**3GPP TSG-RAN WG4 Meeting#102-e *REV\_R4-2204611***

**Electronic meeting, 21 February – 3 March 2022**

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| *CR-Form-v12.2* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
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|  | **38.101-2** | **CR** | **CRNum** | **rev** | **1** | **Current version:** | **17.4.0** |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network |  | Core Network |  |

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| ***Title:*** | Introduction of power limits for serving cells of UL CA | | | | | | | | | |
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| ***Source to WG:*** | Ericsson | | | | | | | | | |
| ***Source to TSG:*** | R4 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_RF\_FR1-Core | | | | |  | ***Date:*** | | | 2022-02-21 |
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| ***Category:*** | **F** |  | | | | | ***Release:*** | | | Rel-17 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)* | |
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| ***Reason for change:*** | | Prevent excessive power scaling of secondary cells by applying power offset (attenuation) on uplink serving cells. The limit is relative to the actual configured power PCMAX,f,c for a serving cell *c*. An absolute limit is not feasible for two reasons:  1. for FR2 the PCMAX governing the power prioritization for CA is specified in a plane of reference that is implementation specific (the same plane of reference as the measured/reported RSRP)  2. notwithstanding item 1, an absolute limit would have no effect if the applied power reduction (up to MPR) on the total signal (the same as the MPR on each serving cell) is larger.  Example: setting a relative limit (attenuation) of 3 dB on the primary cell in the case of two uplink serving cell would leave the remaining power to the secondary cell regardless of the MPR appplied (‘equal PSD’ ideally). Setting a limit of 3 dB on both the primary and secondary cell would prevent any scaling or dropping (the UE not power limited)  The relative limit is feasible from an implementation standpoint: it is similar to the relative power boosting DPIBE but without the problem of a possible violation of the unwanted emission requirements or EVM since the power is decreased.  The relative limits should be activated/deactivated or modified by a MAC-CE to allow fast adaptation to changing radio conditions. Limits should apply if transmissions in a slot for serving cell c is not overlapping with transmissions on any slot of another serving cell of the CA configuration (reduces the need for MAC-CE signaling). | | | | | | | | |
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| ***Summary of change:*** | | Clause 6.2.4: a limit PCMAX,f,c relative to the configured maximum output power for each serving cell is introduced. The lower bound of PUMAX,f,c and the upper bound of PTMAX,f,c are decreased accordingly (the upper bound of the PUMAX,f,c is a regulatory limit)  When limits are not configured by the MAC-CE (tentatively denoted ‘Serving Cell Maximum Power MAC CE’) then PCMAX,f,c = 0 dB. Only relative limits are indicated for FR2 (but the upper abolute limit of TRP also reduced as a consequence).  If the PCMAX,f,c is indicated by the MAC-CE then the UE shall reduce the actual *configured* power PCMAX,f,c by PCMAX,f,c such that the *measured* total radiated power PUMAX,f,c and the measured TRP PTMAX,f,c are decreased by the same amount and are within the respective (absolute) bounds. The PH Type 1 for carrier *c* shall be decreased accordingly for a given fixed PRB allocation (and the reported PCMAX,f,c modified).  Clause 6.2A.4: first it is specified that for intra-band carrier aggregation, the total PCMAX ≥ PCMAX,f,c for each configured serving cell c with PCMAX,f,c as specified in clause 6.2.4 but with the MPRc and A-MPRc for each serving cell the same as the total MPR and A-MPR, respectively. Equality between PCMAX and PCMAX,f,c is consistent with standard practice for intra-band CA in FR1 and means that the PHR for each cell conveys the total MPR. PCMAX ≥ PCMAX,f,c allows for power reduction by the relative limits and flexibility in view of the implementation-specific plane of references for the configured power.  The lower bound of the total measured power PUMAX is modified by the sum of the attenuations PCMAX,f,c on all serving cells c, denoted DPUMAX  ,0)  In practice this reduction is only needed for large PCMAX,f,c such that DPUMAX > 0 dB and the total maximum configured power PCMAX (above which power prioritization occurs) cannot be attained. Remark that the PCMAX *configured* is unchanged, only the lower limit of the *measured* power PUMAX is modified.  An additional requirement verifying that secondary cells are not dropped is added: when PCMAX,f,c = 3.1 dB on each serving cell c, the UE shall meet the requirement on the measured total peak PUMAX with non-zero output power on both uplink serving cells regardless of transmission priority. If PCMAX = PCMAX,f,c before application of the relative limits, PCMAX,f,c = 3.1 dB implies “equal power/PSD” for the two cells but is not necessarily measured due to inaccuracy (3.1 dB used since 3 dB slightly exceeds 1/2 in linear scale). | | | | | | | | |
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| ***Consequences if not approved:*** | | Dropping or large power scaling of secondary cells or excessive power scaling of lower-priority transmissions would occur in the field as already observed in conformance testing. | | | | | | | | |
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| ***Clauses affected:*** | | 6.2.4, 6.2A.4 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | |  | **X** | Other core specifications | | | |  | | |
| ***affected:*** | |  | **X** | Test specifications | | | | . | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | |  | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
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| ***This CR's revision history:*** | | r1: the verification/measurement of the relative limits per cell in 6.2.4 removed. This is replaced by a requirement that the PH type 1 report shall be modified (decreased) when a relative power limit is applied to the Pcmax,f,c.  The definition of the power offset is clarified further. | | | | | | | | |

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*< start of changes >*

### 6.2.4 Configured transmitted power

The UE can configure its maximum output power. The configured UE maximum output power PCMAX,f,c for carrier f of a serving cell c is defined as that available to the reference point of a given transmitter branch that corresponds to the reference point of the higher-layer filtered RSRP measurement as specified in TS 38.215 [11].

The configured UE maximum output power PCMAX,f,c for carrier *f* of a serving cell *c* shall be set such that the corresponding measured peak EIRP PUMAX,f,c is within the following bounds

PPowerclass + DPIBE – MAX(MAX(MPRf,c, A- MPRf,c,) + ΔMBP,n, P-MPRf,c) – DPCMAX,f,c – MAX{T(MAX(MPRf,c, A- MPRf,c,) + DPCMAX,f,c), T(P-MPRf,c)} ≤ PUMAX,f,c ≤ EIRPmax

while the corresponding measured total radiated power PTMAX,f,c is bounded by

PTMAX,f,c ≤ TRPmax – DPCMAX,f,c

with

- PPowerclass the UE power class as specified in sub-clause 6.2.1;

- EIRPmax the applicable maximum EIRP as specified in sub-clause 6.2.1;

- MPRf,c as specified in sub-clause 6.2.2;

- A-MPRf,c as specified in sub-clause 6.2.3;

- ΔMBP,n the peak EIRP relaxation as specified in clause 6.2.1;

- TRPmax the maximum TRP for the UE power class as specified in sub-clause 6.2.1;

- DPIBE is 1.0 dB if UE declares support for *mpr-PowerBoost-FR2-r16*, UL transmission is QPSK, MPRf,c = 0 and when NS\_200 applies and the network configures the UE to operate with *mpr-PowerBoost-FR2-r16,* otherwise DPIBE is 0.0 dB;

- DPCMAX,f,c ≥ 0 is the power offset (attenuation) of the configured UE maximum output power PCMAX,f,c with values in dB, activated and configured by the [Serving Cell Configured Power MAC CE]; ΔPCMAX,f,c = 0 dB if ΔPCMAX,f,c is [deactivated] by the [Serving Cell Maximum Power MAC CE] or when carrier *f* of serving cell *c* is part of a CA configuration and transmissions in a slot for this serving cell are not overlapping with transmissions on a slot of any other serving cell of the same CA configuration.

The requirement is verified in beam peak direction.

When DPCMAX,f,c > 0 dB for carrier *f* of serving cell *c* part of a CA configuration and transmissions in a slot on this serving cell are overlapping with transmissions on a slot of another active serving cell of the same CA configuration, the UE shall apply the power offset DPCMAX,f,c to the PCMAX,f,c such that the PUMAX,f,c and PTMAX,f,c are within their respective bounds specified above and such that the the Type 1 power headroom report computed by the UE for carrier *f* of serving cell *c* decreases by DPCMAX,f,c dB within the reporting resolution specified in [12] for a fixed resource allocation on this serving cell.

*maxUplinkDutyCycle-FR2,* as defined in TS 38.306 [14], is a UE capability to facilitate electromagnetic power density exposure requirements. This UE capability is applicable to all FR2 power classes.

If the field of UE capability *maxUplinkDutyCycle-FR2* is present and the percentage of uplink symbols transmitted within any 1 s evaluation period is larger than *maxUplinkDutyCycle-FR2*, the UE follows the uplink scheduling and can apply P-MPRf,c.

If the field of UE capability *maxUplinkDutyCycle-FR2* is absent, the compliance to electromagnetic power density exposure requirements are ensured by means of scaling down the power density or by other means.

P-MPRf,c is the power management maximum output power reduction. The UE shall apply P-MPRf,c for carrier f of serving cell c only for the cases described below. For UE conformance testing P-MPRf,c shall be 0 dB.

a) ensuring compliance with applicable electromagnetic power density exposure requirements and addressing unwanted emissions / self desense requirements in case of simultaneous transmissions on multiple RAT(s) for scenarios not in scope of 3GPP RAN specifications;

b) ensuring compliance with applicable electromagnetic power density exposure requirements in case of proximity detection is used to address such requirements that require a lower maximum output power.

NOTE 1: P-MPRf,c was introduced in the PCMAX,f,c equation such that the UE can report to the gNB the available maximum output transmit power. This information can be used by the gNB for scheduling decisions.

NOTE 2: P-MPRf,c and *maxUplinkDutyCycle-FR2* may impact the maximum uplink performance for the selected UL transmission path.

NOTE 3: MPE P-MPR Reporting, as defined in TS 38.306 [14], is an optional UE capability to report P-MPRf,c when the reporting conditions configured by gNB are met. This UE capability is applicable to all FR2 power classes.

The tolerance T(∆P) for applicable values of ∆P (values in dB) is specified in Table 6.2.4-1.

Table 6.2.4-1: PUMAX,f,c tolerance

|  |  |  |
| --- | --- | --- |
| Operating Band | ∆P (dB) | Tolerance T(∆P)  (dB) |
| n257, n258, n259, n260, n261, n262 | P = 0 | 0 |
|  | 0 < P ≤ 2 | 1.5 |
|  | 2 < P ≤ 3 | 2.0 |
|  | 3 < P ≤ 4 | 3.0 |
|  | 4 < P ≤ 5 | 4.0 |
|  | 5 < P ≤ 10 | 5.0 |
|  | 10 < P ≤ 15 | 7.0 |
|  | 15 < P ≤ X | 8.0 |
| NOTE: X is the value such that Pumax,f,c lower bound, PPowerclass - P – T(P) = minimum output power specified in clause 6.3.1 | | |

## 6.2A Transmitter power for CA

*< text omitted >*

### 6.2A.4 Configured transmitted power for CA

A UE configured with carrier aggregation can configure its maximum output power for each uplink activated serving cell *c* and its total configured maximum output power PCMAX. The definition of the configured UE maximum output power PCMAX,*f,c* for each carrier *f* of a serving cell *c* is used for power headroom reporting for carrier *f* of serving cell *c* only and is in accordance with that specified in clause 6.2.4 with parameters MPR, A-MPR and P-MPR replaced with those specified in subclause 6.2A.2, 6.2A.3 and 6.2.4, respectively. The UE maximum configured power PCMAX in a transmission occasion is determined by the UL grants for carriers *f* of all serving cells *c* with non-zero granted power in the respective reference point.

For uplink intra-band contiguous carrier aggregation, MPR is specified in clause 6.2A.2. PCMAX is calculated under the assumption that power spectral density for each RB in each component carrier is same.

For intra-band carrier aggregation, PCMAX ≥ PCMAX,f,c for each configured serving cell *c* with PCMAX,f,c as specified in clause 6.2.4 but with parameters MPR and A-MPR replaced with those specified in subclause 6.2A.2 and 6.2A.3, respectively.

The configured UE maximum output power PCMAX shall be set such that the corresponding measured total peak EIRP PUMAX is within the following bounds

PPowerclass – MAX(MAX(MPR, A-MPR) + ΔMBP,n, P-MPR) – DPUMAX – MAX{T(MAX(MPR, A-MPR) + DPUMAX),T(P-MPR)} ≤ PUMAX ≤ EIRPmax

with

- PPowerclass the peak EIRP as specified in sub-clause 6.2A.1;

- EIRPmax the applicable maximum EIRP as specified in sub-clause 6.2A.1;

- MPR as specified in sub-clause 6.2A.2;

- A-MPR as specified in sub-clause 6.2A.3;

- ΔMBP,n the peak EIRP relaxation as specified in clause 6.2.1;

- P-MPR the power management term for the UE as described in 6.2.4;

- ,0) is the relaxation of the measured power PUMAX taken over all configured uplink serving cells *c* with ΔPCMAX,f,c activated and configured by the [Serving Cell Maximum Power MAC CE] with the linear value of DPCMAX,f,c as specified in clause 6.2.4, DPUMAX = 0 dB otherwise.

The measured configured power PUMAX for carrier aggregation is defined as

where pUMAX,f,c is the linear value of the measured power PUMAX,f,c for carrier *f=f(c)* of serving cell *c*. The measured total radiated power PTMAX for carrier aggregation is defined as

where pTMAX,f,c is the linear value of the measured total radiated power PTMAX,f,c for carrier *f* = *f*(*c*) of serving cell *c*. The total radiated power PTMAX is bounded by

PTMAX ≤ TRPmax

where TRPmax the maximum TRP for the UE power class as specified in sub-clause 6.2A.1.

The following requirement applies for intra-band carrier aggregation with two configured uplink serving cells of equal channel bandwidth: when DPCMAX,f,c = 3.1 dB on carrier *f* of each serving cell *c*, the UE shall meet the requirement on the measured total peak EIRP PUMAX with non-zero output power on both uplink serving cells regardless of transmission priorities.

The tolerance T(ΔP) for applicable values of ΔP (values in dB) is specified in Table 6.2A.4-1.

Table 6.2A.4-1: PUMAX tolerance

|  |  |  |
| --- | --- | --- |
| Operating Band | ∆P (dB) | Tolerance T(∆P)  (dB) |
| n257, n258, n259, n260, n261, n262 | P = 0 | 0 |
|  | 0 < P ≤ 2 | 1.5 |
|  | 2 < P ≤ 3 | 2.0 |
|  | 3 < P ≤ 4 | 3.0 |
|  | 4 < P ≤ 5 | 4.0 |
|  | 5 < P ≤ 10 | 5.0 |
|  | 10 < P ≤ 15 | 7.0 |
|  | 15 < P ≤ X | 8.0 |
| NOTE: X is the value such that Pumax lower bound, PPowerclass - P – T(P) = minimum output power specified in clause 6.3A.1 | | |

## 6.2D Transmitter power for UL MIMO

*< end of changes >*