**3GPP TSG-RAN WG4 Meeting # 112 R4-2411818**

**Maastricht, Netherlands, 19th – 23rd August, 2024**

**Agenda item:** 8.22.5

**Source:** Moderator (vivo)

**Title:** Topic summary for [112][223] NR\_LPWUS

**Document for:** Information

# Introduction

*Briefly introduce background, the scope of this email discussion (e.g. list of treated agenda items) and provide some guidelines for email discussion if necessary.*

This document provides the summary of RRM part for NR\_LPWUS.

Based on the latest approved WI in [RP-240135], the objectives of the WI are duplicated as below:

The objectives of the work item are the following:

* To specify an LP-WUS design commonly applicable to both IDLE/INACTIVE and CONNECTED modes (RAN1, RAN4)
	+ Specify OOK (OOK-1 and/or OOK-4) based LP-WUS with overlaid OFDM sequence(s) over OOK symbol
		- The LP-WUS design shall ensure that for IDLE/INACTIVE operation, the same information is delivered irrespective of LP-WUR type. The OFDM sequence can carry information.
	+ At least duty-cycled monitoring of LP-WUS is supported
* For IDLE/INACTIVE modes
	+ Specify procedure and configuration of LP-WUS indicating paging monitoring triggered by LP-WUS, including at least configuration, sub-grouping and entry/exit condition for LP-WUS monitoring (RAN2, RAN1, RAN3, RAN4)
	+ Specify LP-SS with periodicity with Yms for LP-WUR, for synchronization and/or RRM for serving cell. (RAN1, RAN4)
		- LP-SS is based on OOK-1 and/or OOK-4 waveform with or without overlaid OFDM sequences. Further down selection between with and without overlaid OFDM sequences is to be done within WI.
		- Note: For LP-WUR that can receive existing PSS/SSS, existing PSS/SSS can be used for synchronization and RRM instead of LP-SS.
		- Y will be decided within WI. 320ms is the start point.
	+ Specify further RRM relaxation of UE MR for both serving and neighbor cell measurements, and UE serving cell RRM measurement offloaded from MR to LP-WUR, including the necessary conditions (RAN4, RAN2)
* For CONNECTED mode, specify procedures to allow UE MR PDCCH monitoring triggered by LP-WUS including activation and deactivation procedure of LP-WUS monitoring (RAN2, RAN1)
	+ Check in RAN#105 for potential TU adjustment in RAN2
	+ Note: In CONNECTED mode, UE MR ultra-deep sleep is not considered, and UE RRM/RLM/BFD/CSI measurements are performed by MR
* Note: The target coverage of LP-WUS and LP-SS shall be the coverage of PUSCH for message3.
* Note: The optimization of LP-WUS signal design for idle/inactive mode is prioritized over the optimization for connected mode.
* Specify the necessary RAN4 core requirement(s) to support the feature (RAN4).
	+ Specifying UE low-power wake-up receiver requirements, at least REFSENS, ACS and ASCS requirements with consideration of possible new methodology
		- Define guard RBs for ACS and ASCS cases
		- Study testability of above requirements
		- Consider impacts of different architecture and impairments
	+ Study and specify, if necessary, any BS requirements, e.g., increase upper limit for LP-WUS/LP-SS beyond current dynamic range
	+ Specify necessary RRM requirements

Recommendation topic to be discussed online in order of priority identified by the moderator.

**Issue 1-1-1: Cases/states to be considered for RRM relaxation and serving cell measurement offloading**

**Issue 2-1-1: SINR setting**

**Issue 2-1-1-1: SNR setting for serving and interference cell derivation from SINR setting**

**Issue 2-1-2: Measurement metrics**

**Issue 2-1-3: Time/frequency error**

**Issue 2-1-4: Accuracy baseline for simulation**

**Issue 2-1-5: Measurement interval**

**Issue 1-1-8: On jointly consideration on issue 1-1-5, 1-1-6 and 1-1-7**

**Issue 1-2-6: Nubmer of Rx for LP-WUR requirements**

**Issue 1-1-3: Core requirements to be specified for MR RRM relaxation**

**ssue 1-3-1: MR RRM relaxation for serving cell/neighbour cell**

# Topic #1: RRM core requirements for LP-WUS/WUR

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2411362**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411362.zip) | CATT | Proposal 1: RAN4 to prioritize case#1 and case #3 for defining the requirements. Proposal 2: RAN4 to firstly align the understanding on the meaning of entry/exit for LP-WUS monitoring, LP-WUR measurement and MR RRM measurement relaxation. Proposal 3: For the entry/exit condition for LP-WUS monitoring, follow RAN1/2 conclusions, i.e., * + - The UE may start LP-WUS monitoring if
			* the serving cell measurement performed by the MR is above entry threshold(s), if configured by the gNB
		- If UE starts LP-WUS monitoring, it may stop the legacy PO monitoring before UE receives LP-WUS indicating wake-up
		- The UE monitors the legacy PO (and may monitor PEI) and may stop LP-WUS monitoring if
			* the serving cell measurement performed by the LR is below exit threshold(s), if configured by the gNB

Proposal 4: Do not define entry/exit conditions for LP-WUR measurement. Proposal 5: The entry/exit conditions for MR measurement relaxation are defined as: * + For the entry/exit conditions for MR measurement relaxation in IDLE/ INACTIVE mode,
		- The MR enters the relaxation mode and meets the relaxed measurement requirements if
			* the serving cell measurement performed by the MR is above entry threshold(s), if configured by the gNB,
			* FFS whether other conditions e.g., Rel-16 ‘not at cell edge’ and ‘low mobility’ criteria are needed.
			* FFS whether the conditions of LR measurement quality are needed.
		- The MR exits the relaxation mode and meets the normal measurement requirements if
			* the serving cell measurement performed by the LR is below exit threshold(s), if configured by the gNB.

Proposal 6: The criterion discussion for fully offloading case (i.e., case #1) is left to RAN2 and RAN4 focus on the LP-WUR measurement requirements. Proposal 7: Both LP-SS and SSS based measurement can be used for LP-WUR to evaluate the entry/exit condition. Whether to define different conditions can be discussed after performing the simulation. Proposal 8: Both RSRP and RSRQ measurements are used for LP-WUR and MR to evaluate the entry/exit condition. Proposal 9: RAN4 to discuss whether to define evaluation requirements for cell selection criterion based on LR measurement for fully offloading case. Proposal 10: RAN4 discuss LP-WUR measurement requirements starting from SSS based measurement and wait for more progress from RAN1 for LP-SS based measurement. Proposal 11: For SSS based LP-WUR measurement, the existing intra-frequency cell reselection requirements can be used as baseline with the side condition to be further discussed. Proposal 12: The following values agreed in RAN1 can be used to perform simulation and RAN4 to decide whether to use all of them as side condition based on the results. * SNR=-3dB for NF of LR = NF of MR+ 8dB
* SNR= -0.5dB for NF of LR = NF of MR+ 5dB
* SNR=2dB for NF of LR = NF of MR+ 2dB
* Note 1: The NF of MR is assumed as 7dB

Proposal 13: RAN4 to use the legacy measurement accuracy for CONNECTED mode in Clause 10.1.2 TS 38.133 as baseline. Proposal 14: Define LP-WUR measurement accuracy in dedicated section. Whether/how to reflect it in the core requirements can be further discussed after the simulation by taking the results into account. Proposal 15: For MR neighbor cell measurement relaxation, the existing relaxed requirements in 4.2.2 can be used as baseline. Proposal 16: For MR serving cell measurement relaxation, a scaling factor can be introduced on existing serving cell measurement requirements in 4.2.2.2. Further discuss whether to use same scaling factor as neighbor cell measurement. Proposal 17: For LP-WUS operation in RRC\_CONNECTED state, no RAN4 impact is expected so far. |
| [**R4-2411450**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411450.zip) | Apple | *Proposal 1: At Rel-19 LP-WUR WI, for LP-WUR measurement, RAN4 specifies measurement requirements for the following:** *Measurement requirements for OOK based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state*
* *Measurement requirements for LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state*
* *FFS on measurement requirements for OFDM based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state after RAN1 has concrete conclusion.*

*Proposal 2: higher priority layer neighbor cell measurement shall also be OFF for case #1.**Proposal 3: assumption of thresholds for RAN4 discussion can be:** *the threshold for MR fully offloading to LR can be same as the threshold for neighbor cell measurement triggering (highest one between SIntraSearchP/SIntraSearchQ and SnonIntraSearchP/SnonIntraSearchQ), or at least offloading threshold can be not lower than threshold for neighbor cell measurement triggering.*
* *the threshold to turn on LR or to involve LR for measurement can be equivalent to the threshold of entry condition for LP-WUS monitoring.*

*Proposal 4: at this stage, remove case#2 and case#4 from the last meeting WF, and only following cases are considered. RAN4 can revisit the cases if in the future RAN1/2 has any conclusion conflicting with RAN4 assumptions.*

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| --- | --- | --- | --- |
| *RRM measurement case index* | *MR serving cell measurement* | *MR neighboring cell measurement* | *LR measurement* |
| *#1 Fully offloading case* | *Off*  | *Off* | *ON* |
| *#3 Relaxed case b* | *On with relaxation measurement* | *On with relaxation measurement* | *ON* |

*Proposal 5: LR measurement can be used to check the criteria for neighbor cell measurement triggering/relaxation.* *Proposal 6: to support proposal 5, LR measurement result shall be comparable to MR measurement result or shall be equivalent to MR measurement result with certain offset/margin (e.g., LR threshold is MR threshold + offset/margin).**Proposal 7: the criteria design for RRM relaxation of UE MR for both serving and neighbor cell measurements can be left to RAN2 to decide**Proposal 8: RAN4 specifies MR relaxation requirements for both serving cell and neighbor cell measurements at idle/inactive mode for UE supporting LP-WUR.** *RAN4 can* *investigate the mobility performance to quantify the relaxation, e.g., scaling factor for measurement period.*
* *If both LR and MR are ON, RAN4 to discuss whether UE uses LR measurement or UE uses both LR and MR measurement to check with the relaxation/offloading/LP-WUS-monitoring criteria (especially in case#3).*

*Proposal 9: Depending on different cases, UE may use MR measurement, or LR measurement, or MR+LR measurement to check the criteria; and followings are considered:** *If only MR is ON for measurement, the delay requirements for entry/exit criteria evaluation shall be same as legacy MR serving cell measurement delay requirement.*
* *If only LR is ON for measurement, RAN4 to discuss the delay requirements for entry/exit criteria evaluation.*
* *If both LR and MR is ON for measurement (MR is in relaxation mode), RAN4 to discuss the delay requirements for entry/exit criteria evaluation and also discuss how to combine or select measurement results from MR and LR.*

*Proposal 10: Regarding the consecutive time period for UE to meet the criteria, it shall be left to RAN2 to decide.**Proposal 11: RAN2 shall be the main group for criteria (entry/exit conditions) design**Proposal 12: RAN4 can work on the RRM measurement relaxations (e.g., Scaling factor) and offloading mechanisms based on the criteria defined by RAN2.**Proposal 13: RAN4’s involvement on entry/exit conditions for LP-WUS monitoring can be triggered by other groups if necessary. And RAN4 assumptions can be as in proposal 3.**Proposal 14: before entering LP-WUS monitoring or after exiting LP-WUS monitoring, the state of UE also needs to be clarified:* * *Alt 1: MR is ON with RRM measurement on serving cell and neighbour cell (if any) and LP-WUR is ON for serving cell measurement*
* *Alt 2: MR is ON with RRM measurement on serving cell and neighbour cell (if any) and LP-WUR is ON without RRM measurement*
* *Alt 3: MR is ON with RRM measurement on serving cell and neighbour cell (if any) and LP-WUR is OFF without RRM measurement.*

*We slightly prefer alt 2 or 3.**Proposal 15: this issue 1-1-9 can be discussed after when the whole mechanism of offloading, LP-SS/LP-WUS design and measurement metrics are concluded.**Proposal 17:* *For RAN4 requirement of LR based RRM measurement in Idle/inactive states, no dedicated accuracy requirement is defined in the performance section, and reflect the accuracy performance as a margin in the core requirement.**Proposal 18:* *Single Rx is assumed for LR based RRM measurement.**Proposal 21: to define RRM requirement, RAN4 assumed LR and MR are operating on the same carrier frequency as baseline, and FFS on the other scenarios if RAN1 has agreement.**Proposal 22: regarding RRM relaxation of UE MR for both serving and neighbor cell measurements, neighbor cell measurement shall have the more relaxation than or equivalent relaxation as serving cell measurement.**Proposal 23: regarding RRM relaxation of UE MR for both serving and neighbor cell measurements, consider to use 16 for serving cell measurement relaxation and neighbor cell measurement relaxation .**Proposal 24: no RRM objectives is needed for connected mode in this LP-WUR/LP-WUS WI.**Proposal 25: RAN4 to discuss followings LP-SS based RRM issue in IDLE/Inactive mode:** *how to enter and exit offloading status if eDRX is configured with PTW.*
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| [**R4-2411493**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411493.zip) | OPPO | Proposal 1: Focus on the scenario when inter-frequency with higher priority is not configured, and then the FFS part in case #1 can be removed and the whole case #4 could be deprioritized. Proposal 2: Case #3 should be prioritized over case #2. Proposal 3: Specify MR relaxation requirements for both serving cell and neighbor cell measurements in RRC idle/inactive mode.Proposal 4: The criteria (entry/exit conditions) for LP-WUR measurement, MR RRM relaxation and LP-WUS monitoring should be determined by RAN2/RAN1.Proposal 5: No dedicated accuracy requirement is defined in the performance section for LR-WUR based RRM measurement in RRC idle/inactive mode.Proposal 6: Follow RAN1 agreement that at least LP-RSRP/LP-RSRQ for OOK-based LP-WUR should be considered as measurement metrics.Proposal 7: No impact on the existing RRM/RLM/BFD/L1-RSRP measurement requirements in RRC connected mode.  |
| [**R4-2411617**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411617.zip) | Xiaomi | Observation 1: Measurements on neighbor cell can only be conducted in MR, irrespective of normal measurements or relaxed measurements.Observation 2: According to existing cell selection/reselection procedure:* The initiation of intra-frequency measurements, as well as NR inter-frequency or inter-RAT frequency measurements with equal or lower priority, depends on the serving cell measurement results from the MR;
* The initiation of NR inter-frequency or inter-RAT frequencies measurements with higher priority depends on NW configuration.

Proposal 1: For RRM relaxation case #2 to #4, it is suggested to prioritize case 3.Proposal 2: RAN4 specifies MR relaxation requirements for both serving cell and neighbor cell measurements at idle/inactive mode for UE supporting LP-WUR.Proposal 3: RAN4’s discussion on entry/exit conditions for LP-WUS monitoring can be triggered by RAN1 if needed.Proposal 4: It is suggested to define the same entry/exit conditions for LP-WUR serving cell measurement and LP-WUS monitoring.Proposal 5: It's suggested that RAN4 concentrate on discussing relaxation cases, while the entry/exit criteria should be based on RAN2 design.Proposal 6: RAN4 should define the requirements to guarantee the paging reception and RRM measurements when UE MR existing sleep mode. Proposal 7: The Rel-16 relaxation method, i.e., extending measurement interval, could be taken as baseline when considering the MR RRM relaxation for UE supporting LP-WUR. The detailed scaling factor can be discussed after RAN4 have concrete agreements on the MR RRM relaxation cases.Proposal 8: RAN4 to determine the measurement accuracy in RRC\_IDLE/INACTIVE state for simulation purpose, and NO need to define dedicated accuracy requirement in the performance section.Proposal 9: It is suggested to take the accuracy requirement defined for CA/DC Idle Mode Measurements, i.e., ±6dB RSRP measurement accuracy and ±4dB RSRQ measurement accuracy, as the starting point when determining the measurement accuracy in RRC\_IDLE/INACTIVE state for LP-WUR serving cell measurement.Proposal 10: RAN4 to consider the same target accuracy when defining LP-SS based and PSS/SSS based RRM delay requirements for LP-WUR.Proposal 11: No RAN4 impact of LP-WUS/WUR features in RRC\_CONNECTED mode is expected. |
| [**R4-2411683**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411683.zip) | NTT DOCOMO, INC. | Proposal 1: At Rel-19 LP-WUR WI, for LP-WUR measurement, RAN4 specifies measurement requirements for the following:* Measurement requirements for OOK based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state by considering:
	+ Interruption time between LP-WUS received paging indication to MR ready for Paging monitoring, and MR going to be turned off
* Suspend the discussion of OFDM-based LP-WUR serving cell measurement requirement based on LP-SS at Idle/Inactive state until more RAN1 progress is available
* Other related requirements are FFS

Proposal 2: It is better to wait RAN2 outcome of neighboring cell measurement to select case 2 to 4.Proposal 3: RAN4 specifies MR relaxation requirements for both serving cell and neighbor cell measurements at idle/inactive mode for UE supporting LP-WUR. The details are discussed according to other WGs outcomes. |
| [**R4-2411762**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411762.zip) | CMCC | Proposal 1: Case#1 and Case#3 are valid cases correspond to the link quality in descending order.Proposal 2: Case#4 is valid case for high priority frequency layer configured scenario, corresponding to the same link quality as Case#1.Proposal 3: Study the following measurement requirements in the first phase.* Measurement requirements for OOK-based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state
* Measurement requirements for OFDM-based LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state

Proposal 4: Suspend the discussion of OFDM-based LP-WUR serving cell measurement requirement based on LP-SS at Idle/Inactive state, until RAN1 achieve the consensus about whether it can be target for sync and RRM measurement.Proposal 5: Interruption requirements may need to be specified for the following transition periods:* Between LP-WUS reception and MR to start paging monitoring
* Between LP-WUR measurement result fulfills exit criteria and MR to start measurement
* Between MR measurement result fulfills entry criteria and LP-WUR to start measurement

Proposal 6: Further discuss MR RRM measurement relaxation after Case#2 and Case#3 are agreed by RAN4 or other work groups.Proposal 7: RAN4 skip the discussion about the criteria, and further define the specific threshold value and evaluation method of the criteria after RAN2 achieving consensus if necessary.Proposal 8: In order to guarantee the power saving gain, the serving cell quality threshold in entry/exit condition for LP-WUS monitoring and the serving cell quality threshold entry/exit condition for LP-WUR measurement should be considered jointly.Proposal 9: Take SNR=-3dB as the starting point for simulation for both OOK-based receiver and OFDM-based receiver.Proposal 10: Take the legacy measurement accuracy for Connected Mode (TS 38.133 Clause 10.1.2.1.1) as simulation baseline for both OOK-based receiver and OFDM-based receiver.Proposal 11: Postpone the discussion of whether and how to define the dedicated accuracy requirement in the spec. Options can be kept.Proposal 12: For OOK-based LP-WUR measurement based on LP-SS, LP-RSRP and LP-RSRQ will be used as measurement metrics. For OFDM-based LP-WUR measurement based on SSS, LP-SSS-RSRP and LP-SSS-RSRQ will be used as measurement metrics. Details should follow RAN1’s agreement.Proposal 13: Use 20ppm Residual Frequency error as the simulation baseline, 0ppm and 10ppm can also be involved if companies interested. Further update is not precluded.Proposal 14: For the measurement based on both MR with RRM relaxation (X time relaxation) and LP-WUR, X should be larger than or equal to 8 if Case#2 and/or Case#3 introduced.Proposal 15: The legacy accuracy for relaxed MR measurement should be reused if Case#2 and/or Case#3 introduced.Proposal 16: Update following simulation parameters:* SSB burst periodicity: 20ms
* LP-SS block BW: 132 subcarriers for SCS=30kHz
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| [**R4-2412041**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412041.zip) | LG Electronics Inc. | *Proposal 1*: According to the channel quality the three cases are can be necessary.

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|  RRM measurement case index | MR serving cell measurement | MR neighboring cell measurement | LR measurement |
| #1 Fully offloading case | Off  | Off | On |
| #2 Relaxed case a | On with relaxation measurement | Off | On |
| #3 Relaxed case b | On with relaxation measurement | On with relaxation measurement | On |
| #5 Legacy case | On | On | Off |

*Proposal 2*: Further MR based RRM measurement relaxation for serving cell and/or neighbour cells should be applied when LP-WUR measurement is performed.*Proposal 3*: entry/exit conditions for LP-WUR measurement can be based on entry/exit condition for LP-WUS monitoring agreed in RAN2, and additionally UE mobility condition should be considered.*Proposal 4*: RAN4 to discuss and provide input to RAN2 such as possible serving/neighbour measurement relaxation conditions or which receiver (i.e., MR or LP-WUR) to base it on for MR based RRM measurement relaxation depending on the decision for MR measurement relaxation scenarios.*Proposal 5*: RAN4 needs to consider overall entry/exit condition for LP-WUR measurement, MR measurement relaxation, and LP-WUS monitoring jointly based on RAN2 agreements of entry/exit condition for LP-WUS monitoring. And if there are other conditions that should be considered, RAN4 needs to provide input to RAN2.*Proposal 6*: RAN4 needs to wait further conclusion from RAN1.*Proposal 7*: Do not define measurement accuracy requirements for LP-WUR in Idle/Inactive state in performance section.*Proposal 8*: RAN4 to further discuss MR RRM relaxation factor for serving and/or neigbhor cell after scenario and detailed criterion for measurement relaxation have been clarified.*Proposal 9*: Focus on RRM core requirements only for IDLE/INACTIVE mode in Rel-19. |
| [**R4-2412121**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412121.zip) | China Telecom | Proposal 1: Regarding cases/states to be considered for RRM relaxation, it’s proposed to consider case #2 and case #3.Proposal 2: RAN4 specifies MR relaxation requirements for both serving cell and neighbor cell measurements at idle/inactive mode for UE supporting LP-WUR.Proposal 3: RAN2 is the main group for criteria (entry/exit conditions) design for LP-WUR measurement/ MR RRM measurement relaxation/ LP-WUS monitoring.Proposal 4: RAN4 to discuss and define the requirements on verifying UE correct implementation of the entry/exit criteria based on RAN1 and RAN2 design.Proposal 5: It’s proposed to start RRM requirements for LP-WUR at idle/inactive state after RAN4 has sufficient information on LP-SS design and LP-SS based measurement metric from other sources.Proposal 6: It’s proposed to discuss relaxation factors within the range from 8 to 16 as the starting point for the relaxation factor for MR RRM relaxation.Proposal 7: There is no RRM objective for connected mode in LP-WUR/LP-WUS WI. |
| [**R4-2412291**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412291.zip) | vivo | Observation 1: Case 2 is a natural extension of case 3 when neighbour cell measurements are not needed. Compared with case 1, case 2 will provide another trade-off point on performance in terms of MR ramping time and mobility performance, with reasonable cost of power consumption. Observation 2: How case 4 works for equal or lower priority frequency layer measurement is not clear since MR neighbour cell measurement is triggered however MR serving cell measurement is still not triggered. If the case 4 is merely for higher priority frequency layer measurement case, it is suggested to consider it at later stage. Observation 3: Requirements on how many samples/times for evaluating entry/exit conditions for either LP-WUS monitoring or MR RRM relaxation could be partially covered by accuracy requirements. 1. For the “Specify further RRM relaxation of UE MR for both serving and neighbor cell measurements” in the WID and cases to be considered for RRM relaxation, besides agreed case 1, relaxed cases should include the following two cases:

Case 2: MR has RRM relaxation on serving cell measurement (the neighbour cell measurement is not triggered due to good cell quality) and LP-WUR performs serving cell measurement Case 3: MR has RRM relaxation on both serving cell measurement and neighbour cell measurement and LP-WUR performs serving cell measurement. 1. In case 1, higher priority frequency layer search will not be performed if the MR is off. For relaxed cases (case 2, 3 or 4 or other cases up to future decision), higher priority frequency layer search can be considered at later stage.
2. RAN4 should discuss whether to support or how to handle these extra relaxed cases, case #5 and #6..
3. For issue 1-1-5, 1-1-6 and 1-1-7, RAN2 is be the main group on designing the criteria and corresponding threshold for LP-WUR serving cell measurement, MR RRM measurement relaxation and LP-WUS monitoring.
4. Same criteria and same/different entry/exit conditions can be used for LP-WUS monitoring and serving cell RRM measurement offloading, i.e., case 1, or for LP-WUS monitoring and RRM measurement relaxed cases, i.e., case 2 or 3.
5. RAN4 should focus on requirements of OOK based receiver based on LP-SS initially and wait for more RAN1 progress on the option where LP-SS with overlaid OFDM sequences. Update the first bullet of RAN4 110bis’s agreement on issue 2-2-1 as:

Measurement requirements for OOK based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state1. On requirements for entry/exit criteria evaluation for WUS paging monitoring/LP-WUR measurement/MR RRM relaxation,
	1. For MR, no new requirements will be defined for entry/exit evaluation for MR RRM relaxation.
	2. For LR serving cell measurement, similar requirements as that of MR legacy requirements, i.e., filter the serving cell measurement at least using 2 samples and within the set of samples used for filtering at least 2 samples are spaced by LP-SS periodicity, can be considered.
2. For LP-WUR status before entering offloading or after exiting offloading, postpone the discussion until more RAN1/2 conclusions.
3. For relaxed MR measurement, the legacy accuracy requirements for MR are re-used.
4. Consider relaxation factors within the range from 8 to 16 as the starting point for the relaxation factor for the MR RRM relaxation.
5. In principle there is no RAN4 RRM actions at Connected state. Suggest to postpone the discussion for CONNECTED mode.
6. The eDRX related issue to be down prioritized
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| [**R4-2412505**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412505.zip) | Ericsson | *Proposal 1: When UE supports Rel-19 LP-WUS capability, the following scenarios are possible.*

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| *RRM measurement case index* | *MR serving cell measurement* | *MR neighboring cell measurement* | *LR measurement* |
| *#2 Relaxed case a* | *On with relaxation measurement* | *Off* | *ON* |
| *#3 Relaxed case b* | *On with relaxation measurement* | *On with relaxation measurement* | *ON* |
| *#4 Relaxed case c* | *Off*  | *On* | *ON* |

*Proposal 2: Whether any LR based serving cell RRM relaxation cases are valid is fully up to NW’s configuration, such as NW can enable/disable any RRM relaxation scenario based on the configured thresholds.**Proposal 3: Serving cell measurement relaxation/offloading with LR measurement is independent with neighbour cell measurement relaxation/offloading, such as NW can control serving and neighbour cell measurement with different thresholds.**Proposal 4: MR RRM further relaxation without LR measurement is out of scope in Rel-19.**Proposal 5: RAN4 to send LS to RAN2 to discuss the criteria to enter/exit each RRM relaxation scenario which should be captured in RAN2 spec.**Proposal 6: To minimize the negative impact on paging and cell reselection, the following entry/exit principles should be followed if RAN4 decides to define entry/exit requirement.**Proposal 7: RAN4 to discuss the requirement about exit the LR based on the LP-RSRP/LP-RSRQ simulation results.**Proposal 8: RAN4 to discuss the requirement about entry the LR based on both MR SSB RSRP/RSRQ and whether includes LR evaluation.**Proposal 9: RAN4 to follow RAN1’s LP-RSRP and LP-RSRQ definition to evaluate the LP-SS performance.**Proposal 10: RAN4 to discuss the PSS/SSS periodicity to evaluate the LP-WUR exiting condition in LR.**Proposal 11: RAN4 should consider both the MR relaxation power saving gain and LR’s performance to define MR relaxation scaling factor.**Proposal 12: RAN4 to evaluate how long the MR wake up is needed to assist LR measurement.**Proposal 13: No dedicated accuracy requirement in the performance section are defined for LP-SS based measurement and reflect the accuracy performance as a margin in the IDLE/INACTIVE mode core requirement.**Proposal 14: LP-WUS CONNECTED mode requirements is postoponed until more progress is achieved in other WGs.* |
| [**R4-2412531**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412531.zip) | Samsung | Proposal 1: In additional to case 1, RAN4 shall consider case 2 (relaxed case a) and case 3 (relaxed case b) at least. * RRM measurement with high priority can be considered separately

Proposal 2: RAN4 needs to further evaluate serving cell measurement relaxation and neighbouring cell measurement relaxation by MR Proposal 3: RAN4 shall be involved on criterion and scenario (entry/exit condition) design for LP-WUR measurement and MR RRM measurement relaxation together with RAN1 and RAN2.* RAN4 shall further discuss the applicable side condition /scenario with corresponding assumption on MR serving cell measurement, MR neighboring cell measurement and LP-WUR measurement as a package

Proposal 4: For Entry/exit condition for LP-WUS monitoring, the performance of miss detection rate on LP-WUS can be considered as side condition in addition to RSRP and RSRQ.Observation 1: LP-WUS entrance condition is specified based on MR measurement and exit condition is specified base LR measurement. There is potential mismatch between MR and LR measurement pending on UE architecture. Proposal 5: Calibration between MR measurement and LR measurement maybe required which also pending on the progress of UE RF session on LP-WUR RF architecture, NF assumption.Proposal 6: Follow RAN1 conclusion on target SINR condition, and further evaluate measurement accuracy and measurement period. * Target SINR for OOK based LR: -3dB
* Target SINR for OFDM based on LR: -0.5dB and/or 2dB

Proposal 7: RAN4 need to specify RRM measurement requirements following metrics:* OOK based on LP-WUR: LP-RSRP and LP-RSRQ.
* OFDM based on LP-WUR: SS-RSRP and SS-RSRP

Proposal 8: 20 ppm frequency error can be considered for OOK based on LR for initial RAN4 evaluation work. Proposal 9: New requirements need to be specified for the processing/interruption time between LP-WUS received paging indication to MR ready for Paging monitoring.Proposal 10: Relaxation factors within the range from 8 to 16 as the starting point for the relaxation factor for the MR RRM relaxation.Observation 2: No impact is observed for RRC\_CONNECTED state mobility, timing, signalling characteristic, and measurement procedure requirements.Proposal 11: FFS whether need to introduce LP-WUS monitoring activation and deactivation delay requirements pending on RAN2/RAN1 progress. Proposal 12: Paging reception requirement impact can be discussed after further input from RAN2 and RAN1. |
| [**R4-2412670**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412670.zip) | Huawei, HiSilicon | Proposal 1: RAN4 to define requirements for serving cell evaluation against the entry/exit condition for LP-WUS monitoring, including * Measurement delay (number of samples)
* Measurement accuracy (margin for evaluation)
* Measurement filtering (number of samples and separation between samples)

Proposal 2: RAN4 to support the following cases for MR and LR measurement in addition to fully offloading case.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| RRM measurement case index | MR serving cell measurement | MR neighboring cell measurement | LR measurement | Remarks |
| #3 Relaxed case b | ON with relaxation measurement | ON with relaxation measurement | ON | Neighboring cell measurement on lower or equal priority carrier is triggered based on serving cell quality measured by LR |
| #4 Relaxed case c | OFF | ON with relaxation measurement | ON | Neighboring cell measurement on higher priority carrier is triggered |

Proposal 3: RAN4 to define requirements for OFDM-based LR serving cell measurement based on LP-SS. Exact requirements and applicability are FFS.Proposal 8: RAN4 to specify relaxed MR measurement requirements for both serving and neighbor cells when serving cell RRM is offloaded to LR.Proposal 9: For MR measurement with relaxation the relaxation factor should be >= 16, and same relaxation factor applies to serving and neighbor cell measurements.Proposal 10: For LP-WUS monitoring, RAN4 to consider additional entry/exit condition on inter-carrier interference level besides the serving cell quality.Proposal 11: RAN4 not to further discuss the entry/exit condition for serving cell RRM measurement offloading to LR unless triggered by other WGs.Proposal 12: RAN4 not to further discuss the entry/exit condition for MR RRM measurement relaxation, unless triggered by other WGs.Proposal 13: RAN4 to postpone the discussion on RRM impacts of LP-WUR at CONNECTED mode until more RAN1/2 conclusions are available. |
| [**R4-2412802**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412802.zip) | Nokia | [Observation 1: Measurement periodicity relaxation: MR serving cell or neighbouring cell measurement periodicity is relaxed allowing UE longer time to collect necessary number of samples according to the current requirements. Relaxation factor may be applied on top of existing measurement requirements.](#_Toc174113957)[Observation 2: Relaxation of the number of carriers to measure: At least some of the MR neighbouring cell measurement are not required to be performed while UE is in LP-WUS mode.](#_Toc174113958)[Observation 3: Measurement offloading: MR measurements of a serving cell are offloaded to LR.](#_Toc174113959)[Observation 4: The thresholds when relaxation as well as offloading are expected to be configurable by the network](#_Toc174113960)[Proposal 1: MR Measurement relaxations requirements may only be applied when the corresponding entry conditions have been fulfilled, and the UE has been configured with LP-WUS/WUR configuration.](#_Toc174113961)[Proposal 2: MR Serving cell measurement offloading requirements may only be applied when the serving cell entry conditions have been fulfilled, and the UE has been configured with LP-WUS/WUR configuration.](#_Toc174113962)[Proposal 3: Relaxation / offloading may be applied based on connected mode MR measurements](#_Toc174113963)[Proposal 4: In fully offloading case (#1), the UE is performing LR measurements, and UE may be either listening to LP-WUS or legacy paging.](#_Toc174113964)[**Observation 6:** In case MR measurement periodicity scaling is long, the MR may be turned off, in which case the case #2 may be similar to case #3.](#_Toc174113965)[Proposal 5: Discuss if case #2 scenario can be covered by case #3.](#_Toc174113966)[Proposal 6: Define requirements for Scenario #3](#_Toc174113967)[Proposal 7: Discuss high priority carrier topic separately, and no need to define specific scenario where MR serving cell measurements are offloaded to LR but the neighbouring cell measurements are still being performed.](#_Toc174113968)[**Observation 7:** LR is not going to do neighboring cell measurements.](#_Toc174113969)[Proposal 8: RAN4 to discuss which, if any, of the legacy MR neighboring cell RRM measurement relaxation applicable to MR while configured with LP-WUS.](#_Toc174113970)[**Observation 8:** In legacy mobility measurements, the UE only has the option of using the MR](#_Toc174113971)[**Observation 9:** Fully or partial offloading of MR measurements to LR leads to MR measurement relaxation and hence delayed neighbor cell detection and measurements.](#_Toc174113972)[**Observation 10:** MR measurements need to be performed such that existing MR idle mode mobility is not impacted by use of LR on UE side.](#_Toc174113973)[Proposal 9: Existing idle mode mobility test cases applies for a UE configured with LP-WUR usage](#_Toc174113974)[Proposal 10: RAN4 need to define LR measurement accuracy requirements at least for the fully offloading scenario.](#_Toc174113975)[**Observation 11:** If MR does paging monitoring and LP-WUS is not monitored, power saving gains would be limited because UE would still need to wake up every PO and read at least one SSB.](#_Toc174113976)[**Observation 12:** LP-WUS introduces implementation complexity to the network side and currently only brings UE power saving benefits to the UE side.](#_Toc174113977)[**Observation 13:** Based on RAN2 agreement on entry, when configured, the UE may start to monitor LP-WUS and stop monitoring of Legacy PO currently only if MR measured RSRP / RSRQ is above threshold.](#_Toc174113978)[Proposal 11: RAN4 requirements are applicable for UEs supporting LP-WUS signal, and configured with LP-WUS configuration by higher layers.](#_Toc174113979)[Proposal 12: UE may receive LP-WUS signal but is not paged. Discuss whether the UE starts measurements after the LP-WUS signal, or after LP-WUS signal + when UE has discovered it has been being paged.](#_Toc174113980)[**Observation 14:** It is still open whether the measurements are done by LR, MR, or LR & MR together, and whether PSS/SSS is used or LP-SS. what are the measurement metrics to be evaluated, and what is the considered WUR architecture.](#_Toc174113981)[Proposal 13: RAN4 to discuss whether to consider LR based measurements, MR based measurements or LR & MR combined measurements to be used for evaluating LP-WUS entry and exit criteria.](#_Toc174113982) |
| [**R4-2413041**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413041.zip) | ZTECorporation,Sanechips | Observation 1: RAN1 has already defined the exit/entry conditions for LP-WUS monitoring:* Entry condition: If the serving cell measurement performed by the MR is above entry threshold(s), the UE may start LP-WUS monitoring.
* Exit condition: If the serving cell measurement performed by the LR is below exit threshold(s), the UE may stop LP-WUS monitoring.

Observation 2: * When entry condition is met, the UE may stop the legacy PO monitoring and before UE receiving LP-WUS indicating wake-up. Thus, the time delay for MR wake-up shall be considered (UE monitors the LW-WUS and then turn on the MR to monitor the legacy PO).
* When exit condition is met, the UE may stop LP-WUS monitoring and then turn on the MR to back to MR coverage. Thus, the time delay for MR wake-up exists.

Observation 3: In most cases the network does not page the UE since UE MR will stay deep sleep state and only LR is ON before UE exits LR coverage, there is even no paging. Thus, time delay for MR wake-up will not cause the bad service or communication delay when exit condition is met.Proposal 1: RAN4 to define requirements on UE paging monitoring to make sure that UE does not miss paging when the entry condition for LP-WUS monitoring is met. The timing requirements can be TMR\_wake\_up.Proposal 2: It is not necessary for RAN4 to define timing requirements on MR wake-up when exit condition is met.Observation 4: Three cases for defining RRM requirements shall be considered as below:* Case 1: Legacy case. Only MR performs the RRM measurements.
* Case 2: Partially offload. MR RRM relaxation and LR performs the RRM measurements.
* Case 3: Fully offload. MR stops any RRM measurement and LR performs the RRM measurements.

Observation 5: MR and LR shall perform serving cell measurement. Only MR performs neighbour cell measurement. Observation 6: Different cases may perform different measurements without configured high priority frequency:

|  |  |  |  |
| --- | --- | --- | --- |
|  | MR performs serving cell measurement | MR performs neighbour cell measurement | LR performs serving cell measurement |
| Case 1 (fully MR) | ON | ON | OFF |
| Case 2 (MR+LR) | ON (measurement relaxation) | ON (measurement relaxation) /OFF | ON |
| Case 3 (fully LR) | OFF | OFF | ON |
| Case 4 (back to Case 2) | ON (measurement relaxation) | ON (measurement relaxation) /OFF | ON |
| Case 5 (back to Case 1) | ON  | ON  | OFF |

Proposal 3: RAN4 shall specify the whole procedure based on serving cell measurement and specify the UE behaviour when it satisfies the entry/exit condition:* When the entry condition is satisfied:
* Option 1: Fully MR →MR+LR →Fully LR
* Option 2: Fully MR →Fully LR
* When the exit condition is satisfied:
* Option 1: Fully LR →MR+LR→ Fully MR
* Option 2: Fully LR→ Fully MR

Observation 7: When UE camps on fully MR state, only MR is ON and LR is OFF. MR performs serving cell measurement and also neighbour cell measurement.Proposal 4: RAN4 shall reuse the legacy cell re-selection requirements when UE stays in fully MR state.Observation 8: In case 2, MR and LR are ON. The serving cell measurement is performed by LR and MR, MR measurement relaxation is aimed at reducing power consumption.Observation 9: RAN4 only defines the relaxed measurement requirements for neighbour cell not for serving cell. Observation 10: The serving cell measurement bias between LP-SS and MR SSB may be occurred.Proposal 5: RAN4 shall wait for RAN2 to define the relaxed measurement condition for serving cell measurement.Proposal 6: In this case, RAN4 shall consider the MR serving cell measurement relaxation and also can study the mobility performance to quantify the relaxation such as scaling factor for time period. Proposal 7: RAN4 shall wait for RAN2 to define the final relaxed measurement conditions for neighbour cell measurement.Proposal 8: The legacy intra-/inter-frequency and inter-RAT neighbour cell measurement requirements can be the baseline and RAN4 can study the relaxed scaling factor.Observation 11: When UE camps on MR+LR state, MR and LR shall be ON. MR performs serving cell measurement and neighbour cell measurement based on the service of current cell. If the service of serving cell is good, UE MR will not perform the neighbour cell measurement. On the contrary, if service of serving cell is bad, UE MR will perform neighbour cell measurement without high priority frequency.Observation 12: When UE camps on fully LR state, MR is OFF and only LR is ON, it means that UE is in the center area of the current cell. UE LR performs serving cell measurement and there is no neighbour cell measurement without high priority frequency.Observation 13: In legacy, RAN1 introduced SMTC in order to reduce the complexity of UE measurements because of neighbour cell measurement.Proposal 9: RAN4 shall define the serving cell measurement requirements based on LP-SS. However, we deem that the time window like SMTC may not be introduced.Observation 14: For case 4 and case 5, UE will be back to fully MR state or MR+LR state from fully LR state. If UE will be back to MR+LR, it is similar to case 2. If UE will be back to fully MR state, it is similar to case 3.Proposal 10: RAN4 shall use the same cell re-selection requirements as case 2 and case 3 for case 4 and case 5. Observation 15: The different cases can be seen as following table with high priority frequency:

|  |  |  |  |
| --- | --- | --- | --- |
|  | MR performs serving cell measurement | MR performs neighbour cell measurement | LR performs serving cell measurement |
| Case 1 (fully MR) | ON | ON | OFF |
| Case2 (MR+LR) | ON | ON/OFF | ON |
| Case 3 (fully LR) | OFF | ON | ON |
| Case 4 (back to Case 2) | ON | ON/OFF | ON |
| Case 5 (back to Case 1) | ON | ON | OFF |

Observation 16: MR will perform inter-frequency measurement with high priority frequency and inter-RAT measurement with high priority frequency if high priority frequency information is provided by the serving cell even if the service of current cell is good enough. Proposal 11: RAN4 shall study the MR neighbour cell measurement relaxation when the high priority frequency is configured..If the legacy relaxed conditions are reused, the legacy relaxed measurement requirements can be the baseline and RAN4 shall study the relaxed scaling factor.Observation 17: If the factor is less than 8 times the power saving gain is average 4%. However, if the relaxation factor is equal or larger than 8, the power saving gain has a sharp increase.Proposal 12: Relaxation factors within the range from 8 to 16 as the starting point for the relaxation factor for the MR RRM relaxation.Proposal 13: RAN4 shall not define the measurement requirements at CONNECTED state. |
| [**R4-2413325**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413325.zip) | MediaTek inc. | Proposal 1: For fully offloading case, MR is Off and LR is ON, LR should at least perform wake-up signal monitoring and serving cell measurements in IDLE/INACTIVE mode.Proposal 2: As a starting point for RRM relaxation case (MR is relaxed and LR is ON), RAN4 can consider RRM relaxation for intra-frequency measurements in IDLE/INACTIVE mode where both serving and neighbour cells can be measured in the same frequency layer.Proposal 3: RAN4 to discuss the following options for RRM relaxation: * Option 1: MR RRM Relaxation from 8 to 16 times
* Option 2: MR RRM Relaxation >=16 times

Proposal 4: RAN4 to study the consideration of single stage of RRM relaxation or multiple stages of RRM relaxation (e.g., with different scaling factors) depending on conditions (e.g., channel condition, UE mobility, UE location). |
| [**R4-2413452**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413452.zip) | Qualcomm Incorporated | Observation 1: RAN4 currently specifies the conditions for when the UE is not required to perform neighbor cell measurements.Proposal 1: RAN4 to specify full measurement offloading (i.e., serving cell measurements by the WUR and no neighbor cell measurements) when the following criteria are met:* Srxlev > SIntraSearchP and Squal > SIntraSearchQ
* Srxlev > SnonIntraSearchP and Squal > SnonIntraSearchQ

Observation 2: Combining measurements across the two radios, i.e., MR and WUR increases the implementation complexity of the UE.Proposal 2: RAN4 to not consider combining serving cell measurements across the MR and WUR.Proposal 3: Preclude scenario #2 and #3 for specifying RRM requirements.Observation 3: Scenario #4, i.e., serving cell measurements by the WUR and relaxed neighbor cell measurements by the MR compliments scenario #1 and may be useful for cell-edge scenarios.Proposal 4: RAN4 to consider scenario #4, i.e., serving cell measurements by the WUR and relaxed neighbor cell measurements by the MR for RRM requirements specification.Proposal 5: RAN4 to use, at-least, the existing neighbor cell measurement relaxation mechanisms for scenario#4.Proposal 6: RAN4 to specify RRM core requirements for serving cell measurement offloading to the WUR only for the case when WUR and MR are operating on the same carrier frequency. Proposal 7: RAN4 specifies the following for entry/exit criteria evaluation for WUS paging monitoring:1. The number of measurement samples needed for filtering.
2. The number of consecutive times the UE needs to meet the entry/exit criteria.
 |

## Open issues summary

*Before Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 1-1 General aspects

**Issue 1-1-1: Cases/states to be considered for RRM relaxation and serving cell measurement offloading**

*Background:*

*The RAN4 #111 meeting’s agreement for this issue are copied below [R4-2410296]*

Agreement: Discuss the RAN4 requirements first for the following case #1, and FFS for case #2 to #5.

|  |  |  |  |
| --- | --- | --- | --- |
| **RRM measurement case index** | **MR serving cell measurement** | **MR neighboring cell measurement** | **LR measurement** |
| #1 Fully offloading case | Off  | Off: FFS the condition and the details | ON |

RAN4 to further discuss case #2 to #4:

|  |  |  |  |
| --- | --- | --- | --- |
| RRM measurement case index | MR serving cell measurement | MR neighboring cell measurement | LR measurement |
| #2 Relaxed case a | On with relaxation measurement | Off | ON |
| #3 Relaxed case b | On with relaxation measurement | On with relaxation measurement | ON |
| #4 Relaxed case c | Off  | On, FFS the condition and the details | ON |

* Proposals

Case 2: Supported (CT LG vivo Ericsson Samsung); not supported (Apple Huawei QC);

Case 3: Supported (CATT Apple oppo xiaomi CMCC CT LG vivo Ericsson Samsung Huawei Nokia MTK, ZTE); not supported (QC)

Case 4: (a) Case 4 MR neighbour cell measurements include equal or low priority frequency layers

Supported with relaxed neighbour cell measurements (QC); not supported (Apple vivo Nokia)

 (b) Case 4 MR neighbour cell measurements intends for higher priority frequency layers

Supported when case 4 is for higher priority frequency layers (CMCC Huawei, ZTE, Ericsson)

Issues are related to higher priority frequency layers are discussed separately/later (Apple oppo vivo Samsung Nokia)

* Other related proposals:
	+ P1: Whether any LR based serving cell RRM relaxation cases are valid is fully up to NW’s configuration, such as NW can enable/disable any RRM relaxation scenario based on the configured thresholds. Serving cell measurement relaxation/offloading with LR measurement is independent with neighbour cell measurement relaxation/offloading, such as NW can control serving and neighbour cell measurement with different thresholds. (Ericsson)
	+ P2: RAN4 shall specify the whole procedure based on serving cell measurement and specify the UE behaviour when it satisfies the entry/exit condition (ZTE)
	+ P3: For fully offloading case, MR is Off and LR is ON, LR should at least perform wake-up signal monitoring and serving cell measurements in IDLE/INACTIVE mode (Nokia MTK)
	+ P4: It is better to wait RAN2 outcome of neighboring cell measurement to select case 2 to 4 (Docomo)
	+ P5: LR measurement can be used to check the criteria for neighbor cell measurement triggering/relaxation. LR measurement result shall be comparable to MR measurement result or shall be equivalent to MR measurement result with certain offset/margin (e.g., LR threshold is MR threshold + offset/margin). (Apple)
	+ P6: RAN4 should have conclusion on whether to support or how to handle extra relaxed cases, case #5 and #6. (vivo)

|  |  |  |  |
| --- | --- | --- | --- |
| RRM measurement case index | MR serving cell measurement | MR neighbouring cell measurement | UE with LR-WUR capability however LP-WUR is off  |
| #5 Relaxed case  | On with relaxation measurement | Off | OFF |
| #6 Relaxed case  | On with relaxation measurement | On with relaxation measurement | OFF |

*Recommendations:*

Determine whether the following cases will be supported:

Case 3: Supported (CATT Apple oppo xiaomi CMCC CT LG vivo Ericsson Samsung Huawei Nokia MTK, ZTE); not supported (QC)

Further clarify on case 4 and determine the procedure on how to handle higher priority frequency layer

Case 4: (a) Case 4 MR neighbour cell measurements include equal or low priority frequency layers

Supported with relaxed neighbour cell measurements (QC); not supported (Apple vivo Nokia)

 (b) Case 4 MR neighbour cell measurements intends for higher priority frequency layers

Supported when case 4 is for higher priority frequency layers (CMCC Huawei, ZTE, Ericsson)

Issues are related to higher priority frequency layers are discussed separately/later (Apple oppo vivo Samsung Nokia)

Discuss case 2



*Figure for illustration different cases, only for information purpose*

**Issue 1-1-2: Measurement requirements to be specified for LP-WUR**

* Proposals
	+ P1: RAN4 suspends study on measurement requirements for OFDM based LP-WUR based on LP-SS signal at idle/inactive state until more RAN1 conclusions; RAN4 shall focus on following cases; (Apple Docomo CMCC vivo, ZTE):
		- *Measurement requirements for OOK-based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state*
		- *Measurement requirements for OFDM-based LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state*
	+ P2: RAN4 to define requirements for OFDM-based LR serving cell measurement based on LP-SS. (Huawei)
	+ P3: RAN4 discuss LP-WUR measurement requirements starting from SSS based measurement and wait for more progress from RAN1 for LP-SS based measurement. For SSS based LP-WUR measurement, the existing intra-frequency cell reselection requirements can be used as baseline with the side condition to be further discussed. (CATT)
	+ P4：RAN4 shall define the serving cell measurement requirements based on LP-SS. However, we deem that the time window like SMTC may not be introduced since LP-SS will not perform neighbor cell measurement. (ZTE)

Background: RAN4 110bis agreement

* + At Rel-19 LP-WUR WI, for LP-WUR measurement, RAN4 specifies measurement requirements for the following:
		- Measurement requirements for LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state
		- Measurement requirements for LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state
	+ Other related requirements are FFS

*Recommendations:*

* Check whether to update the first bullet of RAN4 110bis’s agreement on issue 2-2-1 as
	+ - *Measurement requirements for OOK-based LP-WUR serving cell measurement based on LP-SS at Idle/Inactive state*
		- *Measurement requirements for OFDM-based LP-WUR serving cell measurement based on existing PSS/SSS at Idle/Inactive state*

**Issue 1-1-3: Core requirements to be specified for MR RRM relaxation**

* Proposals
	+ P1: RAN4 specifies MR relaxation requirements for both serving cell and neighbor cell measurements at idle/inactive mode for UE supporting LP-WUR. (Apple oppo xiaomi Docomo CT LG Huawei, ZTE, CATT)
		- RAN4 can investigate the mobility performance to quantify the relaxation, e.g., scaling factor for measurement period. (Apple)
		- If both LR and MR are ON, RAN4 to discuss whether UE uses LR measurement or UE uses both LR and MR measurement to check with the relaxation/offloading/LP-WUS-monitoring criteria (especially in case#3) (Apple).
	+ P2: RAN4 needs to further evaluate serving cell measurement relaxation and neighbouring cell measurement relaxation by MR (Samsung)
	+ P3: Further discuss MR RRM measurement relaxation after Case#2 and Case#3 are agreed by RAN4 or other work groups (CMCC)
	+ P4: When UE stays in MR+LR state, RAN4 shall consider the MR serving cell measurement relaxation and also study the mobility performance to quantify the relaxation such as scaling factor for time period (ZTE)

*Recommendations:*

Suggest to agree P1 following the WI, details on requirements are encouraged to be purposed and are FFS

**Issue 1-1-4: On requirements for entry/exit criteria evaluation for WUS paging monitoring/LP-WUR measurement/MR RRM relaxation**

* Proposals
	+ P1: RAN4 to define requirements for serving cell evaluation against the entry/exit condition for LP-WUS monitoring (CT Huawei)
		- For measurement delay most likely the existing serving cell evaluation requirements in clause 4.2.2.2 (for evaluation against the S-criterion) can be re-used also for evaluation against the entry condition for LP-WUS monitoring (Huawei)
		- Defines measurement filtering (number of samples and separation between samples) (Huawei)
	+ P2: The following entry/exit principles should be followed if RAN4 decides to define entry/exit requirement (Ericsson)
		- The entry should be made carefully, and delay is not critical.
		- The exit should be made quickly because LP-SS measurement and mobility detection may delay for the exit condition to be fulfilled.
		- RAN4 to discuss the requirement about exit the LR based on the LP-RSRP/LP-RSRQ simulation results and about entry the LR based on both MR SSB RSRP/RSRQ and whether includes LR evaluation. (Ericsson)
	+ P3: On requirements for entry/exit criteria evaluation for WUS paging monitoring/LP-WUR measurement/MR RRM relaxation (vivo)
		- On entry requirement, for MR, no new requirements will be defined for entry/exit evaluation for MR RRM relaxation. Legacy filtering requirements can be used.
		- On exit requirements, for LR serving cell measurement, similar requirements as that of MR legacy requirements, i.e., filter the serving cell measurement at least using x samples and within the set of samples used for filtering at least 2 samples are spaced by LP-SS periodicity, can be considered.
	+ P4: Regarding the consecutive time period for UE to meet the criteria, it shall be left to RAN2 to decide. (Apple)
	+ P5: RAN4 specifies the following for entry/exit criteria evaluation for WUS paging monitoring: (QC)
		- The number of measurement samples needed for filtering.
		- The number of consecutive times the UE needs to meet the entry/exit criteria

*Recommendations:*

For entry/exit condition for LP-WUS monitoring requirement discussion, using the following RAN1 #116bis working assumption

**Working Assumption**

From RAN1 perspective, for the entry/exit conditions for LP-WUS monitoring in IDLE/inactive mode,

* The UE may start LP-WUS monitoring if
	+ the serving cell measurement performed by the MR is above entry threshold(s), if configured by the gNB~~, and/or~~
	+ FFS other conditions, and if any, whether all or one or some of the conditions need to be satisfied
* If UE starts LP-WUS monitoring, it may stop the legacy PO monitoring before UE receives LP-WUS indicating wake-up
* The UE monitors the legacy PO (and may monitor PEI) and may stop LP-WUS monitoring if
	+ the serving cell measurement performed by the LR is below exit threshold(s), if configured by the gNB~~, and/or~~
	+ FFS other conditions, and if any, whether all or one or some of the conditions need to be satisfied

**Issue 1-1-4-1: Entry/exit criteria evaluation when results from MR and/or LP-WUR are avaiable for WUS paging monitoring/LP-WUR measurement/MR RRM relaxation**

* Proposals
	+ P1: RAN4 discuss whether and how to use MR measurement, or LR measurement, or MR+LR measurement to check the criteria (Apple Nokia Ericsson)
	+ If only MR is ON for measurement, the delay requirements for entry/exit criteria evaluation shall be same as legacy MR serving cell measurement delay requirement. (Apple)
	+ If only LR is ON for measurement, RAN4 to discuss the delay requirements for entry/exit criteria evaluation. (Apple)
	+ If both LR and MR is ON for measurement (MR is in relaxation mode), RAN4 to discuss the delay requirements for entry/exit criteria evaluation and also discuss how to combine or select measurement results from MR and LR. (Apple)
	+ P2: Calibration between MR measurement and LR measurement maybe required which also pending on the progress of UE RF session on LP-WUR RF architecture, NF assumption. (Samsung)

*Recommendations:*

**Issue 1-1-4-2: Reference signals and measurement types to be used for Entry/exit criteria evaluation for WUS paging monitoring/LP-WUR measurement/MR RRM relaxation**

* Proposals
	+ P1: Both LP-SS and SSS based measurement can be used for LP-WUR to evaluate the entry/exit condition. FFS whether to define different conditions for different signals. (CATT)
	+ P2: Both RSRP and RSRQ measurements are used for LP-WUR and MR to evaluate the entry/exit condition. (CATT)

*Recommendations:*

**Issue 1-1-5: Criteria (entry/exit conditions) for LP-WUR serving cell measurement**

* Proposals
	+ P1: Do not define entry/exit conditions for LP-WUR measurement (CATT)
	+ P2: Up to RAN2/other group decision (Apple oppo CT CMCC LG vivo Huawei)
		- Additionally UE mobility condition should be considered (LG)
	+ P3: RAN4 shall wait for RAN2 to define the relaxed measurement condition for serving cell measurement if it has. (ZTE)

*Recommendations:*

**Issue 1-1-6: Criteria (entry/exit conditions) for MR RRM measurement relaxation**

* Proposals
	+ P1: Up to RAN2/other group decision (Apple oppo xiaomi CT CMCC vivo Huawei, ZTE)
	+ P2: For the entry/exit conditions for MR measurement relaxation in IDLE/ INACTIVE mode (CATT)
		- The MR enters the relaxation mode and meets the relaxed measurement requirements if the serving cell measurement performed by the MR is above entry threshold(s), if configured by the gNB,
			* FFS whether other conditions e.g., Rel-16 ‘not at cell edge’ and ‘low mobility’ criteria are needed.
			* FFS whether the conditions of LR measurement quality are needed.
		- The MR exits the relaxation mode and meets the normal measurement requirements if the serving cell measurement performed by the LR is below exit threshold(s), if configured by the gNB.
	+ P3: RAN4 to discuss and provide input to RAN2 such as possible serving/neighbour measurement relaxation conditions or which receiver (i.e., MR or LP-WUR) to base it on for MR based RRM measurement relaxation depending on the decision for MR measurement relaxation scenarios (LG)
	+ P4: RAN4 to use, at-least, the existing neighbor cell measurement relaxation mechanisms for scenario#4. (QC)

*Recommendations:*

**Issue 1-1-7: Criteria (entry/exit conditions) for LP-WUS monitoring**

* Proposals
	+ P1: For the entry/exit condition for LP-WUS monitoring, follow RAN1/2 conclusions or can be triggered by other groups if necessary (CATT Apple oppo xiaomi CT vivo, ZTE)
	+ P2: For Entry/exit condition for LP-WUS monitoring, the performance of miss detection rate on LP-WUS can be considered as side condition in addition to RSRP and RSRQ (Samsung)
	+ P3: For LP-WUS monitoring, RAN4 to consider additional entry/exit condition on inter-carrier interference level besides the serving cell quality. (Huawei)
	+ P4: RAN4 requirements are applicable for UEs supporting LP-WUS signal, and configured with LP-WUS configuration by higher layers. (Nokia)

*Recommendations:*

**Issue 1-1-8: On jointly consideration on issue 1-1-5, 1-1-6 and 1-1-7**

* Proposals
	+ P1: It is suggested to define the same entry/exit conditions for LP-WUR serving cell measurement and LP-WUS monitoring (Xiaomi LG)
	+ P2: Same criteria and same/different entry/exit conditions can be used for LP-WUS monitoring and case 1, or case 2 or 3 if case 2 or 3 are supported (vivo).
	+ P3: In order to guarantee the power saving gain, the serving cell quality threshold in entry/exit condition for LP-WUS monitoring and the serving cell quality threshold entry/exit condition for LP-WUR measurement should be considered jointly. (CMCC)
	+ P4: RAN4 needs to consider overall entry/exit condition for LP-WUR measurement, MR measurement relaxation, and LP-WUS monitoring jointly based on RAN2 agreements of entry/exit condition for LP-WUS monitoring. And if there are other conditions that should be considered, RAN4 needs to provide input to RAN2 (LG)
	+ P5: RAN4 shall be involved on criterion and scenario (entry/exit condition) design for LP-WUR measurement and MR RRM measurement relaxation together with RAN1 and RAN2. (Samsung)
		- RAN4 shall further discuss the applicable side condition /scenario with corresponding assumption on MR serving cell measurement, MR neighbouring cell measurement and LP-WUR measurement as a package
	+ P6: assumption of thresholds for RAN4 discussion can be (Apple):
		- the threshold for MR fully offloading to LR can be same as the threshold for neighbor cell measurement triggering (highest one between SIntraSearchP/SIntraSearchQ and SnonIntraSearchP/SnonIntraSearchQ), or at least offloading threshold can be not lower than threshold for neighbor cell measurement triggering.
		- the threshold to turn on LR or to involve LR for measurement can be equivalent to the threshold of entry condition for LP-WUS monitoring.

*Recommendations:*

*Suggest to check whether the following top level description:*

*LP-WUR monitoring is triggered not early than MR RRM relaxation or MR serving cell offloading (case 1)*

**Issue 1-1-9: LP-WUR status**

* Proposals
	+ P1: LP-WUR status before entering LP-WUS monitoring or after exiting LP-WUS monitoring (Apple)
		- Alt 1: MR is ON with RRM measurement on serving cell and neighbour cell (if any) and LP-WUR is ON for serving cell measurement
		- Alt 2: MR is ON with RRM measurement on serving cell and neighbour cell (if any) and LP-WUR is ON without RRM measurement (Apple)
		- Alt 3: MR is ON with RRM measurement on serving cell and neighbour cell (if any) and LP-WUR is OFF without RRM measurement. (Apple)
	+ P2: For LP-WUR status before entering offloading or after exiting offloading, postpone the discussion until more RAN1/2 conclusions (vivo)

*Recommendations:*

**Issue 1-1-10: UE measurement behivour after receiving LP-WUS signal**

* Proposals
	+ P1: UE may receive LP-WUS signal but is not paged. Discuss whether the UE starts measurements after the LP-WUS signal, or after LP-WUS signal + when UE has discovered it has been being paged. (Nokia)

*Recommendations:*

*Maybe it is not a RAN4 issue, suggest to check RAN1/2 for clarification.*

**Issue 1-1-11: Considerations on higher priority frequency layer**

* Proposals
	+ P1: higher priority layer neighbor cell measurement could also be OFF for case #1. (Apple vivo)
	+ P2: RAN4 shall study the MR neighbour cell measurement relaxation when the high priority frequency is configured. If the legacy relaxed conditions are reused, the legacy relaxed measurement requirements can be the baseline and RAN4 shall study the relaxed scaling factor. (ZTE)

*Recommendations:*

**Issue 1-1-12: Impact on specification**

* Proposals
	+ P1：Discuss this issue after more RAN4’s conclusion are available (Apple)

*Recommendations:*

### Sub-topic 1-2 Detail LP-WUR requirements at RRC\_IDLE/INACTIVE state

**Issue 1-2-1: Accuracy requirements**

* Proposals
	+ P1: No dedicated accuracy requirement is defined in the performance section for LR-WUR based RRM measurement in Idle/inactive states, and reflect the accuracy performance as a margin in the core requirement. (Apple oppo xiaomi Ericsson, ZTE)
	+ P2: Do not define measurement accuracy requirements for LP-WUR in Idle/Inactive state in performance section (LG)
	+ P3: Define LP-WUR measurement accuracy in dedicated section. Whether/how to reflect it in the core requirements can be further discussed after the simulation by taking the results into account (CATT)
	+ P4: Postpone the discussion on this issue (CMCC)
	+ P5: RAN4 need to define LR measurement accuracy requirements at least for the fully offloading scenario. (Nokia)

*Recommendations:*

**Issue 1-2-2: Possible interruption related requirements for LP-WUR**

* Proposals
	+ P1: Interruption requirements could be defined for the time between LP-WUS received paging indication to MR ready for Paging monitoring (Samsung xiaomi Docomo CMCC)
		- In addition, between LP-WUR measurement result fulfills exit criteria and MR to start measurement (CMCC)
		- In addition, between MR measurement result fulfills entry criteria and LP-WUR to start measurement. (CMCC ZTE)
	+ P2: RAN4 shall clarify the timeline from decoding LP-WUS to MR wake-up in order to monitor legacy PO. (ZTE)

*Recommendations:*

**Issue 1-2-3: Possible cell selection evaluation requirements for fully offloading case based on LP-WUR**

* Proposals
	+ P1: RAN4 to discuss whether to define evaluation requirements for cell selection criterion based on LR measurement for fully offloading case (CATT)

*Recommendations*

**Issue 1-2-4: LP-WUR operating carrier frequency**

* Proposals
	+ P1: RAN4 assumed LR and MR are operating on the same carrier frequency as baseline, and FFS on the other scenarios if RAN1 has agreement. (Apple QC)

*Recommendations:*

**Issue 1-2-5: Timeline on RRM requirement evaluation work**

* Proposals
	+ P1: RAN4 start RRM requirement for LP-WUR at idle/inactive state after RAN4 has sufficient information on LP-SS design and LP-SS based measurement metric from other sources. (CT)

*Recommendations:*

**Issue 1-2-6: Nubmer of Rx for LP-WUR requirements**

* Proposals
	+ P1: Single Rx is assumed for LR based RRM measurement. (Apple)

*Recommendations:*

*Check P1 is agreeable.*

**Issue 1-2-7: Other considerations**

* Proposals
	+ P1: Discuss whether the relaxations can be activated once the UE enters idle-mode - Relaxation / offloading may be applied based on connected mode MR measurements (Nokia)

*Recommendations:*

### Sub-topic 1-3 MR RRM relaxation

**Issue 1-3-1: MR RRM relaxation for serving cell/neighbour cell**

* Proposals
	+ P1: Use relaxation/scaling factor for MR serving/neighbour cell relaxation(CATT Apple xiaomi CT CMCC vivo Huawei Samsung ZTE MTK)
		- P1-1: Relaxation factors within the range from 8 to 16 as the starting point for the relaxation factor (CT vivo Samsung ZTE MTK)
		- P1-2: >=8 if case 2 or case 3 are introduced (CMCC)
		- P1-3 >=16 (Apple Huawei vivo MTK)
	+ P2: RAN4 has further study on MR RRM relaxation factor for serving and/or neigbhor cell (LG Ericsson)
	+ P3: RAN4 to discuss which, if any, of the legacy MR neighboring cell RRM measurement relaxation applicable to MR while configured with LP-WUS. (Nokia)
		- Existing idle mode mobility test cases applies for a UE configured with LP-WUR usage (Nokia)
	+ P4: The legacy intra-/inter-frequency and inter-RAT neighbour cell measurement requirements can be the baseline and RAN4 can study the relaxed scaling factor. (CATT ZTE)
	+ P5: As a starting point for RRM relaxation case (MR is relaxed and LR is ON), RAN4 can consider RRM relaxation for intra-frequency measurements in IDLE/INACTIVE mode where both serving and neighbour cells can be measured in the same frequency layer. (MTK)

*Recommendations:*

**Issue 1-3-2: On Neighbour cell and serving cell relaxation factor**

* Proposals
	+ P1: Neighbour measurements have the more relaxation than or equivalent relaxation as serving cell measurement. (Apple)
	+ P2: Same relaxation factor applies to serving and neighbor cell measurements (Apple Huawei MTK)
	+ P3: RAN4 to study the consideration of single stage of RRM relaxation or multiple stages of RRM relaxation (e.g., with different scaling factors) depending on conditions (e.g., channel condition, UE mobility, UE location) (MTK)
	+ P4: Further discuss whether to use same scaling factor or not (CATT)

*Recommendations:*

**Issue 1-3-3: Accuracy for relaxed MR measurement**

* Proposals
	+ P1: The legacy accuracy for relaxed MR measurement should be reused if Case#2 and/or Case#3 introduced. (CMCC vivo HW)

*Recommendations:*

### Sub-topic 1-4 LP-WUR CONNECTED mode

**Issue 1-4-1: LP-WUR at CONNECTED mode**

* Proposals
	+ P1: No RRM objectives is expected for connected mode in this WI. (CATT oppo Apple xiaomiCT LG vivo ZTE)
	+ P2: Postponed until more progress (Ericsson)
	+ P3: FFS whether need to introduce LP-WUS monitoring activation and deactivation delay requirements pending on RAN2/RAN1 progress. Paging reception requirement impact can be discussed after further input from RAN2 and RAN1 (Samsung)

*Recommendations:*

### Sub-topic 1-5 Others

**Issue 1-5-1: eDRX related**

* Proposals
	+ P1: RAN4 to discuss followings LP-SS based RRM issue in IDLE/Inactive mode: how to enter and exit offloading status if eDRX is configured with PTW. (Apple)
	+ P2: eDRX can be discussed after further input from RAN1 (Samsung vivo)

*Recommendations:*

Suggest eDRX related issue to be down prioritized at the early stage of this WI.

# Topic #2: Simulation assumptions and results

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2411450**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411450.zip) | Apple | *Proposal 16: RAN4 RRM session to decide which target SINR can be chosen from RAN1 candidate list [-3dB, -0.5dB, 2dB] after RAN4 RF conclusion on noise figure.**Proposal 19: Discuss Time/frequency error in simulation assumption based on RAN1’s and RF’s agreement.**Proposal 20:* *LP-SS measurement requirement in IDLE/Inactive mode shall be defined based on LP-SS periodicity.* |
| [R4-2412505](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412505.zip) | Ericsson | *Proposal 9: RAN4 to follow RAN1’s LP-RSRP and LP-RSRQ definition to evaluate the LP-SS performance* |
| [R4-2412531](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412531.zip) | Samsung | Proposal 6: Follow RAN1 conclusion on target SINR condition, and further evaluate measurement accuracy and measurement period. * Target SINR for OOK based LR: -3dB
* Target SINR for OFDM based on LR: -0.5dB and/or 2dB

Proposal 7: RAN4 need to specify RRM measurement requirements following metrics:* OOK based on LP-WUR: LP-RSRP and LP-RSRQ.
* OFDM based on LP-WUR: SS-RSRP and SS-RSRP

Proposal 8: 20 ppm frequency error can be considered for OOK based on LR for initial RAN4 evaluation work.  |
| [R4-2412670](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412670.zip) | Huawei, HiSilicon | Proposal 4: Use -3dB SINR as starting point for defining requirements for LR measurements.Proposal 5: RAN4 not to define baseline for accuracy requirements for LR measurement.Proposal 6: RAN4 to use the following value for evaluating LR measurement performance.* Frequency error: 5ppm
* Time error: up to companies to report

Proposal 7: Define the LR measurement requirements based on measurement interval of [320]ms for both LP-SS and SSB based measurement.  |
| [R4-2413325](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413325.zip) | MediaTek inc. | Proposal 5: For Idle/Inactive mode, it is important to ensure SNR no less than -3dB for LP-WUS monitoring in order not to miss any paging. For the case determination of LP-WUS monitoring is based on LP-SS measurement by LR, 2 to 3 dB measurement inaccuracy need to be considered as a margin to define the final side condition. Therefore, RAN4 to define -6dB as the final side condition. |
| [**R4-2411361**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411361.zip) | CATT | Proposal 1: The following measurements are to be simulated:* LP-RSRP
* LP-RSRQ
* LP-SSS-RSRP
* LP-SSS-RSRQ

Proposal 2: The following values agreed in RAN1 can be used as SINR value in RAN4 simulation: * SNR=-3dB for NF of LR = NF of MR+ 8dB
* SNR= -0.5dB for NF of LR = NF of MR+ 5dB
* SNR=2dB for NF of LR = NF of MR+ 2dB
* Note 1: The NF of MR is assumed as 7dB

Proposal 3: Use the same SINR values for LP-SS based and LP-SSS based measurement. Proposal 4: RAN4 to wait for more progress on LP-SS design, e.g., sequence, waveform and periodicity etc. From RAN1 to derive the simulation assumption. Proposal 5: The simulation assumption can be defined as the above tables.  |
| [**R4-2411449**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411449.zip) | Apple | *Proposal 1: For LP-WUR based RRM, RAN1’s LLS simulation assumption and RAN4 RF session’s LLS simulation assumption can be used as baseline for RAN4 RRM simulation work.**Proposal 2: to agree the following LLS simulation assumption for LP-WUR based RRM measurement.* |
| [**R4-2411616**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2411616.zip) | Xiaomi | Observation 1: For LP-SS based RSRP measurement, accuracy results show slightly difference between OOK-1, OOK-4 with M=2 and OOK-4 with M=4. Observation 2: Assuming CA/DC Idle Mode Measurements accuracy requirements (e.g., +/- 6 dB), measurement with 3 LP-SS samples is sufficient at SNR = -3dB in TDL-C channel.  |
| [**R4-2412290**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412290.zip) | vivo | Observation 1: For RRM measurement purpose, UE can satisfy RSRP/RSRQ measurement accuracy based on 2-3 LP-SS samples at SINR = -3dB under TDL-C channel based on 320ms periodicity of LP-SS. Proposal 1: Use two cells for RAN4 simulation. -3 dB Ês/Iot value is used for serving cell in the simulation for both OOK based and OFDM based LP-WUR.Proposal 2: In order to derive SNR for serving cell and interference cell from serving cell Ês/Iot, a relationship for the SNR or transmission power between serving cell and interference cell need be pre-defined.Proposal 3: Suggest to consider the SNR/transmission of the interference cell is 9 dB or 6 dB lower compared with that of the serving cell. Proposal 4: RAN4 uses RAN1’s definition on LP-RSRP and LP-RSRQ, and RAN1’s working assumption on the definition for LP-SSS-RSRP and LP-SSS-RSRQ in RAN4’s simulation work. Proposal 5: Suggest that 5 ppm is used for SSB based LP-WUR receivers and [5 10 20]ppm is used for OOK based receivers. Suggest the timing error are: OFDB type receiver: Residual timing error + 5\*320ms; OOK type receiver: Residual timing error + [5 10 20] \*320msProposal 6: The accuracy requirement defined for Redcap with 1Rx for RSRP or RSRQ in 10.1A can be used as the base when defining requirements for LP-WUR serving cell measurement. Proposal 7: Further relaxation on the accuracy target based on reference accuracy maybe needed. The amount of relaxation could be based on RAN4’s simulation outcome. |
| [**R4-2412441**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412441.zip) | OPPO | Observation 1: LP-RSRP measurement could achieve 4.5dB accuracy performance at Es/Iot=-3dB with 4 samples in TDL-C channel. Observation 2: For simulation assumptions, some parameters should be updated which are highlighted as red in the Table1/2/3 above. |
| [**R4-2412506**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412506.zip) | Ericsson | Observation 1. LP-SS measurement performance has significant decreased when the interference signal is higher than the serving signal.Proposal 1: RAN4 to agree the LP-SS simulation assumption. |
| [**R4-2412669**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412669.zip) | Huawei, HiSilicon | Proposal: Take suggested updated in Table 1 and Table 2 into account in the simulation assumption for LP-WUR measurement.  |
| [**R4-2412801**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2412801.zip) | Nokia | [Proposal 1: Our simulations indicate that $X\geq 4$ LP-SS samples are required to estimate LP-RSRP reliably irrespective of the operating SNR.](#_Toc174104482)[Proposal 2: Discuss what is the meaning of Cell 1 and Cell 2 in the simulated scenario as the LP-WUR only supports serving cell measurements.](#_Toc174104483)[Proposal 3: Discuss if M=8 can be removed from the RAN4 simulation assumptions until / if RAN1 agrees to support it.](#_Toc174104484)[Proposal 4: Consider the simulation assumptions provided in this paper.](#_Toc174104485) |
| [**R4-2413324**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_112/Docs/R4-2413324.zip) | MediaTek inc. |  |
|  |  |  |

## Open issues summary

### Sub-topic 2-1 On simulation assumptions and parameters

**Issue 2-1-1: SINR setting**

* Proposals
	+ P1: -3 dB Ês/Iot value is used for serving cell in the simulation for both OOK based and OFDM based LP-WUR. (CMCC vivo Huawei)
	+ P2: RAN4 RRM session to decide which target SINR can be chosen from RAN1 candidate list [-3dB, -0.5dB, 2dB] after RAN4 RF conclusion on noise figure. (CATT Apple)
	+ P3: Follow RAN1 conclusion on target SINR condition, and further evaluate measurement accuracy and measurement period: Target SINR for OOK based LR: -3dB; Target SINR for OFDM based on LR: -0.5dB and/or 2dB (Samsung)
	+ P4: RAN4 to define -6dB as the final side condition (MTK)

*Recommendations:*

*Suggest to consider P1*

**Issue 2-1-1-1: SNR setting for serving and interference cell derivation from SINR setting**

* Proposals
	+ P1: Use two cells for RAN4 simulation. To derive SNR for serving cell and interference cell from serving cell Ês/Iot, a relationship for the SNR or transmission power between serving cell and interference cell need be pre-defined. Suggest to consider the SNR/transmission power of the interference cell is 9 dB or 6 dB lower compared with that of the serving cell. (vivo, Ericsson)
	+ P2: Discuss what is the meaning of Cell 1 and Cell 2 in the simulated scenario as the LP-WUR only supports serving cell measurements. (Nokia)

*Recommendations:*

*Suggest to check the methodology in P1 is agreeable or not.*

**Issue 2-1-1-2: Same or different SINR setting for OOK based and OFDM based LP-WUR**

* Proposals
	+ Option 1: Same (CMCC CATT vivo Huawei)
	+ Option 2: Different (Samsung)

*Recommendations:*

**Issue 2-1-2: Measurement metrics**

* Proposals
	+ P1: RAN4 uses RAN1’s definition on LP-RSRP and LP-RSRQ for OOK based LP-WUR requirement specification (CATT oppo CMCC vivo Ericsson Samsung)
	+ P2: RAN1’s working assumption (use the same definition of SS-RSRP and SS-RSRQ for LP-SSS-RSRP and LP-SSS-RSRQ) could be used in RAN4’s simulation work for OFDM-based LP-WUR based on SSS. (CATT CMCC vivo Samsung)

*Recommendations:*

*Confirm the following measurement metrics*

* LP-RSRP and LP-RSRQ for OOK based LP-WUR
* SS-RSRP and SS-RSRQ (terms may be updated) for OFDM-based LP-WUR based on SSS

**Issue 2-1-3: Time/frequency error**

* Proposals
	+ P1: Suggest that 5 ppm is used for SSB based LP-WUR receivers and [5 10 20]ppm is used for OOK based receivers. Suggest the timing error are: OFDM type receiver: Residual timing error + 5\*320ms; OOK type receiver: Residual timing error + [5 10 20] \*320ms. (vivo)
	+ P2: Discuss Time/frequency error in simulation assumption based on RAN1’s and RF’s agreement (Apple)
	+ P3: Use 20ppm Residual Frequency error as the simulation baseline, 0ppm and 10ppm can also be involved if companies interested. Further update is not precluded. (CMCC)
	+ P4: 20 ppm frequency error can be considered for OOK based on LR for initial RAN4 evaluation work. (Samsung)
	+ P5: Frequency error: 5ppm; Time error: up to companies to report (Huawei)
	+ P5: Frequency error: 5ppm for SSB based and [5, 10]ppm for OOK based (Ericsson)

*Recommendations:*

*Residual frequency error:*

*OFDM based receiver 5 ppm*

*OOK based receiver [10 20]ppm*

Timing error

Timing error = Residual timing error (up to company report) + residual frequency error\* reference signal periodicity (320ms);

**Issue 2-1-4: Accuracy baseline for simulation**

* Proposals
	+ P1: The accuracy requirement defined for Redcap with 1Rx for RSRP or RSRQ in 10.1A can be used as the base when defining requirements for LP-WUR serving cell measurement. (vivo)
	+ P2: RAN4 to use the legacy measurement accuracy for CONNECTED mode in Clause 10.1.2 TS 38.133 as baseline. (CATT CMCC)
	+ P3: Use the accuracy requirement defined for CA/DC Idle Mode Measurements, i.e., ±6dB RSRP measurement accuracy and ±4dB RSRQ measurement accuracy, as the starting point when determining the measurement accuracy in RRC\_IDLE/INACTIVE state for LP-WUR serving cell measurement. RAN4 to consider the same target accuracy when defining LP-SS based and PSS/SSS based RRM delay requirements for LP-WUR (xiaomi)
	+ P4: RAN4 not to define baseline for accuracy requirements for LR measurement. (Huawei)

*Recommendations:*

**Issue 2-1-5: Measurement interval**

* Proposals
	+ P1: LP-SS measurement requirement in IDLE/Inactive mode shall be defined based on LP-SS periodicity (Apple, Ericsson)
	+ P2: Define the LR measurement requirements based on measurement interval of 320ms for both LP-SS and SSB based measurement. (vivo Huawei)
	+ P3: SSB burst periodicity: 20ms (CMCC, Ericsson)

*Recommendations:*

*Suggest to use 320ms for SSB based LP-WUR.*

### Sub-topic 2-2 Simulation assumptions and results summary

**Issue 2-2-1: Observations from simulation results**

* Proposals
	+ P1: (Xiaomi)
	+ Observation : For LP-SS based RSRP measurement, accuracy results show slightly difference between OOK-1, OOK-4 with M=2 and OOK-4 with M=4.
	+ Observation : Assuming CA/DC Idle Mode Measurements accuracy requirements (e.g., +/- 6 dB), measurement with 3 LP-SS samples is sufficient at SNR = -3dB in TDL-C channel.
	+ P2: For RRM measurement purpose, UE can satisfy RSRP/RSRQ measurement accuracy based on 2-3 LP-SS samples at SINR = -3dB under TDL-C channel based on 320ms periodicity of LP-SS. (vivo)
	+ P3: oppo
	+ Observation 1: LP-RSRP measurement could achieve 4.5dB accuracy performance at Es/Iot=-3dB with 4 samples in TDL-C channel.
	+ Observation 2: For simulation assumptions, some parameters should be updated which are highlighted as red in the Table1/2/3 above.
	+ P4: (Nokia)
	+ Our simulations indicate that $X\geq 4$ LP-SS samples are required to estimate LP-RSRP reliably irrespective of the operating SNR.

*Recommendations:*

**Issue 2-2-2: Simulation parameters (include all other parameters not discussed in above issues)**

***Summary of issues other than issues list above***

Table 1: General parameters

|  |  |
| --- | --- |
| **Simulation parameters** | **Comments/values** |
| Carrier frequency for Cell 1 and Cell 2 | O1: FR1: 2.6 GHz and 700MHz (vivo Ericsson Nokia)O2: FR1: 2.6 GHz (CATT Apple MTK) |
| System bandwidth | O1: 20 and 100 MHz; (vivo CATT)O2: 20MHz (Apple Ericsson MTK)O3: 20MHz for 700MHz carrier frequency/100 MHz for 2.6GHz carrier frequency (Huawei) |
| Prior knowledge of Cell 1 / Cell 2 by the UE | Interfering cell (Cell 2) is not known to UE |
| DRX | No applicable for LP-WUR |
| BS transmit antennas for LP-SS blocks | 1 Tx  |
| UE receive antennas | 1 Rx  |
| Data and control channel subcarrier spacing | Data, SSB and LP-SS have the same SCS [for cell 1 and cell 2] |
| Subcarrier spacing | 30KHz [15 KHz for 700 MHz] (Huawei) |
| Measurement period (in number of measurement samples) | LP-SS for OOK based LP-WUR: [4, 5, other number could be studied upon a need]SSB for OFDM based LP-WUR: [4, 5] (other number could be studied upon a need) |
| LP-SS/SSB burst periodicity | LP-SS: 320 msSSB: 320 ms (vivo Ericsson Huawei) 160ms (CATT) 20ms (CMCC) |
| LP-SS block BW | 132 subcarriers for SCS=30kHz for LP-SS TBD subcarriers for SCS=15kHz if 15KHz is considered (Huawei)264 subcarriers for SCS=15kHz (MTK)Note: May need be updated based on RAN1 conclusion |
| SSS block  | 20PRBs for 15kHz and 30kHz for SSS (CATT) |
| Actual LP-SS transmissions | always transmitted |
| Guard band | 1 RB on each side of LP-SS/LP-WUS signal |

Table 2: Cell-specific parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Unit | Cell 1 | Cell 2 |
| RF Channel number | - | Channel 1 | Channel 1 |
| NR-PSS, NR-SSS (OFDM based LP-WUR) | - | To be indicated by companies Same as in R4-1708698 (Apple) | To be indicated by companiesSame as in R4-1708698 (Apple) |
| LP-SS (OOK based LP-WUR receiver) |  | OOK-1; orOOK-4 with M = 2,4,[8]Note: 8 is up to company’s preferenceTo be indicated by companies, including number of OFDM symbols, M value for OOK-4, binary sequence and overlaid sequence (Huawei) | when Cell 1 uses OOK-1; OOK-1 or NR signal is used for Cell 2when Cell 1 uses OOK-4,OOK-4 with same M value as cell 1 or NR signal is used for Cell 2Same as Cell 1 but with different sequences (Huawei) |
| LP-SS pattern |  | [M sequence] [Golden sequence] [Computer search sequence]Note: Company can simulate one or all of them | [M sequence] [Golden sequence] [Computer search sequence]Note: Company can simulate one or all of them |
| PBCH and DMRS power offset with respect to NR-PSS, NR-SSS and LP-SS | dB | 0 | 0 |
| Data and control PSD relative to NR-PSS,NR-SSS and LP-SS | dB | 0 | 0 |
| RB Utilization | % | 100 | 100 |
| Data Modulation | - | QPSK | QPSK |
| Slot length | - | 14 symbols | 14 symbols |
| CP Length | - | Normal | Normal |
| Frequency offset relative to UE frequency reference | Hz | OFDM [5] ppmOOK: [5; 10; 20] ppmNote: RAN1 may have further conclusion at future meeting[0/10/20]ppm (Apple)[5 10] (Ericsson) | N/A |
| Timing error |  | Residual timing error + timing drift (frequency offset\* 320ms (reference signal periodicity) Residual timing error: company report  |  |
| 1)Relative Delay of 1st Path (synchronous) | µs | 0 | CP/2 |
| 2) Relative Delay of 1st Path (asynchronous): Fixed delay | ms | 0 | 3 ms |
| SNR  | dB | Set 1: SNR = [-2.7]Set 2: SNR = [-2.4] | Set 1: SNR = [-11.7] (The power of cell 2 is relative [9 dB] lowercompared with Cell 1)Set 2: SNR = [-8.4] (The power of cell 2 is relative [6 dB] lowercompared with Cell 1) |
| Ês/Iot | dB | [-3]  | N/A |
| Propagation conditions | - | FR1:AWGNTDL-C 300ns |
| UE speed |  | FR1: 3 km/h 30km/h (MTK) |
|  |

Table 3: UE-specific parameters

|  |  |
| --- | --- |
| [Receiver Filter] | [3th/5th Order Butterworth with 3.96MHz bandwidth] |
| [Receiver ADC bit width] | [4 or 8-bitADC] |
| [Receiver Sampling Rate for LP-SS only] | [3.84 or 7.68MHz] |

***CATT***

Table 1: General parameters

|  |  |  |
| --- | --- | --- |
| **Parameters** | **LP-SSS based** | **LP-SS based** |
| Carrier frequency for Cell 1 and Cell 2 | FR1: 2.6 GHz |
| System bandwidth | 10MHz, 20 MHz |
| Prior knowledge of Cell 1 / Cell 2 by the UE | No/Yes |
| DRX | No |
| BS transmit antennas  | 1 tx or single layer transmissions |
| UE receive antennas | 1 rx  |
| Data and control channel subcarrier spacing | The same as SS block | The same as LP-SS |
| Number of measurement samples | [5] | [3, 5] |
| Propagation conditions | AWGN, TDL-C (300 ns delay spread, 100 Hz), TDL-A (30 ns delay spread, 5Hz),TDL-B (100 ns delay spread, 200Hz) |
| UE speed | FR1: 30 km/h |
| SS burst set/LP-SS configuration |
| Subcarrier spacing | 15 kHz, 30 kHz |
| Number of SS/LP-SS blocks per set | [1] |
| LP-SS/SSB burst periodicity | [160 ms] | [320 ms] |
| SSS/LP-SS block BW | 20PRBs for 15kHz and 30kHz | 11PRBs for 30kHzFFS for 15kHz |
| Actual SS/LP-SS block transmissions | Always transmitted | Always transmitted |
| SSS/LP-SS sequences | Company report | TBD |
| LP-SS ‘ON-OFF’ pattern | - | TBD |
| Data Modulation | QPSK | TBD |

Table 2: Cell-specific parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Unit | Cell 1 | Cell 2 |
| RF Channel number | - | Channel 1 | Channel 1 |
| PBCH and DMRS power offset with respect to LP-SSS and LP-SS  | dB | 0 | 0 |
| Data and control PSD relative to LP-SSS and LP-SS | dB | 0 | 0 |
| RB Utilization | % | 100 | 100 |
| Waveform |  | OOK-1;OOK-4 with M = 2,4;OFDM; | Same as Cell 1 |
| Slot length | - | 14 symbols | 14 symbols |
| CP Length | - | Normal | Normal |
| Frequency Offset relative to UE frequency reference | Hz | [TBD] | [TBD] |
| 1)Relative Delay of 1st Path (synchronous) | µs | 0 | [CP/2] |
| 2) Relative Delay of 1st Path (asynchronous): Fixed delay | Ms | 0 | [3 ms] |
| SNR  | dB |  |  |
| Es/IoT | dB | N/A | -3dB, -0.5dB, 2dB  |
| NOTE: the companies are encouraged to state channel model parameters together with the results, the parameters are to be further discussed and aligned |

Table 3: UE-specific parameters

|  |  |
| --- | --- |
| [Receiver Filter] | [5th Order Butterworth with 4.32MHz bandwidth] |
| [Receiver ADC bit width] | [4/8-bitADC] |
| [Receiver Sampling Rate] | [3.84/7.68MHz] |

***Apple***

Table 1: General parameters

|  |  |
| --- | --- |
| **Simulation parameters** | **Comments/values** |
| Carrier frequency for Cell 1 and Cell 2 | FR1: 2.6 GHz |
| System bandwidth | 20MHz; |
| BS transmit antennas for LP-SS blocks | 1 tx or single layer transmissions |
| UE receive antennas | 1 rx  |
| Data and control channel subcarrier spacing | 30kHz for data/control/SSB/LP-SS |
| Measurement period (in number of measurement samples) |  OOK based: [4, other number of samples may also be studied upon a need]OFDM based: [4] |
| Subcarrier spacing | 30KHz |
| Number of LP-SS blocks per SS burst set, K | [1], FFS on other values |
| LP-SS/SSB burst periodicity | LP-SS based [320 ms]OFDM based: [320 ms] |
| Number of transmit antenna ports | 1 (the same port for NR-SSS, NR-PSS, NR-PBCH) |
| LP-SS block BW | [132 subcarriers for SCS=30kHz;]Note: May need be updated based on RAN1 conclusion |
| Actual LP-SS block transmissions | always transmitted |
| Guard band | 1 RB on each side of LP-SS/LP-WUS signal |

Table 2: Cell-specific parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Unit | Cell 1 | Cell 2 |
| RF Channel number | - | Channel 1 | Channel 1 |
| PSS, SSS of SSB(OFDM based LP-WUR) | - | Same as in R4-1708698 |
| Overlaid OFDM sequence(s) for LP-SS |  | FFS | FFS |
| LP-SS assumption |  | OOK-1, OOK-4 with M=2,4, FFS:1,8,16Note: select one M for OOK-4 based simulation. | Same assumption as for cell 1. |
| Binary LP-SS sequence type for the ‘ON-OFF’ pattern in a LP-SS |  | Wait for RAN1 conclusion | Same assumption as for cell 1. |
| number of binary LP-SS sequences for the ‘ON-OFF’ pattern |  | Wait for RAN1 conclusion | Same assumption as for cell 1. |
| PBCH and DMRS power offset with respect to NR-PSS, NR-SSS and LP-SS | dB | 0 | 0 |
| Data and control PSD relative to NR-PSS,NR-SSS and LP-SS | dB | 0 | 0 |
| RB Utilization | % | 100 | 100 |
| Data Modulation |  | Uncorrelated pseudo random QPSK modulated data | Uncorrelated pseudo random QPSK modulated data |
| Slot length | - | 14 symbols | 14 symbols |
| CP Length | - | Normal | Normal |
| Residual Frequency error |  | [0/10/20]ppmNote: can also be FFS  | [0/10/20]ppmNote: can also be FFS |
| Timing error |  | 0  |  |
| 1)Relative Delay of 1st Path (synchronous) | µs | 0 | [CP/2] |
| 2) Relative Delay of 1st Path (asynchronous): Fixed delay | Ms | 0 | [3 ms] |
| SNR  | dB | FFS | FFS |
| Es/IoT (calculated from SNR) | dB | [-3dB]Note: -3dB can be used as starting point but need FFS based on RAN1 discussion. Other candidate values are not precluded. | NA |
| Propagation conditions | - | FR1:AWGNTDL-C 300ns |
| UE speed |  | FR1: 3 km/h |

Table 3: UE-specific parameters

|  |  |
| --- | --- |
| **Parameters** | **Assumptions** |
| [Receiver 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
 |
| [Receiver ADC bit width] | 4/8 bits ADC for ASCS/ACS |
| [Receiver Sampling Rate for LP-SS only] | 7.68MHz |

***Vivo***

Table 1: General parameters

|  |  |
| --- | --- |
| **Simulation parameters** | **Comments/values** |
| Carrier frequency for Cell 1 and Cell 2 | FR1: 2.6 GHz and 700MHz |
| System bandwidth | 20 and 100 MHz; |
| DRX | No applicable for LP-WUR |
| BS transmit antennas for LP-SS blocks | 1 Tx  |
| UE receive antennas | 1 Rx  |
| Data and control channel subcarrier spacing | Data, SSB and LP-SS have the same SCS  |
| Subcarrier spacing | 30KHz |
| Measurement period (in number of measurement samples) | LP-SS for OOK based LP-WUR: [5, other number could be studied upon a need]SSB for OFDM based LP-WUR: [5] (other number could be studied upon a need) |
| LP-SS/SSB burst periodicity | LP-SS: 320 msSSB: 320 ms |
| LP-SS block BW | 132 subcarriers for SCS=30kHz;Note: May need be updated based on RAN1 conclusion |
| Actual LP-SS transmissions | always transmitted |
| Guard band | 1 RB on each side of LP-SS/LP-WUS signal |

Table 2: Cell-specific parameters

|  |  |  |  |
| --- | --- | --- | --- |
| Parameter | Unit | Cell 1 | Cell 2 |
| RF Channel number | - | Channel 1 | Channel 1 |
| NR-PSS, NR-SSS (OFDM based LP-WUR) | - | To be indicated by companies  | To be indicated by companies |
| LP-SS (OOK based LP-WUR receiver) |  | OOK-1; orOOK-4 with M = 2,4,[8]Note: 8 is up to company’s preference | when Cell 1 uses OOK-1; OOK-1 or NR signal is used for Cell 2when Cell 1 uses OOK-4,OOK-4 or NR signal is used for Cell 2 |
| LP-SS pattern |  | [M sequence] [Golden sequence] [Computer search sequence]Note: Company can simulate one or all of them | [M sequence] [Golden sequence] [Computer search sequence]Note: Company can simulate one or all of them |
| PBCH and DMRS power offset with respect to NR-PSS, NR-SSS and LP-SS | dB | 0 | 0 |
| Data and control PSD relative to NR-PSS,NR-SSS and LP-SS | dB | 0 | 0 |
| RB Utilization | % | 100 | 100 |
| Data Modulation | - | QPSK | QPSK |
| Slot length | - | 14 symbols | 14 symbols |
| CP Length | - | Normal | Normal |
| Frequency offset relative to UE frequency reference | Hz | OFDM [5] ppmOOK: [5; 10; 20] ppmNote: RAN1 may have further conclusion at future meeting | N/A |
| Timing error |  | Residual timing error + timing drift (frequency offset\* 320ms (reference signal periodicity) Residual timing error: company report  |  |
| 1)Relative Delay of 1st Path (synchronous) | µs | 0 | CP/2 |
| 2) Relative Delay of 1st Path (asynchronous): Fixed delay | ms | 0 | 3 ms |
| SNR  | dB | Set 1: SNR = [-2.7]Set 2: SNR = [-2.4] | Set 1: SNR = [-11.7] (The power of cell 2 is relative [9 dB] lowercompared with Cell 1)Set 2: SNR = [-8.4] (The power of cell 2 is relative [6 dB] lowercompared with Cell 1) |
| Ês/Iot | dB | [-3]  | N/A |
| Propagation conditions | - | FR1:AWGNTDL-C 300ns |
| UE speed |  | FR1: 3 km/h |
|  |

Table 3: UE-specific parameters

|  |  |
| --- | --- |
| [Receiver Filter] | [3th/5th Order Butterworth with 3.96MHz bandwidth] |
| [Receiver ADC bit width] | [4 or 8-bitADC] |
| [Receiver Sampling Rate for LP-SS only] | [3.84 or 7.68MHz] |

**Ericsson**

**Table 1: General parameters**

|  |  |
| --- | --- |
| **Simulation parameters** | **Comments/values** |
| Carrier frequency for Cell 1 and Cell 2 | FR1: 2.6 GHz/700MHz |
| System bandwidth | 20 MHz; |
| Prior knowledge of Cell 1 / Cell 2 by the UE | Yes / No |
| DRX | No |
| BS transmit antennas for LP-SS blocks | 1 tx  |
| UE receive antennas | 1 rx  |
| Data and control channel subcarrier spacing | OFDM based: The same as SS block subcarrier spacingOOK based: the same as one of the SCS(s) used for other NR transmissions in the same CP-OFDM symbol   |
| Measurement period (in number of measurement samples) |  - |
| Subcarrier spacing | 30 kHz;  |
| Number of LP-SS blocks per SS burst set, K | 1 |
| LP-SS/SSB burst periodicity | 320 msOFDM based: 320 ms |
| Number of transmit antenna ports | 1 (the same port for NR-SSS, NR-PSS, NR-PBCH) |
| LP-SS block BW | 132 subcarriers for SCS=30kHz; |
| Actual LP-SS block transmissions | always transmitted |

**Table 2: Cell-specific parameters**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Unit** | **Cell 1** | **Cell 2** |
| RF Channel number | - | Channel 1 | Channel 1 |
| PBCH and DMRS power offset with respect to NR-PSS, NR-SSS and LP-SS | dB | 0 | 0 |
| Data and control PSD relative to NR-PSS, NR-SSS and LP-SS | dB | 0 | 0 |
| RB Utilization | % | 100 | 100 |
| LP-SS |   | OOK-1;OOK-4 with M = 2,4; | when Cell 1 uses OOK-1, NR signal is used for Cell 2when Cell 1 uses OOK-4,OOK-4 or NR signal is used for Cell 2 |
| LP-SS binary sequence pattern |   | OOK-4: [1010] | OOK-4: [0101] |
| Data Modulation | - | QPSK | QPSK |
| Slot length | - | 14 symbols | 14 symbols |
| CP Length | - | Normal | Normal |
| Frequency Offset relative to UE frequency reference | Hz | OFDM: 5 ppmOOK: 5 or 10 ppm | - |
| 1)Relative Delay of 1st Path (synchronous) | µs | 0 | CP/2 |
| 2)Relative Delay of 1st Path (asynchronous): Fixed delay | ms | 0 | [3] ms |
| SNR  | dB | 3: 6: 9  | 3  |
| Es/IoT (calculated from SNR) | dB | -1.7:1.2:4.2 |
| Propagation conditions | - | AWGN,TDL-C 300ns   |
| UE speed |   | 3 km/h  |
| NOTE: the companies are encouraged to state channel model parameters together with the results, the parameters are to be further discussed and aligned.  |

Huawei

**Table 1: General parameters**

|  |  |  |
| --- | --- | --- |
| **Simulation parameters** | **Comments/values** | **Remarks** |
| Carrier frequency for Cell 1 and Cell 2 | FR1: 2.6 GHz/700MHz |  |
| System bandwidth | 20MHz for 700MHz carrier frequency /100 MHz for 2.6GHz carrier frequency; | Typical system BW for corresponding carrier frequency |
| Prior knowledge of Cell 1 / Cell 2 by the UE | Yes / No | Cell 1 is the serving cell and should be known to UE; Cell 2 is interfering cell and not known to UE |
| DRX | No |  |
| BS transmit antennas for LP-SS blocks and SSB | 1 tx or single layer transmissions | Same Tx number for SSB and LP-SS |
| UE receive antennas | 1 rx  |  |
| Data and control channel subcarrier spacing | Same SCS for LP-SS, SSB and PDCCH/PDSCH | SCS should not depend on Rx type, and for simplicity we assume same SCS for all BS transmissions |
| Measurement period (in number of measurement samples) |  LP-SS: [5, other number of samples may also be studied upon a need]SSB: [5] | Measurement period should depend on RS but not Rx type |
| Subcarrier spacing | 2.6GHz: 30 kHz; 700MHz: 15kHz | 15kHz is not typical for 2.6GHz |
| Number of LP-SS blocks per LP-SS burst set, K | [1] | Typo correction |
| LP-SS/SSB burst periodicity | [320 ms]OFDM based: [320 ms] |  |
|  |  | Included above  |
| LP-SS block BW | 132 subcarriers for SCS=30kHz;[TBD subcarriers for SCS=15kHz ]Note: May need be updated based on RAN1 conclusion | Based on RAN1#117 agreements |
| Guard band between LP-SS and NR data | 1RB | Needed to model the interference from other NR transmissions from the serving BS |
| Actual LP-SS block transmissions | always transmitted |  |

**Table 2: Cell-specific parameters**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Parameter** | **Unit** | **Cell 1** | **Cell 2** | **Remarks** |
| RF Channel number | - | Channel 1 | Channel 1 |  |
| NR-PSS,NR-SSS | - | To be indicated by companies | To be indicated by companies | Suggest to keep LP-SS related settings in one place |
| PBCH and DMRS power offset with respect to NR-PSS, NR-SSS and LP-SS | dB | 0 | 0 |  |
| Data and control PSD relative to NR-PSS,NR-SSS and LP-SS | dB | 0 | 0 |  |
| RB Utilization | % | 100 | 100 |  |
| LP-SS |  | To be indicated by companies, including number of OFDM symbols, M value for OOK-4, binary sequence and overlaid sequence |  Same as Cell 1 but with different sequences | RAN1 has not made conclusion on LP-SS waveform, sequence, etc., can be updated based on RAN1#118 agreement, otherwise can be left to companies’ report.For Cell 2, suggest to model LP-SS to LP-SS interference, which is more typical |
|  |  |  |  | Included above |
| Data Modulation | - | QPSK | QPSK | We assume this is for NR data. LP-SS parameters included above  |
| Slot length | - | 14 symbols | 14 symbols |  |
| CP Length | - | Normal | Normal |  |
| Frequency Offset relative to UE frequency reference | Hz | 5 ppm |  5 ppm | Based on our companion discussion paper |
| Time error |  | To be indicated by companies | N/A | Based on our companion discussion paperFor Cell 2, the timing error is determined by the relative delay |
| 1)Relative Delay of 1st Path (synchronous) | µs | 0 | [CP/2] |  |
| 2) Relative Delay of 1st Path (asynchronous): Fixed delay | Ms | 0 | [3 ms] |  |
| SNR  | dB | -2.7dB, -2.4dB | -11.7dB, -8.4dB | Target to achieve -3dB SINR for Cell 1, and Cell 2 is 9dB or 6dB lower than Cell 1 |
| Es/IoT (calculated from SNR) | dB | -3dB | N/A | SINR for Cell 1 is -3dB |
| Propagation conditions | - | FR1:AWGNTDL-A 30ns (optional)TDL-B 100ns (optional)TDL-C 300ns | Make TDL-A and TDL-B optional to reduce simulation efforts |
| UE speed |  | FR1: 3km/h | 3km/h is more typical for LP-WUR use case |
| NOTE: the companies are encouraged to state channel model parameters together with the results, the parameters are to be further discussed and aligned |  |

**Table 3: UE-specific parameters**

|  |  |
| --- | --- |
| [Receiver Filter] | [5th Order Butterworth with 4.32MHz bandwidth] |
| [Receiver ADC bit width] | [4/8-bitADC] |
| [Receiver Sampling Rate for LP-SS only] | [3.84/7.68MHz] |

Nokia

**Table 1: General parameters**

|  |  |
| --- | --- |
| **Simulation parameters** | **Comments/values** |
| Carrier frequency for Cell 1 and Cell 2 | FR1: 2.6 GHz/700MHz |
| System bandwidth | 20/[100] MHz; |
| DRX | No applicable for LP-WUR |
| BS transmit antennas for LP-SS blocks | 1 tx or single layer transmissions  |
| UE receive antennas | 1 rx  |
| Data and control channel subcarrier spacing | Data, SSB and LP-SS have the same SCS  |
| Subcarrier spacing | 30KHz |
| Measurement period (in number of measurement samples) | LP-SS (signal based) OOK based: [5, other number of samples could be studied upon a need](SSB based) - OFDM based: [5] (other samples if necessary) |
| LP-SS/SSB burst periodicity | LP-SS based: 320 msOFDM based: 320 ms |
| LP-SS block BW | 132 subcarriers for SCS=30kHz;Note: May need be updated based on RAN1 conclusion |
| Actual LP-SS ~~block~~ transmissions | always transmitted |
| Guard band | 1 RB on each side of LP-SS/LP-WUS signal |

**Table 2: Cell-specific parameters**

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **Unit** | **Cell 1** | **Cell 2** |
| RF Channel number | - | Channel 1 | Channel 1 |
| NR-PSS, NR-SSS (OFDM based LP-WUR) | - | To be indicated by companies  | To be indicated by companies |
| [Overlaid OFDM sequence(s) for LP-SS]Note: up to RAN1 further decision |  |  |  |
| LP-SS (OOK based LP-WUR receiver) |  | OOK-1; OOK-4 with M = 2,4,~~[8]~~~~Note: 8 is up to company’s preference.~~[M sequence] [Golden sequence] [Computer search sequence]Note: Company can simulate one or all of them | when Cell 1 uses OOK-1; OOK-1 or NR signal is used for Cell 2when Cell 1 uses OOK-4,OOK-4 or NR signal is used for Cell 2 |
| PBCH and DMRS power offset with respect to NR-PSS, NR-SSS and LP-SS | dB | 0 | 0 |
| Data and control PSD relative to NR-PSS,NR-SSS and LP-SS | dB | 0 | 0 |
| RB Utilization | % | 100 | 100 |
| Data Modulation | - | QPSK | QPSK |
| Slot length | - | 14 symbols | 14 symbols |
| CP Length | - | Normal | Normal |
| Frequency offset relative to UE frequency reference | Hz | OFDM [5] ppmOOK: [5] or [10 20] ppmNote: RAN1 may have further conclusion at future meeting | N/A |
| Timing error |  | Residual timing error + timing drift (frequency offset\* 320ms (reference signal periodicity) Residual timing error: company report  |  |
| 1)Relative Delay of 1st Path (synchronous) | µs | 0 | [CP/2] |
| 2) Relative Delay of 1st Path (asynchronous): Fixed delay | ms | 0 | [3 ms] |
| SNR  | dB | Set 1: SNR = [-2.7]Set 2: SNR = [-2.4] | Set 1: SNR = [-11.7] (Relative [9 dB] lowercompared with Cell 1)Set 2: SNR = [-8.4] (Relative [6 dB] lowercompared with Cell 1) |
| Es/IoT (calculated from SNR) | dB | [-3]  | N/A |
| Propagation conditions | - | FR1:AWGNTDL-C 300ns |
| UE speed |  | FR1: 3 km/h |
| NOTE: the companies are encouraged to state channel model parameters together with the results, the parameters are to be further discussed and aligned |

**Table 3: UE-specific parameters**

|  |  |
| --- | --- |
| [Receiver Filter] | [3th/5th Order Butterworth with 3.96MHz bandwidth] |
| [Receiver ADC bit width] | [4 or 8-bitADC] |
| [Receiver Sampling Rate for LP-SS only] | [3.84 or 7.68MHz] |

MTK

Table 1: General parameters

|  |  |
| --- | --- |
| **Simulation parameters** | **Comments/values** |
| Carrier frequency  | FR1: 2.6 GHz |
| Channel bandwidth | 20 MHz |
| DRX | No |
| BS transmit antennas for LP-SS blocks | 1 tx or single layer transmissions |
| UE receive antennas | 1 rx  |
| Data and control channel subcarrier spacing | OFDM based: The same as SS block subcarrier spacingOOK based: the same as one of the SCS(s) used for other NR transmissions in the same CP-OFDM symbol  |
| Measurement period (in number of measurement samples) |  OOK based/OFDM based: [2] |
| Subcarrier spacing | 15 kHz and 30 kHz |
| LP-SS periodicity | 320 ms |
| LP-SS block BW | 132 subcarriers for SCS=30kHz;264 subcarriers for SCS=15kHz |
| Actual LP-SS block transmissions | always transmitted |

Table 2: Cell-specific parameters

|  |  |  |
| --- | --- | --- |
| Parameter | Unit | Cell 1 |
| RF Channel number | - | Channel 1 |
| PBCH and DMRS power offset with respect to NR-PSS, NR-SSS and LP-SS | dB | 0 |
| Data and control PSD relative to NR-PSS,NR-SSS and LP-SS | dB | 0 |
| RB Utilization | % | 100 |
| LP-SS waveform |  | OOK-1;OOK-4 with M value based on RAN1 conclusion |
| LP-SS duration(Number of OFDM symbols) |  | Based on RAN1 conclusion |
| LP-SS pattern |  | Binary sequence based on RAN1 conclusion |
| Slot length | - | 14 symbols |
| CP Length | - | Normal |
| SNR | dB | OFDM based: -6 dBOOK based: -6dB |
| Channel |  | TDL-C 300ns |
| UE speed |  | 30km/h |