3GPP TSG-RAN WG4 Meeting # 98-e R4-2103284

Electronic Meeting, 25 January – 5 February 2021

**Agenda Item:** **14.1.2**

**Source: Nokia, Nokia Shanghai Bell**

**Title:** **TP to TR 37.880: Coexistence Simulation Results for High-power UE Vs NB-IoT guard band operation for fixed-wireless/vehicle-mounted use cases in Band 12, Band 5, and Band n71**

**Document for:** **Approval**

**1. Introduction**

The study item on High-power UE operation for fixed-wireless/vehicle-mounted use cases in Band 12, Band 5, and Band n71 was approved at TSG RAN#88-e [1]. The purpose of this study item is to study RF requirements that are applicable for high power UE operation in LTE band 12 and band 5, and in NR band n71 for fixed wireless and vehicle-mounted use cases, in ITU Region 2.

One of the objectives of this study item is to carry out coexistence study to evaluate the throughput OOBE impact on a victim band from a high-power aggressor in Band 12, Band 5, and Band n71. The simulation assumptions for the coexistence study was agreed in RAN4#96-e [2], where the UL HPUE Vs NB-IoT guard band operation scenario was classified as medium priority. This contribution provides the coexistence simulation results for this scenario according to the agreed assumptions in [2] and a text proposal for approval to record the simulation results and observations into TR 37.880 [3].

**2. Discussion**

The interference leaked from LTE UL to NB-IoT UL (on 3.75kHz subcarrier level) are the average leakage values based on the inputs from several interested companies [4] and provided in Table 1 below [5].

**Table 1: LTE leakage to NB-IoT**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **LTE to NB-IoT, leakage in dB** | | | | | | | | |
| NB-IoT subcarrier | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Leakage | -5.38 | -14.87 | -14.69 | -10.43 | -11.99 | -19.59 | -16.56 | -13.54 |
| NB-IoT subcarrier | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Leakage | -15.59 | -20.50 | -18.97 | -15.84 | -17.58 | -22.04 | -20.38 | -17.60 |
| NB-IoT subcarrier | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Leakage | -18.75 | -22.70 | -20.76 | -18.67 | -19.62 | -23.43 | -21.75 | -19.67 |
| NB-IoT subcarrier | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| Leakage | -19.98 | -23.72 | -22.52 | -20.82 | -20.65 | -24.57 | -23.82 | -21.37 |
| NB-IoT subcarrier | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| Leakage | -21.02 | -25.10 | -24.10 | -22.03 | -21.71 | -25.57 | -25.22 | -21.84 |
| NB-IoT subcarrier | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
| Leakage | -21.76 | -25.83 | -26.69 | -22.05 | -22.07 | -26.49 | -27.00 | -22.33 |

The simulation results of the victim NB-IoT UE (with 2km cell radius) and interfering UE transmit power with 23dBm LTE UE (with 2km cell radius) and 31dBm HPUE (with 4km cell radius) are provided in Figures 1 and 2 below. It can be seen from the figures that around 8% and 5% of the interfering UE are transmitting at maximum power, respectively, with 23dBm LTE UE and 31dBm HPUE.



Figure 1: NB-IoT and 23dBm LTE UE transmit power



Figure 2: NB-IoT and 31dBm HPUE transmit power

The simulation results of the victim NB-IoT UE UL SINR with 23dBm interfering LTE UE (with 2km cell radius) and 31dBm interfering HPUE (with 4km cell radius) are provided in Figures 3 and 4 below. It can be seen from the figures that the victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE are similar (within 1.5dB difference).



Figure 3: NB-IoT UE UL SINR with 23dBm interfering LTE UE



Figure 4: NB-IoT UE UL SINR with 31dBm interfering HPUE

The victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE at 5%, 50%, 95% and 99% CDF points are summarized in Table 2 below. It can be seen from the table that the victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE have 1.5dB, 0.6dB, 0.3dB and 0.3dB differences, respectively, at 5%, 50%, 95% and 99% CDF points.

Table 2: NB-IoT UE UL SINR loss at different CDF points

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Interfering UE maximum output power (dBm)** | **NB-IoT UE UL SINR loss at 5% (dB)** | **NB-IoT UE UL SINR loss at 50% (dB)** | **NB-IoT UE UL SINR loss at 95% (dB)** | **NB-IoT UE UL SINR loss at 99% (dB)** |
| 23 | 1.5 | 0.9 | 1.1 | 1.1 |
| 31 | 3 | 1.5 | 1.4 | 1.4 |

As the victim NB-IoT subcarriers are within the guard band of the aggressor LTE channel bandwidth, i.e. within the same operator spectrum, it is expected that the operator will handle the UL SINR degradation using mitigation techniques like improved filtering or internal gap between the NB-IoT and LTE subcarriers.

**3. Conclusion**

This contribution has provided the coexistence simulation results for the UL HPUE Vs NB-IoT guard band operation scenario according to the agreed assumptions.

The simulation results have shown that:

1) The victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE are similar (within 1.5dB difference).

2) The victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE have 1.5dB, 0.6dB, 0.3dB and 0.3dB differences, respectively, at 5%, 50%, 95% and 99% CDF points.

As the victim NB-IoT subcarriers are within the guard band of the aggressor LTE channel bandwidth, i.e. within the same operator spectrum, it is expected that the operator will handle the UL SINR degradation using mitigation techniques like improved filtering or internal gap between the NB-IoT and LTE subcarriers.

**4. Text proposal**

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2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP RP-201261: "New SID on high-power UE operation for fixed-wireless/vehicle-mounted use cases in Band 12, Band 5, and Band n71", U.S. Cellular.

[3] 3GPP TR 36.837: "Public safety broadband high power User Equipment (UE)".

[4] 3GPP TS 38.101-1: "NR; User Equipment (UE) radio transmission and reception; Part 1: Range 1 Standalone".

[5] 3GPP R4-2008924: " LS on Parameters of terrestrial component of IMT for sharing and compatibility studies in preparation for WRC-23 (below 5 GHz)", Ericsson.

[6] 3GPP TR 36.802: "Evolved Universal Terrestrial Radio Access (E-UTRA); NB-IOT; Technical Report for BS and UE radio transmission and reception".

[7] 3GPP TR 36.942: "Evolved Universal Terrestrial Radio Access (E-UTRA); Radio Frequency (RF) system scenarios".

[8] 3GPP TS 36.101: " Evolved Universal Terrestrial Radio Access (E-UTRA); User Equipment (UE) radio transmission and reception".

[9] 3GPP R4-78AH-0150, “Summary of in-band/guard-band interference modeling from various companies”, Intel, Huawei, Ericsson, ZTE, Nokia Networks.

[10] 3GPP R4-163556, “Simulation results of coexistence studies between NB-IoT and LTE, guard-band case”, Intel Corporation.

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3.3 Abbreviations

For the purposes of the present document, the abbreviations given in 3GPP TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in 3GPP TR 21.905 [1].

3GPP 3rd Generation Partnership Project

BS Base Station

BW Bandwidth

CL Coupling Loss

DL Downlink

HPUE High Power User Equipment

ITU International Telecommunication Union

LTE Long Term Evolution

MTC Machine-Type Communications

NB Narrowband

NR New Radio

OOBE Out Of Band Emissions

PA Power Amplifier

PC Power Class

PRB Physical Resource Block

RF Radio Frequency

Rx Receiver

SW Software

TR Technical Report

Tx Transmitter

UE User Equipment

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5.2 Simulation results

5.2.1 UL HPUE Vs NB-IoT standalone operation

The simulation results of the victim NB-IoT UE (with 2km cell radius) and interfering UE transmit power with 23dBm LTE UE (with 2km cell radius) and 31dBm HPUE (with 4km cell radius) are provided in Figures 5.2.1-1 and 5.2.1-2 below. Here the uplink ACIR is obtained using 30dB LTE UE and 37dB HPUE ACLR and 45dB BS ACS. It can be seen from the figures that around 8% and 5% of the UE are transmitting at maximum power, respectively, with 23dBm LTE UE and 31dBm HPUE.



Figure 5.2.1-1: NB-IoT and 23dBm LTE UE transmit power



Figure 5.2.1-2: NB-IoT and 31dBm HPUE transmit power

The simulation results of the victim NB-IoT UE UL SINR with 23dBm interfering LTE UE (with 2km cell radius) and 31dBm interfering HPUE (with 4km cell radius) are provided in Figures 5.2.1-3 and 5.2.1-4 below. Here again the uplink ACIR is obtained using 30dB LTE UE and 37dB HPUE ACLR and 45dB BS ACS. It can be seen from the figures that the victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE are similar (within 0.5dB difference). It can also be seen from the figures that the victim NB-IoT UE UL SINR degradation caused by the 31dBm interfering HPUE is less than 1dB at 5%, 50%, 95% and 99% CDF points.



Figure 5.2.1-3: NB-IoT UE UL SINR with 23dBm interfering LTE UE



Figure 5.2.1-4: NB-IoT UE UL SINR with 31dBm interfering HPUE

The simulation results of the victim NB-IoT BS received blocking signal power at the antenna connector with 23dBm interfering LTE UE (with 2km cell radius) and 31dBm interfering HPUE (with 4km cell radius) are provided in Figures 5.2.1-5 and 5.2.1-6 below. The 99.99%-tile received blocking signal power levels are around -56dBm and -48dBm, respectively, with 23dBm interfering LTE UE and 31dBm interfering HPUE. Therefore, the currently specified -43dBm BS receiver blocking requirement can provide enough protection for the NB-IoT BS receiver against the HPUE transmission.



Figure 5.2.1-5: NB-IoT BS received blocking signal power with 23dBm interfering LTE UE



Figure 5.2.1-6: NB-IoT BS received blocking signal power with 31dBm interfering HPUE

To summarize, the simulation results have shown that:

1) The victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE are similar (within 0.5dB difference).

2) The victim NB-IoT UE UL SINR degradation caused by the 31dBm interfering HPUE is less than 1dB at 5%, 50%, 95% and 99% CDF points.

3) The currently specified -43dBm BS receiver blocking requirement can provide enough protection for the NB-IoT BS receiver against the HPUE transmission.

5.2.2 UL HPUE Vs NR / NB-IoT guard band operation

The interference leaked from LTE UL to NB-IoT UL (on 3.75kHz subcarrier level) are the average leakage values based on the inputs from several interested companies [9] and provided in Table 5.2.2-1 below [10].

**Table 5.2.2-1: LTE leakage to NB-IoT**

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **LTE to NB-IoT, leakage in dB** | | | | | | | | |
| NB-IoT subcarrier | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| Leakage | -5.38 | -14.87 | -14.69 | -10.43 | -11.99 | -19.59 | -16.56 | -13.54 |
| NB-IoT subcarrier | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 |
| Leakage | -15.59 | -20.50 | -18.97 | -15.84 | -17.58 | -22.04 | -20.38 | -17.60 |
| NB-IoT subcarrier | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 |
| Leakage | -18.75 | -22.70 | -20.76 | -18.67 | -19.62 | -23.43 | -21.75 | -19.67 |
| NB-IoT subcarrier | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 |
| Leakage | -19.98 | -23.72 | -22.52 | -20.82 | -20.65 | -24.57 | -23.82 | -21.37 |
| NB-IoT subcarrier | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 |
| Leakage | -21.02 | -25.10 | -24.10 | -22.03 | -21.71 | -25.57 | -25.2.12 | -21.84 |
| NB-IoT subcarrier | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 |
| Leakage | -21.76 | -25.83 | -26.69 | -22.05 | -22.07 | -26.49 | -27.00 | -22.33 |

The simulation results of the victim NB-IoT UE (with 2km cell radius) and interfering UE transmit power with 23dBm LTE UE (with 2km cell radius) and 31dBm HPUE (with 4km cell radius) are provided in Figures 5.2.2-1 and 5.2.2-2 below. It can be seen from the figures that around 8% and 5% of the interfering UE are transmitting at maximum power, respectively, with 23dBm LTE UE and 31dBm HPUE.



Figure 5.2.2-1: NB-IoT and 23dBm LTE UE transmit power



Figure 5.2.2-2: NB-IoT and 31dBm HPUE transmit power

The simulation results of the victim NB-IoT UE UL SINR with 23dBm interfering LTE UE (with 2km cell radius) and 31dBm interfering HPUE (with 4km cell radius) are provided in Figures 5.2.2-3 and 5.2.2-4 below. It can be seen from the figures that the victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE are similar (within 1.5dB difference).



Figure 5.2.2-3: NB-IoT UE UL SINR with 23dBm interfering LTE UE



Figure 5.2.2-4: NB-IoT UE UL SINR with 31dBm interfering HPUE

The victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE at 5%, 50%, 95% and 99% CDF points are summarized in Table 5.2.2-2 below. It can be seen from the table that the victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE have 1.5dB, 0.6dB, 0.3dB and 0.3dB differences, respectively, at 5%, 50%, 95% and 99% CDF points.

Table 5.2.2-2: NB-IoT UE UL SINR loss at different CDF points

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Interfering UE maximum output power (dBm)** | **NB-IoT UE UL SINR loss at 5% (dB)** | **NB-IoT UE UL SINR loss at 50% (dB)** | **NB-IoT UE UL SINR loss at 95% (dB)** | **NB-IoT UE UL SINR loss at 99% (dB)** |
| 23 | 1.5 | 0.9 | 1.1 | 1.1 |
| 31 | 3 | 1.5 | 1.4 | 1.4 |

To summarize, the simulation results have shown that:

1) The victim NB-IoT UE UL SINR degradation caused by the 23dBm interfering LTE UE and 31dBm interfering HPUE are similar (within 1.5dB difference).

2) The 31dBm interfering HPUE generate 1.5dB, 0.6dB, 0.3dB and 0.3dB (respectively, at 5%, 50%, 95% and 99% CDF points) additional UL SINR degradation to NB-IoT UE UL SINR comparing to the 23dBm interfering LTE UE.

It should be noted that this evaluation is done considering a worst case deployment, where the NB-IoT PRB is adjacent to LTE PRBs, which might not always be the case depending on the considered LTE channel BW and if NB-IoT carrier is an anchor carrier or not. Moreover, as the NB-IoT subcarriers are located within the operator’s own spectrum, it is expected that the operator will handle the UL SINR degradation using mitigation techniques like improved filtering or internal gap between the NB-IoT and LTE subcarriers.

**<End of text proposal>**

**References**

[1] RP-201261, “New SID on high-power UE operation for fixed-wireless/vehicle-mounted use cases in Band 12, Band 5, and Band n71”, U.S. Cellular.

[2] R4-2011833, “TP to TR 37.xxx: Simulation assumptions for coexistence study on High-power UE operation for fixed-wireless/vehicle-mounted use cases in Band 12, Band 5, and Band n71”, Nokia, Nokia Shanghai Bell.

[3] R4-2101799, “TR 37.880 V0.2.0: High-power UE operation for fixed-wireless/vehicle-mounted use cases in Band 12, Band 5, and Band n71”, Nokia, Nokia Shanghai Bell.

[4] R4-78AH-0150, “Summary of in-band/guard-band interference modeling from various companies”, Intel, Huawei, Ericsson, ZTE, Nokia Networks.

[5] R4-163556, “Simulation results of coexistence studies between NB-IoT and LTE, guard-band case”, Intel Corporation.