**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: How to provide the potential TRS/CSI-RS occasion(s) to the idle/inactive UEs

# Discussion

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

|  |
| --- |
| **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?** |

Regarding the question, most of companies think it is up to gNB implementation and there should not be any restriction and specification impact related to this question.

Panasonic think the network is allowed to send TRS/CSI-RS for idle/inactive UEs even when the cell does not have any connected UE and the occasion(s) are no longer used for connected mode UE.

However, DOCOMO and Sony think it is not aligned with the WID if TRS/CSI-RS is transmitted for idle/inactive UEs when the TRS/CSI-RS is not used for connected mode UEs.

Sony asks that “when the TRS/CSI-RS is no longer used for connected mode UE” means that “there is a connected mode UE in a cell but the UE is no longer using TRS/CSI-RS” or “the connected mode UE is no longer in a cell”.

Ericsson think the discussion should be about what the UE can expect rather than what NW can or cannot do.

Apple and Samsung think it is transparent to idle/inactive UEs.

Although the companies share the similar view, but detailed understanding is somewhat different. **Especially, Panasonic view and Sony view are contradictory**.

Panasonic think the network is still allowed to send TRS/CSI-RS to idle/inactive UEs even when there is no connected mode UEs in the cell. However, Sony think if it is allowed, this is not inline with the WID.

Based on above discussion, as long as the majority companies think it is just up to gNB implementation and do not want to have any restriction in use of TRS/CSI-RS for idle/inactive mode, following conclusion is suggested.

**Proposal for conclusion:**

**It is up to gNB implementation whether or not to transmit a TRS/CSI-RS to idle/inactive UEs even when the TRS/CSI-RS is no longer used for connected UEs (e.g., when there is a connected mode UE in a cell but the UE is no longer using the TRS/CSI-RS, or when there is no longer connected mode UE in a cell, etc.)**

* **Note: According to above, it is understood that the TRS/CSI-RS can be transmitted to idle/inactive UEs even when the TRS/CSI-RS is no longer used for connected UEs.**

**Alt 1. Capture above as a conclusion**

**Alt 2. Do not capture above as a conclusion**

**Please provide your view on above clarification in the table below:**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Alt 1 or Alt 2?** | **Comments** |
| Vivo | Alt 1 |  |
| CMCC | Alt 1 |  |
| Panasonic | Alt 1 | Although this gNB implementation is transparent to UE, aligned understanding is necessary to better clarify the specification impact for next step work. |

## Topic #2: Proposals for clarification (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).****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.** |

Regarding proposal 3, the companies’ views are as below:

* Support: [Panasonic], DOCOMO, MediaTek, [Spreadtrum], InterDigital, Sony, CMCC, Nokia, Intel, Ericsson
* Object: Huawei, HiSilicon, Futurewei
* FFS: ZTE

Huawei, HiSilicon, Samsung think it is not agreeable if the proposal 3 requires that the UE needs to blindly detect the availability of TRS/CSI-RS.

Panasonic, Intel, Apple, and Qualcomm think it is depending on the functionalities and types of the TRS/CSI-RS for idle/inactive mode

Sony, Nokia, and Ericsson it is depending on network situation on connected mode activity.

Spreadtrum suggests to add a note from proposal 2 to proposal 3.

Futurewei, Apple suggests to combine proposal 3 and proposal 4

Regarding proposal 4, the companies’ views are as below:

* Support: Huawei, Panasonic, DOCOMO, MediaTek, ZTE, [Spreadtrum], InterDigital, [Sony], CMCC, [Futureway]
* Object: Nokia, Intel, Ericsson
* FFS: ZTE

Spreadtrum suggests to add a note “**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.**”

CMCC requests to clarify that whether the “availability information” contains the re-configuration of other TRS/CSI-RS or just inform the UE whether TRS/CSI-RS is actually transmitted or not.

Nokia and Ericsson requests further clarification such that before committing to an indication, it should be understood what are the implications to network operation or the actual UE idle mode power consumption due to frequent indication monitoring cycle.

Intel, Apple, and Qualcomm think it is depending on the functionalities and types of the TRS/CSI-RS for idle/inactive mode

Since the original intention of proposal 3 and proposal 4 is to check the potential specification impacts and corresponding expected UE behaviour. Many companies think there is a joint issue with paging enhancement (e.g., functionality related to paging reception indication). Some companies think it should be first studied that what are the implications to network operation or the actual UE idle mode power consumption due to the frequent indication monitoring cycle.

Based on above discussion, following is suggested.

**Proposal:**

**After that the potential TRS/CSI-RS occasion(s) is 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 corresponds to the information for whether TRS/CSI-RS is actually transmitted or not.**

**- Note: It does not exclude using the TRS/CSI-RS as a paging reception indication.**

**Alt 1: Agree**

**Alt 2: Study further and decide in the next meeting.**

**Please provide your view on above clarification in the table below:**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Alt 1 or Alt 2?** | **Comments** |
| vivo | Alt 1 | The UE may need to always blind detect of the TRS/CSI-RS availability if it is not informed to the UE. These should be avoided as much as possible. In our view, the configuration of potential TRS/CSI-RS can be via SIB. When the TRS/CSI-RS availability for idle UE is changed, network can indicate this via paging indication. Existing procedure of paging can be reused. |
| CMCC | Alt 1 | We agree UE should be informed the availability of TRS/CSI-RS.We think the providing of TRS/CSI-RS can be UE-specific which up to gNB’s decision to provide the potential TRS/CSI-RS occasion or not. The TRS/CSI-RS can be configured by dedicated RRC signaling or RRC release message, and L1 signaling, e.g., paging can be used to inform the availability information of TRS/CSI-RS. |
| Panasonic | Alt 1 |  |

In addition, in order to avoid duplicated discussion between agenda 8.7.1.1 and 8.7.1.2, following is suggested.

**Moderator suggestion:**

**Whether or not to support paging reception indication functionality for TRS/CSI-RS for idle/inactive UE(s) is discussed in agenda 8.7.1.1 Paging enhancement.**

**Please provide your view on above suggestion in the below table:**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments** |
| Vivo | no | Whether TRS/CSI-RS availability can be informed should be decided in 8.7.1.2. Hence, whether TRS/CSI-RS availability by paging indication should be in section 8.7.1.2 |
| CMCC | Yes | Reusing TRS/CSI-RS is one of the RS-based indication scheme to indicate UE whether to receive paging data in the upcoming PO, and should be discussed in agenda 8.7.1.1. |
| Panasonic | Yes |  |

## Topic #3: How to provide the potential TRS/CSI-RS occasion(s) to the idle/inactive UEs.

From the companies’ contributions, it is observed that many companies proposed signalling method and potential information for configuration to provide the potential TRS/CSI-RS occasion(s) to idle/inactive Ues.

For the signalling method, many companies proposed to use SIB, some companies proposed to use other higher layer signalling such as dedicated RRC, RRC release message, and some companies proposed to use pre-configuration.

Based on above observation, following is suggested:

**Proposal:**

**The potential TRS/CSI-RS occasion(s) for idle/inactive mode Ues is provided at least by SIB**

* **FFS for other signalling candidates (e.g., dedicated RRC, RRC release message, pre-configuration, etc.)**
* **FFS for detailed configuration parameters**

**Please provide your views whether above proposal is agreeable or not in the table below:**

|  |  |  |
| --- | --- | --- |
| **Company**  | **Yes/No** | **Comments** |
| Vivo | Yes | We are in principle fine with the following change:**The potential TRS/CSI-RS occasion(s) for idle/inactive mode Ues is provided at least by SIB*** **FFS for other signalling candidates (e.g., dedicated RRC, RRC release message, pre-configuration, etc.)**
* **FFS for detailed configuration parameters**
* **FFS how to additionally inform UE whether the SIB configured TRS/CSI-RS are present**

The added sub-bullet informs the availability of TRS/CSI-RS should be solved in addition to configuration. Thus people can have a whole picture of this problem. |
| CMCC | No | As the major view from companies, the TRS/CSI-RS is used for AGC and time/frequency tracking before PO, that is the TRS/CSI-RS is more important for UE(s) with higher paging rate. We think the providing of TRS/CSI-RS to IDLE/INACTIVE UE should be UE-specific, which it is up to gNB’s decision to provide additional TRS/CSI-RS service to one idle/inactive UE or not. For example, gNB can decide to provide TRS/CSI-RS to UE(s) transferring between connected mode and idle/inactive mode frequently (UE with higher paging rate).The dedicated RRC signaling or RRC release message can easily realize the UE-specific TRS/CSI-RS configuration.Therefore, we think we should not make a fast decision on using SIB as the configuration signaling, we are fine with the following change:**The potential TRS/CSI-RS occasion(s) for idle/inactive mode Ues is provided ~~at least~~ by ~~SIB~~ higher layer signalling*** **FFS higher layer signalling candidates (e.g., SIB, dedicated RRC, RRC release message, etc.)**
* **FFS for other signalling candidates (e.g., ~~dedicated RRC, RRC release message,~~ pre-configuration, etc.)**
* **FFS for detailed configuration parameters**
 |
| Panasonic | Yes |  |

# Summary of Phase III email discussion

[TBD]

# Summary of Phase II email discussion

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

**For Proposal 1:**

All companies agree with following proposal 1. Following is suggested.

**Proposal for agreement:**

**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.**

**For Proposal 2:**

All companies except for Spreadturm agree with the proposal 2 in the principle.

Spreadtrum suggests making this proposal 2 as a Note for Proposal 3.

Since it is estimated that the revised version from Ericsson can be acceptable to other companies, following is suggested.

**Proposal for agreement:**

**The potential TRS/CSI-RS occasion(s) available in connected mode can be shared to idle/inactive mode UE.**

**For Question 1:**

Regarding the question, all companies except for DOCOMO and Sony think it is up to gNB implementation.

DOCOMO and Sony think it is not aligned with the WID if TRS/CSI-RS for idle/inactive mode is transmitted when the TRS/CSI-RS is not used for connected mode.

Ericsson think the discussion should be about what the UE can expect rather than what NW can or cannot do.

Based on the discussion, following is suggested.

**Moderator suggestion:**

**Continue to discuss this in Phase III email discussion.**

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

**For Proposal 3:**

From phase II email discussion, companies view on proposal 3 are as following:

**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).**

* Support: [Panasonic], DOCOMO, MediaTek, [Spreadtrum], InterDigital, Sony, CMCC, Nokia, Intel, Ericsson
* Object: Huawei, HiSilicon, Futurewei
* FFS: ZTE

Panasonic think it is depending on the functionalities and types of the TRS/CSI-RS for idle/inactive mode

Sony, Nokia, and Ericsson it is depending on network situation on connected mode activity.

Spreadtrum suggests to add a note from proposal 2 to proposal 3.

Futurewei suggests to combine proposal 3 and proposal 4

Based on the discussion, following is suggested.

**Moderator suggestion:**

**Continue to discuss this in Phase III email discussion.**

**For Proposal 4:**

From phase II email discussion, companies view on proposal 4 are as following:

**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.**

* Support: Huawei, Panasonic, DOCOMO, MediaTek, ZTE, [Spreadtrum], InterDigital, [Sony], CMCC, [Futureway]
* Object: Nokia, Intel, Ericsson
* FFS: ZTE

Spreadtrum suggests to add a note “**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.**”

CMCC requests to clarify that whether the “availability information” contains the re-configuration of other TRS/CSI-RS or just inform the UE whether TRS/CSI-RS is actually transmitted or not.

Nokia and Ericsson requests further clarification such that before committing to an indication, it should be understood what are the implications to network operation or the actual UE idle mode power consumption due to frequent indication monitoring cycle.

Based on the discussion, following is suggested.

**Moderator suggestion:**

**Continue to discuss this in Phase III email discussion.**

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

From phase II email discussion, companies mentioned their preferred options for RS types of TRS/CSI-RS for idle/inactive mode as below:

For 4 types of CSI-RS,

* Opt 1-1. CSI-RS for CSI:
* Opt 1-2. CSI-RS for tracking (TRS): MediaTek, ZTE, InterDigital, Sony, CMCC, Nokia, Intel, Samsung
* Opt 1-3. CSI-RS for beam management
* Opt 1-4. CSI-RS for mobility

For 3 types of CSI-RS time behaviour,

* Opt 2-1. Periodic: Panasonic, MediaTek, ZTE, InterDigital, Sony, CMCC, Nokia, Intel, Samsung
* Opt 2-2. Semi-persistent
* Opt 2-3. Aperiodic

Nokia and Ericsson mentioned that regarding option 2, it should be further clarified that this is from the perspective of Connected Mode UE not from IDLE mode UE

All companies think at least Opt 1-2 and Opt 2-1 should be supported and other options are needed to be studied further.

Based on above discussion, following is suggested.

**Proposal for agreement:**

**For TRS/CSI-RS for idle/inactive mode, at least periodic TRS is supported.**

* **FFS for other RS types**

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

From phase II email discussion, companies mentioned their preferred functionalities as below:

* Opt 1. AGC: Panasonic, MediaTek, ZTE, Spreadtrum, Sony, CMCC, Nokia, Intel, Samsung
* Opt 2. Time/frequency tracking: Panasonic, MediaTek, ZTE, Spreadtrum, Sony, CMCC, Nokia, Intel, Ericsson, Samsung
* Opt 3. RRM measurement: [Panasonic], Sony, [Nokia], [Samsung]
* Opt 4. Paging reception indication: Panasonic, Sony, Intel, [Samsung]
* Opt 5. Others?

MediaTek, ZTE, CMCC, mentioned for Opt 3 that there is potential impact on RAN2/RAN4.

MediaTek, ZTE, Nokia, are not sure how to use TRS/CSI-RS available for connected mode UE(s) to indicate the paging reception for idle/inactive mode UE(s).

Spreadtrum, CMCC think Opt. 4 is related to agenda 8.7.1.1 “Paging enhancement”.

Panasonic requests the clarification whether Opt 3 includes RRM measurement for both serving cell and neighbor cell or for serving cell only.

Ericsson think it is up to UE implementation how to use these. the RS from connected mode will be reused, and no changes are expected to enable certain UE functionality, etc.

Based on above discussion, following is suggested.

**Proposal for agreement:**

**For TRS/CSI-RS for idle/inactive mode, following functionalities are supported:**

* **AGC, time/frequency tracking**
* **FFS: RRM measurement for serving cell, RRM measurement for neighbour cell, paging reception indication**

# 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.*** |

# References

1. RP-200938, “Revised WID UE Power Saving Enhancements for NR”
2. R1-2005263 Assistance RS occasions for IDLE/inactive mode Huawei, HiSilicon
3. R1-2005389 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs vivo
4. R1-2005521 Reference signal for RRC idle and inactive UEs ZTE
5. R1-2005583 On the usage of TRS/CSI-RS for the UE in Idle Mode Sony
6. R1-2005616 On TRS/CSI-RS occasion(s) for idle/inactive mode UE power saving MediaTek Inc.
7. R1-2005720 Configuration of TRS/CSI-RS for paging enhancement CATT
8. R1-2005739 Discussion on TRS CSI-RS occasions for idle/inactive UEs Beijing Xiaomi Software Tech
9. R1-2005885 Discussion on TRS/CSI-RS reception during idle/inactive mode Intel Corporation
10. R1-2006042 RS occasion for idle/inactive UEs OPPO
11. R1-2006158 On TRS/CSI-RS occasion(s) for idle/inactive Ues Samsung
12. R1-2006222 Discussion on potential TRS CSI-RS occasion(s) for idle/inactive UEs CMCC
13. R1-2006269 Consideration on TRS/CSI-RS occasion(s) for idle/inactive UEs Spreadtrum Communications
14. R1-2006312 Discussion on TRS/CSI-RS occasion(s) for idle/inactive UEs LG Electronics
15. R1-2006386 Potential enhancements for TRS/CSI-RS occasion(s) for idle/inactive Ues Panasonic
16. R1-2006528 Indication of TRS/CSI-RS for idle/inactive-mode UE power saving Apple
17. R1-2006666 Provisioning of potential TRS/CSI-RS occasion(s) for Idle/Inactive UEs Ericsson
18. R1-2006737 Discussion on TRS/CSI-RS occasion for idle/inactive UEs NTT DOCOMO, INC.
19. R1-2006816 TRS/CSI-RS for idle/inactive UE power saving Qualcomm Incorporated
20. R1-2006897 On RS information to IDLE/Inactive mode Ues Nokia, Nokia Shanghai Bell