3GPP TSG-RAN WG1 Meeting #106bis-e R1-21xxxxx

e-Meeting, 11th – 19th October 2021

**Agenda Item: 8.6.1.2**

**Title: FL summary #1 on duplex operation for RedCap**

**Source: Moderator (Qualcomm Inc.)**

**Document for: Discussion, Decision**

# Introduction

This feature lead (FL) summary (FLS) concerns the Rel-17 work item (WI) for support of reduced capability (RedCap) NR devices [1]. Earlier RAN1 agreements for this WI are summarized in [2].

This document summarizes contributions [3] – [27] submitted to agenda item 8.6.1.2 and captures this email discussion on duplex operation for RedCap:

|  |
| --- |
| [106bis-e-NR-R17-RedCap-02] Email discussion regarding aspects related to duplex operation – Chao (Qualcomm)* 1st check point: October 14
* Final check point: October 19
 |

The issues in this document are tagged and color coded with High Priority or Medium Priority. The issues that are in the focus of the first round of discussion in this meeting are furthermore tagged FL1.

# Whether to define the guard times in symbol units

RAN1#104e made the following agreements related to switching time [2]:

|  |
| --- |
| Agreements:* (Working assumption) For HD-FDD switching time, reuse existing switching times for UE not capable of full duplex in TS 38.211, Table 4.3.2-3.
	+ FFS: whether to define the guard times in symbol units
	+ FFS: the switching positions
* Sending an LS to RAN4 to inform the above working assumption, and to ask for feedback if any
	+ The LS will not include the two FFS bullets

Draft LS in [R1-2102094](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2102094.zip) is approved. Final LS to be uploaded/updated depending on whether or not there are additional agreements for RedCap related to RAN4. Final LS in [R1-2102146](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_104-e/Inbox/R1-2102146.zip) |

In [28], RAN4 has replied the LS confirming the working assumption for the HD-FDD switching time for RedCap UE.

For the second FFS in the WA, the following working assumption was made in RAN1#104bis-e [2]:

|  |
| --- |
| Working assumption:* For HD-FDD, no additional UE behavior for switching position determination is specified as compared to the existing specification.
 |

For the first FFS in the WA, [Ericsson04, vivo06, Nokia11, LG21] express view that there is no need to define guard time in symbol units and the working assumption can be confirmed by removing the two FFSs.

In contribution [QC25], it is discussed that at least one guard symbol needs to be configured for Rx-to-Tx switching in Type-A HD-FDD operation to account for RF returning and timing advance.

**Moderator observation/suggestion**:

Based on the input, the following FL proposal is proposed for consideration.

**FL1 High Priority Proposal 2-1:**

Confirm the WA with the following modification:

* For HD-FDD switching time, reuse existing switching times for UE not capable of full duplex in TS 38.211, Table 4.3.2-3.
	+ ~~FFS: whether to define the guard times in symbol units~~
	+ ~~FFS: the switching positions~~
* For HD-FDD, no additional UE behaviour for switching position determination is specified as compared to the existing specification
* Note: RAN1 understands there is at least one symbol gap between DL and UL when HD-FDD UE switches from DL reception to UL transmission

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | Partially | Only remove the FFSs should be fine. The Note should not be included. Please noted the HD-FDD working in FDD band and the UL / DL time offset could be in a range. The required Ntx-rx and Nrx-tx could be less than a symbol.  |
| Qualcomm | Y partially | Similar to NR TDD:* For UL-to-DL switching, no guard symbol is needed for Type-A HD-FDD UE;
* For DL-to-UL switching, at least one guard symbol is needed for Type-A HD-FDD UE.
 |
| vivo | Y in general | We have a preference to remove the Note, as it is sufficient to say no additional UE behaviour is specified.  |
| CATT | Y in general | We think the note is not needed. |
| Sharp | Y  | The gap mentioned in note can be considered in conjunction with case 9  |
| Spreadtrum | Y | Yes in general, we prefer to remove the note in red. |
| Intel | Partially | The note may be not accurate. In general, for HD-FDD operation, there must exist a gap between a DL reception (or UL transmission) and a UL transmission (or DL reception) after applying UL TA. The gap is normally not integer of symbols.We are fine with adding some clarification on the non-integer symbol(s) of switching gap. Removing the not is also fine assuming such interpretation is already reflected by other bullets.  |
| Ericsson | Y partially | Removing FFS points should be sufficient.  |
| Huawei, HiSilicon | Y in general | Remove the two FFSs and no need to add the Note. The switching time between DL and UL can be solved by Case 9. |
| DOCOMO | Y | Also fine to remove the note |

# Case 1: Dynamically scheduled DL reception vs. semi-statically configured UL transmission

For Case 1, it was agreed to reuse the existing collision handling principles in Rel-15/16 NR for operation on a single carrier/single cell in unpaired spectrum:

|  |
| --- |
| Agreements:* For Case 1 (dynamically scheduled DL reception vs. semi-statically configured UL transmission), reuse the existing collision handling principles in Rel-15/16 NR for operation on a single carrier /single cell in unpaired spectrum.
	+ FFS whether the timeline is extended to include the RX/TX switching time for HD-FDD
 |

The remaining FFS is regarding whether the timeline in the above rule should be extended to include the Tx/Rx switching time for HD-FDD.

Contributions [Ericsson04, SPRD05, vivo06, CT09, Nokia11, Xiaomi13, Samsung15, Intel17, LG21, WILUS27] express views that there is no need to extend the timeline to include the Tx/Rx switching time and gNB would take into account the switching time when scheduling dynamic DL to avoid collision with the switching time.

Contribution [Ericsson04] also points out that if there are still colliding symbols with the switching time after partial cancellation, then the UE behavior to be clarified under Case 9 can be applied.



Figure 1 from [4]: In case of UE capable of partial cancellation, gNB can take into account the switching time when scheduling dynamic DL, e.g., schedule a PDSCH after T\_{proc,2} + switching time, to avoid collision with the switching time



Figure 2 from [4]: After partial cancellation of CG PUSCH based on the timeline, there may still be symbols colliding with the switching time. In this case, a UE behavior to be clarified under Case 9 can be applied to ensure that UE does not receive or transmit during the switching time

**Moderator observation/suggestion**:

Since no contribution proposes to extend the timeline to include the Tx/Rx switching time for HD-FDD, the following FL proposal can be considered.

**FL1 High Priority Proposal 3-1:**

* For Case 1, the existing timeline in Rel-15/16 NR for operation on a single carrier /single cell in unpaired spectrum is reused for HD-FDD

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y |  |
| Qualcomm | Y |  |
| vivo | Y |  |
| CATT | Y |  |
| Sharp | Y |  |
| Spreadtrum | Y |  |
| Intel | Y |  |
| Ericsson | Y |  |
| Huawei, HiSilicon | Y |  |
| DOCOMO | Y |  |

# Case 3: Semi-statically configured DL reception vs. semi-statically configured UL transmission

RAN1#104bis-e reached the following agreements [2]:

|  |
| --- |
| Agreements:* For Case 3, semi-statically configured DL reception vs. semi-statically configured UL transmission
	+ A HD-FDD UE does not expect to receive both dedicated higher layer parameters configuring transmission from the UE in the set of symbols of the slot and dedicated higher layer parameters configuring reception in the set of symbols of the slot
	+ A HD-FDD UE does not expect to receive both dedicated higher layer parameters configuring transmission from the UE in the set of symbols of the slot and cell specific higher layer parameters configuring reception in the set of symbols of the slot
	+ A HD-FDD UE does not expect to receive both cell specific higher layer parameters configuring transmission from the UE in the set of symbols of the slot and dedicated higher layer parameters configuring reception in the set of symbols of the slot
	+ FFS on cell-specifically configured DL reception vs. cell-specifically configured UL transmission
	+ FFS: whether or not there are conditions that need to be considered
 |

Some contributions [Ericsson04, vivo06, Intel17] indicate that there is mismatch between the RAN1#106-e meeting agreement for Case 8 and the 3rd sub-bullet in the above agreement since valid RO should be cell specific configured UL transmission. Therefore, it would be good to clarify that the agreement made in RAN1#106-e meeting should supersede the earlier RAN1#104bis-e meeting agreement.

In contributions [Nokia11, Xiaomi13], it is also indicated that the first FFS has been treated under Case 5 (collision with SSB) and Case 8 (collision with RO), and therefore can be removed from the agreement.

Contribution [Xiaomi13, Intel17] propose to clarify that SSB are not considered in the 2nd sub-bullet in the above agreement since the UL/DL collision involving SSB has been categorized as case 5.

**Moderator observation/suggestion**:

**FL1 Medium Priority Proposal 4-1: Revise the RAN1#104bis-e agreement for Case 3 as the following**

* For Case 3, semi-statically configured DL reception vs. semi-statically configured UL transmission
	+ A HD-FDD UE does not expect to receive both dedicated higher layer parameters configuring transmission from the UE in the set of symbols of the slot and dedicated higher layer parameters configuring reception in the set of symbols of the slot
	+ A HD-FDD UE does not expect to receive both dedicated higher layer parameters configuring transmission from the UE in the set of symbols of the slot and cell specific higher layer parameters configuring reception in the set of symbols of the slot
		- Cell-specifically configured DL reception refers to PDCCH in Type-0/0A/1/2 CSS set
	+ ~~A HD-FDD UE does not expect to receive both cell specific higher layer parameters configuring transmission from the UE in the set of symbols of the slot and dedicated higher layer parameters configuring reception in the set of symbols of the slot~~
	+ ~~FFS on cell-specifically configured DL reception vs. cell-specifically configured UL transmission~~
	+ FFS: whether or not there are conditions that need to be considered

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y | Fine for adding clarification bullet and removing the duplicated bullets. |
| Qualcomm | Y | Clarification is needed for the CSS associated with R17 PEI and RA-SDT, which are also cell-specifically configured DL reception |
| vivo | Y |  |
| CATT | Y |  |
| Spreadtrum | Y |  |
| Intel | Y |  |
| Ericsson | Y |  |
| Huawei, HiSilicon | Y |  |
| DOCOMO | Y |  |

Another remaining aspect is whether or not there are conditions that need to be considered. Contribution [Samsung15] presents two conditions can be further considered as following.

|  |
| --- |
| *Proposal 2: For Case 3, SFI can be used to cancel one of the directions whether the semi-statically configured DL is received or the semi-statically configured UL is transmitted.* *Proposal 3: When a priority is configured with semi-static UL and DL, HD-FDD RedCap UE can solve the conflict between semi-static UL and DL based on the associated priority indication. Details are FFS* |

The first above proposal from [Samsung15] is related to the question on whether or not SFI can be optionally supported for HD-FDD UEs. It can be discussed further in section 8.1. For the second proposal, companies are welcome to provide comments if they wish.

**FL1 Medium Priority Question 4-2:**

* **Companies are invited to comment whether a priority indicator can be configured for semi-statically configured DL or UL and used for collision handling?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | N | We do not see the issue to be solved by that indicator. Not prefer to have that in the RRC list. |
| Qualcomm |  | Is there such a priority indicator for NR TDD/non-RedCap UE ? If not, why consider it for RedCap UE ? |
| vivo | N | The concerned collision case were agreed to be error case by the current agreement, there is no need to introduce additional behaviour.  |
| CATT | N | Considering the limited TU left, the group does not have enough time to come up with a flawless priority list. |
| Intel | N | We prefer to avoid introduction of new RRC signalling and procedure.  |
| Ericsson | N | The proposal was raised during the collision handling discussion earlier but was not included for down-selection. Given the stage of the discussion, we think there is no need to bring it up again.  |
| Huawei, HiSilicon | Open |  |
| DOCOMO | N | We don’t think such optimization is necessary |

# Case 5: Configured SSB vs. dynamically scheduled or configured UL transmission

## SSB overlaps with dynamically scheduled UL transmission

For Case 5, it has been agreed to re-use the existing collision handling principles (i.e., SSB is prioritized over configured UL transmission) for configured UL transmission which includes CG-PUSCH, SRS, and PUCCH.

|  |
| --- |
| Agreements:* For Case 5 of SSB overlaps with in configured UL transmission, re-use the existing collision handling principles of Rel-15/16 for NR TDD that SSB is prioritized over configured UL transmission
	+ The configured UL transmission includes CG-PUSCH, or SRS
	+ FFS: Confirm that PUCCH is included

Agreements:* For Case 5 of SSB overlaps with configured UL transmission, the configured UL transmission includes PUCCH transmission configured by higher layers
* Note: The UL transmission indicated by DCI is supposed to be dynamic UL transmission.
 |

The remaining issue in Case 5 is collision handling for the case of SSB overlapping with dynamically scheduled UL transmission. According to RAN1#106-e agreement below, one or both of the following two options should be determined.

|  |
| --- |
| Agreements:* For Case 5 of dynamically scheduled UL transmission vs. SSB, one or both of the following options to be determined till next meeting:
	+ Option 1: Dynamically scheduled UL transmission is prioritized over SSB
	+ Option 2: Reuse the existing collision handling principles of Rel-15/16 for NR TDD that SSB is prioritized over dynamically scheduled UL transmission
 |

Table 5.1-1 summarizes companies’ views on the two options.

**Table 5.1-1: Views on collision handling for SSB overlapping with dynamically scheduled UL transmission**

|  |  |  |  |
| --- | --- | --- | --- |
| Index | Description  | Companies | # of Companies |
| Option 1 | Dynamically scheduled UL transmission is prioritized over SSB | Huawei, Ericsson, vivo, China Telecom, CMCC, Nokia, WILUS | 7 |
| Option 2 | SSB is prioritized over dynamic scheduled UL transmission | Spreadtrum, OPPO, Xiaomi, Potevio, Samsung, Intel, DoCoMo, IDCC, LG, Sharp, Apple, Qualcomm, NordicSemi | 13 |

Specific comments regarding benefits, advantages, drawbacks, concerns and impacts for each of the two options are summarized below.

**Option 1: dynamically scheduled UL transmission is prioritized over SSB**

 Justifications/benefits/advantages:

* gNB can transmit and receive simultaneously on paired spectrum
* More flexibility and consistent with principle of dynamic scheduling
* Same handling as Case 2 by treating SSB as semi-static DL reception

Drawbacks/concerns/impacts:

* Significant impact on UE implementation for SSB measurement
* UE may not be able to monitor the overlapped SSB and RAN4 RRM timeline may be violated
* Rules for determining the available slots for Rel-17 PUSCH repetition will be different for CG- and DG-PUSCH for HD-FDD making the UE behaviour unnecessarily complicated

**Option 2: SSB is prioritized over dynamically scheduled UL transmission**

 Justifications/benefits/advantages:

* A unified solution for dynamic and semi-static UL transmission
* Same UE implementation for SSB measurement
* Optimization for UL throughput and/or latency is not in scope of this WID
* gNB has the full control on the timing of dynamically scheduled UL channel/signal to avoid collision

Drawbacks/concerns/impacts:

* Increased scheduling complexity for FDD gNB
* Lack of flexibility and resource utilization is sacrificed

In addition, some contributions also express view on the possibility to consider both options for the case of SSB overlapping with dynamically scheduled UL transmission.

* Support both options based on UE’s capability and gNB configuration [vivo06, Apple23]
* Option 1 for Msg3 (re)transmission and PUCCH for Msg4 overlap with SSB transmission and Option 2 for other dynamically scheduled UL transmission [ZTE12]
* Option 1 is taken if SSB transmission is not mandated in RedCap specific DL BWP and Option 2 is used if SSB transmission is mandated in RedCap specific DL BWP [Panasonic19]

Contribution [CATT08] notes that uncertainty has been introduced to dynamically scheduled DL or UL due to unspecified UE behaviour for PDCCH monitoring when colliding with valid RO and thinks it is derisible to leave it to UE implementation whether to receive SSB or transmit UL when collision happens.

Specially, contribution [Ericsson04] indicates that PRACH triggered by PDCCH order which is considered as dynamically scheduled UL in view of the previous agreement for Case 2 should be prioritized over SSB if Option 1 is supported.

**Moderator observation/suggestion**:

From the above, it seems companies’ positions have not changed as compared to last RAN1 meeting. Considering the discussion in the last RAN1 meeting, it seems difficult to make down-selection between option 1 and 2. Therefore, one possible solution to make process is to support both options, e.g., with separate UE capabilities.

**FL1 High Priority Question 5.1-1:**

* **Companies are invited to comment whether both of option 1 and 2 can be supported considering the possible solutions proposed in [vivo06, Apple23, ZTE12, Panasonic19].**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | N | We should not further complicate RedCap UE by 2 options. Go with the Option 2 with more supporting companies have no issue. |
| Qualcomm | N | Option 2 is supported. Unified solution should be supported for dynamic UL and semi-static UL. |
| vivo |  | As compromise, we would be fine to support both options as separate UE capabilities |
| CATT |  | As proposed in our contribution, ‘Up to UE implementation’ can be regarded as a combination of Option 1 and 2. If this is not acceptable, we can live with up to separate UE capabilities. |
| Sharp |  | We still think option2 should be selected. The schemes combining option1 and option2 will add additional complexity to redcap |
| Spreadtrum | N | Option 2 only is preferred, it is unnecessary to specify two options for this case. |
| Intel | N | Option 2 is preferredDefining UE capabilities doesn’t help for the overlap handling between SSB and Msg3 PUSCH, since UE doesn’t report its UE capability yet in initial access.  |
| Ericsson | N | Supporting both options with capability signalling is not preferred as it increases complexity. We prefer Option 1 but can be open to option 2 if it helps the group to move forward.  |
| Huawei, HiSilicon | N |  |
| DOCOMO | N | We shared the view with Intel that supporting both options with capability signalling doesn’t help for the overlap handling between SSB and Msg3 PUSCH or PUCCH for Msg4/B HARQ-ACK. |

## Whether to account for Tx/Rx switching time before and after the set of SSB symbols

An FFS identified in RAN1#104bis-e for Case 5 is whether the Tx/Rx switching time should be accounted before and after the set of SSB symbols.

* Contribution [Ericsson04, vivo06, Samsung15] express view that the UL transmissions in case 5 is either dynamically scheduled or configured by dedicated higher layer parameters and gNB should ensure the sufficient Tx/Rx switching time before and after the set of SSB symbols for the most cases
* In contribution [Ericsson04], it is further clarified that for the case of SSB immediately followed by an UL transmission or SSB immediately following the last symbol of UL transmission, if the UE behavior for Case 9 is clarified to ensure that Tx/Rx switching time is fulfilled, there is no need to further account for the Tx/Rx switching time under Case 5
* Contribution [Samsung15] also indicates that the TX/RX switching time for the case of SRS overlapping with SSB can be further discussed in Case 9
* Contribution [LG21] proposed that the Rx-to-Tx switching time should be accounted for HD-FDD operation in FDD bands after the set of SSB symbol and UE is not expected to transmit in the uplink earlier than the Rx-to-Tx switching time after the end of the last received downlink symbol for SSB

**Moderator observation/suggestion**:

From the above, only one company supports that the Tx/Rx switching is accounted after the set of SSB symbols. Other companies view that gNB should ensure the sufficient Tx/Rx switching time before and after the set of SSB symbols but seems okay to further discuss it under Case 9.

**FL1 Medium Priority Conclusion 5.2-1:**

* **Whether or not to account for the Tx/Rx switching time before and after the set of SSB symbols can be further discussed under Case 9**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y |  |
| Qualcomm | Y | Rules similar to NR TDD are re-used by Type-A HD-FDD RedCap UE. |
| vivo | Y |  |
| CATT | Y |  |
| Spreadtrum | Y |  |
| Intel | Y |  |
| Ericsson | Y |  |
| Huawei, HiSilicon | OK |  |
| DOCOMO | Y |  |

# Case 8: Dynamic or semi-static DL vs. valid RO

## valid RO overlaps with dynamically scheduled DL reception

For Case 8, the remaining collision scenario to be resolved is the case of valid RO overlapping with dynamically scheduled DL reception. According to RAN1#106-e agreement below, one option among Option 2, 3, and 4 should be down selected.

|  |
| --- |
| Agreements:* For Case 8 of valid RO overlapping with dynamically scheduled DL reception, down select one of following options in next meeting
	+ Option 2: Leave to UE implementation whether to receive the dynamically scheduled DL or transmit PRACH
	+ Option 3: Follow the handling of Case 1 (dynamically scheduled DL reception vs. semi-statically configured UL transmission)
	+ Option 4: Valid RO is prioritized over dynamic DL reception
 |

Table 6.1-1 summarizes the companies view for the three options in RAN1#106-e agreement.

**Table 6.1-1: Views on collision handling for valid RO overlapping with dynamically scheduled DL reception**

|  |  |  |  |
| --- | --- | --- | --- |
| Index | Description  | Companies | # of Companies |
| Option 2 | Leave to UE implementation whether to receive the dynamically scheduled DL or transmit PRACH | Spreadtrum (1st), vivo (2nd), CATT, Nokia, Xiaomi, Samsung, MTK, Panasonic, Apple, Qualcomm, NordicSemi | 11 |
| Option 3 | Follow the handling of Case 1 (dynamically scheduled DL reception vs. semi-statically configured UL transmission) | Huawei, vivo (1st), China Telecom, Sharp, ASUSTeK | 5 |
| Option 4 | Valid RO is prioritized over dynamic DL reception | Ericsson, Spreadtrum (2nd), OPPO, CMCC, Potevio, Intel, DoCoMo, IDCC, LG  | 9 |

Specific comments regarding benefits, advantages, drawbacks, concerns and impacts for each of the three options are summarized below.

**Option 2: Leave to UE implementation whether to receive the dynamically scheduled DL or transmit PRACH**

 Justifications/benefits/advantages:

* A unified solution for dynamic and semi-static DL reception
* PRACH transmission is not so frequent for UE in RRC\_CONNECTED state
* No preclusion for gNB to schedule DL transmission overlapping with the valid RO
* No specification impact and UE can transmit NACK to trigger a retransmission for the failed PDSCH reception

Drawbacks/concerns/impacts:

* Degrade resource utilization if the scheduled DL transmission is not received by the UE

**Option 3: Follow the handling of Case 1**

 Justifications/benefits/advantages:

* Same handling as Case 1 by treating valid RO as semi-statically configured UL transmission

Drawbacks/concerns/impacts:

* Limit RACH configuration and performance in case of dynamically scheduled PDSCH with K0=0
* Deprioritizing RO in case of out-of-sync in UL leads to a waste of DL resources and increased RA latency
* UE may decode PDCCH but not be allowed to receive the scheduled PDSCH with K0=0

**Option 4: Valid RO is prioritized over dynamic DL reception**

 Justifications/benefits/advantages:

* Relatively simpler compared to other options

Drawbacks/concerns/impacts:

* Increased scheduling complexity for FDD gNB
* Too restrictive to drop DL reception regardless of UE's intention to transmit PRACH
* UE may decode PDCCH but not be allowed to receive the scheduled PDSCH with K0=0

**Moderator observation/suggestion**:

Option 2 has a slight majority support. The concern on Option 2 is gNB cannot know when the UE will transmit PRACH, thus leading to resource utilization inefficiency if the scheduled DL transmission is not received by the UE [4]. However, it is well known that PRACH transmission is not so frequent for UE in RRC\_CONNECTED state and therefore the probability for UE not receiving the dynamically scheduled DL transmission is expected to be low.

For Option 3, the concern is that dropping PRACH may lead to serious system performance degradation, e.g., in case of out-of-sync in UL [23]. Also, there is a common issue for both Option 3 and 4 that UE may decode PDCCH but not be able to receive the scheduled PDSCH with K0=0 thus degrading PDSCH performance [11, 25].

From the above analysis, each option has its pros and cons. Option 2 seems to be a considerable trade-off.

**FL1 High Priority Proposal 6.1-1:**

* For Case 8 of valid RO overlapping with dynamically scheduled DL reception, leave it to UE implementation whether to receive the dynamically scheduled DL or transmit PRACH

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | N | Making clear UE behaviour is more important. The issue is different to SSB collision with RO, which could be delayed too long in the initial access. The DL overriding should not be introduced as very small optimization for RedCap. |
| Qualcomm | Y |  |
| vivo | Y | Although our preference was Option3, we understand the FL proposal may be the most feasible way to move forward.  |
| CATT | Y | We reconsider our position a bit from the last meeting and can live with Option 2. Just remind that LTE did not introduce any rule like ‘prioritizing RO over DL recpetion’ when supporting HD-FDD eMTC UE. Similarly, we do not see Option 4 is needed in NR. |
| Spreadtrum | Y |  |
| Intel | Y | We can compromise to Option 2 though our first preference is still Option 4.  |
| Ericsson |  | We prefer Option 4 but can accept the proposal if it helps the group to move forward. |
| Huawei, HiSilicon |  | Option 3 is preferred while Option 2 is acceptable. |
| DOCOMO |  | We can live with the proposal for the sake of progress |

## Whether or not Ngap symbols before the valid RO is included

**FFS: whether or not the set of symbols overlapping with dynamic DL reception includes also Ngap symbols before the valid RO and whether the same value for Ngap in current spec is reused for HD-FDD**

* Contributions [Ericsson04, CATT08, Nokia11] express view the same principle as in TDD rule can be reused where the set of symbols overlapping with DL reception includes Ngap symbols before the valid RO, and the same value for Ngap in the current specification is reused for HD-FDD
* In contribution [vivo06], it is discussed that for the collision cases of valid RO overlapping with PDCCH in Type 0/0A/1/2 CSS set or SSB, including Ngap symbols before the valid RO may be beneficial to account for the DL-to-UL switching time, but for collision case of valid RO overlapping with UE-dedicated configured or dynamically scheduled DL reception, including Ngap symbols before the valid RO is not necessary
* In contribution [Samsung15], it is proposed that Ngap symbols can be specified for HD-FDD as in TDD and in case of Ngap equals to 0, the Tx/Rx switching time is considered.
* Contribution [LG21] indicates that the Rx-to-Tx switching time before the valid RO needs to be accounted for HD-FDD at least for the case that Ngap is zero
* Contribution [Intel17] has a different view on the benefit of applying Ngap symbols to HD-FDD operation and perfers to consider a unified solution for handling the gap for Tx-Rx or Rx-Tx switching time

**Moderator observation/suggestion**:

From the above, a majority view is that the same principle as in TDD rule can be reused for HD-FDD. The only concern is whether the Rx-to-Tx switching time before the valid RO needs to be additionally accounted for HD-FDD when Ngap is zero. From the FL’s understanding, there are benefits to include Ngap symbols before the valid RO for HD-FDD. Also, considering the target to support HD-FDD is to have the minimum spec change, it would be desirable to reuse the same principle as in TDD as much as possible.

**FL1 High Priority Proposal 6.2-1:**

* For Case 8, the set of symbols overlapping with semi-static or dynamic DL reception include Ngap symbols before the valid RO, and the same values for Ngap in Table 8.1-2 in TS 38.213 is reused for HD-FDD
* FFS: whether or not to account for the Rx-to-Tx switching time when Ngap is zero

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y | We agree FL proposal. |
| Qualcomm | Y | We can live with this proposal |
| vivo | Y |  |
| CATT | Y |  |
| Sharp | Depend on | If collisions handling between RO and other channels are all up to UE implementation, the Ngap make no sense. And the gap for the Rx-to-Tx switching can be considered in case9. |
| Spreadtrum | Y |  |
| Intel | N | We have a concern on the proposal since it is still not clear what is the real technical benefit of using the ‘Ngap symbols’.On the other hand, we prefer to make decision on ‘FL1 High Priority Proposal 6.1-1’ first. If all overlap handling related to valid RO is up to UE implementation, we may not need to specify ‘Ngap symbols’ at all. Above all, we prefer to define all switching gap related behaviour in Case 9. A unified solution is preferred  |
| Ericsson | Y |  |
| Huawei, HiSilicon | Ok to further discussion as Intel commented |  |
| DOCOMO | Y |  |

all

## Whether or not the same principle is applied to PUSCH occasion of MsgA in 2-step RACH, if supported

In contribution [Huawei03], it is proposed that the validation rules of MsgA PUSCH occasions and RO/Preamble-to-PRU mapping rules of HD-FDD UEs follow the rules of FDD’s definition.

Contribution [Ericsson04, CATT08] expresses view that PUSCH occasion of MsgA in the 2-step RACH can be treated in the same way as either configured PUSCH or valid RO.

Contribution [Nokia11, MTK16] proposes to reuse the the same handling principle for MsgA PUSCH occasion and leave it to UE implementation whether to receive the DL or transmit MsgA when collision happens.

In contribution [Intel17], there is a different proposal considering whether DL reception is semi-statically configured or dynamically scheduled. More specially, when a MsgA PUSCH is overlapped with a dynamically scheduled DL reception, the MsgA PUSCH is cancelled if the cancellation time for MsgA PUSCH is met (follow the handling of Case 1); and when a MsgA PUSCH is overlapped with a configured DL reception, the MsgA PUSCH is cancelled.

**Moderator observation/suggestion**:

From the above, two issues are discussed. One is the validation rules of MsgA PUSCH occasion and RO/Preamble-to-PRU mapping rules for HD-FDD UEs. The other is how to handle the collision between MsgA PUSCH and a DL reception, e.g., reusing the same handling principle for valid RO or configured PUSCH.

The second issue may be dependent on the discussion in section 6.1 for collision handling between valid RO and dynamically scheduled DL. The FL suggestion is to deprioritize it until there is any outcome in section 6.1. For the first issue, companies are welcome to provide comments if they wish.

**FL1 High Priority Question 6.3-1:**

* **Companies are invited to comment whether or not the validation rules of MsgA PUSCH occasions and RO/Preamble-to-PRU mapping rules of HD-FDD UEs can follow the rules of FDD’s definition**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y | It can be supported seems share same scheme as Type1 PRACH. |
| Qualcomm |  | We can live with re-using FD-FDD rule for validation of msgA PO. However, whether or not UE can transmit on the “valid” RO/PO depends on the size of DL-to-UL switching gap needed by Type-A HD-FDD UE. |
| vivo |  | We are fine to reuse the existing validation rule in FDD.  |
| CATT | Y | We are fine with the proposal. |
| Sharp | Y |  |
| Spreadtrum |  | We prefer to follow the rules of FDD’s definition |
| Intel | Y |  |
| Ericsson |  | The same validation rule of Msg A PUSCH occasions for FDD can be reused for HD-FDD. |
| Huawei, HiSilicon | Y |  |
| DOCOMO |  | The same validation rule of Msg A PUSCH occasions for FDD can be reused for HD-FDD |

**FL1 Medium Priority Proposal 6.3-2:**

* For MsgA PUSCH occasion overlapping with a DL reception, the following alternatives are considered
	+ Alt.1: MsgA PUSCH follows the same handling of valid RO.
	+ Alt.2: MsgA PUSCH follows the same handling of configured UL transmission.

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y | Alt2 |
| Qualcomm |  | Alt 2 is preferred |
| vivo |  | Alt 2 may be too restrictive as MSGA PUSCH occasions are configured in cell specific manner therefore a bit difficult to completely avoid the collision with configured DL reception.  |
| CATT | Y | Fine with the proposal. Given the fact that all (or most, depends on outcome of 6.1) of collision handling case when valid RO is involved will be ‘up to UE implementation’, we slightly prefer Alt.1, i.e. transmission of MsgA PUSCH will be up to UE implementation. |
| Intel |  | Alt 1 is not fine since MsgA PUSCH is not as important as PRACH preambleAlt 2 is not good since the overlap between MsgA PUSCH and configured DL is treated as error case. Since NR supports that 2-step RACH falls back to 4-step RACH if MsgA PUSCH cannot be transmitted, the proper way should be drop MsgA PUSCH if it is overlapped with configured DL. Therefore, our preference is* If overlapped with a dynamically scheduled DL receptions, the MsgA PUSCH is cancelled if the cancellation time for MsgA PUSCH is met (overlap handling Case 1)
* If overlapped with a configured DL reception, the MsgA PUSCH is cancelled
 |
| Ericsson | Y | We are open to the discussion. |
| Huawei, HiSilicon | Open |  |
| DOCOMO |  | This proposal can be discussed after further progress is made on the collision handling for valid RO.Alt 2 is not preferred since it is difficult to avoid collision with configured DL. |

# Case 9: Collision due to direction switching

RAN1#104bis-e reached the following working assumptions [2]:

|  |
| --- |
| Working assumption:* For HD-FDD, reuse the same principle as Rel-15/16 UE not capable of full-duplex communication
	+ A HD-FDD UE is not expected to transmit in the uplink earlier than [*NRX-TX Tc*] after the end of the last received downlink symbol in the same cell
	+ A HD-FDD UE is not expected to receive in the downlink earlier than [*NTX-RX Tc*] after the end of the last transmitted uplink symbol in the same cell
	+ FFS NTX-RX and NRX-TX
	+ FFS: how it jointly works with the agreement for other collision cases
 |

The further question is whether the back-to-back UL/DL without sufficient gap is allowed or not for HD-FDD UEs, and what is the assumed UE behaviour if happens.

Contributions [CATT08, CT09, Nokia11] express view that the gNB should take care to schedule the back-to-back UL/DL with the necessary gap and if there is no sufficient switching time, it is an error case same as in TDD.

Contribution [vivo06] indicates that gNB may avoid such collision for all cases except for the collision cases of valid RO vs. SSB and valid RO vs. configured PDCCH in Type 0/0A/1/2 CSS set(s). If including Ngap symbols before the valid RO is supported for HD-FDD, no additional rule/solution is needed.

A similar view is provided in contribution [Apple23] that the case of the “back-to-back” non-overlapping UL/DL without sufficient gap is NOT allowed except the collision case involving a valid RO. In such case, it can be up to UE to ensure the switching time is satisfied

Contributions [Ericsson04, OPPO07, Xiaomi13, DoCoMo18] express a different view that it may be difficult in general for the network to guarantee the switching time is always enough, especially for semi-statically configured DL/UL due to the co-existence with full-duplex UE.

Contributions [ZTE12, Samsung15, Intel17] further discuss the following two subcases identified in email discussion in RAN1#106-e for collision due to direction switching.

* Subcase 1: Non-overlapping DL/UL but with no sufficient gap
* Subcase 2: Overlapping DL/UL and no sufficient gap after collision handling

Contribution [Samsung15] indicates that the first subcase can be handled by UE implementation to ensure the switching gap or as error case where UE is not expected to handle, and the second sub-case can be handled by UE implementation or clear UE behaviour to ensure the switching gap.

Contributions [ZTE12, Intel17, LG21, Sharp22] also indicates both subcases may happen for HD-FDD UEs and thus it is preferred to define a clear UE behaviour to guarantee sufficient gap for switching.

It is also indicated in contribution [vivo06] that the similar issue had been discussed for TDD but without consensus. The following agreement was made in RAN1#93. But after that, no additional UE behavior was agreed for TDD.

|  |
| --- |
| Agreements (RAN1#93)**:*** **UE is not required to** receive on a downlink symbol and then transmit on a uplink symbol if those two symbols are not separated by at least Rx2Tx us on unpaired spectrum for a given serving cell, from the UE perspective
	+ **Discuss further whether it’s an error case or to specify a UE behavior**
	+ Note that the exact value of Rx2Tx has been specified in RAN4 [R4-1805766]
 |

**Moderator observation/suggestion**:

Based on the FL understanding, the “back-to-back” non-overlapping UL/DL without sufficient gap may happen also for the collision cases of MsgA PUSCH overlapping with SSB or configured PDCCH in Type 0/0A/1/2 CSS set(s) in addition to the collision cases involving a valid RO. Considering the coexistence with FD-FDD UEs, it is quite restrictive for network configuration if the back-to-back UL/DL is treated as error case. Differentiation from TDD should be considered.

For the above subcase 2 of the overlapping DL/UL with no sufficient gap after collision handling, the FL understanding it may happen only for Case 1 of SRS overlapping with dynamically scheduled DL reception overlapping or if UE is capable of partial cancellation of PUCCH or PUSCH or PRACH. Since these may also happen for TDD, no additional rule is thus needed for HD-FDD.

**FL1 High Priority Proposal 7-1: Confirm the working assumption with the following modifications:**

* For HD-FDD, reuse the same principle as Rel-15/16 UE not capable of full-duplex communication
	+ A HD-FDD UE is not expected to transmit in the uplink earlier than ~~[~~*NRX-TX Tc*~~]~~ after the end of the last received downlink symbol in the same cell
	+ A HD-FDD UE is not expected to receive in the downlink earlier than ~~[~~*NTX-RX Tc*~~]~~ after the end of the last transmitted uplink symbol in the same cell
	+ ~~FFS N~~~~TX-RX~~ ~~and N~~~~RX-TX~~ *NRX-TX Tc* and *NTX-RX Tc* are the same as NR TDD operation in FR1
	+ ~~FFS: how it jointly works with the agreement for other collision cases~~
* The case of the “back-to-back” non-overlapping UL/DL without sufficient gap may happen, i.e., are allowed for HD-FDD UEs.
	+ Discuss further whether to specify a clear UE behavior, or leave it to UE implementation to ensure that the switching time is satisfied

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | Y | We see the spec. will have different descriptions to be discussed. |
| Qualcomm | N | We agree with the first bullet on re-using the same principle of NR Rel-15/16 UE not capable of full-duplex communication.We don’t agree with the second bullet on allowing “back-to-back” DL-to-UL switching without a sufficient gap for RX-to-TX switching, which is not consistent with the rule specified for NR TDD.• Based on TS 38.133, the fixed TA offset between DL and UL carriers in SA deployment (on TDD and FDD bands) can be used to compensate for the UL-to-DL switching time, but not the DL-to-UL switching time.• All the TDD slot formats specified in TS 38.213 have at least one flexible symbol for DL-to-UL switching.• For NR TDD, R15/16 spec does not mandate back-to-back DL-to-UL switching for non-RedCap UE. By the same token, NR R17 should not mandate Type-A HD-FDD UE to support back-to-back DL-to-UL switching without a sufficient switching gap.• Whether or not to support back-to-back DL-to-UL switching in Type-A HD-FDD can be specified as a UE capability for RedCap devices. |
| vivo | Y for the 1st bullet only.  | We are fine with the 1st bullet (and the sub-bullets) but suggest to treat the 2nd bullet (and the sub-bullets) separately.For the 2nd bullet, we see there are following possible cases* Case A: Back-to-back semi-statically configured transmission/reception vs. dynamically scheduled reception/transmission
* Case B: Back-to-back transmission/reception configured by dedicated higher layer parameters vs. reception/transmission configured by dedicated or cell specific higher layer parameters
* Case C: back-to-back transmission/reception configured by cell-specific higher layer parameters and reception/transmission configured by cell-specific higher layer parameters

For Case A and Case B, sine dedicated configuration/scheduling are involved, we think it should be always possible for gNB to avoid the back-to-back transmission and reception without sufficient gap. Case C may be difficult to avoid from gNB perspective, and we think the existing agreement can be extended to relax the gNB configuration restriction, as followingProposal: **At least for the collision cases of valid RO vs. PDCCH in Type 0/0A/1/2 CSS set(s) or SSB, the set of symbols overlapping with PDCCH in CSS set or SS includes also Ngap symbols before the valid RO.** |
| CATT | Y  | From the 1st bullet, it is clear that A HD-FDD UE is not expected to ‘handle’ the case when gap is not sufficient. So, for the 2nd bullet, when a case of “back-to-back” non-overlapping UL/DL without sufficient gap happens, HD-FDD UE is not required to handle it (leave it up to UE implementation).  |
| Sharp | Y partially | The first bullet is fine. But for the second bullet, we think a clear UE behaviour should be defined.The situation is different with TDD where the DL-UL gap (at least one flexible symbol) and non-zero TA\_offset are configured. But it will confuse a UE on how to do back-to-back switching in a FDD cell when these two lengths are zero. |
| Intel |  | We prefer to define the two subcases first, then discuss the handling for each subcase. Clarification on whether each subcase is error case should be done first. Then, if a subcase is allowed, a solution is to be discussed later.In our understanding, the first bullet in FL proposal is for the 2nd subcase. Does it imply that it is error case if there is no enough switching gap after overlap handling case 1/2/3/4/5/8? The second bullet is related to 1st subcase, we share the view 1st subcase is allowed  |
| Ericsson | Y | The first bullet is similar to the principle for NR Rel-15/16 UE not capable of full-duplex communication. The second bullet is to clarify that for HD-FDD UE, the scenario of “back-to-back” non-overlapping UL/DL without sufficient gap can happen, i.e., allowed, and whether a clear UE behaviour to handle the swithcing time is defined or not is to be discussed further.  |
| Huawei, HiSilicon | Open |  |
| DOCOMO | Y |  |

# Other aspects

## Whether SFI can be optionally supported for HD-FDD UE

Currently, a FDD UE can optionally support SFI operation. The dynamic SFI provides a means for gNB to cancel the configured DL reception or UL transmission on flexible symbols in a slot. Regarding whether SFI can be optionally supported for HD-FDD UEs, the following are discussed in a few contributions:

* Contribution [Nokia11] indicates there is no need to support dynamic SFI for HD-FDD RedCap UE.
* Contribution [Intel17] raises one issue when SFI is supported for HD-FDD UEs. Currently, the DL SFI and UL SFI are separately processed in NR FDD, an if SFI is supported for HD-FDD UEs, the order to check SFI and to apply overlap handling of a DL reception and a UL transmission needs to be determined.

**FL1 Medium Priority Question 8.1-1:**

* **Companies are invited to comment whether SFI can be optionally supported for HD-FDD UEs and the potential impact on collision handling if supported?**

|  |  |  |
| --- | --- | --- |
| **Company** | **Y/N** | **Comments** |
| OPPO | N | It should not be supported by RedCap UE in FDD band. |
| Qualcomm | N | SFI should not be discussed in HD-FDD operation of RedCap UE. |
| vivo |  | We are fine to not support SFI by specification for HD-FDD RedCap UEs.  |
| CATT |  | We are fine to not supporting SFI for HD-FDD UE, since it leads to higher complexity/cost and more power consumption. |
| Intel | Y | We prefer to support SFI indication as an optional capability for HD-FDD UE (same as FD-FDD UE) |
| Ericsson |  | We do not see the need to support SFI for HD-FDD RedCap UE.  |
| Huawei, HiSilicon |  | There is overlapping discussion on support of DCI format 2\_0 in another thread. |
| DOCOMO |  | We are fine not to support SFI for HD-FDD RedCap UE |

## Definition and capability of HD-FDD UE

One contribution presents view on the UE capability reporting of HD-FDD. Contribution [OPPO07] proposes that UE capability of HD-FDD is explicitly defined and known by gNB.

Since this is related to UE feature discussion, the FL suggestion is to discuss it under the AI 8.6.2.

## Switching gap for neighbour cell SSB measurement

Contribution [LG21] proposes to discuss the impact of switching gap for a HD-FDD UE on the measurement based on SSB, e.g., whether the switching gap need to be considered for determination of time duration of SSB reception for measurement.

# References

|  |  |  |  |
| --- | --- | --- | --- |
| [1] | [RP-211574](https://www.3gpp.org/ftp/TSG_RAN/TSG_RAN/TSGR_92e/Docs/RP-211574.zip) | Revised WID on support of reduced capability NR devices | Ericsson |
| [2] | [R1-2108271](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_106-e/Docs/R1-2108271.zip) | RAN1 agreements for Rel-17 NR RedCap | Rapporteur (Ericsson) |
| [3] | [R1-2108754](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2108754.zip) | Duplex operation for RedCap | Huawei, HiSilicon |
| [4] | [R1-2108821](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2108821.zip) | Duplex operation for RedCap | Ericsson |
| [5] | [R1-2108914](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2108914.zip) | Discussion on duplex operation for RedCap | Spreadtrum Communications |
| [6] | [R1-2108982](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2108982.zip) | Discussion on RedCap half-duplex operation | vivo, Guangdong Genius |
| [7] | [R1-2109083](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109083.zip) | On half-duplex operation | OPPO |
| [8] | [R1-2109231](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109231.zip) | Discussion on HD-FDD operation | CATT |
| [9] | [R1-2109253](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109253.zip) | Discussion on duplex operation for RedCap | China Telecom |
| [10] | [R1-2109288](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109288.zip) | Discussion on collision handling of HD-FDD operation | CMCC |
| [11] | [R1-2109311](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109311.zip) | Half-Duplex Operation for Reduced Capability Devices | Nokia, Nokia Shanghai Bell |
| [12] | [R1-2109333](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109333.zip) | HD-FDD for reduced capability NR devices | ZTE, Sanechips |
| [13] | [R1-2109418](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109418.zip) | Discussion on the remaining issues of HD-FDD for RedCap | Xiaomi |
| [14] | [R1-2109451](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109451.zip) | Discussion on aspects related to duplex operation | Potevio Company Limited |
| [15] | [R1-2109497](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109497.zip) | HD-FDD Operation for RedCap UEs | Samsung |
| [16] | [R1-2109574](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109574.zip) | On half duplex operation for RedCap UEs | MediaTek Inc. |
| [17] | [R1-2109618](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109618.zip) | Support of HD-FDD for RedCap | Intel Corporation |
| [18] | [R1-2109686](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109686.zip) | Discussion on duplex operation for RedCap | NTT DOCOMO, INC. |
| [19] | [R1-2109842](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109842.zip) | Aspects related to duplex operation for RedCap | Panasonic Corporation |
| [20] | [R1-2109949](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109949.zip) | Duplex operation for RedCap UEs | InterDigital, Inc. |
| [21] | [R1-2109976](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109976.zip) | Aspects related to the duplex operation of RedCap | LG Electronics |
| [22] | [R1-2109997](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2109997.zip) | Discussion on duplex operation for redcap UEs | Sharp |
| [23] | [R1-2110041](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2110041.zip) | Duplex Operation for Redcap | Apple |
| [24] | [R1-2110108](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2110108.zip) | Discussion on aspects related to duplex operation | ASUSTeK  |
| [25] | [R1-2110194](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2110194.zip) | Type-A HD-FDD Operation for RedCap UE | Qualcomm Incorporated |
| [26] | [R1-2110281](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2110281.zip) | On aspects related to duplex operation | Nordic Semiconductor ASA |
| [27] | [R1-2110325](file:///C%3A%5CUsers%5Cweichao%5CAppData%5CLocal%5CDocs%5CR1-2110325.zip) | Discussion on duplex operation for RedCap UE | WILUS Inc. |
| [28] | [R4-2114996](https://www.3gpp.org/ftp/tsg_ran/WG4_Radio/TSGR4_100-e/Docs/R4-2114996.zip) | Reply LS to Half-duplex FDD switching for RedCap UE | 3GPP TSG WG4 #100-e |