**3GPP TSG-RAN WG4 Meeting # 102 -e (Draft)R4-210XXXX**

**Electronic Meeting, 21st Feb– 3rd Mar, 2022**

**Agenda item:** 10.9.3.3

**Source:** Moderator (Samsung)

**Title:** Email discussion summary for [102-e] [213] NR\_HST\_FR2\_RRM\_2

**Document for:** Information

# Introduction

This contribution will be used to guide and summarize the email discussion for the topic of Rel-17 NR HST FR2 enhancements RRM core requirements (AI 10.9.3.4) in RAN4 #102, with the email thread identifier “[102-e][213] NR\_HST\_FR2\_RRM\_2”.

This e-mail thread will capture the e-mail discussions for the following sub-agenda items for FR2 HST RRM

* AI 10.9.3.3 Timing requirements

In previous RAN4 meeting, WF on one shot large uplink timing adjustment has been approved

# Topic #1: Timing requirements

*Main technical topic overview. The structure can be done based on sub-agenda basis.*

## Companies’ contributions summary

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| **T-doc number** | **Company** | **Proposals / Observations** |
| [R4-2203711](https://www.3gpp.org/ftp/TSG_RAN/WG4_Radio/TSGR4_101-e/Docs/R4-2117302.zip) | Qualcomm | *Moderator note:* *3711 is submitted in the different agenda but part of proposals are related to uplink timing adjustment which is copied below for further discussions.*Proposal 2: Add a MAC-CE command to inform UE of the TCI state switch is across RRH and send an LS to RAN2.Observation 1: The proposed aperiodic L1-RSRP request can prevent false alarm and miss detection in large DL timing detection by enabling UE to use the updated SSB timing from the latest SSB occasion instead of stale SSB timing from SSB detection.Observation 2: The aperiodic L1-RSRP report approach for enabling large timing adjustment is more efficient than RACH procedure from throughput impact and network/UE implementation perspective.Proposal 3: Apply the following procedure to cross-RRH TCI state switch:* Network schedules an aperiodic L1-RSRP report to trigger DL timing difference detection before cross-RRH TCI state switch.
* RAN4 imposes UL and DL scheduling restriction after cross-RRH TCI state switch before first TRS reception. UE performs the large UL timing adjustment on the first UL transmission after the first TRS reception, and this timing adjustment is allowed to exceed the Tq requirement in 38.133 clause 7.1.2.1.

Observation 3: Propagation delay difference between two RRHs can cause large UL to DL interference when two UEs are close two each other and an RRH.Proposal 4: Network applies different offsets to DL frame boundaries of different RRHs to pre-compensate the propagation delay difference across different RRHs to eliminate UL to DL interference across UEs. Network then inform UE the TA change needed after TCI state change across RRHs |
| R4-2203754 | Apple | Proposal 1: Enable light weight inter-RRH signaling to UE. Proposal 2: Support network assisted information, i.e., enable network assisted signaling of SSB index and order per RRH.  For example:  * The signaling can reuse current SSB signaling by reinterpretation of the bit field when FR2 HST deployment flag is set.
* Group represent RRH, max 8 RRH per cell. SSB index is in order along the track.
* No additional signaling overhead.

Proposal 3: RAN4 can determine max number of RRH per cell supported in SIB1 signaling and leave detailed signaling design to RAN2. Proposal 4: Scheduling constraint of DL/UL reception/transmission follow TCI state switching delay.  |
| R4-2203899 | CATT | Proposal 1: For the value of timing difference threshold, we support option 3 with CP/4.Proposal 2: The UL scheduling restriction is necessary, when TCI is switched.  |
| R4-2205959 | Nokia | 1. An error in the UE transmit timing after large one-shot timing adjustment is directly dependent on the error in the UE evaluation of the DL timing, which is not limited by any existing requirement.
2. Immediately after large one-shot UL timing adjustment, the UE can transmit in UL with a timing error above Te.
3. RAN4 to prohibit UE transition immediately after large one-shot UL timing adjustment until the timing error (i.e., of the first transmission after the TCI state switch) is within Te.
4. If the UE needs to synchronize to any target beam after the TCI state switch to evaluate the DL timing difference in between the source and the target beams, then a systematic error above Te can be always present in the UE transmit timing after the TCI state switch, i.e., on the level of , where is an error in DL timing evolution.
5. The value of the threshold impacts the error in the UL transmit timing after the TCI state switch, especially if the timing difference is below the threshold. To avoid additional errors, it is preferred to select a lower threshold if the error in the DL timing evaluation is also low. For example, if DL timing is evaluated based on TRS with the error on the level of 10.7 ns, then the threshold can be around 3.5\*64\*Tc. However, if the error in DL timing evaluation is higher, e.g., on the level of 21.4 ns, then the threshold can be higher as well, e.g., as in Option 2: 4.5\*64\*Tc.
6. RAN4 to select a threshold on UE measurement of DL timing difference for triggering large one-shot UL timing adjustment on the level of 3.5\*64\*Tc = 115 ns.
7. Network signalling indicating inter-RRH TCI state switch to the UE can be beneficial to mitigate UL transmit timing error that appears due to a need to synchronize to the target beam in the case of intra-RRH TCI state switch.
8. RAN4 to introduce lightweight network signaling for the indication of inter-RRH TCI state switch to the UE, e.g., in the form of the one-bit flag in the TCI state switch command.
9. Use inter-RRH indication as a triggering condition for large one-shot UL timing adjustment.
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| R4-2204719 | Ericsson | Proposal 1: Support Option 2: Tq = 4.5\*64\*TC = CP/4.Proposal 2: UL performance degradation is expected before TRS is received after the TCI state switch, but no UL scheduling restriction is needed.  |
| R4-2204715 | Ericsson | Proposal 2: Support Option 3: Introduce inter-RRH indication, because of easy implementation. |
| R4-2205890 | Samsung | Proposal 1: For FR2 HST UE, it is dependent on UE implementation to perform SSB-based timing acquisition/tracking on the target SSB during Layer-1 SS-RSRP measurement before inter-RRH beam switching. Observation 1: For FR2 HST UE, if absolute DL timing difference before and after beam switching |Tp2 -Tp1| < CP/4 = 4.5\*64\*Tc, with UE’s autonomous timing adjustment (Tq = 4.5\*64\*Tc), UE’s uplink timing mismatch can be no larger than CP/2. Proposal 2: FR2 HST UE is allowed to perform one shot large UL timing adjustment only if UE identified the DL timing is changed with the magnitude larger than one fourth of OFDM symbol CP length, i.e., 4.5\*64\*Tc. Proposal 3: Support the proposal that the accuracy of one-shot timing adjustment is 4 times of DL timing estimation error. Observation 2: One more slot shall be allowed for interruption after TCI switching for FR2 HST scenario.Proposal 4: The DL interruption shall be accommodated in the RRM requirement for active TCI switching delay. Proposal 5: No need to consider DL scheduling restriction (until first TRS), because the current active TCI switching requirement already allow extra time for tracking if target TCI is not in the active TCI state list. Proposal 6: UL scheduling restriction (i.e., the UE is not expected to transmit PUCCH/PUSCH/SRS until the first TRS is received after the TCI state switch) is introduced for all TCI state switch.Proposal 7: The NW and UE behavior for FR2 HST scenario (in which one shot large UL timing adjustment is utilized) is illustrated in the flow-chart. Proposal 8: The text proposal is provided to introduce the requirement for one shot large UL timing adjustment.  |
| R4-2205008 | ZTE | Proposal 2: If only starting from RRM-1, we can not see strong request to introduce network assisted signalling. However in order to address the large propagation delay difference issue in RRM-2, we prefer Option 3 since the Uni-directional and bi-directional deployment flag has been approved. |

## Open issues summary

*Before e-Meeting, moderators shall summarize list of open issues, candidate options and possible WF (if applicable) based on companies’ contributions.*

Based on the submitted papers, different views have been observed on whether to introduce the inter-RRH indications.

Companies which prefer to introduce inter-RRH indication also proposed different signalling design approach, i.e., MAC-CE to indicate inter-RRH (Nokia, Qualcomm, Ericsson, ZTE) and SSB index and order per RRH (Apple, Ericsson). From operation procedure perspective, different procedure has been proposed.

Companies which prefer only rely on the timing difference threshold seems to have aligned threshold value which is CP/4 (CATT, Samsung) but different procedure has been proposed in Qualcomm paper (3711) and Samsung (5890)

From above observation, it is moderator understanding, the essential question to be answered is whether the inter-RRH indication is needed or not. The detailed procedure as well as signalling design can be further discussed assuming RAN4 will agree on either of introducing inter-RRH or not.

Meanwhile, it is also observed that three CRs have been proposed to introduce one shot large uplink timing adjustment.

* Nokia CR (4631) and Qualcomm CR (3713) based on inter-RRH indication
* Samsung CR (5892) based on no inter-RRH indication

To have more efficient discussion, moderator suggest to have parallel discussions assuming eventually RAN4 will agree on either to have inter-RRH indication or not to have inter-RRH indication. Therefore, moderator suggest to collect comments for all these three CRs in the 1st round. By doing that, it is expected corresponding CR could be ready for approval together with the decision on whether inter-RRH indication shall be introduced or not.

Also, companies proposed the considerations for scheduling restrictions. To have more focused discussions for above essential question, moderator suggest to skip this topic in the 1st round and open the discussions for scheduling restriction in the 2nd round.

Samsung propose the TP to TR on uplink timing adjustment in 5891. As similar as scheduling restriction, moderator suggest to skip comments on TP to TR in the 1st round and open the discussions in the 2nd round.

Based on above observation, moderator suggest to have the following sub topics for 1st rounds

* Sub topic 1-1: Whether to introduce inter-RRH indication?
* Sub topic 1-2: If RAN4 agree to introduce inter-RRH indication, what is the exact procedure for network to configure such inter-RRH indication
* Sub topic 1-3: If RAN4 agree NOT to introduce inter-RRH indication, what is the exact procedure for applying one shot large uplink timing adjustment
* Sub topic 1-4: Companies’ comments on the CR 4631 and 3713 assuming RAN4 will introduce inter-RRH indication
* Sub topic 1-5 Companies’ comments on the CR 5892 assuming RAN4 will NOT introduce inter-RRH indication

### Sub-topic 1-1: Inter-RRH indication

*Open issues and candidate options before e-meeting:*

* Whether to introduce inter-RRH indication?
	+ Option 1: Yes (Apple, Qualcomm, Nokia, Ericsson, ZTE)
	+ Option 2: No (CATT, Samsung)
* Recommended WF
	+ Companies are invited to provide the comments to above options in the 1st round

Companies views’ collection for 1st round

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| Company | Comments |
| Moderator | The following agreements have been achieved in the Monday GTW session. * Inter-RRH indication
* Do not introduce explicit inter-RRH indication signalling for NR FR2 HST in Rel-17
* FR2 HST Inter-RRH indication signalling enhancement can be considered in Rel-18 subject to RAN plenary decision
* FFS whether additional assumptions for the definition one shot UL timing adjustment requirements shall be introduced (e.g., UE is configured with aperiodic L1-RSRP reporting before the TCI state switch, or UE performed fine time tracking with Xms before/after TCI state switching)

Based on above agreements, moderator suggest to close this sub-topic in 1st round and focus on the FFS part in the 1st round  |
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### Sub-topic 1-2: Detailed procedure with inter-RRH indication

*Sub-topic description*

* If RAN4 agree to introduce inter-RRH indication, what is the exact procedure for network to configure such inter-RRH indication
	+ Option 1: (Apple’s proposal in 3754)
	+ Option 2: (Nokia’s proposal in 5959)
* Recommended WF
	+ Companies are invited to provide the comments to above options in the 1st round
	+ To facilitate the discussions, proponents (Apple and Nokia) input on high level descriptions of procedure are required

Companies views’ collection for 1st round

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| Company | Comments |
| Moderator | Based on the GTW agreements, moderator suggest to close this sub topic in 1st round  |

### Sub-topic 1-3: Detailed procedure without inter-RRH indication

*Sub-topic description*

* If RAN4 agree NOT to introduce inter-RRH indication, what is the exact procedure for applying one shot large uplink timing adjustment
	+ Option 1: (Qualcomm’s proposal in 3711)

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| * Step 1: UE detect the timing difference before TCI state switch
	+ Network schedules an aperiodic L1-RSRP report before cross-RRH TCI state switch
	+ After receives the aperiodic L1-RSRP report, UE refines timing based on PSS/SSS and performs the detection on the next SSB measurement occasion for a set of candidate SSBs. Options for candidate SSBs
		- Option 1: Network configures one set in csi-SSB-ResourceSetList with the first x SSBs in each RRH that UE can switch to when switching to the RRH. Alternatively, network configures one set for each RRH in csi-SSB-ResourceSetList with the first x SSBs in the RRH that UE can switch to when switching to the RRH. csi-SSB-ResourceSet in CSI-AssociatedReportConfigInfo point to this set, and UE use it as candidate SSBs.
		- Option 2: x SSBs with the largest RSRPs reported previously
	+ Detection rule: any of the candidate SSBs satisfy |SSB timing – current DL timing|>threshold
		- If any of the candidate SSBs satisfies the condition, the next TCI state switch to that SSB is cross-RRH
* Step 2: UE adjust DL and UL timing after cross-RRH TCI state switch
	+ Apply DL/UL scheduling restriction after cross-RRH TCI state switch until the first TRS is received after the TCI state switch.
		- No DL and UL reception/transmission is scheduled before first TRS is received to prevent UE from receiving/transmitting signals based on the coarse timing from the SSB measurement.
	+ UE adjust DL timing by using coarse timing from the SSB measurement after the aperiodic L1-RSRP report, and refine the DL timing by the TRS received after TCI state switch
		- UE applies TA adjustment magnitude of 2\*|TRS timing – previous DL timing| on the first UL after TRS reception (UL TA adjustment is twice of DL timing change)
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* + Option 2: (Samsung’s proposal in 5890)

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* Recommended WF
	+ Companies are invited to provide the comments to above options in the 1st round

Companies views’ collection for 1st round

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| Company | Comments |
| Moderator | * Based on the GTW agreements below,
* Inter-RRH indication
* Do not introduce explicit inter-RRH indication signalling for NR FR2 HST in Rel-17
* FR2 HST Inter-RRH indication signalling enhancement can be considered in Rel-18 subject to RAN plenary decision
* FFS whether additional assumptions for the definition one shot UL timing adjustment requirements shall be introduced (e.g., UE is configured with aperiodic L1-RSRP reporting before the TCI state switch, or UE performed fine time tracking with Xms before/after TCI state switching)

Moderator suggest companies which suggest to perform fine time tracking within Xms before/after TCI state switching to provide detailed procedure descriptions as additional option. Meanwhile, companies comments on above procedure are expected in the 1st round.  |
| QC | First, we want to clarify that “fine time tracking within Xms” is not feasible as an UE requirement, since UE doesn’t know the TCI state switch timing before it receives the command. But with option 1, UE can achieve “coarse timing tracking within Xms” but X is determined by the timing network sends aperiodic L1-RSRP request and TCI state timing, and we suggest to leave it to network implementation.We addressed comments on option 1 received during GTW:1. Additional delay due to the aperiodic L1-RSRP request: the proposal is to refine SSB timing and detect large DL timing change after the L1-RSRP request. Hence the additional delay is one SSB period plus a few ms, if network schedules TCI state switch in time. SSB period is expected to be 20ms, and UE can only travel 2m within 20ms. No matter which scenario we considered, 2m can not lead to large SNR difference. Note that comparing to L1-RSRP periodic reporting delay, which is the major source of TCI state switch delay (network needs to receive the report to decide TCI state switch), typical Treport value is much larger than one SSB period. Furthermore, network can further optimize it if delay is a concern, e.g., send aperiodic L1-RSRP request when received L1-RSRP is close between serving and best target beams.2. Feasibility of network implementation: since TCI state switch is a network command, network has full control on when to send it, and adding one aperiodic L1-RSRP request before the switch command shouldn’t be an issue. 3. Feature/spec discussion: note that option 1 didn’t change the interpretation aperiodic L1-RSRP request as a standalone command. The requirement in option 1 is “When one shot large UL timing adjustment is enabled, UE is required to take additional actions after aperiodic L1-RSRP request”. Therefore, the procedure is defined corresponding to the one shot large UL timing adjustment enablement signaling, and aperiodic L1-RSRP request only provides a timing as a side information of this procedure. Regarding whether this procedure is considered as a new feature, according to our proposal, we support to consider this procedure as an optional feature, but the feature is the detection procedure and the aperiodic L1-RSRP request only serves as a side condition in this procedure. Option 2 is not feasible for UE, it effectively asking UE to (1) predict when TCI state switch can happen (2) predict which SSBs are the possible new TCI state. Even UE has an effective algorithm to do all these predictions, UE is required to include a lot measurement occasions and large number of SSBs to avoid missing any possible inter-RRH TCI state switch detection occasions. As we mentioned before in our contributions, UE has a lot of beam management/refinement procedures to execute, and adding both the prediction algorithm and timing tracking in many measurement occasions and many SSB indexes push out the processing resources for essential and indispensable beam management/refinement procedures. * If we compare option 1 with option 2, network has full information for (1) when inter-RRH TCI state switch can happen (2) which SSB index is the inter-RRH TCI state switch one. It is a more reasonable design to have network provide the information to UE by aperiodic L1-RSRP request which is an existing signaling procedure with entries to indicate necessary information instead of asking UE figures out all the information that network already has by itself. We already compromised not to introduce network assistant signaling, and this proposal leverages existing signaling while keeps all the existing functions of this signaling unchanged. Therefore, we see significant advantage of option 1 over option 2.
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| Apple | Here is the timeline for time/freq after TCI state switching. For UL timing adjustment, it is 2\*(T2-T1), where T1 is the DL timing measured at the last slot receiving from old TCI, T2 is the DL timing measured at the 1st slot receiving from the new TCI.  |
| ZTE | We believe Option 1 is some replacement since lack of inter-RRH indication. Once UE acquired the new DL timing, then UE can perform detection with the *offset = new DL timing - old DL timing* compared with threshold. So how and when to identify new DL timing is the key issue.For Option 1, we understand the acquirement of new DL timing was split into two steps: 1) Acquiring coarse new DL timing based on the SSB triggered by a-periodic L1-RSRP request. Since such SSB transmitted right before TCI state switching, so UE can receive the SSB based on old DL timing, and obtain coarse new DL timing based on them. Which complies with the UE procedure if timing update is necessary during TCI state switching process defined in current spec; 2) Acquiring fine new DL timing based on the TRS transmitted after TCI state switching so as to refine the coarse new DL timing acquired in step 1). Since a-periodic L1-RSRP request is an existing scheme, so no new signalling introduced by Option 1.For Option 2, since no special SSB transmitted to let UE identify new DL timing, so UE can only depend on the periodic SSB/CSI-RS to acquire new DL timing before TCI state switching, whether such SSB/CSI-RS are fresh enough, which should be considered. |
| Ericsson | Regarding moderator’s question ‘Moderator suggest companies which suggest to perform fine time tracking within Xms before/after TCI state switching to provide detailed procedure descriptions as additional option.’, it’s unclear to us what’s the actual definition of ‘fine time tracking’, e,g. SSB based or TRS based, and what’s the purpose, e.g. identify inter-RRH or determine exact UL timing adjustment. If the question is to determine UL timing adjustment (after TCI state switch), proposal 1 has explicit TRS delay compared to proposal 2, but proposal 2 needs TA command by network. The difference of effect on requirements may be delay by TRS delay or TA command, but it is possible to define a unified slot number of the delay. |
| Nokia | Even though it was agreed not to define any explicit network assistance signaling in Rel-17 for inter-RRH beam switch we still see obvious benefits in letting the UE know whether the beam switch is inter-RRH or intra-RRH, both from the delay and performance perspectives.As Option 2 does not consider such a possibility, it is not our preference.It seems that the goal of Option 1 is to provide to the UE additional information about inter-RRH TCI state switch and trigger target beam time tracking without explicit signaling.However, Option 1 challenge is the network impact as is it implies non-straightforward network implementation, as follows:* An aperiodic L1-RSRP report request needs to be sent **before** the TCI state switch is triggered by the NWTo enable this the NW needs to **pre-indicated** the TCI state switch. If the TCI state switch does not happen after the pre-indication, then the NW might need to send more requests. It is not trivial to define how to trigger pre-indication or how frequent those requests shall be. Moreover, several beams could be candidates for TCI state switch.
* An aperiodic RSRP report request needs to be sent **after** the TCI state switch (conditions) is triggered by the NW.In this case, sending aperiodic request will delay triggering of TCI state switch for the UE. It is not desirable because in some HST FR2 scenarios (e.g. when the train is moving opposite to the serving beam) the signal strength of the serving beam can degrade drastically during a short time.

Hence, this approach impacts the network in terms of adding additional steps to the basic TCI state switch procedure.In general, aperiodic RSRP could be beneficial for more accurate time tracking in the target beam, when this is needed. As a compromised solution we would like to propose more straightforward approach of allowing UE to known when a TCI state switch is an inter-RRH beam switching.**Option 3 (Active TCI sate list for inter-RRH indication)**1. In HST FR2 scenario NW adds to the active TCI state list for PDSCH of the UE only beams that are collocated to serving beam (intra-RRH).
2. When the UE receives a TCI state change and the target beam is in the active TCI state list (intra-RRH beams), then the UE can perform TCI state switch as currently, and no additional delay for synchronization in the target TCI state is needed (TOk in TCI state switch delay = 0)
3. When the UE receives a TCI state change and the target beam is not in the list (not an intra-RRH beam), then UE will be allowed more time for synchronization and time tracking after the TCI state change, i.e. for the TCI state switch, e.g., TOk = 1.

**This can be done without new signaling**. The whole package solution for UL timing in HST FR2 scenario is illustrated in the flow chart:Diagram  Description automatically generatedIf the UEs can track both source and target beams together, the additional TCI state switch delay can be avoided for such UEs. |

### Sub-topic 1-4: Comments on the CR 4631 assuming RAN4 will introduce inter-RRH indication

*Sub-topic description*

* Comments on CR 4631 assuming RAN4 will introduce inter-RRH indication
* Recommended WF
	+ Companies are invited to provide the comments to above options in the 1st round

Companies views’ collection for 1st round

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| Company | Comments |
| Moderators | Moderator suggest to close this sub topics based on GTW session agreements.  |
| Nokia | Our Draft CR is not fully based on the assumption that RAN4 introduces inter-RRH indication.The only related part is[the UE is indicated about the inter-RRH TCI state switch]which is in the square brackets. And if our Option 3 above is areeable then it is till relevant.Morover, we also have a change request for the section 7.1.2.1 Gradual timing adjustment.Therefore, we cannot agree that our draftCR shall be excluded from the discussion completely.Even more, we propose our draftCR to be used as a baseline because it describes the whole package soltuion and the Timing requiremnts section is allocated to Nokia following the CR work split. |

### Sub-topic 1-5: Comments on the CR 5892 and 3713 assuming RAN4 will NOT introduce inter-RRH indication

*Sub-topic description*

* Comments on CR 5892 and 3713 assuming RAN4 will not introduce inter-RRH indication
* Recommended WF
	+ Companies are invited to provide the comments to above options in the 1st round

Companies views’ collection for 1st round

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| Company | Comments |
| Moderator | Moderator suggest companies continually provide comments/suggestions for the above two CRs  |

## Summary for 1st round

### Open issues

*Moderator tries to summarize discussion status for 1st round, list all the identified open issues and tentative agreements or candidate options and suggestion for 2nd round i.e. WF assignment.*

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| **Sub-topic** | **Status summary**  |
| **Sub-topic #1-1** |  |
| **Sub-topic #1-2** |  |
| **Sub-topic #1-3** |  |
| **Sub-topic #1-4** |  |
| **Sub-topic #1-5** |  |

### CRs/TPs

*Moderator tries to summarize discussion status for 1st round and provides recommendation on CRs/TPs Status update*

*Note: The tdoc decisions shall be provided in Section 3 and this table is optional in case moderators would like to provide additional information.*

|  |  |
| --- | --- |
| **CR/TP number** | **CRs/TPs Status update recommendation**  |
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## Discussion on 2nd round (if applicable)

TBA

## Summary on 2nd round (if applicable)

*Moderator tries to summarize discussion status for 2nd round and provided recommendation on CRs/TPs/WFs/LSs Status update suggestion*

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| **CR/TP/LS/WF number** | **T-doc Status update recommendation**  |
| XXX | *Based on 2nd round of comments collection, moderator can recommend the next steps such as “agreeable”, “to be revised”* |

# Annex

Contact information

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| --- | --- | --- |
| **Company** | **Name** | **Email address** |
| Moderator (Samsung) | Xutao Zhou | xutao.zhou@samsung.com |

Note:

1. Please add your contact information in above table once you make comments on this email thread.
2. If multiple delegates from the same company make comments on single email thread, please add you name as suffix after company name when make comments i.e. Company A (XX, XX)