**3GPP TSG-RAN WG4 Meeting # 107 R4-23xxxxx**

**Incheon, KR, May 22nd – May 26th , 2023**

**Agenda item:** 8.5.1.3

**Source:** Moderator (Huawei, HiSilicon)

**Title:** Topic summary for [107][126] FR1\_enh2\_part1

**Document for:** Information

# Introduction

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

Thread [126] includes following topics:

1. Topic #1: Information & approaches for lower MSD signalling design
2. Topic #2: UE RF requirements for lower MSD
3. Topic #3: TPs for TR 38.881

# Topic #1: Information & approaches for lower MSD signalling design

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

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| [**R4-2307081**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307081.zip) | Views on lower MSD signaling overhead | Nokia, Nokia Shanghai Bell | ***Observation 1****: If frequency ranges available per band under a network are taken into account by a UE, the UE can report lower MSD capabilities and associated information only relevant to the network. This would significantly reduce the number of lower MSD capabilities to be reported. The effect will even increase if lower MSD capabilities are signaled per power class.*  ***Observation 2****: For 4th and 5th harmonic for CA\_n5-n77, without the information of the order, network cannot take a suitable measure.*   * *If a network knows the lower MSD capability is about 4th harmonic, the network may schedule n5 UL and n77 DL frequency resources even if 4th harmonic of n5 frequency resources hits the n77 DL frequency resources and may refrain from doing a similar action for 5th harmonic*   ***Observation 3****: Possible ways to resolve the issue mentioned in Observation 2 are*   * *Setting a rule that in case multiple UL harmonics are defined for a CA configuration, lower MSD capability applies all UL harmonic orders (Not preferred way since this requires network to store the rule.* * *Filterization mentioned in Section 2.1. this is not perfect, while it can address most of the cases.*   ***Proposal****: Consider a following lower MSD capability filterization as one possible approach.*   * *Conveying actually available frequency ranges per band under a network to a UE*   + *Note that even now network conveys available bands under the network as filterizaiton*   *UE reports only relevant lower MSD capabilities relevant to the network* |
| [**R4-2307092**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307092.zip) | Discussion on lower MSD signaling design | Spreadtrum Communications | ***Observation 1:*** *In the case of low SNR, the optimization of MSD and the improvement of SNR are linear.*  ***Proposal 1:*** *Revised option 2 as follows:*  *Option 2: If the actual MSD is larger than the maximum threshold ThM-1 (i.e. out of range), the UE cannot report low-MSD capability for this REFSENS exception case. As long as the actual MSD improvement exceeds 1dB or more, reporting is allowed.*  ***Proposal 2****: The requirement of MSD has contain bandwidths, there is no need to report CBW of aggressor UL and victim DL.*  ***Proposal 3:*** *The MSD source to be reported is selected from the set of {UL harmonic, Harmonic mixing, cross-band ISO, IMDn}*  ***Proposal 4:*** *For harmonic order, it will be reported if there is more than one kind of harmonic order in someone band combination, otherwise it will not be reported. For IMD orders, it can be from 2 to 9.*  ***Proposal 5:*** *The lower bound is 0dB and the upper bound is 28dB, and the improvement of the granularity is 1dB.*  ***Proposal 6:*** *Support option2* |
| [**R4-2307121**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307121.zip) | Discussion on the remaining open issues for lower MSD capability signaling | Facebook Japan K.K. | ***Proposal #1****: UE could indicate Lower MSD capability for a band combination as long as one kind of MSD from one victim band is improved. Additionally, it is unnecessary to report the Lower MSD values in case the specified MSD itself is small or the MSD improvement is not significant. The small MSD improvement will be discussed in different sub-topic based on the specific band combinations.*  ***Proposal #2****: The aggressor UL and victim DL CBW information is not necessary since the network controller will not expect any different behaviour according to the CBW information. If RAN4 makes consensus on the necessity of the UL/DL CBW information based on the reasonable evidence and explicit NW behaviour, then RAN4 can report the CBW information of the aggressor UL and victim DL CBW.*  ***Proposal #3****: RAN4 introduces multiple MSD thresholds using 3-bit MSD reporting bitmap in Table 1 to apply lower capability for all CA/DC band combinations according to the different MSD types and different order.*  ***Proposal #4****: For the conformance test aspect, meta supports the option 2 in the sub-topic 1-6 [3]. In Particular, we prefer not to define the explicit MSD requirements for lower MSD capability in TS38.101-1 and TS38.101-3.*  ***Proposal #5****: Single bit indication and 2-bits MSD reporting bitmap for the small MSD capability (MSD <= [3] dB) can be considered to apply the improved MSD level by the high order IMD/harmonic problems.* |
| **R4-2309737** | Signalling for low MSD | Qualcomm Technologies Int | ***Observation 1****: Using MSD tables having large thresholds makes the MSD information less accurate as UEs reporting MSD values from the upper portion of a given threshold are treated similar to those reporting values from the lower part of the same threshold step. These inaccuracies grow with the magnitude of the MSD threshold step.*  ***Proposal 1****: Adopt the following MSD table with large dynamic range and moderate MSD granularity having the thresholds indicated below:*   |  |  |  | | --- | --- | --- | | *Index* | *Maximum allowed actual MSD (dB)* | *Note (dB)* | | *0* | *0* | *Actual MSD=0* | | *1* | *3* | *0 < Actual MSD ≤ 3* | | *2* | *6* | *3 ＜ Actual MSD ≤ 6* | | *3* | *9* | *6 ＜ Actual MSD ≤ 9* | | *4* | *12* | *9 ＜ Actual MSD ≤ 12* | | *5* | *15* | *12 ＜ Actual MSD ≤ 15* | | *6* | *18* | *15 ＜ Actual MSD ≤ 18* | | *7* | *21* | *18 ＜ Actual MSD ≤ 21* | | *8* | *24* | *21 ＜ Actual MSD ≤ 24* |   ***Proposal 2****: An impairment can indicate lower MSD if it has sufficient improvement compared to the value in the standard such that it at least falls into the next lower MSD threshold range in the agreed MSD table.*  ***Proposal 3****: Do not restrict the maximum order of the IMDs that are considered for lower MSD improvement to the maximum value in the current spec (i.e. n=9).*  ***Proposal 4****: Included the UL/DL harmonic order when reporting lower MSDs for UL harmonics or harmonic mixing impairments.*  ***Observation 2****: Whether to report the CBW of the UL aggressor and the DL victim can be resolved after agreement on details related to conformance testing are reached.* |
| [**R4-2307476**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307476.zip) | Signaling approach for low MSD | Skyworks Solutions Inc. | ***Proposal on MSD types to be signalled:***   * *Six different low MSD types signaling for R18 + 3 in R19* * *One specific MSD type can be signaled on top of the “All” MSD type if significantly better MDS class* * *New MSD types can be added as new MSD requirements are developed in RAN4 one release after the new requirement framework is finalized.*   ***Proposal on MSD classes for all MSD types and power class:***   * *The UE declares the MSD class is supports per MSD types it supports for the highest power class it supports* * *The UE declares the MSD class for the worst-case UL/DL CBW combination it supports* * *The UE cand declare a low MSD class if its upper bond is at least 1dB better that the RAN4 specified MSD.*  |  |  | | --- | --- | | *MSD type* | *MSD* | | *No signaling* | *Legacy and default: MSD as specified in RAN4 spec* | | *MSD class I* | *MSD <1dB for all power class* | | *MSD class II* | *MSD <5dB for all power class* | | *MSD class III* | *MSD <15dB for PC3, <16dB for PC2, <17dB for PC1.5* | | *MSD class IV* | *MSD <20dB for PC3, <22dB for PC2, <24dB for PC1.5* |   ***Proposal on conformance test:***   * *All low MSD capability signalled should be verified* * *No additional test or test point is added or tested for UEs signaling low MSD*   *When a low MSD class is signaled it is valid for all power classes and the worst-case CBW combinations that the UE supports using the normal test points where the MSD requirement is replaced by the upper bound of the MSD class signaled per power class tested.* |
| [**R4-2307919**](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_107/Docs/R4-2307919.zip) | On the signalling design for lower-MSD capability | Huawei, HiSilicon | ***Proposal 1****: Consider the following two options (down-select or merge) for reporting MSD values for different power classes:*  *Option a): Report the MSD value for the power class requested by the network, otherwise for the highest power class supported by the UE.*  *Option b): Report a list of MSD values for all supported power classes in one instance, e.g.: <(MSD value for PC2, MSD value for PC3), MSD type, victim band> for UE indicating PC2.*  ***Proposal 2****: No need to report the CBW of aggressor UL and victim DL. It is assumed that the network can extrapolate the MSD for the actual CBW in use based on the reported lower-MSD information.*  ***Observation 1****: One principle to select MSD types and orders is to enable the network/TE to identify a unique test point in the 3GPP specifications when performing table look-up with <MSD type, Victim band> as the indices.*  ***Observation 2****: Without reporting the harmonic order, the test point for MSD caused by harmonic/harmonic mixing can still be identified in the spec. Otherwise, up to 11 UL/DL harmonic types would be needed, resulting in excessive signalling overhead.*  ***Proposal 3****: No need to report UL/DL harmonic order. The MSD types below can be reported in this release:*  *{UL harmonic, Harmonic mixing, cross-band ISO, IMD2, IMD3, IMD4, IMD5, IMD7, IMD9}.*  ***Proposal 4****: Inform RAN2 that new MSD types may be added in the future and a maximum of 16 MSD types are reserved for Rel-18.*  ***Proposal 5****: For the benefit of reducing signalling overhead, consider to introduce special MSD types, such as ALL, ALL\_BUT\_2nd\_ORDER, to enable the UE to report the same MSD value for multiple normal MSD types (i.e. harmonic, harmonic mixing, cross-band, IMD, etc) in one instance.*  ***Proposal 6****: Use at least 3 bits to report the quantised MSD value and limit the reporting range to around 20dB, which can give reasonable resolution and rule out excessively large MSD values to be reported.*  ***Proposal 7****: Merge different options proposed for lower-MSD conformance test and consider how to capture the requirement in the spec.* |
| [**R4-2308121**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308121.zip) | Views on signalling information for Lower MSD | Samsung, KT corporation | ***Proposal 1****: It is suggested to adopt below table as condition to report lower MSD capability.*    ***Proposal 2****: No need to report order for harmonic/ harmonic mixing/cross band isolation.*  ***Proposal 3****: Take 13 as the maximum order for IMD.*  ***Proposal 4****: Our preference of lower MSD thresholds is 3-bit solution with maximum threshold around 20dB.*  ***Proposal 5****: No additional (new) conformance test point be set for lower MSD capability against specified MSD. More specifically:*   1. *In case UE supports the specified worst case configuration which corresponds to the largest MSD, this configuration is selected as test configuration for verifying both existing specified MSD and lower MSD capability* 2. *In case UE does not support the specified worst case configuration, but support the second test configuration (if introduced) which is an optionally defined one to address operator’s demand, the second configuration is selected as test configuration for verifying both existing specified MSD and lower MSD capability* 3. *In case UE does not support any of the specified configuration, the worst case configuration the UE supported itself for this band combination should be chosen as test configuration for verifying both existing specified MSD and lower MSD capability*   *Note: Whether 1)2)3) is valid, should wait for RAN5’s final confirmation.*  ***Proposal 6****: If Proposal 5 is agreeable, then correspondingly CBW of aggressor UL and victim DL are not necessary to be included in the essential information for lower MSD capability.* |
| [**R4-2308173**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308173.zip) | On lower MSD for inter-band CA/ENDC | ZTE Corporation | ***Proposal 1****. If the actual MSD is larger than the maximum threshold ThM-1 (i.e. out of range), the UE cannot report low-MSD capability for this REFSENS exception case*  *- If UE reports the lower MSD capability, the reported MSD value should be improved at least by [3] dB against a specified MSD*  ***Proposal 2****. CBW of aggressor UL and victim DL should be reported, but it is fine to wait for RAN5’s feedback.*  ***Proposal 3****. For UL/DL harmonic order, there is no need to be included for harmonic mixing MSD, but it should be included for harmonic MSD.*  ***Proposal 4****. For IMDn, n should be 13.*  ***Proposal 5****. New cross band isolation MSD types, i.e. from 2 aggressor NR UL bands, should be considered for indicating lower MSD capability.*  ***Proposal 6****. 0~20dB MSD thresholds range with small granularity such as [1, 2, 3]dB should be considered.* |
| [**R4-2308201**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308201.zip) | discussion on MSD capability | CMCC | ***Proposal 1****: to make MSD capability used in commercial network, it’s better to study how to reduce capability overhead.*  ***Proposal 2****: to reduce MSD capability overhead, one solution is to allow gNB query UE capability and UE only report certain capability filtered by gNB’s query information. Query information could include following information, e.g. band combinations, power class, Tx power, aggressor and victim CBW, victim operation band.*  ***Observation 1****: gNB needs the relationship between UL Tx power and DL MSD performance to trade off UL and DL performance.*  ***Proposal 3****: it’s suggested to report additional information to show under which Tx power, all the MSD would be negligible, e.g. less than 3dB or 5dB. gNB could use this information for final UE scheduling algorithm or deciding final UE Tx power.*  ***Observation 2****: solution in proposal 3 is the extension of legacy single-bit indicator with Tx power information and only focus on the case when MSD is negligible. it’s much directly and simply for gNB to know under which case MSD is negligible.*  ***Observation 3****: if only report MSD with the same aggressor/victim CBW configuration as minimum MSD RF requirements, this MSD information can’t be fully used by gNB because the value is not applicable for configured CBW and gNB have no information of how to translate MSD value among different CBW.*  ***Proposal 4****: it’s suggested to report MSD values for the aggressor and victim CBW that are configured by network rather than the CBW combinations only for testing points. UE could only report capability information for several typical CBW combinations that are used by commercial network rather than all CBW combinations.*  *Detailed CBW combinations could be requested by gNB and UE reply the MSD under corresponding aggressor and victim CBW combinations.*  ***Proposal 5****: to reduce capability overhead, gNB could query CBW configurations for aggressor and victim carrier and UE reply corresponding MSD.*  ***Observation 4****: several dB (e.g. 1-2dB) MSD enhancement will not change final scheduling algorithm because the granularity or accuracy of all inputs factors for scheduling algorithm are comparable or larger than several dB (e.g. 1-2dB).* |
| [**R4-2308240**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308240.zip) | Further discussion of lower MSD Signalling | vivo | ***Observation 1:*** *The idea of mandating the reported MSD value should be improved at least by TBD dB, is against the previous agreement of use “absolute thresholds”, and may greatly increase the complexity of verification.*  ***Proposal 1:*** *Do not consider mandating the reported MSD value should be improved at least by TBD dB.*  ***Proposal 2:*** *Do not report CBW of aggressor UL and victim DL for lower MSD capability.*  ***Proposal 3:*** *The harmonic order is not needed for signalling, and IMD order up to 4/5 is enough.*  ***Proposal 4:*** *Choose 0~20dB as compromise range for lower MSD. Any range larger than that would be deviating too much from what “lower MSD” should pursued.*  ***Proposal 5:*** *The following thresholds are proposed:*   * + *0≤ MSD＜3 dB*   + *3≤ MSD＜6 dB*   + *6≤ MSD＜12dB*   + *12≤ MSD＜[20]dB*   ***Proposal 6:*** *Continue discuss conformance test configurations related topic for lower MSD after receiving RAN5 reply.*  ***Proposal 7:*** *Single-bit low-MSD indicator for a UE is proposed to do more study and considered.* |
| [**R4-2308277**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308277.zip) | Discussion for lower MSD threshold | LG Electronics France | ***Proposal 1****: Consider higher threshold upper limit for lower MSD to cover the all MSD types, orders and power classes.* |
| [**R4-2308925**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308925.zip) | Further discussion on low-MSD capability signalling | MediaTek Inc. | ***Observation 1****: LS [4] is only applicable on threshold-based reporting approach, not for non-threshold based approach*  ***Observation 2****: The lower MSD capability signaling can be specified as per victim band per BC as a 2-tuple of < MSD mechanism/Aggressor power class and its order, MSD value > as below examples can save 1-tuple signaling overhead on adaptive network signaling approach.*  ***Proposal 1****: We propose below 3-bits index table for threshold-based low-MSD reporting.*   |  |  | | --- | --- | | *Index* | *Actual MSD range (dB)* | | *0* | *0 ≤ Actual MSD ≤ 3* | | *1* | *3 ＜ Actual MSD ≤ 6* | | *2* | *6 ＜ Actual MSD ≤ 9* | | *3* | *9 ＜ Actual MSD ≤ 12* | | *4* | *12 ＜ Actual MSD ≤ 15* | | *5* | *15 ＜ Actual MSD ≤ 18* | | *6* | *18 ＜ Actual MSD ≤ 21* | | *7* | *21 ＜ Actual MSD* |   *We also propose low-MSD singling in granularity of 1dB for non-threshold based reporting.*  ***Observation 3****: An adaptive signaling approach that network can require UE only to report the top K largest MSD values together with its mechanism indexing and improved MSD values can save large amount of signaling overhead*  ***Proposal 2*** *RAN4 consider both threshold-based approach and non-threshold-based approach to indicate the lower MSD capability*  ***Proposal 3*** *RAN4 down select for each type of approach* |
| [**R4-2309011**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309011.zip) | Discussion on lower MSD signaling for inter-band CA/EN-DC/DC | Xiaomi | ***Observation 1****: it is hard to define a uniform and fair necessary amount of MSD improvement for all kinds of MSD type and band combinations.*  ***Observation 2****: even we define a condition that only the amount of MSD improvement is above X dB could allow UE report lower MSD capability, the network could not get a more accurate MSD value compared with no condition is defined because the network doesn’t know the UE minimum requirement.*  ***Proposal 1****: No need to define the necessary amount of MSD improvement for allowing UE to indicate lower MSD capability*  ***Proposal 2****: For the same MSD types with orders, only one lower MSD value is reported for each victim band even multiple test points are defined in the spec.*  ***Proposal 3****: the information of aggressor UL and victim DL bandwidth is not necessary.*  ***Proposal 4****: From the reducing signaling overhead point of view, UE is not supposed to report the MSD improvement for all supported power class.*  ***Proposal 5****: 20dB could be as max threshold.*  ***Proposal 6****: adapt only 2 bits for reporting MSD value.*  ***Observation 3****: whether a single bit MSD indicator is needed or not depends on how to design the capability.* |
| [**R4-2309096**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309096.zip) | On lower MSD signaling and UE RF requirements | Apple | ***Proposal 1****: The trade-off between the signaling complexity and the network efficiency on scheduling the MSD impacted combinations to UEs shall also be based on the inputs from network side, for example, on the MSD threshold granularity.*  ***Proposal 2****: The need for lower MSD threshold signaling shall only be triggered by the network, but not initiated by UE.*  ***Proposal 3****: A per UE lower MSD capability may also be needed in addition to other lower MSD parameters as an early indication of the per UE capability would prevent network from unnecessary triggering of lower MSD signaling for UE without the lower MSD capability at all.* |
| [**R4-2309436**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309436.zip) | Discussion on the CBW and 4Rx support in the Lower MSD capability | CHTTL | ***Proposal 1:*** *The following aspect should be considered when defining the MSD requirements.*  *- For NR CA, at least one of the test configurations should be compatible with all of the BCS.*  *- For EN-DC and NE-DC, at least one of the test configurations should be compatible with the mandatory channel bandwidth of each band.*  ***Proposal 2:*** *Include the aggressor UL and victim DL bandwidth information in the lower MSD capability report only when the following conditions are met.*  *- The referred MSD test configuration for the lower MSD is not aligned with the worst case scenario of the supported channel bandwidths of the UE. (i.e. the worst case scenario cannot be assumed.)*  *If the UE does not provide the aggressor UL and victim DL bandwidth information, it means that following conditions are assumed by default.*  *- The aggressor UL and victim DL bandwidth is the minimum supported bandwidth of the corresponding band by the UE in the MSD report for the harmonic, harmonic mixing and the IMD.*  *- The aggressor UL is the maximum supported bandwidth of the corresponding band by the UE in the MSD report for the cross band isolation.*  *- The victim DL bandwidth is the minimum supported bandwidth of the corresponding band by the UE in the MSD report for the cross band isolation.*  ***Proposal 3:*** *Discuss whether the 2Rx/4Rx indication for the DL victim band is needed in the lower MSD capability report.*  ***Proposal 4:***  *Further consider a joint solution to allow a one bit low MSD indication per BC to potentially reduce the signalling overhead. This indication can be used when all MSD types for this BC have been improved to above a threshold. Details can be further discussed.* |

## Open issues summary

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

### Sub-topic 1-1: Conditions to indicate Lower MSD capability

*Sub-topic description:*

***Open issues and candidate options before meeting:***

* *Candidate options in RAN#106-bis-e:*
* *Option 1: For the purpose of MSD improvement, if the minimum requirement for a given REFSENS exception case falls into the interval of MSD ≤ Thi dB, the actual MSD should be at least one-level lower (i.e., actual MSD ≤ Thi-1 dB) in order for the UE to report the low-MSD capability. If the actual MSD is larger than the maximum threshold ThM-1 (i.e. out of range), the UE cannot report low-MSD capability for this REFSENS exception case* ***(Samsung, Xiaomi, Nokia, AT&T, Skyworks, HW****)*
* *If UE reports the lower MSD capability, the reported MSD value should be improved at least by TBD dB against a specified MSD*
* *Option 2: For the purpose of MSD improvement, if the minimum requirement for a given REFSENS exception case falls into the interval of MSD ≤ Thi dB, the actual MSD should be at least one-level lower (i.e., actual MSD ≤ Thi-1 dB) in order for the UE to report the low-MSD capability. If the actual MSD is larger than the maximum threshold ThM-1 (i.e. out of range), the UE cannot report low-MSD capability for this REFSENS exception case (****QC, OPPO, vivo****)*
* *~~If UE reports the lower MSD capability, the reported MSD value should be improved at least by TBD dB against a specified MSD~~*
* *Option 3: Others (****Meta, MediaTek, Apple****)*

*The main difference between option 1 and option 2 is whether the MSD reporting relies on sufficient MSD improvement, e.g. 3dB against the specified MSD.*

* Proposals
  + Option 1: For the purpose of MSD improvement, if the minimum requirement for a given REFSENS exception case falls into the interval of MSD ≤ Thi dB, the actual MSD should be at least one-level lower (i.e., actual MSD ≤ Thi-1 dB) in order for the UE to report the low-MSD capability. If the actual MSD is larger than the maximum threshold ThM-1 (i.e. out of range), the UE cannot report low-MSD capability for this REFSENS exception case. If UE reports the lower MSD capability, the reported MSD value should be improved at least by TBD dB against a specified MSD (Samsung, HW)
    - Option 1a: On top of option 1, some clarification of conditions to be reflected in the spec (Samsung)

|  |  |
| --- | --- |
| **Specified MSD** | **Condition to report lower MSD capability** |
| ＞The maximum lower MSD threshold | 1. The actual MSD should be at least less than the maximum lower MSD threshold 2. The actual MSD should be improved at least by X dB against a specified MSD |
| ＜The minimum lower MSD threshold  *Note: If the minimum lower MSD threshold is 0, then this case is not needed.* | No need to report lower MSD capability |
| Fall into the interval of two adjacent lower MSD thresholds | 1. The actual MSD should be at least one-level lower than the specified MSD in terms of lower MSD capability class 2. The actual MSD should be improved at least by X dB against a specified MSD |
| *Note: The exact value of X should be determined after the lower MSD thresholds are concluded* | |

* + - Option 1b: An impairment can indicate lower MSD if it has sufficient improvement compared to the value in the standard such that it at least falls into the next lower MSD threshold range in the agreed MSD table (QC)
    - Option 1c: If UE reports the lower MSD capability, the reported MSD value should be improved at least by [3] dB against a specified MSD (ZTE)
  + Option 2: If the actual MSD is larger than the maximum threshold ThM-1 (i.e. out of range), the UE cannot report low-MSD capability for this REFSENS exception case. As long as the actual MSD improvement exceeds 1dB or more, reporting is allowed (Spreadtrum).
  + Option 3: UE could indicate Lower MSD capability for a band combination as long as one kind of MSD from one victim band is improved. (Meta, [vivo], [Xiaomi])
    - Additionally, it is unnecessary to report the Lower MSD values in case the specified MSD itself is small or the MSD improvement is not significant. The small MSD improvement will be discussed in different sub-topic based on the specific band combinations (Meta)
  + Option 4: The UE can declare a low MSD class if its upper bond is at least 1dB better that the RAN4 specified MSD (Skyworks)
  + Option 5: A per UE lower MSD capability may also be needed in addition to other lower MSD parameters as an early indication of the per UE capability would prevent network from unnecessary triggering of lower MSD signaling for UE without the lower MSD capability at all (Apple)
* Recommended WF
  + TBA

### Sub-topic 1-2: MSD for different power classes

*Sub-topic description*

*Open issues and candidate options before meeting:*

* Proposals
  + Option 1: Report the MSD value for the power class requested by the network, otherwise for the highest power class supported by the UE (HW, [Xiaomi])
  + Option 2: Report a list of MSD values for all supported power classes in one instance (HW)
    - e.g., <(MSD value for PC2, MSD value for PC3), MSD type, victim band> for UE indicating PC2.
  + Option 3: The UE declares the MSD class is supports per MSD types it supports for the highest power class it supports (Skyworks)
  + Option 4: it’s suggested to report additional information to show under which Tx power, all the MSD would be negligible, e.g. less than 3dB or 5dB. gNB could use this information for final UE scheduling algorithm or deciding final UE Tx power (CMCC)
* Recommended WF
  + TBA

### Sub-topic 1-3: MSD orders

*Sub-topic description*

*Open issues and candidate options before meeting:*

#### **Issue 1-3-1: Order for harmonic/ harmonic mixing/cross band isolation MSD**

* Proposals
  + Option 1: No need to report order for harmonic/ harmonic mixing/cross band isolation (Samsung, HW, vivo, [Xiaomi])
  + Option 2: For harmonic order, it will be reported if there is more than one kind of harmonic order in someone band combination, otherwise it will not be reported (Sptreadtrum)
  + Option 3: Included the UL/DL harmonic order when reporting lower MSDs for UL harmonics or harmonic mixing impairments (QC)
  + Option 4: For UL/DL harmonic order, there is no need to be included for harmonic mixing MSD, but it should be included for harmonic MSD (ZTE)
* Recommended WF
  + TBA

#### **Issue 1-3-2: Order for IMD MSD**

* Proposals
  + Option 1: Take 13 as the maximum order for IMD (Samsung, ZTE)
  + Option 2: For IMD orders, it can be from 2 to 9 (Sptreadtrum)
    - Option 2a: n=2,3,4,5,7,9 (HW)
  + Option 3: Do not restrict the maximum order of the IMDs that are considered for lower MSD improvement to the maximum value in the current spec (i.e. n=9) (QC)
  + Option 4: IMD order up to 4/5 is enough (vivo)
  + Option 5: For the same MSD types with orders, only one lower MSD value is reported for each victim band even multiple test points are defined in the spec (Xiaomi)
* Recommended WF
  + TBA

#### **Issue 1-3-3: New MSD types can be added as new MSD requirements are developed in RAN4 for future proof**

* Proposals
  + Option 1: Yes (Samsung, Skyworks, HW, ZTE)
    - Option 1a: Inform RAN2 that new MSD types may be added in the future and a maximum of 16 MSD types are reserved for Rel-18 (HW)
    - Option 1b: New cross band isolation MSD types, i.e. from 2 aggressor NR UL bands, should be considered for indicating lower MSD capability (ZTE)
  + Option 2: No
* Recommended WF
  + Option 1, some MSD types can be reserved for future proof in signalling design
  + TBA on the reserved MSD types, and bits reserved for MSD types, e.g. 3 or 4 bits for Rel-18

#### **Issue 1-3-4: Others**

* Proposals
  + Option 1: (Skyworks)
    - Six different low MSD types signaling for R18 + 3 in R19
    - One specific MSD type can be signaled on top of the “All” MSD type if significantly better MDS class

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **MSD type** | **UL conf.** | **DL conf.** | **Signaling scope** | **Priority** |
| All | Any | 2/3DL bands | * Low MSD class per victim band valid for all possible MSD per UL configuration | R18 |
| UL Harmonics | 1UL/1CC | 2DL band | * Low MSD class per victim band for worst case MSD and valid for higher order if exist | R18 |
| Harmonic mixing | 1UL/1CC | 2DL band | * Low MSD class per victim band for worst case MSD and valid for higher order if exist | R18 |
| Cross-band isolation | 1UL/1CC | 2DL band | * Low MSD class per victim band for worst case MSD for the UL/DL CBW the UE supports | R18 |
| IMD | 2UL/2CC | 2/3DL bands | * Low MSD class per victim band for the worst-case even order IMD and valid for other higher even order IMDs if exist * Low MSD class per victim band for the worst-case odd order IMD and valid for other higher odd order IMDs if exist | R18 |
| 1UL/2CC | 2DL band | * Low MSD class per victim band for the worst-case even order IMD and valid for other higher even order IMDs if exist * Low MSD class per victim band for the worst-case odd order IMD and valid for other higher odd order IMDs if exist | R19 |
| 2UL/3CC  (2 cont.) | 2/3DL bands | * Low MSD class per triple beat victim band | R19 |

* + Option 2: For the benefit of reducing signalling overhead, consider to introduce special MSD types, such as ALL, ALL\_BUT\_2nd\_ORDER, to enable the UE to report the same MSD value for multiple normal MSD types (i.e. harmonic, harmonic mixing, cross-band, IMD, etc) in one instance. (HW)
* Recommended WF
  + TBA

### Sub-topic 1-4: Candidate MSD thresholds

*Sub-topic description*

*Open issues and candidate options before meeting:*

* Proposals
  + Option 1: 3-bit solution with maximum threshold around 20dB (Samsung, Meta, QC, HW, ZTE, MTK)

|  |  |  |  |
| --- | --- | --- | --- |
| **Bit** | **Maximum allowed actual MSD**  **(i.e. Thresholds)** | **Lower MSD**  **Capability classes** | **Note** |
| 000 | 0dB | Ⅰ | Actual MSD = 0 |
| 001 | 3 dB | Ⅱ | Actual MSD ≤ 3 |
| 010 | 6 dB | Ⅲ | Actual MSD ≤ 6 |
| 011 | 9 dB | IV | Actual MSD ≤ 9 |
| 100 | 12 dB | Ⅴ | Actual MSD ≤ 12 |
| 101 | 15 dB | Ⅵ | Actual MSD ≤ 15 |
| 110 | 18 dB | Ⅶ | Actual MSD ≤ 18 |
| 111 | 21dB | Ⅷ | Actual MSD ≤ 21 |

* + Option 2: The lower bound is 0dB and the upper bound is 28dB, and the improvement of the granularity is 1dB (Sptreadtrum)
  + Option 3: Single bit indication and 2-bits MSD reporting bitmap for the small MSD capability (MSD <= [3] dB) can be considered to apply the improved MSD level by the high order IMD/harmonic problems (Meta)

|  |  |  |
| --- | --- | --- |
| **Bit map** | **MSD range**  **(i.e. Thresholds)** | **Note** |
| 00 | - | Not supported the lower MSD capability. Only apply the existing MSD requirements in TS38.101-1 and TS38.101-3. |
| 01 | [1] dB | 0 ≤ Actual MSD ≤ [1] |
| 10 | [2] dB | 1 < Actual MSD ≤ [2] |
| 11 | [3] dB | 2 < Actual MSD ≤ [3] |

* + Option 3: (Skyworks)
    - The UE declares the MSD class is supports per MSD types it supports for the highest power class it supports
    - The UE declares the MSD class for the worst-case UL/DL CBW combination it supports

|  |  |
| --- | --- |
| **MSD type** | **MSD** |
| No signaling | Legacy and default: MSD as specified in RAN4 spec |
| MSD class I | MSD <1dB for all power class |
| MSD class II | MSD <5dB for all power class |
| MSD class III | MSD <15dB for PC3, <16dB for PC2, <17dB for PC1.5 |
| MSD class IV | MSD <20dB for PC3, <22dB for PC2, <24dB for PC1.5 |

* + Option 4: Any range larger than that would be deviating too much from what “lower MSD” should pursued (vivo, [Xiaomi])
    - 0≤ MSD＜3 dB
    - 3≤ MSD＜6 dB
    - 6≤ MSD＜12dB
    - 12≤ MSD＜[20]dB
  + Option 5: Consider higher threshold upper limit for lower MSD to cover the all MSD types, orders and power classes (LGE)
  + Option 6: RAN4 consider both threshold-based approach and non-threshold-based approach to indicate the lower MSD capability, and RAN4 down select for each type of approach (MTK)
    - low-MSD singling in granularity of 1dB for non-threshold based reporting
  + Option 7: The trade-off between the signaling complexity and the network efficiency on scheduling the MSD impacted combinations to UEs shall also be based on the inputs from network side, for example, on the MSD threshold granularity (Apple)
    - The need for lower MSD threshold signaling shall only be triggered by the network, but not initiated by UE
* Recommended WF
  + TBA, to check firstly if max threshold around 20dB supported by most companies is agreeable, then check whether 3 bits or 2 bits used for the threshold range

### Sub-topic 1-5: Conformance test for lower MSD

*Sub-topic description*

*Open issues and candidate options before meeting:*

* *Candidate options in RAN#106-bis-e:*
  + *Option 1: For cross band isolation, in terms of lower MSD capability (Samsung, QC, Meta)*
* *If UE supports the specified worst case configuration which corresponds to the largest MSD, it should be chosen to verify lower MSD capability*
* *If UE does not support the specified worst case configuration，FFS on the test configuration for lower MSD*
* *Alt 1: The worst case configuration the UE supports itself is chosen as test configuration (→ But may lead to new test point against the exiting specified test point for conformance test)*
* *Alt 2: Others*
  + *Option 1a: For cross band isolation, in terms of lower MSD capability (Samsung)*
* *UE supports the specified worst case configuration which corresponds to the largest MSD, this configuration is selected as test configuration for verifying both existing specified MSD and lower MSD capability → No additional test point needed for lower MSD compared with existing specified MSD*
* *UE does not support the specified worst case configuration, but support the second test configuration (if introduced )which is an optionally defined one to address operator’s demand, the second configuration is selected as test configuration for verifying both existing specified MSD and lower MSD capability → No additional test point needed for lower MSD compared with existing specified MSD*
* *UE does not support any of the specified configuration, the worst case configuration the UE supported itself for this band combination should be chosen as test configuration for verifying both existing specified MSD and lower MSD capability → No additional test point needed for lower MSD compared with existing specified MSD*
  + *Option 2: (Skyworks, Meta, [HW], Apple, Meta, Xiaomi, AT&T, QC)*
* *A UE signalling the optional lower MSD capability should not have more or different conformance test points than a legacy UE without lower MSD capability, only the test limits should be impacted*
* *When a UE signals a lower MSD threshold for a given MSD type, the currently applicable inter-band worst case MSD tests are performed, and the limit is modified to the signalled threshold value instead of the MSD value in 3.101-1 or 38.101-3.*
* *If other MSD test points exits for the same MSD type (for example H3 on top of worst case H2 or IMD3 on top of worst case IMD2…), the test is also performed with the limit modified to the signalled threshold value instead of the MSD value in 3.101-1 or 38.101-3.*
* *If the UE fails the test, the conformance test will have to be passed again either:*
  + - *With the UE now passing the test with the same threshold after HW/SW modifications*
    - *With the UE passing the test with the higher threshold signalled*
    - *With the UE passing the normal test without the lower MSD capability*
* *It should be noted that there are worst case MSD test points cases in 38.101-1 or 38.101-3 that some UE cannot pass as:*
  + - *They do not support the lowest channel UL CBW (very rare) for all 1UL and 2UL IMD test*
    - *They do not support the largest channel UL CBW for the 1UL cross-band MSD case:*
    - *In many cases, there is a second cross-band MSD test point that uses a lower UL CBW that a majority of UEs would support; in this case, this test point is used with the signalled threshold value as the limit*
    - *In the rare case where a UE would not support the UL CBW of all the cross-band MSD test points, the UE is tested with the largest CBW it supports and uses the signalled threshold value as the limit*
    - *The worst-case MSD test point is not valid for the support frequency range in a given region*
    - *For this case, there is usually a second MSD test point that can be measured in any applicable region; in this case, this test point is used with the signalled threshold value as the limit.*
  + *Option 3: No new test configurations (points) be set for lower MSD compared to current MSD requirements (vivo, OPPO)*
* Proposals
  + Option 1: No additional (new) conformance test point be set for lower MSD capability against specified MSD (Samsung, Skyworks, HW)
    - Option 1a: Detailed consideration on test configurations (Samsung):

1. In case UE supports the specified worst case configuration which corresponds to the largest MSD, this configuration is selected as test configuration for verifying both existing specified MSD and lower MSD capability
2. In case UE does not support the specified worst case configuration, but support the second test configuration (if introduced) which is an optionally defined one to address operator’s demand, the second configuration is selected as test configuration for verifying both existing specified MSD and lower MSD capability
3. In case UE does not support any of the specified configuration, the worst case configuration the UE supported itself for this band combination should be chosen as test configuration for verifying both existing specified MSD and lower MSD capability

Note: Whether 1)2)3) is valid, should wait for RAN5’s final confirmation.

* + - Option 1b: When a low MSD class is signaled it is valid for all power classes and the worst-case CBW combinations that the UE supports using the normal test points where the MSD requirement is replaced by the upper bound of the MSD class signaled per power class tested (Skyworks)
  + Option 2: Support option2 in last meeting (Sptreadtrum)
  + Option 3: Continue discuss conformance test configurations related topic for lower MSD after receiving RAN5 reply (vivo)
* Recommended WF
  + No additional (new) conformance test point be set for lower MSD capability against specified MSD
  + TBA details if needed

### Sub-topic 1-6: Whether to report CBW of aggressor UL and victim DL

***Sub-topic description***

*During the discussion in last meeting, most companies agree that the CBW info is relevant to the conformance test. The conclusion of sub-topic 1-5 is the basis for this sub-topic.*

*It is noticed that in the LS to RAN2, aggressor UL and victim DL bandwidth is in bracket. If any conclusion, the update should be informed to RAN2.*

*Open issues and candidate options before meeting:*

* Proposals
  + Option 1: With conclusion on conformance test points, CBW of aggressor UL and victim DL are not necessary to be included in the essential information for lower MSD capability (Samsung, Spreadtrum, Meta, Xiaomi, HW)
  + Option 2: CBW of aggressor UL and victim DL should be reported, but it is fine to wait for RAN5’s feedback (ZTE)
  + Option 3: It’s suggested to report MSD values for the aggressor and victim CBW that are configured by network rather than the CBW combinations only for testing points. UE could only report capability information for several typical CBW combinations that are used by commercial network rather than all CBW combinations (CMCC)
    - To reduce capability overhead, gNB could query CBW configurations for aggressor and victim carrier and UE reply corresponding MSD
  + Option 4: Include the aggressor UL and victim DL bandwidth information in the lower MSD capability report only when the following conditions are met (CHTTL)
    - The referred MSD test configuration for the lower MSD is not aligned with the worst case scenario of the supported channel bandwidths of the UE. (i.e. the worst case scenario cannot be assumed.)
    - If the UE does not provide the aggressor UL and victim DL bandwidth information, it means that following conditions are assumed by default.
    - The aggressor UL and victim DL bandwidth is the minimum supported bandwidth of the corresponding band by the UE in the MSD report for the harmonic, harmonic mixing and the IMD.
    - The aggressor UL is the maximum supported bandwidth of the corresponding band by the UE in the MSD report for the cross band isolation.
    - The victim DL bandwidth is the minimum supported bandwidth of the corresponding band by the UE in the MSD report for the cross band isolation.
* Recommended WF
  + TBA

### Sub-topic 1-7: Signaling overhead reduction

*Sub-topic description*

*Open issues and candidate options before meeting:*

* Proposals
  + Option 1: Consider a following lower MSD capability filterization as one possible approach (Nokia).
    - Conveying actually available frequency ranges per band under a network to a UE

Note that even now network conveys available bands under the network as filterizaiton

* + - UE reports only relevant lower MSD capabilities relevant to the network
  + Option 2: For the benefit of reducing signalling overhead, consider to introduce special MSD types, such as ALL, ALL\_BUT\_2nd\_ORDER, to enable the UE to report the same MSD value for multiple normal MSD types (i.e. harmonic, harmonic mixing, cross-band, IMD, etc) in one instance (HW)
  + Option 3: Report the MSD value for the power class requested by the network, otherwise for the highest power class supported by the UE (HW)
  + Option 4: to reduce MSD capability overhead, one solution is to allow gNB query UE capability and UE only report certain capability filtered by gNB’s query information. Query information could include following information, e.g. band combinations, power class, Tx power, aggressor and victim CBW, victim operation band (CMCC)
  + Option 5: An adaptive signaling approach that network can require UE only to report the top K largest MSD values together with its mechanism indexing and improved MSD values can save large amount of signaling overhead (MediaTek)
* Recommended WF
  + TBA

### Sub-topic 1-8: Other approaches for lower MSD capability reporting

*Sub-topic description*

*Open issues and candidate options before meeting:*

* Proposals
  + Option 1: Single-bit low-MSD indicator for a UE is proposed to do more study and considered (vivo)
  + Option 2: Discuss whether the 2Rx/4Rx indication for the DL victim band is needed in the lower MSD capability report (CHTTL)
  + Option 3: Further consider a joint solution to allow a one bit low MSD indication per BC to potentially reduce the signalling overhead. This indication can be used when all MSD types for this BC have been improved to above a threshold. Details can be further discussed (CHTTL)
  + Option 4: it’s suggested to report additional information to show under which Tx power, all the MSD would be negligible, e.g. less than 3dB or 5dB. gNB could use this information for final UE scheduling algorithm or deciding final UE Tx power (CMCC)
* Recommended WF
  + TBA

# Topic #2: UE RF requirements for Lower MSD

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

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| [**R4-2308122**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308122.zip) | Views on UE RF requirements for lower MSD | Samsung | ***Observation 1:*** *Explicit Lower MSD capability thresholds should be predefined in both RAN2 and RAN4 spec.*  ***Observation 2:*** *The condition to derive and verify lower MSD capability should be made clear in RAN4 spec.* |
| [**R4-2309436**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309436.zip) | Discussion on the CBW and 4Rx support in the Lower MSD capability | CHTTL | ***Proposal 1:*** *The following aspect should be considered when defining the MSD requirements.*  *- For NR CA, at least one of the test configurations should be compatible with all of the BCS.*  *- For EN-DC and NE-DC, at least one of the test configurations should be compatible with the mandatory channel bandwidth of each band.* |

## Open issues summary

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

### Sub-topic 2-1

*Sub-topic description:*

*Open issues and candidate options before meeting:*

#### **Issue 2-1: Requirements reflected in the specs**

* Proposals
  + Proposal 1: Explicit Lower MSD capability thresholds should be predefined in both RAN2 and RAN4 spec (Samsung)
  + Proposal 2: The condition to derive and verify lower MSD capability should be made clear in RAN4 spec (Samsung)
* Recommended WF
  + TBA, relevant to discussion in Topic#1

#### **Issue 2-2: Test configurations for NR CA and MR-DC**

* Proposals
  + Proposal 1: The following aspect should be considered when defining the MSD requirements (CHTTL)
    - For NR CA, at least one of the test configurations should be compatible with all of the BCS.
    - For EN-DC and NE-DC, at least one of the test configurations should be compatible with the mandatory channel bandwidth of each band
* Recommended WF
  + TBA

# Topic #3: TPs for TR 38.881

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

## Companies’ contributions summary

|  |  |  |  |
| --- | --- | --- | --- |
| **T-doc number** | **T-doc name** | **Company** | **Proposals / Observations** |
| R4-2307145 | TR 38.881 v0.5.0 | Huawei, HiSilicon |  |
| [**R4-2307089**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2307089.zip) | TP for TR 38.881 update of MSD 0 dB region approach | Nokia, Nokia Shanghai Bell |  |
| [**R4-2308926**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308926.zip) | TP for TR 38.881 on the signalling design for low-MSD capability | MediaTek Inc. |  |

## Open issues summary

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

### Sub-topic 3-1: TR 38.881 v0.5.0

*Sub-topic description:*

*Open issues and candidate options before meeting:*

* Recommended WF
  + Return to

### Sub-topic 3-2: TPs for TR

#### **Issue 3-2-1: TP in R4-2307089 (Nokia)**

* Recommended WF
  + TBA, relevant to discussion in Topic#1

#### **Issue 3-2-2: TP in R4-2308926 (MediaTek)**

* Recommended WF
  + TBA, relevant to discussion in Topic#1