**3GPP TSG RAN WG1 #102-e R1-200xxxx**

**e-Meeting, August 17th – 28th, 2020**

**Agenda Item:** 8.7.1.2

**Source:** Moderator (Samsung)

**Title:**  Summary for TRS/CSI-RS occasion(s) for idle/inactive UEs

**Document for:** Discussion/Decision

# Introduction

This document provides summary for the first round of email discussion on following issues:

[102-e-NR-UE\_pow\_sav\_enh-02] Email discussiona/approval – Taehyoung (Samsung)

* By 8/21 – high priority
* By 8/27 – medium

For the decision, the following phases are to be suggested:

* Phase I (due 20th Aug 3 am PST): Quick check companies view on the priority
* Phase II (20th Aug 6 am PST – 21th Aug 6 am PST): Convergence on high priority proposals
* Phase III (24th Aug 3 am PST – 26th Aug 11 pm PST): Convergence on medium priority proposals

This document is for Phase II discussions for topics as below:

* Topic #1: Proposals for clarification (1)
* Topic #2: Proposals for clarification (2)
* Topic #3: RS types of TRS/CSI-RS for idle/inactive mode
* Topic #4: Functionalities of TRS/CSI-RS for idle/inactive mode

# Discussion

## Topic #1: Proposals for clarification (1)

After Phase I discussion, following proposal 1 is derived not to introduce any new TRS/CSI-RS for idle/inactive UE.

**Proposal 1: New types/patterns of TRS/CSI-RS are not introduced specifically for idle/inactive mode UE.**

* **Note: The new patterns of TRS/CSI-RS means the patterns of TRS/CSI-RS in a slot.**

**Please provide your view whether Proposal 1 is agreeable or not in the below table:**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments** |
| Huawei, HiSilicon | Yes |  |
| Panasonic | Yes |  |
| DOCOMO | Yes |  |
| MediaTek | Yes |  |
| ZTE | Yes |  |
| Spreadtrum | Yes |  |
| InterDigital | Yes |  |

After Phase I discussion, following proposal 2 is derived for clarification on the potential TRS/CSI-RS occasions for idle/inactive mode.

**Proposal 2: The TRS/CSI-RS occasion(s) available in connected mode UE can be share in idle/inactive mode for a UE.**

**Please provide your view whether Proposal 1 is agreeable or not in the below table:**

|  |  |  |
| --- | --- | --- |
| **Company** | **Yes/No** | **Comments** |
| Huawei, HiSilicon | No | For the updated proposal, we think this proposal means that an idle/inactive mode UE can only use the TRS/CSI-RS occasions that were available for the same UE when the UE is in connected mode. This miss-interprets the scope of the WID and will restrict the usage and benefit of potential TRS/CSI-RS occasions. Therefore, we have concerns on this update.Actually, the original proposal from the moderator is clear. If the intention of the change was aligning the wording with WID, it should be fully aligned with the WID. Some updates are made to resolve the issue:**Proposal 2: The TRS/CSI-RS occasion(s) available in connected mode ~~UE~~ can be shared ~~in~~ to idle/inactive mode ~~for a~~ UEs.** |
| Panasonic | Yes in the intention | We suggest wording update as following.The TRS/CSI-RS occasion(s) available for certain connected mode UE(s) can be shared with idle/inactive mode UE(s). |
| DOCOMO | Yes | In our understanding, the TRS/CSI-RS occasion(s) available in connected mode UE, e.g., UE(A), can be shared to other idle/inactive mode UE, e.g., UE(B). |
| MediaTek | Yes | We are fine with Huawei’s change. |
| ZTE | Yes in the intention |  Suggest the following updateThe TRS/CSI-RS occasion(s) available for connected mode UE(s) can be shared with idle/inactive mode UE(s). |
| Spreadtrum |  | Honestly, we do not know how this proposal impacts the spec or progress of specification. In legacy, every TRS/CSI-RS can be shared by UEs, and it is totally transparent to UEs. We suggest making this proposal as a Note for Proposal 3 for clarification of “no always-on transmission”. |
| InterDigital | Partially Yes | We agree that some revision is needed in the proposal to reflect the fact that TRS/CSI-RS available for connected mode UEs can also be used by idle/inactive mode UEs. The current language is somewjat misleading. |

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During Phase I discussion, some companies think that TRS/CSI-RS for idle/inactive mode is always subject to the TRS/CSI-RS for connected mode, while other companies think that TRS/CSI-RS for idle/inactive mode can still be transmitted when the TRS/CSI-RS is no longer used for connected mode UE. Since the companies views are diverge, we need to align the views for move forward.

**Question 1: Can the TRS/CSI-RS be transmitted for idle/inactive UEs when the TRS/CSI-RS is no longer used for connected mode UE?**

**Please provide your view on Question 1 in the table below:**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments** |
| Huawei, HiSilicon |  | It can be transmitted but it is up to gNB decision/implementation. We should not restrict the network implementation and therefore, we consider this does not have specification impact. |
| Panasonic | Yes | When TRS/CSI-RS is used for time/frequency tracking by idle/inactive UE, TRS/CSI-RS needs to be available periodically. Even when the cell does not have any connected UE and the occasion(s) are no longer used for connected mode UE, the network is allowed to send TRS/CSI-RS for idle/inactive UEs.  |
| DOCOMO |  | It should be up to gNB implementation, and gNB can determine to transmit the TRS/CSI-RS for idle/inactive UEs when the TRS/CSI-RS is no longer used for connected mode UE. However, the new scheme in Rel-17 should not demand gNB transmits the TRS/CSI-RS only for idle/inactive UEs when the TRS/CSI-RS is not used for connected mode UE. |
| MediaTek |  | It is up to gNB implementation, and there is no need to introduce any restriction. |
| ZTE |  | This is up to gNB implementation. gNB can stop transmit the TRS/CSI-RS for idle mode if it is no longer used for connected mode U, or continue to transmit the TRS/CSI-RS. However, continuing to transmit the TRS/CSI-RS is not mandatory/required for gNB. |
| Spreadtrum | Yes | Yes, but it is up to NW implementation. |
| InterDigital | Yes | It should be up to gNB. |

## Topic #2: Proposals for clarification (2)

During Phase I discussion, regarding the question on clarification of “no always-on transmission”, most of companies support both interpretation #1 and interpretation #2, some companies support interpretation#1 only, and other companies support interpretation #2 only. Therefore, it can be compromised proposal to take both interpretation #1 and #2 for the progress. Please check whether the potential proposals in below is acceptable or not.

**Proposal 3: When the potential TRS/CSI-RS occasion(s) is informed to idle/inactive mode UE, the TRS/CSI-RS may or may not be transmitted in the potential TRS/CSI-RS occasion(s).**

**Please provide your view whether Proposal 3 is agreeable or not in the below table:**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments** |
| Huawei, HiSilicon | No | We cannot understand the description of ‘may or may not be transmitted’. This seems another way to say UE needs to blindly detect the availability of TRS. We don’t think this is agreeable without justification/evaluation on the impact of IDLE mode UEs performance. |
| Panasonic | Depends on the type | For the purpose of time/frequency tracking, AGC and serving cell measurement of RRM, when the potential TRS/CSI-RS occasion(s) is informed to idle/inactive mode UE, the TRS/CSI-RS is transmitted in the potential TRS/CSI-RS occasion(s). Although it should be addressed in AI of "a paging enhancement(s) to reduce unnecessary UE paging receptions", for the purpose of Paging reception indication, the TRS/CSI-RS may or may not be transmitted in the potential TRS/CSI-RS .occasion(s) depending on the need of paging reception. |
| DOCOMO | Yes | In our understanding, “When the potential TRS/CSI-RS occasion(s) is informed to idle/inactive mode UE” means such as higher-layer indication for the potential TRS/CSI-RS occasion(s), and not includes the (dynamic) indication of the availability of TRS/CSI-RS for idle/inactive mode UE (proposal 4). In such case, the answer is yes, and proposal 4 is needed. |
| MediaTek | Yes |  |
| ZTE | FFS | Regarding the proposal, we would like first to clarify1. how “the potential TRS/CSI-RS occasion(s) is **informed** to idle/inactive mode UE”, by higher layer signaling(like SIB) or L1 signaling?
2. which interpretation does the proposal correspond to, interpretation 1 or 2?

In our understanding, if the RS is informed/configured by SIB, we think it the TRS/CSI-RS may or may not be transmitted in the potential TRS/CSI-RS occasion(s). If the RS is not transmitted, gNB can inform UE by e.g., L1 signaling. |
| Spreadtrum | Yes | We do not think Proposal 3 implies the blind detection at UE. We are fine for it and suggest adding a Note from Proposal 2:**Proposal 3: When the potential TRS/CSI-RS occasion(s) is informed to idle/inactive mode UE, the TRS/CSI-RS may or may not be transmitted in the potential TRS/CSI-RS occasion(s).****Note: The TRS/CSI-RS occasion(s) available in connected mode UE can be shared in idle/inactive mode for a UE** |
| InterDigital | Yes | After configuration (i.e., indicating the potantial resources) TRS/CSI-RS may or may not be transmitted. If it is transmitted, gNB may use L1 signaling to inform the UE of the availability of the TRS/CSI-RS. |

**Proposal 4: When the potential TRS/CSI-RS occasion(s) is informed to idle/inactive mode UE, the availability of TRS/CSI-RS for idle/inactive mode is informed to the UE (FFS implicitly or explicitly).**

**- Note: Availability correspond to the information for whether TRS/CSI-RS is actually transmitted or not.**

**Please provide your view whether Proposal 4 is agreeable or not in the below table:**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments** |
| Huawei, HiSilicon | Partially Yes | Generally supportive, but it is not clear on the description of “occasion(s) is informed”. Therefore, we support Weimin’s change on this:**Proposal 4: When potential TRS/CSI-RS occasion(s) is ~~informed~~ configured to idle/inactive mode UE, the availability of TRS/CSI-RS for idle/inactive mode is informed to the UE (FFS implicitly or explicitly).****- Note: Availability correspond to the information for whether TRS/CSI-RS is actually transmitted or not.** |
| Panasonic | Y |  |
| DOCOMO | Yes |  |
| MediaTek | Yes | Considering the benefit of power saving, it is better that UE knows the existence of TRS/CSI-RS. Otherwise, it may increase UE power consumption and complexity due to blind detection of TRS/CSI-RS existence. |
| ZTE | Yes | We agree with the proposal in principle. If UE has no idea when the potential TRS/CSI-RS is not transmitted, UE always has to prepare for the worse case. Hence, it is not feasible for UE to reduce power consumption.Regarding the wording, we prefer Huawei’s change, “configured” is better than “informed” |
| Spreadtrum | Yes | As explained by Panasonic in email discussion, this proposal is not related to paging enhancement, so we suggest adding a Note for this Proposal: **Note: It does not exclude using TRS/CSI-RS as sequence based paging indication, and using TRS/CSI-RS as sequence based paging indication is in the scope of “Paging enhancement”, which needs a further evaluation.** |
| InterDigital | Yes. |  |

## Topic #3: RS types of TRS/CSI-RS for idle/inactive mode

From the companies’ contributions, there are some discussions on which types of RS can be candidate the TRS/CSI-RS for idle/inactive mode. Some companies explicitly propose to support specific RS types and other companies just assume specific RS types as the baseline. Therefore, it is required to decide what types of CSI-RS can be used for TRS/CSI-RS for idle inactive mode. All types of CSI-RS and time behaviours are listed up as following:

 NR supports total 4 types of CSI-RS as below:

* Opt 1-1. CSI-RS for CSI
	+ CSI-RS configured without higher layer parameter *trs-Info* and without higher layer parameter *repetition.*
* Opt 1-2. CSI-RS for tracking (TRS)
	+ CSI-RS configured with higher layer parameter *trs-Info*.
* Opt 1-3. CSI-RS for beam management
	+ CSI-RS configured with higher layer parameter *repetition.*
* Opt 1-4. CSI-RS for mobility
	+ CSI-RS configured by *CSI-RS-Resource-Mobility*

NR supports total 3 types of CSI-RS time behaviour as below:

* Opt 2-1. Periodic
* Opt 2-2. Semi-persistent
* Opt 2-3. Aperiodic

**Please provide your views on supportable combinations of options (e.g., {Opt 1-x, Opt 2-y}) in the table below:**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Supported options****{Opt 1-x, Opt 2-y}** | **Comments** |
| Panasonic |  | We'd like to study further among Opt 1-1/1-2/1-3/1-4. For the purpose of AGC, time/frequency tracking, and serving cell RRM measurement, we support option 2-1. |
| MediaTek | {Opt 1-2, Opt 2-1} | We support Opt 1-2: to effectively save UE power, the provided RS should be able to assist AGC and T/F tracking, therefore, the required number of SSB processing can be reduced before SIB1 or paging message reception. No matter which type of CSI-RS is used, it can be used for AGC. But, TRS is well-designed for T/F tracking. So we prefer TRS.We support Opt 2-1: frequent re-configuration of potential TRS/CSI-RS occasion(s) may be needed. So considering the signaling overhead, we don’t support aperiodic RS type.  |
| ZTE | {Opt 1: at least Opt 1-2, open to other RS; Opt 2: Opt 2-1;} | 1. The basic intention of objective 1b) is to introduce potential RS for idle/inactive mode UE to perform AGC/T-F sync, which is the functionality of TRS, hence, at least Opt 1-2 is supported. Besides, we are open to consider other CSI-RS if there is PS gain.
2. The configuration/reconfiguration periodic RS is achieve by RRC signaling,which is semi-static, while the transmission of semi-persistent /aperiodic RS requires indication of MAC CE / DCI, which is quite dynamic. Considering the potential RS for idle/inactive mode is configured via SIB, and the availability indication can be carried by paging DCI/paging indication (if any), which are not so frequently transmitted compared with MAC CE/scheduling DCI. Hence, it is suggested to support Option 2-1 to reduce signaling overhead and UE wake-up times to detect the availability indication(if any).
 |
| InterDigital | {Opt 1: at least Opt 1-2, open to other RS; Opt 2: Opt 2-1;} | Agree with ZTE and MTK comments. |

## Topic #4: Functionalities of TRS/CSI-RS for idle/inactive mode

From the companies’ contributions, following functionalities are proposed to be supported for TRS/CSI-RS for idle/inactive mode.

* Opt 1. AGC
* Opt 2. Time/frequency tracking
* Opt 3. RRM measurement
* Opt 4. Paging reception indication
* Opt 5. Others?

**Please provide your views on supported options in the table below:**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Supported options** | **Comments** |
| Panasonic | Option 1, 2, 3Option 4 | Option 3 is meant as serving cell measurement of RRM. It is FFS for neighbor cell measurement. |
| MediaTek | Option 1, 2 | Opt 3: RAN4 requirement for measurement based on CSI-RS in idle mode is not complete.Opt 4: We are not sure how to use TRS/CSI-RS available for connected mode UE(s) to indicate the paging reception. Maybe more clarifications on this option are needed. |
| ZTE | Opt 1. Opt 2.(FFS:Opt 3.)  | 1. The basic intention of objective 1b) is to introduce potential RS for idle/inactive mode UE to perform AGC/T-F sync, hence, Opt 1 and Opt 2 is supported.
2. Regarding opt 3, it should be noted that if the RS is used for RRM measurement, there is potential impact on RAN2/RAN4. However, objective 1b in current WID only involves RAN1. So, if Opt 3 is supported, RAN2 /RAN4 needs to involved in this objective .
	1. Potential impact on RAN2: The legacy cell selection or re-selection criterion are based on the measurement results of SSB, if the additional CSI-RS/TRS can be used for RRM measurement, no matter it is solely used, or the measurement results can be consolidated with SSB measurement, the impact on cell selection or re-selection criterion should be considered.
	2. Potential impact on RAN4: The detection/ measurement/ evaluation interval is defined in terms of SSB, if the additional CSI-RS/TRS can be used for RRM measurement, the potential impact should be considered as well.
3. Regarding paging indication, it should be noted that the potential RS is also shared by other UEs in the connected mode. Whether there is paging message for idle mode UE is not relevant to other UE in the RRC connected mode. Hence, we are not clear how to use the potential RS in objective 1b as paging indication.
 |
| Spreadtrum | Option 1, 2 | Option 3 and 4 depends on whether TRS/CSI-Rs can be paging indication, which should be decided in “Paging enhancement”. Before the evaluation results for the next meeting, we reserve our view |

# Summary of Phase I email discussion

## Clarification on WID

|  |
| --- |
| **Proposal for conclusion 1: New RSs specifically intended for IDLE/INACTIVE mode Ues is not introduced.** |

Regarding the above proposal

* Oppo, Ericsson, CMCC, Intel, Samsung, DOCOMO, ZTE, MTK, Vivo, Spreadtrum, Sony, Interdigital, Qualcomm, CATT, Futurewei agreed.
* Xiaomi, Huawei, LG, Panasonic, Apple, Futurewei mentioned that clarification on “New RS” is needed.
* ZTE, Spreadtrum, Apple want to clarify that whether the potential functionalities can be restricted according to outcome of this proposal
* Xiaomi mentioned that whether the TRS/CSI-RS for a UE A in idle mode is always referred from the TRS/CSI-RS for the UE A or not.
* Panasonic and Apple think the TRS/CSI-RS can be still transmitted for idle/inactive UE when the TRS/CSI-RS is no longer used for connected-mode UE.
* On the other hand, Nokia and Sony think the TRS/CSI-RS cannot be transmitted for idle/inactive UE when the TRS/CSI-RS is no longer used for connected-mode UE.

### **Moderator proposal#1:**

**Proposal 1: New types/patterns of TRS/CSI-RS are not introduced specifically for idle/inactive mode UE.**

**Proposal 2: The TRS/CSI-RS for connected mode UE can be shared with idle/inactive UE.**

**- FFS: Whether the TRS/CSI-RS can be still sent for idle/inactive UE when the TRS/CSI-RS is no longer used for connected-mode UE.**

**- FFS: Whether the connected mode UE and idle/inactive mode UE should be the same or not.**

|  |
| --- |
| **Question for clarification: What is your understanding on NOTE: Always-on TRS/CSI-RS transmission by gNodeB is not required?*** **Interpretation#1: gNB may or may not be transmit the configured TRS/CSI-RS and it is up to implementation.**
* **Interpretation#2: Whether the TRS/CSI-RS is transmitted or not is somehow known to the UE (implicitly/explicitly).**
 |

Regarding the above question

* Interpretation#1: OPPO, Ericsson, CMCC, Intel, DOCOMO, Xiaomi, Huawei, ZTE, MediaTek, Spreadtrum, Nokia, Panasonic, Sony, LG, InterDigital, Apple, Futurewei
* Interpretation#2: OPPO, CMCC, Samsung, DOCOMO, Xiaomi, Huawei, ZTE, MediaTek, Vivo, Spreadtrum, Panasonic, LG, InterDigital, Qualcomm, CATT, Apple, Futurewei
* Xiaomi mentioned additional interpretations as below:
	+ Interpretation 3, gNB may activate/deactivate the configured TRS/CSI-RS explicitly/implicitly.
	+ Interpretation 4, gNB may transmit or not transmit the configured TRS/CSI-RS based on some other conditions, for example, whether there are paging message in the following PO.
* Apple think we should not exclude the potential functionalities of TRS/CSI-RS in idle/inactive mode at this stage.

### **Moderator proposal#2:**

**Proposal 3: The TRS/CSI-RS for idle/inactive mode may or may not be transmitted once it is configured.**

**Proposal 4: The existence of TRS/CSI-RS for idle/inactive mode is informed to the UE implicitly/explicitly.**

## Discussion priority

Most of companies think issue #1, #2, #3, and #4 are important and {issue #1, issue #3} and {issue #2, issue #4} need to be discussed together since there are some interaction.

Combining outcome from 3.1 and 3.2, moderator suggests discussion priority as below:

### **Moderator suggestion:**

1. **Discuss FFSs for Proposal 2 in Phase II (20th Aug 6 am PST – 21th Aug 6 am PST)**
2. **Discuss Issue #1 and Issue #2 in Phase II (20th Aug 6 am PST – 21th Aug 6 am PST)**
3. **Discuss Issue #3 and Issue #4 in Phase III (24th Aug 3 am PST – 26th Aug 11 pm PST)**
4. **Discuss details in the next meeting**

# Summary of Phase II email discussion

**[TBD]**

# Conclusion

**[TBD]**

# Summary of proposals

|  |  |
| --- | --- |
| Huawei [1] | ***Observation 1. Providing the potential TRS/CSI-RS for IDLE/INACTIVE mode UE reduces the power consumption of UEs by 6~12% when assistance RS is located in the middle of a SSB periodicity.******Observation 2. The availability of assistance RS needs to be informed to IDLE/INACTIVE mode UE implicitly or explicitly.******Observation 3. The following information is relevant for configuring assistance RS resources:*** ***- RS time/frequency resource;******- sequence generating parameter;******- periodicity/offset;******- QCL parameter.*** ***Proposal 1: Inform the availability of TRS/CSI-RS though legacy paging DCI or early transmitted paging DCI for power saving.******Proposal 2: UE assumes the configured assistance TRS/CSI-RS is transmitted in a configured/pre-defined window, which is close to the start of the PO or close to the end of the SSB bursts before the PO.******Proposal 3: Discuss how to configure assistance RS for IDLE/INACTIVE mode UEs, and how to reduce the signaling overhead for assistance RS configuration if it is configured by SIB.*** |
| vivo [2] | ***Observation 1: For idle/inactive UEs, with TRS/CSI-RS assisted for loop convergence / time-frequency tracking and RRM for serving cell, UE processing timeline can be optimized to save power consumption.******Proposal 1: Further investigate the followings for TRS/ CSI-RS in power consumption evaluation******- whether TRS / CSI-RS can be solely used without SSB for loop convergence / time-frequency tracking******- whether TRS / CSI-RS can be solely used without SSB for RRM for serving cell******Observation 2: Accuracy of RRM/AGC can not be guaranteed at UE, if the CSI-RS configuration is updated but not timely indicated to UE.******Observation 3: If CSI-RS configuration for idle/inactive UE is updated by reusing existing system information acquisition procedure, it will bring about increased notification delay, degraded measurement accuracy, excessive system overhead for paging, and increased UE power consumption.******Proposal 2: The CSI-RS configuration for idle/inactive mode UE can be broadcasted in system information.******Proposal 3: CSI-RS configuration update mechanism can be developped, and following alternatives can be considered.******- Alt 1 : Paging PDCCH indicating on/off state of the SIB configured CSI-RS resource.******- Alt 2 : Paging PDCCH indicating CSI-RS configuration update, and UE to obtain updated CSI-RS configuration with enhanced SIB reception procedure.*** ***Observation 4: UE may need to handle signals/channels with more numerologies if there is no restriction in CSI-RS configuration.******Proposal 4: Further consider restrctions on SCS for CSI-RS resources configured for idle/inactive UEs.******Proposal 5: The CSI-RS/TRS resource should be QCLed with one of the actually transmitted SSBs indicated by SIB1.******Proposal 6: The power difference between CSI-RS/TRS and SSB should be explicitly configured in CSI-RS resource configuration to idle/inactive UEs.******Proposal 7: To facilitate idle/inactive UEs to take full advantage of the CSI-RS resources in UE implementation, the purposes of the CSI-RS resources for connected UEs can also be configured for idle and inactive UEs.*** |
| ZTE [3] | ***Observation 1: In high SINR, due to the gap between the SSB for serving cell measurement and PO, there is 13% energy consumed by light sleep.******Observation 2: In low SINR, due to the multiple SSB processing before PO, UE cannot enter into deep sleep for a duration of several SSB periodicities, the energy contributed by light sleep increases to 39%.*** ***Observation 3: The introduced RS with smaller periodicity can reduce the gap between RRM measurement and paging occasion. The power saving gain is 2.6%.******Observation 4: If the introduced RS can be used for RRM measurement and time/frequency synchronization, the energy consumed by light sleep decreases from 38% to 7%, the power saving gain is 23.8%.******Observation 5: If the introduced RS can be used for time/frequency synchronization, the power saving gain is 23.8%.******Observation 6: It costs more UE energy to detect the invalid RS if the CSI-RS for UE in RRC connected state is reconfigured or updated.******Proposal 1: The following CSI-RS can be considered to be provided to UE in idle/inactive state to reduce UE power consumption.**** ***CSI-RS for mobility***
* ***TRS***

***Proposal 2: The PDCCH monitoring occasion within a PO can also be associated the introduced RS.******Proposal 3: The configuration of CSI-RS is indicated to UE in RRC idle/inactive state via system information.******Proposal 4: To reduce resource overhead, the location of CSI-RS in time domain can be configured in relative to SSB or PO/PF.******Proposal 5: The configuration change notification of CSI-RS can be carried by L1 signaling.*** |
| Sony [4] | ***Observation 1 – Providing synchronization signal block (SSB) as the only reference signal can result in high power consumption at the UE.*** ***Observation 2 – Using reference signals available in connected mode to idle/inactive-mode UE can be beneficial and results in UE power saving.******Proposal 1 – Study the information/configuration to enable the idle/inactive mode UE to use TRS and also validation mechanism whether the UE can use TRS of other UEs.*** |
| MediaTek [5] | ***Observation 1: Compared to general CSI-RS, TRS has some constraints on the configuration. Besides, for the 2 or 4 nzp-CSI-RS-Resource composing one TRS, most of the configurations are the same. Therefore, using TRS as potential RS occasion(s) available in connected mode to idle/inactive-mode UEs requires less signalling overhead than CSI-RS.******Observation 2: For idle/inactive mode UE, the provided potential TRS/CSI-RS occasion(s) should be able to assist gain control (AGC) and time-frequency tracking.******Observation 3: For idle/inactive mode UE, both potential TRS/CSI-RS occasion(s) can provide assistance for gain control (AGC), while TRS provides more significant assistance for time/frequency tracking.******Proposal 1: NW configures one or multiple periodic NZP-CSI-RS-ResourceSet with trs-Info for IDLE mode UE to utilize this (these) potential TRS, since compared to CSI-RS, TRS requires less signalling overhead and provides more significant assistance for time/frequency tracking.*** |
| CATT [6] | ***Obervation1: Reception of two SSB bursts can be as the baseline of power saving gain evaluation of additional TRS/CSI-RS.******Observation 2: Additional TRS/CSI-RS can provide 5.05% ~18.66% power saving gain over SSB based paging reception.******Observation 3: With TRS/CSI-RS occasion associated with paging occasion(s)*** ***• TRS/CSI-RS resource configuration signaling overhead is very low;******• TRS/CSI-RS can be used as power saving signal to indicate paging reception.******Observation 4: With CSI-RS resources configured with SI without association relation with paging occasion(s), TRS/CSI-RS resource configuration usually at least contain CSI-RS pattern / scrambling ID/ QCL information.******Observation 5: As option 1(TRS/CSI-RS occasion is associated with paging occasion) can support paging reception indication, significant power saving gain can be achieved over option 2 (TRS/CSI-RS resources are configured with SI without association relation with paging occasion).******Proposal 1: TRS/CSI-RS configuration for Idle/Inactive mode should be associated with paging occasion(s).*** |
| Beijing Xiaomi Software Tech [7] | ***Observation 1: Additional TRS/CSI-RS before PO can facilitate time-frequency synchronization and RRM measurement to reduce UE wake-up time, as well as acting like WUS.******Proposal 1: Group-based WUS signal using TRS/CSI-RS should be studied.*** ***Proposal 2: How to configure the additional TRS/CSI-RS configuration should be further studied.*** |
| Intel Corporation [8] | ***Proposal 1: SI may include CSI-RS and/or TRS configuration for measurement and/or channel tracking******Proposal 2: If CSI-RS or TRS configuration of RRC connected mode is active in idle/inactive mode, UE may ignore the initial CSI-RS or TRS configuration provided by SI.******Proposal 3: TRS can be periodic with paging DRX cycle and can be monitored at an offset before PO, where the TRS can also be used as wake-up signal.******• TRS burst in each periodic occasion may include repetitions.*** |
| OPPO [9] | ***Observation 1: There would be power saving gain loss when using system information to signal TRS/CSI-RS configuration. The overhead is significant when using paging.*** |
| Samsung [10] | ***Observation #1: For an idle/inactive mode UE, power consumption overhead for synchronization based on SS/PBCH blocks is high due to multiple SS/PBCH bursts used or a large time gap between a nearest SS/PBCH burst and PO.*** ***Observation #2: For an idle/inactive mode UE, power consumption overhead for serving cell RRM measurement based on SS/PBCH blocks is high due to multiple L1 samples needed or a large time gap between SMTC window and PO.******Observation #3: TRS/CSI-RS for synchronization achieves remarkable power saving gain for cell-edge UE but marginal power saving gain for cell-center UE in idle/inactive mode.******Observation #4: TRS/CSI-RS for synchronization and serving cell RRM measurement achieves remarkable power saving gain for both cell-edge UE and cell-center UE in idle/inactive mode.******Proposal #1: Support functionalities of TRS/CSI-RS for idle/inactive UEs, including**** ***Synchronization***
* ***FFS: RRM measurement or indication for paging reception***

***Proposal #2: Support configuration of cell-specific TRS/CSI-RS resources included in SIB1.******Proposal #3: Support time alignment between TRS/CSI-RS reception occasion and PO.******Proposal # 4: Support activation or deactivation of TRS/CSI-RS reception for idle/inactive mode UEs based on physical layer signal/channel.******Proposal #5: Support relative power for TRS/CSI-RS reception,*** $P\_{CSI, X}$***, such that*** $P\_{CSI, X}=P\_{MS}+\left(P\_{CSI, 14}-P\_{MS}\right)×\frac{X}{14}$***, where x is occupied symbols of TRS/CSI-RS per slot, and*** $P\_{MS}$ ***is relative power for micro-sleep.***  |
| CMCC [11] | ***Observation 1. Broadcasting the TRS/CSI-RS current using by connected mode UE(s) to idle/inactive-mode UE(s) will cause “always-on RS” or more UE power consumption.******Proposal 1. For one UE, gNB can indicate TRS/CSI-RS occasion(s) have been configured in connected mode beforehand are still effective in idle/inactive-mode.******Proposal 2. gNB can using dedicated RRC signalling or RRC release message to indicate the TRS/CSI-RS be still used in idle/inactive mode.******Proposal 3. The time domain configuration of potential TRS/CSI-RS to idle/inactive UE(s) can be as a larger periodicity of 80ms or as a time window before each PO.*** |
| Spreadtrum Communications [12] | ***Proposal 1: UE can perform AGC, T/F tracking, serving cell measurement with TRS/CSI-RS in idle/inactive mode.******Proposal 2: Both cell specific and UE-specific TRS/CSI-RS configuration should be considered.*** |
| LG Electronics [13] | ***Proposal 1: CSI-RS/TRS types which are used in connected mode can be considered as a starting point to support CSI-RS/TRS transmission for the UEs in idle/inactive mode: periodic, aperiodic, and semi-persistent CSI-RS.*** |
| 14 Panasonic [14] | ***Observation 1: Due to only relying on SSB for time/frequency synchronization and beam tracking, UE needs to wake up one or several SSB periodicities before starting to detect paging PDCCH in the monitoring occasions of the PO.*** ***Observation 2: As the parameters for SSB and paging do not share same periodicity and are configured independently, the gap between SSB and paging can be possibly large and makes UE wake up further earlier before monitoring paging.******Proposal 1: For RRC INACTIVE/IDLE mode UE, new TRS/CSI-RS occasions can be studied to enhance the synchronization and beam tracking before paging monitoring.******Proposal 2: To shorten the UE active time for paging monitoring, the additional TRS/CSI-RS location in time and frequency domain and how to configure should be studied.******Proposal 3: The influence/interaction with UE's periodic frequency/time tracking should be checked for additional TRS/CSI-RS.*** |
| 15 Apple [15] | ***Proposal: Consider the support of indicating periodic TRS/CSI-RS occasions to idle/inactive-mode UEs via broadcast message such as SIB.*** |
| 16 Ericsson [16] | ***Observation 1 TRS is the most suitable connected mode CSI-RS resource whose potential occasion(s) can be provided to the idle UE.******Observation 2 Using TRS during idle mode provides UE power saving gain of up to 4.7% in the most optimistic case under the assumption that there is 100% increase in persistent transmissions by the NW (i.e., a TRS with same periodicity as SSB is always available to the UE).******Observation 3 Idle UEs should be able to handle the case where TRS is present/absent in potential TRS occasions without additional signaling from NW.******Proposal 1 RAN1 should prioritize provisioning of potential TRS occasions to idle/inactive UEs.******Proposal 2 Higher layer signaling is used to convey potential TRS occasions to Idle/Inactive UEs. It is up to the UE to detect whether a potential TRS occasion contains TRS or not (Note: NW is not required to transmit TRS in potential TRS occasions).******Proposal 3 Provisioning of compact TRS configurations by omitting/identifying optional parameters for conveying potential TRS occasions can be considered.*** |
| NTT DOCOMO, INC. [17] | ***Proposal 1: Pre-configured information on TRS/CSI-RS, e.g., resource location, should be indicated to idle/inactive-mode UEs via SIB1 and/or dedicated RRC signalling which was indicated when the UE was in connected-mode.**** ***FFS: how to indicate whether TRS/CSI-RS is available or not dynamically***

***Obaservation 1: It would be beneficial TRS/CSI-RS is located near paging occasion in terms of power consumption and performance.******Proposal 2: The resource location of TRS/CSI-RS can be indicated based on the resource location of paging occasion.*** |
| Qualcomm Incorporated [18] | ***Observation 1: Power saving gain of additional TRS/CSI-RS depends on the number of SSBs used for loop update and location of the TRS/CSI-RS relative to the PO.******Observation 2: Whether a TRS/CSI-RS can provide more processing gain than a SSB depends on channel frequency selectivity, bandwidth of the TRS/CSI-RS and frequency drifting rate.******Observation 3: TRS/CSI-RS is especially beneficial for decoding broadcast PDSCH.******Observation 4: From power saving perspective, it is preferred to have the TRS overlap with or very close to the PDSCH.*** ***Proposal 1: If it is agreed that network configures TRS/CSI-RS for time/frequency tracking and AGC loop update, the UE assumes TRS/CSI-RS is transmitted only when page message is transmitted for the UE.*** ***Proposal 2: The TRS/CSI-RS can be UE group based for idle/inactive UEs.******Proposal 3: Network configures cross-slot scheduling for PDCCH CRC scrambled by P-RNTI for the scheduling of paging PDSCH.******Proposal 4: If TRS/CSI-RS is adopted, TRS/CSI-RS can be optionally used for RRM measurement.******Proposal 5: If TRS/CSI-RS is adopted, information of TRS/CSI-RS can be provided to idle/inactive UEs by******• Pre-configuration in SIB or specifications******• Unused bits in DCI format 1\_0 with CRC scrambled by P-RNTI******• UE hypothetical detection of the other information.*** |
| Nokia, Nokia Shanghai Bell [19] | ***Observation: Actual specification work for objective 1b would seem to fall under RAN2 jurisdiction.*** ***Proposal: Do not introduce new RSs spesifically intented for IDLE/Inactive mode UEs.******Proposal: While network can provide RS configuration to IDLE/Inactive UEs, UE shall not assume that the RS are always present. UEs are required to autonomously detect the presence of RS when in RRC Idle/Inactive.*** ***Proposal: At least initially, RAN1 should focus on periodic tracking RS (TRS) related information for the serving cell only.*** |

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