**3GPP TSG-RAN WG1 Meeting #122 R1-250xxxx**

**Bengaluru, India, Aug 25th-29th, 2025**

**Source: Moderator (vivo)**

**Title: Summary #1 of discussion on LP-WUS and LP-SS design**

**Agenda Item: 8.6.1**

**Document for: Discussion and Decision**

1. Introduction

This contribution summarizes the discussions on LP-WUS and LP-SS design in RAN1# 122.

The issues in this document are tagged and color coded with [H] or [M].

1. Proposals for Online Sessions
	1. Proposals for Tuesday online session

1. LP-WUS design
	1. LP-WUS targeting to wake up OFDM-based LP-WUR only

**Background**:

As discussed in last meeting, there are two scenarios that LP-WUS targets to wake-up OFDM-based LP-WUR only, where a shorter WUS transmission duration is possible and thus, network overhead can be reduced. Scenario 1) and scenario 2) -B can be supported by current agreement/spec, and scenario 2)-A needs to configure a new WUS actual duration indication to OFDM-based LP-WUR.

Scenario1): gNB enables LP-WUS feature only for one LP-WUR type in the cell, e.g., only OFDM-based receiver is to be served

* A) For IDLE/INACTIVE mode, gNB configures the LP-WUS entry/exit conditions for OFDM-based receiver only
* B) For CONNECTED mode, gNB provides the P-WUS configuration for OFDM-based receiver only

Scenario 2): gNB enables LP-WUS feature for both LP-WUR types in the cell

* A) For IDLE/INACTIVE mode, gNB configures the LP-WUS entry/exit conditions for both LP-WUR types. However, it is possible that only OFDM-based receiver is to be paged by a WUS transmission at a given time
* B) For CONNECTED mode operation, gNB configures LP-WUS separately for OFDM-based receiver and OOK-based receiver, e.g., with different MOs and/or codepoints

[2][4][6][7][11] discuss whether to support a new WUS actual duration/repetition number indication to OFDM-based LP-WUR:

* **Support:** [2][4][6][7]

[2]

Proposal 1: Introduce a new RRC parameter WUS\_ActualMO\_duration\_ IDLE/INACTIVE\_OFDM in addition to WUS\_ActualMO\_duration\_ IDLE/INACTIVE

* If only WUS\_ActualMO\_duration\_ IDLE/INACTIVE is provided, UE monitors LP-WUS based on this parameter, irrespetive of LP-WUR type.
* If both WUS\_ActualMO\_duration\_IDLE/INACTIVE and WUS\_ActualMO\_duration\_ IDLE/INACTIVE \_OFDM are provided, UE with OOK-based LP-WUR monitors LP-WUS according to WUS\_ActualMO\_duration\_ IDLE/INACTIVE, and UE with OFDM-based LP-WUR can monitor LP-WUS according to *WUS\_ActualMO\_duration\_ IDLE/INACTIVE* \_*OFDM*.

[4]

1. In order to reduce resource overhead, transmission duration of a LP-WUS targeting to wake up OFDM-based receiver can be shorter than the transmission duration required for ED based receiver.
* separate RRC configuration for the actual duration (or repetition number) of OFDM-based receiver.

 [6]

Proposal 4: Repetitions of overlaid OFDM sequences are not applied by default for LP-WUS transmission. Repetitions are explicitly enabled by network configuration.

* When repetitions are enabled, network configures the number of repetitions
* Network configures the repetition pattern, i.e., the set of all overlaid OFDM sequences for a codepoint is repeated or each overlaid OFDM sequence in the set is repeated first.

[7]

Proposal 1: Support the scenario that the gNB enable LP-WUS feature only for OFDM-based LP-WUR type in the cell.

* FFS: implicit configuration or explicit configuration.
* **Not support**: [11]

[11]

Proposal 2: Single transmission duration configured by gNB is used for transmitting the LP-WUS for OOK-based LP-WUR and OFDM-based LP-WUR.

Based on the discussion above, considering the benefit of the scenarios LP-WUS targets to wake-up OFDM-based LP-WUR only allowing reduced network overhead, FL suggests the following:

**[H][FL1] Proposal 3.1-1: Support adopting a new RRC parameter WUS\_ActualMO\_duration\_ IDLE/INACTIVE\_OFDM in addition to WUS\_ActualMO\_duration\_ IDLE/INACTIVE:**

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| --- | --- |
| **Parameter name in the text**  | **Description** |
| WUS\_ActualMO\_duration\_ IDLE/INACTIVE | To configure the actual MO duration for LP-WUS in IDLE/INACTVE, in number of OFDM symbols |
| WUS\_ActualMO\_duration\_ IDLE/INACTIVE\_OFDM | To configure the actual duration for LP-WUS in IDLE/INACTVE, in number of OFDM symbols, for OFDM-based LP-WUR.  |

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| Company | Y/N | Comments |
| Qualcomm | Y | We support the proposal. We think at least for the case that all UEs in the cell only support OFDM-based LP-WUS, there is an opportunity to optimize the configuration so that WUS resource overhead and the total WUS detection delay (i.e., interval from start of the WUS transmission to the start of the triggered PDCCH monitoring) can be reduced.Besides, if some UEs support OOK WUS and some support OFDM WUS, it is possible that network sends OFDM sequences for 2nd UE subgroup in the OOK WUS duration in the 1st UE subgroup. This can reduce the awake time for OFDM based LP-WUR and save UE power.  |
| CATT | N | During the whole discussion in Rel-19 LP-WUS/WUR, we assume that LP-WUS is designed for both OOK-based and OFDM-based LR i.e. the OOK waveform is design for OOK-based LR, the overlaid sequence is for OFDM-based LR. Also, we discussed how to overlaid the ZC sequence for OOK-1 and OOK-4. All this discussion implies that single LP-WUS is transmitted for both OOK-based and OFDM-based LR with a unified LP-WYS duration. For OFDM-based LP-WUR, the early determination is on the implementation of UE. |
| vivo | Y | Support the proposal. Allowing gNB to transmit a shorter LP-WUS when gNB intends to only wake-up OFDM-based receiver can dramatically reduce LP-WUS overhead. It is noted that, gNB can still transmit single LP-WUS with duration of *WUS\_ActualMO\_duration\_ IDLE/INACTIVE* for both OFDM and OOK receiver, if the UEs to be waken-up include both OFDM and OOK receiver.  |
| OPPO | N | No need to configure two separate LP-WUS durations. If two LP-WUS durations are configured by gNB, UE don’t know which LP-WUS duration is the actual duration that LP-WUS used. * It is OK for OFDM-based WUR due to it always could detect the LP-WUS no matter shorter duration or longer duration.
* However, for OOK-based WUR, when gNB transmit the LP-WUS with shorter duration, it still needs to monitor the MO and process the detection of LP-WUS, in this case, it can’t detect the LP-WUS successfully due to the assumption of longer duration.
* If gNB always transmits LP-WUS with shorter duration when configures two durations for LP-WUS, it is friendly for OFDM-based WUR while cause unnecessary detection for OOK-based WUR.
* If gNB transmits LP-WUS with longer duration when configures two durations for LP-WUS. For OFDM-based WUR, it could have a better detection performance by detecting the LP-WUS in longer duration, but due to the shorter duration configuration, it can only detect the LP-WUS in shorter duration.

If only one LP-WUS duration configured by gNB, no need to distinguish whether it is configured for OOK-based WUR or OFDM-based WUR. * When gNB wants to wake up OFDM-based WUR only, it can configure one shorter duration value.
* It also no need to further discuss the waveform and modulation in case of only waking up OFDM-based WUR.

In our views, no need to configure two separate LP-WUS duration, single configuration on LP-WUS duration is enough. |
| Ericsson1 | N | There is no parameter “WUS\_ActualMO\_duration\_ IDLE/INACTIVE” in the list of approved RRC parameters in R1-2503243. FL is referring to row38 “LP-WUS\_Actual\_WUS\_duration\_IDLE/INACTIVE”?Then on issue of whether to configure a separate duration of OFDM, we actually prefer to introduce signaling via which gNB can indicate the supported LP-WUS type in a cell as proposed in 9.6.2 contribution (R1-2504029). Need for other additional specification impact is not clear to us. |
| LGE | N | One clarification is needed. The repetition pattern for the overlaid OFDM sequences is included in the new RRC parameter? We are generally fine with introducing the new RRC parameter for OFDM-based LR only, but it is not clear if the new parameter is for with repetition or without repetition.  |
| InterDigital | N | We don’t see the need to configure separate durations. |
| Samsung | Y | We support the proposal.For the clarification, we would like to know whether “WUS\_ActualMO\_duration\_ IDLE/INACTIVE\_OFDM” is configured when only OFDM-based LP-WUR are supported in a cell or not. And we wonder how the UE determines supported LP-WUS type in a cell will be discussed separately or not. |
| ZTE, Sanechips | N | Not necessary. 1. It should be flexible for NW to disable OOK WUR or OFDM WUR. Current proposal can only disable OOK WUR, which is not beneficial for NW management.
2. The same effect can be achieved via: disable OOK WUR and configure WUS\_ActualMO\_duration\_ IDLE/INACTIVE with a short time. Then no need to introduce additional actual MO duration.
 |
| Spreadtrum | N | Not necessary. The early determination is on the implementation of UE. |
| Huawei, HiSilicon | Y | It is beneficial for reducing the resource overhead if the LP-WUS is targeted to a OFDM based WUR, since gNB may choose to transmit only WUS\_ActualMO\_duration\_ IDLE/INACTIVE\_OFDM symbols.If gNB chooses to do so, for the OOK based receivers, the remaining ‘WUS\_ActualMO\_duration\_ IDLE/INACTIVE - WUS\_ActualMO\_duration\_ IDLE/INACTIVE\_OFDM’ OFDM symbols can be regarded as noise. Thanks to the enough length of WUS\_ActualMO\_duration\_ IDLE/INACTIVE, the FAR to OOK based receivers can be limited under the target value. |
| docomo |  | We have the same view with LGE. New parameter for the repetition of overlaid OFDM should be discussed at first. |

* 1. Candidate WUS duration value

**Background**: the value ranges of RRC parameters LP-WUS\_NominalMO\_duration\_IDLE/INACTIVE, LP-WUS\_Actual\_WUS\_duration\_IDLE/INACTIVE, LP-WUS\_NominalMO\_duration\_CONNECTED, and LP-WUS\_Actual\_WUS\_duration\_CONNECTED are FFS

**For actual duration**: LP-WUS\_Actual\_WUS\_duration\_IDLE/INACTIVE, LP-WUS\_Actual\_WUS\_duration\_CONNECTED

* + [8] proposes the actual duration is determined by the agreed code-block length (before Manchester encoding) of any value in the range 1-32. Therefore, M=1: 2-64 OFDM symbols, M=2: 1-32 OFDM symbols, M=4: 1-16 OFDM symbols
	+ [9] considers minimum code block length which can achieve maximum Hamming distance and good flexibility for multiplexing between LP-WUS and other signals, as well as Manchester coding and M value, then proposes {2, 4, 6, 7, 8, 10, 12, 14, 16, 18, 20, 24, 28, 36, 42, 48, 56, 60, 64} symbols can be supported for actual duration.
	+ [4] discusses that the number of OFDM symbols for M=1 should be even, considering Manchester coding is always applied.
	+ [13] discusses that the number of OFDM symbols can be from 1 symbol to 6 slots for OOK-based LP-WUR, and 1 symbol to 3 slots for OFDM-based LP-WUR.

FL agrees with HW that number of OFDM symbols for M=1 should be even. And based on the agreement that code-block length before Manchester coding can be any value in the range of 1-32, FL proposes following:

**[H][FL1] Proposal 3.2-1:** For RRC parameter *LP-WUS\_Actual\_WUS\_duration\_IDLE/INACTIVE* and *LP-WUS\_Actual\_WUS\_duration\_CONNECTED*,

* 2n OFDM symbols for M=1, n=1, 2,…6
* 1-32 OFDM symbols for M=2
* 1-16 OFDM symbols for M=4

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| Company | Y/N | Comments |
| Qualcomm |  | For M=1, should the number of OFDM symbols be 2\*(1,2,3,…,32)? |
| CATT |  | OK with the proposal.  |
| vivo | Partially Y | Support the value for M=2 & M=4. Agree with QC’s modification for M=1.  |
| OPPO |  | For M=1, if limit 2n OFDM symbols, it means only 6 coded block length would be supported, while no restriction for M=2/4. Share same views as Qualcomm, the number of OFDM symbols should be 2\*(1,2,3,…,32). |
| Ericsson1 | N | For M=1, it should be 2\*n where n=[1-32] |
| LGE | N | We think one more restriction is required for 2 information bits. I.e., For K=2, the actual duration is the integer multiple of 3As discussed in our contribution [12], for K=2, decoder at LP-WUR only requires the actual WUS duration in multiple of 3. Any other length may be a waste of resources. |
| Samsung |  | For clarification, we agreed on the range of code block length per information bits during WI phase. But the symbol values in the proposal seems not consider that aspect. For example, for 5bit information and M=4, 1 OFDM symbol can be configured? |
| ZTE, Sanechips |  | Similar as Quacomm |
| Huawei, HiSilicon |  | OK for M=2 and M=4.For M=1, we are confused. Shouldn’t it be 2\*n OFDM symbols where n=1~32? |
| docomo |  | We have similar view with Qualcomm and Ericsson. For M=1, the number of OFMD symbols is not a power of 2. It should be 2\*n where n= [1-32]. |

* **For nominal duration:** LP-WUS\_NominalMO\_duration\_IDLE/INACTIVE, LP-WUS\_NominalMO\_duration\_CONNECTED
	+ [8] thinks, the MO duration should cover cases with short WUS durations (i.e., a few symbols) as well as full slots lengths. The duration should be sufficiently long to ensure sufficient available symbols excluding OFDM symbols for PDCCH and SSB in the MO. Therefore, [8] proposes M=1: FR1: {2:1:14, 14\* [2-10]} OFDM symbols，FR2: {2:1:14, 14\*[2:25]} OFDM symbols. M=2: FR1: {1-14, 14\* [2-6]} OFDM symbols, FR2: {1-14, 14\*[2:22]} OFDM symbols. M=4: FR1: {1-14, 14\* [2-5]} OFDM symbols, FR2: {1-14, 14\*[2:21]} OFDM symbols.
	+ [9] thinks, at least full slots lengths seem practical, and the duration less than one slot should be supported, at least for M=2 & M=4, thus, nominal MO duration the following values could be considered: {4, 7, 14, 28, 42, 56, 70, 84} symbols.
	+ [13] thinks, the MO duration should cover short WUS durations less than one slot as well as full slots lengths. Considering PDCCH OFDM symbols, SSB symbols and UL symbols, maximum 12 slots are needed. Thus, the duration can be 1 ~12\*14 OFDM symbols.

In FL’s understanding, it is reasonable to consider the case that a nominal MO includes OFDM symbols for PDCCH, SSB and UL symbol. As shown below, assuming 3 OFDM symbols for PDCCH per DL slot and Flexible slot, 4 SSB, and TDD configuration of DDDFU with F slot of 10 DL symbols + 2 Flexible symbols + 2 UL symbols, and maximum actual duration of 64 symbols, 11 slots in FR1 is sufficient. For FR2, larger number of SSBs, e.g., up to 64 SSBs, while PDCCH may not appear in every slot, 25 slots in FR2 would be sufficient.



**[H][FL1] Proposal 3.2-2:** For RRC parameter LP-*WUS\_NominalMO\_duration\_IDLE/INACTIVE*, and *LP-WUS\_NominalMO\_duration\_ CONNECTED*

* 1~14 symbols (1 is not applicable to M=1), and 14\*[2-11] symbols for FR1,
* 1~14 symbols (1 is not applicable to M=1), and 14\*[2-25] symbols for FR2.

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| Company | Y/N | Comments |
| Qualcomm | Y |  |
| CATT | Y |  |
| vivo | Y |  |
| OPPO | Y |  |
| Ericsson1 | Y |  |
| LGE |  | Generally fineBut, there are similar issues on the range of WUS actual duration in 8.6.2 (Proposal 10-1) and in 8.6.3 (Proposal 3.10). Duplicated discussion can be avoided. |
| ZTE, Sanechips |  | Does it mean always exclude the PDCCH symbols? , if LP-WUS is deployed in the same carrier but at the edge, is it necessary? |
| Spreadtrum | Y |  |
| Huawei, HiSilicon |  | It is not clear to me why the duration length > 1 slot can only be the unit of slot.  |

* 1. DFT shift and pulse shaping

**Background:**

[3] [4] [9][10] propose to add DFT shift after DFT processing before mapping the LP-WUS samples to frequency doamin REs with the following reasons:

* spectrum shifting changes the signal’s phase and thus OOK detection performance[4]
* the LP- WUS can be guaranteed to have a constant DC which will ease signal processing for the LP-WUR [4]
* OOK-4 waveform generation with fftshift has smaller energy jitter in time domain [3]
* The sequence as specified in the specification 38.211 can be used to generate the desired sequence for correlation in the LR if DFT shift is employed, otherwise additional operation of should be used before performing interpolation that is not specified. [9]
* If DFT shift is not applied, the time domain sequence received at the UE will no longer be the original ZC sequences. [10]

However, during CR review after RAN1#121, there are several companies considering such DFT shift is not necessary since it has marginal impact for envelope detection given overlaid sequence improving spectral flatness and for sequence based detection, the compensation of DFT shift can be done by UE implementation, namely, it works well even without DFT shift.

**[H][FL1] Proposal 3.3-1:** Support DFT shift for LP-WUS/LP-SS signal generation.

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| Company | Y/N | Comments |
| Qualcomm | Y |  |
| vivo | N | No need of additional DFT shift. * For OOK-based LP-WUR, because of the overlaid OFDM sequence, the spectrum is flattened, then DFT shift has no impact on OOK detection performance.
* For OFDM-based LP-WUR, by UE implementation, e.g., UE uses the specified overlaid OFDM sequence multiplied with ‘1’ and ‘-1’ as local sequence, there is no impact on OFDM detection performance.

In our tdocs in previous meetings, e.g., R1-2503369, we provided our evaluation results to show the unnecessity of additional DFT shift.  |
| OPPO | N | No need of additional DFT shift. |
| LGE | N | As summarized above by FL, if compensation of DFT shift can be done by implementation, no need of additional DFT shift. |
| InterDigital | N |  |
| Samsung | N | During the WI phase, several companies showed the result that can achieve the target performance without DFT shift, and we believe that other parameters such as the code block length range were decided based on the result without DFT shift. |
| ZTE, Sanechips | Y | With DFT shift, the received signal is not ZC sequence, which is not aligned with our design principle. |
| Spreadtrum | N | No need of additional DFT shift. |
| Huawei, HiSilicon | Y | In our view, only with pulse shaping, after the DFT-s-OFDM procedure, the sequence is based on ZC, which provides good cross-correlation property. Otherwise, the performance cannot be guaranteed. |
| docomo | N |  |

The corresponding TP is as below:

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| **7.4.4.1.2 Generation of** The block of complex-valued symbols is defined bywhereThe quantity is given by the higher-layer parameter *LP-WUS\_Mvalue\_IDLE/INACTIVE* or *LP-WUS\_Mvalue\_CONNECTED*.The bit sequence and the number of bits corresponds to and , respectively, in clause 7.4.3 of [4, 38.212].<Unchanged part is omitted>**7.4.5.1.3 Generation of** The block of complex-valued symbols is defined bywhere<Unchanged part is omitted>---------------------------------------------End of the TP for TS 38.211----------------------------------------------- |

* 1. Alignment TP

[TP1] Replace L with Nseq in TS 38.211: [8] [10]

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| ---------------------------------Start of Text Proposal on 3GPP TS 38.211 V19.0.0-----------------------<Unchanged part is omitted>7.4.4.1.1 Generation of <Unchanged part is omitted>The sequence number if, otherwise is given bywhere- ~~is given by the higher-layer parameter XXX~~- and are given by clause 7.4.2.2 of [4, 38.212]<Unchanged part is omitted>--------------------------------------End of Text Proposal on 3GPP TS 38.211 V19.0.0 ------------------ |

[TP2] Replace L1 with Nseq in TS 38.212: [5]

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| -------------------------------------------- Start of text proposal to TS 38.212 v19.0.0 ------------------------------<Unchanged part is omitted>If the number of sequences configured by higher layer parameter *LP-WUS\_num\_overlaidSeq\_CONNECTED* or *LP-WUS\_num\_overlaidSeq\_IDLE/INACTIVE*, denoted as , is larger than one, padding is performed and the bits after padding are denoted by, where , . The relation between and is:        for         for .<Unchanged part is omitted>------------------------------------------- End of text proposal to TS 38.212 v19.0.0 -------------------------------- |

[TP3] Update higher-layer parameter names in TS 38.211 based on RAN2 running CR: [8]

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| ---------------------------------Start of Text Proposal on 3GPP TS 38.211 V19.0.0-----------------------<Unchanged part is omitted>7.4.4.1.1 Generation of The sequence is defined bywhere- is the largest prime number such that - The root sequence number is obtained as entry of the root sequence numbers configured by the higher-layer parameter ~~XXX~~ *lpwus-OverlaidSeqRoots*  and the cyclic shift is given bywhere - is the number of sequences configured by the higher-layer parameter ~~XXX~~  *lpwus-OverlaidSeqNum* or *lpwus-OverlaidSeqNum-SCS-60kHz* or *lpwus-OverlaidSeqNum-SCS-120kHz.*- is the number of root sequence numbers configured by the higher-layer parameter ~~XXX~~ *lpwus-OverlaidSeqRoots*The sequence number if, otherwise is given by~~where~~* ~~is given by the higher-layer parameter XXX~~

<Unchanged part is omitted>7.4.5.1.1 Generation of The sequence is defined by Tables 7.4.5.1.1-1 to 7.4.5.1.1-3 with the quantity given by the higher-layer parameter ~~XXX~~ *lpss-MvalueAndSeqConfig*.<Unchanged part is omitted>7.4.5.1.2 Generation of If the quantity is configured by the higher-layer parameter ~~XXX~~ *lpss-OverlaidSeqRoots*, the sequence is defined by<Unchanged part is omitted>--------------------------------------End of Text Proposal on 3GPP TS 38.211 V19.0.0 ------------------ |

[TP4]Update higher-layer parameter names in TS 38.212 based on RAN2 running CR: [8]

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| ---------------------------------Start of Text Proposal on 3GPP TS 38.212 V19.0.0-----------------------<Unchanged part is omitted>7.4 Wake-up informationThe wake-up information is carried by a wake-up signal as defined in clause 7.4.4 of [4, TS 38.211]. - For a UE configured with higher layer parameter *~~LP-WUS\_LP-SS\_startRB\_IDLE\_INACTIVE~~* *lpwus-LPSS-StartRB* and operating in the RRC\_IDLE or RRC\_INACTIVE state, the wake-up information bit sequence is the binary sequence of the codepoint as defined by Clause 10.4C of [5, TS38.213], where is the most significant bit and is<Unchanged part is omitted>7.4.2.1 Rate matching for OOK modulationThe input bit sequence to rate matching is .Rate matching is performed according to Clause 5.4.3 by setting the rate matching output sequence length , where , , where- for a UE configured with higher layer parameter *~~LP-WUS\_LP-SS\_startRB\_IDLE\_INACTIVE~~* *lpwus-LPSS-StartRB* and operating in the RRC\_IDLE or RRC\_INACTIVE state, is configured by higher layer parameter *~~LP-WUS\_ActualMO\_duration\_IDLE/INACTIVE~~ lpwus-ActualDuration* and is configured by higher layer parameter *~~LP-WUS\_Mvalue\_IDLE/INACTIVE~~ lpwus-MvalueAndSeqConfigFR1* or *lpwus-MvalueAndSeqConfigFR2;* - for a UE configured with higher layer parameter *LP-WUS\_startRB\_CONNECTED* and operating in the RRC\_CONNECTED state, is configured by higher layer parameter *~~LP-WUS\_ActualMO\_duration\_CONNECTED~~ lpwus-ActualDuration* and is configured by higher layer parameter *~~LP-WUS\_Mvalue\_CONNECTED~~* *lpwus-MvalueAndSeqConfigFR1* or *lpwus-MvalueAndSeqConfigFR2*.<Unchanged part is omitted>--------------------------------------End of Text Proposal on 3GPP TS 38.212 V19.0.0 ------------------ |

[TP5] Update higher-layer parameter names in TS 38.213 based on RAN2 running CR: [8]

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| ---------------------------------Start of Text Proposal on 3GPP TS 38.213 V19.0.0-----------------------<Unchanged part is omitted>10.4C PDCCH monitoring activation by WUS in RRC\_IDLE/RRC\_INACTIVEA UE configured with DRX mode operation and operating in the RRC\_IDLE or RRC\_INACTIVE state can be provided for LPSS/WUS reception - a number of OOK symbols per OFDM symbol, a first RB, and an overlaid OFDM sequence per OOK symbol for LPSS reception, and an EPRE ratio relative to SS/PBCH blocks [4, TS 38.211], - a number of OOK symbols per OFDM symbol, the first RB, and one or more overlaid OFDM sequences per OOK symbol for WUS reception, and an EPRE ratio relative to SS/PBCH blocks [4, TS 38.211], andA UE determines to receive LPSS/WUS based on procedures defined in [17, TS 38.304]. A UE assumes that an SCS configuration for LPSS/WUS receptions is same as an SCS of the initial DL BWP and an SCS configuration of an SS/PBCH block the UE used to obtain *SIB1*. A UE receives an LPSS in consecutive symbols within a slot. The UE can be provided one or two first symbols for respective one or two LPSS reception occasions in the slot by *lpss-StartSymbol*. The UE determines slots for LPSS reception occasions based on a periodicity and a time offset, relative to a system frame with SFN 0, provided by *~~lpss-periodicityoffset~~ lpss-PeriodicityAndOffset.* Within a period of LPSS reception occasions, LPSS reception occasions are in a set of consecutive slots that have all symbols indicated as downlink by *tdd-UL-DL-ConfigurationCommon*, if provided, and start from the first slot provided by the time offset in the period, where is the number of transmitted SS/PBCH blocks indicated by *ssb-PositionsInBurst* in *SIB1* and is the number of LPSS reception occasions in a slot.LPSS reception occasions are indexed sequentially in time. An LPSS reception at the -th LPSS reception occasion is quasi co-located with the -th transmitted SS/PBCH block, with respect to quasi co-location ‘typeC’ or ‘typeD’ properties when applicable, where . If a UE is provided *~~wus-LPSS-beamSubset~~ lpwus-LPSS-BeamSubset*, the UE receives LPSS/WUS based on the quasi co-location properties of transmitted SS/PBCH blocks indicated by *~~wus-LPSS-beamSubset~~ lpwus-LPSS-BeamSubset* [12, TS 38.331]; otherwise, the UE receives LPSS/WUS based on the quasi co-location properties for transmitted SS/PBCH blocks indicated by *ssb-PositionsInBurst* in *SIB1*. A WUS occasion includes WUS monitoring occasions that are indexed sequentially in time, where- is the number of transmitted SS/PBCH blocks indicated by *ssb-PositionsInBurst* in *SIB1*, is a number of WUS monitoring occasions associated with each of the transmitted SS/PBCH blocks provided by *~~MONumperLO~~ lpwus-MoNumPerLo*, and- a WUS monitoring occasion with index , where and , is quasi co-located with the -th transmitted SS/PBCH block with respect to quasi co-location ‘typeC’ or ‘typeD’ properties, when applicableA UE can be provided, by *~~WUS\_available\_slot\_IDLE/INACTIVE~~* *lpwus-AvailableSlot*, a bitmap that corresponds to a set of time units that repeats continuously and indicates a subset of time units from the set of time units that is available for the UE to monitor WUS [12, TS 38.331]. A time unit includes one slot or two slots. The UE can be additionally provided, by *~~WUS\_available\_symbol\_IDLE/INACTIVE~~* *lpwus-AvailableSymbol*, an indication of symbols in each time unit from the subset of time units that is available for the UE to monitor WUS. If the UE is not provided *~~WUS\_available\_slot\_IDLE/INACTIVE~~ lpwus-AvailableSlot*, the UE assumes that all time units are available for the UE to monitor WUS. If the UE is not provided *~~WUS\_available\_symbol\_IDLE/INACTIVE~~* *lpwus-AvailableSymbol*, the UE assumes that, for a time unit that is available for the UE to monitor WUS, all symbols in the time unit are available for the UE to monitor WUS. The UE assumes that a symbol is not available to monitor WUS when- the symbol is indicated as uplink, by *tdd-UL-DL-configurationCommon* - the symbol is indicated for an SS/PBCH block transmission, by *ssb-PositionsInBurst* in *SIB1*, and the SS/PBCH block transmission would overlap in frequency with the WUS transmission- the symbol is indicated for PDCCH transmissions, by *pdcch-ConfigSIB1*, and CORESET 0 for the PDCCH transmissions would overlap in frequency with the WUS transmissionA WUS monitoring occasion is over a first number of symbols, provided by *~~WUS\_NominalMO\_duration\_ IDLE/INACTIVE~~* *lpwus-NominalMoDuration*. If a number of available symbols for the UE to monitor WUS in a WUS monitoring occasion is smaller than a second number of symbols, provided by *~~WUS\_ActualMO\_duration\_ IDLE/INACTIVE~~ lpwus-ActualDuration*, the UE does not monitor WUS in the WUS monitoring occasion. The UE monitors WUS in a WUS monitoring occasion over the earliest available *~~WUS\_ActualMO\_duration\_ IDLE/INACTIVE~~ lpwus-ActualDuration* symbols in the WUS monitoring occasion. If a number of available symbols for the UE to monitor WUS in a WUS monitoring occasion includes a symbol for LPSS reception, the UE does not monitor WUS in the WUS monitoring occasion.A UE assumes that WUS occasions occur with a periodicity equal to the I-DRX cycle in the RRC\_IDLE/RRC\_INACTIVE state [17, TS 38.304]. The UE determines WUS occasions associated with a paging occasion based on *PO-to-LO association*. A reference frame of a WUS occasion starts a number of frames prior to the first of a number of paging frames associated with the WUS occasion. Each number of frames is provided by *~~LO-FrameOffsets~~ lpwus-LoFrameOffsetList*. The first WUS monitoring occasion of a WUS occasion starts at an offset provided by *~~offset\_firstMO\_withinLO~~* *lpwus-OffsetFirstMoWithinLo* relative to the start of the reference frame. If multiple values for the number of frames provided by *~~LO-FrameOffsets~~* *lpwus-LoFrameOffsetList* are larger than or equal to the value of *XYZ*, the UE monitors WUS starting at a WUS occasion corresponding to the smallest of the multiple values. If all values for the number of frames provided by *~~LO-FrameOffsets~~ lpwus-LoFrameOffsetList* are smaller than the value of *XYZ*, the UE monitors PDCCH according to Type2-PDCCH CSS sets associated with the paging occasion and does not monitor WUS.A paging occasion associated with a WUS occasion has index where is a number of paging occasions associated with a WUS occasion, , , , and are defined in [17, TS 38.304], and is defined in clause 7.1 of [17, TS 38.304]. If a number of subgroups per paging occasion, provided by *~~subgroupNumber-PO-WUS~~* *lp-SubgroupsNumPerPO*, is , the codepoint for the subgroup index in a PO is, and the codepoint for all subgroups in the PO is; otherwise, the codepoint for the PO isIf, in a WUS monitoring occasion, a UE determines a codepoint associated with the UE [17, TS 38.304], the UE performs PDCCH monitoring according to Type2-PDCCH CSS sets for the paging occasion associated with the WUS monitoring occasion when a time from the end of the WUS reception to the start of the PDCCH monitoring occasion is not smaller than the value of *XYZ*; otherwise, the UE is not required to perform the PDCCH monitoring. The UE may also perform PDCCH monitoring for Type2A-PDCCH CSS sets for DCI format 2\_7, if provided.<Unchanged part is omitted>--------------------------------------End of Text Proposal on 3GPP TS 38.213 V19.0.0 ------------------ |

|  |
| --- |
| ---------------------------------Start of Text Proposal on 3GPP TS 38.213 V19.0.0-----------------------<Unchanged part is omitted>10.4D PDCCH monitoring activation by WUS in RRC\_CONNECTEDA UE configured with DRX mode operation and operating in the RRC\_CONNECTED state can be provided for WUS reception on the primary cell of a cell group- a number of OOK symbols per OFDM symbol, a first RB, and overlaid OFDM sequences per OOK symbol for WUS reception [4, TS 38.211], and- a number of codepoints provided for the UE by the WUS [6, TS 38.212], by *WUS-codepoint\_CONNECTED* A UE assumes that a WUS is quasi co-located with an SS/PBCH block or a CSI-RS with respect to quasi co-location ‘typeC’ or ‘typeD’ properties, when applicable. If a UE is provided *ABC*, the UE receives WUS based on the quasi co-location information of the TCI states indicated by a most recent DCI format or MAC CE, after a respective application time; otherwise, the UE receives WUS based on the quasi co-location information of the TCI states for a CORESET with *controlResourceSetId* value that is same as the one indicated by *~~WUS\_TCI\_states\_CONNECTED~~* *lpwus-TCI-States*. A UE assumes that an SCS configuration for WUS receptions is same as an SCS configuration for the active DL BWP.A UE does not monitor a WUS during Active Time [11, TS 38.321].A UE does not monitor WUS during DTX inactive period for the primary cell.A UE can be provided by *~~WUS-MOCONNECTED-Option1-1~~ lpwus-Mo11* a periodicity, by *periodicityMO-Option 1-1*, and a time offset, by *offsetMO-Option 1-1*, relative to the start of a system frame with SFN 0, for the UE to determine WUS monitoring occasions. The UE starts to monitor WUS in a first WUS monitoring occasion that is not earlier than a first slot that is prior to a second slot where the *drx-onDurationTimer* would start by a time provided by *timeOffsetCONNECTEDOption1-1*, and monitors WUS for a number of monitoring occasions provided by *~~numMO-Option 1-1~~ lpwus-NumOfMo11*. The UE reports a number of slots [18, TS 38.306] where the UE is not required to monitor WUS prior to the slot where the *drx-onDurationTimer* would start. The UE is not required to monitor WUS within the reported number of slots prior to the slot where the *drx-onDurationTimer* would start. If the UE determines to monitor PDCCH based on a detected WUS, the UE starts the *drx-onDurationTimer* [11, TS 38.321].A UE can be provided by *~~WUS-MOCONNECTED-Option1-2~~* *lpwus-Mo12* a periodicity, by *periodicityMO-Option 1-2*, and a time offset, by *offsetMO-Option 1-2*, relative to the start of a system frame with SFN 0, for the UE to determine first WUS monitoring occasions from a number of WUS monitoring occasions per periodicity, provided by *~~numMO-perPeriodicity-Option 1-2~~ lpwus-NumOfMo12*. The UE reports a number of slots [18, TS 38.306] and expects that a time gap, from a last WUS monitoring occasion from the number of WUS monitoring occasions per periodicity to the slot where the *wus-PDCCHMonitoringTimer* would start, is no smaller than the reported number of slots. If the UE determines to monitor PDCCH based on a detected WUS, the UE starts *wus-PDCCHMonitoringTimer* [11, TS 38.321] after a time, provided by *timeOffsetCONNECTEDOption1-2*, with respect to the start of the first WUS monitoring occasion from the number of WUS monitoring occasions per periodicity. A UE can be provided, by *~~WUS\_available\_slot\_CONNECTED~~* *lpwus-AvailableSlot*, a bitmap that corresponds to a set of time units that repeats continuously and indicates a subset of time units from the set of time units that is available for the UE to monitor WUS [12, TS 38.331]. A time unit includes one slot or two slots. The UE can be additionally provided, by *~~WUS\_available\_symbol\_CONNECTED~~* *lpwus-AvailableSymbol*, an indication of symbols in each time unit from the subset of time units that is available for the UE to monitor WUS. If the UE is not provided *~~WUS\_available\_slot\_CONNECTED~~* *lpwus-AvailableSlot*, the UE assumes that all time units are available for the UE to monitor WUS. If the UE is not provided *~~WUS\_available\_symbol\_CONNECTED~~ lpwus-AvailableSymbol*, the UE assumes that, for a time unit that is available for the UE to monitor WUS, all symbols in the time unit are available for the UE to monitor WUS. The UE assumes that a symbol is not available to monitor WUS when- the symbol is indicated as uplink, by tdd-UL-DL-configurationCommon or tdd-UL-DL-ConfigurationDedicated - the symbol is indicated for transmission of SS/PBCH blocks, by ssb-PositionsInBurst in SIB1 or in ServingCellConfigCommonA WUS monitoring occasion is over a first number of symbols, provided by *~~WUS\_NominalMO\_duration\_CONNECTED~~* *lpwus-NominalMoDuration*. If a number of available symbols for the UE to monitor WUS in a WUS monitoring occasion is smaller than a second number of symbols, provided by *~~WUS\_ActualMO\_duration\_CONNECTED~~* *lpwus-ActualDuration*, the UE does not monitor WUS in the WUS monitoring occasion. The UE monitors WUS in a WUS monitoring occasion over the earliest available *~~WUS\_ActualMO\_duration\_CONNECTED~~ lpwus-ActualDuration* symbols in the WUS monitoring occasion. If a UE detects a codepoint in a WUS reception, from the number of codepoints, on the primary cell of the cell group, the UE starts monitoring PDCCH on all applicable serving cells of the cell group. <Unchanged part is omitted>--------------------------------------End of Text Proposal on 3GPP TS 38.213 V19.0.0 ------------------ |

**[H][FL1] Proposal 3.4-1:** Adopt the alignment TPs above.

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| Qualcomm | Y |  |
| CATT | Y |  |
| vivo | Y |  |
| OPPO | Y |  |
| LGE | Y |  |
| ZTE, Sanechips | Y |  |
| Huawei, HiSilicon | Y |  |

* 1. Others

[3] proposes to add definition of OOK-On symbol and OOK-Off symbol for LP-WUS waveform generation in TS 38.211

|  |
| --- |
| The bit sequence and the number of bits corresponds to and , respectively, in clause 7.4.3 of [4, 38.212]. OOK symbols for Wake-up signal includes OOK-ON symbol and OOK OFF symbol, where the bit sequence is carried by OOK-On symbol and the bit sequence is carried by OOK-Off symbol. |

In FL’s understanding, since b(m) corresponds to g0(m) in TS 38.212, and it is already clear that g0(m) is 0 or 1, as shown below. Thus, it seems no need to add OOK-ON/OFF symbol definition in TS 38.211.

|  |
| --- |
| Line coding is performed according to the following by setting : ; ; |

[4] proposes to revert the agreed 0 padding at MSB bits, instead using 0 padding at LSB bits :

Proposal 8: For WUS information carried by the overlaid OFDM sequence(s), raw information bits are mapped to sequence(s), in case N/log2L is not an integer, Bit 0 as LSB is used for padding.

FL understands the spirit of the proposal is trying to use a subset of sequences with larger CS gap if there is 0 padding, however, considering the full set of sequences are well designed and the performance are guaranteed even the full set is applied. Such optimization is not needed.

[6] proposes gNB should transmit LP-WUS from the first MO and occupies consecutive MOs if more than one LP-WUS is to be transmitted in a period, to facilite UE early terminatio of LP-WUS reception. UE can stop LP-WUS monitoring if UE has detected an LP-WUS for itself, or UE does not detect any LP-WUS for any UE in the MO.

In FL’s understanding, LP-WUS transmission without such restriction captured in current specifciation can work properly. FL thinks no need of further discussion on non-critical optimization in maintaince phase.

[6] proposes an optional UE feature for the UE to support the case that LP-WUS/LP-SS frequency resource can be outside the initial DL BWP.

In FL’s understanding, RAN1 already agreed to support the case that LP-WUS/LP-SS frequency resource can be outside the initial DL BWP without UE capability, thus no need of further discussion.

[6] proposes that RAN1 asks RAN4 for the RF tuning time if the LP-WUR needs to tune RF before and after SSB reception, and Available symbols for LP-WUS exclude the RF tuning time for LP-WUR.

In FL’s understanding, it’s been agreed as below, we can wait for RAN4’s progress

|  |
| --- |
| **Agreement**From RAN1 perspective, there is no restriction on the maximum frequency bandwidth covering both LP-WUS/LP-SS and SSB.* It is up to RAN4 to introduce any restriction depending on their discussions
* Above applies for IDLE and INACTIVE mode UEs
 |

[8] proposes to revise the equation to derive CS for different sequences to increase CS among sequences.

This was discussed in RAN1#121, but was not agreed and thus would not be discussed unless broken issue is identified.

[11] proposes to separately configure frequency locations for LP-WUS/SS in idle/inactive mode and LP-WUS in connected mode should be configured.

In FL’s understanding, agreed RRC parameters for frequency location already use different RRC parameter for Idle and connected mode, i.e., LP-WUS\_startRB\_CONNECTED and LP-WUS/LP-SS\_startRB\_IDLE/INACTIVE.

1. LP-SS
	1. How to specify OOK waveform if overlaid OFDM sequence is not configured

**Background:**

It’s been agree that transmitting LP-SS by using a specified overlaid OFDM sequence is configurable for OOK-1, if not configured, whether/how to specify OOK waveform if overlaid OFDM sequence is not configured shall be determined.

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| --- |
| **RAN1#120 agreement**Proposal 4.3-1: Update the agreements in RAN1 #118bis as below**Agreement**Support overlaid OFDM sequence(s) for LP-SS:* LP-SS reuses the overlaid OFDM sequence(s) specified for LP-WUS. The design on overlaid OFDM sequence(s) specified for LP-WUS doesn’t target for sync and RRM measurement performance based on overlaid OFDM sequence for LP-SS.
	+ Applicable to both OOK-1 and OOK-4
* Whether to transmit LP-SS by using a specified overlaid OFDM sequence is configurable.
	+ Applicable ~~at least~~ for OOK-1 only ~~and FFS for OOK-4~~
* From RAN1 perspective, it is not intended to introduce new RAN4 requirements specific to overlaid sequences
 |

* Approach 1 [4]: A fixed OFDM sequence is specified to be used when the overlaid OFDM sequence is not configured.
* Approach 2 [12]: The lowest root index of the overlaid sequence configured for LP-WUS can be used as the overlaid sequence for LP-SS when the overlaid OFDM sequence for LP-SS.
* Approach 3 [8]: when specified overlaid OFDM sequence is not configured, , for .
	+ Approach 3-1 [2]: For LP-SS with M=1, when specified overlaid OFDM sequence is not configured, , for , where is generated from pseudo-random sequence defined in TS 38.211 clause 5.2.1 or clause 5.2.2, when .
* Approach 4 [2]: when specified overlaid OFDM sequence is not configured, t is BPSK or QPSK symbol, when , where for different subcarriers is not the same.
* Approach 5 [5]: when specified overlaid OFDM sequence is not configured, =

In FL’s understanding, this approach implies all ‘1’s for DFT output in OOK-ON chip while all ‘0’s for DFT output in OOK- OFF chip. It results in non-flat envelope for OOK-ON chip, which would degrade OOK-based receiver performance.

* Approach 6 [3]: when specified overlaid OFDM sequence is not configured, is unspecified, but at least constant modulus feature should be satisfied by the generation of OOK waveform based on .
* Approach 7 [2]: when specified overlaid OFDM sequence is not configured, is unspecified, and it is up to gNB to generate any sequence as long as it meets RAN4 requirements.
* Approach 8 [4]: Revise the previous agreement and agree to specify overlaid sequence also for M=1
* Approach 9 [4]: Revise the previous agreement and agree to NOT support OOK-1 for LP-SS

Among the above 9 approaches, 1-6 provide ways on how to specify OOK waveform, as discussed in [8], approach 3 provides the flexibility on the DFT output but ensuring the constant modulus 1of each DFT output, thus FL suggests the following:

**[H][FL1] Proposal 4.1-1:** Regarding how to specify OOK waveform if overlaid OFDM sequence is not configured for LP-SS with M=1, the output of DFT is specified by , for .

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| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | N | There seems no strong reason why a known is not always determined for LP-SS with M=1 when it is always determined for LP-WSS with M=2,4. We prefer Approach 1,2,8,9. |
| vivo |  | We prefer approach 4, which covers the case that gNB can transmit TRS, or PDCCH, or PDSCH with QPSK/BPSK, in OOK ON chips, which provides sufficient flexibility for gNB. Having said that, we can be fine with the proposal, as long as the randomization of each element of can be guaranteed by gNB to ensure the OOK demodulation performance can meet RAN4 requirement. We have strong concern on approaches which revert the previous agreement.  |
| Ericsson1 |  | Support the FL proposal.  |
| LGE | N | We share the same view with QC. Reusing the overlaid OFDM sequence of LP-WUS can ensure reliable OOK detection performance. However, in cases where random QPSK/BPSK symbols are overlaid, it may be necessary to evaluate whether this impacts the OOK detection performance. To avoid this kind of situation, it will be beneficial to use supported sequences. In this manner, we prefer Approach 1, 2. |
| Samsung |  | We slightly prefer not to specify a sequence for that case. But if most of companies want to specify something in RAN1 spec for OOK-based LP-WUR performance, we are fine with the proposal. |
| ZTE, Sanechips |  | Fine with it. |
| Huawei, HiSilicon | N | First, this alternative cannot let OFDM receiver to utilize overlaid sequence. Second, it causes problem for RAN4 to define the performance requirement, since except all-1 sequence, no sequence can perfectly satisfy , considering that the various sampling rate.Third, if my memory is correct, the argument on not to specify the overlaid sequence is to reuse some existing signal/channel. However, no existing signal can satisfy . Thus the comment of utilizing existing sequence is not valid by this way to specify the signal.Therefore, we don’t think this is the good way to specify it. |

* 1. Others

[5] discusses that, RAN1 agreed Multiple sequences are used to differentiate LP-SS from different cells, but the specification of LP-SS generation in TS 38.211 does not differentiate the LP-SS from other LP-SS of different cells. [5] proposes to add that the LP-SS configuration index is from high-layer parameter *lpss-BinarySeqIndex* which is configured in SIB1.

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| The sequence is defined by Tables 7.4.5.1.1-1 to 7.4.5.1.1-3 with the quantity given by the higher-layer parameter XXX.The value of configuration defined in Tables 7.4.5.1.1-1 to 7.4.5.1.1-3 can be indicated by the higher-layer parameter *lpss-BinarySeqIndex*; |

**[H][FL1] Proposal 4.2-1:** Add the higher-layer parameter of LP-SS sequence index in TS 38.211.

|  |
| --- |
| The sequence is defined by Tables 7.4.5.1.1-1 to 7.4.5.1.1-3 with the quantity given by the higher-layer parameter XXX.The value of configuration defined in Tables 7.4.5.1.1-1 to 7.4.5.1.1-3 can be indicated by the higher-layer parameter *lpss-BinarySeqIndex*; |

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| Qualcomm | Y |  |
| CATT | Y | The current configuration of LP-SS cannot differentiate LP-SS from different cells. A relation between configuration and *lpss-BinarySeqIndex* should be defined. |
| vivo | Y |  |
| OPPO | Y |  |
| LGE | Y | Support the proposal. |
| ZTE, Sanechips | Y |  |
| Spreadtrum | Y |  |
| Huawei, HiSilicon |  | It is not agreed yet whether the binary sequence index is explicitly configured or derived from other parameters, e.g., cell ID. We need to discuss and agree on it first, then agree on the TP. |

1. RRC parameter conditions
2. Condition of LP-WUS\_overlaidSeq\_roots\_IDLE/INACTIVE configuration for OFDM-based LP-WUR for LP-WUS operation in IDLE/INACTIVE

**Background:**

For the FFS in the below RRC parameter, [7] thinks this parameter is essential for an OFDM-based LP-WUR to obtain wake-up information, thus should be configured. [8] thinks this depends on UE capability discussions.

|  |  |  |
| --- | --- | --- |
| **Parameter name in the spec** | **Description** | **Value range** |
| LP-WUS\_overlaidSeq\_roots\_IDLE/INACTIVE | Configuration of one or two roots for the overlaid OFDM sequence(s) for LP-WUS in IDLE/INACTIVEFFS: This parameter shall be configured for OFDM-based LP-WUR for LP-WUS operation in IDLE/INACTIVETwo roots shall be configured for the case when the value of parameter LP-WUS\_num\_overlaidseq\_IDLE/INACTIVE is configured as 16/8/4 for M=1/2/4, respectively, otherwise, one or two roots can be configured.  | a list of up to two roots can be configuredFor each root- For M=1, the value range is 1~131- For M=2, the value range is1~61- For M=4, the value range is 1~31 |

FL shares same understanding with Samsung. Regarding how to inform UE that LP-WUS is enabled for OFDM-based LP-WUR, in FL’s understanding, the presence of entry/exist threshold for OFDM-based LP-WUR can inform that LP-WUS is enabled for OFDM-based LP-WUR. FL suggests the following:

**[H][FL1] Proposal 5-1:** Confirm ‘This parameter shall be configured for OFDM-based LP-WUR for LP-WUS operation in IDLE/INACTIVE’ of the RRC parameter description

|  |  |  |
| --- | --- | --- |
| **Parameter name in the spec** | **Description** | **Value range** |
| LP-WUS\_overlaidSeq\_roots\_IDLE/INACTIVE | Configuration of one or two roots for the overlaid OFDM sequence(s) for LP-WUS in IDLE/INACTIVE~~FFS:~~ This parameter shall be configured for OFDM-based LP-WUR for LP-WUS operation in IDLE/INACTIVETwo roots shall be configured for the case when the value of parameter LP-WUS\_num\_overlaidseq\_IDLE/INACTIVE is configured as 16/8/4 for M=1/2/4, respectively, otherwise, one or two roots can be configured.  | a list of up to two roots can be configuredFor each root- For M=1, the value range is 1~131- For M=2, the value range is1~61- For M=4, the value range is 1~31 |

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| Qualcomm |  | Suggest to change the wording to “This parameter shall be configured for OFDM-based ~~LP-WUR for~~ LP-WUS operation in IDLE/INACTIVE” which is aligned with UE feature name.  |
| vivo | Y | Fine with updated wording.  |
| InterDigital |  | Support the updated wording from Qualcomm.  |
| ZTE, Sanechips | Y |  |
| Huawei, HiSilicon | N | We can understand the intention, but the necessity may be not so strong, since it is for IDLE/INACTIVE mode, where the configuration is anyway broadcasted. Also note that according to the WID, LP-WUS is always based on OOK with overlaid OFDM sequence, thus the roots of overlaid sequence shall be always configured if LP-WUS is configured.In this sense, we don’t think this highlighted part is necessary. |

1. Condition of LP-SS\_binary sequence and sequence length configuration

**Background**:

For the FFS in the below RRC parameter, [8] prefers “Option 2: This parameter shall be configured when LP-SS is configured” as this parameter is needed only if LP-SS is configured in the cell.[7] thinks these parameters shall be configured only when the gNB enables a support for OOK-based LP-WUR.

To FL’s understanding, when the parameters ‘LP-SS\_Binary\_Seq’, ‘LP-SS\_Binary\_Seq\_Length’, and ‘ LP-SS\_periodicityoffset’ are configured, LP-SS is configured, there is no other parameters to enable configuring LP-SS, thus option 2 is trivial. Furthermore, LP-SS is essential for OOK-based LP-WUR for sync and RRM measurement, and thus FL suggests to go option 1.

|  |  |  |
| --- | --- | --- |
| **Parameter name in the spec** | **Description** | **Value range** |
| LP-SS\_Binary\_Seq | Provides the LP-SS binary sequence index in the cell for IDLE/INACTIVE. FFS between the following optionsOption 1: This parameter shall be configured for OOK-based LP-WUR for LP-WUS operation in IDLE/INACTIVE Option 2: This parameter shall be configured when LP-SS is configured | Sequence index {1,2,3,4} |
| LP-SS\_Binary\_Seq\_Length | Provides the LP-SS binary sequence length in the cell for IDLE/INACTIVE. FFS between the following optionsOption 1: This parameter shall be configured for OOK-based LP-WUR for LP-WUS operation in IDLE/INACTIVE Option 2: This parameter shall be configured when LP-SS is configured | [Length1, Length2] |
| LP-SS\_periodicityoffset | Porvides the configuration of LP-SS periodicity and time offset.The time offset is configured for the first LP-SS occasion with reference to SFN0.FFS between the following: Option 1: This parameter shall be configured for OOK-based LP-WUR for LP-WUS operation in IDLE/INACTIVE.Optoin 2: This parameter shall be configured when LP-SS is configured | Periodicity: [320ms, 160ms]Offset:  For 320ms periodicity: {0, 1, …, 319}ms For 160ms peirodiicty: {0, 1, …, 159}ms |

 Besides, though there is no condition for *LP-SS\_Start\_Symbol*, as captured in R1-2503243 (agreed RRC parameter) in FL’s understanding, it is reasonable to add same condition for this parameter.

|  |  |  |
| --- | --- | --- |
| **Parameter name in the spec** | **Description** | **Value range** |
| LP-SS\_Start\_Symbol | To configure one or two start symbol locations within a slot for LP-SS, where the slot is determined from the periodicity/offset configuration for LP-SS | A list of one or two starting symbols, with each starting symbol in range of {{0, 1, …, 10}} |

**[H][FL1] Proposal 5-2: Adopt option 1 as condition for *‘LP-SS\_Binary\_Seq’, ‘LP-SS\_Binary\_Seq\_Length’, ‘LP-SS\_periodicityoffset’ and ‘LP-SS\_Start\_Symbol’***

* Option 1: This parameter shall be configured for OOK-based LP-WUR for LP-WUS operation in IDLE/INACTIVE

|  |  |  |
| --- | --- | --- |
| **Parameter name in the spec** | **Description** | **Value range** |
| LP-SS\_Binary\_Seq | Provides the LP-SS binary sequence index in the cell for IDLE/INACTIVE. This parameter shall be configured for OOK-based LP-WUR for LP-WUS operation in IDLE/INACTIVE | Sequence index {1,2,3,4} |
| LP-SS\_Binary\_Seq\_Length | Provides the LP-SS binary sequence length in the cell for IDLE/INACTIVE. This parameter shall be configured for OOK-based LP-WUR for LP-WUS operation in IDLE/INACTIVE  | [Length1, Length2] |
| LP-SS\_periodicityoffset | Porvides the configuration of LP-SS periodicity and time offset.The time offset is configured for the first LP-SS occasion with reference to SFN0.This parameter shall be configured for OOK-based LP-WUR for LP-WUS operation in IDLE/INACTIVE. | Periodicity: [320ms, 160ms]Offset:  For 320ms periodicity: {0, 1, …, 319}ms For 160ms peirodiicty: {0, 1, …, 159}ms |
| LP-SS\_Start\_Symbol | To configure one or two start symbol locations within a slot for LP-SS, where the slot is determined from the periodicity/offset configuration for LP-SSThis parameter shall be configured for OOK-based LP-WUR for LP-WUS operation in IDLE/INACTIVE. | A list of one or two starting symbols, with each starting symbol in range of {{0, 1, …, 10}} |

|  |  |  |
| --- | --- | --- |
| Company | Y/N | Comments |
| Qualcomm |  | Suggest to remove “LP-WUR for” for all parameters to align with the UE feature name. |
| vivo | Y |  |
| InterDigital |  | Support the wording update from Qualcomm.  |
| Samsung |  | We would like to know that these parameters should be always configured when the gNB activates LP-WUS operation for RRC IDLE/INACTIVE mode or configured only when the gNB activates the operation for OOK-based LP-WUS |
| ZTE, Sanechip |  | Does it mean for ODM WUR, we would have another parameters for LP-SS? Why these parameters is only applied for OOK WUR? |
| Huawei, HiSilicon | N | For the same reason mentioned for Proposal 5-1, we prefer Option 2. |

1. References
2. RP-234056, New WID: Low-power wake-up signal and receiver for NR (LP-WUS/WUR).
3. R1-2505381, Maintenance on LP-WUS and LP-SS design, vivo
4. R1-25035598, Discussion on LP-WUS design, ZTE Corporation, Sanechips
5. R1-2505226, Maintenance on LP-WUS and LP-SS, Huawei, HiSilicon
6. R1-2505330, Remaining issues on LP-WUS and LP-SS design, CATT
7. R1-2506183, Maintenance on LP-WUS and LP-SS Design, Qualcomm Incorporated
8. R1-2505545, Remaining issues on LP-WUS and LP-SS design, Samsung
9. R1-2505951, Maintenance on LP-WUS and LP-SS design, Ericsson
10. R1-2505773, Remaining issues relating LP-WUS and LP-SS design, Nokia
11. R1-2505880, Maintenance on LP-WUS and LP-SS design, Apple
12. R1-2505742, Signal design for LP-WUS and LP-SS, OPPO
13. R1-2505845, Remaining issues on LP-WUS and LP-SS design, LG Electronics
14. R1-2505382, Maintenance on LP-WUS operation in IDLE/INACTIVE mode, vivo.
15. Appendix : Proposals from contributions

## R1-2505381\_vivo

Proposal 1: Introduce a new RRC parameter *WUS\_ActualMO\_duration\_ IDLE/INACTIVE\_OFDM* in addition to *WUS\_ActualMO\_duration\_ IDLE/INACTIVE*

* If only *WUS\_ActualMO\_duration\_ IDLE/INACTIVE*  is provided, UE monitors LP-WUS based on this parameter regardless of LP-WUR type.
* If both *WUS\_ActualMO\_duration\_IDLE/INACTIVE* and *WUS\_ActualMO\_duration\_ IDLE/INACTIVE \_OFDM* are provided, UE with OOK-based LP-WUR monitors LP-WUS according to *WUS\_ActualMO\_duration\_ IDLE/INACTIVE*, and UE with OFDM-based LP-WUR can monitor LP-WUS according to *WUS\_ActualMO\_duration\_ IDLE/INACTIVE* \_*OFDM*.

|  |  |
| --- | --- |
| Parame Parameter name in the text ter name in the text | Description |
| WUS\_ActualMO\_duration\_ IDLE/INACTIVE \_OFDM | To configure the actual duration for LP-WUS in IDLE/INACTVE, in number of OFDM symbols, for OFDM-based LP-WUR.  |

Proposal 2: Adopt following correction for TS 38.213 clause 10.4C.

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| --- | --- | --- | --- | --- | --- | --- |
|

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| Reason for change:  | Single LP-WUS actual duration is defined without differentiation of LP-WUR types, which results in unnecessary overhead.  |
| Summary of change: | Adding one new RRC parameter for LP-WUS actual duration determination for OFDM-based LP-WUR to support different acutal duration for different LP-WUR type.  |
| Consequences if not approved: | LP-WUS acutal duration is always based on OOK-based LP-WUR even when gNB only intends to wake-up OFDM-based LP-WUR, resulting in large overhead.  |

\*\*\* Unchanged parts are omitted \*\*\*10.4C PDCCH monitoring activation by WUS in RRC\_IDLE/RRC\_INACTIVE\*\*\* Unchanged parts are omitted \*\*\*A WUS monitoring occasion is over a first number of symbols, provided by *WUS\_NominalMO\_duration\_ IDLE/INACTIVE*. If a number of available symbols for the UE to monitor WUS in a WUS monitoring occasion is smaller than a second number of symbols, provided by *WUS\_ActualMO\_duration\_ IDLE/INACTIVE*, the UE does not monitor WUS in the WUS monitoring occasion. The UE monitors WUS in a WUS monitoring occasion over the earliest available *WUS\_ActualMO\_duration\_ IDLE/INACTIVE* symbols in the WUS monitoring occasion. If *WUS\_ActualMO\_duration\_ IDLE/INACTIVE\_OFDM* symbols is provided, a UE with OFDM-based LP-WUR monitors WUS in a WUS monitoring occasion [at least] in the earliest available *WUS\_ActualMO\_duration\_ IDLE/INACTIVE\_OFDM* symbols in the WUS monitoring occasion. If a number of available symbols for the UE to monitor WUS in a WUS monitoring occasion includes a symbol for LPSS reception, the UE does not monitor WUS in the WUS monitoring occasion.\*\*\* Unchanged parts are omitted \*\*\* |

Proposal 3:Down-select between modified Option 1 and Option 2, and adopt corresponding TB in TS 38.211 Clause 7.4.5.1.3

* Option 1: the output of DFT shall satisfy for , where is generated from pseudo-random sequence defined in TS 38.211 clause 5.2.1 or clause 5.2.2, when .
* Option 2: the output of DFT shall satisfy is BPSK or QPSK symbol, when , where for different subcarriers is not the same.
* Option 4: the output of DFT is unspecified.

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| --- | --- | --- | --- | --- | --- | --- |
| TP for option 1

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| --- | --- |
| Reason for change:  | OOK waveform generation is missing, if specified overlaid OFDM sequence is not configured for LP-SS with M=1 |
| Summary of change: | Adding OOK waveform generation when the specified overlaid OFDM sequence is not configured for LP-SS  |
| Consequences if not approved: | OOK waveform generation when specified overlaid OFDM sequence is not configured for LP-SS with M=1 is not clear |

\*\*\* Unchanged parts are omitted \*\*\*7.4.5.1.3 Generation of If the quantity in Cluse 7.4.5.1.2 is configured by the higher-layer parameter XXX, t~~T~~he block of complex-valued symbols is defined bywhereOtherwise, is defined by  for where is generated by pseudo-random sequence defined in clause 5.2.1 or Low-PARP sequence defined in clause 5.2.2, if \*\*\* Unchanged parts are omitted \*\*\* |

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| TP for option 2

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| --- | --- |
| Reason for change:  | OOK waveform generation is missing, if specified overlaid OFDM sequence is not configured for LP-SS with M=1 |
| Summary of change: | Adding OOK waveform generation when the specified overlaid OFDM sequence is not configured for LP-SS  |
| Consequences if not approved: | OOK waveform generation when specified overlaid OFDM sequence is not configured for LP-SS with M=1 is not clear |

\*\*\* Unchanged parts are omitted \*\*\*7.4.5.1.3 Generation of If the quantity in Cluse 7.4.5.1.2 is configured by the higher-layer parameter XXX, t~~T~~he block of complex-valued symbols is defined bywhereOtherwise, is defined by  for where is BPSK or QPSK symbol generated according to clause 5.1.2 or 5.1.3, and is not the same for different subcarrier *k*. \*\*\* Unchanged parts are omitted \*\*\* |

## R1-2505598\_ZTE Corporation, Sanechips

*Proposal 1: For LP-SS with M=1, in case of the overlaid OFDM sequence is not configured, at least constant modulus feature should be satisfied for the generation of OOK waveform.*

*Proposal 2: An operation of fftshift is added after DFT for OOK-4 waveform generation.*

The corresponding text proposal is shown as follows

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| --- |
| TS38.2117.4.4.1.2 Generation of <Unchanged Text Omitted>The block of complex-valued symbols is defined bywhereThe quantity is given by the higher-layer parameter *LP-WUS\_Mvalue\_IDLE/INACTIVE* or *LP-WUS\_Mvalue\_CONNECTED*.The bit sequence and the number of bits corresponds to and , respectively, in clause 7.4.3 of [4, 38.212].<Unchanged Text Omitted> |

*Proposal 3: Definition of OOK-On symbol and OOK-Off’symbol is necessary.*

The corresponding text proposal is provided as follows

|  |
| --- |
| TS38.2117.4.4.1.2 Generation of <Unchanged Text Omitted>The block of complex-valued symbols is defined bywhereThe quantity is given by the higher-layer parameter *LP-WUS\_Mvalue\_IDLE/INACTIVE* or *LP-WUS\_Mvalue\_CONNECTED*.The bit sequence and the number of bits corresponds to and , respectively, in clause 7.4.3 of [4, 38.212].  OOK symbols for Wake-up signal includes OOK-ON symbol and OOK OFF symbol, where the bit sequence is carried by OOK-On symbol and the bit sequence is carried by OOK-Off symbol.<Unchanged Text Omitted> |

## R1-2505226\_Huawei, HiSilicon

1. *In order to reduce resource overhead, transmission duration of a LP-WUS targeting to wake up OFDM-based receiver can be shorter than the transmission duration required for ED based receiver.*
* *separate RRC configuration for the actual duration (or repetition number) of OFDM-based receiver.*
1. *The code block length is determined based on the configured resources (e.g., OFDM symbols) for LP - WUS/MO, to avoid a LP-WUS occupying non-integer number of OFDM symbols.*
2. *Ensure that both the code length and a LP-WUS occupying number of OFDM symbols are inter numbers.*
3. *Capture the updated parameters in Appendix B in the RRC parameter list.*
4. *No strong need is identified to further restrict the code block length.*
5. *For the DFT operation used to generate the LP - WUS signal, the DC component needs to be mapped to the center subcarrier.*
6. *Adopt TP1 in Appendix C.*
7. *For WUS information carried by the overlaid OFDM sequence(s), raw information bits are mapped to sequence(s), in case N/log2L is not an integer, Bit 0 as LSB is used for padding.*
8. *Adopt TP2 in Appendix C.*
9. *For transmit LP-SS in the case of OOK-1:*
* *Alt1: Revise the previous agreement and agree to specify overlaid sequence also for M=1.*
* *Alt2: A fixed OFDM sequence is specified to be used when the overlaid sequence is not configured.*
* *Alt3: Do not support the case of OOK-1 for LP-SS.*

## R1-2505330\_CATT

Proposal 1: Adopt the TP#1 for alignment of the parameter name for the number of sequences defined in TS 38.211 and TS 38.212.

Proposal 2: Adopt the TP#2 for the generation formula of LP-SS sequence.

Proposal 3: Adopt the TP#3 for describling the relation between *lpss-BinarySeqIndex* and the configuration of LP-SS.

## R1-2506183\_Qualcomm Incorporated

Proposal 1: When multiple MOs are configured in each LP-WUS occasion, LP-WUS transmission always starts from the first MO and occupies consecutive MOs if more than one LP-WUS is transmitted in the LP-WUS occasion. UE skips detecting LP-WUS in the remaining MOs of the LP-WUS occasion if any of the following two conditions is met

* UE has detected an LP-WUS for itself, or
* UE does not detect any LP-WUS for any UE in the MO.

Proposal 2: Support the mapping of multiple codepoint values into overlaid OFDM sequences in the same MO

* Support that network only transmits overlaid OFDM sequences for UEs that only support OFDM based LP-WUR.

Proposal 3: At least for connected mode UE, network configures the starting OOK On chip in a LP-WUS MO where overlaid OFDM sequences are transmitted for the UE.

Proposal 4: Repetitions of overlaid OFDM sequences are not applied by default for LP-WUS transmission. Repetitions are explicitly enabled by network configuration.

* When repetitions are enabled, network configures the number of repetitions
* Network configures the repetition pattern, i.e., the set of all overlaid OFDM sequences for a codepoint is repeated or each overlaid OFDM sequence in the set is repeated first.

Proposal 5: It is an optional UE feature for the UE to support the case that LP-WUS/LP-SS frequency resource can be outside the initial DL BWP.

Proposal 6: RAN1 asks RAN4 for the RF tuning time if the LP-WUR needs to tune RF before and after SSB reception.

Proposal 7: Available symbols for LP-WUS exclude the RF tuning time for LP-WUR.

Proposal 8: Adopt RRC parameters in Table 1 for early termination of LP-WUS detection.

Proposal 9: Adopt RRC parameters in Table 2 for repetitions of overlaid OFDM sequences for LP-WUS.

## R1-2505545\_Samsung

Proposal 1: Support the scenario that the gNB enable LP-WUS feature only for OFDM-based LP-WUR type in the cell.

* FFS: implicit configuration or explicit configuration.

Proposal 2: For higher layer parameters related to LP-SS, these parameters shall be configured only when the gNB enables a support for OOK-based LP-WUR.

* LP-SS\_Binary\_Seq
* LP-SS\_Binary\_Seq\_Length
* LP-SS\_periodicityoffset

Proposal 3: The configuration status of LP-SS-related parameters can be used to indicate whether the gNB targets only OFDM-based LP-WUR or all LP-WUR types.

Proposal 4: LP-WUS\_overlaidSeq\_roots\_IDLE/INACTIVE shall be configured when the gNB enables the LP-WUS feature.

## R1-2505951\_Ericsson

Proposal 1 For LP-SS with M=1, when specified overlaid OFDM sequence is not configured, , for .

Proposal 2 Adopt the text proposal in Section 2 of this paper regarding LP-SS overlaid sequence.

Proposal 3 Adopt the text proposal in Section 3 of this paper regarding cyclic shift (CS) equation for OFDM sequences.

Proposal 4 Adopt the text proposal in Section 4 of this paper regarding RRC parameter names.

Proposal 5 Adopt the text proposal in Section 5 of this paper regarding RRC parameter values.

## R1-2505773\_Nokia

Proposal 1: RAN1 shall consider performing DFT-shift operation before mapping the LP-WUS samples to frequency domain REs after DFT operation.

Proposal 2: Consider at least values {2, 4, 6, 7, 8, 10, 12, 14, 16, 18, 20, 24, 28, 36, 42, 48, 56, 60, 64} symbols for the actual WUS duration configuration (in LP\_WUS\_Actual\_WUS\_duration\_{IDLE/INACTIVE and CONNECTED})

Proposal 3: Consider at least values {4, 7, 14, 28, 42, 56, 70, 84} symbols for nominal MO duration (LP\_WUS\_NominalMO\_duration\_{IDLE/INACTIVE and CONNECTED})

## R1-2505880\_Apple

Proposal 1: For LP-WUS, DFT shift is applied after DFT processing before mapping to frequency domain REs.

Proposal 2: Adopt the following TP for TS 38.211:

## R1-2505742\_OPPO

*Proposal 1: For OFDM-based LP-WUR, whether and when to stop the sequence detection of LP-WUS could depend on the implementation of UE.*

*Proposal 2: Single transmission duration configured by gNB is used for transmitting the LP-WUS for OOK-based LP-WUR and OFDM-based LP-WUR.*

*Proposal 3: Separated frequency locations for LP-WUS/SS in idle/inactive mode and LP-WUS in connected mode should be configured.*

## R1-2505845\_LG Electronics

Proposal #1: For 2 information bits, L is an integer multiple of 3 within the range of 2~32

Proposal #2: For the overlaid OFDM sequence on each OOK ON symbol within an OFDM symbol, two different overlaid OFDM sequences should be used for each OOK ON symbol.

Proposal #3: The lowest root index of the overlaid sequence configured for LP-WUS can be used as the overlaid sequence for LP-SS when the overlaid OFDM sequence for LP-SS is not configured to UE