**3GPP TSG-RAN WG4 Meeting #109 R4-23xxxxx**

**Chicago, US, November 13th – 17th, 2023**

**Agenda item:** 8.19.4

**Source:** Moderator (Samsung)

**Title:** Topic summary for [109][305] FS\_NR\_duplex\_evo\_Part1

**Document for:** Information

# Introduction

This thread is on Rel-18 SI for Study on evolution of NR duplex operation, in which the following highlighted agenda items are supposed to be covered:

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| * 1. Study on evolution of NR duplex operation [FS\_NR\_duplex\_evo]      1. General aspects (TR) [FS\_NR\_duplex\_evo]      2. Study the feasibility of and impact on RF requirements [FS\_NR\_duplex\_evo]         1. Adjacent channel co-existence evaluation [FS\_NR\_duplex\_evo]         2. Implementation feasibility of SBFD [FS\_NR\_duplex\_evo]            1. Feasibility of FR1 BS aspects [FS\_NR\_duplex\_evo]            2. Feasibility of FR2 BS aspects [FS\_NR\_duplex\_evo]            3. Feasibility of FR1 UE aspects [FS\_NR\_duplex\_evo]            4. Feasibility of FR2 UE aspects [FS\_NR\_duplex\_evo]         3. Impacts on BS RF requirements [FS\_NR\_duplex\_evo]         4. Impacts on UE RF requirements [FS\_NR\_duplex\_evo]      3. Summary of regulatory aspects [FS\_NR\_duplex\_evo]      4. Moderator summary and conclusions |

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

# Topic #1: General: TR and RAN4 part conclusion

## Companies’ contributions summary

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| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318923 | CMCC | TP for TR 38.858 to add RAN4 conclusion part |
| R4-2318925 | CMCC | Draft TR 38.858 SBFD (reserved to capture the approved TP after RAN4#109) |

## Open issues summary

#### Issue 1-1-1: Text proposal on RAN4 part conclusion

* Text Proposal (CMCC) on conclusion part:

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| **<<Start of Change for TR 38.858>>**  **<<Next Change for TR 38.858>>** 13 Conclusions and recommendations13.1 SBFD **<<Next Change for TR 38.858>>**  13.1.2 RAN4  RAN4 has studied the implementation feasibility of SBFD-capable BS considering self-interference, co-channel inter-sub-band co-site inter-sector interference and co-channel inter-sub-band inter-site interference. Both FR1 and FR2 BS classes are studied, including FR1 wide area BS, FR1 medium range BS, FR1 local area BS and FR2-1 wide area BS. When considering the RSIC for self-interference and inter-sector interference, the following aspects and self-interference mitigation techniques have been considered: spatial antenna isolation, Tx beam nulling, suppression of transmitter leakage (i.e., frequency isolation), analogue interference cancellation, digital interference cancellation, receive beam-forming, receiver linearity performance, phase noise and other considerations.  RAN4 has also studied the implementation feasibility of UE considering modeling of UE-UE co-channel inter-sub-band CLI and UE-UE adjacent channel CLI. Both FR1 and FR2-1 UE are studied and CLI modeling combines both Tx and Rx parts. It’s worth noting that half duplex operation at UE side is assumed according to the objective of this study item.  Besides, the impact on both BS and UE RF requirements are studied. For the BS aspects, impact on Tx requirements, impact on Rx requirements and potentially new requirements for SBFD operation are analyzed. For the UE aspects, existing UE RF requirements has been applied as default assumptions for study phase conclusion, since no issues related to existing UE RF requirements has been identified in the co-existence study.  Moreover, the adjacent channel co-existence studies were performed under a total of 8 deployment scenarios as described in Table 11-1. For each deployment scenario, a total of 4 cases were performed as described in Table 11-2. The performance metrics were the 5% throughput loss threshold at the cell edge and average cell throughput loss performance. In the summary sub-section, value ranges and median values are collected from all companies' simulation results with respect to the different scenarios, cases, victims, and the four kinds of simulation parameters. The final conclusion is derived for the four "victim/ aggressor" network combinations.  Finally, regulatory considerations for deploying the duplex enhancements in TDD unpaired spectrum are summarized with respect to three ITU Regions, namely ITU Region 1, ITU Region 2 and ITU Region 3.  Regarding detailed conclusions, Table 1 below summarizes the different study conclusions and their respective section.  Table 1 RAN4 conclusions reference   |  |  | | --- | --- | | Study conclusion | Section | | Feasibility of FR1 wide area BS aspects | 9.2.4 | | Feasibility of FR1 medium range BS aspects | 9.3.4 | | Feasibility of FR1 local area BS aspects | 9.4.3 | | Feasibility of FR2 BS aspects | 9.5.4 | | Feasibility of FR1 UE aspects | 9.6.2 | | Feasibility of FR2 UE aspects | 9.7.2 | | Impact on RF requirements (BS and UE) | 10 | | Adjacent channel co-existence evaluation | 11.3 | | Regulatory aspects | 12.4 |   13.2 Dynamic/flexible TDD  For dynamic/flexible TDD, the gNB-to-gNB co-channel CLI handling schemes and UE-to-UE co-channel CLI handling schemes, which can be specific for dynamic/flexible TDD and/or common for both SBFD and dynamic/flexible TDD, were studied, including analysis, performance and specification impact, which are included in Section 8.3 and Section 8.4. The summary of observations for gNB-to-gNB CLI handling schemes are included in Section 8.3.  [RAN4 did not conduct any simulations with dynamic TDD in Rel-18 SI as similar discussions took place under Rel-16 and were captured in TR 38.828. The following recommendations were made in section 6.3.1.1 of TR 38.828  -    Concerning Urban Macro to Urban Macro scenario in FR1, *“Performance degradation was observed from the BS-to-BS interference for macro-macro scenario, which suggests that dynamic TDD should not be operated in such scenarios.”*  -   Concerning indoor network and a macro network scenario in FR1 and vice versa*, “Performance degradations were not observed from operating dynamic TDD between an indoor network and a macro network and vice versa if there is sufficient isolation between them. No significant impact from operating dynamic TDD for the indoor scenario was observed as long as the BS and UE powers are similar and the operator’s co-ordinate so that base station positions are offset. If higher BS power is assumed, some throughput degradation in the indoor scenario was observed due to BS-to-BS interference. The observations imply that dynamic TDD can be used in indoors as long as care is taken.”*  The recommendations for dynamic TDD in TR38.828 are still valid and should be taken into consideration. Any mitigation techniques of dynamic TDD to address adjacent channel interference can apply to SBFD operation in symbols configured as flexible.]  **<<End Change for TR 38.858>>** |

* Moderator Recommendation:
  + Collect companies’ view on the following proposals one by one:
    - P1: To avoid duplication of conclusions, it is recommended to delete section 9.8 and only capture RAN4 conclusion into section 13.
    - P2: For the SBFD conclusion, we only list what RAN4 has done and detailed conclusion refer to corresponding conclusion sub-section.
    - P3: For dynamic TDD conclusion, we just copy the agreements in last meeting WF about dynamic TDD.

# Topic #2: Feasibility study on SBFD-capable BS

*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** |
| R4-2318471 | Murata Manufacturing Co Ltd. | Observation 1: If the guard band is expanded from 5PRB to 5MHz, possible to achieve > 25dB attenuation and < 3dB insertion loss with Q-factor 2,000 blocking filter. But it is not including the influence of temperature dependence and individual variation.  Observation 2: TCF (Temperature Coefficients of Frequency) of conventional filter is -40 to 20 ppm/℃. Some filters with good performance have achieved 8 ppm/℃.  Observation 3: Considering versatility, at least 20 ppm/℃ TCF should be considered to investigate the impact of temperature dependence of filter.  Observation 4: In case of TCF = -20 ppm/℃, it is not possible to expect blocking for SBFD. Thus, it is difficult to suppress interference of DL Tx signal by implementing BPF in RF front end. |
| R4-2318472 | Murata Manufacturing Co Ltd. | TP to TR 38.858: Feasibility of FR1 WA BS aspects |
| R4-2319678 | Huawei, HiSilicon | TP to TR 38.858: Feasibility of FR1 BS |
| R4-2320051 | Nokia, Nokia Shanghai Bell | TP to TR 38.858: Feasibility of FR1 MR BS |
| R4-2320052 | Nokia, Nokia Shanghai Bell | TP to TR 38.858: Feasibility of FR1 WA BS |
| R4-2320327 | ZTE Corporation | Proposal 1: for multi-carrier SBFD operation (interpretation 1), feasibility study for single carrier SBFD could be applicable for it.  Observation 1: FR1 antenna isolation among different sectors separated in the vertical domain on the mast are expected to be around 60dBc which is much less than 100dBc. |
| R4-2320615 | Samsung | Text Proposal to TR 38.858 on feasibility of FR1 Wide Area BS aspects |
| R4-2320616 | Samsung | Text Proposal to TR 38.858 on feasibility of FR1 Medium Range BS aspects |
| R4-2319679 | Huawei, HiSilicon | TP to TR 38.858: Feasibility of FR2 wide area BS |
| R4-2320053 | Nokia, Nokia Shanghai Bell | TP to TR 38.858: Feasibility of FR2 BS aspects |

*The moderator can suggest a limited number of papers which could be presented.*

## Open issues summary

*Before f2f meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

### Sub-topic 2-1: Remaining feasibility issues

#### Issue 2-1-1: High-Q Analogue filter design feasibility: TCF impact

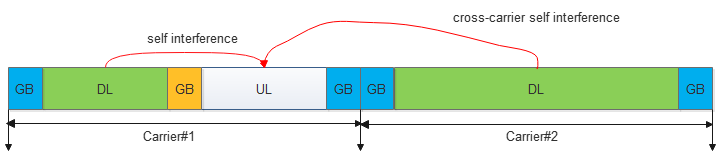
* Observations from Murata (R4-2318471):
  + Observation 1: If the guard band is expanded from 5PRB to 5MHz, possible to achieve > 25dB attenuation and < 3dB insertion loss with Q-factor 2,000 blocking filter. But it is not including the influence of temperature dependence and individual variation.
  + Observation 2: TCF (Temperature Coefficients of Frequency) of conventional filter is -40 to 20 ppm/℃. Some filters with good performance have achieved 8 ppm/℃.
  + Observation 3: Considering versatility, at least 20 ppm/℃ TCF should be considered to investigate the impact of temperature dependence of filter.
  + Observation 4: In case of TCF = -20 ppm/℃, it is not possible to expect blocking for SBFD. Thus, it is difficult to suppress interference of DL Tx signal by implementing BPF in RF front end.
* Moderator Recommendation:
  + Discussion on the TCF (Temperature Coefficients of Frequency) impact:
    - The impact of TCF (Temperature Coefficients of Frequency) of conventional filter on SBFD: even some DL subband is contained in filter passband or transition band(s), what will be the impact?
    - Typical filter TCF performance for conventional SAW or new ceramic dielectric filters?
    - Any possible solution to mitigate the impact of TCF on SBFD?
  + Other comments on TP R4-2318472.

#### Issue 2-1-2: Multi-carrier support

* [Moderator] The following agreement achieved in RAN4#108:

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| **Issue 2-1-3: Multi-carrier BS analysis**   * Agreement:   + During Rel-18 SI, RAN4 will only discuss the interpretation-1 of multi-carrier support for SBFD-capable BS, i.e., SBFD operates in only one BS carrier, and legacy TDD operates in other intra-band BS carrier(s) contiguous or non-contiguous to the SBFD carrier.   + RAN4 didn’t study the feasibility for the case on interpretation-2 of multi-carrier support for SBFD-capable BS i.e., SBFD operates in more than one BS carriers, and legacy TDD operates in the other intra-band BS carrier(s) (if any), which is contiguous or non-contiguous to the SBFD carriers. |

* Proposal 1 (ZTE): for multi-carrier SBFD operation (interpretation 1), feasibility study for single carrier SBFD could be applicable for it.



* Moderator Recommendation:
  + In last meeting, no time to discuss this proposal, so suggest to collect views from companies firstly.
  + Considering the similarity between the above case and DUD in one carrier case, suggest the group to adopt P1.

### Sub-topic 2-2: Text proposal for FR1 WA BS

* The list of TPs related to FR1 WA BS

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| R4-2318472 | Murata Manufacturing Co Ltd. | TP to TR 38.858: Feasibility of FR1 WA BS aspects |
| R4-2319678 | Huawei, HiSilicon | TP to TR 38.858: Feasibility of FR1 BS |
| R4-2320052 | Nokia, Nokia Shanghai Bell | TP to TR 38.858: Feasibility of FR1 WA BS |
| R4-2320615 | Samsung | Text Proposal to TR 38.858 on feasibility of FR1 Wide Area BS aspects |

* Moderator Recommendation:
  + The following issues can be discussed firstly.
  + Further view collection on the above TPs for the company-specific clause TP.
  + Revise the responsible company (Samsung)’s TP, and merge TPs from others.

#### Issue 2-2-1: Conclusion parts for FR1 WA BS (clause 9.2.1.3, and 9.2.2.3)

* TP combining the input from Huawei (9678), Nokia (0052) and Samsung (0615):

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| 9.2.1.3 Conclusion Based on the self-interference analysis provided in Section 9.2.1 for FR1 wide area BS, it can be observed that the implementation feasibility of controlling the residual interference to meet the 1dB receiver desensitization target depends on the implementation aspects including:   * Maximum BS transmit power * Spatial isolation capability * beam nulling/ isolation capability * Blocker suppression at the RX * Frequency isolation at the TX and RX * The digital interference suppression/cancellation capabilities   Based on the different assumptions and/or technique adoption for the above-mentioned implementations aspects, and based on 6 companies’ technical inputs, companies have come to the following conclusions:   * 1dB receiver desensitization target is achievable by self-interference cancellation capability according to 3 companies. * 1dB receiver desensitization target is not achievable or is challenging based on existing technology and technology roadmaps that are viewed as viable in the current time or foreseeable future according to 3 companies. |

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| 9.2.2.3 Conclusion Based on the analysis on co-site inter-sector co-channel inter-subband interference provided in Section 9.2.2 for FR1 wide area BS, it can be observed that the implementation feasibility of controlling the co-site inter-sector co-channel inter-subband interference to meet the target (i.e., being less than certain level of receiver desensitization) depends on the implementation aspects including:   * Maximum BS transmit power * Number of co-site, co-channel sectors and the separation between them and other site constraints * The achievable spatial isolation and use of absorbing material and choke structure depending on site constraints * Beam nulling/isolation capability * Frequency isolation at the TX and RX * The digital interference suppression/cancellation capability.   Based on the different assumptions and/or technique adoption for the above-mentioned implementations aspects, and based on 4 companies’ technical inputs, companies have come to the following conclusions:   * the implementations can achieve reasonable residual level for co-site inter-sector co-channel inter-subband interference, up to 1dB desensitization, according to 2 companies. * the implementations are not able to achieve that because the receiver is saturated, and the RX processing is not feasible, based on co-site deployment limitation, existing technology and technology roadmaps that are viewed as viable in the current time or foreseeable future according to 2 companies.   It should be noted that gNB-to-gNB co-channel CLI handling schemes provided in Section 8.3 have not yet been considered in concluding the implementation feasibility study for controlling the co-site inter-sector co-channel inter-subband interference. |

* Moderator Recommendation:
  + Discuss on the above combined TP firstly.
  + The summary clause in clause 9.2.4 can be updated accordingly.
  + FR1 MR, LA BS and FR2 BS may need similar change.

### Sub-topic 2-3: Text proposal for FR1 MR BS

* The list of TPs related to FR1 MR BS

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| R4-2319678 | Huawei, HiSilicon | TP to TR 38.858: Feasibility of FR1 BS |
| R4-2320051 | Nokia, Nokia Shanghai Bell | TP to TR 38.858: Feasibility of FR1 MR BS |
| R4-2320616 | Samsung | Text Proposal to TR 38.858 on feasibility of FR1 Medium Range BS aspects |

* Moderator Recommendation:
  + The following issues can be discussed firstly.
  + Further view collection on the above TPs for the company-specific clause TP.
  + Revise the responsible company (Nokia)’s TP, and merge TPs from others.

#### Issue 2-3-1: Conclusion parts for FR1 MR BS (clause 9.3.1.3, and 9.3.2.3)

* TP from Nokia (R4-2320051):

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| 9.3.2.3 Conclusion  Based on the co-channel inter-sub-band co-site inter-sector interference analysis in Section 9.3.2, two companies provided technical inputs, concluding that the total interference caused by two co-site sectors would be above the noise floor, causing a desensitization of the receiver. |

* TP from Samsung (R4-2320616) based on the company observation:

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| 9.3.2.2.3 Samsung  For FR1 medium range BS, it is not necessarily to require co-site multi-sector deployment while omni-directional antenna could also be the deployment option. And the co-site inter-sector interference is only present for the case where directional antennas are used.  For the case of 3-sector site deployment with directional antenna, Table 9.3.2.1-1 presents the company’s view on the co-site inter-sector interference analysis for a medium range base station. Similar to FR1 wide area BS counterpart, the achievable antenna isolation is key factor to analyze the co-site inter-sector co-channel gNB-gNB CLI. It has been demonstrated that even without analog subband filter implemented, the residual co-site inter-sector interference can be well controlled with proper implementation of spatial isolation, frequency isolation, beam nulling, and optional digital cancellation for FR1 medium range BS. |

* Moderator Recommendation:
  + Conclusion part TP needs to consider the current input from three companies.

### Sub-topic 2-4: Text proposal for FR1 LA BS

* The list of TPs related to FR1 LA BS

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| R4-2319678 | Huawei, HiSilicon | TP to TR 38.858: Feasibility of FR1 BS |

* Moderator Recommendation:
  + Huawei’s TP related to FR1 LA BS (as company input description) shall be adopted.
  + Since there is not other TP for FR1 LA BS, suggest Huawei to revise 9678 by only capture the TP on FR1 LA BS part for approval.

### Sub-topic 2-5: Text proposal for FR2-1 BS

* The list of TPs related to FR2-1 BS

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| R4-2319679 | Huawei, HiSilicon | TP to TR 38.858: Feasibility of FR2 wide area BS |
| R4-2320053 | Nokia, Nokia Shanghai Bell | TP to TR 38.858: Feasibility of FR2 BS aspects |

* Moderator Recommendation:
  + The following issues can be discussed firstly.
  + Further view collection on the above TPs for the company-specific clause TP.
  + Revise the responsible company (Huawei)’s TP, and merge TPs from others.

#### Issue 2-5-1: Conclusion parts for FR2-1 BS (clause 9.5.3, and 9.5.4)

* TP combining the input from Huawei (9679):

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| 9.5.3 Co-channel inter-sub-band inter-site interference analysis  *Editor's note: This section captures the typical assumption of RF requirements and the analysis results*  On the feasibility and how to model inter-site gNB-gNB CLI modelling considering unwanted emission and receiver selectivity, RAN4 agree that   * The same transmitter leakage and receiver impairment model as used for investigating gNB self-interference, but antenna isolation is replaced with inter-site isolation.   + TX leakage baseline: gNB ACLR   + Receiver impairment can be studied with gNB ACS as baseline for system level simulation and feasibility study, and further study on the possibility of improved receiver impairment performance compared to gNB ACS shall not be precluded in future RAN4 works.   **<<Next Change>>**  9.5.4 Summary  *Editor's note: This section captures the conclusion of BS SBFD feasibility.*  Based on RAN4 feasibility study on FR1 wide area BS, specifically the analysis on self-interference, co-site inter-sector co-channel inter-subband interference and inter-site inter-subband interference, RAN4 concluded that:   * For self-interference analysis, the implementation feasibility of controlling the residual interference to meet the 1dB receiver desensitization target depends on the implementation aspects mentioned in clause 9.5.1. Based on the companies’ technical inputs, it can be concluded that it is feasible to meet the 1 dB desensitization target considering self-interference supression for FR2-1 BS with TX output power levels up to around 33dBm. * For co-site inter-sector co-channel inter-subband interference, that the implementation feasibility of controlling the co-site inter-sector co-channel inter-subband interference to meet the target (i.e., being less than certain level of receiver desensitization) depends on the implementation aspects mentioned in clause 9.5.2. Based on the different assumptions and/or technique adoption for the above-mentioned implementations aspects, and based on 3 companies’ technical inputs, two companies conclude that it is feasible to supress inter-sector interference to a level that it meets 1 dB desensitization target, whereas one company concludes that it is not feasible for a proportion of beam directions. The difference between the conclusions is mainly due to differences in assumption on whether it is possible to build isolation materials within sites and whether sufficient beam nulling is possible in all directions. * For inter-site co-channel inter-subband interference, since the feasibility is deployment-dependent, RAN4 has provided the inter-site gNB-gNB CLI modelling used for coexistence study by considering unwanted emission and receiver selectivity modelling.   **<<End of Change for TR 38.858>>** |

* Moderator Recommendation:
  + Discuss on the above TP and if no objection, it can be approved.

# Topic #3: Impacts on BS RF requirements

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2318305 | CATT | Proposal 1: The following new RF requirements are needed for SBFD BS, the requirements can be derived from the co-existence simulation.  • In-channel adjacent sub-band leakage power ratio  • In-channel adjacent sub-band selectivity  Proposal 2: In-channel adjacent sub-band blocking requirement may be needed. Both colocation and non-colocation scenario should be analyzed or simulated for the blocking signal level.  Proposal 3: The existing additional spurious emissions requirements and co-location with other base stations requirements can be reused on SBFD slots.  Observation 1: For transmitter intermodulation requirement, co-location coupling loss assumption can’t use 30 dB for SBFD capable gNB.  Proposal 4: The transmitter intermodulation co-location scenario should be revisited for SBFD deployment.  Observation 2: For receiver IMD requirement, it’s difficult to say the two interfering signal scenario can cover the single interfering signal scenario for both DUD and DU subband configuration.  Observation 3: For receiver IMD requirement, single interfering signal scenario may not be equal to IBB scenario. |
| R4-2318926 | CMCC | Observation 1: further discussion is needed regarding whether RAN4 could assume some typical D-U and U-D guard band for total power dynamic range RF requirements definition in work phase stage.  Proposal 1: TX IM is not applied in SBFD slots to avoid blocking receiver. But for testing, Tx IMD is still suggested to be tested in non-SBFD slot for the SBFD gNB.  Proposal 2: No updating on existing inter-band co-location requirements, Manufacturer will declare whether support co-location requirements in SBFD symbols/slots  Proposal 3: For intra-band adjacent channel co-location requirements, One alternation solution is to define requirements but with explicitly stating assumed spatial isolation and max gNB Tx power and keep in mind that this is not the minimum requirements, instead this is the typical/optimal BS performance under declaration basis.  Proposal 4: Sub-band Tx leakage falling into the same carrier should be discussed together with OTA sensitivity requirements.  Proposal 5: both sub-band selectivity and blocking requirements should be considered.  Proposal 6: Sub-band selectivity requirements when Tx interference is within the same carrier should be discussed together with OTA sensitivity requirements. If OTA sensitivity will consider encompass these sub-band interference, sub-band selectivity with Tx interference signal within carrier is not needed. |
| R4-2319648 | Ericsson | TP to TR 38.858: Update on BS requirements |
| R4-2319649 | Ericsson | Observation 1 Requirements on inter-sub-band emissions and selectivity are needed to enable design of node placement and power when planning based on expected minimum performances.  Based on the discussion in the previous sections we propose the following:  Proposal 1 Define the output power dynamic range requirement for SBFD as the ratio of the declared rated output power with all DL RBs active for SBFD (maximum) and the same single RB power as non-SBFD (minimum).  Proposal 2 Keep the inter-band co-location requirements the same as for non-SBFD, and keep them declared.  Proposal 3 Do not consider the 30dB isolation as part of SBFD, but consider whether to investigate more generally in RAN4.  Proposal 4 The TX IM requirement should be applied in SBFD slots. However, during these tests, the RX sub-band is not intended to achieve and throughput and may be deactivated during the test.  Proposal 5 Define a requirement on TX sub-band emissions similar to the ACLR requirement.  Proposal 6 Define a requirement on RX sub-band selectivity based on the ACS requirement. |
| R4-2319680 | Huawei, HiSilicon | TP to TR 38.858: BS RF requirements |
| R4-2320054 | Nokia, Nokia Shanghai Bell | Proposal 1: There is no need to define a new total dynamic range requirement for SBFD operation.  Proposal 2: No update on existing requirements for co-location and co-existence is needed.  Proposal 3: TX IM is applied in SBFD slots with 30dB interferer offset. SBFD RX requirements are not applicable when the TX IM interferer is applied.  Observation 1: The OTA sensitivity requirement does not capture the effects from inter-sector and inter-gNB interference.  Observation 2: In RAN4#107, some companies argued that, since RAN4 has not agreed on a reference implementation for the gNB, it is difficult to define additional requirements. Though we agree that depending on the gNB implementation the adjacent channel leakage, for example, can be different, in our view, RAN4 is responsible to define minimum requirements which should be achievable for reasonable implementations to guarantee the minimum performance.  Observation 3: In channel adjacent subband leakage ratio, in-channel adjacent subband blocking and in-channel adjacent subband selectivity requirements cannot be guaranteed implicitly by the OTA sensitivity requirement, since the methods used for self-interference cancellation, might not be available for cancelling interference from other sectors and gNBs, especially when considering a multi-vendor deployment.  Observation 4: Even though RAN4 has not agreed on a reference implementation for SBFD operation, minimum requirements can still be defined to ensure proper operation considering self-interference, inter-site and inter-gNB interference.  Proposal 4: RAN4 to define in-channel adjacent sub-band leakage ratio requirements within SBFD time slots considering inter-sector interference and inter-site interference. The exact value of the requirement can be discussed in the work item phase. Existing ACLR requirements could be used as baseline with proper scaling between the bandwidths of the DL and UL subbands.  Proposal 5: RAN4 to define either in-channel adjacent sub-band selectivity or blocking requirements, the exact requirement limits could be discussed during the WI. |
| R4-2320328 | ZTE Corporation | Proposal 1: to define the total dynamic range requirement as 10\*log10(the number of DL scheduled PRB)  Proposal 2: for in-channel ACLR requirement, to consider this ACLR requirement in the gNB Refsens degradation via self interference and inter-sector interference implicitly.  Proposal 3: for in-channel emission/OBUE, to consider this emission in the gNB Refsens degradation via self interference and inter-sector interference implicitly.  Proposal 4: for co-location and coexistence requirement, go with option 2 with declaration basis.  Proposal 5a: the existing Tx requirement is not applicable for SBFD time slots especially from Rx side and further discuss the exact requirement if necessary.  Proposal 5b: if Tx requirement is considered for SBFD slots, then to add the Refsens degradation as one more performance metric in addition to transmitter OBUE/ACLR/spurious emission requirements.  Proposal 6: for receiver intermodulation requirement in the SBFD uplink symbols/slot, consider IMD between CW/NBB/general intermodulation interfering signal intermodulate with SBFD DL transmission with some performance degradation on SBFD receiver as shown in Figure 2.2.2-1.  Proposal 7a: for the co-site inter-sector, in-channel blocking, in-channel selectivity and in-channel sub-band leakage, this could be left up to the vendor declaration without defining any specific power or freq offset of the corresponding requirement.  Proposal 7b: for the inter-site scenario, propose to define the minimum RF requirement as worst assumption if there are any coordination scheme specified in other WGs. |
| R4-2320329 | ZTE Corporation | TP to TR 38.858 Impact on BS RF requirements |
| R4-2320613 | Samsung | Proposal 1: For output power dynamics requirement for SBFD-capable BS:  - Total power dynamic range: new total power dynamic range for SBFD slots/symbols can be considered in normative phase, by reusing the existing total power dynamic range requirement can also be applied by using “SBFD DL subband bandwidth” for “BS channel BW” instead.  Proposal 2: For Co-location and co-existence requirements for SBFD-capable BS:  - The requirement limit and conformance testing during SBFD symbols/slots will be further discussed in the normative stage, by considering the two options agreed.  Proposal 3: For transmitter intermodulation:  - The transmitter intermodulation requirement shall still be applicable during SBFD symbols:   The interfering signal level depends on RAN4’s conclusion on how to define requirement for co-located/co-existence.  - The transmitter intermodulation level shall not exceed the unwanted emission limits in clauses 6.6.3, 6.6.4 and 6.6.5 in the presence of an NR interfering signal.   No need to consider receiver degradation for transmitter intermodulation requirement.  Proposal 4: For conducted reference sensitivity level:  - The existing requirement for conducted reference sensitivity level shall also be applied to BS in SBFD symbols, i.e, no degradation allowed.  - Self-interference from TX from transmission in the DL subband(s) is not relevant in the conducted testing.  - UL subband bandwidth shall be used for BS channel bandwidth in the existing requirement.  Proposal 5: For dynamic range:  - Conducted dynamic range: The existing requirements shall also be applied to BS in SBFD symbols, and self-interference from TX from transmission in the DL subband(s) is not relevant in the conducted testing.  - OTA dynamic range: The existing requirements shall also be applied to BS in SBFD symbols and the self-interference impact can be ignored.  Proposal 6: For ACS and in-band blocking, the requirements shall be defined out of the BS channel bandwidth instead of uplink subband.  Observation 1: It is difficult for RAN4 to agree on a reference scheme for self-interference suppression and the necessary inter-gNB interference suppression by considering the different possible inter-gNB CLI mitigation schemes implemented to derive the potential new requirement in-channel adjacent subband leakage ratio.  Proposal 7: For in-channel adjacent subband leakage ratio, keep option 1 and 2 in the study item phase, and the necessity of introducing new requirement shall be decided in normative phase:  - FFS the necessity of new requirement by considering the fact that RAN4 will introduce OTA sensitivity requirements for SBFD-capable gNB with the simultaneous TX in the SBFD time slot;  - The requirement can only be introduced if different gNB implementations with different self-interference suppression schemes and/or the different inter-gNB CLI handling schemes are allowed.  Proposal 8: For In-channel adjacent subband blocking and adjacent subband selectivity, keep option 1-4 in the study item phase, and the necessity of introducing new requirement shall be decided in normative phase:  - FFS the necessity of new requirement by considering the fact that RAN4 will introduce OTA sensitivity requirements for SBFD-capable gNB with the simultaneous TX in the SBFD time slot;  - The requirement can only be introduced if different gNB implementations with different self-interference suppression schemes and/or the different inter-gNB CLI handling schemes are allowed. |
| R4-2320614 | Samsung | Text Proposal to TR 38.858 on BS RF requirements |

## Open issues summary

### Sub-topic 3-1: BS TX Requirement Impact for SBFD

#### Issue 3-1-1: Output power dynamics

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| RAN#107:   * Agreement from Ad-Hoc session:   + Output power dynamics for conducted and OTA TX requirement     - To reuse the existing RE power control dynamic range requirement for SBFD BS;     - FFS the necessity and how to define the total dynamic range requirement for SBFD based on the DL transmission bandwidth configuration for SBFD DL symbols/slots.   RAN#108:  Agreement:   * RE power control dynamic range: Same requirements can be applied. * Total dynamic range: Requirements applicable for SBFD slots   + FFS for the requirements limit and conformance testing   RAN4#108bis:  Total power dynamic range   * The requirement limit for the total power dynamic range for SBFD slots is not as yet agreed. Contributions proposing a requirement limit are encouraged. |

* Proposals/Observations on total power dynamic range:
  + Proposal 1 (Ericsson/Samsung/ZTE): Define the output power dynamic range requirement for SBFD as the ratio of the declared rated output power with all DL RBs active for SBFD (maximum) and the same single RB power as non-SBFD (minimum).
    - Proposal 1a (Samsung): New total power dynamic range for SBFD slots/symbols can be considered in normative phase, by reusing the existing total power dynamic range requirement can also be applied by using “SBFD DL subband bandwidth” for “BS channel BW” instead.
  + Proposal 2 (CMCC): Further discussion in work phase is needed regarding whether RAN4 could assume some typical D-U and U-D guard band for total power dynamic range RF requirements definition in work phase.
  + Proposal 3 (Nokia): There is no need to define a new total dynamic range requirement for SBFD operation.
* Moderator Recommendation:
  + Proposal 1 and 1a.

#### Issue 3-1-2: Co-location and co-existence

[Moderator] In RAN4#108-bis, there are two options provided in the WF:

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| For co-location and coexistence requirement, further contributions are encouraged to decide on one of the following options:   * + - Option 1: Co-location requirement can’t use 30 dB coupling loss as the coupling loss assumption for SBFD capable gNB co-location related requirement.     - Option 2: No update on existing requirements, it’s declaration basis whether BS need to follow the requirements. |

* Proposals on reconsidering 30dB coupling loss assumption:
  + Proposal 1 (Ericsson): Do not consider the 30dB isolation as part of SBFD, but consider whether to investigate more generally in RAN4.
* Proposals for inter-band co-location and co-existence requirements for SBFD-capable BS:
  + Proposal 2 (Samsung): The requirement limit and conformance testing during SBFD symbols/slots will be further discussed in the normative stage, by considering the two options agreed.
  + Proposal 3 (CMCC/CATT/Ericsson/Nokia/ZTE): No updating on existing inter-band co-location requirements, Manufacturer will declare whether support co-location requirements in SBFD symbols/slots
* Proposals for intra-band adjacent carrier co-location requirement, i.e. co-location ACLR and ACS
  + Proposal 4 (CMCC): For intra-band adjacent channel co-location requirements, One alternation solution is to define requirements but with explicitly stating assumed spatial isolation and max gNB Tx power and keep in mind that this is not the minimum requirements, instead this is the typical/optimal BS performance under declaration basis.
* Moderator Recommendation:
  + Proposal 1 to be discussed not only within SBFD group, but involving more experts in BDaT session.
  + Further discussion on P2-P4.

#### Issue 3-1-3: Unwanted emission

* Proposals/Observations on in-channel emission/OBUE:
  + Proposal 1 (ZTE): for in-channel emission/OBUE, to consider this emission in the gNB Refsens degradation via self interference and inter-sector interference implicitly.
* Proposals/Observations on ACLR:
  + Proposal 1 (ZTE): for in-channel ACLR requirement, to consider this ACLR requirement in the gNB Refsens degradation via self interference and inter-sector interference implicitly.
* Moderator Recommendation:
  + Discuss further on how self-interference and inter-sector interference considered implicitly.

#### Issue 3-1-4: Transmitter intermodulation

[Moderator] During RAN4#106-bis-e, the following WF is approved [6]:

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| Issue 4-1-5: Tx intermodulation requirement and co-location out-of-band blocking **WF:**   * Further discuss Tx intermodulation requirement for co-location scenario. * The following aspects are mentioned in this meeting,   + Large Tx IM signal may block SBFD BS, no requirement or a reasonable requirement may be needed.   + If new requirement is needed, the REFSENS DESENS should take self-interference DESENS into account.   + If larger coupling loss between co-located gNBs should be considered for this requirement.   + TX IM may be needed to ensure that TX emissions are maintained in the presence of an interferer (even if the interferer would de-sensitize the SBFD receiver, or during non-SBFD DL slots). |

And the following RAN4 agreement is achieved in RAN4#107 and RAN4#108bis:

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| RAN4#107:  **Issue 3-1-5: Tx intermodulation requirement**   * Agreement: Existing IMD requirements still applicable for normal DL slots on SBFD capable gNBs   + FFS whether Tx IMD requirements still applicable during SBFD time slots   RAN4#108bis:  Transmitter intermodulation  For transmitter intermodulation in SBFD slots, further contributions are encouraged to decide on one of the following options:  • TX IM is not applied in SBFD slots  • TX IM is applied in SBFD slots, but with a different interferer offset than 30dB  • TX IM is applied in SBFD slots with 30dB interferer offset. SBFD RX requirements are not applicable when the TX IM interferer is applied. |

* Proposals/Observations on TX IM requirement applicable on SBFD slot:
  + Proposal 1 (CMCC): TX IM is not applied in SBFD slots to avoid blocking receiver. But for testing, Tx IMD is still suggested to be tested in non-SBFD slot for the SBFD gNB.
  + Proposal 2 (Samsung/CATT/Ericsson): For transmitter intermodulation requirement, co-location coupling loss assumption can’t use 30 dB for SBFD capable gNB. The transmitter intermodulation co-location scenario should be revisited for SBFD deployment.
    - Proposal 2a (Samsung/Ericsson): Proposal 2, and no need to consider receiver degradation for transmitter intermodulation requirement.
  + Proposal 3 (Nokia/ZTE): TX IM is applied in SBFD slots with 30dB interferer offset. SBFD RX requirements are not applicable when the TX IM interferer is applied.
    - Proposal 3a (ZTE): if Tx requirement is considered for SBFD slots, then to add the Refsens degradation as one more performance metric in addition to transmitter OBUE/ACLR/spurious emission requirements.
* Moderator Recommendation:
  + Further discussion, and maybe further refinement on the options given in RAN4#108bis.

### Sub-topic 3-1: BS RX Requirement Impact for SBFD

#### Issue 3-2-1: Reference sensitivity level and OTA sensitivity

[Moderator] Existing agreement:

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| *<WF achieved in RAN4#106-bis-e>*  Issue 4-1-1: OTA sensitivity within SBFD time slot  **WF:**   * OTA sensitivity can be derived based on the following equation as a starting point:   + The followings should be discussed further     - The exact value for []     - The declaration of maximum TRP for the requirement of OTA sensitivity within SBFD time slot     - If OTA sensitivity should be defined considering all of the scenarios including self-interference, inter-site interference and inter-sector interference.   *<WF achieved in RAN4#107>*  **Issue 3-1-1: Conducted/OTA sensitivity within SBFD time slot**   * Agreement:   + New OTA sensitivity requirements in SBFD time slot with self-interference only can be specified     - Candidate value [0.5 ~1.0] dB degradation       * Final value will be specified in WI phase.     - FFS how to address the digital IC impact on requirement definitions for the case with separate RRU and BBU in gNB     - FFS whether the conductive sensitivity requirements needed or not   *<WF achieved in RAN4#108>*  Issue 3-3-1: Reference sensitivity level and OTA sensitivity  Agreement:   * For BS type 1-H if supported: The existing requirement for conducted reference sensitivity level shall also be applied to BS in SBFD symbols, i.e, no degradation allowed. * For BS type 1-C: FFS whether supported for SBFD capable BS, FFS for the requirements and conformance testing |

* Proposals:
  + Proposal 1 (Samsung): For conducted reference sensitivity level:
    - The existing requirement for conducted reference sensitivity level shall also be applied to BS in SBFD symbols, i.e, no degradation allowed.
    - Self-interference from TX from transmission in the DL subband(s) is not relevant in the conducted testing.
    - UL subband bandwidth shall be used for BS channel bandwidth in the existing requirement.
* Moderator Recommendation:
  + Discussion to see P1 is adopted or not.

#### Issue 3-2-2: Dynamic range

[Moderator] Existing agreement from RAN4#108bis:

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| Issue 3-3-2: Dynamic range  Agreement:   * Dynamic range requirements applicable for SBFD symbols/slots   + FFS for IoT level, and wanted signal power level |

* Proposals on conducted dynamic range requirement:
  + Proposal 1 (Samsung): The existing requirements shall also be applied to BS in SBFD symbols, and self-interference from TX from transmission in the DL subband(s) is not relevant in the conducted testing.
* Proposals on OTA dynamic range requirement:
  + Proposal 2 (Samsung): The existing requirements shall also be applied to BS in SBFD symbols and the self-interference impact can be ignored.
* Moderator Recommendation:
  + Discussion to see P1 and P2 are adopted or not.

#### Issue 3-2-3: In-band selectivity and blocking

[Moderator] Following agreements achieved in RAN#108:

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| Issue 3-3-3: In-band selectivity and blocking  Agreement:   * ACS requirement and the interference level shall be determined by RAN4 co-existence study, and for the definition of ACS requirement:   + Conducted ACS: Take the existing wanted signal of ACS requirement by using the existing reference sensitivity level.   + OTA ACS: The OTA sensitivity degradation shall be taken into account to determine the level of wanted signal and interference signal mean power. * In-band blocking requirement and the interference level shall be determined by RAN4 co-existence study, and for the definition of In-band blocking requirement:   + Conducted In-band blocking: Take the existing wanted signal of In-band blocking requirement by using the existing reference sensitivity level.   + OTA In-band blocking: The OTA sensitivity degradation shall be taken into account to determine the level of wanted signal and interference signal mean power. |

* Proposals/Observations:
  + Proposal 1 (Samsung/ZTE): For ACS and in-band blocking, the requirements shall be defined out of the BS channel bandwidth instead of uplink subband.
* Moderator Recommendation:
  + Discussion to see P1 is adopted or not.

#### Issue 3-2-4: Receiver intermodulation

[Moderator] Following agreements achieved in RAN#108:

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| Issue 3-3-6: Receiver intermodulation  * Agreement:   + RX intermodulation requirement and the interference levels shall be determined by RAN4 co-existence study, and for the definition of RX intermodulation requirement:     - Conducted RX intermodulation: Take the existing wanted signal of RX intermodulation requirement by using the existing reference sensitivity level.     - OTA RX intermodulation: The OTA sensitivity degradation shall be taken into account to determine the level of wanted signal and interference signal mean power.   + FFS whether an additional requirement based on a single input signal placed to cause IM with the RX sub-band provides any additional robustness, and whether such a requirement is anyhow implicitly captured by the SBFD RX blocking requirement. |

* Proposals/Observations from CATT:
  + Observation 1: For receiver IMD requirement, it’s difficult to say the two interfering signal scenario can cover the single interfering signal scenario for both DUD and DU subband configuration.
  + Observation 2: For receiver IMD requirement, single interfering signal scenario may not be equal to IBB scenario.
* Proposal from ZTE:
  + Proposal 1: for receiver intermodulation requirement in the SBFD uplink symbols/slot, consider IMD between CW/NBB/general intermodulation interfering signal intermodulate with SBFD DL transmission with some performance degradation on SBFD receiver as shown in Figure 2.2.2-1.

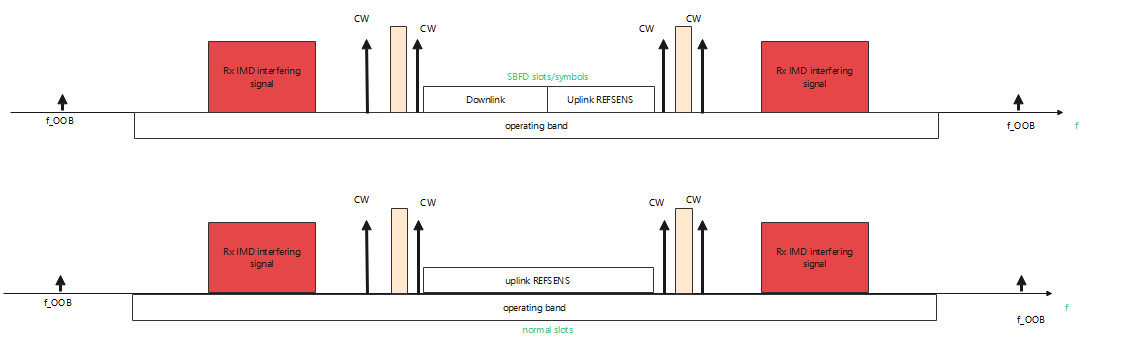


Figure 2.2.2-1: Example of Rx intermodulation requirement for SBFD BS

* Moderator Recommendation:
  + Discussion more on O1, O2 and P1.

### Sub-topic 3-3: Potentially new requirements for SBFD operation

*Sub-topic description:*

#### Issue 3-3-1: In-channel adjacent subband leakage ratio

In RAN4#108bis, the following agreement is achieved with two options listed:

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| In channel adjacent sub-band leakage ratio  Further contributions are welcomed taking into account the following options:   * Option 1: Do not create a new requirement for in-channel adjacent sub-band leakage ratio * Option 2: Create a new requirement on in-channel adjacent sub-band leakage ratio, similar to ACLR   + Requirement limit should also be proposed |

* Proposals/Observations for in-channel adjacent subband leakage ratio:
  + Proposal 1 (Samsung): For in-channel adjacent subband leakage ratio, keep option 1 and 2 in the study item phase, and the necessity of introducing new requirement shall be decided in normative phase:
    - FFS the necessity of new requirement by considering the fact that RAN4 will introduce OTA sensitivity requirements for SBFD-capable gNB with the simultaneous TX in the SBFD time slot;
    - The requirement can only be introduced if different gNB implementations with different self-interference suppression schemes and/or the different inter-gNB CLI handling schemes are allowed.
  + Proposal 2 (CMCC): This sub-band Tx leakage falling into the same carrier should be discussed together with OTA sensitivity requirements.
  + Proposal 3 (Nokia/CATT/Ericsson): RAN4 to define in-channel adjacent sub-band leakage ratio requirements within SBFD time slots considering inter-sector interference and inter-site interference. The exact value of the requirement can be discussed in the work item phase. Existing ACLR requirements could be used as baseline with proper scaling between the bandwidths of the DL and UL subbands.
    - Proposal 3a (CATT): interference level based on coexistence study.
  + Proposal 4 (ZTE):
    - for the co-site inter-sector, in-channel blocking, in-channel selectivity and in-channel sub-band leakage, this could be left up to the vendor declaration without defining any specific power or freq offset of the corresponding requirement.
    - for the inter-site scenario, propose to define the minimum RF requirement as worst assumption if there are any coordination scheme specified in other WGs.
* Moderator Recommendation:
  + Suggest to consider P1, i.e., to keep option 1 and 2 open and decide in normative phase.
  + It should be noted the possibility to introduce in-channel CLI handling scheme in RAN1 in normative phase, so this in-channel adjacent subband leakage requirement can be impacted by the detailed WI scope on in-channel CLI handling scheme.

#### Issue 3-3-2: In-channel adjacent subband Blocking and adjacent subband selectivity

In RAN4#108bis, the following agreement is achieved with four options listed:

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| --- |
| In-channel adjacent sub-band selectivity and blocking  Further contributions are welcomed taking into account the following options:   * Option 1: Do not create a new requirement for in-channel adjacent sub-band selectivity or blocking * Option 2: Create a new requirement on in-channel adjacent sub-band selectivity (similar to ACS), but no blocking requirement   + Requirement limit should also be proposed * Option 3: Create a new requirement on in-channel adjacent sub-band blocking, but no selectivity requirement   + Requirement limit should also be proposed * Option 4: Create new requirements on in-channel adjacent sub-band selectivity (similar to ACS) and blocking   + Requirement limits should also be proposed |

* Proposals/Observations for in-channel adjacent subband blocking and adjacent subband selectivity:
  + Proposal 1 (Samsung): For In-channel adjacent subband blocking and adjacent subband selectivity, keep option 1-4 in the study item phase, and the necessity of introducing new requirement shall be decided in normative phase:
    - FFS the necessity of new requirement by considering the fact that RAN4 will introduce OTA sensitivity requirements for SBFD-capable gNB with the simultaneous TX in the SBFD time slot;
    - The requirement can only be introduced if different gNB implementations with different self-interference suppression schemes and/or the different inter-gNB CLI handling schemes are allowed.
  + Proposal 2 (CMCC): Sub-band selectivity requirements when Tx interference is within the same carrier should be discussed together with OTA sensitivity requirements. If OTA sensitivity will consider encompass these sub-band interference, sub-band selectivity with Tx interference signal within carrier is not needed.
  + Proposal 3 (CATT):
    - In-channel adjacent subband selectivity: requirement needed;
    - In-channel adjacent subband blocking: may be needed. Both colocation and non-colocation scenario should be analyzed or simulated for the blocking signal level.
  + Proposal 3a (Ericsson): Define a requirement on RX sub-band selectivity based on the ACS requirement (Moderator: only selectivity is enough, and no need blocking requirement, which could be defined similarly).
  + Proposal 3b (Nokia): define either in-channel adjacent sub-band selectivity or blocking requirements, the exact requirement limits could be discussed during the WI.
* Moderator Recommendation:
  + Maybe we can only keep option 1 and option 2?
  + It should be noted the possibility to introduce in-channel CLI handling scheme in RAN1 in normative phase, so this in-channel adjacent subband leakage requirement can be impacted by the detailed WI scope on in-channel CLI handling scheme.

### Sub-topic 2-4: Text proposal on BS RF requirements

* The list of TPs related to BS RF requirement impact

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| --- | --- | --- |
| R4-2319648 | Ericsson | TP to TR 38.858: Update on BS requirements |
| R4-2319680 | Huawei, HiSilicon | TP to TR 38.858: BS RF requirements |
| R4-2320329 | ZTE Corporation | TP to TR 38.858 Impact on BS RF requirements (Moderator mark: it is placeholder TP) |
| R4-2320614 | Samsung | Text Proposal to TR 38.858 on BS RF requirements |

* Moderator Recommendation:
  + Based on the discussion on above issues, further view collection on the above four TPs.
  + Revise the responsible company (ZTE)’s TP, and merge TPs from others.

# Topic #4: Regulatory survey

## Companies’ contributions summary

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| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2320449 | Qualcomm | TP for TR 38.858 on Europe regulatory requirements |

## Open issues summary

#### Issue 4-1-1: TP on Europe regulatory requirements

* Text Proposal (Qualcomm):

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| 2 References ...  [3] ECC Report 331, Efficient usage of the spectrum at the border of CEPT countries between TDD MFCN in the frequency band 3400- 3800 MHz, approved 05 November 2021. Online available: https://docdb.cept.org/download/3515.  ...  To address the cross-border issue and facilitate coordination, the Electronics Communications Committee (ECC) recommended the usage of two frame structures in the 3.4 – 3.8 GHz frequency band [2]. Additionally, a technique for cross-border interference mitigation was studied in [3] based on sub-band DL blanking on overlapping UL/DL resources (termed also subband half-duplex). |

* Moderator Recommendation:
  + Considering TP is just a description of status report for ECC on cross-border solution, TP shall be accepted.
  + From moderator perspective, suggest companies to double check the terms “sub-band DL blanking” and “subband half-duplex” here, because strictly “sub-band blanking” is used and seems subband half-duplex is not used?