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

**Incheon, South Korea, May 22nd – 26th, 2023**

**Title:** Ad-hoc minutes for lower MSD

**Agenda Item:** 8.5.1.3

**Source:** Huawei, HiSilicon

**Document for:** Approval

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

### Sub-topic 1-1: Conditions to indicate the lower MSD capability

* Candidate options
	+ 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
	+ 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
* Discussion
* Agreement

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

* Candidate options
	+ 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
	+ Option 3. The UE declares the MSD class per MSD types it supports for the highest supported power class
* Discussion

Samsung: support option 3

* Agreement

The UE reports the MSD class per MSD types for the highest supported power class for the band combination

* UE can additionally report lower MSD for other PCs if NW/regulator requested
* Conformance test is only performed for the highest supported power class
	+ Lower MSD reported for lower power class does not need to be tested

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

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

* Candidate options:
	+ 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
	+ Option 1
* Discussion

Meta: since it is optional, why we have the limitation, support option 3

Skyworks: only two cases in the spec.

Samsung: agree with Sky, if lower order is improved so do the high order. Suggest option 1.

Only case for CA\_n5-n77, could put a note for some clarification if company do have concern

Huawei: only one special case, 11 types should be reported, too many

OPPO: Option 1

CHTTL: if UE report harmonic order, better for NR scheduling.

* Agreement
* No need to report order for harmonic/ harmonic mixing/cross band isolation
	+ Lower MSD capability class reported apply for all specified orders

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

* Candidate options:
	+ 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
	+ IMD order up to 5 as starting point
* Discussion

HW: clarification for IMD 7/9, how about if power class is PC2 or PC1.5

Skyworks: intra-band CA IMD would not be changed for higher power class, also considering the MPR/A-MPR for the corresponding PC

AT&T: for intra band case, IMD is very low

* Agreement
	+ IMD order up to 5 in Rel-18

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

* + 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
* Discussion

Samsung: add new MSD type “ALL”, reserve some MSD type for future proof

 All refer to the MSD threshold table.

Nokia: bits seems RAN2 scope

Meta: in Rel-18 we only have certain MSD types, why new MSD type

Vivo: for “ALL” type, does it means all MSD types can comply with the thresholds. Direction could be good, details need more discussion; MSD types number

E//: is it the intention UE to reported all MSD types for a band combination, concern on the overhead, how NW use the capability

 HW: some solutions proposed to reduce the overhead. Better to have NW enquiry

AT&T: if not report, it could means the threshold apply to all types

* Agreement
* New MSD types may be added later
* Inform RAN2 the MSD types/order agreed to be reported based on existing spec
	+ Harmonic, harmonic mixing, crossband isolation, IMD 2, 3, 4, 5
* Add a new special lower MSD type as “ALL”
	+ FFS on detail of “ALL” type

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

* + 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)
* Discussion
* Agreement

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

* Candidate options:
	+ 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: Others
* Agreement on Tuesday online session
	+ The maximum threshold is around 20dB
		- FFS on the concrete values for thresholds
		- FFS on whether 2 or 3 bits will be used for threshold range.
* Recommended WF
	+ Adopt the Table in Option 1 as details for the FFS issues
* Discussion
* Agreement

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

* Candidate options:
	+ 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
	+ Use option 1a as starting point to consider the test configurations
		- The solution can also be used for existing MSD requirements
* Discussion
* Agreement

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

* Candidate options:
	+ 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
	+ Option 1
* Discussion
* Agreement

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

* Candidate options:
	+ 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
	+ Discuss possible solutions based on option 2 and option 4. Others are not precluded if helpful to reduce the overhead.
* Discussion
* Agreement

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

* Candidate options:
	+ 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)
* Discussion
* Agreement