**3GPP TSG-RAN WG4 Meeting #111 R4-240xxxx**

**Fukuoka City, Fukuoka, Japan, 20th – 24th May, 2024**

**Agenda item:** 10.14.5

**Source:** vivo

**Title:** Ad-hoc minutes for [111][136] NR\_LPWUS\_UERF

**Document for:** Information

# Introduction

This is ad-hoc minutes for Rel-19 LP-WUS UE RF, chaired by Ruixin Wang (vivo).

# Topic #1: General and system parameters

### Sub-topic 1-1 General and system parameters

**Issue 1-1-1: Operation bands for LP-WUS feature**

* Proposals
  + **Proposal 1: RAN4 confirm LP-WUS is a general feature not limited to specific example band(s). (vivo)**
* Recommended WF
  + TBA

ZTE： does this mean LP-WUS can be applied to all FR1 licenced bands

E///: this is per-band feature, UE will support the capability.

Nokia: REFSENS will be different for bands?

Ad-hoc Agreements:

**RAN4 confirm LP-WUS is a general feature not limited to specific example band(s)**

**Issue 1-1-2: FR1 example bands for requirements as phase 1**

* Proposals
  + **Proposal 1: It is proposed to select some FR1 bands lower than 2GHz as starting point for LP-WUS/WUR in Rel-19. (Huawei)**
  + **Proposal 2: RAN4 to consider the selection of three example bands for band-specific requirements LP-WUR, with one band representing each band group, e.g., n1, n8, and n77. (CATT)**
  + **Proposal 3: Not limit the LPWUS example bands under 2GHz, and NR bands n28 and n41 could be chosen as example bands. (CMCC)**
  + **Proposal 4: Choose band n28 (700MHz), band n3 (1800MHz) and band n41 (2.6GHz) as example bands for band specific requirement study. (ZTE)**
* Recommended WF
  + Check whether n8, n41, n78 can be selected

QC: RAN4 should finalize all FR1 bands

Sony: example band is not needed.

Huawei: we think LP-WUR can only support part of bands. For the UE support LP-WUS feature, only few operation bands can be considered. Limiting the number of bands could make the feature more useful for commercialization purpose.

QC: UE can make the choice on supporting or operation bands. Based on operator and marketing

CMCC: we do not want to limit the supported bands. The example frequencies for simulation are sufficient.

**Issue 1-1-3: FR2 example bands for requirements as phase 1**

* Proposals
  + **Proposal 1: RAN4 to consider using n258 as the example FR2 band. (Qualcomm)**
* Recommended WF
  + FFS FR2 work. Current not considered in RAN1

Moderator：this has been discussed in issue 2-1-10

**Issue 1-1-4: one or two sets of requirements (REFSENS)**

* Proposals
  + **Proposal 1: To accommodate different UE architectures, two sets of requirements at least with different NF should be considered for LP-WUR. (Huawei, CMCC, Apple, vivo)**
    - **Different NF for OOK-based receivers and OFDM-based receivers**
    - **Whether SNR is different, is FFS**
  + **Proposal 2: Strive for the single set of RF requirement, may allow the different RF requirement for OOK WUR or OFDM WUR if needed depending on further discussion. (E///, Sony)**
* Recommended WF
  + Working on two sets of requirements, not preclude final harmonize to one

Moderator：this will be considered when discuss NF, and potential SNR

**Issue 1-1-5: Rx diversity gain assumption for LP-WUR**

* Proposals
  + **Proposal 1: More discussion around Rx diversity for WUR. (E///)**
  + **Proposal 2: To minimize current consumption for wake-up receiver do not include Rx diversity. (Apple)**
  + **Proposal 3: Consider No diversity gain for RENSENS. (Nokia)**
  + **Proposal 4: fully consider the antenna sharing and switching architecture. (Samsung)**
* Recommended WF
  + No diversity gain as baseline. More Rx could be implementation choice

**Ad-hoc Agreements:**

No diversity gain as baseline for FR1. More Rx could be implementation choice

**Issue 1-1-6: CBW and RB number for LP-WUR**

* Proposals
  + **Proposal 1: It is proposed to specify the LP-WUS requirements based on 5MHz and FFS on the NR CBW. Determination of NR CBW depends on further discussion on operating bands and BS power boosting. (Huawei)**
  + **Proposal 2: RAN4 should analyze and decide the minimum NR operation bandwidth for LP-WUS, e.g., 5MHz or 10MHz, based on outcome of ACS/ASCS requirements and guard RBs. (vivo)**
  + **Proposal 3: The BW of WUR should be specified in X PRB of LP-WUS referencing to the RB grid of MR. (E///)**
  + **Proposal 4: RAN4 to clarify the NR channel bandwidth and RB number in which LP-WUS is deployed for ACS/ASCS simulation purpose. (CATT)**
  + **Proposal 5: 5MHz channel bandwidth could be used as the starting point. (CMCC)**
* Recommended WF
  + 5MHz NR CBW should be studied

Moderator：this has been discussed and decided in LLS paramters

**Issue 1-1-7: Channel raster for LP-WUR**

* Proposals
  + **Proposal 1: Channel raster design for LP-WUR should guarantee flexible placement within the in-band NR signal PRB grid, and be specified after RAN1 design is completed. (CATT)**
  + **Proposal 2：Reuse existing channel raster as a start point for LP-WUS study. (ZTE)**
  + **Proposal 3: Channel raster does not apply to WUR. (E///)**
* Recommended WF
  + Check and confirm proposal 3

Discussion:

QC: what is the benefit of separated channel raster for LP-WUS

Huawei: specific frequency is not that important for LP-WUR

ZTE: our proposal is to follow NB-IoT method. For the standalone LP-WUS, the raster should be aligned with in-band NR.

E///: the LPWUS in configured with MR, within the MR channel.

CMCC: UE know the location of LP-WUS?

Nokia: not understand why new raster is needed for LP-WUS

E///: why WUR should know the channel raster, given the UE know LP-WUS signal location in-band

**Ad-hoc Agreements:** RAN4 further check whether no channel raster is needed for LP-WUR.

**Issue 1-1-8: system parameters for LP-WUR**

* Proposals
  + **Proposal 1: No specification impact on WUR in terms of system parameter. (E///)**
* Recommended WF
  + TBA

Moderator：based on discussion, only channel raster needs further check.

**Issue 1-1-9: Side condition for LP-WUR requirements**

* Proposals
  + **Proposal 1: RAN4 to reflect both idle and connected mode conditions in the side conditions for the LPWUR requirements. (Qualcomm)**
* Recommended WF
  + TBA

**Issue 1-1-10: conducted test for LP-WUR**

* Proposals
  + **Proposal 1: Same conducted test should be applied to WUR and MR. (E///)**
* Recommended WF
  + TBA

# Topic #2: REFSENS, ASCS and ACS requirements

### Sub-topic 2-1 Alignment of LLS parameters to specify ACS/ASCS requirements

**Issue 2-1-1: Center frequencies for LLS simulation**

**Online Agreement:**

* For ACS and ASCS simulation, select 900MHz, 2.6GHz and 3.5GHz as example frequencies for FR1.
* FFS on FR2 example band(s)

**Issue 2-1-2: Performance metric (MDR/BLER value) for LLS simulation (apply to ACS/ASCS and REFSENS)**

Online Agreement:

* For LLS simulation (apply to ACS/ASCS and REFSENS), the metric includes
  + 1% MDR/BLER as baseline and 5% MDR/BLER as optional
  + The following false alarm rate can be considered
    - 1%
    - 5%
    - Providing the information whether the false alarm rate is considered or not
* Further down-select the performance metric for the requirements and testing

**Issue 2-1-3: Waveform for LLS simulation**

Online Agreement:

* Use both OOK1 and OOK4 based on RAN1 agreements for link level simulations

**Issue 2-1-4: number of LP-WUS RBs for LLS simulation**

**Online Agreement:**

* Assume 11PRB for LP-WUS signal with 30kHz SCS for simulations
* FFS on RB number(s) for 15KHz SCS depending on RAN1 decision

**Issue 2-1-5: number of ADC assumption for LLS simulation**

Online Agreement:

* Number of ADC assumption for LLS simulation
  + Option 1: 8 bit
  + Option 2: 4 bit
  + Encourage companies to provide simulation results with both options for comparison

**Issue 2-1-6: Frequency error assumption for LLS simulation**

Online Agreement

* Frequency error assumption for LLS simulation
  + Up to 20ppm

**Issue 2-1-7: Phase noise model for LLS simulation**

Online Agreement:

* Not needed in LLS. Consider as RF impairment of implementation.

**Issue 2-1-8: For ASCS, the BWinterferer for ASCS evaluation**

Online Agreement:

* For ASCS evaluation, only 10MHz and 20MHz NR CBWs are assumed and the BWinterferer is
  + All RBs between WUS edge to channel edge

**Issue 2-1-10: The overall simulation parameters for LLS simulation**

Online Agreement:

* Wait for RAN1 conclusion on FR2 to decide the parameters for evaluations

|  |  |  |  |
| --- | --- | --- | --- |
| Attributes | Assumptions | | |
| Case name | OOK-1 waveform | | OOK-4 waveform |
| Channel structure [TBD impacts] | Total 8/16 bits | | |
| Chip rate | M=1 | M=1/2/4 | |
| WUS duration | FFS | | |
| Waveform | OOK-1/OOK-4 | | |
| Coding | 1/2 rate Manchester coding | | |
| Time error | 0 | | |
| Residual Frequency error | 0/10/20 ppm | | |
| SCS | 30kHz | | |
| UE Channel BW | 20MHz (51 RB)-case 1  10MHz (24 RB)-case 2  5MHz (11 RB)-case 3 | | |
| WUS RB | * Fixed 11RB ~ 3.96MHz for 10MHz and 20MHz cases | | |
| 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 | | |
| 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 = [20~33] 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 | 8 bits ADC for ASCS/ACS | | |
| Phase noise | none | | |
| 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 300  Option 2: AWGN  Note: encourage companies to provide simulation results with both options | | |
| Performance metric | MDR/BLER x% | | |

### Sub-topic 2-2 REFSENS requirements

**Issue 2-2-1: Only MDR for REFSENS**

* Proposals
  + **Option 1: Only MDR is sufficient for REFSENS.** 
    - **FAR can be considered as a dedicated demodulation requirements**
  + **Option 2: Both MDR and FAR should be considered.**
* Recommended WF
  + TBD

Ericsson: false alarm could be used for demodulation test. We do not need test it in RF.

Huawei: when we discuss the requirement, we need consider the testability issue. False alarm rate needs be considered in FESENS. We need consider both to ensure it can work.

Apple: What is the metric to indicate the false alarm? Message 1? It is not easy to test.

Xiaomi: MDR and FAR are different definitions. FAR is just with noise. FAR should be checked in the demodulation.

Nokia: with or without FAR the performance will be different. UE can easily pass the requirement.

Sony: we only discuss the test metric for REFSENS requirement. It is not only test for receiver. We can guarantee the FRA performance by demod.

Moderator: for REFSENS, the test is under external noise free condition. FAR test needs considering the higher noise level.

*Moderator: agreed only LP-WUS is needed for REFSENS, in WF*

**Issue 2-2-2: signal configuration for REFSENS requirements**

* Proposals
  + **Proposal 1: Both LP-SS and LP-WUS should be configured in REFSNES test. (Samsung)**
* Recommended WF
  + TBD

**Issue 2-2-3: SNR value (not requirement) for REFSENS**

* Proposals
  + **Proposal 1: Specify two sets of SNR for LP-WUS. (CMCC)**
  + **Proposal 2: Additional relaxation on SNR value is to be agreed once SNR values based on simulations are available. (Nokia)**
  + **Proposal 3: Wait for RAN1 SNR progress. (E///, Nokia,** **Spreadtrum, OPPO)**
  + **Proposal 4: No need to combine SNR and NF together to target the same coverage of MSG3 for different set of requirements. (Huawei)**
  + **Proposal 5: The Refsens condition is determined as the more stringent on the two: (Qualcomm)**
    - **A NF and SNR based projection (UE feasibility consideration)**
    - **Coverage consideration including legacy DL signal in adjacent subcarriers (network consideration)**
  + **Proposal 6: Based on the legacy method, RAN4 shall further refine the estimation of NF and SNR, once the LP-WUS signal design is stable, to ensure that the MIL of LP-WUS can be comparable with msg.3, based on the defined REFSENS requirement of LP-WUS. (Sony)**
* Recommended WF
  + Wait for RAN1 SNR progress

**Issue 2-2-4: NF Gap between LR and MR for REFSENS (assume MR as 9dB)**

* Proposals
  + **Option 1: +5dB for OFDM-based, +8dB for OOK-based (Huawei)**
  + **Option 2: +2dB, +5dB, +8dB for LR’s NF. (Xiaomi)**
  + **Option 3: 0dB for the OFDM signal, +3-6dB gap for OOK signal. (CMCC)**
  + **Option 4:** +**3 dB gap as a baseline for LP\_WUR. (Nokia)**
  + **Option 5: +0-7dB for OFDM-based, +3~7dB for OOK-based. (vivo)**
  + **Option 6: +2 dB for OFDM-based, +8dB for OOK-based. (Spreadtrum)**
  + **Option 7: +5dB for OOK-based. (ZTE)**
* Recommended WF
  + Discuss based on the summarized value

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| NF gap (on top of MR 9dB) | Huawei | Xiaomi | CMCC | Nokia | vivo | Spreadtrum | ZTE |
| **OFDM-based** | 5dB | 2/5/8dB | 0dB | 3dB | 0-7dB | 2dB | ? |
| **OOK-based** | 8dB | 2/5/8dB | 3-6dB | 3dB | 3-7dB | 8dB | 5dB |

Discussion:

QC: the real issue is that the coverage sensitivity is not clear to the group.

Samsung: the coverage will be addressed based on decision of required SNR.

Huawei: for the UE design, the legacy approach is also workable for LP-WUR. NF and SNR will dominate the coverage performance. RAN4 just need to consider the feasible value of NF

E///: full coverage is the decision for LP-WUR.

**Issue 2-2-5: Diversity Gain value for REFSENS**

* Proposals
  + **Option 1: Set to 0. (Nokia, Apple)**
  + **Option 2: other**
* Recommended WF
  + Agreeable

**Issue 2-2-6: IM value for REFSENS**

* Proposals
  + **Option 1: less than 2.5 dB. (Nokia)**
  + **Option 2: Check whether to reuse legacy 2.5dB. (ZTE)**
* Recommended WF
  + TBD

**Issue 2-2-7: False alarm rate requirements for LP-WUS receiver**

* Proposals
  + **Proposal 1: False alarm rate is a demodulation requirement related to the setting of the demodulation threshold. Whether to have false alarm rate should discuss in demodulation part not in FR part. (Xiaomi)**
  + **Proposal 2: False alarm rate can be considered as a dedicated performance requirements for baseband demodulation, e.g., X% FAR at -Y dBm AWGN level. (vivo)**
  + **Proposal 3: Whether we should define requirements of false alarm rate depends on RAN1’s progress. (Spreadtrum)**
  + **Proposal 4: RAN4 to introduce a requirement for false alarm rate for LP-WUS in order to guarantee the merits of introducing LP-WUS/LP-WUR. (CATT)**
* Recommended WF
  + Consider FAR as demodulation requirements

**Issue 2-2-8: Whether a baseline architecture is needed for LP-WUS receiver**

* Proposals
  + **Proposal 1: Agree to use zero-IF receiver as a baseline architecture for LP\_WUR. (Nokia)**
  + **Proposal 2: Exclude RF envelope detection architecture for LP-WUR. (ZTE, Sony)**
  + **Proposal 3: It is proposed that RAN4 start to select candidate LP-WUR reference architectures, which will be used to derive the REFSENS requirements in the future. (Sony)**
  + **Proposal 4: RAN4 to decide one or two reference architectures prior to proceeding with the detailed specification of RF requirements for LP-WUR. (CATT)**
  + **Proposal 5: It is proposed to fully consider the antenna sharing and switching architecture when deciding NF and REFSNES requirements. (Samsung)**
* Recommended WF
  + Discuss NF for each type as architecture agnostic.

### Sub-topic 2-3 ASCS requirements

**Issue 2-3-1: Align the definition of ASCS requirements**

* Proposals
  + **Proposal 1: The ASCS requirement definition should consider both the ASCS value in dB scale and also applicable guard RB. (CMCC)**
  + **Proposal 2: RAN4** **can specify the definition of ASCS, as following**
    - **Adjacent SubCarrier Selectivity (ASCS) is a measure of a receiver's ability to receive an LP-WUS signal at its assigned channel frequency in the presence of an adjacent subcarrier NR signal at a given frequency offset (guard RB) between LP-WUS and NR. ASCS is the ratio of the receive filter attenuation on the assigned LP-WUR channel frequency to the receive filter attenuation on the adjacent NR subcarrier**
* Recommended WF
  + TBD

**Issue 2-3-2: ASCS requirements value**

* Proposals
  + **Proposal 1: If guard RB is specified for ASCS scenario, there is no need to define specific requirement for ASCS. (Huawei, vivo)**
    - **test case condition (e.g., bandwidth, power level, MDR) and required guard RB should be specified**
  + **Proposal 2: further investigating if the ACSC should be set to the same value as the ACS requirement. (Sony)**
* Recommended WF
  + Check whether proposal 1 is agreeable

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

* Proposals
  + **Proposal 1: It is proposed to adopt 1 RB as the size of guard RB for LP-WUS ASCS regardless of the applied SCS. (Huawei)**
  + **Proposal 2: RAN4 shall derive the number of guard RB based on some practical filter assumption once the ACS/ASCS requirement is agreed. (Sony)**
* Recommended WF
  + Guard RB value needs further discussion based on LLS outcome

**Issue 2-3-4: Test case for ASCS**

* Proposals
  + **Proposal 1: The ASCS requirements can not be verified directly, the test case should be designed at a fixed DL power of NR and LP-WUS (same PSD, X dB higher than REFSENS) to check whether the MDR is within Y%. (vivo)**
* Recommended WF
  + TBA

### Sub-topic 2-4 ACS requirements

**Issue 2-4-1: Whether to update the ACS definition for LP-WUS**

* Proposals
  + **Proposal 1: the ACS requirement definition for LP-WUR. (vivo)**
    - **Adjacent channel selectivity (ACS) is a measure of a receiver's ability to receive an ~~NR~~ LP-WUS signal at its assigned channel frequency in the presence of an adjacent channel signal at a given frequency offset from the center frequency of the assigned channel. ACS is the ratio of the receive filter attenuation on the assigned channel frequency to the receive filter attenuation on the adjacent channel(s).**
* Recommended WF
  + TBA

**Issue 2-4-2: ACS requirements value**

* Proposals
  + **Proposal 1: It is proposed to relax ACS requirement for LP-WUR from co-existence and performance perspective. The proposed ACS could be in the range of 20~25dBc. (Huawei)**
  + **Proposal 2: Wen LP-WUS is located in a NR UE channel bandwidth larger than WUS signal and packed with NR legacy DL signal on both sides: (Xiaomi)**
    - **The ACS can keep the same requirements with legacy NR UE**
    - **The parameters of unwanted interferring for the narrow band blocking and in band blocking can reuse the values of legacy NR UE, the wanted signalling can be defined based on the REFSENS of LP-WUS.**
  + **Proposal 3: Define the ACS requirement for LP-WUS as 33 dB. (Sony)**
* Recommended WF
  + TBA

**Issue 2-4-3: Required guard RB for ACS case**

* Proposals
  + **Proposal 1: It is proposed to define 1 RB for 30kHz SCS as guard RB size for LP-WUR ACS case. (Huawei)**
  + **Proposal 2: RAN4 shall derive the number of guard RB based on some practical filter assumption once the ACS/ASCS requirement is agreed. (Sony)**
  + **Proposal 3: Define the ACS requirement with guard RBs as the LP-WUS signal at the edge of NR channel and the interference NR signal is directly next to the first NR channel. (OPPO)**
* Recommended WF
  + TBA

**Issue 2-4-4: Side condition for ACS test case**

* Proposals
  + **Proposal 1: - LP-WUS occupies all assigned NR UE channel bandwidth standalone as figure 2-4. (Xiaomi)**
* Recommended WF
  + TBA

**Issue 2-4-5: Test parameters for LP-WUR ACS case**

* Proposals
  + **Proposal 1: Test parameters defined in Table 7.5-3, 7.5-4, 7.5-5, and 7.5-6 of TS 38.101-1 apply for LP\_WUR ACS test case. (Nokia)**
    - **In test case where Pinterferer depends on REFSENS, main receiver REFSENS should be used**
* Recommended WF
  + TBD

# Topic #3: Other RF requirements

### Sub-topic 3-1 General for UE RF

**Issue 3-1-1: IBB and OBB assumption**

* Proposals
  + **Proposal 1: The WUR should tolerate the same level RF interferer of IBB and OBB as main receiver. (E///)**
  + **Proposal 2: FFS whether LR can work well in presence of strong interference (Huawei)**
* Recommended WF
  + TBA

**Issue 3-1-2: IBB and OBB requirements**

* Proposals
  + **Proposal 1: In order to guarantee the coverage of LP-WUR, the interference levels for IBB and OBB could be relaxed compared to the values defined for MR. (Huawei)**
  + **Proposal 2: The IBB/OBB can reuse legacy NR UE requirements. (CMCC, OPPO, Xiaomi)**
  + **Proposal 3: The IBB/OBB/intermodulation requirements for LP-WUS is related to the allocated position of LP-WUS signal within NR channel, the definition and test cases should be modified. (vivo)**
  + **Proposals 4: The WUR requirement should be set in relation to the MR channel bandwidth. (E///)**
* Recommended WF
  + TBA

**Issue 3-1-3: IBB and OBB test case**

* Proposals
  + **Proposal 1: The DL power level for IBB/OBB requirements should also be re-evaluated for LP-WUS at different bandwidth and different location. (vivo)**
    - **The Guard RBs for ACS/ASCS should be configured for the above requirements**
  + **Proposal 2: The same of the degradation of wanted power level of the WUR. The same condition set for WUR REFSESN requirements should be extended for IBB and OBB test (E///)**
* Recommended WF
  + TBA

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

* Proposals
  + **Proposal 1: FFS whether intermodulation requirement needs to be relaxed for LP-WUR. (Huawei)**
  + **Proposal 2: the WUR requirement should be tested with interferer setting from MR. (E///)**
  + **Proposal 3: The DL power level for intermodulation requirements should also be re-evaluated for LP-WUS at different bandwidth and different location. (vivo)**
    - **The Guard RBs for ACS/ASCS should be configured for the above requirements**
  + **Proposal 4:** **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 OOK signal.**
* Recommended WF
  + TBD

**Issue 3-1-5: IF LP-WUS occupies all assigned NR UE channel bandwidth**

* Proposals
  + **Proposal 1: - The parameters of unwanted interferring for the narrow band blocking and in band blocking need be re-evaluated, the wanted signalling can be defined based on the REFSENS of LP-WUS. (Xiaomi)**
* Recommended WF
  + TBD

### Sub-topic 3-2 spurious emissions and response requirements

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

* Proposals
  + **Proposal 1: The same level of receiver spurious emissions for MR shall be defined for LR as well. (Huawei, CMCC, vivo, Xiaomi, OPPO, E///)**
* Recommended WF
  + TBD

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

* Proposals
  + **Proposal 1: spurious response as a remedial measure for blocking tests needs to be considered for LP-WUR. (Huawei)**
  + **Proposal 2: Spurious response should be treated the same with the IBB and OBB for WUR. (E///)**
* Recommended WF
  + TBD

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

**Issue 3-3-1: Maximum input level requirements**

* Proposals
  + **Proposal 1: Specify maximum input level requirements and side conditions for LP-WUR. (Nokia)**
    - **A single value as of -25 dBm is sufficient**
* Recommended WF
  + TBD

**Issue 3-3-2: Narrow band blocking requirements**

* Proposals
  + **Proposal 1: No need to define narrow band blocking requirements. (Nokia)**
* Recommended WF
  + TBD

# Topic #4: Testability issues

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

**Issue 4-1-1: Test performance metric**

* Proposals
  + **Proposal 1: Test metric should be aligned with the performance metric of each requirement.**
  + **Proposal 2: If the additional test mode would be preferred from RAN5 perspective, ask also if other testing metric would be better than MDR. E.g (BER/BLER)**
* Recommended WF
  + TBA

**Issue 4-1-2: 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 for these modes. (Huawei)**
* Recommended WF
  + TBA

**Issue 4-1-3: BLER/MDR counting based on MR wake-up or not**

* Proposals
  + **Proposal 1: 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)**
* Recommended WF
  + TBA

**Issue 4-1-4: How to get feedback from LP-WUR**

* + **Proposal 1: For LP-WUR testability issue, RAN4 can consider the following two options, e.g., (vivo)**
    - **Option1: MR connection mode, but MR should not receive and detect LP-WUS signal. The MDR can be calculated based on “ACK/NACK” results of LP-WUR which is feedback to gNB by MR**
    - **Option2: MR idle mode, there is no LP-WUS feedback to gNB during testing, a new UE test mode is needed. MR should be waken-up after testing of all LP-WUS signal and connected to gNB to feedback the LP-WUS detection results**
  + **Proposal 2: Feedback from the UE regarding LP-WUR performance should be gathered in the RRC\_CONNECTED mode. (Nokia)**
  + **Proposal 3: RNA4 should determine to perform the test of LP-WUR in IDLE mode or CONNECTED mode first. (ZTE)**
    - **For IDEL mode test, TE should be designed to transmit Paging message corresponding to LP-WUS and receive PRACH from the main radio after LP-WUS is transmitted**
    - **For CONNECTED mode test, legacy test method can be reused while the test metric is MDR (or with FAR together) rather than throughput**
  + **Proposal 4: After setting up the test mode in connected mode, when the UE enters into the IDLE/INACTIVE mode, the UE can record the detection rate and false alarm rate then report the rates to TE when the UE enter back to the connected mode. The test mode as well as the details of the test mode can also be left to RAN5. (Huawei)**
* Recommended WF
  + TBA

**Issue 4-1-5: Consider FAR for LP-WUS RF test or not?**

* + **Proposal 1: False alarm rate should be considered for the LP-WUS test. (Huawei, Nokia)**
  + **Proposal 2: FAR is considered as demodulation test metric but not RF. (E///, vivo)**
* Recommended WF
  + TBA

**Issue 4-1-6: detailed Test configuration**

* + **Proposal 1: Set the SNR of the PDCCH higher than TS 38.101-4 for the corresponding antenna configuration of main receiver to decrease the PDCCH detection impact on WUR testing metric. (E///)**
  + **Proposal 3: A higher SNR for the main radio signals can be used, so that we just test the performance of the LP-WUR. RAN5 can decide the confidence level to be used for testing the LP-WUR requirements in a reasonable amount of time. (Nokia)**
* Recommended WF
  + TBA

**Issue 4-1-7: detailed Test procedure**

* + **Proposal 1: RAN5 defines the detailed test procedure for the conformance tests. (Nokia)**
  + **Proposal 2: Leave the details of test cases design to RAN5. (Huawei)**
* Recommended WF
  + TBA

**Issue 4-1-8: UE test mode for LP-WUR**

* Proposals
  + **Option 1: UE test mode is needed.**
  + **Option 2: other**
* Recommended WF
  + TBA

**Issue 4-1-9: whether a LS to RAN5 on test issue**

* Proposals
  + **Proposal 1: Discuss if a LS to RAN5 or a note in RAN4 specification is sufficient. (Nokia)**
  + **Proposal 2: Send a LS to RAN5 to see if MDR could be further optimized from testing perspective. (E///)**
    - **RAN4 are discussing the test metric for wake up receiver RF performance test. As the WUR only detect LP-WUS/LP-SS and no other signals, legacy throughout monitoring for PDSCH is not possible anymore. Therefore, RAN4 propose the test metric of Miss Detection Rate of LP-WUS (target 1%) as one option. To test MDR of LP-WUS, there are two options to do it and RAN4 agree that it will be up to RAN5 to decide which options is suitable for WUR receiver test**
    - **Two options below to test**
      * **Using the legacy paging procedure to detect successfully LP-WUS reception by WUR**
      * **New test mode for testing the successfully LP-WUS reception by WUR**
    - **RAN4 also want to ask if the new test mode would be preferred from testing time perspective, would the test metric of BER/BLER be a better performance metric than MDR (1%).**
* Recommended WF
  + TBA