3GPP TSG-RAN WG4 Meeting #112 R4-2413411

Maastricht, Netherlands, August 19th – 23rd, 2024

**Agenda item:** 8.25.5

**Source:** Moderator (Qualcomm)

**Title:** Topic summary for [112][311] NR\_NTN\_Ph3\_UE\_RF

**Document for:** Information

# Introduction

This summary is split into two main topics aligned with the agenda:

* Topic 1: RedCap UE RF requirements
* Topic 2: other requirements

There were 13 Tdocs for RedCap, with majority of Tdocs discusseing HD-FDD Refsens and PC3 output power. In addition there were individual proposals for frequency error and simultaneous operation with GNSS. For other requirements there were only 2 Tdocs, both addressing the WI objective for UL capacity enhancements.

For online discussion, recommendation is to go in the order of the issues.

Previous agreements can be found from the WFs:

* RAN4#110bis: R4-2406610
* RAN#111: R4-2410574

# Topic #1: RedCap UE RF requirements

*Topic description:* RedCap UE RF requirements

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2411069 | CATT | **Proposal 1:** The NR UE frequency error requirements could be reused for NTN (e)RedCap UE.  **Observation 1:** Observation 1: The power level for PC3 HD-FDD (e) NTN RedCap could refer to the conclusions of the NTN HPUE evaluation.  **Proposal 2:** RAN4 may consider the definition of suffixes for NTN RedCap / eRedCap UE shown in Table 4.3-1 as starting point.  Table 4.3-1: Definition of suffixes   |  |  | | --- | --- | | Clause suffix | Variant | | None | Single Carrier | | A | RedCap | |
| R4-2411172 | Apple | **Proposal 1:** NR NTN RedCap UE 2Rx HD-FDD REFSENS requirements and UL configurations are specified as in Table 2-2 and Table 2-3 respectively.  **Table 2-2 Proposed NR NTN RedCap UE 2Rx HD-FDD REFSENS requirements**   | Operating Band | SCS  (kHz) | 5 MHz (dBm) | 10 MHz (dBm) | 15 MHz (dBm) | 20 MHz (dBm) | | --- | --- | --- | --- | --- | --- | |  | 15 | -100.0 | -96.8 | -95.0 | -93.8 | | n256 | 30 |  | -97.1 | -95.1 | -94.0 | |  | 60 |  | -97.5 | -95.4 | -94.2 | |  | 15 | -100.0 | -96.8 | -95.0 | -93.8 | | n255 | 30 |  | -97.1 | -95.1 | -94.0 | |  | 60 |  | -97.5 | -95.4 | -94.2 | |  | 15 | -100.0 | -96.8 | -95.0 |  | | n254 | 30 |  | -97.1 | -95.1 |  | |  | 60 |  | -97.5 | -95.4 |  |   **Table 2-3 Uplink configurations for NR NTN RedCap UE 2Rx HD-FDD REFSENS requirements**   | **Operating Band** | **SCS**  **(kHz)** | **5 MHz** | **10 MHz** | **15 MHz** | **20 MHz** | **Duplex Mode** | | --- | --- | --- | --- | --- | --- | --- | |  | 15 | 25 | 50 | 75 | 100 | HD-FDD | | n256 | 30 |  | 24 | 36 | 50 | |  | 60 |  | 10 | 18 | 24 | |  | 15 | 25 | 50 | 75 | 100 | HD-FDD | | n255 | 30 |  | 24 | 36 | 50 | |  | 60 |  | 10 | 18 | 24 | |  | 15 | 25 | 50 | 75 |  | HD-FDD | | n254 | 30 |  | 24 | 36 |  | |  | 60 |  | 10 | 18 |  |   **Proposal 2:** For NR NTN (e)RedCap UE maximum output power, wait for the completion of PC2 for NR NTN UE and PC2 for RedCap UE TDD bands before the introduction of HPUE. |
| R4-2411496 | Spreadtrum Communications | **Proposal 1:** Adopting the following REFSENS for NTN HD-FDD Redcap UE: - 2RX HD-FDD Redcap REFSENS:■ n256: Existing n256 2RX FD-FDD RESENS-0.5 dB ■ n255: Existing n255 2RX FD-FDD RESENS-0 dB **Proposal 2:** Support option 2. PC3 power level is the same for non-RedCap NR NTN UE and (e)RedCap NR NTN UE. |
| R4-2411498 | Mediatek India Technology Pvt. | **Observation 1:** Regarding NTN HD-FDD REFSENS for 2Rx, in RAN4#111 meeting, because NTN connection performance between SAN and UE is important, some comments indicate that it is desired to achieve more than 0.5 dB tightening on n254 and n256. Therefore, WF [3] indicates that [0.5] dB tightening for n254 and n256, FFS for n255, and n256 to be confirmed in RAN4#112.  **Observation 2**: In TS 38.101-5[4], 2Rx FD-FDD REFSENS are -99.5dBm, -100dBm, and -99.5dBm for n256, n255 and n254 for 5MHz CBW, respectively.  **Observation 3:** Switching from FD-FDD mode to HD-FDD mode would obviously improve REFSENS due to lower front-end insertion loss but may only show a little improvement where original FD-FDD REFSENS is already quite good.  **Proposal 1:** Based on observations 1 to 3, regarding HD-FDD REFSENS for 2 Rx, consider whether 0.5 dB tightening for n254 (i.e., 2Rx HD-FDD REFSENS is -100dBm/5MHz) would be applicable.  **Proposal 2:** Based on observations 1 to 3, regarding HD-FDD REFSENS for 2 Rx, consider whether 0.6 dB tightening for n256 (i.e., 2Rx HD-FDD REFSENS is -100.1 dBm/5MHz) would be applicable.  **Proposal 3:** Based on observations 1 to 3, regarding HD-FDD REFSENS for 2 Rx, consider whether 0.2 dB tightening for n255 (i.e., 2Rx HD-FDD REFSENS is -100.2 dBm/5MHz) would be applicable.  **Observation 4:** In RAN4#111 meeting, some company indicated that the HD-FDD RF front-end (FE) insertion loss is lower compared to FD-FDD FE insertion loss and can improve the RX REFSENS and TX maximum output power simultaneously.  **Observation 5:** When NTN-RedCap UE supports both HD-FDD and FD-FDD operations for a band, if HD-FDD FE and FD-FDD FE are implemented separately, it is observed that TX maximum output power would increase when FD-FDD operation is switched to HD-FDD operation.  **Observation 6:** When NTN-RedCap UE supports both HD-FDD and FD-FDD operations for a band, if only FD-FDD FE is implemented, it is observed that the same TX maximum output power may be applicable for both FD-FDD and HD-FDD operations due to the same FE insertion loss.  **Observation 7:** When NTN-RedCap UE only supports HD-FDD operation for a band, it is observed that the HD-FDD TX maximum output power would be obviously better compared to FD-FDD TX maximum output power.  **Proposal 4:** Clarify whether only FD-FDD FE circuits are implemented and additional HD-FDD FE circuits are precluded when NTN-RedCap UE supports both HD-FDD and FD-FDD operations for a NTN band.  **Proposal 5:** For a NTN band, if implementing additional HD-FDD FE is not precluded for NTN-RedCap UE which supports both HD-FDD and FD-FDD operations, consider PC3 maximum output power under HD-FDD operation as:  **Option 1:** PC3 of [23.2~23.4] dBm for NTN-RedCap UE under HD-FDD operation for a NTN band.  **Option 2:** PC3 of 23 dBm with +[2.4]/-2 dB power tolerance for NTN-RedCap UE under HD-FDD operation for a NTN band.  **Option 3:** PC3 of [23.2] dBm with +[2.2]/-2 dB power tolerance for NTN-RedCap UE under HD-FDD operation for a NTN band.  **Proposal 6:** Consider PC3 maximum output power:  **Option 1:** For a NTN band, PC3 of [23.4~23.8] dBm for NTN-RedCap UE under only HD-FDD support.  **Option 2:** For a NTN band, PC3 of 23 dBm with +[2.8]/-2 dB power tolerance for NTN-RedCap UE under only HD-FDD support.  **Option 3:** For a NTN band, PC3 of [23.4] dBm with +[2.4]/-2 dB power tolerance for NTN-RedCap UE under only HD-FDD support. |
| R4-2411539 | Sony | **Observation 1:** Adopting the same principle in defining the TN Redcap and NTN Redcap REFSENS can facilitate the time-to-market of the Redcap NTN system and reduce its cost.  **Observation 2:** Making the REFSENS for HD-FDD NTN Redcap more stringent may not significantly benefit network coverage as the uplink is usually the bottleneck.  **Observation 3:** It is challenging for GNSS and NR NTN to operate simultaneously in some frequency bands due to the extremely closed frequency allocation.  **Proposal 1:** RAN4 confirms the 0.5 dB tightening for n254 and n256, and 0 dB tightening for n255 for the REFSENS of HD-FDD Redcap NTN, e.g., -100 dBm for 5MHz BW for n256, n255 and n254.  **Proposal 2:** Reuse the same way as in Rel-18 eRedcap REFSENS (as in 7.3I.3 of 38.101-1) to define the NTN eRedcap REFSENS.  **Proposal 3:** RAN4 shall further study the impact if GNSS can’t operate simultaneously with NR NTN.  **Proposal 4:** Keep the output power level of PC3 for Redcap NTN. |
| R4-2411600 | Xiaomi | **Proposal 1:** 0.5 dB tightening for n254 and n256, 0 dB tightening for n255.  **Proposal 2:** The refsens requirements for 2Rx HD-FDD NTN UE shall be specified as table 2.  **Proposal 3:** it is preferred not to consider increase in current PC3 power level even for UE only supports HD-FDD operation. |
| R4-2411657 | Nokia | **Observation 1:** Reasoning for 0.5dB improvement goes back to almost 10 years old survey on insertion loss differences. **Observation 2:** n256 is same as n65 and 0.5dB had been used for HD-FDD case in n65. **Proposal 1:** Agree to use 0.8 dB tightening for n254. **Proposal 2:** Agree to use 0.5 dB tightening for n256. **Observation 3:** Changing PC3 level for HD-FDD in NTN context is not a good approach. **Observation 4:** Better approach would be via introduction of a new power class. **Observation 5:** Another approach to improve the uplink link budget would be via reduced MPR for HD-FDD in NTN case. **Proposal 3:** PC3 power level should be the same in NTN and TN context. |
| R4-2411862 | ZTE Corporation, Sanechips | **Proposal 1:** Considering RF front-end implementation is expected to be the same for band n255 and n24, HD-FDD RedCap REFSENS for band n255 should align with n24 instead of 0.5dB tighter than n24. **Proposal 2:** PC3 power level is the same for non-RedCap NR NTN UE and (e)RedCap NR NTN UE. |
| R4-2412081 | vivo | **Proposal 1:** The 2Rx REFSENS for FR1-NTN HD-FDD bands are proposed:   | Operating Band | SCS kHz | 5  MHz (dBm) | 10  MHz (dBm) | 15  MHz (dBm) | 20  MHz (dBm) | | --- | --- | --- | --- | --- | --- | |  | 15 | -100.0 | -96.8 | -95.0 | -94.3 | | n256 | 30 |  | -97.1 | -95.1 | -94.5 | |  | 60 |  | -97.5 | -95.4 | -94.7 | |  | 15 | -100.0 | -96.8 | -95.0 | -93.8 | | n255 | 30 |  | -97.1 | -95.1 | -94.0 | |  | 60 |  | -97.5 | -95.4 | -94.2 | |  | 15 | -100.0 | -96.8 | -95.0 |  | | n254 | 30 |  | -97.1 | -95.1 |  | |  | 60 |  | -97.5 | -95.4 |  |   **Proposal 2:** The 1Rx REFSENS for FR1-NTN HD-FDD bands are proposed:   | Operating Band | SCS kHz | 5  MHz (dBm) | 10  MHz (dBm) | 15  MHz (dBm) | 20  MHz (dBm) | | --- | --- | --- | --- | --- | --- | |  | 15 | -97.5 | -94.3 | -92.5 | -91.8 | | n256 | 30 |  | -94.6 | -92.6 | -92.0 | |  | 60 |  | -95.0 | -92.9 | -92.2 | |  | 15 | --97.5 | -94.3 | -92.5 | -91.3 | | n255 | 30 |  | -94.6 | -92.6 | -91.5 | |  | 60 |  | -95.0 | -92.9 | -91.7 | |  | 15 | -97.5 | -94.3 | -92.5 |  | | n254 | 30 |  | -94.6 | -92.6 |  | |  | 60 |  | -95.0 | -92.9 |  |   **Proposal 3：**Not to consider increase in PC3 power level for NTN (e)RedCap UE which only supports HD-FDD operation. |
| R4-2412607 | Samsung | **Proposal 1:** Propose to have 0.5 dB tightening for n254 and n256, and 0dB for n255. |
| R4-2412953 | Huawei, HiSilicon | **Observation 1:** RAN4 has agreed that the power class for full duplex FDD NR NTN RedCap UE is PC3.  **Proposal 1:** RAN4 can discuss whether to increase the power class 3 level for NR NTN HD-FDD RedCap UE, considering the following three kinds of implementation. Implementation 1: To reuse the current Tx-Rx duplexer for HD-FDD band. Implementation 2: To separate the Tx filter and Rx filter for HD-FDD band. The insertion loss could be reduced 0.5~1dB Implementation 3: No Tx filter for HD-FDD band, so the insertion loss could be reduced more than 1dB.  **Proposal 2:** It’s preferred to use suffix letter “A” for NR NTN RedCap UE feature. It’s better to distinguish sub-clause for FR1-NTN and FR2-NTN in clause 4.3. And the power class clarification for NR NTN RedCap UE is needed as what we did for TN RedCap UE. |
| R4-2412983 | Ericsson | **Proposal-1:** 0.5 dB tightening for n256 for NTN RedCap operating at HD-FDD mode based on the generic requirement of the REFSENS of the n256 operating at FD-FDD mode.  **Proposal-2:**Consider the 0.5 dB tightening for the n255.  **Proposal-3:**Use the same suffix with suffix for RedCap in TS 38.101-1. |
| R4-2413142 | Qualcomm Incorporated | draftCR to introduce RedCap and eRedCap to TS 38.101-5 |

## Open issues summary

*Open issues and candidate options before meeting:*

### Issue 1-1: PC3 output power for HD-FDD (e)RedCap

**Background:** In previous meeting there was a proposal to consider increased output power level for HD-FDD operation considering that insertion loss may be reduced due to simpler front-end design compared to FD-FDD. WF agreed in R4-2410574 set higher output power as further option to discuss.

* Proposals
  + Option 1: 23 dBm, i.e. PC3 power level is the same for non-RedCap NR NTN UE and (e)RedCap NR NTN UE. (Spreadtrum, Sony, Xiaomi, Nokia, ZTE, Qualcomm)
  + Option 2: Increased output power
    - Up to 0.8 dB increased transmit power either by increasing nominal power level or upper tolerance (MediaTek)
    - Consider different filter implementation options and discuss further whether to increase PC3 power level (Huawei)
  + Option 3: For NR NTN (e)RedCap UE maximum output power, wait for the completion of PC2 for NR NTN UE and PC2 for RedCap UE TDD bands before the introduction of HPUE. (Apple)
* Recommended WF
  + Option 1 and Option 3: Agree 23 dBm for nominal PC3 output power and consider higher power classes for NTN (e)RedCap after NTN HPUE and TN PC2 RedCap work have completed.

### Issue 1-2: HD-FDD refsens for 2 Rx

**Background:** 2Rx FD-FDD Refsens for (e)RedCap UE has been agreed to re-use non-RedCap NTN UE Refsens.

In previous meeting [0.5] dB tightening compared to 2Rx FD-FDD was for 2Rx HD-FDD for bands n254 and n256, FFS for n255. Delta between 2Rx and 1Rx for HD-FDD has been agreed as 2.5 dB.

Also in previous meeting there was a maintenance correction to n256 refsens (R4-2408787).

* Proposals
  + n254:
    - 0.5 dB tightening (Apple, Sony, Xiaomi, ZTE, Vivo Samsung, Ericsson, Qualcomm, Mediatek)
    - 0.8 dB tightening (Nokia)
  + n255
    - no change (Apple, Spreadtrum, Sony, Xiaomi, ZTE, Vivo, Samsung, Qualcomm)
    - 0.2 dB tightening (Mediatek)
    - 0.5 dB tightening (Ericsson)
  + n256
    - 0.5 dB tightening (Apple, Spreadtrum, Sony, Xiaomi, ZTE, Vivo, Samsung, Ericsson, Qualcomm, Nokia)
    - 0.6 dB tightening (Mediatek)
* Recommended WF
  + n254: 0.5 dB tightening
  + n255: no change
  + n256: 0.5 dB tightening

final values shown in table below

| Operating Band | SCS  (kHz) | 5 MHz (dBm) | 10 MHz (dBm) | 15 MHz (dBm) | 20 MHz (dBm) |
| --- | --- | --- | --- | --- | --- |
|  | 15 | -100.0 | -96.8 | -95.0 | -93.8 |
| n256 | 30 |  | -97.1 | -95.1 | -94.0 |
|  | 60 |  | -97.5 | -95.4 | -94.2 |
|  | 15 | -100.0 | -96.8 | -95.0 | -93.8 |
| n255 | 30 |  | -97.1 | -95.1 | -94.0 |
|  | 60 |  | -97.5 | -95.4 | -94.2 |
|  | 15 | -100.0 | -96.8 | -95.0 |  |
| n254 | 30 |  | -97.1 | -95.1 |  |
|  | 60 |  | -97.5 | -95.4 |  |

### Issue 1-3: Frequency error

**Background:** In previous meeting frequency error requirement correction proposal was agreed to be common between non-RedCap and (e)RedCap and discuss that in maintenance thread. At the same time it was agreed to further discuss to consider existing NR NTN UE frequency error requirement to apply for (e)RedCap

* Proposals
  + Option 1: The NR NTN UE frequency error requirements are reused for NTN (e)RedCap UE. (CATT)
* Recommended WF
  + Option 1

### Issue 1-4: Simultaneuous operation with GNSS

**Background:** WID has a note: ”GNSS (Global Navigation Satellite Systems) capabilities and simultaneous GNSS and NR-NTN operation is supported in RedCap/eRedCap UE.”

Moderator’s understanding based on discussion to RAN1 and plenary delegates is that the intention of the note is to state that NTN (e)RedCap operates under the same GNSS support assumption as non-RedCap NR NTN UE. For IoT NTN simultaneous GNSS operation is not expected.

* Proposals
  + Option 1: RAN4 shall further study the impact if GNSS can’t operate simultaneously with NR NTN (Sony)
* Recommended WF
  + If option 1 is agreed, it needs to be clarified whether discussion is under maintenance or this WI, given that the issue is common to NR NTN and not specific to RedCap

### Issue 1-5: Specification updates

**Background:** In previous meeting it was agreed to take draft CR R4-2408816 as starting point for specification structure for introduction of (e)RedCAp, while requirement values itself can be updated and based on agreements in other issues and companies proposals. Suffix letter was left as FFS.

Before this meeting moderator discussed with TN specification rapporteur, who preferred to align RedCap suffix with TN and NTN

* Proposals
  + Option 1: Capture any further agreement in this meeting to R4-2413142 and aim to endorse it on 2nd round
    - Option 1a: Change RedCap suffix from I to A for for NTN (Huawei, CATT)
    - Option 1b: RedCap suffix for NTN is aligned with TN and kept as I (Qualcomm, Ericsson)
* Recommended WF
  + Option 1b

# Topic #2: Other requirements

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| R4-2412981 | Ericsson | **Observation 1** The CFO impairment has impact on the OCC performance in inter-slot OCC scheme. **Observation 2** Inter-slot OCC scheme is relevant to RAN4 RF discussion. **Observation 3** UE should maintain the same CFO during the OCC transmission so the OCC performance gain could be achieved. **Proposal-1**:Wait RAN1 reach conclusions on OCC feature before RAN4 start to evaluate the RF impact. |
| R4-2413141 | Qualcomm Incorporated | **Proposal 1:** RAN4 needs to evaluate whether there is any requirement impact from the orthogonal cover code (OCC) schemes.  **Proposal 2:** There is no UE RF requirement impact from symbol- or slot-level OCC schemes. **Observation 1:** Waveform from pre-DFT-s OCC-scheme is similar to PUCCH format 4, and therefore specification impact is expected to be minor, if any at all. **Observation 2:** UE can meet SEM mask with MPR specified in TS 38.101-5 with 3-subcarrier and 6-subcarrier comb-transmissions at worst position at outer edge of RF channel (RB#0) |

## Open issues summary

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

### Issue 2-1: UL capacity enhancements

**Background:** RAN4 has not yet had proper discussion on the UL capacity enhancements. RAN1 has reached preliminary agreements on which orthogonal cover code (OCC) schemes are considered, but it is not yet clear if all of those will be specified or if there is going to be further changes in RAN1.

* Proposals
  + Option 1: Wait RAN1 reach conclusions on OCC feature before RAN4 start to evaluate the RF impact. (Ericsson)
    - Potential impact identified on frequency error identified for inter-slot OCC scheme
  + Option 2: RAN4 needs to evaluate whether there is any requirement impact from the orthogonal cover code (OCC) schemes. (Qualcomm)
    - No impact from inter-symbol and inter-slot OCC schemes
    - SEM mask can be met with pre-DFT comb OCC scheme
* Recommended WF
  + Confirm no impact from inter-symbol OCC