**3GPP TSG-RAN WG4 Meeting # 109 DRAFT R4-2318147**

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

**Agenda item:** 8.27.3

**Source:** Moderator (Nokia)

**Title:** Topic summary for [109][141] NR\_cov\_enh2\_part2

**Document for:** Information

# Introduction

This summary handles the Tdocs submitted for agenda:

* 5.27.1.2

The discussion is a continuation of previus discussions with a startingpoint in the WF from last meeting [R4-2317652 ].

**List of targeted discussions for this topic during the meeting.**

* The scope of transparent schemes to be included within Rel-18 timeframe.
* How to introduce MPR reduction and/or Power Boosting for QPSK with DFT-s-OFDM to the specification.
* Whether or not new capabilities are needed defined by RAN2, if so shall there be multiple and if pi/2 BPSK also is a part of the Rel-18 coverage enhancement work.

## List of Companies’ contributions

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| --- | --- | --- |
| **T-doc number** | **Company** | **Title / Proposals / Observations** |
| [**R4-2318715**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318715.zip) | MediaTek Inc. | ***Further discussion on MPR reduction***  **Proposal 1:** Considering power boosting applicable to a sub-set of inner region with MPR=0, and the scope of the WID and time limitation to complete the WID, power boosting is proposed to be tied with transparent scheme in Rel-18.  **Proposal 2:** RAN4 to specify a simple solution for power boosting and transparent scheme:  **•** Introduce power boosting only for the enhanced inner region ( a subset of inner region where 1-dB power boosting can work alone)  o Introduce a new capability of relaxed spectrum flatness, and with the capability reported, power boosting is done with >1 dB, otherwise, 1dB.  • Other regions than the inner region, no power boosting is allowed, and only improved MPR is specified.  **•** In the exceptional inner region slice, no enhancement is expected, i.e., only legacy operation applies. |
| [**R4-2318760**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318760.zip) | Apple | ***On coverage enhancement using transparent schemes***  **Observation 1:** The increased build-in linearity of PC2 amplifiers (compared to PC3) result into about 0.2 to 0.3 dB increased power for inner allocations without the use of FDSS. PC3 inner allocations are close to 1dB above the nominal power class while there is more headroom for PC2.  **Proposal 1:** Since PC3 inner allocations without FDSS are very close to the envisaged 1dB it is proposed to enable/allow FDSS for inner allocations to account for implementation challenges. The maximum allowed equaliser ripple shall be chosen to only allow light filter to minimise the impact on the receiver side.  **Observation 2:** When considering 2-Tab filter the use of light filter such as [1 0.17] provide the majority of power boost advantage. More aggressive setups only provide minimal gains compared to [1 0.17]. In total it seems that filter setups of [1 0.26] or lighter should be used.  **Observation 3:** At high output power the spectral domain shaped waveform is typically EVM or IBE limited. It is important to consider that the simulations typically do not include all impairments of the transmit chain. The main impairments are power amplifier non-linearity and IQ image. Other aspects such as transmitter chain non-linearity or memory are typically not modelled which can cause additional impact on the ripple. A UE vendor might therefore not be able to use shaping filter which exactly reach the spectral flatness requirement but need to deploy less aggressive filter to fit inside the mask. These effects need to be accounted for when specifying tightened equalizer spectral flatness requirements.  **Observation 4:** UE power boost indication can be done by a single capability option. In this case, power boost should only be applicable for the advertised power class with ΔPPowerClass = 0dB. Otherwise, if two signalling options are introduced (one for advertised power class and one for fallback, ΔPPowerClass = 3dB) the UE vendor can indicate support of power boost in case of ΔPPowerClass = 3dB. This is especially beneficial in case the UE does not support power boost for the advertised power class but can support power boost in case of ΔPPowerClass = 3dB. The UE can signal one of the options or both. The network statically configures power enhancement, and the UE applies power boost according to its signalled capability.  **Proposal 2:** Introduce a UE power boost capability signalling for the advertised power class and another signalling for ΔPPowerClass = 3dB. This allows the UE vendor to indicate to the network that power boost is available for advertised power class or in case of ΔPPowerClass = 3dB or for both options.  **Observation 5:** During last RAN4 meeting it was discussed to include Pi/2 BPSK modulation for boosting with the same RB allocations regions. The reasoning is that in a cell edge scenario the network might switch from QPSK boosting to Pi/2 BPSK and there should be a gain when reducing modulation order. However, the proposed allocation regions for QPSK are not in line with the findings of the Rel-17 study item. The Pi/2 BPSK region needs to be different than the currently proposed QPSK boost regions and a dedicated region for Pi/2 BPSK seems to be needed.  **Proposal 3:** To avoid the introduction of several new RB allocation regions, define QPSK power boosting for the entire inner region. Allow light filter such as 2-Tab filter (those which have low degradation at receiver side) in the inner RB region to guarantee that the targeted 1dB is achievable in all cases. Define new region for Pi/2 BPSK power boosting according to the findings of the Rel-17 study item |
| [**R4-2318761**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318761.zip) | Apple | ***CR on Introducing Rel-18 Power Boost for QPSK and Pi/2 BPSK*** |
| [**R4-2318772**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318772.zip) | Qualcomm Incorporated | ***An approach to specify transparent UL enhancements for Rel-18***  **Observation 1:** The value of RB offset parameter P1 has dependence on PA characteristics, even after the RAN4 power normalization. The values are similar across PC2 and PC3.  **Observation 2:** For PC2, simulation data for boosted performance is well aligned with lab observations.  **Proposal 1:** The enhanced inner region that can support 1 dB boost without FDSS is defined as the legacy inner region that is retracted by the parameter ‘P1’:  RBStart,Low,enhInner ≤ RBStart,enh ≤ RBStart,High,enhInner,  where:  RBStart,Low,enhInner = max(1, floor(LCRB/2)) + P1  RBStart,High,enhInner = NRB – RBStart,Low,enhInner – LCRB  **Proposal 2:** To lower the barrier for PC2 UEs to support PC2 boost, non-zero MPR (for example: 0.5 dB) can be instituted for the enhanced inner region that is reserved for boost without FDSS.  **Observation 3:** For maximizing network benefit, the enhancement area should be framed as a *minimum* area where the UE must demonstrate the enhancement.  **Observation 4:** If parameters P1 and P2 are each specified as a range, their maximum values set a minimum enhancement area.  **Proposal 3:** The minimum region that can support UL enhancement when the UE selectively uses FDSS is derived from the enhanced inner region as:  RBStart,Low,enh = max(1, P1, P2\*floor(LCRB/2))  RBStart,High,enh = NRB – RBStart,Low,enh – LCRB  Where:  P1 <= min(12, ceil (2+NRB/25))  P2 <= [4/9]  **Proposal 4**: Define as a package, an enhancement based on the legacy waveform as well as a complementary enhancement based on use of FDSS  **Observation 5:** If a UE can support DFT-s-QPSK enhancement with FDSS, it can typically meet the same requirements with DFT-s-BPSK with additional margin.  **Proposal 5:** For completeness, RAN4 includes pi/2 BPSK as part of the Rel-18 coverage enhancement. |
| [**R4-2318774**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318774.zip) | Qualcomm Incorporated | ***dCR on coverage enhancements using FDSS*** |
| [**R4-2318805**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318805.zip) | Qualcomm, Verizon, Ericsson, AT&T, T-Mobile, ZTE, Fujitsu, KDDI, NTT-Docomo | ***Scope of transparent UL enhancements for Rel-18***  **Proposal 1:** PC2 and PC3 are enabled for the Rel-18 UL power enhancements (FR1)  **Proposal 2:** The Rel-18 UL power enhancement feature is enabled for TDD as well as FDD bands for single CC UL in the supported band.  **Proposal 3:** Any UE capabilities defined for the Rel-18 UL power enhancement feature are defined as optional per band, per band combination, for futureproofing. |
| [**R4-2318962**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318962.zip) | vivo | ***Discussion on transparent schemes for coverage enhancement***  **Observation 1:** Within the inner region, not all RB allocations can achieve 1 dB boost value even using FDSS.  **Observation 2:** To reach 1dB power boosting value, FDSS is necessary for most part of the inner region.  **Observation 3:** The △Ppowerclass implies the change of power level is comparable to the difference between different power class, e.g., 3 dB, 6dB etc. Reusing this parameter for 1 dB power boost will break this original intention.  **Observation 4:** ΔPpowerclass takes effect on the entire RB allocation regions. But power boosting in R18 will only be defined within a certain region of RB allocation.  **Observation 5：**In scheme1, the bounds of PCMAX,f,c could be changed as follows. It should be noted that, ΔPPowerBoost =1 dB only applies to inner region.  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) }  PCMAX\_H,f,c = MIN {PEMAX,c, PPowerClass – ΔPPowerClass + ΔPPowerBoost }  **Observation 6:** The MPR of the outer + edge region can be reduced to a lower level, i.e., 0.6dB with FDSS, and the reference power of 0 dB MPR retains at 23dBm for PC3 in scheme 1.  **Observation 7:** MPR requirement for scheme 1 could be changed as Table 1.  **Observation 8:** In scheme2, the bounds of PCMAX,f,c could be changed as follows. It should be noted that, ΔPPowerBoost =0.3 dB only applies to inner region.  PCMAX\_L,f,c ≤ PCMAX,f,c ≤ PCMAX\_H,f,c with  PCMAX\_L,f,c = MIN {PEMAX,c– ∆TC,c, (PPowerClass – ΔPPowerClass + ΔPPowerBoost) – MAX(MAX(MPRc+∆MPRc, A-MPRc)+ ΔTIB,c + ∆TC,c +∆TRxSRS, P-MPRc) }  PCMAX\_H,f,c = MIN {PEMAX,c, PPowerClass – ΔPPowerClass + ΔPPowerBoost }  **Observation 9:** MPR requirement for scheme 2 could be changed as Table 2.  **Proposal 1:** The power boosting is only applied to current inner region, and only upper bound of PCMAX,f,c can be improved. The MPR requirement for the inner region retains at 0dB.  **Proposal 2:** Introducing a new parameter to indicate power boost value is better than reusing ΔPPowerclass, e.g., ΔPPowerBoost.  **Proposal 3:** Scheme1 can be used as baseline for R18 power boosting.  **Proposal 4：**If both the bounds of PCMAX,f,c need to be increased, the boost value should be set to smaller than 1dB, e.g. ΔPPowerBoost =0.3dB. |
| [**R4-2318963**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318963.zip) | vivo | ***Draft CR1 for TS38.101-1 on coverage enhancement*** |
| [**R4-2318964**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2318964.zip) | vivo | ***Draft CR2 for TS38.101-1 on coverage enhancement*** |
| [**R4-2320031**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2320031.zip) | Nokia, Nokia Shanghai Bell | ***On completion of Rel-18 MPR-PAR objective***  **Observation 1:**  According to WID and agreements made until now, there are two transparent MPR/PAR reduction schemes on table:   * Reference case (legacy DFT-s-OFDM) without FDSS * FDSS (transparent scheme)   **Observation 2**: For 700MHz case:   * 2-tap filter (the least aggressive) maximizes the net gain in almost all cases​ * When using filter(s) maximizing the net gain:​   + OBO gain for outer is 0.6 - 0.9 dB​   + OBO gain for inner is typically 0.2-0.3 dB (however net gain is close to zero)   **Observation 3**: For 4GHz case:   * 2-tap filter (the least aggressive) maximizes the net gain in almost all cases​ * When using filter(s) maximizing the net gain:​   + OBO gain for outer is close to 1dB​   + OBO gain for inner is typically 0.2-0.4 dB (again, net gain is close to zero)​   **Observation 4:**  Less aggressive filter optimizes the net gain in most cases.  **Observation 5:** Due to already zero MPR requirement, the transmission power for inner allocations cannot be increased without applying power boosting.  **Observation 6:**  Spectrum flatness requirements for the UE is needed to ensure base station receiver performance.  **Observation 7**: Even 2-tap filter does not meet the generic spectral flatness requirement and hence relaxed requirement is needed for FDSS.  **Proposal 1:**  Derive new MPR requirements based on FDSS.  **Proposal 2:**  Prioritize FR1 and power class 3 in Rel-18 WI.  **Proposal 3:**  Prioritize QPSK modulation in Rel-18 WI.  **Proposal 4**: For FDSS, RAN4 shall focus on MPR reduction for outer allocations.  **Proposal 5**: RAN4 shall consider the allocation sizes when defining RF requirements (i.e. spectrum flatness).  **Proposal 6**: Introduce new spectral flatness requirement for FDSS with QPSK in Rel-18 together with MPR/PAR reduction.  **Proposal 7**: Discuss values for X1 and X2, X1=6dB and X2=10dB can be used as starting point.  **Proposal 8**: Discuss the approach presented and related MPR values and introduce MPR reduction for Rel-18.  **Proposal 9**: Reuse duty cycle threshold approach used in pi/2 BPSK for Rel-18 MPR/PAR reduction  **Proposal 10**: Introduce single capability for Rel-18 MPR/PAR reduction covering both power boosting and transparent MPR/PAR reduction. |
| [**R4-2320032**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2320032.zip) | Nokia, Nokia Shanghai Bell | ***CR to 38.101 for introduction of MPR reduction*** |
| [**R4-2320081**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2320081.zip) | Huawei, HiSilicon, SmarterMicro | ***On further enhancements to reduce MPR&PAR***  **Observation 1**: For PC2 power boosting at TDD bands like n41 and n79, the spectrum efficiency has to be traded off since current filter design could be the bottleneck considering at least following factors:   * Qualified flatness performance across the whole large bandwidth. * Steep roll-off during the short gap to the adjacent frequency ranges in order to provide required attenuation for co-existence purpose.   **Observation 2:** The measurements with commercial ready RF components show that there is ~3dB degradation of the noise PSD at 2.4GHz ISM band if 1dB power boosting is applied for PC2 @ band n41.  **Observation 3:** Further measurements with commercial ready RF components show that extra ~0.5dB insertion loss at CBW in Band n41 would be the trade-off if the ~3dB degradation of the noise PSD at 2.4GHz ISM band due to 1dB power boosting based on PC2 is aimed to be accommodated to maintain the original co-ex performance.  **Observation 4:** The measurements with commercial ready RF components show that extra ~1dB insertion loss at CBW in Band n79 would be the trade-off as the 3~4B degradation of the noise PSD at 5GHz ISM band will be introduced by 1dB power boosting based on PC2 and it is aimed to be accommodated to maintain the original co-ex performance.  **Observation 5:** The measurements with commercial ready RF components supporting PC3 for FDD band n3 and n5 show that more than 5dB isolation between Tx and Rx from duplexer must be considered if the Tx power will be increased to PC2 +1dB just to maintain the MSD performance of PC3.  **Observation 6:** Operators’ demands on UL performance enhancement at FDD bands cannot be fulfilled by PC2 power boosting since it will cause MSD degradation that cannot be ignored.  **Observation 7:** The increased power consumption along with the overheating risk that come with such power boosting are still non negligible problems from UE vendor perspective.  **Proposal 1:** Do not consider power boosting on top of PC2 with 1Tx**.**  **Proposal 2:** Power boosting can be considered for PC3 with the following conditions:   * Only for legacy inner region or a sub-set of the legacy inner region with maximum power boost 1dB. * Do not consider other regions. * It can be optionally indicated per band. |
| [**R4-2320082**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2320082.zip) | Huawei, HiSilicon | ***Draft CR for TS 38.101-1 PC3 power boosting*** |
| [**R4-2320356**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2320356.zip) | Spreadtrum Communications | ***Draft CR for TS 38.101-1 PC3 power boosting*** |
| [**R4-2320457**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2320457.zip) | Skyworks Solutions Inc. | ***Proposal on power boosting regions for QPSK w/wo shaping***  **Proposal** on MPR value for QPSK boosting: MPR based on power class plus 3dB is ≤2dB for both DFT-s-QPSK with shaping (spectrum flatness exception allowed) and without shaping (no spectrum flatness relaxation).  **Proposal** on power class and ACLR: power boosting for DFT-s-OFDM QPSK w/wo shaping applies to both PC3 and PC2 with 30db and 31dB ACLR respectively. Since PC1.5 ACLR is 31dB like for PC2, the impact is acceptable.  **Proposal** on spectrum flatness specification:   * Spectrum flatness specified in Table 6.4.2.4.1-1 applies to DFT-s-OFDM QPSK with FDSS * Spectrum flatness specified in Table 6.4.2.4-1 and Table 6.4.2.4-2 applies to DFT-s-OFDM QPSK without FDSS.   **Proposal** on boosting regions:   * Boosting for DFT-s-OFDM QPSK w/wo FDSS does not apply to edge and inner allocations as defined in 38.101-1 section 6.2.2 for PC3 and PC2. * Boosting is specified for DFT-s-OFDM QPSK with FDSS within the current inner region as defined in 38.101-1 section 6.2.2 for PC3 and PC2. * Boosting is specified for DFT-s-OFDM QPSK without FDSS for newly defined region “inner third” which applies to PC3 and PC2 for allocations such that LCRB≤NRB/3 and LCRB<RBstart and RBend<LCRB.   **Proposal** on reduced MPR: Once the boosting region for DFT-s-OFDM QPSK without shaping is agreed, reduced MPR for QPSK CP-OFDM and 16QAM DFT-s-OFDM can be studied |
| [**R4-2320543**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2320543.zip) | Ericsson | ***RF spec impact for transparent MPR reduction scheme***  **Observation 1** For PC3, the 1 dB power boosting can be realized with the baseline performance without the FDSS scheme.  **Observation 2** For PC3, Applying the FDSS stretches the 1 dB power boosting area to part of outer RB region  **Observation 3** For PC2, the 1 dB power boosting can not be realized with baseline scheme.  **Observation 4** For PC2, Applying the FDSS stretches the 1 dB power boosting area to part of outer RB region, but the area is very limited.  **Observation 5** New parameter may introduce complexity on UE power fallback behaviour and complexity on specification update.  **Observation 6** For a UE implementing the FDSS scheme using the 2-tap or 3-tap filter, the general spectrum flatness requirement cannot be met.  **Proposal-1:** Prioritize the inner RB power boosting for both PC2 and PC3 in Rel-18.  **Proposal-2:** To have maximum net gain with 1 dB power boosting, a mild filter should be selected for FDSS scheme.  **Proposal-3:** Only specify the new spectrum flatness requirement for PC2 for inner RB region.  **Proposal-4:** Consider the above spectrum flatness when UE supports the transparent schemes of FDSS  **Proposal-5:** Consider the same spectrum flatness for both BPSK and QPSK when FDSS is applied. |
| [**R4-2320544**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_109/Docs/R4-2320544.zip) | Ericsson | ***CR for NR coverage enhancement Rel-18*** |

# Topic #1: General Issues

## Open issues summary

### Sub-topic 1-1 - Targeted Power Classes

It is suggested by some to only focus on MPR/PAR reduction and/or Power Boosting for PC3 UEs while others want to also include PC2 UEs.

**Issue 1-1: Targeted Power Classes**

* Proposals
  + Option 1: RAN4 shall only consider PC3 UEs for MPR/PAR reduction and/or Power Boosting within Rel-18 timeframe.
  + Option 2: RAN4 shall consider both PC3 and PC2 UEs for MPR/PAR reduction and/or Power Boosting within Rel-18 timeframe.
* Recommended WF
  + TBA

### Sub-topic 1-2 - Targeted Duplex Scheme and/or Band(s)

It is suggested by some to only focus on Power Boosting for TDD bands only, while others want to also include FDD bands and others want this to be a per-band optional feature.

**Issue 1-2: Targeted Duplex Scheme and/or Band(s)**

* Proposals
  + Option 1: RAN4 shall only consider TDD bands for MPR/PAR reduction and/or Power Boosting within Rel-18 timeframe.
  + Option 2: RAN4 shall consider both TDD and FDD bands for MPR/PAR reduction and/or Power Boosting within Rel-18 timeframe.
  + Option 3: RAN4 shall consider MPR/PAR reduction and/or Power Boosting on a per-band level within Rel-18 timeframe.
* Recommended WF
  + TBA

### Sub-topic 1-3 – Targeted Modulation Scheme

It is suggested by some to only focus on MPR/PAR reduction and/or Power Boosting for QPSK while others want to also include pi/2 BPSK.

**Issue 1-3: Modulation Scheme under consideration**

* Proposals
  + Option 1: RAN4 shall only consider MPR/PAR reduction and/or Power Boosting for QPSK.
  + Option 2: RAN4 shall consider MPR/PAR reduction and/or Power Boosting for both QPSK and pi/2 BPSK.
* Recommended WF
  + TBA

### Sub-topic 1-4 – RB region(s) for MPR/PAR reduction and/or Power Boosting.

Based on already discussed simulation results and further input provided for this meeting it can be questioned if and how RB regions shall be divided and if RAN4 shall consider MPR/PAR reduction and/or Power Boosting for all, or only a subset.

**Issue 1-4: RB region(s)**

* Proposals
  + Option 1: RAN4 shall consider MPR/PAR reduction and Power Boosting for “inner” RB regions.
  + Option 2: RAN4 shall consider MPR/PAR reduction and Power Boosting for both “outer” and “inner” RB regions.
  + Option 3: RAN4 shall consider Power Boosting for “inner” RB regions and MPR/PAR reduction for “outer” RB regions.
  + Option 4: RAN4 shall consider Power Boosting and MPR/PAR reduction for “inner” RB regions and MPR/PAR reduction for “outer” RB regions.
  + Option 5: RAN4 shall consider Power Boosting for “inner” RB regions.
* Recommended WF
  + TBA

### Sub-topic 1-5 – UE Capability for Transparent scheme(s)

It has been proposed that RAN4 needs to ask RAN2 to define a UE capability to indicate the support of Transparent MPR/PAR reduction capability and/or Power Boosting of the UE.

**Issue 1-5: UE Capability**

* Proposals
  + Option 1: RAN4 request a single UE capability for Transparent MPR/PAR reduction including potential Power Boosting.
  + Option 2: RAN4 request separate UE capabilities for Transparent MPR/PAR reduction and Power Boosting.
* Recommended WF
  + TBA

# Topic #2: CR for introduction of MPR reduction

## Open issues summary

### Sub-topic 3-2 – draft CRs for introduction of MPR/PAR reduction.

A number of CRs were submitted for this meeting according to the workplan this meeting is supposed to be the last meeting. Hence, efforts on a final agreeable CR should be made.

**Issue 3-2: MPR tables**

* Proposals
  + Option 1: RAN4 shall work on a joint CR for the introduction of MPR/PAR reduction.
  + Option 2: TBA
* Recommended WF
  + TBA