**3GPP TSG-RAN WG4 Meeting #114-bis R4-2504382**

**Wuhan, China, April 7th – 11st 2025**

**Source:** Ericsson

**Title:** Simulation results for Rel-19 SCM for demodulation

**Agenda item:** 7.16.2

**Document for:** Information

# Introduction

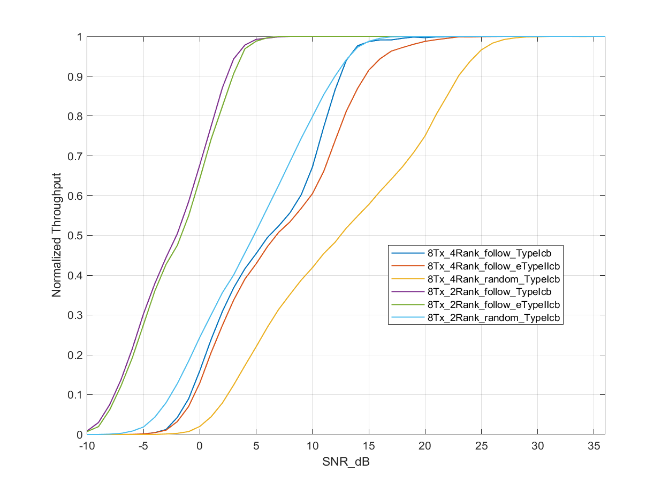
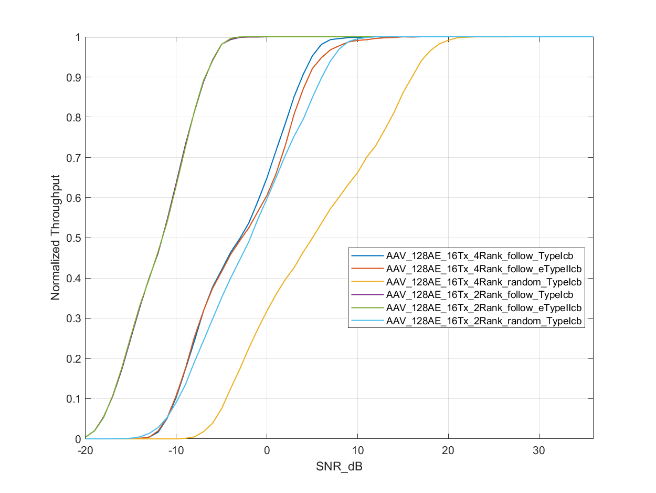
In RAN4#114 meeting, companies agreed to run simulations for PMI with eType-II and the parameters were agreed in WF [1]. Furthermore, some simulations for SNR scaling factor and channel characters comparison between different methodologies are also provided in this contribution.

# Simulation

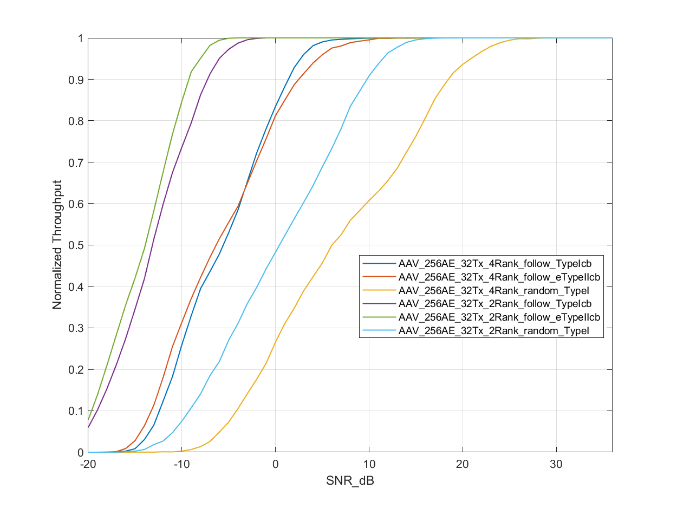
## 2.1 SU-MIMO PMI with eType-II codebook

Table 2.1 Parameters for eType-II

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| Parameter | | | Unit | 8TX | 16TX (for information) | 32TX (for information) |
| Bandwidth | | | MHz | 40 | | |
| Subcarrier spacing | | | kHz | 30 | | |
| Duplex Mode | | |  | TDD | | |
| TDD DL-UL configurations | | |  | FR1.30-1 as specified in Annex A | | |
| Antenna configuration | | |  | 8 x 4  (N1,N2) = (4,1) | 16 x 4  (N1,N2) = (4,2) | 32 x 4  (N1,N2) = (8,2) |
| NZP CSI-RS for CSI acquisition | CSI-RS resource Type | |  | Periodic | | |
| Number of CSI-RS ports (*X*) | |  | 8 | 16 | 32 |
| CDM Type | |  | CDM4 (FD2, TD2) | CDM4 (FD2, TD2) | CDM4 (FD2, TD2) |
| Density (ρ) | |  | 1 | 1 | 1 |
| First subcarrier index in the PRB used for CSI-RS (k0, k1, k2, k3) | |  | Row 8,(4,6) | Row 12,(2, 4, 6, 8) | Row 17,(2, 4, 6, 8) |
| First OFDM symbol in the PRB used for CSI-RS (l0) | |  | Row 8,(5) | Row 12,(5) | Row 17,(5, 12) |
| CSI-RS  interval and offset | | slot | 10, 0 | | |
|  | |  |  | | |
| cqi-FormatIndicator | | |  | Wideband | | |
| pmi-FormatIndicator | | |  | Not configured for eType II  FFS Subband or Wideband for Type I | | |
| Sub-band Size | | | RB | 8 | | |
| csi-ReportingBand | | |  | 11111111111111 | | |
| Codebook configuration | Codebook Type | |  | 1. typeII-r16 2. typeI-SP | | |
| eType II CB config | *paramCombination-r16* |  | 6  (L =4, *pν* =1/2, β=1/2 ) | | |
| R*(numberOfPMISubbandsPerCQISubband-r16)* |  | 1 | | |
| (CodebookConfig-N1,CodebookConfig-N2) | |  | (4,1) | (4,2) | (8,2) |
| (CodebookConfig-O1,CodebookConfig-O2) | |  | (4,1) | (4,4) | (4,4) |
| CodebookSubsetRestriction | |  | 0x FFFF | 0x 7FF FFFF FFFF FFFF FFFF | 0x  FFFF FFFF FFFF FFFF  FFFF FFFF FFFF FFFF  FFFF FFFF FFFF FFFF  FFFF FFFF FFFF FFFF |
| RI Restriction (typeII-RI-Restriction-r16) | |  | Rank 2: 0010  Rank 4: 1000 | | |
| Physical channel for CSI report | | |  | PUSCH | | |
| CQI/RI/PMI delay | | | ms | 7 | | |
| Maximum number of HARQ transmission | | |  | 4 | | |
| Measurement channel | | |  | R.PDSCH.2-8.3 TDD | | |
| PDSCH & PDSCH DMRS Precoding configuration for random Precoding | | |  | Single Panel Type I, Random precoder selection updated per slot, with equal probability of each applicable i1, i2 combination, and with i1 wideband granularity and i2 subband granularity | | |
| Note: Use DM-RS based FOE and compensation. | | | | | | |

1. 8AE 8Tx (b) 128AE 16Tx



(c) 256AE 32Tx

**Figure 2.1-1 PMI simulation results for 4 ranks and 2 ranks with Type-I and eType-II**

Table 2.1-2 Results summary of Type-I and eType-II codebook

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| BS antenna Config. | Rank | Channel model | Codebook | SNR of Follow PMI at 90% NThp | NThp. of Random PMI | Gamma |
| **256AE 32Tx**  **SV (16,8,2, 8, 1)** | 4 | FR1 Uma CDL | Type-I | 1.37 | 32% | 2.81 |
| eType-II | 2.48 | 37% | 2.43 |
| 2 | Type-I | -7.26 | 17% | 5.29 |
| eType-II | -9.26 | 10% | 9 |
| **128AE 16Tx**  **SV (16,4,2, 8, 1)** | 4 | FR1 Uma CDL | Type-I | 3.88 | 46% | 1.95 |
| eType-II | 4.59 | 49% | 1.83 |
| 2 | Type-I | -6.78 | 26% | 3.46 |
| eType-II | -6.82 | 25% | 3.6 |
| **8AE 8Tx**  **(1, 4, 2, 1, 1)** | 4 | FR1 Uma CDL | Type-I | 12.47 | 50% | 1.8 |
| eType-II | 14.67 | 57% | 1.57 |
| 2 | Type-I | 2.4 | 37% | 2.43 |
| eType-II | 2.92 | 40% | 2.25 |

1. With 256AE and 32Tx, eType-II codebook starts outperforming Type-I codebook for rank 2 and partially over low SNR values up to -4dB for rank 4. For other antenna configuration and rank combinations, no gain of eType-II is observed. Therefore, to reap the benefits of beam resolution in eType-II codebook, high number of transmit antenna elements and CSIRS ports might be necessary.

Table 2.1-3 SNR at 70% normalized throughput for SU-PMI comparison

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
| BS antenna Config.  (M,N,P,Ms,Ns) | Port mapping | Channel model | Rank | SNR (dB) | | |
| Type-I follow PMI | eType-II follow PMI | Type-I Random PMI |
| 256AE (16,8,2,8,1) | SV | FR1 Uma CDLC | 4 | -11 | -13 | 4 |
| 2 | -3 | -3 | 13 |
| 128AE (16, 4, 2, 8,1) | SV | FR1 Uma CDLC | 4 | -10 | -10 | 2 |
| 2 | 1 | 0 | 11 |
| 8AE (1, 4, 2,1,1) | 1 to 1 | FR1 Uma CDLC | 4 | 2 | 2 | 8 |
| 2 | 13 | 10 | 18 |

## 2.2 Eigen value of CDL channel

In this section, the eigen value of FR1 Uma CDLC (channel A1) is analyzed during the simulation of SU-PMI above. The different eigen value CDF distribution with antenna configurations are captured in below figures.

A graph of different colored lines

AI-generated content may be incorrect.A graph of different colored lines

AI-generated content may be incorrect.

**A graph of different colored lines

AI-generated content may be incorrect. A graph of different colored lines

AI-generated content may be incorrect.**

1. The CDF curves become steeper with the increasement of antenna elements.
2. The eigen modes get less variant with the increasement of antenna elements.

# Conclusions

In the previous sections we made the following observations:

[Observation 1 With 256AE and 32Tx, eType-II codebook starts outperforming Type-I codebook for rank 2 and partially over low SNR values up to -4dB for rank 4. For other antenna configuration and rank combinations, no gain of eType-II is observed. Therefore, to reap the benefits of beam resolution in eType-II codebook, high number of transmit antenna elements and CSIRS ports might be necessary.](#_Toc193621218)

[Observation 2 The CDF curves become steeper with the increasement of antenna elements.](#_Toc193621219)

[Observation 3 The eigen modes get less variant with the increasement of antenna elements.](#_Toc193621220)

Based on the discussion in the previous sections we propose the following:

* **No table of figures entries found.**

# References

[1] R4-2502378, Way Forward for [114][322] FS\_NR\_demod\_SCM, Nokia

[2]