**3GPP TSG RAN meeting #92-e RP-210XXX**

**Electronic Meeting, June 14-18, 2021**

## Status Report to TSG

**Agenda item:** 9.7.2.3 UE power saving enhancements for NR [RAN2 WI: NR\_UE\_pow\_sav\_enh]

|  |  |
| --- | --- |
| **WI / SI Name** | UE power saving enhancements for NR |
| included in this status report | Study Item: - | Core part: Yes | Performance part:No | Testing part:- |
| **Acronym** | NR\_UE\_pow\_sav\_enh |
| **Unique ID** | 860047 |
| **TSG Tdoc of latest approved WI/SI description (if any)** | RP-200938 |
| **Target Completion Date****(indicate if changed)** | Study Item: - | Core part: 03/2022 | Performance part: 09/2022 | Testing part: - |
| **Overall Completion level** | Study Item: - | Core part: Overall: 55%  | Performance Part: Overall: 0%  | Testing part: - |

Note: Overall completion level percentage numbers should use one of the colors below:

* xx%: Normal progress, no RAN plenary action needed
* xx%: Progress behind schedule, may need RAN plenary intervention. If so, SR should clearly define requested action
* xx%: Progress critically behind, RAN plenary shall intervene. SR should define requested action

**Source:**

|  |  |
| --- | --- |
| **Leading WG** | RAN2 |
| **Rapporteur** | **Name** | Weide Wu |
| **Company** | MediaTek Inc. |
| **Email** | weide.wu@mediatek.com |

## 1 Work plan related evaluation

|  |  |
| --- | --- |
| **Do you want to modify the time budget for this WI/SI compared to what was endorsed at the last RAN meeting?** | No |

*If you answered No: Then please remove the Excel file from the zip file of this status report.*

*If you answered Yes: Then please fill out the attached Excel template to request a modification of the time budgets for your WI /SI. The Excel table has to be filled out for all affected RAN WGs and up to the target date of the WI/SI. The basis are the endorsed time budgets of the last RAN meeting. Please highlight all changes of the values.
 One time unit (TU) corresponds to ~ 2 hours in the meeting.
 If this status report covers a WI with Core and Performance part, then please have one line for each in the attached Excel table.
 Note: If no Excel table is attached, then this means no time budget change.*

**Additional explanations/motivations for the time budget changes in the attached Excel table: N/A**

## 2. Detailed progress in RAN WGs since last TSG meeting (for all involved WGs)

 NOTE: Agreements and Open issues impacted cross-TSG aspects shall be explicitly highlighted

## 2.1 RAN1

#### 2.1.1 Agreements

|  |
| --- |
| **Relating to scope item 1) – a):**1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]
	1. Study and specify paging enhancement(s) to reduce unnecessary UE paging receptions, subject to no impact to legacy UEs [RAN2, RAN1]
* NOTE: RAN1 to check and update, if needed, evaluation methodology in RAN1 #102-e meeting

**The following agreements are achieved:** |
| **RAN1 #104-bis-e meeting**Agreement:**Observation 1a:**For the evaluation and comparison of PEI candidate designs, the following observations for coexistence with legacy PDSCH are identified:1. For coexistence with legacy PDSCH, semi-static resouce sharing by configuring RB-symbol-level or RE-level rate-matching patterns covering PEI REs is supported for all PEI candidate designs.
2. For coexistence with legacy PDSCH, dynamic resource sharing can be realized for all PEI candidates if PDSCH is scheduled by DCI format 1\_1
	* For PDCCH based PEI, CORESET-level rate matching can be realized for the PDSCH as per mandatory capability
	* For SSS-based PEI, CORESET-level rate matching may be realized for the PDSCH as per mandatory capability, depending on the design of SSS-based PEI and UE capability regarding number of supported CORESETs
	* For TRS/CSI-RS based PEI, RE-level rate matching can be realized for the PDSCH as per mandatory capability
	* When PDSCH is not scheduled by DCI format 1\_1, it is up to gNB implementation whether and how PEI is transmitted in PDSCH resource

Agreement:**Observation 2a:**For the evaluation and comparison of PEI candidate designs, the following summarize the identified configurations of PEI candidate designs, including pairs of the minimum required resource and maximum UE (sub)group indication capacity per PEI, that can comply with the mandatory performance metrics agreed in RAN1 #104-e:* If Behv-A is assumed,

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Paging Setting | PEI candidate design | Physical-layer configuration and resource | UE (sub)group indication capcity  | Number of companies providing performance results |
| PDSCH: MCS0, TB scaling 1.0PDCCH: AL8, 41-bit payload | PDCCH-based PEI | AL4 PDCCH with 12-bit payload, occupying 288 REs | 12 bits | 5 (HW/HiSi, OPPO, ZTE, CATT, MTK) |
| AL8 PDCCH with 12-bit payload, occupying 576 REs | 12 bits | 7 (Xiaomi, Intel, QC, Samsung, IDCC, Ericsson, vivo) |
| AL8 PDCCH with 41-bit payload, occupies 576 REs | 41 bits | 1 (CATT)  |
| SSS-based PEI | 1-symbol SSS, occupying 132 REs (11 RB x 1 symbol) | 3 bits | 1 (IDCC) |
| 2-symbol SSS, occupying 264 REs (11 RB x 2 symbols) | 1 bit | 6 (HW/HiSi, vivo, ZTE, CATT, QC, Samsung) |
| 3 bits | 1 (IDCC) |
| 3-symbol SSS, occupying 396 REs (11 RB x 3 symbols) | 4 bits | 1 (MTK) |
| TRS/CSI-RS-based PEI | 1-slot 24-RB TRS, occupying 144 REs (24 RB x 3 REs per RB x 2 symbols) | ≥ 8 bits | 1 (Intel) |
| 1-slot 28-RB TRS, occupying 168 REs (28 RB x 3 REs per RB x 2 symbols)  | 1 bit | 1 (HW/HiSi) |
| 1-slot 36-RB TRS, occupying 216 REs (36 RB x 3 REs per RB x 2 symbols) | 1 bit | 1 (Samsung) |
| 1-slot 48-RB TRS, occupying 288 REs (48 RB x 3 REs per RB x 2 symbols) | 1 bit | 3 (vivo, ZTE, Ericsson) |
| 6 bits | 1 (CATT)  |
| 1-slot 50-RB TRS, occupying 300 REs (50 RB x 3 REs per RB x 2 symbols) | 1 bit | 2 (OPPO, QC) |
| 4 bits | 1 (MTK) |
|   |
| PDSCH: MCS0, TB scaling 0.5;PDCCH: AL16, 41-bit payload | PDCCH-based PEI | AL8 PDCCH with 12-bit payload, occupying 576 REs | 12 bits | 4 (OPPO, ZTE, MTK, Intel) |
| SSS-based PEI | 3-symbol SSS, occupying 396 REs (11 RB x 3 symbols) | 4 bits | 1 (MTK) |
| TRS/CSI-RS-based PEI | 1-slot 24-RB TRS, occupying 144 REs (24 RB x 3 REs per RB x 2 symbols) | 3 bits | 1 (Intel) |
| 1-slot 36-RB TRS, occupying 216 REs (36 RB x 3 REs per RB x 2 symbols) | 8 bits | 1 (Intel) |
| 1-slot 50-RB TRS, occupying 300 REs (50 RB x 3 REs per RB x 2 symbols) | 1 bit | 1 (OPPO) |
| 4 bits | 1 (MTK) |

* If Behv-B is assumed,

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Paging Setting | PEI candidate design | Physical-layer configuration | UE (sub)group indication capcity | Number of companies providing performance results |
| PDSCH: MCS0, TB scaling 1.0PDCCH: AL8, 41-bit payload | PDCCH-based PEI | AL4 PDCCH with 12-bit payload, occupying 288 REs | 12 bits | 4 (HW/HiSi, OPPO, ZTE, MTK) |
| AL8 PDCCH with 12-bit payload, occupying 576 REs | 12 bits | 2 (vivo, Samsung) |
| SSS-based PEI | 2-symbol SSS, occupying 264 REs (11 RB x 2 symbols) | 1 bit | 3 (HW/HiSi, vivo, ZTE) |
| 3-symbol SSS, occupying 396 REs (11 RB x 3 symbols) | 1 bit | 1 (MTK) |
| TRS/CSI-RS-based PEI | 1-slot 28-RB TRS, occupying 168 REs (28 RB x 3 REs per RB x 2 symbols) | 1 bit | 1 (HW/HiSi) |
| 1-slot 48-RB TRS, occupying 288 REs (48 RB x 3 REs per RB x 2 symbols) | 1 bit | 2 (vivo, ZTE) |
| 6 bits | 1 (CATT) |
| 1-slot 50-RB TRS, occupying 300 REs (50 RB x 3 REs per RB x 2 symbols) | 1 bit | 1 (OPPO) |
| 2 bits | 1 (MTK) |
|   |
| PDSCH: MCS0, TB scaling 0.5PDCCH: AL16, 41-bit payload | PDCCH-based PEI | AL8 PDCCH with 12-bit payload, occupying 576 REs | 12 bits | 3 (OPPO, ZTE, MTK) |
| SSS-based PEI | 3-symbol SSS, occupying 396 REs (11 RB x 3 symbols) | 1 bit | 1 (MTK) |
| TRS/CSI-RS-based PEI | 1-slot 50-RB TRS, occupying 300 REs (50 RB x 3 REs per RB x 2 symbols) | 1 bit | 1 (OPPO) |
| 2 bits | 1 (MTK) |

Agreement:**Observation 3a**:For the evaluation and comparison of PEI candidate designs, the following summarize average resource overheads per PO for PEI candidate designs, considering the configurations identified from performance observation.* ~~The average overhead results are based on PO settings without impact from UE sub-grouping indication within the PO.~~
* Note: For comparison purpose, single-beam transmission for PEI is assumed, and results with multi-beam transmission for PEI is scaled. This doesn’t preclude any beam-forming related design for PEI.
* If Behv-A is assumed:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Paging Setting | PEI candidate design | Physical-layer configuration and resource | UE (sub)group indication capacity  | Number of companies providing performance results | Average resource overhead per PO (REs) | PO and PEI related assumptions | Resource sharing assumption |
| PDSCH: MCS0, TB scaling 1.0PDCCH: AL8, 41-bit payload | PDCCH-based PEI | AL4 PDCCH with 12-bit payload, occupying 288 REs | 12 bits | 5 (HW/HiSi, OPPO, ZTE, CATT, MTK) | 17.2 | OPPO | 1 PEI for up to 12 PO's |  PEI is transmitted as a Rel-15 PDCCH in a CORESET when a UE group is paged  |
| 17.2 | ZTE | 1 PEI for up to 12 PO's |
| 17.6 | HW/HiSi | 1 PEI for up to 12 PO's |
| 21.8 | MTK | 1 PEI for up to 12 PO's; averaged all PO settings for 1.28-sec cycle |
| 28.8 | CATT | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 288.0 | CATT | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| AL8 PDCCH with 12-bit payload, occupying 576 REs | 12 bits | 7 (Xiaomi, Intel, QC, Samsung, IDCC, Ericsson, vivo) | 49.5 | vivo | 1 PEI for 4 PO |  PEI is transmitted as a Rel-15 PDCCH in a CORESET when a UE group is paged  |
| 57.6 | vivo | 1 PEI for 1 PO |
| 57.6 | QC | 1 PEI for 1 PO |
| 57.6 | Samsung | 1 PEI for 1 PO; PEI RE# scaled w.r.t. 1-beam |
| AL8 PDCCH with 41-bit payload, occupies 576 REs | 41 bits | 1 (CATT)  | 57.6 | CATT | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 576.0 | CATT | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| SSS-based PEI | 1-symbol SSS, occupying 132 REs (11 RB x 2 symbols) | 3 bits | 1 (IDCC) |   |   |   |   |
| 2-symbol SSS, occupying 264 REs (11 RB x 2 symbols) | 1 bit | 6 (HW/HiSi, vivo, ZTE, CATT, QC, Samsung) | 25.4 | Samsung | 1 PEI for 1 PO; PEI RE# scaled w.r.t. 1-beam | Dynamic rate-matching in PDSCH |
| 25.4 | vivo | 1 PEI for 1 PO |
| 26.4 | ZTE | 1 PEI for 1 PO |
| 28.8 | CATT | 1 PEI for 1 PO |
| 28.8 | QC | 1 PEI for 1 PO |
| 254.0 | HW/HiSi | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| 264.0 | ZTE | 1 PEI for 1 PO |
| 288.0 | QC | 1 PEI for 1 PO |
| 3 bits | 1 (IDCC) |   |   |   |   |
| 3-symbol SSS, occupying 396 REs (11 RB x 3 symbols) | 4 bits | 1 (MTK) | 34.0 | MTK | 1 PEI for up to 4 PO's; averaged all PO settings for 1.28-sec cycle | Dynamic rate-matching in PDSCH |
| 437.0 | MTK | 1 PEI for up to 4 PO's; averaged all PO settings for 1.28-sec cycle; RB-symbol rate-matching pattern period up to 40 ms | Semi-static rate-matching in PDSCH |
| TRS/CSI-RS-based PEI | 1-slot 24-RB TRS, occupying 144 REs (24 RB x 3 REs per RB x 2 symbols) | ≥ 8 bits | 1 (Intel) | 14.4 | Intel | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 1-slot 28-RB TRS, occupying 168 REs (28 RB x 3 REs per RB x 2 symbols)  | 1 bit | 1 (HW/HiSi) | 123.4 | HW/HiSi | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 168.0 | HW/HiSi | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| 1-slot 36-RB TRS, occupying 216 REs (36 RB x 3 REs per RB x 2 symbols) | 1 bit | 1 (Samsung) | 21.6 | Samsung | 1 PEI for 1 PO; PEI RE# scaled w.r.t. 1-beam | Dynamic rate-matching in PDSCH |
| 1-slot 48-RB TRS, occupying 288 REs (48 RB x 3 REs per RB x 2 symbols) | 1 bit | 3 (vivo, ZTE, Ericsson) | 28.8 | vivo | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 28.8 | ZTE | 1 PEI for 1 PO |
| 1-slot 48-RB TRS, occupying 288 REs (48 RB x 3 REs per RB x 2 symbols) | 6 bits | 1 (CATT)  | 28.8 | CATT | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 288.0 | CATT | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| 1-slot 50-RB TRS, occupying 300 REs (50 RB x 3 REs per RB x 2 symbols) | 1 bit | 2 (OPPO, QC) | 30.0 | OPPO | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 30.0 | QC | 1 PEI for 1 PO |
| 300.0 | QC | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| 4 bits | 1 (MTK) | 26.0 | MTK | 1 PEI for up to 4 PO's | Dynamic rate-matching in PDSCH |
|   |
| PDSCH: MCS0, TB scaling 0.5;PDCCH: AL16, 41-bit payload | PDCCH-based PEI | AL8 PDCCH with 12-bit payload, occupying 576 REs | 12 bits | 4 (OPPO, ZTE, MTK, Intel) | 34.4 | OPPO | 1 PEI for up to 12 PO's | PEI is transmitted as a Rel-15 PDCCH in a CORESET when a UE group is paged |
| 43.6 | MTK | 1 PEI for up to 12 PO's; averaged all PO settings for 1.28-sec cycle |
| 57.6 | Intel | 1 PEI for 1 PO | PEI is transmitted as a Rel-15 PDCCH in a CORESET when a UE group is paged |
| SSS-based PEI | 3-symbol SSS, occupying 396 REs (11 RB x 3 symbols) | 4 bits | 1 (MTK) | 34.0 | MTK | 1 PEI for up to 4 PO's; averaged all PO settings for 1.28-sec cycle | Dynamic rate-matching in PDSCH |
| 437.0 | MTK | 1 PEI for up to 4 PO's; averaged all PO settings for 1.28-sec cycle; RB-symbol rate-matching pattern period up to 40 ms | Semi-static rate-matching in PDSCH |
| TRS/CSI-RS-based PEI | 1-slot 24-RB TRS, occupying 144 REs (24 RB x 3 REs per RB x 2 symbols) | 3 bits  | 1 (Intel) | 14.4 | Intel | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 1-slot 36-RB TRS, occupying 216 REs (36 RB x 3 REs per RB x 2 symbols) | 8 bits | 1 (Intel) | 21.6 | Intel | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 1-slot 50-RB TRS, occupying 300 REs (50 RB x 3 REs per RB x 2 symbols) | 1 bit | 1 (OPPO) | 30.0 | OPPO | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 4 bits | 1 (MTK) | 26.0 | MTK | 1 PEI for up to 4 PO's; averaged all PO settings for 1.28-sec cycle | Dynamic rate-matching in PDSCH |

* If Behv-B is assumed:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| Paging Setting | PEI candidate design | Physical-layer configuration | UE (sub)group indication capacity | Number of companies providing performance results | Average resource overhead per PO (REs) | PO and PEI related assumptions | Coexistence assumption |
| PDSCH: MCS0, TB scaling 1.0PDCCH: AL8, 41-bit payload | PDCCH-based PEI | AL4 PDCCH with 12-bit payload, occupying 288 REs | 12 bits | 4 (HW/HiSi, OPPO, ZTE, MTK) | 24.0 | HW/HiSi | 1 PEI for up to 12 PO's | PEI is ALWAYS transmitted as a Rel-15 PDCCH in a CORESET |
| 24.0 | OPPO | 1 PEI for up to 12 PO's |
| 24.0 | ZTE | 1 PEI for up to 12 PO's |
| 51.0 | MTK | 1 PEI for up to 12 PO's; averaged all PO settings for 1.28-sec cycle |
| AL8 PDCCH with 12-bit payload, occupying 576 REs | 12 bits | 2 (vivo, Samsung) | 518.4 | vivo | 1 PEI for 1 PO | PEI is ALWAYS transmitted as a Rel-15 PDCCH in a CORESET |
| 518.4 | Samsung | 1 PEI for 1 PO;PEI RE# scaled w.r.t. 1-beam |
| SSS-based PEI | 2-symbol SSS, occupying 264 REs (11 RB x 2 symbols) | 1 bit | 3 (HW/HiSi, vivo, ZTE) | 228.6 | vivo | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 228.6 | ZTE | 1 PEI for 1 PO |
| 254.0 | HW/HiSi | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| 264.0 | ZTE | 1 PEI for 1 PO |
| 3-symbol SSS, occupying 396 REs (11 RB x 3 symbols) | 1 bit | 1 (MTK) | 561.0 | MTK | 1 PEI for 1 PO;average over all PO settings for 1.28-sec cycle; RB-symbol rate-matching pattern period up to 40 ms | Semi-static rate-matching in PDSCH |
| TRS/CSI-RS-based PEI | 1-slot 28-RB TRS, occupying 168 REs (28 RB x 3 REs per RB x 2 symbols) | 1 bit | 1 (HW/HiSi) | 168.0 | HW/HiSi | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| 1-slot 48-RB TRS, occupying 288 REs (48 RB x 3 REs per RB x 2 symbols) | 1 bit | 2 (vivo, ZTE) | 259.2 | ZTE | 1 PEI for 1 PO | Dynamic rate-matching in PDSCH |
| 259.2 | vivo | 1 PEI for 1 PO |
| 6 bits | 1 (CATT) | 288.0 | CATT | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| 1-slot 50-RB TRS, occupying 300 REs (50 RB x 3 REs per RB x 2 symbols) | 1 bit | 1 (OPPO) | 279.0 | OPPO | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| 2 bits | 1 (MTK) | 150.0 | MTK | 1 PEI for 2 PO's | Semi-static rate-matching in PDSCH |
|   |
| PDSCH: MCS0, TB scaling 0.5PDCCH: AL16, 41-bit payload | PDCCH-based PEI | AL8 PDCCH with 12-bit payload, occupying 576 REs | 12 bits | 3 (OPPO, ZTE, MTK) | 48.0 | OPPO | 1 PEI for up to 12 POs | PEI is ALWAYS transmitted as a Rel-15 PDCCH in a CORESET |
| 102.0 | MTK | 1 PEI for up to 12 POs |
| SSS-based PEI | 3-symbol SSS, occupying 396 REs (11 RB x 3 symbols) | 1 bit | 1 (MTK) | 561.0 | MTK | 1 PEI for 1 PO; RB-symbol rate-matching pattern period up to 40 ms | Semi-static rate-matching in PDSCH |
| TRS/CSI-RS-based PEI | 1-slot 50-RB TRS, occupying 300 REs (50 RB x 3 REs per RB x 2 symbols) | 1 bit | 1 (OPPO) | 270.0 | OPPO | 1 PEI for 1 PO | Semi-static rate-matching in PDSCH |
| 2 bits | 1 (MTK) | 150.0 | MTK | 1 PEI for 2 PO's | Semi-static rate-matching in PDSCH |

 |
| **RAN1 #105-e meeting**Agreement:For UE subgroups indication in physical layer, maximum of 8 subgroups per PO is supported.**Conclusion:**To down-select one solution for PEI physical-layer channel/signal in RAN1 #106-e, using below as a starting point:* PDCCH-based PEI
* SSS-based PEI
* TRS/CSI-RS-based PEI

Note: Additional details for each of the above 3 solutions are encouraged for more informed down-selectionNote: further refinement of the above list is possible, e.g., by merging/further splitting, depending on significance of the commonality and/or differencesAgreement:**Observation:**Dynamically sharing PDCCH resource***s*** of Rel-15 UEs (whether or not this is an important aspect to consider for PEI is FFS)* + For PDCCH-based PEI,
		- PEI can dynamically share resources with PDCCH for Rel-15 UEs within a PDCCH CORESET at granularity of one or more candidates
			* Exact number of multiplexed/impacted Rel-15 PDCCH candidates depends on AL used for PDCCH-based PEI and relative size of PDCCH CORESET, etc.
	+ For SSS-based PEI and for the case of partial overlap of CORESET and PEI
		- For interleaved CORESET (such as CORESET#0), SSS-based PEI can dynamically share resources with PDCCH for Rel-15 UEs only at CORESET-level granularity
		- For non-interleaved CORESET, SSS-based PEI can dynamically share resources with PDCCH for Rel-15 UEs within a PDCCH CORESET at granularity of one or more candidates
			* Exact number of impacted Rel-15 PDCCH candidates depends on relative size and location of PDCCH CORESET, etc.
	+ For TRS/CSI-RS-based PEI and for the case of partial overlap of CORESET and PEI
		- For interleaved CORESET (such as CORESET#0), TRS/CSI-RS-based PEI can dynamically share resources with PDCCH for Rel-15 UEs only at CORESET-level granularity
		- For non-interleaved CORESET, TRS/CSI-RS-based can dynamically share resources with PDCCH for Rel-15 UEs within a PDCCH CORESETat candidate level granularity
			* Exact number of impacted Rel-15 PDCCH candidates depends on CSI-RS mapping pattern, relative size and location of PDCCH CORESET, etc.)

Agreement:For paging indication to the subgroups in a PO,* For PDCCH-based PEI, subgroups in a PO are indicated by one PEI
	+ One bit in the DCI payload indicating one UE subgroup is supported
		- FFS: Whether code-point based mapping is utilized, and, if so, how to map to the subgroups in a PO
* For SSS-based PEI, subgroups in a PO are indicated by a set of sequence realizations
	+ FFS: Sequence mapping design for supporting up to 8 subgroups per PO
	+ Physical-layer configuration(s) and sequence generation design are subject to no impact to initial access and RRM measurements of legacy UEs
* For TRS/CSI-RS-based PEI, subgroups in a PO can be indicated by the following alternatives
	+ Alt 1:One TRS sequence with orthogonal cover as PEI transmitted in the PEI monitoring occasion where one orthogonal cover of the PEI indicates one subgroup or combination of subgroups
		- FFS: Design details for the orthogonal cover
	+ Alt 2: A set of TRS sequences indicating the subgroups with one selected sequence transmitting in one TRS resource
		- FFS: Sequence mapping design for supporting up to 8 subgroups per PO and combination of subgroups
	+ Alt 3: Multiple TRS/CSI-RS resources FDMed/TDMed /CDMed in the same monitoring occasion where one TRS/CSI-RS resource indicates one subgroup
		- Reuse Rel-15/16 CSI-RS FDM/TDM/CDM patterns for supporting up to 8 subgroups per PO
* Note : It is RAN1 understanding that Physical-layer configuration(s) for paging early indication to the subgroups is subject to the same idle-mode reception bandwidth as CORESET-0 frequency span

AgreementObservation:For the comparison of PEI candidate designs, the following table summarizes average power saving gains based on companies contributions:

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
| UE subgroups in a PO | PEI candidate type (PDCCH, SSS, TRS/CSI-RS) | #SS burst(s) before PO in Rel-16 baseline | PO paging rate | **Power Saving Gain** | Company | Assumed #SS burst(s) before PEI | Assumed #SS burst(s) between PEI and PO when UE is paged |
| 1 | PDCCH | 1 | 10% | **8.95%** | Samsung | 1 | 0 |
| 10% | **11.09%** | QC | 1 | 0 |
| 10% | **14.8%** | MTK | 1 | 0 |
| 10% | **15.7%** | ZTE | 1 | 0 |
| 10% | **~~[~~16.32%~~]~~** | Intel | 1 | ~~[~~1~~]~~ |
| 40%-60% | **6.2% - 9.8%** | ZTE | 1 | 0 |
| 2 | 10% | **2.16%** | Samsung | 2 | 0 |
| 10% | **5.0%** | QC | 1 | 1 |
| 10% | **15.60%** | Intel | 2 | 0 |
| 10% | **15.64%** | Samsung | 1 | 1 |
| 10% | **19.5%** | MTK | 1 | 1 |
| 10% | **22.5%** | ZTE | 1 | 1 |
| 10% | **~~[24.938%]~~26.14%** | Intel | 1 | 1 |
| 40%-60% | **9.3% - 14.4%** | ZTE | 1 | 1 |
| 3 | 10% | **1.88%** | Samsung | 3 | 0 |
| 10% | **5.83%** | CATT | 3 | 0 |
| 10% | **13.92%** | Intel | 3 | 0 |
| 10% | **15.7%** | QC | 1 | 2 |
| 10% | **25.5%** | MTK | 1 | 2 |
| 10% | **25.33%** | Samsung | 1 | 2 |
| 10% | **26.3%** | Apple | 1 | 2 |
| 10% | **29.6%** | DoCoMo | 1 | 2 |
| 10% | **31.4%** | ZTE | 1 | 2 |
| 10% | **33% - 37%** | Ericsson | 1 | 2 |
| 10% | **~~[31.75%]~~32.82%** | Intel | 1 | 2 |
| 40%-60% | **12.5%** | DoCoMo | 1 | 2 |
| 40%-60% | **13.2% - 20.3%** | ZTE | 1 | 2 |
| SSS or TRS/CSI-RS (same results) | 1 | 10% | **11.09%** | QC | 1 | 0 |
| 10% | **14.8%** | MTK | 1 | 0 |
| 10% | **15.4%** | Samsung | 1 | 0 |
| 10% | **15.7%** | ZTE | 1 | 0 |
| 10% | **17.67%** | Intel | 1 | 0 |
| 40%-60% | **6.2% - 9.8%** | ZTE | 1 | 0 |
| 2 | 10% | **5.0%** | QC | 1 | 0 |
| 10% | **6.3%** | QC | 0 | 1 |
| 10% | **20.49%** | Samsung | 1 | 0 |
| 10% | **20.7%** | MTK | 1 | 0 |
| 10% | **22.5%** | ZTE | 1 | 0 |
| 10% | **27.33%** | Intel | 1 | 0 |
| 40%-60% | **9.3% - 14.4%** | ZTE | 1 | 0 |
| 3 | 10% | **15.7%** | QC | 1 | 0 |
| 10% | **17.8%** | QC | 0 | 1 |
| 10% | **26.6%** | MTK | 1 | 1 |
| 10% | **27.9%** | Apple | 1 | 0 |
| 10% | **30.19%** | CATT | 1 | 0 |
| 10% | **30.84%** | Samsung | 1 | 0 |
| 10% | **31.4%** | ZTE | 1 | 2 |
| 10% | **34.96%** | Intel | 1 | 0 |
| 40%-60% | **13.2% - 20.3%** | ZTE | 1 | 2 |
| 8 | PDCCH | 1 | 10% | **11.31%** | Samsung | 1 | 0 |
| 10% | **11.9%** | CMCC | 1 | 0 |
| 10% | **12.5%** | QC | 1 | 0 |
| 10% | **18.0%** | MTK | 1 | 0 |
| 20%-35% | **11.89%** | Samsung | 1 | 0 |
| 20%-35% | **12.04%** | CMCC | 1 | 0 |
| 20%-35% | **18.40%** | MTK | 1 | 0 |
| 40%-60% | **19.20% - 20.00%** | MTK | 1 | 0 |
| 2 | 10% | **6.3%** | QC | 1 | 1 |
| 10% | **20.36% - 31.70%** | HW | 1 | 1 |
| 10% | **22.40%** | MTK | 1 | 1 |
| 10% | **25.40%** | ZTE | 1 | 1 |
| 20%-35% | **22.50%** | MTK | 1 | 1 |
| 20%-35% | **20.71% - 31.95%** | HW | 1 | 1 |
| 40%-60% | **20.73% - 31.64%** | HW | 1 | 1 |
| 40%-60% | **22.80% - 23.20%** | MTK | 1 | 1 |
| 40%-60% | **25.40% - 25.70%** | ZTE | 1 | 1 |
| 3 | 10% | **17.9%** | QC | 1 | 2 |
| 10% | **22.65%** | CMCC | 1 | 2 |
| 10% | **28.70%** | MTK | 1 | 2 |
| 10% | **30.65% - 42.19%** | HW | 1 | 2 |
| 10% | **35.1%** | ZTE | 1 | 2 |
| 20%-35% | **23.08%** | CMCC | 1 | 2 |
| 20%-35% | **28.80%** | MTK | 1 | 2 |
| 20%-35% | **30.72% - 42.12%** | HW | 1 | 2 |
| 40%-60% | **29.00% - 29.10%** | MTK | 1 | 2 |
| 40%-60% | **29.42% - 42.11%** | HW | 1 | 2 |
| 40%-60% | **33.6% - 34.5%** | ZTE | 1 | 2 |
| SSS | 1 | 10% | **12.5%** | QC | 1 | 0 |
| 10% | **15.80%** | MTK | 1 | 0 |
| 20%-35% | **14.10%** | MTK | 1 | 0 |
| 40%-60% | **7.60% - 10.80%** | MTK | 1 | 0 |
| 2 | 10% | **6.3%** | QC | 1 | 0 |
| 10% | **7.7%** | QC | 0 | 1 |
| 10% | **18.53%- 28.90%** | HW | 1 | 1 |
| 10% | **21.40%** | MTK | 1 | 0 |
| 10% | **23.50% - 25.40%** | ZTE | 1 | 0 |
| 20%-35% | **16.98% - 26.18%** | HW | 1 | 1 |
| 20%-35% | **20.60%** | MTK | 1 | 0 |
| 40%-60% | **10.70% - 20.77%** | HW | 1 | 1 |
| 40%-60% | **15.00% - 25.70%** | ZTE | 1 | 0 |
| 40%-60% | **17.50% - 19.00%** | MTK | 1 | 0 |
| 3 | 10% | **17.9%** | QC | 1 | 0 |
| 10% | **20.2%** | QC | 0 | 1 |
| 10% | **27.20%** | MTK | 1 | 1 |
| 10% | **27.69% - 38.11%** | HW | 1 | 2 |
| 10% | **35.1%** | ZTE | 1 | 2 |
| 20%-35% | **25.15% - 34.49%** | HW | 1 | 2 |
| 20%-35% | **25.80%** | MTK | 1 | 1 |
| 40%-60% | **14.30% - 26.7%** | HW | 1 | 2 |
| 40%-60% | **20.30% - 23.00%** | MTK | 1 | 1 |
| 40%-60% | **33.6% - 34.5%** | ZTE | 1 | 2 |
| TRS/CSI-RS | 1 | 10% | **12.5%** | QC | 1 | 0 |
| 10% | **15.80%** | MTK | 1 | 0 |
| 10% | **18.08%** | Samsung | 1 | 0 |
| 20%-35% | **14.10%** | MTK | 1 | 0 |
| 20%-35% | **18.54%** | Samsung | 1 | 0 |
| 40%-60% | **7.60% - 10.80%** | MTK | 1 | 0 |
| 2 | 10% | **6.3%** | QC | 1 | 0 |
| 10% | **7.7%** | QC | 0 | 1 |
| 10% | **19.99% - 30.66%** | HW | 1 | 0 |
| 10% | **21.40%** | MTK | 1 | 0 |
| 10% | **23.50% - 25.40%** | ZTE | 1 | 0 |
| 20%-35% | **19.93% - 29.79%** | HW | 1 | 0 |
| 20%-35% | **20.60%** | MTK | 1 | 0 |
| 40%-60% | **15.00% - 25.70%** | ZTE | 1 | 0 |
| 40%-60% | **17.50% - 19.00%** | MTK | 1 | 0 |
| 40%-60% | **19.34% - 26.11%** | HW | 1 | 0 |
| 3 | 10% | **17.9%** | QC | 1 | 0 |
| 10% | **20.2%** | QC | 0 | 1 |
| 10% | **27.20%** | MTK | 1 | 1 |
| 10% | **29.05% - 39.74%** | HW | 1 | 1 |
| 10% | **31.55%** | CATT | 1 | 0 |
| 10% | **35.1%** | ZTE | 1 | 2 |
| 20%-35% | **25.80%** | MTK | 1 | 1 |
| 20%-35% | **27.72% - 37.54%** | HW | 1 | 1 |
| 40%-60% | **20.30% - 23.00%** | MTK | 1 | 1 |
| 40%-60% | **21.90% - 32.78%** | HW | 1 | 1 |
| 40%-60% | **33.6% - 34.5%** | ZTE | 1 | 2 |

 |
| **Relating to scope item 1) – b):**1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]
	1. Specify means to provide potential TRS/CSI-RS occasion(s) available in connected mode to idle/inactive-mode UEs, minimizing system overhead impact [RAN1]
* NOTE: Always-on TRS/CSI-RS transmission by gNodeB is not required

**The following agreements are achieved:** |
| **RAN1 #104-bis-e Meeting**Agreement:SCS of TRS/CSI-RS occasion(s) for idle/inactive UEs is same as SCS of CORESET#0.Agreement:Support higher layer configuration of the QCL information of TRS/CSI-RS occasion(s) for idle/inactive UEs.* FFS details of the QCL information, e.g. associated SSB index

Agreement:IDLE/INACTIVE mode UE is not expected to receive TRS/CSI-RS outside the initial DL BWP.* Configuration of the frequency location of TRS/CSI-RS occasion(s) for idle/inactive UEs is not restricted by initial BWP.

Working assumption:Support at least L1 based signaling for the availability indication of TRS/CSI-RS at the configured occasion(s) to the idle/inactive UEs.* FFS details, including paging DCI and/or PEI for L1 based signaling
* FFS SIB-based signaling/configuration
	+ **Note:** It is RAN1 understanding that existing SI update procedure is used for SIB based signaling

Agreement:**Configuration for TRS/CSI-RS occasion(s) for idle/inactive UEs is based on periodic TRS only, including** **following limitations*** **Configuration parameters that are necessary to provide configuration of periodic TRS for idle/inactive UEs**
* **Applicable values that are necessary to provide configuration of periodic TRS for idle/inactive** **UEs**
* **If the configuration is provided, idle/inactive UEs can always implicitly assume that trs-info is configured.**
	+ **The parameter trs-info does not need to be provided in the configuration**

Agreement:For the information provided by a physical layer availability indication of TRS/CSI-RS at the configured occasion(s) to the idle/inactive UEs, one or more alternatives from the following can be supported:* Alt1: Availability/unavailability information for all or some of configured RS resources using a bitmap or codepoint
* e.g. using bitmap, where each bit ~~from a bitmap or a codepoint~~ is associated with at least one resource~~/configuration~~ or a set/group of resources
* e.g. a codepoint to indicate a state of availability/unavailability for all or some of configured RS resources
* Alt2: value or codepoint to indicate one or more resource/configuration indices that correspond to the available RS resources
* FFS whether and how to indicate the ‘availability’ in beam selective manner.
* Other alternatives are not precluded

 |
| **RAN1 #105-e Meeting**Agreement:Confirm the following working assumption:Support at least L1 based signaling for the availability indication of TRS/CSI-RS at the configured occasion(s) to the idle/inactive UEs.* FFS details, including paging DCI and/or PEI for L1 based signaling
* FFS SIB-based signaling/configuration
	+ Note: It is RAN1 understanding that existing SI update procedure is used for SIB based signalling

 Agreement:**For the information provided by a physical layer availability indication of TRS/CSI-RS at the configured occasion(s) to the idle/inactive UEs, support availability/unavailability information for configured RS resources using a bitmap or codepoint*** **e.g. using bitmap, where each bit is associated with at least one resource/configuration or a set/group of resources**
* **e.g. a codepoint to indicate a state of availability/unavailability for all or some of configured RS resources**
* **FFS** **maximum number of** **configured RS resources per physical layer availability indication to support.**
* **FFS whether availability/unavailability information is for all or some of configured RS resources**

 Agreement:**Support applicable values for the following configuration parameters as below.*** **powerControlOffsetSS:** **{-3, 0, 3, 6}dB**
* **scramblingID:** **0 to 1023**
* **firstOFDMSymbolInTimeDomain:** **0 to 9**
	+ **firstOFDMSymbolInTimeDomain indicates first symbol in a slot, a second symbol in the same slot can be derived implicitly with symbol index as firstOFDMSymbolInTimeDomain+4**
* **startingRB:** **0 to 274**
* **nrofRBs:** **24 to 276**

  Agreement:The QCL information of TRS/CSI-RS occasion(s) for idle/inactive UEs is indicated as a SSB index in range of 0 to 63.* FFS: how the QCL information can be configured, e.g. per RS resource set or per configuration
* FFS: QCL type, which is predetermined

**Working assumption:****Support paging PDCCH based availability indication of TRS/CSI-RS occasions for idle/inactive UEs.****Support PEI based availability indication of TRS/CSI-RS occasions for idle/inactive UEs at least if PDCCH-based PEI is down-selected.*** **FFS ~~whether and~~ how to enable/disable L1 based availability indication configurable by SIB**

Agreement:Configuration of TRS/CSI-RS occasion(s) for idle/inactive UEs include:* periodicityAndOffset {10, 20, 40, 80} ms
* frequencyDomainAllocation for row1 with applicable values from {0, 1, 2, 3} to indicate the offset of the first RE to RE#0 in a RB
* FFS Configuration index
	+ details,
		- E.g. Per resource or resource set or group of resource sets
		- E.g. explicit or implicit indication based on QCL source

Agreement:Further study supporting SIB based signaling for availability information of TRS/CSI-RS occasions for idle/inactive UEs at least based on the presence/absence of the configuration of the TRS/CSI-RS occasion in SIB\_X in case L1 based availability indication is not configured.* FFS whether and how SIB based signaling and L1 based signaling can be configured simultaneously
 |
| **Relating to scope item 2) – a):**1. Study and specify, if agreed, enhancements on power saving techniques for connected-mode UE, subject to minimized system performance impact [RAN1, RAN4]
	1. Study and specify, if agreed, extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time for an active BWP, including PDCCH monitoring reduction when C-DRX is configured [RAN1]
* NOTE: Rel-15 and Rel-16 available power saving solutions should be supported by the UE and included in the evaluation. RAN1 will ask the confirmation from RAN2 that Rel-15 and Rel-16 available power saving solutions are properly utilized.

**The following agreements are achieved:** |
| **RAN1 #105-e Meeting**Agreement:* PDCCH schedules data and also indicates PDCCH monitoring adaptation by SSSG switching and PDCCH skipping for a duration is supported.
	+ At least DCI format(s) 1-1, 0-1, 1-2 and 0-2 can be used for the indication(s)

Agreement:* ~~At least~~ one of  Alt 1 and Alt 2 is supported, to be decided in RAN1#106,
* Alt 1: Supporting SSSG  switching to emulate PDCCH skipping functionality,
	+ Alt 1-1: by an ‘empty’ SSSG which no SS set(s) is configured for the ‘empty’ SSSG, UE does not monitoring PDCCH on the ‘empty’  SSSG,
	+ Alt1-2: by a ‘dormant SSSG’ which may have associated SS sets, and monitored conditionally (e.g., depending on HARQ NACK or RTT/ReTx timers)
* Alt 2: PDCCH schedules data and also indicates PDCCH monitoring adaptation by PDCCH skipping for a duration is supported.
	+ FFS details, including
		- e.g., joint / separate indication of SSSG switching and PDCCH skipping
		- Determination of the duration(s) for PDCCH skipping, e.g.,
			* by RRC signaling,
			* by DCI indication
			* Implicitly, to the end of C-DRX active time

Agreement:At least SSSG#0 and SSSG#1 switching is supported for Rel-17 SSSG switching indicated by PDCCH scheduling data and/or timer.* FFS: support of more than 2 SSSGs
 |

#### 2.1.2 Remaining open issues

RAN1 continues discussing and deciding the physical layer details for idle-mode and connected-mode power saving enhancements. In particular, the following are the remaining open issues:

* For scope item 1) - a):
	+ To down-select one solution for PEI physical-layer channel/signal in RAN1 #106-e , using the following as a starting point: PDCCH-based PEI, SSS-based PEI and TRS/CSI-RS-based PEI
	+ Specify how to provide subgroups indication with PEI; FFS whether and how to utilize paging DCI
	+ Specify monitoring occasion(s) of PEI and UE paging monitoring behaviour with PEI.
	+ Discuss and decide whether and what additional indication(s) other than paging indication is carried in PEI
	+ Specify how to interpret the carried indication(s) for the decided PEI physical-layer channel/signal
* For scope item 1) - b):
	+ Specify how gNodeB indicates the availability of configured TRS/CSI-RS occasion(s) for idle/inactive UEs based on at least physical layer signaling
	+ Specify additional details for the configuration of TRS/CSI-RS occasion(s) for idle/inactive UEs
* For scope item 2) - a):
	+ Discuss and decide one of Alt 1 (Supporting SSSG switching to emulate PDCCH skipping functionality) or Alt 2 (PDCCH schedules data and also indicates PDCCH monitoring adaptation by PDCCH skipping for a duration) in RAN1#106-e.
	+ Discuss and decide
		- Whether and how to minimize impact to data scheduling (for new transmissions and retransmissions)
		- Application delay
		- Other mechanism (if support), e.g., non-scheduling DCI, implicit indication, etc.

## 2.2 RAN2

#### 2.2.1 Agreements

|  |
| --- |
| **Relating to scope item 1) - a)** 1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]
	1. Study and specify paging enhancement(s) to reduce unnecessary UE paging receptions, subject to no impact to legacy UEs [RAN2, RAN1]
* NOTE: RAN1 to check and update, if needed, evaluation methodology in RAN1 #102-e meeting

**The following agreements are achieved:** |
| RAN2 #113-bis-e Meeting[R2-2102621](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_113bis-e%5CDocs%5CR2-2102621.zip) Reply LS on Paging Enhancement (R1-2102136; contact: MediaTek) RAN1 LS in Rel-17 NR\_UE\_pow\_sav\_enh-Core To:RAN2* Noted
* Short Post email discussion, agree preference of no of groups if possible, approved reply LS out.
* [Post113bis-e][055][ePowSav] Reply LS on Paging Enhancement (Mediatek)

 Scope: On Reply LS to RAN1, agree R2 preference for no of groups if possible to reply to R1 LS. Inforn on R2 progress Intended outcome: Approved LS out Deadline: Short[R2-2104496](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_113bis-e%5CDocs%5CR2-2104496.zip) Summary of Idle/Inactive-mode UE Power Saving (AI 8.9.2) MediaTek Inc. discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core* Noted

[R2-2102919](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_113bis-e%5CDocs%5CR2-2102919.zip) UE sub-grouping mechanism with Paging Enhancement CATT discussion Rel-17 NR\_UE\_pow\_sav\_enh-Core * Noted

[R2-2103258](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_113bis-e%5CDocs%5CR2-2103258.zip) Paging Enhancement with UE Grouping MediaTek Inc., CMCC discussion* Noted
* If we go for network controlled subgrouping, If the network chooses to not provide specific subgrouping information, there will be configuration option where subgrouping can be supported by randomization (by UE-ID).
* We adopt Network controlled subgrouping (based on individual UE characteristics, not specified or limited to paging prob as EUTRA, possibly with additional randomization)
 |
| RAN2 #114-e Meeting* [AT114-e][025][ePowSav] Subgrouping network architecture (Mediatek)

 Scope: Address whether CN or RAN shall be responsible for paging subgrouping based on UE characteristics. As this may be related to availability of information on UE characteristics in the CN or RAN network entity, can also discuss if needed provisioning of assistance information (e.g. between the network entities or from UE to the responsible network entity). The discussion shall be based on the contributions under 8.9.2.  Intended outcome: Report, with discussion, and presenting the main alternatives on the table with documented justifications, way forward. CLOSED[R2-2106666](file:///D%3A%5CDocuments%5C3GPP%5Ctsg_ran%5CWG2%5CTSGR2_114-e%5CDocs%5CR2-2106666.zip) Report of [AT114-e][025][ePowSav] Subgrouping network architecture Mediatek Inc. DISCUSSIONThe following is supported:* CN is responsible for allocating UEs to UE paging subgroups based on UE characteristics
* Use same UE subgroups when in RRC\_IDLE and RRC\_INACTIVE
 |
| **Relating to scope item 1) – b):**1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]
	1. Specify means to provide potential TRS/CSI-RS occasion(s) available in connected mode to idle/inactive-mode UEs, minimizing system overhead impact [RAN1]
* NOTE: Always-on TRS/CSI-RS transmission by gNodeB is not required

**Awaiting more RAN1 progress; no discussion in Q2 2021** |

#### 2.2.2 Remaining open issues

With the above, the following are remaining issues for idle-mode power saving enhancements in RAN2:

* For scope item 1) – a):
	+ Discuss and decide whether and how UE paging subgroups can also be assigned by RAN.
	+ Specify configurations for UE subgrouping as well as paging early indication based on RAN1 design
* For scope item 1) – b):
	+ Discuss and decide whether and how dedicated high-layer signalling methods (e.g., dedicated RRC, RRC release message, etc.) can be additionally utilized with justification.
	+ Discuss and decide SIB type, Option 2 (Existing SIB) or Option 3 (New SIB type), for providing the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s), based on RAN1 design on detailed configurations.

## 2.3 RAN3

#### 2.3.1 Agreements: N/A (RAN3 is not involved in the WI)

#### 2.3.2 Remaining Open issues: N/A

## 2.4 RAN4

#### 2.4.1 Agreements

|  |
| --- |
| **Relating to scope item 2) - b)** 1. Study and specify, if agreed, enhancements on power saving techniques for connected-mode UE, subject to minimized system performance impact [RAN1, RAN4]
	1. Study the feasibility and performance impact of relaxing UE measurements for RLM and/or BFD, particularly for low mobility UE with short DRX periodicity/cycle, and specify, if agreed, relaxation in the corresponding requirements [RAN4]
* NOTE: Supplementary RAN2 work, if needed, can be triggered by RAN4 LS

**The following agreements are achieved:** |
| **RAN4 #98-bis-e Meeting****Approved: WF on RLM/BM relaxation (R4-2105797):****Evaluation assumption:**Issue 2-1-2: assumption on other RRM measurement* Background for information: The guidance from RP-91-e,
	+ *“For Rel-17 WI of UE power saving enhancements for NR, no specification impact to RRM measurement procedure requirements and measurement performance requirements is expected.“*

Issue 2-1-3: Impact on PDCCH monitoring* RAN4 shall assess the interaction between PDCCH relaxation (as being discussed in RAN1) and RLM/BM relaxation (as being discussed in RAN4) from power consumption perspective once there is more progress in RAN1 on PDCCH relaxation.

**Feasible scenarios for relaxation:*** RAN4 conclude the feasible scenario and will define the RLM/BFD requirements for R17 UE measurements relaxation for RLM and/or BFD in work phase for the following cases,
	+ Case 1: SSB based RLM/BFD measurement relaxation in FR1
	+ Case 2: CSI-RS based RLM/BFD measurement relaxation in FR1
	+ Case 3: CSI-RS based RLM/BFD measurement relaxation in FR2
	+ Case 4: SSB based RLM/BFD measurement relaxation in FR2
	+ *Note: UE is allowed but not mandatory to perform relaxed RLM/BFD measurements when the relaxation criteria is met in above feasible scenarios.*
	+ For the feasible cases with positive power saving gain
		- Option 1: When defining relaxation requirement, RAN4 should consider the maximum additional delay of RLF declaration within a confidence level due to power saving, i.e., the probability of maximum additional delay within x is larger than y, for power saving evaluation on different schemes.
	+ further considerations as bellows are considered
		- Option 1: Negative system level impact due to RLM/BFD relaxation should be minimized
		- Option 2: RAN4 can further discuss whether the beneficial scenario is a reasonable case for network configuration.

Issue 2-2-6: DRX cycle applicability* Relaxation is applicable for DRX<=80ms.
	+ FFS adjustment to other DRx cycles is needed to keep the monotonicity of DRx cycles w.r.t. evaluation time
	+ FFS Maximum relaxation factor should be related to DRX cycle and RS periodicity.

Issue 2-2-7: Potential spec impact * + The spec impact of R17 power saving will be discussed in the work phase.

**Relaxation criteria:**Issue 2-3-1: Criteria of RLM/BFD relaxation – Generalwhether relaxed RLM/BFD requirements can be applied depends on both the serving cell quality and UE mobility state* FFS the precise and robust metric for serving cell quality and UE mobility state

Issue 2-3-2/2-3-3/2-3-4: Good serving cell quality criteria of RLM/BFD relaxation* Good serving cell quality criteria of RLM/BFD relaxation is defined as the radio link quality is better than a threshold.
	+ FFS radio link quality > Qout + X (dB) for RLM
	+ FFS radio link quality > Qout,LR + Y (dB) for BFD relaxation.
	+ FFS how to derive the values of X, Y
* The radio link quality in good serving cell quality criteria for R17 RLM/BFD relaxation is based on SINR
	+ FFS how to derive the corresponding SINR level of the threshold used in good serving cell quality criteria
	+ FFS which SINR is used
		- Option 1: Reuse SINR for RLM/BFD evaluation
	+ FFS whether RSRP is also needed for BFD as additional condition
* FFS: The thresholds are configured or pre-defined.
	+ FFS: Different threshold configuration (i.e. different IEs in RRC signaling )for SSB based and CSI-RS based RLM/BFD is allowed

**Relaxation factors:*** FFS on following:
	+ Option 1: Evaluation period based on fixed sample number
		- The relaxation factor is implicitly defined, similar to the beam sweeping factor implicitly defined in FR2 RRM measurement requirements.
	+ Option 2: Evaluation period scaling with the relaxation factor
		- The relaxation factor is explicitly defined
		- FFS whether Different relaxation factors between FR1 and FR2
		- FFS whether Different relaxation factors for different SINR range
		- FFS whether Different relaxation factors for SSB and CSI-RS
		- FFS What UE speed is used as reference for derving the relaxation factor
	+ Option 3: Up to UE implementation as long as the additional delay for RLM/BFD declaration is within the (to be defined) relaxed requirement
	+ Other options are not precluded.

**Issue 2-3-5: Low mobility criteria of RLM/BFD relaxation:*** Low mobility criterion for identifying low mobility scenario under which the UE is allowed to apply the RLM/BM requirements is determined and configured to UE by the network, and it is up to the UE whether to apply relaxed RLM/BM requirements when configured.
* Given the this feature is enabled by the network, the low mobility criterion is defined based on
	+ FFS until RAN4 #99e
		- Option A: UE will need to verify whether the low mobility criterion is fulfilled based on the channel condition
			* Option A1: RSRP variation (reuse R16 low mobility criterion and procedure)
			* Option A2: SINR variation
		- Option B: UE will **not** need to verify whether the low mobility criterion is fulfilled based on the channel condition
			* Option B1: UE defines if the low mobility criterion is fulfilled (e.g. fixed UE) or not fulfilled (e.g. vehicular UE).
			* Option B2: Network configures whether the low mobility criterion is fulfilled or not
		- Option C: The low mobility criterion can be left for RAN2 to decide. Send LS to RAN2 to trigger RAN2 discussion.
		- Option D: Other options on how often UE verifies the low mobility criterion is open for discussions at next meeting.

**Issue 2-3-6: Exiting criteria of RLM relaxation:*** Background:
	+ Following agreement was made at last meeting [R4-2103670]:
		- “*The UE while performing relaxed RLM upon detecting certain number of out-of-sync indications or upon triggering T310 or upon observed link quality degradation or mobility state change reverts to the normal RLM operation (i.e. without relaxation).”*

Following additional options are listed below:FFS which of the following options can be used as the exiting criteria of RLM relaxation* Option 1: exit relaxation mode when any relaxation criterion is not met
	+ Option 1a: a hysteresis value (e.g. 3dB) could be used to avoid ping-ping effect.
		- Relaxation exiting condition: Qualitymeasured + Hys < Thresh
* Option 2: exit relaxation mode when the radio link quality is worse than a certain SINR threshold Thexit, which is higher than Qout.
	+ Option 2a: set different radio link quality threshold for entering and exiting the relaxation
	+ Option 2b: either the averaged SINR based on reduced number of samples is below Thexit, or the one-shot SINR is below Qout.
* Option 3: exit relaxation mode based on out-of-sync indication.
	+ Option 3a: exit when N310 starts to count, i.e. 1 out-of-sync indication.
	+ Option 3b: exit when T310 is running witch is triggered by a new counter
	+ Option 3c: exit when certain number of out-of-indications
	+ Option 3d: exit when certain consecutive out-of-sync indications
* Option 4: Additional time is allowed for UE to evaluate first OOS indication when UE is in power saving mode. UE is in normal mode after first OOS indication. The additional delay for RLF declaration is guaranteed to be within OOS evaluation time (TEvaluate\_out\_SSB) in normal mode. Relaxation factor and exit SINR threshold (for good cell quality condition) is up to UE implementation, but the “first OOS indication” requirement has to be satisfied.

**Issue 2-3-7: Exiting criteria of BFD relaxation:**FFS which of the following options can be used as the exiting criteria of BFD relaxation* Option 1: exit relaxation mode when any relaxation criterion is not met
	+ Option 1a: a hysteresis value (e.g. 3dB) could be used to avoid ping-ping effect.
		- Relaxation exiting condition: Qualitymeasured + Hys < Thresh
* Option 2: exit relaxation mode when the radio link quality is worse than a certain threshold Thexit , which is higher than Qout\_LR.
	+ Option 2a: set different radio link quality threshold for entering and exiting the relaxation
	+ Option 2b: either the averaged SINR based on reduced number of samples is below Thexit, or the one-shot SINR is below Qout\_LR.
* Option 3: exit relaxation mode based beam failure instance indication
	+ Option 3a: exit upon detecting the 1 beam failure instance indication.
	+ Option 3b: exit after BFI\_COUNTER add to the value of a new counter or a new parameter, the new counter or the new parameter is configured by network.
* Other options are not precluded

**Relaxation scheme:**Issue 2-4-1: Relaxed evaluation period of RLM/BFDScaling factor defining the relaxed RLM/BFD evaluation period is defined based on max(TDRX, TSSB). FFS the following options* Option 1:The similar definition of RLM/BFD evaluation period in Rel-15 can be reused as Max(T, Ceil([Y] x P x N) x Max(TDRX,TSSB))
* Option 2: If power saving conditions are satisfied, allow TEvaluate\_ps\_out\_SSB for the first OOS indication and the original TEvaluate\_out\_SSB doesn’t apply
* Option 3: modify the Rel-15 wording in the requirements as follows
	+ the new evaluation period TEvaluate\_out\_SSB-Relaxed is specified as K1\* TEvaluate\_out\_SSB, where TEvaluate\_out\_SSB is as specified in clause 8.1.3.2 in TS 38.133 .
	+ the new indication period TIndication\_interval-Relaxed is specified as K2\* TIndication\_interval where TIndication\_interval is as specified in clause 8.1.6 in TS 38.133.
	+ FFS whether K1=K2
* Other options are not precluded.

**Issue 2-4-2: Are the parameters of relaxation criteria predefined or configurable:*** The parameters of relaxation criteria can be configured by the network.
	+ Option 1: The relaxation criteria shall be configured by the network to the UE. If the threshold (criteria) is not configured, it means the UE cannot go into relaxation mode.”
	+ Option 2: The parameters of relaxation criterion of low mobility and entering condition of good cell quality can be configured by the network. Exit condition of good cell quality is FFS.
	+ Option 3: The parameters used in good serving link quality criteria are predefined. FFS other potential parameters.

Issue 2-4-3: network or UE to determine the relaxation criteria is fulfilled or notUE determines whether the relaxation criteria can be fulfilled or not based on the relaxation criteria.Issue 2-5-4: Applicability for BFD relaxation requirementAs the legacy BFD requirement, the BFD relaxation requirement is applicable for PCell, PSCell and all configured SCells. Issue 2-5-2/2-5-3* scenarios for which RAN4 is going to develop relaxation requirements for RLM/BFD is FFS

**Relaxation in intra-band CA:**Issue 2-5-2: Exiting relaxation mode in intra-band CA/DC* Option 1: For intra-band CA, if UE has fulfilled the criterion for operating RLM/BFD in relaxed mode in one serving cell, then it is allowed to operate RLM/BFD in relaxed mode in all other serving cells if same type of RS are used for RLM/BFD in the serving cell and other serving cells.
* Other options are not precluded

 Issue 2-5-3: Relaxation criteria in intra-band CA/DC* Option 1: For intra-band CA, if UE meets the conditions of reverting to the normal RLM/BFD in one serving cell, it is expected the reversion operations are applied to other serving cell(s) if same type of RS are used for RLM/BFD in the serving cell and other serving cells.
* Other options are not precluded

 |
| **RAN4 #99-e Meeting****Approved: WF on RLM/BFD relaxation for UE Power Saving enhancements (R4-2108351):****Relaxation Scenarios:**Issue 2-1-3: Relaxation for deployment scenarios* Relaxed BFD/RLM requirements shall be supported for all deployment scenarios supported by current specification which includes: NR SA, EN-DC, NE-DC, NR intra-band CA, NR inter-band CA and NR-DC.

**Entering Relaxation criteria:**Issue 2-2-1: Good serving cell quality criteria for RLM/BFD: the radio link quality metric for RLM* UE reuse the SINR for RLM/BFD evaluation when determine whether the serving cell quality criteria is fulfilled or not
	+ FFS what is the SINR definition
	+ FFS whether RSRP is also needed for RLM/BFD as additional condition

Issue 2-2-2: Good serving cell quality criteria for RLM/BFD: predefined or configured threshold* + Option A: The thresholds are configured to the UE by the network
		- FFS: based on a set of discrete threshold values.
	+ Option B: The thresholds can be pre-defined.

Issue 2-2-5/2-2-6: Low mobility criteria of RLM/BFD relaxation* UE verifies whether the low mobility criterion is fulfilled or not based on the RSRP variation and/or SINR variation, provided that the variation thresholds are configured by the NW.
* FFS the variation thresholds for low mobility criterion
	+ Option 1: RSRP variation
	+ Option 2: SINR variation
	+ Option 3: RSRP variation and SINR variation.
* FFS how to calculate the variation

**Exiting Relaxation criteria:**Issue 2-3-1: Exiting criteria of RLM/BFD relaxation – Basic* If the UE fulfills any of serving cell quality exit condition or low mobility exit condition, or DRX cycle length is NOT allowed for relaxation, UE will exit relaxation mode.
	+ Note1: Whether the exit condition for serving cell quality is explicitly specified or not is up to issue 2-3-2.
	+ Note2: FFS the details of the exit condition of low mobility’
* FFS the observation period for the exiting criteria

Issue 2-3-2: Exiting criteria of RLM relaxation – Additional FFS the following options, which have been discussed in this meeting.* + Option 1: exit relaxation mode when the radio link quality of the serving cell is worse than a certain threshold, which is higher than Qout.
		- Option 1a: a hysteresis value could be used to avoid ping-ping effect, e.g. SINRexit = SINRenter - 3dB
		- Option 1b: SINRexit = Qout + 7dB
		- Option 1c: SINRexit = Qout +Margin or SINRexit = Qin
		- Option 1d: The threshold can be configured by network with margin
	+ Option 2: exit relaxation mode when the radio link quality is worse than Qout, and the UE is still in the relaxation mode when the radio link quality is better than Qout.
		- Option 2b: UE shall revert to non-relaxed RLM/BFD measurement and evaluation period at the 1st Qout based on relaxed RLM/BFD measurements and evaluation period.
	+ Option 3: Leave the fall back mechanism as UE implementation, as long as UE makes sure it has already fallen back to normal measurement if it has identified one out-of-sync indication.
	+ Option 4: exit when certain consecutive out-of-sync indications

**During Relaxation:**Issue 2-4-0: UE behaviour when the measured SINR is worse than Qout during the relaxation modeFFS whether it would happen if the threshold for exiting criteria is defined as a certain value higher than QoutFFS the following options * Option 1:
	+ UE is required to send the first OOS indication to higher layers and required to start N310 immediately
	+ The evaluation period of the first OOS indication is the relaxed evaluation period in the relaxation mode.
	+ For information, assuming the relaxation factor is K,
		- the fist OOS evaluation period is K\*T\_evaluate\_out\_SSB,
		- the observation period for the exit criteria is K\*T\_evaluate\_out\_SSB.
* Option 2:
	+ UE is not required to send the first OOS indication to higher layers.
		- The OOS indication based on relaxed measurement is not sent to higher layers.
	+ After exit, UE is required to send the first OOS indication after normal evaluation period if SNR<Qout. The evaluation period of the first OOS indication is the summation of the evaluation period in the relaxation mode + normal evaluation period.
	+ For information, assuming UE is applying RLM/BFD measurement relaxation
		- given the fist OOS evaluation period is 2\*T\_evaluate\_out\_SSB,
		- the observation period for the exit criteria is T\_evaluate\_out\_SSB. The power saving gain when applying RLM/BFD relaxation is achieved by using less samples for exit criteria evaluation. Measurement accuracy needs to be investigated.
* Option 3: UE follows the legacy behaviour for sending OoS indications.

Issue 2-4-2: Relaxed evaluation period of RLM/BFDFFS the following options, which have been discussed in this meeting.* Option 1: The similar definition of RLM/BFD evaluation period in Rel-15 can be reused as Max(T, Ceil([Y] x P x N) x Max(TDRX, TRLM-RS/BFD-RS)).
	+ FFS the Y
* Option 2a: For FR1, If power saving conditions are satisfied, allow TEvaluate\_ps\_out\_SSB for the first OOS indication and the original TEvaluate\_out\_SSB doesn’t apply.
* Option 2b: For FR1 and FR2, If power saving conditions are satisfied, for the first OOS indication the original TEvaluate\_out\_SSB  apply.
* Option 3: extended based on the legacy RLM/BFD requirements by considering the scaling factors.
	+ the new evaluation period TEvaluate\_out\_SSB-Relaxed is specified as K1\* TEvaluate\_out\_SSB, where TEvaluate\_out\_SSB is as specified in clause 8.1.3.2 in TS 38.133 .
	+ FFS the new indication period TIndication\_interval-Relaxed is specified as K2\* TIndication\_interval where TIndication\_interval is as specified in clause 8.1.6 in TS 38.133.
* Option 4 :
	+ For RLM, the oos triggering latency requirements should be extended with an additional delay not shorter than (K-1) ×1.5 DRX cycles, while K is the relaxation factor.
	+ For BFD, the beam failure instance triggering latency requirements should be extended with an additional delay not shorter than (K-1) ×1.5 DRX cycles, while K is the relaxation factor.
	+ Extending the out-of-sync evaluation period requirements and beam failure evaluation period requirements by a same factor X can be considered. X can be 2 for DRX <= 40ms, and X can be 1.5 for 40ms <DRX <= 80ms.

Issue 2-4-3: Relaxation scheme and specification impactFFS* + Option 1: Relaxed RLM/BFD requirements are introduced in new subsections within the existing RLM/BFD sections TS 38.133.
	+ Option 2: no new subsection only for short DRX

Issue 2-4-4a: Different Relaxation factors between FR1 and FR2* Different Relaxation factors are allowed for FR1 and FR2.
	+ FFS whether to apply different relaxation factors for SSB and CSI-RS based evaluations in FR2

**Other aspects:**Issue 2-5-1/2: Entering and exiting relaxation mode in intra-band CA* FFS
	+ For intra-band CA with CSI-RS based RLM/BFD, if UE has fulfilled the criterion for operating RLM/BFD in relaxed mode in all serving cells, then it is allowed to operate RLM/BFD in relaxed mode in all other serving cells if same type of RS (CSI-RS) are used for RLM/BFD in the serving cell and other serving cells.
	+ For intra-band CA with CSI-RS based RLM/BFD, if UE meets the conditions of reverting to the normal RLM/BFD in any of the serving cells, it exists the relaxation mode in all other serving cell(s) if same type of RS (CSI-RS )are used for RLM/BFD in the serving cell and other serving cells.

Issue 2-5-3: Entering and Exiting Relaxation criteria for multiple RLM-RS/BFD-RS * FFS
	+ Option 1:
		- radio link quality is better than the threshold (Qout + X1) for **any** RLM-RS resource.
		- The exiting condition of RLM relaxation for multiple RLM-RS resources can be defined as when the radio link quality is worse than the threshold (Qout + X2) for **all** the RLM-RS resources.
		- FFS X1, X2
	+ Option 2:
		- radio link quality is better than the threshold (Qout + X1) for **all** RLM-RS resource.
		- The exiting condition of RLM relaxation for multiple RLM-RS resources can be defined as when the radio link quality is worse than the threshold (Qout + X2) for **any** the RLM-RS resources.
		- FFS X1, X2
 |

#### 2.4.2 Remaining open issues

With the above, the following are remaining open issues for RLM/BFD relaxation in RAN4:

* Scheme of RLM/BFD measurements relaxation
	+ UE behaviour when the measured SINR is worse than Qout during the relaxation mode (Issue 2-4-0)
	+ Relaxed evaluation period of RLM/BFD (Issue 2-4-2)
* Criteria which the UE is allowed to relax the RLM/BM requirements / Network or UE to determine if the criteria for relaxation is fulfilled
	+ FFS the variation thresholds for low mobility criterion (FFS under issue 2-2-5/2-2-6)
	+ FFS how to calculate the variation (FFS under issue 2-2-5/2-2-6)
	+ Good serving cell quality criteria for RLM/BFD: predefined or configured threshold (Issue 2-2-2)
* Reverting to the normal RLM/BFD operation
	+ FFS the observation period for the exiting criteria (FFS under issue 2-3-1)
	+ Exiting criteria of RLM relaxation (Issue 2-3-2)
* Relaxation of BM when not all serving cells in intra-band CA/DC meets relaxation criteria
	+ Entering and exiting relaxation mode in intra-band CA (Issue 2-5-1/2)

## 2.5 RAN5

#### 2.5.1 Agreements: N/A (RAN5 is not involved in the WI)

#### 2.5.2 Remaining Open issues: N/A

#### 2.5.3 Remaining Open issues with cross-WG dependencies: N/A

## 2.6 RAN6

#### 2.6.1 Agreements: N/A (RAN6 is not involved in the WI)

#### 2.6.2 Remaining Open issues: N/A

## 3. Detailed progress in SA/CT WGs since last TSG meeting (for all involved WGs)

NOTE: This section only needs to be filled in for WI/SIs where there is a corresponding relevant WI/SI in SA/CT.

## 3.1 SAx/CTs

#### 3.1.1 Agreements with cross-TSG impacts: N/A

#### 3.1.2 Remaining Open issues with cross-TSG impacts: N/A

## 4. References

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| --- |
| * **Previous status report(s)**

RP-210733 Status report for WI\_UE Power Saving Enhancements for NR Rapporteur (MediaTek)RP-202685 Status report for WI\_UE Power Saving Enhancements for NR Rapporteur (MediaTek)RP-201701 Status report for WI\_UE Power Saving Enhancements for NR Rapporteur (MediaTek) |
| **RAN1 Contributions** |
| **RAN1 #104-bis-e Meeting*** **Potential paging enhancements:**

R1-2102316 Paging enhancements for UE power saving in IDLE/inactive mode Huawei, HiSiliconR1-2102405 Further discussion on Paging enhancements for power saving OPPOR1-2102463 Discussion on potential paging enhancements Spreadtrum CommunicationsR1-2102532 Paging enhancements for idle/inactive mode UE power saving vivoR1-2102565 Discussion on power saving enhancements for paging ZTE,SanechipsR1-2102641 Paging enhancement for UE power saving CATTR1-2102681 On paging enhancements for idle/inactive mode UE power saving MediaTek Inc.R1-2102805 On paging enhancement PanasonicR1-2102892 Discussion on paging early indication design CMCCR1-2102991 Paging enhancement for power saving XiaomiR1-2103041 On Paging Enhancements for UE Power Saving Intel CorporationR1-2103115 Paging early indication for idle/inactive-mode UE AppleR1-2103177 Paging enhancements for idle/inactive UE power saving Qualcomm IncorporatedR1-2103249 Discussion on paging enhancements SamsungR1-2103310 Discussion on potential paging enhancements SonyR1-2103355 Discussion on potential paging enhancements LG ElectronicsR1-2103405 On paging enhancements for UE power saving Nokia, Nokia Shanghai BellR1-2103424 Paging enhancements for UE power saving InterDigital, Inc.R1-2103586 Discussion on paging enhancements NTT DOCOMO, INC.R1-2103614 Paging enhancement for UE power saving Lenovo, Motorola MobilityR1-2103642 Design of Paging Enhancements EricssonR1-2103653 On paging early indication Nordic Semiconductor ASAR1-2103768 Paging enhancement for power saving XiaomiR1-2103848 Summary of paging enhancements Moderator (MediaTek)R1-2102407 Paging and TRS indication in idle/inactive modes OPPOR1-2102534 Discussion on paging grouping vivoR1-2102643 Details of PEI configuration CATTR1-2103426 Paging indication based on sub-time units InterDigital, Inc.* **TRS/CSI-RS occasion(s) for idle/inactive UEs**

R1-2102317 Assistance RS occasions for IDLE/inactive mode Huawei, HiSiliconR1-2102406 Further discussion on RS occasion for idle/inactive UEs OPPOR1-2102464 Consideration on TRS/CSI-RS occasion(s) for idle/inactive UEs Spreadtrum CommunicationsR1-2102478 TRS/CSI-RS occasions for idle/inactive UE TCL Communication Ltd.R1-2102533 TRS/CSI-RS occasion(s) for idle/inactive UEs vivoR1-2102566 TRS for RRC idle and inactive UEs ZTE,SanechipsR1-2102642 Configuration of TRS/CSI-RS for paging enhancement CATTR1-2102682 On TRS/CSI-RS occasion(s) for idle/inactive mode UE power saving MediaTek Inc.R1-2102806 Potential enhancements for TRS/CSI-RS occasion(s) for idle/inactive UEs PanasonicR1-2102893 Discussion on TRS/CSI-RS occasion(s) for IDLE/INACTIVE-mode UEs CMCCR1-2102992 On TRS/CSI-RS configuration and indication for idle/inactive UEs XiaomiR1-2103042 TRS/CSI-RS functionality during idle/inactive mode Intel CorporationR1-2103116 Indication of TRS/CSI-RS for idle/inactive-mode UE power saving AppleR1-2103178 TRS/CSI-RS for idle/inactive UE power saving Qualcomm IncorporatedR1-2103250 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs SamsungR1-2103251 Moderator summary for TRS/CSI-RS occasion(s) for idle/inactive UEs Moderator (Samsung)R1-2103311 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs SonyR1-2103356 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs LG ElectronicsR1-2103406 On RS information to IDLE/Inactive mode UEs Nokia, Nokia Shanghai BellR1-2103425 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs InterDigital, Inc.R1-2103479 On TRS/CSI-RS occasions for idle/inactive UEs SharpR1-2103587 Discussion on TRS/CSI-RS occasion for idle/inactive UEs NTT DOCOMO, INC.R1-2103615 Provision of TRS/CSI-RS for idle/inactive UEs Lenovo, Motorola MobilityR1-2103643 Provisioning of TRS occasions to Idle/Inactive UEs EricssonR1-2103654 On TRS design for idle/inactive UEs Nordic Semiconductor ASAR1-2104115 Final summary for TRS/CSI-RS occasion(s) for idle/inactive UEs Moderator (Samsung)* **Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time**

R1-2103634 Discussion on DCI-based power saving adaptation ITRI* **Others**

R1-2102567 Additional simulation results of UE power consumption in RRC idle and inactive state ZTE,SanechipsR1-2103389 Analysis on power consumption for IDLE mode and RedCap Huawei, HiSiliconR1-2103644 Modeling of Network Power Consumption Ericsson |
| **RAN1 #105-e Meeting*** **Potential paging enhancements:**

R1-2104221 Discussion on power saving enhancements for paging ZTE, SanechipsR1-2104251 Paging enhancements for UE power saving in IDLE/inactive mode Huawei, HiSiliconR1-2104371 Paging enhancements for idle/inactive mode UE power saving vivoR1-2104432 Discussion on potential paging enhancements for UE Power Saving Spreadtrum R1-2104532 Paging enhancement for UE power saving CATTR1-2104622 Discussion on paging early indication design CMCCR1-2104682 Paging enhancements for idle/inactive UE power saving Qualcomm IncorporatedR1-2104787 Further discussion on Paging enhancements for power saving OPPOR1-2104916 On Paging Enhancements for UE Power Saving Intel CorporationR1-2105116 Paging early indication for idle/inactive-mode UE AppleR1-2105174 Considerations on potential paging enhancements SonyR1-2105321 Discussion on paging enhancements SamsungR1-2105386 On Paging Enhancements for Idle/Inactive Mode UE Power Saving MediaTek Inc.R1-2105434 Discussion on potential paging enhancements LG ElectronicsR1-2105474 On paging enhancement PanasonicR1-2105504 On paging enhancements for UE power saving Nokia, Nokia Shanghai BellR1-2105573 Paging enhancements for power saving XiaomiR1-2105708 Discussion on paging enhancements NTT DOCOMO, INC.R1-2105742 Paging enhancements for UE power saving InterDigital, Inc.R1-2105770 Paging enhancement for UE power saving Lenovo, Motorola MobilityR1-2105791 Design of Paging Enhancements EricssonR1-2105886 On paging early indication Nordic Semiconductor ASAR1-2106011 Paging enhancements for idle/inactive mode UE power saving vivoR1-2106076 Summary of paging enhancements Moderator (MediaTek)R1-2106143 Summary#2 of paging enhancements Moderator (MediaTek)R1-2104373 Discussion on paging grouping vivoR1-2104534 Details of PEI configuration CATTR1-2104536 Link level performance for UE power saving CATTR1-2104789 Paging and TRS indication in idle/inactive modes OPPO* **TRS/CSI-RS occasion(s) for idle/inactive UEs**

R1-2104222 TRS for RRC idle and inactive UEs ZTE, SanechipsR1-2104252 Assistance RS occasions for IDLE/inactive mode Huawei, HiSiliconR1-2104308 TRS/CSI-RS occasions for idle/inactive UE TCL Communication Ltd.R1-2104372 TRS/CSI-RS occasion(s) for idle/inactive UEs vivoR1-2104433 Consideration on TRS/CSI-RS occasion(s) for idle/inactive UEs Spreadtrum CommunicationsR1-2104533 Configuration of TRS/CSI-RS for paging enhancement CATTR1-2104623 Discussion on TRS/CSI-RS occasion(s) for IDLE/INACTIVE-mode UEs CMCCR1-2104683 TRS/CSI-RS for idle/inactive UE power saving Qualcomm IncorporatedR1-2104788 Further discussion on RS occasion for idle/inactive UEs OPPOR1-2104917 Discussion on TRS/CSI-RS Design in idle/inactive mode Intel CorporationR1-2105117 Indication of TRS configurations for idle/inactive-mode UE power saving AppleR1-2105175 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs SonyR1-2105322 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs SamsungR1-2105323 Summary#1 for TRS/CSI-RS occasion(s) for idle/inactive UEs Moderator (Samsung)R1-2105387 On TRS/CSI-RS occasion(s) for idle/inactive mode UE power saving MediaTek Inc.R1-2105435 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs LG ElectronicsR1-2105475 Potential enhancements for TRS/CSI-RS occasion(s) for idle/inactive UEs PanasonicR1-2105506 On RS information to IDLE/Inactive mode Ues Nokia, Nokia Shanghai BellR1-2105574 On TRS/CSI-RS configuration and indication for idle/inactive UEs XiaomiR1-2105639 Discussion on TRS/CSI-RS occasions for idle/inactive UEs SharpR1-2105709 Discussion on TRS CSI-RS occasion for idleinactive UEs NTT DOCOMO, INC.R1-2105743 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs InterDigital, Inc.R1-2105771 Provision of TRS/CSI-RS for idle/inactive UEs Lenovo, Motorola MobilityR1-2105792 Provisioning of TRS occasions to Idle/Inactive UEs EricssonR1-2105887 On TRS design for idle/inactive UEs Nordic Semiconductor ASAR1-2106117 Summary#2 for TRS/CSI-RS occasion(s) for idle/inactive UEs Moderator (Samsung)* **Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX Active Time**

R1-2104224 Extension to Rel-16 DCI-based power saving adaptation during DRX Active Time ZTE, SanechipsR1-2104253 Extensions to Rel-16 DCI-based power saving adaptation for an active BWP Huawei, HiSiliconR1-2104374 Discussion on DCI-based power saving adaptation in connected mode vivoR1-2104434 Discussion on power saving techniques for connected-mode UEs Spreadtrum CommunicationsR1-2104535 PDCCH monitoring adaptation CATTR1-2104624 Discussion on PDCCH monitoring reduction during DRX active time CMCCR1-2104684 DCI-based power saving adaptation during DRX ActiveTime Qualcomm IncorporatedR1-2104790 DCI-based power saving adaptation solutions OPPOR1-2104918 Discussion on DCI-based UE Power Saving Schemes during active time Intel CorporationR1-2105118 Enhanced DCI-based power saving adaptation AppleR1-2105263 DCI-based Power Saving Enhancements Fraunhofer HHI, Fraunhofer IISR1-2105324 Discussion on DCI-based power saving techniques SamsungR1-2105388 On enhancements to DCI-based UE power saving during DRX active time MediaTek Inc.R1-2105436 Discussion on DCI-based power saving adaptation during DRX ActiveTime LG ElectronicsR1-2105476 Potential extension(s) to Rel-16 DCI-based power saving adaptation during DRX ActiveTime PanasonicR1-2105505 UE power saving enhancements for Active Time Nokia, Nokia Shanghai BellR1-2105710 Discussion on extension to DCI-based power saving adaptation NTT DOCOMO, INC.R1-2105744 PDCCH monitoring reduction in Active Time InterDigital, Inc.R1-2105758 Discussion on DCI-based power saving adaptation ITRIR1-2105772 Enhanced DCI based power saving adaptation Lenovo, Motorola MobilityR1-2105794 Design of active time power savings mechanisms EricssonR1-2105824 Discussion on extension(s) to Rel-16 DCI-based power saving adaptation Asia Pacific Telecom, FGIR1-2105850 A common framework for SSSG switching and PDCCH skipping ASUSTeKR1-2105888 On PDCCH monitoring adaptation Nordic Semiconductor ASAR1-2106040 FL summary#1 of DCI-based power saving adaptation Moderator (vivo)R1-2106041 FL summary#2 of DCI-based power saving adaptation Moderator (vivo)R1-2106243 FL summary#3 of DCI-based power saving adaptation Moderator (vivo)* **Others**

R1-2104223 Additional simulation results of UE power consumption in RRC idle and inactive state ZTE, SanechipsR1-2104225 Further discussion on potential power saving schemes for RRC connected UEs ZTE, SanechipsR1-2104375 Discussion on RLM/BFD relax vivoR1-2104435 Discussion on other power saving techniques Spreadtrum CommunicationsR1-2104791 Discussion on RLM relaxation OPPOR1-2105527 Analysis on power consumption for IDLE mode UE Huawei, HiSiliconR1-2105528 Other considerations on power saving in Rel-17 Huawei, HiSiliconR1-2105793 Modeling of Network Power Consumption EricssonR1-2105795 Evaluation results for UE power saving schemes Ericsson |
| **RAN2 Contributions** |
| **RAN2 #113-bis-e Meeting****Organizational, Scope and Requirements:**R2-2102621 Reply LS on Paging Enhancement (R1-2102136; contact: MediaTek) RAN1**Idle/inactive-mode UE power saving:**R2-2102680 UE subgroup for paging reception Qualcomm IncorporatedR2-2102704 Paging Enhancements\_UE Grouping Samsung Electronics Co., LtdR2-2102705 Paging Enhancements\_DRX cycle for monitoring paging Samsung Electronics Co., LtdR2-2102733 Discussion on grouping-based paging OPPOR2-2102734 Discussion on signaling aspects of TRS/CSI-RS occasion(s) for idle/inactive UEs OPPOR2-2102856 Paging enhancement in idle inactive mode for power saving vivoR2-2102857 Discussion on TRS CSI-RS in idle inactive mode vivoR2-2102865 Network assigned subgrouping Intel CorporationR2-2102871 Procedure details for Network assigned subgrouping Intel CorporationR2-2102919 UE sub-grouping mechanism with Paging Enhancement CATTR2-2103058 TRS/CSI-RS configuration and enhancement to short message Qualcomm IncorporatedR2-2103149 Discussion on UE subgroup for paging Xiaomi CommunicationsR2-2103207 TRS CSI-RS for idle and inactive mode UE SHARP CorporationR2-2103258 Paging Enhancement with UE Grouping MediaTek Inc., CMCCR2-2103259 [Draft] Reply LS on UE Sub-grouping for Paging Enhancement MediaTek Inc.R2-2103266 Discussion on indications for UE power saving Asia Pacific Telecom co. Ltd, FGIR2-2103363 UE subgrouping for paging enhancement LG Electronics Inc.R2-2103368 Details on paging sub-grouping indication Nokia, Nokia Shanghai BellR2-2103369 Details on paging sub-grouping determination Nokia, Nokia Shanghai BellR2-2103396 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola MobilityR2-2103443 Further discussion on UE grouping ZTE Corporation, SanechipsR2-2103585 Discussion on the UE grouping mechanism Huawei, HiSiliconR2-2103586 Discussion on potential TRS/CSI-RS Huawei, HiSiliconR2-2103587 Discussion on other paging enhancements Huawei, HiSiliconR2-2103591 Discussion on enhancements for idle/inactive-mode UE power saving Sony Europe B.V.R2-2103596 Discussion on TRS/CSI-RS configuration of idle/inactive-mode UEs Sony Europe B.V.R2-2103724 Considerations on paging subgrouping CMCCR2-2103772 Grouping methods for Paging EricssonR2-2103773 Group info signaled via Paging PDCCH EricssonR2-2103833 NR UE Power Save IDLE/INACTIVE Paging Grouping Schemes AppleR2-2103834 NR UE Power Save TRS/CSI-RS Signaling for IDLE/INACTIVE UEs AppleR2-2103960 Enhancement to paging reception with cross-slot scheduling Qualcomm IncorporatedR2-2103975 UE grouping paging enhancement InterDigitalR2-2104163 draft LS on Paging Enhancement for UE power saving LG Electronics Inc.R2-2104496 Summary of Idle/Inactive-mode UE Power Saving (AI 8.9.2) MediaTek Inc. * Other aspects RAN2 impacts

R2-2102706 TRS\_CSIRS for RRC IDLE and RRC INACTIVE Samsung Electronics Co., LtdR2-2102735 power saving enhancement for connected mode UE OPPOR2-2102858 RAN2 impact on RLM/BFD relaxation for power saving vivoR2-2102863 Discussion on TRS CSI-RS for RRC-IDLE and RRC-INACTIVE State UE Xiaomi R2-2102864 LS to RAN1 on TRS CSI-RS for RRC-IDLE and RRC-INACTIVE State UE Xiaomi R2-2102867 TRS/CSI-RS configuration for idle/inactive mode UE Intel CorporationR2-2103395 TRS/CSI-RS configuration for Idle/inactive mode UE Lenovo, Motorola MobilityR2-2103442 Futrther consideration on the CSI-RS/TRS for Idle/Inactive UE ZTE Coporation, SanechipsR2-2103496 Potential TRS/CSI-RS occasion(s) Nokia, Nokia Shanghai BellR2-2103774 TRS exposure to UEs in idle and inactive EricssonR2-2104157 Further Considerations on Configuration of TRS/CRI-RS CATT R2-2104278 Considerations on TRS CSI-RS occasion(s) for idle inactive UE(s) CMCC   |
| **RAN2 #114-e Meeting****Idle/inactive-mode UE power saving:**R2-2104773 Paging subgroup assignment Qualcomm IncorporatedR2-2104783 Paging Enhancements\_UE Grouping Samsung Electronics Co., LtdR2-2104807 Discussion on grouping-based paging OPPOR2-2104909 UE sub-grouping for paging enhancement vivoR2-2105021 Further considerations of network assigned subgrouping Intel CorporationR2-2105087 NR UE Power Save IDLE/INACTIVE Paging Grouping Schemes AppleR2-2105283 UE subgrouping schemes with paging enhancement CATTR2-2105293 UE Paging Subgroup Assignment for Power Saving MediaTek Inc.R2-2105295 Discussion on idle\_inactive\_mode UE power saving Xiaomi CommunicationsR2-2105411 Details on paging subgrouping determination and indication Nokia, Nokia Shanghai BellR2-2105656 Grouping methods for Paging EricssonR2-2105718 Discussion on the control node for UE grouping Huawei, HiSiliconR2-2105736 PEI monitoring in NR: CN and System level impacts VODAFONE Group PlcR2-2105809 Consideration on Idle/inactive-mode UE power saving Lenovo, Motorola MobilityR2-2105855 Further Consideration on UE Grouping ZTE, SanechipsR2-2105956 Discussion on UE grouping control entity Futurewei TechnologiesR2-2106257 Considerations on paging subgrouping CMCCR2-2106349 UE subgrouping for paging enhancement LG Electronics Inc.R2-2106666 Report of [AT114-e][025][ePowSav] Subgrouping network architecture MediaTek Inc.* Other aspects RAN2 impacts

R2-2105088 NR UE Power Save TRS/CSI-RS Signaling for IDLE/INACTIVE UEs Apple  |
| **RAN4 Contributions** |
| **RAN4 #98-bis-e Meeting*** **General and work plan [NR\_UE\_pow\_sav\_enh]:**

R4-2107082 Considerations on study phase conclusions for R17 RLM BFD relaxation vivo* **UE measurements relaxation for RLM and/or BFD [NR\_UE\_pow\_sav\_enh-Core]**

R4-2104605 Discussion on RLM/BFD relaxation for NR power saving enhancement CMCCR4-2104693 Discussion on RLM/BFD measurement relaxation for power saving XiaomiR4-2104756 Discussion on RLM/BFD relaxation measurement CATTR4-2104757 Update simulation results for RLM/BFD relaxation CATTR4-2104850 UE measurements relaxation for RLM and/or BFD AppleR4-2104908 Power saving RRM discussion Qualcomm, Inc.R4-2106461 Discussions on UE power saving for RLM and BM Intel CorporationR4-2106539 Discussion on RRM requirements for R17 RLM/BFD relaxation OPPOR4-2106540 Simulation results for R17 RLM/BFD relaxation OPPOR4-2106581 Simulation results for RLM/BFD measurement relaxation Nokia, Nokia Shanghai BellR4-2106582 Discussion about RLM/BFD measurement relaxation Nokia, Nokia Shanghai BellR4-2106851 Simulation results on UE power saving for RLM and BM EricssonR4-2106852 Discussions on UE power saving for RLM and BM EricssonR4-2106915 On RLM and RLF relaxation for UE power saving ZTE CorporationR4-2106942 Discussion on RLM/BFD measurement relaxation for power saving enhancements Huawei, HiSiliconR4-2106943 Updated simulation results for RLM/BFD relaxation evaluation Huawei, HiSiliconR4-2107083 Discussion on R17 RLM and BFD relaxation for NR vivoR4-2107084 Evaluation results on R17 RLM and BFD relaxation for NR vivoR4-2107085 Updated evaluation assumptions for R17 RLM and BFD relaxation vivoR4-2107124 Evaluation on Rel-17 RLM/BFD measurement relaxation MediaTek inc. |
| **RAN4 #99-e Meeting*** **General and work plan [NR\_UE\_pow\_sav\_enh]:**

R4-2111266 Discussion on work split between RAN2 and RAN4 on R17 RLM and BFD relaxation for NR vivo* **UE measurements relaxation for RLM and/or BFD [NR\_UE\_pow\_sav\_enh-Core]**

R4-2108764 On RLM and RLF relaxation for UE power saving ZTE CorporationR4-2109067 Further discussion on RLM/BFD relaxation measurement CATTR4-2109242 Discussion on UE power saving for RLM and BM Intel CorporationR4-2109246 Further discussion on UE measurements relaxation for RLM and/or BFD XiaomiR4-2109364 UE measurements relaxation for RLM and/or BFD AppleR4-2109494 Discussion on RLM/BFD relaxation for NR power saving enhancement CMCCR4-2109550 Discussion about RLM/BFD measurement relaxation Nokia, Nokia Shanghai BellR4-2109551 Simulation results for UE power saving enhancements Nokia, Nokia Shanghai BellR4-2109561 On Power Saving RRM Requirement Qualcomm, Inc.R4-2109886 Evaluation on Rel-17 RLM/BFD measurement relaxation MediaTek inc.R4-2110303 Further discussion on RLM/BFD measurement relaxation Huawei, HiSiliconR4-2111248 Simulation results on UE power saving for RLM and BM EricssonR4-2111249 Discussions on UE power saving for RLM and BM EricssonR4-2111267 Discussion on R17 RLM and BFD relaxation for NR vivo |