**3GPP TSG RAN WG1 #112bis-e R1-2304122**

**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:

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| --- |
| 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
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## 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 , i.e., SD basis index over all resources: Prio(,l,m,n) = 2Ltot.RI.P(m)+ RI.+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

**Proposal 1.E.2:** On the Type-II codebook refinement for CJT mTRP, regarding UCI omission, reuse the Rel-16 eType-II (legacy) permutation function P(m)**FL Note**: **MOVED TO EMAIL ENDORSEMENT 5** | **Proposal 1.E.2**: **- Support/fine:** ZTE, vivo, Samsung, Huawei/HiSi, Lenovo/MotM, Xiaomi, OPPO, NTT DOCOMO, Fujitsu, CATT**- Not support:** MediaTek, Qualcomm**Alt1 (legacy P):** ZTE, vivo, Samsung, Huawei/HiSi, Lenovo/MotM, Xiaomi, OPPO **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,[Version 1* For Rel-16 eType-II-based: with the largest resulting from the *NL* configured {*Ln*} combinations
* For Rel-17 FeType-II-based:  with the largest resulting from the *NL* configured {} combinations
	+ Note: and .

]VS[Version 2* For Rel-16 eType-II-based:
	+ where represents the indices of the *N* selected CSI-RS resources (out of the *NTRP*configured CSI-RS resources)
	+ The payload of is determined by where the maximum is taken over the *NL* configured {*Ln*} combinations
* For Rel-17 FeType-II-based:
	+ where represents the indices of the *N* selected CSI-RS resources (out of the *NTRP*configured CSI-RS resources)
	+ The payload of is determined by where the maximum is taken over the *NL* configured {*n*} combinations
	+ Note: and .

]**FL Note**: Both V1 and V2 guarantee that KNZ,TOT doesn’t result in variable total payload for Part 1 UCI | **Which version do you prefer?*** **V1:** Huawei/HiSi
* **V2:** ZTE, Samsung, Ericsson, Nokia/NSB

**Proposal 1.F.1 (in principle)**: * **Support/fine:** LG, Qualcomm, Samsung, Huawei/HiSi, ZTE, Lenovo/MotM, Xiaomi, OPPO, NTT DOCOMO, vivo, Ericsson, CATT
* **Not support:**
 |
| 1.6.2 | **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, i.e. the configured *NTRP* CSI-RS resources are located either in the same slot or consecutive slots
* 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
	+ Alt3. The UE can assume that the PDSCH EPRE for a given CSI-RS port follows a commonly configured *powerControlOffset* value defined as averagePDSCH-to-averageCSIRS EPRE ratio, where averagePDSCH and averageCSIRS are average power across for all the *N* selected CSI-RS resources (i.e.the PDSCH EPRE divided by N for a given CSI-RS port follows a commonly configured *powerControlOffset* value for all the N selected CSI-RS resources)
	+ Alt 4: The UE can assume that the PDSCH EPRE for a given CSI-RS port follows the *powerControlOffset* value for one of the configured NTRP 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: The total number of CSI-RS ports summed across *N* selected (out of the configured *NTRP*) CSI-RS resources will be used in the TS38.214 equation for CSI calculation**FL Note**: Re proposal on reference resource enhancement and CQI calculation equation due 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.**MOVED TO EMAIL ENDORSEMENT 5** | **Proposal 1.F.2**: * **Support/fine:** LG, Samsung, Qualcomm, Huawei/HiSi, ZTE, Lenovo/MotM, OPPO, NTT DOCOMO,
* **Not support:** Xiaomi (1st bullet)
 |
| 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/ NTRP* 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

**MOVED TO EMAIL ENDORSEMENT 5** | **Proposal 1.F.3**: * **Support/fine:** LG, NEC, Samsung, Qualcomm, Huawei/HiSi, ZTE, NTT DOCOMO, Lenovo/MotM, Xiaomi, OPPO, vivo, Fujitsu, Ericsson, CATT
* **Not support:**
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| 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**MOVED TO EMAIL ENDORSEMENT 5** | **Proposal 1.F.4:*** **Support/fine:** Samsung (ok), Qualcomm, Huawei/HiSi, ZTE, Xiaomi, OPPO, NTT DOCOMO, Fujitsu, Ericsson, CATT
* **Not support:** vivo, MediaTek,
 |
| 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**Conclusion 1.F.5**: On the Type-II codebook refinement for CJT mTRP, regarding the codebook parameter *R*, there is no consensus on supporting *R*=4**MOVED TO EMAIL ENDORSEMENT 5** | **Yes:** Huawei/HiSi**No:** Samsung, ZTE, Lenovo/MotM, Xiaomi, OPPO, NTT DOCOMO, vivo, Fujitsu, Ericsson, CATT |
| 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{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 ignalling
* 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 ignalling) 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**Conclusion 1.F.6**: On the Type-II codebook refinement for CJT mTRP, there is no consensus on supporting other RRC-configured TRP selection restriction(s)**MOVED TO EMAIL ENDORSEMENT 5** | **Yes (configure a subset as always selected/rejected):** NEC, Qualcomm (2nd), Huawei/HiSi, ZTE **No:** Samsung, Qualcomm (1st), Xiaomi, OPPO, NTT DOCOMO, vivo, Ericsson, CATT **Discussed together with CPU/Z/Z’**: LG |
| 1.6.7 | **Question 1.6.7**: For the Rel-18 Type-II codebook refinement for CJT mTRP, regarding CSI calculation and measurement, for interference measurement, * Alt1. Should the legacy specification be fully reused, including the configuration for NZP CSI-RS for interference measurement or CSI-IM in relation to the configured CMR (no IMR enhancement), i.e. only one NZP CSI-RS for interference measurement or only one CSI-IM can be configured irrespective of the value of NTRP or
* Alt2. Should some enhancement on IMR, e.g. supporting >1 IMRs in relation to the configured CMR, be specified?

**Conclusion 1.F.7**: For the Rel-18 Type-II codebook refinement for CJT mTRP, regarding interference measurement, beyond that supported in legacy specification, there is no consensus on supporting any additional enhancement on IMR (including the configuration for NZP CSI-RS for interference measurement or CSI-IM in relation to the configured CMR(s)).* Note: This implies that only one NZP CSI-RS for interference measurement or only one CSI-IM can be configured irrespective of the value of NTRP

**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, IMO, this is a good topic for Rel-19

**MOVED TO EMAIL ENDORSEMENT 5** | **Alt1:** Qualcomm, Samsung, LG, ZTE, Lenovo/MotM, OPPO, NTT DOCOMO, vivo, Fujitsu, Ericsson, CATT**Alt2:** Huawei/HiSi, Xiaomi, **Note that Alt1 is the default outcome in the absence of consensus** |
| 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 | *Only reported when NTRP >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 (-bit indicator)* Non-existent if *NL*=1
 | Complete |
| N Bitmap(s) per layer | Part 2 | For RI=1-4: for layer *l* and CSI-RS resource *n*, size- where *n* denotes the *n*-th CSI-RS resource  | Complete |
| Strongest coefficient indicator (SCI) | Part 2 | RI=1: A -bit indicator for the strongest coefficient index 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 -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 (basic) or (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 (-bit indicator)* Non-existent if *NL*=1
 | Complete |
| N Bitmap(s) per layer | Part 2 | For layer *l* and CSI-RS resource *n*, size-, or ( where ) | Complete |
| Strongest coefficient indicator (SCI) | Part 2 | For layer *l*: A -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 -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 (basic) or (optional), *n*=1,2,…,*N*–1Mode-2: a bit indicator only if *N>M=2,* where is configured with the higher-layer parameter *valueOfN,* when . | 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 is a –bit () indicator. The location (index) of the strongest LC coefficient for layer before index remapping is  , , and is not reported |
| Index remapping | For layer , the index of each nonzero LC coefficient is remapped with respect to to such that . The FD basis index associated to each nonzero LC coefficient is remapped with respect to to such that . The sets and are reported.Informative note (for the purpose of reference procedure):The index of nonzero LC coefficients is remapped as . The codebook index associated with nonzero LC coefficient index is remapped as .  |
| Combinatorial indicator for  |  bits  |
| Combinatorial indicator for  |  bits  |
|  | 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

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| **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 ), which diminishes the meaningfulness of permutation 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 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 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**  |
| LG | **Proposal 1.F.1, Proposal 1.F.2 and Proposal 1.F.3**Support.**Question 1.6.6**:As we mentioned in Round 0, this issue should be discussed with CPU/Z/Z’. we prefer comeback this issue in next meeting with the proposal 1.F.3. |
| NEC | **Proposal 1.F.3**Support. **Question 1.6.6**We support RRC configured restriction for TRP selection, not only the value N can be configured, but also the selection of TRPs can also be configured for restriction, for example, one or more TRPs can be restricted to be always selected (e.g. the one of serving TRP).  |
| Qualcomm | **Proposal 1.F.1**: Fine**Proposal 1.F.2**For IMR, support to reuse legacy;For *powerControlOffset*, Alt1 basically is requiring per-TRP power of **precoded** PDSCH determined by W(i) (PMI), which cannot be guaranteed – if required, this is worse than soft CBSR, regarding requiring “block-wise” power (associated with each certain TRP n). Therefore, Alt1 does not workAlt2, from description, seems to be a special case of Alt1;Therefore, we propose Alt3, which also use a common for *powerControlOffset* all TRPs, but with definition modified w.r.t. Alt2

|  |
| --- |
| * + Alt3. The UE can assume that the PDSCH EPRE for a given CSI-RS port follows a commonly configured *powerControlOffset* value defined as averagePDSCH-to-averageCSIRS EPRE for all the *N* selected CSI-RS resources
 |

where averagePDSCH and averageCSIRS are average power across all the N selected TRPsFor port indexing, the “Note” is about P ports of PDSCH, not CSI-RS (although we all know this is N\*2N1N2). Seems there is no ambiguity regarding CSI-RS port indexing, consider we have resource index n=1,…,N[Mod: I agree it is obvious. It was added due to the comment from Fujitsu that it was not. The Note is anyway harmless]**Proposal 1.F.3**: Fine with the proposal, although we don’t think computational resource counting needs to be determined so “accurately” and “dynamically” – from UE perspective, the purpose is mainly to limit a maximum computational budget**Proposal 1.F.4**: OK for NL=3, and seems NL=4 is not supported already, according to agreed PC – we are also OK to remove NL=4[Mod: Removing 4 would require reverting agreement, let’s not get into that at this stage]**Question 1.6.6**: No restriction is slightly preferred, but OK with restriction if there is some specific consideration from network side (a little similar as hard-CBSR) |
| Huawei, HiSilicon | For issue 1.5, we prefer Alt 1 to reuse legacy. For issue 1.6, since the #NZC (*KNZ,TOT* ∈{1,2,…, 2*K*0}) needs to be reported in part 1, which should have a fixed range. However, following the proposal, the K0 will be related to the #selected TRP N, and the range of #NZC will be changed accordingly. To fix the range of #NZC thus fixed bit width in part I, it’s more reasonable that for the configured Ln combination with largest .[Mod: Very good point and I agree, changed the proposal per your input]For issue 1.6.2, proposal 1.F.2,* For the first sub-bullet, what is the restriction? Is it that the configured CSI-RS resources should be within two contiguous slots?

[Mod: Yes]* For the second sub-bullet, this issue is similar to NCJT as highlighted below, for the TRP in the cooperating set, then they are not serving the UE, they will be a strong interference for the UE, thus they should be considered when calculating the CQI.

(38.214) and the indices are associated to the two Resource Groups configured in the corresponding CSI-RS Resource Set for channel measurement; that the signals , , fully overlap in time and frequency, and that, for the calculation of RI, PMI and LI (if configured) of layers, , the interference from the other layers is derived from channel measurement and precoding matrix corresponding to the other layers[Mod: OK I have moved this issue to 1.6.7, let’s see if we can have consensus on what you want]* For the third sub-bullet, since TRP tends to transmit the PDSCH with full power, when different #TRPs serves the UE, the PDSCH power may be different. Therefore, we propose the following alternative:

Alt3. The UE can assume that the PDSCH EPRE divided by N for a given CSI-RS port follows a commonly configured *powerControlOffset* value for all the N selected CSI-RS resourcesFor issue 1.6.2, we are fine with proposal 1.F.3.* For the first sub-bullet, it should be “the selection/configuration of *N/N\_TRP* CSI-RS resources for Type-II CSI”

[Mod: Correct, thanks]For issue 1.6.4, we are fine with proposal 1.F.4.For issue 1.6.5, we support R=4 to handle the increased frequency selectivity due to delay difference between TRPs.For issue 1.6.6, we support the configuration of value N to reduce the UE complexity. As gNB has more information on scheduling, it’s beneficial to let gNB has flexibility on configuration. |
| ZTE | **Proposal 1.F.1:** Support in principle* Firstly, if our understanding is correct, in legacy procedure, K0 has two usages, i.e., #1 determining the range of #. NZP coefficient and then #2 the bit-size of the field of # NZ coefficients. But, considering that the #2 (as mentioned by HW but only handling bit-size issue) need to be further studied due to the fact that, in CSI part-1, under UE dynamic TRP/{Ln} selection, the number of 2K0 may be changed dynamically, but we should have a fix bit-size for any field in CSI Part-1.
* Therefore, we have the following suggestion for R16 in red, and it seems that similar update for rel-17 is also needed.

|  |
| --- |
| …* For Rel-16 eType-II-based: where represents the indices of the *N* selected CSI-RS resources (out of the *NTRP*configured CSI-RS resources)
	+ Notes: K0 denotes a maximum number of non-zero coefficients summed for one layer;
	+ FFS: bit-size of the field of #NZ coefficients, considering dynamic selection of TRP/TRP-group and {Ln} by UE

… |

[Mod: The revised proposal makes it not dynamic anymore. The 1st note is not needed since K0 is clearly defined in previous agreement just as you spelled it out. We don’t need to develop a habit of repeating previous agreements in Notes]**Proposal 1.F.2:**The following bullet is unclear for us. What’s the legacy specification? In our views, the legacy specification may mean that we need to provide NTRP>1 NZP-IMR and/or ZP-IMR which corresponds to respective CMRs. But, after reviewing FL’s observation from companies input, the meaning of the follow may refer to that only one ZP-IMR + NZP-IMR should be supported, regardless of number of CMRs to be configured.

|  |
| --- |
| * 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
 |

[Mod: I have moved this issue to 1.6.7 so I assume you can agree to this proposal]**Proposal 1.F.3:**Besides for above candidates, additional UE capability signalling may be needed.[Mod: Of course, but we haven’t started UE feature yet No need to add this note]**Proposal 1.F.4:** Support.**Question 1.6.5:** Based on latest agreement, the motivation of introducing R=4 may be unclear.**Question 1.6.6:** We suggest that the following information can be configured by gNB for assisting UE selection:* #1 minimum number of CSI-RS resource(s) to be reported
	+ From gNB perspective, we should guarantee that the number of selected CSI-RS should not be too small (e.g., always N=1 is reported)
* #2 candidate combination(s) of TRP(s) which can be reported, that is, the TRP selection should be from the candidate combinations of TRP(s).

**Conclusion 1.G:*** Regarding CSI-RS resource selection bitmap, we think that the field may be non-existent if NTRP=1. It does not make sense that we still to report the ‘1’-bit bitmap in such case.
* Regarding N Bitmap(s) per layer. A short comment: it seems, regardless of RI, the size should be per layer per CSI-RS. As you see, v in Pv is based on the reported rank rather than ‘i-th layer’.

|  |
| --- |
| For RI=1-4: for layer *l* and CSI-RS resource *n*, size-… |

[Mod: Thanks, fully agree this is more concise. Done]  |
| Lenovo/ MotM | **Question 1.5:**Support Alt1. **Proposal 1.F.1/2/3:**Support**Question 1.6.5:**Do not support adding R=4**Question 1.6.6:**We believe network vendors should weigh in on whether further RRC restriction of TRP selection is needed**Question 1.G:**Agree with ZTE’s commen regarding the TRP bitmap when NTRP=1 |
| Mod V15 | **Revision per inputs****Added issue 1.6.7 to separate IM issue**  |
| NTT DOCOMO | **Question 1.5:**Prefer Alt1. **Proposal 1.F.1:**For the updated proposal, it still needs to clarify the meaning of {Ln} if multiple sets of {Ln} are configured, e.g., the max configured Ln value per CMR?**Proposal 1.F.2/3/4:**Support.**Question 1.6.5:**Do not support R=4.**Question 1.6.6:**Slightly prefer no further configuration.**Question 1.6.7:**Support Alt1. And we do not think we need to call Alt1 the legacy specification as multiple CMR configuration for CJT and its IMR configuration is a new feature.[Mod: True, legacy only in the sense of 1 IMR. Please check conclusion 1.F.7]**Question 1.G:**Support. |
| Xiaomi | **Question 1.5**Support Alt1, i.e., reuse FD permutation as Rel-16-analogous.**Proposal 1.F. 1**Support**Proposal 1.F.2**For Rel-17 NCJT CSI, there are up two resources. However, for CJT mTRP, there are up four resources. It needs to study how to configure the NTRP resources. E.g., when NTRP =3 and the NTRP are configured within two adjacent slots, the first two resources are configured in the first slot, while the third resource is configured in the second adjacent slot. Or, the first resource is configured in the first slot and the remained resources are configured in the second slot.In our understanding, how to configure NTRP resources needs to consider the total number of CSI-RS ports as well. As show in the following table, if the total number of CSI-RS ports is less than the threshold value Pth, e.g., Pth = 48, it is feasible that all the resources (the green highlight part) are configured in one slot. Otherwise, two slots are required for the NTRP resources configuration. The value Pth can be FFS.

|  |  |
| --- | --- |
|  | NTRP |
| 2 | 3 | 4 |
| P | 4 | 8 | 12 | 16 |
| 8 | 16 | 24 | 32 |
| 12 | 24 | 36 | 48 |
| 16 | 32 | 48 | 64 |
| 24 | 48 | 72 | 96 |
| 32 | 64 | 96 | 128 |

[Mod: Sadly we have 2 meetings left and have no luxury to study. So either we fully reuse the legacy restriction from Rel-17 NCJT CSI or (if no consensus) no restriction ]**Proposal 1.F. 3**We are fine with this proposal**Proposal 1.F. 4**We would like to clarify that if NL = 3 is supported, only 3 SD combos with same **Ltot** can be configured together, or 3 SD combos with same or different **Ltot** can be configured together? We don’t think there is a restriction on only same **Ltot** can be configured together. **[Mod: Since the proposal doesn’t say anything about having the same Ltot for the 3, NL=3 can also be used by NW to configure 3 SD combos with possibly different Ltot]****Question 1.6. 5**We prefer not to add additional value.**Question 1.6. 6**We prefer no other restriction.**Question 1.6. 7**We prefer >1 IMRs for different selected TRPs. If only 1 IMR is supported, the interference from the non-selected TRP can’t be calculated correctly. |
| Mod V19 | **No revision** |
| OPPO | **Question 1.5:**We prefer to reuse legacy P(m).**Proposal 1.F.1:**The value of Ln needs further clarification, e.g. the configured Ln combination with largest as suggested by HW.**Proposal 1.F.2:**We are fine with the proposal. But the difference between Alt2 and Alt3 is unclear to us, can any company clarify?[Mod: Me either. The two came from Qualcomm and Huawei. It is OK at this stage. We will discuss this OFFLINE and if they can be merged it’s better]**Proposal 1.F.3:**Fine. **Proposal 1.F.4:**Fine. **Question 1.6.5:**Do not support R=4.**Question 1.6.6:**We cannot see the necessity. More discussion is needed. **Question 1.6.7:**Support Alt1 if the intention is that one IMR for a set of CMRs for CJT. It should be noticed that for NCJT, one IMR can be configured per CMR and it is also legacy.[Mod: Correct, please see conclusion 1.F.7] |
| vivo | **Proposal 1.F.1**We suggest to FFS for now, as this implies K0 is dynamically changed following UCI parameters in Part 1. On the other hand, K\_nz is also reported in part 1, and its bit-width depends on K0 as in the current specification. Hence we suggest to further assess which is better, i.e., to revise the bit-width of K\_nz, or to revise the definition of K0.The updated one looks fine.**Proposal 1.F.2**We think to enable gNB’s accurate controlling of the SNR range UE can see, it is better to use one common power offset value for multiple CSI-RS resources. To achieve same power offset for multiple resources, we does not need to introduce a new RRC parameter for that. Instead, we can set a rule that all the resources follow the power offset configured for one of the NTRP CSI-RS resources (e.g., the first one). Further, this does not require new RRC parameter and can facilitate the configured CSI-RS resource to be reused by other UEs or use cases.Therefore, we propose to add a new alt as follows.Alt 5: The UE can assume that the PDSCH EPRE for a given CSI-RS port follows the *powerControlOffset* value for one of the configured NTRP CSI-RS resources**Proposal 1.F.3**OK**Proposal 1.F.4**It may not be a good idea to re-open the parameter combination discussion. Hence we prefer not to introduce NL=3.**Question 1.6.5**Based on our evaluation, R=4 does not provide clear gain over R=2. Hence we don’t support R=4.**Question 1.6.6**We think the current mechanism is sufficient. There is no need to further introduce RRC configured TRP selection restriction.**Question 1.6.7**Alt 1 |
| Huawei, HiSilicon | For issue 1.6.6, similar view with NEC and ZTE, it can be configured that at least a sub-set of TRPs should be selected.For issue 1.6.7, we suggest to re-use the interference measurement for NCJT, that the TRPs not selected are also considered as interference. |
| Fujitsu | **Question 1.5:**We prefer to reuse legacy P(m).**Proposal 1.F.2:**For CMR restriction commented by Xiaomi, we think the legacy restriction for NCJT on multiple CMRSs in one DRX active time can be reused greatly for CJT. And there seems no problems even for max port numbers, e.g., 32\*4=128 ports.Re TS38.214 equation for CQI calculation in ‘Note’, we agree with the association should be refined by the CSI RS ports cross N CMRs with v PDSCH layers. However, as commented by Qualcomm, the current version has to N\*P ports indexing additionally. Thus, our suggestion is to refine TS38.214 equation for CQI calculation as shown below, which is simplest solution for CQI calculation.where  is a vector of PDSCH symbols from the layer mapping defined in Clause 7.3.1.4 of [4, TS 38.211],  is the number of CSI-RS ports. is the *j* signal equivalent to corresponding symbols transmitted on antenna ports [3000,…, 3000+P-1]. are associated to *N* CMRs selected by UE.[Mod: This proposal shouldn’t be intended for me since it is strictly spec-related formatting 😊 Please make this proposal when the first CR on 38.214 is available, i.e. after RAN1#113. I cannot include this proposal.]**Proposal 1.F.3 and 1.F.4:**Support. **Question 1.6.5:**Do not support R=4.**Question 1.6.7:**We prefer Alt 1. |
| Ericsson | **On Proposal 1.F.1**,Wonder what happens when NL {Ln} combinations are configured. In that case, may be we can simply use the among the NL combinations that results in the largest K0.[Mod: Added]**On Proposal 1.F.3**, Support.**On Proposal 1.F.4**, Support.**Question 1.6.5,** we do not support additional values of R due to large overhead associated with it.**Question 1.6.6,** Do not see the need for other RRC-configured TRP selection restriction. So, we do not support other RRC-configured TRP selection restriction.**Question 1.6.7,** Alt 1. |
| Mod V30 | **Added proposal 1.E.2, conclusions 1.F.5/6/7** |
| CATT | Support proposal 1.E.2, 1.F.1, 1.F.3, 1.F.4, 1.F.5.**Proposal 1.F.2:**Alt3 is not clearly formulated. What is averagePDSCH-to-averageCSIRS EPRE?**Issue 1.6.6**We share similar view with HW, NEC, ZTE that a subset of TRPs that should be selected can be configured by gNB. |
| ZTE | **Proposal 1.F.1:** For determining the payload/bit-size of *KNZ,TOT*, we tend to agree this updated proposal which can guarantee the fixed size of field of # NZ coefficients. Then, as an upper bound of maximum number of NZ coefficients, we have different views, and the original proposal from the FL more makes sense. Firstly, please review the following paragraphs as for eTypeII CSI in TS 38.214. If going with current proposal, and if UE chooses N=1 TRPs from 4TRPs, the upper bound of “ with the largest resulting from the *NL* configured {*Ln*} combinations” will be very high, and even may be larger than the total number of bits of ‘bitmap’ corresponding N=1 TRP.

|  |
| --- |
| Let . The bitmap whose nonzero bits identify which coefficients in and are reported, is indicated by for , such that is the number of nonzero coefficients for layer and is the total number of nonzero coefficients.  |

Therefore, for payload, i.e., determining KNZ,TOT, we can go with the current proposal, but for K0, we need to use the legacy one, i.e., being based on N, rather than NTRPSo, please review the following update (red part is from original proposal from FL). **Proposal 1.F.1**: For the Rel-18 Type-II codebook refinement for CJT mTRP,* For Rel-16 eType-II-based: where represents the indices of the *N* selected CSI-RS resources (out of the *NTRP*configured CSI-RS resources)
	+ The bitsize of # NZ coefficients in CSI part-1 is determined according to with the largest resulting from the *NL* configured {*Ln*} combinations
* For Rel-17 FeType-II-based:  where represents the indices of the *N* selected CSI-RS resources (out of the *NTRP*configured CSI-RS resources)
	+ The bitsize of # NZ coefficients field in CSI part-1 is determined according to with the largest resulting from the *NL* configured {} combinations
	+ Note: and .

[Mod: Reworded this in a much simpler manner in V2] |
| Mod V33 | **Per offline input and request from ZTE, please select between V1 and V2 of proposal 1.F.1** |
| Samsung | **Proposal 1.F.1**We support V2, since K0 should be based on N but not on NTRP. The effective value of the upper bound based on when, e.g., UE chooses N=1 TRPs from 4TRPs, becomes , which makes the possible range of . It is not relevant to what we have been treating as so far (it should act as 1). |
| MediaTek | **Conclusion 1.F.5, 1.F.6 and 1.F.7:** Support**Proposal 1.F.4**: Prefer not to support new configurations with NL=3. |
| Huawei, HiSilicon | For issue 1.6.1, we support V1. As gNB will allocate the UCI resource (PUSCH) according to the worst case (N\_TRP), there’s no saving of overhead by K0 based on N. And as there are several very small beta agreed, if UE reporting only 1 TRP, the #NZC reported will be even smaller than single TRP, which may make the performance less than single-TRP.In current spec, the K0 is related to M1, if we reuse the legacy, shouldn’t the equation be like ?(38.214, section 5.2.2.2.5)Let . The bitmap whose nonzero bits identify which coefficients in and are reported, is indicated by [Mod: True 😊] |
| Qualcomm | **Proposal 1.F.2**Per @CATT’s comments on Alt3, some rewording:

|  |
| --- |
| * + Alt3. The UE can assume that the PDSCH EPRE for a given CSI-RS port follows a commonly configured *powerControlOffset* value defined as averagePDSCH-to-averageCSIRS EPRE ratio, where averagePDSCH and averageCSIRS are average power across all the *N* selected CSI-RS resources
 |

Seems this is no different from Huawei’s proposed Alt4 – but only my understanding[Mod: I combined Alt3 and 4 while keeping both Qualcomm and Huawei wordings – yes I thought they erre equivalent as OPPO said, thanks for confirming] |
| Fujitsu | **Proposal 1.F.2:**If the specific mapping equation to be handled in CR is a consensus among most companies, we intend to agree this can be discussed in CR phase. However, the current “Note” is directly for re-indexing of all the CMR ports. In order not to cause ambiguity and limit too much in the later CR stage, we suggest some revises as shown below.[Mod: OK}

|  |
| --- |
| Note: ~~P is~~ The total number of CSI-RS ports summed across *N* selected (out of the configured *NTRP*) CSI-RS resources is used in the TS38.214 equation for CSI calculation.~~:~~  |

 |
| Mod V42  | **Editorial revision for 1.F.2** |
| Mod V45 | **Moved the following to email endorsement 5: 1.E.2, 1.F.2/3/4/5/6/7,**  |
| Ericsson | on **Issue 1.6.1**, we prefer Version 2. |
| Samsung | **Proposal 1.F.1**On some of HW’s comments: We also think is better since it guarantees the same upper bound value of NZCs regardless of rank value. If we use , for the case of rank=3,4, the upper bound value of NZCs will be reduced by a half compared to the case of rank=1,2 (when one of the first four FD combos is configured, e.g., pv=1/4 for v=1,2, pv=1/8 for v=3,4). In general, representing high-rank channel needs more NZCs than (or at least the same NZCs as) representing low-rank channel. We have concern on that the current form of upper bound is likely to yield performance degradation for the high-rank case.[Mod: Agree. Changed Mv to M1]  |
| Nokia/NSB | **Proposal 1.F.1**We prefer version 2, with replacing for Rel16-based, as per legacy, Version 2 gives a tighter definition of . Basically, version 1 is used only to determine the payload size in part 1**[Mod: Changed Mv to M1]** |
| Mod V52 | **Changed Mv to M1 following legacy in 1.F.1** |
| Intel | For **Issue 1.6.1**, our preference is V2. |
| AT&T | **Proposal 1.E.2:** OK**Proposal 1.F.1/2/3/4:** OK |

### 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 G1**FL Note**: **MOVED TO EMAIL ENDORSEMENT 5** | **Proposal 2.E:*** **Support/fine:** Qualcomm, vivo, ZTE, NEC, Fujitsu, OPPO, Ericsson, LG, Lenovo/MotM, Xiaomi, OPPO, CATT, MediaTek
* **Not support:** Samsung, Intel

**Alt1 (DDBI in G0):** Samsung, Xiaomi (1st), Intel, **Alt2 (DDBI in G1):** Qualcomm, vivo, ZTE, NEC, Fujitsu, OPPO, Ericsson, LG, Lenovo/MotM, Xiaomi(2nd), Huawei/HiSi |
| 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:
* For Rel-17 FeType-II-based:
	+ Note: and .

**MOVED TO EMAIL ENDORSEMENT 5** | **Proposal 2.F.1**: * **Support/fine:** Samsung, LG, Qualcomm, ZTE, [Xiaomi], OPPO, vivo, Huawei/HiSi, Ericsson, CATT, MediaTek
* **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
* [All the K configured CSI-RS resources comprising the CMR share the same BW and RE locations]
* 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, i.e. only one NZP CSI-RS for interference measurement or only one CSI-IM can be configured irrespective of the value of K
* On PDSCH EPRE assumption for CQI calculation, a same *powerControlOffset* value is assumed for all the K configured CSI-RS resources comprising the CMR
	+ Alt 1: The configured *powerControlOffset* value is the same for all the K configured CSI-RS resources comprising the CMR
	+ Alt 2: The assumed PDSCH EPRE of all the K CSI-RS resources follows the configured *powerControlOffset* value of one fixed CSI-RS resource, e.g. the first one

Note: This may imply that existing section 5.2.2.2.7 of TS38.214 can apply to Rel-18 Type-II Doppler codebook in terms of Rel-18 CMR (burst of CSI-RS resources) and Rel-18 CSI reference resource**FL Note**: **MOVED TO EMAIL ENDORSEMENT 5** | **Proposal 2.F.2**: * **Support/fine:** LG, Samsung, Qualcomm, Xiaomi, OPPO, vivo, Huawei/HiSi, Ericsson, CATT,
* **Not support:**
 |
| 2.6.3 | **Proposal 2.F.3**: For the Type-II codebook refinement for high/medium velocities, regarding the required number and/or occupation time of CPUs, the values of Z/Z’, and total number active/simultaneous CSI-RS resource/ports, 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, UE-side prediction based on multiple CSI-RS occasions before CSI triggering, and, when the configured N4 value is >1, DD compression

**FL Note**: **MOVED TO EMAIL ENDORSEMENT 5** | **Proposal 2.F.3**: * **Support/fine:** Qualcomm, ZTE, OPPO, Huawei/HiSi, Ericsson, MediaTek
* **Not support:**
 |
| 2.6.4 | **Question 2.6.4:** For the Type-II codebook refinement for high/medium velocities, regarding SCI definition, should the index remapping scheme analogous to that for FD basis be used for DD basis as well, thereby facilitating the use of -bit indicator (rather than -bit) irrespective of the value of Q (1 or 2)?**FL Note**: There seems no disadvantage of using index remapping for DD basis (?) | **Yes:** Nokia/NSB,**No:** Samsung, Lenovo/MotM |
| 2.6.5 | **Question 2.6.5:** * A: Should X=2 be supported for N4=1, and if so, what would be the scheme (since the current agreement for X=2 requires N4>1\_?
* B: If the answer to A is NO, should the following additional restriction beyond the current agreements for d values be introduced: for N4=1, support only d=1?

**FL Note**: The two questions inquire of some additional spec supports (agreements) beyond what we current have | **X=2 for N4=1:*** **Yes:** Samsung (no scheme mentioned)
* **No:** Lenovo/MotM, Ericsson, Nokia/NSB,

**d=1 only for N4=1?*** **Yes:** Samsung
* **No:** Lenovo/MotM,
 |
| 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  | Complete  |
| Wideband CQI for the second TD CQI | Part 2 | Only applicable for X=2 (same format as CQIs for 2CW when RI>4 in R15)  | Complete |
| Subband CQI for the second TD CQI | Part 2 | Only applicable for X=2 (same format as CQIs for 2CW when RI>4 in R15)  | Complete |
| 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 -bit indicator for the strongest coefficient index RI>1: See Table 2 above | Complete  |
| SD basis subset selection indicator  | Part 2 | SD basis subset selection indicator is a -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 -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 (only X=1 TD CQI is supported) | Complete  |
| Bitmap per layer | Part 2 | Same as R17 eType-II | Complete |
| Strongest coefficient indicator (SCI) | Part 2 | For layer *l*: A -bit indicator for the strongest coefficient index | Complete |
| SD basis subset (port) selection indicator  | Part 2 | SD basis subset selection indicator is a -bit indicator. where , Details follow Rel.17 | Complete |
| FD basis subset selection indicator | Part 2 | a bit indicator only if *N>M=2,* where is configured with the higher-layer parameter *valueOfN,* when . | 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 is a –bit () indicator. The location (index) of the strongest LC coefficient for layer before index remapping is  , indicates and is not reportedFor Rel-17-based, only Q=1 is supported  |
| Index remapping | For layer , the index of each nonzero LC coefficient is remapped with respect to to such that . The FD basis index associated to each nonzero LC coefficient is remapped with respect to to such that . The sets and are reported.Informative note (for the purpose of reference procedure):The index of nonzero LC coefficients is remapped as . The codebook index associated with nonzero LC coefficient index is remapped as .  |
| Combinatorial indicator for  |  bits  |
| Combinatorial indicator for  |  bits  |
|  | 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** |
| LG | Q2.5: We support Alt 2.Proposal 2.F.1, 2.F.2: supportProposal 2.F.3:We also need to consider the fact that the antenna ports for the same antenna port index across the K AP CSI-RS resources are the same. It also has an impact on complexity because K CMRs shows a time varying channel, not K independent channels.**[Mod: I agree. But this hasn’t been agreed. We can add this once 2.F.2 is agreed]****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
* The antenna ports for the same antenna port index across the K CSI-RS resources are the same.
 |
| NEC | **Question 2.5**Support G1, as DD basis has lower priority than FD basis. |
| Qualcomm | **Proposal 2.F.1**Since Rel-17 CB only supports N4=1, [Mod: Thanks for the catch, I removed Q in Rel-17 equation]my understanding is, 214 may not need a new 5.2.2.2.x for Rel-17-based Type-II-Doppler, but can simply say existing 5.2.2.2.7 FeType-II can apply to:* Rel-18 CMR i.e. burst of CSI-RS resources
* Rel-18 CSI reference resource (first slot of WCSI, i.e. PUSCH slot + )

Other than the above 2 bullets, seems no additional spec impact is needed for Rel-17-based (same comments apply to **Conclusion 2.G**)**[Mod: We don’t usually make an agreement that dictates what spec editor should do. Rather we make agreements on features. I gather you have no issue with the content. To accommodate your comment I added a note that this “may” imply that the section applies.]****Proposal 2.F.2 and .3**Fine**Conclusion 2.G**One question, per agreements, given that Rel-17 CB only supports N4=1, do we still have X=2 CQIs?**[Mod: Yes. The agreement on X is not conditioned on N4 value. N4=1 means that UE-side prediction and its associated features are supported w/o Doppler compression][Mod: Correction. The answr is no as Huawei commented]** |
| ZTE | **Proposal 2.F.1**: Support**Proposal 2.F.2**: Similar comment as proposal 1.F.2. We suggest to clarify the case that only one NZP-IMR and ZP-IMR is supported, regardless of value of ‘K’[Mod: Done]**Proposal 2.F.3**: Support**Conclusion 2.G**: Support. |
| Lenovo/ MotM | **Proposal 2.E:**Support Alt2 based on the agreement to assign DD basis with the lowest priority, agree with vivo’s comment **Proposal 2.F.1/2/3:**Support**Conclusion 2.G:**Same question as QC on applicability of X=2 CQIs for Rel-17 CB with N4=1, given that it would require a new UCI mapping order of CSI fields. Our understanding is that X=2 CQIs only applies to Rel-16 based CB, but we would appreciate the FL and companies sharing their views on that**[Mod: You are correct]** |
| Mod V15 | **Minor editorial revision per comments****Added proposal 2.E** |
| Xiaomi | **Question 2.5**We support Alt1 as there are up to 3 bits per layer for indicating the selected DD basis. gNB can utilize the obtained DD basis to determine whether to configure N4=1. For Alt 2, it is our second preference considering it has agreed that priority of DD basis is lower than that of FD basis.**Proposal 2.F.1:**Support.For Rel-16 eType-II-based, should be equal to , hich reuse legacy method. If is adopted, the total number of NZC may be too less due to pv=1/8 or 1/4 when v>2.[Mod: Sorry bit this is incorrect. Legacy spec for Rel-16 eType-II uses Mv and yes, K0 (per layer) is dependent on RI. This is a well-known fact]**Proposal 2.F.2**:Support**Conclusion 2.G**:Regarding SCI for RI>1, we think -bit is enough to indicate the strongest coefficient through DD basis permutation and remapping. [Mod: This is true for Rel-17, but not for Rel-16-based (since Q=2 is supported. I will add clarification][Mod: Correction: sorry you are right after re-indexing as Huawei commented] |
| Mod V19 | **No revision, added minor clarification on Table 3E** |
| OPPO | **Proposal 2.E:** support**Proposal 2.F.1/3:** support. **Proposal 2.F.2:** support.We think R18 reporting window is also applicable to R17 CB. |
| vivo | **Proposal 2.F.1**OK**Proposal 2.F.2**In order to perform UE CSI prediction, we agree that it is needed to use a same power offset for CSI-RS resources. But to achieve this, one way is to limit the per-resource power offset configuration is same for K resources. Another way is the configuration can still be resource-specific, but for UE prediction CSI calculation, a same power offset (e.g., the power offset of the first resource) is used. The benefit of the second way is the configured CSI-RS resources for Type II Doppler can be reused for other use cases.Hence we suggest the following revision.**Proposal 2.F.2**: For the Rel-18 Type-II codebook refinement for high/medium velocities, regarding CSI calculation and measurement, * …
* …
* On PDSCH EPRE assumption for CQI calculation, a same *powerControlOffset* value is assumed for all the K configured CSI-RS resources comprising the CMR
	+ Alt 1: The configured *powerControlOffset* value is the same for all the K configured CSI-RS resources comprising the CMR
	+ Alt 2: The assumed PDSCH EPRE of all the K CSI-RS resources follows the configured *powerControlOffset* value of one CSI-RS resource

Further, as the transmission power of CSI-RS resources can also be different among K resources, which is configured by *powerControlOffsetSS*. We also need to take that into account for UE prediction. For example, if one resource (with channel H1) has *powerControlOffsetSS* as 0dB, and the second resource (with channel H2) has *powerControlOffsetSS* as 6dB, UE needs to compensate the Tx power when performing UE prediction, using either [H1, H2/2] or [2H1, H2]. Then for [H1, H2/2] or [2H1, H2], CQI calculation for PDSCH will be different if we follow Alt 1. Hence there would be ambiguity between gNB and UE. However, if we follow Alt 2, [H1, H2/2] or [2H1, H2] leads to same CQI, which will not cause any ambiguity.[Mod: OK]**Proposal 2.F.3**For CPU, as UE needs to perform CSI prediction based on the measurement on a number of CSI-RS occasions before CSI triggering for periodic CSI-RS, this also brings extra UE buffering and processing cost. Hence we suggest the following revision.**Proposal 2.F.3**: For the Type-II codebook refinement for high/medium velocities, regarding the required number and/or occupation time 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, UE-side prediction based on multiple CSI-RS occasions before CSI triggering, and, when the configured N4 value is >1, DD compression

[Mod: OK] |
| Huawei, HiSilicon | For issue 2.5, this is related to whether the SCI of DD basis is re-indexed to 0. From the UCI omission, the DD basis with index 0 (DC) is of higher priority, which implies the SCI is re-indexed to 0. In such case, Alt 2 is more reasonable.For issue 2.6.1, we are fine with proposal 2.F.1.For issue 2.6.2, we are fine with proposal 2.F.2. For issue 2.6.3, we are fine with proposal 2.F.3.For issue 2.7, conclusion 2.G,* Table 3C, for SCI, since the FD basis and DD basis have been re-indexed to 0, should the bit width of the indicator be as legacy?

[Mod: Thanks, you are correct, fixed]* Table 3D, for subband CQI, as N4=1 for Rel-17 based, per previous agreement, there should be no X=2?
	+ X=2 and
		- The 1st CQI is associated with the first/earliest slot of the CSI reporting window (slot *l*) and the first/earliest of the *N*4 **W**2 matrices, and
		- The 2nd CQI is associated with the middle slot of the CSI reporting window (slot *l*+*WCSI*/2) and the (*N*4 /2)-th**W**2 matrix
		- FFS: Whether/how to include CQI overhead reduction for X=2

[Mod: Thanks again, you are correct again, fixed] |
| Fujitsu | **Proposal 2.F.1:** Support |
| vivo | **Conclusion 2.G**Based on the following two agreements, second TD CQI includes both WB CQI and SB CQI, and they are put in Part 2.**Agreement**For the Type-II codebook refinement for high/medium velocities, when a UE is configured with X=2 for CQI calculation and reporting, the 2nd CQI includes 4-bit wideband CQI and 2-bit sub-bands CQIs calculated independently from the 1st CQI**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

We suggest the following revision.

|  |  |  |  |
| --- | --- | --- | --- |
| Wideband CQI | Part 1 | Same as R15 | Complete |
| Subband CQI | Part 1 | Same as R15 ~~for X=1~~~~Two independent CQIs (same format as CQIs for 2CW when RI>4 in R15) for X=2~~ | Complete ~~for X=1~~ and 2 |
| Wideband CQI for the second TD CQI | Part 2 | Only applicable for X=2 (same format as CQIs for 2CW when RI>4 in R15)  | Complete |
| Subband CQI for the second TD CQI | Part 2 | Only applicable for X=2 (same format as CQIs for 2CW when RI>4 in R15)  | Complete |

[Mod: Thanks so much for this good and careful catch. Added]  |
| Ericsson | Support **Proposal 2.F.1**Support **Proposal 2.F.2**Support **Proposal 2.F.3** |
| Mod V30 | **Revision per inputs** |
| CATT | Ok with proposal 2.E, 2.F.1.**Proposal 2.F.2:**gNB needs to know which value is used by UE for CQI calculation. Alt2 does not mention which value is used. If the value is selected by UE, gNB may have problem in link adaptation.[Mod: We can discuss during down selection process] |
| Mod V33 | **No revision** |
| vivo | **Proposal 2.F.2**To CATT:The intention is to use a fixed resource as the reference to determine power control offset, e.g., the first one. We are fine to clarify this in the proposal, like followingAlt 2: The assumed PDSCH EPRE of all the K CSI-RS resources follows the configured *powerControlOffset* value of one fixed CSI-RS resource, e.g., the first one[Mod: OK] |
| MediaTek | **Proposal 2.E:** Support.**Proposal 2.F.1:** Support.**Proposal 2.F.2**: We also like to add a restriction that CSI-RS BW and RE locations, i.e.,* All the K configured CSI-RS resources comprising the CMR share the same BW and RE locations

[Mod: Added this in crackets and we can check with companies during email endorsement]We believe the added restriction will be needed for reliable channel prediction.**Proposal 2.F.3:** The wording is very confusing. We are not sure what is meant by this proposal, hence, do not support it. If the intention is to decide on the CPU rules, Z/Z’ values in RAN1#113, we agree we can discuss these issues. However, we want to refrain from any assumptions on what the CSI processing rules are based on now, we need more time to evaluate. For example, the fact that the active CSI-RS resources/ports for this codebook type needs to be captured is not mentioned, which we think is an important issue.**[Mod: Please note the use of “at least”, meaning that other relevant factors are not precluded. This proposal is simply a kick-off for discussing this issue]** |
| Mod V42 | **Editorial revision on 2.F.2** |
| Samsung | **Conclusion 2.G*** Table 3C, for SCI, yes, we have agreed to include DD basis 0, but we haven’t agreed to any re-mapping (similar to FD basis remapping). So, the bit width of the indicator should be We have the similar solution in Rel.17, where FD basis include FD basis 0 (there is no FD remapping unlike Rel.16) and SCI is bits.

[Mod: Added issue 2.6.4 for this]Re the HW comment on X=2 for N4=1, * we are not sure why X=2 can’t be supported for N4=1 and d>=2, given that we support X=2 for N4=2 and X=2.
* Besides, in our understanding, the X=2 issue for N4=1 has not been discussed. The previous agreement mainly focused DD compression case (since there were alts based on DD unit which applies only to N4>1).
* Finally, we only X=1 is supported for N4=1, then why we need to support d>1 (DD unit) for N4=1. In particular, when (legacy CSI ref resource), then X=1 will correspond to legacy slot, implying we may not to perform UE-side prediction, and perhaps, we can simply use legacy codebooks.

**[Mod: This is a new proposal. Based on the current agreement, since the support for X=2 requires N4>1 (the second W2 and slot reference), it implies that X=2 is not supported for N4=1. The condition you propose is new.****Added issue 2.6.5 for this]** |
| MediaTek | **Proposal 2.F.3:** Thank you for the clarification @FL. In that case prefer to explicitly capture the possible impact to active CSI-RS resources/ports in the proposal, similar to how its captured for CJT, i.e.,:**Proposal 2.F.3**: For the Type-II codebook refinement for high/medium velocities, regarding the required number and/or occupation time of CPU, ~~and~~ the values of Z/Z’, and total number active/simultaneous CSI-RS resource/ports, 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, UE-side prediction based on multiple CSI-RS occasions before CSI triggering, and, when the configured N4 value is >1, DD compression

[Mod: OK] |
| Mod V45 | **Moved the following to email endorsement 5: 2.E, 2.F.1/2/3****Added issues 2.6.4, 2.6.5** |
| Lenovo/ MotM | **Question 2.6.4:**We do not support DD basis index remapping.**Question 2.6.5:****Our preference is to restrict X=1 for N4=1, but not restrict to d=1 for N4=1.** - For N4=1, the same W2 matrix is applied for the entire WCSI window, and hence the CQI should be based on the same precoding matrix, with the CQI based on WCSI window.- Since “CQI shall be calculated conditioned on the reported PMI, …”, it is reasonable to condition X=2 on N4=2  |
| Ericsson | **on Question 2.6.5:**Regarding Question A, the answer is No.For Question B, we need some time to think about this. |
| Nokia/NSB | **Issue 2.6.4**We agree with FL that in our view there is no disadvantage in reusing the index remapping scheme (in both FD and DD) to obtain a -bit indicator for SCI as per legacy Rel16. So, in our view, the answer to the question is yes**Issue 2.6.5**In our view, the agreement for X=2 requires to be even so it is not applicable to . So, there is no need for additional spec support and no need for restricting d=1 when .In our understanding, the optional feature for , however does apply to as well.[Mod: Correct]* Optional features:
	+ X=1 and the CQI is associated with:
		- the first/earliest slot of the CSI reporting window (slot *l*) and the first/earliest of the *N*4 **W**2 matrices, and
		- the last slot of the CSI reporting window (slot *l*+*WCSI*–1) and the *N*4-th**W**2 matrix
	+ X=2 and
		- The 1st CQI is associated with the first/earliest slot of the CSI reporting window (slot *l*) and the first/earliest of the *N*4 **W**2 matrices, and
		- The 2nd CQI is associated with the middle slot of the CSI reporting window (slot *l*+*WCSI*/2) and the (*N*4 /2)-th**W**2 matrix
		- FFS: Whether/how to include CQI overhead reduction for X=2
 |
| Samsung | Re Q2.6.5: if we read the yellow highlighted text, which says the *N*4 **W**2 matrices (plural), implying N4>1, hence N4=1 is not included in the previous agreement. * Optional features:
	+ X=1 and the CQI is associated with:
		- the first/earliest slot of the CSI reporting window (slot *l*) and the first/earliest of the *N*4 **W**2 matrices, and
		- the last slot of the CSI reporting window (slot *l*+*WCSI*–1) and the *N*4-th**W**2 matrix
	+ X=2 and
		- The 1st CQI is associated with the first/earliest slot of the CSI reporting window (slot *l*) and the first/earliest of the *N*4 **W**2 matrices, and
		- The 2nd CQI is associated with the middle slot of the CSI reporting window (slot *l*+*WCSI*/2) and the (*N*4 /2)-th**W**2 matrix
		- FFS: Whether/how to include CQI overhead reduction for X=2

[Mod: Since it was not included in previous agreement, it clearly means it is not supported. Arguing that something isn’t included in the previous agreement hence it is not precluded simply means that you need to propose it and achieve consensus regardless whether it reverts the previous agreement or not. So, arguing for your proposal should be accepted because the previous agreement didn’t include it is a logical fallacy (essentially circular reasoning) and not compelling 😊 All you need to do is to come up with arguments (technical for instance) why your proposal is beneficial to convince the other companies.]Re the scheme for N4=1 case, we can use the scheme, we either (A) delete the text “the (*N*4 /2)-th**W**2 matrix” since there is no 2nd pre-compressed W2 in case of N4=1, Or (B) we add “if N4>1” in the previous agreement, since it only makes sense when N4>1.* + - A: The 2nd CQI is associated with the middle slot of the CSI reporting window (slot *l*+*WCSI*/2)
		- B: The 2nd CQI is associated with the middle slot of the CSI reporting window (slot *l*+*WCSI*/2) and, if N4>1, the (*N*4 /2)-th**W**2 matrix

[Mod: If you delete text A, it means the 2nd CQI has no calculation procedure (since it isn’t associated with any slot and any pre-compression W2). Deleting text B still provides a reference slot, but no reference precoder. Since CI is calculated conditioned on PMI, this still has the same issue as deleting text A. Either way, your proposed fix is not complete, or if a 2nd CQI (with large overhead) is reported, it will offer no benefit]  |
| Mod V52 | **No revision** |
| Intel | **Question 2.6.4**Yes, we think that remapping can be used to reduce the overhead and in our view there is no disadvantage of remapping (agree with FL). **Question 2.6.5**(B) We think that it is not necessary to support X = 2 for N4 =1. Also, we are not sure if any other restrictions (e.g., for d value) are needed in case of N4 = 1. |

### 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 3.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
* When one of the KTRS configured resource sets is aperiodic, the UE can assume that the aperiodic resource set is configured with QCL-Type-A and, if applicable, Type-D source with the resources of the one of the (KTRS – 1) periodic TRS resource sets
	+ Note: Following the legacy specification, no more than 1 of the KTRS resource sets is aperiodic

**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 and same (type-A/D) P-TRS QCL source for all AP-TRS”: Nokia/NSB
 | **Proposal 2.A.3:*** **Support/fine:** Samsung, Qualcomm, vivo, [ZTE], OPPO, Fujitsu, Ericsson, Nokia/NSB, [MediaTek]
* **Not support:** NEC,
 |
| 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. , where
	+ : legacy (Rel.16) based
		- Linear: legacy -PSK
		- Exponential: legacy Rel.16 amplitude, or
	+ a slope value from depending on the amplitude ) of the 1st correlation (smallest delay), e.g. the slope decreases towards 0 as increases towards 1
* Alt5. A given correlation phase value is quantized to based on the following alphabet (where denotes delay):
* Alt6. A given correlation phase value is quantized to based on the following alphabet (where denotes delay and p(.) denotes amplitude quantization values used for Rel-16 e-TypeII codebook and ):
	+ Mode 1: ,
	+ Mode 2:
	+ The quantization mode is selected by UE and reported to gNB.
* Alt7. A given correlation phase value is quantized to based on the following alphabet: , with , . TBD value(s) of

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 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 is quantized to based on the following alphabet (where denotes delay and p(.) denotes amplitude quantization values used for Rel-16 e-TypeII codebook):
	+ When : ,
	+ When :
	+ Whether or 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** |
| NEC | **Proposal 3.A.3:** Rather than restricting the QCL for the TRS sets, we’d like to assume the resources in the TRS sets with same antenna port, which has been applied for the resources in one TRS set in current spec as:“For a *NZP-CSI-RS-ResourceSet* configured with the higher layer parameter *trs-Info*, the UE shall assume the antenna port with the same port index of the configured NZP CSI-RS resources in the *NZP-CSI-RS-ResourceSet* is the same. ”**Proposal**:For the Rel-18 TRS-based TDCP reporting, for TDCP measurement and calculation, at least the following restrictions are supported:The UE shall assume the antenna port with the same port index of the configured NZP CSI-RS resources in the configured KTRS resource sets is the same. |
| Qualcomm | **Proposal 2.A.3**@ZTE: If KTRS-1 set(s) are not used for tracking (per agreement), it only causes 214 description difficulty to still name them TRS. From network Tx perspective, it may have no difference; But from UE Rx perspective, only if used for as root source of QCL-TypeA for PDxCH DMRS chanEst, would make it TRS (note than Rx assumption is exactly what QCL definition intends to). – Actually I don’t think we have different understanding regarding PDxCH receiving behavior related to the KTRS-1 set(s).We are OK with current 2A3 revision. |
| Lenovo/ MotM | **Proposal 3.B.3:**We understand the FL’s intention to be inclusive of all the proposals for phase quantization, however many alrernatives are not clear (specifically Alt5 and Alt6, which have been further modified compared with the version in the previous round). Is it possible that proponents of Alt5 and Alt6 provide further clarification, and more importantly, may we suggest that only alternatives with at least 2 supporting companies are considered? |
| Mod V15 | **No revision****@Alt5/6 proponents: please respond to Lenovo’s question (FL Note: the convoluted proposals seem to assume that the residual phase after DLL is close to zero, hence small positive and small negative)** |
| Samsung | **Proposal 3.B.3:** to make our proposal clear, we think for a given delay value, we can have a linear model for the phase angle (similar to legacy phase quantization), however, the range of phase values is adapted depending on reported delay values. Below can be an example in Alt4, or a new Alt7.**Linear model**: , * is a function of (note: in legacy, , and ), e.g. linear/ parabolic (), exponential (, base)
* a slope value, determined based on the amplitude ) of the 1st correlation (i.e. smallest non-zero), can be determined implicitly (without reporting) or reported

**[Mod: OK … adding Alt7 would make this proposal even more cramped so I replaced Alt4 with the above description since Alt4 was from Samsung. It seems that 3C3 becomes destabilized again with the above revision – It is quite likely that the new Alt4 will generate even more questions since although the scheme is a bit more specific, unlike Alt5/6 (already convoluted) you still leave MANY things open and e.g.’s which makes it almost impossible for other companies to cross check Samsung’s Alt4 proposal.****So my suggestion is to narrow things down and be MUCH more specific]** |
| Xiaomi | **Proposal 3.A.3**:The proposal should be indexed in proposal 3.A.3.For the note in the sub-sub-bullet, does it mean that only at most one aperiodic TRS resource set is support? We think multiple aperiodic TRS resources can be supported for TDCP reporting by different DCI triggers.**Proposal 3.B.3**:For Alt5 and Alt6, what does the mean? It needs to clarify.**[Mod: epsilon is a standard mathematical notation used to describe an arbitrary positive increment e.g. used a lot in mathematical proofs especially in Real Analysis. I added clarification that epsilon is >0]**  |
| Mod V19 | **Minor revision** |
| ZTE | **Proposal 3.B.3:**@Lenovo/ MotM: We can elaborate Alt6. As mentioned by FL, the most interested phases in quantization (phases corresponding to small delays in slow-speed scenarios) are close to zero, but small positive or small negative (depends on the direction of UE velocity). Hence, Alt6 provide two phase quantization modes, i.e., mode-1 and mode2, which are corresponding to the first and second bullets of Alt6, respectively. In mode-1, the quantization granularity is set finer for the positive phases around 0. While in mode-2, the quantization granularity is set finer for the negative phases around 0 (or, equivalently around 2pi). UE can decide which quantization mode is adopted, and which is indicated by a 1-bit indicator reported to gNB.To be clearer, when the bitwidth is 3 or 4, the specified phase quantization levels of Alt6 are listed in the following table.**Table** Specified phase quantization levels with quantization bitwidth n = 3, 4(the quantization levels are normalized by 2)

|  |  |  |
| --- | --- | --- |
| Phase indicator | Bitwidth = 3 | Bitwidth = 3 |
| mode-0 | mode-2 | mode-1 | mode-2 |
| 0 | 0.5000 | 0.5000 | 0.2929 | 0.7071 |
| 1 | 0.7500 | 0.2500 | 0.5000 | 0.3536 |
| 2 | 0.8750 | 0.1250 | 0.6464 | 0.5000 |
| 3 | 0.9375 | 0.0625 | 0.7500 | 0.2500 |
| 4 | 0.9688 | 0.0312 | 0.8232 | 0.1768 |
| 5 | 0.9844 | 0.0156 | 0.8750 | 0.1250 |
| 6 | 0.9922 | 0.0078 | 0.9116 | 0.0884 |
| 7 | 1.0000 | 0 | 0.9375 | 0.0625 |
| 8 |  |  | 0.9558 | 0.0442 |
| 9 |  |  | 0.9688 | 0.0312 |
| 10 |  |  | 0.9779 | 0.0221 |
| 11 |  |  | 0.9844 | 0.0156 |
| 12 |  |  | 0.9890 | 0.0110 |
| 13 |  |  | 0.9922 | 0.0078 |
| 14 |  |  | 0.9945 | 0.0055 |
| 15 |  |  | 1.0000 | 0 |

 |
| OPPO | **Proposal 2.A.3**:We are generally fine with the proposal. However, the second sub-bullet for the second bullet in red seems not related to the bullet. Maybe we needed “or not” at the end.**[Mod: Thanks]****Proposal 3.B.3**:Considering we have so many alternatives, if down selection cannot be done, does it mean that phase quantization and reporting is not supported?**[Mod: Correct, this is the normal RAN1 way. Sad but it surely seems absolutely possible with the growing # of unnecessarily fancy and open-ended (general) alternatives]** |
| Fujitsu | **Proposal 3.A.3**: Support. |
| Ericsson | We are ok with **Proposal 3.A.3****Proposal 3.B.3**Agree with the revised Alt 5 from the FL. Note that Alt 5 is a fixed non-linear phase quantization scheme. It is not adaptive. The reason for proposing non-linear phase quantization is that after CFO compensation at the UE, the phase may be more non-linear.@Lenovo/MotM: We have simplified Alt 5 above. As clarified above, it is a fixed non-linear quantization scheme. As mentioned by the FL, after CFO compensation at the UE, the phase may be more non-linear. We do not have any throughput values available for phase quantization scheme for the agreed use cases. So, we do not think it is a good idea to start counting companies when there are no results available. As this is the first time we are discussing the phase quantization schemes, it is good to list the alternatives that can be simulated until next meeting. |
| Mod V30 | **No revision** |
| MediaTek | **Proposal 3.A.3** We believe important factors which highlighted previously are not captured yet, which is the power offset settings. @FL, can you please confirm that powerControlOffset and powerControlOffsetSS. Restrictions will be discussed? If the current proposal on restriction means power offset is not going to discussed later, we can not support it. [Mod: This proposal was made because QCL was the most mentioned topic for restriction. I only received 1 vague input on power control so I don’t have enough “data” to make any proposal for such. Since we haven’t concluded no support, you are still free to propose it. If there is consensus, it can be supported. This can be done in the next meeting (please come up with one for RAN1#113)] **Proposal 3.B.3**: We do not support Alt 5 and 6, these are over complicated designs and should be avoided in future discussions, especially given the limited time left for completing R18 features. |
| Lenovo/ MotM | We would like to thank Samsung, Ericsson and ZTE for clarifying Alt4/5/6, respectively. @Ericsson: we understand your comment, however the concern here is the growing number of alternatives. We are OK with the current list but we hope the number of alternatives does not grow beyond 6. [Mod: I echo 😊 that] |
| ZTE | **Proposal 3.A.3:**@MTK: Based on our evaluation, Alt6 shows better performance over legacy uniform quantization schemes (e.g., 8-psk and 16-psk) using aligned quantization overhead. I think companies can do more evaluation, and make the decision later (at next meeting).Besides, to make Alt6 clearer and more straightforward, we prefer the following description:* Alt6. A given correlation phase value is quantized to based on the following alphabet (where denotes delay and p(.) denotes amplitude quantization values used for Rel-16 e-TypeII codebook ~~and~~ ):
	+ Mode-1: ,
	+ Mode-2:
	+ The quantization mode is selected by UE and reported to gNB.

[Mod: It seems just as what Samsung did, you just managed to re-destabilize 3.C.3 😊 I don’t see how this description makes Alt6 “clearer and more straightforward” but I’ll just take your proposed wording since it is your proposal.] |
| Mod V42 | **Revised 3.A.3 per ZTE input** |
| Samsung | P 3.B.3: per the FL’s comment, we simply Alt4 as below* Alt4. Adaptive/gNB-configurable phase quantizer e.g. , where
	+ : legacy (Rel.16) based
		- Linear: legacy -PSK
		- Exponential: legacy Rel.16 amplitude, or
	+ a slope value from depending on the amplitude ) of the 1st correlation (smallest delay), e.g. the slope decreases towards 0 as increases towards 1

**[Mod: Check my comment for ZTE – similar remark]** |
| MediaTek | **Proposal 3.A.3:** Thank you for the comments @FL. In that case perhaps we need clarifications on what is meant by “first periodic TRS resource set”, for example in the sub-bullet, i.e.,* + That the QCL source of KTRS-1 resource sets is the first periodic TRS resource set (QCL-source inheritance) is not precluded

[Mod: reworded]The is the first set, the set with the lowest ID? Or based on the order that is configured at RRC? Also regarding the above sub-bullet it is a bit hard for us to follow; are we trying to say that the case where the remaining KTRS-1 resource sets having the first P-TRS as their QCL source is not precluded?We believe we do not need the sub-bullet mentioned above. Since the QCL information are configured at RRC, specifically for P-TRS, and UE doesn’t need to make any assumption and rules on how to tie down QCL sources. If the QCL sources for different sets are conflicting, then UE will drop the TDCP report. Are we suggesting in the conflicting QCL sources, the UE to override the QCL source configured at RRC and compute the TDCP? Or are we trying to introduce a new QCL rules?[Mod: I tend to agree with you that we don’t need it, removed] |
| Mod V45 | **No revision** |
| Nokia/NSB | Proposal 3.A.3* The bullet point after the note on supporting a single aperiodic TRS seems contradicting the note, so we suggest removing it.
* We suggest rewording the second bullet for clarity. Now that we have a single aperiodic TRS, this is QCLed to one of the periodic TRSs as per legacy
* We suggest replacing ‘first’ with a more generic ‘one of the’, because it may not be clear what order is assumed (order in the CSI-ResourceConfig or resource set ID order..)

**Proposal 3.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~~ one of the 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 aperiodic resource set ~~share a same~~ is configured with QCL-Type-A and, if applicable, Type-D ~~source as~~ ~~the first~~ with the resources of one of the -1 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 + (K~~~~TRS~~ ~~– 1) aperiodic resource set(s) should be supported or not~~

[Mod: OK, thanks this is better]Finally, on the first bullet, is the understanding correct that a UE may assume that either all the TRSs share the same QCL source, or periodic TRSs are QCLed with one of the periodic TRSs?Do we really need both assumptions, or can we just down-select one?[Mod: The intention of the proposal is to support both, not to down-select]**Proposal 3.A.3**Sorry FL and Lenovo, but we feel compelled to suggest adding a 7th simple alternative, which is a straightforward extension of legacy R16 (i.e. Alt3). Basically, it’s a uniform phase quantiser between and , with midpoint 0 and value(s) of TBD. In fact, Alt3 is a special case with . In our view, this solution achieves similar results as Alt4,5,6 but in a simpler way.Alt7. A given correlation phase value is quantized to based on the following alphabet: , with , . TBD value(s) of [Mod: The excitement over this already optional feature that can be turned on/off seems quite contagious 😊] |
| Mod V52 | **Revised proposals per input** |

# References