**3GPP TSG-RAN WG4 Meeting #113 R4-2419595**

**Orlando, US, 18th – 22nd November, 2024**

**Agenda item:** 7.23.5

**Source:** Moderator (Huawei)

**Title:** Topic summary for [113][308] NR\_LPWUS

**Document for:** Information

# Introduction

This contribution summarizes the documents that are submitted to agenda 7.23.3 for RAN4#113 and it concentrates on the following aspect.

* Topic #1: On BS RF requirements for LP-WUS/WUR

# Topic #1: On the BS RF requirement for LP-WUS

## Companies’ contributions summary

|  |  |  |
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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2417543 | Nokia | ***Proposal 1: Modify Proposal 1 to handle the case when there is no NR REs allocation.***  ***Proposal 2: The core requirement for the dynamic range for LP-WUS/LP-SS shall be specified the same as 64QAM, i.e., 0 dB, and BS manufacturers should be allowed to declare the supported LP-WUS power boosting level.***  ***Proposal 3: There is no need to cap the LP-WUS power boosting.***  ***Proposal 4: There is no need to preclude small CBW for LP-WUS power boosting.***  ***Proposal 5: Both conducted and radiated BS RF requirements should be defined for LP-WUS.***  ***Proposal 6: First focus on the power boosting and transmit signal quality requirements that clearly need to be defined, then work on other Tx requirements when their need become clear.***  ***Proposal 7: A new EVM requirement shall be added for LP-WUS/LP-SS and it should be derived by considering the EVM impacts on overall link performance according to RAN1 waveform design.*** |
| R4-2417860 | CATT | ***Observation 1: There are still not applicable configurations for a power dynamic range value with the number of LP-WUS RBs updated from 25 to 11.***  ***Observation 2: Since power boosting does not change the total maximum transmit power of BS, there is no power boosting for the case where all RBs are used by LP-WUS and 0 RBs for NR, i.e., SCS 30kHz and CBW 5MHz.***  ***Observation 3: 2dB NR power degradation already precludes the configuration from power boosting where LP-WUS occupies all REs within the NR carrier, i.e., SCS 30kHz and CBW 5MHz.***  ***Proposal 1: RAN4 to define LP-WUS power boosting in terms of EPRE ratio as:***  ***The LP-WUS power boosting is the difference between the average power of LP-WUS REs (which occupy certain REs within a NR transmission bandwidth configuration and the average power NR REs (the NR carrier excluding the LP-WUS REs) when both LP-WUS and NR are transmitted at the same time in the NR carrier.***  ***Proposal 2: channel bandwidths for power boosting operation are indicated by the combinations consisting of allowed NR power degradation, SCS, power boosting level, minimum allowed channel bandwidth as shown in below table.***   |  |  |  |  | | --- | --- | --- | --- | | Allowed NR power degradation (dB) | SCS (kHz) | Power boosting level (dB) | Minimum allowed channel bandwidth (MHz) | | 2 | 15 | 3 | 5 | | 2 | 15 | 6 | 15 | | 2 | 15 | 9 | 20 | | 2 | 30 | 3 | 10 | | 2 | 30 | 6 | 25 | | 2 | 30 | 9 | 40 |   ***Proposal 3: Power boosting operation is declared via enumerations of allowed NR power degradation, SCS, power boosting level and minimum supported channel bandwidth (no less than the corresponding minimum allowed channel bandwidth).***  ***Proposal 4: Introduce a minimum power boosting level, e.g., 3dB, for LP-WUS power boosting.***  ***Proposal 5: Do not introduce a cap for power boosting level for LP-WUS power boosting.***  ***Proposal 6: Do not introduce any restriction on applicable BS type for LP-WUS feature.***  ***Proposal 7: RAN4 to focus on defining conductive requirements for supported BS types at this stage.*** |
| R4-2417889 | Huawei, HiSilicon | ***Proposal 1: An NB-IoT-like approach to defining power boosting could serve as a baseline, offering flexibility in declaration. Additionally, the option for a single-value declaration should also be permitted, accommodating different scenarios. A definition that incorporates perspectives from both sides might be as follows:***   * + **The LP-WUS RB power dynamic range is the difference between the average power of LP-WUS REs (which occupy certain REs within a NR transmission bandwidth configuration) and the average power over all REs (from both LP-WUS and the NR carrier containing the LP-WUS REs). If a single power booting value is to be declared irrespective of channel bandwidth, the difference in per-RE power ratios between the average power of LP-WUS REs (within the NR transmission bandwidth configuration) and the average power NR REs (excluding LP-WUS REs) could alternatively be used.**   ***Proposal 2: For an NB-IoT-like power boosting declaration, excluding small channel bandwidths is unnecessary. However, if using the alternative single-value declaration, the smallest supported channel bandwidth should be explicitly declared.***  ***Proposal 3: Only conductive based BS type 1-C and 1-H requirements are considered for LP-WUS.***  ***Proposal 4: Determine whether a full set, simplified set of BS Tx requirements or just dynamic range requirement should be specified for LP-WUS.***  ***Proposal 5: FFS whether transmitted signal quality requirements should be defined for LP-WUS.*** |
| R4-2418219 | vivo | ***Proposal 1: RAN4 should use LP-WUS power boosting concept rather than “dynamic range” as definition for this requirement. The power boosting concept and RE dynamic range concept for LP-WUS be separated.*** |
| R4-2418605 | Qualcomm | ***Observation 1: Based on RAN guidance and previous agreements in RAN4, FR2 support for LP-WUS is within the scope of Rel-19 work item.***  ***Proposal 1: Following RAN guidance, RAN4 to consider FR2 support when discussing BS RF requirements for LP-WUS.***  ***Proposal 2: RAN4 not to set restriction on applicable BS types to support LP-WUS.***  ***Observation 2: Following RAN guidance, normative work in Rel-19 will be missing if no BS type 2-O requirements are not defined.***  ***Proposal 3: RAN4 to define conducted (i.e., BS type 1-C) and radiated (i.e., BS type 1-H, BS type 1-O, and BS type 2-O) requirements for LP-WUS.*** |
| R4-2418735 | CMCC | ***Proposal 1: Not need to define the minimum power boosting level.***  ***Proposal 2: Leave the maximum power dynamic range to manufacturer’s declaration***  ***Proposal 3: If the minimum power boosting level requirements is not defined, there is no need to preclude the small CBW.***  ***Proposal 4: All the BS types should be supported by LP-WUS.***  ***Proposal 5: Define a set of the BS Tx requirements for LP-WUS.*** |
| R4-2418827 | ZTE Corporation, Sanechips | ***Proposal 1: Use concept of LP-WUS dynamic range/power boosting in Option 2 rather than EPRE ratio: The LP-WUS RB power dynamic range (or LP-WUS power boosting) is the difference between the average power of LP-WUS REs (which occupy certain REs within an NR transmission bandwidth configuration) and the average power over all REs (from both LP-WUS and the NR carrier containing the LP-WUS REs).***  ***Proposal 2: Set the LP-WUS power boosting a complete manufacture declaration feature.***  ***Proposal 3: Not to introduce a minimum limitation or a maximum limitation for LP-WUS power boosting.***  ***Proposal 4: FFS whether the modulation depth can be used as transmitted signal quality for LP-WUS.***  ***Proposal 5: It is propose to use BS Type 1-C as applicable BS type as a start point.*** |
| R4-2419482 | Ericsson | ***Observation 1 EPRE is not fixed for different bandwidth when the power boosting factor is fixed for each of bandwidth.***  ***Observation 2 Whether to de-boost NR signal transmission power should be up to network implementation.***  ***Observation 3 The NR de-boosting transmission power is for the testing purpose only.***  ***Proposal-1: Align the RAN4 view on the power boosting of WUS signal with and without the NR signal at the same time:***   * *The WUS signal should be transmitted always with x dB above the average power.* * *There is no NR signal de-boosting in normal transmission.*   ***Proposal-2: The average power over all REs should be fixed.***  ***Proposal-3: Use option 2 in issue 1-2.***  ***Proposal-4: No power boosting for OOK4.***  ***Proposal-5: Limit the power boosting discussion only for OOK1.***  ***Observation 4 TM1.2 can be referred to for LP-WUS power boosting for wider bandwidth but not for narrow bandwidth.***  ***Proposal-6: Define a new test model for power boosting of LP-WUS signal in conformance testing phase.***  ***Proposal-7: The power boosting of LP-WUS should be manufacture declared.***  ***Proposal-8: Exclude the narrow bandwidth (less and equal than 5 MHz ) for power boosting of LP-WUS***  ***Proposal-9: Manufacture declare the min channel bandwidth to support the power boosting of LP-WUS.***  ***Observation 5 ZC sequence in frequency domain generation is specified for LTE PSS signal***  ***Observation 6 No RF requirement defined for LTE PSS signal.***  ***Proposal-10: No new RF requirements is identified for OOK-1.***  ***Observation 7 RAN4 discuss whether to define a frequency domain testing data for OOK-4 if the measurement point for signal quality would be kept.***  ***Observation 8 WID objective mandates the BS new requirement subject to the declaration and use the legacy NR requirement as baseline.***  ***Observation 9 The performance loss for LP-WUS signal detection at WUR due to transmitter remapping constellation to existing QAM constellation is around 0.2 dB for 64QAM remapping and 0.6 dB for 16QAM remapping.***  ***Observation 10 The time domain OOK-4 signal can tolerate a distortion in frequency domain equivalent to and less than the EVM of 64QM before iFFT.***  ***Proposal-11: RAN4 discuss whether to introduce the “EVM” requirement in frequency domain for a OOK-4 signal quality measurement.***  ***Proposal-12: No other new RF requirement than the dynamic range or potential EVM requirement for OOK-4 is identified for LP-WUS.*** |

## Open issues summary

### Sub-topic 1-1 On dynamic range for LP-WUS

**Issue 1-1: Concept of LP-WUS power boosting**

* Proposals
  + Proposal 1: EPRE ratio can be used for the LP-WUS power boosting concept.
    - ***The LP-WUS power boosting is the difference between the average power of LP-WUS REs (which occupy certain REs within a NR transmission bandwidth configuration and the average power NR REs) when both LP-WUS and NR are transmitted at the same time in the NR carrier.*** (CATT)
    - The case when there is no NR REs allocation should be covered.(Nokia)
  + Proposal 2: Adopt following definition rather than introduce EPRE ratio. (ZTE, Ericsson, Nokia)
    - ***The LP-WUS RB power dynamic range (or LP-WUS power boosting) is the difference between the average power of LP-WUS REs (which occupy certain REs within a NR transmission bandwidth configuration) and the average power over all REs (from both LP-WUS and the NR carrier containing the LP-WUS REs)*.**
  + Proposal 3: An NB-IoT-like approach to defining power boosting could serve as a baseline, offering flexibility in declaration. Additionally, the option for a single-value declaration should also be permitted, accommodating different scenarios. (Huawei)
    - ***The LP-WUS RB power dynamic range is the difference between the average power of LP-WUS REs (which occupy certain REs within a NR transmission bandwidth configuration) and the average power over all REs (from both LP-WUS and the NR carrier containing the LP-WUS REs). If a single power booting value is to be declared irrespective of channel bandwidth, the difference in per-RE power ratios between the average power of LP-WUS REs (within the NR transmission bandwidth configuration) and the average power NR REs (excluding LP-WUS REs) could alternatively be used.***
* Recommended WF
  + Check whether the merged concept in Proposal 3 can be accepted as a compromised definition.

**Issue 1-2: How to comprehend the de-boost on the NR transmission power**

* Proposals
  + Proposal 1: LP-WUS power boosting does not change the total maximum transmit power of BS. (CATT)
    - There is no power boosting for the case where all RBs are used by LP-WUS and 0 RBs for NR, i.e., SCS 30kHz and CBW 5MHz.
    - For the cases where there would be RB(s) allocated to NR, x dB NR power degradation is allowed.
  + Proposal 2: The average power over all REs should be fixed and when the power boost of WUS is enabled with or w/o the NR signal at the same time: (Ericsson)
    - The WUS signal should be transmitted always with x dB above the average power.
    - There is no NR signal de-boosting in normal transmission.
    - The NR de-boosting transmission power is for the testing purpose only and whether to de-boost NR signal transmission power should be up to network implementation.
* Recommended WF
  + To discuss in which cases, NR signal de-boosting is allowed or not allowed

**Issue 1-3: Core requirement for LP-WUS power boosting**

* Proposals
  + Proposal 1: Power boosting level is declared via enumerations of allowed NR power degradation, SCS, power boosting level and minimum supported channel bandwidth (no less than the corresponding minimum allowed channel bandwidth). (CATT)
    - Introduce a minimum LP-WUS power boosting level e.g. 3dB.
    - No need to cap the LP-WUS power boosting.

|  |  |  |  |
| --- | --- | --- | --- |
| Allowed NR power degradation (dB) | SCS (kHz) | Power boosting level (dB) | Minimum allowed channel bandwidth (MHz) |
| 2 | 15 | 3 | 5 |
| 2 | 15 | 6 | 15 |
| 2 | 15 | 9 | 20 |
| 2 | 30 | 3 | 10 |
| 2 | 30 | 6 | 25 |
| 2 | 30 | 9 | 40 |

* + Proposal 2: Power boosting level shall be specified as 0dB and BS manufacturers should be allowed to declare the supported LP-WUS power boosting level. (Nokia)
    - No need to cap the LP-WUS power boosting.
    - No need to preclude small CBW for LP-WUS power boosting.
  + Proposal 3: Power boosting level is up to BS manufacture declaration. Other configurations are relating to the LP-WUS power boosting concept. (Huawei)
    - No need to preclude small CBW for LP-WUS power boosting if an NB-IoT-like power boosting declaration is adopted. But the smallest supported channel bandwidth should be explicitly declared if using the alternative single-value declaration.
  + Proposal 4: Power boosting level is up to BS manufacture declaration. (ZTE, CMCC)
    - No need to introduce a minimum or maximum LP-WUS power boosting level
    - No need to preclude small CBW if minimum LP-WUS power boosting level is not defined
  + Proposal 5: Limit the power boosting only for OOK-1. (Ericsson)
    - Exclude the narrow bandwidth (less and equal than 5 MHz ) for power boosting of LP-WUS and manufacture declares the min channel bandwidth to support the power boosting of LP-WUS
* Recommended WF
  + Option 1: Leave the power boosting level to manufacturer declaration
    - Smallest CBW for power boosting could be declared
    - FFS the test requirements
  + Option 2: Introduce a minimum LP-WUS power boosting level

**Issue 1-6: On applicable BS type for LP-WUS feature**

* Proposals
  + Proposal 1: Not to set restriction on applicable BS types to support LP-WUS. (CMCC, CATT)
* Recommended WF
  + Drop the discussion, there was an agreement in last meeting that:
    - *Non-AAS, AAS could be considered for LP-WUS feature.*

**Issue 1-7: Requirement type(s) for LP-WUS**

* Proposals
  + Proposal 1: RAN4 to define conducted (i.e., BS type 1-C) and radiated (i.e., BS type 1-H, BS type 1-O, and BS type 2-O) requirements for LP-WUS. (Nokia, Qualcomm)
  + Proposal 2: RAN4 to focus on defining conductive requirements for supported BS types. (CATT, Huawei, ZTE)
* Recommended WF
  + To define conductive requirements for FR1 and OTA requirements for FR2.

### Sub-topic 1-2 Other considerations apart from power boosting for LP-WUS

**Issue 1-8: General consideration on other requirements**

* Proposals
  + Proposal 1: Define a set of the BS Tx requirements for LP-WUS. (CMCC)
  + Proposal 2: RAN4 to determine whether a full set, simplified set of BS Tx requirements or just dynamic range requirement should be specified for LP-WUS. (Huawei)
  + Proposal 3: First focus on the power boosting and transmit signal quality requirements that clearly need to be defined, then work on other Tx requirements when their need become clear. (Nokia)
  + Proposal 4: No new RF requirements is identified for OOK-1. No other new RF requirement than the dynamic range or potential EVM requirement for OOK-4 is identified for LP-WUS. (Ericsson)
* Recommended WF
  + Discuss on whether transmit signal quality should be defined
  + Check if it’s OK not to define other Tx requirements, which is similar to the case for NB-IoT in-band operation

**Issue 1-9: Transmitted signal quality**

* Proposals
  + Proposal 1: A new EVM requirement shall be added for LP-WUS/LP-SS and it should be derived by considering the EVM impacts on overall link performance according to RAN1 waveform design. (Nokia)
  + Proposal 2: RAN4 discuss whether to introduce the “EVM” requirement in frequency domain for an OOK-4 signal quality measurement. (Ericsson)
  + Proposal 3: FFS whether transmitted signal quality requirements should be defined for LP-WUS. (Huawei)
  + Proposal 4: FFS whether the modulation depth can be used as transmitted signal quality for LP-WUS. (ZTE)
* Recommended WF
  + Option 1: Define LP-WUS EVM requirement
    - Alt 1: derived by considering the EVM impacts on overall link performance according to RAN1 waveform design
    - Alt 2: consider an “EVM” requirement in frequency domain for an OOK-4 signal quality measurement
    - Alt 3: consider modulation depth
  + Option 2: Not to define LP-WUS EVM requirement.

**Issue 1-10: Test model for LP-WUS power boosting**

* Proposals
  + Proposal 1: Define a new test model for power boosting of LP-WUS signal in conformance testing phase. (Ericsson)
    - TM1.2 can be referred to for LP-WUS power boosting for wider bandwidth but not for narrow bandwidth.
* Recommended WF
  + TBA.