**3GPP TSG RAN WG1 Meeting #107-e R1-21xxxxx**

**e-Meeting, November 11th – 19th, 2021**

**Agenda Item: 8.9.1**

**Source: Moderator (Huawei)**

**Title: Feature lead summary #3 on 107-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].

[107-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

From previous discussion, the following proposals are agreeable.

**Proposal 1: confirm the following working assumption.**

**For the new term**  **introduced for power control of NPUSCH,**

* 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.
* 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 can also be applied to NPUSCH with QPSK, when 16-QAM is configured.
* Option 2: An offset to is configured from a set of {[1dB], [2dB], [4dB], [6dB]}, when 16-QAM is configured.

For information, the calculated are summarized in the following table:

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Modulation |  |  |  | | | | | | | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| QPSK | 13 | TBS | 224 | 488 | 744 | 1032 | 1256 | 1544 | 2024 | 2536 |
|  | 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.

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

**Proposal 2: it is down-selected from following options in this meeting:**

* **Option 1: The term can also be applied to NPUSCH with QPSK, when 16-QAM is configured.**
* **Option 2: An offset to is configured from a set of {[1dB], [2dB], [4dB], [6dB]}, when 16-QAM is configured.**

Please input your comments regarding following points in the table:

* Your comments to the proposals.
* Your proposal on the offset.

|  |  |
| --- | --- |
| Companies | Comments |
| Moderator | From the comments, there are concerns for option 1 as below:  ZTE: If the term is used for QPSK, the legacy QPSK power for some entries would be decreased, which would effect the legacy QPSK performance.  Ericsson: Option 1 results in side effects that should not be overlooked, and that is the reason why Option 2 is preferred.  And the concerns over option 2 is:  Nokia: In our understanding, when deltaMCS is enabled, the UL power should be adjusted according to the MCS level. If this is only done for 16QAM, then in our view this does not follow the underlying principle of this power control operation.  Please proponents of each option address the above concerns. |
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|  |  |

## Channel quality reporting

### Issue 2: CQI table

The following has been achieved:

Agreement

* The table is taken as working assumption.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Reported value | NPDCCH repetition level | NPDSCH transport block  error probability not exceeding 0.1 | | | | SNR |
| Modulation | Code rate x 1024 | Repetition | Efficiency |
| noMeasurement | No measurement reporting | Out of range | | | |  |
| candidateRep-A | 1 | QPSK (TBS index 4) | 221 | 1 | 0.4316 | -0.6 dB ([2]) |
| candidateRep-B | 2 | QPSK (TBS index 2) | 280 | 1 | 0.2737 | -3.6 |
| candidateRep-C | 4 | QPSK (TBS index 0) | 81 | 1 | 0.1579 | -6.6 |
| candidateRep-D | 8 | QPSK (TBS index 0) | 81 | 2 | 0.0789 | -9.6 |
| candidateRep-E | 16 | QPSK (TBS index 0) | 81 | 4 | 0.0395 | -12.6 |
| Working assumption  candidateRep-F | 32 | QPSK (TBS index 0) | 81 | 8 | 0.0198 | -15.6 |
| candidateRep-G | 1 | QPSK (TBS index 6) | 336.8 | 1 | 0.6579 | 1.0 dB ([3]) |
| candidateRep-H | 1 | QPSK (TBS index 8) | 453.6 | 1 | 0.8860 | 2.6 dB ([3]) |
| candidateRep-I | 1 | QPSK (TBS index 10) | 579.4 | 1 | 1.1316 | 4.1 dB ([3]) |
| candidateRep-J | 1 | QPSK (TBS index 12) | 759 | 1 | 1.4825 | 6.3 dB ([3]) |
| candidateRep-K | 1 | 16QAM (TBS index 14) | 487.3 | 1 | 1.9035 | 8.9 dB ([3]) |
| candidateRep-L | 1 | 16QAM (TBS index 16) | 541.2 | 1 | 2.1140 | 9.7 dB ([3]) |
| candidateRep-M | 1 | 16QAM (TBS index 18) | 658 | 1 | 2.5702 | 11.7 dB ([3]) |
| candidateRep-N | 1 | 16QAM (TBS index 20) | 783.7 | 1 | 3.0614 | 13.0 dB ([3]) |
| candidateRep-O | 1 | 16QAM (TBS index 21) | 837.6 | 1 | 3.2719 | 14.1 dB ([3]) |

Note: The (TBS index X) and SNR are just for information, based on standalone deployment. They will be removed once it’s agreed.

On the CQI derivation, there’s the following in TS 36.213:

For a BL/CE UE, based on an unrestricted observation interval in time and frequency, the UE shall derive for each CQI value the highest CQI index between 1 and 10 in Table 7.2.3-3 which satisfies the following condition, or CQI index 0 if CQI index 1 does not satisfy the condition:

- A single PDSCH transport block with a combination of modulation scheme and transport block size corresponding to the CQI index, and occupying a group of downlink physical resource blocks termed the CSI reference resource, could be received with a transport block error probability not exceeding 0.1.

And for NB-IoT measurement report, there’s the following TS 36.133:

The DL channel quality provides the serving eNB with information about the minimum NPDCCH repetition level to satisfy the hypothetical NPDCCH block error rate of 1% with the parameters specified in Table 6.6.2.6-1.

Then, it would be straightforward to combine the above for channel quality reporting of 16QAM:

The DL channel quality provides the serving eNB with information about the minimum entry satisfying the folllowing condition,

- NPDCCH repetition level to satisfy the hypothetical NPDCCH block error rate of 1% with the parameters specified in Table 6.6.2.6-1, and

- A single PDSCH transport block with a combination of modulation scheme and transport block size corresponding to the CQI index, and occupying a group of downlink physical resource blocks termed the CSI reference resource, could be received with a transport block error probability not exceeding 0.1.

As this is verbose, and the majority view is to capture it in RAN4, maybe the above can be included in the LS to RAN4 as an information.

On the concern on different deployment, as there’s the sentence “A single PDSCH transport block with a combination of modulation scheme and transport block size corresponding to the CQI index” as in legacy, the eNB and UE can derive the corresponding TBS for different deployments based on available REs, which is known to both eNB and UE.

With the above explanation, please give your comments on confirming the above working assumption:

|  |  |
| --- | --- |
| Companies | Comments |
|  |  |
|  |  |
|  |  |

### Issue 3: Switching of CQI table

As commented by several companies, the switching between the legacy table and the CQI table should be discussed.

**Proposal 3: When 16QAM is configured, the new CQI table is used. FFS on use of legacy measurement reporting down-selected from following 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.**
  + **Option 3: eNB configures the use of legacy or new CQI table via RRC configuration**
  + **Option 4: if Rmax<=16, the new CQI table is used, otherwise, the legacy CQI table is used.**

For Qualcomm’s preference and option 5 proposed by Ericsson, my understanding is that it has been captured in the main bullet of the above proposal. The 4 options are FFS whether a further step is needed based on the main bullet. Therefore, the option 5 seems not needed. Please check whether this makes sense.

Please input your comments regarding the above options.

|  |  |
| --- | --- |
| Companies | Comments |
| Huawei, HiSilicon | We prefer option 1. For option 2 and option 3, the report is controlled by eNB, which will lead to the result that the CQI reporting will lack accuracy and does not reflect the channel condition level according to the UE real-time measurement. Thus, the switching of CQI table should be determined by the UE. |
| MTK | Our first preference is **Option 1**, second preference is **Option 2**. Although network can take legacy report in Msg3 as initial reference for selection of new or old CQI table, the indicated CQI table may be mismatched due to the channel are varying. For example, UEs may report NPDCCH repletion 16/32 in Msg3 and accordingly the network should indicate the use of new CQI table, but the UE measured Channel quality may become too worse after an uncertain period so that UE need to report 64 repetition, this will cause CQI table changing. Option 1 can completely accommodate this case. |
| ZTE, Sanechips | Option1 is preferred.  From option1 to option4, it is observed that the flexibility for reporting is decreasing.   * For option1, UE can flexibly choose any entry to report according the channel condition. Moreover, Mac CE report is faster than RRC configuration. * For option2, eNB decide which table will be used for UE CQI reporting. Compared with option1, eNB is not as sensitive to channel condition as UE and switching between legacy table and new table is also not as flexible as option1. * For option3, as mentioned, RRC configuration would have larger delay than Mac CE report. * For option4, it is a kind of eNB implementation of option3 and option4 can be viewed as an specific example of option3. |
| Ericsson v020 | As we said we prefer Option 4, and as a second preference we are open to discuss MAC CE-based solutions (although that will create another impact in the “MAC CE impacts” list).  To Qualcomm, by “variant of Option 3”, do you mean that 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, so no additional signal explicitly indicates to switch the table in connected mode? |
| Qualcomm | @Ericsson: Yes. This is the same approach that was followed in LTE in the past (the CQI and MCS table are configured together). Additionally, when we discussed the feature list for 16-QAM, Qualcomm wanted to make the CSI report optional in a separate FG from 16-QAM, but companies commented (summary [here](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_106b-e/Docs/R1-2109715.zip)) that the enhanced CSI report was necessary to schedule 16-QAM. |
| Moderator | The discussion of each option is reserved for further reference. And the situation is as following:   * + Option 1: UE indicates the use of legacy or new CQI table via MAC CE.     - Huawei, HiSilicon, MTK (1st), ZTE, Sanechips,   + Option 2: eNB indicates the use of legacy or new CQI table via MAC CE.     - Ericsson (2nd), Lenovo, Moto (2nd), MTK(2nd)   + Option 3: eNB configures the use of legacy or new CQI table via RRC configuration     - Lenovo, Moto (2nd), Nokia, NSB   + Option 4: if Rmax<=16, the new CQI table is used, otherwise, the legacy CQI table is used.     - Ericsson (1st), Lenovo, Moto (1st),   + The legacy CQI table is not needed.     - QC   Please continue discussion to address the concerns presented by companies. |
|  |  |
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### Issue 4: The capturing of CQI table in spec

Based on the comments, the following seems to be agreeable:

**Proposal 4: The new CQI table is captured in TS 36.133, send LS to RAN2/RAN4 of the agreements on channel quality reporting.**

Please input your comments regarding the above options.

|  |  |
| --- | --- |
| Companies | Comments |
|  |  |
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# Summary

# References

1. RP-211340, “WID revision: Additional enhancements for NB-IoT and LTE-MTC”, Huawei, HiSilicon, RAN#92e, E-meeting, June 2021.
2. R1-2110857 Support of 16QAM for unicast in UL and DL in NB-IoT Huawei, HiSilicon
3. R1-2111070 Discussion on 16QAM for NB-IoT ZTE, Sanechips
4. R1-2111133 Support of 16-QAM for NB-IoT Nokia, Nokia Shanghai Bell
5. R1-2111449 Support of 16-QAM for NB-IoT Qualcomm Incorporated
6. R1-2112001 Support 16QAM for NBIoT Lenovo, Motorola Mobility
7. R1-2112300 Discussion on CQI table and NPUSCH power control parameter for 16QAM MediaTek Inc.
8. R1-2112361 Support of 16-QAM for unicast in UL and DL in NB-IoT Ericsson
9. R1-2111939 Further considerations on Rel-17 NB-IoT and eMTC enhancements Huawei, HiSilicon
10. R1-2112363 On the support of 16-QAM for unicast in UL and DL in TDD NB-IoT Ericsson

# Appendix A

## A.1 The coding rate and efficiency

Assuming 2 NRS ports in standalone deployment, then the coding rate and efficiency for QPSK and 16QAM MCS are summarized in the following table, assuming repetition number is one

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Modulation | I\_TBS | I\_sf | | | | | | | | | | | |
| 0 | | | 1 | | | 2 | | | 3 | | |
| TBS | Coding rate (X 1024) | Efficiency | TBS | Coding rate (X 1024) | Efficiency | TBS | Coding rate (X 1024) | Efficiency | TBS | Coding rate (X 1024) | Efficiency |
| BPSK | 0 | 16 | 107.7894737 | 0.105263158 | 32 | 107.7894737 | 0.105263158 | 56 | 125.754386 | 0.122807018 | 88 | 148.2105263 | 0.144736842 |
| QPSK | 1 | 24 | 80.84210526 | 0.157894737 | 56 | 94.31578947 | 0.184210526 | 88 | 98.80701754 | 0.192982456 | 144 | 121.2631579 | 0.236842105 |
| BPSK | 2 | 32 | 215.5789474 | 0.210526316 | 72 | 242.5263158 | 0.236842105 | 144 | 323.3684211 | 0.315789474 | 176 | 296.4210526 | 0.289473684 |
| QPSK | 3 | 40 | 134.7368421 | 0.263157895 | 104 | 175.1578947 | 0.342105263 | 176 | 197.6140351 | 0.385964912 | 208 | 175.1578947 | 0.342105263 |
| QPSK | 4 | 56 | 188.6315789 | 0.368421053 | 120 | 202.1052632 | 0.394736842 | 208 | 233.5438596 | 0.456140351 | 256 | 215.5789474 | 0.421052632 |
| QPSK | 5 | 72 | 242.5263158 | 0.473684211 | 144 | 242.5263158 | 0.473684211 | 224 | 251.5087719 | 0.49122807 | 328 | 276.2105263 | 0.539473684 |
| QPSK | 6 | 88 | 296.4210526 | 0.578947368 | 176 | 296.4210526 | 0.578947368 | 256 | 287.4385965 | 0.561403509 | 392 | 330.1052632 | 0.644736842 |
| QPSK | 7 | 104 | 350.3157895 | 0.684210526 | 224 | 377.2631579 | 0.736842105 | 328 | 368.2807018 | 0.719298246 | 472 | 397.4736842 | 0.776315789 |
| QPSK | 8 | 120 | 404.2105263 | 0.789473684 | 256 | 431.1578947 | 0.842105263 | 392 | 440.1403509 | 0.859649123 | 536 | 451.3684211 | 0.881578947 |
| QPSK | 9 | 136 | 458.1052632 | 0.894736842 | 296 | 498.5263158 | 0.973684211 | 456 | 512 | 1 | 616 | 518.7368421 | 1.013157895 |
| QPSK | 10 | 144 | 485.0526316 | 0.947368421 | 328 | 552.4210526 | 1.078947368 | 504 | 565.8947368 | 1.105263158 | 680 | 572.6315789 | 1.118421053 |
| QPSK | 11 | 176 | 592.8421053 | 1.157894737 | 376 | 633.2631579 | 1.236842105 | 584 | 655.7192982 | 1.280701754 | 776 | 653.4736842 | 1.276315789 |
| QPSK | 12 | 208 | 700.6315789 | 1.368421053 | 440 | 741.0526316 | 1.447368421 | 680 | 763.5087719 | 1.49122807 | 904 | 761.2631579 | 1.486842105 |
| QPSK | 13 | 224 | 754.5263158 | 1.473684211 | 488 | 821.8947368 | 1.605263158 | 744 | 835.3684211 | 1.631578947 | 1032 | 869.0526316 | 1.697368421 |
| 16QAM | 14 | 256 | 431.1578947 | 1.684210526 | 552 | 464.8421053 | 1.815789474 | 840 | 471.5789474 | 1.842105263 | 1128 | 474.9473684 | 1.855263158 |
| 16QAM | 15 | 280 | 471.5789474 | 1.842105263 | 600 | 505.2631579 | 1.973684211 | 904 | 507.5087719 | 1.98245614 | 1224 | 515.3684211 | 2.013157895 |
| 16QAM | 16 | 296 | 498.5263158 | 1.947368421 | 632 | 532.2105263 | 2.078947368 | 968 | 543.4385965 | 2.122807018 | 1288 | 542.3157895 | 2.118421053 |
| 16QAM | 17 | 336 | 565.8947368 | 2.210526316 | 696 | 586.1052632 | 2.289473684 | 1064 | 597.3333333 | 2.333333333 | 1416 | 596.2105263 | 2.328947368 |
| 16QAM | 18 | 376 | 633.2631579 | 2.473684211 | 776 | 653.4736842 | 2.552631579 | 1160 | 651.2280702 | 2.543859649 | 1544 | 650.1052632 | 2.539473684 |
| 16QAM | 19 | 408 | 687.1578947 | 2.684210526 | 840 | 707.3684211 | 2.763157895 | 1288 | 723.0877193 | 2.824561404 | 1736 | 730.9473684 | 2.855263158 |
| 16QAM | 20 | 440 | 741.0526316 | 2.894736842 | 904 | 761.2631579 | 2.973684211 | 1384 | 776.9824561 | 3.035087719 | 1864 | 784.8421053 | 3.065789474 |
| 16QAM | 21 | 488 | 821.8947368 | 3.210526316 | 1000 | 842.1052632 | 3.289473684 | 1480 | 830.877193 | 3.245614035 | 1992 | 838.7368421 | 3.276315789 |

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Modulation | I\_TBS | I\_sf | | | | | | | | | | | |
| 4 | | | 5 | | | 6 | | | 7 | | |
| TBS | Coding rate (X 1024) | Efficiency | TBS | Coding rate (X 1024) | Efficiency | TBS | Coding rate (X 1024) | Efficiency | TBS | Coding rate (X 1024) | Efficiency |
| BPSK | 0 | 120 | 161.6842105 | 0.157894737 | 152 | 170.6666667 | 0.166666667 | 208 | 175.1578947 | 0.171052632 | 256 | 172.4631579 | 0.168421053 |
| QPSK | 1 | 176 | 118.5684211 | 0.231578947 | 208 | 116.7719298 | 0.228070175 | 256 | 107.7894737 | 0.210526316 | 344 | 115.8736842 | 0.226315789 |
| BPSK | 2 | 208 | 280.2526316 | 0.273684211 | 256 | 287.4385965 | 0.280701754 | 328 | 276.2105263 | 0.269736842 | 424 | 285.6421053 | 0.278947368 |
| QPSK | 3 | 256 | 172.4631579 | 0.336842105 | 328 | 184.1403509 | 0.359649123 | 440 | 185.2631579 | 0.361842105 | 568 | 191.3263158 | 0.373684211 |
| QPSK | 4 | 328 | 220.9684211 | 0.431578947 | 408 | 229.0526316 | 0.447368421 | 552 | 232.4210526 | 0.453947368 | 680 | 229.0526316 | 0.447368421 |
| QPSK | 5 | 424 | 285.6421053 | 0.557894737 | 504 | 282.9473684 | 0.552631579 | 680 | 286.3157895 | 0.559210526 | 872 | 293.7263158 | 0.573684211 |
| QPSK | 6 | 504 | 339.5368421 | 0.663157895 | 600 | 336.8421053 | 0.657894737 | 808 | 340.2105263 | 0.664473684 | 1032 | 347.6210526 | 0.678947368 |
| QPSK | 7 | 584 | 393.4315789 | 0.768421053 | 680 | 381.754386 | 0.745614035 | 968 | 407.5789474 | 0.796052632 | 1224 | 412.2947368 | 0.805263158 |
| QPSK | 8 | 680 | 458.1052632 | 0.894736842 | 808 | 453.6140351 | 0.885964912 | 1096 | 461.4736842 | 0.901315789 | 1352 | 455.4105263 | 0.889473684 |
| QPSK | 9 | 776 | 522.7789474 | 1.021052632 | 936 | 525.4736842 | 1.026315789 | 1256 | 528.8421053 | 1.032894737 | 1544 | 520.0842105 | 1.015789474 |
| QPSK | 10 | 872 | 587.4526316 | 1.147368421 | 1032 | 579.3684211 | 1.131578947 | 1384 | 582.7368421 | 1.138157895 | 1736 | 584.7578947 | 1.142105263 |
| QPSK | 11 | 1000 | 673.6842105 | 1.315789474 | 1192 | 669.1929825 | 1.307017544 | 1608 | 677.0526316 | 1.322368421 | 2024 | 681.7684211 | 1.331578947 |
| QPSK | 12 | 1128 | 759.9157895 | 1.484210526 | 1352 | 759.0175439 | 1.48245614 | 1800 | 757.8947368 | 1.480263158 | 2280 | 768 | 1.5 |
| QPSK | 13 | 1256 | 846.1473684 | 1.652631579 | 1544 | 866.8070175 | 1.692982456 | 2024 | 852.2105263 | 1.664473684 | 2536 | 854.2315789 | 1.668421053 |
| 16QAM | 14 | 1416 | 476.9684211 | 1.863157895 | 1736 | 487.2982456 | 1.903508772 | 2280 | 480 | 1.875 | 2856 | 481.0105263 | 1.878947368 |
| 16QAM | 15 | 1544 | 520.0842105 | 2.031578947 | 1800 | 505.2631579 | 1.973684211 | 2472 | 520.4210526 | 2.032894737 | 3112 | 524.1263158 | 2.047368421 |
| 16QAM | 16 | 1608 | 541.6421053 | 2.115789474 | 1928 | 541.1929825 | 2.114035088 | 2600 | 547.3684211 | 2.138157895 | 3240 | 545.6842105 | 2.131578947 |
| 16QAM | 17 | 1800 | 606.3157895 | 2.368421053 | 2152 | 604.0701754 | 2.359649123 | 2856 | 601.2631579 | 2.348684211 | 3624 | 610.3578947 | 2.384210526 |
| 16QAM | 18 | 1992 | 670.9894737 | 2.621052632 | 2344 | 657.9649123 | 2.570175439 | 3112 | 655.1578947 | 2.559210526 | 4008 | 675.0315789 | 2.636842105 |
| 16QAM | 19 | 2152 | 724.8842105 | 2.831578947 | 2600 | 729.8245614 | 2.850877193 | 3496 | 736 | 2.875 | 4264 | 718.1473684 | 2.805263158 |
| 16QAM | 20 | 2344 | 789.5578947 | 3.084210526 | 2792 | 783.7192982 | 3.061403509 | 3752 | 789.8947368 | 3.085526316 | 4584 | 772.0421053 | 3.015789474 |
| 16QAM | 21 | 2472 | 832.6736842 | 3.252631579 | 2984 | 837.6140351 | 3.271929825 | 4008 | 843.7894737 | 3.296052632 | 4968 | 836.7157895 | 3.268421053 |