|  |  |
| --- | --- |
| 3GPP TR 38.865 V18.0.0 (2022-09) | |
| Technical Report | |
| 3rd Generation Partnership Project;  Technical Specification Group Radio Access Network;  Study on further NR RedCap UE complexity reduction  (Release 18) | |
|  | |
|  |  |
|  | |
| The present document has been developed within the 3rd Generation Partnership Project (3GPP TM) and may be further elaborated for the purposes of 3GPP. The present document has not been subject to any approval process by the 3GPPOrganizational Partners and shall not be implemented. This Specification is provided for future development work within 3GPPonly. The Organizational Partners accept no liability for any use of this Specification. Specifications and Reports for implementation of the 3GPP TM system should be obtained via the 3GPP Organizational Partners' Publications Offices. | |

|  |
| --- |
|  |
| ***3GPP***  Postal address  3GPP support office address  650 Route des Lucioles - Sophia Antipolis  Valbonne - FRANCE  Tel.: +33 4 92 94 42 00 Fax: +33 4 93 65 47 16  Internet  http://www.3gpp.org |
| ***Copyright Notification***  No part may be reproduced except as authorized by written permission. The copyright and the foregoing restriction extend to reproduction in all media.  © 2022, 3GPP Organizational Partners (ARIB, ATIS, CCSA, ETSI, TSDSI, TTA, TTC).  All rights reserved.  UMTS™ is a Trade Mark of ETSI registered for the benefit of its members  3GPP™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners LTE™ is a Trade Mark of ETSI registered for the benefit of its Members and of the 3GPP Organizational Partners  GSM® and the GSM logo are registered and owned by the GSM Association |

Contents

Foreword 4

1 Scope 5

2 References 5

3 Definitions of terms, symbols and abbreviations 6

3.1 Terms 6

3.2 Symbols 6

3.3 Abbreviations 6

4 Introduction 6

5 Study objectives 7

6 Evaluation methodology 7

6.1 Evaluation methodology for UE complexity reduction 7

6.2 Evaluation methodology for coverage impact 8

7 UE complexity reduction features 12

7.1 Introduction to UE complexity reduction features 12

7.2 Further UE bandwidth reduction 12

7.2.1 Description of feature 12

7.2.2 Analysis of UE complexity reduction 13

7.2.3 Analysis of performance impacts 17

7.2.4 Analysis of network deployment and coexistence impacts 17

7.2.5 Analysis of specification impacts 17

7.3 Further UE peak rate reduction 17

7.3.1 Description of feature 17

7.3.2 Analysis of UE complexity reduction 18

7.3.3 Analysis of performance impacts 21

7.3.4 Analysis of network deployment and coexistence impacts 21

7.3.5 Analysis of specification impacts 21

7.4 Relaxed UE processing timeline 21

7.4.1 Description of feature 21

7.4.2 Analysis of UE complexity reduction 22

7.4.3 Analysis of performance impacts 22

7.4.4 Analysis of network deployment and coexistence impacts 22

7.4.5 Analysis of specification impacts 23

7.5 Combinations of UE complexity reduction features 23

7.5.1 Description of feature combinations 23

7.5.2 Analysis of UE complexity reduction 23

7.5.3 Analysis of performance impacts 24

7.5.4 Analysis of network deployment and coexistence impacts 24

7.5.5 Analysis of specification impacts 24

8 Coverage impact 25

8.1 Introduction to coverage impact 25

8.2 Coverage impact evaluation 25

8.2.1 Urban scenario at 2.6 GHz 25

8.2.2 Rural scenario at 0.7 GHz 34

8.2.3 Urban scenario at 4 GHz 40

8.2.4 Summary of coverage impact evaluation 47

9 Conclusions and recommendations 50

Annex A: Change history 52

# Foreword

This Technical Report has been produced by the 3rd Generation Partnership Project (3GPP).

The contents of the present document are subject to continuing work within the TSG and may change following formal TSG approval. Should the TSG modify the contents of the present document, it will be re-released by the TSG with an identifying change of release date and an increase in version number as follows:

Version x.y.z

where:

x the first digit:

1 presented to TSG for information;

2 presented to TSG for approval;

3 or greater indicates TSG approved document under change control.

y the second digit is incremented for all changes of substance, i.e. technical enhancements, corrections, updates, etc.

z the third digit is incremented when editorial only changes have been incorporated in the document.

In the present document, modal verbs have the following meanings:

**shall** indicates a mandatory requirement to do something

**shall not** indicates an interdiction (prohibition) to do something

The constructions "shall" and "shall not" are confined to the context of normative provisions, and do not appear in Technical Reports.

The constructions "must" and "must not" are not used as substitutes for "shall" and "shall not". Their use is avoided insofar as possible, and they are not used in a normative context except in a direct citation from an external, referenced, non-3GPP document, or so as to maintain continuity of style when extending or modifying the provisions of such a referenced document.

**should** indicates a recommendation to do something

**should not** indicates a recommendation not to do something

**may** indicates permission to do something

**need not** indicates permission not to do something

The construction "may not" is ambiguous and is not used in normative elements. The unambiguous constructions "might not" or "shall not" are used instead, depending upon the meaning intended.

**can** indicates that something is possible

**cannot** indicates that something is impossible

The constructions "can" and "cannot" are not substitutes for "may" and "need not".

**will** indicates that something is certain or expected to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**will not** indicates that something is certain or expected not to happen as a result of action taken by an agency the behaviour of which is outside the scope of the present document

**might** indicates a likelihood that something will happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

**might not** indicates a likelihood that something will not happen as a result of action taken by some agency the behaviour of which is outside the scope of the present document

In addition:

**is** (or any other verb in the indicative mood) indicates a statement of fact

**is not** (or any other negative verb in the indicative mood) indicates a statement of fact

The constructions "is" and "is not" do not indicate requirements.

# 1 Scope

This document captures the findings from the study item "Study on further NR RedCap UE complexity reduction" [2].

The study concerns potential solutions for reducing UE complexity further compared to the RedCap UE type introduced in Rel-17 [3], providing NR support for low-tier devices between existing LPWA UEs and Rel-17 RedCap UEs to further expand the market for RedCap use cases with relatively low cost, low energy consumption, and low data rate requirements, targeting 10 Mbps peak rate.

The study focuses on UE bandwidth reduction to 5 MHz and/or UE peak rate reduction to 10 Mbps, possibly in combination with relaxed UE processing timeline. The scope of the study includes support for FR1 bands for FDD and TDD and coexistence with Rel-15/16/17 UEs. The scope of the study does not include LPWA use cases.

# 2 References

The following documents contain provisions which, through reference in this text, constitute provisions of the present document.

- References are either specific (identified by date of publication, edition number, version number, etc.) or non‑specific.

- For a specific reference, subsequent revisions do not apply.

- For a non-specific reference, the latest version applies. In the case of a reference to a 3GPP document (including a GSM document), a non-specific reference implicitly refers to the latest version of that document *in the same Release as the present document*.

[1] 3GPP TR 21.905: "Vocabulary for 3GPP Specifications".

[2] 3GPP RP-213661: "New SID on Study on further NR RedCap UE complexity reduction".

[3] 3GPP RP-221163: "Summary of WI on support of reduced capability (RedCap) NR devices"

[4] 3GPP TS 38.306: "NR; User Equipment (UE) radio access capabilities".

[5] 3GPP TR 38.875: "Study on support of reduced capability NR devices".

[6] 3GPP TR 38.830: "Study on NR coverage enhancements".

[7] 3GPP R1-2207981: "FL summary #2 for collection of evaluation results for Rel-18 RedCap SI".

# 3 Definitions of terms, symbols and abbreviations

## 3.1 Terms

For the purposes of the present document, the terms given in TR 21.905 [1] and the following apply. A term defined in the present document takes precedence over the definition of the same term, if any, in TR 21.905 [1].

**RedCap UE:** A UE with reduced capabilities as specified in clause 4.2.21.1 in TS 38.306 [4].

## 3.2 Symbols

For the purposes of the present document, the following symbols apply:

<symbol> <Explanation>

## 3.3 Abbreviations

For the purposes of the present document, the abbreviations given in TR 21.905 [1] and the following apply. An abbreviation defined in the present document takes precedence over the definition of the same abbreviation, if any, in TR 21.905 [1].

<ABBREVIATION> <Expansion>

# 4 Introduction

5G aims to accelerate industrial transformation and digitalization, which improve flexibility, enhance productivity and efficiency, reduce maintenance, and improve operational safety. Industrial sensors play an important role for realizing such a vision. Not only widely used in industrial automation and digitalization use cases, industrial sensors are also widely used in the general environmental monitoring use cases such as monitoring of critical infrastructure (e.g., buildings, bridges, water dams, etc.) or monitoring for natural disasters (e.g., wild fire, flood, tsunami, earthquake, etc.).

Another emerging new class of new 5G use cases is the smart city vertical, which covers data collection and processing to more efficiently monitor and control city resources, and to provide services to city residents. Especially, the deployment of surveillance cameras is an essential part of the smart city but also of factories and industries.

Furthermore, there have been increasing interests in wearables use cases such as smart watches, eHealth related devices, and medical monitoring devices. These use cases call for different design considerations and have different requirements in terms of form factor, UE complexity and energy efficiency, compared to eMBB devices.

The support of industrial sensors, video surveillance, and wearables were the motivations behind Rel-17 RedCap. Through the Rel-17 NR RedCap work item, 3GPP has established a framework for enabling reduced capability NR devices suitable for a range of use cases, including the industrial sensors, video surveillance, and wearables use cases, with requirements on low UE complexity and sometimes also on low UE power consumption.

Now when the foundation has been laid in Rel-17 [3], enhancements can be considered to improve the support for the mentioned use cases and also to expand RedCap into a new range of use cases such as smart grid.

To further expand the market for RedCap use cases with relatively low cost, low energy consumption, and low data rate requirements, e.g., industrial wireless sensor network use cases, some further complexity reduction enhancements should be considered.

Rel-18 RedCap should provide NR support for low-tier devices between existing LPWA UEs and the capabilities of Rel-17 RedCap UEs. The supported peak data rate for Rel-18 RedCap targets to 10Mbps. Rel-18 RedCap should not overlap with existing LPWA solutions.

The enhancements should be introduced while maintaining the integrity of the RedCap ecosystem and maximizing the benefit of economies of scale. The SI targets enhancements applicable to the RedCap framework defined in Rel-17, including principles of network awareness of device capabilities.

# 5 Study objectives

The study includes the following objectives:

- Study further UE complexity reduction techniques based on Rel-17 evaluation methodology in TR 38.875.

- Consider network impact, coexistence of Rel-17 and Rel-18 RedCap and non-RedCap UEs in a cell, UE impact, specification impact.

- Potential solutions, which may complement each other, for reducing device complexity are focusing on:

- UE bandwidth reduction to 5MHz in FR1,

- Possibly in combination with relaxed UE processing timeline for PDSCH and/or PUSCH and/or CSI

- Reduced UE peak data rate in FR1,

- Possibly including restricted bandwidth for PDSCH and/or PUSCH

- Possibly in combination with relaxed UE processing timeline for PDSCH and/or PUSCH and/or CSI

- Notes:

- Rel-15 SSB should be reused and L1 changes minimized.

- Operation in BWP with/without SSB and without/with RF retuning should be considered.

- It is not precluded that some solutions for FR1 can be applied to FR2 in WI stage.

- Aim to define a single Rel-18 RedCap UE type for further UE complexity reduction.

# 6 Evaluation methodology

## 6.1 Evaluation methodology for UE complexity reduction

For complexity evaluation of UE complexity reduction techniques, the methodology used in TR 38.875 was used as a starting point.

The reference NR devices were defined for FR1 FDD and FR1 TDD in clause 6.1 in TR 38.875 and are reused in this study. For complexity reduction estimation, the detailed complexity breakdown for the Rel-15 reference NR devices according to Table 6.1-1 is reused, where the RF-to-baseband complexity ratio is assumed to be 40:60 for an FR1 UE.

For comparison with a Rel-17 baseline when evaluating the potential Rel-18 UE complexity reduction features, the Rel-17 RedCap UE supports 20 MHz, 1 Rx, 1 layer, DL 64QAM, UL 64QAM, FDD or TDD. In addition, cases with 2 Rx, 2 MIMO layers, and HD-FDD features are optionally evaluated. In all comparisons, the Rel-17 RedCap UEs and the potential Rel-18 UEs being compared have the same number of antenna branches, the same number of layers, the same maximum supported modulation order, and the same duplex mode (among HD-FDD, FD-FDD, and TDD).

NOTE: This study assesses, from a 3GPP standpoint, the technical feasibility of further reducing the complexity of RedCap devices. Given that factors outside 3GPP responsibility influence the cost of a modem/device, this study item (and this study report) cannot guarantee, or be used as a guarantee, that such modem/device will be low-cost in the market.

Table 6.1-1: Detailed complexity breakdown for the FR1 reference NR devices

|  |  |  |
| --- | --- | --- |
| Functional block | FR1 FDD (2Rx) | FR1 TDD (4Rx) |
| RF | | |
| Power amplifier | ~25% | ~25% |
| Filters | ~10% | ~15% |
| RF transceiver (incl. LNAs, mixer, and local oscillator) | ~45% | ~55% |
| Duplexer / Switch | ~20% | ~5% |
| Baseband | | |
| ADC / DAC | ~10% | ~9% |
| FFT/IFFT | ~4% | ~4% |
| Post-FFT data buffering | ~10% | ~10% |
| Receiver processing block | ~24% | ~29% |
| LDPC decoding | ~10% | ~9% |
| HARQ buffer | ~14% | ~12% |
| DL control processing & decoder | ~5% | ~4% |
| Synchronization / cell search block | ~9% | ~9% |
| UL processing block | ~5% | ~5% |
| MIMO specific processing blocks | ~9% | ~9% |

## 6.2 Evaluation methodology for coverage impact

Coverage recovery evaluation is based on link budget evaluations.

The evaluation methodology and assumptions in the Rel-17 RedCap SI [5] are reused by default, with the revision or addition described below.

The channels and messages used in link budget evaluations primarily include PBCH, PDCCH CSS, and SIB1. Sourcing companies can additionally provide evaluation results of other channels and messages such as PDCCH USS, PRACH, Msg2, Msg3, Msg4, PDSCH, PUCCH and PUSCH.

The impact of small form factor can be considered for all the uplink and downlink channels. To reflect such an impact, a 3dB loss of antenna gain can be optionally included in link budget calculation for the FR1 bands by sourcing companies.

The assumptions in the Rel-17 RedCap SI regarding link budget templates and antenna array gain are reused [5]. Furthermore, the Rel-17 RedCap SI assumptions on gNB antenna configuration, # gNB Tx and Rx chains, channel model and delay spread are reused as shown in Table 6.2-1.

Table 6.2-1: Assumptions used for coverage impact evaluation

|  |  |
| --- | --- |
| Parameters | FR1 values |
| Deployment scenario and frequency | Urban: 2.6GHz (TDD), 4GHz (TDD, optional)  Rural: (FDD) |
| Frame structure for TDD | DDDDDDDSUU (S: 6D:4G:4U) for 2.6GHz  DDDSUDDSUU (S: 10D:2G:2U) for 4GHz |
| Channel model | TDL-C |
| Delay spread | 300ns |
| UE velocity | 3 km/h |
| Antenna correlation | Low |
| # gNB Tx chains | 2 or 4 |
| # gNB Rx chains | 2 or 4 |

For coverage evaluation, the assumptions for reference NR UE, reference Rel-17 RedCap UE, and the potential Rel-18 UE are shown in Tables 6.2-2, 6.2-3 and 6.2-4, respectively.

Table 6.2-2: Assumptions for reference NR UE

|  |  |
| --- | --- |
| Parameters | FR1 values |
| # UE Tx chains | 1 |
| # UE Rx chains | Urban: 4 and Rural: 2 |
| UE bandwidth | Urban: 100 MHz (273 PRBs, 30 kHz SCS)  Rural: 20 MHz (106 PRBs, 15 kHz SCS) |

Table 6.2-3: Assumptions for reference Rel-17 RedCap UE

|  |  |
| --- | --- |
| Parameters | FR1 values |
| # UE Tx chains | 1 |
| # UE Rx chains | 1 |
| UE bandwidth | Urban: 20 MHz (51 PRBs, 30 kHz SCS)  Rural: 20 MHz (106 PRBs, 15 kHz SCS) |

Table 6.2-4: Assumptions for the potential Rel-18 UE

|  |  |
| --- | --- |
| Parameters | FR1 values |
| # UE Tx chains | 1 |
| # UE Rx chains | 1 |
| UE bandwidth | Urban: 5 MHz (11 PRBs or 12 PRBs (optional), 30 kHz SCS)  Rural: 5 MHz (25 PRBs, 15 kHz SCS) |

The assumptions for channel specific parameters are also based on reusing the Rel-17 RedCap SI agreements [5], with the revision or addition described below.

For PBCH, the assumptions listed in Table A.1-8 from TR 38.830 [6] were adopted for reference NR UE, reference Rel-17 RedCap UE, and the potential Rel-18 UE.

For SIB1, the assumptions listed in Table 6.2-5 were adopted for reference NR UE, and reference Rel-17 RedCap UE. For the potential Rel-18 UE, the assumptions listed in Table 6.2-6 were adopted.

Table 6.2-5: Assumptions for SIB1 for reference NR UE and reference Rel-17 RedCap UE

|  |  |
| --- | --- |
| Parameters | Values |
| PRBs/TBS/MCS | TBS is 1256 bits. SIB1 bandwidth is larger than 5MHz, e.g. 48PRBs. Companies to report the used number of PRBs, corresponding MCS, and whether interleaving mapping is assumed. |

Table 6.2-6: Assumptions for SIB1 for the potential Rel-18 UE

|  |  |
| --- | --- |
| Parameters | Values |
| PRBs/TBS/MCS | TBS is 1256 bits. Other TBS are not precluded.  For PRB numbers, two options are assumed:  - Option 1: SIB1 bandwidth is larger than 5MHz, e.g. 48PRBs.  - Option 2: SIB1 bandwidth is within 5MHz.  Companies to report the used number of PRBs, corresponding MCS, and whether interleaving mapping is assumed. |

For PDCCH common search space (PDCCH CSS), the assumptions listed in Table 6.2-7 were adopted for reference NR UE and reference Rel-17 RedCap UE.

Table 6.2-7: Assumptions for PDCCH Common Search Space (PDCCH CSS) for reference NR UE and reference Rel-17 RedCap UE

|  |  |
| --- | --- |
| Parameters | Values |
| DCI format and payload size | DCI format 1\_0 with payload of 40bits |
| CORESET size and aggregation level (AL) configuration | The CORESET size is 2 symbols and 48 PRBs. AL is 16. |

For PDCCH common search space (PDCCH CSS), the assumptions listed in Table 6.2-8 were adopted for the potential Rel-18 UE.

Table 6.2-8: Assumptions for PDCCH Common Search Space (PDCCH CSS) for the potential Rel-18 UE

|  |  |
| --- | --- |
| Parameters | Values |
| DCI format and payload size | DCI format 1\_0 with payload of 40bits |
| CORESET size and aggregation level (AL) configuration | For 15kHz SCS, the following options are assumed.  - Option 1: The CORESET size is 2 symbols and 48 PRBs. AL is 16.  - Option 2: The CORESET size is 3 symbols and 24 PRBs. AL is 8.  For 30kHz SCS, the following options are assumed.  - Option 1: The CORESET size is 2 symbols and 24 PRBs. AL is 8.  - Option 2: The CORESET size is 3 symbols and 6 PRBs. AL is 2.  - Option 3: The CORESET size is 3 symbols and 12 PRBs. AL is 4.  Other configurations can be optionally evaluated and reported by companies. |

For Msg2, the assumptions for reference NR UE, reference Rel-17 RedCap UE, and the potential Rel-18 UE listed in Table 6.2-9 were adopted.

Table 6.2-9: Assumptions for Msg2

|  |  |
| --- | --- |
| Parameters | Values |
| PRBs/TBS/MCS | TBS is 72bits. Companies to report the used number of PRBs and corresponding MCS. |

For Msg4, the assumptions for reference NR UE, reference Rel-17 RedCap UE, and the potential Rel-18 UE listed in Table 6.2-10 were adopted.

Table 6.2-10: Assumptions for Msg4

|  |  |
| --- | --- |
| Parameters | Values |
| PRBs/TBS/MCS | TBS is 1040bits. Companies to report the used number of PRBs and corresponding MCS.  A smaller TBS can be optionally evaluated and reported by companies. |

For PRACH, the assumptions for reference NR UE, reference Rel-17 RedCap UE, and the potential Rel-18 UE listed in Table 6.2-11 were adopted.

Table 6.2-11: Assumptions for PRACH

|  |  |
| --- | --- |
| Parameters | Values |
| PRACH format | Urban: Format B4  Rural: Format 0  Format C2 can be optionally evaluated and reported by companies. |

The target data rates for the potential Rel-18 UEs are:

- FR1 Rural: 250 kbps on DL and 25 kbps in UL

- FR1 Urban: 500 kbps on DL and 250 kbps in UL

- Note: The target data rates are the scaled value in the Rel-17 RedCap SI by a factor of 0.25

The TBS, PRB, and MCS of PDSCH and PUSCH for the potential Rel-18 UE are based on the agreed target data rates or message sizes and reported by sourcing companies.

For all channels affected by reduced UE complexity including prioritized broadcast channels and optionally evaluated channels, the following methodology is used to evaluate the coverage impact in terms of coverage margins:

- Step 1: Obtain the link budget performance of the channel based on link budget evaluation

- Step 2: Obtain the target performance requirement for the potential Rel-18 UE within a deployment scenario

- Step 3: Find the coverage margin for the channel by comparing the link budget performance with the target performance requirement.

For step 2, the study applied the following option for determining the target performance for coverage impact evaluation in terms of coverage margins.

- The target performance requirement for each channel is identified by the link budget of the bottleneck channel for the reference UE within the same deployment scenario. The "bottleneck channel" is the physical channel that has the lowest MIL value. The reference UE is an NR UE with mandatory features only as defined in Clause 6.1 of [5].

In this coverage impact evaluation in terms of coverage margins, a single coverage target based on the same bottleneck channel is used for all channels including the prioritized broadcast channels and optionally evaluated channels of the potential Rel-18 UE. Each sourcing company reports a sourcing-company-specific coverage margin for each channel by comparing the link budget of the channel with the link budget of the bottleneck channel for the reference UE.

A representative value of the coverage margin for a channel is derived by taking the mean value (in dB domain) from the coverage margins from all sourcing companies, including both negative and non-negative values based on the following adjustments.

- Excluding the highest & the lowest values when the number of samples is more than 3.

- If the number of samples is less than 4 for a channel in a scenario, no representative value is provided.

The representative value of a channel is used for identifying whether the channel has coverage margin compared to the bottleneck channel of the reference NR UE.

In Step 2 in the above methodology for determining coverage margins, a sourcing company might not be able to identify a bottleneck channel for the reference NR UE and the corresponding MIL link budget if it had not evaluated all channels for the reference NR UE, especially if it had not evaluated uplink channels since uplink channels were often the bottleneck channels for the reference NR UE. For such a sourcing company, a bottleneck channel and the corresponding link budget for the reference NR UE can be determined based on evaluation results of the identified bottleneck channels and MIL values from the Rel-17 RedCap SI in [5] for a scenario. Specifically, for an evaluated scenario, a bottleneck channel is determined by the one identified by most sourcing companies and its corresponding MIL value is derived by taking the mean value (in dB domain) from the MIL values from all sourcing companies after excluding the highest & the lowest values. For the evaluated scenarios, the following tables from Rel-17 RedCap SI in [5] are used:

- For Urban scenario at 2.6GHz, Table 9.1.1-1 in [5] is used for determining a bottleneck channel and MIL value for the reference NR UE by such a sourcing company.

- For Rural scenario at 0.7GHz, Table 9.1.2-1 in [5] is used.

- For Urban scenario at 4 GHz, Table 9.1.3-1 in [5] is used.

For each table of coverage margins of evaluated channels in a deployment scenario shown in Clause 8.2.1 through Clause 8.2.3, the rows of the table are composed of sourcing companies' names, representative value 1, number of samples 1, representative value 2, and number of samples 2. For an evaluated channel in the scenario,

- the representative value 1 is derived from the coverage margins only from sourcing companies who had provided uplink coverage evaluation results for the reference NR UE

- the number of samples 1 is the total number of sourcing companies that had provided uplink coverage evaluation results for the reference NR UE

- the representative value 2 is derived from the coverage margins from all sourcing companies regardless of whether or one had provided uplink coverage evaluation results for the reference NR UE

- the number of samples 2 is the total number of all sourcing companies

Besides comparing link budgets of all evaluated channels to that of the bottleneck channel for the reference NR UE and deriving coverage margins for all channels, comparisons of the coverage differences between the potential Rel-18 UE and the reference NR UE in addition to comparisons of the coverage differences between the potential Rel-18 UE and the reference Rel-17 RedCap UE were carried out for the broadcast channels including PBCH, PDCCH CSS, and SIB1 in Urban scenario at 2.6 GHz. For PDCCH CSS and SIB1, the comparisons were also carried out for Rural scenario at 0.7 GHz. Detailed comparisons and assumptions are provided in Clause 8.2.1 and Clause 8.2.2 for Urban at 2.6 GHz and Rural at 0.7 GHz, respectively.

# 7 UE complexity reduction features

## 7.1 Introduction to UE complexity reduction features

The following UE complexity reduction techniques have been studied:

- Further UE bandwidth reduction ("BW" for short)

- Further UE peak rate reduction ("PR" for short)

- Relaxed UE processing timeline ("PT" for short)

The evaluation results for each one of the studied individual UE complexity reduction techniques are captured in clauses 7.2 through 7.4, respectively. For relaxed UE processing timeline, analysis is provided in clause 7.4, while complexity evaluations are provided only in combination with other techniques in clause 7.5 where the properties of combinations of different individual UE complexity reduction techniques are described. The evaluation of the potential coverage impacts is described in clause 8. Recommendations based on the evaluations are captured in clause 9.

## 7.2 Further UE bandwidth reduction

### 7.2.1 Description of feature

In the study, the main UE bandwidth reduction options considered for FR1 are as follows:

- Option BW1: Both RF and BB bandwidths are 5 MHz for UL and DL.

- Option BW2 (optionally considered for evaluations): 5 MHz BB bandwidth for all signals and channels with 20 MHz RF bandwidth for UL and DL.

- Option BW3: 5 MHz BB bandwidth only for PDSCH (for both unicast and broadcast) and PUSCH with 20 MHz RF bandwidth for UL and DL. The other physical channels and signals are still allowed to use a BWP up to the 20 MHz maximum UE RF+BB bandwidth.

For the above bandwidth reduction options, the following aspects are considered:

- The resource allocation spans a bandwidth of maximum 5 MHz.

- The same option is used for UL and DL.

- The same option is used for idle/inactive and connected mode.

- Note: As part of study of above options, it is not precluded to indicate that an observation is relevant for UL only or DL only.

- For 15 kHz SCS, 25 contiguous RBs are assumed to fit within the 5 MHz.

- For 30 kHz SCS, 11 contiguous RBs are assumed to fit within the 5 MHz.

- Note: For 30 kHz SCS, 12 contiguous RBs are also optionally studied.

The evaluation results for each one of the studied individual UE complexity reduction techniques are captured in clauses 7.2 through 7.4, respectively. The properties of combinations of different individual UE complexity reduction techniques are described in clause 7.5. Recommendations based on the evaluations are captured in clause 9.

### 7.2.2 Analysis of UE complexity reduction

For BW1, the main contributors of the complexity reduction are the following functional blocks:

- Baseband: ADC/DAC

- Baseband: FFT/IFFT

- Baseband: Post-FFT data buffering

- Baseband: Receiver processing block

- Baseband: LDPC decoding

- Baseband: HARQ buffer

- Baseband: DL control processing & decoder

- Baseband: UL processing block

For BW2, the main contributors of the complexity reduction are the following functional blocks:

- Baseband: Post-FFT data buffering

- Baseband: Receiver processing block

- Baseband: LDPC decoding

- Baseband: HARQ buffer

- Baseband: DL control processing & decoder

- Baseband: UL processing block

For BW3, the main contributors of the complexity reduction are the following functional blocks:

- Baseband: Post-FFT data buffering

- Baseband: Receiver processing block

- Baseband: LDPC decoding

- Baseband: HARQ buffer

- Baseband: UL processing block

Note 1: BW3 may have different degrees of impacts on the post-FFT data buffering depending on the scheduling aspects (cross-slot scheduling, RF retuning, etc.).

Note 2: For BW2, some sources have indicated that the complexity of the ADC/DAC and FFT/IFFT blocks might also be reduced.

Note 3: For BW1, one source shows complexity reduction for RF filters and one source shows complexity reduction for MIMO specific processing block.

Note 4: BW1 and BW2 may have different degrees of impacts on the downlink control processing and decoder depending on the CCE and BD complexity reduction.

For the UE bandwidth reduction options BW1, BW2, and BW3, the complexity reduction is mainly in the BB part, and although there may be a possibility to reduce RF complexity, there is no significant complexity reduction in the RF part.

The tables below show the average value of the initial complexity evaluation results captured in [7]. Specifically, results are provided for Rel-17 RedCap and potential Rel-18 RedCap cases with FD-FDD 1Rx, TDD 1Rx, HD-FDD 1Rx, FD-FDD 2Rx, TDD 2Rx, and HD-FDD 2Rx.

Note that the reference Rel-15 NR UE has the following features:

- FDD: 100 MHz, 2 Rx, 2 layers, DL 256QAM, FD-FDD

- TDD: 100 MHz, 4 Rx, 4 layers, DL 256QAM

Table 7.2.2-1: Average UE complexity reduction achieved by BW reduction options for FD-FDD 1Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE bandwidth | Rel-15 reference | Rel-17 RedCap | BW1 | BW2 | BW3 |
| RF: Power amplifier | 25% | 24.12% | 24.02% | 24.64% | 24.09% |
| RF: Filters | 10% | 5.06% | 4.72% | 5.12% | 5.06% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 45% | 23.76% | 23.52% | 24.30% | 23.76% |
| RF: Duplexer / Switch | 20% | 19.52% | 19.52% | 19.57% | 19.52% |
| **RF: Total** | **100%** | 72.46% | 71.78% | 73.63% | 72.43% |
| BB: ADC / DAC | 10% | 1.30% | 0.50% | 0.99% | 1.27% |
| BB: FFT/IFFT | 4% | 0.67% | 0.21% | 0.45% | 0.65% |
| BB: Post-FFT data buffering | 10% | 1.05% | 0.36% | 0.46% | 0.67% |
| BB: Receiver processing block | 24% | 4.42% | 2.00% | 1.86% | 2.07% |
| BB: LDPC decoding | 10% | 1.29% | 0.51% | 0.50% | 0.51% |
| BB: HARQ buffer | 14% | 1.46% | 0.45% | 0.45% | 0.45% |
| BB: DL control processing & decoder | 5% | 4.73% | 3.98% | 3.95% | 4.52% |
| BB: Synchronization / cell search block | 9% | 4.61% | 4.55% | 4.59% | 4.58% |
| BB: UL processing block | 5% | 2.69% | 1.55% | 1.54% | 1.69% |
| BB: MIMO specific processing blocks | 9% | 4.04% | 3.77% | 3.85% | 3.91% |
| **BB: Total** | **100%** | 26.26% | 17.88% | 18.65% | 20.31% |
| **RF+BB: Total** | **100%** | **44.74%** | **39.44%** | **40.65%** | **41.15%** |

Table 7.2.2-2: Average UE complexity reduction achieved by BW reduction options for TDD 1Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE bandwidth | Rel-15 reference | Rel-17 RedCap | BW1 | BW2 | BW3 |
| RF: Power amplifier | 25% | 24.08% | 23.97% | 24.56% | 24.05% |
| RF: Filters | 15% | 3.94% | 3.86% | 4.08% | 3.94% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 55% | 19.05% | 18.78% | 19.98% | 19.05% |
| RF: Duplexer / Switch | 5% | 4.97% | 4.97% | 4.98% | 4.97% |
| **RF: Total** | **100%** | 52.04% | 51.58% | 53.59% | 52.01% |
| BB: ADC / DAC | 9% | 0.76% | 0.30% | 0.57% | 0.73% |
| BB: FFT/IFFT | 4% | 0.40% | 0.14% | 0.27% | 0.38% |
| BB: Post-FFT data buffering | 10% | 0.59% | 0.22% | 0.28% | 0.36% |
| BB: Receiver processing block | 29% | 3.21% | 1.54% | 1.48% | 1.56% |
| BB: LDPC decoding | 9% | 0.79% | 0.33% | 0.34% | 0.33% |
| BB: HARQ buffer | 12% | 0.79% | 0.40% | 0.23% | 0.40% |
| BB: DL control processing & decoder | 4% | 3.68% | 3.15% | 3.19% | 3.55% |
| BB: Synchronization / cell search block | 9% | 2.49% | 2.44% | 2.45% | 2.45% |
| BB: UL processing block | 5% | 2.69% | 1.54% | 1.50% | 1.70% |
| BB: MIMO specific processing blocks | 9% | 2.27% | 2.04% | 2.07% | 2.21% |
| **BB: Total** | **100%** | 17.66% | 12.08% | 12.40% | 13.68% |
| **RF+BB: Total** | **100%** | **31.41%** | **27.88%** | **28.88%** | **29.01%** |

Table 7.2.2-3: Average UE complexity reduction achieved by BW reduction options for HD-FDD 1Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE bandwidth | Rel-15 reference | Rel-17 RedCap | BW1 | BW2 | BW3 |
| RF: Power amplifier | 25% | 24.50% | 24.50% | 24.50% | 24.50% |
| RF: Filters | 10% | 5.17% | 4.64% | 5.17% | 5.17% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 45% | 24.46% | 24.06% | 24.46% | 24.46% |
| RF: Duplexer / Switch | 20% | 3.68% | 3.68% | 3.68% | 3.68% |
| **RF: Total** | **100%** | 57.81% | 56.87% | 57.81% | 57.81% |
| BB: ADC / DAC | 10% | 1.25% | 0.54% | 1.03% | 1.26% |
| BB: FFT/IFFT | 4% | 0.71% | 0.25% | 0.44% | 0.72% |
| BB: Post-FFT data buffering | 10% | 1.10% | 0.42% | 0.50% | 0.66% |
| BB: Receiver processing block | 24% | 4.22% | 1.92% | 1.92% | 2.04% |
| BB: LDPC decoding | 10% | 1.41% | 0.58% | 0.58% | 0.58% |
| BB: HARQ buffer | 14% | 1.61% | 0.52% | 0.52% | 0.52% |
| BB: DL control processing & decoder | 5% | 4.70% | 3.84% | 3.84% | 4.49% |
| BB: Synchronization / cell search block | 9% | 4.68% | 4.63% | 4.63% | 4.68% |
| BB: UL processing block | 5% | 3.10% | 1.79% | 1.78% | 1.91% |
| BB: MIMO specific processing blocks | 9% | 3.81% | 3.56% | 3.58% | 3.81% |
| **BB: Total** | **100%** | 26.58% | 18.05% | 18.82% | 20.70% |
| **RF+BB: Total** | **100%** | **39.07%** | **33.58%** | **34.41%** | **35.60%** |

Table 7.2.2-4: Average UE complexity reduction achieved by BW reduction options for FD-FDD 2Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE bandwidth | Rel-15 reference | Rel-17 RedCap | BW1 | BW2 | BW3 |
| RF: Power amplifier | 25% | 24.87% | 24.87% | 25.00% | 24.87% |
| RF: Filters | 10% | 10.00% | 9.02% | 9.49% | 9.56% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 45% | 42.47% | 41.51% | 42.63% | 42.47% |
| RF: Duplexer / Switch | 20% | 20.00% | 20.00% | 20.00% | 20.00% |
| **RF: Total** | **100%** | 97.33% | 95.40% | 97.12% | 96.90% |
| BB: ADC / DAC | 10% | 2.12% | 1.03% | 1.52% | 2.13% |
| BB: FFT/IFFT | 4% | 1.25% | 0.47% | 0.86% | 1.28% |
| BB: Post-FFT data buffering | 10% | 2.17% | 0.84% | 1.11% | 1.52% |
| BB: Receiver processing block | 24% | 8.97% | 4.47% | 4.78% | 4.60% |
| BB: LDPC decoding | 10% | 2.71% | 1.18% | 1.19% | 1.18% |
| BB: HARQ buffer | 14% | 2.53% | 0.97% | 0.91% | 0.97% |
| BB: DL control processing & decoder | 5% | 4.93% | 4.13% | 4.25% | 4.93% |
| BB: Synchronization / cell search block | 9% | 8.61% | 8.47% | 8.38% | 8.61% |
| BB: UL processing block | 5% | 3.20% | 1.99% | 2.04% | 2.08% |
| BB: MIMO specific processing blocks | 9% | 7.33% | 6.01% | 6.48% | 7.33% |
| **BB: Total** | **100%** | 43.84% | 29.57% | 31.52% | 34.65% |
| **RF+BB: Total** | **100%** | **65.24%** | **55.90%** | **57.76%** | **59.55%** |

Table 7.2.2-5: Average UE complexity reduction achieved by BW reduction options for TDD 2Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE bandwidth | Rel-15 reference | Rel-17 RedCap | BW1 | BW2 | BW3 |
| RF: Power amplifier | 25% | 24.44% | 24.44% | 25.00% | 24.44% |
| RF: Filters | 15% | 7.69% | 7.11% | 7.75% | 7.69% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 55% | 33.61% | 31.83% | 33.90% | 33.14% |
| RF: Duplexer / Switch | 5% | 4.99% | 4.99% | 5.00% | 4.99% |
| **RF: Total** | **100%** | 70.72% | 68.36% | 71.65% | 70.25% |
| BB: ADC / DAC | 9% | 1.13% | 0.56% | 0.89% | 1.13% |
| BB: FFT/IFFT | 4% | 0.66% | 0.25% | 0.52% | 0.70% |
| BB: Post-FFT data buffering | 10% | 1.17% | 0.47% | 0.52% | 0.83% |
| BB: Receiver processing block | 29% | 5.82% | 3.08% | 3.34% | 3.15% |
| BB: LDPC decoding | 9% | 1.33% | 0.64% | 0.67% | 0.64% |
| BB: HARQ buffer | 12% | 1.16% | 0.44% | 0.43% | 0.44% |
| BB: DL control processing & decoder | 4% | 3.75% | 3.10% | 3.13% | 3.75% |
| BB: Synchronization / cell search block | 9% | 4.50% | 4.56% | 4.50% | 4.63% |
| BB: UL processing block | 5% | 2.83% | 1.76% | 1.82% | 1.83% |
| BB: MIMO specific processing blocks | 9% | 3.82% | 3.05% | 3.26% | 3.75% |
| **BB: Total** | **100%** | 26.17% | 17.90% | 19.09% | 20.85% |
| **RF+BB: Total** | **100%** | **43.99%** | **38.08%** | **40.12%** | **40.61%** |

Table 7.2.2-6: Average UE complexity reduction achieved by BW reduction options for HD-FDD 2Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE bandwidth | Rel-15 reference | Rel-17 RedCap | BW1 | BW2 | BW3 |
| RF: Power amplifier | 25% | 25.00% | 25.00% | 25.00% | 25.00% |
| RF: Filters | 10% | 10.00% | 9.03% | 10.00% | 10.00% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 45% | 43.04% | 41.51% | 43.04% | 43.04% |
| RF: Duplexer / Switch | 20% | 4.33% | 4.33% | 4.33% | 4.33% |
| **RF: Total** | **100%** | 82.38% | 79.88% | 82.38% | 82.38% |
| BB: ADC / DAC | 10% | 2.06% | 1.09% | 1.52% | 2.07% |
| BB: FFT/IFFT | 4% | 1.15% | 0.49% | 0.73% | 1.18% |
| BB: Post-FFT data buffering | 10% | 2.14% | 0.90% | 1.10% | 1.40% |
| BB: Receiver processing block | 24% | 9.01% | 4.78% | 4.78% | 4.78% |
| BB: LDPC decoding | 10% | 2.69% | 1.19% | 1.19% | 1.19% |
| BB: HARQ buffer | 14% | 2.41% | 0.91% | 0.91% | 0.91% |
| BB: DL control processing & decoder | 5% | 5.00% | 4.25% | 4.25% | 5.00% |
| BB: Synchronization / cell search block | 9% | 8.55% | 8.38% | 8.38% | 8.55% |
| BB: UL processing block | 5% | 3.17% | 2.04% | 2.04% | 2.04% |
| BB: MIMO specific processing blocks | 9% | 7.23% | 6.48% | 6.48% | 7.23% |
| **BB: Total** | **100%** | 43.39% | 30.52% | 31.39% | 34.36% |
| **RF+BB: Total** | **100%** | **58.99%** | **50.26%** | **51.79%** | **53.57%** |

For comparison, the average complexity reduction estimates from [7] for different BW reduction options compared to the corresponding Rel-17 RedCap baselines are presented in the table below.

Table 7.2.2-7: Average UE complexity reduction achieved by BW reduction options compared to corresponding Rel-17 baselines

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Option | FD-FDD 1Rx | TDD 1Rx | HD-FDD 1Rx | FD-FDD 2Rx | TDD 2Rx | HD-FDD 2Rx |
| BW1 | 11.85% | 11.25% | 14.06% | 14.31% | 13.42% | 14.79% |
| BW2 | 9.15% | 8.08% | 11.92% | 11.46% | 8.81% | 12.21% |
| BW3 | 8.02% | 7.66% | 8.90% | 8.72% | 7.68% | 9.19% |

### 7.2.3 Analysis of performance impacts

**Peak data rate:**

Reducing the UE bandwidth leads to peak data rate reduction, but the reduced peak data rate can still fulfill the targeted data rate in Rel-18. In TDD, with 5 MHz UE bandwidth (for all BW options), the achievable peak data rate for UL or DL can be less than 10 Mbps depending on the TDD pattern.

**Coverage:**

For all BW options, there is link performance impact for SIB1 PDSCH if the bandwidth allocation for SIB1 PDSCH exceeds 5 MHz. However, in all scenarios except for 4 GHz with 24 dBm PSD, there is no or negligible coverage impact for SIB1 PDSCH even if the bandwidth allocation for SIB1 PDSCH exceeds 5 MHz.

Furthermore, for BW1/BW2, there is link performance degradation for PDCCH due to reduced maximum AL in a 5-MHz CORESET, and for PBCH (30 kHz SCS).

For a more detailed description of the coverage impacts, see clause 8.2.4.

**Latency:**

The impact of further UE bandwidth reduction on the latency is insignificant, and 5 MHz UE bandwidth (for all BW options) can sufficiently fulfil relaxed latency requirements of RedCap use cases.

### 7.2.4 Analysis of network deployment and coexistence impacts

If the common channels such as SIB1, OSI, RAR, MSG3 etc. are scheduled within 5MHz, then none of the UE bandwidth reduction options (BW1, BW2, BW3) have coexistence issues with legacy UEs, but otherwise there are some coexistence issues with legacy UEs.

BW1 and BW2 are expected to have the largest coexistence impacts among the evaluated options, whereas the expected coexistence impacts for BW3 are smaller. BW1 and BW2 can have coexistence impacts in terms of support of SSB/CORESET #0 configurations (especially 30 kHz SCS) and limitations of RACH configurations and PRACH sharing procedure. Furthermore, BW1 has impact on SSB transmissions (e.g., NCD-SSB overhead) and BWP operation.

Early indication (through Msg1/MsgA) might be needed for all BW options.

### 7.2.5 Analysis of specification impacts

BW1 and BW2 can have significant specification impacts, considering the impacts on initial access, random access, and SSB/CORESET #0 configurations (especially 30 kHz SCS). For BW1, the specification impacts may also include SSB presence requirements. BW3 has smaller specification impacts compared to BW1 and BW2.

## 7.3 Further UE peak rate reduction

### 7.3.1 Description of feature

In the study, the main UE peak rate reduction options considered for FR1 are as follows:

- Option PR1: Relaxation of the constraint   for peak data rate reduction.



- The relaxed constraint is 1 (instead of 4).

- The parameters (, , ) can be as in Rel-17 RedCap [4].



- Option PR2: Restriction of maximum TBS for PDSCH and PUSCH.

- For 15 kHz SCS, the maximum TBS is 10000 bits per TB and per slot.

- For 30 kHz SCS, the maximum TBS is 5000 bits per TB and per slot.

- Option PR3: Restriction of maximum number of PRBs for PDSCH and PUSCH.

- For 15 kHz SCS, the maximum number of RBs is 25.

- For 30 kHz SCS, the maximum number of RBs is 11.

- The restricted number of PRBs in Option PR3 is a hardcoded limit.

For the above peak rate reduction options, the following aspects are considered:

- The studied peak rate reduction applies to both UE-specific (unicast) and common (broadcast) channels.

- The resource allocation spans a bandwidth of maximum 20 MHz (maximum UE channel bandwidth).

- The same option is used for UL and DL.

- The same option is used for idle/inactive and connected mode.

- Note: As part of study of above options, it is not precluded to indicate that an observation is relevant for UL only or DL only.

### 7.3.2 Analysis of UE complexity reduction

For PR1 and PR2, the main contributors of the complexity reduction are the following functional blocks:

- Baseband: LDPC decoding

- Baseband: HARQ buffer

- Baseband: UL processing block

For PR3, the main contributors of the complexity reduction are the following functional blocks:

- Baseband: Receiver processing block

- Baseband: LDPC decoding

- Baseband: HARQ buffer

- Baseband: UL processing block

The tables below show the average value of the initial complexity evaluation results captured in [7]. Specifically, results are provided for Rel-17 RedCap and potential Rel-18 RedCap cases with FD-FDD 1Rx, TDD 1Rx, HD-FDD 1Rx, FD-FDD 2Rx, TDD 2Rx, and HD-FDD 2Rx.

Note that the reference Rel-15 NR UE has the following features:

- FDD: 100 MHz, 2 Rx, 2 layers, DL 256QAM, FD-FDD

- TDD: 100 MHz, 4 Rx, 4 layers, DL 256QAM

Table 7.3.2-1: Average UE complexity reduction achieved by PR reduction options for FD-FDD 1Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE peak rate | Rel-15 reference | Rel-17 RedCap | PR1 | PR2 | PR3 |
| RF: Power amplifier | 25% | 24.12% | 24.12% | 24.12% | 24.12% |
| RF: Filters | 10% | 5.06% | 5.06% | 5.06% | 5.06% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 45% | 23.76% | 23.76% | 23.76% | 23.76% |
| RF: Duplexer / Switch | 20% | 19.52% | 19.52% | 19.52% | 19.52% |
| **RF: Total** | **100%** | 72.46% | 72.46% | 72.46% | 72.46% |
| BB: ADC / DAC | 10% | 1.30% | 1.26% | 1.26% | 1.26% |
| BB: FFT/IFFT | 4% | 0.67% | 0.65% | 0.65% | 0.65% |
| BB: Post-FFT data buffering | 10% | 1.05% | 1.07% | 1.07% | 1.01% |
| BB: Receiver processing block | 24% | 4.42% | 4.21% | 4.21% | 2.46% |
| BB: LDPC decoding | 10% | 1.29% | 0.45% | 0.44% | 0.49% |
| BB: HARQ buffer | 14% | 1.46% | 0.43% | 0.41% | 0.43% |
| BB: DL control processing & decoder | 5% | 4.73% | 4.67% | 4.67% | 4.55% |
| BB: Synchronization / cell search block | 9% | 4.61% | 4.58% | 4.58% | 4.58% |
| BB: UL processing block | 5% | 2.69% | 1.94% | 1.89% | 1.66% |
| BB: MIMO specific processing blocks | 9% | 4.04% | 3.91% | 3.91% | 3.91% |
| **BB: Total** | **100%** | 26.26% | 23.18% | 23.09% | 21.00% |
| **RF+BB: Total** | **100%** | **44.74%** | **42.89%** | **42.84%** | **41.58%** |

Table 7.3.2-2: Average UE complexity reduction achieved by PR reduction options for TDD 1Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE peak rate | Rel-15 reference | Rel-17 RedCap | PR1 | PR2 | PR3 |
| RF: Power amplifier | 25% | 24.08% | 24.08% | 24.08% | 24.08% |
| RF: Filters | 15% | 3.94% | 3.94% | 3.94% | 3.94% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 55% | 19.05% | 19.05% | 19.05% | 19.05% |
| RF: Duplexer / Switch | 5% | 4.97% | 4.97% | 4.97% | 4.97% |
| **RF: Total** | **100%** | 52.04% | 52.04% | 52.04% | 52.04% |
| BB: ADC / DAC | 9% | 0.76% | 0.73% | 0.73% | 0.73% |
| BB: FFT/IFFT | 4% | 0.40% | 0.39% | 0.39% | 0.39% |
| BB: Post-FFT data buffering | 10% | 0.59% | 0.57% | 0.57% | 0.56% |
| BB: Receiver processing block | 29% | 3.21% | 3.03% | 3.03% | 1.84% |
| BB: LDPC decoding | 9% | 0.79% | 0.30% | 0.29% | 0.32% |
| BB: HARQ buffer | 12% | 0.79% | 0.39% | 0.38% | 0.39% |
| BB: DL control processing & decoder | 4% | 3.68% | 3.58% | 3.58% | 3.58% |
| BB: Synchronization / cell search block | 9% | 2.49% | 2.45% | 2.45% | 2.45% |
| BB: UL processing block | 5% | 2.69% | 1.91% | 1.85% | 1.66% |
| BB: MIMO specific processing blocks | 9% | 2.27% | 2.21% | 2.21% | 2.22% |
| **BB: Total** | **100%** | 17.66% | 15.56% | 15.49% | 14.14% |
| **RF+BB: Total** | **100%** | **31.41%** | **30.15%** | **30.11%** | **29.30%** |

Table 7.3.2-3: Average UE complexity reduction achieved by PR reduction options for HD-FDD 1Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE peak rate | Rel-15 reference | Rel-17 RedCap | PR1 | PR2 | PR3 |
| RF: Power amplifier | 25% | 24.50% | 24.50% | 24.50% | 24.50% |
| RF: Filters | 10% | 5.17% | 5.17% | 5.17% | 5.17% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 45% | 24.46% | 24.46% | 24.46% | 24.46% |
| RF: Duplexer / Switch | 20% | 3.68% | 3.68% | 3.68% | 3.68% |
| **RF: Total** | **100%** | 57.81% | 57.81% | 57.81% | 57.81% |
| BB: ADC / DAC | 10% | 1.25% | 1.25% | 1.25% | 1.25% |
| BB: FFT/IFFT | 4% | 0.71% | 0.71% | 0.71% | 0.71% |
| BB: Post-FFT data buffering | 10% | 1.10% | 1.10% | 1.10% | 1.04% |
| BB: Receiver processing block | 24% | 4.22% | 4.05% | 4.04% | 2.37% |
| BB: LDPC decoding | 10% | 1.41% | 0.50% | 0.49% | 0.56% |
| BB: HARQ buffer | 14% | 1.61% | 0.48% | 0.46% | 0.49% |
| BB: DL control processing & decoder | 5% | 4.70% | 4.70% | 4.70% | 4.49% |
| BB: Synchronization / cell search block | 9% | 4.68% | 4.68% | 4.68% | 4.68% |
| BB: UL processing block | 5% | 3.10% | 2.07% | 2.00% | 1.77% |
| BB: MIMO specific processing blocks | 9% | 3.81% | 3.81% | 3.81% | 3.81% |
| **BB: Total** | **100%** | 26.58% | 23.33% | 23.24% | 21.20% |
| **RF+BB: Total** | **100%** | **39.07%** | **37.12%** | **37.06%** | **35.90%** |

Table 7.3.2-4: Average UE complexity reduction achieved by PR reduction options for FD-FDD 2Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE peak rate | Rel-15 reference | Rel-17 RedCap | PR1 | PR2 | PR3 |
| RF: Power amplifier | 25% | 24.87% | 24.87% | 24.87% | 24.87% |
| RF: Filters | 10% | 10.00% | 9.56% | 9.29% | 9.29% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 45% | 42.47% | 42.47% | 40.32% | 40.32% |
| RF: Duplexer / Switch | 20% | 20.00% | 20.00% | 20.00% | 20.00% |
| **RF: Total** | **100%** | 97.33% | 96.90% | 94.48% | 94.48% |
| BB: ADC / DAC | 10% | 2.12% | 2.05% | 2.05% | 2.05% |
| BB: FFT/IFFT | 4% | 1.25% | 1.20% | 1.20% | 1.20% |
| BB: Post-FFT data buffering | 10% | 2.17% | 2.11% | 2.11% | 2.08% |
| BB: Receiver processing block | 24% | 8.97% | 8.68% | 8.68% | 5.31% |
| BB: LDPC decoding | 10% | 2.71% | 0.93% | 0.90% | 1.08% |
| BB: HARQ buffer | 14% | 2.53% | 0.84% | 0.80% | 0.88% |
| BB: DL control processing & decoder | 5% | 4.93% | 4.93% | 4.93% | 4.93% |
| BB: Synchronization / cell search block | 9% | 8.61% | 8.36% | 8.36% | 8.36% |
| BB: UL processing block | 5% | 3.20% | 2.12% | 2.12% | 2.11% |
| BB: MIMO specific processing blocks | 9% | 7.33% | 7.08% | 7.08% | 7.08% |
| **BB: Total** | **100%** | 43.84% | 38.30% | 38.23% | 35.07% |
| **RF+BB: Total** | **100%** | **65.24%** | **61.74%** | **60.73%** | **58.83%** |

Table 7.3.2-5: Average UE complexity reduction achieved by PR reduction options for TDD 2Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE peak rate | Rel-15 reference | Rel-17 RedCap | PR1 | PR2 | PR3 |
| RF: Power amplifier | 25% | 24.44% | 24.44% | 24.44% | 24.44% |
| RF: Filters | 15% | 7.69% | 7.69% | 7.69% | 7.69% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 55% | 33.61% | 33.14% | 33.14% | 33.14% |
| RF: Duplexer / Switch | 5% | 4.99% | 4.99% | 4.99% | 4.99% |
| **RF: Total** | **100%** | 70.72% | 70.25% | 70.25% | 70.25% |
| BB: ADC / DAC | 9% | 1.13% | 1.13% | 1.13% | 1.13% |
| BB: FFT/IFFT | 4% | 0.66% | 0.68% | 0.68% | 0.68% |
| BB: Post-FFT data buffering | 10% | 1.17% | 1.21% | 1.19% | 1.20% |
| BB: Receiver processing block | 29% | 5.82% | 5.71% | 5.71% | 3.55% |
| BB: LDPC decoding | 9% | 1.33% | 0.54% | 0.53% | 0.61% |
| BB: HARQ buffer | 12% | 1.16% | 0.41% | 0.40% | 0.43% |
| BB: DL control processing & decoder | 4% | 3.75% | 3.75% | 3.75% | 3.75% |
| BB: Synchronization / cell search block | 9% | 4.50% | 4.63% | 4.63% | 4.63% |
| BB: UL processing block | 5% | 2.83% | 1.93% | 1.90% | 1.91% |
| BB: MIMO specific processing blocks | 9% | 3.82% | 3.76% | 3.76% | 3.76% |
| **BB: Total** | **100%** | 26.17% | 23.75% | 23.68% | 21.65% |
| **RF+BB: Total** | **100%** | **43.99%** | **42.35%** | **42.31%** | **41.09%** |

Table 7.3.2-6: Average UE complexity reduction achieved by PR reduction options for HD-FDD 2Rx

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Reduced UE peak rate | Rel-15 reference | Rel-17 RedCap | PR1 | PR2 | PR3 |
| RF: Power amplifier | 25% | 25.00% | 25.00% | 25.00% | 25.00% |
| RF: Filters | 10% | 10.00% | 10.00% | 10.00% | 10.00% |
| RF: Transceiver (incl. LNAs, mixer, and local oscillator) | 45% | 43.04% | 43.04% | 43.04% | 43.04% |
| RF: Duplexer / Switch | 20% | 4.33% | 4.33% | 4.33% | 4.33% |
| **RF: Total** | **100%** | 82.38% | 82.38% | 82.38% | 82.38% |
| BB: ADC / DAC | 10% | 2.06% | 2.04% | 2.04% | 2.04% |
| BB: FFT/IFFT | 4% | 1.15% | 1.15% | 1.15% | 1.15% |
| BB: Post-FFT data buffering | 10% | 2.14% | 2.14% | 2.14% | 2.09% |
| BB: Receiver processing block | 24% | 9.01% | 8.77% | 8.77% | 5.43% |
| BB: LDPC decoding | 10% | 2.69% | 0.94% | 0.90% | 1.11% |
| BB: HARQ buffer | 14% | 2.41% | 0.82% | 0.78% | 0.87% |
| BB: DL control processing & decoder | 5% | 5.00% | 5.00% | 5.00% | 5.00% |
| BB: Synchronization / cell search block | 9% | 8.55% | 8.55% | 8.55% | 8.55% |
| BB: UL processing block | 5% | 3.17% | 2.09% | 2.09% | 2.07% |
| BB: MIMO specific processing blocks | 9% | 7.23% | 7.23% | 7.23% | 7.23% |
| **BB: Total** | **100%** | 43.39% | 38.74% | 38.65% | 35.55% |
| **RF+BB: Total** | **100%** | **58.99%** | **56.19%** | **56.14%** | **54.28%** |

For comparison, the average complexity reduction estimates from [7] for different peak rate reduction options compared to the corresponding Rel-17 RedCap baselines are presented in the table below.

Table 7.3.2-7: Average UE complexity reduction achieved by PR reduction options compared to corresponding Rel-17 baselines

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Option | FD-FDD 1Rx | TDD 1Rx | HD-FDD 1Rx | FD-FDD 2Rx | TDD 2Rx | HD-FDD 2Rx |
| PR1 | 4.13% | 4.02% | 4.99% | 5.36% | 3.73% | 4.74% |
| PR2 | 4.26% | 4.16% | 5.14% | 6.91% | 3.82% | 4.82% |
| PR3 | 7.06% | 6.74% | 8.12% | 9.81% | 6.59% | 7.98% |

### 7.3.3 Analysis of performance impacts

**Peak data rate:**

The UE peak rate reduction options (PR1/PR2/PR3) can all fulfil the data rate requirements.

**Coverage:**

For the UE peak rate reduction options PR1 and PR2, no coverage loss is expected.

For PR3, the coverage impacts are similar as for BW3, see clause 7.2.3.

For a more detailed description of the coverage impacts, see clause 8.2.4.

### 7.3.4 Analysis of network deployment and coexistence impacts

For UE peak rate reduction options PR1 and PR2, there is no or small coexistence issue.

For UE peak rate reduction option PR3 (in the same way as for UE bandwidth reduction option BW3 described in clause 7.2), SIB1, OSI, RAR and MSG4 need to be scheduled within 5 MHz, otherwise there may be coexistence impacts on legacy UEs.

Early indication (through Msg1/MsgA) might be needed for PR3.

### 7.3.5 Analysis of specification impacts

The UE peak rate reduction options (PR1/PR2/PR3) all have minimal specification impact.

## 7.4 Relaxed UE processing timeline

### 7.4.1 Description of feature

In the study, relaxed UE processing timeline is considered for FR1. The main options for the study are as follows:

- Option PT1: Relaxation of UE processing time for PDSCH/PUSCH in terms of N1 and N2 (as defined in TS 38.214) compared to those of UE processing time capability 1

- The relaxation factor for N1 and N2 is assumed to be 2 in the study.

- Option PT2: Relaxation of UE processing time for CSI in terms of Z and Z' compared to the values defined in TS 38.214 clause 5.4

- The relaxation factor for Z and Z' is assumed to be 2 in the study.

For the above relaxed UE processing timeline options, the following aspects are considered:

- The combination of Options PT1 and PT2 is also studied.

- UE complexity reduction estimates for relaxed UE processing timeline are only reported for combinations with UE bandwidth reduction or UE peak rate reduction.

### 7.4.2 Analysis of UE complexity reduction

For PT1, the main contributors of the complexity reduction are the following functional blocks:

- Baseband: Receiver processing block

- Baseband: LDPC decoding

- Baseband: DL control processing & decoder

- Baseband: UL processing block

For PT2, the main contributors of the complexity reduction are the following functional blocks:

- Baseband: DL control processing & decoder (when both PT1 and PT2 are supported)

- Baseband: UL processing block

- Baseband: MIMO specific processing block

Whether PT1 or PT2 may reduce the complexity in the 'DL control processing & decoder' block depends on the UE implementation. Complexity evaluations are provided only in combination with other techniques in clause 7.5.

### 7.4.3 Analysis of performance impacts

**Coverage:**

No coverage impact is expected from PT1 and PT2.

**Data rate:**

No impact on instantaneous peak data rate is expected from PT1 and PT2.

**Latency:**

Both PT1 and PT2 have impact on latency. For downlink transmission, relaxed N1 value in PT1 impacts how fast HARQ-ACK feedback can be sent after the reception of PDSCH. For uplink transmission, relaxed N2 value in PT1 impacts how fast PUSCH can be scheduled with respect to the UL grant and relaxed Z/Z' in PT2 impacts the scheduling of a PUSCH traffic that arrives after the DCI triggering A-CSI is sent since such PUSCH TB cannot be scheduled to be transmitted before the A-CSI is transmitted. How significant the impact on latency depends on use cases and scheduled number of retransmissions.

Note: For information on other performance impacts (throughput, power consumption), see TR 38.875 clause 7.5.3 [5].

### 7.4.4 Analysis of network deployment and coexistence impacts

For PT1, i.e., relaxed UE processing time in terms of N1 and N2:

- In scenarios where Rel-18 RedCap UEs coexist with legacy UEs, PT1 may increase the complexity for the scheduling.

- PT1 may have an impact on scheduling flexibility as several timing requirements are related to N1/N2 values.

- If PT1 is applicable during the initial/random access, it may cause potential coexistence issues with legacy UEs if early identification of Rel-18 RedCap UEs prior to Msg2 scheduling is not supported, or conservative scheduling is not possible. If gNB schedules all UEs according to relaxed timing relationships for Rel-18 RedCap UEs, legacy UEs may experience an increase in control plane latency.

For PT2, i.e., relaxed UE processing time in terms of Z and Z':

- PT2 may have impacts on scheduling flexibility and potentially make the scheduler more complex.

- PT2 may impact the scheduler's ability to track the channel when making scheduling decisions, especially in a fast-varying channel condition.

- No coexistence impact is expected from PT2.

### 7.4.5 Analysis of specification impacts

A new UE processing time capability needs to be defined if relaxed UE processing time in terms of N1 and N2 is introduced. New values of N1 and N2, as well as how the PDSCH processing time and PUSCH preparation time are determined by N1 and N2, need to be defined. Depending on the degree of relaxation of the N1 and N2 values, specification details on scheduling timing may be updated, such as HARQ-ACK timing range. Moreover, PT1 may introduce a need for early indication in Msg1. And PT1 does not need to define new default TDRA table for downlink.

New CSI computation delay requirements need to be defined if relaxed UE processing time in terms of Z and Z' is introduced. New values of Z and Z', as well as how the CSI computation time is determined by Z and Z', need to be defined.

## 7.5 Combinations of UE complexity reduction features

### 7.5.1 Description of feature combinations

The evaluation results for the studied individual UE complexity reduction techniques are captured in clauses 7.2 through 7.4. In this clause, the properties of combinations of different individual UE complexity reduction techniques are described.

### 7.5.2 Analysis of UE complexity reduction

The table below show the average value of the UE complexity reduction evaluation results for different combinations of UE complexity reduction features captured in [7].

Furthermore, all BW and PR reduction options that correspond to target max 10 Mbps data rate result in reduction of memory size, although these aspects are not captured in the complexity reduction evaluation results in the table. The required L2 buffer size at the UE scales linearly with the UE peak data rate and with the UE bandwidth.

Table 7.5.2-1: Average complexity reduction achieved by combinations of UE complexity reduction features compared to corresponding Rel-17 baselines

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Option | FD-FDD 1Rx | TDD 1Rx | HD-FDD 1Rx | FD-FDD 2Rx | TDD 2Rx | HD-FDD 2Rx |
| BW1 | 11.85% | 11.25% | 14.06% | 14.31% | 13.42% | 14.79% |
| BW1 + PT1 | 12.44% | 11.64% | 14.30% | 17.65% | 14.58% | 16.38% |
| BW1 + PT1 + PT2 | 14.75% | 14.73% | 17.51% | 19.10% | 15.80% | 17.89% |
| BW2 | 9.15% | 8.08% | 11.92% | 11.46% | 8.81% | 12.21% |
| BW2 + PT1 + PT2 | 11.54% | 10.91% | 15.27% | 16.70% | 10.99% | 15.18% |
| BW3 | 8.02% | 7.66% | 8.90% | 8.72% | 7.68% | 9.19% |
| BW3+PT1 | 8.70% | 7.84% | 10.15% | 12.48% | 8.98% | 10.77% |
| BW3 + PT1 + PT2 | 11.55% | 11.50% | 12.92% | 14.59% | 10.82% | 12.76% |
| PR1 | 4.13% | 4.02% | 4.99% | 5.36% | 3.73% | 4.74% |
| PR1 + PT1 | 5.40% | 4.85% | 6.58% | 8.80% | 5.49% | 6.54% |
| PR1 + PT1 + PT2 | 7.88% | 8.67% | 9.33% | 10.99% | 6.76% | 8.63% |
| PR2 | 4.26% | 4.16% | 5.14% | 6.91% | 3.82% | 4.82% |
| PR2 + PT1 + PT2 | 7.17% | 6.23% | 9.48% | 10.89% | 6.81% | 8.70% |
| PR3 | 7.06% | 6.74% | 8.12% | 9.81% | 6.59% | 7.98% |
| PR3 + PT1 | 7.69% | 7.23% | 9.32% | 11.49% | 8.11% | 9.67% |
| PR3 + PT1 + PT2 | 10.22% | 10.70% | 12.07% | 13.55% | 9.88% | 11.60% |

### 7.5.3 Analysis of performance impacts

For performance impacts for each UE complexity reduction technique, refer to clauses 7.2 through 7.4.

### 7.5.4 Analysis of network deployment and coexistence impacts

For network deployment and coexistence impacts for each UE complexity reduction technique, refer to clauses 7.2 through 7.4.

### 7.5.5 Analysis of specification impacts

For specification impacts for each UE complexity reduction technique, refer to clauses 7.2 through 7.4.

# 8 Coverage impact

## 8.1 Introduction to coverage impact

Potential coverage reduction due to the device complexity reduction was studied. The evaluation methodology is described in clause 6.2. Evaluation results for different scenarios are described in clause 8.2.1 through clause 8.2.3 where it was assumed the potential Rel-18 UE had the maximum bandwidth reduced to 5MHz in both RF and BB. In other words, the complexity reduction option BW1 from clause 7.2 was assumed for the coverage impact evaluation in clause 8.2.1 through clause 8.2.3. Starting from the coverage evaluation results for BW1, clause 8.2.4 presents a summary of observations on coverage impact evaluation for different complexity reduction options particularly BW1, BW2, BW3, and PR3.

## 8.2 Coverage impact evaluation

### 8.2.1 Urban scenario at 2.6 GHz

For Urban scenario at 2.6 GHz, the bottleneck channel for the reference NR UE and the corresponding maximum isotropic loss (MIL) value by the sourcing companies [7] are shown in Table 8.2.1-1. For this Urban scenario at 2.6 GHz, the study primarily evaluated the potential Rel-18 UE with 11-PRB UE bandwidth. Sourcing companies could additionally report evaluation results with 12-PRB UE bandwidth.

As can be seen from Table 8.2.1-1, for Urban scenario at 2.6GHz, PUSCH is the bottleneck channel for the reference NR UE.

Table 8.2.1-1: Bottleneck channels and MIL values for the reference R15 NR UE in Urban scenario at 2.6GHz

|  |  |  |
| --- | --- | --- |
| Company | Bottleneck Channel | MIL (dB) |
| MediaTek | PUSCH (\*) | 142.55 |
| Spreadtrum | PUSCH | 145.74 |
| ZTE | PUSCH | 141.43 |
| Ericsson | PUSCH | 137.14 |
| Samsung | PUSCH | 139.44 |
| vivo | PUSCH | 139.57 |
| Nokia | PUSCH | 140.02 |
| CMCC | PUSCH | 141.01 |
| NTT DOCOMO | PUSCH | 145.46 |
| CATT | PUSCH | 144.34 |
| OPPO | PUSCH | 145.14 |
| Panasonic | PUSCH (\*) | 142.55 |
| Mavenir | PUSCH (\*) | 142.55 |
| Xiaomi | PUSCH | 146.85 |
| Huawei | PUSCH | 138.95 |
| Lenovo | PUSCH | 142.96 |
| Intel | PUSCH | 140.35 |
| Qualcomm | PUSCH | 139.37 |
| NOTE: For a sourcing company labeled with (\*) that did not provide evaluation results for uplink channels for the reference NR UE, the bottleneck channel and its MIL value were derived from Table 9.1.1-1 of TR 38.875 [5] based on the methodology in Clause 6.2. | | |

For the potential Rel-18 UE with maximum 11-PRB bandwidth, the coverage margins relative to the bottleneck channel of the reference NR UE are summarized in Table 8.2.1-2 (part 1 and part 2) and Table 8.2.1-3 (part 1 and part 2). In Table 8.2.1-2, no UE antenna efficiency loss is assumed for the potential Rel-18 UE with maximum 11-PRB bandwidth. In Table 8.2.1-3, UE antenna efficiency loss of 3dB is assumed in both DL and UL for the potential Rel-18 UE with maximum 11-PRB bandwidth. For every sourcing-company result, the coverage margin for each channel that has MIL below the bottleneck channel for the reference NR UE is highlighted in red.

The representative value 1, number of samples 1, representative value 2, and number of samples 2 in the last four rows of Table 8.2.1-2 and Table 8.2.1-3 are determined according to the methodology described in clause 6.2. A negative representative value for a channel of the potential Rel-18 UE indicates the coverage of the channel is worse than that of the bottleneck channel of the reference NR UE.

As can be seen from the representative values in Table 8.2.1-2 and Table 8.2.1-3, for Urban scenario at 2.6 GHz with DL PSD of 33 dBm/MHz and maximum 11-PRB UE bandwidth:

- Without 3-dB UE antenna efficiency loss: the representative values of the coverage margins for the potential Rel-18 UE with 11-PRB BW for all channels are positive.

- With 3-dB UE antenna efficiency loss: the representative values of the coverage margins for the potential Rel-18 UE with 11-PRB BW for all channels are positive except for PDCCH CSS with AL2 and certain configuration of SIB1. The coverage of PDCCH CSS with AL2 has worse coverage by less than 1 dB than the bottleneck channel of the reference NR UE. A similar observation applies to SIB1. It should be noted that the reception schemes for SIB1 coverage simulations have different assumptions among sourcing companies. For example, some punctured the bits transmitted outside the potential Rel-18 UE's bandwidth while some performed soft combining the bits transmitted outside the potential Rel-18 UE's bandwidth by RF retuning at UE side.

As can be seen from the representative values in Table 8.2.1-2 and Table 8.2.1-3, PUSCH for the potential Rel-18 UE with maximum 11-PRB bandwidth, with or without 3dB UE antenna efficiency loss, has better coverage than the bottleneck channel of the reference NR UE and hence coverage recovery is not needed for PUSCH. This is because the cell-edge target data rates are scaled by a factor of 0.25 for the potential Rel-18 UE compared to the reference Rel-17 RedCap UE.

Table 8.2.1-2 (part 1): In Urban scenario at 2.6GHz with DL 33dBm/MHz PSD, coverage margins for the potential Rel-18 UE with maximum 11-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.1-1 when no UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin (dB) | PBCH  target BLER1% | PBCH  target BLER10% | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 24 PRBs; AL8) | PDCCH CSS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | SIB1 (BW1, 11 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | SIB1 (BW1, 11 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) | Msg2 (BW1, 11 PRBs; TBS 72 bits) | Msg4 (BW1, 11 PRBs; TBS 1040 bits) |
| MediaTek | 13.42 | - | 8.32 | 7.72 | 3.62 | 2.72 | 5.52 | 10.12 | 6.32 |
| Spreadtrum | - | 7.23 | 4.73 | 4.03 | 0.53 | **-0.57** | 0.83 | 11.23 | 4.83 |
| ZTE | - | 10.90 | 0.90 | **-4.00** | **-2.80** | **-1.70** | 4.10 | 10.60 | 5.50 |
| Ericsson | 8.53 | - | 6.53 | 6.03 | **-0.67** | **-2.23** | 1.04 | 6.69 | 2.01 |
| Samsung | - | - | - | - | 7.43 | - | 5.53 | 14.13 | 7.33 |
| vivo | 7.80 | 12.92 | 11.38 | 9.39 | 7.36 | 8.92 | 8.53 | - | - |
| Nokia | 18.19 | - | 15.19 | 15.19 | 11.19 | 11.89 | 11.39 | 24.59 | 10.69 |
| CMCC | 12.62 | - | 3.44 | 3.44 | **-0.32** | 5.35 | 7.85 | 18.75 | 14.95 |
| NTT DOCOMO | 10.33 | - | 6.02 | 6.02 | 1.50 | **-3.64** | 3.04 | 8.96 | 4.16 |
| CATT | 10.93 | - | 5.53 | 3.13 | **-0.17** | 0.93 | 2.73 | 6.23 | 3.93 |
| OPPO | 7.92 | - | 8.02 | 7.42 | 4.02 | 6.12 | 9.32 | 10.64 | 10.32 |
| Panasonic | - | - | **-2.58** | **-3.38** | **-8.98** | **-3.68** | **-4.38** | - | - |
| Mavenir | - | - | - | 4.16 | 2.51 | **-0.58** | 0.91 | - | - |
| Xiaomi | 4.30 | - | - | 4.37 | **-1.78** | **-3.58** | **-1.08** | 5.72 | 1.79 |
| Huawei | 13.81 | - | 9.61 | 9.21 | 5.31 | 15.61 | 11.11 | 12.31 | 7.81 |
| Lenovo | 8.7 | - | - | - | 5.01 | - | 4.3 | - | - |
| Intel | 17.43 | - | 11.13 | 9.93 | 6.43 | 2.13 | 5.83 | 12.53 | 7.43 |
| Qualcomm | 14.89 |  | 5.87 |  | 3.17 | 4.89 | 5.19 | 11.69 | 6.59 |
| **Representative value 1** | **11.30** | **10.90** | **7.23** | **6.30** | **2.91** | **2.92** | **5.34** | **11.25** | **6.42** |
| **# of samples 1** | 12 | 3 | 12 | 12 | 15 | 13 | 15 | 13 | 13 |
| **Representative value 2** | **11.49** | **10.90** | **6.79** | **5.50** | **2.57** | **2.19** | **4.67** | **11.16** | **6.41** |
| **# of samples 2** | 13 | 3 | 14 | 15 | 18 | 16 | 18 | 14 | 14 |

Table 8.2.1-2 (part 2): In Urban scenario at 2.6GHz with DL 33dBm/MHz PSD, coverage margins for the potential Rel-18 UE with maximum 11-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.1-1 when no UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin (dB) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 12 PRBs; AL4) | PDSCH (BW1, 11 PRBs; 0.5 Mbps) | PRACH B4 (BW1, 11 PRBs) | PRACH C2 (BW1, 11 PRBs) | Msg3 (BW1, 11 PRBs) | PUSCH (BW1, 11 PRBs; 0.25 Mbps) | PUCCH 2bit (BW1, 11 PRBs) | PUCCH 11bit (BW1, 11 PRBs) | PUCCH 22 bits (BW1, 11 PRBs) |
| MediaTek | 6.02 | 12.22 | 15.92 | - | - | - | - | - | - | - |
| Spreadtrum | 4.53 | 9.93 | 12.53 | 7.06 | 5.06 | 7.76 | 4.06 | 11.47 | 12.37 | 9.97 |
| ZTE | 0.33 | 10.43 | 21.03 | - | - | 13.76 | 5.06 | 21.27 | 18.67 | 16.67 |
| Ericsson | 3.33 | 8.13 | 11.98 | 17.96 | - | 14.06 | 5.46 | 13.07 | 18.56 | 16.63 |
| Samsung | 11.53 | 16.73 | 17.33 | - | - | 10.56 | 4.97 | 20.17 | 15.37 | 13.17 |
| vivo | - | - | - | - | - | - | - | - | - | - |
| Nokia | 11.19 | 15.69 | 18.59 | - | - | 11.86 | 3.94 | - | - | - |
| CMCC | 5.68 | 11.27 | 19.35 | 14.74 | 12.77 | 11.70 | 4.44 | 15.60 | 13.75 | 11.84 |
| NTT DOCOMO | 5.50 | - | 14.17 | - | - | 9.37 | 5.35 | 17.53 | 17.58 | - |
| CATT | 3.83 | 8.03 | 12.43 | 10.56 | 10.26 | 8.46 | 4.36 | 15.87 | 14.47 | 12.47 |
| OPPO | - | - | - | - | - | - | - | - | - | - |
| Panasonic | - | - | - | - | - | - | - | - | - | - |
| Mavenir | - | - | - | - | - | - | - | - | - | - |
| Xiaomi | 2.22 | - | 10.90 | - | - | 8.19 | 5.04 | - | - | - |
| Huawei | 8.31 | 13.41 | 15.91 | 6.28 | 6.38 | 11.66 | 3.68 | 21.63 | 19.33 | - |
| Lenovo | - | - | - | - | - | 11.24 | - | - | - | - |
| Intel | 7.69 | 13.09 | 14.19 | - | - | 7.14 | 5.63 | - | - | - |
| Qualcomm | - | - | 17.39 |  |  | 8.86 | 4.87 |  |  | 7.16 |
| **Representative value 1** | **5.81** | **11.71** | **15.39** | **10.79** | **8.32** | **10.31** | **4.76** | **17.25** | **16.40** | **12.82** |
| **# of samples 1** | 11 | 9 | 12 | 5 | 4 | 13 | 12 | 8 | 8 | 7 |
| **Representative value 2** | **5.83** | **11.77** | **15.44** | **10.79** | **8.32** | **10.31** | **4.76** | **17.25** | **16.40** | **12.82** |
| **# of samples 2** | 12 | 10 | 13 | 5 | 4 | 13 | 12 | 8 | 8 | 7 |

Table 8.2.1-3 (part 1): In Urban scenario at 2.6GHz with DL 33dBm/MHz PSD, coverage margins for the potential Rel-18 UE with maximum 11-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.1-1 when 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin (dB) | PBCH  target BLER1% | PBCH  target BLER10% | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 24 PRBs; AL8) | PDCCH CSS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | SIB1 (BW1, 11 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | SIB1 (BW1, 11 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) | Msg2 (BW1, 11 PRBs; TBS 72 bits) | Msg4 (BW1, 11 PRBs; TBS 1040 bits) |
| MediaTek | 10.42 | - | 5.32 | 4.72 | 0.62 | **-0.28** | 2.52 | 7.12 | 3.32 |
| Spreadtrum | - | 4.23 | 1.73 | 1.03 | **-2.47** | **-3.57** | **-2.17** | 8.23 | 1.83 |
| ZTE | - | 7.90 | **-2.10** | **-7.00** | **-5.80** | **-4.70** | 1.10 | 7.60 | 2.50 |
| Ericsson | 5.53 | - | 3.53 | 3.03 | **-3.67** | **-5.23** | **-1.96** | 3.69 | **-0.99** |
| Samsung | - | - | - | - | 4.43 | - | 2.53 | 11.13 | 4.33 |
| vivo | 4.80 | 9.92 | 8.38 | 6.39 | 4.36 | 5.92 | 5.53 | - | - |
| Nokia | 15.19 | - | 12.19 | 12.19 | 8.19 | 8.89 | 8.39 | 21.59 | 7.69 |
| CMCC | 9.62 | - | 0.44 | 0.44 | **-3.32** | 2.35 | 4.85 | 15.75 | 11.95 |
| NTT DOCOMO | 7.33 | - | 3.02 | 3.02 | **-1.50** | **-6.64** | 0.04 | 5.96 | 1.16 |
| CATT | 7.93 | - | 2.53 | 0.13 | **-3.17** | **-2.07** | **-0.27** | 3.23 | 0.93 |
| OPPO | 4.92 | - | 5.02 | 4.42 | 1.02 | 3.12 | 6.32 | 7.64 | 7.32 |
| Panasonic | - | - | **-5.58** | **-6.38** | **-11.98** | **-6.68** | **-7.38** | - | - |
| Mavenir | - | - | - | 1.16 | **-0.49** | **-3.58** | **-2.09** | - | - |
| Xiaomi | 1.30 | - | - | 1.37 | **-4.78** | **-6.58** | **-4.08** | 2.72 | **-1.21** |
| Huawei | 10.81 | - | 6.61 | 6.21 | 2.31 | 12.61 | 8.11 | 9.31 | 4.81 |
| Lenovo | 5.7 | - | - | - | 2.01 | - | 1.3 | - | - |
| Intel | 14.43 | - | 8.13 | 6.93 | 3.43 | **-0.87** | 2.83 | 9.53 | 4.43 |
| Qualcomm | 11.89 |  | 2.87 |  | 0.17 | 1.89 | 2.19 | 8.69 | 3.59 |
| **Representative value 1** | **8.30** | **N/A** | **4.23** | **3.30** | **-0.09** | **-0.08** | **2.34** | **8.25** | **3.42** |
| **# of samples 1** | 12 | 3 | 12 | 12 | 15 | 13 | 15 | 13 | 13 |
| **Representative value 2** | **8.49** | **N/A** | **3.79** | **2.50** | **-0.43** | **-0.81** | **1.67** | **8.16** | **3.41** |
| **# of samples 2** | 13 | 3 | 14 | 15 | 18 | 16 | 18 | 14 | 14 |

Table 8.2.1-3 (part 2): In Urban scenario at 2.6GHz with DL 33dBm/MHz PSD, coverage margins for the potential Rel-18 UE with maximum 11-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.1-1 when 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin (dB) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 12 PRBs; AL4) | PDSCH (BW1, 11 PRBs; 0.5 Mbps) | PRACH B4 (BW1, 11 PRBs) | PRACH C2 (BW1, 11 PRBs) | Msg3 (BW1, 11 PRBs) | PUSCH (BW1, 11 PRBs; 0.25 Mbps) | PUCCH 2bit (BW1, 11 PRBs) | PUCCH 11bit (BW1, 11 PRBs) | PUCCH 22 bits (BW1, 11 PRBs) |
| MediaTek | 3.02 | 9.22 | 12.92 | - | - | - | - | - | - | - |
| Spreadtrum | 1.53 | 6.93 | 9.53 | 4.06 | 2.06 | 4.76 | 1.06 | 8.47 | 9.37 | 6.97 |
| ZTE | **-2.67** | 7.43 | 18.03 | - | - | 10.76 | 2.06 | 18.27 | 15.67 | 13.67 |
| Ericsson | 0.33 | 5.13 | 8.98 | 14.96 | - | 11.06 | 2.46 | 10.07 | 15.56 | 13.63 |
| Samsung | 8.53 | 13.73 | 14.33 | - | - | 7.56 | 1.97 | 17.17 | 12.37 | 10.17 |
| vivo | - | - | - | - | - | - | - | - | - | - |
| Nokia | 8.19 | 12.69 | 15.59 | - | - | 8.86 | 0.94 | - | - | - |
| CMCC | 2.68 | 8.27 | 16.35 | 11.74 | 9.77 | 8.70 | 1.44 | 12.60 | 10.75 | 8.84 |
| NTT DOCOMO | 2.50 | - | 11.17 | - | - | 6.37 | 2.35 | 14.53 | 14.58 | - |
| CATT | 0.83 | 5.03 | 9.43 | 7.56 | 7.26 | 5.46 | 1.36 | 12.87 | 11.47 | 9.47 |
| OPPO | - | - | - | - | - | - | - | - | - | - |
| Panasonic | - | - | - | - | - | - | - | - | - | - |
| Mavenir | - | - | - | - | - | - | - | - | - | - |
| Xiaomi | **-0.78** | - | 7.90 | - | - | 5.19 | 2.04 | - | - | - |
| Huawei | 5.31 | 10.41 | 12.91 | 3.28 | 3.38 | 8.66 | 0.68 | 18.63 | 16.33 | - |
| Lenovo | - | - | - | - | - | 8.24 | - | - | - | - |
| Intel | 4.69 | 10.09 | 11.19 | - | - | 4.14 | 2.63 | - | - | - |
| Qualcomm | - | - | 14.39 |  |  | 5.86 | 1.87 |  |  | 4.16 |
| **Representative value 1** | **2.81** | **8.71** | **12.39** | **7.79** | **5.32** | **7.31** | **1.76** | **14.25** | **13.40** | **9.82** |
| **# of samples 1** | 11 | 9 | 12 | 5 | 4 | 13 | 12 | 8 | 8 | 7 |
| **Representative value 2** | **2.83** | **8.77** | **12.44** | **7.79** | **5.32** | **7.31** | **1.76** | **14.25** | **13.40** | **9.82** |
| **# of samples 2** | 12 | 10 | 13 | 5 | 4 | 13 | 12 | 8 | 8 | 7 |

For the potential Rel-18 UE with maximum 12-PRB bandwidth, the coverage margins relative to the bottleneck channel of the reference NR UE are summarized in Table 8.2.1-4 (part 1 and part 2) and Table 8.2.1-5 (part 1 and part 2). In Table 8.2.1-4, no UE antenna efficiency loss is assumed for the potential Rel-18 UE with maximum 12-PRB bandwidth. In Table 8.2.1-5, the 3dB UE antenna efficiency loss is assumed in both DL and UL for the potential Rel-18 UE with maximum 12-PRB bandwidth. For every sourcing-company result, the coverage margin for each channel that has MIL below the bottleneck channel for the reference NR UE is highlighted in red.

The representative value 1, number of samples 1, representative value 2, and number of samples 2 in the last four rows of Table 8.2.1-4 and Table 8.2.1-5 are determined according to the methodology described in clause 6.2. A negative representative value for a channel of the potential Rel-18 UE indicates the coverage of the channel is worse than that of the bottleneck channel of the reference NR UE.

For Urban scenario at 2.6 GHz with DL PSD of 33 dBm/MHz and maximum 12-PRB UE bandwidth:

- Without 3-dB UE antenna efficiency loss: the representative values of the coverage margins for Rel-18 UE with maximum 12-PRB bandwidth for all channels are positive.

- With 3-dB UE antenna efficiency loss: the representative values of the coverage margins for Rel-18 UE with maximum 12-PRB bandwidth for all channels are positive. Again, it is noted that the reception schemes for SIB1 coverage simulations have different assumptions among sourcing companies. For example, some punctured the bits transmitted outside the potential Rel-18 UE's bandwidth while some performed soft combining the bits transmitted outside the potential Rel-18 UE's bandwidth by retuning RF.

As can be seen from the representative values in Table 8.2.1-4 and Table 8.2.1-5, PUSCH for the potential Rel-18 UE with maximum 12-PRB bandwidth, with or without 3dB UE antenna efficiency loss, has better coverage than the bottleneck channel of the reference NR UE and hence coverage recovery is not needed for PUSCH. This is because the cell-edge target data rates are scaled by a factor of 0.25 for the potential Rel-18 RedCap UE compared to the reference Rel-17 RedCap UE.

Table 8.2.1-4 (part 1): In Urban scenario at 2.6GHz with DL 33dBm/MHz PSD, coverage margins for the potential Rel-18 UE with maximum 12-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.1-1 when no UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PBCH  target BLER1% | PBCH  target BLER10% | PDCCH CSS (BW1, 12 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | PDCCH CSS (BW1, 12 PRBs; CORESET: 2 symbols, 24 PRBs; AL8) | PDCCH CSS (BW1, 12 PRBs; CORESET: 3 symbols, 12 PRBs; AL4) | SIB1 (BW1, 12 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | SIB1 (BW1, 12 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) | Msg2 (BW1, 12 PRBs; TBS 72 bits) | Msg4 (BW1, 12 PRBs; TBS 1040 bits) |
| MediaTek | 13.42 | - | 9.02 | 8.42 | 9.92 | 3.82 | 5.52 | 10.12 | 6.62 |
| Spreadtrum | - | 7.93 | 5.33 | 4.53 | 6.03 | 0.23 | 0.83 | 11.23 | 5.23 |
| Ericsson | 8.53 | - | 7.33 | 6.43 | 4.43 | **-0.37** | 1.91 | 6.69 | 3.07 |
| vivo | 5.80 | 13.07 | 11.81 | 10.51 | 12.22 | 9.90 | 8.53 | - | - |
| CMCC | 12.82 | - | 4.54 | 4.53 | 5.27 | 6.75 | 9.15 | 18.75 | 15.95 |
| CATT | 11.53 | - | 6.23 | 4.53 | 5.43 | 2.13 | 3.23 | 6.23 | 4.33 |
| Xiaomi | 4.67 | - | - | 4.84 | 4.48 | **-0.96** | 1.47 | 5.54 | 3.50 |
| Huawei | 14.21 | - | 10.41 | 10.01 | 10.81 | 15.91 | 12.51 | 12.31 | 8.81 |
| Intel | 18.33 | - | 11.93 | 10.93 | 11.83 | 4.23 | 6.83 | 12.53 | 8.33 |
| Qualcomm | 15.49 |  |  |  | 6.27 |  | 6.89 | - | - |
| **Representative value 1** | **11.40** | **N/A** | **8.22** | **6.81** | **7.16** | **3.81** | **5.43** | **9.80** | **6.04** |
| **# of samples 1** | 8 | 2 | 7 | 8 | 9 | 8 | 9 | 7 | 7 |
| **Representative value 2** | **11.69** | **N/A** | **8.36** | **7.04** | **7.51** | **3.81** | **5.44** | **9.85** | **6.14** |
| **# of samples 2** | 9 | 2 | 8 | 9 | 10 | 9 | 10 | 8 | 8 |

Table 8.2.1-4 (part 2): In Urban scenario at 2.6GHz with DL 33dBm/MHz PSD, coverage margins for the potential Rel-18 UE with maximum 12-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.1-1 when no UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin (dB) | PDCCH USS (BW1, 12 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | PDCCH USS (BW1, 12 PRBs; CORESET: 3 symbols, 12 PRBs; AL4) | PDSCH (BW1, 12 PRBs; 0.5 Mbps) | PRACH B4 (BW1, 12 PRBs) | PRACH C2(BW1, 12 PRBs) | Msg3 (BW1, 12 PRBs) | PUSCH (BW1, 12 PRBs; 0.25 Mbps) | PUCCH 2bit (BW1, 12 PRBs) | PUCCH 11bit (BW1, 12 PRBs) | PUCCH 22 bits (BW1, 12 PRBs) |
| MediaTek | 6.02 | 12.92 | 15.92 | - | - | - | - | - | - | - |
| Spreadtrum | 4.53 | 10.83 | 12.63 | 6.83 | 4.83 | 7.76 | 3.68 | 11.47 | 12.37 | 9.97 |
| Ericsson | 3.33 | 8.43 | 12.02 | 17.93 | - | 14.06 | 5.38 | 13.07 | 18.57 | 16.64 |
| vivo | - | - | - | - | - | - | - | - | - | - |
| CMCC | 5.68 | 11.27 | 19.05 | 14.62 | 12.77 | 11.70 | 4.45 | 15.53 | 13.79 | 11.82 |
| CATT | 3.83 | 9.43 | 14.13 | 13.43 | 8.93 | 8.46 | 4.28 | 15.87 | 14.47 | 12.47 |
| Xiaomi | 2.22 | 8.48 | 12.62 | - | - | 8.13 | 5.25 | - | - | - |
| Huawei | 8.21 | 13.81 | 16.91 | 6.35 | 6.45 | 11.66 | 4.10 | 21.63 | 19.33 | - |
| Intel | 7.69 | 13.09 | 14.19 | - | - | 7.14 | 5.63 | - | - | - |
| Qualcomm | - | - | - | - | - | - | - | - | - | - |
| **Representative value 1** | **5.01** | **10.62** | **14.10** | **11.63** | **7.69** | **9.54** | **4.69** | **14.82** | **15.61** | **12.15** |
| **# of samples 1** | 7 | 7 | 7 | 5 | 4 | 7 | 7 | 5 | 5 | 4 |
| **Representative value 2** | **5.18** | **11.00** | **14.40** | **11.63** | **7.69** | **9.54** | **4.69** | **14.82** | **15.61** | **12.15** |
| **# of samples 2** | 8 | 8 | 8 | 5 | 4 | 7 | 7 | 5 | 5 | 4 |

Table 8.2.1-5 (part 1): In Urban scenario at 2.6GHz with DL 33dBm/MHz PSD, coverage margins for the potential Rel-18 UE with maximum 12-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.1-1 when 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin (dB) | PBCH  target BLER1% | PBCH  target BLER10% | PDCCH CSS (BW1, 12 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | PDCCH CSS (BW1, 12 PRBs; CORESET: 2 symbols, 24 PRBs; AL8) | PDCCH CSS (BW1, 12 PRBs; CORESET: 3 symbols, 12 PRBs; AL4) | SIB1 (BW1, 12 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | SIB1 (BW1, 12 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) | Msg2 (BW1, 12 PRBs; TBS 72 bits) | Msg4 (BW1, 12 PRBs; TBS 1040 bits) |
| MediaTek | 10.42 | - | 6.02 | 5.42 | 6.92 | 0.82 | 2.52 | 7.12 | 3.62 |
| Spreadtrum | - | 4.93 | 2.33 | 1.53 | 3.03 | **-2.77** | **-2.17** | 8.23 | 2.23 |
| Ericsson | 5.53 | - | 4.33 | 3.43 | 1.43 | **-3.37** | **-1.09** | 3.69 | 0.07 |
| vivo | 2.80 | 10.07 | 8.81 | 7.51 | 9.22 | 6.90 | 5.52 | - | - |
| CMCC | 9.82 | - | 1.54 | 1.53 | 2.27 | 3.75 | 6.15 | 15.75 | 12.95 |
| CATT | 8.53 | - | 3.23 | 1.53 | 2.43 | **-0.87** | 0.23 | 3.23 | 1.33 |
| Xiaomi | 1.67 | - | - | 1.84 | 1.48 | **-3.96** | **-1.53** | 2.54 | 0.50 |
| Huawei | 11.21 | - | 7.41 | 7.01 | 7.81 | 12.91 | 9.51 | 9.31 | 5.81 |
| Intel | 15.33 | - | 8.93 | 7.93 | 8.83 | 1.23 | 3.83 | 9.53 | 5.33 |
| Qualcomm | 12.49 |  |  |  | 3.27 |  | 3.89 |  |  |
| **Representative value 1** | **8.40** | **N/A** | **5.22** | **3.81** | **4.16** | **0.81** | **2.43** | **6.80** | **3.04** |
| **# of samples 1** | 8 | 2 | 7 | 8 | 9 | 8 | 9 | 7 | 7 |
| **Representative value 2** | **8.69** | **N/A** | **5.36** | **4.04** | **4.51** | **0.81** | **2.44** | **6.85** | **3.14** |
| **# of samples 2** | 9 | 2 | 8 | 9 | 10 | 9 | 10 | 8 | 8 |

Table 8.2.1-5 (part 2): In Urban scenario at 2.6GHz with DL 33dBm/MHz PSD, coverage margins for the potential Rel-18 UE with maximum 12-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.1-1 when 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin (dB) | PDCCH USS (BW1, 12 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | PDCCH USS (BW1, 12 PRBs; CORESET: 3 symbols, 12 PRBs; AL4) | PDSCH (BW1, 12 PRBs; 0.5 Mbps) | PRACH B4 (BW1, 12 PRBs) | PRACH C2(BW1, 12 PRBs) | Msg3 (BW1, 12 PRBs) | PUSCH (BW1, 12 PRBs; 0.25 Mbps) | PUCCH 2bit (BW1, 12 PRBs) | PUCCH 11bit (BW1, 12 PRBs) | PUCCH 22 bits (BW1, 12 PRBs) |
| MediaTek | 3.02 | 9.92 | 12.92 | - | - | - | - | - | - | - |
| Spreadtrum | 1.53 | 7.83 | 9.63 | 3.83 | 1.83 | 4.76 | 0.68 | 8.47 | 9.37 | 6.97 |
| Ericsson | 0.33 | 5.43 | 9.02 | 14.93 | - | 11.06 | 2.38 | 10.07 | 15.57 | 13.64 |
| vivo | - | - | - | - | - | - | - | - | - | - |
| CMCC | 2.68 | 8.27 | 16.05 | 11.62 | 9.77 | 8.70 | 1.45 | 12.53 | 10.79 | 8.82 |
| CATT | 0.83 | 6.43 | 11.13 | 10.43 | 5.93 | 5.46 | 1.28 | 12.87 | 11.47 | 9.47 |
| Xiaomi | **-0.78** | 5.48 | 9.62 | - | - | 5.13 | 2.25 | - | - | - |
| Huawei | 5.21 | 10.81 | 13.91 | 3.35 | 3.45 | 8.66 | 1.10 | 18.63 | 16.33 | - |
| Intel | 4.69 | 10.09 | 11.19 | - | - | 4.14 | 2.63 | - | - | - |
| Qualcomm | - | - | - | - | - | - | - | - | - | - |
| **Representative value 1** | **2.01** | **7.62** | **11.10** | **8.63** | **4.69** | **6.54** | **1.69** | **11.82** | **12.61** | **9.15** |
| **# of samples 1** | 7 | 7 | 7 | 5 | 4 | 7 | 7 | 5 | 5 | 4 |
| **Representative value 2** | **2.18** | **8.00** | **11.40** | **8.63** | **4.69** | **6.54** | **1.69** | **11.82** | **12.61** | **9.15** |
| **# of samples 2** | 8 | 8 | 8 | 5 | 4 | 7 | 7 | 5 | 5 | 4 |

In Urban scenario at 2.6GHz with maximum 11-PRB UE bandwidth, for evaluation of PBCH coverage impact, the comparison between the potential Rel-18 UE and the reference NR UE in addition to the comparison between the potential Rel-18 UE and the Rel-17 RedCap UE by sourcing companies are summarized in Table 8.2.1-6.

The representative values in the last row of Table 8.2.1-6 are derived by taking the mean value (in dB domain) from all the companies results after excluding the highest and the lowest values.

Different PBCH decoding schemes were evaluated in the study. Some companies evaluated soft combining of same portion of PBCH within 11 PRBs without performing RF retuning. Some companies evaluated soft combining of different portions of PBCH by performing RF retuning. Some companies performed RF retuning for receiving different portions of PBCH for each decoding trial but without soft combining.

The following are observed on PBCH coverage impact from the representative values in the last row of Table 8.2.1-6:

- Compared to Rel-15 NR UE with soft/selective combining, the PBCH performance degradation of the potential Rel-18 UE by soft/selective combining without RF retuning is 11.87 dB.

- Compared to Rel-15 NR UE with soft/selective combining, the PBCH performance degradation of the potential Rel-18 UE with soft/selective combining and RF retuning is 9.3 dB.

- Compared to Rel-17 RedCap UE with soft/selective combining, the PBCH performance degradation of the potential Rel-18 UE with soft/selective combining without RF retuning is 5.05dB.

- Compared to Rel-17 RedCap UE with soft/selective combining, the PBCH performance degradation of the potential Rel-18 UE with soft/selective combining and RF retuning is 2.51dB.

Table 8.2.1-6: In Urban scenario at 2.6GHz with a target BLER of 1% for PBCH, coverage differences between a potential Rel-18 UE with maximum 11-PRB UE BW and the reference NR UE and between the potential Rel-18 UE and the Rel-17 RedCap UE

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Coverage difference (dB) | | Comparison with Rel-15 Reference UE (MIL) | | Comparison with Rel-17 RedCap UE (MIL) | |
| 5MHz UE with soft/selective combining without RF retuning | 5MHz UE with soft/selective combining with RF retuning | 5MHz UE with soft/selective combining without RF retuning | 5MHz UE with soft/selective combining with RF retuning |
| Intel | R1-2207740 | -11 |  | -4.9 |  |
| Ericsson | R1-2207741 | **-** | -14. 1 | **-** | -7.4 |
| Nokia, NSB | R1-2206444 | -12.9 |  | -5.7 |  |
| ZTE | R1-2207058 | -16 | -9.3 | -9.4 | -2.7 |
| vivo | R1-2206052 |  |  |  | -2.32 |
| Qualcomm | R1-2207244 | -11.7 | -9.2 | -4.25 | -1.75 |
| MediaTek | R1-2207003 | -10.5 |  | -4.6 |  |
| **Representative value (dB)** |  | **-11.87** | **-9.3** | **-5.05** | **-2.51** |

In Urban scenario at 2.6GHz with maximum 11-PRB UE bandwidth for the potential Rel-18 UE, for evaluation of broadcast channels PDCCH CSS and SIB1 coverage impact particularly from the coexistence perspective, the comparison between the potential Rel-18 UE and the reference NR UE in addition to the comparison between the potential Rel-18 UE and the Rel-17 RedCap UE by sourcing companies are summarized in Table 8.2.1-7. It is noted that the target BLER of PDCCH CSS is 1% and the target BLER of SIB1 is 10% in the evaluation. In addition, one-shot decoding is assumed for both PDCCH CSS and SIB1 in all cases in Table 8.2.1-7.

For the comparison of PDCCH CSS and SIB1 coverage differences between the potential Rel-18 UE and the reference Rel-17 RedCap UE, the configurations and evaluations assumptions are listed in the following.

- The potential Rel-18 UE is configured with PDCCH CSS with AL16 and CORESET of 48 PRBs and 2 OFDM symbols.

- The reference Rel-17 RedCap UE for comparison is configured with PDCCH CSS with AL16 and CORESET of 48 PRBs and 2 OFDM symbols.

- The potential Rel-18 UE is scheduled with SIB1 larger than 5MHz.

- The reference Rel-17 RedCap UE for comparison is scheduled with SIB1 larger than 5MHz.

- For both cases, the exact PRB numbers and MCS values are reported by sourcing companies in [7].

- The potential Rel-18 UE is scheduled with SIB1 within 5MHz.

- The reference Rel-17 RedCap UE for comparison is scheduled with SIB1 larger than 5MHz.

- For both cases, the exact PRB numbers and MCS values are reported by sourcing companies in [7].

- It is noted this pair of comparison can provide the following two aspects:

- The SIB1 coverage difference between the potential Rel-18 UE and the reference Rel-17 RedCap if a dedicated SIB1 within 5MHz is transmitted for the potential Rel-18 UE.

- The SIB1 coverage loss for the reference Rel-17 RedCap UE if a universal SIB1 that is confined within 5MHz to accommodate the maximum bandwidth of the potential Rel-18 UE is transmitted for both the potential Rel-18 UE and the reference Rel-17 RedCap UE.

For all the cases listed above, one-shot decoding without any soft combining was assumed for this evaluation to represent the coverage differences between the potential Rel-18 UE and the reference Rel-15 NR UE and between the potential Rel-18 UE and the reference Rel-17 RedCap UE before applying any coverage enhancement schemes.

The representative values in the last row of Table 8.2.1-7 are derived by taking the mean value (in dB domain) from all the companies results after excluding the highest and the lowest values.

In Urban scenario at 2.6GHz with maximum 11-PRB UE bandwidth for the potential Rel-18 UE, from the representative values in the last row of Table 8.2.1-7, the following observations can be made:

- Observation 1: for PDCCH CSS with AL16 and 48PRB and 2 symbols, performance degradation of the potential Rel-18 UE is 15.26 dB and 8.91 dB compared with Rel-15 NR UE and Rel-17 RedCap UE, respectively.

- Observation 2: for SIB1 greater than 5MHz, performance degradation of the potential Rel-18 UE is 17.50 dB and 11.24 dB compared with Rel-15 NR UE and Rel-17 RedCap UE, respectively.

Table 8.2.1-7: In Urban scenario at 2.6GHz with 30kHz SCS, the comparisons of PDCCH CSS and SIB1 coverage differences between the potential Rel-18 UE and reference Rel-15 NR UE as well as those between the potential Rel-18 UE and the reference Rel-17 RedCap UE where one-shot decoding is assumed for all cases and maximum UE bandwidth of 11 PRBs is assumed for the potential Rel-18 UE. (Unit: dB)

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Coverage Difference (dB) | | Comparison with reference Rel-15 NR UE (MIL) | | Comparison with reference Rel-17 RedCap UE (MIL) | | |
| PDCCH CSS AL16 | SIB1 > 5MHz | PDCCH CSS (48 RBs) with 1% BLER | SIB1 (>5 MHz) with 10% BLER | SIB1 (<5 MHz) with 10% BLER |
| Sourcing company | T-doc | 5MHz-UE (BW1, 11 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | 5MHz-UE (BW1, 11 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | 5MHz-UE (BW1, 11 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | 5MHz-UE (BW1, 11 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | 5MHz-UE (BW1, 11 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) |
| CATT | R1-2207969 | -14.90 | -17.00 | -8.70 | -10.90 | -9.10 |
| Intel | R1-2207740 | -12.98 | -20.20 | -7.50 | -14.20 | -10.50 |
| Ericsson | R1-2207741 | -14.30 | -20.27 | -7.60 | -13.21 | -9.94 |
| NTT DOCOMO | R1-2207692 | -14.16 | -22.71 | -7.92 | -16.24 | -9.56 |
| Nokia NSB | R1-2206444 | -15.90 | -15.90 | -9.20 | -9.30 | -9.80 |
| ZTE | R1-2207058 | -14.70 | -19.30 | -8.50 | -14.60 | -8.80 |
| vivo | R1-2206052 | -13.62 | -12.53 | -7.97 | -4.77 | -5.16 |
| Qualcomm | R1-2207244 | -16.10 |  | -9.60 | -10.10 | -9.80 |
| MediaTek | R1-2207003 | -14.80 | -17.50 | -9.20 | -11.50 | -8.70 |
| OPPO | R1-2206304 | -15.90 | -15.50 | -9.60 | -10.90 | -7.70 |
| CMCC | R1-2206294 | -17.59 | -12.20 | -10.25 | -6.40 | -3.90 |
| Huawei,  Hisilicon | R1-2205874 | -16.43 |  | -10.31 |  |  |
| Xiaomi | R1-2206654 |  | -19.32 |  | -12.42 | -9.92 |
| Panasonic | R1-2206437 | -17.10 | -17.5 | -9.5 | -10.10 | -10.80 |
| **Representative value (dB)** | | **-15.26** | **-17.50** | **-8.91** | **-11.24** | **-9.00** |

### 8.2.2 Rural scenario at 0.7 GHz

For Rural scenario at 0.7 GHz, the bottleneck channel for the reference NR UE and the corresponding maximum isotropic loss (MIL) value by the sourcing companies [7] are shown in Table 8.2.2-1. The coverage margins for the potential Rel-18 UE in Rural scenario at 0.7 GHz, relative to the bottleneck channel of the reference NR UE are summarized in Table 8.2.2-2 and Table 8.2.2-3. In Table 8.2.2-2, no UE antenna efficiency loss is assumed for the potential Rel-18 UE with maximum 25-PRB bandwidth. In Table 8.2.1-3, UE antenna efficiency loss of 3dB is assumed in both DL and UL for the potential Rel-18 UE with maximum 25-PRB bandwidth. For every sourcing-company result, the coverage margin for each channel that has MIL below the bottleneck channel for the reference NR UE is highlighted in red.

The representative value 1, number of samples 1, representative value 2, and number of samples 2 in the last four rows of Table 8.2.2-2 and Table 8.2.2-3 are determined according to the methodology described in clause 6.2. A negative representative value for a channel of the potential Rel-18 UE indicates the coverage of the channel is worse than that of the bottleneck channel of the reference NR UE.

As can be seen from Table 8.2.2-1, for Rural scenario at 0.7GHz, PUSCH is the bottleneck channel for reference NR UE.

Table 8.2.2-1: Bottleneck channels and MIL values for reference NR UE in Rural scenario at 0.7GHz

|  |  |  |
| --- | --- | --- |
| Company | Bottleneck Channel | MIL (dB) |
| MediaTek | PUSCH (\*) | 145.36 |
| Spreadtrum | PUSCH | 146.46 |
| ZTE | Msg3 | 142.12 |
| Ericsson | PUSCH | 142.96 |
| Samsung | PUSCH | 146.56 |
| vivo | PUSCH | 140.30 |
| Nokia | PUSCH | 141.59 |
| CMCC | PUSCH | 136.35 |
| NTT DOCOMO | PUSCH | 146.70 |
| CATT | PUSCH | 146.46 |
| OPPO | PUCCH PF3 22 bits | 148.95 |
| Panasonic | PUSCH (\*) | 145.36 |
| Mavenir | PUSCH (\*) | 145.36 |
| Xiaomi | PUSCH | 148.99 |
| Huawei | PUSCH | 141.78 |
| Lenovo | PUSCH | 144.82 |
| Intel | PUSCH | 145.96 |
| Qualcomm | PUSCH | 141.29 |
| NOTE: For a sourcing company labeled with (\*) that did not provide evaluation results for uplink channels for the reference NR UE, the bottleneck channel and its MIL value were derived from Table 9.1.2-1 in TR 38.875 based on the methodology in Clause 6.2. | | |

For Rural scenario at 0.7 GHz, as can be seen from the representative values in Table 8.2.2-2 and Table 8.2.2-3:

- Without 3-dB UE antenna efficiency loss: the representative values of the coverage margins for the potential Rel-18 UE for all channels are positive and all channels have better coverage than reference NR UE.

- With 3-dB UE antenna efficiency loss: except for Msg3, the representative values of the coverage margins for a potential Rel-18 RedCap UE for all channels are positive. For Msg3, its coverage is slightly worse than the bottleneck channel of the reference NR UE. It is also noted that PUSCH for the potential Rel-18 UE has similar coverage as the bottleneck channel for the reference NR UE.

As can be seen from the representative values in Table 8.2.2-2 and Table 8.2.2-3, PUSCH for the potential Rel-18 UE with maximum 25-PRB bandwidth, with or without 3dB UE antenna efficiency loss, has similar or better coverage than the bottleneck channel of the reference NR UE. This is because the cell-edge target data rates are scaled by a factor of 0.25 for the potential Rel-18 RedCap UE compared to the reference Rel-17 RedCap UE.

Table 8.2.2-2 (part 1): In Rural scenario at 0.7GHz, coverage margins for the potential Rel-18 UE with maximum 11-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.2-1 when no UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PBCH  target BLER1% | PBCH  target BLER10% | PDCCH CSS (BW1, 25 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | PDCCH CSS (BW1, 25 PRBs; CORESET: 3 symbols, 24 PRBs; AL8) | SIB1 (BW1, 25 PRBs; SIB1 > 5 MHz; TBS 1256 bits) | SIB1 (BW1, 25 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) | Msg2 (BW1, 25 PRBs; TBS 72 bits) | Msg4 (BW1, 25 PRBs; TBS 1040 bits) |
| MediaTek | 13.47 | - | 10.17 | 10.27 | 6.47 | 6.37 | 7.17 | 8.87 |
| Spreadtrum | - | 9.57 | 8.57 | 10.37 | 6.27 | 6.97 | 8.47 | 6.57 |
| ZTE | - | 11.66 | 8.06 | 5.26 | 6.56 | 7.66 | 6.56 | 9.16 |
| Ericsson | 9.97 | - | 3.57 | 5.17 | 4.61 | 5.59 | 5.49 | 6.93 |
| Samsung | - | - | - | 8.27 | - | 5.27 | 5.67 | 6.27 |
| vivo | 9.50 | 13.21 | 11.20 | 10.16 | 9.46 | 6.51 | - | - |
| Nokia | 14.63 | - | 11.83 | 11.23 | 9.03 | 7.53 | 14.73 | 8.93 |
| CMCC | 15.75 | - | 11.75 | 11.93 | 12.67 | 16.47 | 14.87 | 17.47 |
| NTT DOCOMO | - | - | 9.40 | 9.10 | 6.18 | 6.70 | 6.96 | 8.03 |
| CATT | 11.47 | - | 7.17 | 5.67 | 4.37 | 6.37 | 2.87 | 6.17 |
| OPPO | 10.17 | - | 10.07 | 10.37 | 9.87 | 10.77 | 6.20 | 10.27 |
| Panasonic | - | - | 10.08 | 9.68 | 9.18 | 9.48 | - | - |
| Mavenir | - | - | - | 6.45 | 4.16 | 3.58 | - | - |
| Xiaomi | 2.39 | - | 3.53 | 3.03 | **-1.47** | **-2.17** | **-1.25** | 1.48 |
| Huawei | 4.53 | - | 8.63 | 8.53 | 8.33 | 3.93 | 3.93 | 5.13 |
| Lenovo | 8.50 | - | - | 11.21 | - | 8.61 | - | - |
| Intel | 14.37 | - | 8.47 | 7.97 | 5.47 | 6.07 | 6.47 | 6.87 |
| Qualcomm | 14.11 | - | 9.41 | 9.31 | 7.31 | 8.61 | 7.11 | 6.91 |
| **Representative value 1** | **10.81** | **N/A** | **8.75** | **8.66** | **7.04** | **6.97** | **6.77** | **7.39** |
| **# of samples 1** | 11 | 3 | 13 | 15 | 13 | 15 | 13 | 13 |
| **Representative value 2** | **11.07** | **N/A** | **8.97** | **8.69** | **6.95** | **6.88** | **6.80** | **7.51** |
| **# of samples 2** | 12 | 3 | 15 | 18 | 16 | 18 | 14 | 14 |

Table 8.2.2-2 (part 2): In Rural scenario at 0.7GHz, coverage margins for the potential Rel-18 UE with maximum 11-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.2-1 when no UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PDCCH USS (BW1, 25 PRBs; CORESET: 3 symbols, 24 PRBs; AL8) | PDSCH (BW1, 25 PRBs; 0.25 Mbps) | PRACH Format 0 (BW1, 25 PRBs) | Msg3 (BW1, 25 PRBs) | PUSCH (BW1, 25 PRBs; 25 kbps) | PUCCH 2bit (BW1, 25 PRBs) | PUCCH 11bit (BW1, 25 PRBs) | PUCCH 22 bits (BW1, 25 PRBs) |
| MediaTek | 9.17 | 8.87 | - | - | - | - | - | - |
| Spreadtrum | 10.57 | 9.07 | 6.37 | 5.11 | 0.00 | 7.42 | 6.12 | 4.92 |
| ZTE | 9.15 | 17.95 | - | 0.40 | 5.58 | 10.70 | 8.20 | 5.70 |
| Ericsson | 5.17 | 7.43 | 4.97 | 2.01 | 3.22 | 4.90 | 6.91 | 4.39 |
| Samsung | 8.27 | 6.17 | - | 3.01 | 3.41 | 12.22 | 7.62 | 5.32 |
| vivo | - | - | - | - | - | - | - | - |
| Nokia | 11.23 | 9.13 | - | 2.31 | 3.52 | - | - | - |
| CMCC | 11.93 | 17.37 | 9.64 | 7.54 | 4.95 | 11.45 | 9.84 | 7.54 |
| NTT DOCOMO | 9.10 | 9.08 | - | 2.82 | 4.36 | 6.92 | 10.78 | - |
| CATT | 5.67 | 8.07 | 3.77 | 1.21 | 0.00 | 10.22 | 7.42 | 4.72 |
| OPPO | - | - | - | - | - | - | - | - |
| Panasonic | - | - | - | - | - | - | - | - |
| Mavenir | - | - | - | - | - | - | - | - |
| Xiaomi | 3.03 | 0.93 | - | 2.09 | 2.69 | - | - | - |
| Huawei | 8.53 | 4.73 | 9.27 | 3.52 | 2.91 | 11.02 | 8.77 | - |
| Lenovo | - | - | - | 4.25 | - | - | - | - |
| Intel | 7.97 | 6.57 | - | 3.86 | 5.32 | - | - | - |
| Qualcomm | - | 8.61 | - | 2.51 | 3.02 | - | - | 2.5 |
| **Representative value 1** | **8.41** | **8.62** | **6.87** | **2.97** | **3.84** | **9.62** | **8.13** | **5.01** |
| **# of samples 1** | 11 | 12 | 5 | 13 | 10 | 8 | 8 | 7 |
| **Representative value 2** | **8.48** | **8.65** | **6.87** | **2.97** | **3.34** | **9.62** | **8.13** | **5.01** |
| **# of samples 2** | 12 | 13 | 5 | 13 | 12 | 8 | 8 | 7 |

Table 8.2.2-3 (part 1): In Rural scenario at 0.7GHz, coverage margins for the potential Rel-18 UE with maximum 11-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.2-1 when 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PBCH  target BLER1% | PBCH  target BLER10% | PDCCH CSS (BW1, 25 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | PDCCH CSS (BW1, 25 PRBs; CORESET: 3 symbols, 24 PRBs; AL8) | SIB1 (BW1, 25 PRBs; SIB1 > 5 MHz; TBS 1256 bits) | SIB1 (BW1, 25 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) | Msg2 (BW1, 25 PRBs; TBS 72 bits) | Msg4 (BW1, 25 PRBs; TBS 1040 bits) |
| MediaTek | 10.47 | - | 7.17 | 7.27 | 3.47 | 3.37 | 4.17 | 5.87 |
| Spreadtrum | - | 6.57 | 5.57 | 7.37 | 3.27 | 3.97 | 5.47 | 3.57 |
| ZTE | - | 8.66 | 5.06 | 2.26 | 3.56 | 4.66 | 3.56 | 6.16 |
| Ericsson | 6.97 | - | 0.57 | 2.17 | 1.61 | 2.59 | 2.49 | 3.93 |
| Samsung | - | - | - | 5.27 | - | 2.27 | 2.67 | 3.27 |
| vivo | 6.50 | 10.21 | 8.20 | 7.16 | 6.46 | 3.51 | - | - |
| Nokia | 11.63 | - | 8.83 | 8.23 | 6.03 | 4.53 | 11.73 | 5.93 |
| CMCC | 12.75 | - | 8.75 | 8.93 | 9.67 | 13.47 | 11.87 | 14.47 |
| NTT DOCOMO | - | - | 6.40 | 6.10 | 3.18 | 3.70 | 3.96 | 5.03 |
| CATT | 8.47 | - | 4.17 | 2.67 | 1.37 | 3.37 | **-0.13** | 3.17 |
| OPPO | 7.17 | - | 7.07 | 7.37 | 6.87 | 7.77 | 3.20 | 7.27 |
| Panasonic | - | - | 7.08 | 6.68 | 6.18 | 6.48 | - | - |
| Mavenir | - | - | - | 3.45 | 1.16 | 0.58 | - | - |
| Xiaomi | **-0.61** | - | 0.53 | 0.03 | **-4.47** | **-5.17** | **-4.25** | **-1.52** |
| Huawei | 1.53 | - | 5.63 | 5.53 | 5.33 | 0.93 | 0.93 | 2.13 |
| Lenovo | 5.50 | - | - | 8.21 | - | 5.61 | - | - |
| Intel | 11.37 | - | 5.47 | 4.97 | 2.47 | 3.07 | 3.47 | 3.87 |
| Qualcomm | 11.11 | - | 6.41 | 6.31 | 4.31 | 5.61 | 4.11 | 3.91 |
| **Representative value 1** | **7.81** | **N/A** | **5.75** | **5.66** | **4.04** | **3.97** | **3.77** | **4.39** |
| **# of samples 1** | 11 | 3 | 13 | 15 | 13 | 15 | 13 | 13 |
| **Representative value 2** | **8.07** | **N/A** | **5.97** | **5.69** | **3.95** | **3.88** | **3.80** | **4.51** |
| **# of samples 2** | 12 | 3 | 15 | 18 | 16 | 18 | 14 | 14 |

Table 8.2.2-3 (part 2): In Rural scenario at 0.7GHz, coverage margins for the potential Rel-18 UE with maximum 11-PRB bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.2-1 when 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PDCCH USS (BW1, 25 PRBs; CORESET: 3 symbols, 24 PRBs; AL8) | PDSCH (BW1, 25 PRBs; 0.25 Mbps) | PRACH Format 0 (BW1, 25 PRBs) | Msg3 (BW1, 25 PRBs) | PUSCH (BW1, 25 PRBs; 25 kbps) | PUCCH 2bit (BW1, 25 PRBs) | PUCCH 11bit (BW1, 25 PRBs) | PUCCH 22 bits (BW1, 25 PRBs) |
| MediaTek | 6.17 | 5.87 | - | - | - | - | - | - |
| Spreadtrum | 7.57 | 6.07 | 3.37 | 2.11 | **-3.00** | 4.42 | 3.12 | 1.92 |
| ZTE | 6.15 | 14.95 | - | **-2.60** | 2.58 | 7.70 | 5.20 | 2.70 |
| Ericsson | 2.17 | 4.43 | 1.97 | **-0.99** | 0.22 | 1.90 | 3.91 | 1.39 |
| Samsung | 5.27 | 3.17 | - | 0.01 | 0.41 | 9.22 | 4.62 | 2.32 |
| vivo | - | - | - | - | - | - | - | - |
| Nokia | 8.23 | 6.13 | - | **-0.69** | 0.52 | - | - | - |
| CMCC | 8.93 | 14.37 | 6.64 | 4.54 | 1.95 | 8.45 | 6.84 | 4.54 |
| NTT DOCOMO | 6.10 | 6.08 | - | **-0.18** | 1.36 | 3.92 | 7.78 | - |
| CATT | 2.67 | 5.07 | 0.77 | **-1.79** | **-3.00** | 7.22 | 4.42 | 1.72 |
| OPPO | - | - | - | - | - | - | - | - |
| Panasonic | - | - | - | - | - | - | - | - |
| Mavenir | - | - | - | - | - | - | - | - |
| Xiaomi | 0.03 | **-2.07** | - | **-0.91** | **-0.31** | - | - | - |
| Huawei | 5.53 | 1.73 | 6.27 | 0.52 | **-0.09** | 8.02 | 5.77 | - |
| Lenovo | - | - | - | 1.25 | - | - | - | - |
| Intel | 4.97 | 3.57 | - | 0.86 | 2.32 | - | - | - |
| Qualcomm | - | 5.61 | - | **-0.49** | 0.02 | - | - | **-0.5** |
| **Representative value 1** | **5.41** | **5.62** | **3.87** | **-0.03** | **0.34** | **6.62** | **5.13** | **2.01** |
| **# of samples 1** | 11 | 12 | 5 | 13 | 12 | 8 | 8 | 7 |
| **Representative value 2** | **5.48** | **5.65** | **3.87** | **-0.03** | **0.34** | **6.62** | **5.13** | **2.01** |
| **# of samples 2** | 12 | 13 | 5 | 13 | 12 | 8 | 8 | 7 |

In Rural scenario at 0.7GHz with maximum 25-PRB UE bandwidth for the potential Rel-18 UE, for evaluation of PDCCH CSS/SIB1 coverage impact particularly from the coexistence perspective, the comparison between the potential Rel-18 UE and the reference NR UE in addition to the comparison between the potential Rel-18 UE and the Rel-17 RedCap UE by sourcing companies are summarized in Table 8.2.2-6. It is noted that the target BLER of PDCCH CSS is 1% and the target BLER of SIB1 is 10% in the evaluation. In addition, one-shot decoding is assumed for both PDCCH CSS and SIB1 in all cases in Table 8.2.2-6.

For the comparison of PDCCH CSS/SIB1 coverage differences between the potential Rel-18 UE with maximum 25-PRB UE bandwidth and the reference Rel-15 NR UE, the configurations and evaluation assumptions are listed as in the following.

- The potential Rel-18 UE is configured with PDCCH CSS with AL16 and CORESET of 48 PRBs and 2 OFDM symbols.

- The reference Rel-15 NR UE for comparison is configured with PDCCH CSS with AL16 and CORESET of 48 PRBs and 2 OFDM symbols.

- The potential Rel-18 UE is scheduled with SIB1 larger than 5MHz.

- The reference Rel-15 NR UE for comparison is scheduled with SIB1 larger than 5MHz.

- The exact PRB numbers and MCS values are reported by sourcing companies in [7].

For the comparison of PDCCH CSS/SIB1 coverage differences between the potential Rel-18 UE and the reference Rel-17 RedCap UE, the configurations and evaluations assumptions are listed in the following.

- The potential Rel-18 UE is configured with PDCCH CSS with AL16 and CORESET of 48 PRBs and 2 OFDM symbols.

- The reference Rel-17 RedCap UE for comparison is configured with PDCCH CSS with AL16 and CORESET of 48 PRBs and 2 OFDM symbols.

- The potential Rel-18 UE is configured with PDCCH CSS with AL8 and CORESET of 24 PRBs and 3 OFDM symbols.

- The reference Rel-17 RedCap UE for comparison is configured with PDCCH CSS with AL16 and CORESET of 48 PRBs and 2 OFDM symbols.

- It is noted this pair of comparison can provide the following two aspects:

- The PDCCH CSS coverage difference between the potential Rel-18 UE and the reference Rel-17 RedCap if a dedicated PDCCH CSS that is confined within 5MHz is transmitted for the potential Rel-18 UE.

- The PDCCH CSS coverage loss for the reference Rel-17 RedCap UE if a universal PDCCH CSS that is confined within 5MHz to accommodate the maximum bandwidth of the potential Rel-18 UE is transmitted for both the potential Rel-18 UE and the reference Rel-17 RedCap UE.

- The potential Rel-18 UE is scheduled with SIB1 larger than 5MHz.

- The reference Rel-17 RedCap UE for comparison is scheduled with SIB1 larger than 5MHz.

- For both cases, the exact PRB numbers and MCS values are reported by sourcing companies in [7].

- The potential Rel-18 UE is scheduled with SIB1 within 5MHz.

- The reference Rel-17 RedCap UE for comparison is scheduled with SIB1 larger than 5MHz.

- For both cases, the exact PRB numbers and MCS values are reported by sourcing companies in [7].

- It is noted this pair of comparison can provide the following two aspects:

- The SIB1 coverage difference between the potential Rel-18 UE and the reference Rel-17 RedCap if a dedicated SIB1 within 5MHz is transmitted for the potential Rel-18 UE.

- The SIB1 coverage loss for the reference Rel-17 RedCap UE if a universal SIB1 that is confined within 5MHz to accommodate the maximum bandwidth of the potential Rel-18 UE is transmitted for both the potential Rel-18 UE and the reference Rel-17 RedCap UE.

For all the cases listed above, one-shot decoding without any soft combining was assumed for this evaluation to represent the coverage differences between the potential Rel-18 UE and the reference Rel-15 NR UE and between the potential Rel-18 UE and the reference Rel-17 RedCap UE before applying any coverage enhancement schemes.

The representative values in the last row of Table 8.2.2-6 are derived by taking the mean value (in dB domain) from all the companies results after excluding the highest and the lowest values. In Rural scenario at 0.7GHz with maximum 25-PRB UE bandwidth for the potential Rel-18 UE, from the representative values in the last row of Table 8.2.2-6, the following observations can be made:

- Observation 1: for PDCCH CSS with AL16 and 48PRB and 2 symbols, performance degradation of the potential Rel-18 UE is 7.30 dB and 3.53 dB compared with Rel-15 NR UE and Rel-17 RedCap UE, respectively.

- Observation 2: for SIB1 greater than 5MHz, performance degradation of the potential Rel-18 UE is 7.57 dB and 3.93 dB compared with Rel-15 NR UE and Rel-17 RedCap UE, respectively.

Table 8.2.2-6: In Rural scenario at 0.7GHz with 15kHz SCS, the comparisons of PDCCH CSS and SIB1 coverage differences between the potential Rel-18 UE and reference Rel-15 NR UE as well as those between the potential Rel-18 UE and the reference Rel-17 RedCap UE where one-shot decoding is assumed for all cases and maximum UE bandwidth of 25 PRBs is assumed for the potential Rel-18 UE. (Unit: dB)

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage Difference (dB) | | Comparison with reference Rel-15 NR UE (MIL) | | Comparison with reference Rel-17 RedCap UE (MIL) | | | |
| PDCCH CSS AL16 | SIB1 > 5MHz | PDCCH CSS (48 RBs) with 1% BLER | PDCCH CSS (24 RBs) with 1% BLER | SIB1 (>5 MHz) with 10% BLER | SIB1 (<5 MHz) with 10% BLER |
| Sourcing company | T-doc | 5MHz-UE (BW1, 25 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | 5MHz-UE (BW1, 25 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | 5MHz-UE (BW1, 25 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | 5MHz-UE (BW1, 25 PRBs; CORESET: 2 symbols, 24 PRBs; AL8) | 5MHz-UE (BW1, 25 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | 5MHz-UE (BW1, 25 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) |
| CATT | R1-2207969 | -8.40 | -8.00 | -4.70 | -6.20 | -4.90 | -2.90 |
| Intel | R1-2207740 | -6.50 | -7.60 | -3.10 | -3.60 | -4.20 | -3.60 |
| Ericsson | R1-2207741 | -10.10 | -8.54 | -6.30 | -4.70 | -4.57 | -3.59 |
| NTT DOCOMO | R1-2207692 | -6.39 | -7.92 | -3.08 | -3.38 | -4.41 | -3.89 |
| Nokia NSB | R1-2206444 | -7.10 | -6.40 | -3.40 | -4.00 | -2.90 | -4.4 |
| ZTE | R1-2207058 | -4.80 | -6.70 | -1.40 | -4.20 | -3.00 | -1.90 |
| Qualcomm | R1-2207244 | -7.70 |  | -3.90 | -4.00 | -3.80 | -3.80 |
| vivo | R1-2206052 | -6.31 | -6.77 | -2.94 | -3.98 | -2.67 | -5.62 |
| OPPO | R1-2206304 | -7.68 | -7.00 | -3.08 | -2.78 | -3.60 | -2.70 |
| MediaTek | R1-2207003 | -6.90 | -7.30 | -3.00 | -2.90 | -3.80 | -3.90 |
| CMCC | R1-2206294 | -8.31 | -8.90 | -4.25 | -5.36 | -5.30 | -1.50 |
| Huawei, Hisilicon | R1-2205874 | -6.83 |  | -3.48 |  |  |  |
| Panasonic | R1-2206437 | -8.2 | -8.3 | -3.9 |  | -4.1 | -3.8 |
| **Representative value (dB)** | | **-7.30** | **-7.57** | **-3.53** | **-4.52** | **-3.93** | **-3.45** |

### 8.2.3 Urban scenario at 4 GHz

For this Urban scenario at 4 GHz, sourcing companies could optionally report evaluation results with maximum 11-PRB UE bandwidth under different under different downlink power spectrum density (PSD) assumptions of 33dBm/MHz and/or 24dBm/MHz .

For Urban scenario at 4 GHz with downlink power spectrum density of 33dBm/MHz, the bottleneck channel for the reference NR UE and the corresponding maximum isotropic loss (MIL) value by the sourcing companies [7] are shown in Table 8.2.3-1.

As can be seen from Table 8.2.3-1, for Urban scenario at 4 GHz, PUSCH is the bottleneck channel for the reference NR UE.

Table 8.2.3-1: Bottleneck channels and MIL values for the reference NR UE in Urban scenario at 4GHz with downlink power spectrum density of 33 dBm/MHz

|  |  |  |
| --- | --- | --- |
| Company | Bottleneck Channel | MIL (dB) |
| Ericsson | PUSCH | 139.24 |
| Samsung | PUSCH | 142.04 |
| vivo | PUSCH | 139.62 |
| Nokia | PUSCH | 142.12 |
| MediaTek | PUSCH (\*) | 143.54 |
| CATT | PUSCH | 145.14 |
| Huawei | PUSCH | 140.03 |
| Lenovo | PUSCH | 143.53 |
| Intel | PUSCH | 141.19 |
| Qualcomm | PUSCH | 139.99 |
| NOTE: For a sourcing company labeled with (\*) that did not provide evaluation results for uplink channels for the reference NR UE, the bottleneck channel and its representative MIL value were derived from Table 9.1.3-1 of TR 38.875 based on the methodology in Clause 6.2. | | |

In Urban scenario at 4 GHz with DL PSD of 33dBm/MHz, for the potential Rel-18 UE with maximum 11-PRB bandwidth, the coverage margins relative to the bottleneck channel of the reference NR UE are summarized in Table 8.2.3-2 (part 1 and part 2) and Table 8.2.3-3 (part 1 and part 2). In Table 8.2.3-2, no UE antenna efficiency loss is assumed for the potential Rel-18 UE. In Table 8.2.3-3, UE antenna efficiency loss of 3dB is assumed in both DL and UL for the potential Rel-18 UE. For every sourcing-company result, the coverage margin for each channel that has MIL below the bottleneck channel for the reference NR UE is highlighted in red.

The representative value 1, number of samples 1, representative value 2, and number of samples 2 in the last four rows of Table 8.2.3-2 and Table 8.2.3-3 are determined according to the methodology described in clause 6.2. A negative representative value for a channel of the potential Rel-18 UE indicates the coverage of the channel is worse than that of the bottleneck channel of the reference NR UE.

As can be seen from the representative values in Table 8.2.3-2 and Table 8.2.2-3, for Urban scenario at 4 GHz with DL PSD of 33 dBm/MHz and maximum 11-PRB UE bandwidth:

- Without 3-dB UE antenna efficiency loss: the representative values of the coverage margins for the potential Rel-18 UE with 11-PRB BW for all channels are positive.

- With 3-dB UE antenna efficiency loss: the representative values of the coverage margins for the potential Rel-18 UE with 11-PRB BW for all channels are positive. It is noted that PDCCH CSS with AL2, SIB1 and PUSCH have slightly better coverage by less than 2dB than the bottleneck channel of the reference NR UE.

It is noted that results of individual sourcing companies show that Urban scenario at 4 GHz with 33 dBm/MHz DL PSD follows similar trend as the Urban scenario at 2.6 GHz with 33 dBm/MHz DL PSD.

As can be seen from the representative values in Table 8.2.3-2 and Table 8.2.3-3, PUSCH for the potential Rel-18 UE, with or without 3dB UE antenna efficiency loss, has better coverage than the bottleneck channel of the reference NR UE and hence coverage recovery is not needed for PUSCH. This is because the cell-edge target data rates are scaled by a factor of 0.25 for the potential Rel-18 UE compared to the reference Rel-17 RedCap UE.

Table 8.2.3-2 (part 1): In Urban scenario at 4GHz with DL PSD of 33 dBm/MHz, the coverage margins of the potential Rel-18 UE with maximum 11-PRB UE bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.3-1 when no UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PBCH  target BLER1% | PBCH  target BLER10% | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 24 PRBs; AL8) | PDCCH CSS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | SIB1 BW>5MHz (BW1, 11 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | SIB1 (BW1, 11 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) | Msg2 (BW1, 11 PRBs; TBS 72 bits) | Msg4 (BW1, 11 PRBs; TBS 1040 bits) |
| Ericsson | 6.63 | - | 4.63 | 4.53 | **-2.37** | **-4.33** | **-1.02** | 4.78 | **-0.07** |
| Samsung | - | - | - | - | 4.93 | - | 2.93 | 11.53 | 4.73 |
| vivo | 7.56 | 12.71 | 10.87 | 9.38 | 7.31 | 8.85 | 8.52 | - | - |
| Nokia | 16.09 | - | 13.09 | 13.09 | 9.09 | 9.79 | 9.29 | 22.49 | 8.59 |
| MediaTek | 12.43 | - | 7.33 | 6.73 | 2.63 | 1.73 | 4.53 | 9.13 | 5.33 |
| CATT | 10.13 | - | 4.73 | 2.33 | **-1.17** | 0.13 | 1.93 | 5.43 | 3.13 |
| Huawei | 15.53 | - | 11.73 | 11.43 | 7.23 | 17.53 | 13.33 | 14.23 | 9.53 |
| Lenovo | 8.13 | - | - | - | 4.44 | - | 3.63 | - | - |
| Intel | 16.82 | - | 4.05 | - | 5.07 | 0.87 | 4.57 | 11.27 | 6.17 |
| Qualcomm | 12.15 | - | - | - | 2.55 | 2.15 | 2.45 | 8.95 | 3.85 |
| **Representative value 1** | **11.60** | **N/A** | **7.99** | **8.45** | **4.34** | **4.36** | **4.76** | **10.28** | **5.29** |
| **# of samples 1** | 8 | 1 | 6 | 5 | 9 | 7 | 9 | 7 | 7 |
| **Representative value 2** | **11.72** | **N/A** | **7.86** | **8.02** | **4.12** | **3.92** | **4.73** | **10.09** | **5.30** |
| **# of samples 2** | 9 | 1 | 7 | 6 | 10 | 8 | 10 | 8 | 8 |

Table 8.2.3-2 (part 2): In Urban scenario at 4GHz with DL PSD of 33 dBm/MHz, the coverage margins of the potential Rel-18 UE with maximum 11-PRB UE bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.3-1 when no UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin (dB) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 12 PRBs; AL4) | PDSCH (BW1, 11 PRBs; 0.5 Mbps) | PRACH B4 (BW1, 11 PRBs) | PRACH C2 (BW1, 11 PRBs) | Msg3 (BW1, 11 PRBs) | PUSCH (BW1, 11 PRBs; 0.25 Mbps) | PUCCH 2bit (BW1, 11 PRBs) | PUCCH 11bit (BW1, 11 PRBs) | PUCCH 22 bits (BW1, 11 PRBs) |
| Ericsson | 1.63 | 5.73 | 9.92 | 15.56 | - | 11.96 | 5.66 | 11.05 | 16.48 | 14.55 |
| Samsung | 8.93 | 14.13 | 15.93 | - | - | 7.96 | 3.64 | 17.57 | 12.87 | 10.47 |
| vivo | - | - | - | - | - | - | - | - | - | - |
| Nokia | 9.09 | 13.59 | 15.79 | - | - | 9.76 | 4.04 | - | - | - |
| MediaTek | 5.03 | 11.23 | 14.93 | - | - | - | - | - | - | - |
| CATT | 2.83 | 7.23 | 11.63 | 9.76 | - | 7.66 | 5.36 | 15.07 | 13.67 | 11.87 |
| Huawei | 7.23 | 12.13 | 14.73 | 8.30 | 8.40 | 13.63 | 5.40 | 20.49 | 18.19 | - |
| Lenovo | - | - | - | - | - | 10.67 | - | - | - | - |
| Intel | 6.24 | 11.74 | 10.24 | - | - | 12.30 | 5.59 | - | - | - |
| Qualcomm | - | - | 14.65 | - | - | 7.04 | 4.51 | - | - | 6.55 |
| **Representative value 1** | **6.31** | **11.17** | **13.41** | **N/A** | **N/A** | **10.05** | **4.98** | **16.32** | **15.08** | **11.17** |
| **# of samples 1** | 6 | 6 | 7 | 3 | 1 | 8 | 7 | 4 | 4 | 4 |
| **Representative value 2** | **6.05** | **11.18** | **13.66** | **N/A** | **N/A** | **10.05** | **4.98** | **16.32** | **15.08** | **11.17** |
| **# of samples 2** | 7 | 7 | 8 | 3 | 1 | 8 | 7 | 4 | 4 | 4 |

Table 8.2.3-3 (part 1): In Urban scenario at 4GHz with DL PSD of 33 dBm/MHz, the coverage margins of the potential Rel-18 UE with maximum 11-PRB UE bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.3-1 when 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PBCH  target BLER1% | PBCH  target BLER10% | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 24 PRBs; AL8) | PDCCH CSS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | SIB1 BW>5MHz (BW1, 11 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | SIB1 (BW1, 11 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) | Msg2 (BW1, 11 PRBs; TBS 72 bits) | Msg4 (BW1, 11 PRBs; TBS 1040 bits) |
| Ericsson | 3.63 | - | 1.63 | 1.53 | **-5.37** | **-7.33** | **-4.02** | 1.78 | **-3.07** |
| Samsung | - | - | - | - | 1.93 | - | **-0.07** | 8.53 | 1.73 |
| vivo | 4.56 | 9.71 | 7.87 | 6.38 | 4.31 | 5.85 | 5.52 | - | - |
| Nokia | 13.09 | - | 10.09 | 10.09 | 6.09 | 6.79 | 6.29 | 19.49 | 5.59 |
| MediaTek | 9.43 | - | 4.33 | 3.73 | **-0.37** | **-1.27** | 1.53 | 6.13 | 2.33 |
| CATT | 7.13 | - | 1.73 | **-0.67** | **-4.17** | **-2.87** | **-1.07** | 2.43 | 0.13 |
| Huawei | 12.53 | - | 8.73 | 8.43 | 4.23 | 14.53 | 10.33 | 11.23 | 6.53 |
| Lenovo | 5.13 | - | - | - | 1.44 | - | 0.63 | - | - |
| Intel | 13.82 | - | 1.05 | - | 2.07 | **-2.13** | 1.57 | 8.27 | 3.17 |
| Qualcomm | 9.15 | - | - | - | **-0.45** | **-0.85** | **-0.55** | 5.95 | 0.85 |
| **Representative value 1** | **8.60** | **N/A** | **4.99** | **5.45** | **1.34** | **1.36** | **1.76** | **7.28** | **2.29** |
| **# of samples 1** | 8 | 1 | 6 | 5 | 9 | 7 | 9 | 7 | 7 |
| **Representative value 2** | **8.72** | **N/A** | **4.86** | **5.02** | **1.12** | **0.92** | **1.73** | **7.09** | **2.30** |
| **# of samples 2** | 9 | 1 | 7 | 6 | 10 | 8 | 10 | 8 | 8 |

Table 8.2.3-4 (part 2): In Urban scenario at 4GHz with DL PSD of 33 dBm/MHz, the coverage margins of the potential Rel-18 UE with maximum 11-PRB UE bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.3-1 when 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 12 PRBs; AL4) | PDSCH (BW1, 11 PRBs; 0.5 Mbps) | PRACH B4 (BW1, 11 PRBs) | PRACH C2 (BW1, 11 PRBs) | Msg3 (BW1, 11 PRBs) | PUSCH (BW1, 11 PRBs; 0.25 Mbps) | PUCCH 2bit (BW1, 11 PRBs) | PUCCH 11bit (BW1, 11 PRBs) | PUCCH 22 bits (BW1, 11 PRBs) |
| Ericsson | **-1.37** | 2.73 | 6.92 | 12.56 | - | 8.96 | 2.66 | 8.05 | 13.48 | 11.55 |
| Samsung | 5.93 | 11.13 | 12.93 | - | - | 4.96 | 0.64 | 14.57 | 9.87 | 7.47 |
| vivo | - | - | - | - | - | - | - | - | - | - |
| Nokia | 6.09 | 10.59 | 12.79 | - | - | 6.76 | 1.04 | - | - | - |
| MediaTek | 2.03 | 8.23 | 11.93 | - | - | - | - | - | - | - |
| CATT | **-0.17** | 4.23 | 8.63 | 6.76 | - | 4.66 | 2.36 | 12.07 | 10.67 | 8.87 |
| Huawei | 4.23 | 9.13 | 11.73 | 5.30 | 5.40 | 10.63 | 2.40 | 17.49 | 15.19 | - |
| Lenovo | - | - | - | - | - | 7.67 | - | - | - | - |
| Intel | 3.24 | 8.74 | 7.24 | - | - | 9.30 | 2.59 | - | - | - |
| Qualcomm | - | - | 11.65 | - | - | 4.04 | 1.51 | - | - | 3.55 |
| **Representative value 1** | **3.31** | **8.17** | **10.41** | **N/A** | **N/A** | **7.05** | **1.98** | **13.32** | **12.08** | **8.17** |
| **# of samples 1** | 6 | 6 | 7 | 3 | 1 | 8 | 7 | 4 | 4 | 4 |
| **Representative value 2** | **3.05** | **8.18** | **10.66** | **N/A** | **N/A** | **7.05** | **1.98** | **13.32** | **12.08** | **8.17** |
| **# of samples 2** | 7 | 7 | 8 | 3 | 1 | 8 | 7 | 4 | 4 | 4 |

For Urban scenario at 4 GHz with downlink power spectrum density of 24 dBm/MHz, the bottleneck channel for the reference NR UE and the corresponding maximum isotropic loss (MIL) value by the sourcing companies [7] are shown in Table 8.2.3-4. For the potential Rel-18 UE with maximum 11-PRB bandwidth, the coverage margins relative to the bottleneck channel of the reference NR UE are summarized in Table 8.2.3-5 (part 1 and part 2) and Table 8.2.3-6 (part 1 and part 2). In Table 8.2.3-5, no UE antenna efficiency loss is assumed for the potential Rel-18 UE. In Table 8.2.3-6, UE antenna efficiency loss of 3dB is assumed in both DL and UL for the potential Rel-18 UE. For every sourcing-company result, the coverage margin for each channel that has MIL below the bottleneck channel for the reference NR UE is highlighted in red.

As can be seen from Table 8.2.3-1 and Table 8.2.3-4, for Urban scenario at 4 GHz, when DL PSD is reduced from 33dBm/MHz to 24dBm/MHz, PUSCH is still the bottleneck channel for the reference NR UE. This implies for the reference NR UE all downlink channels have more link budgets than PUSCH by at least 9dB when DL PSD is 33dBm/MHz.

Table 8.2.3-4: Bottleneck channels and MIL values for the reference NR UE in Urban scenario at 4GHz with downlink power spectrum density of 24 dBm/MHz

|  |  |  |
| --- | --- | --- |
| Company | Bottleneck Channel | MIL (dB) |
| Ericsson | PUSCH | 139.24 |
| Samsung | PUSCH | 142.04 |
| vivo | PUSCH | 139.62 |
| MediaTek | PUSCH (\*) | 143.54 |
| CATT | PUSCH | 145.14 |
| Huawei | PUSCH | 140.03 |
| Intel | PUSCH | 141.19 |
| Qualcomm | PUSCH | 139.99 |
| NOTE: For a sourcing company labeled with (\*) that did not provide evaluation results for uplink channels for the reference NR UE, the bottleneck channel and its MIL value were derived from Table 9.1.3-1 of TR 38.875 based on the methodology in Clause 6.2. | | |

As can be seen from the representative values in Table 8.2.3-5 and Table 8.2.3-6, for Urban scenario at 4 GHz with DL PSD of 24 dBm/MHz and maximum 11-PRB UE bandwidth:

- Without 3-dB UE antenna efficiency loss: PDCCH CSS, SIB1, Msg4, and PDCCH USS with AL2 have worse coverage than the bottleneck channel of the reference NR UE. For other downlink channels, PBCH, Msg2, and PDCCH USS with AL4, the coverage margins are less than 3dB. Only PDSCH has a coverage margin slightly more than 3dB than the bottleneck channel.

- With 3-dB UE antenna efficiency loss: PBCH, PDCCH CSS, SIB1, Msg2, Msg4, and PDCCH USS all show worse coverage than the bottleneck channel of the reference NR UE. PDSCH has a similar coverage to the bottleneck channel.

Like other scenario, it again can be seen from the representative values in Table 8.2.3-5 and Table 8.2.3-6, PUSCH for the potential Rel-18 UE, with or without 3dB UE antenna efficiency loss, has better coverage than the bottleneck channel of the reference NR UE and hence coverage recovery is not needed for PUSCH. This is because the cell-edge target data rates are scaled by a factor of 0.25 for the potential Rel-18 UE compared to the reference Rel-17 RedCap UE.

Table 8.2.3-5 (part 1): In Urban scenario at 4GHz with DL PSD of 24 dBm/MHz, the coverage margins of the potential Rel-18 UE with maximum 11-PRB UE bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.3-4 when no UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PBCH  target BLER1% | PBCH  target BLER10% | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 24 PRBs; AL8) | PDCCH CSS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | SIB1 BW>5MHz (BW1, 11 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | SIB1 (BW1, 11 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) | Msg2 (BW1, 11 PRBs; TBS 72 bits) | Msg4 (BW1, 11 PRBs; TBS 1040 bits) |
| Ericsson | **-2.37** | - | **-4.37** | **-4.47** | **-11.37** | **-13.33** | - | **-4.22** | **-9.07** |
| Samsung | - | - | - | - | **-4.07** | - | **-6.07** | 2.53 | **-4.27** |
| vivo | **-1.44** | 3.71 | 1.87 | 0.38 | **-1.69** | **-0.15** | **-0.48** | - | - |
| MediaTek | 3.43 | - | **-1.67** | **-2.27** | **-6.37** | **-7.27** | **-4.47** | 0.13 | **-3.67** |
| CATT | 1.13 | - | **-4.27** | **-6.67** | **-10.17** | **-8.87** | **-7.07** | **-3.57** | **-5.87** |
| Huawei | 6.53 | - | 2.73 | 2.43 | **-1.77** | 8.53 | 4.33 | 5.23 | 0.53 |
| Intel | 7.82 | - | 0.97 | **-0.13** | **-3.93** | **-8.13** | **-4.43** | 2.27 | **-2.83** |
| **Representative value 1** | **2.07** | **N/A** | **-0.48** | **-1.41** | **-4.99** | **-5.72** | **-3.66** | **0.41** | **-4.32** |
| **# of samples 1** | 5 | 1 | 5 | 5 | 6 | 5 | 5 | 5 | 5 |
| **Representative value 2** | **2.41** | **N/A** | **-0.78** | **-1.62** | **-5.26** | **-6.11** | **-3.86** | **0.34** | **-4.16** |
| **# of samples 2** | 6 | 1 | 6 | 6 | 7 | 6 | 6 | 6 | 6 |

Table 8.2.3-5 (part 2): In Urban scenario at 4GHz with DL PSD of 24 dBm/MHz, the coverage margins of the potential Rel-18 UE with maximum 11-PRB UE bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.3-4 when no UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin  (dB) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 12 PRBs; AL4) | PDSCH (BW1, 11 PRBs; 0.5 Mbps) | PRACH B4 (BW1, 11 PRBs) | PRACH C2 (BW1, 11 PRBs) | Msg3 (BW1, 11 PRBs) | PUSCH (BW1, 11 PRBs; 0.25 Mbps) | PUCCH 2bit (BW1, 11 PRBs) | PUCCH 11bit (BW1, 11 PRBs) | PUCCH 22 bits (BW1, 11 PRBs) |
| Ericsson | **-7.37** | **-3.27** | 0.92 | 15.56 | - | 11.96 | 5.66 | 11.05 | 16.48 | 14.55 |
| Samsung | **-0.07** | 5.13 | 6.93 | - | - | 7.96 | 3.64 | 17.57 | 12.87 | 10.47 |
| vivo | - | - | - | - | - | - | - | - | - | - |
| MediaTek | **-3.97** | 2.23 | 5.93 | - | - | - | - | - | - | - |
| CATT | **-6.17** | **-1.77** | 2.63 | 9.76 | - | 7.66 | 5.36 | 15.07 | 13.67 | 11.67 |
| Huawei | **-1.77** | 3.13 | 5.73 | 8.30 | 8.40 | 13.63 | 5.40 | 20.49 | 18.19 | - |
| Intel | **-2.76** | 2.74 | 1.24 | - | - | 12.30 | 5.59 | - | - | - |
| **Representative value 1** | **-3.57** | **1.37** | **3.20** | **N/A** | **N/A** | **10.74** | **5.45** | **16.32** | **15.08** | **N/A** |
| **# of samples 1** | 5 | 5 | 5 | 3 | 1 | 5 | 5 | 4 | 4 | 3 |
| **Representative value 2** | **-3.67** | **1.58** | **3.88** | **N/A** | **N/A** | **10.74** | **5.45** | **16.32** | **15.08** | **N/A** |
| **# of samples 2** | 6 | 6 | 6 | 3 | 1 | 5 | 5 | 4 | 4 | 3 |

Table 8.2.3-6 (part 1): In Urban scenario at 4GHz with DL PSD of 24 dBm/MHz, the coverage margins of the potential Rel-18 UE with maximum 11-PRB UE bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.3-4 when 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PBCH  target BLER1% | PBCH  target BLER10% | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | PDCCH CSS (BW1, 11 PRBs; CORESET: 2 symbols, 24 PRBs; AL8) | PDCCH CSS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2) | SIB1 BW>5MHz (BW1, 11 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | SIB1 (BW1, 11 PRBs; SIB1 BW < 5 MHz; TBS 1256 bits) | Msg2 (BW1, 11 PRBs; TBS 72 bits) | Msg4 (BW1, 11 PRBs; TBS 1040 bits) |
| Ericsson | **-5.37** | - | **-7.37** | **-7.47** | **-14.37** | **-16.33** | - | **-7.22** | **-12.07** |
| Samsung | - | - | - | - | **-7.07** | - | **-9.07** | **-0.47** | **-7.27** |
| vivo | **-4.44** | 0.71 | **-1.13** | **-2.62** | **-4.69** | **-3.15** | **-3.48** | - | - |
| MediaTek | 0.43 | - | **-4.67** | **-5.27** | **-9.37** | **-10.27** | **-7.47** | **-2.87** | **-6.67** |
| CATT | **-1.87** | - | **-7.27** | **-9.67** | **-13.17** | **-11.87** | **-10.07** | **-6.57** | **-8.87** |
| Huawei | 3.53 | - | **-0.27** | **-0.57** | **-4.77** | 5.53 | 1.33 | 2.23 | **-2.47** |
| Intel | 4.82 | - | **-2.03** | **-3.13** | **-6.93** | **-11.13** | **-7.43** | **-0.73** | **-5.83** |
| **Representative value 1** | **-0.93** | **N/A** | **-3.48** | **-4.41** | **-7.99** | **-8.72** | **-6.66** | **-2.59** | **-7.32** |
| **# of samples 1** | 5 | 1 | 5 | 5 | 6 | 5 | 5 | 5 | 5 |
| **Representative value 2** | **-0.59** | **N/A** | **-3.78** | **-4.62** | **-8.26** | **-9.11** | **-6.86** | **-2.66** | **-7.16** |
| **# of samples 2** | 6 | 1 | 6 | 6 | 7 | 6 | 6 | 6 | 6 |

Table 8.2.3-6 (part 2): In Urban scenario at 4GHz with DL PSD of 24 dBm/MHz, the coverage margins of the potential Rel-18 UE with maximum 11-PRB UE bandwidth compared to the bottleneck channel for the reference NR UE in Table 8.2.3-4 when 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE.

|  |  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage margin(dB) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 6 PRBs; AL2; baseline) | PDCCH USS (BW1, 11 PRBs; CORESET: 3 symbols, 12 PRBs; AL4) | PDSCH (BW1, 11 PRBs; 0.5 Mbps) | PRACH B4 (BW1, 11 PRBs) | PRACH C2 (BW1, 11 PRBs) | Msg3 (BW1, 11 PRBs) | PUSCH (BW1, 11 PRBs; 0.25 Mbps) | PUCCH 2bit (BW1, 11 PRBs) | PUCCH 11bit (BW1, 11 PRBs) | PUCCH 22 bits (BW1, 11 PRBs) |
| Ericsson | **-10.37** | **-6.27** | **-2.08** | 12.56 | - | 8.96 | 2.66 | 8.05 | 13.48 | 11.55 |
| Samsung | **-3.07** | 2.13 | 3.93 | - | - | 4.96 | 0.64 | 14.57 | 9.87 | 7.47 |
| vivo | - | - | - | - | - | - | - | - | - | - |
| MediaTek | **-6.97** | **-0.77** | 2.93 | - | - | - | - | - | - | - |
| CATT | **-9.17** | **-4.77** | **-0.37** | 6.76 | - | 4.66 | 2.36 | 12.07 | 10.67 | 8.67 |
| Huawei | **-4.77** | 0.13 | 2.73 | 5.30 | 5.40 | 10.63 | 2.40 | 17.49 | 15.19 | - |
| Intel | **-5.76** | **-0.26** | **-1.76** | - | - | 9.30 | 2.59 | - | - | - |
| **Representative value 1** | **-6.57** | **-1.63** | **0.20** | **N/A** | **N/A** | **7.74** | **2.45** | **13.32** | **12.08** | **N/A** |
| **# of samples 1** | 5 | 5 | 5 | 3 | 1 | 5 | 5 | 4 | 4 | 3 |
| **Representative value 2** | **-6.67** | **-1.42** | **0.88** | **N/A** | **N/A** | **7.74** | **2.45** | **13.32** | **12.08** | **N/A** |
| **# of samples 2** | 6 | 6 | 6 | 3 | 1 | 5 | 5 | 4 | 4 | 3 |

### 8.2.4 Summary of coverage impact evaluation

In the coverage evaluation in Clause 8.2.1 through Clause 8.2.3, we have assumed the potential Rel-18 is a UE with maximum bandwidth reduced to 5MHz in both RF and BB, i.e., the BW1 complexity reduction option described in Clause 7.2, and have studied the corresponding coverage impact in different deployment scenarios.

When comparing to the bottleneck channels of the reference NR UE, the evaluation results on coverage margins in clauses 8.2.1 through 8.2.3 can be summarized as follows for the potential Rel-18 UE with BW1 complexity reduction option.

- For Urban scenario at 2.6 GHz with 11-PRB UE BW and DL PSD of 33 dBm/MHz:

- Without 3dB antenna efficiency loss: all channels have positive coverage margins

- With 3dB antenna efficiency loss: all channels have positive coverage margins except for PDCCH CSS with AL2 and SIB1. Both are slightly worse than the bottleneck channel of the reference NR UE by less than 1dB.

- For Urban scenario at 2.6 GHz with 12-PRB UE BW and DL PSD of 33 dBm/MHz:

- All channels have positive coverage margins with or without 3dB antenna efficiency loss.

- For Rural scenario at 0.7 GHz:

- Without 3dB antenna efficiency loss: all channels have positive coverage margins

- With 3dB antenna efficiency loss: all channels have positive coverage margins except for Msg3 which is worse than the bottleneck channel by less than 0.1dB.

- For Urban scenario at 4 GHz with 11-PRB UE BW and DL PSD of 33 dBm/MHz

- Without 3dB UE antenna efficiency loss: all channels have positive coverage margins.

- With 3dB UE antenna efficiency loss: all channels have positive coverage margins. It is noted that PDCCH CSS with AL2, SIB1 and PUSCH have slightly better coverage by less than 2dB than the bottleneck channel of the reference NR UE.

- It is noted that results of individual sourcing companies show that Urban scenario at 4 GHz with 33 dBm/MHz DL PSD follows similar trends as the Urban scenario at 2.6 GHz with 33 dBm/MHz DL PSD.

- For Urban scenario at 4 GHz with 11-PRB UE BW and DL PSD of 24 dBm/MHz:

- Without 3dB antenna efficiency loss: PDCCH CSS, SIB1, Msg4, and PDCCH USS with AL2 have worse coverage than the bottleneck channel of the reference NR UE.

- With 3dB UE antenna efficiency loss: PBCH, PDCCH CSS, SIB1, Msg2, Msg4, and PDCCH USS all show worse coverage than the bottleneck channel of the reference NR UE.

Based on the above summary on coverage margins for complexity reduction option BW1, we know that the determination of which channels have worse coverage than the bottleneck channel of reference NR UE, and the amount of coverage margins, would depend on the deployment scenario, on whether the 3dB UE antenna efficiency loss is assumed for the potential Rel-18 UE, and the value of DL PSD. It is also noted that PUSCH for the potential Rel-18 UE, with or without 3dB UE antenna efficiency loss, has better coverage than the bottleneck channel of the reference NR UE. This is because the cell-edge target data rates are scaled by a factor of 0.25 for the potential Rel-18 UE compared to the reference Rel-17 RedCap UE.

The coverage evaluation results based on complexity reduction option BW1 are further extended to other complexity reduction options introduced in Clause 7. It is noted in Clause 7.3.3 that PR1 and PR2 are not expected to have coverage impact. It is also noted in Clause 7.4.3 that PT1 and PT2 are not expected to impact coverage. Therefore, in the rest of this clause, the potential coverage impact in terms of coverage margins and broadcast channel coverage differences are summarized for complexity reduction options BW1, BW2, BW3 and PR3. It is noted that BW3 and PR3 are not expected to have coverage impact on PDCCH and PBCH since the bandwidth of channels other than PDSCH/PUSCH can be up to 20MHz with BW3 and PR3. It should be also noted that in the following comparison results, contiguous resource allocation has been assumed for PR3 which hence has same coverage impact results as BW3. Finally, no frequency hopping has been assumed for BW2 in the following evaluation results.

For complexity reduction options, BW1, BW2, BW3 and PR3, channels with negative representative coverage margins are summarized in Table 8.2.4-1. It is noted that results of individual sourcing companies show that Urban scenario at 4 GHz with 33 dBm/MHz DL PSD and maximum 11-PRB UE BW follows a similar trend as the Urban scenario at 2.6 GHz with 33 dBm/MHz DL PSD and maximum 11-PRB UE BW. However, Table 8.2.4-1 does not present the same results for these two scenarios. This is because Table 8.2.4-1 is summarized based on representative values which are determined by inputs of sourcing companies. And the number of sourcing companies for these two scenarios is different.

Table 8.2.4-1: Channels with negative representative coverage margins for different complexity reductions options and different deployment scenarios

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Deployment scenario and frequency (and UE bandwidth, and DL PSD) | 3dB antenna efficiency loss? | Complexity reduction options in Clause 7 | | | |
| BW1 | BW2 | BW3 | PR3 |
| Urban at 2.6 GHZ with 11 PRBs | w/o 3dB ant. eff. loss | None | None | None | None |
| with 3dB ant. eff. loss | PDCCH CSS w/ AL2 (<1dB)  SIB1(<1dB) | PDCCH CSS w/ AL2 (<1dB)  SIB1(<1dB) | SIB1(<1dB) | SIB1(<1dB) |
| Urban at 2.6 GHZ with 12 PRBs | w/o 3dB ant. eff. loss | None | None | None | None |
| with 3dB ant. eff. loss | None | None | None | None |
| Rural at 0.7 GHz | w/o 3dB ant. eff. loss | None | None | None | None |
| with 3dB ant. eff. loss | Msg3 (<0.1dB) | Msg3 (<0.1dB) | None | None |
| Urban at 4 GHz with 11 PRBs and DL PSD of 33dBm/MHz | w/o 3dB ant. eff. loss | None | None | None | None |
| with 3dB ant. eff. loss | None | None | None | None |
| Urban at 4 GHz with 11 PRBs and DL PSD of 24dBm/MHz | w/o 3dB ant. eff. loss | - PDCCH CSS (w/ AL16, AL8 and AL2)  - PDCCH USS with AL2  - SIB1  - Msg4 | - PDCCH CSS (w/ AL16, AL8 and AL2)  - PDCCH USS with AL2  - SIB1  - Msg4 | - SIB1  - Msg4 | - SIB1  - Msg4 |
| with 3dB ant. eff. loss | - PBCH  - PDCCH CSS  - PDCCH USS  - SIB1  - Msg2  - Msg4 | - PBCH  - PDCCH CSS  - PDCCH USS  - SIB1  - Msg2  - Msg4 | - SIB1  - Msg2  - Msg4 | - SIB1  - Msg2  - Msg4 |

Based on the evaluation results on coverage difference in Clause 8.2.1 and 8.2.2 based on the complexity reduction option BW1 and the description of the complexity reduction options in Clause 7, the following tables show the coverage differences with respective to the reference NR UE and the Rel-17 RedCap UEs for the complexity reduction options, BW1, BW2, BW3, and PR3, over the considered scenarios.

If not otherwise notified, 2.6GHz is assumed for Urban scenario since Urban scenario at 4GHz with DL PSD of 33dBm/MHz shares a similar trend with 2.6 GHz with 33dBm/MHz regarding broadcast channel coverage difference comparison between the potential Rel-18 UE and the reference NR UE/the Rel-17 RedCap UE. For Rural scenario, the coverage difference for PBCH is not available in the captured tables since bandwidth of PBCH is confined with the potential Rel-18 UE's maximum BW for all complexity reduction options evaluated.

For a potential Rel-18 UE with BW3 or PR3, it should be noted no PBCH and PDCCH CSS coverage differences are observed compared to the reference Rel-17 RedCap UE. When compared to the reference Rel-15 NR UE, PDCCH CSS coverage differences of -5.18 dB and -3.04 dB are observed for Urban at 2.6 GHz and Rural scenario at 0.7 GHz, respectively. PBCH coverage difference of 6.8 dB is observed for Urban scenario at 2.6GHz. The observed differences also represent for the differences between the reference Rel-17 RedCap UE and the reference Rel-15 NR UE. Furthermore, the observed differences are mainly resulted in the different numbers of receive antennas.

Table 8.2.4-2: In Urban scenario at 2.6GHz with 30kHz SCS, coverage differences of broadcast channels including PBCH, PDCCH CSS, and SIB1 between the potential Rel-18 UE and the reference Rel-15 NR/Rel-17 RedCap UEs with complexity reduction options BW1, BW2, BW3 and PR3.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
| Coverage difference (dB) | Compared with reference Rel-15 NR UE (MIL) | | | |  | Compared with reference Rel-17 RedCap UE (MIL) | | | |
| PBCH (20 RBs) with 1% BLER | | PDCCH CSS (48 RBs) with 1% BLER | SIB1 (>5 MHz) with 10% BLER | PBCH (20 RBs) with 1% BLER | | PDCCH CSS (48 RBs) with 1% BLER | SIB1 (>5 MHz) with 10% BLER |
| Rel-18 UE with soft/selective combining without RF retuning | Rel-18 UE with soft/selective combining with RF retuning | Rel-18 UE (11 PRBs; CORESE: 2 symbols, 48 PRBs; AL16) | Rel-18 UE (11 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | Rel-18 UE with soft/selective combining without RF retuning | Rel-18 UE with soft/selective combining with RF retuning | Rel-18 UE (11 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | Rel-18 UE (11 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) |
| BW1 | -11.87 | -9.3 | -15.26 | -17.50 | -5.05 | -2.51 | -8.91 | -11.24 |
| BW2 | -11.87 | -9.3 | -15.26 | -17.50 | -5.05 | -2.51 | -8.91 | -11.24 |
| BW3 | -6.8 | | -6.28 | -17.50 | 0 | | 0 | -11.24 |
| PR3 | -6.8 | | -6.28 | -17.50 | 0 | | 0 | -11.24 |

Table 8.2.4-3: In Rural scenario at 0.7 GHz with 15kHz SCS, coverage differences of broadcast channels including PDCCH CSS and SIB1 between the potential Rel-18 UE and the reference Rel-15 NR/Rel-17 RedCap UEs with complexity reduction options BW1, BW2, BW3 and PR3

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Coverage difference (dB) | Compared with reference Rel-15 NR UE (MIL) | | Compared with Rel-17 RedCap UE (MIL) | |
| PDCCH CSS (48 RBs) with 1% BLER | SIB1 (>5 MHz) with 10% BLER | PDCCH CSS (48 RBs) with 1% BLER | SIB1 (>5 MHz) with 10% BLER |
| Rel-18 UE (25 PRBs; CORESE: 2 symbols, 48 PRBs; AL16) | Rel-18 UE (25 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) | Rel-18 UE (25 PRBs; CORESET: 2 symbols, 48 PRBs; AL16) | Rel-18 UE (25 PRBs; SIB1 BW > 5 MHz; TBS 1256 bits) |
| BW1 | -7.30 | -7.57 | -3.53 | -3.93 |
| BW2 | -7.30 | -7.57 | -3.53 | -3.93 |
| BW3 | -3.71 | -7.57 | 0 | -3.93 |
| PR3 | -3.71 | -7.57 | 0 | -3.93 |

From the above comparison on broadcast channel coverage differences between the potential Rel-18 UE and the reference Rel-15 NR/Rel-17 RedCap UEs, the following observations can be made for complexity reduction options BW1, BW2, BW3, and PR3:

- Coverage difference is larger in Urban scenario (30 kHz SCS) than in Rural scenario (15 kHz SCS) due to a smaller RB number with 30 kHz SCS within 5MHz bandwidth.

- In Urban scenario (30 kHz SCS), the coverage difference is the largest for SIB1 and the smallest for PBCH, with PDCCH CSS (48 RBs) in the middle.

- For SIB1 (>5MHz), coverage degradation of 11.24 dB is observed with BW1, BW2, BW3 and PR3 options compared to Rel-17 RedCap UE.

- For PDCCH (AL16 and 48 RBs), coverage degradation of 8.91 dB is observed with BW1 and BW2 options compared to Rel-17 RedCap UE

- For PBCH (20 RBs), coverage degradation of 5.05 dB (2.51 dB) is observed with BW1 and BW2 options without RF retuning (with RF retuning) compared to Rel-17 RedCap UE.

- It is noted that BW3 and PR3 do not cause coverage degradation to PBCH and PDCCH compared to Rel-17 RedCap UE.

For broadcast channels with large coverage differences such as SIB1, the potential Rel-18 UE may utilize additional processing/combining to compensate the coverage difference when considering coexistence and minimizing impact on legacy UEs.

# 9 Conclusions and recommendations

Further NR RedCap UE complexity reduction techniques have been analyzed individually in clauses 7.2 through 7.4 as well as in different combinations in clause 7.5. The coverage impacts of the complexity reduction techniques have been analyzed in clause 8. The main observations from the coverage impact evaluations are summarized in clause 8.2.4.

Based on the analysis of the studied UE complexity reduction options, most companies in RAN1 recommend that a single option is down-selected from a list of options as the main Rel-18 RedCap UE complexity reduction option at RAN plenary. The list includes the following options.

- Option BW3:

- 5 MHz BB bandwidth only for PDSCH (for both unicast and broadcast) and PUSCH with 20 MHz RF bandwidth for UL and DL.

- The other physical channels and signals are still allowed to use a BWP up to the 20 MHz maximum UE RF+BB bandwidth.

- Option PR3:

- Restriction of maximum number of PRBs for PDSCH and PUSCH.

- For 15 kHz SCS, the maximum number of RBs is 25.

- For 30 kHz SCS, the maximum number of RBs is 11 or 12.

- The restricted number of PRBs in Option PR3 is a hardcoded limit.

Some of the companies who participated in the study also wanted to include one or both of the following options in the above list, for RAN plenary to assess the trade-off between degree of complexity reduction and specification impact.

- Option PR1:

- Relaxation of the constraint for peak data rate reduction.



- The relaxed constraint is, e.g., 1 (instead of 4).

- The parameters (, , ) can be as in Rel-17 RedCap [4].



- Option BW1:

- Both RF and BB bandwidths are 5 MHz for UL and DL.

Furthermore, RAN1 recommends that Option PR1 is considered as a potential add-on. Whether to adopt this potential add-on can be decided during WI phase.

Whether or not to also introduce support for option PT1 and/or PT2 for a Rel-18 RedCap UE can be decided at RAN plenary.

- Option PT1:

- Relaxation of UE processing time for PDSCH/PUSCH in terms of N1 and N2 (as defined in TS 38.214) compared to those of UE processing time capability 1

- The relaxation factor for N1 and N2 is assumed to be 2 in the study.

- Option PT2:

- Relaxation of UE processing time for CSI in terms of Z and Z' compared to the values defined in TS 38.214 clause 5.4

- The relaxation factor for Z and Z' is assumed to be 2 in the study.

Annex A:  
Change history

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| **Change history** | | | | | | | |
| **Date** | **Meeting** | **TDoc** | **CR** | **Rev** | **Cat** | **Subject/Comment** | **New version** |
| 2022-05 | RAN1#109-e | R1-2205621 |  |  |  | TR skeleton | 0.0.0 |
| 2022-05 | RAN1#109-e | R1-2205693 |  |  |  | Endorsed TR skeleton | 0.0.1 |
| 2022-09 | RAN1#110 | R1-2208316 |  |  |  | Endorsed TR | 0.1.0 |
| 2022-09 | RAN#97-e | RP-222207 |  |  |  | TR for one-step approval | 1.0.0 |
| 2022-09 | RAN#97-e |  |  |  |  | TR under change control further to RAN approval as part of Rel-18 | 18.0.0 |