**3GPP TSG RAN WG1 #112bis-e R1-230xxxx**

**e-Meeting, April 17th – April 26th, 2023**

**Agenda item:** 9.1.2

**Source:** Moderator (Samsung)

**Title:** Moderator Summary#4 on Rel-18 CSI enhancements: Round 3

**Document for:** Discussion and Decision

## Introduction

The scope given in the Rel-18 NR Evolved MIMO WID pertaining to CSI enhancement is as follows:

|  |
| --- |
| 1. Study, and if justified, specify CSI reporting enhancement for high/medium UE velocities by exploiting time-domain correlation/Doppler-domain information to assist DL precoding, targeting FR1, as follows:
	* Rel-16/17 Type-II codebook refinement, without modification to the spatial and frequency domain basis
	* UE reporting of time-domain channel properties measured via CSI-RS for tracking
2. Study, and if justified, specify enhancements of CSI acquisition for Coherent-JT targeting FR1 and up to 4 TRPs, assuming ideal backhaul and synchronization as well as the same number of antenna ports across TRPs, as follows:
	1. Rel-16/17 Type-II codebook refinement for CJT mTRP targeting FDD and its associated CSI reporting, taking into account throughput-overhead trade-off
 |

## Summary of companies’ views

### Issue 1: Type-II codebook refinement for CJT

Table 1A Summary: issue 1

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 1.1 | [110bis-e] **Agreement**On the Type-II codebook refinement for CJT mTRP, regarding W2 quantization group, for each layer:* Support the following: (Alt1) One group comprises one polarization across all N CSI-RS resources (*C*group,phase=1, *C*group,amp=2)
	+ FFS: Amplitude quantization table enhancement
	+ For the amplitude group other than the group associated with the SCI, the reference amplitude is reported
* Working assumption: Alt3 is supported in addition to Alt1 (to be confirmed in RAN1#111)
	+ (Alt3). One group comprises one polarization for one CSI-RS resource with a common phase reference across N CSI-RS resources (Cgroup,phase=1, Cgroup,amp=2N)
		- For each of the (2N–1) amplitude groups (other than the group associated with the SCI), the reference amplitude is reported
* If the support Alt3 in addition to Alt1 is confirmed, only one of the two schemes will be a basic feature for UEs supporting Rel-18 Type-II CJT codebook

**Proposal 1.A.1**: On the Type-II codebook refinement for CJT mTRP, *revert* the following working assumption: * Working assumption: Alt3 is supported in addition to Alt1 (to be confirmed in RAN1#111)
	+ (Alt3). One group comprises one polarization for one CSI-RS resource with a common phase reference across N CSI-RS resources (Cgroup,phase=1, Cgroup,amp=2N)
		- For each of the (2N–1) amplitude groups (other than the group associated with the SCI), the reference amplitude is reported

**FL Note**: Just as what we did in RAN1#110bis-e, this has to be decided based on empirical evidence (i.e. SLS results). Per agreement this needs to be concluded in this meeting. Since the WA was made conditioned upon the benefit of Alt3 over Alt1* If there is no confirmed benefit from Alt3 over Alt1 in the alleged scenarios (inter-site CJT, 500m ISD), the WA should be **reverted** (hence no support of Alt3).
* Otherwise, **confirmed** as an agreement.

The available SLS results are summarized as follows for the alleged “missing” scenarios from Alt3 proponents in RAN1#110bis-e (500m ISD or larger, inter-site CJT):* “Notable” (small in FL perspective) gain: Huawei (2-3% mean UPT), ZTE (0.2-1.2% mean UPT)
* No demonstrable gain: Samsung, vivo
 | **Support/fine (want to revert WA):** vivo, Samsung, OPPO, MediaTek, Fraunhofer IIS/HHI, Apple, DOCOMO, Intel, Nokia/NSB, Ericsson, Sharp, Google, Sony, AT&T**Not support (want to confirm WA)**: ZTE, Spreadtrum, CATT, LG, Huawei/HiSi, Lenovo/MotM, Fujitsu, NEC, Xiaomi,  |
| 1.5 | [112] **Agreement**On the Type-II codebook refinement for CJT mTRP, regarding UCI omission, support reusing the legacy UCI omission mechanism while (Alt3) replacing SD basis index *l* in legacy Prio calculation with $\sum\_{k=0}^{n-1}2L\_{k}+l\_{n}$, i.e., SD basis index over all resources: Prio(,l,m,n) = 2Ltot.RI.P(m)+ RI.$\sum\_{k=0}^{n-1}2L\_{k}$+RI.l(n)+ * FFS: FD permutation P(.) as Rel-16-analogous, or no permutation i.e. P(m)=m

**Question 1.5:** Please share your view on FD permutation P(.)* Alt1. P(m) fully reusing legacy (Rel-16 eType-II)
* Alt2. P(m)=m

**FL Note**:  | **Alt1 (legacy P):** ZTE, vivo, Samsung**Alt2 (P=m):** MediaTek, Qualcomm**,**  |
| 1.6.1 | [110bis-e] **Agreement**For the Rel-18 Type-II codebook refinement for CJT mTRP, the constraint on the maximum number of non-zero coefficients (NZCs) per-layer (K0) is defined jointly across all N CSI-RS resourcesFor the Rel-18 Type-II codebook refinement for CJT mTRP, also support a constraint on the total number of non-zero coefficients (NZCs) summed across all layers:* Following the legacy specification, the maximum total number is 2K0

**Proposal 1.F.1**: For the Rel-18 Type-II codebook refinement for CJT mTRP,* For Rel-16 eType-II-based: $K\_{0}=\left⌈2βM\_{v}\sum\_{n=1}^{N}L\_{σ(n)}\right⌉$ where $\left\{σ\_{1},σ\_{2},…,σ\_{N}\right\}$ represents the indices of the *N* selected CSI-RS resources (out of the *NTRP*configured CSI-RS resources)
* For Rel-17 FeType-II-based:  $K\_{0}=\left⌈βM\sum\_{n=1}^{N}K\_{1,σ(n)}\right⌉$ where $\left\{σ\_{1},σ\_{2},…,σ\_{N}\right\}$ represents the indices of the *N* selected CSI-RS resources (out of the *NTRP*configured CSI-RS resources)

Note: $L\_{σ\left(n\right)}=K\_{1,σ(n)}/2$ and $K\_{1,σ(n)}=α\_{σ(n)}P\_{CSI-RS}$. | **Proposal 1.F.1**: * **Support/fine:** Samsung,
* **Not support:**
 |
| 1.6.2 | [110] **Agreement**For the Rel-18 Type-II codebook refinement for CJT mTRP with *NTRP*>1 TRP/TRP-groups, the following is supported:* The CMR comprises *K*>1 NZP CSI-RS resources, where one resource corresponds to one TRP/TRP-group (i.e. *K*=*NTRP*)
	+ Each of the CSI-RS resources has a same number of CSI-RS ports
* Note: The terms TRP and TRP-group are used for discussion purposes only (no spec impact is implied).

**Proposal 1.F.2**: For the Rel-18 Type-II codebook refinement for CJT mTRP, regarding CSI calculation and measurement, * For the configured *NTRP* CSI-RS resources comprising the CMR, the restriction specified for Rel-17 NCJT CSI is fully reused
* For interference measurement, legacy specification is fully reused, including the configuration for NZP CSI-RS for interference measurement or CSI-IM in relation to the configured CMR
* On PDSCH EPRE assumption for CQI calculation, down-select between the two alternatives:
	+ Alt1. The UE can assume that the PDSCH EPRE for a given CSI-RS port follows the configured *powerControlOffset* value associated with its respective CSI-RS resource
	+ Alt2. The UE can assume that the PDSCH EPRE for a given CSI-RS port follows a commonly configured *powerControlOffset* value for all the *N* selected CSI-RS resources
	+ Note: In legacy specification, different CSI-RS resources can be configured with different *powerControlOffset* values
* Decide, in RAN1#113, whether an ordering of CSI-RS port indices (e.g. according to the CSI-RS resource ID in TS38.331) for CSI calculation needs to be specified or not

Note: *P* is the total number of CSI-RS ports summed across *N* selected (out of the configured *NTRP*) CSI-RS resources in the TS38.214 equation for CSI calculation: $\left[\begin{array}{c}y^{\left(3000\right)}(i)\\\cdots \\y^{\left(3000+P-1\right)}(i)\end{array}\right]=W(i)\left[\begin{array}{c}x^{\left(0\right)}(i)\\\cdots \\x^{\left(ν-1\right)}(i)\end{array}\right]$**FL Note**: Re IMR, while some companies propose to allow configuring >1 IMRs for Rel-18 Type-II CJT (e.g. Xiaomi, Huawei), this is not tenable for the following reasons: * From the WID, IM/IMR enhancement is out scope
* Even if there is some strong desire to do this it still requires study since the benefit is unclear while the impact in UE complexity is significant.
* Re benefit, the proponents argue based on dynamic TRP selection. However, during the discussion, it was clear that the reason for the opponents of dynamic TRP selection chose not to maintain their concern was because the proponents claimed that dynamic TRP selection doesn’t require CSI calculation for different TRP selection hypotheses (2^NTRP-1 possibilities). Rather, L1-RSRP is used for selecting the N out of NTRP TRPs. L1-RSRP doesn’t require interference measurement. The proponents of >1 IMRs may argue that L1-SINR can be used. However, this requires careful study.
* Given that we have 2 meetings left before maintenance kicks in, there is not enough time to assess such proposal (e.g. whether L1-SINR offers better TRP selection than L1-RSRP, impact on UE complexity, different scenarios, etc.
* Overall this is a good topic for Rel-19 😊

Re proposal on reference resource enhancement and CQI calculation equation doe to the use of >1 CSI-RS resources (e.g. Fujitsu), there is no need for such. Reference resource guides the NW for the allocation of CSI-RS resources long with the configuration. Not the other way around. Secondly, a note is added on CQI equation and that should suffice to clarify the impact. | **Proposal 1.F.2**: * **Support/fine:**
* **Not support:**
 |
| 1.6.3 | **Proposal 1.F.3**: On the Type-II codebook refinement for CJT mTRP, regarding the required number of CPUs and the values of Z/Z’, decide, in RAN1#113, at least based on the following factors: * The potential increase in the total number of CSI-RS ports due to the selection/configuration of *N* CSI-RS resources for Type-II CSI
* The support for dynamic TRP selection, wherein *N* CSI-RS resources are selected out of the configured *NTRP* CSI-RS resources
	+ Note: The fall-back of gNB configuring *N*=*NTRP* via RRC signalling is supported
* The support for dynamic {*Ln*} selection, wherein 1 out of *NL* {*Ln*} combinations is selected
	+ Note: The fall-back of gNB configuring *NL*=1 is supported
 | **Proposal 1.F.3**: * **Support/fine:** Samsung
* **Not support:**
 |
| 1.6.4 | [112] **Agreement**On the Type-II codebook refinement for CJT mTRP, only support NL ={2,4} as additional candidate values to NL=1.* FFS: Additional restriction(s) depending on the configured value for NTRP

**From the agreement on supported linkages, for a given value of FD combo, the maximum number of linkages (corresponding to different SD combos) is either 1, 2, 3, or 5. Especially for NTRP=3, for the first two FD combos, if the NW wants to configure a UE with SD combos of the same Ltot, only NL=2 is possible even if there are 3 supported SD combos wit the same Ltot=6 (3 permutations). While this is not catastrophic it is quite unfortunate.** **Proposal 1.F.4**: For the Rel-18 Type-II codebook refinement for CJT mTRP, in addition to the supported NL ={1,2,4}, also support NL = 3 | **Proposal 1.F.4:*** **Support/fine:** Samsung (ok)
* **Not support:**
 |
| 1.6.5 | [111] **Agreement**On the Type-II codebook refinement for CJT mTRP, regarding the codebook parameter *R*, the supported value(s) from the legacy specification are reused.* FFS: whether additional value 4 can also be added

**Question 1.6.5**: Please share your view on whether additional value for R of 4 should be supported | **Yes:****No:** Samsung |
| 1.6.6 | [110bis-e] **Agreement**On the Type-II codebook refinement for CJT mTRP, the selection of N CSI-RS resources is performed by UE and reported as a part of CSI report where N$\in ${1,..., NTRP} * N is the number of cooperating CSI-RS resources, while NTRP is the maximum number of cooperating CSI-RS resources configured by gNB via higher-layer signaling
* The selection of N out of NTRP CSI-RS resources is reported via NTRP-bit bitmap in CSI part 1
	+ Note: The value of N is inferred from the selection
* A restricted configuration (gNB-configured via higher-layer signaling) where N=NTRP is supported
	+ NTRP-bit bitmap is not reported when the restriction is configured
	+ FFS: Whether other RRC-configured TRP selection restriction including configuring the value of N is supported
* This feature is UE optional

Note: This agreement does not impact the decision on Ln being configured by gNB or selected by UENote: per WID and previous agreement, the candidate values for NTRP of are 1, 2, 3, and 4.Note: only one transmission hypothesis is reported. UE is not mandated to calculate CSI for multiple transmission hypotheses.**Question 1.6.6**: Please share your view on whether other RRC-configured TRP selection restriction should be supported, e.g. to reduce UE computational complexity | **Yes:****No:** Samsung |
| 1.7 | **Conclusion 1.G**: On the Type-II codebook refinement for CJT mTRP, the lists of UCI parameters (along with the description of each parameter) are given in Table 1C, 1D, and 1E.* Note: The manner in which the UCI parameters are captured is up to the spec editors

***Table 1C: UCI parameter list for Rel-16 based***

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **UCI** | **Details/description** | **Status** |
| # NZ coefficients | Part 1 | RI (∈{1,…, RIMAX}) and *KNZ,TOT* (the total number of non-zero coefficients summed across all the layers and all N CSI-RS resources, where *KNZ,TOT* ∈{1,2,…, 2*K*0} are reported in UCI part 1  | Complete |
| Wideband CQI | Part 1 | Same as R15 | Complete |
| Subband CQI | Part 1 | Same as R15 | Complete |
| CSI-RS resource selection bitmap | Part 1 | *NTRP*-bit bitmap to indicate the UE recommendation of *N* CSI-RS resources* Non-existent if the value of *N* is RRC-configured to NTRP
 | Complete |
| Indication of number of SD basis vectors {*L*1, …, *LNTRP*} | Part 1 | UE recommendation selecting one of the *NL* RRC-configured value combinations ($\left⌈log\_{2}(N\_{L})\right⌉$-bit indicator)* Non-existent if *NL*=1
 | Complete |
| N Bitmap(s) per layer | Part 2 | RI=1-2: for layer *l* and CSI-RS resource *n*, size-$2L\_{n}M$For RI=3-4, bitmaps, each with size-2$L\_{n}$*Mi* (*i*=0,1,…, *RI*-1, where *I* denotes the *i*-th layer and *n* denotes the *n*-th CSI-RS resource) are reported in UCI part 2 | Complete |
| Strongest coefficient indicator (SCI) | Part 2 | RI=1: A $\left⌈log\_{2}K\_{NZ}\right⌉$-bit indicator for the strongest coefficient index $\left(l^{\*},m^{\*},n^{\*}\right)$RI>1: See Table below | Complete |
| SD basis subset selection indicator for each of the *N* CSI-RS resources | Part 2 | SD basis subset selection indicator is a $\left⌈log\_{2}\left(\begin{matrix}N\_{1}N\_{2}\\L\_{n}\end{matrix}\right)\right⌉$-bit indicator for n=0,1,…,*N–*1. Details follow Rel.15 | Complete |
| FD basis subset selection indicator | Part 2 | Mode-1: See Table “SCI and FD basis subset selection indicator“ below + (*N –* 1) FD basis selection window offset values $φ\_{n}\in \left\{0,1,2,…,N\_{3}-1\right\}$ (basic) or $φ\_{n}\in \left\{0,\frac{1}{4},\frac{1}{2}…,N\_{3}-\frac{1}{4}\right\} $(optional), *n*=1,2,…,*N*–1Mode-2: See Table 1E “SCI and FD basis subset selection indicator“ below | Mode-1 completeMode-2 complete |
| LC coefficients: phase | Part 2 | Quantized independently across layers  | Complete |
| LC coefficients: amplitude | Part 2 | Alt1 (agreed): Quantized independently across layers (including a reference amplitude for weaker polarization, for each layer)Alt3 (WA): Quantized independently across layers (including 2N-1 reference amplitudes for 2N-1 (polarization, CSI-RS resource) pairs excluding the pair of (polarization, CSI-RS resource) associated with the SCI, for each layer) | WA on Alt3 support needs to be confirmed or reverted  |
| SD oversampling (rotation) factor q1, q2  | Part 2 | Values of q1,n, q2,n follow Rel.15, reported per CSI RS resource  | Complete |

***Table 1D: UCI parameter list for Rel-17 based***

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **UCI** | **Details/description** | **Status** |
| # NZ coefficients | Part 1 | RI (∈{1,…, RIMAX}) and *KNZ,TOT* (the total number of non-zero coefficients summed across all the layers and all N CSI-RS resources, where *KNZ,TOT* ∈{1,2,…, 2*K*0} are reported in UCI part 1  | Complete |
| Wideband CQI | Part 1 | Same as R15 | Complete |
| Subband CQI | Part 1 | Same as R15 | Complete |
| CSI-RS resource selection bitmap | Part 1 | *NTRP*-bit bitmap to indicate the UE recommendation of *N* CSI-RS resources* Non-existent if the value of *N* is RRC-configured to NTRP
 | Complete |
| Indication of number of SD basis vectors {*L*1, …, *LNTRP*}, where *Ln*=*alphan*\**PCSI-RS/2* | Part 1 | UE recommendation selecting one of the *NL* RRC-configured value combinations ($\left⌈log\_{2}(N\_{L})\right⌉$-bit indicator)* Non-existent if *NL*=1
 | Complete |
| N Bitmap(s) per layer | Part 2 | For layer *l* and CSI-RS resource *n*, size-$2L\_{n}M$, or ($K\_{1,n}M$ where $L\_{n}=K\_{1,n}/2$) | Complete |
| Strongest coefficient indicator (SCI) | Part 2 | For layer *l*: A $\left⌈log\_{2}2M\sum\_{n=0}^{N-1}L\_{n}\right⌉$-bit indicator for the strongest coefficient index | Complete |
| SD basis subset selection indicator for each of the *N* CSI-RS resources | Part 2 | SD basis subset selection indicator is a $\left⌈log\_{2}\left(\begin{matrix}N\_{1}N\_{2}\\L\_{n}\end{matrix}\right)\right⌉$-bit indicator for n=0,1,…,*N–*1, where *Ln*=*alphan*\**PCSI-RS/2*. Details follow Rel.15 | Complete |
| FD basis subset selection indicator | Part 2 | Mode-1: See Table “SCI and FD basis subset selection indicator“ below + (*N –* 1) FD basis selection window offset values $φ\_{n}\in \left\{0,1,2,…,N\_{3}-1\right\}$ (basic) or $φ\_{n}\in \left\{0,\frac{1}{4},\frac{1}{2}…,N\_{3}-\frac{1}{4}\right\} $(optional), *n*=1,2,…,*N*–1Mode-2: a $\left⌈log\_{2}(N-1)\right⌉$ bit indicator only if *N>M=2,* where $N\in \{2,4\}$ is configured with the higher-layer parameter *valueOfN,* when $M=2$. | Mode-1 completeMode-2 complete |
| LC coefficients: phase | Part 2 | Quantized independently across layers  | Complete |
| LC coefficients: amplitude | Part 2 | Alt1 (agreed): Quantized independently across layers (including a reference amplitude for weaker polarization, for each layer)Alt3 (WA): Quantized independently across layers (including 2*N*-1 reference amplitudes for 2*N*-1 (polarization, CSI-RS resource) pairs excluding the pair of (polarization, CSI-RS resource) associated with the SCI, for each layer) | WA on Alt3 support needs to be confirmed or reverted |

***Table 1E: SCI and FD basis subset selection indicator for Type-II CJT***

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| --- |
| **SCI and FD basis subset selection indicator** |
| SCI for RI>1 | Per-layer SCI defined across N CSI-RS resources, where $SCI\_{i}$ is a $\left⌈log\_{2}2\sum\_{n=0}^{N-1}L\_{n}\right⌉$–bit ($i=0,1,…,(RI-1)$) indicator. The location (index) of the strongest LC coefficient for layer $i$ before index remapping is  $(l\_{i}^{\*},m\_{i}^{\*})$, $SCI\_{i}indicates l\_{i}^{\*}$, and $m\_{i}^{\*}$ is not reported |
| Index remapping | For layer $i$, the index $m\_{i}$ of each nonzero LC coefficient $c\_{l\_{i},m\_{i}}$ is remapped with respect to $m\_{i}^{\*}$ to $\tilde{m}\_{i}$ such that $\tilde{m}\_{i}^{\*}=0$. The FD basis index $k\_{m\_{i}}$ associated to each nonzero LC coefficient $c\_{l\_{i},m\_{i}}$ is remapped with respect to $k\_{m\_{i}^{\*}}$ to $\tilde{k}\_{m\_{i}}$ such that $\tilde{k}\_{m\_{i}^{\*}}=0$. The sets $\left\{c\_{l\_{i},\tilde{m}\_{i}}\ne c\_{l\_{i}^{\*},0}\right\}$ and $\left\{\tilde{k}\_{m\_{i}}\ne 0\right\}$are reported.Informative note (for the purpose of reference procedure):The index $\left(l\_{i},m\_{i}\right)$ of nonzero LC coefficients is remapped as $(l\_{i},m\_{i})\rightarrow (l\_{i},\left(m\_{i}-m\_{i}^{\*}\right)modM\_{i})$. The codebook index associated with nonzero LC coefficient index $\left(l\_{i},m\_{i}\right)$ is remapped as $k\_{m\_{i}}\rightarrow \left(k\_{m\_{i}}-k\_{m\_{i}^{\*}}\right)modN\_{3}$.  |
| Combinatorial indicator for $N\_{3}\leq 19$ | $\left⌈log\_{2}\left(\begin{matrix}N\_{3}-1\\M\_{i}-1\end{matrix}\right)\right⌉$ bits  |
| Combinatorial indicator for $N\_{3}>19$ | $\left⌈log\_{2}\left(\begin{matrix}N\_{3}^{'}-1\\M\_{i}-1\end{matrix}\right)\right⌉$ bits  |
| $$M\_{initial}$$ | Reported in UCI part 2, ,  bits |

(\*) The red highlight parts are the new components in Rel-18 |

Table 1B Type II CJT: summary of observation from SLS

|  |  |
| --- | --- |
| **Company** | **SLS results** |
| **Issue #** | **Metric** | **Observation** |
| Huawei/HiSi | 1.1 | Mean UPT gain vs overhead | Observation 9: For inter-site CJT with large inter-site distance, Alt 3 (Cgroup,amp=2N) has better performance compared to Alt1 (Cgroup,amp=2). |
| ZTE | 1.1 | Avg UPT gain vs overhead,5% UPT gain vs overhead | We observe that 0.2%~1.2% average UPT gain and 2.2%~12.1% cell-edge UE gain can be achieved using Alt 3 compared with Alt1. |
| Vivo | 1.1 | SE gain vs overhead | Alt3 shows negligible performance improvement over Alt1 for the scenario with 500m ISD and the high payload case of the scenario with 200m ISD.Combining the payload and the SE gain, Alt1 outperforms Alt 3. |
| Samsung | 1.1 | Average UPT gain vs overhead | There is no benefit of Alt3 over Alt1 shown in our SLS results for both mode 1 and mode 2 cases even in the inter-site inter-cell scenarios. |
| MediaTek | 1.1 | Average UPT gain vs different paraComb | We observe that Alt 3 cannot provide consistent performance benefit over Alt 1. Further, the cost of this little performance benefit must be borne by the increased overhead of feeding back multiple reference amplitudes. Therefore, supporting quantization Alt 3 is not necessary. |

Table 2 Additional inputs: issue 1

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 1A** |
| Qualcomm | Alt2: P(m)=mWe could understand reusing Rel-16 may be more natural in a first thought. But for CJT, different TRPs may have its own “local” strongest FD index (different than e.g. FD index 0 of the reference/first TRP $\tilde{n}$), which diminishes the meaningfulness of permutation $\left[0,N\_{3}-1,1,N\_{3}-2,2,…\right]$Besides, UCI omission is just a small/corner issue and does not deserve such over-optimization |
| vivo | **Question 1.5**Alt 1.We support to reuse legacy P(m) as the whole intention of UCI omission Alt 3 is to reuse legacy Pri as much as possible.Further, based on our evaluation results below, the have FD permutation provides clear performance gain (around 5%) over no permutation. Note in our evaluation, all UEs in a cell omit half of the non-zero coefficients following the current agreement for UCI omission.Therefore, to reuse legacy is clearly more beneficial than no permutation. We don’t see any reason not to reuse legacy. |
| ZTE | We support Alt1 (legacy solution). |
| Mod V5 | **Added 1.F series proposals (based on Tdocs and inputs in round 0) and conclusion 1.G for UCI** |
| Samsung | **Question 1.5**Although we agree with QC’s comment on that UCI omission is a rare event and there is no need to over-optimize, the 5% gain looks huge shown in the SLS results performed by vivo. Hence, we incline to support Alt1.**Proposal 1.F.1**Support.**Proposal 1.F.2**We suggest to add another alternative, one *powerControlOffset* can be configured across $N\_{TRP}$ CSI-RS resources. In our view, the current framework on that different CSI-RS resources can be configured with different *powerControlOffset* values (semi-static PC offset configuration via RRC) is not needed since we already have mechanisms to enable NW to dynamically assign different powers to different TRPs:* dynamic TRP selection feature can make weaker TRPs filtered out
* W2 reporting including amplitude and NZC selection can also provide some sort of dynamic soft-TRP selection

In addition, configuring different PC offsets makes UE processing complexity high since the UE needs to properly perform scaling on channel measurement, interference measurement, precoder selection and CQI calculation.Hence, we support configuring one *powerControlOffset* across $N\_{TRP}$ CSI-RS resources.[Mod: OK, added Alt2. Note that Alt2 introduces additional restriction in the spec since, as noted, the current spec supports resource-specific PC]**Proposal 1.F.3**:We are OK with this proposal**Proposal 1.F.4**:Although we see no need, we will be fine of majority view on it.**Question 1.6.5**We don’t support, since Mode 1 with FD offset selection already properly handles this issue.**Question 1.6.6**:We don’t think it is needed.  |
| Mod V7 | **Added Alt2 in 1.F.2 for later down-selection**  |

### Issue 2: Type-II codebook refinement for high/medium UE velocities (with time/Doppler-domain compression)

Table 3A Summary: issue 2

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 2.3 | **{Placeholder for PC for Rel-17 based}** |  |
| 2.5 | [112bis-e] **Agreement**On the Type-II codebook refinement for high/medium velocities, regarding UCI omission* When X=2 is configured, the 2nd TD CQI location reuses the legacy rule for the 2nd codeword CQI when RI>4, i.e. wideband CQI in G0, even-indexed sub-band CQIs in G1, odd-indexed sub-band CQIs in G2
* FFS: When the configured value of N4 is >1, whether the DD basis selection indicator is placed in G0 or G1

**Question 2.5:** Please share your view on the location of DDBI when N4>1* Alt1. G0
* Alt2. G1

**Proposal 2.E**: On the Type-II codebook refinement for high/medium velocities, regarding UCI omission, when the configured value of N4 is >1, the DD basis selection indicator is placed in ….**FL Note**:  | **Alt1 (DDBI in G0):** Samsung, Xiaomi, LG, Intel, Lenovo/MotM**Alt2 (DDBI in G1):** Qualcomm, vivo, ZTE, NEC, Fujitsu, OPPO, Ericsson |
| 2.6.1 | [112] **Agreement**For the Type-II codebook refinement for high/medium velocities, * The constraint on the maximum number of non-zero coefficients (NZCs) per-layer (K0) is defined jointly across all Q DD basis vectors.
	+ FFS: How K0 is calculated

**Proposal 2.F.1:** For the Type-II codebook refinement for high/medium velocities,* For Rel-16 eType-II-based: $K\_{0}=\left⌈2βLM\_{v}Q\right⌉$
* For Rel-17 FeType-II-based: $K\_{0}=\left⌈βK\_{1}MQ\right⌉$

Note: $L=K\_{1}/2$ and $K\_{1}=αP\_{CSI-RS}$. | **Proposal 2.F.1**: * **Support/fine:** Samsung
* **Not support:**
 |
| 2.6.2 | [110bis-e] **Agreement**On the CSI reporting and measurement for the Rel-18 Type-II codebook refinement for high/medium velocities, support the following CSI-RS resource types/structures for CMR, support the following: * (Alt1) Support K>1 NZP CSI-RS resources, received via a single triggering instance, for aperiodic (AP) CSI-RS-based channel measurement in a same CSI-RS resource set where the separation between 2 consecutive AP-CSI-RS resources is m slot(s)

**Proposal 2.F.2**: For the Rel-18 Type-II codebook refinement for high/medium velocities, regarding CSI calculation and measurement, * The number of CSI-RS ports is the same for all the K configured CSI-RS resources comprising the CMR
* For interference measurement, legacy specification is fully reused, including the configuration for NZP CSI-RS for interference measurement or CSI-IM in relation to the configured CMR
* On PDSCH EPRE assumption for CQI calculation, the *powerControlOffset* value is the same for all the K configured CSI-RS resources comprising the CMR

**FL Note**:  | **Proposal 2.F.2**: * **Support/fine:**
* **Not support:**
 |
| 2.6.3 | **Proposal 2.F.3**: For the Type-II codebook refinement for high/medium velocities, regarding the required number of CPUs and the values of Z/Z’, decide, in RAN1#113, at least based on the following factors: * The measurement of *K*>1 CSI-RS resources for Type-II CSI required to perform UE-side prediction and, when the configured N4 value is >1, DD compression

**FL Note**:  | **Proposal 2.F.3**: * **Support/fine:**
* **Not support:**
 |
| 2.7 | **Conclusion 2.G**: On the Type-II codebook refinement for high/medium velocities, the lists of UCI parameters (along with the description of each parameter) are given in Table 3C, 3D, and 3E.* Note: The manner in which the UCI parameters are captured is up to the spec editors

***Table 3C: UCI parameter list for Rel-16 based***

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **UCI** | **Details/description** | **Status** |
| # NZ coefficients | Part 1 | RI (∈{1,…, RIMAX}) and *KNZ,TOT* (the total number of non-zero coefficients summed across all the Q selected DD basis and across all the layers, are reported in UCI part 1  | Complete  |
| Wideband CQI | Part 1 | Same as R15 | Complete |
| Subband CQI | Part 1 | Same as R15 for X=1Two independent CQIs (same format as CQIs for 2CW when RI>4 in R15) for X=2 | Complete for X=1 and 2 |
| Q Bitmap(s) per layer | Part 2 | Q bitmaps where each bitmap has the same format/design as R16 eType-II | Complete  |
| Strongest coefficient indicator (SCI) | Part 2 | RI=1: A $\left⌈log\_{2}K\_{NZ}\right⌉$-bit indicator for the strongest coefficient index $\left(l^{\*},m^{\*},d^{\*}\right)$RI>1: See Table 2 above | Complete  |
| SD basis subset selection indicator  | Part 2 | SD basis subset selection indicator is a $\left⌈log\_{2}\left(\begin{matrix}N\_{1}N\_{2}\\L\end{matrix}\right)\right⌉$-bit indicator. Details follow Rel.15 | Complete |
| FD basis subset selection indicator | Part 2 | Details follow Rel.15 (Table 2 above) | Complete |
| DD basis subset selection indicator (per layer) | Part 2 | Reported only when N4>2 and Q=2: the selection of Q out of N4 DD basis vectors is indicated by a $\left⌈log\_{2}\left(N\_{4}-1\right)\right⌉$-bit indicator | Complete |
| LC coefficients: phase | Part 2 | Quantized independently across layers | Complete  |
| LC coefficients: amplitude | Part 2 | Quantized independently across layers (including a reference amplitude for weaker polarization, for each layer) | Complete |
| SD oversampling (rotation) factor q1, q2 | Part 2 | Values of q1, q2 follow Rel.15 | Complete |

***Table 3D: UCI parameter list for Rel-17 based***

|  |  |  |  |
| --- | --- | --- | --- |
| **Parameter** | **UCI** | **Details/description** | **Status** |
| # NZ coefficients | Part 1 | RI (Î{1,…, RIMAX}) and *KNZ,TOT* (the total number of non-zero coefficients summed across all the layers, are reported in UCI part 1  | Complete |
| Wideband CQI | Part 1 | Same as R15 | Complete |
| Subband CQI | Part 1 | Same as R15 for X=1Two independent CQIs (same format as CQIs for 2CW when RI>4 in R15) for X=2 | Complete for X=1 and 2 |
| Bitmap per layer | Part 2 | Same as R17 eType-II | Complete |
| Strongest coefficient indicator (SCI) | Part 2 | For layer *l*: A $\left⌈log\_{2}2ML\right⌉$-bit indicator for the strongest coefficient index | Complete |
| SD basis subset (port) selection indicator  | Part 2 | SD basis subset selection indicator is a $\left⌈log\_{2}\left(\begin{matrix}N\_{1}N\_{2}\\L\end{matrix}\right)\right⌉$-bit indicator. where $L=\frac{αP\_{CSIRS}}{2}$, Details follow Rel.17 | Complete |
| FD basis subset selection indicator | Part 2 | a $\left⌈log\_{2}(N-1)\right⌉$ bit indicator only if *N>M=2,* where $N\in \{2,4\}$ is configured with the higher-layer parameter *valueOfN,* when $M=2$. | Complete |
| LC coefficients: phase | Part 2 | Quantized independently across layers | Complete  |
| LC coefficients: amplitude | Part 2 | Quantized independently across layers (including a reference amplitude for weaker polarization, for each layer) | Complete |

***Table 3E: SCI and FD basis subset selection indicator for Type-II Doppler***

|  |
| --- |
| **SCI and FD basis subset selection indicator** |
| SCI for RI>1 | Per-layer SCI defined across Q DD basis vectors, where $SCI\_{i}$ is a $\left⌈log\_{2}2LQ\right⌉$–bit ($i=0,1,…,(RI-1)$) indicator. The location (index) of the strongest LC coefficient for layer $i$ before index remapping is  $(l\_{i}^{\*},m\_{i}^{\*},d\_{i}^{\*})$, $SCI\_{i}$ indicates $(l\_{i}^{\*},d\_{i}^{\*})$ and $m\_{i}^{\*}$ is not reported |
| Index remapping | For layer $i$, the index $m\_{i}$ of each nonzero LC coefficient $c\_{l\_{i},m\_{i}}$ is remapped with respect to $m\_{i}^{\*}$ to $\tilde{m}\_{i}$ such that $\tilde{m}\_{i}^{\*}=0$. The FD basis index $k\_{m\_{i}}$ associated to each nonzero LC coefficient $c\_{l\_{i},m\_{i}}$ is remapped with respect to $k\_{m\_{i}^{\*}}$ to $\tilde{k}\_{m\_{i}}$ such that $\tilde{k}\_{m\_{i}^{\*}}=0$. The sets $\left\{c\_{l\_{i},\tilde{m}\_{i}}\ne c\_{l\_{i}^{\*},0}\right\}$ and $\left\{\tilde{k}\_{m\_{i}}\ne 0\right\}$are reported.Informative note (for the purpose of reference procedure):The index $\left(l\_{i},m\_{i}\right)$ of nonzero LC coefficients is remapped as $(l\_{i},m\_{i})\rightarrow (l\_{i},\left(m\_{i}-m\_{i}^{\*}\right)modM\_{i})$. The codebook index associated with nonzero LC coefficient index $\left(l\_{i},m\_{i}\right)$ is remapped as $k\_{m\_{i}}\rightarrow \left(k\_{m\_{i}}-k\_{m\_{i}^{\*}}\right)modN\_{3}$.  |
| Combinatorial indicator for $N\_{3}\leq 19$ | $\left⌈log\_{2}\left(\begin{matrix}N\_{3}-1\\M\_{i}-1\end{matrix}\right)\right⌉$ bits  |
| Combinatorial indicator for $N\_{3}>19$ | $\left⌈log\_{2}\left(\begin{matrix}N\_{3}^{'}-1\\M\_{i}-1\end{matrix}\right)\right⌉$ bits  |
| $$M\_{initial}$$ | Reported in UCI part 2, ,  bits |

(\*) The red highlighted parts are the new components in Rel-18 |

Table 3B Type II Doppler: summary of observation from SLS

|  |  |
| --- | --- |
| **Company** | **SLS results** |
| **Issue #** | **Metric** | **Observation** |
|  |  |  |  |

Table 4 Additional inputs: issue 2

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 3A** |
| Qualcomm | Alt2: G1 |
| vivo | **Question 2.5**G1. SD basis is in G0, and FD basis is in G1. G0 has higher priority than G1 in UCI mapping and omission. Based on previous discussion on UCI omission, DD basis shouldn’t have higher priority than FD basis. |
| ZTE | We support Alt2. |
| Mod V5 | **Added 2.F series proposals (based on Tdocs and inputs in round 0) and conclusion 2.G for UCI** |
| Samsung | Support Alt1: G0. Since SCI indicates SD and DD bases of the strongest coefficient. So, it makes more sense to include DDBI in G0Proposal 2.F.1: supportProposal 2.F.2: * **Typo:**
	+ **Proposal 2.F.2**: For the Rel-18 Type-II codebook refinement for high/medium velocities ~~CJT mTRP~~

[Mod: Thanks for catching this]* + 1st bullet: does it mean that other CSI-RS parameters can be different across resources, e.g. RE pattern?

**[Mod: As of now other than the agreed slot offset and, if the proposal is endorsed, the number of ports, yes]**Conclusion: OK, perhaps the following can be added for completenessFor N4=2 and Q=2, the DD basis is fixed {0,1} and the DD basis subset selection indicator is not reported.**[Mod: Added “reported only when N4>2 and Q=2: …” With this, the above clarification is not needed since it is implied from the previous agreements]** |
| Mod V7 | **Editorial revision per Samsung’s input for 2.F.2 and conclusion 2.G** |

### Issue 3: TRS-based reporting of time-domain channel properties (TDCP)

Table 5A Summary: issue 3

|  |  |  |
| --- | --- | --- |
| **#** | **Issue** | **Companies’ views** |
| 3.1 | [112bis-e] **Agreement** For the Rel-18 TRS-based TDCP reporting, for TDCP measurement and calculation, * KTRS ≥1 TRS resource set(s) can be configured in the CSI reporting setting when ReportQuantity is ‘tdcp’
	+ Note: the TRS resource set(s) configured for TDCP report do not impact or impose any new requirements on the UE behavior when processing TRS used as QCL type A/D source for reception of PDxCH.
* No further spec enhancement on TRS is supported
* All the TRS resources in the configured resource set(s) share the same RE locations
* FFS: Whether to add further restrictions on the TRS resource set(s) on, e.g. QCL relationship, power control, slot offset between TRS resource set(s), relation with resource set used for legacy usage

**Proposal 2.A.3**: For the Rel-18 TRS-based TDCP reporting, for TDCP measurement and calculation, at least the following restrictions are supported:* When all the configured KTRS resource sets are periodic, the UE can assume that all the resource sets share a same QCL-Type-A/C and, if applicable, Type-D source
	+ That the QCL source of KTRS-1 resource sets is the first periodic TRS resource set (QCL-source inheritance) is not precluded
* When one of the KTRS configured resource sets is aperiodic, the UE can assume that all the resource sets share a same QCL-Type-A and, if applicable, Type-D source as the first periodic TRS resource set
	+ Note: Following the legacy specification, no more than 1 of the KTRS resource sets is aperiodic
	+ This does not impact whether P-TRS + (KTRS – 1) aperiodic resource set(s) should be supported

**FL Note**: From Round 2:* Same QCL Type-A and, if applicable, Type-D for K\_TRS resource sets: ZTE
* Either the QCL-TypeA/D source of resources in KTRS-1 resource set(s) is the first set (if the first set is P-TRS), or, the QCL-TypeA/D source of resources in all KTRS resource set(s) is the same (if the first set is AP-TRS): Qualcomm, [ZTE, NEC, Ericsson]
* Same (type-C/D) QCL source for all periodic $K\_{TRS}$ and same (type-A/D) P-TRS QCL source for all $K\_{TRS}-1$ AP-TRS”: Nokia/NSB
 | **Proposal 2.A.3:*** **Support/fine:** Samsung
* **Not support:**
 |
| 3.2 | **Proposal 3.B.3**: For the Rel-18 TRS-based TDCP reporting, regarding phase quantization, down-select (by RAN1#113) from the following candidates:* Alt1. 1-bit (early vs. late) phase indicator
* Alt2. 3-bit (8-PSK) uniform quantization
* Alt3. 4-bit (16-PSK) uniform quantization (full reuse of Rel-16 eType-II W2 phase quantization)
* Alt4. Adaptive/gNB-configurable phase quantizer e.g. based on some combination of Alt1/2/3, based on amplitude or additional sign indicator in TDCP report, $e^{\frac{j2πn}{k×2^{N}}}$ where parameter $k$ controls the adaptation
* Alt5. A given correlation phase value $θ(D)$ is quantized to $\hat{θ}(D)$ based on the following alphabet (where $D$ denotes delay):
	+ $\hat{θ}(D)\in \left\{2^{-(N-q)∙s} ∙π, q=0,1,2,…, 2^{Q}-1\right\}$,
	+ When $θ\left(D+ε\right)<θ\left(D\right)$: $\hat{θ}(D)\in \left\{-2^{-(N-q)∙s} ∙π, q=0,1,2,…, 2^{Q}-2\right\}$,
	+ When $θ\left(D+ε\right)=θ\left(D\right)$: $\hat{θ}\left(D\right)=0$
* Alt6. A given correlation phase value $θ(D)$ is quantized to $\hat{θ}(D)$ based on the following alphabet (where $D$ denotes delay and p(.) denotes amplitude quantization values used for Rel-16 e-TypeII codebook):
	+ When $θ\left(D+ε\right)\geq θ\left(D\right)$: $\hat{θ}(D)\in \left\{p(q)^{2}∙2π, q=0,1,2,…, 2^{Q}-1\right\}$,
	+ When $θ\left(D+ε\right)<θ\left(D\right)$: $\hat{θ}(D)\in \left\{\left(1-p(q)^{2}\right)∙2π, q=0,1,2,…, 2^{Q}-1\right\}$
	+ Whether $θ\left(D+ε\right)\geq θ\left(D\right)$ or $θ\left(D+ε\right)<θ\left(D\right)$ is reported by the UE via a 1-bit indicator

The evaluation should consider the impact of delay tracking operation at the UE where the phase difference between two slots can be close to zero.Note: This proposal doesn’t preclude the UE supporting only smaller delay values (e.g. 4-symbol only) for the phase report (which is already optional)**Question 3.2: The text for Alts 1 to 4 is stable. Please check the text for Alt5 and Alt6****FL Note**:  | **Proposal 3.B.3:*** **Support/fine:** Samsung, Xiaomi, OPPO, Qualcomm, vivo, Fujitsu, NTT DOCOMO, ZTE, Lenovo/MotM, Ericsson
* **Not support:**
 |

Table 5B TDCP: summary of observation from simulation

|  |  |
| --- | --- |
| **Company** | **SLS results** |
| **Issue #** | **Metric** | **Observation** |
|  |  |  |  |

Table 6 Additional inputs: issue 3

|  |  |
| --- | --- |
| **Company** | **Input** |
| Mod V0 | **Please share your inputs on each of the issues and, if applicable, proposals in TABLE 5A** |
| Qualcomm | **Proposal 2.A.3**: We suggest to:1. KTRS-1 resource sets, whether P or AP, not defined as TRS (why bother to name them TRS since agreement says they are not intended for loop tracking, they can be treated similar as CSI-RS, but only single-port and freq-density 3) – thus their QCL-TypeA source can’t be SSB, and can be the (1st) resource set: TRS
2. Leave the case of P+AP resources FFS to RAN1#113

Therefore, two editorial suggestions:

|  |
| --- |
| **Proposal 2.A.3**: For the Rel-18 TRS-based TDCP reporting, for TDCP measurement and calculation, at least the following restrictions are supported:* When all the configured KTRS resource sets are periodic, all the resource sets share a same QCL-Type-A/C and, if applicable, Type-D source
	+ It does not preclude the QCL source of KTRS-1 resource sets is the first periodic TRS resource set (QCL-source inheritance)
* When (KTRS – 1) of the KTRS configured resource sets are aperiodic, all the resource sets share a same QCL-Type-A and, if applicable, Type-D source as the first periodic TRS resource set
	+ It does not impact whether P-TRS + (KTRS – 1) aperiodic resource set(s) should be supported
 |

[Mod: OK]**Proposal 3.B.3**: We’d like to add one note:

|  |
| --- |
| For this optional UE capability of phase report, it does not preclude UE only supports a limited delay e.g. 4-symbol only |

[Mod: OK] |
| vivo | **Proposal 2.A.3**: It seems the second sub-bullet implies there may be multiple AP TRS sets triggered by a DCI. This is not a TRS mechanism supported in the current specification, and we have agreed no further spec enhancement on TRS is supported. Hence we think it is needed to clarify in the proposal that no more than one AP TRS resource can be triggered in one DCI.We suggest the following revision.For the Rel-18 TRS-based TDCP reporting, for TDCP measurement and calculation, at least the following restrictions are supported:* When all the configured KTRS resource sets are periodic, all the resource sets share a same QCL-Type-A/C and, if applicable, Type-D source
* When *~~(K~~~~TRS~~ ~~– 1)~~ one* of the KTRS configured resource sets *~~are~~ is* aperiodic, all the resource sets share a same QCL-Type-A and, if applicable, Type-D source as the first periodic TRS resource set
* *No more than 1 of the KTRS resource sets is aperiodic*

**[Mod: You are correct. Thanks for the catch]** |
| ZTE | **Proposal 2.A.3**: @QC: We have already agreed to use legacy TRS to measure TDCP. Therefore, all KTRS resource sets should be TRS, even with some trimming mechanisms. Besides, for avoiding ambiguities of cross TRS QCL relationship (e.g., between two P-TRS or two AP-TRS) or QCL source RS (i.e., SSB or first TRS), as QC mentioned, we may add a separate bullet as a general assumption in red.**Proposal 2.A.3**: For the Rel-18 TRS-based TDCP reporting, for TDCP measurement and calculation, at least the following restrictions are supported:* When all the configured KTRS resource sets are periodic, all the resource sets share a same QCL-Type-A/C and, if applicable, Type-D source
* When (KTRS – 1) of the KTRS configured resource sets are aperiodic, all the resource sets share a same QCL-Type-A and, if applicable, Type-D source as the first periodic TRS resource set

UE can assume that all TRS resources in KTRS resource sets are QCLed with respect to QCL-Type-A, and if applicable, QCL-Type-D. [Mod: Please check the revised version. I concluded “UE can assume” in the bullets. The statement you proposed to add is clearly implied from the two bullets hence not needed.]**Proposal 3.B.3**: To make Alt6 clearer, we prefer the following modification. That is, from spec perspective, we do not need to mentioned condition of “when $θ\left(D+ε\right)\geq θ\left(D\right)$ or not”, besides that indicating which phase quantization mode (i.e., mode-1 corresponds to the first bullet, mode-2 corresponds to the second subbullet) is used by 1-bit indicator.* Alt6. A given correlation phase value $θ(D)$ is quantized to $\hat{θ}(D)$ based on the following alphabet (where $D$ denotes delay and p(.) denotes amplitude quantization values used for Rel-16 e-TypeII codebook):
	+ When $θ\left(D+ε\right)\geq θ\left(D\right)$: $\hat{θ}(D)\in \left\{p(q)^{2}∙2π, q=0,1,2,…, 2^{Q}-1\right\}$,
	+ When $θ\left(D+ε\right)<θ\left(D\right)$: $\hat{θ}(D)\in \left\{\left(1-p(q)^{2}\right)∙2π, q=0,1,2,…, 2^{Q}-1\right\}$
	+ Whether $θ\left(D+ε\right)\geq θ\left(D\right)$ or $θ\left(D+ε\right)<θ\left(D\right)$ is indicated by a 1-bit indicator, the indicator is determined by UE and reported to gNB

[Mod: OK] |
| Samsung | **Proposal 3.A.3: OK** |

# References