3GPP TSG-RAN WG4 Meeting #109 R4-2321821

**Chicago, USA, November 13 – 17, 2023**

**Title:** [Draft] LS reply on further clarifications on enhancements to realize increasing UE power high limit for CA and DC

**Response to:** R4-2318078 (R2-2311611)

**Release:** Rel-18

**Work Item:** NR\_cov\_enh2

**Source:** TSG RAN WG4

**To:** TSG RAN WG2

**Cc:** TSG RAN WG1

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**Attachments: None**

# 1 Overall description

RAN4 thanks RAN2 for the LS on further clarifications on enhancements to realize increasing UE power high limit for CA and DC in R2-2311611.

Regarding the questions from RAN2, RAN4 would like to share the following answers.

* **Q1**: What exact information is required to be reported by the UE (i.e., how many bits are required to support the reporting of this information)?

Answer: 2 bit

**Answer from RAN4**:

Both ΔPPowerClass, ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC should be considered, in addition to *ulFullPower* parameters.

* For single band operation, signalling is needed to cover 0, 3 and 6 dB for ΔPPowerClass.
* For CA operation, signalling is needed to cover 0, 3 and 6 dB for ΔPPowerClass, CA. The reporting is related to the total aggregated power of the band combination (PCMAX) rather than ΔPPowerClass for each serving cell.
  + ΔPPowerClass for each serving cell is not reported.
  + RAN4 defers to RAN2 choice on how to populate the unused bits in the PHR report if the existing PHR framework is used.
* For EN-DC operation, signalling is needed to cover 0, 3 and 6 dB for ΔPPowerClass, EN-DC. The reporting is related to the total aggregated power of the band combination (PCMAX, f, c, NR) rather than ΔPPowerClass for each serving cell.
  + ΔPPowerClass for each serving cell is not reported.
  + RAN4 defers to RAN2 choice on how to populate the unused bits in the PHR report if the existing PHR framework is used.
* For NR-DC operation, signalling is needed to cover 0, 3 and 6 dB for ΔPPowerClass, NR-DC. The reporting is related to the total aggregated power of the band combination (PCMAX, f, c, MCG and PCMAX, f, c, SCG, respectively) rather than ΔPPowerClass for each serving cell.
  + ΔPPowerClass for each serving cell is not reported.
  + RAN4 defers to RAN2 choice on how to populate the unused bits in the PHR report if the existing PHR framework is used.

In addition to the parameters above, a suggested method for the UE to convey the applicable *ulFullPower* mode is below:

For each fallback level (or positive value of the parameter ΔPPowerClass or ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC), the UE needs to optionally convey to the network an applicable *ul-FullPower* capability. The choices correspond to *ul-FullPower*, *ul-FullPowerMode1* and *ul-FullPowerMode2* [38.306]. Not reporting an *ul-FullPower* capability for a new fallback level implies no change from declared ULFPTx mode for the declared power class. See figure below:

A diagram of a diagram

Description automatically generated

RAN4 is aware that the first two options (*ul-FullPower*, *ul-FullPowerMode1*) only require a bit each, so special care is needed only for *ul-FullPowerMode2* parameters. To support this goal in an efficient way, the signaling can be divided into a static ‘pre-conveyed’ part and a dynamic pointing via MAC-CE or similar. Specifically, the UE would additionally report as part of initial access, sets of *ul-FullPowerMode2* parameters for each foreseen fallback level. The UE is then only required to dynamically point to one of the three options for each fallback level. When the new parameter value is 0, the original capability set for the declared power class applies.

In summary, 7 possible states need to be conveyed by MAC-CE. These states correspond to the 7 blue boxes in the figure above. 3 bits would therefore suffice.

EAB preferred answer:

Agreement: Use the following bullets as the baseline

* For ΔPPowerClass
* Both ΔPPowerClass for a serving cell (the reduction of the maximum output power per serving cell) and ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC for a band combination (reduction of the maximum total output power per band combination) should be considered.
  + For a serving cell, 2 bits are needed to cover 0, 3 and 6 dB for ΔPPowerClass.
  + For a band combination a granularity of 1 bit for ΔPPowerClass, ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC: then 0 dB and ≥[3] dB.
* ΔPPowerClass for a serving cells of a band combination should also be reported with a 2 bit granularity.

Conclusions: RAN4 has no consensus on the full power transmission mode capability reporting in Rel-18

[Moderator: One possible compromise solution for full power transmission mode capability reporting:]

* Semi-static indication should be considered, which means the UE indicated the full power transmission mode capability {*ul-FullPower*, *ul-FullPowerMode1, ul-FullPowerMode2*} for each ΔPPowerclass value {0, 3 and 6dB}.
* **Q2**: What is the granularity of the information to be reported (e.g., per UE / per cell / other option)?

**Answer from RAN4**:

Based on the answers to the previous question, RAN4 provide the following information.

* ΔPPowerClass reported per serving cell
* ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC per band combination
* If UE only supports the single CC, the capability of reporting the above per UE (same for all serving cells and BC) but with two options for a band combination:
  + Reporting of ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC only
  + Reporting of both ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC and ΔPPowerClass for configured serving cells

Agreement:

* The capability of reporting is per UE
  + [ΔPPowerClass reported per serving cell
  + ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC per band combination
  + For a band combination, UE can choose the two options below:
    - Reporting of ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC only
    - Reporting of ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC per band combination and ΔPPowerClass per serving cell of band combination configured]
* Network configures the reporting of ΔPPowerClass and/or ΔPPowerClass, CA/ΔPPowerClass, EN-DC/ΔPPowerClass, NR-DC forthe overhead reduction purpose
* **Q3**: Will RAN4 specification(s) specify the triggering condition(s) when this reporting should be performed by the UE, to which RAN2 specification(s) could then refer to when writing the reporting procedure?

**Answer from RAN4**:

Option 1:

RAN4 will specify the triggering conditions for UE report on ∆PPowerClass and∆PPowerClass,CA and associated information in TS 38.101-1, and those for UE report on ∆PPowerClass, EN-DC and∆PPowerClass,NR-DC and associated information in TS 38.101-3, respectively.

The triggering of a power capability change ΔPPowerClass, the corresponding for the BC and duty-cycle management are up to UE implementation and will therefore not be specified by RAN4.

Option 2:

RAN4 provide following clarifications with the understanding that no dedicated RAN4 specification impacts would be needed to reflect triggering conditions:

* The ΔPPowerClass and associated reporting is triggered by a change in the value of the ΔPPowerClass parameter and when the parameter value is non-negative. The condition that triggers a parameter value change as described above and the relation among ΔPPowerClass, scheduled duty cycle and maximum duty cycle capabilities are defined in clause 6.2.4 of 38.101-1 for single band, clause 6.2A.4 of 38.101-1 for CA, 6.2B.4 of 38.101-1 for NR-DC, and 6.2B.4 of 38.101-3 for EN-DC in these cases.

Ericsson preferred answer:

The ΔPPowerClass reduces the configured maximum power (Pcmax,f,c) of the UL power control and the corresponding for the BC the maximum power at which the UE prioritizes transmissions. RAN4 assumes that these changes of the maximum output power can trigger an aperiodic report similarly to DL PL changes for the existing PHR (the DL PL also part of the UL power control). The triggering of a power capability change ΔPPowerClass, the corresponding for the BC and duty-cycle management are up to UE implementation and will therefore not be specified by RAN4.

# 2 Actions

**To RAN2**

**ACTION:** RAN4 respectfully ask RAN2 to consider above information for their future work on the implementation of ΔPPowerClass reporting and full-power MIMO transmission capability reporting.

# 3 Dates of next TSG RAN WG4 meetings

TSG RAN WG4 Meeting #110 February 26 – March 1, 2024 Athens, Greek