**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:** Post-meeting email discussion summary for RAN4#96e\_#107\_NR\_unlic\_UE\_RF

**Document for:** Information

# Introduction

Email discussion of NR-U UE RF requirements is summarized in [1] for RAN4 #96-e. At the conclusion of the RAN4 #96-e meeting, a CR [2] was presented in response to comments received during the meeting. The RAN4 chairman has allotted a one-week email approval process for the CR to be concluded by 5pm UTC September 4. This document summarizes comments received during the post-meeting email discussion.

# Email discussion

There is strong desire and passion to complete the NR-U work. Therefore, the following NR-U UE tdocs are for email approval by 5pm UTC Sept. 4.

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| R4-2011943 | Introduction of NR-based access to unlicensed spectrum | Qualcomm Incorporated, Nokia |

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| **Company** | **Comments** |
| MediaTek | MediaTek cannot agree on this revision on 7.3F.2 REFSENS for n96 since our concerns are not addressed, the values are still copy from those of n46.  We've provided our proposal in the moderator summary report during 2nd round. |
| Charter Communications Inc | To Mediatek, question: if the values are change to your proposal but we leave them in [ ] for further confirmation by other companies, would this be acceptable? |
| Huawei | Comments applicable to BS and UE CR: there is no agreement on channelization. It should be further discussed especially after hearing the comments at Aug.27 GTW that proponents of option 2 (adopted in previous CR) emphasis option 2 is the best choice considering current status of uncertainty of IEEE draft standard. We may need the decision based on 3GPP study or have some coordination with IEEE to minimize the risk on the misalignment between NR-U and WIFI. The SU for 20 MHz with 60 KHz SCS is TBD for both single carrier case and wideband operation case. It is not acceptable since we had an agreement long time ago (R4-1910537) that 25 PRB should be adopted.  Comments specific to UE CR: For the reference sensitivity of 6GHz band, as we comment before, we believe the UE reference architecture should be selected firstly and then the insertion loss data must be provided before REFSENS can be given. We prefer MTK’s approach. And if there is some update on channelization, the A-MPR for 6 GHz band should be re-evaluated. New simulation or measurements are needed. There are lots of updates in the CR, which were new and provided in the last minute of RAN4#96e. We would like to take more time for review and will come back later. |
| AT&T | We support the Nokia CR draft revision R4-2011701. However, we also can support Charter’s suggestion to make progress on the work and to allow time for companies to confirm the values while also allowing for the band definition in Rel-16. We note that front-end and filter vendors have commented on the GTWs that the front-end insertion loss is similar to 5 GHz band with existing solutions, but we can support the compromise proposal.  Concerning channelization and any impact to related requirements, the following was agreed at the 27 Aug GTW.  “If there is updates from IEEE/WiFi Alliance, the channelization and related requirements should be further updated.”  This should allow for future revisions to align with any outcome from IEEE, if RAN4 determines that the revisions are necessary. As mentioned on the GTW, 3GPP RAN4 should not have to arbitrarily wait for IEEE to include n96 in the Rel-16 specification. |
| Intel | We cannot accept the CR as written because it does not include the previous SU agreement for 20 MHz CBW with 60 kHz SCS. It should be included in the revised CR. We echo Huawei’s comment on this issue. Upon this revision, we would be fine.  Regarding 6 GHz REFSENS, we propose as a compromise that the values to be TBD or in square brackets, and RAN4 takes more time to discuss this issue under Rel-16 maintenance. |
| LG Electronics | On channelization: as stated above by AT&T and discussed in GTW we think that further updates when proven necessary are normal way of working in 3GPP and RAN4 and in this case this would be well justified to achieve better and fair co-existence with other technologies within the same band.  On REFSENS: We can accept the proposed values, but leaving the square brackets to allow more time to study this topic is also OK. |
| Ericsson | The CR should be revised.  Clause 5.2: the note should read “this band is *intended* for operations subject to FCC NPRM R&O” as agreed during the GTW.  Clause 5.3.3: shall be as proposed in R4-2010345 to make clear the GB and RB sets applicable also for the 20 MHz channel bandwidth. This was agreed during the first round also by the company raising concerns with the proposed changes (which were in fact agreed at RAN4#95-e but not implemented in the running CR). The 38.331 will refer to the 38.101-1 for the intra-cell GB configuration so important that all bandwidths are covered (10 MHz is only CA). It should also be made clear that intra-cell GBs can only be configured for shared spectrum channel access.  In general: the NR-U requirements are specified under a suffix F (additional requirements), but the general requirements (without suffix) still apply unless band specific. Therefore, the e.g. the general ON-OFF time masks, power control, maximum input power and ACS also apply for n46 and n96. The most stringent, the general or the additional, applies (see clause 4.2). This can be addressed in each relevant sub-clause or by a general statement.  A comment of sub-clause 5.3A.5: no additional notes are needed for M, N and O, the aggregated CA bandwidth is the configured CA bandwidth. In licensed bands a case similar to an LBT failure occurs for intra-band contiguous CA when one of the Scells is not scheduled or deactivated.  Clause 6.3F.3 transmit ON/OFF time mask: the general mask applies for “transmissions”. Unclear if this also includes PRACH and SRS. PRACH should also have its leading transient partly inside the first PRACH symbol to prevent ramping in the preceding sensing slot (CAT4 LBT). The PRACH ON power measurement periods affected. This clause is not complete.  Clause 6.4F.2.3: the RIV should be corrected for IBE for both the LO leakage and IQ suppression (could be maintenance)  A comment on Clause 7.1 and requirement for the wanted channels assigned in or overlapping with 5350-5470 MHz, the would be no wanted channels in the gap by means of the reduced channel raster as pointed out by the rapporteur. We assume that the IBB requirements (interferer range in the gap) also apply in the gap.  Sub-clause 7.6F.2 In-band blocking, table 7.6F.2.1-1: missing info on RMC for interferer and also TX power (recognizing that there is no simultaneous TX and RX)  Clause 7.6F.3: the IBB range is not extended to 3\*CHBW outside the band (the offset for Case 2 is incorrect). Why change the IBB range? Easier to add a range 1 with a -44 dBm interferer in OOBB test (could be maintenance).  OOBB requirements missing for CA\_n46-n48 (NSA operation).  Sub-clause 7.6F.4 Narrow band blocking: This sub-clause can be removed, no need to state that requirements do not apply (nether do the general NBB requirements, these do not contain n46 and n96)  The RMC: for the DL, the minimum requirements apply for Mode 1 with zero size GB (not configured) and are not dependent on the FG 4-2 that only applies for Mode 2 and Mode 3. For the UL the requirements could be subject to FG (UL Case 2a/2b/3/4).  To sum up:  The clauses 5.2 and 5.3.3 should be revised at the very minimum. The specification is not complete. |
| Charter Communications, Inc | We did not make clear in our first statement that we agree with the CR. We also agree with AT&T and LG regarding the channelization statement at the Aug 27 GTW, “If there is updates from IEEE/WiFi Alliance, the channelization and related requirements should be further updated.”  With regards to Mediatek reference sensitivity comments, I will like to further comment that it appears that multiple companies have values in mind and perhaps some kind of averaging value might be reached as a compromise.  Lastly, we are open to a revision to clean up some of the items highlighted by Ericsson. |
| Skyworks | MediaTek proposal for REFSENS is 2.6dB higher for n96 vs n46, this is not acceptable to us nor justified technically. We still believe that n96 REFSENS is equivalent to n46 and our WiFi products performance supports this. As a reminder: **IEEE did not differentiate REFSENS for 5GHz and 6GHz with full bands assumption (5GHz UNII1-4 and 6GHz UNII5-8)**  Some companies keep discussing of absolute frequency but in reality only relative frequence and fractional bandwidth are of importance to judge differences between bands. As a reference here is the comparison of bands above 3GHz   |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | band | Flow | Fhigh | frac BW | BW ext  vs | 20MHz@15kHz REFSENS | | n77 | 3300 | 4200 | 24% | 11% vs n78 | -92.2 | | n78 | 3300 | 3800 | 14% |  | -92.7 | | n79 | 4400 | 5000 | 13% | 19% vs n77 | -92.9 (scalled from 40MHz) | | n46 | 5150 | 5925 | 14% | 19% vs n79 | -89.7 | | n96 | 5925 | 7125 | 18% | 20% vs n46 | [-89.7] (MTK: -87.1) |   From this we can observe:   * that n46, n96 have similar fractional bandwidth than n78/n79, n77 with >20% BW has a 0.5dB handicap vs n78 due to BW but note that this is only for frequencies >3800MHz * **n46 REFSENS is already >3dB higher than n79 at 20MHz equivalent** * n96 BW extension vs n46 is similar than n79 vs n77 or n46 vs n79 at 20%. so there is no technological step here for switches, filters, PAs or LNAs. In this case n79 is only 0.2dB higher than n78 with >20% frequency extension. Also with that 20% increase, so there is no technological step here for switches, filters, PAs or LNAs.   Some of the claimed difference between n96 and n46 is related to attenuation requirement in band n77 but again this would affects n46 more than n96 and should not be accounted for in the stand-alone REFSENS (we have already said that we are open to discuss relaxation in the scope of CA/DC that would affect n46 more as there is only ~1GHz distance to n77 for n46 vs ~2GHz for n96. Also the >3dB higher REFSENS of n46 already accounts for protection of lower bands as it is already needed for WiFi or LAA concurrent operation.  This shows that a 2.6dB difference between n46 and n96 cannot be justified but we are ready to address extra loss in the context of CA/DC but that again should be equal or smaller for n96 vs n46.  For all these arguments and our current WIFI 5GHz and 6 GHz products performance our position is to maintain REFSENS as proposed in brackets in the CR.  If it needs to be revisited a 0.5dB increase as suggested by some companies is the only reasonable difference that can be justified for the sake of a slightly higher frequency and fractional BW. |
| Qorvo | We support the Skyworks comments above on REFSENS and agree the filter IL requirements should be driven by the standalone case.  Degradations to account for higher implementation losses for certain CA/DC combinations, if any are needed should be covered by the appropriate ΔRIB,c |
| Qualcomm | On reference sensitivity, our understanding remains that the noise figure between 5 GHz and 6 GHz will be substantially the same as demonstrated in our paper. In addition, the NF of the 5 GHz band has already been agreed as 13 dB which is the highest of any 3GPP band and expect to be more than enough to cover any small differences in FE loss between 5 GHz and 6 GHz. For losses due to filtering to enable simultaneous cross-band Tx-Rx, these are covered by DTIB and DRIB for CA not by baseline refsens for SA. The FE loss is the same or even higher for the 5 GHz band so it doesn’t make technical sense that the refsens for 6 GHz would need to be increasd by as much as 2.6 dB. We don’t believe the proposed relaxation of 2.6 dB leading to a value effectively 15.6 dB NF from MTK is technically justified.  On channelization, the revised CR’s under consideration were modified according to the latest understanding of IEEE channelization in 6 GHz. The A-MPR tables were also revised accordingly. For NS\_53 as explained in our paper, the output power is limited by PSD rather than additional spurious emissions. Therefore, the modification to channelization has no effect. For NS\_54, the outer channels are potentially affected by an additional 10 MHz of guard band at the low band edge. This has been reflected by adjusting the outer channel definition. The upper channels are still protected by U-NII-8 so there is no impact. |
| Verizon | Essentially, we continually support CR [2] from both Qualcomm and Nokia and expect the NR-U WID to be closed on time.  For the comments on the REFSENS to n96, we share the same view as Charter and suggest to leave the values in the brackets for further confirmation, in case a censuses cannot be reached in this week. |
| Apple | We have concern for directly reusing n46 REFSENS for n96. Compared to n46, n96 needs to support wider band range and higher carrier frequency where NF degradation is expected. As we commented in 2nd round discussions during the WG meeting, we proposed to add 0.5dB margin to n96 REFSENS as compared to n46.  For A-MPR requirements, thanks to Qualcomm and Skyworks for forging the PC5 A-MPR proposal in the CR during the WG meeting. In our views, the n46 requirements can be stable based on what had been developed for eLAA. However, for n96, we propose to leave the A-MPR numbers in square brackets as the contributions were quite limited and only presented for the first time in this meeting. We need more time to evaluate the n96 A-MPR requirements and come back with our proposal for consideration in October meeting.  We identified some error and typos which should be corrected for the final version:   * Section 6.2F.3.4: Full CP-OFDM for Note2 with 64QAM has only 6.0dB while 16QAM has 6.5dB. Shouldn’t it also be 6.5dB? * Section 6.2F.3.5 refers to NS\_30 instead of NS\_31 in the very first sentence. * Section 6.2F.3.5: Note3 should refer to Note2 instead of Note1. * Section 6.2F.3.5: Partial DFT-s-OFDM for Note3 with 16QAM has only 6.0dB while QPSK has 6.5dB. Shouldn’t it also be 6.5dB?   For the new NR-U CA BW classes M, N, O, though we understand that there was no consensus during the WG meeting discussions as commented by the Moderator, we also do not think by keeping the current definition in the running CR would be agreeable. At least the lower limits for classes M and N should be equated with “≤” instead of only “<”. On the other hand, during the WG meeting discussions, a few companies commented that Apple’s proposal in R4-2009934 makes sense. As we are not sure if the current upper limit definition (n x 60MHz) would represent the majority preference, if companies did not have specific concern nor preference on the upper limits, we would suggest to incorporate Apple’s proposal in the running CR. |
| Nokia | First of all, we would like to make clear that we support this CR.  On channelization: The current proposal is according to GTW agreement: "If there is updates from IEEE/WiFi Alliance, the channelization and related requirements should be further updated" updated as given in R4-2012608. The updated channel and sync raster points to the latest draft 802.11ax – i.e. shift of additional 10 MHz is taking into account (20MHz total), and alignment with Wi-Fi latest draft 802.11ax is achieved.  In general: We believe the introduction of NR-U is important and a great amount of work have been made to come to the content now included in the CR. The willingness of multiple parties to keep values in brackets for further discussion shows that consideration to others with concern is included. Therefor we fail to see the reason for not going forward with this CR and in future meetings focus on settling the remaining values. |
| MediaTek | Regarding n96 REFSENS,  UE architecture and the requirement was firstly discussed in #96-e and filter performance data is also first time provided in this meeting that leaves companies not sufficient time to characterize the requirements. n96 is a brand new spectrum with new high operation frequency in FR1. As UE design complexity gets higher with more and more bands integrated in on UE with limited space, antenna number is also another concern. Just like using multiplexer for CA implementation, NR-U is sharing spectrum with WiFi thus it is natural to share antenna with WiFi. As supporting more and more bands combination, FE loss gets higher with using Xplexer+switch. Though DTIB/DRIB is allowed for CA/SUL/DC combinations, but not allowed in single band requirement. I’m confused though this approach has been adopted for years, it seems not reasonable for single band requirement not allowed to apply DTIB/DRIB since it is not physically possible for UE to bypass Xplexer+switch loss for single band operation and apply Xplexer+switch loss for CA/SUL/DC combination? We may need more discussion and we hope companies can provide views on above questions.  Qualcomm and Skyworks’ FE loss estimation are mainly based on integrated module based solution while there are discrete component FE solutions widely used as we comment in the summary report. There are more PCB trace loss as well as discrete components matching loss than integrated module based solution. Those additional loss shall be considered. With above justifications we believe our proposal is reasonable.  We cannot agree the CR as it is and thanks for Charter’s proposal, we can compromise with taking average of 0, 0.5 and 2.6  1.1dB relaxation than n46. If there’s still no consensus, we would suggest the values to be TBD.  Regarding NR-U CA BW class M, N and O, in 1st round summary report, companies also consider n x 80MHz as the upper limits instead of n x 60MHz for removing restriction. Apple provided further clarification that upper limits also need to be defined without inducing ambiguity w.r.t other BW class. Apple’s proposal about upper limits is the middle way and make sense. As for lower limits, they should be equated with “≤” instead of only “<”. We can accept Apple’s proposal. |
| Samsung | We generally support the CR to be agreed in this meeting given the ongoing works from regulators and market preparations in some countries with following comments.  REFSENS: we agree that the current level of REFSENS in the CR needs more discussions and confidences by companies considering the lack of consensus although the current levels in the CR are in the brackets. For the sake of the completion, we also suggest to have the averaged levels as proposed by Charter and MediaTek by taking the brackets for further study if needed.  Channelization: in our understanding, the alignment with the latest draft 802.11ax is needed as it is anyway our intermediate agreement in the GTW session as mentioned by multiple companies and having such alignment is meaningful for this feature to achieve better co-existence with other technologies. Also, given the IEEE and regulators continue to update the requirement, having the latest channelization and A-MPR is reasonable if it has some room for future revisions in 3GPP. |
| Qualcomm | In response to the questions from MediaTek, in sub-clause 7.3.3 of 38.101-1, the specification states “For a UE supporting CA, SUL or DC band combination, the minimum requirement for reference sensitivity in Table 7.3.2-1 shall be increased by the amount given by ΔRIB,c…” In other words, the DRIB relaxation applies as long as the UE supports CA. It doesn’t need to be configured, or activated, because this is recognition that as long as the UE supports the CA configuration, the hardware and its associated FE loss will be always present. It was never suggested that those FE components are switched out based on configuration (anyways, switches would have losses that might even be more than the incremental loss on the multiplexer!). Sharing antenna or other front-end components with WiFi is not new for 6 GHz; it is the same for 5 GHz, so there is no incremental loss in 6 GHz for this aspect. The same is true for supporting multiple bands and the challenges associated with that; a UE supporting 5 GHz will also have to support multiple band, so this is not new for 6 GHz. |
| Apple | After our last comment we conducted further analysis on A-MPR for n96. Many values in NS\_53 are strongly limited by the -1dBm/MHz requirement. Since this limitation is independent of PA characteristics, we don’t think that the values for 20MHz and 40MHz have to be put in brackets. Since not all values for 60MHz and 80MHz are limited by the PSD requirement, they need further simulations and should be tentative. |
| CHTTL | We support Huawei’s view on the channelization.  And regarding the section 6.5F.3.2, we would like to understand why the requirements are not applicable, also the wording is confusing, need to clarify the stand-alone operation here, whether it refers to the scenario C only, then scenario A is missing?  Table 7.3.2-3 is mentioned in some Rx sections, for example, ACS, blocking, but there is no Table 7.3.2-3 in this CR, probably some of them are referring to another table, suggest to further check. |
| MediaTek | On channelization, we believe some of the sync raster are wrong and they can be further moved even closer to the band edge, e.g., 9576, 9590, 9701, 9715, … .  Also we agree with Huawei that the impact on A-MPR for 6 GHz band may need to be further checked.  Thanks Qualcomm for clarification on DRIB. However in R4-2011344 the RF switch loss seems not considered. Further, the architecture assumption looks like UE sharing RX for n46+n96. We don’t think RAN4 has consensus on sharing RX for the two NR-U bands. If sharing RX is not yet consensus, then we need to consider switch loss for both n46 and n96. On top of that, additional trace loss and on board matching components loss due to n96 higher operation frequency for discrete FE implementation, plus additional system noise figure all need to be taken into consideration. Here I list considerations that have no consensus yet,   1. Architecture assumption: Sharing RX or separate RX for n46/n96?   a-1. Additional switch loss due to separate RX   1. Additional PCB trace loss (discrete FE) due to higher frequency 2. Additional matching components loss (discrete FE) due to higher frequency 3. Additional RFIC receiver noise figure due to higher frequency   So for the WF information page and revised CR, we do not agree taking average with multiple count companies agree with Qualcomm’s proposal into average. We can accept average of 0, 0.5, 2.6 = 1.1dB in square brackets. If companies has no consensus, then it shall put TBD in n96 REFSENS sub clause.  As for UE co-existence in sub clause 6.5F.3.2, since NR-U supports stand-alone operation, this sub clause shall reflect the operation scenarios accordingly. |
| Skyworks | I don’t understand why MediaTek seem to pick and choose which company number can be taken into account, I remind that only Qualcomm and Skyworks had an input on n96 REFSENS at the beginning of the meeting and others did not provide justification before second round. There are companies that have provided technical justification that account for the differences between n96 and n46 but also the fact that n46 is 3dB higher than n79 and will see similar impact from different architecture and implementation options. At this point if averaging is taken from companies that have some technical justification it should at least be from Qualcomm (0dB), Skyworks (0dB), Apple (+0.5dB) and Mediatek (+2.6dB). In this case the average is 0.8dB not 1,1dB.  AMPR for 6GHz is limited by in-band PSD for NS53 and thus does not have dependency on channel position and if any there is now a 20MHz guard band instead of 10MHz, same applies to NS54 that there is a higher guard band and it is proposed to have brackets so verification is possible in the future. |
| Huawei | Thanks moderator for providing the WF. However we can’t agree on the WF given following reasons (similar comments also shared in thread 305).  1. The channelization was updated at the last day of meeting week. It will impact channel raster, sync raster and also A-MPR simulation, which should give more time for study.  2. On SU for 60 kHz, TBD is not acceptable to us since it does not include the previous agreements (R4-1910537). And it seems there is no negative comments on 25 RB SU during post-meeting email approval process.  3. On refsense sensitivity, we support TBD sicne the difference of proposals is too large.  4. The handling of the remaining open issues under maintenance is not preferred.  Specific to the comment from CHTTL on section 6.5F.3.2, we checked with 36.101. Due to there is no stand-alone operation LAA hence there is no UE co-existence for LAA single band but there is the requirement for UE co-existence for CA. In our understanding, since NR-U support stand-alone operation, it should protect coexisted licensed bands. |
| MediaTek | Regarding the CR, we do not agree with the current REFSNS value for n96.  Regarding the 3rd page in the WF, we think it is important to consider that all requirements (system parameter, UE RF , BS RF) as a package.  Therefore, our suggestion is to let RAN Plenary to decide what to do on all remaining issues in the 2nd bullets, e.g., under Rel-16 maintenance, in a further WI extension by 1Q, or others. |
| Charter Communications | For Huawei  I requested clarification under the BS email thread on some of your questions below. I would recopy here  “The channelization was updated at the last day of meeting week. It will impact lots of requirements and also feasibility evaluation which should give some time for study.”  [CC] Can you be specific on what requirements are impacted by the channelization?  On your comment, “And it seems there is no negative comments on 25 RB SU during post-meeting email approval process.”  [CC] We had commented that adding the rb and reducing the guard band can cause potential interference and I believe other companies have commented as well.  Can you clarify your comment further?  Finally, Can you also clarify why handling remaining issues under maintenance is not preferred? What is the problem? |
| Apple | With regards to SU, our reading of the email discussion summary document is that opinions varied a lot. Thus, our understanding is that the WF prepared by Qualcomm reflects correctly SU as one of the open issues. |

# Reference

1. R4-2011847, “Email discussion summary for RAN4#96e\_#107\_NR\_unlic\_UE\_RF,” Moderator (Qualcomm Incorporated)
2. R4-2011943, “Introduction of NR-based access to unlicensed spectrum,” Qualcomm Incorporated, Nokia