**3GPP TSG-RAN WG4 Meeting # 107 R4-2310028**

**Incheon, KR, May 22nd – May 26th , 2023**

**Agenda item:** 8.28.3

**Source:** Moderator (Nokia)

**Title:** Topic summary for [107][145] NR\_cov\_enh2\_part2

**Document for:** Information

# Introduction

This summary handles the Tdocs submitted for agenda:

* 8.28.2.1 - General and work plan for Enhancement to reduce MPR/PAR   
  (This will include the Tdocs submitted mistakenly under 8.28.2)
* 8.28.2.2 - RF simulation parameters
* 8.28.2.3 - RF simulation results for transparent schemes
* 8.28.2.4 - RF simulation results for non-transparent schemes
* 8.28.2.5 - RF specification impact

The positions from different companies have not changed much and again this meeting seems it difficult to make final agreements on solutions for enhancements to reduce MPR/PAR. As a result, the order of the treatment of the agenda items in this summary are shifted such that we can start with something we may need to progress on before being able to take decision on a solution for MPR/PAR reduction.

At RAN4#106 it was agreed in the WF R4-2306627 that a decision on a solution for MPR/PAR reduction is expected now in RAN4#107.

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

* Obtain agreements on the presented simulation results.
* Convey any agreements on solution for MPR/PAR reduction to RAN1.
* Consider RAN4 specification impact.

# Topic #1: Simulation parameters for transparent and non-transparent schemes (AI 8.28.2.2)

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2308106**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308106.zip) | Nokia, Nokia Shanghai Bell | ***Observation 1***: *RF Simulation parameters are well aligned between RAN1 & RAN4, as well as between different companies.*  ***Proposal 1***: *No further discussion is needed for RF simulation parameters for MPR/PAR evaluations* |
| [**R4-2309200**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309200.zip) | Ericsson | In this contribution, we present our simulation parameters used in non-transparent and transparent schemes. |

## Open issues summary

Based on provided contributions it seems there is no need for further discussion on this topic.

### Sub-topic 1-1: Further discussions on simulation parameters

**Issue 1-1: Is there are need to further discuss simulation parameters for MPR/PAR reduction evaluation?.**

* Proposals
  + Option 1: Yes
  + Option 2: No
* Recommended WF
  + Option 2.

# Topic #2: Evaluation of transparent schemes for MPR/PAR reduction (AI 8.28.2.3)

## Companies’ contributions summary

|  |  |  |
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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2308107**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308107.zip) | Nokia, Nokia Shanghai Bell | **Observation 1:** It can be noted that OBO gain from transparent schemes (compared to the case without filter) is typically less than 1 dB. For the largest RB allocations, the OBO gain is about 1.5 dB.  **Observation 2:** The two-taps filter [1 0.28] requires higher OBO than the three-taps filter [0.335 1 0.335] or TRRC filter.  **Observation 3:** When compared to non-transparent schemes (in [5]), it can be noted that non-transparent schemes outperform transparent schemes with a clear margin.  **Observation 4:** Furthermore, as shown in [5], transparent schemes don’t provide net gain with QPSK (in other words, OBO gain < Rx loss).  **Observation 5:** For similar FDRA, OBO behaviour is very similar between different SCSs.  **Observation 6:** There are no major differences in OBO performance between 20 MHz CBW and 100 MHz CBW cases.  **Observation 7:** Non-transparent schemes outperform transparent schemes with a clear margin in FR2. |
| [**R4-2308275**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308275.zip) | vivo | **Based on OBO performance:**  **Observation 1:** Overall for FDSS w/o SE, the power improvement of TRRC filter is more stable than other filters.  **Observation 2:** For FDSS w/o SE, only minor or even no power boost can be seen for small RB allocation, the boost is more obvious with the increasement of RB allocation.  **Observation 3:** There are no obvious differences in OBO performance between 20 MHz CBW and 100 MHz CBW for transparent cases.  **Observation 4:** The ability of FDSS w/o SE to increase output power is relatively limited, and the overall power boost for FDSS w SE is no more than 1dB compared to legacy DFT-s-OFDM in both 20 MHz and 100 MHz channels.  **Based on net gain:**  **Observation 5:** The FDSS transparent schemes seem to have no net gain in both outer and inner allocations, for some cases with 3tap filter [0.28 1 0.28], the net gain is generally negative. |
| [**R4-2309202**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309202.zip) | Ericsson | **Observation 1** For DFT-s-OFDM and QPSK, at least 0.5 dB gain can be achieved for outer allocation without power boosting. With power boosting, around half to 1 dB gain can be achieved for outer allocation.  **Observation 2** For CP-OFDM and QPSK , there is around 1 dB gain for inner allocation and outer allocation.  **Observation 3** There is 0.3 dB SNR loss for MCS index 0 and around 0.4 dB SNR loss for higher MCS index 6.  **Observation 4** For inner RB allocation, there is no net gain for smaller RB size with or without power boosting.  **Observation 5** For inner RB allocation for bigger RB size and without power boosting, there is 0.5 dB to 1 dB net gain for lower MCS , the net gain is diminishing for higher MCS.  **Observation 6** For inner RB allocation for bigger RB size and with power boosting, there is 0.5 dB to 1.7 dB net gain for lower MCS , the net gain is compressed to 0.5 dB to 1 dB for higher MCS.  **Observation 7** For outer RB allocation without power boosting, the net gain is between 0.5 dB to 1 dB for lower MCS. For higher MCS index (MCS 6), the net gain is compressed to from no gain to around 0.2 dB  **Observation 8** For outer RB allocation with power boosting and for lower MCS index, the net gain can be up to 0.5 dB to 1.7 dB but will be compressed to around 0.5 dB for higher MCS index.  **Observation 9** For CP-OFDM, there is around 1 dB net gain for outer allocation, there is more than 1 dB gain for some of the inner allocation. |

## Open issues summary

Multiple companies have contributed to the evaluation of transparent schemes for MPR/PAR reduction. The results have been collected R4-2308110. The definition of transparent schemes can be referred to the agreement listed below.

**Agreement**: (RAN4 #104bis-e)

* *Frequency domain spectrum shaping without spectrum extension for DFT-S-OFDM is the transparent scheme thus far according to the WID*
* *Other techniques can be discussed depending on RAN Plenary decision*

### Sub-topic 2-1: Collected observations from the evaluation of transparent schemes for MPR/PAR reduction

Based on the provided observations some collected views are tired captured below:

1. Achievable OBO gain from the transparent scheme is typical less than 0.5 dB without power boosting enabled and typical less than 1 dB with power boosting.
2. The largest OBO gain from the transparent scheme is achieved only for the largest RB allocations. For smaller RB allocations the power gain is significantly lower.
3. The OBO gain from the transparent scheme is dependent on RB allocation sizes and placement.
4. Power boosting could be beneficial in certain cases to take the full power gain benefit from transparent schemes

**Issue 2-1: : Simulation results for transparent schemes**

* It is proposed to capture the above general observations in a WF
  + Option 1: Agree
  + Option 2: Do not agree
* Recommended WF
  + TBA

# Topic #3: Evaluation of non-transparent schemes for MPR/PAR reduction (AI 8.28.2.4)

## Companies’ contributions summary

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| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2308108**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308108.zip) | Nokia, Nokia Shanghai Bell | **Observation 1:** Transmitter performance varies with the allocation size in 20 MHz channel: small allocations benefit for larger extension than larger allocations.  **Observation 2:** Less aggressive filters provide good performance especially for inner RB regions and small RB allocations. On the other hand, more aggressive filter provides the smallest MPR for outer RB allocations and larger RB allocations.  **Observation 3:** Non-transparent schemes outperform transparent schemes at least in terms of the amount of MPR reduction  **Observation 4:** For similar FDRA, OBO behaviour is very similar between different SCSs.  **Observation 5:** Transmitter performance varies with the allocation size in 100 MHz channel: small allocations benefit for larger extension than larger allocations.  **Observation 6:** Up to 1.5 dB lower MPR can be obtained with respect to legacy DFT-s-OFDM in both 20 MHz and 100 MHz channels.  **Observation 7:** From the transmitter point of view, tone reservation does not offer gains with respect to FDSS with spectral extension for QPSK modulation and DFT-s-OFDM.  **Observation 8:** Higher order modulations (than QPSK) may benefit from tone reservation over FDSS from the transmitter point of view. |
| [**R4-2308276**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308276.zip) | vivo | **Based on OBO performance:**  **Observation 1:** Overall for FDSS w SE, the power improvement of 3-tap filter and TRRC filter is more obvious than that of 2tap filter.  **Observation 2:** FDSS w SE with extension factor of α=0.25 has the best comprehensive performance for power boost.  **Observation 3:** Compared to 20MHz channel BW, 100MHz channel BW is beneficial for lager extension factor in the same RB allocation case, and the gap of power boost between different RB-start position is also smaller. Beyond that, there are no obvious differences in OBO performance between 20 MHz CBW and 100 MHz CBW cases.  **Observation 4:** The overall power boost for FDSS w SE is generally no more than 2dB compared to legacy DFT-s-OFDM in both 20 MHz and 100 MHz channels. For the small RB allocations typically used in cell edge, the power boost will be significally smaller, e.g. smaller than 1dB.  **Based on net gain:**  **Observation 5**: The net gain of FDSS W SE is generally positive.  **Observation 6:** With the same MCS index, extension factors, filter and RB allocations, the net gain of the outer cases (RB start position is at the egde) is more obvious than inner cases (RB start position is in the middle).  **Observation 7**: Net gain diminishes when MCS index is too high.  **Observation 8:** There are no obvious differences in net gain performance between 20 MHz CBW and 100 MHz CBW for non-transparent cases. |
| [**R4-2309075**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309075.zip) | Apple | **Observation 1:** If a conventional receiver (which only considers the in-band portion of the signal) is deployed at gNB then some of the waveform energy is excluded during the demodulation process and therefore information which would improve the result. In case of spectrum extension, the extension contributes to the total output power which also contributes to the OBO. If a conventional receiver would be deployed in the field, then the net-gain analysis needs to consider this loss by adjusting OBO accordingly.  **Observation 2:** Outstanding for transparent schemes are the results from Qualcomm as those report up to 1.5dB. Qualcomm results are obtained by using other peak cancelation techniques which differ from FDSS. It seems that transparent schemes other than FDSS should be considered to find optimum performance.  **Observation 3:** The net-gain of transparent techniques can never fall below zero if optimization is done by considering all options. The worst case for the net-gain is that it approaches zero.  **Observation 4:** The average advantage of FDSS-SE versus transparent techniques across all analyzed RB allocations is approximately 0.74dB. For outer allocations the average advantage is approximately 0.65dB. The largest RB allocation size consists of 40 RBs.  **Observation 5:** Transparent techniques have the advantage that those are far simpler to be implemented. Impact on baseband processing is lower. Also, the optimization effort during implementation is reduced. With transparent techniques a UE vendor has only to consider the amount of RBs and their location for finding an optimum setup. In case of non-transparent techniques such as FDSS-SE the UE vendor must additionally consider the extension factor and the adapted MCS. The extension factor introduces another dimension which needs to be handled when optimizing the net-gain. The various data needs to be stored in the UE with large tables creating additional costs as more memory is required.  **Proposal:** Considering the low advantage of FDSS-SE versus existing transparent schemes it is proposed to lay the focus on optimizing transparent techniques. |
| [**R4-2309201**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309201.zip) | Ericsson | **Observation 1** For DFT-s-OFDM and QPSK and inner allocation without power boosting, 0.5 dB again of MPR can be achieved for bigger RB size. With power boosting, around 1 dB gain can be achieved for inner allocation.  **Observation 2** For DFT-s-OFDM and QPSK and outer allocation without power boosting, most schemes can achieve at least 0.5 dB gain compared to baseline. With power boosting, the gain still around 1.5 dB.  **Observation 3** For CP-OFDM and QPSK , there is around 1 dB gain for inner allocation and outer allocation.  **Observation 4** There is 0.6 dB SNR loss for lower MCS index and and around 1.6 dB SNR loss for higher MCS index 6.  **Observation 5** For inner RB allocation, there is no net gain for smaller RB size with or without power boosting.  **Observation 6** For inner RB allocation for bigger RB size and without power boosting, there is 0.5 dB to 1 dB net gain for lower MCS , the net gain is diminishing for higher MCS.  **Observation 7** For inner RB allocation for bigger RB size and with power boosting, there is 1 dB to 2 dB net gain for lower MCS , the net gain is compressed to 0.2 dB to 1 dB for higher MCS.  **Observation 8** For outer RB allocation without power boosting, the net gain is between 0.5 dB to 1 dB for lower MCS. For higher MCS index (MCS 6), the net gain is compressed to from no gain to negative gain.  **Observation 9** For outer RB allocation with power boosting and for lower MCS index, the net gain can be up to 0.8 dB to 2 dB but will be compressed to around 0.5 dB for higher MCS index.  **Observation 10** For CP-OFDM and tone reservation scheme, there is around 1 dB net gain for outer allocation, there is more than 1 dB gain for some of the inner allocation. |

## Open issues summary

Multiple companies have contributed to the evaluation of non-transparent schemes for MPR/PAR reduction. The results have been collected R4-2308110.

### Sub-topic 3-1: Collected observations from the evaluation of non-transparent schemes for MPR/PAR reduction

Based on the provided observations some collected views are tired captured below:

1. Achievable OBO gain from the non-transparent scheme is typical less than 1 dB without power boosting enabled and typical less than 2 dB with power boosting.
2. The largest OBO gain from the non-transparent scheme is achieved only for the largest RB allocations. For smaller RB allocations the power gain is significantly lower.
3. The OBO gain from the non-transparent scheme is dependent on RB allocation sizes and placements.
4. Power boosting could be beneficial in certain cases to take the full power gain benefit from non-transparent schemes

**Issue 3-1: : Simulation results for non-transparent schemes**

* It is proposed to capture the above general observations in a WF
  + Option 1: Agree
  + Option 2: Do not agree
* Recommended WF
  + TBA

# Topic #4: Candidate solution for further coverage enhancements (AI 8.28.2 and 8.28.2-1)

## Companies’ contributions summary

|  |  |  |
| --- | --- | --- |
| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2308110**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308110.zip) | Nokia, Nokia Shanghai Bell | ***Observation 1***: *The collected Excel with all provided simulations results for MPR/PAR reduction it found in the same zip file as this document.* |
| [**R4-2308950**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308950.zip) | Huawei, HiSilicon | ***Observation 1:*** *Based on the simulation results towards the cases listed in Table 1, the net gain can be around 1dB for inner region for QPSK under FDSS with**spectrum extension, while the net gain from FDSS without spectrum extension is negligible.*  ***Observation 2:*** *The best extension ratio for different combination of MCS and RB allocation is different:*   * *For edge RB allocation, the best extension ratio maximizing the total gain is 1/4.* * *For inner RB allocation, when MCS index exceeds 4, extension ratio 1/9 shows better performance comparing to extension ratio 1/4.*   ***Observation 3:*** *Option 1 and Option 2 are special cases of Option 3 with specific cyclic shift .*  ***Observation 4:*** *The choice of does not change the set of symbols in the in-band and thus does not change the receiver requirement.*  ***Observation 5:*** *All options can either be implemented as a cyclic extension or symmetric extension****.***  ***Observation 6:*** *Cyclic shift on with symmetric extension can provide 0.1~0.2 MPR gain compared to no cyclic shift for inner RB allocation without any additional impact to the receiver.*  ***Observation 7:*** *There is no identified implementation complexity increment for spectrum extension comparing to the specified FDSS scheme.*  ***Proposal 1:*** *For spectrum extension ratio, both 1/4 and 1/9 should be specified.*  ***Proposal 2:*** *Define RF requirements to support FDSS with spectrum extension for further coverage enhancement towards QPSK with DFT-s-OFDM waveform.*  ***Proposal 3:*** *Regarding the transparent schemes other than FDSS, more clarification on the details should be provided in order to get convinced evaluation of the gain.* |
| [**R4-2309285**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309285.zip) | Qualcomm Incorporated | **Observation 1:** No decision on viability of any method can be made without deciding whether UE power boost is formally enabled by the standard.  **Observation 2:** Evaluation of viability of any method also depends on whether the gNB Rx uses a legacy receiver (legacy DMRS, ignore extension RBs) or an advanced receiver (PAPR optimized DMRS, leverage diversity gain from extension RBs).  **Observation 3:** For a target rate of 1Mbps in a typical TDD system (DDDSU), the optimal RB allocation is between 16 and 32, assume < 50.  **Observation 4:** For a target rate of 0.1Mbps in a typical FDD system, the optimal RB allocation is 2 or 4, assume < 10.  **Proposal 1:** RAN4 to discuss if coverage enhancement is relevant for wide allocation low MCS cell-edge cases. Wide allocation in this context is >50 for 100M channels and >10 for 20M channels.  **Proposal 2:** RAN4 to study the impact of using legacy DMRS with FDSS.  **Observation 5:** FDSS+BWE is penalized by legacy receivers that do not consider diversity across replicated tones by 0.2 dB or more for the FDSS schemes studied.  **Proposal 3:** To systematically identify enhancement opportunities, RAN4 to pursue evaluation by decoupling inner/outer and differentiating by system assumptions (DMRS, extension RBs, power boost).  **Observation 6:** For inner DFT-s-QPSK waveforms 8/10 representative cases are better enhanced by schemes other than FDSS+BWE, i.e. by schemes that do not need advanced gNB receivers or upgraded DMRS.  **Observation 7:** For inner DFT-s-QPSK waveforms with legacy assumptions (legacy gNB receivers and boost precluded UEs), FDSS+BWE schemes enjoy marginal superiority in just 1/10 representative cases, but are inferior to even legacy techniques for 9/10 representative cases.  **Observation 8:** For boost-enabled UEs working in concert with advanced receivers, BWE+FDSS has theoretical benefit, but only if the UE dynamically optimizes its pulse shaping filter mask based on RB size and MCS.  **Observation 9:** For legacy receivers and boost-precluded UEs, UL enhancement is best served by transparent schemes. In some select cases non-transparent schemes like peak cancellation and FDSS+BWE may provide mild benefit over transparent schemes.  **Observation 10:**   |  |  |  | | --- | --- | --- | | Optimal enhancement scheme | Inner waveforms | Outer waveforms | | Need advanced system features:   1. Diversity combining of repetition tones at gNB Rx. 2. Low-PAPR DMRS design 3. UE power boost enabled | **Transparent** | **A uniformly optimal scheme is not evident**  In some cases, BWE+FDSS provides best benefit, but it requires UE to dynamically change filter profile with RB allocation and MCS.  In other cases, transparent schemes are the optimal choice. | | Legacy system assumptions ok:   1. gNB Rx only focuses on non-extension part 2. Legacy DMRS design 3. UE not enabled to boost | **Transparent** | **Transparent\***  (\*) In very select cases, non-transparent peak cancellation and FDSS+BWE provide more benefit than transparent. |   **Proposal 4:** To confirm FDSS+BWE as an enhancement feature, several concerns must first be addressed in the study phase:   1. confirmation of scope limitation to outer waveforms 2. skeleton real-life link adaptation strategy (to establish confidence in spectral eff. benefit) 3. demod requirements for the gNB supporting this feature   how to determine the subset of the outer waveform region in waveform space where this scheme may be used (MPR table fragmentation) |
| [**R4-2308105**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308105.zip) | Nokia, Nokia Shanghai Bell | ***Observation 1***: *Based on the progress in both RAN1 and RAN4, the simulation parameters are well aligned between RAN1 and RAN4*  ***Observation 2***: *RAN4 is ready for selecting the Rel-18 MPR/PAR reduction solution(s)*  ***Observation 3:***  *According to WID and agreements made until now, there are four MPR/PAR reduction schemes on table:*   * *Reference case (legacy) without FDSS and without spectrum extension* * *FDSS without spectrum extension (transparent scheme)* * *FDSS with spectrum extension (non-transparent scheme)* * *Tone reservation (non-transparent scheme)*   ***Proposal 1***: *Support FDSS with spectrum extension as a solution for MPR/PAR reduction in Rel-18.* |
| [**R4-2309212**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309212.zip) | Ericsson | * The spreadsheet results provide a limited window into behavior, since   + A small number of companies provided results   + A limited number of bandwidth and MCS combinations were simulated   + There are many configurations simulated, and selecting among them is complicated, which leads to taking the ‘best’ configuration although this may exaggerate gains.   + Companies do not provide results for all configurations, boosting/not, inner/outer, etc. * Companies providing simulations generally seem to focus on the boosting case   + Only E//, and we understand vivo, provide results for both boosting & non, but others all provide results for boosting * Companies generally found worse gains of FDSS-SE for MCS8, but not much differences between MCS 1 & 3 * E/// and QC show reduced or no gains for inner PRBs for FDSS-SE vs. transparent   + Nokia tends to show worse performance for inner PRBs, especially for transparent schemes * E/// and QC tend to show less benefit of FDSS-SE over the transparent schemes compared to HW & Nok   + This could be in part due to the selection of the transparent scheme: HW & Nok use FDSS, whereas E/// and QC use Clipping, Clipping+Filtering, and/or Peak Cancelation   + HW found no benefit at all from transparent schemes |

## Open issues summary

The positions from different companies have not changed much and again this meeting seems it difficult to make final agreements. At RAN4#106 it was agreed in the WF R4-2306627 that a decision on a solution for MPR/PAR reduction is expected now in RAN4#107.

According to WID and agreements made until now, there are four MPR/PAR reduction schemes under consideration:

1. Reference case (legacy) without FDSS and without spectrum extension
2. FDSS without spectrum extension (transparent scheme)
3. FDSS with spectrum extension (non-transparent scheme)
4. Tone reservation (non-transparent scheme)

Related to this some relevant agreements to be kept in mind.

The following was agreed in RAN4 #104bis-e and RAN1 #110bis-e.

**Agreement**: (RAN4 #104bis-e)

* *Frequency domain spectrum shaping without spectrum extension for DFT-S-OFDM is the transparent scheme thus far according to the WID*
* *Other techniques can be discussed depending on RAN Plenary decision*

**Agreement**: (RAN1 #110bis-e)

*At least the following candidate solutions for MPR/PAR reduction will be studied in RAN1.*

* *Frequency domain spectrum shaping w/ spectrum extension*
* *Frequency domain spectrum shaping w/o spectrum extension*
* *Tone reservation (which can only be w/ spectrum extension)*

The following was agreed in RAN4 #106:

**Agreement**:

* QPSK is the targeted modulation for further coverage enhancements
  + At least for simulation study
* RAN4 shall prioritizes DFT-S-OFDM as a solution for coverage enhancements
  + FSS on CP-OFDM if companies can show gains
* RAN4 shall evaluate both FR1 and FR2 scenarios.
* RAN4 shall not consider other channels and signals (than PUSCH and the associated DMRS)
* RAN4 shall not consider intra band UL CA scenario in Rel-18 WI

### Sub-topic 4-1: Candidate solution for further coverage enhancements

As attempted at RAN4#106bis a compromise agreement to progress the work is attempted by the moderator below.

**Issue 4-1: Candidate solutions for further coverage enhancements**

* Proposal:
* RAN4 agrees that power boosting via network signalling control is a candidate solution for further coverage enhancements.
  + How power boosting via network signalling control can be introduced to specification shall be further discussed.
  + The intention is that the Network can control when the UE can boost its power beyond its nominal power class
  + The UE can only boost power beyond its nominal power when configured by the Network
  + Whether to use delta\_Ppowerclass for the above purpose can be further discussed, while other solutions are not precluded.
* RAN4 agrees that FDSS with spectrum extension is a candidate solution for further coverage enhancements.
  + How FDSS with spectrum extension can be introduced to specification shall be further discussed.
* RAN4 agrees that other transparent schemes can be considered based on RAN Plenary decision.
* Recommended WF
  + TBA

# Topic #5: Specification impact for further coverage enhancements (AI 8.28.5)

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [**R4-2308109**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2308109.zip) | Nokia, Nokia Shanghai Bell | **Observation 1:**  *RAN4 RF impacts of Transparent scheme in Rel-18 CE (i.e. FDSS w/o spectrum extension) would be quite similar to those defined for pi/2 BPSK in Rel-15/16*  **Proposal 1:** *Update spectral flatness requirements in TS 38.101-x to cover FDSS with spectrum extension with QPSK modulation. Two ranges defined for pi/2 BPSK are applied for the total allocation (Inband + Excess band)*  **Proposal 2:** *Consider the following options for excess band usage:*   * *Option 1: UE must use the excess band, if provided by gNB* * *Option 2: The usage of excess band is left for UE implementation. In this approach, if UE can meet the minimum Tx power requirement also without excess band, it can do so.*   **Proposal 3:** *Consider two set of spectrum flatness requirements:*   * *Current requirements defined for pi/2 BPSK (allowing also more aggressive filters)* * *Tighter requirements (allowing only less aggressive filters)*   **Proposal 4:** *Determine EVM according to inband only.*  **Proposal 5:** *Update MPR tables (at least Table 6.2.2-1) in TS 38.101-1.*   * *In order to minimize the specification complexity, it makes sense to consider definition of the current RB regions (Edge/Outer/Inner) as the starting point.*   **Proposal 6:** *Support power boost with Rel-18 MPR/PAR reduction schemes*   * *Extend the power boost solution defined for pi/2 BPSK also for QPSK scenario.* * *Network can control when the UE can boost its power beyond its nominal power class*   **Proposal 7:** *Define ACLR requirement according to power class also with power boost.* |
| [**R4-2309199**](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_107/Docs/R4-2309199.zip) | Ericsson | **Observation 1** Without boosting, for QPSK, transparent schemes can produce a modest (e.g. nearly 0.75 dB at 700 MHz) MPR reduction for some allocations toward the band edge and with wider bandwidth, but generally not in the center of the band.  **Observation 2** With boosting, for QPSK, transparent schemes can produce a somewhat greater (e.g. nearly 1 dB at 700 MHz) MPR reduction for some allocations near the center of the band as well as some MPR reduction near the band edge.  **Observation 3** While a 3/8 spectrum expansion factor for FDSS-SE has some benefit at the lowest code rates compared to a 1/4 expansion factor, there are losses that are as much or more than the gains at even modest code rates such as 0.24.  **Observation 4** The net gain of non-transparent scheme is more pronounced at the outer allocation than inner allocation for low coding rate.  **Observation 5** When boosting is used for FDSS-SE, it can have maximum gains of roughly 2 dB for narrow portions of edge PRBs at low code rate, when compared to clipping with the same bandwidth and code rate, but no gain or a small loss in the inner PRBs. However, if FDSS-SE is compared to clipping with a similar MCS and TBS size but smaller bandwidth, and clipping is shifted away from the band edge, the gains of FDSS-SE are substantially smaller and isolated. Gains are limited to the very largest allocations or particular locations in edge PRBs, and losses are found for inner PRBs.  **Observation 6** Large RB allocations with low coding rate are rare in system simulation.  **Observation 7** For a UE implementing the FDSS scheme using the 2-tap or 3-tap filter, the general spectrum flatness requirement cannot be met.  **Observation 8** 14 dB ripple at the edge PRB allocation may result in 0.9 dB link budget loss for high MCS if 14 dB ripple would be allowed.  **Observation 9** 14 dB ripple at the edge PRB allocation may result in 0.3 dB link budget loss for low MCS if 14 dB ripple would be allowed.  **Observation 10** Clipping scheme can meet the general spectrum flatness requirement.  **Observation 11** PC3 output power can be the same PC2 when IE *powerBoostPi2BPSK* is set to 1.  **Observation 12** Applying a PC3 ACLR on a PC2 output level UE may incur throughput degradation for a the small ISD cell compared with a PC2 UE (with PC2 ALCR).  **And with below proposals:**  **Proposal-1:** RAN4 specify the transparent scheme for MPR reduction.  **Proposal-2:** In case of the relaxing the spectrum flatness requirement for transparent scheme, the requirement should not be the same with Pi/2 BPSK, the exact amount could be further discussed.  **Proposal-3:** RAN4 collects operators’ view on whether to apply the ACLR of a PC2 UE to a PC3 UE when the output power can be boosted to the same level with a PC2 UE |

## Open issues summary

### Sub-topic 1-1: Specification impact for further coverage enhancements

While the specification impact is also an aspect which RAN4 needs to resolve it seems it is first needed which solutions to consider for MPR/PAR reduction.

**Issue 5-1: Specification impact for further coverage enhancements**

* Postpone discussion on specification impact until it is clear which solutions to consider for MPR/PAR reduction
  + Option 1: Agree
  + Option 2: Do not agree
* Recommended WF
  + TBA