Issues for [104-bis-e][131] FR2 UL 256QAM

**Agenda item:** 6.7.4

**Source:** Moderator (Xiaomi)

# Topic #2: UL 256QAM

### Sub-topic 2-1: EVM evaluation by link level simulation

Summary of link level simulation results based on CP-OFDM from companies:

29GHz:

|  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |
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| Parameter | | | Nokia | | | LG Electronics | | | vivo | | | Huawei | | | Sony | | | Xiaomi | | | ZTE | | |
| Carrier frequency | | | 29 GHz | | | 29 GHz | | | 29 GHz | | | 29 GHz | | | 29 GHz | | | 29 GHz | | | 29 GHz | | |
| CBW | | | 50MHz | | | 100MHz | | | 50MHz/100MHz | | | 50MHz | | | 100MHz | | | 50MHz | | | 100MHz | | |
| SCS | | | 120kHz | | | 120kHz | | | 120kHz | | | 120kHz | | | 120kHz | | | 120kHz | | | 120kHz | | |
| Phase noise model | | | Option a):  example1 (UE)  + example1(BS) | | | Option b): example2 (UE) + example2(BS) | | |  | | | Option d): example1 (UE) + example2(BS) | | | Option b): example2 (UE) + example2(BS) | | | Option b): example2 (UE) + example2(BS) | | | Option b): example2 (UE) + example2(BS) | | |
| Tx EVM=Rx EVM | | | 3% | 3.5% | 4% | 2% | 3% | 3.5% | 3% | 3.5% | 4% | 3% | 3.5% | 4% | 3% | 3.5% | 4% | 3% | 3.5% | 4% | 3% | 3.5% | 4% |
| Target SNR(dB) | TDL-A |  |  |  |  | 24.5 | 27 | 30 | 22.5/23.8 | 22.7/24 | 23.2/24.7 |  |  |  |  |  |  | 21.8 | 22.7 | 23.8 | 25.90 | 26.45 | 27.23 |
| MCS23 |  |  |  | 29 | NA | NA |  |  |  |  |  |  |  |  |  | 26.5 | 28 | NA | 31.49 | 34.31 | - |
| TDL-D | MCS21 | 24-25 | | | 18.5 | 20 | 21 | 20.3/21.5 | 20.8/21.8 | 21.2/22 | 19.9 | 20.1 | 20.3 |  |  |  | 21.8 | 22.5 | 23.1 | 23.42 | 23.73 | 24.16 |
| MCS23 | 28 | 32 | NA | 23 | 24.5 | 27 |  |  |  |  |  |  |  |  |  | 25.8 | 27.3 | NA | 28.44 | 30.10 | 34.28 |
| AWGN | MCS21 |  |  |  | 16 | 16.5 | 17 | 19.2/19.7 | 19.5/19.7 | 19.8/19.9 |  |  |  | 22 | 23 | 24 | 19.3 | 19.5 | 19.6 | 21.31 | 21.71 | 22.19 |
| MCS23 |  |  |  | 19 | 20 | 21 |  |  |  |  |  |  |  |  |  | 23 | 23.5 | 25.5 | 25.92 | 27.66 | 31.06 |

39GHz

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| Parameter | | | Nokia | | vivo | | | Huawei | | | Xiaomi | | | ZTE | | |
| Carrier frequency | | | 39 GHz | | 39 GHz | | | 39 GHz | | | 39 GHz | | | 39 GHz | | |
| CBW | | | 50MHz | | 50MHz/100MHz | | | 50MHz | | | 50MHz | | | 100MHz | | |
| SCS | | | 120kHz | | 120kHz | | | 120kHz | | | 120kHz | | | 120kHz | | |
| Phase noise model | | | Option a):  example1 (UE)  + example1(BS) | |  | | | Option d): example1 (UE) + example2(BS) | | | Option b): example2 (UE) + example2(BS) | | | Option b): example2 (UE) + example2(BS) | | |
| Tx EVM=Rx EVM | | | 0% | 3%-4% | 3% | 3.5% | 4% | 3% | 3.5% | 4% | 3% | 3.5% | 4% | 3% | 3.5% | 4% |
| Target SNR(dB) | TDL-A | MCS21 |  |  | 28/NA | 29.2/NA | 34/NA |  |  |  | 25.2 | 26.7 | NA | 30.48 | 32.35 | 36.62 |
| MCS23 |  |  |  |  |  |  |  |  | NA | NA | NA | NA | NA | NA |
| TDL-D | MCS21 | 36 | NA | 24/NA | 25/NA | 25.8/NA | 20.8 | 21 | 21.2 | 24.1 | 25.2 | 28 | 26.36 | 27.50 | 29.23 |
| MCS23 |  |  |  |  |  |  |  |  | NA | NA | NA | NA | NA | NA |
| AWGN | MCS21 |  |  | 21.5/26 | 21.8/28 | 22/30 |  |  |  | 20 | 21.5 | 22 | 21.28 | 21.64 | 21.95 |
| MCS23 |  |  |  |  |  |  |  |  | NA | NA | NA | 25.86 | 27.64 | 30.62 |

48GHz:

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| Parameter | | | LG Electronics | | | vivo | | | Huawei | | | Xiaomi | | | ZTE | | |
| Carrier frequency | | | 48 GHz | | | 48 GHz | | | 48 GHz | | | 48 GHz | | | 48 GHz | | |
| CBW | | | 100MHz | | | 50MHz/100MHz | | | 50MHz | | | 50MHz | | | 100MHz | | |
| SCS | | | 120kHz | | | 120kHz | | | 120kHz | | | 120kHz | | | 120kHz | | |
| Phase noise model | | | Option b): example2 (UE) + example2(BS) | | |  | | | Option d): example1 (UE) + example2(BS) | | | Option b): example2 (UE) + example2(BS) | | | Option b): example2 (UE) + example2(BS) | | |
| Tx EVM=Rx EVM | | | 2% | 3% | 3.5% | 3% | 3.5% | 4% | 3% | 3.5% | 4% | 3% | 3.5% | 4% | 3% | 3.5% | 4% |
| Target SNR(dB) | TDL-A | MCS21 | NA | NA | NA | NA | NA | NA |  |  |  |  |  |  | NA | NA | NA |
| MCS23 | NA | NA | NA |  |  |  |  |  |  |  |  |  |  |  |  |
| TDL-D | MCS21 | 30 | NA | NA | NA | NA | NA | 22.4 | 22.6 | 23.2 |  |  |  | NA | NA | NA |
| MCS23 | NA | NA | NA |  |  |  |  |  |  |  |  |  |  |  |  |
| AWGN | MCS21 | 22.5 | 24 | 27.5 | NA | NA | NA |  |  |  | 24 | 25 | 28 | NA | NA | NA |
| MCS23 | NA | NA | NA |  |  |  |  |  |  | NA | NA | NA |  |  |  |

**Issue 2-1-1: EVM requirement for 29GHz**

* Proposals
  + Option 1: 3.5% EVM for 29GHz and operating SNR of 32 dB.
  + Option 2: 3.5% EVM for 29GHz and FFS for operating SNR. (i.e., use the average value based on the simulation results).
  + Option 3: 3.5% EVM for 29GHz and FFS operating SNR with limited MCS.
  + Option 4: Others.
* Recommended WF

Majority companies agree Option2, one company prefers Option 3 with limited MCS, from current submitted simulation results for MCS 23, majority companies’ simulation results for UL 256 QAM can get higher throughput than 64QAM.

For operating SNR based on TDL-D, MCS23, EVM 3.5%:

Nokia: 32dB;

LGE: 24.5dB;

Vivo: 27dB;

Xiaomi: 27.7dB;

ZTE: 30.1dB;

Average: 28dB.

Moderator recommends:

* + 3.5% EVM for 29GHz and using average value 28dB for operating SNR

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| --- | --- |
| **Company** | **Comments** |
| XXX | …. |
| vivo | both option 1 and option 2 are ok for us. |
| Nokia | Propose option 1.  Ok for option 2.  For option 3, simulation results show no need to limit MCS if higher operating SNR is available, need to first study system level SNR CDF. |
| LGE | Option3, Our link level simulation results about UL256QAM with 3.5% EVM for 29 GHz shows UL256QAM can get higher throughput than 64QAM. But it does not have throughput gain under certain condition (EVM:3.5%, TDL-A, MCS23). The throughput potential is good at high MCS but it requires high SNR or even with high SNR, it cannot get throughput gain. Therefore, we should study the limited MCS for UL256QAM operation.  **To Nokia**: Even with high operating SNR, There are cases that UL256QAM cannot get throughput gain in EVM 3.5% with MCS23.  **Question**: SNR(Signal to noise ratio) about 3.5% EVM is 29.1 dB. Then can we achieve the operating SNR above 29.1 dB in 3.5% EVM? |
| Huawei | Option 2 is ok to us  One question: why we need to agree on operating SNR? |
| Xiaomi | Prefer Option 2. Since majority companies’ simulation results for MCS 23 UL 256 QAM can get higher throughput than 64QAM.  About Huawei’s question, I think the operating SNR will affect the definition of minimum EIRP. So I thinks 32 is too large, propose to use average value 28dB based on TDL-D MCS 23 from the submitted simulation results . |
| ZTE | We are fine with option 1 and option 2 |
| Sony | Option 2. 3.5% EVM is reasonable. SNR for performance testing? (throughput) need to be further discussed. |
| AT&T | We are OK with Option 1 or Option 2. |
| Apple | Option 2 is fine for PC1, PC2 and PC5 devices |
| Ericsson | Option 2. We think that the most fair is to take the average value based on the simulation results once the simulator assumptions are aligned. |
| MediaTek | Option 2 |
| Verizon | Option 2 |

**Issue 2-1-2: EVM requirement for 39GHz**

* Proposals
  + Option 1: 3.5% EVM for 39GHz and FFS for operating SNR. (i.e., use the average value based on the simulation results)
  + Option 2: Others
* Recommended WF

Majority companies agree 3.5% EVM for 39GHz, and some companies accept LGE’s modification with limited MCS. From the submitted simulation results, UL 256QAM with MCS 23 can’t get higher throughput than 64QAM under some propagation channels.

For operating SNR based on TDL-D, MCS21, EVM 3.5%:

Vivo: 25dB;

Huawei: 21 dB;

Xiaomi: 25.2dB;

ZTE: 27.5dB;

Average: 24.6dB.

Moderator recommends:

* + 3.5% EVM for 39GHz and using average value 25dB for operating SNR with limited MCS.

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| **Company** | **Comments** |
| XXX | …. |
| Vivo | Based on the simulation results, UL 256QAM only achieve performance gain in rare cases for 39GHz and 48GHz, focus on 29GHz may be better. |
| Nokia | For option 1, may need to consider limited MCS. |
| LGE | We have similar view with Nokia. We propose modifying option as bellow:  o Option 1: 3.5% EVM for 39GHz and FFS for operating SNR with limited MCS. (i.e., use the average value based on the simulation results)  o Option 2: Others |
| Huawei | Option 1 |
| Xiaomi | Option 1 with LGE’s modification, from the simulation results, the simulation results from companies can’t get higher throughput than 64QAM for UL 256QAM with MCS 23 for some propagation channel. |
| ZTE | Option 1  Based on the simulation results, performance gain can not be expected for FR2 UL 256QAM for high code rate MCS @39GHz. We are fine with the modification from LGE. |
| Sony | Option 1 |
| AT&**T** | We support Option 1 with the proposed modification from LGE. |
| Apple | Option 1 is fine for PC1, PC2 and PC5 devices |
| Ericsson | Option 1 |
| MediaTek | Option 1 |
| Verizon | Option 1 |

### Sub-topic 2-2: EVM test

**Issue 2-2-1: PTRS configuration**

* Proposals
  + Option 1: PTRS configuration shall be aligned with the UE’s recommended PTRS configuration. (IE PTRS-DensityRecommendationSetUL)
  + Option 2: Using a fixed PTRS configuration for all devices for the EVM test:
* For CP-OFDM: LPT-RS = 1 and KPT-RS = 2
* For DFT-s-OFDM: (,)=(8, 4)
  + Option 3: Others.
* Recommended WF

Majority companies agree Option 1 that PTRS configuration shall be aligned with the UE’s recommended PTRS configuration, two companies support Option 2 using a fixed PTRS configuration for all devices for EVM test.

Moderator recommends:

* + Option 1

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| **Company** | **Comments** |
| XXX | …. |
| Qualcomm | Option 1. While we agree at a high level with the recommendations, it is not possible to use a general treatment for all UEs and all RB sizes. Note: Our contribution R4-2216784 has calculation results that show why a fixed configuration will not work. An example of an obviously fatal problem with option 2 is that it does not work for narrow allocations due to lack of available symbols. |
| vivo | Prefer option1 |
| Nokia | Prefer option 2.  For option 1, would UE performance be worse in the field if gNB cannot configure such PTRS for the UE? |
| LGE | Option 1 is our preference. |
| Huawei | For the consideration of performance, we think (16,2) PTRS configuration for DFT is better than that of configuration (8,4). Hence we prefer Option 1 among the options. |
| Xiaomi | We are also OK with Option 1.  To Huawei, we check the TS 38.211 Table 6.4.1.2.2.2-1 PT-RS symbol mapping for DFT, the highest density is (8, 4), we can’t find the PTRS configuration (16, 2). |
| ZTE | We are fine with option 1 for better performance. |
| Apple | Option 1: The gain of PTRS configuration is dependent on the phase noise profile. Leaving the configuration to UE preference would allow optimisation of the UL performance. |
| Ericsson | We support Option 2. If CPE compensation only is used then it should be as performant as possible, which is in the case of K=2, L=1. Also, from testability perspective it is more convenient to have a fixed configuration. |

**Issue 2-2-4: ICI compensation**

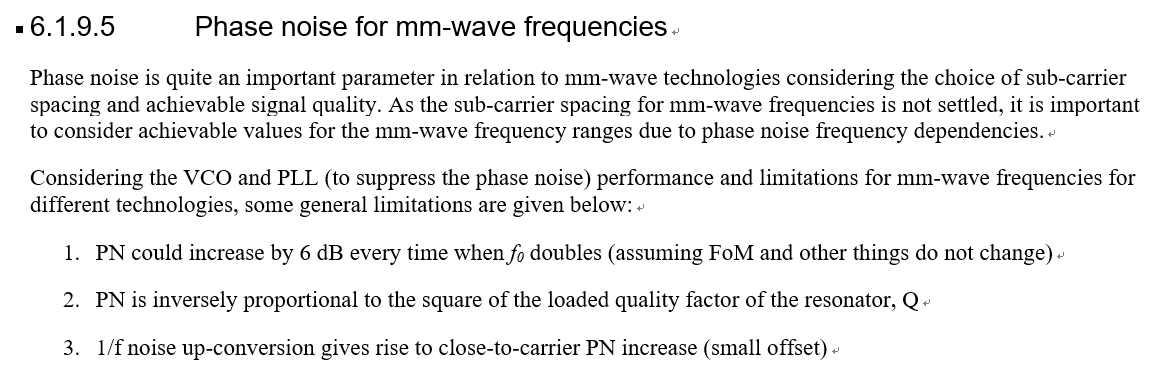
* Proposals
  + Option 1: To consider ICI compensation only if sufficient performance improvement is shown by proponent with explanation of the underlying algorithm.
  + Option 2: Others
* Recommended WF
  + Option 1, encourage companies input more analysis, if no any input, ICI compensation won’t be considered for UL 256QAM.

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| **Company** | **Comments** |
| XXX | …. |
| Qualcomm | Option 1. Note that we need definition of details of the phase noise compensation procedure for MPR calculation much sooner than close of release. |
| vivo | OK with option1. |
| Nokia | Propose option 1. |
| LGE | Option1 is OK. But, We think ICI compensation is still under implementation area. |
| Xiaomi | OK with option 1. |
| ZTE | We are fine with option 1. |
| Sony | Option 2: More analysis is needed. |
| Apple | Option 1 is fine |
| Ericsson | We do not expect that the ICI can bring any gain, but OK with Option 1 for larger channel bandwidths (200MHz or more). |
| MediaTek | Option 1 |

### Sub-topic 2-3: EVM budget in MPR simulation

**Issue 2-3: Phase noise assumption on EVM budget**

* Proposals
  + Option 1: Using the findings recorded in TR 38.803 on phase noise for mm-wave frequencies as a basis.



* + Option 2: Others
* Recommended WF

The screenshot is added by moderator, and check again that the screenshot content is the whole clause for phase noise for mm-wave frequencies in TR 38.803, please proponent further clarify it.

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| **Company** | **Comments** |
| XXX | …. |
| Qualcomm | Option 2: We have shown in R4-2216784 that UE example 1 and 2 in TR38.803 are not good enough to support 256QAM operation. |
| Vivo | OK with option 1. |
| Nokia | Propose option 1. |
| LGE | Option 1 is OK. |
| Huawei | Ok to Option 1 |
| Xiaomi | Option 1 |
| ZTE | We are fine with option 1. |
| Sony | Option 2: We need to further understand the actual proposal? What more need to be clarified besides what is written in Example 1 in Sec. 6.1.10 and Example 2 in Sec. 6.1.11 in TR 38.803? |
| Apple | Is option 1 meant to be the part of the screenshot only or the whole clause? |

### Sub-topic 2-4: System simulation assumption

**Issue 2-4: System simulation assumption**

* Proposals
  + Option 1:

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameters** | | **Urban macro** | **Indoor** |
| Network layout | | hexagonal grid, 19 macro sites, 3 sectors per site with wrap around | 50m x 120m, 12BSs |
| Inter-site distance | | 200m (baseline)  300m (optional) | 20m |
| BS antenna height | | 25 m | 3 m |
| UE location | Outdoor/indoor | Outdoor and indoor | Indoor |
| Indoor UE ratio | 20% |  |
| Low/high Penetration loss ratio | 50% low loss, 50% high loss |  |
| LOS/NLOS | LOS and NLOS | LOS and NLOS |
| UE antenna height | Same as 3D-Uma in TR 36.873 | 1 m |
| UE distribution (horizontal) | | Uniform | |
| Minimum BS – UE distance (2D) | | 35 m | 0 m |
| Shadowing correlation | | Between cells: 1.0  Between sites: 0.5 |  |
| Pathloss | | Uma LOS and NLOS in table 5.2.2.1-1 of 38.803 | InH – Office LOS and NLOS in table 5.2.2.1-1 of 38.803 |
| Carrier frequency | | 29GHz | |
| BS antenna configuration | | (Mg, Ng, M, N, P) = (1, 1, 8, 16, 2)  (dv, dh) = (0.5λ, 0.5λ)  GE,max = 8 dBi | (Mg, Ng, M, N, P) = (1, 1, 8, 16, 2)  (dv, dh) = (0.5λ, 0.5λ)  GE,max = 5 dBi |
| UE antenna configuration | | PC1/PC5:  (Mg, Ng, M, N, P) = (1, 1, 4, 4, 2) (dv, dh) = (0.5λ, 0.5λ)  GE,max = 5 dBi  PC3:  (Mg, Ng, M, N, P) = (1, 1, 2, 2, 2) (dv, dh) = (0.5λ, 0.5λ)  GE,max = 5 dBi | |
| System bandwidth | | 200MHz | |
| ACIR | | 15 dB | |
| Target SNR at BS side | | [25] dB | |
| UE max output power | | PC1: 35 dBm/PC3: 23 dBm/PC5: 23 dBm | |

* + Option 2: modification is needed. (Please list which parameters need to be modified and how modify)
  + Option 3: Others.
* Recommended WF

Majority companies can accept this system level simulation assumption with some modifications and some companies would like to clarify the purpose of the simulation.

Moderator recommends:

Approve the system level simulation assumption with below clarification and some modifications as yellow highlight parts：

* + The system level simulation as supplementary for link level simulation is to check whether the UE working on FR2 UL 256QAM can achieve target SNR at BS side and to further confirm FR2 UL 256QAM is feasible.

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| **Parameters** | | **Urban macro** | **Indoor** |
| Network layout | | hexagonal grid, 19 macro sites, 3 sectors per site with wrap around | 50m x 120m, 12BSs |
| Inter-site distance | | 200m (baseline)  300m (optional) | 20m |
| BS antenna height | | 25 m | 3 m |
| UE location | Outdoor/indoor | Outdoor and indoor | Indoor |
| Indoor UE ratio | 20% |  |
| Low/high Penetration loss ratio | 50% low loss, 50% high loss |  |
| LOS/NLOS | LOS and NLOS | LOS and NLOS |
| UE antenna height | Same as 3D-Uma in TR 36.873 | 2 m |
| UE distribution (horizontal) | | Uniform | |
| Minimum BS – UE distance (2D) | | 35 m | 0 m |
| Shadowing correlation | | Between cells: 1.0  Between sites: 0.5 |  |
| Pathloss | | Uma LOS and NLOS in table 5.2.2.1-1 of 38.803 | InH – Office LOS and NLOS in table 5.2.2.1-1 of 38.803 |
| Carrier frequency | | 29GHz, 39GHz | |
| BS antenna configuration | | (Mg, Ng, M, N, P) = (1, 1, 8, 16, 2)  (dv, dh) = (0.5λ, 0.5λ)  GE,max = 8 dBi | (Mg, Ng, M, N, P) = (1, 1, 8, 16, 2)  (dv, dh) = (0.5λ, 0.5λ)  GE,max = 5 dBi |
| UE antenna configuration | | First priority:  PC1/PC2/PC5:  (Mg, Ng, M, N, P) = (1, 1, 4, 4, 2) (dv, dh) = (0.5λ, 0.5λ)  GE,max = 5 dBi  Second priority:  PC3:  (Mg, Ng, M, N, P) = (1, 1, 2, 2, 2) (dv, dh) = (0.5λ, 0.5λ)  GE,max = 5 dBi | |
| System bandwidth | | 200MHz | |
|  | |  | |
| Target SNR at BS side | | - [28] dB for 29GHz, [25] dB for 39GHz | |
| UE max output power | | PC1: 35 dBm/PC2: 23dBm/PC3: 23 dBm/PC5: 23 dBm | |

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| **Company** | **Comments** |
| XXX | …. |
| Qualcomm | Option 3: Some context would be helpful. What is the aim of the simulation study? What are possible outcomes for the WI? |
| vivo | To Qualcomm:  Considering the UE is power limited in uplink, the system level simulation tries to evaluate the percentage of UEs that can achieve target SNR (which we concluded in link level simulation) at the BS side in a real deployment, and we think this should be a part of feasibility study. If some power class only have few UE can achieve operating SNR in the actual deployment, there is no needed to further discuss its EVM or MPR under UL 256QAM.  The assumption may not be so perfect, and we can accept further modifications. |
| Nokia | Ok for option 1 as baseline, with target SNR using the average value based on the simulation results. |
| LGE | Option 1 is OK. But we need to discuss about target SNR. |
| Xiaomi | Option 2, the simulation assumption should include PC2, since in the WID, the first priority power classes are PC1, PC2 and PC5. ACIR is not needed since the system level simulation is tring to evaluate the percentage of UEs that can achieve target SNR. |
| Sony | Option 2: PC3 is down prioritized in the WI. We think the simulation assumption shall reflect this (e.g. with a comment). Besides, antenna height, as described in TR 36.873 may not reflect how PC1 and PC5 devices are deployed. Maybe a fixed height of 2m is more appropriate? |
| Apple | Option 1 is fine and can be used as a starting point for following analysis during the next meetings. |
| Ericsson | Option 2. We should consider PC2 instead of PC3 and think about the assumptions for vehicular UEs as well. |