**3GPP TSG RAN WG1 #101 R1-200xxxx**

**e-Meeting, May 25th – June 5th, 2020**

Source: moderator (vivo)

Title: Feature lead summary on [101-e-NR-eMIMO-ULFPTx-01]

Agenda Item: 7.2.6.4

Document for: Discussion and Decision

1. Introduction

Per guidance from Mr. Chairman, this is to kick-off following email discussion, please provide your views below.

[101-e-NR-eMIMO-ULFPTx-01] Additional entries of full power TPMI grouping indication with Mode 2 operation by 5/29 and corresponding TP (if any) by 6/5 – Rakesh (vivo)

* Issue 1 of the FL summary
* Companies are encouraged to provide simulation results
* Note that having this email thread does not automatically mean that additional entries will be included into the specification

For reference, the agreement from RAN1#99 is copied below.

**Agreement**

For 4 ports, number of bits to indicate TPMI(s) which can deliver UL full power:

* + Non Coherent 2 bits
	+ Partial coherent 4 bits
		- Additional entries on top of existing entries may be added to table 1 and table 2
	+ Whether is this capability reporting is optional or not will be discussed as part of UE capability discussions

Table 1.

|  |  |
| --- | --- |
| 4Tx, nonCoherent | 4Tx, partial coherent (4bit) |
| G0 | G0 |
| G1 | G1 |
| G2 | G2 |
| G3 | G3 |
|  | G4 |
|  | G5 |
|  | G6 |
|  |  |

Definition of G0~G6 can be found in the table below.

Table 2.



1. Remaining issues
	1. Issue 1: Additional entries of full power TPMI grouping indication with Mode 2 operation

There are diverging views/proposals on this issue in contribution submitted in this RAN1#101-e and following alternatives are listed:

Alt1: Whether to revise the number of bits for partial coherent case? i.e. revise the bit size to 3bits for 4Tx partial coherent

~~Alt2: Whether to revise TPMI groups G0~G6? i.e. revise the existing TPMI groups~~

Alt3: Whether to introduce more TPMI groups for 4Tx partial coherent? If yes, how many groups and TPMI group details

|  |  |
| --- | --- |
| Company | Comment |
| ZTE | For Alt 1, we do not agree to reduce the bit size to 3bits, because it means the number of supported UE PA architectures will be reduced from 16 to 8 for partial-coherent case. From the technical perspective, it make no sense to penalize this functionality by restricting the diversity of UE implementation. Instead, some more types of the partial-coherent 4-Tx UE with different PA architectures should be captured to optimize this functionality.For Alt 2, we propose to adopt the following modifications, because there are still some obvious logical leaks of the existing G0 to G6.* Considering the beam-forming gain from partial-coherent ports, precoding matrices , ,  and  should be added in the existing G1 and G2.
* In order to optimize TPMI group based full power capability reporting, entries of TPMI groups should be decoupled as much as possible and corresponds to independent PA architectures and coherent capabilities. Based on that, G3 is a redundant entry of G5 and should be removed accordingly.

For Alt 3, we propose to add six new TPMI groups, which are G0+G4, G0+G5, G1+G5, G0+G6, G1+G6 and G2+G6, with the following comments. * From the perspective of permutation and combination of antenna ports PA architecture, there are 76 out of 81 types of the partial-coherent 4-Tx UE should be captured. However, the size of partial-coherent 4-Tx UE is 4 bits, up to 16 TPMI groups can be adopted.
* As a middle ground between signaling overhead and supported UE types, if just consider the PA combination architecture, there are only 12 out of 15 types of the partial-coherent 4-Tx UE need to be captured. Further, the existing G0 to G6 have captured 6 PA combination architectures. Therefore, it is only need to capture the remaining 6 PA combinations.
* Based on the first two reasons, it is recommended that the maximum power value of PA for each port obey the following rule: port {1000} ≥ port {1002} ≥ port {1001} ≥ port {1003}. Correspondingly, G0+G4, G0+G5, G1+G5, G0+G6, G1+G6 and G2+G6 should be introduced.
 |
| Huawei, HiSilicon | 1. The TPMIs for , ,  and are obviously missing in the TPMIs reporting groups G1/2/3 for partial coherent UEs during the discussion stage. Since the TPMI for rank-2 [1 0 0 0; 0 0 1 0] is supported for full power transmission in G1/2/3, the same two antennas (1st and 3rd ) should be also support full power transmissions for the partial coherent UE. So, the missing 4 TPMIs are at least need to be included.

Please note that, in the coverage limited cases, for rank-1 full power transmission, the two antennas transmission with [1 0 1 0], [1 0 -1 0], [1 0 j 0] and [1 0 –j 0] is with beamforming gain compared to only with one antenna transmission, such as [1 0 0 0] and [0 1 0 0]. The simulation results are shown as follows.Then, use Alt.2 just add the four TPMIs in the exist G1/2/3, or just add new 3 TPMI groups as Alt.3, i.e., the 4 TPMIs+G1/2/3. We are fine both of alternatives. cid:image001.jpg@01D62FC0.6F7233F01. Since there is 4 bits for UE reporting agreed for 4Tx, we are fine to add more TPMI groups to reflect the true PA architectures as ZTE proposed to minimize the UE architecture restrictions for full power transmission.
 |
| Apple | We think this is the sequence of the questions that we need to answer Alt3: Whether to introduce more TPMI groups for 4Tx partial coherent? If yes, how many groups and TPMI group details We think more TPMI is needed. The current 7 TPMI groups cannot provide full flexibility in terms of UE capability reporting to address all the possible UE PA architecture and implementation decision. Alt2: Whether to revise TPMI groups G0~G6? i.e. revise the existing TPMI groupsWe slightly prefer to revise excising TPMI group Alt1: Whether to revise the number of bits for partial coherent case? i.e. revise the bit size to 3bits for 4Tx partial coherent Too early to answer, we need to reach a conclusion whether we will add new groups first.  |
| Samsung | First, Alt2 is not within the scope this email discussion, and also beaks the previous agreement made in RAN1#99, so, it should be removed. I deleted it from above.Now, we support Alt1 due the following reasons.* The current spec is not broken (hence beyond the scope of normative maintenance work)
* Additional TPMI groups is a minor optimization of this feature, hence is non-essential
* Additional TPMI groups, if any, will bring small performance gain.
* There is hardly any quantitative analysis (simulation results) provided by the proponents supporting additional TPMIs. Without any simulation analysis, it is unclear how the need for additional TPMI groups can be discussed.

Re the argument about missing PA combinations or/and missed TPMIs, we would like understand the following:* Is there any PA combination which can’t be supported (may not be optimized) by the agreed G0-G6?
* If yes, are they really important for real UE implementations?
* If no, there is at least one TPMI among G0-G6 that supports a given PA combination. Then, why do we need another TPMI group for the given PA combination. The proponents need to provide simulation results in support of their proposals in order to understand the need for any additional TPMI groups.
 |
| NTT DOCOMO | Regarding Alt1, we do not agree on reducing the bit size from 4 bits to 3 bits at this stage. This is because, as per our understanding, the current TPMI groups cover only a limited number of PA architectures. Regarding Alt2, one thing we need to clarify is whether there are two TPMI group tables for non-coherent and partial-coherent UEs. It seems, there are different understandings between companies about this fact. In case if there are different TPMI group tables, we are fine with updating existing entries.Regarding Alt3, we support introducing new TPMI groups to partial-coherent UEs for allowing more PA architectures to benefit from UL full power feature. However, we think companies should first align their understanding on following points:1. Regarding the coherent port combinations of 4Tx partial-coherent UE, it is generally understood that, port pairs {0, 2} and{1, 3} are coherent. We should respect this port coherency when designing new TPMI groups. Hence, new TPMI groups for partial-coherent UEs need to consider antenna port switching is applicable only between coherent ports
2. While complying to 1 above, the mapping rule between Tx chain and antenna port is up to the UE implementation. In other words, if a given TPMI can provide UL full Tx power for PA architecture $[X\_{1}X\_{2}X\_{3}X\_{4}]$, then that TPMI can provide UL full Tx power for PA architecture $[X\_{4}X\_{3}X\_{2}X\_{1}]$ as well

These are reasonable considerations and with these, all possible PA architectures (as shown in our tdoc R1-2004397) can be covered with 8 new TPMI groups. In particular, we believe TPMI groups, #1, #2, #6, #14, #15, #16, #17 and #19 in the Annex are enough to cover all possible PA architectures  |
| InterDigital | Alt1: Supported. As it provides adequate resolution to support a wide range of PA configurations. Also, it helps to reduce unnecessary overhead.Alt2: Not a valid alternative to be considered. Per chairman’s guidance, it is clearly out of the scope of this email thread.Alt3: Do not support. The current specification already supports many different PA configuration. Also, it is not clear to us whether there is sufficient technical evidence to justify introducing additional TPMI groups. |
| QC | Alt 1: Do not support. Alt 2: Support revise G1/G2/G3 for partial coherent UEs, because apparently, the agreement made before has an error not including partial coherent precoders $\frac{1}{2}\left[\begin{matrix}1\\0\\1\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}1\\0\\-1\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}1\\0\\j\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}1\\0\\-j\\0\end{matrix}\right]$ in G1/G2/G3. An error is an error. Let’s admit it and correct it. Alt 3: we are in general supportive to add more entries for TPIM grouping for partial coherent UEs. However, just a reminder to the group, we should not use up all 9 reserved entries. The reason is that, I believe that NO UE vendor is building 4 Tx UEs now. We are proposing new entries based on what we believe are reasonable PA combinations now. No one can make sure that we have exhausted all reasonable PA combinations for 4 Tx UEs. If in the future, based on new requirements, a certain PA combination becomes interested to pursue but we already used up all entries, which is a situation we want to avoid. Therefore, I suggest we just add 3 or 4 new entries that are necessary, and leave 5 or 6 entries reserved for future. To facilitate the discussion, I suggest, let’s identify the additional PA combinations that are necessary to add, rather than discuss which TPMI groups to add. It is much easier to understand the motivation by looking at a proposed new PA combination rather than a TPMI group. After we identify those additional PA combinations, agreeing on the TPMIs should be very straightforward. In particular, QC think the following PA combinations are beneficial and should be added for partial-coherent UEs. * G7: (23+20) + (17+17) dBm
* G8: (23+23) + (20+20) dBm
* G9: (23+23) + (23+23) dBm

Notation wise, the two PAs in () are coherent, and the PAs in different () are non-coherent. With G7, a UE can conveniently support full power with PUCCH/PRACH by putting PUCCH/PRACH transmission on antenna port 0, without extra effort to implement S-CDD to support full power for PUCCH/PRACH. For PUSCH full power transmission, it can support G0+G4. With G8, the UE can support full power with any precoder in 2Tx codebook when it reduced to a 2 Tx UE in case of max number of MIMO layers is reduced to 2 in BWP switch. On top of that, as a 4 Tx UE, it can support full power with both pair of coherent PAs. When on pair of coherent antennas gets hand-blocked, it allows NW to switch precoders to transmission full power with the other pair of coherent PAs. With G9, the UE can support full power with any partial and noncoherent precoders either as a 4 Tx UE or reduced to a 2 Tx UE. Rel-16 should allow and support this “super UE”, which give NW full flexibility to schedule PUSCH with any precoder even at cell edge. |
| CATT | For a 4Tx partial-coherent UE with 2 full-rated PAs, all TPMIs in G1 and G4 can deliver full power. For a 4Tx partial-coherent UE with 3 full-rated PAs, all TPMIs in G2 and G5 can deliver full power. It is suggested to introduce two additional TPMI groups, e.g. TPMI groups with G1+G4, and G2+G5.  |

# References

[1] R1-2003402, “Feature lead summary on ULFPTx”, vivo, RAN1#101-e

**Annex**

|  |  |  |
| --- | --- | --- |
| **TPMI groups** | **Precoder** | **Source company** |
| 1 | $$ \frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\right]$$ | DCM |
| 2 | $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\right]$ | DCM |
| 3 | $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\end{array}\right]$ | LG |
| 4 | $$\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\1\end{matrix}\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\-1\end{matrix}\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\j\end{matrix}\\0\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\-j\end{matrix}\\0\end{matrix}\right]$$ | NOK |
| 5 | $$\left\{\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}0\\0\end{matrix}\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}0\\0\\\begin{matrix}1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}-1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}j\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}-j\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0\\0&0\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right]\right\}$$ | HW, LG, CATT |
| 6 | $\frac{1}{2}\left[\begin{matrix}1\\0\\0\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\1\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}1\\0\\-1\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}1\\0\\j\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}1\\0\\-j\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}1&0\\0&0\\0&1\\0&0\end{matrix}\right]$ | QC, ZTE, DCM, CMCC |
| 7 | $$\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\1\end{matrix}\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\-1\end{matrix}\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\j\end{matrix}\\0\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\-j\end{matrix}\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}1\\0\end{matrix}&\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}1\\0\end{matrix}&\begin{matrix}0\\1\end{matrix}\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}0\\0\end{matrix}\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}0\\1\end{matrix}&\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right] $$ | NOK |
| 8 | $$\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\1\end{matrix}\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\-1\end{matrix}\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\j\end{matrix}\\0\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\-j\end{matrix}\\0\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}0\\1\end{matrix}\\0\end{matrix}\\1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}0\\1\end{matrix}\\0\end{matrix}\\-1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}0\\1\end{matrix}\\0\end{matrix}\\j\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}0\\1\end{matrix}\\0\end{matrix}\\-j\end{matrix}\right]$$ | NOK |
| 9 | $$\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\1\end{matrix}\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\-1\end{matrix}\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\j\end{matrix}\\0\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}1\\0\end{matrix}\\-j\end{matrix}\\0\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}0\\1\end{matrix}\\0\end{matrix}\\1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}0\\1\end{matrix}\\0\end{matrix}\\-1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}0\\1\end{matrix}\\0\end{matrix}\\j\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}\begin{matrix}0\\1\end{matrix}\\0\end{matrix}\\-j\end{matrix}\right], $$$$\frac{1}{2}\left[\begin{matrix}\begin{matrix}1\\0\end{matrix}&\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}1\\0\end{matrix}&\begin{matrix}0\\1\end{matrix}\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}0\\0\end{matrix}\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}0\\1\end{matrix}&\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}0\\1\end{matrix}&\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}0\\1\end{matrix}\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}1\\0\end{matrix}&\begin{matrix}0\\0\end{matrix}\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}0\\1\end{matrix}\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}\begin{matrix}0\\0\end{matrix}&\begin{matrix}0\\0\end{matrix}\\\begin{matrix}1\\0\end{matrix}&\begin{matrix}0\\1\end{matrix}\end{matrix}\right]$$ | NOK |
| 10 | $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\1\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-1\end{array}\right],\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\j\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-j\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}\begin{matrix}0&0\end{matrix}\\\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\end{array}\right]$ | LG, vivo |
| 11 | $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\0\\0\\1\end{array}\right]$, $ \frac{1}{2}\left[\begin{array}{c}0\\1\\0\\1\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-1\end{array}\right],\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\j\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-j\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}\begin{matrix}0&0\end{matrix}\\\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\end{array}\right]$ | LG |
| 12 | $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\0\\0\\1\end{array}\right]$, $ \frac{1}{2}\left[\begin{array}{c}0\\1\\0\\1\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-1\end{array}\right],\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\j\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-j\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}\begin{matrix}0&0\end{matrix}\\\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\end{array}\right]$ | vivo |
| 13 | $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\0\\0\\1\end{array}\right]$, $ \frac{1}{2}\left[\begin{array}{c}0\\1\\0\\1\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-1\end{array}\right],\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\j\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-j\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\\\begin{matrix}0&0\end{matrix}\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\end{array}\right]$ | vivo |
| 14 | $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}1\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\j\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-j\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$ | DCM, ZTE |
| 15 | $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}1\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\j\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-j\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\1\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-1\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\j\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-j\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\0\\0\\1\end{array}\right]$*,* $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\0\\1\end{array}\right]$*,* $\frac{1}{2}\left[\begin{array}{c}0\\0\\1\\0\end{array}\begin{array}{c}0\\0\\0\\1\end{array}\right]$*,* $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$ | DCM, ZTE, CMCC, LG |
| 16 | $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}1\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\j\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-j\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$ | DCM, ZTE |
| 17 | $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{}{}\left[\begin{array}{c}\\\\\\\end{array}\begin{array}{c}\\\\\\\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}1\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\j\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-j\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\1\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-1\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\j\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-j\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\0\\0\\1\end{array}\right]$*,* $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\0\\1\end{array}\right]$*,* $\frac{1}{2}\left[\begin{array}{c}0\\0\\1\\0\end{array}\begin{array}{c}0\\0\\0\\1\end{array}\right]$*,* $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$ | DCM, OPPO,ZTE |
| 18 | $\frac{1}{2}\left[\begin{matrix}1\\0\\0\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\0\\1\\0\end{matrix}\right]$,$\frac{1}{2}\left[\begin{matrix}1\\0\\1\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}1\\0\\-1\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}1\\0\\j\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}1\\0\\-j\\0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}0\\1\\0\\1\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}0\\1\\0\\-1\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}0\\1\\0\\j\end{matrix}\right]$,$ \frac{}{}\left[\begin{matrix}\\\\\\\end{matrix}\right]$$\frac{1}{2}\left[\begin{matrix}1&0\\0&1\\0&0\\0&0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0\\0&0\\0&1\\0&0\end{matrix}\right] ,\frac{1}{2}\left[\begin{matrix}1&0\\0&0\\0&0\\0&1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0&0\\1&0\\0&1\\0&0\end{matrix}\right]$,$ \frac{1}{2}\left[\begin{matrix}0&0\\1&0\\0&1\\0&0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0&0\\0&0\\1&0\\0&1\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}1&0&0\\0&1&0\\0&0&1\\0&0&0\end{matrix}\right]$ | QC, CMCC,LG |
| 19 | $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{}{}\left[\begin{array}{c}\\\\\\\end{array}\begin{array}{c}\\\\\\\end{array}\right]$,$ \frac{1}{2}\left[\begin{array}{c}1\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\j\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-j\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\1\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-1\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\j\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\-j\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\0\\0\\1\end{array}\right]$*,* $\frac{1}{2}\left[\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\0\\1\end{array}\right]$*,* $\frac{1}{2}\left[\begin{array}{c}0\\0\\1\\0\end{array}\begin{array}{c}0\\0\\0\\1\end{array}\right]$*,* $\frac{1}{2}\left[\begin{array}{c}1\\0\\0\\0\end{array}\begin{array}{c}0\\1\\0\\0\end{array}\begin{array}{c}0\\0\\1\\0\end{array}\right]$ | DCM, ZTE, CMCC, LG |
| 20 | $$\frac{1}{2}\left[\begin{matrix}1\\0\\0\\0\end{matrix}\right]$$$\left\{\frac{1}{2}\left[\begin{matrix}1\\0\\1\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\-1\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\j\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\-j\\0\end{matrix}\right]\right\};\{\frac{1}{2}\left[\begin{matrix}0\\1\\0\\1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\1\\0\\-1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\1\\0\\j\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\1\\0\\-j\end{matrix}\right]\}$;$\{\frac{1}{2}\left[\begin{matrix}1&0\\0&0\\0&1\\0&0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0&0\\1&0\\0&0\\0&1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0\\0&1\\0&0\\0&0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0\\0&0\\0&0\\0&1\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}0&0\\1&0\\0&1\\0&0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0&0\\0&0\\1&0\\0&1\end{matrix}\right]\}$;$\frac{1}{2}\left[\begin{matrix}1&0&0\\0&1&0\\0&0&1\\0&0&0\end{matrix}\right]$ | CMCC, LG |
| 21 | $$\frac{1}{2}\left[\begin{matrix}1\\0\\0\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\1\\0\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\0\\1\\0\end{matrix}\right]\}$$$\left\{\frac{1}{2}\left[\begin{matrix}1\\0\\1\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\-1\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\j\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\-j\\0\end{matrix}\right]\right\};\{\frac{1}{2}\left[\begin{matrix}0\\1\\0\\1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\1\\0\\-1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\1\\0\\j\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\1\\0\\-j\end{matrix}\right]\}$;$\{\frac{1}{2}\left[\begin{matrix}1&0\\0&0\\0&1\\0&0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0&0\\1&0\\0&0\\0&1\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0\\0&1\\0&0\\0&0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0\\0&0\\0&0\\0&1\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}0&0\\1&0\\0&1\\0&0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0&0\\0&0\\1&0\\0&1\end{matrix}\right]\}$;$\frac{1}{2}\left[\begin{matrix}1&0&0\\0&1&0\\0&0&1\\0&0&0\end{matrix}\right]$ | CMCC, LG |
| 22 | $$\left\{\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}0\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\1\\\begin{matrix}0\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\0\\\begin{matrix}1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}-1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}j\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}-j\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0\\0&0\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0\\0&1\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}0\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0&0\\1&0\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0&0\\0&1&0\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right]\right\}$$ | HW, LG |
| 23 | $$\left\{\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}-1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}j\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1\\0\\\begin{matrix}-j\\0\end{matrix}\end{matrix}\right], \frac{1}{2}\left[\begin{matrix}1&0\\0&0\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0\\0&1\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}0\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0&0\\1&0\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}1&0&0\\0&1&0\\\begin{matrix}0\\0\end{matrix}&\begin{matrix}0\\0\end{matrix}&\begin{matrix}1\\0\end{matrix}\end{matrix}\right]\right\}$$ | HW |
| 24 | $\frac{1}{2}\left[\begin{array}{c}1\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-1\\0\end{array}\right],\frac{1}{2}\left[\begin{array}{c}1\\0\\j\\0\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}1\\0\\-j\\0\end{array}\right],\frac{1}{2}\left[\begin{array}{c}\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\\\begin{matrix}0&0\end{matrix}\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}\begin{matrix}0&0\end{matrix}\\\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\\\begin{matrix}0&0\end{matrix}\end{array}\right],\frac{1}{2}\left[\begin{array}{c}\begin{matrix}1&0&0\end{matrix}\\\begin{matrix}0&1&0\end{matrix}\\\begin{matrix}0&0&1\end{matrix}\\\begin{matrix}0&0&0\end{matrix}\end{array}\right]$ | LG |
| 25 | $All precoders$ in partial/noncoherent codebooksubset for 4 Tx UE | QC |
| 26 | $\frac{1}{2}\left[\begin{matrix}1\\0\\0\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\1\\0\\0\end{matrix}\right],\frac{1}{2}\left[\begin{matrix}0\\0\\1\\0\end{matrix}\right]\}$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\1\\0\end{array}\right]$, $\frac{1}{2}\left[\begin{array}{c}1\\0\\-1\\0\end{array}\right],\frac{1}{2}\left[\begin{array}{c}1\\0\\j\\0\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}1\\0\\-j\\0\end{array}\right],$$\frac{1}{2}\left[\begin{array}{c}\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\\\begin{matrix}0&0\end{matrix}\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\\\begin{matrix}0&0\end{matrix}\\\begin{matrix}0&0\end{matrix}\end{array}\right]$,$\frac{1}{2}\left[\begin{array}{c}\begin{matrix}0&0\end{matrix}\\\begin{matrix}1&0\end{matrix}\\\begin{matrix}0&1\end{matrix}\\\begin{matrix}0&0\end{matrix}\end{array}\right]$, $\frac{1}{2}\left[\begin{matrix}1&0&0\\0&1&0\\0&0&1\\0&0&0\end{matrix}\right]$ | CATT |