**3GPP TSG RAN WG1 #102-e R1-** **200xxxx**

**e-Meeting, August 17th – 28th, 2020**

**Agenda item:** 8.8.2.2

**Source:** Qualcomm Incorporated

**Title:** FL summary of PUCCH coverage enhancement

**Document for:** Discussion/Decision

# Introduction

In this document, a summary of companies’ view on potential techniques for PUCCH coverage enhancement is provided.

# Summary of submitted proposals

There were in total 20 contributions submitted to this meeting under 8.8.2.2. The proposed techniques for PUCCH coverage enhancement are categorized and summarized in the following Table.

The list of supporting companies is an initial list based on FL’s understanding of companies’ position expressed in their contributions. Companies are welcome to add your name in the list to support a scheme or modify the list if the position is changed.

Table 0: Summary of PUCCH coverage enhancement techniques and supporting companies

|  |  |
| --- | --- |
| **Proposed PUCCH coverage enhancement techniques** | **Supporting companies** |
| Sequence based DMRS-less PUCCH | ZTE/Sanechips, Huawei/HiSi, NEC, Intel, CMCC, QC, Interdigital, Sharp, EURECOM (11) |
| PUSCH repetition Type-B like PUCCH repetition | Nokia/NSB, VIVO, Huawei/HiSi, Panasonic, WILUS, Samsung (8) |
| (Explicit or implicit) Dynamic PUCCH repetition factor indication  | OPPO, ZTE/Sanechips, CATT, Ericsson, QC, Samsung (7) |
| Sequence based PF 0/1 with Pi/2 BPSK | IITH, CeWiT, IITM, Reliance Jio, Tejas Networks (5) |
| Pre-DFT data-RS multiplexing for PF2 with Pi/2 BPSK | IITH, CeWiT, IITM, Reliance Jio, Tejas Networks (5) |
| DMRS bundling for PUCCH | Intel, CATT, VIVO, NEC, Panasonic (5) |
| Compact UCI | OPPO, QC, Nokia/NSB (low priority), Sony (5) |
| Freq hopping enhancement for PUCCH | Intel, NEC, Panasonic, Wilus (4) |
| Short/mini-slot PUCCH repetition | DCM, Panasonic, Sharp, QC (4) |
| Power control enhancement for PUCCH  | Huawei/HiSi, Sony, Samsung (4) |
| Increase maximum # allowed repetitions for PUCCH | OPPO, Intel, CATT, Samsung (4) |
| PUCCH Transmit diversity scheme | Intel, CATT, Sony (3) |
| DMRS overhead reduction | OPPO, Intel (2) |
| UE Antenna configuration enhancement for FR2 | Sony (1) |
| Higher DMRS density | Intel (1) |
| A-CSI on PUCCH | Ericsson (1) |
| Symbol-level PUCCH repetition | Panasonic (1) |
| Relay (including sidelink relay) | Sony (1) |
| Reflective arrays | Sony (1) |

# Discussion

The next phase is to have technical discussions on each proposed technique. Companies are welcome to express feedback and comments to discuss the pros. and cons. for each technique in the following tables. For those schemes that already been evaluated with link level simulations (LLS), companies are welcome to report the observed gain in the following tables.

## Sequence based DMRS-less PUCCH

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Sequence based DMRS-less PUCCH”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## PUSCH repetition Type-B like PUCCH repetition

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “PUSCH repetition Type-B like PUCCH repetition”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## (Explicit or implicit) Dynamic PUCCH repetition factor indication

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “(Explicit or implicit) Dynamic PUCCH repetition factor indication”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Sequence based PF 0/1 with Pi/2 BPSK

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Sequence based PF 0/1 with Pi/2 BPSK”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Pre-DFT data-RS multiplexing for PF2 with Pi/2 BPSK

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Pre-DFT data-RS multiplexing for PF2 with Pi/2 BPSK”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## DMRS bundling for PUCCH

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “DMRS bundling for PUCCH”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Compact UCI

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Compact UCI”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Freq hopping enhancement for PUCCH

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Freq hopping enhancement for PUCCH”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Short/mini-slot PUCCH repetition

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Short/mini-slot PUCCH repetition”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Power control enhancement for PUCCH

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Power control enhancement for PUCCH”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Increase maximum # allowed repetitions for PUCCH

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Increase maximum # allowed repetitions for PUCCH”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## PUCCH Transmit diversity scheme

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “PUCCH Transmit diversity scheme”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## DMRS overhead reduction

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “DMRS overhead reduction”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## UE Antenna configuration enhancement for FR2

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “UE Antenna configuration enhancement for FR2”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Higher DMRS density

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Higher DMRS density”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## A-CSI on PUCCH

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “A-CSI on PUCCH”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Symbol-level PUCCH repetition

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Symbol-level PUCCH repetition”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Relay (including sidelink relay)

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Relay (including sidelink relay)”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

## Reflective arrays

Companies are welcomed to provide views in the following table to identify the pros. and cons. of this scheme.

Table : Comments on the “Reflective arrays”

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| Company name | LLS gain observed over Rel-15 baseline | Pros. of the proposed scheme | Cons. of the proposed scheme | Other comments |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |
|  |  |  |  |  |

# References

|  |  |  |
| --- | --- | --- |
| **Tdoc #** | **Title** | **Source** |
| [R1-2005273](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005273.zip) | Discussion on the potential coverage enhancement solutions for PUCCH | Huawei, HiSilicon |
| [R1-2005300](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005300.zip) | Discussion on potential approaches and solutions for NR PUCCH coverage enhancement | Nokia, Nokia Shanghai Bell |
| [R1-2005396](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005396.zip) | Discussion on Solutions for PUCCH coverage enhancement | vivo |
| [R1-2005428](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005428.zip) | Discussion on potential techniques for PUCCH coverage enhancements | ZTE |
| [R1-2005585](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005585.zip) | On PUCCH coverage enhancement techniques | Sony |
| [R1-2005725](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005725.zip) | Discussion on potential techniques for PUCCH coverage enhancement | CATT |
| [R1-2005759](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005759.zip) | Discussion on PUCCH coverage enhancement | NEC |
| [R1-2005890](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2005890.zip) | Discussion on potential techniques for PUCCH coverage enhancement | Intel Corporation |
| [R1-2006048](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006048.zip) | Consideration on PUCCH coverage enhancement | OPPO |
| [R1-2006163](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006163.zip) | PUCCH coverage enhancement | Samsung |
| [R1-2006227](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006227.zip) | Discussion on the PUCCH coverage enhancement | CMCC |
| [R1-2006246](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006246.zip) | PUCCH coverage enhancement | InterDigital, Inc. |
| [R1-2006349](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006349.zip) | Discussion on PUCCH coverage enhancements | Panasonic Corporation |
| [R1-2006457](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006457.zip) | PUCCH coverage enhancements | IITH, CeWiT, IITM, Reliance Jio, Tejas Networks |
| [R1-2006580](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006580.zip) | PUCCH coverage enhancement | Sharp |
| [R1-2006614](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006614.zip) | PUCCH coverage enhancement | Ericsson |
| [R1-2006742](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006742.zip) | Potential techniques for PUCCH coverage enhancements | NTT DOCOMO, INC. |
| [R1-2006821](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006821.zip) | Potential coverage enhancement techniques for PUCCH | Qualcomm Incorporated |
| [R1-2006880](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006880.zip) | Limitations of NR short block-length codes for PUCCH coverage enhancement | EURECOM/Sophia Antipolis |
| [R1-2006893](https://www.3gpp.org/ftp/tsg_ran/WG1_RL1/TSGR1_102-e/Docs/R1-2006893.zip) | Discussion on potential techniques for PUCCH coverage enhancement | WILUS Inc. |