3GPP TSG RAN Meeting #94-e Draftv3\_R5-221346r2

Electronic Meeting, 21st Feb – 4th Mar 2022

Agenda item: 5.3.1.17

Source: Apple Portugal

Title: Avoiding Scell Drop in FR2 RF UL-CA tests

Document for: DISCUSSION AND ENDORSEMENT

# 1 Introduction

There have been extensive discussions over the course of several meetings regarding the SCell drop in FR2 UL-CA RF test cases. The purpose of this discussion paper is to summarize current status in RAN5 on the issue of FR2 EN-DC UEs dropping NR SCell during the TRx measurement and thereby ceasing to be in UL-CA mode. This is in lieu of the DUT following the prioritization rules in TS 38.101-2 [1] and TS 38.213 [2]. The issue has been discussed in length in RAN5 [5] [6] [7] [8], [9].We further propose some solutions for agreement.

It should also be noted that there was a way forward in RAN4 (R4-2202341) as of RAN4#101-bise which discussed possible ways to limit the serving cell power to prevent excessive power scaling of secondary cells, however there is no immediate solution seemingly available. While the actual method is still under discussion, the impact of this to conformance testing and possible options to consider in RAN5 spec are discussed.

# Proposed Way Forward at RAN5#94e.

The below options were discussed vis-à-vis avoiding SCell Drop in FR2 UL-CA tests with UE operating at or close to Max Tx Power.

**Option 1 (TPC based approach):** Improve the test procedure by adopting either of the following options if it is agreed to use Option 1 for SCell drop issue.

* **Option 1A**

 Procedure: Send TPC up to ensure PUMAX

 -> Send TPC down to set PCell to (PCMAX – XMAX)

 -> Send TPC up to set SCell to (PCMAX – XMAX)

 The procedure is simpler than Option 1B, but there could be additional SCell drop issue.

* **Option 1B**

 Procedure: Send TPC up to ensure PUMAX

 -> Send TPC down to set PCell between (PCMAX – XMAX)

 and (PCMAX – XMAX – PW)

 -> Send TPC up to set SCell between (PCMAX – XMAX)

 and (PCMAX – XMAX – PW)

 -> Send TPC 1dB up in order from the lowest Cell to ensure PUMAX

 All Cells are at similar levels around (PCMAX – XMAX).

**Option 2:** Use RAN5-defined **Conformance Test Function** to apply relevant power limit/back-off to avoid SCell Drop during FR2 UL-CA tests (no impact on PCC prioritization rules), for Release 16 and forward.

**Option 3:** Await core spec (RAN4/RAN2) defined mechanism to avoid SCell Dropping during FR2 UL-CA tests

**Based on discussions at RAN5#94e, the below Way Forward is requested to be endorsed.**

**Proposal 1:** Adopt **Option 2** as RAN5 way forward to enable FR2 RF UL-CA testing for scenarios with UE operating close to Max Tx power.

draftCRs to implement this option shall be endorsed by RAN5.

**Proposal 2:** Send an LS to RAN4 to seek clarification

A draft of the proposed LS is provided below.

**Proposal 3:** RAN5 shall further analyse testability aspects based on adoption of Option 2.

# Proposed LS to RAN4 seeking clarification on RAN5 proposed approach to avoid SCell Dropping.

**3GPP TSG-RAN5 Meeting #94-e *R5-22????***

**Electronic Meeting, 21st Feb – 04th Mar. 2022**

**Title:** LS on SCell Dropping in FR2 RF UL-CA tests

**Response to:**

**Release:** Release 16

**Work Item:** NR\_RF\_FR2\_req\_enh-UEConTest

**Source:** TSG RAN WG5

**To:** TSG RAN WG4

**Cc:** N/A

**Contact Person:**

**Name:** Ashwin Mohan

**E-mail Address:** ashwin\_mohan@apple.com

**Send any reply LS to: 3GPP Liaisons Coordinator,** **3GPPLiaison@etsi.org**

**Attachments:**

**1. Overall Description:**

RAN5 has been discussing the issue seen in FR2 RF UL-CA conformance test cases wherein UEs stop transmitting UL signals of FR2 NR SCC (Scell Drop) when set to transmit at maximum power, as described in [3], [4] and [6].

RAN4 provided information to RAN5 via [1] on aspects to consider when defining FR2 UL-CA conformance test cases. In addition, RAN1 acknowledged via [5] that SCell drop due to priority rules can occur and that RAN1 has not identified any issue with the priority rules in TS 38.213.

RAN5 is considering the usage of a conformance-only test function to test FR2 RF UL-CA conformance tests, for 3GPP Release 16 and forward. Such a conformance-only test function approach includes usage of a parameter that defines the power back-off needed to be applied to the PCell to potentially avoid SCell drop in FR2 UL-CA conformance test cases. RAN5 will further define the test procedures to accomplish the FR2 UL-CA conformance test.

RAN5 requests RAN4 for responses to the following questions:

1. Whether RAN4 sees a need to define within TS 38.101-2, the aforementioned power backoff parameter which will be used by conformance-only test function?
2. Whether RAN4 can share guidance on any impact on absolute and relative power tolerance accuracy that needs to be factored because of usage of such a conformance-only test function to apply power limits/back-off?

**2. Actions:**

**To RAN4 group.**

**ACTION:** RAN5 respectfully requesting RAN4 group to provide feedback on the questions raised above.

**3. Date of Next TSG-RAN WG5 Meetings:**

TSG-RAN5 Meeting#95e 16rd – 27th May 2022 Electronic Meeting

TSG-RAN5 Meeting#96 22nd – 26th August 2022 Toulouse, FR

References

1. R4-2103410, LS to RAN5 on SCell dropping, Oppo, RAN4#98e
2. R4-2114950, LS to RAN1 on Scell dropping issue of CA, Huawei, RAN4#100e
3. R5-221346, Avoiding Scell Drop in FR2 RF UL-CA tests, Apple Portugal, RAN5#94e
4. R5-218400, Avoiding Scell Drop in FR2 RF UL-CA tests, Apple Portugal, RAN5#93e
5. R1-2110698, Reply LS to RAN4 on SCell dropping issue of CA, Huawei, RAN1#106-bise
6. R4-2009656, NR SCC UL power drop behaviour with EN-DC UE in FR2, Anritsu, RAN4#96e

# Summary of discussion at RAN5#94e

- **Option 1** has been discussed for several meetings but the MU/testability and test coverage limitation have persisted. Apple was initial proponent of this TPC option but considering the concerns heard we became open to Option 2.

- **Option 3** is ongoing in RAN4 for several meetings and as Verizon indicated deadlock across various sub-topics related to this issue continues in RAN4 due to which conformance test solution in RAN5 is critical to pursue..

- **Option 2:** There is request from at least one operator (Verizon) to pursue this option and unblock coverage.  At the same time, Ericsson raised question about Option 2 also requiring core spec definition of Xmax,f,PCell  (Apple does not believe so based on the TS 38.521-2/38.509 CRs we produced which I encourage the group to review - TDoc#s in the table below)

**As a way forward,** RAN5 can consider incorporating Ericsson’s suggestion and send an LS to RAN4 seeking clarification along the lines:

*Assuming RAN5 explores conformance-only test function approach to limit PCell power and avoid SCell dropping in FR2 RF UL-CA tests operating at max Tx power -*

*a) would this violate the RAN4 defined Pcmax definitions?*

*b) would Xmax,f,PCell  needed by conformance-only test function have to be defined in TS 38.101-2 Clause 6.2?*

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| **TDoc** | **Takeaways** | **Supporting Companies***(Within [] -> not opposed)* |
| **R5-220889**(Option 1a and 1b) Modified TPC approach to avoid SCell drop *[Could apply to Rel15 and fwd]* | -       Least number of test points. -       Most MU/testability concerns which remain unresolved.  | Anritsu |
| **R5-221346r1**(Option 2) - Test Function to Limit PCell Power *[Could apply to Rel16 and fwd]* CRs - *R5-221348r1, R5-221347r1, R5-221349* | -       Higher test coverage than Option 1 possible but further testability analysis needed to determine viability, per Keysight-       Ericsson thinks that *Xmax,i,PCell* will still have to be defined in 38.101-2 Apple suggests probably not based on 38.521-2/38.509 CRs created. (ask RAN4?)-       Operator (VZW) requests to unblock testing. | Apple, Verizon, [Anritsu], [R&S] |
| **R5-221250**(Option 3 - RAN2/RAN4 updates to signaling to limit PCell power) *[Release TBD – Could apply to earlier Rel if solution if RAN4 deems that a solution is necessary]* | -       Same test coverage as Option 2 and further testability analysis needed to determine viability, per Keysight-       No consensus in RAN4 as of today even in RAN4#102. As Verizon pointed out doubtful if agreement will be reached as there is deadlock on key points.  | Ericsson, R&S, [Anritsu] |

# Collection of Comments from Companies at RAN5#94e

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| --- | --- | --- | --- | --- |
| **TDoc** | **Contributor** | **Proposals** | **Comments** | **Supporting Companies***(Within [] -> not opposed)* |
| R5-220889(Option 1a and 1b) Modified TPC approach to avoid SCell drop | Anritsu | **Proposal 1:** Improve the test procedure by adopting either of the following options if it is agreed to use Option 1 for SCell drop issue [Could apply to Rel15 and fwd] | **[Apple]** *Updates to RAN4#93e discussion:*  *Modified TPC approaches (adjust SCell power along with PCell) to prevent SCell drop.*Thanks to Anritsu for revisiting this option. A key concern that has stayed with this approach when Apple proposed it previously, was MU/testability issues and limited test point coverage. It seems those issues remain even with these modified options?**[R&S]** Thanks to Anritsu for the discussion of this approach. We have a clear preference of Option 1A compared to Option 1B since test procedure complexity for Option 1B is increased with an increase of test time.In principle, we are in favor of RAN4 solving the issue also for operation in the network. However, if an interim solution is considered as essential by the group, we should choose a solution with low complexity which is more robust.Moreover, we are not convinced that Option 1B is working properly. Is “up” in step 8 correct?**[Anritsu]** Thanks to comments from Apple, R&S, Verizon. There is no concern for testability issue and limited test point coverage. It is because Delta-SNR depends on the total power and BW, and total power is not changed by Option 1A/1B. The reason, why the concern for limited test point coverage was raised at RAN5#93, was that total power could be decreased by power window in the previous TPC approach. Option 1A/1B is proposed to not decrease the total power, so there is no concern for limited test point coverage now.From the viewpoint of test procedure simplicity, we prefer Option 1A as well as R&S. However, we added Option 1B, because I heard from Apple that Option 1A has concerns about Additional SCell drop (one SCell has priority and other SCells drop). To be honest, we are not sure whether Option 1A will actually cause Additional SCell drop and Option 1B will solve it, so I would like to hear the views of the RAN5 group members who are familiar with the behavior of UE.To the last question from R&S, “up” in Option 1B step 8 is correct. This is because SCells are dropped in step 6, and not all SCells always increase to target level in step 7.**[Keysight]:** According to my understanding in Option 1A (step 8), the UE might drop SCell as when sending TPC commands up for 200ms, there will be a moment where SCell power levels will make the device go over power class limit so the device drops the SCell again. The impact of Pw has not been considered in Option 1A either.In Option 1B (step 9), there is also a risk to get SCell dropped as once all PCC and SCell have been set to PCMAX -Xmax , TPC commands up are sent. Finally, this document is not covering testability issues due to lower dynamic range.[Verizon] If I understand it correctly, while it is helpful to utilize discussion papers (R5-206611, R5-211104) from other areas to address FR2 Scell Drop issue, but the solution results in limited test points based on last RAN5 meeting (RAN5#93e) discussions. For example,For aggregated BW <=200, no relaxation, MPR=5, can’t cover 64 QAMFor aggregated BW <=400, no relaxation, MPR=3, can only cover DFT-s-OFDM QPSK | Anritsu |
| R5-221346r1(Option 2) - Test Function to Limit PCell Power | Apple | **Proposal 1:** Prefer Option 2 (test function) to enable coverage for the testable UL-CA FR2 RF tests with no core WG dependency.[Could apply to Rel16 and fwd] | [Apple] *Updates to RAN4#93 discussion: Preliminary analysis shows test point coverage will be higher than Option 1 but some test point limitation will still be seen.  (Note: similar test point coverage limitation is also expected with Option 3). Aligns with operator feedback to prefer higher test coverage compared to previous Option 1.*[R&S] We prefer Option2 over Option 1A/1B.[Ericsson]* From the CR in 1347:  *“Xmax,i,PCell  is the back-off in transmit power applied on the primary component carrier fom PCMAX,f,c”*. This sentence is definitely RAN4 responsibility and not RAN5. If RAN5 invents a Xmax parameter it invalidates the Pcmax formula from 38.101-2 and without core requirement the test is of little value.
* Also, how is the UE supposed to know this Xmax value if it is not signalled? The value depend on number of CC and also BW combinations.
* As brought up in the Ericsson paper and also in RAN4 discussions, Xmax on PCell is not enough to prevent dropping of SCell. It is needed for SCells as well

[Anritsu] We prefer Option 2 if Rel-15 is abandoned.* [Keysight]: In section 2.3.2.2, it is indicated that “Since measurement for UL-CA tests occurs on per CC basis, some of the dynamic range impact can be approximated to the single carrier case.”: However, analysis in R5-206611 didn’t take into account the Xmax value. The outcome of analysis mentioned in observation 8 might show that testable test points are so limited that it might not be worthy to add all signalling changes proposed in any of the discussion papers. We think testability and signalling changes should be handled as one package. Regarding observation 11a, the accuracy expected on UE side when setting the power level through a test function will be undefined.

[Verizon] Given the urgent testing needs, and thanks to Apple for bringing in the related CRs (R5-221347, R5-221348, R5-221349), Option 2 seems reasonable and doable to have this action point addressed from Rel-16 and onward. | Apple, Verizon, [Anritsu], [R&S] |
| R5-221250(Option 3 - RAN2/RAN4 updates to signaling to limit PCell power) | Ericsson | **Proposal 1:** With both option 2 and 3 there is RAN4 dependency to update the UE configured power requirements in 38.101-2, clause 6.2A.4**Proposal 2:** Considering the RAN4 impact for both option 2 and option 3, option 3 is preferrable since it does not introduce unnecessary UE implementation and it is available to real networks and not just for conformance testing.[Release TBD – Could apply to earlier Rel if solution if RAN4 solution is deemed necessary] | [Apple] Thanks for the contribution. I have included the RAN4 WF from RAN4#101-bis in my paper for reference.**Proposal 1 feedback:** Option 2 does not deal with a new requirement, so we do not see a RAN4 dependency. The factor to back-off/limit PCell power is required for the conformance-only test function and can be defined within RAN5.**Proposal 2 feedback:** The key concern is that RAN4 does not seem close to a conclusion. There are several FFS and the variety of options include one indicating a possibility of “no consensus” as well as making any network-controlled parameter as “optional” which, if agreed, may not help RAN5 eventually.  How long to wait for RAN4 is the question?[R&S] For overall network performance, Option 3 is a good solution and we prefer it over Option 2.[Ericsson] We don’t agree with Apple proposal 1 feedback. The UE power control performance is clearly under RAN4 control. Regarding proposal 2 feedback, one option is to formulate a question to RAN4 regarding the Xmax parameter to ask for their feedback of introducing it.[Anritsu] We prefer Option 3 if Rel-15 and Rel-16 are abandoned.[Verizon] It is ideal that the technical issues can be solved by RAN4 during Rel-17. Given the time left for Rel-17 and the impacts to RAN2, it seems the solution will not be finalized for Rel-17 and RAN5 should treat testing needs separately. | Ericsson, R&S, [Anritsu] |

[Keysight]: even if we could progress on the way to set equal PSD in all CC through any of the mechanisms under discussion, we really think that no conclusion should be achieved until testability is analyzed. As mentioned below, it might happen that signalling changes are not worthy taking into account the coverage obtained as an outcome of the testability analysis.

# 2 Discussion

## 2.1 Core and Test Specification background

It would be useful to recap the background from TS 38.213 [2] and TS 38.101-2 [1]. Associated clauses are extracted in the appendix at the bottom of this contribution. In summary:

* In TS 38.213 clause 7.5, UE is defined to prioritize the primary cell in case of same priority order of transmission and for operation with CA, which means the primary cell of the SCG (NR cell group) is prioritized than secondary cell in the EN-DC UE case. Moreover, this is also the default mode of operation in real deployments.

**Observation 1: As per TS 38.213 prioritization rules, PCC is prioritized over SCC. This is also the mode of operation in the field**

* In TS 38.101-2 clause 6.2A.4, configured transmitted power for CA is defined only with PCMAX, which is the total power of CCs as NR. Thus, it is possible to configure the output power of each component carrier with an imbalanced output power. This led to the question on whether “equal power spectral density for each RB in each component carrier” should be a mandatory condition or not.

Extract from TS 38.101-2 clause 6.2A.4
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.

In addition, RAN4 has confirmed the below

To this end, RAN4 has discussed the following two options for verification of the CA test cases:

1. Option 1: Equal PSD between CCs.
2. Option 2: Measure the UE as is even SCC output may be scaled down under CA mode.

RAN4 considers that equal PSD is a preferred test condition to verify the UL CA requirements. However, considering the actual UE behaviour in the field, which is subject to the prioritization rules in 38.213.RAN4 recognizes that testing details (configures/procedures) are ultimately up to RAN5.

**Observation 2: RAN4 clarified via LS [2] to RAN5 that equal PSD is preferred test condition. However, actual UE behavior in the field has to be considered as well as prioritization rules in TS 38.213 to identify testing details.**

**Observation 3: RAN5 has agreed that the way forward recognizes prioritization rules in TS 38.213 [10]**

**Observation 4: RAN5 has to analyse and define test procedures which will ensure testability for intra-band UL-CA scenarios. Considering the ongoing RAN4 discussion, a potential solution from RAN4 cannot be precluded.**

As discussed during RAN5#93 a summary of the LS communication between RAN4 and RAN1 was available.

**Observation 5: RAN1 confirms that no changes to prioritization rules is planned as there is no known issue as such. Further any UE-specific configuration of power limits to prevent SCell drop would not conflict with RAN1 specifications but a confirmation on this is dependent on the actual RAN4 solution.**

## Discussion on possible ways forward for RAN5

### 2.3.1 Background: Previous RAN5 discussion on FR2 RF Tx tests impacted by this issue

As part of the discussions during earlier RAN5 meetings, a list of tests that are impacted was identified. This information is useful to determine the real impact on coverage solely because of the SCell drop issue and how much bandwidth to spend/how best to identify a temporary workaround for the issue before a RAN4/RAN2 solution is identified.

**Observation 6: There are 3 (three) completed FR2 RF UL-CA tests that are blocked solely by SCell drop issue. Other tests are not complete in the spec : either have multiple other blocking issues or are not yet introduced in the spec even in Release 15 work plan for the past many RAN5 meetings.**

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| **TS38.521-2 clause number** | **Test case title** | **Coverage Blocked by SCell Drop Issue?** | **Comments** |
| 6.2A.1 | UE maximum output power for CA | No | The MOP CA test case requires to be tested at MPR=0 and according to RAN 4 this condition is met only with 1CC. This means SCell drop cannot happen in this test case |
| 6.2A.2 | UE maximum output power reduction for CA | Yes, if other incomplete items are addressed | Multiple other incomplete items in test so SCell Drop is not only issue |
| 6.2A.3 | A-MPR for CA | No | No contents in the test case (FFS). |
| 6.2A.4 | Configured output power for CA | No | No contents in the test case (FFS). |
| 6.3A.4.2 | Absolute power tolerance | No | MU/TT is FFS |
| 6.3A.4.3 | Relative power tolerance | No | No contents in the test case (FFS). |
| 6.3A.4.4 | Aggregate power tolerance | No | No contents in the test case (FFS). |
| 6.5A.1 | Occupied bandwidth for CA | No | MU/TT is FFS, TP Analysis has been pending |
| 6.5A.2.1 | Spectrum emission mask for CA | Yes. |  |
| 6.5A.2.2 | Adjacent channel leakage ratio for CA | Yes. |  |
| 6.5A.3.0 | General spurious emissions for CA | No | Test is incomplete |
| 6.5A.3.1 | Spurious emission band UE co-existence for UL CA | No | Other incomplete items in test |
| 6.5A.3.2 | Additional spurious emissions | No | Other incomplete items in test |

### 2.3.2 Testability issues raised for approach using Pcell power limiting via TPC approach.

###  The Aspect of beam peak search

It was identified by some contributors that the peak beam search will have to be performed uniquely for CA tests unless there is a UE vendor declaration of reusing the beam peak result from single carrier [9]. With the approach of limiting power on the PCell, one aspect that needs to be discussed is if this would apply during the peak beam search process as well. If so, then the limiting of PCell power would potentially prevent the SCell drop and peak beam search can be carried out in CA mode. However, the concern about time to obtain peak beam search while trying to limit the PCell power and attain equal PSD on both component carriers was raised at RAN5#92. For intra-band CA, it can be assumed that the peak beam would not differ significantly across component carriers. This has been confirmed by agreement on R5-215819 which can be extended to UL-CA.

**Observation 7: RAN5 has agreed that PCC beam peak direction as the beam peak for intra-band DL CA for a frequency separation of up to 800 MHz. This can be extended to UL-CA.**

###  Dynamic Range Issues and Noise Impact

Another testability issue that has been raised is dynamic range issues and the need to incorporate impact of Noise on testability and MU. An analysis of some test points performed earlier for the MPR FR2 UL-CA test indicates a few aspects

* The impact of noise floor increases with channel bandwidth
* Impact is lower for lower MPR values
* Since measurement for UL-CA tests occurs on per CC basis, some of the dynamic range impact can be approximated to the single carrier case.

[12] provided an extensive analysis of the testability limit and MU value for “influence of noise” for FR2 CA tests where MPR tests.

**Observation 8: Focusing on a reduced set of test points for MPR UL-CA tests allows to avoid testability issues related to noise impact while enabling testing for UL-CA configurations. This can be based on**

* **- Limited to up to aggregated channel bandwidth of 800 MHz**
* **- Limit test points to MPR of 5 dB (from <=200 MHz CBW Single Carrier MPRwt Table) and 3 dB (from 400 MHZ CBW Single Carrier MPRwt Table).**
* **Additional analysis and selecting a subset of test points would help arrive at a stable set of MPR FR2 UL-CA test points where noise impact to measurements are minimal.**

2.3.3 Option 1: Use TPC to limit PCell Power

Most of the focus of RAN5 has been to explore test mode versus non test mode options to accomplish the desired objective of the FR2 RF CA test scenarios. There has been no agreement to adopt one or the other and in lieu of the ongoing RAN4 discussion.

As stated in [4] and [7], one way of preventing SCell dropping would be to limit the maximum power for the PCell to reserve power for SCell transmissions, at least for particular transmissions e.g. for PUSCH without UCI. Moreover, by limiting the SCell maximum power in addition, a behavior similar to that for LTE in which scaling applies uniformly for each serving cell as noted previously, from 36.213,



an “equal PSD” condition, could be achieved for PUSCH transmissions.

For FR1, the configured maximum output power is specified at the antenna connector and can be determined by . For FR2, on the other hand, both the configured power per cell and the total configured power are specified in implementation-specific plane of references internal to the UE. Absolute power limits configured by the network are therefore not viable for these parameters. Moreover, the UE power class for FR2 is specified in terms of EIRP that is impossible to control for UE operations in the field.

Again from [4], it can be gathered that a limit relative to the configured power can be specified to work around the issue of PCell and SCell power getting limited. This would also account for the *actual* power back-off (up to MPR) that is applied by the UE, which is unknown to the network but included in the PHR determination. The network would then configure the UE with UE-specific relative limits *X*max,f,c on the PCell and possibly also one or more SCells

relative to an absolute reference power Pref that could be implementation specific. The relative limitation must not necessarily apply to all transmissions, only to specific transmissions like PUSCH without UCI or of priority 0. Other transmissions would not be limited.

From 38.521-2 clause 6.2.4.3, we know that

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

Also 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 [24].

For intra-band CA, the MPR for each serving cell is the same as that for the total power. Hence the same power back-off is normally assumed for both the and the . Suppose we pick . If the network configures the UE with a value of *X*max,f,PCell > 0 dB, then the for the PCell should be reduced by this value and power for SCells would therefore be ensured as the total power is unchanged.

An example of intra-band UL CA with allowed MPR for FR2 UE configured with a limit relative to and four UL component carriers is shown in Figure 4.1. The ordinate shows the transmitted power density of the component carriers in relation to the , the and the as seen in the respective plane of reference (different at least for the power class). The power back-off up to the allowed MPR is measured relative to the power class. Configuration of the relative limit reduces the configured power for the PCell, the remaining power up to is available for the SCells. Setting = 6 dB would make possible transmissions with equal power spectral density on all configured cells if the same limit is configured for the SCells.



Figure 4.1: UL intra-band contiguous CA – avoiding power limitation on SCell in FR2

Based on reference diagram in [4] with additional parameters added

**Observation 9: To prevent SCell dropping due to a large power reduction, the discussed approach in RAN5 aligns with ongoing discussions in RAN4 that seek to attain the same objective i.e. limit the PCell power.**

**Option 1: To prevent SCell dropping due to a large power reduction, configure a power back-off on the PCC power via TPC so that remaining power up to Pcmax is available for Scells. Start with a limited set of test points on MPR CA tests to unblock UL-CA testing.**

**Observation 10: One aspect that kept arising with this option, however, is the MU impact of the dynamic range/noise issues discussed in this section. Based on some feedback from TE vendors, this aspect could not really be resolved and has been a constant limitation of Option 1.**

2.3.4 Option 2: Use Conformance Test Function to apply limit on PCell Power *(no impact on PCC prioritization rules)*



To help avoid some of the testability issues that are of concern when adjusting the power levels of PCC and SCCs during UL-CA RF conformance tests, it is proposed to have a test function that can apply the backoff or limit of power on the PCell. This will enable to UE to apply the backoff in response to the conformance test function and enable the SCells to stay active. This will enable testing of UL-CA configuration with prioritization rules enabled per TS 38.213. However, considering the impact on UEs that are already commercialized, this option should be limited to Release 16 and forward until and if a RAN4 solution is available ~~since the RAN4/RAN2 solution is planned in Release 17~~. This option potentially serves as a compromise among the solutions available.

**Option 2: Introduce a conformance test function, for Release 16 onward testing only, to apply the backoff Xmax,f,Pcell that the UE can apply during the UL-CA conformance tests that are configured to test at max transmit power.**

**Observation 11a: Based on prior discussions, this approach effectively puts the responsibility on the UE to backoff/set it transmit power in response to the test function.**

Based on clarification shared during email discussions the impact of Noise has to be evaluated assuming a back-off of Xmax,f,c to the PCell power applied via a conformance test function as well.

|  |  |
| --- | --- |
| **Number of CCs** | **Xmax,f,c (dB)** |
| 2 | 3.0103 |
| 3 | 4.771213 |
| 4 | 6.0206 |
| 5 | 6.9897 |
| 6 | 7.781513 |
| 7 | 8.45098 |
| 8 | 9.0309 |

Based on the above the below computation of the delta SNR can be performed using the approach outlined in

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  |  | Xmax | 4.77 | dB |  |
| MPR SNR | ACP SNR | DSNR 3 CC |  |  |  |
|  |  | 400MHz | 200MHz | 100MHz | 50Mhz |
| **24.48** | 7.48 | **0.71** | **0.37** | **0.19** | **0.10** |
| **22.48** | 5.48 | **1.08** | **0.58** | **0.30** | **0.15** |
| **21.98** | 4.98 | **1.20** | **0.64** | **0.33** | **0.17** |
| **21.48** | 4.48 | **1.32** | **0.71** | **0.37** | **0.19** |
| **20.98** | 3.98 | 1.46 | **0.79** | **0.41** | **0.21** |
| **19.98** | 2.98 | 1.77 | **0.98** | **0.52** | **0.27** |
| **19.48** | 2.48 | 1.95 | **1.08** | **0.57** | **0.30** |
| **17.98** | 0.98 | 2.55 | 1.46 | **0.79** | **0.41** |
| **17.48** | 0.48 | 2.78 | 1.61 | **0.88** | **0.46** |
| **15.98** | -1.02 | 3.55 | 2.13 | **1.19** | **0.64** |
| **15.48** | -1.52 | 3.84 | 2.33 | **1.32** | **0.71** |
| **13.98** | -3.02 | 4.78 | 3.02 | 1.76 | **0.97** |
| **13.48** | -3.52 | 5.12 | 3.27 | 1.94 | **1.08** |
| 12.98 | -4.02 | 5.47 | 3.55 | 2.12 | **1.19** |
| 12.48 | -4.52 | 5.83 | 3.83 | 2.32 | **1.32** |
| 11.98 | -5.02 | 6.21 | 4.13 | 2.54 | 1.45 |
| 11.48 | -5.52 | 6.59 | 4.44 | 2.77 | 1.60 |
| 10.98 | -6.02 | 6.99 | 4.77 | 3.01 | 1.76 |
| 10.48 | -6.52 | 7.39 | 5.11 | 3.27 | 1.93 |
| 9.98 | -7.02 | 7.81 | 5.46 | 3.54 | 2.12 |
| 9.48 | -7.52 | 8.23 | 5.83 | 3.83 | 2.32 |
| 6.98 | -10.02 | 10.43 | 7.80 | 5.46 | 3.53 |
| 6.48 | -10.52 | 10.89 | 8.22 | 5.82 | 3.82 |
| 5.98 | -11.02 | 11.35 | 8.65 | 6.19 | 4.12 |
| 5.48 | -11.52 | 11.82 | 9.08 | 6.58 | 4.43 |

**Observation 11b:** Based on preliminary analysis (additional feedback and analysis is welcome), it is likely there will be some limitation on the number of testable points even with test function usage.

2.3.5. Await RAN4/RAN2 configuration updates

As per the way forward identified in RAN4 [11], which will be worked on in Release 17 timeframe (but could be backward release compatible), the discussion includes “a ‘RAN4 only solution’ but changes to RAN2 specifications also needed: configured power limits for UL serving cells and MAC-CE for enabling/disabling limits”.

**Observation 12: RAN4 solution being worked on in Release 17 with possibility of RAN2 updates**

**Option 3: Based on the Observation 7 and Observation 11, the option is to wait for RAN4/RAN2 solution (configured power limits for PCell/SCell and MAC-CE for enabling/disabling limits).**

**Observation 13: One aspect that has arisen from discussions is that even this approach will have the same issue of uncertainty on the UE side with respect to setting transmit power as Option 2 (same as Observation 11b).**

**Considering:**

* **Persistent MU (due to dynamic range/noise) impact seen with relying on TPC to back off PCell power (Option 1)**
* **Option 2 and 3 will need similar analysis in terms of which UL-CA test points are testable (both options effectively limit PCell power to enable Scell to stay active)**
* **Considering Option 3 is still ongoing discussion in RAN4 and not yet discussed in RAN2, timeline favors Option 2 as it will enable RAN5 to understand the effects of UL-CA conformance testing using the PCell Limit approach. From technical standpoint, both options seem to have similar disadvantages and disadvantages.**

**Observation 14: The RAN4 WF from RAN4#101-bis is added as reference under Appendix A.1. This gives an idea about the number of FFS items and options being discussed for this topic**

**Proposal 1: Prefer Option 2 (test function) to enable coverage for the testable UL-CA FR2 RF tests with no core WG dependency.**

***Option 3 would become the default way forward if there are strong concerns with Option2. RAN5 company inputs/preferences to both these options are critical to achieve consensus either way.***

# 3 Summary

In this contribution, the following observations were made

**Observation 1:** As per TS 38.213 prioritization rules, PCC is prioritized over SCC. This is also the mode of operation in the field

**Observation 2:** RAN4 clarified via LS [2] to RAN5 that equal PSD is preferred test condition. However, actual UE behavior in the field has to be considered as well as prioritization rules in TS 38.213 to identify testing details.

**Observation 3:** RAN5 has agreed that the way forward recognizes prioritization rules in TS 38.213 [10]

**Observation 4:** RAN5 has to analyse and define test procedures which will ensure testability for intra-band UL-CA scenarios. Considering the ongoing RAN4 discussion, a potential solution from RAN4 cannot be precluded.

**Observation 5:** RAN1 confirms that no changes to prioritization rules is planned as there is no known issue as such. Further any UE-specific configuration of power limits to prevent SCell drop would not conflict with RAN1 specifications but a confirmation on this is dependent on the actual RAN4 solution.

**Observation 6:** There are 3 (three) completed FR2 RF UL-CA tests that are blocked solely by SCell drop issue. Other tests are not complete in the spec : either have multiple other blocking issues or are not yet introduced in the spec even in Release 15 work plan for the past many RAN5 meetings.

**Observation 7:** RAN5 has agreed that PCC beam peak direction as the beam peak for intra-band DL CA for a frequency separation of up to 800 MHz. This can be extended to UL-CA

**Observation 8:** Focusing on a reduced set of test points for MPR UL-CA tests allows to avoid testability issues related to noise impact while enabling testing for UL-CA configurations

**Observation 9:** To prevent SCell dropping due to a large power reduction, the discussed approach in RAN5 aligns with ongoing discussions in RAN4 that seek to attain the same objective i.e. limit the PCell power.

*Option 1: To prevent SCell dropping due to a large power reduction, configure a power back-off on the PCC power via TPC so that remaining power up to Pcmax is available for Scells. Start with a limited set of test points on MPR CA tests to unblock UL-CA testing.*

**Observation 10:** One aspect that kept arising with this option, however, is the MU impact of the dynamic range/noise issues discussed in this section. Based on some feedback from TE vendors, this aspect could not really be resolved and has been a constant limitation of Option 1.

*Option 2: Introduce a conformance test function, for Release 16 onward testing only, to apply the backoff Xmax,f,Pcell that the UE can apply during the UL-CA conformance tests that are configured to test at max transmit power.*

**Observation 11a:** Based on prior discussions, this approach effectively puts the responsibility on the UE to backoff/set its transmit power in response to the test function.

**Observation 11b:** Based on preliminary analysis (additional feedback and analysis is welcome), it is likely there will be some limitation on the number of testable points even with test function usage.

**Observation 12:** RAN4 solution being worked on in Release 17 with possibility of RAN2 updates

*Option 3: Based on the Observation 7 and Observation 11, the option is to wait for RAN4/RAN2 solution (configured power limits for PCell/SCell and MAC-CE for enabling/disabling limits).*

**Observation 13:** One aspect that has arisen from discussions is that Option 3 will require similar analysis of testability and UE side uncertainty with respect to setting transmit power as Option 2.

**Observation 14:** The RAN4 WF from RAN4#101-bis is added as reference under Appendix A.1. This gives an idea about the number of FFS items and options being discussed for this topic

**Proposal 1: Prefer Option 2 (test function) to enable coverage for the testable UL-CA FR2 RF tests with no core WG dependency.**

***Option 3 would become the default way forward if there are strong concerns with Option2. RAN5 company inputs/preferences to both these options are critical to achieve consensus either way.***

# 4 References

1. Action\_Points\_RAN5#90-e\_atRFsession
2. R5-2103124, LS from RAN4 to RAN5 on SCell Dropping due to PCC Prioritization, 3GPP TSG RAN WG5 Meeting #91-e, February 2021
3. R5-211227, Discussion on PCC prioritization, 3GPP TSG RAN WG5 Meeting #90-e, February 2021
4. R4-2101722 Scell Dropping behavior and verification thereof, Ericsson, 3GPP TSG RAN WG4 Meeting #98-e, February 2021
5. R5-212812 Discussion on Tx power allocation prioritization for FR2 UL CA testing, Qualcomm, 3GPP TSG RAN WG5 Meeting #91-e, May 2021
6. R5-213809 Discussion on SCell dropping and UL CA testing in NR FR2, Ericsson, 3GPP TSG RAN WG5 Meeting #91-e, May 2021
7. R5-213818 Discussion on FR2 test procedure updates to handle PCC Prioritization, Apple, 3GPP TSG RAN WG5 Meeting #91-e, May 2021
8. R5-212919, Discussion on FR1 and FR2 PCC priorization, Huawei, 3GPP TSG RAN WG5 Meeting #91-e, May 2021
9. R5-213809, Consideration on Scell drop issue for FR2 UL CA, Anritsu, 3GPP TSG RAN WG5 Meeting #91-e, May 2021
10. R5-211941, Discussion on PCC prioritization for FR1 and FR2 UL CA testing, Qualcomm Finland, 3GPP TSG RAN WG5 Meeting #90-e, February 2021

[11] R4-2114949, WF on solution for Scell dropping issue, Huawei, RAN4#100

[12] R5-206611, Noise impact for FR2 CA test case where MPR applies, Anritsu, RAN5#89e

[13] R5-211104, Correction of parameters of FR2 ACLR test case, RAN5#90e

# APPENDIX

A.1 RAN4 WF from RAN4#101-bis

**Background**

*SCell dropping proposals*

* Option 1: the configured maximum power Pcmax,f,c for the serving cells are modified by UE-specific configured power limits, and can be modified/enabled/disabled by MAC/CE for fast adaptation to changing radio conditions and applies for concurrent transmissions; The relative limits apply for concurrent UL transmissions, if only transmission scheduled on one cell this would get all available power up to PCMAX
* Option 2: Power distribution among PCell and SCell proportionally should be considered at NW side according to the RB resource scheduling info for CCs, and the power ratio for PCell and SCell(s) can be configured to UE. The power ratio can be configured via RRC on UE specific basis, and enable/disable via DCI or MAC-CE for fast adaption of the dynamic RB resource allocation for PCell and SCell(s).
* Option 3: Define new parameter to indicate priority between configured UL cells for the UE. Supporting Ran4 based solution introducing any new network controlled parameters should be optional for the UE.
* Option 4: RAN4 will not agree a solution before receiving RAN1 feedback about the feasibility of one of the proposed solutions.
* Option 5: Considering postpone this work to future release if no consensus can be made.

*Pcmax,CA and PHR for CA Proposals*

* Consider reporting Pcmax,CA and total PHR for band combination.

**Way forward**

*SCell dropping solution if needed, the following aspects are to be further discussed*

*Agreement:*

* Consider adding a new RRC signalling in the feature list, details depends on the final solution if any
	+ Discuss whether to test delta-Pcmax to minimize the efforts in RAN5 testing
* FFS: Configured maximum power Pcmax,f,c for serving cells can be modified by a UE-specific parameter, which is configured by network
* FFS the network configured parameter
	+ can be semi-persistent/dynamic configured
	+ can be fast enabled/disabled
	+ can be adjusted dynamically due to the allocated resource in PCell/Scells
	+ need to make sure the priority is not always on PCell
	+ can be fast enable/disable or modified by MAC-CE
	+ can guarantee equal PSD among CCs, though equal PSD is not always the case
* The solution should have no RAN1 impact in Rel-17
* Whether and how to implement the RAN4 requirements based on the final solution if any
* FFS on the measurement, i.e. whether to reflect the network configured parameter in Pumax
* FFS whether Pcmax,CA and PHR for CA is needed considering the following issues
	+ 1) Whether the proposal is mandatory from now on
	+ 2) Whether it override the current Per-CC PHR reporting? Or what is NW expected to do if receiving both per-CC and per-BC PHR reports? Or there is only one report, either per-CC or per-BC, but not both?
	+ 3) Does network really need to know the PCMAX,CA?
* FFS on how to proceed if no consensus can be reached.

A.2 Summary of email discussion during RAN5#94

A.3 Summary of feedback and Company preferences/support during RAN5#93e

|  |  |  |
| --- | --- | --- |
| **Options** | **Companies Supporting***[ ] -> not opposed to* | **Comments** |
| **Option 1**     Configure a power back-off on the PCC power via TPC so that remaining power up to Pcmax is available for Scells. Start with one prioritized scenario (For example 2CC 100+100 MHz QPSK modulation) in MPR CA tests to unblock UL-CA testing. | Huawei, Apple, *[Qualcomm], [Ericsson], [DISH]* | Apple associated CR R5-217717 aligned with this option**Pros**       - Aligns with potential solution being discussed in RAN4 (limit PCell power) but accomplishes it with RAN5 test procedure updates       -  Some test complexity indicated previously (beam peak search) can be resolved via earlier agreements to use PCC based beam peak direction which can be extended to UL-CA, and by limiting test points-    Applicable from Rel.15 onwards **Cons**-   Additional analysis needed for some pending testability items and to be captured in Editor’s notes if adopted (MU, power tolerance, stability impact especially with higher # of CCs) |
| **Option 2**Introduce a conformance test function, for Release 16 testing only, to apply the backoff *Xmax,f,Pcell* (no impact on prioritization rules) that the UE can apply during the UL-CA conformance tests that are configured to test at max transmit power. | *[Apple],*Qualcomm, Verizon, Anritsu | Example CR implementation listed in Annex of Discussion Paper.**Pros**     -  Enables use of test function to limit PCell power; while aligning with prioritization rules (as expected by 38.213/real network behavior) and potentially simplifying procedure (Per Ericsson this needs to be investigated as RAN4 approach could be similar and open issues have been identified).       -  Applicable in Rel16 and forward**Cons**-  UE tested in “conformance test only” mode not aligned with real network-  Additional UE implementation of TF. Updates needed across specs other than 38.521-2 (38.508-1, 38.509). |
| **Option 3**Based on the Observation 7\* and Observation 11\*, the option is to wait for RAN4/RAN2 solution targeted in Release 17 | Ericsson, DISH |      - Ericsson CR R5-217652 (RAN4 dependent) was aligned with this option**Pros**      -  Default option. Helps align with way forward from core WG      -  Long term solution, when available **Cons**  -    Timeline and RAN4/RAN2 agreements are TBD. No conclusion at RAN4#100 (discussion will continue at RAN4#101-bis). RAN2 discussion pending start.-  As of now, applicable Rel17 and forward only [Ericsson] - although might be early implementable in Rel-16). |
| **Option4**: Implement option1 for Rel 15 and Option2 for Rel16 and forward. | Orange*, [Apple], [Qualcomm]* | **Pros**-  Allows test to be completed for Rel16 and above via Option 2 and updated for Rel15 with Editor’s notes capturing pending items for Option 1.**Cons**-   Spec update becomes complicated to manage for two releases. Will need maintenance/update within test case.-   Device validations will be different in Rel.15 and Rel.16 as test procedure and MU impact is different in each (although one option *might* potentially have lower MU impact) |