**3GPP TSG-RAN WG4 Meeting#102-e *REV\_R4-2204610***

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

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| *CR-Form-v12.2* |
| **CHANGE REQUEST** |
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|  | **38.101-1** | **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 |
|  |  |
| ***Source to WG:*** | Ericsson |
| ***Source to TSG:*** | R4 |
|  |  |
| ***Work item code:*** | NR\_RF\_FR1-Core |  | ***Date:*** | 2022-02-21 |
|  |  |  |  |  |
| ***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 canbe 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)* |
|  |  |
| ***Reason for change:*** | Prevent excessive power scaling of secondary cells *c* by applying power offset (attenuation) on uplink serving cells. The limit is either absolute or relative to the actual configured power PCMAX,f,c for a serving cell *c*. An absolute limit similar to the cell specific P-Max is not always feasible since this would have no effect on the PCMAX,f,c in case the configured power is already reduced by a power back-off up to MPRc.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 secaondary cell regardless of the MPR applied (‘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 MPR but without the problem of a possible violation of the unwanted emission requirements or EVM since the power is decreased. The absolute/relative limits should be activated/deactivated or modified by a MAC-CE to allow fast adaptation to changing radio conditions. The relative 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). If the limit is indicated as absolute, then only the bounds of the PCMAX,f,c are modified (reduced); if relative then the actual PCMAX,f,c should also be reduced.Changes are relevant for all types of uplink band combinations.  |
|  |  |
| ***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 (absolute) lower and upper bounds of PCMAX,f,c are decreased accordingly. This implies that the upper bound of the maximum power on a carrier is Ppowerlclass - PCMAX,f,c [dBm]where Ppowerlclass is the power class indicated for the NR band.When limits for serving cell c are not activated (or deactivated) by the MAC-CE (tentatively denoted ‘Serving Cell Maximum Power MAC CE’) then PCMAX,f,c = 0 dB.If the PCMAX,f,c is not indicated as [absolute] (i.e. relative) in the configuration by the MAC-CE then the UE *shall* reduce the actual configured power PCMAX,f,c by PCMAX,f,c such that the resulting P’CMAX,f,c = PCMAX,f,c - PCMAX,f,c is within the (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). If the PCMAX,f,c is indicated as [absolute], then only the bounds of PCMAX,f,c are modified imilar to a P-Max indication (the UE *may* still reduce the actual PCMAX,f,c).Clause 6.2A.4: the lower bound of the total measured power PUMAX is modified by the sum of the attenuations PCMAX,f,c for the configured 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 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.For intra-band UL CA (for which relative limit are most relevant), 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).  |
|  |  |
| ***Consequences if not approved:*** | Dropping or large power scaling of secondary cells or excessive power scaling would occur in the field as already observed in conformance testing. |
|  |  |
| ***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:*** |  |
|  |  |
| ***This CR's revision history:*** | r1: the verification/measurement of the relative limits in 6.2.4 removed and 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 and the cell is part of a CA configuration. The definition of the power offset is clarified further. |

*< start of changes >*

### 6.2.4 Configured transmitted power

The UE is allowed to set its configured maximum output power PCMAX,f,c for carrier f of serving cell c in each slot. The configured maximum output power PCMAX,f,c is set within the following bounds:

PCMAX\_L,f,c ≤ PCMAX,f,c ≤ PCMAX\_H,f,c with

 PCMAX\_L,f,c = MIN {PEMAX,c– ∆TC,c, (PPowerClass – ΔPPowerClass) – MAX(MAX(MPRc+∆MPRc, A-MPRc)+ ΔTIB,c + ∆TC,c +∆TRxSRS, P-MPRc) } – ΔPCMAX,f,c

PCMAX\_H,f,c = MIN {PEMAX,c, PPowerClass – ΔPPowerClass } – ΔPCMAX,f,c

where

 PEMAX,c is the value given by either the *p-Max* IE or the field *additionalPmax* of the *NR-NS-PmaxList IE*, whichever is applicable according to TS 38.331[7];

 PPowerClass is the maximum UE power specified in Table 6.2.1-1 without taking into account the tolerance specified in the Table 6.2.1-1;

 When the IE *powerBoostPi2BPSK* is set to 1, PEMAX,c is increased by +3 dB for a power class 3 capable UE operating in TDD bands n40, n41, n77, n78, and n79 with PI/2 BPSK modulation and UE indicates support for UE capability *powerBoosting-pi2BPSK* and 40% or less symbols in certain evaluation period are used for UL transmission when PEMAX,c ≥ 20 dBm (The exact evaluation period is no less than one radio frame).

 When the IE *powerBoostPi2BPSK* is set to 1, ΔPPowerClass = -3 dB for a power class 3 capable UE operating in TDD bands n40, n41, n77, n78, and n79 with Pi/2 BPSK modulation and UE indicates support for UE capability *powerBoosting-pi2BPSK* and 40% or less slots in radio frame are used for UL transmission.

 ΔPPowerClass =

- 3 dB for a power class 2 capable UE or 6 dB for a power class 1.5 UE when P-max of 23 dBm or lower is indicated; or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is absent and the field of UE capability *maxUplinkDutyCycle-MPE-FR1* is absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than 50%; or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is not absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than *maxUplinkDutyCycle-PC2-FR1* as defined in TS 38.306 (The exact evaluation period is no less than one radio frame); or when the field of UE capability *maxUplinkDutyCycle-MPE-FR1* is not absent and half the percentage of uplink symbols transmitted in a certain evaluation period is larger than *maxUplinkDutyCycle-MPE-FR1* as defined in TS 38.306 (The exact evaluation period is no less than one radio frame).

- 3 dB for a power class 1.5 capable UE when P-max of between 23 dBm and 26 dB is indicated; or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is absent and the field of UE capability *maxUplinkDutyCycle-MPE-FR1* is absent and the percentage of uplink symbols transmitted in a certain evaluation period is between 25% and 50%; or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is not absent and the percentage of uplink symbols transmitted in a certain evaluation period is between *maxUplinkDutyCycle-PC2-FR1* and *maxUplinkDutyCycle-PC2-FR1/2* as defined in TS 38.306 (The exact evaluation period is no less than one radio frame); or when the field of UE capability *maxUplinkDutyCycle-MPE-FR1* is not absent and the percentage of uplink symbols transmitted in a certain evaluation period is larger than *maxUplinkDutyCycle-MPE-FR1* as defined in TS 38.306 (The exact evaluation period is no less than one radio frame).

- 3dB when the UE is configured with SUL configurations and the requirements of default power class are applied as specified in sub-clause 6.2C.1 on the band where UE indicates power class 2;

- 0 dB otherwise;

ΔPCMAX,f,c 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 Maximum 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 on this serving cell are not overlapping with transmissions on a slot of any other active serving cell of the same CA configuration and ΔPCMAX,f,c is not configured as [absolute];

 ∆TIB,c is the additional tolerance for serving cell c as specified in clause 6.2A.4.2 for NR CA, clause 6.2C.2 for SUL, or TS 38.101-3 clause 6.2B.4.2 for EN-DC; ∆TIB,c = 0 dB otherwise; In case the UE supports more than one of band combinations for V2X operating bands for concurrent operation, CA, SUL or DC, and an operating band belongs to more than one band combinations then

a) When the operating band frequency range is ≤ 1 GHz, the applicable additional ∆TIB,c shall be the average value for all band combinations defined in clause 6.2A.4.2, 6.2C.2 in this specification and 6.2B.4.2 in TS 38.101-3 [3], truncated to one decimal place that apply for that operating band among the supported band combinations. In case there is a harmonic relation between low band UL and high band DL, then the maximum ∆TIB,c among the different supported band combinations involving such band shall be applied

b) When the operating band frequency range is > 1 GHz, the applicable additional ∆TIB,c shall be the maximum value for all band combinations defined in clause 6.2A.4.2, 6.2C.2 in this specification and 6.2B.4.2 in TS 38.101-3 [3] for the applicable operating bands.

 ∆TC,c = 1.5dB when NOTE 3 in Table 6.2.1-1 in 38.101-1 applies for a serving cell c, otherwise ∆TC,c = 0 dB ;

 MPRc and A-MPRc for serving cell c are specified in clause 6.2.2 and clause 6.2.3, respectively;

 ∆MPRc for serving cell c is specified in clause 6.2.2.

 ∆TRxSRS is applied during SRS transmission occasions with *usage* in *SRS-ResourceSet* set as ‘antennaSwitching’ when

a) UE transmits SRS on the second SRS resource in every configured SRS resource set when the *SRS-TxSwitch* capability is indicated as 't1r2'

b) UE transmits SRS on the second, third and fourth SRS resources of the total 4 SRS resources from all configured SRS resource set(s) consisting of one SRS port when the *SRS-TxSwitch* capability is indicated as 't1r4' or, 't1r4-t2r4'

c) UE transmits SRS from the second SRS port pair on the second SRS resource in every configured SRS resource set consisting of two SRS ports when the *SRS-TxSwitch* capabilityis indicated as' t2r4' or ' t1r4-t2r4', or

d) UE transmits SRS to a DL-only carrier

 The value of ∆TRxSRS is 4.5dB for bands whose FUL\_high is higher than the FUL\_low of n79 and 3 dB for bands whose FUL\_high is lower than the FUL\_low of n79 when the device is capable of power class 3 or power class 5 in the band, or when the device is capable of power class 2 in the band and ΔPPowerClass = 3 dB. The value of ∆TRxSRS is 7.5dB for bands whose FUL\_high is higher than the FUL\_low of n79 and 6 dB for bands whose FUL\_high is lower than the FUL\_low of n79 when the device is capable of power class 2 and 1.5 in the band and ΔPPowerClass = 0 dB.

For other SRS transmissions ∆TRxSRS is zero;

 P-MPRc is the power management maximum power reduction for

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

 The UE shall apply P-MPRc for serving cell c only for the above cases. For UE conducted conformance testing P-MPRc shall be 0 dB

NOTE 1: P-MPRc 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-MPRc may impact the maximum uplink performance for the selected UL transmission path.

When DPCMAX,f,c > 0 dB with DPCMAX,f,c not configured as [absolute] 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 reduce the PCMAX,f,c by the power offset DPCMAX,f,c such that the modified configured power P’CMAX,f,c  = PCMAX,f,c – DPCMAX,f,c is within the bounds specified above:

 PCMAX\_L,f,c ≤ P’CMAX,f,c ≤ PCMAX\_H,f,c

and such that 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 [13] for a fixed resource allocation on this serving cell.

TREF and Teval are specified in Table 6.2.4-1. For each TREF, the PCMAX,L,c for serving cell c are evaluated per Teval and given by the minimum value taken over the transmission(s) within the Teval; the minimum PCMAX\_L,f,c over one or more Teval is then applied for the entire TREF

Table 6.2.4-1: Evaluation and reference periods for Pcmax

|  |  |  |
| --- | --- | --- |
| TREF | Teval | Teval with frequency hopping |
| Physical channel length | Physical channel length | Min(*Tno\_hopping*, Physical Channel Length) |

The measured configured maximum output power PUMAX,f,c shall be within the following bounds:

 PCMAX\_L,f,c – MAX{TL,c, T(PCMAX\_L,f,c)} ≤ PUMAX,f,c ≤ PCMAX\_H,f,c + T(PCMAX\_H,f,c).

where the tolerance T(PCMAX,f,c) for applicable values of PCMAX,f,c is specified in Table 6.2.4-1. The tolerance TL,c is the absolute value of the lower tolerance for the applicable operating band as specified in Table 6.2.1-1.

Table 6.2.4-1: PCMAX tolerance

|  |  |
| --- | --- |
| PCMAX,f,c (dBm) | Tolerance T(PCMAX,f,c) (dB) |
| 23 < PCMAX,c ≤ 33 | 2.0 |
| 21 ≤ PCMAX,c ≤ 23 | 2.0 |
| 20 ≤ PCMAX,c < 21 | 2.5 |
| 19 ≤ PCMAX,c < 20 | 3.5 |
| 18 ≤ PCMAX,c < 19 | 4.0 |
| 13 ≤ PCMAX,c < 18 | 5.0 |
| 8 ≤ PCMAX,c < 13 | 6.0 |
| -40 ≤ PCMAX,c < 8 | 7.0 |

## 6.2A Transmitter power for CA

*< text omitted >*

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

#### 6.2A.4.1 Configured transmitted power level

##### 6.2A.4.1.1 Configured transmitted power for Intra-band contiguous CA

For uplink carrier aggregation the UE is allowed to set its configured maximum output power PCMAX,*c* for serving cell *c* and its total configured maximum output power PCMAX.

The configured maximum output power PCMAX,*c* on serving cell *c* shall be set as specified in clause 6.2.4, but with MPR*c* = MPR and A-MPR*c* = A-MPR with MPR and A-MPR as determined by subclause 6.2A.2 and 6.2A.3, respectively. For PH reporting the following exception applies: if the UE is configured with multiple uplink serving cells, the power PCMAX,*c* used for the purpose of PH reporting on first serving cell *c* = *c*1 does not consider for computation of the PH report transmissions on a second serving cell *c*2 as exempted in subclause 7.7.1 in [8]. There is one power management term for the UE, denoted P-MPR, and P-MPR*c* = P-MPR.

The total configured maximum output power PCMAX shall be set within the following bounds:

 PCMAX\_L ≤ PCMAX ≤ PCMAX\_H

For uplink intra-band contiguous carrier aggregation when same slot pattern is used in all aggregated serving cells,

 PCMAX\_L  = MIN{10 log10 ∑ pEMAX,c  - TC , PEMAX,CA,(PPowerClass,CA– ΔPPowerClass,CA) – MAX(MAX(MPR, A-MPR) + ΔTIB,c + TC + TRxSRS, P-MPRc ) }

 PCMAX\_H  = MIN{10 log10 ∑ pEMAX,c , PEMAX,CA ,PPowerClass,CA– ΔPPowerClass,CA }

where

- pEMAX,c is the linear value of PEMAX,*c* which is given by IE *P-Max* for serving cell *c* in [7];

- PPowerClass is the maximum UE power specified in Table 6.2A.1.1-1 without taking into account the tolerance;

- MPR and A-MPR are specified in clause 6.2A.2 and 6.2A.3, respectively;

- ΔPPowerClass,CA = 3 dB for a power class 2 capable UE when 10 log10 ∑ pEMAX,c of 23 dBm or lower is indicated; or when PEMAX,CA of 23dBm or lower is indicated; or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is absent and the percentage of total uplink symbols transmitted on all UL CCs in a certain evaluation period is larger than 50%; or when the field of UE capability *maxUplinkDutyCycle-PC2-FR1* is not absent and the percentage of total uplink symbols transmitted in a certain evaluation period is larger than *maxUplinkDutyCycle-PC2-FR1* as defined in TS 38.331 (The exact evaluation period is no less than one radio frame); otherwise ΔPPowerClass,CA = 0 dB;

- TIB,c is the additional tolerance for serving cell *c* as specified in clause 6.2A.4.2 for NR CA, clause 6.2C.2 for SUL, or TS 38.101-3 clause 6.2B.4.2 for EN-DC; In case the UE supports more than one of band combinations for CA, SUL or DC, and an operating band belongs to more than one band combinations then

a) When the operating band frequency range is ≤ 1 GHz, the applicable additional ∆TIB,c shall be the average value for all band combinations defined in clause 6.2A.4.2, 6.2C.2 in this specification and 6.2B.4.2 in TS 38.101-3 [3], truncated to one decimal place that apply for that operating band among the supported band combinations. In case there is a harmonic relation between low band UL and high band DL, then the maximum ∆TIB,c among the different supported band combinations involving such band shall be applied

b) When the operating band frequency range is > 1 GHz, the applicable additional ∆TIB,c shall be the maximum value for all band combinations defined in clause 6.2A.4.2, 6.2C.2 in this specification and 6.2B.4.2 in TS 38.101-3 [3] for the applicable operating bands.

- P-MPR is the power management term for the UE;

- TC is the highest value TC,c among all serving cells *c*;

- ∆TRxSRS is the highest value among all serving cells *c;*

- PEMAX,CA is the value indicated by *p-NR-FR1* or by *p-UE-FR1* whichever is the smallest if both are present*.*

For uplink intra-band contiguous carrier aggregation, when at least one different numerology/slot pattern is used in aggregated cells, the UE is allowed to set its configured maximum output power PCMAX,c(i),i for serving cell c(i) of slot numerology type *i*, and its total configured maximum output power PCMAX.

The configured maximum output power PCMAX,c(i),i (p) in slot p of serving cell c(i) on slot numerology type *i* shall be set within the following bounds:

PCMAX\_L,f,c(i),i (p) ≤ PCMAX,f,c(i), i (p) ≤ PCMAX\_H,f,c(i),i (p)

where PCMAX\_L,f,c (i),i (p) and PCMAX\_H,f,c(i),i (p) are the limits for a serving cell c(i) of slot numerology type i as specified in clause 6.2.4.

The total UE configured maximum output power PCMAX (p,q) in a slot p of slot numerology or symbol pattern *i*, and a slot q of slot numerology or symbol pattern *j* that overlap in time shall be set within the following bounds unless stated otherwise:

PCMAX\_L(p,q) ≤ PCMAX (p,q) ≤ PCMAX\_H (p,q)

When slots p and q have different transmissions lengths and belong to different cells on different or same bands:

PCMAX\_L (p,q) = MIN {10 log10 [pCMAX\_L,f,c(i),i (p) + pCMAX\_L,f,c(i),j (q)], PPowerClass,CA, PEMAX,CA}

PCMAX\_H (p,q) = MIN {10 log10 [pCMAX\_ H,f,c(i),i (p) + pCMAX\_ H,f,c(i),j (q)], PPowerClass,CA, PEMAX,CA}

where pCMAX\_L,f,c (i),i and pCMAX\_ H,f,c(i),i are the respective limits PCMAX\_L,f,c (i),i and PCMAX\_H,f,c(i),i expressed in linear scale.

TREF and Teval are specified in Table 6.2A.4.1.1-0 when same and different slot patterns are used in aggregated carriers. For each TREF, the PCMAX\_L is evaluated per Teval and given by the minimum value taken over the transmission(s) within the Teval; the minimum PCMAX\_L over the one or more Teval is then applied for the entire TREF. The lesser of PPowerClass,CA and PEMAX,CA shall not be exceeded by the UE during any period of time.

Table 6.2A.4.1.1-0: PCMAX evaluation window for different slot and channel durations

|  |  |  |
| --- | --- | --- |
| TREF | Teval | Teval with frequency hopping |
| TREF of largest slot duration over both UL CCs | Physical channel length | Min(Tno\_hopping, Physical Channel Length) |

If the UE is configured with multiple TAGs and transmissions of the UE on slot *i* for any serving cell in one TAG overlap some portion of the first symbol of the transmission on slot *i* +1 for a different serving cell in another TAG, the UE minimum of PCMAX\_L for slots *i* and *i* + 1 applies for any overlapping portion of slots *i* and *i* + 1. The lesser of PPowerClass,CA and PEMAX,CA shall not be exceeded by the UE during any period of time.

The measured maximum output power PUMAX over all serving cells with same slot pattern shall be within the following range:

 PCMAX\_L – DPUMAX – MAX{TL, TLOW(PCMAX\_L + DPUMAX ) } ≤ PUMAX  ≤ PCMAX\_H + THIGH(PCMAX\_H)

 PUMAX = 10 log10 ∑ pUMAX,c

 ,0)

where pUMAX,c denotes the measured maximum output power for serving cell *c* expressed in linear scale and DPUMAX ≥ 0 dB 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 tolerances TLOW(PCMAX) and THIGH(PCMAX) for applicable values of PCMAX are specified in Table 6.2A.4.1.1-1. The tolerance TL is the absolute value of the lower tolerance for applicable NR CA configuration as specified in Table 6.2A.1.1-1 for intra-band carrier aggregation.

The measured maximum output power PUMAX over all serving cells, when at least one slot has a different transmission numerology or slot pattern, shall be within the following range:

 P'CMAX\_L– DPUMAX – MAX{TL, TLOW (P'CMAX\_L + DPUMAX)} ≤ P'UMAX  ≤ P'CMAX\_H + THIGH (P'CMAX\_H)

 P'UMAX = 10 log10 ∑ p'UMAX,c

where p'UMAX,c denotes the average measured maximum output power for serving cell *c* expressed in linear scale over TREF. The tolerances TLOW(P'CMAX) and THIGH(P'CMAX) for applicable values of P'CMAX are specified in Table 6.2A.4.1.1-1 for intra-band carrier aggregation. The tolerance TL is the absolute value of the lower tolerance for applicable NR CA configuration as specified in Table 6.2A.1.1-1 for inter-band carrier aggregation.

where:

 P'CMAX\_L  = MIN{ MIN {10log10∑( pCMAX\_L,f,c(i),i), PPowerClass,CA} over all overlapping slots in TREF}

 P'CMAX\_H = MAX{ MIN{10 log10 ∑ pEMAX,c , PPowerClass,CA} over all overlapping slots in TREF}

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* with DPCMAX,f,c not configured as [absolute], the UE shall meet the requirement on the measured PUMAX with non-zero output power on both uplink serving cells regardless of transmission priorities.

Table 6.2A.4.1.1-1: PCMAX tolerance for uplink intra-band contiguous CA

|  |  |  |
| --- | --- | --- |
| PCMAX(dBm) | ToleranceTLOW(PCMAX)(dB) | ToleranceTHIGH(PCMAX)(dB) |
| 23 < PCMAX ≤ 26 | 3 | 2 |
| 21 ≤ PCMAX ≤ 23 | 2.0 |
| 20 ≤ PCMAX < 21 | 2.5 |
| 19 ≤ PCMAX < 20 | 3.5 |
| 18 ≤ PCMAX < 19 | 4.0 |
| 13 ≤ PCMAX < 18 | 5.0 |
| 8 ≤ PCMAX < 13 | 6.0 |
| -40 ≤ PCMAX < 8 | 7.0 |

##### 6.2A.4.1.2 Configured transmitted power for Intra-band non-contiguous CA

For uplink carrier aggregation the UE is allowed to set its configured maximum output power PCMAX,*c* for serving cell *c* and its total configured maximum output power PCMAX.

The configured maximum output power PCMAX,*c* on serving cell *c* shall be set as specified in subclause 6.2.4.

The configured maximum output power PCMAX,c on serving cell c shall be set as specified in subclause 6.2.4, but with MPRc = MPR and A-MPRc = A-MPR with MPR and A-MPR as determined by subclause 6.2A.2 and 6.2A.3, respectively. For PH reporting the following exception applies: if the UE is configured with multiple uplink serving cells, the power PCMAX,c used for the purpose of PH reporting on first serving cell c = c1 does not consider for computation of the PH report transmissions on a second serving cell c2 as exempted in subclause 7.7.1 in [8]. There is one power management term for the UE, denoted P-MPR, and P-MPR c = P-MPR.

The total configured maximum output power PCMAX shall be set within the following bounds:

 PCMAX\_L ≤ PCMAX ≤ PCMAX\_H

For uplink intra-band non-contiguous carrier aggregation when same slot pattern is used in all aggregated serving cells,

 PCMAX\_L  = MIN{10 log10 ∑ pEMAX,c  - TC , PEMAX,CA,PPowerClass,CA – MAX(MAX(MPRc, A-MPRc) + ΔTIB,c + TC + DTRxSRS, P-MPR) }

 PCMAX\_H  = MIN{10 log10 ∑ pEMAX,c , PEMAX,CA ,PPowerClass,CA}

where

- pEMAX,c is the linear value of PEMAX,*c* which is given by IE *P-Max* for serving cell *c* in [7];

- PPowerClass,CA is the maximum UE power specified in Table 6.2A.1.2-1 without taking into account the tolerance;

- MPR and A-MPR are specified in subclause 6.2A.2 and subclause 6.2A.3 respectively;

- TIB,c is the additional tolerance for serving cell *c* as specified in clause 6.2A.4.2 for NR CA, clause 6.2C.2 for SUL, or TS 38.101-3 clause 6.2B.4.2 for EN-DC; In case the UE supports more than one of band combinations for CA, SUL or DC, and an operating band belongs to more than one band combinations then

a) When the operating band frequency range is ≤ 1 GHz, the applicable additional ∆TIB,c shall be the average value for all band combinations defined in clause 6.2A.4.2, 6.2C.2 in this specification and 6.2B.4.2 in TS 38.101-3 [3], truncated to one decimal place that apply for that operating band among the supported band combinations. In case there is a harmonic relation between low band UL and high band DL, then the maximum ∆TIB,c among the different supported band combinations involving such band shall be applied

b) When the operating band frequency range is > 1 GHz, the applicable additional ∆TIB,c shall be the maximum value for all band combinations defined in clause 6.2A.4.2, 6.2C.2 in this specification and 6.2B.4.2 in TS 38.101-3 [3] for the applicable operating bands.

- P-MPR is the power management term for the UE;

- TC is the highest value TC,c among all serving cells *c*;

- ∆TRxSRS is the highest value among all serving cells *c;*

- PEMAX,CA is the value indicated by *p-NR-FR1* or by *p-UE-FR1* whichever is the smallest if both are present*.*

[For uplink intra-band non-contiguous carrier aggregation, when at least one different numerology/slot pattern is used in aggregated cells, the UE is allowed to set its configured maximum output power PCMAX,c(i),i for serving cell c(i) of slot numerology type *i*, and its total configured maximum output power PCMAX.

The configured maximum output power PCMAX,c(i),i (p) in slot p of serving cell c(i) on slot numerology type *i* shall be set within the following bounds:

 PCMAX\_L,f,c(i),i (p) ≤ PCMAX,f,c(i), i (p) ≤ PCMAX\_H,f,c(i),i (p)

where PCMAX\_L,f,c (i),i (p) and PCMAX\_H,f,c(i),i (p) are the limits for a serving cell c(i) of slot numerology type i as specified in subclause 6.2.4.

The total UE configured maximum output power PCMAX (p,q) in a slot p of slot numerology or symbol pattern *i*, and a slot q of slot numerology or symbol pattern *j* that overlap in time shall be set within the following bounds unless stated otherwise:

 PCMAX\_L(p,q) ≤ PCMAX (p,q) ≤ PCMAX\_H (p,q)

When slots p and q have different transmissions lengths and belong to different cells on different or same bands:

 PCMAX\_L (p,q) = MIN {10 log10 [pCMAX\_L,f,c(i),i (p) + pCMAX\_L,f,c(i),j (q)], PPowerClass,CA, PEMAX,CA}

 PCMAX\_H (p,q) = MIN {10 log10 [pCMAX\_ H,f,c(i),i (p) + pCMAX\_ H,f,c(i),j (q)], PPowerClass,CA, PEMAX,CA}

where pCMAX\_L,f,c (i),i and pCMAX\_ H,f,c(i),i are the respective limits PCMAX\_L,f,c (i),i and PCMAX\_H,f,c(i),i expressed in linear scale.]

TREF and Teval are specified in Table 6.2A.4.1.2-1 when same and different slot patterns are used in aggregated carriers. For each TREF, the PCMAX\_L is evaluated per Teval and given by the minimum value taken over the transmission(s) within the Teval; the minimum PCMAX\_L over the one or more Teval is then applied for the entire TREF. The lesser of PPowerClass,CA and PEMAX,CA shall not be exceeded by the UE during any period of time.

Table 6.2A.4.1.2-1: PCMAX evaluation window for different slot and channel durations

|  |  |  |
| --- | --- | --- |
| TREF | Teval | Teval with frequency hopping |
| TREF of largest slot duration over both UL CCs | Physical channel length | Min(Tno\_hopping, Physical Channel Length) |

If the UE is configured with multiple TAGs and transmissions of the UE on slot *i* for any serving cell in one TAG overlap some portion of the first symbol of the transmission on slot *i* +1 for a different serving cell in another TAG, the UE minimum of PCMAX\_L for slots *i* and *i* + 1 applies for any overlapping portion of slots *i* and *i* + 1. The lesser of PPowerClass,CA and PEMAX,CA shall not be exceeded by the UE during any period of time.

The measured maximum output power PUMAX over all serving cells with same slot pattern shall be within the following range:

 PCMAX\_L – DPUMAX – MAX{TL, TLOW(PCMAX\_L + DPUMAX) } ≤ PUMAX  ≤ PCMAX\_H + THIGH(PCMAX\_H)

 PUMAX = 10 log10 ∑ pUMAX,c

 ,0)

where pUMAX,c denotes the measured maximum output power for serving cell *c* expressed in linear scale and DPUMAX ≥ 0 dB 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 tolerances TLOW(PCMAX) and THIGH(PCMAX) for applicable values of PCMAX are specified in Table 6.2A.4.1.2-2. The tolerance TL is the absolute value of the lower tolerance for applicable NR CA configuration as specified in Table 6.2A.1.2-1 for intra-band carrier aggregation.

The measured maximum output power PUMAX over all serving cells, when at least one slot has a different transmission numerology or slot pattern, shall be within the following range:

 P'CMAX\_L– DPUMAX – MAX{TL, TLOW (P'CMAX\_L + DPUMAX)} ≤ P'UMAX  ≤ P'CMAX\_H + THIGH (P'CMAX\_H)

 P'UMAX = 10 log10 ∑ p'UMAX,c

where p'UMAX,c denotes the average measured maximum output power for serving cell *c* expressed in linear scale over TREF. The tolerances TLOW(P'CMAX) and THIGH(P'CMAX) for applicable values of P'CMAX are specified in Table 6.2A.4.1.2-2 for intra-band carrier aggregation. The tolerance TL is the absolute value of the lower tolerance for applicable NR CA configuration as specified in Table 6.2A.1.2-2 for intra-band carrier aggregation.

where:

 P'CMAX\_L  = MIN{ MIN {10log10∑( pCMAX\_L,f,c(i),i), PPowerClass,CA} over all overlapping slots in TREF}

 P'CMAX\_H = MAX{ MIN{10 log10 ∑ pEMAX,c , PPowerClass,CA} over all overlapping slots in TREF}

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* with DPCMAX,f,c not configured as [absolute], the UE shall meet the requirement on the measured PUMAX with non-zero output power on both uplink serving cells regardless of transmission priorities.

Table 6.2A.4.1.2-2: PCMAX tolerance for uplink intra-band non-contiguous CA

|  |  |  |
| --- | --- | --- |
| PCMAX(dBm) | ToleranceTLOW(PCMAX)(dB) | ToleranceTHIGH(PCMAX)(dB) |
| 21 ≤ PCMAX ≤ 23 | 3.0 | 2.0 |
| 20 ≤ PCMAX < 21 | 2.5 |
| 19 ≤ PCMAX < 20 | 3.5 |
| 18 ≤ PCMAX < 19 | 4.0 |
| 13 ≤ PCMAX < 18 | 5.0 |
| 8 ≤ PCMAX < 13 | 6.0 |
| -40 ≤ PCMAX < 8 | 7.0 |

##### 6.2A.4.1.3 Configured transmitted power for Inter-band CA

For uplink carrier aggregation the UE is allowed to set its configured maximum output power PCMAX,*c* for serving cell *c* and its total configured maximum output power PCMAX.

The configured maximum output power PCMAX,*c* on serving cell *c* shall be set as specified in clause 6.2.4.

For uplink inter-band carrier aggregation, MPR*c* and A-MPR*c* apply per serving cell *c* and are specified in clause 6.2.2 and clause 6.2.3, respectively. P-MPR*c* accounts for power management for serving cell *c*. PCMAX,*c* is calculated under the assumption that the transmit power is increased independently on all component carriers.

The total configured maximum output power PCMAX shall be set within the following bounds:

 PCMAX\_L ≤ PCMAX ≤ PCMAX\_H

For uplink inter-band carrier aggregation with one serving cell c per operating band when same slot symbol pattern is used in all aggregated serving cells,

 PCMAX\_L = MIN {10log10∑ MIN [ pEMAX,c/(tC,c), pPowerClass.c/(MAX(mprc·∆mprc, a-mprc)·tC,c ·tIB,c·tRxSRS,c), pPowerClass,c/pmprc], PEMAX,CA, PPowerClass,CA-ΔPPowerClass, CA}

 PCMAX\_H = MIN{10 log10 ∑ pEMAX,c , PEMAX,CA, PPowerClass,CA-ΔPPowerClass, CA}

where

- pEMAX,c is the linear value of PEMAX, *c* which is given by IE *P-Max* for serving cell *c* in [7];

- PPowerClass,CA is the maximum UE power specified in Table 6.2A.1.3-1 without taking into account the tolerance specified in the Table 6.2A.1.3-1;

- pPowerClass,c is the linear value of the maximum UE power for serving cell *c* specified in Table 6.2.1-1 without taking into account the tolerance;

- ΔPPowerClass, CA = 3 dB for a power class 2 capable UE when the requirements of default power class are applied as specified in sub-clause 6.2.A.1.3; otherwise ΔPPowerClass, CA = 0 dB; - mpr *c* and a-mpr *c* are the linear values of MPR *c* and A-MPR *c* as specified in clause 6.2.2 and clause 6.2.3, respectively;

- ∆mpr *c* is the linear value of ∆MPR *c* as specified in clause 6.2.2;

- pmprc is the linear value of P-MPR*c*;

- ∆tRxSRS,c is the linear value of ∆TRxSRS,c;

- tC,c is the linear value of TC,ctC,c = 1.41 when NOTE 2 in Table 6.2A.1.3-1 applies for a serving cell *c*, otherwise tC,c = 1;

- tIB,c is the linear value of the inter-band relaxation term TIB,c of the serving cell *c* as specified in clause 6.2A.4.2 for NR CA, clause 6.2C.2 for SUL, or TS 38.101-3 clause 6.2B.4.2 for EN-DC; otherwise tIB,c In case the UE supports more than one of band combinations for CA, SUL or DC, and an operating band belongs to more than one band combinations then

a) When the operating band frequency range is ≤ 1 GHz, the applicable additional TIB,c shall be the average value for all band combinations defined in clause 6.2A.4.2, 6.2C.2 in this specification and 6.2B.4.2 in TS 38.101-3 [3], truncated to one decimal place that apply for that operating band among the supported band combinations. In case there is a harmonic relation between low band UL and high band DL, then the maximum ∆TIB,c among the different supported band combinations involving such band shall be applied

b) When the operating band frequency range is > 1 GHz, the applicable additional ∆TIB,c shall be the maximum value for all band combinations defined in clause 6.2A.4.2, 6.2C.2 in this specification and 6.2B.4.2 in TS 38.101-3 [3] for the applicable operating bands.

- PEMAX,CA is the value indicated by *p-NR-FR1* or by *p-UE-FR1* whichever is the smallest if both are present.For uplink inter-band carrier aggregation with one serving cell *c* per operating band when at least one different numerology/slot pattern is used in aggregated cells, the UE is allowed to set its configured maximum output power PCMAX,c(i),i for serving cell c(i) of slot numerology type *i*, and its total configured maximum output power PCMAX.

The configured maximum output power PCMAX,c(i),i (p) in slot p of serving cell c(i) on slot numerology type *i* shall be set within the following bounds:

PCMAX\_L,f,c(i),i (p) ≤ PCMAX,f,c(i), i (p) ≤ PCMAX\_H,f,c(i),i (p)

where PCMAX\_L,f,c (i),i (p) and PCMAX\_H,f,c(i),i (p) are the limits for a serving cell c(i) of slot numerology type i as specified in clause 6.2.4.

The total UE configured maximum output power PCMAX (p,q) in a slot p of slot numerology or symbol pattern *i*, and a slot q of slot numerology or symbol pattern *j* that overlap in time shall be set within the following bounds unless stated otherwise:

PCMAX\_L(p,q) ≤ PCMAX (p,q) ≤ PCMAX\_H (p,q)

When slots p and q have different transmissions lengths and belong to different cells on different bands:

PCMAX\_L (p,q) = MIN {10 log10 [pCMAX\_L,f,c(i),i (p) + pCMAX\_L,f,c(i),j (q)], PPowerClass,CA, PEMAX,CA}

PCMAX\_H (p,q) = MIN {10 log10 [pCMAX\_ H,f,c(i),i (p) + pCMAX\_ H,f,c(i),j (q)], PPowerClass,CA, PEMAX,CA}

where pCMAX\_L,f,c (i),i and pCMAX\_ H,f,c(i),i are the respective limits PCMAX\_L,f,c (i),i and PCMAX\_H,f,c(i),i expressed in linear scale.

For combinations of intra-band and inter-band carrier aggregation with UE configured for transmission on three serving cells (up to two contiguously aggregated carriers per operating band), the following apply:

For the case when p and q belong to the same band and k belongs to a different band, but p, q and k are of the same numerology and slot patterns.

 PCMAX\_L = MIN {10log10∑( pCMAX\_L, Bi), PEMAX,CA, PPowerClass}

 PCMAX\_H = MIN{10 log10 ∑ pEMAX,c , PEMAX,CA, PPowerClass}

Where

- pCMAX\_L, Bi is the linear values of PCMAX\_L specified for the specific operating band *Bi*.

- The linear value of PCMAX\_L specified for uplink intra-band contiguous carrier aggregation in subclause 6.2A.4.1.1 applies for operating band supporting two contiguous serving cells, designated by its band index *Bi*. The linear value of PCMAX\_L specified for single carrier in subclause 6.2.4 applies for operating band *Bj* supporting one serving cell.

For the case when p and q belong to the same band and are of the same numerology *i* and slot patterns (p,q),while k belong to a different band and is of different numerology *j* and/or slot pattern on the 3rd cell then:

PCMAX\_L (p,q,k) = MIN {10 log10 [pCMAX\_L,Bi,i(p,q) + pCMAX\_L,c(3),Bj,j(k)], PEMAX,CA, PPowerClass}

PCMAX\_H (p,q,k) = MIN {10 log10 [pCMAX\_ H,Bi,i (p,q) + pCMAX\_ H,c(3), Bj,j(k)], PEMAX,CA, PPowerClass}

Where

- pEMAX,c is the linear value of PEMAX, *c* which is given by IE *P-Max* for serving cell *c* in [7];

- PEMAX,CA is p-UE-FR1 value signalled by RRC and defined in [38.331];

- PPowerClass is the maximum UE power specified in Table 6.2A.1.3-1 without taking into account the tolerance specified in the Table 6.2A.1.3-1 or Table 6.2F.1A.1-1 for shared spectrum bands;

- pCMAX\_L,c(3),Bj,j(k) and pCMAX\_ H,c(3), Bj,j(k)are the linear values of PCMAX\_L and PCMAX\_H respectively, specified for single carrier in subclause 6.2.4 and applies for operating band supporting one serving cell in the *Bj* band on numerology *j*, using slot pattern k;

- pCMAX\_L,Bi,i(p,q) and pCMAX\_ H,Bi,i (p,q) are the linear values of PCMAX\_L respectively PCMAX\_H for uplink intra-band contiguous carrier aggregation specified in subclause 6.2A.4.1.1 which applies for operating band *Bi* on numerology *i*, supporting two contiguous serving cells, using the same slot pattern (p,q).

TREF and Teval are specified in Table 6.2A.4.1.3-0 when same and different slot patterns are used in aggregated carriers. For each TREF, the PCMAX\_L is evaluated per Teval and given by the minimum value taken over the transmission(s) within the Teval; the minimum PCMAX\_L over the one or more Teval is then applied for the entire TREF. The lesser of PPowerClass,CA and PEMAX,CA shall not be exceeded by the UE during any period of time.

Table 6.2A.4.1.3-0: PCMAX evaluation window for different slot and channel durations

|  |  |  |
| --- | --- | --- |
| TREF | Teval | Teval with frequency hopping |
| TREF of largest slot duration over both UL CCs | Physical channel length | Min(Tno\_hopping, Physical Channel Length) |

If the UE is configured with multiple TAGs and transmissions of the UE on slot *i* for any serving cell in one TAG overlap some portion of the first symbol of the transmission on slot *i* +1 for a different serving cell in another TAG, the UE minimum of PCMAX\_L for slots *i* and *i* + 1 applies for any overlapping portion of slots *i* and *i* + 1. The lesser of PPowerClass,CA and PEMAX,CA shall not be exceeded by the UE during any period of time.

The measured maximum output power PUMAX over all serving cells with same slot pattern shall be within the following range:

 PCMAX\_L – DPUMAX – MAX{TL, TLOW(PCMAX\_L + DPUMAX) } ≤ PUMAX  ≤ PCMAX\_H + THIGH(PCMAX\_H)

 PUMAX = 10 log10 ∑ pUMAX,c

 ,0)

where pUMAX,c denotes the measured maximum output power for serving cell *c* expressed in linear scale and DPUMAX ≥ 0 dB 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 tolerances TLOW(PCMAX) and THIGH(PCMAX) for applicable values of PCMAX are specified in Table 6.2A.4.1.3-1. The tolerance TL is the absolute value of the lower tolerance for applicable NR CA configuration as specified in Table 6.2A.1.3-1-2 for inter-band carrier aggregation.

The measured maximum output power PUMAX over all serving cells, when at least one slot has a different transmission numerology or symbol pattern, shall be within the following range:

 P'CMAX\_L– DPUMAX – MAX{TL, TLOW (P'CMAX\_L + DPUMAX)} ≤ P'UMAX  ≤ P'CMAX\_H + THIGH (P'CMAX\_H)

 P'UMAX = 10 log10 ∑ p'UMAX,c

where p'UMAX,c denotes the average measured maximum output power for serving cell *c* expressed in linear scale over TREF. The tolerances TLOW(P'CMAX) and THIGH(P'CMAX) for applicable values of P'CMAX are specified in Table 6.2A.4.1.3-1 for inter-band carrier aggregation. The tolerance TL is the absolute value of the lower tolerance for applicable NR CA configuration as specified in Table 6.2A.1.3-1 for inter-band carrier aggregation.

where:

 P'CMAX\_L  = MIN{ MIN {10log10∑( pCMAX\_L,f,c(i),i), PPowerClass,CA} over all overlapping slots in TREF}

 P'CMAX\_H = MAX{ MIN{10 log10 ∑ pEMAX,c , PPowerClass,CA} over all overlapping slots in TREF}

Table 6.2A.4.1.3-1: PCMAX tolerance for uplink inter-band CA (two bands)

|  |  |  |
| --- | --- | --- |
| PCMAX(dBm) | ToleranceTLOW(PCMAX)(dB) | ToleranceTHIGH(PCMAX)(dB) |
| 23 ≤ PCMAX ≤ 26 | 3.0 | 2.0 |
| 22 ≤ PCMAX < 23 | 5.0 | 2.0 |
| 21 ≤ PCMAX < 22 | 5.0 | 3.0 |
| 20 ≤ PCMAX < 21 | 6.0 | 4.0 |
| 16 ≤ PCMAX < 20 | 5.0 |
| 11 ≤ PCMAX < 16 | 6.0 |
| -40 ≤ PCMAX < 11 | 7.0 |

##### 6.2A.4.1.4 Void

*< end of changes >*