**3GPP TSG-RAN WG4 Meeting #94-e R4-20xxxxx**

**Electronic Meeting, Feb.24th – Mar.6th 2020**

**Agenda item:** 8.1.2

**Source:** Moderator (Qualcomm Incorporated)

**Title:** Email discussion summary for RAN4#94e\_#10\_NR\_unlic\_UE\_RF

**Document for:** Information

# Introduction

This document summarizes the email discussion on topics related to NR-U UE RF requirements. The contributions presented on this topic can be divided into the following sub-topics: Tx requirements, Rx requirements, MPR, band combinations.

# Topic #1: Tx requirements

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2000399**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000399.zip) | Intel Corporation | Title: On NR-U ACLR requirement  Proposal 1: It is proposed to define 27 dB as NR-U ACLR for PC5. |
| [**R4-2002095**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002095.zip) | Qualcomm Incorporated | Title: NR-U general and Band n46 specific Tx requirements  Proposal 1: PC5 is 20 dBm ± 2 dB, PC3 is FFS  Proposal 2: it is proposed that ACLR is superfluous and not needed  Proposal 3: In-band emissions start with eLAA definition but further verification needed   1. The PA model, especially for PC5 at 5 to 7 GHz, is not the same as a 2 GHz LTE PA 2. The LO leakage and IQ image for NR is -28 dBc 3. Modulation should include 256QAM 4. NR-U includes both DFT-S-OFDM as well as CP-OFDM without DFT pre-coding 5. The location of RB’s for DFT-S-OFDM may be shifted relative to the center of a channel that is intended to hold 106 RB’s for 20 MHz CP-OFDM. This may have an impact on the exact RIV waveform and the expected location of image products.   Proposal 4: UL MIMO is allowed for Band n46. UL TxDiv to enable PC3 is subject to general discussion on UL TxDiv.  Proposal 5: it is proposed that the scenarios requiring A-MPR study for Band n46 are the same ones identified for eLAA in Band 46. These include NS\_28 for Europe, NS\_29 for Japan, NS\_30 for US, and NS\_31 for Korea. Companies are encouraged to check whether these regulatory requirements as adopted for eLAA are up to date so that A-MPR simulations and measurements can be conducted. |

## Open issues summary

### Power class

* Option 1: PC5 only (20 dBm ± 2 dB), PC3 is FFS
* Option 2: Both PC5 (20 dBm ± 2 dB) and PC3 (23 dBm ± 2 dB) where PC3 is allowed to be met using TxDiv between two PC5 PA’s

### ACLR

* Option 1: 27 dB
* Option 2: ACLR is not specified for NR-U

### Other Tx requirements

* See proposals 3, 4, and 5 from Qualcomm. Which ones can be agreed? If not, is there a counter-proposal?

## Companies views’ collection for 1st round

### Open issues

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| **Company** | **Comments** |
| Skyworks | Sub topic 1-1:  Skyworks proposal 3 in R4-2000708 in not captured:  “Proposal 3:  Power class definition of PC5: 0 dB MPR waveform: 20 MHz 100RB0 fully allocated DFT-s-OFDM QPSK for 27 dB ACLR and NRU SEM passed. Power class tolerance: 20 dBm +2/-3 dB  Power class definition of PC3: 1 dB MPR waveform: 20 MHz 100RB0 fully allocated DFT-s-OFDM QPSK for 30 dB ACLR and NRU SEM passed. Power class tolerance: 23 dBm +2/-3 dB”  Also covers 1-2 since ACLR is proposed.  Sub topic 1-2:  ….Skyworks proposals should be captured as options:  1-2.1  Our position is that +2/-3 tolerance should be used and allowe more flexibility in managing MPR and product variations.  We support introduction of both PC5 and PC3 and support of PC3 with two PC5 Tx as an option  1.2.2  If ACLR may be seen as redundant for PC5 (which our measurement also shows) it is not the case for PC3. In order to support LAA coexistence and have a consistent set of requirement for PC5 and PC3, ACLR should be specified at 27dB PC5 and 30dB PC3.  1-2.3  Proposal 3: Skyworks supports Qualcomm’s views with some further details:   * The LO leakage and IQ image for NR is -28 dBc   + SKWKS: But not for 256QAM * Modulation should include 256QAM   + SKWKS: Image should be >34dB for 256QAM support * NR-U includes both DFT-S-OFDM as well as CP-OFDM without DFT pre-coding   + SKWKS: agree although rules for DFT-s-OFDM interleaved waveforms should be understood for both single carrier and wideband operation (puncturing) * The location of RB’s for DFT-S-OFDM may be shifted relative to the center of a channel that is intended to hold 106 RB’s for 20 MHz CP-OFDM. This may have an impact on the exact RIV waveform and the expected location of image products.   + SKWKS: agree that worst case are the shifted waveforms, some specific centered interleaved waveform could be used as 0dB MPR case.   Proposal 4: SKWKS supports but need to clarify if Tx Diversity support is transparent or not.  Proposal 5: SKWKS supports but restricted to 5GHz band NRU  Others: |
| Huawei | 1.2.1:  We support option 2  1.2.2:  We support option 2 since it is covered by general mask  1.2.3:  Ok with proposals 3, 4, and 5 from Qualcomm |
| Ericsson | 1.2.1: we support Option 2 but with tolerances for both PC3 and PC5 as +2/-3 dB  1.2.2: Option 1 but also a specification for PC3: an ACLR specification is key for coexistence between systems. We support ACLR = 27 dBc for PC5 and 30 dBc for PC3, i.e. slightly tighter than the mask for PC5 but significantly so for PC3 and consistent with LAA.  1.2.3: Proposal 4: this is subject to discussion for eMIMO full-power modes (support of antenna virtualization will be specified). Proposal 5: agree for 5 GHz NR-U, the regulatory requirements on unwanted emissions are the same as for eLAA (unless additional regional requirements can be identified, but NS values can be added later) |
| Nokia | Sub topic 1.2.1:  Introducing both PC3 and PC5 is in our opinion beneficial. We therefor support option 2  Sub topic 1.2.2:  It might be that ACLR is redundant due to the SEM in some cases. However, we still suggest defining it as 30dB for PC3 and 27dB for PC5 as this would align to the general NR ACLR requirement and form consistency.  Sub topic 1.2.3:  We are okay with proposal 3, 4 and 5 from QC but would like to continue with the discussion for 256QAM. |
| Charter Communications | Sub topic 1-1:  We agree with Skyworks proposal 3 in R4-2000708  Furthermore, we also agree with Skyworks proposals for wideband operation in R4-2000709  Sub topic 1.2.1:  Option 2 is our preference   * Option 2: Both PC5 (20 dBm ± 2 dB) and PC3 (23 dBm ± 2 dB) where PC3 is allowed to be met using TxDiv between two PC5 PA’s   Subtopic 1.2.2:  We also suggest defining ACLR as 30 dB for PC3 and 27 dB for PC5. We concur with Nokia’s comments  Subtopic 1.2.3:  We agree in principle with Qc proposal 3,4 and 5 but as pointed out by Nokia and Skyworks, Charter will like to further discuss the details for further understanding |
| Intel | Sub topic 1-1: Power Class  Support option 2 with lower tolerance modifications so that both tolerances are +2/-3 dB.  OK to introduce two PC5 PAs to implement PC3 as an option  Sub topic 1-2: ACLR  Support option 1 while Intel has not evaluate the case and could not confirm the necessity. Based on our observation, current NR-U SEM doesn’t provide enough protection to the adjacent channel like LAA, particularly with larger bandwidth. It’s better idea to specify the requirement.  Sub topic 1-3: Other Tx requirements   * + LO Leakage and IQ imageOK to reuse NR -28 dBc except 256QAM   + For 256 QAM, Intel suggest to have further discussion * 256QAM   + Suggest to have further discussion on the feasible requirement |
| Qualcomm | Subtopic 1.2.1 Power Class:  Our concern with defining PC3 is the time that would be required and the closure of the work item for Rel-16. At least enabling a solution that consists of two PC5 PA’s combined together makes sense to us, but that depends on general Rel-16 Tx diversity discussions that have been controversial so far. In addition, MPR/A-MPR requirements could require a study that includes the impact of two PA’s together on the same channel, whether emissions should be specified per antenna connector or summed, etc. So far, this is not well understood with some initial papers submitted in 29 dBm work item on performance impact related to interaction between two PA’s on the same channel.  Subtopic 1.2.3 Other Tx requirements  Some companies wanted to further consider 256QAM. Do these companies want to defer 256QAM out from Rel-16 NR-U, or still include it but want to further consider the assumptions of LO, image, etc?  In response to Skyworks comments   * The LO leakage and IQ image for NR is -28 dBc   + SKWKS: But not for 256QAM   + [Qualcomm] Agreed. The point is that -25 dBc was assumed in LTE simulations which wouldn’t be appropriate for NR-U. * Modulation should include 256QAM   + SKWKS: Image should be >34dB for 256QAM support   + [Qualcomm] I believe there are already agreed assumptions used when we first evaluated 256QAM. We should locate those references. * NR-U includes both DFT-S-OFDM as well as CP-OFDM without DFT pre-coding   + SKWKS: agree although rules for DFT-s-OFDM interleaved waveforms should be understood for both single carrier and wideband operation (puncturing) * The location of RB’s for DFT-S-OFDM may be shifted relative to the center of a channel that is intended to hold 106 RB’s for 20 MHz CP-OFDM. This may have an impact on the exact RIV waveform and the expected location of image products.   + SKWKS: agree that worst case are the shifted waveforms, some specific centered interleaved waveform could be used as 0dB MPR case.   + [Qualcomm] My point is that the eLAA specification defines exact RIV waveform and specific RB location where the LO and image exceptions are located. For NR-U in-band emissions, I am not proposing a “worst case” but rather that care needs to be taken on the exact RIV waveform and RB locations rather than just copying eLAA specification. |
| Apple | Sub topic 1-2-1: Power class  We support option 1, as a baseline, suggesting focusing first on PC5 with 20dBm. Whether we introduce PC3 and how we do it, e.g. as UL TxDiv between two PC5 PAs, can be discussed further. We share Qualcomm’s concern that we have to stay focused to complete the work in Rel-16.  Sub topic 1-2-2: ACLR  Our general view is that ACLR is essential for co-existence with other systems. According to the opinion of one proponent, if we have SEM then maybe ACLR is not really needed. Ideally it should be checked further by RAN4 whether with the current SEM a UE will not violate ACLR requirements (e.g. 27dBc for PC5); and even if it is the case then there should be nothing wrong in defining ACLR. Furthermore, our understanding is that the ACLR discussion somewhat depends on the power class decisions. It is of course possible to collect preliminary views on the anticipated numbers for PC5 and PC3; but if we decide to tackle only PC5 in Rel-16, then the ACLR discussion should be also focused on PC5. |
| Skyworks | Based on Qualcomm comments and other companies position I believe there is some possible way forward for QPSK MPR:  Assuming that a compromise can be found on EVM budget allowed to the PA for QPSK which we find too restrictive in Qualcom’s approach, the difference between Skyworks and Qualcomm results (wo EVM limitation) have a consistent 1-2dB difference which we believe is related to:   1. higher power capability of our PA but also using the proposed +2/-3 dB power class range to absorb some of the part to part and temperature variations instead of of having it assigned in a margin to post PA losses and a power class with only +2/-2dB range. 2. different methods on applying the mask.   If we can progress on a common assumption on EVM budget for QPSK and higher order modulation and the use the larger tolerance range on the power class definition (+2/-3dB is used for all TDD bands above 2.5GHz) we can further compromise to close the gap  Regarding the test procedure for the mask I want to emphasize here that the usual 3GPP way of starting the measurement with an offset of half the measurement BW is inappropriate for masks that are not square. Moreover there is already a consensus that 100kHz measurement BW is used in the first MHz. The test method we have proposed is more accurate as the mask is applied as is in dBR to a in band peak in 1MHz and is also we one adopted by WiFi.  Regarding the comment on influence of interleaved waveform position and overlap of IMDs and Images we agree with Qualcomm comment (our first comment was misinterpreting Qualcomm’s input)  Ideally we should also agree on the reference waveform and measurement limit to define the XdB MPR for the power class. |
| Nokia | Subtopic 1.2.3  Response to QC – We would still like to include 256QUM but further consider the assumptions of LO, image, etc |

## 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.*

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

*Recommendations on WF/LS assignment*

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|  | **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*

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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”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

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

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

# Topic #2: Rx requirements

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2001714**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2001714.zip) | Ericsson | Title: TP on Inclusion of NR-U standalone combinations in TR 38 716-01-01:  Proposal 1: Following LAA specification, REFSENS for 15kHz SCS with 20MHz CBW can be reused as -90dBm. However, the other REFENS numbers need to be investigated. |
| [**R4-2002092**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002092.zip) | Qualcomm Incorporated | Title: Band n46 reference sensitivity  Proposal 1. Reference sensitivity values according to Table 1 are agreed.  Proposal 2. Reference sensitivity and all other Rx requirements dependent on reference sensitivity for NR-U are defined with all sub-bands allocated and all downlink RB’s fully allocated.  Proposal 3. MSD requirements are to be defined for CA and EN-DC configurations as identified in Table 2. |
| [**R4-2002093**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002093.zip) | Qualcomm Incorporated | Title: NR-U receiver ACS and blocking  Proposal 1: ACS and blocking requirements apply under static/semi-static conditions of configuration and scheduling only. Interfering signals are to be specified with sub-SCS frequency offset relative to wanted signal.  Proposal 2: For 20 MHz channel bandwidth, the ACS requirements shall be 14 dB with the interferer as a 20 MHz OFDM signal.  Proposal 3: The wanted power level for ACS case 1 shall be REFSENS+14 dB. The necessity of case 2 is to be further evaluated.  Proposal 4: It is proposed that for blocking requirements, in-band blocking and out-of-band blocking, the NR requirements are leveraged for NR-U.  Proposal 5: ACS and blocker bandwidths are the same as the wideband channel bandwidth for NR-U. ACS and blocker values do not need to scale with bandwidth to account for baseband filter transition.  Proposal 6: In-channel ACS and blocking are not defined for NR-U. ACS and blocking are defined in the conventional manner to apply outside of the channel. For wideband NR-U operation, ACS and blocking requirements apply when all sub-bands are allocated in the downlink.  Proposal 7: EN-DC out-of-band blocking exception needed for IM2 products for DC\_2\_n46 and DC\_66\_n46.  Proposal 8: ACS and in-band blocking for NR-U intra-band CA according to the following table. Out-of-band blocking to reuse NR requirements. |

## Open issues summary

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

### Reference sensitivity

* Proposal: Reuse NF from LAA refsens, scale to NR-U bandwidth according to Table 1 of R4-2002092
* Reference sensitivity for wideband – with full allocation, all sub-bands allocated, or partial sub-band allocation?

### ACS and blocking

* Proposals 1 to 8 in R4-2002093. Which ones can be agreed? If not, is there a counter-proposal?

## Companies views’ collection for 1st round

### Open issues

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| **Company** | **Comments** |
| XXXSkyworks | Sub topic 2-1:  Sub topic 2-2:  ….2.2-1: OK to reuse LAA and scale. For wideband Skyworks suggest to use REFSENS of fully allocated sub-band but also with intra-band guard bands populated  2-2.2  Prop1: Understand the rationale of sub-SCS frequency offset for Wi-Fi interfering signal but should there be a case for LAA interferer? (half SCS shift??)  Prop 2: agree with 20MHz interfering signal but should it be LAA, 802.11ac, 802.11ax, NR-U? most probably NR-U makes most sense  Proposal 3:  The wanted power level for ACS case 1 shall be REFSENS+14 dB. : SKWKS agree  The necessity of case 2 is to be further evaluated.: SKWKS: FFS  Proposal 4: SKWKS: OK  Proposal 5: SKWKS agree  Proposal 6: SKWKS agree  Proposal 7: EN-DC out-of-band blocking exception needed for IM2 products for DC\_2\_n46 and DC\_66\_n46.  Proposal 8: OK in principle, need to check if BW classes align with Ericsson proposals  Others: |
| Huawei: | 2.2.1:  Ok with full allocation for reference sensitivity for wideband |
| Ericsson | 2.2.1:  The proposal and allocation for WB  Proposal 1: the REFSENS can be aligned with LAA requirements scaled. Proposal 2: full allocation without intra-cell GB configured (this is capability). Proposal 3: MSD specified as exception to REFSENS but no actual MSD value like for LAA? Same for any IMD.  2.2.2:  Proposal 1-8  Proposal 1: agreed, the interferer can be off the SCS grid (not necessarily a LAA/NR-U)  Proposal 2: not agreed, it is not relevant to reduce the NR ACS requirement by the difference between the BS ACLR of 45 dBc and (the proposed but not agreed) NR-U ACLR of 27 or 30 dBc to arrive at ACS = 14 dB. This means that ACIR < 14 dB! ACS should be of the order of 30 dB for the 20 MHz bandwidth to maintain an ACIR of the same order (ACLR = 27/30 dBc). ACIR is also relevant for wideband operation even if no explicit in-channel requirement. Note that the Wi-Fi ACS is not 13 dB, the power difference assumes BPSK reference channel for the wanted signal with > 5 dB SNR that must be accounted for a comparison with LTE. Moreover, aside from a significant relaxation of the adjacent interference rejection capability implied by the proposal, regulators keep a close eye on receiver requirements nowadays.  Proposal 5: it may be more relevant to consider ACI of 20 MHz bandwidth (i.e. same as for NR < 2.7 GHz) since this is the “nominal channel bandwidth” in the band at least in the European regulation. The ACS can be scaled for wider bandwidths like for NR < 2.7 GHz.  Proposal 8: for aggregation with the 20 MHz channel bandwidths (which should be possible as per the WID) the requirements should be on par with LAA. |
| Intel | Sub topic 2-1: REFSENS   * OK to reuse NF from LAA and scale. However, one additional aspect to consider is that it needs reflect RAN4 decision of 25 RB for 20 MHz with 60 kHz SCS. * REFSENS for WB: Support specifying the requirement with full allocation. Might need further time to consider pros and cons of rest of allocation options.   Sub topic 2-2: ACS and blocking  For Qualcomm’s paper (R4-2002093),   * P1: First part could be agreeable while the second part needs more discussion * P2: Agreeable * P3: Agreeable * P4: Agreeable * P5: Agreeable * P6: Agreeable * P7: * P8: In principle, we agree to follow the NR approach for NR-U. However, we want to further evaluate since NR-U BW classes are not fully aligned with NR ones. |
| Qualcomm | Subtopic 2.2.2 ACS and blocking  In response to Ericsson comment regarding ACS, we need to consider the relaxed ACLR requirement in this band. There is no system benefit to a tightened ACS if the receive band is anyways polluted by ACLR from the interferer. The WiFi ACS takes this into account with a much relaxed requirement. |
| Apple | Sub topic 2.2.1: REFSENS  Given that the frequency range is similar to the LAA we can support the proposal to re-use the NF and scale the REFSENS for the wider BW.  In our view the full allocation RBs should be supported for REFSENS for wideband.  Sub topic 2.2.2: ACS and Blocking  We are ok to keep the REFSENS + 14 dB for the power level for ACS requirement. In NR intra-band contiguous CA it was agreed to scale the requirement so as not to make it more stringent than the SC requirement for both ACS and IBB. The requirement considered the jammer BW definition as the minimum CC bandwidth of the CCs located on the edges from the corresponding BW class. The IBB level calculation depends on the jammer BW, in order to maintain the PSD if the jammer BW of BW class C is modified (from BWchannelCA to 20 MHz) then the delta IBB should be scaled accordingly. In our view the interferer BW for the BW class C should be 50 MHz – following the statement of having jammer BW as the minimum CC BW on the edges from the corresponding BW class. |

## 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.*

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

*Suggestion on WF/LS assignment*

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

### CRs/TPs

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

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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”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

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

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

# Topic #3: MPR

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

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2000708**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000708.zip) | Skyworks Solutions Inc. | Title: [NRU] Single Carrier Back-off measurements for UE power class and MPR  Proposal 1: Proposal on spectrum mask: the 802.11ax test procedure is adopted for 3GPP measurements and should be reflected in BRAN.  Proposal 2: Proposal on QPSK PA EVM target: PA QPSK EVM budget for PC5 is 12%  Proposal 3:  Power class definition of PC5: 0 dB MPR waveform: 20 MHz 100RB0 fully allocated DFT-s-OFDM QPSK for 27 dB ACLR and NRU SEM passed. Power class tolerance: 20 dBm +2/-3 dB  Power class definition of PC3: 1 dB MPR waveform: 20 MHz 100RB0 fully allocated DFT-s-OFDM QPSK for 30 dB ACLR and NRU SEM passed. Power class tolerance: 23 dBm +2/-3 dB  Proposal 4:  MPR for PC5 QPSK:  o For all (full and interlace) DFT-s-OFDM QPSK waveforms 1 dB MPR  o For all (full and interlace) CP-OFDM QPSK waveforms 2.5 dB MPR  MPR for PC3 QPSK: one additional dB MPR is added to the PC5 case  Observations for A-MPR in section 2.6 |
| [**R4-2000709**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000709.zip) | Skyworks Solutions Inc. | Title: [NRU] Wideband Operation Back-off Measurements for UE  Proposal 1: Proposal on spectrum mask: the 802.11ax test procedure is adopted for 3GPP measurements and should be reflected in BRAN. (Same as Proposal 1 in R42000708)  Proposal 2 on image exception: exception at 28 dBr is confirmed to have acceptable impact to power capability  Proposal 3 on carrier leakage exception: with NRU mask measurement procedure proposed in [3] that uses 100 kHz resolution bandwidth, the exception bandwidth is reduced to 200 kHz  Proposal 4:  MPR definition of PC5:  o For DFT-s-OFDM QPSK waveforms 0.5 dB additional MPR compared to single carrier operation  o For CP-OFDM QPSK waveforms 1 dB additional MPR compared to single carrier operation  o TBC wideband operation with interlace waveforms (the design of these should be clarified)  MPR definition for PC3: given that PC3 has 3 dB better ACLR by default, no additional MPR is needed for the wideband operation compared to single CC case |
| [**R4-2002094**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002094.zip) | Qualcomm Incorporated | Title: NR-U MPR for PC5 single carrier  Emission requirements   * SEM in accordance with the figure in slide 3 of [2]. Measurement bandwidth in the 0 to 1 MHz transition from 0 dBr to -20 dBr was 100 kHz and compared against a requirement scaled to 100 kHz bandwidth. The mask was evaluated in (near)-continuously swept increments. * ACLR was simulated for both 26 dB and 27 dB. While there is no formal agreement on the ACLR requirement yet, the discussion seemed to gravitate to values in this range. * Spurious emissions are the same as for NR; that is, -30 dBm/MHz beyond CBW+5 MHz from the channel edge * EVM partitioned to the PA using an approach similar to [3] and [4] as follows. EVM was not indirectly estimated by time domain or frequency domain spectral analysis, but was computed directly per tone after symbol decoding in the modulation domain.  |  |  |  | | --- | --- | --- | | Modulation | Total transmitter (%) | Partitioned to PA (%) | | QPSK | 17.5 | 8 | | 16QAM | 12.5 | 7.5 | | 64QAM | 8 | 4 | | 256QAM | 3.5 | 1.5 |  * In-band emissions have not yet been discussed and are not included in these simulations.   Baseline results in Table 1  Proposal: Proposed MPR in Table 2. |

## Open issues summary

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

### Emission requirements and measurement methods

Emission requirements need to be agreed in order to properly evaluate MPR. These include power class definition, ACLR, in-band emissions, EVM and PA allocation. With the exception of allocating EVM to the PA (since that will not actually be a specified requirement, but rather an assumption for simulation), the subject of Tx requirements should be handled under “Topic #1: Tx Requirements.” The discussion in on this bullet should be on PA EVM allocation assumption, measurement bandwidth, continuous vs. stepped frequency sweep, etc.

### Baseline and alignment between different companies’ simulators and measurements

It may not be possible to align the simulation results from different simulators or measurements, but it may still be helpful to understand sources of disrepancy. And, a common understanding of waveform definition would certainly be beneficial.

### MPR results

In the moderator’s opinion, it is too premature to try to reach a conclusion on MPR yet since there are only two inputs and both of these are incomplete. Nonetheless, it may still be beneficial for other companies to ask questions, provide comment, or seek clarification for better understanding of the possible MPR as well as to help shape what simulations they may conduct for the next meeting.

### Wideband MPR

Since proposal 1 is already covered in R4-2000708, are there any comments on Proposals 2, 3, and 4 in R4-2000709 on IQ image, LO leakage exception bandwidth, and MPR. Can any of these proposals be agreed? If not, is there a counter-proposal?

## Companies views’ collection for 1st round

### Open issues

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| --- | --- |
| **Company** | **Comments** |
| XXXSKWKS | Sub topic 2-1:  Sub topic 2-2:  Sub-topic 3-1:  [**R4-2002094**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002094.zip)**:** in general EVM budget for PA needs discussion but for LTE and NR 256QAM PA budget was 1.8% we cannot accept 1.5% in this case. In genral we find the EVM budget for the PA to be very generous for the rest of the system that has to support 64QAM by default while for the PA it is not logical to be too restrictive since EVM can be improved with back-off. See reverse budget for rest of system.   |  |  |  |  |  | | --- | --- | --- | --- | --- | | QPSK | 8 | 15.6 | 17.5 | rest not compatible w 64QAM which is mandatory and 2x PA | | 16QAM | 7.5 | 10.0 | 12.5 | rest not compatible w 64QAM which is mandatory | | 64QAM | 4 | 6.9 | 8.0 | rest Phas 2x PA budget | | 256QAM | 1.8 | 3.0 | 3.5 | Sharing agreed for 256QAM due to TRX image rej requirements |   ….Sub topic 3-2: Agree that current view on MPR is imcomplete and unlikely to be agreed this meeting. Still the inputs should be used to at least align assumptions for QPSK which is the baseline for power class definition:  SKWKS Suggests to try to agree a way forward on EVM assumptions and how to apply the mask in both single carrier and wideband operation  Others: |
| Ericsson | 3.2.1: it appears reasonable use a 100 kHz measurement bandwidth, but the mask is still relative to a 1 MHz reference bandwidth (by regulation)  3.2.3: we agree it is premature to agree the MPR. We are currently running simulations aiming at covering all NS cases, initial results indicate similarity with LAA for DFTS-s-OFDM (using a 3.5 GHz PA). |
| Qualcomm | Subtopic 3.2.1 Emission requirements and measurement methods  On PA EVM budget, we can use the previously agreed values at least for higher order modulations 64QAM and 256QAM (I believe they were 4% and 1.8% as Skyworks pointed out for 256QAM). For lower order modulations QPSK and 16QAM, the allocation is not as straightforward since there is more flexibility (larger system EVM to allocated to sub-system in different ways), and will depend on the implementation. Our simulaton results reflects the allocation as described in our document; we found that in many cases, a more relaxed PA EVM would not have changed the MPR since it now becomes limited by ACLR and/or SEM.  Subtopic 3.2.2 Baseline and alignment between different companies’ simulators and measurements  We request that companies running simulations or measurements at least provide the information as in chapter 2.3 of R4-2002094. Additional information may also be helpful such as P1dB of your PA. We continue to believe that an NR-U UE will reuse the existing WiFi PA’s on the device. It will most probably not add new PA’s just to support NR-U. Feedback from OEM’s is welcomed. |
| Skyworks | On EVM see our comment in power class section. We support having a way forward on those assumptions.  Skyworks also supports the reuse of WiFi PAs (We have used our WiFi PAs developed for UEs in our measurements) and we also have provided the same set of data than QCOM chaper 2.3, for even more channel bandwidths. And EVM vs ACLR is also provided so we believe that there is enough points where QCOM and Skyworks data can be compared. If P1dB is provided the budgeting of post PA loss process/temperature variations and how they are affected to post PA losses or power class tolerances is also needed. |

## Summary for 1st round

### Open issues

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

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

*Suggestion on WF/LS assignment*

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

### CRs/TPs

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

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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”* |

## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

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

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

# Topic #4: Band combinations

A number of CA/DC band combination TP’s are presented in this meeting. TP’s are proposed to basket CA and DC TR’s; however, the combinations have not been included those basket work items. The approach should be that the core requirements for the feature (NR-U) along with at least one combination to complete the work item should be done under the NR-U work item. After the work item is completed, then future combinations may be added using the basket work items. Since the core NR-U work item has not been completed yet, then the band combinations should be discussed within the core work item itself rather than the basket work items. One problem is that there is no TR requested in the NR-U WID. Therefore, there is no TR to capture the band combination TP’s. Guidance from the RAN4 chairman is as follows:

Given that NR-U core part is likely to be extended to June 2020, and that the TPs are not going to take much time to agree on, we can consider the following:

1. Focus on the core requirements/baseline requirements at this e-meeting

2. Discuss the TPs and check if the technical analysis in it is complete and correct, but without any endorsement. Comments or conclusions need to be captured in moderator’s summary tdoc

3. Revise the NR-U WID to add a TR for such TPs or revise the relevant R16 basket WIs to add those band combinations in question

4. Revise and re-submit the TPs to the April meeting for approval

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2001714**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2001714.zip) | Ericsson | Title: TP on Inclusion of NR-U standalone combinations in TR 38 716-01-01: NR intra band CA for xCC DL/yCC UL including contiguous and non-contiguous spectrum, (x>=y)  Intra-band combinations |
| [**R4-2000190**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000190.zip) | Charter Communications | Title: TP for DC\_n48-n46 |
| [**R4-2000191**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2000191.zip) | Charter Communications | Title: TP for CA\_n48-n46 |
| [**R4-2001222**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2001222.zip) | MediaTek Inc., Ericsson | Title: Harmonic MSD discussion for DC\_2\_n46, CA\_n25\_n46 |
| [**R4-2002019**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002019.zip) | Ericsson, T-Mobile US, MediaTek | Title: TP to include CA\_n25A-n46A |
| [**R4-2002020**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002020.zip) | Ericsson, T-Mobile US, MediaTek | Title: TP to include CA\_n46A-n66A |
| [**R4-2002021**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002021.zip) | Ericsson, T-Mobile US, MediaTek | Title: TP to include DC\_2A\_n46A |
| [**R4-2002022**](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2002022.zip) | Ericsson, T-Mobile US, MediaTek | Title: TP to include DC\_66A\_n46A |

## Open issues summary

### Harmonic and harmonic mixing MSD

Option 1: Specify MSD

Option 2: Specify exclusion region

### Other technical content within the TP’s

## Companies views’ collection for 1st round

### Open issues

|  |  |
| --- | --- |
| **Company** | **Comments** |
| XXXSkyworks | Sub topic 2-1:  Sub topic 2-2:  Sub topic 4-1:  [R4-2001714](http://ftp.3gpp.org/TSG_RAN/WG4_Radio/TSGR4_94_e/Docs/R4-2001714.zip): Uses CA\_n46A as UL, should be - or n46A (no CA in UL). is 400MHz CA compatible with coex with WiFi?  R4-2000190: For rel16 WI only one combination should be enough. Also it is unclear if DL CA or WB operation is priority in the WI. Table 6.1.x.5-2 has DC\_148\_n46 (corrected in revision)  R4-2000191: Table 6.x.1.1-1 has wrong B48 definition for rel16 WI only one combination is good enough also it is unclear if DL CA or WB operation is priority in the WI (corrected in revision)  R4-2001222: For harmonic mixing we are talking about de-sense of licensed band, should the exclusion rather be applied on the n46 UL frequencies? Thus the equation should provide F\_HB\_UL rather than F\_LB\_DL.  R4-2002019: n46 uses 2 freq sub-ranges. it would be good that all combinations and n46 band definition adopts that. what about harmonic mixing issue for this combination?  R4-2002020: what about harmonic mixing issue for this combination?  R4-2002021: OK with harmonic mixing specifying n46 UL frequencies exclusions  R4-2002022: what about harmonic mixing issue for this combination?  Sub-topic 4.2.1  Support exclusion region like for LAA for UL harmonics falling in unlicensed band. For harmonic mixing the desense is for the licensed band so the exclusion should be specified in terms of unlicensed UL frequencies.  ….  Others: |
| MediaTek Inc. | Sub topic 4-1:  R4-2000190: The MSD due to cross band isolation need to be considered. The revision captures this. Thanks for Skyworks offline comment, the updated MSD proposal has been provided to Charter.  R4-2000191: similar to R4-2000190 except B48 changed to n48 and CBW changes accordingly  R4-2001222: Response to Skyworks: Many band combinations in LTE licensed band has applied “no requirement” for harmonic desense or harmonic mixing. This might be ok to apply it here. Wording in note and equation can be further improved  R4-2002019: Uplink in n46 is not required in NR CA here. Can consider to put a note?  R4-2002020: Desense due to harmonic mixing does not happen in this case when DL is n66.  R4-2002022: Desense due to harmonic mixing does not happen in this case when DL is B66 |
| Skyworks | We are fine with Mediatek’s answers on 2002019/20/22 and we think it is useful to clarify when a combination only assumes DL in n46.  We are also fine with the concept of n46 UL frequency exclusion proposed in 2001222 but belive that the equation should be reversed so that it gives the results for the UL frequencies that are excluded |

### CRs/TPs comments collection

*Major close to finalize WIs and Rel-15 maintenance, comments collections can be arranged for TPs and CRs. For Rel-16 on-going WIs, suggest to focus on open issues discussion on 1st round.*

|  |  |
| --- | --- |
| **CR/TP number** | **Comments collection** |
| XXX | Company A |
| Company B |
|  |
| YYY | Company A |
| Company B |
|  |

## Summary for 1st round

### Open issues

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

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

*Suggestion on WF/LS assignment*

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

### CRs/TPs

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| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation** |
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## Discussion on 2nd round (if applicable)

## Summary on 2nd round (if applicable)

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

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