**3GPP TSG RAN WG1 #103-e R1-20xxxxx**

**e-Meeting, October 26th – November 13th, 2020**

**Agenda Item:** 7.2.2

**Source:** Moderator (LG Electronics)

**Title:** Summary on remaining issues of wide-band operation for NR-U

**Document for:** Discussion and decision

# Introduction

This is the summary document for 7.2.2 on remaining issues of wide-band operation for NR-U, based on the contributions listed in reference section. The identified 4 topics are summarized as below. Further details for each issue and preliminary Moderator’s views are provided in Sections 2 to 5.

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| # | Issue (summary) | Contributions |
| WB01 | Clarification of initial BWP configuration: Initial BWP should follow nominal GB specified in RAN4 spec, even if UE-specific GB is configured. | [1] |
| WB02 | UE capabilities on wideband operation: No further UE capabilities on DL wideband operation, but need to consider introducing UE capabilities on the number of LBT sub-bands | [2] |
| WB03 | RB set indicator in DCI format 2\_0: UE behaviour when RB set indicator is not configured or indicates all zero state. | [4] |
| WB04 | Editorial changes of Clause 7 in TS 38.214- Change from *BWP-DownlinkCommon,* *BWP-DownlinkDedicated*, *BWP-UplinkCommon,* and *BWP-UplinkDedicated* to *initialDownlinkBWP,* *BWP-Downlink, initialUplinkBWP,* and *BWP-Uplink*, respectively- Change from $GB\_{ s,x}^{start,μ}$ to $GB\_{ s,x}^{,μ}$- Add description for SCS configuration, $μ$ | [1], [3] |

# Issue WB01: Clarification of initial BWP configuration

From [1],

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| Following the current Clause 7 of TS 38.214, a BWP configured by RRC signaling should contain integer number of RB sets. Meanwhile, the UE would determine the RB sets according to the RRC configured intra-cell guard bands if it is configured with intra-cell guard bands by RRC signaling, and according to the pattern defined by RAN4 otherwise. That is, from UE’s perspective, a configured BWP should include integer number of RB sets determined according to the RRC configured guard bands if configured, and according to the RB set pattern defined by RAN4 otherwise, as shown in Case 1 and Case 2 of Figure 1 respectively, assuming no guard bands configured by RRC signaling.Figure 1: Examples of relation between the configured BWP and RB setsHowever, since the initial BWP is cell-specifically configured while the RB sets on a carrier are UE-specifically configured, the initial BWP may not meet the requirement from some UE’s perspective. An example is as shown in the figure below. UE1 is in IDLE state, then it would expect the initial BWP include an RB set determined according to the pattern defined by RAN4. UE2 is in connected state and configured with guard bands, then it would expect the BWP include an RB set determined according to the configured guard bands. From UE2’s perspective, the initial BWP does not include integer number of RB sets.Figure 2: Examples of relation between initial BWP and RB sets from different UEs’ perspectiveTo fix the issue, a solution is that the initial BWP includes an RB set determined according to the RB set pattern defined by RAN4, even if the UE is configured with UE-specific RB sets. Meanwhile, there is a minor issue on cited RRC parameters for BWP configuration in Clause 7 of TS 38.214, i.e. a BWP cannot be configured by *BWP-DownlinkDedicated* or *BWP-UplinkDedicated* alone. The RRC parameters for BWP configuration should be corrected according to Clause 12 of TS 38.213.**Proposal 1:** Initial BWP should include an RB set determined according to the RB set pattern defined by RAN4 even if the UE is configured with UE-specific RB sets and for correcting of RRC parameters for BWP configuration. |

**Moderator’s view:**

* In RAN1#101-e meeting, it was discussed how to align cell-specific initial BWP with RB set boundary, in case zero GB is configured to a UE. During that discussion, it was concluded that gNB has to satisfy alignment condition between any BWP (including initial BWP) and RB set boundaries even for the case where gNB configures zero GB for a UE associated with the gNB. To be specific, for above Figure 2, it is understood that gNB has to configure initial BWP same as RB set 0 configured to connected UE2. With this understanding, the TP proposed from [1] regarding initial BWP configuration seems not necessary.

# Issue WB02: UE capabilities on wideband operation

From [2],

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| Discussion on DL capabilities The following DL wideband operation cases are discussed.* **DL Case 1**: Intra-band CA
* **DL Case 2**: Wideband carrier operation Modes 2/3 without scheduling intra-cell guard bands
	+ DL Case 2a: Mode 2 where single wideband carrier when LBT is successful in a subset of the LBT sub-bands which are contiguous [1]
	+ DL Case 2b: Mode 3 where single wideband carrier when LBT is successful in a subset of the LBT sub-bands which are non-contiguous [1]
* **DL Case 3**: Wideband carrier operation Modes 2/3 with scheduling intra-cell guard bands between transmitted contiguous LBT sub-bands
* **DL Case 4**: Wideband carrier operation Mode 1 where single carrier wideband operation when LBT is successful in all LBT sub-bands [1]

As can be observed from the RAN4 response, AGC issue is there for all the WB modes, this resulting into potential performance degradation. Also RAN4 will not introduce requirements for that purpose. However, this is nothing different to LTE LAA, where requirements for intra-band CA were not introduced either. In case of intra-band CA, performance depends on whether UE implements different filter banks per carrier with separate AGC per carrier, this improving robustness to co-channel interference. Obviously, this resulting in increased cost and complexity and is not mandated by standard. Alternatively, UE may just have sufficiently large ADC dynamic range to deal with co-channel interference.**Observation-2:** *In intra-band CA, UE may or may not implement different filter banks per carrier with separate AGC per carrier or have sufficient large ADC dynamic range, but. implementation of those is not mandatory to UEs in LTE LAA.*Similarly to intra-band CA, for DL Case 2a/2b where intra-cell guard bands cannot be scheduled, the situation is exactly the same. UE may or may not implement different AGC per RB-set. For DL Case 4, performance degradation is unavoidable and depends on ADC convertor dynamic range. **Observation-3:** *In DL Case 2a/2b where intra-cell guard bands cannot be scheduled, UE may or may not implement different filter banks per carrier with separate AGC per carrier, those are not mandatory.*On the other hand, intra-band CA requires separate capability in terms of processing power to receive parallel PDSCH on multiple carriers. This is not the case for DL Case 2a/2b, 3, and 4, and therefore from this point of view there is no need to define capability for DL Case 2a/2b, 3, and 4.In any case, for scheduling the GB (if non-zero) RAN4 already has a capability, feature 4-1. If UE implements filter banks and AGC per RB-set, UE may need to indicate such in-capability, because in this is case it not being able to receive in the GBs. Hence, this is sufficient to address DL Case 1, and hence there is no technical reason to introduce any further capabilities related to base-band processing. **Proposal-1:** *Conclude that* *from baseband processing point of view*, *no further capabilities are needed for DL WB modes* Case 2a/2b, 3, and 4*. RF aspects are up to RAN4.*Discussion on UL capabilitiesThe following UL wideband operation cases are discussed.* **UL Case 1**: UL wideband operation Mode 2A (UL-WB Mode 2A) where UE transmits if LBT passes for single scheduled LBT sub-band
* **UL Case 2**: UL wideband operation Mode 2B (UL-WB Mode 2B) where UE transmits if LBT passes for scheduled multiple contiguous LBT sub-bands
* **UL Case 3**: UL wideband operation Mode 1 (UL-WB Mode 1) where UE transmits only if LBT passes for all LBT sub-bands of BWP

In UL, RAN4 removed capability for scheduling intra-cell GBs. As consequence GBs can be always scheduled, this is clearly aligned with current RAN1 specification, i.e. no further specification change is needed.Furthermore, there is no filter adaptation needed for UL to meet the RF requirements in any of the listed modes. On the other hand, for UL Case 2 and Case 3, UE has to perform LBT for more than one LBT sub-band. Therefore, we could consider introduction of capability for number of LBT sub-bands UE is capable to perform simultaneously. After that if UE can support number of LBT sub-bands matching whole BWP or carrier it may support also Case 3. Similarly to DL, UL Case 2 and UL Case 3 have no impact on implementation other than UE having choice of LBT type, WB LBT or per RB-set LBT(s).**Proposal-2:** *Consider introducing capability for UE to be scheduled on N contiguous sub-bands.* * *N=1 UE supports UL scheduling for 1 RB-set (mandatory when UE indicates capability for unlicensed UL)*
* *N=2 UE supports UL scheduling for up to 2 contiguous RB-sets*
* *N=3 UE supports UL scheduling for up to 3 contiguous RB-sets*
* *N=4 UE supports UL scheduling for up to 4 contiguous RB-sets*
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**Moderator’s view:**

* The proposals can be discussed under AI 7.2.11 (for NR Rel-16 UE Features).

# Issue WB03: RB set indicator in DCI format 2\_0

From [4],

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| Available RB set bitmap in COT-SIWhen the active BWP contains multiple LBT bandwidth, for indication of available LBT bandwidth, a bitmap can be configured in the DCI 2\_0 with each bit corresponds to one LBT bandwidth. There are a few issues we identified* For the COT-SI transmission at the beginning of a COT, since the COT-SI encoding needs processing time, the DCI format 2\_0 cannot carry valid available RB set information. A default value is needed to indicate the available RB set information is not yet available. We propose to use all 0 bitmap to indicate that.
* Also need to consider the case that the bitmap is not configured, in which case, the only UE assumption makes sense is assume all RB sets available when the DCI 2\_0 is detected.
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**Moderator’s view:**

* The proposal was discussed in RAN1#102-e meeting under NR-U DL agenda item, but there was no consensus. Therefore, it is recommended not to discuss this in RAN1#103-e meeting, or this can be discussed in email thread related to DL signal/channel topics, if available.

# Issue WB04: Editorial changes of Clause 7 in TS 38.214

From [1],

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| Meanwhile, there is a minor issue on cited RRC parameters for BWP configuration in Clause 7 of TS 38.214, i.e. a BWP cannot be configured by *BWP-DownlinkDedicated* or *BWP-UplinkDedicated* alone. The RRC parameters for BWP configuration should be corrected according to Clause 12 of TS 38.213.**Proposal 2:** The RRC parameters for BWP configuration in Clause 7 of TS 38.214 should be corrected according to Clause 12 of TS 38.213. |

From [3],

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| Remaining corrections for wideband operation The latest TS38.331 specifies RRC parameters for intra-cell guard bands as follows [1].intraCellGuardBandsDL-List-r16 SEQUENCE (SIZE (1..maxSCSs)) OF IntraCellGuardBandsPerSCS-r16 OPTIONAL, -- Need S intraCellGuardBandsUL-List-r16 SEQUENCE (SIZE (1..maxSCSs)) OF IntraCellGuardBandsPerSCS-r16 OPTIONAL, -- Need SAs above, intra-cell guard band configuration is updated to include configuration per SCS (*IntraCellGuardBandsPerSCS-r16*). The structure of *IntraCellGuardBandsPerSCS-r16* is as follows.IntraCellGuardBandsPerSCS-r16 ::= SEQUENCE { guardBandSCS-r16 SubcarrierSpacing, intraCellGuardBands-r16 SEQUENCE (SIZE (1..4)) OF GuardBand-r16}Section 7 of TS38.214V16.3,0 doesn’t reflect this change. Therefore, we propose to update the spec. as follows. In addition, *intraCellGuardBandDL-r16* and *intraCellGuardBandUL-r16* are replaced by *intraCellGuardBands-r16*. This change should also be reflected.**Proposal: Adopt the following Text Proposal.** |

**Moderator’s view:**

* At least, $GB\_{ s,x}^{start,μ}$ should be changed to $GB\_{ s,x}^{,μ}$, as suggested by [3]. Other editorial changes can be discussed, if available.

# Reference

1. [R1-2007777](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_103%5CDocs%5CR1-2007777.zip) Clarification on restriction of initial BWP configuration Fujitsu
2. [R1-2008205](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_103%5CDocs%5CR1-2008205.zip) Remaining issues on Wideband operation in NR-U Nokia, Nokia Shanghai Bell
3. [R1-2008386](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_103%5CDocs%5CR1-2008386.zip) Remaining corrections for wideband operation for NR-U Sharp
4. [R1-2008603](file:///C%3A%5CUsers%5Cwanshic%5COneDrive%20-%20Qualcomm%5CDocuments%5CStandards%5C3GPP%20Standards%5CMeeting%20Documents%5CTSGR1_103%5CDocs%5CR1-2008603.zip) TP for Wideband operation for NR-U Operation Qualcomm Incorporated

# Appendix A: Text proposals corresponding to each issue

## Issue WB01

### From Fujitsu [1],

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| -------------------------------------- Text Proposal for Clause 7 of TS 38.214----------------------------------\*\*\* Unchanged text omitted \*\*\*For a carrier, the UE expects $ N\_{ BWP,i}^{start,μ}=RB\_{ s0,x}^{start,μ}$ and $N\_{ BWP,i}^{size,μ}=RB\_{ s1,x}^{end,μ}-RB\_{ s0,x}^{start,μ}+1 $ where $0\leq s0\leq s1\leq N\_{RB-set,x}-1$ for a BWP i configured by BWP-DownlinkCommon or BWP-DownlinkDedicated or the DL BWP, or BWP-UplinkCommon or BWP-UplinkDedicated for the UL BWP. Within the BWP i, RB sets are numbered in increasing order from 0 to $N\_{RB-set,x}^{BWP}-1 $ where $N\_{RB-set,x}^{BWP} $ is the number of RB sets contained in the BWP i and RB set 0 within the BWP i corresponds to RB set $s0$ in the carrier and RB set $N\_{RB-set,x}^{BWP}-1$ within the BWP i corresponds to RB set $s1$ in the carrier. For the BWP configured by *initialDownlinkBWP* or *initialUplinkBWP*, the CRB indices for the $N\_{RB-set,x}^{BWP}$ RB sets in the BWP are determined as when the UE is not configured with *intraCellGuardBandDL-r16* or *intraCellGuardBandUL-r16* respectively. For the BWP configured by *BWP-Downlink* or *BWP-Uplink*, the CRB indices for the $N\_{RB-set,x}^{BWP}$ RB sets in the BWP are determined according to *intraCellGuardBandDL-r16* or *intraCellGuardBandUL-r16* if provided respectively.\*\*\* Unchanged text omitted \*\*\*------------------------------------------------ End Text Proposal -------------------------------------------------- |

## Issue WB03

### From Qualcomm [4],

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| ============TP for 38.213 Section 11.1.1====================================--Unchanged part omitted------------------------For each serving cell in the set of serving cells, the UE can be provided: - an identity of the serving cell by *servingCellId*- a location of a SFI-index field in DCI format 2\_0 by *positionInDCI*- a set of slot format combinations by *slotFormatCombinations*, where each slot format combination in the set of slot format combinations includes - one or more slot formats indicated by a respective *slotFormats* for the slot format combination, and - a mapping for the slot format combination provided by *slotFormats* to a corresponding SFI-index field value in DCI format 2\_0 provided by *slotFormatCombinationId*- for unpaired spectrum operation, a reference SCS configuration  by *subcarrierSpacing* and, when a supplementary UL carrier is configured for the serving cell, a reference SCS configuration  by *subcarrierSpacing2* for the supplementary UL carrier- for paired spectrum operation, a reference SCS configuration  for a DL BWP by *subcarrierSpacing* and a reference SCS configuration  for an UL BWP by *subcarrierSpacing2*- a location of an available RB set indicator field in DCI format 2\_0 that is- one bit, if *intraCellGuardBandDL-r16* for the serving cell indicates no intra-cell guard-bands are configured, where a value of '1' indicates that the serving cell is available for receptions, a value of '0' indicates that the serving cell is not available for receptions, by *availableRB-SetPerCell-r16*, and the serving cell remains available or unavailable for reception until the end of the indicated channel occupancy duration- a bitmap having a one-to-one mapping with the RB sets [6, TS 38.214] of the serving cell, if *intraCellGuardBandDL-r16* for the serving cell indicates intra-cell guard-bands are configured, where the bitmap includes $N\_{RB,set,DL}$ bits and $N\_{RB,set,DL}$ is the number of RB sets in the serving cell, a value of '1' indicates that an RB set is available for receptions, a value of '0' indicates that an RB set is not available for receptions, by *availableRB-SetPerCell-r16*, and an RB set remains available or unavailable for receptions until the end of the indicated channel occupancy duration. When all bits in the bitmap are ‘0’, in the *availableRB-SetPerCell-r16*, the availability for all RB sets for reception are considered as unknown, till another DCI format 2\_0 is received.- When *availableRB-SetPerCell-r16* is not configured for a serving cell configured with *CO-DurationPerCell-r16* or *slotFormatCombinations*, the UE considered all RB sets available for reception when the DCI format 2\_0 is detected- a location of a channel occupancy duration field in DCI format 2\_0, by *CO-DurationPerCell-r16*, that indicates a remaining channel occupancy duration for the serving cell starting from a first symbol of a slot where the UE detects the DCI format 2\_0 by providing a value from *CO-DurationList-r16*. The channel occupancy duration field includes $max\left\{\left⌈log\_{2}\left(COdurationListSize\right)\right⌉,1\right\}$ bits, where $COdurationListSize$ is the number of values provided by *CO-DurationList-r16*. If *CO-DurationPerCell-r16* is not provided, the remaining channel occupancy duration for the serving cell is a number of slots, starting from the slot where the UE detects the DCI format 2\_0, that the SFI-index field value provides corresponding slot formats- a location of a search space set group switching field in DCI format 2\_0, by *SearchSpaceSwitchTrigger-r16*, that indicates a group from two groups of search space sets for PDCCH monitoring for scheduling on the serving cell as described in Clause 10.4.--Unchanged part omitted------------------------=============================================================== |

## Issue WB04

### From Fujitsu [1],

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| ------------------------------------ Text Proposal for Clause 7 of TS 38.214--------------------------------\*\*\* Unchanged text omitted \*\*\*For a carrier, the UE expects $ N\_{ BWP,i}^{start,μ}=RB\_{ s0,x}^{start,μ}$ and $N\_{ BWP,i}^{size,μ}=RB\_{ s1,x}^{end,μ}-RB\_{ s0,x}^{start,μ}+1 $ where $0\leq s0\leq s1\leq N\_{RB-set,x}-1$ for a BWP i configured by ~~BWP-DownlinkCommon or BWP-DownlinkDedicated~~ *initialDownlinkBWP* or *BWP-Downlink* for the DL BWP, or ~~BWP-UplinkCommon or BWP-UplinkDedicated~~ *initialUplinkBWP* or *BWP-Uplink* for the UL BWP. Within the BWP i, RB sets are numbered in increasing order from 0 to $N\_{RB-set,x}^{BWP}-1 $ where $N\_{RB-set,x}^{BWP} $ is the number of RB sets contained in the BWP i and RB set 0 within the BWP i corresponds to RB set $s0$ in the carrier and RB set $N\_{RB-set,x}^{BWP}-1$ within the BWP i corresponds to RB set $s1$ in the carrier.\*\*\* Unchanged text omitted \*\*\*---------------------------------------------- End Text Proposal ----------------------------------------------- |

### From Sharp [3],

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| Text proposal--------- beginning of text proposal for TS 38.2147 UE procedures for transmitting and receiving on a carrier with intra-cell guard bandsFor operation with shared spectrum channel access, when the UE is configured with any of *intraCellGuardBands-r16* for UL carrier andfor DL carrier with SCS configuration $μ$, the UE is provided with $N\_{RB-set,x}-1$ intra-cell guard bands on a carrier with SCS configuration $μ$, each defined by start CRB and size in number of CRBs, $GB\_{ s,x}^{start,μ}$ and $GB\_{ s,x}^{,μ}$, provided by higher layer parameters *startCRB-r16* and *nrofCRBs-r16*, respectively, where $s\in \left\{0,1,…,N\_{RB-set,x}-2\right\}$. The subscript *x* is set to DL and UL for the downlink and uplink, respectively. Where there is no risk of confusion, the subscript *x* can be dropped. The intra-cell guard bands separate $N\_{RB-set,x} $RB sets, each defined by start and end CRB, $RB\_{ s,x}^{start,μ} $and $RB\_{ s,x}^{end,μ}$, respectively. The UE does not expect that *nrofCRBs-r16* is configured with non-zero value smaller than the applicable intra-cell guard bands as specified in [8, TS 38.101-1] corresponding to SCS configuration $μ$ and carrier size $N\_{grid,x}^{size,μ}$. The UE determines the start and end CRB indices for $s\in \left\{0,1,…,N\_{RB-set,x}-1\right\}$ as$RB\_{ s,x}^{start,μ}=N\_{grid,x}^{start,μ}+\left\{\begin{matrix}0&s=0\\GB\_{ s-1,x}^{start,μ}+GB\_{ s-1,x}^{size,μ}&otherwise\end{matrix}\right.$ and$RB\_{ s,x}^{end,μ}=N\_{grid,x}^{start,μ}+\left\{\begin{matrix}N\_{grid,x}^{size,μ}-1&s=N\_{RB-set,x}-1\\GB\_{ s,x}^{start,μ}-1&otherwise\end{matrix}\right.$ The RB set with index $s$ consists of $RB\_{s,x}^{size,μ}$ resource blocks where $RB\_{s,x}^{size,μ}=RB\_{ s,x}^{end,μ}-RB\_{ s,x}^{start,μ}+1$. When the UE is not configured with *intraCellGuardBands-r16* for SCS configuration $μ$, the UE determines the CRB indices for the intra-cell guard band(s), if any, and corresponding RB set(s) according to the nominal intra-cell guard band and RB set pattern as specified in [8, TS 38.101-1] corresponding to SCS configuration $μ$ and carrier size $N\_{grid,x}^{size,μ}$. $\_{}^{}$For either or both DL and UL, if the nominal intra-cell guard band and RB set pattern as specified in [8, TS 38.101-1] contains no intra-cell guard bands, the number of RB sets for the carrier is $N\_{RB-set,x}=1$.For a carrier with SCS configuration $μ$, the UE expects $ N\_{ BWP,i}^{start,μ}=RB\_{ s0,x}^{start,μ}$ and $N\_{ BWP,i}^{size,μ}=RB\_{ s1,x}^{end,μ}-RB\_{ s0,x}^{start,μ}+1 $ where $0\leq s0\leq s1\leq N\_{RB-set,x}-1$ for a BWP i configured by *BWP-DownlinkCommon* or *BWP-DownlinkDedicated* for the DL BWP, or *BWP-UplinkCommon* or *BWP-UplinkDedicated* for the UL BWP. Within the BWP i, RB sets are numbered in increasing order from 0 to $N\_{RB-set,x}^{BWP}-1 $ where $N\_{RB-set,x}^{BWP} $ is the number of RB sets contained in the BWP i and RB set 0 within the BWP i corresponds to RB set $s0$ in the carrier and RB set $N\_{RB-set,x}^{BWP}-1$ within the BWP i corresponds to RB set $s1$ in the carrier.When a UE is provided with *nrofCRBs-r16=*0 for all intra-cell guard band(s) on a carrier with SCS configuration $μ$, the UE is indicated that no intra-cell guard-bands are configured for the carrier and expects $N\_{RB-set,x}>1$. For SCS configuration $μ=0$, the UE expects the number of RBs within a RB set is between 100 and 110. For SCS configuration $μ=1$, the UE expects the number of RBs within a RB set is between 50 and 55 except for at most one RB set which may contain 56 RBs.-------- Unchanged contents are omitted--------- end of text proposal |