**3GPP TSG-RAN WG4 Meeting #113 R4-2420394**

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

**Agenda item:** 7.23.5

**Source:** Moderator (vivo)

**Title:** WF on UE RF requirements for LP-WUS

**Document for:** Approval

# Introduction

This is WF for Rel-19 LP-WUS UE RF.

# Topic #1: General and system parameters

### Sub-topic 1-1 General

**Issue 1-1-3: General issue on how to introduce LP-WUS feature into core specs 38.101-x**

Agreements:

* + **Add a new suffix “M” as “LP-WUS/WUR”**

**Issue 1-1-4: views on which requirements should be updated in core spec**

Agreements:

* + **The part should be updated for LP-WUS/WUR in spec.**
    - **The additional requirements are not precluded, if needed.**

|  |  |
| --- | --- |
| **Sections or requirements** | **Needed or not?** |
| Operation bands | FFS |
| UE channel bandwidth | FFS |
| Channel raster | FFS |
| REFSENS | YES |
| Maximum input level | YES |
| ACS | YES |
| ASCS | YES |
| In-band blocking | YES |
| Out-of-band blocking | YES |
| Narrow band blocking | YES |
| Spurious response | FFS |
| Wide band Intermodulation | FFS |
| Spurious emissions | FFS |
| Annex A  Measurement channels | YES |

### Sub-topic 1-2 System parameters

**Issue 1-2-1: Channel raster for LP-WUR**

Agreements:

* + **No new channel raster is introduced dedicated for LP-WUS/WUR.**
    - **FFS on whether there is need of the limited set of frequencies supported by LP-WUS to reduce the receiver complexity and cost**

# 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**

Agreements:

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

Agreements:

* + **Further discussions and alignment on FR2 RF simulation assumption not precluded.**
  + **Use the following as starting point**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 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 | 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 | | |  |
| WUS RB | * Fixed 11RB ~ | | | Based on agreement in RAN1#118-Bis |
| Position within channel | * Center for ASCS, edge for ACS [assume no ASCS impact] | | |  |
| Guardband of NR channel, both wanted cell and interfer cell (ACS) | * 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 | | |  |
| 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;  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 | FFS | | |  |
| 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 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. |

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

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

Agreements:

* + **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 2-2-3: 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 |
|  |  |  |  |  |  |  |  |  |  |  |  |  |

Note: the SNR value may be updated based on new simulation results. RAN1 waveform design is not finalized.

Agreements:

* + **Use 2.5dB IM as a starting point, encourage companies to report the difference aspects due to OOK waveform receiver. 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)(assume MR=9dB) | 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 |

Note: the SNR value may be updated based on new simulation results. RAN1 waveform design is not finalized.

Agreements:

* + **Further discuss next meeting**

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

Agreements:

* + **FR2 LPWUR adopts zero-IF topology baseline assumption. FFS details**
    - **Multiple frequency conversion in RF domain is not precluded**
  + **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**
    - **FFS on whether and how to combine two Rx chains**
    - **Antenna gain is that of a single element**
    - **Coverage target should be considered**

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

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

Agreements:

* + **[0RB] as guard RB for ASCS.**

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

WF:

* + **RAN4 further discuss the test case next meeting**

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

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

Agreements:

* + **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**

Agreements:

* + **For ACS evaluation, companies are encouraged to provide the simulation results by assuming**
    - **Baseline: the same interference experienced by LP-WUR and main radio.**
    - **Optional: the different interference level for LP-WUR and main radio**

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

WF:

* + **RAN4 further discuss detailed test parameters table and how to modify spec.**

# 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.**
  + **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.**

WF:

* + Further discuss IBB and OBB 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.**

WF:

* + FFS

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

**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)**

WF:

* + FFS whether spurious response can be relaxed

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

Agreements:

* + **For maximum input power level, further discuss**
    - **Option 1: use legacy -25dBm**
    - **Option 2: scaled to -26.5dBm.**
    - **Option 3: same as MR, FFS test signal**

# 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**

Agreements:

* + **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**

Agreements:

* + **Group discuss and conclude the general framework for LP-WUS performance verification, consider the following as starting point:**
    - **Option 1: Counter the detection rate without waking up the MR would be enough to verify LP-WUS RF performance.**
    - **FFS if the MR should only be woken up when data transfer the system simulator is needed.**
    - **Other options are not precluded.**