**3GPP TSG RAN Meeting #103 RP-240720**

**Maastricht, Netherlands, March 18-21, 2024**

**Source: RAN4 chair (Huawei)**

**Title: New WID: UE RF enhancements for NR FR1 and FR2, Phase 4**

**Document for: Approval**

**Agenda Item: 9.1.4.1**

3GPP™ Work Item Description

Information on Work Items can be found at <http://www.3gpp.org/Work-Items>
See also the [3GPP Working Procedures](http://www.3gpp.org/specifications-groups/working-procedures), article 39 and the TSG Working Methods in [3GPP TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm)

Title: UE RF enhancements for NR FR1 and FR2, Phase 4

Acronym: NR\_ENDC\_RF\_Ph4

Unique identifier:

NOTE: For new WIs/SIs leave the Unique identifier empty and make a proposal for an Acronym.

 For a revised WI/SI: Take Unique identifier and acronym as shown in 3GPP workplan.

 If this is a RAN WID including Core and Perf. part, then Title, Acronym and Unique identifier refer to the feature WI.

 Please tick (X) the applicable box(es) in the table below:

 Either:

|  |  |
| --- | --- |
| **This WID includes a Core part** | **X** |
| **This WID includes a Performance part** | **X** |

 or:

|  |  |
| --- | --- |
| **This WID includes a Testing part** |  |
| **and it addresses the following 3GPP work area:** | **Radio Access** |  |
| **Core Network** |  |
| **Services** |  |

Potential target Release: *{Rel-19}*

# 1 Impacts

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **Affects:** | UICC apps | ME | AN | CN | Others (specify) |
| **Yes** |  | X |  |  |  |
| **No** | X |  | X | X |  |
| **Don't know** |  |  |  |  |  |

# 2 Classification of the Work Item and linked work items

### 2.1 Primary classification

This description is a

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| Normative Work Item:*tick applicable boxes below* |
|  | Stage 1 |
|  | Stage 2 |
| X | Stage 3 |
|  | Other (e.g. testing) |

### 2.2 Parent Work Item

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| Parent Work / Study Items  |
| Acronym | Working Group | Unique ID | Title (as in 3GPP Work Plan) |
|  |  |  |  |

NOTE: RAN agreed some time ago, that it describes the feature WI + Core/Perf. part WI or Testing part WI in one WID. Therefore the table above should include the feature WI data (In case the feature covers Core and Perf. part, please list under Working Group the leading WG of the Core part).

### 2.3 Other related Work Items and dependencies

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| Other related Work/Study Items (if any) |
| **Acronym** | Unique ID | Title | Nature of relationship |
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|  |  |  |  |

# 3 Justification

This work item targets at the UE RF requirement enhancements for the deployment using both NR frequency range 1 (FR1) and frequency range 2 (FR2). The following working areas are included.

* High power UE (HPUE) for CA in terrestrial network (TN) (including 3Tx)
* Power boosting and/or MPR reduction
* 6 Rx for handheld and FWA UE

**High power UE (HPUE) for CA in terrestrial network (TN)**

This area is made up of two parts: power class 1.5 (PC1.5 29dBm) for band combinations, and general framework to define the high power classes for band combinations.

Firstly, the power class 2 (PC2 26dBm) for the band combinations with uplink (UL) carrier aggregation (CA)/dual connectivity (DC) or EUTRA-NR dual connectivity (EN-DC) were introduced in Rel-17 and Rel-18, and the PC1.5 for the band combinations with one uplink carrier (on TDD band) was introduced in Rel-18.

Given that the uplink coverage is crucial for 5G and 5G-adavanced rolling-out, operators show wide interests in the higher maximum output power, i.e., PC1.5, for their band combinations. Besides, the introduction of 3Tx for inter-band UL CA in Rel-18, which is limited to a number of power configurations in Rel-18, provides another direction to further enhance the transmission power for the band combinations.

In detail, although the band combinations for NR PC1.5 intra-band contiguous/non-contiguous UL band combinations have already been widely proposed by operators in Rel-18, the related work was postponed because the new common requirements are needed and there was lack of TU. Besides, in Rel-18 PC1.5 is only supported on one UL carrier of downlink (DL) band combinations. Many proposals to add PC1.5 for inter-band UL CA or DC were observed.

The baseline of band combinations propose is based on the 2Tx capable UE assumption. The UE architecture with 3Tx across 2 bands would be beneficial to further boost the uplink transmission power for band combinations compared to 2Tx. Moreover, 3Tx across 2 bands was introduced for non-handheld devices only in Rel-18, which enables uplink MIMO (UL-MIMO) together with UL CA/DC. It would be valuable to extend 3Tx across 2 bands to handheld devices.

Secondly, the feature of increasing high power limit was introduced since Rel-17. After Rel-18, now it can only support the cases of one FDD UL carrier with PC3 plus one TDD UL carrier with PC2, and one FDD UL carrier with PC3 plus one UL carrier with PC5. The current specification structure is to define the total maximum output power over the whole band combination. Under that structure, the different power class combinations should be introduced separately for a given power class of band combination, which is the sum of component UL CC powers. Such approach causes the inefficiency and high workload or delay to introduce the band combinations with high power.

Besides, with the introduction of 3Tx across 2 bands, the additional dimension for consideration appears. In the future, the combinations of bands, power classes and transmit antenna (Tx) numbers might need be considered. So in order to optimize the standardization of high power band combinations, the general framework of supporting increasing UE power limit would be needed.

**Power boosting and/or MPR reduction**

This area is made up of two parts: power boosting or MPR reduction for single carrier for PC2 and power class 3 (PC3), and MPR reduction for intra-band UL CA configurations.

Firstly, in the Rel-18 coverage enhancement WI, the power boosting and/or MPR reduction for PC2 and PC3 with QPSK were specified, which is mainly for the inner region of a single UL carrier. The further power enhancement is restricted by out-of-band emission requirements, e.g., ACLR requirement. It is observed that emission requirements could be relaxed under the conditions where no co-existence issue is caused especially for the deployment of two adjacent frequency blocks. Thus there is additional room to enhance the Tx power further.

The UL coverage enhancement is one of key enablers for 5G-advanced. Except for the above area of UL CA/DC with PC1.5, another enhancement direction is to further increase the Tx power for PC2 and PC3 for the single carrier transmission, which have been and will be widely used in the future. And it is reasonable that both RedCap and non-RedCap UE should be taken into account.

Secondly, it was observed that a large margin exists between the current MPR requirements and the measured power back-off for intra-band CA for both FR1 and FR2. The MPR is defined mainly based on the configuration of band combination rather than based on the active UL CCs scheduled. The transmission power capability for UL CA or DC is not fully utilized compared to the single CC transmission. So it is proposed to revisit and improve the MPR definition for the NR intra-band UL CA or DC.

Particularly, the current MPR for intra-band non-contiguous UL CA is defined based on the assumption of single PA and that one Tx branch can support the non-contiguous frequency blocks with separation less than 100MHz. Under such condition, the applied MPR value is larger than that of corresponding non-CA case, which would significantly reduce the coverage for intra-band non-contiguous UL CA.

**6Rx for handheld and FWA UE**

In Rel-18 8Rx requirements were specified for fixed wireless access (FWA) type of devices. 6Rx was also proposed and discussed for handheld UE at the beginning of Rel-18, but deprioritized.

In Rel-19, enabling 6Rx for handheld UE would be possible and useful to improve DL coverage and throughputs for the large size handheld UE, e.g., the foldable smartphone, which would have room to accommodate more receiver antennas (Rx). Depending on the device size, it would be possible to implement 6Rx with the low isolation and thus low correlation between Rx. Higher order diversity can bring throughput and/or performance gain in various scenarios. Many operators show the interests in it.

Besides, the SRS antenna switching requirement need be specified to support DL massive MIMO well. In addition, it is observed that the poor SRS accuracy and variability would degrade the reciprocity-based DL MIMO performance due to poor DL CSI estimation. The root reason is that the actual SRS output power per SRS port(s) is unknown, since the non-reciprocal insertion losses in the signal path(s) are unknown. The problem exists for 6Rx as well as 4Rx and 8Rx.

Based on the above justifications, the following objectives are proposed to address the corresponding issues and/or meet the critical demands of the 5G and 5G-advanced deployment in Rel-19.

# 4 Objective

### 4.1 Objective of Core part WI

The objectives of core part for UE RF enhancements for NR FR1 and FR2 Phase 4 include:

**High power UE (HPUE) for CA in terrestrial network (TN)**

* Specify the generic requirements of high power UE (HPUE) for NR uplink (UL) CA in FR1 and EN-DC with NR FR1 bands
	+ Power class 1.5 (PC1.5) UE for NR TDD intra-band UL contiguous and non-contiguous CA with 2Tx
		- Specify the requirements for intra-band UL contiguous CA with or without UL-MIMO
			* Example band combinations:
				+ CA\_n41C, CA\_n78C, CA\_n77C, CA\_n79C for intra-band uplink contiguous CA configurations
			* Focus on the maximum output power (MOP), MPR/A-MPR requirements, SAR solution
		- Specify the requirements for intra-band UL non-contiguous CA without UL-MIMO
			* Example band combinations:
				+ CA\_n78(2A), CA\_n77(2A) for intra-band uplink non-contiguous CA configurations
			* Focus on the maximum output power (MOP), MPR/A-MPR requirements, SAR solution
		- NOTE: leave the other band combination specific requirements to the corresponding Rel-19 basket WIs
	+ PC1.5 UE for two band NR inter-band uplink CA with 2Tx and/or 3Tx for handheld and FWA, and PC1.5 and PC2 for two band EN-DC with 2Tx and/or 3Tx for handheld and FWA
		- Focus on the SAR solution
		- Enable power class 2 (PC2) and PC1.5 of two band inter-band uplink CA and EN-DC with 3Tx for handheld UE
			* Identify and update the requirements if necessary
		- Only PC3 is considered for LTE FDD in EN-DC
		- NOTE: leave the band combination specific requirements, e.g., MSD to the corresponding Rel-19 basket WIs
	+ Investigate and if feasible, support increasing UE transmission power limit up to the sum of maximum output power per band for NR inter-band uplink CA and EN-DC HPUE with the different existing power classes which have already been specified
	+ Introduce the signaling to support the above objectives, if needed.
	+ Consider release independency, if needed

**Power boosting and/or MPR reduction**

* Specify power domain enhancement, e.g., MPR reduction for NR single carrier and NR intra-band UL CA
	+ Study the scenarios, and if feasible, specify the power domain enhancement, e.g., MPR reduction, for PC2 and PC3 with applicable ACLR/SEM/spurious emission modification with BS indication for NR FR1 on a single UL carrier
		- Include the following scenarios:
			* when there is no adjacent in-band/out-of-band co-existence issue
			* when a UE uses a narrower channel bandwidth within a wider BS bandwidth
		- Include both (e)RedCap UE (only PC3) and non-RedCap UE
		- Limited to QSPK and 16QAM
	+ Specify MPR applicability based on the UL CCs with activated cells for NR intra-band UL CA configuration
		- Include both intra-band UL contiguous CA and intra-band non-contiguous UL CA for FR1
		- Include intra-band UL contiguous CA and intra-band DL contiguous CA with single UL for FR2
		- MPR requirement is not applicable until the SCell is activated
	+ Necessary signaling to support the above objectives

**6Rx for handheld and FWA UE**

* Specify the core requirements to enable 6Rx for higher frequency bands (>2.5GHz) targeting at support of handheld UE for NR FR1 single carrier scenario
	+ Example bands: n41, n77/n78, n79, n104
	+ Support 4 MIMO layers at least, and study the gain and feasibility and if feasible, support 6 MIMO layers
	+ Specify the Rx requirements including reference sensitivity requirements for support 6Rx
		- Note: the specified requirements can be applicable to both handheld UE and FWA devices
	+ Specify the requirements to support SRS antenna switching including t1r6, t2r6, t3r6, t4r6 depending on UE capability
	+ Study the issue of insertion loss imbalance across SRS ports, and if justified, specify the corresponding solution.

**General for all the areas**

* Specify release independence requirements for the core part in TS 38.307/36.307, if needed and feasible.

### 4.2 Objective of Performance part WI

NOTE: Leave empty if the WI proposal does not contain a RAN performance part.

The objectives of performance part for UE RF enhancements for NR FR1 and FR2 Phase 4 include:

**6Rx for handheld and FWA UE**

* Specify the performance requirements to enable 6Rx on higher frequency bands (>2.5GHz) targeting at support of smartphone for NR FR1 single carrier scenario
	+ Investigate and if necessary, specify RLM test cases to support 6Rx
	+ Specify UE PDSCH demodulation performance and CSI requirements to support 6 Rx
		- Support 4 MIMO layers at least, and follow the conclusion in core part for whether to support 6 MIMO layers
	+ Specify the SDR requirements to support 6Rx

**General for all the areas**

* Specify release independence requirements for performance part in TS 38.307/36.307, if needed and feasible.

### 4.3 RAN time budget request (not applicable to RAN5 WIs/SIs)

NOTE: For all new RAN related WIs/SIs which are not led by RAN WG5 the WI/SI rapporteur has to fill out the attached Excel table to request time budgets for corresponding RAN WG meetings.
The Excel table has to be filled out for all affected RAN WGs and up to the target date of the WI/SI.
One time unit (TU) corresponds to ~ 2 hours in the meeting.
If no TU is needed, then leave the field empty otherwise enter a number >0 in the field.

 For revisions of already approved WI/SI descriptions: Please remove the Excel table from the WID/SID's zip file. The time budgets are already recorded. If you want to modify them, then this has to be done via the status report and not via a revised WID/SID.

 If this WID is covering Core and Performance part, then please fill out one line for each part in the attached Excel table.

**additional comments to the time budget request in the attached Excel table:**

# 5 Expected Output and Time scale

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| **New specifications** *{One line per specification. Create/delete lines as needed}* |
| Type  | TS/TR number | Title | For info at TSG#  | For approval at TSG# | Remarks |
|  |  |  |  |  |  |

NOTE: If this is a RAN WI including Core and Perf. part, then all new Core part specs have to be listed first and then all new Perf. part specs. Indicate "Core part" or "Perf. part" under Remarks for each spec.
By default a new specs can only be new for one of both parts.

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| **Impacted existing TS/TR** *{One line per specification. Create/delete lines as needed}* |
| TS/TR No. | Description of change  | Target completion plenary# | Remarks |
| 38.101-1 | Specify UE RF core requirements | #109 | Core part |
| 38.101-3 | Specify UE RF core requirements related to EN-DC | #109 | Core part |
| 38.307 | Specify release independence | #110 | Perf. part |
| 38.101-4 | Specify UE demodulation performance and CSI requirements for >4Rx | #110 | Perf. part |
| 38.133 | Add RRM core requirements if needed | #109 | Core part |
| 38.133 | Add RRM performance requirements if needed | #110 | Perf. part |
| 38.306 | Add impacts on 38.306 User Equipment (UE) radio access capabilities, if needed | #109 | Core part |
| 38.331 | Specify the necessary signalling or capability to support the features | #109 | Core part |
| 38.307 | Release independency requirements | #111 | Perf. part |

NOTE: If this is a RAN WI including Core and Perf. part, then all new Core part specs have to be listed first and then all new Perf. part specs. Indicate "Core part" or "Perf. part" under Remarks for each spec.
If an existing spec is affected by both (Core part and Perf. part), then it has to be listed twice with appropriate approval dates.

# 6 Work item Rapporteur(s)

xxx, company, email, task

NOTE: The first listed Rapporteur has the overall responsibility for this WI (incl all secondary tasks).

# 7 Work item leadership

RAN WG4

# 8 Aspects that involve other WGs

NOTE: For RAN WIs: Section 8 applies only toWGs outside of TSG RAN because all RAN WG aspects have to be covered in section 4.

# 9 Supporting Individual Members

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| Supporting IM name |
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