**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" \t "_parent)** | 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 |
| Ericsson | Sub-topic 1.2.3:  the MPR is 3 dB or greater for CP-OFDM that for NR bands allows a lower tolerance of 2.5-3.5 dB (PC3 with 2 dB tolerance at peak), for PC5 (3 dB tolerance at peak) perhaps around 4 dB. The increased MPR with ACLR and IQ overlap can perhaps be absorbed by the tolerance (i.e. margin for UE implementation)? This would avoid a complex MPR table.  Sub-topic 1.2.6:  A good effort by Qualcomm and Skyworks. Some of the offsets to the protected bands are not quite the same for wideband channels, some results are for offsets = 20 MHz to the protected bands while others are for offsets = channel bandwidth.  A general comment on A-MPR: for NS\_30 and NS\_31 the unwanted emissions requirements are specified in terms of EIRP per reference BW while the A-MPR derived is relative to the conducted nominal output power. The difference is the in-band antenna gain (to the lowest order). Is this handled by UE implementation?  For NS\_28 regulations allow measurements of the unwanted emissions at the antenna port so requirements and A-MPR allowances are consistent for Europe.  Sub-topic 1.2.8:  we proposed upper limits as n\*60 MHz since 80 MHz combination could be covered by existing CA classes and to avoid BCS due to large aggregated BWs. Upper limits specified as n\*80 MHz is also acceptable if deemed necessary.  Regarding the MTK proposals 1 and 2 in R4-2010671, there is no need to include additional notes. Note 1 follows from the definition of the CA BW classes (but the 10 MHz is missing). Note 2 is not correct: the aggregated BW is the aggregate BW of the configured CCs, not the instantaneous BW that follows from LBT failures or SCells not scheduled or deactivated. The same applies for CA BW classes for NR (LBT failures excepted).  Sub-topic 1.2.9.  Support as proponent.  Sub-topic 1.2.10:  which are the TX requirements added to the agreed running CR in R4-2009175?  Sub-topic 1.2.11: The observation in R4-2011330: for the cases where the wanted power is less than the LO with 1 MHz reference bandwidth, the wanted power is less than -30 dBm/MHz, the absolute limit of the mask. The proposal: is this a problem in practice since there is an absolute requirement of -30 dBm/MHz? If so the 0 dBr level could be measured using 100 kHz resolution bandwidth, the two largest adjacent values at the LO position removed (perhaps even without knowledge of the actual LO position) and then reference level found by integrating over 10 measurements (1 MHz). No need to signal the LO frequency, this could be declared by the vendor for the conformance tests (the exceptions to the mask). |
| Skyworks | 1.2.1 6GHz requirements Our view is that generic UL requirements apply to both n46 and n96 and for PC5 are compatible with capabilities of the technology and aligned with WiFi developments at 5GHz and 6GHz. We recognize the following which is related to the different possible implementations.  From a technology prospective the 6GHz band only extends n46 by 20% thus there is no fundamental technology issue.  For the supported BW: 5GHz band is 14% BW, 6GHz band is 18% BW, 5+6GHz band is 32%, 5GHz + up to 6.425 is 22%. For reference n77 is 24% . So there may be issues for implementations that would try to use a single UL path to support n46+n96 but this no different than the issue of supporting multiple bands with one path. In release 16 we could make the assumption that each band is covered separately and in rel 17 agree on a MPR relaxation for a combined n46+n96 support and associated signaling. Baseline MPR For the sake of simplicity, stay with the tentatively agreed MPR from RAN4 #95-e, remove the square brackets. In our opinion the wideband operation case with contiguous RB allocation should get the full MPR aside from a limited number of image issue cases. Applicability to wideband with partial sub-band allocation Clarification that CP\_OFDM MPR is almost enough for image issue but our measurements show 1dB missing for DFT-s-OFDM Pi/2-BPSK MPR With lower PAPR Pi/2 BPSK MPR should be lower than for QPSK at least for full allocation but we are OK to agree with the higher MPR proposed and clarify it is for unshaped case only. But we’d like to understand is the release 16 low PAPR DMRS have been used. A-MPR for PC5 Skyworks input is very close to QCOM proposed tables for QPSK:  NS 28 QCOM table is acceptable but with 1dB lower MPR for 80MHz channel could be added (lower PSD)  NS\_29: QCOM data seem to point at limitation coming from the mask. Can it be confirmed? There are scenarios for which MPR is sufficient for full  NS\_30: QPSK full (both Note 1 and 2) are very close between QCOM and Skyworks but interlace AMPR is very different. We are OK to accept the table but would like to verify partial cases: are they linked to wideband operation mode (ie image issue) or not?  NS\_31: Assume that QCOM proposed table in linked to -27dBm/MHz limitation (which should then be closer to our values or NS54) or is there some 4dBm/MHz cases (still looks high)  NS\_53: QCOM and Skyworks data seem to have the same trend but 2dB difference: is this related to some extra margin due to power control accuracy? It is clear that 20MHz full has a in-band PSD at Pmax of 7.6dBm/MHz so 9dB MPR should be enough.  NS\_54: agree inner channels can use MPR, our -27dBm/MHz data seem to requires a bit higher back-off.  Other aspects on the AMPR tables:  Handling of wideband operation: QCOM approach is to put all wideband operation cases in the partial column but aside from a very small number of cases the contiguous RB allocations wideband operation can use the full allocation A-MPR  Enabling lower MPR for wider BW may be useful and is partially accounted for in QCOM proposals.  We believe this needs some attention to avoid penalizing all wideband operation cases with the partial MPR number for just a few cases with image issue. We propose this is further studied. Tx mask and LO exception Skyworks will work on a TP which we will try to provide within round 1. |
| Apple | 1.2.2 Baseline MPR We agree to the MPR proposed in RAN4#95-e  1.2.3 Applicability to wideband with partial sub-band allocation  During simulations we observed that the -28dBr is a tight bound with the given simulation settings and easily violated by additional emissions falling into image region. We support the proposal.  1.2.6 A-MPR for PC5  At the moment we are still running simulations. We would like to postpone the decision to 2nd round. 1.2.8 Intra-band CA bandwidth class definition It is not clear to us why the aggregated bandwidth upper limit is capped at n x 60MHz for classes M, N, O in the current running CR. On the other hand, if classes M, N, O aggregated bandwidth upper limit would be capped at n x 60MHz, the combinations such as (80 + 60 + 60) MHz and (80 + 80 + 60 + 60) MHz could not be covered by any of the CA BW classes in FR1.  For R4-2010671, in our view the proposed NOTE 4 and NOTE 5 are not necessary and may create more confusions. NOTE 4 is equivalent to describe the number of contiguous CC for each BW class which is already clearly specified in the table. NOTE 5 seemed to indicate that when a UE is configured to a certain CA BW class, it would stay at that BW class at all time irrespective of the LBT failure on certain 20MHz channels and the number of contiguous CC can be less than what is defined for that class. However, this should not be the situation as CA combination can be a mixture of 20MHz carrier(s) and wideband carrier(s). If LBT failure happens to one of the 20MHz carrier(s), the CA can fall back to a lower order BW class which may have one or more carriers less than the original BW class. In this case, the BW class would be changed. Notice that for contiguous CA with 3 or more CCs, it is not allowed to directly fall back to non-contiguous CA by disengaging non-edge CC(s). On the other hand, if LBT failure happens to a wide-band carrier, the impacted sub-channel within the wide-band carrier would stop transmission which however would not affect the CA BW class, nor the total number of CCs as denoted in NOTE 5. We do not think a CA BW class could have different number of CCs which would depend on the LBT situation.  Lastly, NR-U CA combinations are not only limited to CA BW classes M, N, O. They can also be composed in other FR1 CA BW classes, such as D and E. Therefore, when taking into account all possible BW combinations, we have to make sure they can be fully covered by the existing and the new CA BW classes. |
| Qualcomm | 1.2.1 6 GHz band requirements Studies already reflect the expected characteristics of 6 GHz. MPR is band agnostic.  1.2.2 Baseline MPR  Keep the same MPR as from RAN4 #95-e and remove square brackets. If the changes were to be adopted for 64QAM, the change from 4.5 dB to 4.0 dB might not be enough to cover the case for wideband operation with overlap between ACLR and IQ image. For CP-OFDM, the simulation results from Apple show that partial allocation requires less backoff than full allocation. This is inconsistent with other simulation results and with expectation, so we would need to understand this before accepting the result.  1.2.3 Applicability to wideband with partial sub-band allocation  While we did not directly observe the same in our simulation results, it is reasonable that at -28 dBc LO, the SEM floor of -28 dBr will be met with no margin and any other spurious will cause emission to fail. It is unclear that power backoff will be effective and would be difficult to quantify and strongly dependent on implementation since all values here are relative quantities. Nonetheless, we are ok with this approach.  1.2.4 Pi/2-BPSK MPR  Prefer the Qualcomm values even if they may be conservative.  1.2.5 NR waveform (non-interlaced) MPR  The MPR for NR waveform likely needs more study than the casual treatment proposed here. The PC5 PA model is different, the setpoint is different, the emission requirements are different. While MPR was possible considered to follow NR-U interlaced MPR, the same is not likely true for A-MPR. Therefore, the best alternative at this time is to leave the MPR as TBD for the NR waveform. It may also be possible to request a capability bit for non-interlaced waveform.  1.2.6 A-MPR for PC5  We propose the tables from Qualcomm but are willing to consider other companies simulation/measurement results if they are provided in a format where a direct comparison can be made and where resimulation can be easily done if needed.  1.2.7 Power class 3 requirements  The moderator seems to have made an error. The R4-2009901 paper in thread 106 talks about 100 MHz channel bandwidth, not PC3. Qualcomm proposes that PC3 is not included for Rel-16 since there are many open requirements that cannot be completed in this meeting. The work item is scheduled to complete this meeting. PC3 can be added in future work especially recognizing that first deployments where regulations have been finalized have strict requirements on PSD and/or AFC so that PC3 is of extremely limited value in the near-term.  1.2.8 Intra-band CA bandwidth class definition  The proposal from Apple seems reasonable. However, it is not clear the need for the changes that MediaTek proposes. In our understanding BW class is a matter of configuration; it is not expected that BW class is reconfigured in response to LBT.  1.2.9 ON/OFF time mask  We are ok with the time mask which places the trailing 10us halfway inside and halfway outside the end of the transmission. This is a good compromise between maintaining fidelity in the last symbol of transmission while minimizing interruption to the LBT of another UE.  1.2.10 Other Tx requirements  1.2.11 Tx mask and LO exception  Excluding 2 MHz of the signal might result in a slightly different 0 dBr reference for the SEM if the “true peak” were inside the excluded range. However, since the PSD of the signal is mostly flat, the difference may not be significant and probably within measurement uncertainty anyways. On the other hand, it may be possible to remove the LO in the time domain as part of the Global In-channel Tx test procedure if truly needed. |
| Mediatek | 1.2.1 6GHz requirements From implementation experience, it is difficult to achieve same performance on whole range for n77 with nominal board level matching circuit. The pass bandwidth for the new 6GHz is even wider to 1.2GHz. We believe it is needed to allow two PA path implementation for optimized 6GHz performance.  1.2.2 Baseline MPR  The evaluation at MTK side is still on-going. We can provide whether our result is aligned with current WF in next meeting.  1.2.8 Intra-band CA bandwidth class definition  Not sure the upper bound number of CA carriers for different CBW 20M, 40M, 60M and 80M.  We share same view with observation 1 in [R4-2009934](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2009934.zip). Suggest to consider approved Tdoc 94-e R4-2002748 for not limiting the CBW usage.  Carriers of CA BW class with LBT failure could not be fully used. gNB or UE are not expected to transmit/receiver data in the interference location of 20MHz BW. According to LBT result, whether to reconfigure BW or not, we encourage companies providing views.  1.2.11 Tx mask and LO exception To clarify whether gNB judge LO position according to LBT pass or failure. |
| Intel | 1.2.1 6 GHz band requirements Question for clarification: Are we going to assume a single PA architecture or multiple PAs to cover 6 GHz spectrum? Given the very wideband spectrum, we are not clear if the existing 5 GHz tolerance can be reused. What is UE architecture assumption in 6 GHz?  1.2.7 Power class 3 requirements  We prefer to include PC3 in Rel-16. Given the time limitation for Rel-16, however, we recommend RAN4 to keep working PC3 MPR in TEI-16 if there is a strong demand. We are open for further discussion how to manage this.  1.2.8 Intra-band CA bandwidth class definition  We don’t have a strong preference but would like to understand the proposal from Apple: Given 80 MHz is the max. single CBW, what justifies 200 MHz with 3CC (not 240 MHz) and 300 MHz with 4CCs (not 320 MHz)? |
| Nokia | 1.2.1 MPR should be band agnostic  1.2.2  Option 1 - Remove brackets from RAN4#95e agreement  1.2.3  We are fine to follow the proposal from Skyworks but would prefer simpler MPR definition without differentiating.  1.2.5  We propose to agree the TP for MPR table provided by Skyworks in R4-2010273  1.2.6  Given the relatively close values from Qualcomm and Skyworks we are fine to use the A-MPR tables proposed from Qualcomm.  1.2.8  80MHz channel bandwidths are covered by BW class C, D and E. Furthermore, fallback group 3 has been added to class C to cover the fallback from class M/N/O. We are fine to extend aggregated channel BW to class M/N/O but was wondering why not to use maximum of 240MHz for M and 320MHz for N if 400MHz is proposed for O?    1.2.9  We are okay with the moderator proposal |
| Huawei | 1.2.1 6GHz requirements We agree with Mediatek that more component data should be collected and mores studies are needed to conclude the requirements for the new band. Furthermore, the reference architecture should be also discussed to decide the requirements. E.g. two-path implementation may have better performance than single path implementation. The comments should be general. It is not limited to single requirement, e.g. MPR.  1.2.4 Pi/2-BPSK  Do we need Pi/2-BPSK for NR-U? leave it as TBD might be ok.  1.2.8 Intra-band CA bandwidth class definition  Separate CA bandwidth class definition for NR-U is preferred.  1.2.9 on/off mask  Clarification question: what is the issue if we reuse NR on/off mask, i.e. put the TP outside of the transmission. |
| CHTTL | 1.2.1: We also agree with Huawei. |
| Skyworks: | 1.2.4 Pi/2-BPSK MPR  Can it be clarified which DMRS have been used or whether this would have an influence on MPR. Provided we understand this we are OK with QCOM and Apple values  1-2-6: A-MPR for PC5 we are doing further analysis of QCOM input and to the most part we have good agreements, we will further align. St this moment we are aligned for NS54 as our data with higher MPR did not account for 10MHz offset. QCOM NS54 table is agreeable to us. 1.2.11 Tx mask and LO exception If we agree that it may not be dramatic if the 2MHz exclusion would hide the actual in-band peak for a flat spectrum (full or interlace) it is not the case for normal NR partial allocation. Also depending on how the DC power is removed to the total power, it could impact the wanted signal power measurement (if 2MHz is removed you can lose the power of 20% of full allocation or two interlaces) so we believe that DC cancellation needs to be solved. |
| Qualcomm | On 6 GHz multiple PA, MTK proposes that multiple PA implementation should be allowed in 3GPP and cites n77 as an example. However, n77 is conventionally implemented with single PA and has an even wider relative BW than n96. MTK further justifies the need for multiple PA by saying that “normal board level matching” is difficult, but we think it can be accomplished without the need for dual PA. We are aware of n77 designs that fulfill all of the 3GPP requirements without resorting to dual PA so we don’t believe dual PA is necessary for n96.  On A-MPR, Qualcomm will work closely with Skyworks to resolve any remaining differences in results. If there are other companies with quantitative results and the ability to provide technical justification to those results, we would be happy to consider them as they should have been provided at the beginning of this meeting. |

## 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# 1.2.1**  6 GHz band requirements | *Tentative agreements:*  Based on the GTW discussion on August 20, it was agreed that single PA is the default assumption for Band n96. The front-end loss is to be further investigated in the case of single PA.  *Candidate options:*  *Option 1:* PC5 maximum output power for Band n96 is 20 dBm with tolerance +2/-3 dB  *Option 2:* A different value for MOP and/or tolerance. Proponent to provide a value for consideration.  *Option 3:* MOP and tolerance of 20 dBm +2/-3 dB in square brackets.  *Recommendations for 2nd round:*  Agree on whether or not 20 dBm +2/-3 MOP and tolerance can be specified for Band n96. If it cannot, then provide an alternate value for consideration. If an alternate value cannot be provided and agreed upon, then agree to 20 dBm +2/-3 value in square brackets.  Capture agreed value in the revised CR. |
| **Sub-topic# 1.2.2**  Baseline MPR | *Tentative agreements:*  Most companies agree to adopt the MPR that had already been tentatively agreed in RAN4 #95-e. MediaTek is still in the process of evaluation but since the MPR has already been discussed for several meetings and MediaTek has never provided any contribution, data, or proposal on MPR.  *Candidate options:*  *Recommendations for 2nd round:*  Remove the square brackets around the MPR in revised CR. |
| **Sub-topic #1.2.3** Applicability to wideband with partial sub-band allocation | *Tentative agreements:*  There is general agreement that wideband configurations may require additional backoff for some waveforms. Skyworks has a proposal on how this can be handled for MPR, but other companies prefer not to overly complicate the MPR specification.  *Candidate options:*  *Recommendations for 2nd round:*  Continued discussion on how to implement this into the specification. If agreed, this needs to be added to the revised CR. |
| **Sub-topic #1.2.4**  Pi/2-BPSK MPR | *Tentative agreements:*  Use the same values for Pi/2-BPSK MPR as QPSK. Include clarification that this applies only for non-power boosted BPSK ZC-DMRS Pi/2-BPSK.  *Candidate options:*  *Recommendations for 2nd round:*  Include this into the revised CR. |
| **Sub-topic #1.2.5**  NR waveform (non-interlaced) MPR | *Tentative agreements:*  Very little techincal evaluation and discussion for this topic. For the NR non-interlaced waveform, there may be changes required for MPR as well as A-MPR and consideration in case the removal of LO in the SEM mask removes all of the signal.  *Candidate options:*  *Recommendations for 2nd round:*  Do not include requirements for NR non-interlaced waveform into the CR. |
| **Sub-topic #1.2.6**  A-MPR for PC5 | *Tentative agreements:*  Very close agreement between the simulation results from Qualcomm and the measurements from Skyworks.  *Candidate options:*  *Recommendations for 2nd round:*  Qualcomm and Skyworks to work offline to either come up with a merged proposal or two separate proposals with comprehensive set of A-MPR tables for all NS’s to share on this thread and to include in the revised CR. |
| **Sub-topic #1.2.7**  Power class 3 requirements | *Tentative agreements:*  While companies have expressed a desire for power class 3, the specifications are not complete and data to complete specifications is not available. Furthermore, PC3 with 2 PC5 Tx paths has a dependency on the completion of the Tx Diversity discussion in NR which is still ongoing.  *Candidate options:*  *Recommendations for 2nd round:*  Do not include requirements for PC3 into the CR. |
| **Sub-topic #1.2.8**  Intra-band CA bandwidth class definition | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  Continue discussion on whether 80 MHz channels should be included in classes M, N, and O. Also discuss whether bandwidth class definition needs to be clarified for the case where LBT failure triggers a deconfiguration of one of the CC’s in the bandwidth class. |
| **Sub-topic #1.2.9**  ON/OFF time mask | *Tentative agreements:*  General ON/OFF mask starts 5us before start of transmission and extends 10us into the start of the CP. At the end of the transmission, the transient is with 5us during the end of the transmission and 5us after the transmission stops.  *Candidate options:*  *Recommendations for 2nd round:*  Capture into the revised CR |
| **Sub-topic #1.2.10**  Other Tx requirements | *Tentative agreements:*  There were no objections received so the proposed Tx requirements can be agreed.  *Candidate options:*  *Recommendations for 2nd round:*  The proposal is agreed. |
| **Sub-topic #1.2.11**  Tx mask and LO exception | *Tentative agreements:*  *Candidate options:*  *Recommendations for 2nd round:*  Continued discussion including whether any modification to the existing 2 MHz exclusion is needed and if so, a proposal for modification to the CR should be provided for companies to evaluate. |

*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  Moderator: There were no objections to this CR, but MTK pointed out that the inclusion of Band n96 is still under discussion in the second round.  Moderator recommendation: Return To |
| [**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  Nokia: This CR contains topics also discussed in this summary, so revision is needed.  For section 5.3.3 – The change is unnecessary as it is already clearly defined in RAN1 spec.   that no intra-cell GB are defined for 20MHz channels. However, if this addition to the RAN4   spec. makes Ericsson more comfortable we are okay with the proposed change.  For section 5.3A.5 – This part should be revised based on discussion related to topic 1.2.8 in   this summary.  For section 5.5A.1 and 6.3F.3 – We are okay.  Moderator recommendation: Noted (unique agreeable content merged with revision of R4-2011347) |
| [**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  Ericsson: this CR should be revised. Once the running CR is sufficiently complete (include inputs from track #106) and agreed, it can be turned into a feature CR.  Nokia: We agree with this CR. A revision might be needed dependent on related discussions.  Moderator recommendation: Revised |

## Discussion on 2nd round (if applicable)

Comments from companies for 2nd round discussion on the following topics

Sub-topic 1.2.1. 6 GHz band requirements

Sub-topic 1.2.3. Applicability to wideband with partial sub-band allocation

Sub-topic 1.2.6. A-MPR for PC5

R4-2011344 has been revised to R4-2011895 to correct errors

Sub-topic 1.2.8. Intra-band CA bandwidth class definition

Sub-topic 1.2.11. Tx mask and LO exception

Revised CR (revision of R4-2011347)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Charter Communications | Sub-topic 1.2.1. 6 GHz band requirements   * We agree with Option 1:PC5 maximum output power for Band n96 is 20 dBm with tolerance +2/-3 dB   Sub-topic 1.2.3. Applicability to wideband with partial sub-band allocation   * We agree with Skyworks proposal.   Sub-topic 1.2.6. A-MPR for PC5   * We agree with moderator’s proposal, *”Qualcomm and Skyworks to work offline to either come up with a merged proposal or two separate proposals with comprehensive set of A-MPR tables for all NS’s to share on this thread and to include in the revised CR.”*   Revised CR (revision of R4-2011347)   * We agree with the revision of this CR and we will like this revision to remove [ ] from Table 7.3F.5.2-1 MSD for cross band isolation |
| Mediatek | 1.2.1 6 GHz band requirements  There’s no need to change MOP requirement. But for performance evaluation, according to latest data updated from vendor pool, post PA path loss shall be assumed to **5dB** due to higher PCB trace loss and matching components parasitic loss, 2dB filter IL is the assumption.  1.2.8 Intra-band CA bandwidth class definition  We put companies’ and our views below. We also provide another perspective for forward compatibility.  As for NR-U CCA BW class M, N and O :  Observation: single-CC CBW of 100MHz is still under discussion, whether to restrict maximum single-CC CBW in CCA or not is considered. We are not sure that upper bound of Rel-15 NR, max. aggregated BW is up to 400 MHz.  Option 1: maximum aggregated BW = number of CC \* Maximum CBW for forward compatibility and maximum aggregated BW can be up to 500MHz, lower limit of aggregated BW are not changed.  Option 2: maximum aggregated BW = number of CC \* 80MHz  Option 3: maximum aggregated BW = number of CC \* 60MHz  Option 4:   |  |  |  | | --- | --- | --- | | 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 |   We think that equation based “CC number\*Maximum CBW” could be upper bound of aggregated BW.  As for NR-U CCA carrier number with LBT failure, we would like to provide few examples for getting further clarification from companies.  First, for example, BW class N of 4\*20MHz, the original CC configuration is [1 1 1 1]\*20MHz. When encountering 1 edge LBT failure, to presume configuration is [1 1 1 1] and new scheduled CC is [1 1 1 0]\*20MHz or [0 1 1 1]\*20MHz  **Based on Apple’s understanding it seems the mentioned example above would fall back to BW class M with CC configuration [1 1 1]\*20MHz?**  Secondly, we are not sure about the sentence *“not allowed to directly fall back to non-contiguous CA by disengaging non-edge CC(s).”*  To our understanding, intra-band NCCA can be used for dealing with blocker between CA carrier 1 and carrier 2. To us, NCCA can provide same TX/RX throughput as CCA with LBT failure. To use NCCA is easier for defining blocker requirement. And for CCA with LBT failure, it is not expected to reconfigure. Therefore filter BW and LO are not adapted. The interferer location and new scheduled CC scenario will definitely affect the RF requirements if companies want to define requirements in next meeting. **Whether to have RF requirements or not is still not clarified.**  **Is our understanding correct that BW class, filter BW and LO would not be adapted when LBT failure happen?**  Next, to consider another example, CC configuration [1 1 1 1]\*20MHz with 2 LBT failure -> 20M\*([1 0 0 1]). To us, under LBT failure, the scheduled CC number in example is smaller.  For LTE/NR CCA, scheduled CC number could be smaller than activated/configured CC number defined in BW class table, and the defined spec does not have to deal with blocker overlapped with LBT failure subband. It means scheduled CC location would not be occupied by interferer. For RX, NR CCA with partially scheduled CC still follows RF requirements of NR CCA with fully scheduled CC.  **It seems there is no NR-U CCA RF requirement with LBT failures**, **to us,** **NR-U CCA with LBT failure is not equal to NR CCA with non-scheduled CC.**  Finally, complicate usage is mixture of 20MHz carrier(s) and wideband carrier(s) under LBT failure. For example, if CCA with configuration of [20 60 60 60]\*1MHz encounter 2 LBT failure in carrier 1 and 2. **To clarify whether gNB will activate CC to [0 [0 20 20] 60 60] ]\*1MHz, [0 0 60 60]\*1MHz or fall back to lower BW class [60MHz 60MHz].** |
| Skyworks | # 1.2.1. We support option 1 but if justified, we are OK with option 3. At this point we do not agree that band n96 filters have higher loss than for n46, if higher rejection at n77/n79 is neeedthis will affect n46 filter rather than n96 filter.  #1.2.3 we believe that our proposal is essential to allow wideband operation to have similar performance to single CC case. As discussed in 1.2.6 this is also important to clarify mapping of wideband operation cases for A-MPR  #1.2.6:  Table values and behavior vs BW of the revised results form QCOM in R4-2011895 are closer to our evaluation and we agree with the table values in R4-2011895.  Separatelly we want to address how wideband operation cases with partial transmitted sub-bands are mapped to the right column and BW as for in-band PSD there is ambiguity if a 20MHz transmitted sub-band in a wideband operation of 80MHz should get the 80MHz A-MPR (which would be wrong for cases limited by in-band PSD) or the 20MHz A-MPR (right). We will propose a text for a note to add to the tables where this issue arises today.  #1.2.11  Here is text proposal in yellow to handle LO leakage issue for 0dBr setting.   |  |  |  |  |  |  |  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | | Spectrum emission limit (dBr) / Channel bandwidth | | | | | | | | | | | | | | ΔfOOB  (MHz) | 10 MHz | 20 MHz | | 40 MHz | 60 MHz | | | 80 MHz | Measurement bandwidth (MBW) | | | | | ± 0-1 |  | | | | | | | | [100kHz]3 | | | | | ± 1-5 | NOTE 1 | NOTE 1 | | NOTE 1 | NOTE 1 | | | NOTE 1 | 1 MHz | | | | | ± 5-10 | NOTE 2 | | ± 10-20 | -40 | NOTE 2 | | | ± 20-30 |  | -40 | | NOTE 2 | | ± 30-40 |  |  | | NOTE 2 | | | | ± 40-50 |  |  | | -40 | NOTE 2 | | ± 50-60 |  |  | |  | | ± 60-70 |  |  | |  | -40 | | | | ± 70-80 |  |  | |  |  | | | | ± 80-100 |  |  | |  |  | | | -40 | | NOTE 1:   Given as: where  NOTE 2:   Given as: where  NOTE 3:   The measured value shall be scaled by a factor equal to the ratio of the reference bandwidth (1 MHz) to the measurement bandwidth before the emission limit (dBr) is applied.  NOTE 4:   The carrier leakage exceptions from Table 6.4F.2.3-1 apply and carrier leakage contribution shall be ignored when setting the 0dBr level of the mask, the reported carrier frequency location in *txDirectCurrentLocation* field of the *UplinkTxDirectCurrentBWP* can be used to cancel the carrier leakage contribution. If *txDirectCurrentLocation* is not available or is reported with value 3300 or 3301, a carrier frequency location at the center of the channel shall be assumed. | | | | | | | | | | | | | |  |  |  |  |  | |  |  | | |  |  |  | |
| Qualcomm | 1.2.1. Option 1. We believe the FE loss will be largely the same between Band n46 and Band n96 so the same MOP and tolerance can be applied for both bands.  1.2.3. We are ok with the approach proposed by Skyworks. It does introduce a bit more complexity into the MPR table but the extra backoff has been justified. The approach is reflected in the revised CR.  1.2.6. We have worked closely together with Skyworks to align and understand the differences between the results. The A-MPR tables have been modified to accommodate these differences merging the results together. The updated tables are provided in the revised CR.  1.2.11. We prefer a slight change of wording to the text provided by Skyworks. Instead of ignored, we suggest changing the wording to ”removed prior to”. The revised CR reflects this change that we had already communicated with Skyworks about. |
| Huawei | 1.2.1 6GHz band  Agree with MTK that the asumption on post PA path loss should be agreed for performance evaluation.  1.2.6. A-MPR for PC5  It is related to the decision on channellization of 6GHz. The A-MPR evluation for 6GHz should use the channel defined in the band edge. |
| Skyworks | 1.2.1 on 6GHz post PA losses: The additional loss for providing 40dB rejection in band n77 should not be impacted to SA operation and can be accommodated for CA or DC combination with Delta T and Delta R. and this rejection affect n46 more than n96 so post PA losses in n96 can be assumed the same than for n46 and is a generous 5dB (and we still have further margins with our PA)  1.2.6 We agree with the revised tables from the CR but would ask the Notes for NS\_29 and NS\_53 about mapping of partial wideband cases to be further clarified by adding the text in yellow highlight:  ” **When not all sub-bands within the channel are transmitted, the A-MPR associated with the channel bandwidth according to the bandwidth of the contiguously transmitted sub-bands and according to the allocation type applies.”**  1.2.11. we agree to the wording change proposed by Qualcomm |
| Nokia | 1.2.1 Option 1 – There should be no difference to n46  1.2.3 We are ok with the approach proposed by Skyworks.  1.2.6 We are ok with the tables in the CR from Qualcomm.  1.2.8 Again, in our understanding 80MHz channel bandwidths are covered by BW class C, D and E. Furthermore, fallback group 3 has been added to class C to cover the fallback from class M/N/O. We are fine to extend aggregated channel BW to class M/N/O if this is deemed necessary by some companies to separate the BW classes for NR-U. If there is agreement to extend O to 400MHz, M/N shall be extended to 240/320, respectively.  1.2.11 We are ok with the suggestion from Skyworks and the amended wording from Qualcomm now captured in the CR from Qualcomm. |

## 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** |
| **[R4-2011347](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2011347.zip" \t "_parent)** | **Charter Communications: We agree with draft revision R4-2011347 38.101-1 CR v2 and endorse its content**  **Mediatek: for BW class M,N and O, considering forward compatibility provided in our discussion, we think that equation based “CC number\*Maximum CBW” could be upper bound of aggregated BW.**  Huawei:1.the SU for 60 KHz SCS need to be updated to 25 RB for NR-U. 2. for 6GHz band, the channelization should be revised and so impact to A-MPR evluation.  **Nokia**: We support this CR to be endorsed as is.  Intel: SU of 20 MHz with 60 kHz SCS shall be 25 RB for NR-U. |

# 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" \t "_parent)** | 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 |
| Ericsson | Sub-topic 2-2-2: ACS values for intra-band contiguous CA should be based on the agreed R4-2009175, i.e. the ACS scaled with the configured aggregate channel bandwidth under test, not the maximum aggregate channel BW for the CA bandwidth class.  Regarding OOBB, the Ericsson draft CR in R4-2010347 corrects the SA OOBB requirements introduced in the running CR. The interferer frequencies are incorrect: IBB applies up to a 50 MHz interferer offset, but the stated OOBB interferer incorrectly starts at 3\*CHBW that is greater than 60 MHz for wideband channels. The OOBB for NR carrier frequencies > 3300 MHz should not have been used. NSA requirements are not introduced in the said draft CR.  For NSA operation we propose that the existing OOBB interferer profile for eLAA is reused (the same applies for UL inter-band CA). |
| skyworks | Related to [R4-2011344](file:///C:\Users\bruneld\Documents\Standardization\3GPP2020\RAN4_96e_Aug17-28_2020\Docs\R4-2011344.zip) we agree with QCOM that same REFSENS tahn n46 can be used for n96. Our 6GHz wifi products have same NF and antenna losses in 6GHz band compared to 5GHz band and is dominated by band edge roll off of the filters. |
| Apple | We are ok with moderator’s proposal for the ACS compromise value of 24 dB for 20 MHz.The OBB requirements were agreed last meeting as provided in R4-2009175. |
| Qualcomm | 2.2.2 Even for NSA out-of-band blocking, we prefer the interferer profile as already agreed for SA since it accounts for wider Rx bandwidths and wider filters for the 5 and 6 GHz bands. These same bandwidths and filters would be used in NSA as well. |
| Mediatek | Related to R4-2011344 we have different view on REFSENS. From filter insertion loss perspective, taking n77 as example, in TR38.813, simulated IL was around 2dB(max). And from real component data that in R4-1906155, it is up to 2.5dB IL depends on how the out of band rejection ratio profiles look like. So in our view filter IL assumption in the contribution is not reasonable from UE implementation perspective. In our database, band 46 filter insertion loss is about 1.2dB which only provides less than 20dB rejection in n77 range. To further improve filter out of band rejection ratio usually requires more IL. 35-40dB rejection to licensed band would introduce several dB MSD degradation which seems not enough for CA/DC usage. For 6GHz filter simulation data from one of our vendor shows IL is up to 2.5dB for >40dB rejection to licensed bands including n77. Considering gap between simulation and real component performance, we think 2.8~3dB is a reasonable assumption for filter insertion loss. So far we don’t even see filter performance data provided by other companies. We encourage companies to provide more data for reference.And further consider FE architecture discussed in R4-2010585, it is needed to allow two path implementation for UE thus additional RF switch IL needs to be considered. Further, the PCB trace loss and matching component loss difference between 5925MHz and 7125MHz shall not be precluded.With above clarification, we do not think the REFSENS of n46 can be applied directly to n96. 2-2-1: ACS value  We agree to have NR-U ACS1 value better than WiFi ACI value. Think to align WiFi ACI value from companies first.  Based on evaluation, 9dB difference between UE RX ACS and gNB TX ACLR only induce 0.5dB error in UE RX ACS test. We believe that ACS value with 4~5 dB better than WiFi ACI plus gNB ACLR of 35dB in R4-2009966 Table.1 sufficiently provide enough and better ACIR performance in unlicensed band with respect to WiFi 802.11ax performance. |
| Huawei | Sub topic 2-2-1 We do not agree with 24 dB ACS. It looks that companies misunderstood the ACS capability of WIFI. Although ACR of WIFI can be as low as 13 dB, the equivalent ACS is in the range from 22 dB to 29 dB. Hence we propose to reuse LAA 27 dB ACS for NR-U UE  Table 8.4.2-1 of TR 36.889: Adjacent Channel Rejection and Sensitivity from [25]   |  |  |  |  | | --- | --- | --- | --- | | Modulation | Coding Rate | Adjacent Channel Rejection (dB) | Sensitivity (dBm) for 20MHz channels | | BPSK | 1/2 | 16 | –82 | | QPSK | 1/2 | 13 | –79 | | QPSK | 3/4 | 11 | –77 | | 16-QAM | 1/2 | 8 | –74 | | 16-QAM | 3/4 | 4 | –70 | | 64-QAM | 2/3 | 0 | –66 | | 64-QAM | 3/4 | -1 | –65 | | 64-QAM | 5/6 | -2 | –64 |   Table 8.4.2-2 of TR 36.889: ACIR values when Wi-Fi is the victim system.   |  |  |  |  | | --- | --- | --- | --- | | Study Case | Wi-Fi ACS (dB) | Aggressor ACLR (dBc) | ACIR (dB) | | LAA node to Wi-Fi AP/STAs | 22 | 45 | 21.98 | | 25 | 24.96 | | 29 | 28.89 | | LAA UE to Wi-Fi AP/STAs | 22 | 30 | 21.36 | | 25 | 23.81 | | 29 | 26.46 | | Wifi AP/STAs to Wi-Fi AP/STAs | 22 | 26.35 | 20.64 | | 25 | 22.61 | | 29 | 24.47 | |
| Skyworks | To Mediatek: We do agree that some of the aspect discussed here are to be considered, the impact is mainly on n46 (OOB filter rejection for n77) or equal for n46 and n96 (switch) and is already accounted for in the post PA losses and REFSENS. So we do not see that n96 should be different from n46. What we believe might be more a challenge is a single PA covering n46+n96 (32% fractional BW) but we do not usually consider 1PA for multiple bands in RAN4 requirements. |
| Qualcomm | If I understood correctly, MTK is proposing that carriers configuration or bandwidth is reconfigured at an outcome of LBT. MTK suggests that the definition of intra-band BW classes is modified to account for this and LO placement might also have to the accounted for if the bandwidth is reconfigured. However, it is our understanding that RRC reconfiguration events are not suitable for LBT since they are far too slow. Thus, we don’t believe reconfiguration is the correct assumption for LBT.\ For Ericsson, we believe that the already agreed out-of-band blocker profile for SA is correct in using >3300 MHz approach from NR. It is not an error. |

## 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#2.2.1**  ACS value | *Tentative agreements:*  Most companies could agree to a compromise value of 24 dB. MediaTek prefers further study. Huawei insists upon 27 dB.  *Candidate options:*  *Option 1:* Capture [24] dB in the CR with square brackets. All other ACS values since they are scaled from this baseline value will also be in square brackets.  *Option 2:* Capture 24 dB in the CR as the compromise agreement without square brackets.  *Recommendations for 2nd round:*  This topic has been extensively discussed for the past 4 meetings with numerous technical arguments. The initial proposals were widely varying but most companies have been willing to compromise to achieve progress. However, one company has been unwilling to compromise from their originally proposed value. As there have been good technical inputs from all companies and it is natural that different companies may have different technical analyses and may not share the same technical views, further study and technical discussion does not appear to be productive.  Agree on option 1 or option 2 and capture in the revised CR. |
| **Sub-topic#2.2.2**  Intra-band CA | *Tentative agreements:*  *Candidate options:*  *Option 1:* Out-of-band blocker for NSA according to R4-2010346  *Option 2:* Out-of-band blocker for NSA consistent with SA requirements that were agreed last meeting.  *Recommendations for 2nd round:*  Agree on option 1 or option 2 and provide a draft CR for 38.101-3 |
| **Sub-topic#2.2.3**  6 GHz | This is a new sub-topic added as a consequence of the discussion during Round 1. This topic is for 6 GHz Rx requirements with a focus on reference sensitivity and possible impact due to front-end filtering requirements and/or other Band n96 radio performance characteristics.  *Tentative agreements:*  *Candidate options:*  *Option 1:* Band n46 reference sensitivity can also apply for Band n96  *Option 2:* A different value than Band n46. Proponent to provide a value for consideration.  *Option 3:* Band n46 reference sensitivity values in square brackets for Band n96  *Recommendations for 2nd round:*  Agree on whether or not Band n46 reference sensitivity can also apply for Band n96. If it cannot, then provide an alternate value for consideration. If an alternate value cannot be provided and agreed upon, then agree with the Band n46 value in square brackets.  Capture the agreed value in the revised CR. |

*Suggestion on WF/LS assignment*

|  |  |  |
| --- | --- | --- |
|  | **WF/LS t-doc Title** | **Assigned Company,**  **WF or LS lead** |
| #1 | Draft CR to 38.101-3 on out-of-band blocking for NSA operation | Ericsson |

### CRs/TPs

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

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| --- | --- |
| **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)  Moderator recommendation: Noted (unique agreeable content merged with revision of R4-2011347) |
| [**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  Ericsson: the changes relative to the agreed running CR in R4-2009175 are not shown, this would have simplified review of this new version.  Moderator recommendation: Noted (this CR has already been superceded) |

## Discussion on 2nd round (if applicable)

Comments from companies for 2nd round discussion on the following topics

Sub-topic 2.2.1. ACS value

Sub-topic 2.2.2. NSA out-of-band blocking (Intra-band CA from Round 1) – draft CR to 38.101-3

Sub-topic 2.2.3. 6 GHz Rx requirement

Revised CR (revision of R4-2011347)

|  |  |
| --- | --- |
| **Company** | **Comments** |
| Charter Communications | Sub-topic 2.2.1. ACS value   * Option 2: Capture 24 dB in the CR as the compromise agreement without square brackets but if there is a consensus agreement to keep this value in [ ], we could consider   Sub-topic 2.2.2. NSA out-of-band blocking (Intra-band CA from Round 1) – draft CR to 38.101-3  We agree with Option 2:Out-of-band blocker for NSA consistent with SA requirements that were agreed last meeting.  Sub-topic 2.2.3. 6 GHz Rx requirement   * We agree with Option 1:Band n46 reference sensitivity can also apply for Band n96 |
| Mediatek | Sub-topic#2.2.3: Option 2Related to R4-2011344 we have different view on filter performance assumption. Here we provide filter evaluation data and encourage companies to provide more data for reference since n96 is brand new band and there shall be sufficient evaluation data. Considering small difference between simulation and real product and the operation frequency is twice than 3.5GHz band, 2dB filter loss assumption seems reasonable for evaluation. Here we further provide latest n96 filter data just get from vendor pool. **Here we provide simulated filter data in below table:**   |  |  |  |  | | --- | --- | --- | --- | | Parameter | Frequency range | **Band n96 BPF A-1** | **Band n96 BPF A-2** | | Insertion Loss | 5925-7125 MHz | 2.5 dB (simulation, ETC) | 1.1 dB (typ) | | Attenuation  (Typ) | 698-2690 MHz | 45 dB | 45 dB | | 3300-4200 MHz | 40 dB | 40 dB |  The 0.9dB trace loss was based on module solution while **there are discrete components solutions widely used in worldwide**. Trace loss shall take PCB loss into consideration also. Further, the system NF would **degrade 0.6~1dB** due to higher operation frequency comparing to n46. With these justifications and latest filter data updated from vendor pool we would propose REFSENS for n96 in below table as our compromise:  |  |  |  |  |  |  | | --- | --- | --- | --- | --- | --- | | Operating band / SCS / Channel bandwidth | | | | | | | Operating Band | SCS kHz | 20 MHz (dBm) | 40 MHz (dBm) | 60 MHz (dBm) | 80 MHz (dBm) | | n96 | 15 | -87.1 | -84.0 |  |  | | 30 | -87.3 | -84.1 | -82.2 | -81.0 | | 60 | -87.5 | -84.3 | -82.4 | -81.0 |   Sub-topic#2.2.1: Option 1  From RF UE/STA perspective, we do the benchmark of WiFi and NR-U for justification.  The margin of NR-U compared to WiFi is shown in table below. 24dB ACS was assumed for NR-U in the table.  We assume WiFi has the same SNR assumption w.r.t NR-U for RESENS.  We also found that the other noise from phase noise mixing with interferer and RX IIP3 effect are too low and can be omitted.   |  |  |  |  | | --- | --- | --- | --- | |  | **WIFI ax** | | | | CBW (MHz) | 20 | 40 | 80 | | Interferer power (dBm) | -63 | -60 | -57 | | Desired signal (dBm) | -79 | -76 | -73 | | ACR (dB) | 16 | 16 | 16 | |  | **NR-U n46** | | | | CBW (MHz) | 20 | 40 | 80 | | Interferer power (dBm) | -53.4 | -53.2 | -53.1 | | Desired signal (dBm) | -75.9 | -72.7 | -69.6 | | Interferer to signal Ratio(ISR) (dB) | 22.5 | 19.5 | 16.5 | | **Margin(dB) = NR-U ISR - WiFi\_ACR** | **6.5** | **3.5** | **0.5** |   Since CBW of 100MHz is still under discussion, we support option 1. |
| Skyworks | 2.2.3. 6 GHz Rx requirement: we support option 1, but is justified we are OK with option 3 |
| Qualcomm | 2.2.1: We support Option 2 for ACS of 24 dB without square brackets. 2.2.2: Option 2, requirements should be consistent with SA as agreed last meeting  2.2.3: Option 1, refsens for Band n46 can also apply to Band n96. We expect the FE loss to be largely similar to within small fractions of a dB between the two bands because the filtering requirements will be nearly the same. Moreover, the NF for Band n46 was carried over from LTE Band 46 which was 13 dB. Based on experience with LAA, we don’t expect any problems to meet this refsens for the insertion losses expected in 5 GHz and 6 GHz. |
| Huawei | 2.2.1 Option 1 is ok as a compromise 2.2.3 6GHz RX requirements Basically we think more discussion is needed. The UE reference architecture should be selected firstly and then the insertion loss data must be provided before REFSENS can be given. Hence we support option 2. |
| Skyworks | 2.2.2 The additional loss for providing 40dB rejection in band n77 should not be impacted to SA operation and can be accommodated for CA or DC combination with Delta T and Delta R. regarding NF we state again that the BW extension from n46 to n96 is 20% and cannot grant an extra dB of NF, our WiFi products covering 5GHz and 6GHz bands with a single RX path has similar NF in the two bands and performance is dictated by matching roll off at the edge of the bands and thus affects n46 and n96 similarly |
| Nokia | 2.2.1 Option 2 – A wide range have been proposed and 24 is best compromise. We see no reason for keeping brackets. 2.2.2 Option 2 – We see no reason for reverting agreements from last meeting.  2.2.3 Option 1 – Our understanding is that no issue with reusing Refsens exists. We can accept having the values included in the Qualcomm CR in brackets and return to this discussion next meeting to aid progress. |
| Qualcomm | 2.2.3. Firstly, we would like to thank MediaTek for providing a concrete proposal for consideration. If I calculate the effective NF from MediaTek’s proposal, I get 15.6 dB. We think that 15.6 dB effective noise figure is excessive, remembering that most 3GPP bands assume somewhere in the range of 9 to 12 dB. For Band n46 and for our proposal for Band n96, the effective NF is 13 dB which is already the highest NF of all 3GPP bands to my recollection. But it seems that MediaTek believes that 15.6 dB is needed.Qualcomm cannot speak for other UE and chipset vendors, such as MediaTek and Huawei, but I expect that all Qualcomm-based UE’s following good design practice will be able to meet the SA refsens as proposed by Qualcomm with margin. |

## 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** |
| **[R4-2011347](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_96_e/Docs/R4-2011347.zip" \t "_parent)** | **Charter Communications: We agree with draft revision R4-2011347 38.101-1 CR v2 and endorse its content**  **MediaTek: We do not agree in 7.3F.2 REFSENS of n46 can be applied directly to n96. REFSENS of n96 shall be specified separately. MediaTek already provide values in response of Sub-topic#2.2.3**  **Charter Communications: In response to Mediatek, the vaues for n96 are in [ ] and can be updated once we further review Mediatek values or let’s review Mediatek values before this meeting is completed and update**  **Nokia**: We support this CR to be endorsed as is. We will however be willing to accommodate MediaTek’s concerns by adding brackets for Refsense values for n96.  MediaTek: In response for n96 REFSENS, we are not OK if copy same REFSENS values despite 1.2GHz higher frequency. We are OK if values of our proposal are put in the CR with square brackets. |