**3GPP TSG-RAN WG4 Meeting #113 R4-2420395**

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

**Agenda item:** 7.23.5

**Source:** vivo

**Title:** Ad hoc minutes on UE RF requirements for LP-WUS

**Document for:** Information

# Introduction

This topic summary covers the discussions for Rel-19 LP-WUS UE RF.

# Topic #2: REFSENS, ASCS and ACS requirements

### Sub-topic 2-1 SNR simulation and values

**Issue 2-1-1: Target FR1 SNR value for LP-WUS/WUR**

* Proposals
  + **Option 1: Define a single target SNR for both OOK-based and OFDM-based receivers:** 
    - **-2dB. (Huawei, vivo, Samsung)**
    - **-3dB (Spreadtrum)**
    - **-7dB to -2dB (Sony)**
  + **Option 2: Specify different SNR for OOK-based and OFDM-based receivers:** 
    - **-2.5dB for OOK-based and -4.7dB for OFDM-based. (CMCC)**
    - **-2 dB for OOK-based and -5dB for OFDM-based receiver. (ZTE, vivo)**
    - **The SNR for OFDM WUR detection is -3.2 dB for AWGN with 1 Zadoff Chu sequence and 1 symbol of OFDM symbol. The SNR for OOK WUR detection depends on the filter order OOK1 or OOK4 with range of -5 dB to -1.5 dB. (Ericsson)**
* Recommended WF
  + Check and decide

Ericsson: we need agree a few of things first.

Qualcomm: It is pre-mature to agree on SNR right now. RAN1 has not finished the design of length of sequence. We do not have enough information to determine the SNR.

CATT: Agree with Qualcomm. The final SNR we need wait for RAN1.

Moderator: for OOK based requirement, we give OOK-1 and the SNR is developed based on the worst case. Generally we agree that some part is under working of RAN1. We try to narrow down the range of SNRs.

* WF in AH
  + Agree generally that for OOK-based, use worst case waveform of OOK-4 M=4 to derive SNR.
    - Some detailed aspects should be also confirmed, e.g., CRC bit (8), sequence length (8, 16), codepoint length of known part of the sequence

**Issue 2-1-2: TP to TR for FR1 simulation parameters**

* Proposals
  + **Proposal 1: check and discuss the TPs in R4-2418216 and R4-2417868, for system parameters.**
* Recommended WF
  + Check the TP, collect feedback
  + The TP content can be update based on alignments of NF model
* WF in AH
  + The table for detailed simulation parameters can be removed out of TP, further add it to TR when the uncleared parameters are confirmed.

**Issue 2-1-3: Link level simulation assumption for FR2 LP-WUR**

* Proposals
  + **Proposal 1: RAN4 to adopt the following link level simulation assumptions as starting point for the FR2 use case. (Qualcomm)**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Attributes | Assumptions | | | Notes |
| Case name (waveform) | OOK-1 waveform | | OOK-4 waveform |  |
| Center frequency | 24300MHz | | | n258 example band |
| WUS structure | Total 8/16/32 bits | | | (placeholder for RAN1 decision) |
| ~~Channel structure~~ |  | | | not needed |
| Chip rate | M=1 | M=1/2/4 | |  |
| Coding | 1/2 rate Manchester coding | | |  |
| Time error | ~~0~~ (up to UE implementation) | | | Difficult to separate time and frequency errors in realistic receivers |
| Residual Frequency error | 0/10/20 ppm | | |  |
| SCS | 120kHz | | |  |
| UE Channel BW | 200MHz (132 RB)-case 1  100MHz (66 RB)-case 2  ~~5MHz (11 RB)-case 3~~ | | |  |
| WUS RB | * Fixed 11RB ~ ~~3.96MHz~~ ~~for 10MHz and 20MHz cases~~ | | | Based on agreement in RAN1#118-Bis |
| Position within channel | * ~~For 10/20MHz CBW,~~ Center for ASCS, edge for ACS [assume no ASCS impact] * ~~For 5MHz CBW, fixed center of channel~~ | | |  |
| Guardband of NR channel, both wanted cell and interfer cell (ACS) | * ~~For wanted signal: 505kHz for 5MHz, 665kHz for 10MH, 805kHz for 20Mhz~~ * ~~For interference cell2 5MHz: fixed 505kHz~~ * Refer to 5.3.3 in TS38.101-2 | | |  |
| Guard RB | * For ASCS: 0 or 1RB on each side of LP-WUS bandwidth * For ACS: 1/2/3/4 RB | | |  |
| Filter | * 3th/5th Order lowpass Butterworth matching fixed 3.96MHz RF bandwidth ~~for 10MHz/20MHz case~~   + Other order lowpass filter is not precluded * ~~The filter bandwidth is adapted with actual WUS RBs, for 5MHz case~~ | | |  |
| ASCS | PDSCH mapped on RBs not used for LP-WUS and Guard RB;  EPRE of PDSCH /EPRE of LP-WUS = 0 dB  Same PSD with WUS signal | | |  |
| ACS | PDSCH mapped on interference RBs (11RB for 5MHz CBW), one side;  EPRE of PDSCH /EPRE of in-band LP-WUS = [16~17] dB  NOTE: decide the interference level depending on SNR | | |  |
| Wanted signal level | For ACS, REFSENS + 14 dB for LP-WUS | | |  |
| Sampling rate | 7.68MHz | | |  |
| ADC bit width | 4/8 bits ADC for ASCS/ACS  Encourage companies to provide simulation results with both options for comparison | | |  |
| Phase noise | Not modelled | | |  |
| Non-linearities | Not modelled | | |  |
| Power boosting | EPRE ratio: 0dB/3dB for OOK-1/OOK-4  NOTE: 3dB is optional for simulation | | |  |
| Channel Model | Option 1: ~~TDL-C~~ TDL-C 100  Option 2: AWGN  Note: encourage companies to provide simulation results with both options | | | The procedure for using CDL channel models in demod analysis is not fully established. |

* Recommended WF
  + Discuss FR2 simulation assumptions
  + Discus whether Phase noise modelling can also be considered for FR2
* WF in AH
  + Further discussions and alignment on FR2 RF simulation assumption is needed.

### Sub-topic 2-2 NF and REFSENS requirements

**Issue 2-2-1: General views on REFSENS for LP-WUS**

* Proposals
  + **Proposal 1: RAN4 adopts ED-based receiver to derive a single set of minimum requirements on REFSENS for ED and OFDM receivers. (Sony)**
  + **Proposal 2: At this stage RAN4 can focus on collecting and consolidating REFSENS for the two types of receivers respectively, and then check if one single value or two values are specified pending on the final REFSENS values. (CATT)**
  + **Proposal 3: RAN4 to derive the REFSENS requirement for LP-WUR with the agreed RAN4 assumption and legacy equation approach firstly, and check the coverage target later before finally confirm the REFSENS value. (Samsung)**
  + **Proposal 4: Different LP-WUR types are defined based on different power consumption assumptions, each with distinct noise figure (NF) values compared to the MR. The requirements are specified for different LP-WUR types. (Huawei)**
* Recommended WF
  + Check whether P2 is agreeable or not
* WF in AH
  + Discuss REFSENS for the two types of receivers respectively, and then check if one single value or two values are specified pending on the final REFSENS values.

**Issue 2-2-2: Requirements for idle and connected mode**

* Proposals
  + **Proposal 1: At least in FR1, RAN4 can define the minimum requirement based on idle mode and further check if the same requirement can be used in connected mode. (Sony)**
* Recommended WF
  + The RF requirements value could be applied to both LP-WUR mode. The difference is test setting
  + This is also related to Issue 4-1-1

Moderator: this is covered by issue 4-1-1.

**Issue 2-2-3: companies input on SNR, NF and IM value for FR1 OOK-based LR**

* Proposals
  + **Proposal 1: check the following input from companies and converge the range for OOK-based LR. (Moderator)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FR1 OOK-based receiver** | **Huawei** | **Sony** | **Spread**  **trum** | **Apple** | **vivo** | **QC** | **Samsung** | **LGE** | **CMCC** | **ZTE** | **Nokia** | **E//** |
| IM(dB) | 2.5 | 2.5 | 2.5 | >=2.5 | 2.5 | 2.5 | 3 | 2.5 | 2.5 | 2.5 | 1 | 2.5 |
| NF(dB) (assume MR=9dB) | 17 | 10 | 17 | 16 | 15 | 11.5 | 15 | 16 | 12 | 14 | 12 | 12 |
| SNR(dB) | -2 | -7~-2 | -3 |  | -2 | -1 for sequence length of 18 | -2 |  | -2.5 | -2 |  | -1.5~  -5 |
| RFESENS(dB) |  |  | -90.5 |  |  |  |  |  |  | -93.5/-96.5 |  |  |

Note: Nokia: increase the NF for frequency greater than 2.4 GHz. antenna sharing architecture should be accounted for in NF, not IM.

* WF in AH
  + Use 2.5dB IM as a starting point, encourage companies to report the difference aspects due to OOK waveform receiver. Tighten or relaxed values are not precluded. The corresponding band should also be reported.
  + The total value of NF+IM can be considered.
  + On how to handle the NF values:
    - Option 1: For NF whether average value can be adopted.
    - Option 2: two sets NFs for different LP-WUR types with different power consumption target
    - Option 3: also consider coverage
  + Capture the table in WF as background information

**Issue 2-2-4: companies input on SNR, NF and IM value for FR1 OFDM-based LR**

* Proposals
  + **Proposal 1: check the following input from companies and converge the range for OFDM-based LR. (Moderator)**

|  |  |  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **FR1 OFDM-based receiver** | **Huawei** | **Sony** | **Spread**  **trum** | **Apple** | **vivo** | **QC** | **Samsung** | **LGE** | **CMCC** | **ZTE** | **Nokia** | **E//** |
| IM(dB) | 2.5 | 2.5 | 2.5 | >=2.5 | 2.5 |  |  | 2.5 | 2.5 | 2.5 | 1 | 2.5 |
| NF(dB) | 11 | 10 | 11 | 16 | 11 |  |  | 12 | 9 | 11 | 12 | 12~13 |
| SNR(dB) | -2 | -7~-2 | -3 |  | -2 or -5 |  |  |  | -4.7 | -5 |  | -3.2 |
| RFESENS(dB) |  |  | -96.5 |  |  |  |  |  |  | -99.5/-102.5 |  |  |

Note: Nokia: increase the NF for frequency greater than 2.4 GHz. antenna sharing architecture should be accounted for in NF, not IM.

* Recommended WF
  + Check and confirm 2.5dB IM
  + For NF whether average value can be adopted
  + For OOK-based SNR, -2~-5dB is well-aligned simulation outcome from companies. Discus whether a separate value, e.g. -5dB for OFDM-based.
* WF in AH
  + Capture the table in WF as background information

**Issue 2-2-5: how to derive single value from companies input on SNR, NF and IM**

* Proposals
  + **Proposal 1: In addition to collect inputs of (SNR, NF, IM), RAN4 should also discuss and agree on how to consolidate these inputs into one single value as requirements, and the below two options can be considered as a starting point: (CATT)**
    - **Option 1: averaging all inputs**
    - **Option 2: introducing some validating rules to exclude some values, and averaging validated values**
* Recommended WF
  + Related to issue 2-2-3 and 2-2-4, can be discussed together.

Moderator: this is covered by issue 2-2-3.

**Issue 2-2-6: Baseline OFDM-based architecture for FR2 LP-WUR**

* Proposals
  + **Proposal 1: For deriving a sensitivity requirement, the baseline OFDM-based FR2 LPWUR architecture is assumed to have the following features: (Qualcomm)**
    - **It comprises 2 Rx chains, and the antennas attached to the respective chains are mutually orthogonally polarized**
    - **Best Rx chain is used for LPWUS (pol. selection diversity)**
    - **Antenna gain is that of a single element**
  + **Proposal 2: FR2 LPWUR adopts zero-IF topology baseline assumption from FR1 LPWUR. (Qualcomm)**
* WF in AH
  + FR2 LPWUR adopts zero-IF topology baseline assumption. FFS details
  + **For deriving a sensitivity requirement, the baseline OFDM-based FR2 LPWUR architecture is assumed to have the following features:** 
    - **It comprises 2 Rx chains, and the antennas attached to the respective chains are mutually orthogonally polarized**
    - **Best Rx chain is used for LPWUS (pol. selection diversity)**
    - **Antenna gain is that of a single element**

### Sub-topic 2-3 ASCS simulation and requirements

**Issue 2-3-1: Required number of guard RB for ASCS**

* Proposals
  + **Option 1: 1RB as blank guard RB for ASCS at each side. (Huawei, vivo and E/// [max 1], CMCC)**
  + **Option 2: 0RB as guard RB for ASCS. (Sony, Qualcomm, ZTE, Ericsson)**
* Recommended WF
  + Confirm 1RB or 0 RB as blank RB for ASCS requirements.

**Issue 2-3-2: Detailed Test case for ASCS**

* Proposals
  + **Proposal 1: RAN4 further discuss the test case after confirming the requirements and guard RB. (moderator)**
* Recommended WF
  + Companies input can be starting point for discussion

### Sub-topic 2-4 ACS simulation and requirements

Moderator: in the WF R4-2417112, it was agreed that the phase noise can be considered. The open issue is how to align the common phase noise model file.

*Issue 2-4-1: Phase noise for simulation assumption*

*Agreements:*

* + *Phase noise can be considered in LLS simulation analysis.* 
    - *Phase noise used in R4-2415201, R4-2415780, and R4-2309204 could be considered as a reference. Other profiles are not precluded.*
  + *Number of guard RBs will be further discussed until Feb meeting. Encourage companies to provide simulation results with phase noise modelling.*

**Issue 2-4-1: Phase noise for simulation assumption**

* Proposals
  + **Option 1: Agree to use common phase noise profile for simulations in order to agree derive the requirements. (Nokia, Huawei)**
    - **Phase noise level similar to that of Wi-Fi as assumption. (Huawei, vivo)**
  + **Option 2: Phase noise is an implementation detail and RAN4 stops discussing it in jammer context. (Qualcomm)**
* Recommended WF
  + Discuss whether the phase noise file from IEEE (IEEE802.11-17/0326r0) can be a common assumption used for simulation
* WF in AH
  + Companies can use different phase noise assumptions, the phase noise assumption should be reported.

**Issue 2-4-2: General ACS requirements value and guard RB**

* Proposals
  + **Option 1: Same *absolute interference level* as MR.**
    - **0 RB as guard RB. (Qualcomm, CMCC[starting point], ZTE, E///[ for OOK1], )**
    - **1RB as guard RB. (vivo)**
    - **3RB as guard RB for OOK4. (E///)**
    - **Similar interference only for LP-WUR with moderate power consumption. (Huawei)**
  + **Option 2: Lowered *absolute interferer level* as MR.** 
    - **Less guard RB, and ACS=10dB ((Huawei))**
    - **0 RB as guard RB, if ACS=20dB. (vivo)**
  + **Option 3: other**
* Recommended WF
  + - Firstly, RAN4 align on the ACS selectivity value that due to poor sensitivity value and same *absolute* interference level, then the delta value for ACS should be much smaller for OOK-based.
    - Then group discuss whether to specify different value for different waveform (OOK1 and OOK4), or a single worst case value.
    - After concluding same/lower absolute interference level of MR, further discuss and decide the guard RB, and the new ACS value.

Moderator: for Option 1, he ACS would be around [~23-27]dB?, due to high LP-WUS REFSENS value in issue 2-2-3; for option 2, then the ACS would be less than [~20]dB, due to high LP-WUS REFSENS value in issue 2-2-3, and potential relaxation of ACS.

**Issue 2-4-3: Case 1 and Case 2 ACS requirements**

* Proposals
  + **Proposal 1: It is proposed to only consider case 1 ACS requirement for the LP-WUR type aimed at ultra-low power consumption, while for LP-WUR type aimed at moderate power consumption, both ACS cases could be considered. (Huawei)**
  + **Proposal 2: If both cases are considered for LP-WUR type 1 (aimed at ultra-low power consumption), the dynamic range would not be the same as LP-WUR type 2 (aimed at moderate power consumption). (Huawei)**
* Recommended WF
  + - TBA.

**Issue 2-4-4: Test parameters for LP-WUR ACS case**

* Proposals
  + **Proposal 1: further discuss detailed test parameters table and how to modify spec, after concluding ACS value and guard RBs. (Moderator)**
    - **The proposed tables in R4-2418828, R4-2418734, R4-2417886 can be starting point for collecting feedback from companies.**
* Recommended WF
  + Further discuss test parameters **after** concluding ACS value and guard RBs.
  + Draft CRs to TS can be prepared next meeting

# Topic #3: Other RF requirements

### Sub-topic 3-1 IBB, OBB and Intermodulation requirements for UE RF

**Issue 3-1-1: IBB, OBB requirements**

* Proposals
  + **Option 1: the interference levels for IBB could be relaxed compared to the values defined for MR (at least for the LP-WUR type which targets ultra-low power consumption). OBB could be kept unchanged at least for LP-WUR type which targets moderate power consumption, FFS for ultra-low power consumption LP-WUR. (Huawei)**
  + **Option 2: In-band blocking requirement for legacy UE could be reused. the OBB requirement for legacy UE in TS 38.101-1 could be reused. (CMCC, CATT, Nokia, ZTE, E///)**
* Recommended WF
  + Discuss and conclude high-level common understanding on whether IBB and OBB can be relaxed.

**Issue 3-1-2: General views on test parameters for IBB and OBB test case**

* Proposals
  + **Proposal 1: For IBB and OBB test, bandwidth of the interferer should be 5MHz and LP-WUS should be located at edge of the NR carrier. FFS guard RBs that are used for IBB and OBB. (ZTE)**
  + **Proposal 2: Agree to use larger signal power in blocking test cases compared to MR blocking test cases. (Nokia)**
* Recommended WF
  + Conclude bandwidth and signal power level
  + Further discuss whether guard RB (if defined for ASCS/ACS) should be always configured for all Rx requirements

**Issue 3-1-3: detailed table for test parameters of IBB and OBB test case**

* Proposals
  + **Proposal 1: further discuss detailed test parameters table and how to modify spec, after concluding IBB and OBB requirements value and guard RBs. (Moderator)**
    - **The proposed tables in R4-2418829, R4-2417887 can be starting point for collecting feedback from companies.**
* Recommended WF
  + TBD

**Issue 3-1-4: NBB requirements**

* Proposals
  + **Proposal 1: Due to proximity of the NBB to LP-WUS signal and worse phase noise for LR, relaxation of the interferer level should be considered at least for the LP-WUR type aimed at ultra-low power consumption. (Huawei)**
* Table 3: Narrow Band Blocking or LP-WUR type 1 UE

|  |  |  |
| --- | --- | --- |
| Parameter | Unit | LP-WUS bandwidth (RBs) |
| Pw | dBm | PREFSENS + 16 |
| Puw (CW) | dBm | [-62] |
| Fuw (offset SCS= 15 kHz) | MHz |  |
| NOTE 1: Fuw shall be rounded to half of SCS  NOTE 2: LP-WUS is configured at the edge of the NR carrier with minimum guardband specified in Table 5.3.3-1 for NR channel bandwidth ≥ 5 MHz. | | |

* Recommended WF
  + TBD

**Issue 3-1-5: Intermodulation requirements**

* Proposals
  + **Proposal 1:** **specify two sets of requirements for OFDM signal and OOK signal. (CMCC)**
* **The requirements in TS 38.101-1 for legacy UE could be reused for OFDM signal.**
* **New intermodulation requirements need to be specified for the OOK signal.**
  + **Proposal 2: If the blocking interferer is relaxed to accommodate the low power design for LP-WUR type which targets ultra-low power consumption, intermodulation requirement could also be relaxed for LP-WUR. (Huawei)**
* Recommended WF
  + Discuss and conclude first whether requirements can be reused for OFDM-based.
  + Further discuss how to handle OOK-based.

**Issue 3-1-6: General views on Intermodulation requirements test**

* Proposals
  + **Proposal 1: For intermodulation test, bandwidth of the interferer should be 5MHz and LP-WUS should be located at edge of the NR carrier. FFS guard RBs that are used for intermodulation requirements. (ZTE)**
  + **Proposal 2: For intermodulation response rejection requirement, the WUR requirement should be tested with interferer setting with minimum MR bandwidth. (E///)**
* Recommended WF
  + Discuss and conclude the min bandwidth for intermodulation requirements.

**Issue 3-1-7: detailed table for test parameters of Intermodulation requirements test case**

* Proposals
  + **Proposal 1: further discuss detailed test parameters table and how to modify spec, after concluding Intermodulation requirements value and guard RBs. (Moderator)**
    - **The proposed tables in R4-2418829, R4-2417887 can be starting point for collecting feedback from companies.**
* Recommended WF
  + TBA

### Sub-topic 3-2 Other Rx requirements

**Moderator: for Spurious emissions, it was concluded in WF R4-2410569. No further discussion is needed**

*Issue 3-2-1: Spurious emissions requirements*

*Agreement:*

* + *RAN4 conclude Spurious emissions requirements can be reused for LP-WUR.*

**Issue 3-2-1: spurious response requirements**

* Proposals
  + **Option 1: spurious response should be relaxed at least for the LP-WUR type which targets ultra-low power consumption. (Huawei)**
  + **Option 2: Reuse the spurious response requirements from TS 38.101-1 for LP-WUR. (ZTE)**
* Recommended WF
  + Discuss high-level common understanding on whether spurious response can be relaxed

**Issue 3-2-2: Maximum input level requirements**

* Proposals
  + **Proposal 1: The configurations should be excluded for the use of LP-WUS where all PRBs are occupied by LP-WUS and no PRB left for NR, e.g., 5MHz with 30kHz SCS. (CATT)**
  + **Proposal 2: The max. input power level is specified for all channel bandwidths, in the presence of legacy RBs with the same PSD as the LPWUS RBs. (QC)**
  + **Proposal 3: -25dBm maximum input level should be scaled-down based on the number of LP-WUS RBs. (ZTE, CATT)**
    - **maximum input level for LP-WUR as -26.5dBm. (CATT)**
  + **Proposal 4: -25dBm maximum input level should *NOT* be scaled-down based on the number of LP-WUS RBs. (Nokia)**
* Recommended WF
  + First discuss whether 5MHz with 30kHz should be excluded.
  + Then discuss whether use legacy -25dBm or scaled to -26.5dBm.

**Issue 3-2-3: Reference channel for LP-WUR requirements**

* Proposals
  + **Proposal 1: RAN4 to hold on discussion on reference channel definition until RAN1 finalizes LP-WUS signal design. (CATT)**
* Recommended WF
  + RAN4 has confirmed RMC is needed. Details can be further discussed.
  + Encourage companies to share input next meeting

# Topic #4: Testability issues

### Sub-topic 4-1 Testability for UE RF requirements

**Issue 4-1-1: alignment of common understanding on LP-WUS requirements and corresponding testing**

* Proposals
  + **Proposal 1: The same LP-WUS performance requirements for all three RRC states are assumed. But only one RRC state needs to be verified. (CATT, Ericsson)**
* Recommended WF
  + Check whether P1 is agreeable.

**Agreements in AH:**

**The same LP-WUS RF requirements for all three RRC states are assumed. But only one RRC state needs to be tested.**

**Issue 4-1-2: General framework of** **interface between the MR and the LR to verify RF performance**

* Proposals
  + **Proposal 1: RAN4 define the test interface between the MR and the LR, to ensure the MR is able to enter deep sleep with LR test is ongoing. The MR should only be woken up when data transfer the system simulator is needed. (Nokia)**
  + **Proposal 2: Counter the detection rate without waking up the MR would be enough for the LP-WUS test in terms of verifying the RF requirements. (Huawei, vivo)**
  + **Proposal 3: RAN4 to consider utilize MR to send feedback of LP-WUR during the test. No tet mode with different UE behaviours is required. (CATT)**
  + **Proposal 4: The LPWUS core requirement test method must ensure that the detection outcomes of the UE under test are separately counted for 3 different stimuli: intended WUS sequence, WUS sequence not intended for UE under test, and missing WUS during monitoring occasion. (QC)**
* Recommended WF
  + Group discuss and conclude the general framework for LP-WUS performance verification, consider the following as starting point:
    - Counter the detection rate without waking up the MR would be enough to verify LP-WUS RF performance. The MR should only be woken up when data transfer the system simulator is needed.

**Issue 4-1-3: Separate RF test case for idle and connection mode**

* Proposals
  + **Proposal 1: Test cases should be designed separately LP-WUS operation in IDLE/INACTIVE mode and CONNECTED mode since the procedures are different and the LP-WUS signals could be different. (Huawei)**
  + **Proposal 2: RAN4 not to consider separate test cases for IDLE and CONNECTED modes, and LP-WUS is tested only in RRC\_CONNECTED state. (CATT)**
  + **Proposal 3: RAN4 should also discuss whether the solution could be applied to all LP-WUR capabilities, i.e., supports both idle and connection mode. (vivo)**
  + **Proposal 4: Either connected or idle mode should be tested. (E///)**
* Recommended WF
  + RAN4 align on LP-WUR capabilities first. Conclude whether all UE types support IDLE and/or CONNECTED mode?
  + Then discuss how to verify the performance under different modes.

**Issue 4-1-4: views on general procedure under different mode**

* + **Proposal 1: consider the following steps, (ZTE)**

**Option 1: The test in IDLE mode follows the steps below:**

**Step 1**: TE transmits LP-WUS to the UE, which carries UE group ID.

**Step 2**: UE receives and demodulate the signal. If UE group ID is correct, the MR will be waken up.

**Step 3**: Wake up the MR to receive corresponding Paging message from TE and feed back PRACH to the TE. Then TE record a successful LP-WUS detection.

**Option 2: The test in CONNECTED mode follows the steps below:**

**Step 1**: TE transmits LP-WUS to UE, which carries UE group ID.

**Step 2**: UE receives and demodulates the signal. If UE group ID is correct, go to step 3.

**Step 3**: MR will be ready to receive PDCCH and PDSCH, then feed back ACK/NACK. Then TE record a successful LP-WUS detection.

* Recommended WF
  + TBA

**Issue 4-1-5: UE test mode for LP-WUR**

* Proposals
  + **Option 1: Conclude in RAN4, a UE Test mode is needed. (Samsung, vivo, ZTE)**
  + **Option 2: whether need UE test mode could be left to RAN5. (Huawei, Nokia, Ericsson)**
    - **RAN4 side condition assumptions can be communicated to RAN5 via LS if needed. (QC)**
    - **Test mode shall support RRC\_IDLE, RRC\_INACTIVE, and RRC\_CONNECTED states. (Nokia)**
  + **Option 3: no test mode is needed. (CATT)**
* Recommended WF
  + if the MR needs to wake up each time, potentially a test mode is also needed to make it into sleep mode before next LP-WUS ON/OFF detection.
  + Check whether A UE test mode for LP-WUR performance verification seems to be must.
  + This also depends on outcome in Issue 4-1-2

**Issue 4-1-6: whether a LS to RAN5 on test issue**

* Proposals
  + **Option 1: Send a LS including two options of test approach to RAN5. (E///)**
  + **Option 2: No LS to RAN5 is needed currently. (CATT, Samsung)**
    - **RAN4 should focus on the study of LP-WUR testability as WID required, and a LS to RAN5 is not needed unless a specific RAN5 related issue or question needs RAN5 expertise. (Samsung)**
* Recommended WF
  + Suggest option 2.

**Issue 4-1-7: Test configurations for all Rx requirements**

* + **Proposal 1: Test configurations in Table 1 could be considered as starting point for further discussion. (Huawei)**

**Table 1: Test configurations for LP-WUR**

|  |  |
| --- | --- |
| **Requirements** | **Test Configurations** |
| REFSENS | * 5MHz, 15kHz SCS * LP-WUS is configured at center of the carrier * without NR signals in the same carrier |
| Maximum input level | * 5MHz, 15kHz/30kHz SCS * LP-WUS is configured at center of the carrier * without NR signals in the same carrier |
| ACS | * 10MHz, 15kHz/30kHz SCS * LP-WUS is configured at edge of the carrier * without NR signals in the same carrier |
| ASCS | * L/M/H CBWs, 15kHz/30kHz SCS * LP-WUS is configured at center of the carrier * with adjacent NR signals padded in the same carrier |
| In-band blocking | * 10MHz, 15kHz/30kHz SCS * LP-WUS is configured at edge of the carrier * without adjacent NR signals padded in the same carrier |
| Out-of-band blocking | * LP-WUS is configured at center of the carrier * without adjacent NR signals padded in the same carrier |
| Narrow band blocking | * 10MHz, 15kHz/30kHz SCS * LP-WUS is configured at edge of the carrier * without adjacent NR signals padded in the same carrier |
| Spurious response | * 10MHz, 15kHz/30kHz SCS * LP-WUS is configured at edge of the carrier * without adjacent NR signals padded in the same carrier |
| Wide band Intermodulation | * 10MHz, 15kHz/30kHz SCS * LP-WUS is configured at center of the carrier * without adjacent NR signals padded in the same carrier |
| Spurious emissions | * Maximum CBW, 15kHz/30kHz SCS * LP-WUS is configured at center of the carrier * with adjacent NR signals padded in the same carrier |

* Recommended WF
  + Collect feedback from companies.

**Issue 4-1-8: detailed Test procedure**

* + **Proposal 1: RAN5 defines the detailed test procedure for the conformance tests. A higher SNR for the main radio signals can be used, so that just the performance of the LP-WUR is tested. (Nokia)**
    - **RAN5 can decide the confidence level to be used for testing the LP-WUR requirements in a reasonable amount of time.**
  + **Proposal 2: The detailed test implementation can also be left to RAN5. (ZTE)**
* Recommended WF
  + TBA