3GPP TSG-RAN WG4 Meeting # 100-e R4-2114995

Electronic Meeting, 16-27 August 2021

**Source:** Sony

**Title:** WF on RedCap REFSENS in FR1

**Agenda item:** 9.20.2.3

**Document for:** Approval

1. Background

The WI is to specify a UE feature and parameter list with lower end capabilities, relative to Release 16 eMBB and URLLC NR to serve the three use cases: connected industries (wireless sensors), video surveillance (smart cities) and wearables use cases [1]. The WI was discussed in RAN4 #99-e [2] and further discussed in RAN4 #100-e [3].

This tdoc is a WF on RedCap REFSENS in FR1 and is the outcome of the discussion, based on the following contributions to RAN4 #100-e.

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| **TDoc** | **Title** | **Source** |
| [R4-2112385](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_100-e/Docs/R4-2112385.zip) | RedCap UE REFSENS requirements | Apple |
| [R4-2112890](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_100-e/Docs/R4-2112890.zip) | Considerations on RF receiver for RedCap FR1 | Sony |
| [R4-2112912](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_100-e/Docs/R4-2112912.zip) | Discussion on RedCap UE requirements | ZTE Corporation |
| [R4-2112985](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_100-e/Docs/R4-2112985.zip) | Views on RedCap REFSENS requirements | vivo |
| [R4-2113101](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_100-e/Docs/R4-2113101.zip) | Rx requirements for FR1 Redcap UE | Xiaomi |
| [R4-2113408](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_100-e/Docs/R4-2113408.zip) | Discussion on RF requirements for RedCap UE | Huawei, HiSilicon |
| [R4-2114075](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_100-e/Docs/R4-2114075.zip) | RedCap UE Rx requirements for FR1 | Nokia, Nokia Shanghai Bell |
| [R4-2114341](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_100-e/Docs/R4-2114341.zip) | RF impact analysis on R17 RedCap | Ericsson |

1. Discussion

## Sub-topic 4-1: REFSENS for 1 RX RedCap UE

Possible options discussed:

* + Option 1: Reuse the constant gain adjustment of LTE Cat-1bis 2Rx to 1 Rx REFSENS [Apple]

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| Duplex Mode | 1Rx and 2Rx REFSENS difference (dB) | | | |
| 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| FDD | 2.5 | 3 | 3 | 3 |
| TDD | 2.5 | 2.5 | 2.5 | 2.5 |

* + Option 2: Apply 2.5 dB for FD-FDD and TDD. [Sony, ZTE] Qualcomm for simplicity.
  + Option 3: Apply 3 dB for FD-FDD and 2.5 dB for TDD [Xiaomi]
  + Option 4: Constant 3dB gain relaxation [ Vivo, Huawei, Ericsson, OPPO]

Moderator recommendation [3]: *Down-selection from option 1, 2 and 4*

Proposal 1 Issue 4-1:

Option 1: Reuse the constant gain adjustment of LTE Cat-1bis 2Rx to 1 Rx REFSENS [Nokia]

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| Duplex Mode | 1Rx and 2Rx REFSENS difference (dB) | | | |
| 5 MHz | 10 MHz | 15 MHz | 20 MHz |
| FDD | 2.5 | 3 | 3 | 3 |
| TDD | 2.5 | 2.5 | 2.5 | 2.5 |

Option 2: Apply 2.5 dB for FD-FDD and TDD. [Ericsson, Qualcomm, Sony]  
 Option 4: Constant 3dB gain relaxation.

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| **Company** | **Comments** |
| Ericsson | we are fine with the same factor (2.5 dB) is used to relax the REFSENS from 2 RX to 1 RX. |
| Apple | Option 1 or Option 4 |
| Xiaomi | Option 1 or Option 4 |
| OPPO | Option 4. |
| Sony | Option 2 For simplicity |

Ericsson: the constant relaxation is preferred. The factor that we take for RedCap should not be worse than LTE. We should use the similar approach for NR as for LTE.

ZTE: we agree with 2.5dB for all the bands. There is no Rx diversity gain. And there will be 0.5dB margin.

Apple: Support option 1 which is based on LTE requirements. We are also OK with option 3.

Qualcomm: I would like to change our opionion to option 1 or 3. Prefer option 3.

Xiaomi: Agree with Apple. For FDD, if we reduce to 1Rx, it also has insertion loss than TDD. We support 1 and 3.

Vivo: we share the similar view as Ericsson. We need be careful about the reuiqrements. Option 4 is our preference.

Sony: the RedCap should not be worse than MTC. Support option 2.

Xiaomi: Cat1bis, the relaxation is option 1. Cat1bis is without uplink limitation.

Agreement: For REFSENS of 1Rx, use the constant XdB gain relaxation based on 2Rx REFSENS

* FFS for X dB
  + 2.5dB for TDD
  + FFS for FDD
    - Option 1: 2.5dB
    - Option 2: 3dB

## Sub-topic 4-2: RX RedCap UE in HD-FDD mode

Possible options discussed:

* + Option 1: [Apple] Qualcomm
    - For all NR FDD bands, the 5MHz REFSENS requirements defined for full-duplex operation can be reused for half-duplex operation.
    - HD-FDD REFSENS for channel BW wider than 5 MHz can be calculated by REFSENS(5MHz) + 10log10(n x NRB/25), where NRB is the maximum transmission bandwidth configuration with n=1 for 15kHz SCS and n=2 for 30kHz SCS.
  + Option 2: Relaxation of 0.8 dB of 2 RX REFSENS of NR FDD band[ ZTE]
  + Option 3: Reuse the 2 RX REFSENS of NR FDD band [Xiaomi]
  + Option 4: [Ericsson]
    - Consider the ΔIM modification in Table 1 for 2 RX antenna port REFSENS for RedCap UE operating in HD-FDD mode.
  + Option 5: FFS [Vivo]

Moderator recommendation [3]: *Recommendations for 2nd round:*

*Issue 4-2-a: For the RedCap UE only support HD-FDD, should UE report* *HD-FDD capability to network (e.g in the case duplexer is replaced with switch?), if so, should RAN4 specify different REFSENS than FD-HDD?*

*Issue4-2-b: For the RedCap UE support both FD-HDD and HD-FDD, should UE report HD-FDD and FD-HDD capability to network (e.g in the case duplexer is kept?), if so, should RAN4 specify different REFSENS than FD-HDD?*

*Based on the outcome of discussion, the down selection could be from option 1, 2,3, 4*

Proposal 2 Issue 4-2a: Introduce capability to signal <HD-FDD only> capability  
Option 1. Yes [Ericsson, Sony, Huawei]  
Option 2. No [Qualcomm, Xiaomi, Nokia]

Proposal 3 Issue 4-2b: Introduce capability to signal <better HD-FDD performance>  
Option 1. Yes Qualcomm  
Option 2. No [Xiaomi, Nokia, Huawei]   
Option 3. FFS [Ericsson, Sony]

Proposal 4 Issue 4-2: Different requirements specified for HD-FDD than for FD-FDD  
Option 1: If capability <better HD-FDD performance> is signaled Qualcomm  
Option 2: If capability <better HD-FDD performance> or if capability < HD-FDD only> is signaled  
Option 3: If capability < HD-FDD only> is signaled [Ericsson, Sony, Huawei]  
Option 4: No [Xiaomi]  
Option 5: Other

Ericsson: the critical question is whether device should support both. According to WID, we are going to reduce the cost of device. It seems that supporting both modes are not qualified. If companies want to include that device, the update of WID is needed. There is an impact on RAN1 if device supports both. We should focus on device only supporting HD-FDD. And put FFS on UE supporting both FDD and HD-FDD.

Apple: in our view, choosing the duplexer and use filter for Tx switching. Using duplexer can make UE support both. If using single filter, there would be reduction of insertion loss. If UE supporting both FDD and HD-FDD, and if the test on FDD, the insertion loss is still there.

Huawei: the initial intention to introduce HD-FDD is to reduce the cost of UE. It can also be beneficial for REFSENS. If companies want to use the duplexer implementation, it is not aligned with our intention. If UE reports both mode, how can network can schedule?

Apple: does it imply UE supporting FDD is precluded from supporting HD-FDD.

Qualcomm: we share the same view as Apple. UE should have flexibility to operate with FDD and HD-FDD with single archeticture. Power saving.

Ericsson: We should not ignore the network impact with two capabilities. We are not sure if we understand it clearly from RAN1. We need further discuss this device. We can focus on HD-FDD single mode device.

Sony: we support Ericsson in this. We do not understand both HD-FDD and FDD. Whether it is UE choice or network choice. We should focus on one thing and further discussion on other aspects after we got clarify from RAN1.

Xiaomi: what is the benefit if UE supports both?

Apple: single architecture supports both FDD and HD-FDD would bring in the benefit. In the cell edge, for certain FDD band, UE need FDD to get better uplink performance. When supporting HD-FDD, there is no interference and you can get better DL performance.

Huawei: If HD-FDD can benefit REFSENS, Apple and Qualcomm proposes reusing. Is there any benefit?

Apple: we are talking about the benefit when UE is far from the gNB. It is not about 0.5 insertion loss. There is huge difference.

Ericsson: Apple focuses on cell benefit rather than UE benefit, which is far from the WID not from cost saving perspective.

Ericsson: HD-FDD only mode fits the WID. If companies are interested in dual mode device, it may have impact on RAN1.

Agreement: For RedCap requirements, focus on HD-FDD only mode

* FFS on dual mode, i.e., supporting both FDD and HD-FDD.

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| **Company** | **Comments** |
| Ericsson | For issue 4-2a: For RedCap UE that support HD-FDD only, RAN4 could target to the RAN1 feature HD-FDD stated below in TR 38.875:  - For Type A HD-FDD, a high proportion of the cost saving occurs because the duplexer can be replaced with a switch and a lowpass filter.  - For Type B HD-FDD, uplink and downlink can share one local oscillator, therefore, some additional saving on RF transceiver can be obtained.  The Type A HD-FDD could be used as a baseline for HD-FDD RedCap UE and REFSENS can be scaled perhaps as the same as LTE.  For issue 4-2b: For the RedCap UE supporting both HD-FDD and FD-FDD, if different REFSENS would be defined for FD-FDD and HD-FDD, how such device is deployed in certain coverage? From this aspect, maybe we could treat such device differently. Suggestion is FFS for next meeting.  For issue 4-2: we can start to define the HD-FDD only RedCap UE REFSENS and leave the issue 4-2b to next meeting. |
| Qualcomm | Regarding Proposal 1: Option 1 is preferred because it removes the TX distortion aspect and provides flexibility for RedCap to operate in the same hardware regardless of HD-FDD or FD-FDD.  The problem I see with 4-2 option 2 and 3 is that it re-uses REFSENS values that still have a TX distortion component. Look at NR band n5 at 20MHz for example. Simply applying a small offset gives poorer REFSENS than option 1. I’m not sure if I understand the Delta IM approach. Are we removing all band dependency and TX leakage component for HD-FDD? It seems that way, then the REFSENS is the same for all bands. Maybe I have misunderstood. |
| Apple | Option 1 is our preference. What is the merit of introducing two sets of requirements based on different UE implementation? How would the network handle these two types of UE differently? |
| Xiaomi | For issue 4-2b and issue 4-2: I’m not sure these issues mean the UE supporting FD-FDD mode could fallback to HD-FDD mode. What are the benefits of the UE supporting both FD-FDD mode and HD-FDD mode? Currently, there is no any conclusion in RAN1 for whether the UE can support both modes.  Prefer only consider HD-FDD only currently, according to LTE’s signaling, UE can only report one of HD-FDD mode, FD-FDD mode and TDD mode, there is unnecessary to introduce the capability of HD-FDD only. |
| Sony | Proposal 2: Option 1: We agree with Xiaomi that only supporting HD-FDD (and TDD) would be the best, however, the WI clearly states also support of FD-FDD (how this should work from a network perspective is another discussion?). In case both HD-FDD and FD-FDD shall be supported from a network perspective, we think a capability is needed.  Proposal 3: Option 3: We agree with Ericsson in the question how the network could benefit from knowing better performance => need to study further.  Proposal 4: Option 3: In case <better HD-FDD performance> is introduced Option 2 applies, but this needs further study.  For specification values Option 5 FFS. Option 2 (0.8dB) is a good alternative for simplicity reason, even though, as Qualcomm points out, it doesn’t take the TX distortion component or the band dependent factor (duplex distance) into account. Otherwise, Option 4 may be the most correct. Please refer to how REFSENS was specified for NB-IOT. |
| Nokia | Proposal 2: In our view, there is no reason for a RedCap UE that reports HD-FDD capability to operate as a FD-FDD UE. The network should not have to distinguish between a <HD-FDD + FD-FDD> UE and a <HD-FDD only> UE. Therefore, we do not understand the reason for supporting a <HD-FDD only> capability. Different REFSENS requirements are specified for HD-FDD UE relative to FD-FDD UE and are applicable to a UE that reports HD-FDD capability.  Proposal 3: In our view, the network should have to distinguish only between HD-FDD UE and FD-FDD UE and not between different types of HD-FDD UEs. Therefore, it is not necessary to introduce a <better HD-FDD performance> capability.  Proposal 4: The options presented here seem to presume that the new capabilities from Issue 4-2a and Issue 4-2b are supported. We do not see the need to support these new capabilities. In our view, HD-FDD REFSENS requirements are specified and are applicable to a UE that reports a HD-FDD capability. This option is not currently captured. |

## Sub-topic 4-3: 1 RX RedCap UE in HD-FDD mode

Possible options discussed:

* + Option 1: Relaxation of 1.7 dB of 2 RX NR FDD band REFSENS[Sony, ZTE, Xiaomi, Ericsson]
  + Option 2: [Ericsson]
    - Consider the ΔIM modification in Table 1 for 2 RX antenna port REFSENS for RedCap UE operating in HD-FDD mode.
    - Consider adjusting diversity gain from 3 dB additionally for 1 RX antenna port REFSENS for RedCap UE operating in HD-FDD mode.
  + Option 3: FFS [Vivo] Qualcomm

Moderator recommendation [3]: *Down-selection from option 1, 2, 3, also possibly depend on the issue 4-1 and issue 4-2 if common scaling factor is agreed.*

Proposal 5 Issue 4-3:   
Option 3: FFS (depending on outcome of Issue 4-2, Proposal 2)[Ericsson, Qualcomm, Sony]

Apple: this is to compare 2Rx to 1Rx. There should be tightening, which should be not single values.

Agreement: For Rx RedCap UE in HD-FDD mode, relaxation of Y dB of 2Rx NR FDD band REFSENS

* Y value should be less than 2.5dB.

## Sub-topic 4-4: Uplink Configuration for RedCap UE

Possible options discussed:

* + Option 1: UL configuration for HD-FDD REFSENS requirements is specified with full allocation.
  + Option 2: The uplink configuration for reference sensitivity of 1Rx and HD-FDD mode could reuse the uplink configuration for reference sensitivity of 2Rx with the channel bandwidth of 5MHz, 10MHz, 15MHz, and 20MHz.
  + Option 3: FFS

Moderator recommendation [3]: *Down-selection from option 1, 2*

Proposal 6 Issue 4-4:  
Option 1: UL configuration for HD-FDD REFSENS requirements is specified with full allocation. [ Qualcomm, Sony]  
Option 2: The uplink configuration for reference sensitivity of 1Rx and HD-FDD mode could reuse the uplink configuration for reference sensitivity of 2Rx FD-HDD with the channel bandwidth of 5MHz, 10MHz, 15MHz, and 20MHz.[Ericsson, Xiaomi Nokia, Huawei]

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| **Company** | **Comments** |
| Ericsson | Option 2. This is to align with LTE and also save the testing work by not reconfigure the different RB for FD-FDD and HD-FDD. As this is HD-FDD, there is no RB restriction but on the other hand, to keep this RB allocation for uplink transmission seems also ok? |
| Qualcomm | Either option 1 or option 2 is fine. HD-FDD REFSENS is independent of UL configuration. But why copy FD-FDD? Again no real preference. |
| Apple | Option 1  The essence of RB restriction in FD-FDD REFSENS requirement is meant to mitigate the impact from UL interference. Using restricted RB number in HD-FDD REFSENS requirement would give a wrong impression that the DL might still be impacted by the UL interference. |
| Xiaomi | Option2  For HD-FDD mode, there is no any difference for DL receiver performance no matter how to arrange UL configuration, i.e., full UL configuration or reuse current UL configuration, to simplify the impact for the Spec and save the testing work, it is better to reuse current UL configuration. |
| Sony | Proposal 5: Option3: FFS (Or for simplicity Option 1)  Proposal 6: Option 1. We agree with Apple that Option 1 is the more correct but are OK with Option 2 for simplicity (test) reason. |

1. Conclusion

Agreement after GTW session

**Sub-topic 4-1: REFSENS for 1 RX RedCap UE**

Agreement: For REFSENS of 1Rx, use the constant XdB gain relaxation based on 2Rx REFSENS

* FFS for X dB
  + 2.5dB for TDD
  + FFS for FDD
    - Option 1: 2.5dB
    - Option 2: 3dB

**Sub-topic 4-2: RX RedCap UE in HD-FDD mode**

Agreement: For RedCap requirements, focus on HD-FDD only mode

* FFS on dual mode, i.e., supporting both FDD and HD-FDD.

**Sub-topic 4-3: 1 RX RedCap UE in HD-FDD mode**

Agreement: For Rx RedCap UE in HD-FDD mode, relaxation of Y dB of 2Rx NR FDD band REFSENS

* Y value should be less than 2.5dB.

1. Reference
2. RP-211574, “Revised WID on support of reduced capability NR devices”, *Ericsson*
3. R4-2108005, “WF on RedCap”, *Ericsson*
4. R4-2114742, “Email discussion summary for [100-e][142] NR\_RedCap”, *Moderator (Ericsson)*