**3GPP TSG RAN WG1 #109-e R1-2205470**

**e-Meeting, May 9th – 20th, 2022**

**Agenda item:** 9.1.2

**Source:** Moderator (Samsung)

**Title:** Moderator Summary#5 on Rel-18 CSI enhancements: ROUND 5

**Document for:** Discussion and Decision

## Introduction

The scope given in the Rel-18 NR Evolved MIMO WID [1] 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 |

## Summary of companies’ views

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

Table 1A Summary: issue 1

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| **#** | **Issue** | **Companies’ views** |
| 1.3 | Work scope: Rel-16/17 Type-II codebook/PMI components to be refined or reused for CJT extension   1. SD and FD basis vector designs (not precluding adding new values of N1, N2, N3) 2. SD and FD basis selection schemes (not precluding per-TRP or joint-across-TRPs selection, this refers to, e.g. the combinatorial indication and two-step FD basis selection) 3. W2 coefficient quantization scheme   **FL Note**: Considering work scope and continuity with legacy design (some already being deployed), we should strive for maximum reuse of legacy designs. Although one may claim that evaluation is needed to ensure whether reusing as such results in desirable performance, the above parameters are primarily “format” issue. | **1 (SD/FD basis design):**   * **Fully reuse legacy:** Huawei/HiSi (for R17), Lenovo, Samsung, Apple, DOCOMO, NEC, vivo, CMCC, Nokia/NSB, IDC, Fraunhofer IIS/Fraunhofer HHI, Intel, MTK, CATT, ZTE, CEWiT, IITK, Ericsson, Qualcomm, Xiaomi, AT&T, Sony * **Refinement:** Huawei/HiSi (Joint SD-FD eigen-vector basis for R16)   **3 (W2 quantization):**   * **Fully reuse legacy:** Samsung, Apple, vivo, CMCC, Nokia/NSB (re. co-scaling, both reference amplitudes may need reporting for TRPs other than the strongest), Intel (same as Nokia), CATT, ZTE, CEWiT, IITK, Ericsson, AT&T * **Refinement:** Xiaomi (TRP specific phase and amplitude) |

**Proposal 1.G**: On the spatial-domain (SD) and frequency-domain (FD) basis design for the Rel-16 Type-II codebook refinement for CJT mTRP, down-select from the following alternatives:

* Alt1 (separate, legacy DFT): SD basis and FD basis are separate, each fully reusing the legacy Rel-16 DFT-based design
* Alt2 (joint, DFT): joint SD-FD DFT-based basis
  + FFS: Details on DFT parameters, e.g. length, oversampling (if any), rotation (if any)
* Alt3 (joint, eigenvector): joint SD-FD eigenvector-based basis
  + FFS: eigenvector codebook design, parametrization
* Alt4 (separate, eigenvector): SD basis and FD basis are separate, using eigenvector-based basis
  + FFS: eigenvector codebook design, parameterization

**Proposal 1.H**: On the W2 coefficient quantization scheme for the Type-II codebook refinement for CJT mTRP:

* At least for N=2, reuse *the following components* of the legacy Rel-16/17 per-coefficient quantization scheme:
  + Alphabets for amplitude and phase
  + Quantization of phase and quantization of differential amplitude relative to a reference, reference amplitude (with SCI determining the location of one reference amplitude), where the reference is defined for each layer and each “group” of coefficients
* Further study the following:
  + For larger N values, if supported, whether/how to improve throughout-overhead trade-off using, e.g. lower-resolution alphabets for amplitude and/or phase than legacy, or higher/same resolution alphabets but smaller number of coefficients than legacy
  + What constitutes a “group” (e.g. per polarization across TRPs/TRP-groups, per polarization per TRP/TRP-group, per TRP/TRP-group, combination of the two), the number of “groups” per layer for phase and amplitude (1 ≤ ≤ 2N, 1 ≤ ≤ 2N), and how to indicate/configure “grouping”

Table 2 Additional inputs: issue 1

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| **Company** | **Input** |
| Mod V0 | **Share your inputs, if any, on moderator proposals** |
| Nokia/NSB | **Proposal 1.G**  We agree one alternative is enough to keep the design simple. We also support Alt1 as we don’t see a strong enough justification to depart from earlier Type-II design  **Proposal 1.H**  A small suggestion to clarify that differential quantisation applies to amplitude coefficients   * + Alphabets for amplitude and phase, quantization of differential amplitude relative to a reference, the reference defined for each layer and each polarization   [Mod: OK] |
| Lenovo | **Proposal 1.G**  Support  **Proposal 1.H**  Since for CJT the CSI report can be up to 4 time larger than that of single-TRP CSI (at N=4), in our opinion quantization should be discussed, at least in terms of the amplitude/phase codebook sizes. We do not think tuning the number of non-zero coefficients would suffice to reduce the overall CSI report size. Given that, we suggest adding a second alternative, as follows:  **Alt2: Lower resolution of amplitude and phase quantization compared with legacy Rel. 16/17 quantization are considered for N> α TRPs. FFS: value of α**  [Mod: This is a very good point since personally I think we need good overhead reduction scheme especially for N=4. Parameter combination has been proposed but quantization resolution of W2 is a valid candidate. Please check the latest version] |
| Apple | We are supportive of both proposals |
| Samsung | Proposal 1.G: support  Proposal 1.H   * We support reusing R16 quantization for differential amplitude and phase * Re the reference amplitude, we are not sure we need 2N reference amplitudes (if we follow R16 and have one reference amplitude for each polarization). We prefer to study this. Propose to revise the 2nd bullet as follows:   **Proposal 1.H**: On the W2 coefficient quantization scheme for the Type-II codebook refinement for CJT mTRP:   * Reuse the following components of the legacy Rel-16/17 per-coefficient quantization scheme:   + Alphabets for amplitude and phase, quantization of differential relative to a reference, the reference defined for each layer and each group of coefficients ~~polarization~~ * Further study the following:   + ~~Whether per-TRP/TRP-group references are needed~~   + Number of groups for reference amplitudes across all TRPs, say x, where 2<=x<=2N   + how to group coefficients for a given x?   [Mod: OK, but the proposed wording is a bit ambiguous. If I understand your proposal correctly, 1 group comprises a set of coefficients and a single reference. Revised the wording] |
| LG | Proposal 1.H: we have similar view with Samsung and would like to further study whether the group can be defined based on per polarization, per TRP, or across all TRP. We revise the range of x values including 1.  **Proposal 1.H**: On the W2 coefficient quantization scheme for the Type-II codebook refinement for CJT mTRP:   * Reuse the following components of the legacy Rel-16/17 per-coefficient quantization scheme:   + Alphabets for amplitude and phase, quantization of differential relative to a reference, the reference defined for each layer and each group of coefficients ~~polarization~~ * Further study the following:   + ~~Whether per-TRP/TRP-group references are needed~~   + Number of groups for reference amplitudes across all TRPs, say x, where ~~2~~1<=x<=2N   + how to group coefficients for a given x?   [Mod: OK] |
| MediaTek | Minor comment on Alt 1 of Proposal 1.G: Rel-17 FeType II codebook being a port selection codebook, does not use SD basis (DFT/any other). For more clarity, we could remove “legacy Rel-17”.  [Mod: Correct but DFT is still used for FD even in Rel-17. The current wording seems ok as long as “legacy” is there.] |
| NTT DOCOMO | Proposal 1.G: Okay.  Even though three alternatives are listed here, we believe Alt1 should be the starting point.  Proposal 1.H  ‘per TRP/TRP-group’ exists in many proposals/agreements. We’d like to clarify, whether TRP-group information (how to group multiple TRPs) is configured by NW or selected/reported by UE. We assume it should be the former.  [Mod: Good point, please check ZTE comment below. This will be discussed in one of the FFS we agreed on re spec entity related to TRP, which also applies to TRP group] |
| ZTE | Proposal 1.G: Support  Proposal 1.H: We think that Samsung’s update looks good. We tend to agree with Samsung the the lower bound should be 2, unless that we want to reverse the direction of ‘per polarization’ based reference, as in Rel-16. The motivation is unclear for us. That is, lower bound should 2 rather than 1.  Then, regarding how to group coefficients for a given x, we think that per TRP group should be clarified for facilitating the subsequent discussion. In our views, it is relevant to per-TRP or per TRP-group.   * + how to group coefficients for a given x, e.g., per TRP group?   [Mod: OK]  Regarding DOCOMO’s question, we are open to both. But, technically speaking, TRP-group configured by gNB side seems to be more typical. |
| Xiaomi | Proposal 1.G: support and prefer Alt 1  Proposal 1.H: support |
| Ericsson | For proposal 1.G, we think the starting point should be Alt 1. But we are ok to list the options and downselect later.  For proposal 1.H, we have some suggestion since there is a single phase reference while for amplitude, there is reference per polarization:   * Alphabets for amplitude and phase, quantization of ~~differential~~ phase relative to a reference for each layer , and quantization of differential amplitude relative to a ~~the~~ reference defined for each layer and each polarization   [Mod: Thanks, this is more accurate ] |
| CMCC | Proposal 1.G: Support.  Proposal 1.H: We prefer Samsung’s version, which seems more inclusive. |
| Mod V14 | **Revised proposals per inputs** |
| LG | Proposal 1.H:  For N=3,4, we should first discuss whether it is supported. We suggest the following revision on top of the FL’s latest proposal.  [Mod: Thanks for reminding me. You are correct and suggestion is fair. I added “larger N values, if supported” for the FFS point]  **Proposal 1.H**: On the W2 coefficient quantization scheme for the Type-II codebook refinement for CJT mTRP:   * At least for N=~~{~~2~~, [3]}~~, reuse the following components of the legacy Rel-16/17 per-coefficient quantization scheme:   + Alphabets for amplitude and phase   + Quantization of phase relative to a reference, and quantization of differential amplitude relative to a reference, where the reference is defined for each layer and each ”group” of coefficients * Further study the following:   + ~~For N={[3], 4}: w~~Whether lower-resolution alphabets for amplitude and/or phase than legacy are used to improve throughout-overhead trade-off   + What constitutes a “group” (e.g. polarization per TRP/TRP-group, TRP/TRP-group, combination of the two), the number of “groups” (1 ≤ Cgroup ≤ 2N), and how to indicate/configure “grouping” |
| CATT | **Proposal 1.G：**Support the updated proposal.  **Proposal 1.H：**Support the updated proposal.  We just want to clarify one question for the current description of ‘per TRP/TRP-group’, which also appeared many times in the previous agreements. Does it mean both per TRP and per TRP-group can be considered, but finally, there will be only one choice between the definition of TRP and TRP-group? Since the restriction on maximum number TRPs, the two corresponding codebook designs and overhead considerations will be different.  [Mod: Good question ☺ TRP/TRP-group is simply a “use case” which will not be in the spec. Both will be considered for design. We will discuss what spec entity corresponds to TRP or TRP group (e.g. depending on the decision on supported # resources). I doubt we end up with different solutions for TRP and TRP-group. In terms of restriction, we are discussing N=2,3,4 (need to confirm this since there is FFS on down selection or prioritization). If all are confirmed, the limitation will simply be in terms of N, which will be a codebook parameter. Anyway this will be a next-step discussion] |
| CEWiT | Proposal 1.G: We support the proposal and prefer Alt1.  Proposal 1.H: We support the updated proposal. |
| OPPO | Support proposal 1.G and we prefer Alt.1  Support proposal 1.H. We can further clarify TRP group in the next step. In our understanding, TRP group here refers to all the cooperative TRPs a CSI report associated with.  [Mod: Correct] |
| Mod V20 | **Minor revision** |
| Huawei, HiSilicon | Many thanks for moderator’s update.  For proposal 1.G,   * Considering there are two aspects considered here, i.e. basis and joint/separate, therefore, we suggest to have the 4 options, including alt 4 (separate, eigenvector) also. There was comments in previous rounds that alt 1 may be similar to alt 2, we are also fine to have them listed as options here for further study. * As the Rel-17 FeTypeII codebook is port selection, there’s no basis for spatial domain, therefore, we can narrow our discussion for Rel-16 Type-II codebook perhaps. * We agree to have down-selection, but we prefer to make decisions on further evaluations and studies, so we suggest to change it as below.   **Proposal 1.G**: On the spatial-domain (SD) and frequency-domain (FD) basis design for the Rel-16 Type-II codebook refinement for CJT mTRP, down-select ~~only one of~~ from the following alternatives:   * Alt1 (separate, legacy DFT): SD basis and FD basis are separate, each fully reusing the legacy Rel-16~~/17~~ DFT-based design * Alt2 (joint, DFT): joint SD-FD DFT-based basis   + FFS: Details on DFT parameters, e.g. length, oversampling (if any), rotation (if any) * Alt3 (joint, eigenvector): joint SD-FD eigenvector-based basis   + FFS: eigenvector codebook design, parameterization * Alt4 (separate, eigenvector): SD basis and FD basis are separate, using eigenvector-based basis   + FFS: eigenvector codebook design, parameterization   [Mod: OK, Rel-17 can be discussed separately in the next meeting]   * Regarding LG’s comment, maybe I missed something, but it seems we have agreed for N=3 or 4 already?   **Agreement**  The work scope of Type-II codebook refinement for CJT mTRP includes the support of NTRP={1, 2, 3, 4} cooperating TRPs for CJT CSI report   * FFS: Signaling of NTRP, e.g. higher-layer (RRC) vs. dynamic * FFS: Determination of NTRP, e.g. NW-configured vs UE-selected   FFS: Whether to prioritize or only support NTRP={1, 2}  [Mod: We haven’t agreed on N=3,4 strictly speaking since we have the FFS: Whether to prioritize or only support NTRP={1, 2}. We should resolve this in the next meeting]  For proposal 1.H,   * On the trade-off between performance and overhead, we are not sure whether lower resolution alphabet or higher resolution but smaller number of coefficient is better. Therefore, we suggest to revise it to be more general.   For N={[3], 4}: On how to ~~whether lower-resolution alphabets for amplitude and/or phase than legacy are used to~~ improve throughout-overhead trade-off: such as lower resolution alphabets for amplitude and/or phase than legacy, or higher/same resolution alphabets but smaller number of coefficients than legacy.  [Mod:OK]   * For the first bullet, it’s to reuse legacy, while there’s “group” of coefficients, so does it mean the group here is just the polarization as we are reusing legacy?   [Mod: No. Only the group definition is still open as worded in the proposal. But the other parts are based on legacy.] |
| Mod V22 | **Revision per Huawei inputs** |
| vivo | **Proposal 1.G:** Fine with the latest version.  **Proposal 1.H:** Whether legacy design with minimal spec. impact can be reused needs to be studied and evaluated. We have following comments:   * For the coefficient quantization, we think the amplitude and phase should be considered separately. Multi-level amplitude quantization can possibly increase quantization accuracy, but multi-level phase may not necessarily increase quantization accuracy. For example, the sum of 16QAM pattern and 8PSK pattern is still a 16QAM pattern. * “Reference amplitude” as legacy should be included for amplitude quantization * “Per polarization across N TRPs” as legacy can be one option of the group.   Therefore, we propose to revise the proposal as follows  **Proposed update of Proposal 1.H**: On the W2 coefficient quantization scheme for the Type-II codebook refinement for CJT mTRP:   * At least for N=2, reuse *the following components* of the legacy Rel-16/17 per-coefficient quantization scheme:   + Alphabets for amplitude and phase   + Quantization of phase ~~relative to a reference~~, and quantization of differential amplitude relative to a reference, reference amplitude, where the reference is defined for each layer and each ~~”~~“group” of coefficients * Further study the following:   + For larger N values, if supported, whether/how to improve throughout-overhead trade-off using, e.g. lower-resolution alphabets for amplitude and/or phase than legacy, or higher/same resolution alphabets but smaller number of coefficients than legacy   + What constitutes a “group” (e.g., per polarization across N TRPs, polarization per TRP/TRP-group, TRP/TRP-group, combination of the two), the number of “groups” (1 ≤ Cgroup ≤ 2N), and how to indicate/configure “grouping”   [Mod:OK] |
| Fraunhofer IIS/Fraunhofer HHI | We support both proposals. |
| Nokia/NSB2 | **Proposal 1.H**   * As in legacy quantisation scheme, we can expect to have different “groups” of coefficients associated to a phase reference (1 group in R16/17) and amplitude reference (2 groups in R16/17). Maybe this can be clarified as follows. We can also restrict the max number of phase references to N, as we don’t see a need to consider a phase reference per polarisation. Also, the “grouping” may not need to be configured or indicated if it is defined in specs like in R16/17   + What constitutes a “group” (e.g. polarization per TRP/TRP-group, TRP/TRP-group, combination of the two), the number of “groups” per layer, for phase and amplitude (1 ≤ ≤ N ,1 ≤ ≤ 2N), and whether/how to indicate/configure “grouping” * Lowering the quantisation resolution of the NZC does not seem needed to control overhead as long as the same max number of NZC per layer is applied as in legacy sTRP design. But it’s ok to study   [Mod:OK] |
| Samsung2 | Proposal 1.H  1st bullet: suggest to add “SCI is used as a reference amp for one group” since in legacy, SCI is one of the 2 references  [Mod:OK] |
| AT&T | We support both proposals |
| Mod V37 | **Minor revision per inputs (wording to enhance clarity)** |

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

Table 3 Summary: issue 2

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| **#** | **Issue** | **Companies’ views** |
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**Proposal 2.G**: On the CSI reporting and measurement for the Type-II codebook refinement for high/medium velocities, *at least for discussion purposes*, define the following:

* Assume a CSI report in slot *n*, and let the length of the DD/TD basis vector be *N*4
  + Note that basis vector has no span/window in time-domain, only length
* CSI-RS measurement window of [*k*,*k*+*W*meas –1], representing the window in which CSI-RS occasion(s) are measured for calculating a CSI report
  + *k* is a slot index and *W*meas is the measurement window length (in slots)
  + Note: In the legacy Rel-16/17 CSI, the CSI-RS occasion(s) are configured in *CSI-ReportConfig*
* CSI reporting window of [*l*,*l*+*W*CSI –1], associated to the CSI report in slot n
  + *l* is a slot index and *W*CSI is the reporting window length (in slots)
* CSI reference resource(s) in time-domain
  + The location of a CSI reference resource is denoted as *n*ref (slot index)

**Proposal 2.H**: On the CSI reporting and measurement for the Type-II codebook refinement for high/medium velocities, consider *at least* the following alternatives for potential down-selection:

* Alt1: *n*ref (CSI reference resource slot) as boundary
  + Alt1.A:
  + Alt1.B:
  + Alt1.C: and
* Alt2: *n* (report slot) as boundary
  + Alt2.A:
  + Alt2.B:
  + Alt2.C: and
* Alt3: End slot of Wmeas () as boundary
  + Alt3.A: with the following as a special case: *l=k,* *W*CSI = *W*meas
  + Alt3.B:
  + Alt3.C: and with the following as special cases:
    - *l=k,* *l*+*W*CSI = *n*
    - *l=k,* *l*+*W*CSI = *nf* > *n*

FFS: whether *n*ref represents the slot index of Rel-15 CSI reference resource or a newly defined CSI reference resource

FFS: whether/how the CSI measurement window and reporting window are configured

Table 4 Additional inputs: issue 2

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| **Company** | **Input** |
| **From previous round** | |
| Qualcomm | One more parameter to be considered:  Time-location of the TD codebook, probably including the following two options  Opt1: Relative to CSI-RS observations (burst);  Opt2: Relative to CSI reference resource (Rel-15 reference resource as a starting point)  The FFS bullet 2 in the updated proposal 2.E.2 is aligned with our proposed opt1, which assumes the time-location (let’s say starting slot for instance) relative to (e.g. aligned with) the starting CSI-RS slot in W;  Our proposed opt2, however, has different definition of time-location based on CSI reference resource, which can be more aligned with the mechanism of legacy releases (since time-location is part of the purpose of defining a reference resource) |
| Samsung | We suggest to add an FFS.   * FFS: the relation b/w TD/DD basis vector length (say N4) and the CSI-RS measurement window (W), e.g. whether N4 is within W or can be outside W |
| Nokia | We suggest adding another aspect for study or incorporate it in the second bullet, in case the time intervals are outside the measurement window (UE-side extrapolation):   * The need to configure a time reporting window in addition to the CSI-RS measurement window, e.g. as formed by time intervals outside the measurement window |
| MTK | We support the revised Proposal 2.E.  The proposals from Qualcomm and Samsung can be separated into a different proposal from 2.E, as they are not related to the codebook structure:  Proposal 2.G: On the Type-II codebook refinement for high/medium velocities, the application window is down selected from the following alternatives:  Alt. 1: DD/TD unit(s) ends at R15 CSI reference resource  Alt. 2: DD/TD unit(s) after the CSI reporting slot  Alt. 3: DD/TD unit(s) from a CSI-RS transmission occasion before R15 CSI reference resource until some time after the CSI reporting slot |
| **Round 5** | |
| Mod V0 | **Share your inputs, if any, on moderator proposals** |
| Qualcomm | Thanks FL’s proposal 2.G  What we meant for “time-location” in our original input above is just parameter “*l*” in bullet 3.  For bullet 2, we think for either the measurement window’s time-location “k” or window size “Wmeas”, we cannot preclude another possibility that this can be up to UE implementation, at least at current stage.  [Mod: Agree. Note that the terms are “at least for discussion purposes” for now. Whether to specify is next step. ]  According to our understanding, as long as the time-location of the TD CSI is clear, how to calculate the corresponding CSI more precisely (or how to measure) can be up to UE implementation  Just want to point out the above understanding.  [Mod: This is one option – proposal 2.H will list options to select]  As for the wording of this proposal, we are fine with current proposal saying “for discussion purposes” with bullet 2  Last comment, suggest to represent the time length (in slots) according to TD compression unit (e.g. denoted as Tunit slots) as agreed in Proposal 2.E.2. For instance, N4 --> N4Tunit, WCSI --> WCSITunit, Wmeas --> WmeasTunit  [Mod: I agree with you if we have agreed on TD compression unit. But in Round 4, several companies commented that it’s too early to decide whether TDCU is supported (hence 2.E.2 is still a study). That’s why for now, for discussion purposes, I use slots for everything. If we agree on TDCU, this will be a better unit]  Besides, a typo in bullet 3: to be valid  [Mod: OK thanks] |
| Nokia/NSB | **Proposal 2.G**   * + First bullet. There seems to be a typo (basis vector length is dimensionless, as stated in the note) * Assume a CSI report in slot n, and let the length of the basis vector be N4 ~~(in slots)~~   + Note that basis vector has no span/window in time-domain, only length   + Second bullet. Small suggestion: “occasions” may be more general than “burst(s)” at this stage, as we do not know yet if a “burst” needs different configuration from legacy * CSI-RS measurement window of [k,k+Wmeas], representing the window in which CSI-RS ~~burst(s)~~ occasions are measured for calculating a CSI report   + k is a slot index and Wmeas is the measurement window length (in slots)   + Third bullet. It may be worth adding a similar sub-bullet as for the previous bullet * CSI reporting window of [l,l+WCSI], representing the window in which the CSI report in slot n is expected to be valid   + l is a slot index and WCSI is the reporting window length (in slots)   + Fourth bullet. We suggest simplifying the wording, because the CSI reference resource is defined both in frequency and time domain and it is not only used for CQI calculation. It also determines the latest CSI-RS occasion that can be measured before a CSI report, hence, for example, we may need to assume that * CSI reference resource in the time domain~~, representing (just as in Rel-15) the CSI-RS resource used as a reference for CQI requirement (10% BLER in Rel-15) associated with the CSI report in slot n~~   + ~~The location of CSI reference resource~~ is denoted as nref (slot index)   [Mod: Really appreciate the thorough review and inputs! I agree with all the above.] |
| Apple | * Bullet 1: It is not clear what “Note that basis vector has no span/window in time-domain, only length” means, clarification would be appreciated.   [Mod: N4 denotes the length of the basis vector of the codebook. This has no unit since it is just a construct component from the abstracted precoding matrix. The length is simply the number of elements in the vector.  Later when we discuss how this can be associated with slots or, if agreed, TDCUs, there will be an association with a time-domain unit. But as of now, it is unitless.]   * Bullet 2: On “CSI reference resource, representing (just as in Rel-15) the CSI-RS resource used as a reference for CQI requirement (10% BLER in Rel-15) associated with the CSI report in slot n”,   We still need to discuss whether a single CQI or multiple CQIs (e.g., each for a slot) is/are reported in slot n, e.g. a single CSI reference resource or multiple CSI reference resources are needed at this time. Then we suggest to add “one or more CSI reference resource(s), each representing (just as in Rel-15) ~~the~~ a CSI-RS resource used as a reference for CQI requirement (10% BLER in Rel-15) associated with the CSI report in slot n”  [Mod: Agree, OK] |
| Samsung | **Proposal 2.G**  1st bullet: similar to the definition of N3 in R16, we can define N4 as a number of precoding matrices in TD/DD, each associated with a TD/DD unit. A TD/DD unit comprises >=1 slots (TD/DD unit size).  [Mod: Not really. This is valid only, e.g. for critically sampled DFT basis. Since the choice of basis hasn’t been finalized, this definition is not generally true. Perhaps when the choice of basis is finalized, you can bring this up again. Note that we haven’t agreed that TDCU is supported (check the endorsed proposal 2.E.2) ] |
| LG | **Proposal 2.G:**  Support Nokia’s revision.  On third bullet point: the wording “valid” is unclear. We suggest to revise wording as follows.   * CSI reporting window of [l,l+WCSI], ~~representing the window~~ in which the CSI report in slot n ~~is expected to be valid~~ represents.   [Mod: OK] |
| MediaTek | Thanks for FL’s Proposal 2.G to facilitate discussion.  We support Proposal 2.G with all of Nokia’s suggestions.  To align understanding, the alternatives in our original Proposal 2.G, i.e.,  Alt. 1: DD/TD unit(s) ends at R15 CSI reference resource  Alt. 2: DD/TD unit(s) after the CSI reporting slot  Alt. 3: DD/TD unit(s) from a CSI-RS transmission occasion before R15 CSI reference resource until some time after the CSI reporting slot  , can be translated as  Alt. 1: l+WCSI <=nref  Alt. 2: l > n  Alt. 3: l < nref and l+WCSI > n  [Mod: We will get to this once 2.G is stable ] |
| NTT DOCOMO | **Proposal 2.G**  Support in general.   * First and second bullet: Just for our better understanding, can we understand that the range of N4 and Wmeas is totally up to future discussion (i.e. no restriction at this stage)?   [Mod: Correct, we are still defining terms so that we are on the same page when we discuss this issue you/Samsung pointed out. Without aligning terms, companies may have different understanding. Especially since TD/DD compression is a very new topic ]   * Third bullet: we agree with Nokia that the unit of WCSI can be added.   [Mod: Me too] |
| ZTE | **Proposal 2.G:**   * + Regarding first bullet, we have different views from Nokia. Of course, basis vector length is dimensionless, but we need to provide a physical interpretation for a basis. It is much relevant to the effective time-domain duration of CSI prediction. If ‘in slots’ is controversial, how about providing detailed description as follows.   [Mod: Please see my comment for Apple. There is no unit for N4 as of now. It’s just the number of elements in the vector.  Association with unit is the next step but we cannot do so before we discuss whether TDCU is needed or not (still FFS). I plan to finalize that in Aug since many issues depend on this]   * + Regarding second bullet, it should be k+Wmeas -1.   + Regarding third bullet, firstly okay for Nokia’s update. Then, it should be 1+WCSI -1. Then, we are not sure, why the CSI report is in the slot n, but the starting point is from 1. Does that corresponds to CSI reference resource? But, then the following, the CSI reference resource is in the slot-n. If so, what’s the meaning of ‘1’ as following highlighted herein?   [Mod: Thanks for the excellent catch, you are correct ]  **Proposal 2.G**: On the Type-II codebook refinement for high/medium velocities, *at least for discussion purposes*, define the following:   * Assume a CSI report in slot n, and let the time-domain duration corresponding to the basis vector be N4 (in slots)   + Note that basis vector has no span/window in time-domain, only length * CSI-RS measurement window of [k,k+Wmeas -1], representing the window in which CSI-RS burst(s) are measured for calculating a CSI report   + k is a slot index and Wmeas is the measurement window length (in slots) * CSI reporting window of [l,l+WCSI -1], representing the window in which the CSI report in slot n is expected to be valid   + l is a slot index and WCSI is the reporting window length (in slots) * CSI reference resource, representing (just as in Rel-15) the CSI-RS resource used as a reference for CQI requirement (10% BLER in Rel-15) associated with the CSI report in slot n   + The location of CSI reference resource is denoted as nref (slot index)   [Mod: CSI is reported in slot n. the index l is the start of what we usually call “validity window”. In general l < n. But it can be different now. Not the same as n for sure, especially since we haven’t discussed, e.g. whether UE-side prediction should be assumed in CSI calculation. This is for next level discussion.]   * + Finally, regarding MTK’s comment, we prefer Alt2. |
| Xiaomi | **Proposal 2.G**  Forthefirstbullet: N4 is used to denotes the total number of precoding matrices. In order to avoid confusing, the note in the first bullet can be revised as.   * N4 is the total number of precoding matrices.   [Mod: Not really. Please check my comments to Samsung who made the same suggestion. This is only true when we use, e.g. critically sampled DFT basis.]  Forthethirdbullet: both *l* and WCSI needs to be clarified.  [Mod: Done with Nokia suggestion]  For the fourth bullet: We share similar view with Apple, more CSI-RS reference resources can be considered for calculating more CQI if needs.  [Mod: OK] |
| Ericsson | In first sub-bullet, it is better to clarify that the basis vector refers to Doppler/time domain basis vecotor:   * Assume a CSI report in slot n, and let the length of the Doppler/time domain basis vector be N4 (in slots)   [Mod: OK]  On the sub-bullet, ‘Note that basis vector has no span/window in time-domain, only length’, we have similar clarification question as Apple on what this means. Doesn’t the basis vector have to be mapped to a time span?  [Mod: Please check my comment for Apple and ZTE]  The following bullet only applies to UE based prediction right?   * CSI reporting window of [l,l+WCSI], representing the window in which the CSI report in slot n is expected to be valid   [Mod: It basically accommodates discussion whether UE side prediction is assumed or not in CSI calculation, depending on the values of l and W\_CSI. This is for next-level discussion]  On the last bullet, “The location of CSI reference resource is denoted as nref (slot index)”, should the reference be multiple slots, not a single slot?  [Mod: Even if CSI-RS occasion is a burst (multiple slots), the reference should be a single location/slot index. In legacy measurement, this is also the case, it is possible for the UE to measure CSI from SP CSI-RS for instance. Which is a burst. But n\_ref is still a slot index.] |
| CMCC | **Proposal 2.G**  Support ZTE’s revision.  Besides, we are also a little confused with the meaning of *l,* what’s the relationship between *l* and CSI reporting time?  [Mod: Please check my comment to ZTE and Ericsson, and hope it clarifies the confusion/misunderstanding] |
| Mod V14 | **Revised proposals per inputs** |
| LG | Support the latest FL’s update. |
| CATT | Support the updated proposal. |
| Spreadtrum | We have two questions for clarification:   1. For 3rd bullet, we are not clear about the relationship between l and n. In our mind, since it is for CSI prediction at UE side, it seems to be natural that n should be <=l, right?   [Mod: Proposal 2.G doesn’t discuss the relations among the parameters. The condition n<l is one viable alternative. Please see proposal 2.H]   1. For 4th bullet, it only refers to the denotation of the time location of CSI reference resource, not the definition. Our understanding is that we would discuss it maybe next meeting. So could we add one ‘FFS: the definition of CSI reference resource(s)’ for providing general guidance.   [Mod: Correct. But we don’t need to add such FFS since we already had the following agreement ☺  **Agreement**  The work scope of Type-II codebook refinement for high/medium velocities includes the following CSI measurement and calculation aspects:   * Potential refinement on Resource setting configuration on CSI-RS (for CSI and/or tracking) for measuring a burst of CSI-RS, including the applicable time-domain behaviors * Whether/how UE-side or gNB-side prediction is assumed for CQI/PMI/RI calculation * Potential enhancements on CQI definition and calculation procedure in relation to the PMI of Rel-18 Type-II codebook for high/medium velocities * Potential enhancement on definition of CSI reference resource] |
| OPPO | **Proposal 2.G:**  The relationship between WCSI and N4 is unclear, we suggest to add a sub-bullet   * CSI reporting window of [l,l+WCSI –1], in which the CSI report in slot n represents   + l is a slot index and WCSI is the reporting window length (in slots)   + WCSI =N4\*Tunit (TD compression unit)   since length N4 vector outside the reporting window may be not needed.  [Mod: Please also check my comment to Samsung. Since we haven’t agreed on the need for TDCU (check the endorsed proposal 2.E.2), we cannot define this relationship. This will be a next-step discussion after we decide whether TDCU is needed or not] |
| Mod V20 | **No revision on 2.G. Added 2.H based on MediaTek’s input** |
| Huawei, Hisilicon | On the second bullet of measurement window, it seems to be different with the legacy procedure. In legacy, when a CSI report is triggered, there’s the associated CSI-RS resource set configured by “*resourcesForChannelMeasurement*” so that UE can have the measurements. We think reusing legacy would also be one option for measuring. So perhaps we can have two options for it:   * For CSI-RS measurement :   + Option 1: CSI-RS measurement window of [k,k+Wmeas –1], representing the window in which CSI-RS occasion(s) are measured for calculating a CSI report     - k is a slot index and Wmeas is the measurement window length (in slots)   + Option 2: CSI-RS occasion(s) configured in *CSI-ReportConfig* are measured for calculating a CSI report   [Mod: There is some misunderstanding. There is no need for option since this is just a definition of measurement window mentioned in several Tdocs defined here for discussion (as said in the main sentence). Note that the spec doesn’t define this in legacy spec and it is unlikely it will be defined in Rel-18 spec (at least IMO ☺ e.g. you can see in proposal 2.H, nothing on CSI-RS measurement window is used).  I added that the occasions are configured in CSIReportConfig] |
| Mod V22 | **Minor revision adding a note per Huawei input** |
| Qualcomm 2 | Thanks for MTK’s nice representation and FL’s updates  Just suggest to have some minor modification to Proposal 2.H   * Alt1: *l*+*W*CSI ≤ *n*ref * Alt2: *l* >= *n*ref * Alt3: *l* < *n*ref and *l*+*W*CSI >= *n*ref   Where *n*ref denotes the slot of Rel-15 CSI reference resource  [Mod: added FFS for this]  The last note is added since this can potentially be a separate agreement from proposal 2.G (*n*ref has not been defined in proposal 2.H) |
| vivo | Proposal 2.G: The term “CSI reporting window” is a little bit confusing. Following revision is proposed.  **Proposal 2.G**: On the CSI reporting and measurement for the Type-II codebook refinement for high/medium velocities, *at least for discussion purposes*, define the following:   * Assume a CSI report in slot *n*, and let the length of the DD/TD basis vector be *N*4   + Note that basis vector has no span/window in time-domain, only length * CSI-RS measurement window of [*k*,*k*+*W*meas –1], representing the window in which CSI-RS occasion(s) are measured for calculating a CSI report   + *k* is a slot index and *W*meas is the measurement window length (in slots)   + Note: In the legacy Rel-16/17 CSI, the CSI-RS occasion(s) are configured in *CSI-ReportConfig* * CSI ~~reporting~~ window of [*l*,*l*+*W*CSI –1], in which one or multiple CSIs can be obtained by the CSI report in slot n ~~represents~~   + *l* is a slot index and *W*CSI is the reporting window length (in slots) * CSI reference resource(s) in time-domain   + The location of a CSI reference resource is denoted as *n*ref (slot index)   [Mod: you misunderstand the intention. The window is not about where n is, but represents where the CSI report in slot n is expected to be valid. It may include slot n, but your rewording isn’t the intention.]  **Proposal 2.H:** We think it is too early to have this proposal listing the limited alternatives in this meeting. Other alternatives may be still possible.  [Mod: Added “consider at least”] |
| Fraunhofer IIS/Fraunhofer HHI | We are okay with both tricky proposals ☺ . |
| MediaTek | @QC: The suggested modification is not aligned with our intention.  Alt2 is intended for UE-based prediction. Then, since gNB can only use the CSI after the CSI reporting slot *n*, reporting any CSI representing from slot *n*ref+1 to slot *n* seems redundant.  Alt3 aims to capture Approach 2 in your tdoc, i.e.,  Approach 2: Codebook comprises both observation and extrapolation  Again, since extrapolation is performed, we think it is only meaningful to extrapolate to the slot where gNB can directly apply it.  Nevertheless, we are fine with listing your modifications as Alt4 and Alt5 at this stage. Also, we are fine with referring *n*ref as Rel-15 CSI reference resource in Proposal 2.H.  [Mod: please check latest version per QC update] |
| CATT | **Proposal 2.G:** Support the updated proposal 2.G.  **Proposal 2.H:** We are open to discuss both alternatives. But different alternatives might correspond to different predictions, e.g. Alt2 with UE-side prediction, and Alt1 with gNB-side prediction. Thus, similar views as vivo, we think this proposal can be discussed later until whether/how UE-side or gNB-side prediction assumed in the supported work scope.  [Mod: Added “consider at least”. I don’t intend to discuss in terms of “gNB- side” vs “UE side vs no prediction” since that’s not what we will specify and can be misunderstood (already so, based on some previous comments). It is much better to discuss the timing relation as in 2.H since it is much more precise.] |
| Qualcomm 3 | @MTK: Thanks for the clarification.  Here is our thought. Firstly, since nref<n, the modified Alt2 and Alt3 violate the original version - it is just a little broader than the original formulas. Therefore, the extrapolation purpose (as you explained) is still maintained for both Alt2 and Alt3.  As for whether the **small number** of slots b/w [nref, n] is redundant, we can discuss in next level, right? And it is not precluded to further narrow-down to the original Alt2 or Alt3.  Secondly, the modified version seems to be more clean in the sense that it includes full possibilities. For instance, according to the original version, people can still propose an Alt4 that nref <= *l* < n  Does that sound OK with you?  @vivo: Thanks for the careful consideration for Proposal 2.H. Would you please also check with the updated version? We think it may not harm, since the three Alts can enumerate all possibilities of the time-location of WCSI. |
| LG | Proposal 2.H: We have thought same formulation as QC. CSI reporting window can be defined relative to legacy CSI reference resource because the CSI reference resource is also used as upper bound of legacy measurement window. If MediaTek has a concern on modification of original formulation then we are also fine with listing QC’s suggestion as Alt 4 and 5.  In addition, we would like to open the possibility of selecting multiple Alts or configurability and also another alts, at this time. In this sense we suggest to revise the proposal as follow.  **Proposal 2.H**: On the CSI reporting and measurement for the Type-II codebook refinement for high/medium velocities, ~~down-select only one of~~study the following alternatives:  [Mod: agree, added “consider at least”] |
| Nokia/NSB2 | **Proposal 2.G**   * Second bullet. @HW: we think the suggested option 2 is not needed as it’s already included in option1. In our understanding, the measurement window extends the concept of *timeRestrictionForChannelMeasurements*, rather than changing the association between reporting setting and resource setting   FL’s note is fine   * Third bullet. LG’s rewording sounds a bit broken. Maybe we can go back to the original FL’s formulation or the following if preferred * CSI reporting window of [*l*,*l*+*W*CSI –1], associated to ~~in which~~ the CSI report in slot n ~~represents~~   [Mod: OK]  **Proposal 2.H**   * We think it may be clearer to formulate this proposal in terms of relative position of the reporting window with respect to the measurement window, to better capture the distinction between UE reporting past CSIs, future CSIs or a combination of both. * Alt1: * Alt2: * Alt3: and * Considering that at this stage it’s not yet clear how UE-side prediction compare to gNB-side prediction and whether it’s worth supporting a combination of options, we prefer softening the proposal as follows   On the CSI reporting and measurement for the Type-II codebook refinement for high/medium velocities, consider ~~down-select only one of~~ the following alternatives for possible down-selection:  [Mod: OK] |
| Qualcomm 4 | Proposal 2.H  For all the options listed above (MTK, FL, Nokia, and also us), I think it can be categorized into the following three types, differentiated in what to use as the **boundary of past and future**:  Alt A: nref (CSI reference resource slot) as boundary – (A)   * Alt A1: (MTK) * Alt A2: * Alt A3: and (part from MTK)   Alt B: n (report slot) as boundary   * Alt B1: * Alt B2: (MTK) * Alt B3: and (part from MTK)   Alt C: End slot of Wmeas () as boundary (Nokia)   * Alt C1: * Alt C2: * Alt C3: and   {A1,B1,C1} are past-only, {A2,B2,C2} are future-only, {A3,B3,C3} are past+future  [Mod: thanks for this very good categorization] |
| Samsung2 | Proposal 2.H:   * In our view, the measurement window should be included in the CSI reporting window since the corresponding CSI (e.g. precoder in the measurement window) is more accurate (based on actual measurements) than the predicted CSI (e.g. precoder in the non-measurement window). Besides, the CSI reported in the measurement window can be useful for gNB-side implementations. So, suggest to include alternatives with k=l. * Alt4: *l=k,* *W*CSI = *W*meas * Alt5: *l=k,* *l*+*W*CSI = *n* * Alt6: *l=k,* *l*+*W*CSI = *nf* > *n*     [Mod:OK] |
| Xiaomi2 | For Proposal 2.G, we are fine with it.  For Proposal 2.H, we have similar view with vivo and CATT, i.e., the provided proposal 2.H is premature since it has not decided whether UE or gNB predict future CSI. In addition, the number of CSI-RS reference resource is not ensured as well. Both CSI measurement and reporting can be associated which CSI-RS reference resource when there is more than one CSI-RS reference resource. Thus, we think Proposal 2.H can be brought up after above issues are settled.  [Mod: Added consider at least] |
| Nokia/NSB3 | Proposal 2.H   * In relation to P2.H, in our view, we may also want to discuss whether/how the CSI reporting window and CSI measurement window are configured. In our understanding, Alt 4 suggested by Samsung is already included in Alt 1, and Alt 5 and 6 are included in Alt 3, as possible configurations. So we suggest adding a bullet point * FFS: whether/how the CSI measurement window and reporting window are configured   [Mod:OK] |
| Mod V37 | **Revised proposals based on inputs** |

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

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