**3GPP TSG-RAN WG4 Meeting #96-e R4-201xxxx**

**Electronic Meeting, August 17th – 28th 2020**

**Agenda item:** 7.1.2

**Source:** Moderator (Qualcomm Incorporated)

**Title:** Email discussion summary for RAN4#96e\_#107\_NR\_unlic\_UE\_RF

**Document for:** Information

# Introduction

This document summarizes the email discussion on topics related to NR-U UE RF requirements in Agenda 7.1.2, 7.1.2.1, and 7.1.2.2. Additionally, contributions R4-2009934, R4-2010671, and R4-2011330 from Agenda 7.1.1.3 are treated in this document. Contributions are loosely divided between Tx and Rx requirements.

# Topic #1: Tx requirements

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2010585**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010585.zip) | MediaTek Inc. | Architecture discussion for NRU 6GHz  Proposal 1: There’s no existing component for the new 6GHz band. RAN4 shall collect more component data for evaluating requirements for the new band  Proposal 2: RAN4 shall allow two-path implementation and specify requirements accordingly for the new 6GHz band. |
| [**R4-2009942**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2009942.zip) | Apple Inc. | NR-U MPR for PC5  Proposal: Define MPR for NR-U Single Carrier according to Table2. |
| [**R4-2010273**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010273.zip) | Skyworks Solutions Inc. | [NRU] UE TX measurements and requirements for MPR and A-MPR  TP Proposal on PC5 MPR table  Proposal on A-MPR for fully allocated sub-bands  Proposal on A-MPR for punctured sub-bands  Proposal for AMPR for NS28: Split should be based on contiguous / interlace RB and inner/outer positions  Proposal for AMPR for NS29: inner channels can use MPR  Proposal for AMPR for NS30: Split should be based on contiguous / interlace RB and inner/outer positions  Proposal for AMPR for NS31: Split should be based on contiguous / interlace RB and inner/outer positions  Proposal for AMPR for NS53: Split should be based on contiguous / interlace RB and scale with bandwidth. CP-OFDM and DFT-s-OFDM QPSK have the same A-MPR:  Proposal for AMPR for NS54: Split should be based on contiguous / interlace RB and inner/outer positions |
| [**R4-2010344**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010344.zip) | Ericsson | Additional TX requirements for NR-U operation  Proposal 1: the new NR CA bandwidth classes to allow intra-band contiguous CA for NR-U in multiples of 20 MHz and wider bandwidths are defined as follows …  Proposal 2: the transients of the general NR-U time mask should be fushed fully or partially into the slot (leading and traling edge of the transmission burst). |
| [**R4-2010497**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010497.zip) | Huawei, HiSilicon | Discussion on NR-U UE ACLR and MPR evaluation  Proposal 1: ACLR for PC3 in NR-U should be specified to 28dB.  Proposal 2: Based on our study, we propose to update the MPR proposal as below. |
| [**R4-2010586**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010586.zip) | MediaTek Inc. | Transmitter requirements consideration for NRU 6GHz  Proposal 1: RAN4 shall not apply NR-U 5GHz transmitter requirements directly to NR-U 6GHz band without further characterization. Both n96 and n97 need to be characterized to see if general MPR can be applied or band specific MPR shall be applied individually.  Proposal 2: To have optimized transmitter performance, we propose to specify two PC3 MPR requirements with capability signalling based on PA configurations. |
| [**R4-2011344**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2011344.zip) | Qualcomm Incorporated | Simulation results for NR-U bands n46 and n96  A-MPR simulation results for NS\_28, NS\_29, NS\_30, NS\_31, NS\_53, and NS\_54 |
| [**R4-2011345**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2011345.zip) | Qualcomm Incorporated | Remaining UE RF requirements for stand-alone single carrier NR-U  Proposals are captured in CR R4-2011347 |
| [**R4-2009934**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2009934.zip) | Apple Inc. | NR-U CA BW Classes  Proposal 1: The new NR-U specific CA BW classes are defined as in the following table.  Proposal 2: Add the support of fallback group “3” to BW classes D and E. |
| [**R4-2010671**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010671.zip) | MediaTek Inc. | Discussion and TP for further clarification of NR-U BW Class requirements and intra-band contiguous CA with LBT failure  Proposal 1: Equations of Note 1 should be added in table of NR-U CA BW classes.  Proposal 2: As for NR-U CCA BW classes M, N and O with LBT failure, to add the equations of Note 2 in NR-U BW class table.  Proposal 3: RAN4 needs to think whether RF requirements are needed about NR-U CCA with LBT failure due to in-channel interferer.  Proposal 4: if RF requirements are needed, in-channel ACS level of NR-U intra-band CCA with LBT failure shall be different and relaxed with respect to ACS level of intra-band CCA without LBT failure.  Proposal 5: If RF requirements are needed, when interferer is in intra-band CCA guard band, the additional margin for sensitivity degradation is needed with respect to intra-band CCA without in-channel interferer but with adjacent out-of-channel ACS1 interferer. |
| [**R4-2011330**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2011330.zip) | Skyworks Solutions Inc. | [NRU] LO Leakage Exception Issue and NRU Mask Measurement Procedure  Proposal:  • NRU mask measurement procedure shall be immune to in-band LO leakage issue at all power level  • Proper cancellation of LO leakage without reduction of the wanted signal shall be studied to instruct RAN5 and potentially amend the mask measurement bandwidth and LO leakage exception requirements in 38.101-1 specification  • Use of the signaled LO position is probably necessary |

## Open issues summary

### 6 GHz band requirements

MediaTek questions whether the MPR so far studied can be applied to 6 GHz band since the 6 GHz PA characteristic may differ. The suggestion is to study further and perhaps consider a band-specific MPR. On the other hand, Skyworks has provided A-MPR measurements with a prototype PA that partially covers the 6 GHz band for NS\_53 and NS\_54. According to Skyworks this PA is representative of the design target for a 6 GHz PA product and consistent with 6 GHz WiFi PA targets. Since the spurious emission requirements are measured at specific frequencies across within the 6 GHz band with the PA, the expected performance characteristics of the 6 GHz PA are directly reflected in the provided measurements.

The moderator suggests that studies have already included expected characteristics of the 6 GHz frequency range and therefore the derived MPR can be band-agnostic as it always has. Is this agreeable?

MediaTek further proposes that the requirements are to be derived assuming a split front-end, but does not elaborate on how this would impact the specifications. No implementation whether wide-band or split is precluded so long as the requirements can be met. It would be beneficial if MediaTek can provide specific changes and/or proposals with justification to requirements for companies to consider for split front-end architecture.

### Baseline MPR

MPR has already been tentatively agreed at the last meeting. For this meeting, new simulation results are provided from Apple and Huawei, and additional measurements from Skyworks. A summary of results including those presented previously in RAN4 #95-e is provided below.



Values which are adjusted compared to the agreement in the last meeting are shaded. It can be seen that the changes relate to 64QAM and 256QAM modulations where Qualcomm and Apple have provided simulation results and where Skyworks provided measurements for two 256QAM waveforms. Skyworks measured two waveforms with 256QAM modulation and concluded based on these that there is high margin in the tentatively agreed MPR value based on PA only. However, Skyworks writes that ”NR+0.5 dB seems valid” (which is the RAN4 #95-e tentative agreement for 256QAM). Therefore, leaving the 256QAM according to the RAN4 #95-e agreement, the only potential change is 0.5 dB for 64QAM with partial allocation.

Moderator asks companies to consider two alternatives

1. Stay with the tentatively agreed MPR from RAN4 #95-e, remove the square brackets
2. Adopt the new MPR shown above for 64QAM only (the 256QAM change is not adopted)

It is understood that agreeing to this MPR may have some dependency on whether wideband MPR adjustment in section 1.2.3 can be agreed.

### Applicability to wideband with partial sub-band allocation

In addition to the baseline table, Skyworks observes that for wideband operation where ACLR and IQ image overlap with partially scheduled sub-bands

* + 1dB additional back-off is needed for DFT-s-OFDM
  + 0.5dB additional back-off is needed for CP-OFDM

The proposal to incorporate (partially) the additional backoff is to define an MPR mapping table that indicates whether Full or Partial MPR should be taken for the sub-band configurations listed.

Moderator requests input from other companies on whether they agree with the need for additional backoff where ACLR and IQ image overlap in a partial sub-band configuration for a wideband channel and whether the approach proposed by Skyworks for using Partial MPR in this case is acceptable.

### Pi/2-BPSK MPR

Proposals from Apple, Qualcomm, and Skyworks. Are any of these acceptable or shall we leave Pi/2-BPSK MPR as TBD or omit entirely?

### NR waveform (non-interlaced) MPR

Proposals from Qualcomm and Skyworks. Are either of these acceptable or shall we leave NR MPR as TBD? Note that there is presently no capability indicator for the UE to say that it does not support the NR waveform. Therefore, the NR waveform is mandatory, so omitting it entirely may not be an option. Note also that A-MPR would also need to be specified.

### A-MPR for PC5

Comprehensive proposal from Qualcomm for all A-MPR tables. Skyworks provides a large number of discrete proposals and observations, but not a comprehensive A-MPR table proposal so it is difficult to envision and evaluate how the Skyworks would be implemented in the specification. The results between Qualcomm and Skyworks are very similar.

Can companies either agree with the Qualcomm proposal or provide a similar comprehensive A-MPR proposal in a format that can be implemented in the specification (a draft CR perhaps or a red-lined edit to the Qualcomm tables)?

### Power class 3 requirements

Limited discussion on power class 3 requirements with a proposed ACLR of 28 dB from Huawei and a limited set of measurements from Skyworks. MediaTek proposes to have two sets of MPR requirements depending on the signaled PA configuration/capability. On the other hand, there is a proposal in R4-2009901 (treated in thread 106) that PC3 should not be defined in Rel-16.

Moderator recommends further discussion on technical requirements for PC3 should wait for the conclusion of that proposal in thread 106.

### Intra-band CA bandwidth class definition

Ericsson proposes to agree on the intra-band CA bandwidth classes M, N, and O according to

class “M”: 50 MHz ≤ BWChannel\_CA ≤ 180 MHz, number of contiguous CC = 3

class “N”: 80 MHz ≤ BWChannel\_CA ≤ 240 MHz, number of contiguous CC = 4

class “O”: 100 MHz ≤ BWChannel\_CA ≤ 300 MHz, number of contiguous CC = 5.

However, Apple proposes a different upper limit on bandwidth to enable coverage of configurations including 80 MHz channels.

|  |  |  |
| --- | --- | --- |
| BW Class | Aggregated BW | No. of CC |
| M | 50 MHz ≤ BWChannel\_CA ≤ 200 MHz | 3 |
| N | 80 MHz ≤ BWChannel\_CA ≤ 300 MHz | 4 |
| O | 100 MHz ≤ BWChannel\_CA ≤ 400 MHz | 5 |

Lastly, MediaTek in R4-2010671 proposes additional clarification to the definition of intra-band bandwidth classes with respect to number of CC’s, especially in the event of LBT failure whereby one of the CC’s cannot be scheduled and/or transmitted.

Is the modification of the maximum aggregated bandwidth per bandwidth class proposed by Apple acceptable? Or what was the reason 80 MHz is excluded from these bandwidth classes?

The changes proposed by MediaTek seem to be more fundamental. MediaTek asserts that the new bandwidth classes are ”used for dealing CCA LBT failure and coexistence” and suggests broadening the definition of CA bandwidth classes M, N, and O to include the case when one carrier fails LBT and therefore is not to be used for transmission and/or reception. Any comments?

### ON/OFF time mask

On the ON/OFF time mask, both Qualcomm and Ericsson propose the leading edge transient is 15us, with 5us before the start of the CP and 10us inside the start of transmission. For the trailing edge, Qualcomm proposes to place the entire 10us transient after the transmission, but Ericsson proposes to place the 10us transient halfway at the end of the transmission so that 5us is within the end of the transmission and 5us is after the transmission.

Moderator proposes to accept 15us leading edge transient (5us before transmission + 10us after transmission start) and 10us trailing edge transient (5us before the end of the transmission + 5us after the end of the transmission). Are there any objections to this proposal for general ON/OFF mask?

### Other Tx requirements

Other Tx requirements in R4-2011345 from Qualcomm have no dissenting views. Moderator proposes that they are agreeable. Are there any objections?

### Tx mask and LO exception

Skyworks observes that at the specified level the LO has the potential to distort the NR-U mask measurement since it can skew the 0 dBr in-band PSD reference value. At the same time, excluding up to 2 MHz of the in-band measurement for the LO removes too much of the in-band signal. Skyworks proposes therefore to cancel the LO before measuring the NR-U SEM mask.

Do companies agree that the LO exception currently 2 MHz needs revision? Can Skyworks provide a specific text proposal for the CR for companies to check if it is needed to amend the mask measurement bandwidth and LO leakage exception requirements in 38.101-1 specification?

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Charter Communications, Inc. | Sub topic 1-2-1: 6 GHz band requirements We agree with moderator that studies have included characteristics of the 6 GHz frequency range and derived MPR’s are band agnostics. We also checked with RF/FE vendors and concur that specification requirements shall be independent of implementation. Sub topic 1-2-2: Baseline MPR We agree with the proposal of staying with agreed MPR values from RAN4#95e  Sub topic 1-2-3: Applicability to wideband with partial sub-band allocation  We don’t have a strong opinion on applicability to wideband with partial sub-band allocation but tend to agree with Skyworks’s approach and proposal. Sub topic 1-2-6: A-MPR for PC5 Charter Communications would agree to average out results from Qualcomm and Skyworks to determine PC5 A-MPR. Sub topic 1-2-7: Power class 3 requirements We will like to have PC3 included in Rel 16 and we are flexible for having two sets of MPR’s Sub topic 1-2-8: Intra-band CA bandwidth class definition Charter Communications does not have a strong opinion but believe Apple’s proposal makes sense and it is acceptable to us. Sub topic 1-2-10: Other Tx requirements Agree |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Recommendations on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |
| [**R4-2010740**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010740.zip) | CR to TS 37.106 with introduction of NR-U feature (Nokia)  Comment from Charter Communications, Inc. : We agree with the content of this CR |
| [**R4-2010345**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010345.zip) | Introduction of additional TX requirements for NR-U operation (Ericsson)  Comment from Charter Communications, Inc. : We agree with the content of this CR |
| [**R4-2011347**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2011347.zip) | Introduction of NR-based access to unlicensed spectrum (Qualcomm Incorporated, Nokia)  Comment from Charter Communications, Inc. : We agreed with content of this CR but will like to request a revision to remove [ ] from Table 7.3F.5.2-1 MSD for cross band isolation |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Topic #2: Rx requirements

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

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2009966**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2009966.zip) | Apple Inc. | ACS requirement for NR-U  Proposal 1: NR-U ACS level values for single carrier shall be defined as in Table 2. (Baseline value for 20 MHz is 23 dB)  Proposal 2: RAN4 shall define the ACS requirements for intra-band contiguous CA as provided in Table 3 and Table 4. |
| [**R4-2010346**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010346.zip) | Ericsson | Additional RX requirements for NR-U operation  Proposal 1: an n\*20 MHz channel bandwidth of a wideband carrier shall have consistent requirements with (or when applicable the same as) an intra-band CA configuration of “n” contiguous 20 MHz CCs (CA BW Classes M, N and O).  Proposal 2: ACS should be in the range [24-27] dB (20 MHz interferer- and wanted signal bandwidth) to maintain an ACIR of the same order to ensure compatibility between NR-U operations in adjacent channels.  Proposal 3: the interferer profile for out-of-band blocking specified for LTE CA and eLAA is reused for NR-U NSA operation. |
| [**R4-2010496**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010496.zip) | Huawei, HiSilicon | Discussion on NR-U UE ACS  Proposal 1: ACS for NR-U UE is 27 dB for 20 MHz channel BW.  Proposal 2: Case 2 ACS is not specified. |

## Open issues summary

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

### ACS value

ACS value continues to be debated with a proposal from Apple for 23 dB baseline, from Huawei for 27 dB, and from Ericsson for 24 - 27 dB.

The moderator proposes to accept a compromise value of 24 dB for the 20 MHz baseline. Which companies CANNOT accept this compromise for the sake of moving on?

### Intra-band CA

ACS and out-of-band blocking proposals for intra-band CA from Apple and Ericsson. Values should be based on agreement for the baseline 20 MHz and scaled to bandwidth.

For out-of-band blocking, we already have agreement from the last meeting (not in square brackets in R4-2009175). Unless there is consensus that an error needs to be corrected, the moderator would suggest that companies focus their attention to specs that need to be completed yet, rather than to revisit previous agreements. With this in mind, the proposal for blocking in R4-2010346 is described for NSA operation; yet, the corresponding edits to the CR in R4-2010347 seek to modify already agreed clauses for SA. Unless there is an error in the previous agreement for SA, the moderator understands the intention is for NSA and suggests to revise the proposal in R4-2010347 accordingly. Companies can then consider the proposal for NSA. If this is correct, can we receive comments for NSA blocking interference profile proposal?

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Charter Communications, Inc. | Sub topic 2-2-1: ACS value We agree with moderator’s proposal to accept compromise value of 24 dB for 20 MHz baseline |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

|  |  |
| --- | --- |
|  | **Status summary** |
| **Sub-topic#1** | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:* |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 |  |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provided recommendation on CRs/TPs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
| XXX | *Based on 1st round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |
| [**R4-2010347**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2010347.zip) | Introduction of additional RX requirements for NR-U operation (Ericsson) |
| [**R4-2011346**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2011346.zip) | Introduction of NR-based access to unlicensed spectrum (Qualcomm)  Comment from Charter Communications, Inc. : We agreed with content of this CR but will like to request a revision to remove [ ] from Table 7.3F.5.2-1 MSD for cross band isolation |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

|  |  |
| --- | --- |
| **CR/TP/LS/WF number** | **T-doc Status update recommendation** |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |