**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

# Discussion

## Background

For a UE operating in IDLE/INACTIVE mode, the UE consumes powers for various activities such as AGC, time/frequency synchronization, RRM measurement, paging monitoring, etc. As illustrated in Figure 1, LTE supports always-on CRS in every subframe, on the other hand, NR supports SSB only which is transmitted with a longer periodicity (e.g., 20ms) compared to LTE CRS. NR UE needs to wake-up much earlier, much longer, and more frequently compared to LTE UE for the subsequent activities. Accordingly, the power consumption for NR UE in IDLE/INACTIVE mode is much higher than that for LTE UE in IDLE mode. Based on the motivation, it is agreed to specify to provide additional TRS/CSI-RS occasion(s) for IDLE/INACTIVE mode UE as in WID for Rel-17 UE power saving enhancements [1].

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| (a) LTE | (b) NR |

Figure 1: Illustration of the timeline of an idle/inactive mode UE for data reception from a serving cell.

Generally, for enabling TRS/CSI-RS for idle/inactive mode, following questions need to be answered:

* How to provide the configuration information for TRS/CSI-RS to idle/inactive UEs?
* How to avoid always-on TRS/CSI-RS transmission?
* How to reduce the signaling overhead?

In the following sections, more detailed list of issues is provided for the email discussion.

## Summary of issues and potential priorities

From the companies contributions [1]-[19], following issues are identified:

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **#** | **Issues** | **Description** | **Contributions** | **Tentative Priority** |
| 1 | RS Types | Which type of RS is used?- TRS only- P-CSI-RS- Others (CSI-RS for ‘mobility’, P/AP/SP CSI-RS, etc.) | [3], [5], [13], [16], [19], [9], [7] | High |
| 2 | Configuration method | How to provide the configuration to the UE?- SIB- Others (Dedicated RRC, RRC release message, Pre-configuration in the spec, etc.) | [1], [2], [6], [10], [11], [12], [15], [16], [17], [18], [19], [9], [7] | High |
| 3 | Functionality | What kind of functionalities are supported?- AGC- T/F tracking- Others (RRM measurement, Paging reception indication, beam tracking, etc.) | [2], [3], [5], [6], [7], [8], [10], [12], [18], [9] | Med |
| 4 | Availability | How to provide the information for availability of the configured TRS/CSI-RS occasion(s)?- SIB- L1 signaling- Others (UE autonomous, etc.) | [1], [2], [3], [10], [16], [18], [19], [9] | Med |
| 5 | Configuration details (1) | How to reduce the signaling overhead?Detailed list of parameters for configuration? | [1], [2], [5], [6], [11], [19] | Low |
| 6 | Configuration details (2) | Whether the TRS/CSI-RS occasion is associated with paging occasion or not? | [1], [3], [6], [8], [10], [17], [18], [9], [7] | Low |
| 7 | Others | Individual proposals from the companies |  | Low |

Tentative priority is suggested in the right-most column in the table. It is determined based on the number of contributions mentioning the corresponding issues. For issue#1, it is understood that issue#1 is the most basic one to be decided first for the next-level discussions although the companies does not mention it explicitly in their contributions.

**Please provide the views on the tentative priority or additional suggestions on the priority in the table below:**

|  |  |
| --- | --- |
| **Company**  | **Comments** |
| OPPO | Fine with 1,3.2/4 seem to be duplicated with each other, keep one of them would be ok, the priority shall be high.If we discuss 2 or 4, the details in 5 or 6 may be touched.  |
| Ericsson | For the table, it should be clarified that the discussion is about providing information regarding “potential TRS/CSI-RS occasion(s)” as stated in the WID. This is mentioned in 4,6 (though “potential” is missing) but it needs to be clarified everywhere in the table, e.g. row #1 should be formulated as “Potential occasion(s) of which type of RS can be indicated to the UE?”.  |
| CMCC | Issue 1, 2 and 3 can be with high priority.The Issue 1 and Issue 3 are related, because different RS has its own usage, e.g., CSI-RS for tracking or CSI-RS for mobility, therefore these two issues can be discussed together.In addition, we want to clarify the “availability” in Issue 4, is that means the “signaling to turn on/off the TRS/CSI-RS” or “signaling to re-configure the TRS/CSI-RS”? We think these two functions should be both supported. |
| Intel | 1, 2, 3 can be discussed first. Point 4 can be optionally included as part 2. Our contribution seems to be missing in the table as reference. Added it.  |
| Samsung | Generally OK but we prefer to put the functionality to high priority. Without consensus on the functionality to support, it would be difficult to discuss the other design aspects. In addition, since there exist some joint issues, we think it is desirable to discuss high-level principle first rather than details. |
| DOCOMO | As issue 3 is related to other issues, issue 3 should be also high priority. We are fine with others. |
| Xiaomi | Agree with the tentative priority list. |
| Huawei,Hisilicon | High: Issue#1, Issue#2, Issue# 3, Issue#4Issue#1 and #3 are related and can be discussed together. For Issue#4, The RS is not always-on RS. Therefore, we think Issue#4 is important and should be prioritized. |
| ZTE | Issue#1 and #3 are relevant and can be discussed together. Hence, the priority of issue #3 should be high. Besides, if the understandings of section 2.3 are controversial, it should be tagged with high priority as well, since issue 2/3 is relevant with the understanding of the WID. |
| MediaTek | Agree that Issue #1 and #2 are high priority.But, we also think that Issue #1, #3, and #5 are related and should be discussed together. When determining the RS type, the RS functionalities and signaling overhead should be taken into account. Therefore, we suggest to merge Issue #3 and signaling overhead in Issue #5 into Issue #1 to have a joint discussion.Regarding Issue #4, it is an enhancement to further reduce UE’s effort on blind detection. So, it is reasonable that Issue #4 has lower priority than Issue #1/#2. |
| Vivo | We are OK with the priority with the following comments,1. It would be better to assign ‘(3) Functionality’ as High priority considering vast number of contributions and importance to the design. The design of (1)(2) would be impacted by different purposes of the functionality.2. For (7)others, we would like to propose discuss the followings, which are also included in our company contribution (R1-2005389)* TRS/CSI-RS association with SSB, e.g., QCL association, this is also related to (6). And it depending on whether TRS/CSI-RS is associated with PO or SSB
* Whether the purposes of the CSI-RS resources for connected UEs can also be configured for idle and inactive Ues for specific usage.
 |
| Spreadtrum | We agree that issue 1 and issue 2 are high priority. In addition, issue 3 should be clarified for further progress, since it is tightly related to power saving schemes. |
| Nokia | On high level we are fine with the proposed order of things, but we think we should also consider the overhead impact in conjunction with e.g. issue #1 or as an individual point.We think that issue#1 and #3 are somewhat intervened, i.e. to support proper FD/TD tracking TRS are the most useful. So these two could be merged that we discuss the RS type together with the purpose/use. Bit similarly, the extent of the information needed to be provided will naturally affect the feasibility of different methods to deliver the information, hence #2 relates to #1 as well it does to #5.Also agree with Ericsson comment that we should be talking about providing information about the potential occasions rather e.g. configuring the RS. On issue #4 I think it is more if and how UE is provided information regarding the presence of the RS in the potential occasions. The discussion point seems now to be driven that there will be an indication mechanism or presence guarantee. |
| Panasonic | We agree on the proposal. |
| SONY | We consider (1), (2) and (4) are High Priority |
| LG | We think issue 1, 2, 3, and 4 are related to each other. Regarding the order of discussion, we prefer to start from issue 3. Without a consensus on the functionality, it might be difficult to determine which type of RS is suitable and which information is needed for its configuration. So, we think the issue 3 should be the first priority and issues ½/4 are the next. |
| Qualcomm | 3 may also have a high priority if not higher than 2 because usage of the RS has a impact to UE power consumption. |
| CATT | We are generally fine with all items for study with the assumption of issue 3 as the most important aspect for consideration. We need to define the assumption of network paging strategy (blank paging or progressive paging) in order to evaluate the RS configuration.  |

## Aligning understanding on WID

Before jumping up the detailed discussions, it would be valuable to align the companies understanding on the WID as mentioned in [19].

|  |
| --- |
| 1. Specify enhancements for idle/inactive-mode UE power saving, considering system performance aspects [RAN2, RAN1]
	1. Study and specify paging enhancement(s) to reduce unnecessary UE paging receptions, subject to no impact to legacy UEs [RAN2, RAN1]

NOTE: RAN1 to check and update, if needed, evaluation methodology in RAN1 #100 meeting* 1. Specify means to provide potential TRS/CSI-RS occasion(s) available in connected mode to idle/inactive-mode Ues, minimizing system overhead impact [RAN1]

NOTE: Always-on TRS/CSI-RS transmission by gNodeB is not required |

Regarding the yellow part, it is understood that the potential TRS/CSI-RS occasion(s) available for connected mode UE may be used for idle/inactive mode Ues. This implies that there would be no new RSs specifically intended only for idle/inactive Ues.

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

**Please provide the views on the above potential conclusion in the table below:**

|  |  |
| --- | --- |
| **Company**  | **Comments** |
| OPPO | New RSs are not needed. |
| Ericsson | Agree and such RSs are already precluded by the WI description. |
| CMCC | Agree with this proposal. |
| Intel | Agree with this proposal. |
| Samsung | Agree with this proposal. |
| DOCOMO | Agree with this proposal. |
| Xiaomi | Not quite sure what’s the exact meaning of “new”. Is the Proposal only allows the following?If UE1 is connected to gNB1, and gNB1 configures a TRS/CSI-RS configuration for UE1 in RRC connect mode. Then after some time UE1 turns1 to RRC idle/inactive mode, but UE can assume the TRS/CSI-RS previous configured by gNB1 when it’s in RRC connect mode is still effective.If that is the case, we think it is too restricted. For example, for a UE which is in idle mode and has not connected to gNB1 before, when it moves to gNB1’s coverage, it would not be possible for the UE to utilize TRS/CSI-RS.Our understanding is, gNB can configure or indicate TRS/CSI specifically for idle/inactive UE. And the configuration of TRS/CSI-RS can be like the ones in RRC connect mode.  |
| Huawei,Hisilicon | It is not clear on the ‘New RSs’. It means ‘New RSs type’ , ‘New RSs transmission’ or something else?Prefer to clarify first. |
| ZTE | Agree with the proposal. Besides, if the above conclusion is agreed, it might be inappropriate for the TRS/CSI-RS provided to UE idle/inactive mode UE to support some functionalities.  |
| MediaTek | Agree with this proposal. |
| Vivo | Support proposal 1 |
| Spreadtrum | We basically agree with this proposal. We understand the purpose is to reduce the system overhead, but it is hard to reflect the intention of TRS/CSI-RS in the spec. Furthermore, we should first clarify the functions of the additional RS, e.g. for channel tracking or for mobility. Based on the functions, we can find the exact overhead of the additional RS. |
| Nokia | Agree, the objective clearly restricts to TRS/CSI-RS. Also it is restricted to those available in connected mode. |
| Panasonic | Although we agree the proposal, we think “new RSs specifically intended for IDLE/INACTIVE mode UE” can have multiple interpretations. One interpretation is, if the cell does not send any TRS/CSI-RS for connected mode UE (extreme situation of no RRC\_CONNECTED UE in the cell), this current discussing RSs is not allowed to be sent. As IDLE/INACTIVE mode UE does not know the situation of the other UE’s activity in the cell, we would like to avoid such interpretation. Our interpretation of “new RSs specifically intended for IDLE/INACTIVE mode UE” is “the TRS/CSI-RS sent to connected mode UE can be shared with IDLE/INACTIVE mode UE” and “new pattern/occasion of TRS/CSI-RS are not introduced”. Another point would be the relation of the point “a. Study and specify paging enhancement(s) to reduce unnecessary UE paging receptions, subject to no impact to legacy Ues”. If TRS/CSI-RS is used for this purpose (while keeping backward compatibility with Rel.15/16 Ues), the TRS/CSI-RS for purpose “a” is not required to be same with TRS/CSI-RS used for connected mode UE. “To send TRS/CSI-RS when paging reception is required” is still within WID scope (but not in the scope of “b”). |
| SONY | Support Proposal 1 |
| LG | The meaning of ‘New RS’ is not clear for us. We do not see the needs for introducing ‘New type of RS’ other than TRS/CSI-RS. As this intention is clearly captured in WID, we tend to think this proposal is needed. |
| InterDigital | Agree with the proposal. |
| Qualcomm | Agree that new RS may not be introduced. |
| CATT | Agreed. |

Regarding the blue part, it is understood that the TRS/CSI-RS does not required to be always transmitted by the gNB. However, it is still ambiguous whether this note means that it can be solely decided by gNB implementation or additional specification effort for it will be there.

**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).**

**Please provide the views on the above question for clarification in the table below:**

|  |  |
| --- | --- |
| **Company**  | **Comments** |
| OPPO | “Always-on TRS/CSI-RS transmission by gNodeB is not required”, our understanding is that the gNB will borrow the TRS/CSI-RS transmission for connected UE to idle/inactive UEs, when connected UE does not need the TRS/CSI-RS, the gNB may not transmit it.On the other hand, whether the TRS/CSI-RS is transmitted or not shall be indicated to the UE. Otherwise, the UE may have to continuously blind detect TRS/CSI-RS, which would result in additional power consumption. |
| Ericsson | Interpretation 1 and the wording should be “may or may not transmit in the potential TRS/CSI-RS occasion(s)”. |
| CMCC | We think both two interpretations are needed.From gNB’s side, it is up to implementation to decide whether transmit the TRS/CSI-RS or not.From UE’s side, the signaling about turn on/off the TRS/CSI-RS is needed, otherwise, UE may always assume the existence of TRS/CSI-RS even gNB has not transmitted it, which will cause the decrease of UE performance of T/F tacking, AGC or RRM. |
| Intel | Interpretation # 1, i.e., TRS/CSI-RS occasion can be configured but transmission is up to the gNB. |
| Samsung | Our understanding is Interpretation#2. Interpretation#1 will causes issues such as interpretation of the channel condition, and limit the power saving gain as UE has to be prepared for the worst case in advance. |
| DOCOMO | We agree with CMCC. It is just up to gNB implementation whether gNB actually transmits TRS/CSI-RS or not. Additionally, it should be studied how to indicate the information on the availability of the TRS/CSI-RS. Further discussion is needed for the details, e.g., explicit/implicit. |
| Xiaomi | Both the interpretations are OK, as long as it is not an always-on signal like the CRS in LTE.Other possible interpretation would be,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. |
| Huawei,Hisilicon | The interpretation#1 and interpretation#2 does not conflict actually. The gNB can decide whether to transmit the TRS/CSI-RS or not, and can also implicitly or explicitly inform UE for better power saving.We share similar view with OPPO and CMCC. |
| ZTE | In our understanding, the interpretation #1 and interpretation #2 are not exclusive. As it is required by the WID, the TRS/CSI-RS is not required to be “always-on”, it is up to gNB implementation to transmit or stop transmitting the TRS/CSI-RS, which corresponds to interpretation #1. Meanwhile, if gNB does not inform UE the TRS/CSI-RS is “invalid”, it may cost more UE energy or affect the decoding performance of paging DCI/message. Hence, gNB can indicate to UE the TRS/CSI-RS is de-activated or updated, which is the interpretation #2. |
| MediaTek | Both interpretations are possible.By default, UE cannot assume the TRS/CSI-RS is always transmitted by gNB even if the RS configuration is broadcasted to UE, i.e., Interpretation #1. But it cannot preclude the possibility/solution that gNB further indicates the TRS/CSI-RS existence, e.g., through L1 signaling, to UE. If gNB further indicates the presence of TRS/CSI-RS to a UE, the UE can assume the TRS/CSI-RS is transmitted, i.e., Interpretation #2. However, whether to further include such possibility/solution needs RAN1 discussion.  |
| Vivo | We think the interpretation #2 would be better for UE implementation. For connected Ues, the periodic CSI-RS are not regarded as always-on RS, since the gNB can semi-statically reconfigure CSI-RS or switch on/off the p-CSI-RS, which is quite different from the always-on CRS in LTE. Similarly, for idle and connected Ues, the configured P-CSI-RS resources should not be regarded as always-on RS if there are mechanisms allow gNB to update the CSI-RS configuration or switching on/off of the configured CSI-RS for idle/inactive Ues. Explicit indication of availability of CSI-RS with limited indication overhead can be considered. |
| Spreadtrum | Both interpretation#1 and interpretation#2 are fine for us. The interpretation#1 can be regarded as the baseline. |
| Nokia | Interpretation 1 and as noted above in Section 2.3 above, the objective restricts to those available in connected mode. Our interpretation is that these presence of the RS in the potential occasions, is subject to need of said RS for connected mode users. |
| Panasonic | Our interpretation of “always-on TRS/CSI-RS transmission by gNodeB is not required” is whether to transmit the current discussion of TRS/CSI-RS in a cell is up to gNB implementation in the sense to allow Rel.15/16 type deployment is allowed in the network. “Up to gNB implementation” does not imply gNB suddenly stop the transmission of the TRS/CSI-RS without informing IDLE/CONNECTED mode Ues. The transmission of TRS/CSI-RS is informed to IDLE/CONNECTED mode Ues via SIBs. Therefore, we also have the interpretation #2.In a summary, our view is both interpretation #1 and #2 |
| SONY | Our interpretation is the gNB may or may not transmit the configured TRS/CSI-RS. For example, if there is no connected mode UE then the gNB may not transmit the configured TRS / CSI-RS. The idle mode UE can utilize the potential TRS/CSI-RS occasion(s) assuming the UE knows the TRS/CSI-RS configuration. Furthermore, the idle mode UE shall not expect the TRS/CSI-RS is always available. |
| LG | It is our understanding that it may be up to gNB whether to transmit TRS/CSI-RS or not. However, from UE power saving point of view, we need to discuss whether an implicit/explicit indication of ‘actual TRS/CSI-RS transmission’ is needed with the details FFS. |
| InterDigital | We share the same view as CMCC. The two interpretations are not contradictory and both are needed. |
| Qualcomm | Our understanding is more aligned with interpretation #2. If not, evaluation of the power saving gain by this study may not be very meaningful. However, this does not mean network will transmit always-on TRS/CSI-RS. In other words, we only focus on the period when TRS/CSI-RS is available to the UE and the availability is not a dynamic behavior. In the meanwhile, network can also blank the transmission of the TRS/CSI-RS if the UE associated with the TRS/CSI-RS is not paged. |
| CATT  | Interpretation #2. Additional RS is used for many purpose in order for UE power saving. If it is not known by UE all the time, UE power saving could not be achieved.  |

## Additional suggestions

**Please provide the any suggestions for the email discussion in the table below:**

|  |  |
| --- | --- |
| **Company**  | **Comments** |
| Intel | If UE obtains TRS/CSI-RS configuration from connected mode for use in idle/inactive mode, RAN1 needs to discuss how this configuration is used when an initial TRS/CSI-RS configuration is provided by SI. |
| Samsung | The same evaluation methodology for potential paging enhancement can be reused to evaluate power saving gain for additional TRS/CSI-RS. |
| ZTE | If the provided CSI-RS/TRS is used for RRM measurement, the potential impact on RAN2/RAN4 should be considered. For example, in 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. In 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. |
| Nokia | Like noted in Section 2.2, especially if some ‘persistence’ for the RS is to be assumed, we should consider the RS overhead impact. |

# 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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