**3GPP TSG RAN WG1 #104-e R1-210****xxxx**

**e-Meeting, January 25th – February 5th, 2021**

**Agenda Item:** 8.7.1.2

**Source:** Moderator (Samsung)

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

**Document for:** Discussion/Decision

# Introduction

This document provides the summary of the contributions for TRS/CSI-RS occasion(s) for idle/inactive UEs in Section 8.7.1.2.

# 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.

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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.

For enabling TRS/CSI-RS for idle/inactive mode, the following topics are discussed in RAN1#104-e:

* Topic #1. Availability indication
* Topic #2. RRM measurement for serving cell
* Topic #3. RS types
* Topic #4. Details of configuration

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

## Topic #1. Availability indication

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| **Agreements**:* Discuss further based on the following alternatives and down-select at RAN1#104-e:
	+ Alt 1: The availability of TRS/CSI-RS at the configured occasion(s) is NOT informed to the UE.
	+ Alt 2: The availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.
	+ Alt 3. The conditional availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.
		- The condition can be, e.g., existence of paging.
	+ Alt 4. Combination of the above alternatives.
	+ FFS for details
	+ FFS for UE behavior when the availability is not informed.
	+ Other techniques are not precluded.
	+ Companies encourage to provide sufficient information for the proposal, e.g.,
		- how to achieve power saving gain
		- how to minimize impact on NW

how to minimize extra UE implementation complexity* + - feasibility check on sharing the TRS/CSI-RS between connected UEs and idle/inactive UEs
	+ Proposals should be consistent with the WID objective.
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In RAN1#103-e meeting, it has been agreed to further down-select whether and how to inform the availability of TRS/CSI-RS to idle/inactive mode UE(s). It has been observed that depending on supporting availability indication, there exists a trade-off between UE power consumption and network power consumption as well as signaling overhead.

On the one hand, a few companies have concern that indicating availability increases additional network signaling overhead as well as network power consumption.

On the other hand, the majority reported several critical issues if availability is not indicated to the UE, including

1. the blind detection is required, and it increases the UE power consumption.
2. paging reception performance will be impacted if UE relaxes SSB based synchronization/AGC tracking when no additional RS available.
3. serving RRM measurement is impossible as UE can’t tell the difference between bad channel condition and the case when TRS/CSI-RS RS are not available.

Based on contributions submitted in RAN1#104-e, the companies’ views are summarized as below:

* Alt 1: The availability of TRS/CSI-RS at the configured occasion(s) is NOT informed to the UE.
	+ Ericsson, Nokia, NSB **(3)**
* Alt 2: The availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.
	+ OPPO, Huawei, HiSilicon, CATT, ZTE, Sanechips, TCL, MediaTek, Spreadtrum, Sony, LG, Lenovo, Motorola Mobility, CMCC, Xiaomi, Samsung, Panasonic, Apple, InterDigital, Sharp, NTT DOCOMO, Qualcomm **(22)**
* Alt 3: The conditional availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.
	+ CMCC, TCL, Samsung, Apple, [Qualcomm] **(5)**
* Alt 4. Combination of the above alternatives.
	+ Intel, Sony, CMCC, Samsung, Nokia, NSB **(6)**

### First round discussion

All the companies are aware of the pros and cons for having the availability indication very well. Although the majority view is in supporting the availability indication, some companies still have strong concerns on having it. Therefore, it is estimated that further discussion is needed to find a middle ground. Since Alt1 only or Alt 3 only is not acceptable by the majority, it’s suggested to further discuss and down-select between Alt2 and Alt4.

**Moderator proposal #1**

**Discuss and down select from the following alternatives.**

**Alt 2: The availability of TRS/CSI-RS at the configured occasion(s) is informed to the idle/inactive UE.**

* **The candidates of signalling methods can be, e.g., PEI, paging PDCCH, paging PDSCH, SIB.**
* **FFS availability information.**

**Alt 4. The availability of TRS/CSI-RS at the configured occasion(s) is optionally informed to the idle/inactive UE explicitly or implicitly.**

* **FFS availability indication method(s).**
* **FFS configurable availability information.**

Please provide the detailed views in the following table.

|  |  |  |
| --- | --- | --- |
| **Company**  | **Alternative to support****(Alt2 or Alt4)** | **Comments** |
| ZTE, Sanechips | Alt2 | Alt2 provides the power saving benefits to RRC idle/inactive state UE if it indicates “TRS is available”. Alt2 also the enable the flexibility for network to cease to transmit TRS when there is no TRS configured to RRC connected state UE.The availability indication can be conveyed by PEI or paging DCI.  |
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## Topic #2. Functionality

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| **Agreements:*** Functionality of RRM measurement for neighbour cell is not supported for TRS/CSI-RS for idle/inactive UE(s).

**Agreements**:- Target sending an LS to RAN2 and RAN4 to ask whether it is feasible to allow a UE to use the potential TRS/CSI-RS occasion to enhance the SSB based IDLE/Inactive mode evaluations of the serving cell. (to also include agreements from last meeting)\* Further discussion whether any additional information needs to be included in the LS or not, including potential re-wording of the leading sentence**Conclusion:*** TRS/CSI-RS based PEI is discussed in AI 8.7.1.1.
* PEI functionality is not further discussed under AI 8.7.1.2.
* Note: This does not prevent to potentially use PEI to carry the indication for TRS/CSI-RS presence.
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In RAN1#102-e meeting, it has been agreed to support AGC, time/frequency tracking. In RAN1#103-e meeting, it has been further decided not to support RRM measurement for neighbor cell and PEI functionality is moved to AI 8.7.1.1. It is left as FFS whether or not to support RRM measurement for serving cell.

Based on contributions submitted in RAN1#104-e, the companies’ views regarding RRM measurement for serving cell are summarized as below:

* Alt 1. Can be supported based on UE implementation. There is no RAN2/RAN4 impacts.
	+ Vivo, Intel, Spreadtrum, Samsung, CMCC, Qualcomm **(6)**
* Alt 2. Not consider or deprioritize.
	+ HW, MediaTek, Xiaomi, Ericsson, Nokia, NSB, ZTE, Sanechips **(8)**

### First round discussion

Depending on the outcome of this email discussion, it will be further decided whether or not to send LS to RAN2/RAN4.

**Moderator proposal #2**

**It is up to UE implementation whether the TRS/CSI-RS occasion(s) is used for RRM measurement for serving cell or not.**

* **No need for RAN4 to define new performance test.**
* **Send LS to RAN2/RAN4 for feedback.**

Please provide the detailed views in the following table.

|  |  |  |
| --- | --- | --- |
| **Company**  | **Agree? (Y/N)** | **Comments** |
| ZTE, Sanechips | No | According to the simulation results in our contribution (copied as below), using TRS for serving cell measurement in addition to SSB-based serving cell measurement (as no spec change in RAN2/4 is expected) has **negative** impact on UE power saving, which is not aligned with the WID scope**. So we don’t think we need to specify the TRS based serving cell measurement in any WG, and** **the LS to RAN2/4 is unnecessary**. Table 1 Power saving gain from TRS-based serving cell measurement

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Serving cell measurement** | **Power consumption** | **Power saving gain** |
| **One SSB before PO** | SSB | 1.66 | / |
| SSB and TRS | 1.78 | -7.2% |
| **One SSB and one additional TRS before PO** | SSB | 2.24 | / |
| SSB and TRS | 2.26 | -0.9% |

 Therefore, we would like to clarify that if the down-selection between Alt1 and Alt2 is needed, Alt2 is more consistent with our original intention.  |
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## Topic #3. RS types

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| **Agreements**:* Aperiodic TRS and semi-persistent/aperiodic CSI-RS are not used as TRS/CSI-RS occasion(s) for idle/inactive UEs.
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In RAN1#102-e meeting, it has been agreed to support periodic TRS for the TRS/CSI-RS occasion(s) for idle/inactive mode UEs. In RAN1#103-e meeting, it has been agreed to not support aperiodic TRS and semi-persistent/aperiodic TRS/CSI-RS for idle/inactive UEs. It remains as FFS for other RS types.

Some companies proposed to support only periodic TRS, considering that periodic TRS is enough to fulfil AGC, time/frequency tracking. Also, TRS-only can reduce configuration overhead in SIB. However, some other companies proposed to consider both periodic TRS and CSI-RS for the benefits, including

1. increase the availability chances;
2. common configuration for CSI-RS and TRS is supported in connected mode. Follow the same principle in connected mode, TRS only can be supported by NW implementation;
3. provide the possibility to do serving cell RRM measurement by UE implementation.

Based on contributions submitted in RAN1#104-e, the companies’ views regarding RS types are summarized as below:

* Alt 1. Only periodic TRS is supported.
	+ ZTE, Sanechips, Ericsson, Nokia, NSB **(5)**
* Alt 2. Periodic CSI-RS is additionally supported.
	+ Samsung, CATT **(2)**

### First round discussion

Not too many companies share views on whether or not to support periodic TRS only in their contributions. However, it’s necessary to finalize the RS type before further discuss on the details of configuration. Therefore, it is suggested that companies provide clear views on whether or not periodic CSI-RS can be supported additionally in the first round discussion. The following proposal is drafted based on Alt1, which has slightly more supporters than Alt.2 according to submitted contributions.

**Moderator proposal #3**

**Periodic CSI-RS are not used as TRS/CSI-RS occasion(s) for idle/inactive UEs.**

Please provide the detailed views in the following table.

|  |  |  |
| --- | --- | --- |
| **Company**  | **Agree? (Y/N)** | **Comments** |
| ZTE, Sanechips | Yes | The reasons are as below* As the agreed functionality of the additional RS is AGC and synchronization, periodic TRS is sufficient.
* The RRC connected mode UE is expected to be configured with periodic TRS.
* The configuration of TRS is much simpler compared with other flexible CSI-RS, the signaling resource overhead can be reduced if only periodic TRS is supported
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## Topic #4. Details for the configuration of TRS/CSI-RS occasion(s) for idle/inactive mode UE(s)

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| **RAN1#102--e Agreements:**The configuration of TRS/CSI-RS occasion(s) for idle/inactive mode UE(s) is provided by higher layer signaling-          FFS higher layer signaling candidates (e.g., SIB, dedicated RRC, RRC release message, etc.)-          FFS for other signaling candidates (e.g., pre-configuration, etc.)-          FFS for detailed configuration parameters (e.g., whether and how to reduce the signaling overhead for configuration, etc.)**RAN1#103-e Agreements:*** SIB signaling provides the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s).
	+ Up to RAN2 to decide which SIB is to be used.
	+ Whether or not to additionally support other high-layer signaling methods (e.g., dedicated RRC, RRC release message, etc.) is up to RAN2

Send an LS to RAN2 informing the above agreements, and* To further add that RAN1 is working on the detailed physical layer design
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In RAN1#102-e meeting, it has been agreed to further study detailed configuration parameters, e.g., whether and how to reduce the signalling overhead for configuration, etc. In RAN1#103-e meeting, it has been agreed to use SIB signalling for the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s). Following figure summarizes the list of RRC parameters related to CSI-RS configuration and its signalling structure.

**Figure 2:** RRC parameters for CSI-RS/TRS configuration in connected mode

### First round discussion

All of configuration parameters based on connected mode TRS/CSI-RS are summarized in the following table. **Please note that the parameters not used for periodic TRS is marked as grey colour**.

**Moderator suggestion #4**

* **Further discuss details of configuration parameters based on the following table. The goal of the initial stage of discussion is to identify list of parameters. More details, e.g. applicable value, will be discussed later stages of discussion.**

|  |  |  |
| --- | --- | --- |
| # | Parameters | **Need? (Y/N)** |
| 1 | bwp-Id |  |
| 2 | resourceType {aperiodic, semiPersistant, periodic} |  |
| 3 | repetition {on, off} |  |
| 4 | aperiodicTriggeringOffset |  |
| 5 | trs-Info {true} |  |
| 7 | powerControlOffset |  |
| 8 | powerControlOffsetSS |  |
| 9 | scramblingID |  |
| 10 | periodicityAndOffset |  |
| 11 | qcl-InfoPeriodicCSI-RS |  |
| 12 | frequencyDomainAllocation{row1, row2, row4, others} |  |
| 13 | nrofPorts |  |
| 14 | firstOFDMSymbolInTimeDomain |  |
| 15 | firstOFDMSymbolInTimeDomain2 |  |
| 16 | cdm-Type |  |
| 17 | density |  |
| 18 | startingRB |  |
| 19 | nrofRBs |  |
| 20 | subcarrierSpacing (this is not part of CSI-RS resource configuration) |  |
| 21 | Others. (please provide any missing/additional parameters) |  |

Please provide the list of parameters for TRS/CSI-RS resources configuration for the TRS/CSI-RS occasion(s) for idle/inactive UE(s) in the following table.

|  |  |
| --- | --- |
| **Company**  | **Comments** |
| ZTE, Sanechips | 1. Row #1: Not needed as initial BWP can be assumed.
2. Row #2: The aperiodic RS is not supported.
3. Row #4: The aperiodic RS is not supported, the aperiodic offset is not needed.
4. Row #11: The QCL information can be determined in a similar way as PDCCH monitoring in PO to reduce signaling overhead.
5. Row #12: Not needed if only row1 is assumed.
6. Row #20: open to discuss whether the SCS can be defined the same as SSB or initial BWP
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## Others

Please provide any suggestions/comments on other topics to be discussed in the following table.

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| **Company**  | **Comments** |
| ZTE, Sanechips | To reduce signaling overhead, the offset of TRS can be defined in relative to PO or SSB. |
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# Conclusion

**[TBD]**

# Summary of proposals

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| OPPO [1] | ***Observation 1: There would be no UE’s power saving gain if the availability of TRS/CSI-RS at the configured occasion(s) is not informed to the UE.******Observation 2: For Alt 3, the presence of TRS/CSI-RS is coupled with whether there is paging message. It may require additional TRS/CSI-RS for the idle/inactive-mode UEs when TRS/CSI-RS is not needed for connected UE.******Proposal 1: The availability of TRS/CSI-RS at the configured occasion(s) shall be informed to the UE.******Proposal 2: Paging DCI or PEI can be used to indicate the availability of TRS/CSI-RS.*** |
| Huawei, HiSilicon [2] | ***Observation 1. To get the power saving gain and ensure the performance of paging reception, it is essential to inform the UE the availability of assistance RS.******Observation 2. The availability of the assistance TRS/CSI-RS should not be coupled to the transmission of paging message on the PO.******Observation 3. It is helpful for reducing the signaling overhead by only indicating the availability of assistance RS in a specific window.******Observation 4. The assistance TRS/CSI-RS cannot be used for serving cell measurement if the UE cannot know the availability of the RS in advance before the reception of the required number of SS bursts by UE.*** ***Observation 5. The parameters to be used for determining the time/frequency domain resource location, sequence generating and QCL, should be configured to the UE.*** ***Observation 6. It is expected to configure multiple RS resources to IDLE/INACTIVE mode UEs considering different UEs can be in different MOs of different POs.*** ***Observation 7. Pre-defined values for RS parameters are not desired since they reduce flexibility and potential impact on the network.******Proposal 1: Adopt Alt 2 to inform the availability of TRS/CSI-RS at the configured occasion(s) to IDLE mode UEs.******Proposal 2: Inform the availability of TRS/CSI-RS before the start of PO:******- Through legacy paging DCI or early transmitted paging information in the previous DRX cycle;******- Through early paging information in the current DRX cycle.******Proposal 3: The assistance RS is not used for serving cell measurement.******Proposal 4: Signaling overhead in SIB due to the configuration of assistance RS occasions needs to be minimized.*** |
| CATT [3] | ***Observation 1: Additional TRS/CSI-RS can provide 15.87% ~35.14% power saving gain over SSB based paging reception.******Observation 2: TRS/CSI-RS configuration with potential large size of signalling may need to be configured at another standalone SIB X with the present of SIB X indicated by SIB1.******Proposal 1: TRS/CRS-RS resource/resource set configuration should meet the requirement of SIB message size limit.******Observation 3: With CSI-RS resources configured with SI without association relation with paging occasion(s), TRS/CSI-RS resource configuration usually at least contains CSI-RS pattern /resource mapping/gold sequence scrambling ID/ multi-beam QCL information, etc., which will cause huge SIB overhead.*** ***Observation 4: With CSI-RS resources configured with SI without association relation with paging occasion(s), UE will read system information block update to acquire new TRS/CSI-RS resource configuration information which will penalize power saving gain of TRS/CSI-RS occasion(s) obviously.*** ***Observation 5: The TRS/CSI-RS resources configured for CONNECTED mode UEs can be shared to IDLE mode UE.******Observation 6: With TRS/CSI-RS occasion associated with SSB/paging occasion, it will provide significant power saving gain at cost of low configuration signalling overhead and low specification efforts.******Observation 7: gNB could configure the CONNECTED mode UE with the TRS/CSI-RS resource bundled with SSB/paging occasion which is configured for IDLE mode UE.******Observation 8: Considering that the paging indication (sequence or DCI based) would be transmitted on every paging cycle, TRS/CSI-RS bundled with SSB/paging occasion should not be considered as always on signal.******Proposal 2: TRS/CSI-RS configuration for Idle/Inactive mode should be associated with SSB/paging occasion(s) to achieve good power saving gain with low SIB signaling overhead.******Proposal 3: The following procedure can be used for TRS/CSI-RS occasion(s) configuration:******Step1) predefined parameters of TRS/CSI-RS resource grid;******Step 2) SIB indicate parameters details;******Step 3）To derive TRS occasion(s) according to predefined rule and parameters provided by step1 and step 2.******Proposal 4: The availability of TRS/CSI-RS at the configured occasion(s) should be informed to the UE by the present/not present of SIB-X TRS/CSI-RS configuration.*** |
| vivo [4] | ***Observation 1****: CFO calibration performance based on TRS outerperforms that based on SSB,** *1 TRS or 3 SSB bursts are needed by UE before paging detection in low SINR region.*

***Observation 2:*** *28.4% power saving gain can be achieved if TRS is introduced in low SINR region.****Observation 3:*** *Performance of CFO calibration and AGC can not be guaranteed at UE, if the CSI-RS configuration is updated but not timely indicated to UE, which will degrade paging performance.****Observation 4:*** *Power saving gain can not be achieved, if the CSI-RS configuration is updated but not timely indicated to UE.****Observation 5:*** *Additional overhead for availability indication and CSI-RS transmission can be minimized with proper NW implementation.** *NW can avoid configuring CSI-RS resources that are not stable due to UE mobility to idle/inactive UEs.*

***Observation 6:*** *TRS/CSI-RS availability indication through PEI is not unified solution since PEI and TRS/CSI-RS for idle/inactive UEs are decoupled features for UE power saving.****Observation 7:*** *Feasibility of TRS/CSI-RS availability indication through PEI also depends on the signal/channel design of PEI, and it can be discussed after the details are settled.****Proposal 1:*** *the availability indication can be delievered at least through paging DCI.** *FFS : whether the indication delievered in PEI is supported.*

***Observation 8:*** *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.****Observation 9*:** *It is not necessary to define new RRM requirement for idle and inactive UEs in RAN4, it is up to UE to meet the existing requirements for SSB based measurement, if UE performs RRM measurement on TRS/CSI-RS in implementation.****Proposal 2****: RAN1 to identify* *the parameters to facilitate serving cell RRM measurement on TRS/CSI-RS resources.****Proposal 3:*** *The CSI-RS/TRS resource should be QCLed with one of the actually transmitted SSBs indicated by SIB1.****Proposal 4:*** *The power difference between CSI-RS/TRS and SSB should be explicitly configured in CSI-RS resource configuration to idle/inactive UEs.****Observation 10:*** *UE may need to handle signals/channels with more numerologies if there is no restriction on subcarrier spacing in CSI-RS configuration.****Proposal 5:*** *The SCS for TRS/CSI-RS configured for idle/inactive UEs should be the same as that of initial DL BWP.* |
| ZTE, Sanechips [5] | **Observation 1: Using TRS/CSI-RS for serving cell measurement costs more UE energy.****Proposal 1: Whether the TRS/CSI-RS provided from RRC Connected state UE is used as serving cell measurement for RRC Idle/Inactive state UE is up to UE implementation.****Proposal 2:** **Only periodic TRS is supported for RRC idle/inactive state UE.****Observation 2: For Alt 1, the drawbacks are as follows:*** **It may increase the UE power consumption;**
* **It might decrease the decoding performance of paging DCI or paging message.**

**Observation 3: For Alt 3, the drawbacks are as follows:*** **Network has to always transmit TRS/CSI-RS when the presence of paging message is high;**
* **It requires UE to perform blind detection of TRS/CSI-RS.**

**Observation 4: Alt 2 is beneficial for both gNB sides and UE sides.****Proposal 3: The Alt 2 is adopted as the availability indication for TRS.****Proposal 4: The availability indication is carried by PEI.****Proposal 6: To reduce resource overhead, the location of TRS in time domain can be configured in relative to SSB or PO/PF.** |
| TCL Communication Ltd. [6] | **Proposal 1**: The UE is informed (implicitly or explicitly) about the presence of TRS.**Proposal 2**: Presence of TRS in idle/inactive is indicated via PI or P-DCI.**Proposal 3**: RS-based PI indicates presence or absence of TRS via its location in time and/or frequency. |
| MediaTek Inc. [7] | **Observation 1: When TRS/CSI-RS occasion(s) is right before paging occasion, the UE power saving gain is 23.8% if the blind detection on the RS existence is not needed. If the blind detection is needed, the power consumption is higher than that of baseline.****Observation 2: When TRS/CSI-RS occasion(s) is NOT right before paging occasion, ~13.9% and 10.5% of power saving gain can be achieved for the case without and with blind detection, respectively. Here we assume the TRS/CSI-RS is transmitted by network and the TRS/CSI-RS detection rate is 80%.****Observation 3: If UE blind detection is needed for TRS/CSI-RS occasion to idle/inactive mode UE, how large the power saving gain can be achieved is relevant to the TRS/CSI-RS location, transmission probability and UE detection performance. Due to the uncertainty of these factors, the benefit of this feature would become questionable.****Observation 4: For the sake of progress, RAN1 can prioritize the alternatives with majority view, i.e., Alt 1 and Alt 2, in the agreements firstly. And based on the analysis given above, informing the TRS/CSI-RS availability to the UE can guarantee the effectiveness of the feature.****Proposal 1: gNB to indicate the TRS/CSI-RS availability information to idle/inactive mode UE(s).****• FFS how to minimize the signalling overhead.****Observation 5: If supporting the functionality of RRM measurement for serving cell is up to UE implementation, RAN1 don’t have to spend much time discussing it. If it requires RAN2 and/or RAN4 specification impact, the power saving gain for additionally supporting this functionality should be evaluated and justified carefully before triggering discussion in RAN2/4.****Proposal 2: Deprioritize the discussion for TRS/CSI-RS functionality of RRM measurement for serving cell.****Observation 6: Multiple sets of TRS/CSI-RS configurations to idle/inactive mode UE(s) can avoid frequent higher layer signalling update for changing RS settings and allow better gNB indication flexibility.****Proposal 3: gNB can configure multiple sets of TRS/CSI-RS configurations to idle/inactive mode UE(s).** |
| Intel Corporation [8] | **Proposal 1: UE should be allowed to use potential TRS/CSI-RS occasions to enhance the SSB based IDLE/Inactive mode evaluations of the serving cell.*** **Send LS to RAN4 for feedback.**

**Proposal 2: Availability indication can be provided as part of the TRS higher layer configuration.****Proposal 3: At least the following parameters can be included in TRS configuration:*** **Time and frequency resources, i.e., BW in PRBs and symbol indices in a slot**
* **Sequence generating parameter/scrambling ID**
* **RS density or pattern**
* **Periodicity and offset**
* **Availability indication**
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| Spreadtrum Communication [9] | ***Proposal 1: UE can perform serving cell measurement based on CSI-RS in idle/inactive mode.******Proposal 2: gNB needs to inform the availability of TRS/CSI-RS to idle/inactive mode UE in advance.******Observation 1: UE may need to wake up multiple times for AGC, T/F tracking, serving cell measurement and PO monitoring in each paging cycle.******Observation 2: TRS/CSI-RS transmission for idle/inactive mode UE can bring obvious power saving gains.*** |
| Sony [10] | **Observation 1: TRS/CSI-RS configuration size with mandatory parameters is relatively large and it can have a size of 1728 bytes.****Observation 2: From UE point of view, it is preferred to avoid UE blind detection for TRS/CSI-RS detection.****Proposal 1: RAN1 needs to identify the list of parameters of TRS/CSI-RS configuration provided via SIB. It should at least contain time/frequency resource parameters, periodicity and offset parameters, QCL parameters, sequence generating parameters, and CSI-pattern.** **Proposal 2: Support providing multiple TRS/CSI-RS configuration to idle/inactive UEs.****Proposal 3: Support TRS/CSI-RS configuration in a dedicated RRC/RRC release message.****Proposal 4: Availability information of TRS/CSI-RS at the configured occasion(s) is informed to the UE.****Proposal 5: Availability information of TRS/CSI-RS is signaled in the paging DCI.****Proposal 6: The gNB has flexibility in using a mechanism to provide availability information.** **Proposal 7: Availability information at least contains an indication of the availability of TRS/CSI-RS for idle/inactive UEs. Further study additional availability information (e.g. availability duration, which active TRS/CSI-RS are currently available).** |
| LG Electronics [11] | ***Proposal 1: Select Alt 2 regarding availability of TRS/CSI-RS at the configured occasion(s).******- Alt. 2: The availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE******Proposal 2: Inform idle/inactive mode UEs of the availability of TRS/CSI-RS occasion(s) using paging DCI (and/or paging early indication if supported).***  |
| Lenovo, Motorola Mobility [12] | **Proposal 1: We support Alt 2,** **i.e. informing UE of the availability of TRS/CSI-RS at the configured occasion(s).****Proposal 2: Study mechanism to properly manage signalling overhead and network power consumption related to the availability indication and TRS/CSI-RS transmission.** **Proposal 3: The following methods can be considered as the candidates to inform the availability of TRS/CSI-RS to idle/inactive UE:*** **Use reserved bits in paging DCI or unused bits in short messages**
* **Provide TRS availability information via paging power saving (PPS) PDCCH**
* **Configure a validity time interval for the configuration**
* **Updating the configuration to inform the unavailability of previous configuration**

**Observation 1: It is necessary to reduce the signaling overhead for configuration.****Proposal 4: The following methods can be considered as the candidates to reduce the signalling overhead for configuration:*** **Predefine or fix a part of TRS/CSI-RS parameters in specification**
* **Update a subset parameter of TRS/CSI-RS configuration**
* **Based on configuration parameters of one NZP-CSI-RS resource of a NZP-CSI-RS resource set, derive configuration parameters of remaining NZP-CSI-RS resources of the NZP-CSI-RS resource set**
 |
| CMCC [13] | **Proposal 1. Alt 3. The conditional availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE are supported. And the condition is existence of paging.****Proposal 2. PEI can carry the availability information of TRS/CSI-RS, which indicate UE whether the TRS/CSI-RS is available or not before the associated PO.** **Proposal 3. gNB can configure UE whether the availability information of TRS/CSI-RS is carried in PEI.****Proposal 4. The availability information signalling design of TRS/CSI-RS should also be included in the LS about UE using the potential TRS/CSI-RS occasion to enhance the SSB based IDLE/Inactive mode evaluations of the serving cell.** |
| Xiaomi [14] | ***Proposal 1: It is beneficial to restrict the use of TRS/CSI-RS for AGC and time/frequency tracking if SSB periodicity is already quite dense.*** ***Proposal 2:*** ***The availability of TRS/CSI-RS at the configured occasion should be informed to the UE.******Proposal 3: Compared power consumption at the network side with the power saving gain at UE side, it is worth to support informing TRS/CSI-RS availability to UE.*** |
| Samsung [15] | **Proposal 1: Allow UE to use the TRS/CSI-RS for RRM measurement for serving cell based on implementation.****Proposal 2: Support at least one of the following alternatives for availability indication of TRS/CSI-RS occasion(s) to idle/inactive UEs:*** **Alt 2: The availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.**
* **Alt 3: The conditional availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.**
	+ **The condition can be, e.g., existence of paging.**
* **Alt 4: Configurable availability indication based on Alt 2.**

**Proposal 3: Support configuration of time alignment between TRS/CSI-RS occasion(s) and PO.****Proposal 4: Support configuration of periodic CSI-RS for idle/inactive UE(s).****Observation 1:** 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 2:** There is no power saving gain for Alt 1 if the idle/inactive mode UE is required to perform blind detection of TRS/CSI-RS resources for synchronization or serving cell RRM measurement. **Observation 3:** most of the RRC configuration parameters for connected mode CSI-RS/TRS resources can be reused for idle/inactive mode CSI-RS/TRS configuration. |
| Panasonic [16] | **Proposal 1: UE should be not required to blindly detect the availability of TRS/CSI-RS at the configured occasion(s).****Proposal 2: Signaling support should be specified that availability of TRS/CSI-RS at the configured occasion(s) is informed to UE.****Proposal 3: How the availability of TRS/CSI-RS at the configured occasion(s) is informed and whether the availability is associated with certain condition should be studied.** **Proposal 4: L1 (PEI and paging based) TRS/CSI-RS availability indication is supported.****Proposal 5: QCL parameter with SSB index and power offset with SSB should be indicated in the TRS/CSI-RS configuration in SIB.** |
| Apple [17] | **Proposal 1: Support one or both of the following options:*** **The availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE implicitly or explicitly via SIB. (Alt 2-1)**
* **The conditional availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.By “conditional availability”, it means that the TRS/CSI-RS is required to be transmitted in the occasion(s) before the paging occasion only if there is a paging PDCCH/PDSCH in the paging occasion. (Alt 3)**

**Observation 1: Indicating the presence of TRS/CSI-RS on top of PEI provides meaningful additional gain, especially for high group paging rate.****Proposal 2: If PDCCH is used to carry paging early indication, support the dynamic indication of TRS/CSI-RS together with the early paging indication in the same PDCCH.** |
| Qualcomm Incorporated [18] | **Observation 1: Power saving gain of additional TRS/CSI-RS depends on the number of SSBs needed for loop update in the specific channel condition or for the specific UE implementation 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.** **Observation 5: RRC Release message can be used for network to inform the connected mode UE whether already configured TRS/CSI-RS is still available with potential update of the RS configuration when the connected mode UE enters idle/inactive mode.** **Observation 6: Regarding the three alternatives for availability indication of TRS/CSI-RS****• Alt 1 consistently increases UE implementation complexity and power consumption. It also requires additional RAN4 performance to be defined for the blind detection of TRS/CSI-RS****• Alt 2 is UE implementation and power saving friendly. Network impact is small because the potential additional transmission after the TRS/CSI-RS is not needed by connected mode UEs is a transient behavior****• Alt 3 may result in partially “always-on” transmission of the TRS/CSI-RS if it is conditional on UE paging.****Observation 7: Unused bits of the paging PDCCH can be used to indicate availability of the TRS/CSI-RS. These include****• Reserved bits to indicate the paged UE groups in the PO****• Unused bits 4 to 8 in the Short Message field****• If Short Message Indicator is 01, the entire Short Message field****• If Short Message Indicator is 10, the scheduling field.****Unused bits are partitioned between the sub-grouping indication and RS availability indication functions.****Observation 8: If DCI format 2\_6 is used as paging early indication for idle/inactive mode UEs, it can carry indication of availability of the additional TRS/CSI-RS in a similar way to SCell dormancy indication for connected mode UEs.****Observation 9: If paging early indication is based on RS/sequence, only one bit information is provided to indicate whether all configured TRS/CSI-RSs are available to the idle/inactive UE or not available.****Proposal 1: If UE assumes TRS/CSI-RS is transmitted only when page message is transmitted for the UE, the TRS/CSI-RS can act as a paging early indication.****Proposal 2: The TRS/CSI-RS can be UE group based for idle/inactive UEs.****Proposal 3: If TRS/CSI-RS is adopted, whether and how TRS/CSI-RS is used for RRM idle/inactive measurement is up to UE implementation. There is no need for RAN1 to request RAN4 to define new performance test.****Proposal 4: A TRS/CSI-RS configured to the idle/inactive UE should be QCL’ed with a transmitted SSB of the serving cell. At least one RS is QCL’ed with each transmitted SSB of the serving cell.****Proposal 5: network should provide the availability indication of TRS/CSI-RS in paging early indication or paging PDCCH.****Proposal 6: Paging early indication, UE sub-grouping and availability indication of additional TRS/CSI-RS should be jointly designed if they are adopted.** |
| InterDigital Inc. [19] | **Observation 1: Explicit signaling of the TRS/CSI-RS occasions provides higher power saving gain than blind detection.****Proposal 1: Explicit signaling is used to indicate to the UE the TRS/CSI-RS availability.****Proposal 2: Paging PDCCH and paging indication channel are considered for explicit signaling of the availability of the TRS/CSI-RS occasions.****• Downselect between paging PDCCH or the paging indication channel after more progress is achieved in the design of the paging indication channel.** |
| Sharp [20] | **Observation: Most CSI-RS parameters can be reused with minor update except that the QCL resources of CSI-RS should be informed to idle/inactive UEs****Proposal 1: The availability of TRS/CSI-RS at the configured occasion(s) should be informed to IDLE/inactive UEs implicitly.****Proposal 2: DCI should be used to inform the availability of TRS/CSI-RS****Proposal 3: A CSI-RS resource for idle/inactive mode shall not be associated with one unique SSB index and its reference source may be informed to UEs in some way.** |
| Ericsson [21] | **Observation 1 Using TRS during idle mode provides UE PS gain in terms of idle mode power consumption of up to 17% under the assumption that there is 100% increase in persistent transmissions by the NW.****Observation 2 Idle UEs should be able to handle the case where TRS is present/absent in potential TRS occasions without additional signaling from NW.****Observation 3 Keeping TRS transmissions on solely for supporting idle mode UEs increases NW power consumption significantly (e.g. by 22% to 60% depending TRS periodicity and offset to SSB).****Observation 4 Using L1 signaling to announce activation/deactivation of TRS transmissions without a validity timer for idle UEs increases NW power consumption significantly (e.g. by 41% to 81% depending TRS periodicity and offset to SSB).****Observation 5 Allowing to use TRS occasions for serving cell measurements has RAN4 impact.****Proposal 1 The availability of TRS/CSI-RS at the configured occasion(s) is not informed to the UE.****Proposal 2 Do not support SIB signaling to announce availability of TRS transmissions in potential TRS occasions for idle UEs.****Proposal 3 Only TRS/CSI-RS occasion(s) corresponding to periodic TRS can be shared with idle UEs.****Proposal 4 TRS/CSI-RS occasion(s) that are shared to idle/inactive UEs are not assumed to be used for serving cell measurements.** |
| NTT DOCOMO Inc. [22] | **Proposal 1: Explicit indication of the availability of TRS/CSI-RS for idle/inactive mode UE should be supported.****Proposal 2: Paging DCI and/or paging early indication should explicitly indicate the availability of TRS/CSI-RS for idle/inactive mode UE.****Proposal 3: If UE does not receive the availability indication at least for a certain duration, the UE should assume no TRS/CSI-RS can be obtained.****Observation 1: gNB can indicate, in advance, that TRS/CSI-RS is not available when there is very few connected mode UE(s) using the TRS/CSI-RS and the TRS/CSI-RS is likely to be not transmitted soon.****Observation 2: If availability of TRS/CSI-RS for idle/inactive mode UE is explicitly indicated, it would be beneficial that TRS/CSI-RS for idle/inactive mode UE is located in front of PO.****Observation 3: If availability indication of TRS/CSI-RS for idle/inactive mode UE is not supported, i.e., UE needs to try blind detection, it would be beneficial that TRS/CSI-RS for idle/inactive-mode UE is located after first SSB among three SSBs before PO.** |
| Nokia, Nokia Shanghai Bell [23] | **Proposal:** Do not consider the potential TRS/CSI-RS occasions(s) for RRM measurements of serving cell mobility evaluations.**Proposal:** Focus the RAN1 work on WID objective 1b on designing the mechanism to provide IDLE/INACTIVE mode UEs the information on potential periodic TRS occasions. Do not support additional RS types.**Observation:** The cost of assuming UE autonomous detection of TRS presence is ~7% (over Rel-15 baseline) and can be minimized by UE implementation. **Observation:** Increasing frequency and/or duration of the always ON periodic signals may increase the network power consumption.**Propopsal:** We propose that: * Configuration for potential TRS/CSI-RS occasion can be provided to IDLE/Inactive mode UEs without presence/availability information.
* Network can optionally provide presence/availability information in system information. Details are FFS.
* Need for additional, more frequent presence/availability indication method is studied further.

**Proposal:** The configuration of TRS occasion-related parameters informed to the IDLE/INACTIVE mode UE(s) should be assumed to support similar flexibility as required by Connected Mode UE(s).**Proposal:** The configuration of TRS to the IDLE/INACTIVE mode UEs needs to support independent configuration for each broadcast/SSB beam.**Proposal:** When informing TRS occasions for the IDLE/INACTIVE mode UEs, parameters ‘nrofPorts’, ‘cdm-Type’ and ‘density’ in ‘CSI-RS-ResourceMapping’ can be omitted from the configuration and values are same as fixed by specification TS38.214 for CSI-RS configured with ‘trs-info’.**Proposal:** Following parameters can be assume to be same/common for RS resources in TRS resource set, or could be derived from one parameter for a RS resources defined in TRS resource set:* ‘firstOFDMSymbolInTimeDomain’ would need to be provided only once for a TRS resource set, and location of both of the second symbol in the slot could be derived from it, and in case of two (consecutive) slots are in RS resource set, symbol locations are same in the second slot.
	+ Note: number of slots (1 or 2) is indicated separetly, per resource set or for all resource sets.
* For TRS, ’row1’ and ‘freqBand’ are common/same for the RS resources in a RS resource set, thus would be provided only once per RS resource set.
* In case of single slot, or two consecutive slots, one common ‘CSI-ResourcePeriodicityAndOffset’ parameter can be assumed, and in case of non-consecutive slots, one per slot would suffice.

**Proposal:** ‘powerControlOffsetSS’ and ‘ScramblingId’ are provided for the IDLE/INACTIVE mode UEs as a part of the RS resource set.**Observation:** For CONNECTED mode UEs, TRS can be QCL source for PDCCH (DM-RS), and SSB can be a QCL source for TRS.**Observation:** It could be further evaluated if the QCL source related information could be provided implicitely or in simpler manner for the IDLE/INACTIVE mode UEs based on actually transmitted SSBs.**Observation:** For IDLE/INACTIVE mode UE(s), the configuration of TRS occassions is not associated to active BWP. The frequency location is given ‘freqBand’ and should not be restricted by the initial BWP.**Observation:** For IDLE/INACTIVE mode UE(s), there would need to be assumption made on the SCS used for the TRS or specific parameter provided.**Proposal:** The frequency location for the potential TRS occasions is not restricted by the intial BWP configuration. Also SCS used for TRS can be separately informed. |

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# Agreement summary

## RAN1#102-e

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

Agreements:The TRS/CSI-RS occasion(s) that may be for connected mode UEs can be shared to idle/inactive mode UEs. -  Note: It is understood that gNB can potentially share the occasions to idle/inactive (which would just mean it up to NW whether to share or not share).-  Note: It is understood that TRS/CSI-RS in the TRS/CSI-RS occasion(s) may or may not be transmitted.-  Note: Always-on TRS/CSI-RS transmission by gNodeB is not required-  At least TRS/CSI-RS occasion(s) corresponding to periodic TRS is supported - FFS for other RS types-  FFS: Whether UE blind detection is required or not.Agreements:Idle/inactive UE may use the TRS/CSI-RS occasion(s) that are shared to it for functionalities such as: -           **AGC, time/frequency tracking**-           **FFS: RRM measurement for serving cell, RRM measurement for neighbor cell, paging reception indication****Observation:**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 not needed by 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.)Agreements:The configuration of TRS/CSI-RS occasion(s) for idle/inactive mode UE(s) is provided by higher layer signalling-           FFS higher layer signalling candidates (e.g., SIB, dedicated RRC, RRC release message, etc.)-           FFS for other signalling candidates (e.g., pre-configuration, etc.)-           FFS for detailed configuration parameters (e.g., whether and how to reduce the signalling overhead for configuration, etc.)Agreements:Further study whether and how to inform the availability of TRS/CSI-RS to idle/inactive mode UE (implicitly or explicitly).- Note: Availability corresponds to the information for whether TRS/CSI-RS is actually transmitted or not. |

## RAN1#103-e

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| Agreement:* Functionality of RRM measurement for neighbour cell is not supported for TRS/CSI-RS for idle/inactive UE(s).

Agreements:* SIB signalling provides the configuration of TRS/CSI-RS occasion(s) for idle/inactive UE(s).
	+ Up to RAN2 to decide which SIB is to be used.
	+ Whether or not to additionally support other high-layer signalling methods (e.g., dedicated RRC, RRC release message, etc.) is up to RAN2

Send an LS to RAN2 informing the above agreements, and* To further add that RAN1 is working on the detailed physical layer design

Agreement:* Aperiodic TRS and semi-persistent/aperiodic CSI-RS are not used as TRS/CSI-RS occasion(s) for idle/inactive UEs.

Agreements:* Target sending an LS to RAN2 and RAN4 to ask whether it is feasible to allow a UE to use the potential TRS/CSI-RS occasion to enhance the SSB based IDLE/Inactive mode evaluations of the serving cell. (to also include agreements from last meeting)
* Further discussion whether any additional information needs to be included in the LS or not, including potential re-wording of the leading sentence

Agreements:* Discuss further based on the following alternatives and down-select at RAN1#104-e:
	+ Alt 1: The availability of TRS/CSI-RS at the configured occasion(s) is NOT informed to the UE.
	+ Alt 2: The availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.
	+ Alt 3. The conditional availability of TRS/CSI-RS at the configured occasion(s) is informed to the UE.
		- The condition can be, e.g., existence of paging.
	+ Alt 4. Combination of the above alternatives.
	+ FFS for details
	+ FFS for UE behavior when the availability is not informed.
	+ Other techniques are not precluded.
	+ Companies encourage to provide sufficient information for the proposal, e.g.,
		- how to achieve power saving gain
		- how to minimize impact on NW

how to minimize extra UE implementation complexity* + - feasibility check on sharing the TRS/CSI-RS between connected UEs and idle/inactive UEs
	+ Proposals should be consistent with the WID objective.

**Conclusion:*** TRS/CSI-RS based PEI is discussed in AI 8.7.1.1.
* PEI functionality is not further discussed under AI 8.7.1.2.
* Note: This does not prevent to potentially use PEI to carry the indication for TRS/CSI-RS presence.
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## RAN1#104-e

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| **[TBD]** |