case $I\_{TBS}$ is given by *npusch-MCS-r17* in *PUR-Config-NB*, |
| Huawei, HiSilicon | Generally we are fine and the updates from Lenovo seems more clear. |
| ZTE, Sanechips | We are generally fine with the TP. |
| Moderator | Please check the TP proposed by Lenovo, MotoM as below:============text proposal==============================16.5.1.2 Modulation order, redundancy version and transport block size determination<unchanged part is omitted>The UE shall use (,) and Table 16.5.1.2-2 to determine the TBS to use for the NPUSCH. is given in Table 16.5.1.2-1 if , or $I\_{TBS}=I\_{MCS}^{'}+14$ if NPUSCH with 16QAM except for NPUSCH transmission using preconfigured uplink resource in which case $\_{}$is given by *npusch-MCS-r17* in *PUR-Config-NB*,  otherwise. $I\_{MCS}^{'}$ is the value of the "modulation and coding scheme for 16QAM" in the DCI.============text proposal============================== |
| Ericsson v012 | The text in the specifications starts stating “*The UE shall use (,) and Table 16.5.1.2-2 to determine the TBS to use for the NPUSCH*”. On this matter, when I wrote “indices” (i.e., plural) is because I meant to cover both ITBS and IRU since they are both pre-configured in the case of PUR.So, below I have incorporated the “IRU” index, and I have removed the appended “-r17” since it is not written that way in the RAN2 latest running CR (i.e., the rel-16 field was re-used with a note for 16-QAM in *PUR-Config-NB* field descriptions).<unchanged part is omitted>The UE shall use (,) and Table 16.5.1.2-2 to determine the TBS to use for the NPUSCH. is given in Table 16.5.1.2-1 if , or $I\_{TBS}=I\_{MCS}^{'}+14$ if NPUSCH with 16QAM except for NPUSCH transmission using preconfigured uplink resource in which case $\_{}$and $\_{}$ are respectively given by *npusch-MCS* and *npusch-NumRUsIndex* in *PUR-Config-NB*,  otherwise. $I\_{MCS}^{'}$ is the value of the "modulation and coding scheme for 16QAM" in the DCI.============text proposal============================== |
| Nokia, NSB | We are OK with the FL’s proposal and Ericsson’s update. |
| Lenovo | 1.  has been specified at the beginning of 16.5.1.2, so there is no need duplicated specification in the TBS determination.- read the "resource assignment" field () in the DCI or configured by higher layers for NPUSCH transmission using preconfigured uplink resource, and 2. After reviewing the latest 331 running CR of R2-2202427, Rel.16 field of *npusch-MCS* is reused. So, we are OK to remove the appended“-r17”.***npusch-MCS***Index to tables specified in TS 36.213 [23], Table 16.5.1.2-1 and Table 16.5.1.2-2 for single tone and multi tone respectively, that defines modulation and TBS index for NPUSCH for PUR. In case of *pur-UL-16QAM-Config* included and set to setup, *multiTone* index is used, for the guardband and standalone modes the 16-QAM MCS index is equal to the value of *multiTone* + 14, for the inband mode the 16-QAM MCS index is equal to the value of *multiTone* + 11.Lenovo comment for the latest 331: We are not sure why do we need to separate the operation modes for NPUSCH transmission above.============text proposal==============================16.5.1.2 Modulation order, redundancy version and transport block size determination<unchanged part is omitted>The UE shall use (,) and Table 16.5.1.2-2 to determine the TBS to use for the NPUSCH. is given in Table 16.5.1.2-1 if , or $I\_{TBS}=I\_{MCS}^{'}+14$ if NPUSCH with 16QAM except for NPUSCH transmission using preconfigured uplink resource in which case $\_{}$is given by *npusch-MCS* in *PUR-Config-NB*,  otherwise. $I\_{MCS}^{'}$ is the value of the "modulation and coding scheme for 16QAM" in the DCI.============text proposal============================== |

## Others

There are also following proposals:

|  |  |
| --- | --- |
| Sourcing | Proposals |
| [6] | ***Proposal 3: DL 16QAM in PUR is configured only in condition that DL 16QAM in connected mode is configured*** |

Please input your comments regarding the above proposal, or any other critical issues you think should be discussed:

|  |  |
| --- | --- |
| Companies | Comments |
| Ericsson | In our view there is no need to tie idle-mode to connected-mode for the 16-QAM feature. PUR has its own toolbox to perform adjustments (e.g., ways of determining if the UE requires a PUR re-configuration) and therefore there is no need of conditioning the usage of 16-QAM for PUR based on a configuration for connected-mode, since the PUR feature should maintain its autonomy. |
| Qualcomm | This restriction is unnecessary. |
| Lenovo, MotoM | We are willing to accept the configurations separately. However, eNB schedules MCS for DL 16QAM in connected mode based on the new CQI table, while UE in idle mode (e.g., PUR) don’t support the CQI reporting. We are wondering how does the eNB configure a suitable MCS (e.g., 16QAM) for UE in PUR when DL16QAM in connected mode is disabled while the DL 16QAM in PUR is enabled? Based on RSRP/RSRQ? Based on statical TB BLER? |
| ZTE, Sanechips | For PUR, dedicated signaling pur-UL-16QAM-Config-r17 for 16-QAM is used. No need to introduce this kind of restriction. |
| Nokia, NSB | There is no need to introduce this restriction. |

# Summary

# References

1. RP-211340, “WID revision: Additional enhancements for NB-IoT and LTE-MTC”, Huawei, HiSilicon, RAN#92e, E-meeting, June 2021.
2. R1-2200976 Support of 16QAM for unicast in UL and DL in NB-IoT Huawei, HiSilicon
3. R1-2201135 Discussion on remaining issues for NB-IoT 16QAM ZTE, Sanechips
4. R1-2201407 Support of 16-QAM for unicast in UL and DL for NB-IoT Nokia, Nokia Shanghai Bell
5. R1-2201650 Support of 16-QAM for NB-IoT Qualcomm Incorporated
6. R1-2201968 Support 16QAM for NBIoT Lenovo, Motorola Mobility
7. R1-2202076 Remaining issue for support 16QAM in NB-IOT R17 MediaTek Inc.
8. R1-2202277 Support of 16-QAM for unicast in UL and DL in NB-IoT Ericsson
9. R1-2202280 Clarification on the support of 16-QAM for NB-IoT in TS 36.212 Ericsson
10. R1-2202281 Clarification on the support of 16-QAM for NB-IoT in TS 36.213 Ericsson
11. R1-2202477 Further considerations on Rel-17 NB-IoT and eMTC enhancements Huawei, HiSilicon