**3GPP TSG-RAN WG4 Meeting # 97-e R4-200XXXX**

**Electronic Meeting, Nov. 2020**

**Agenda item:** 12.3.2.1.2, 12.3.2.1.3, 12.3.2.2.1, 12.3.2.2.2

**Source:** Moderator (Qualcomm Incorporated)

**Title:** Email discussion summary for [97e][136] NR\_RF\_FR2\_req\_enh2\_Part\_2

**Document for:** Information

# Introduction

*The topics for discussion are arranged per tables below.*

|  |  |  |
| --- | --- | --- |
| **FR2 Inter-band DLCA** | **bands in same frequency group** | **bands in different frequency groups** |
| *IBM* | *Topic #1* | *Not treated here* |
| *CBM* | *Not treated here* | *Topic #2* |

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| --- | --- |
| **FR2 Inter-band ULCA** | **bands in same frequency group or in different frequency groups** |
| *IBM/CBM* | *Topic #3* |

# Topic #1: Inter-band DL CA: IBM for bands in same frequency group

*Agenda item 12.3.2.1.2*

## Companies’ contributions summary

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| **T-doc number** | **Title** | **Company** | **Proposals / Observations** |
| [**R4-2014233**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014233.zip) | On the feasibility of IBM for FR2 inter-band CA within the same frequency group | Apple | * On collocation and non-collocation deployment scenarios

Observation 1: The cell size or coverage is similar for the bands within the same frequency group. **Proposal 1: Operators’ inputs are needed if collocated deployment can be considered as typical scenario for FR2 inter-band CA within the same frequency group.*** On the metric to evaluate the performance gain of IBM over CBM

**Proposal 2: Based on the assumption of collocated deployment, it should be evaluated on the probability that different beams can be selected with IBM for different bands within the same band group. This should be done with reasonable assumption of frequency separation/beam squint and codebook size (e.g. <64).*** IBM and CBM from UE architecture perspective

Observation 2: Compared to CBM, IBM related cost, form factor and power consumption are expected to be higher. Meanwhile, IBM normally requires larger memory size, multiple BM processing engines and potentially longer BM processing delay.**Proposal 3: The performance gain of IBM over CBM for FR2 inter-band CA within the same band group should be justified, considering the impact on cost, form factor, power consumption, memory size, # of BM engines and processing delay.** |
| [**R4-2014587**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014587.zip) | On IBM feasibility for CA configurations within same frequency group | Intel Corporation | Observation: IBM can support non-collocated gNB deployments.**Proposal: IBM is allowed to support inter-band DL CA within the same frequency group. The PSD imbalance level needs to be reduced or ΔRIB,P,n and ΔRIB,S,n are further relaxed. They are a function of frequency gap between upper channel edge of highest CC in lower band and lower channel edge of lowest CC in upper band.**  |
| [**R4-2015873**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015873.zip) | Views on Feasibility for CA configurations within same frequency group based on IBM | Sony, Ericsson | Observation 1: A CBM UE is assumed to support the co-located deployment scenarios. An IBM UE is assumed to support both co-located and non-co-located deployment scenarios. Observation 2: Supporting IBM UE within the same band group can significantly improve network deployment flexibility.Observation 3: From an RF viewpoint, supporting IBM within the same band group operation mainly requires separated phase shifters for each band but can provide a better performance comparing to the CBM UEs, which is a feasible solution for inter-band DL CA. Observation 4: There is no protocol barrier for supporting IBM UEs within the same band group.**Proposal 1: RAN4 conclude the IBM UEs are feasible for the DL inter-band CA within the same frequency group** |

## Open issues summary

*The primary goal of the study is to establish feasibility of IBM for inter-band CA across bands in the same frequency group. See thread #135 for ‘frequency group’ discussion..*

### Sub-topic 1-1

*On need for UEs to support non-co-located inter-band CA deployment for bands within the same frequency group:*

**Issue 1-1: Can** **co-located deployment be considered a typical scenario for FR2 inter-band CA within the same frequency group?**

### Sub-topic 1-2

*2 out of the 3 contributions have argued that IBM between bands in the same frequency group is feasible, while citing improved network performance, while the third contribution recommends that the performance gain of IBM over CBM in this context should be justified based on UE implementation-specific criteria. Should feasibility stop with network benefit if established, or should it also include UE implementation challenges?*

**Issue 1-2: Feasibility criteria for IBM for inter-band CA between bands in the same frequency group**

* Proposals
	+ Option 1: Network benefit is enough
	+ Option 2: Network benefit must be balanced with UE implementation challenges
	+ Others

### Sub-topic 1-3

*Discussion on what parameters to study to quantify IBM benefit and UE implementation complexity.*

**Issue 1-3: Parameters to study on IBM benefit** **and UE implementation complexity**

## Companies views’ collection for 1st round

### Open issues

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| --- | --- | --- |
| **Issue** | **Options** | **Company Comments** |
| Issue 1-1: Can co-located deployment be considered a typical scenario for FR2 inter-band CA within the same frequency group? | (open discussion) | Intel: From UE perspective, co-located deployments are preferred in term of challenges from PSD imbalance and MRTD from bands in CA, regardless same frequency group or different frequency groups. But co-located deployment is expected to have smaller PSD imbalance and MRTD.Verizon:Yes, the co-located deployment should be considered for FR2 inter-band CA. In actual deployments, it is highly possible to deploy the cell based on the spectrum. Both 28 and 39GHz carriers are possible to be implemented in either co-located or non-co-located in the network (gNB(s)) for high data throughput. |
| Issue 1-2: Feasibility criteria for IBM for inter-band CA between bands in the same frequency group  | (open discussion)For example: network benefit, UE implementation challenges | Intel: Option 2. If non co-located deployments exist, IBM looks more reasonable. Qualcomm: IBM is certainly implementable for multiple bands within the same frequency group, and we think there is network benefit to this implementation. The barriers to adoption of IBM for inter-CA between bands of the same frequency group are mostly related to design choice rather than physics impediment. Feasibility is therefore better left for individual UE vendors to decide for themselves. RAN4 need not debate preclusion of IBM in this contextVerizon: The IBM should be implemented for multiple bands to support both co-located and non-co-located inter-band CA.For flexibility both UE and network deployments, it is possible to consider the IBM/CBM as a UE capability for the UE to select the preferred network. On the network side, the gNB should be able to configure the beam management based on the reported UE capability and availability of network resources.  |
| Issue 1-3: Parameters to study on IBM benefit and UE implementation complexity | (open discussion)(metrics needed) | Intel: 1) minimum gap size between CCs from two bands 2) frequency separations within each bands 3) co-located or non co-located 4) beam squint, etc |

### CRs/TPs comments collection

*N/A.*

## 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** |
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### 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: Inter-band DL CA: CBM for bands across different frequency groups

*Agenda item 12.3.2.1.3*

## Companies’ contributions summary

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| **T-doc number** | **Title** | **Company** | **Proposals / Observations** |
| [**R4-2014232**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014232.zip) | On the feasibility of CBM for FR2 inter-band CA cross different frequency groups | Apple | * On deployment scenarios

Observation 1: The cell size or coverage difference between 28GHz and 37GHz band group can be as large as 3 times based on free space path loss model. If n262 is considered, the corresponding difference can be even larger.**Proposal 1: Operators’ inputs are needed if non-collocated deployment can be considered as typical scenario for FR2 inter-band CA between different frequency groups.**Observation 2: On top of receiving time difference, non-collocated deployment can also impact CBM from the aspects of AGC, TPC due to different propagation loss and phase shifter setting due to the different orientation relative to UE. * On MRTD

Observation 3: When MRTD is more than CP length in CBM, one slot per Rx beam switching can be interrupted on all CCs where the symbol boundry misalignment from the reference CC is more than CP. If PDCCH is interrupted, the corresponding impacts can last multiple slots. Observation 4: When non-collocated scenario is assumed, it is infeasible to assume MRTD is less than CP length due to both TAE and propagation delay differences. The performance degradation due to Rx switch and the corresponding interruption can be quite significant. Observation 5: When MRTD>CP, parallel RRM measurement on FR2 CC becomes questionable since beam switch may happen during the symbol duration. * On frequency separation and beam squint

Observation 6: Substantial performance degradation is expected for CBM with FR2 inter-band CA between different frequency groups from the aspects of frequency separation and beam squint.  |
| [**R4-2015874**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2015874.zip) | Views on Feasibility for CA configurations between different frequency groups based on CBM | Sony, Ericsson | Observation 1: A CBM UE is assumed to support the co-located deployment scenarios. An IBM UE is assumed to support both co-located and non-co-located deployment scenarios. Observation 2: Supporting CBM UEs with different frequency groups can speed up the deployment of inter-band DL CA and save network resources since it does not require advanced phase shift networks on the UEs. **Proposal 1: RAN4 concludes that CBM UEs are feasible for DL inter-band CA between the different frequency groups, at least for the co-located scenarios.**  |

## Open issues summary

*The primary goal of the study is to establish feasibility of CBM for inter-band CA across bands across different frequency groups. See thread #135 for ‘frequency group’ discussion.*

### Sub-topic 2-1

*One contribution has pointed out that UEs that support CBM for bands across different frequency groups suffer from significant functionality impairments due to inability of networks to guarantee sub-CP MRTD and beam squint. Another points out that a UE design is physically possible and there is promise of reduced network overhead. It goes on to propose feasibility at least for co-located case.*

**Issue 2-1: Can non-co-located deployment be considered a typical scenario for FR2 inter-band CA between different frequency groups?**

### Sub-topic 2-2

*Discussion on CBM and MRTD > CP.*

**Issue 2-2: What performance criteria should be discussed to capture mid-symbol beam and AGC changes, and PDCCH interruption**

### Sub-topic 2-3

*Discussion on Beam Squint.*

**Issue 2-3: How would UE and network interact to compensate for beam squint in setting UL power per CC**

## Companies views’ collection for 1st round

### Open issues

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| --- | --- | --- |
| **Issue** | **Options** | **Company Comments** |
| Issue 2-1: Can non-co-located deployment be considered a typical scenario for FR2 inter-band CA between different frequency groups? | (open discussion) | Verizon: In actual deployments, it is highly possible to deploy the cell based on the spectrum availabilities. In this scenario, both 28 and 39GHz carriers are possible to be implemented in either co-located or non-co-located in the network (gNB(s)) and the network should incorporate the functional modules of beam management. An IBM UE is assumed to support both co-located and non-co-located carriers in the deployment scenarios.  |
| Issue 2-2: What performance criteria should be discussed to capture mid-symbol beam and AGC changes, and PDCCH interruption | (open discussion) | Qualcomm: In the short term, we can use REFSENS, but in the presence of PSD difference that is realistic in deployment scenarios. Unlike intra-band or intra-frequency group inter-band, even with co-located scenarios, beam squint and different propagation conditions will potentially cause significant PSD difference for inter-CA across different frequency groups.In the long term, BB test methods may be developed to quantify a UE’s performance in response to beam changes and AGC activity. |
| Issue 2-3: How would UE and network interact to compensate for beam squint in setting UL power per CC | (open discussion) |  |

### CRs/TPs comments collection

*N/A.*

## 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** |
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### 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*

|  |  |
| --- | --- |
| **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: Inter-band UL CA

*Agenda Items 12.3.2.2.1, 12.3.2.2.2.*

## Companies’ contributions summary

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| --- | --- | --- | --- |
| **T-doc number** | **Title** | **Company** | **Proposals / Observations** |
| [**R4-2014715**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2014715.zip) | Inter-band UL CA for FR2 | Qualcomm Incorporated | Observation: (As listed in paper) issues to be discussed for inter-band UL CA …. the list of open items is long:  |
| [**R4-2016086**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_97_e/Docs/R4-2016086.zip) | UL inter-band CA for different band group based on IBE | NTT DOCOMO INC. | **Proposal 1: For maximum TRP for FR2 UL inter-band CA, the sum of TRP from LB and HB shall not exceed maximum TRP associated with each power class, e.g., 23dBm for power class 2/3/4.****Proposal 2: For maximum peak EIRP for FR2 UL inter-band CA, it should be guaranteed that the sum of peak EIRP from LB and HB in any direction does not exceed the allowable level, e.g., 43dBm for PC 2/3/4.****Proposal 3: For FR2 UL inter-band CA, UE should meet minimum peak EIRP of LB and HB individually, and should meet common spherical coverage EIRP.****Proposal 4: UE should meet emission requirements of LB and HB under UL inter-band CA operation, respectively.** |

## Open issues summary

### Sub-topic 3-1

*UE power class discussion. One contribution recommends per-UE applicability for TRP and EIRP limit.*

**Issue 3-1a: Do the power class requirements in TS38.101-2 v16.5 apply per UE or per band.**

**Issue 3-1b: Should there be regional requirements with NS in case of per UE?**

**Issue 3-1c: Per band spherical coverage and peak EIRP discussion**

### Sub-topic 3-2

*Configured power for inter-band UL CA:*

**Issue 3-2: If EIRP is shared in configured power formulation, what is the definition of shared EIRP**

### Sub-topic 3-3

*MPR and A-MPR:*

**Issue 3-3: Open discussion on impact of reverse IMDs and unequal PSDs**

### Sub-topic 3-4

*MPE:*

**Issue 3-4: Open discussion on P-MPR, PHR in context of UL in two bands**

### Sub-topic 3-5

*UE Capabilities:*

**Issue 3-5: Is CBM/IBM enough, or are new capabilities required?**

### Sub-topic 3-6

*Testability:*

**Issue 3-6: Is single AoA/AoD enough?**

### Sub-topic 3-7

*Emissions:*

**Issue 3-7: Can existing emissions limits in TS38.101-2 v16.5 be adopted as being applicable per UE?**

## Companies views’ collection for 1st round

### Open issues

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| --- | --- | --- |
| **Issue** | **Options** | **Company Comments** |
| Issue 3-1a: Do the power class requirements in TS38.101-2 v16.5 apply per UE or per band.  | (open discussion) | Intel: In Rel-15 and 16, only single CC UL and intra-band contiguous UL CA are considered. So V16.5 is per band and also per UE. But for Rel-17 inter-band UL CA, the situation is a bit more complicated. We need further study how to define requirements for inter-band UL CA with 2 UL band active. It imposes challenge on UE design either per UE based or per band based. If per band based, simultaneous UL transmission over two bands will increase UE power consumption which is critical parameter is FR2. If per UE based, how to define/share EIRP and spherical coverage is not clear yet. It also not clear how to handle emission. Qualcomm: The 23 dBm TRP limit was originally derived from co-existence considerations. In our view TRP is a per-band requirement.Verizon: Per band! |
| Issue 3-1b: Should there be regional requirements with NS in case of per UE? | (open discussion) | Qualcomm: For regions that impose per UE limits, other limiting mechanisms can be discussed like Pmax or NS |
| Issue 3-1c: Per band spherical coverage and peak EIRP discussion | (open discussion) | Intel: In general, it is reasonable to consider spherical coverage and peak EIRP per band based. But apparently, in UL CA case, it is challenging to deliver them on both bands simultaneously.Qualcomm: This study will benefit from organization into CBM and IBM UEsVerizon: Per band if it is possible, but a study is needed. |
| Issue 3-2: If EIRP is shared in configured power formulation, what is the definition of shared EIRP | (open discussion) | Intel: EIRP may be defined as per band based in configured power. |
| Issue 3-3: impact of reverse IMDs and unequal PSDs | (open discussion) | Intel: The issue is more challenging for CBM Tx. Need further investigation. |
| Issue 3-4: P-MPR, PHR in context of UL in two bands | (open discussion) | Intel: It is depending on how to handle Tx requirements per band or per UE.  |
| Issue 3-5: Is CBM/IBM enough, or are new capabilities required? | (open discussion) | Intel: Should be consistent with DL assumption |
| Is single AoA/AoD enough? | (open discussion) | Intel: Should be consistent with DL assumption |
| Can existing emissions limits in TS38.101-2 v16.5 be adopted as being applicable per UE | (open discussion) | Intel: Need further investigation.Qualcomm: In our view regulatory-facing emissions limits are per UE (SEM, OBW, general spurious, additional requirements). Others like ACLR can be considered per band. FFS on co-existence requirements.Verizon: this should be per UE.  |

### CRs/TPs comments collection

*N/A.*

## 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”* |