**3GPP TSG RAN WG1 #106bis-e R1-210XXXX**

**e-Meeting, October 11th – 19th, 2021**

Agenda Item: 8.7.1.1

Source: Moderator (MediaTek)

Title: Summary#2 of Paging Enhancements

Document for: Discussion and Decision

# Introduction

In RAN#93-e, there agree guidance for PEI selection and design directions [1]:

|  |
| --- |
| * Support PDCCH-based PEI as the only option

•       Only essential function for PEI is support•     New DCI format•     Higher layer configuration, including SS•     Details of the procedures of PEI monitoring, and identification of MOs before PO•     Only Behv-A (per RAN1#104e agreement) is supported •     If TRS availability indication is agreed to be supported in both paging DCI and the DCI format for PEI, same mechanism/principle for TRS availability indication is adopted for the two DCI formats•     Supporting TRS availability indication in DCI format for PEI shall not delay the completion of essential functionality of PEI  |

In the following Sections 2, 3, and 4, companies’ views and proposals on the design details for the first three sub-bullets will discussed in order to identify possible agreements. Some other remaining topics are collected in Section 5, and Section 6 finally summarize the possible agreements to be discussed and approved online.

# Design of New DCI Format

## Phase-1 Discussion

Relating the DCI format, the following are two related agreements [2] to UE subgrouping:

|  |
| --- |
| Agreement:For UE subgroups indication in physical layer, maximum of 8 subgroups per PO is supported. |
| Agreement:For paging indication to the subgroups in a PO,* For PDCCH-based PEI, subgroups in a PO are indicated by one PEI
	+ One bit in the DCI payload indicating one UE subgroup is supported
		- FFS: Whether code-point based mapping is utilized, and, if so, how to map to the subgroups in a PO
 |

In Table 1, there summarize companies’ views related to design of new DCI format, including whether paging indication for UE subgroups is only carried in PEI or not.

Table 1: Companies’ views related to design of new DCI format

|  |  |
| --- | --- |
| Company | Company views |
| Huawei, HiSilicon | ***Proposal 2: PO-wise code-point based mapping method can be further considered if larger number of sub-groups and POs are supported in one PEI.******Proposal 3: Indicate the availability information for assistance TRS in PEI DCI, using same principle as availability information for assistance TRS in paging DCI.******Proposal 4: Support the configuration of indication SI change and ETWS notifications in PEI DCI.******Proposal 5: Support one PEI associating with multiple POs.******Proposal 6: A new RNTI is used to scramble the CRC of PEI-DCI for idle/inactive mode UEs.******Proposal 7: Sub-grouping indication field, TRS availability indication field and SI change/ETWS field are supported by the new DCI format, where:**** + ***Sub-grouping indication field is mandatory if the DCI format is configured;***
	+ ***TRS availability indication field and SI change/ETWS field are optionally configurable.***
 |
| TCL  | ***Observation 1: Shared physical layer signaling of PDCCH based PEI to inform an idle/inactive UE or subgroups of UEs for paging and TRS availability indication reduces the L1 signaling overhead significantly.*** **Proposal 1: Consider PDCCH based PEI to indicate idle/inactive UE or subgroups of UEs for paging and TRS availability indication.****Proposal 2: Consider a New DCI format to transmit PEI for idle/inactive UE with the payload size to cover: at least the indication of 8 subgroups for paging in a PO and the reserved bits capacity of paging DCI which is used for TRS availability indication.**  |
| ZTE, Sanechips | Observation 1: If the sub-grouping information is carried on the paging PDCCH, the power saving gain is negligible.Proposal 1: The sub-grouping information should be carried by PEI. Proposal 2: A PEI associated with multiple POs should be supported.Proposal 3: The number of POs associated with one PEI should be configurable.Proposal 5: The availability indication conveyed by PEI should be supported.Proposal 6: The SI change and ETWS information carried by PEI should be considered.Proposal 7: Support bitmap mapping method for sub-grouping indication.Proposal 9: The payload size of PDCCH-based PEI can be configured.Proposal 11: A new RNTI with configurable value is preferred for the PDCCH based PEI with a new DCI format. |
| Transsion Holdings | ***Proposal 1: Subgroup indication should be carried by one PEI with multiple POs.******Proposal 2: PEI can carry at least 12 bits and codepoint design can be considered.******Proposal 3: TRS available indication and short message indicator should be carried by PEI.******Proposal 4: Total bits carried by PEI should be taken into account.******Proposal 6: PDCCH-based PEI can reuse P-RNTI value.*** |
| Spreadtrum  | ***Proposal 1: Both 1 PEI to 1 PO mapping and 1 PEI to N POs mapping are supported in R17.******Proposal 2: Introduce a new DCI format like DCI format 2-6 for idle/inactive UEs in R17.******Proposal 4: 1 bit indication of PO can be semi-statically configured by gNB.******Proposal 5: A bitmap indication of subgroups within a PO can be semi-statically configured by gNB.******Proposal 6: When the indication of subgroups within a PO is configured, the 1-bit indication of PO is not applicable.*** |
| vivo | **Proposal 1: Adopt the codepoint-based sub-grouping mapping method introduced in Rel-16 NB-IoT as described in Table 1 as start point. With this method, a UE will be paged when detecting one of the following two codepoints. Otherwise, the UE will not be paged.*** **The sub-group specific codepoint, to indicate only the sub-group which the UE belongs to receive paging, and**
* **The wake-up common codepoint, to indicate all sub-groups to receive paging when no less than two sub-groups need to be waked up.**

**Proposal 2: A new RNTI for scrambling the PDCCH-based PEI is needed.****Proposal 3: The DCI size of the DCI format for PEI should be limited e.g., 12bits in order not to degrade the PEI detection performance.****Proposal 10: One-to-one mapping between PEI and PO is supported, and one-to-multiple mapping between PEI and PO should be precluded.****Proposal 12: 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.****Proposal 13: The design of DCI format for PEI may also need to consider TRS availability indication.****Proposal 14: SI update indication delievered in PEI should be precluded.** |
| OPPO | ***Proposal 1: One-to-one and one-to-many mapping between PEI and PO should be supported.******Proposal 6: The sub-grouping indication is supported by PEI, while sub-grouping indication by paging PDCCH is not supported.*** |
| CATT | ***Proposal 2: Sub-grouping is indicated in PDCCH-based PEI.******Proposal 3: PDCCH-based PEI can support to indicate multiple POs.******Proposal 4: The number of POs associated with one PEI can be determined by the following factors:**** ***Paging parameters: N and Ns***

***Proposal 5: Short messages are not supported by PDCCH-based PEI.******Proposal 9: If one PEI indicates N1 POs and the number of sub-groups per PO is G, the new DCI format of PEI contains N1 groups of bit fields and each bit field of a paging group contains G bits.******Proposal 10: A UE determines the corresponding bit location in PDCCH-based PEI based on PO\_Index, G and its sub-group number, where PO\_Index is the index of PO within multiple POs, and G is the number of sub-groups per PO.*** |
| CMCC | **Proposal 1. Support 1-to-1 and 1-to-N mapping between PEI and PO(s).****Proposal 3. When UE subgrouping is not configured, for one UE which PO’s index is i\_s,** * **If one PEI associates with Ns POs in one PF, the i\_sth bit in PEI is used to indicate wake up information;**
* **If one PEI associates with K\*Ns POs in K PFs, the [(SFN\*N/T mod** **N/NPEI) \*Ns+ i\_s]th bit in PEI is used to indicate wake up information, where SFN is the UE’s PF frame.**

**Proposal 4. When UE subgrouping is configured, for one UE which PO’s index is i\_s and subgroup index is m, where m = 0, 1, … M-1, M is the total number of subgroups in one PO,*** **If one PEI associates with one PO, the mth bit in PEI is used to indicate wake up information;**
* **If one PEI associates with Ns POs in one PF, the [i\_s\*M+m]th bit in PEI is used to indicate wake up information;**
* **If one PEI associates with K\*Ns POs in K PFs, the [(SFN\*N/T mod N/NPEI) \*Ns+ i\_s]\*M+m th bit in PEI is used to indicate wake up information.**
 |
| Xiaomi | ***Proposal 2: If a PEI can corresponds to M POs, then 8\*M bits subgrouping information, each 8 bits corresponding to one PO should be contained in PEI.******Proposal 3: PEI will alert the UE to wake up only when paging message is expected. Solutions to inform short messages in PEI monitoring occasion can be studied.*** |
| Samsung | **Proposal 1: Support PEI with UE subgrouping per PO as the only function for paging enhancements in NR Rel-17.** **Proposal 2: Use a bitmap for PEI with UE subgrouping per PO.****Proposal 3: One of the following alternatives can be considered to determine the RNTI used for the DCI format for PEI:*** **Alt1: a new RNTI configured by SIB, e.g. PS-RNTI,**
* **Alt2: reuse P-RNTI**

**Proposal 4: The payload size of the DCI format for PEI,** $N\_{bits}, $ **can be determined such as** $N\_{bits}=N\_{UE subgroups}^{PO}∙N\_{POs}^{PDCCH}$**, where*** $N\_{bits}$**<= 40,**
* $N\_{UE subgroups}^{PO}$ **is the number of UE subgroups per PO with applicable values of 1 to 8,**
* $N\_{POs}^{PDCCH}$ **is the number of POs associated with a single PDCCH based PEI, and the applicable values is 1 to** $N\_{POs}^{PF}$**, where** $N\_{POs}^{PF}$ **is the number of POs per PF.**
 |
| MediaTek  | Proposal 1: For PEI, a new DCI format is supported to include at least paging indications to UE subgroups of the associated PO(s)* **One bit in the DCI payload indicating one UE subgroup of a PO**
* **P-RNTI is utilized for CRC scrambling**

Proposal 2: Paging indication to UE subgroups is only carried by PEI in physical layer |
| Intel  | **Proposal 1: Essential function of PEI includes providing indication for UE paging sub-grouping information only.** **Proposal 2: When configured, PDCCH PEI provides UE paging sub-grouping indication.** * **A bitmap of size up to 8 bits can be used in the DCI.**
* **No other indications are provided via PDCCH-based PEI.**

**Proposal 3: 1 PEI to 1 PO is supported only for Rel-17 PEI design.****Proposal 5: Discuss DCI payload whether it can be fixed or configurable after agreeing on what information content can be signalled via PEI.*** **Higher layer parameter on configured number of sub-groups per PO or size of the bitmap for UE sub-grouping information is needed.**

**Proposal 10: UE may follow TRS availability indication (if agreed) by PEI regardless of whether UE is indicated to monitor PO or not by the same PEI.** |
| NTT DOCOMO,  | **Proposed 1: Single PEI associated with Multi POs should be supported.****Proposed 2: DCI size for PEI should be implicitly derived from number of POs, number of subgroups, whether or not TRS availability indication and Short Message is included in PEI.** **Proposed 3: UE should be informed, via SIB, of whether or not TRS availability indication and Short Message are included in PEI.**  |
| Sony |  |
| Panasonic | **Proposal 1: In the DCI format for PEI, the early indication of one and multiple POs are both supported. The number of POs are configurable by SIB.****Proposal 2: Sub-grouping information bit width is configurable in SIB. Additional subgroup information can also be carried in the paging DCI. When PEI is configured, more refined sub-grouping information by two level indication can be achieved. When PEI is not configured, just sub-grouping indication within paging DCI can also serve the function.** **Proposal 3: For the DCI format defined for PEI, one or more blocks can be configured for subsequent PO(s) and the TRS availability/unavailability indication. In addition, a upper limit of the DCI format size should be defined.****Proposal 4: Define a new RNTI for Rel.17 PEI****Proposal 5: For DCI format defined for PEI, SIB needs to configure the number of blocks, the number of indicated POs, all or part of the subgroup information for each corresponding PO and corresponding field location in the DCI.** |
| Lenovo, Motorola Mobility | **Proposal 5: A bit field position for a UE in a DCI format of PEI PDCCH is determined based on UE’s PF index within a set of PFs associated with UE’s PO and UE’s PO index.** **Proposal 6: RNTI for a PEI PDCCH is determined based on a reference PF, e.g. the earliest PF of a set of consecutive PFs associated with the PEI PDCCH.**  |
| InterDigital,  | **Proposal 1: One bit is allocated per UE group to indicate wake-up or not-wake-up.****Proposal 2: The index of the bit is determined by at least the UE ID and the number of UE groups.** **Proposal 3: Support availability indication of TRS occasions for idle/inactive UEs within the PEI DCI.****Proposal 5: One-to-one mapping between PEI and PO is supported.****Proposal 6: One-to-many mapping between PEI and corresponding POs should be configurable.** |
| LG Electronics | **Observation 1: The UE sub-group indication using PEI outperforms UE sub-group indication within a PO.****Observation 2: PDCCH based PEI can afford the maximum number of UE sub-groups.****Proposal 1: The UE sub-group indication is provided by PEI only.****Observation 4: TRS/CSI-RS availability indication via PEI is beneficial in terms of UE power saving and reducing NW overhead.****Observation 5: Indicating availability for the TRS/CSI-RS occasion(s) considering beam selectivity manner can reduce the DCI overhead of the PEI.****Observation 6: Once the SI change indication is transmitted, repetitions of SI change indication may occur within preceding modification period.** **Observation 7: Conveying information with regard to SI change indication and/or ETWS/CMAS notification over PEI is beneficial from power saving perspective.****Observation 8: Compared to the Alt 1-a, conveying information with regard to SI change indication and/or ETWS/CMAS notification over PEI does not increase the NW overhead.****Proposal 2: PEI conveys the following information*** **UE sub-group indication**
* **If configured, UE group indication**
* **If configured, TRS/CSI-RS availability indication**
* **Information with regard to SI change indication and ETWS/CMAS notification**

**Proposal 3: The DCI for the PEI contains the bitmap for the UE group and UE sub-group indication.** * **The number of UE sub-group for a PO (i.e. NSG) is configured via higher layer**
* **The number of UE group associated with a PEI is NS, where the NS is a paging parameter that is for determining a number of POs in a PF.**
* **The size of the DCI field for the UE group and UE sub-group indication is NSG\*NS.**

**Proposal 4: If configured, the DCI for the PEI contains [1 or 2] bit for the TRS/CSI-RS availability indication** **Proposal 5: The DCI for the PEI contains 2 bits for indicating SI change indication and ETWS/CMAS notification.** **Proposal 6: The DCI for the PEI contains reserved bits field, the size of which is configured via higher layer.** **Proposal 7: PEI-RNTI that is used for CRC scrambling for the PEI is configured via higher layer.** **Observation 9: The size of the DCI format for the PEI can be aligned with the DCI format 0\_0/1\_0 when zero bit padding is applied.****Observation 10: When the UE only monitors a PEI at a PEI occasion, UE may assume that bits in the padding bit field are frozen bit for PDCCH decoding.****Proposal 8: Zero bit padding for the DCI size alignment is applied to the DCI format for the PEI.****Proposal 12: The UE assumes that the same information on UE group/subgroup indication, SI change indication and ETWS/CMAS notification are repeated in all transmitted beams in a PEI occasion.** **Proposal 13: If the PEI convey availability indication only for the TRS/CSI-RS occasion(s) with the same beam direction, the UE assumes that the information on the TRS availability indication can be different in each transmitted beam in a PEI occasion.** |
| Apple | **Proposal 1: Introduce a new DCI format for PEI, with a configurable size.****Proposal 2: The new DCI format for PEI can also carry subgroup indication and TRS availability indication.****Proposal 6: Do not support code-point based mapping for paging subgroup indication.****Proposal 7: Support paging subgroup indication in both PEI and paging DCI.** |
| Ericsson | Observation 1: In deployments where subgrouping is not used, no bits shall be wasted on subgrouping information. Proposal 1: When subgrouping is not used, PEI presence invokes all UEs at the addressed PO. Observation 2: In deployments of high paging rate, in order to avoid excessive false paging during simultaneous paging of more than one subgroup, PEI should support addressing individual subgroup invocation.Proposal 2: PEI supports addressing individual subgroup invocation (i.e., up to 8 bits, one per each of maximum 8 subgroups in a PO). Observation 3; In deployments of high paging rate and/or multi-beam, one-to-many PEI configuration is a necessary tool for the NW for avoiding excessive resource usage. Proposal 3: PEI supports addressing subgroups of up to 4 consecutive POs (i.e., in addition to the up to 8 bits used for subgroups).Proposal 4: For one-to-many PEI configuration, up to 32 bits (configurable) are used for addressing UEs in up to 4 consecutive POs.Proposal 5: For one-to-many PEI configuration, PEI may address POs associated with different paging frames but not address POs across multiple number of a UEs DRX cycle.Proposal 6: The subgroup/PO addressing bits in the PEI shall be configurable (both number of bits and their meaning).Observation 4: Use of reserved bits in paging DCI (as a PDCCH-PEI) in one PO as paging early indication for UEs in one or more groups in other POs can further reduce PEI signalling overhead.Proposal 7: For the PEI DCI, the RNTI used for CRC masking is configured via higher layers.Proposal 8: PEI design should allow the use of reserved bits in paging DCI in one PO as paging early indication for UEs in one or more groups in other POs.Proposal 9: Following information and corresponding locations within the PEI DCI needs to be configurable:- Number of subgroups per PO- Number of POs addressed (if 1-to-many)- TRS availability |
| Qualcomm  | **Proposal 1: For PDCCH-based PEI, code-point based UE subgroup mapping is not supported.****Proposal 2: For PDCCH-based PEI, the PDCCH configuration is based on the CORESET #0, *pagingSearchSpace* and the P-RNTI**. **DCI size of PEI PDCCH is smaller than that of the paging PDCCH.** |
| Nordic  | ***Proposal-1:*** *Sub-groups indication is provided only by PEI.****Proposal-2:*** *Only bitmap-based mapping is supported for sub-groups.****Proposal-3:**** *For PEI monitoring a gNB may configure*
	+ *…*
	+ *PEI-RNTI*
	+ *payload size of DCI format*
	+ *position of DCI field*
 |
| Nokia | **Proposal: A single PEI should be able to address multiple POs to reduce PEI (PDCCH) indication overhead.****Observation:** *The DCI size for PDCCH-based PEI should be configurable, from 1 to [19] bits.***Proposal: The PEI DCI format configuration should provide for each PO the location of the subgrouping field. It is assumed that the size of the subgrouping field could be common for all PEIs in the cell.****Proposal: If providing additional information, i.e. ‘*systemInfoModification’*, ‘*etwsAndCmasIndication’* and L1 availability indication in PEI is supported, the PEI DCI format configuration should provide the location (and size) for each information field. The location of these fields, if configured, could be at the start of the DCI format so that it can be common for all PEIs/POs.****Observation:** *The PDCCH-based PEI should be monitored only by IDLE/Inactive UEs. The PEI DCI format CRC could be scrambled with P-RNTI.***Proposal:*****Consider further whether PEI could be configured to carry ‘systemInfoModification’* indication bit *and/or ‘etwsAndCmasIndication’ indica tion bit*. Inform RAN2 of the RAN1 decision and assumed UE behaviour.** **Proposal:** **Support configuring L1 availability indication for PEI.** |
| DENSO  | **Proposal 1: A new DCI format of 2\_X is introduced for PDCCH-based PEI.****Proposal 2: A new RNTI is introduced for PDCCH-based PEI (e.g. PEI-RNTI).****Proposal 3: A single value is defined for the new RNTI, which does not have to be configured by the higher layer.****Proposal 6: The new DCI format for PDCCH-based PEI conveys a bit map which indicates paging sub-group(s) to be paged for each PO in a PF.****Proposal 7: The length of the bitmap is determined by Nsg \* Ns, where Nsg is the number of paging sub-groups and Ns is the number of POs in a PF.****Proposal 8: PEI should be able to deliver SI update/ETWS indication to PEI capable UEs.** |

From the above inputs, one can first observe the following:

Code-point based subgroups mapping:

* Yes (3): HW (if one PEI for multiple POs), Transsion, vivo
* No (4): Apple, QC, Nordic, Intel
* Feature lead: Support only ‘bitmap’ subgroups mapping for Rel-17

Indication of one or multiple POs:

* + One PEI indicates multiple POs (17): HW, ZTE, Transsion, Spreadtrum, OPPO, CATT, CMCC, Xiaomi, Samsung (up to Ns POs in a PF), Panasonic, Lenovo (multiple PFs), InterDigital, LG (Ns POs in a PF), Ericsson (Ns POs in a PF), Nokia, DENSO (Ns POs in a PF), DoCoMo
	+ Only one PEI per PO (2): vivo, Intel
* FL suggestion: PEI indicates paging indications for UE group(s)/subgroups of PO(s) in a PF

PEI DCI size:

* Upper limited: vivo, SS, Ericsson
* Aligned with DCI format 0\_0/1\_0: LG
* Discuss after contents indicated via PEI are finalized: Intel
* FL suggestion: Upper limited by 8 (max #subgroups per PO) \* 4 (max value of Ns) for subgroups indication field of PEI DCI

RNTI:

* New RNTI (10): HW, ZTE (configurable value), vivo, SS, Panasonic, Lenovo (based on a reference PF), LG (PEI-RNTI), Ericsson (configurable), Nordic (PEI-RNTI), DENSO (configurable)
* P-RNTI (6): Transsion, Samsung, MTK, QC, Nokia, Intel
* FL suggestion: New PEI-RNTI

By the above, the following proposal for PEI DCI format is suggested, and companies are encouraged to provide views and/or suggested revisions in Table 2.

Possible Proposal 2-1

For PEI, a new DCI format is supported to include at least paging indications to UE group(s)/subgroups of the associated PO(s)

* One bit in the DCI payload indicating one UE subgroup of a PO or one UE group/PO (if UE paging subgrouping is not configured)
* One PEI provides paging indications to UE group(s)/subgroups of Ns PO(s) in a PF
	+ Ns as defined in TS38.304
	+ The maximum number of total bits for paging indication field in PEI DCI format is 32
* A new PEI-RNTI is utilized for CRC scrambling

Table 2: Companies’ views and/or suggested revisions on Proposal 2-1

|  |  |
| --- | --- |
| Company | Company’s view(s) and/or suggested revision(s) |
| Qualcomm | As agreed in RAN#93, only essential function will be discussed in RAN1. We do not think one PEI mapping to multiple POs is an essential function for Rel-17 PEI design. One PEI mapping to one PO should be the only solution. This won’t increase the network overhead substantially because most of the time, UEs associated with a PO are not paged. Thanks to Behv-A, then network does not need to send a PEI to the UE and hence introduces no overhead. Besides, one UE mapping to multiple POs fundamentally changed the idle/inactive behaviour from operating its timeline around its own PO to both the PO and the start of the PF. We do not think it is worth putting the implementation efforts for the support of this function. To meet the performance requirement of the PEI detection (at least one order lower missed detection rate than paging PDCCH), the PEI DCI size needs to be much smaller than that of paging PDCCH. This is against the idea that PEI DCI can provide a bitmap much larger than the minimum size of 12 bits. Based on this, we object to define one PEI mapping to multiple POs. The maximum number of total bits should 12 if TRS availability is not supported in PEI or 14 (8 subgroups + 6 bits for TRS indication) if TRS availability is supported in PEI.We think a new RNTI is unnecessary for PEI. PEI should already have a smaller DCI size than the paging PDCCH. Then P-RNTI can be used for UE to distinguish PEI and paging PDCCH. So our proposal is to use P-RNTI to CRC scramble PEI PDCCH without an explicit configuration of the RNTI.[Moderator] Thanks for providing the point: PEI is not needed if no UE in a PO is paged. According to coexistence observation, PEI resource can be released via CORESET rate-matching scheme. If different DCI size from paging DCI can be guaranteed, reusing P-RNTI is also a reasonable choice. |
| Nordic | * Since the DCI format in CSS is determined by size of CORESET#0, if DCI format size is restricted to be smaller than 36 then P-RNTI can be used, otherwise PEI-RNTI is needed
* We support only bitmap
* We support 1 PDCCH corresponds to POs of one PF

[Moderator] Thanks for providing good consideration for apply P-RNTI or PEI-RNTI |
| Samsung | For one or multiple POs, we are open to consider N>1 POs. But we think N should be flexible and can be configured independently from Ns. In general, we think same design principle should be considered to support N =1 and N>1. We suggest to prioritize 1:1 mapping to complete the other two design aspects first. Extension to N>1 POs can be considered later if same principle/mechanism can be reused. For RNTI, we are not clear how UE can get the new RNTI, e.g. configured by higher layers or be fixed. We think P-RNTI can be reused to avoid unnecessary configuration overhead.  |
| Intel | We have similar view as Qualcomm. We think one PEI to one PO is the essential function of PEI, and one to multiple PO association is not strongly necessary. There are also performance impacts, such as increase in UE power consumption (due to staying in light sleep between PEI and PO for a longer period of time) and paging latency, coverage maybe limited and meeting joint MDR requirement can be challenging, due to increased DCI size.We support only bitmap based indicationNew RNTI is not needed. Due to potentially different DCI size with respect to paging DCI, P-RNTI can still be used.  |
| LG | We support the proposal.**Regarding one PEI mapping to multiple PO issue,** We believe that it can help to reduce the network overhead and to avoid the collision with other PDCCH transmissions. For example, if one PF contains 4 POs, every radio frame will contain 4 POs, hence it would be hard to avoid collision between PEI and paging PDCCH transmission. Moreover it should be noted that the potential number of UE\_ID per PO will be lower as the higher PO density is configured. Thus smaller number of UE subgroups would be enough as the higher PO density is configured. **Regarding maximum number of bits for the UE group/subgroup indication**We are fine with the proposal but also ok with further discussion. As suggested in the last online session, square blanket can be used. However, we believe that gNB will not configure too many bits for the PEI since it aware of the target coverage.**Regarding the RNTI value,**We support using a new RNTI[Moderator] Thanks for pointing out the case where PO density is very high so that 1-PEI-1-PO may be difficult to be accommodated. |
| Spreadtrum | We support the proposal.For one PEI mapping to multiple POs or one PO, we think the current proposal is general enough to include all cases. Here PEI is PEI PDCCH or PEI DCI, the wakeup indication is a bit in PEI. The proposal does not put any restriction on one PEI mapping to multiple POs or one PO, since “UE group(s)/subgroups of Ns PO(s) in a PF” does not mean all UE groups/subgroups of Ns PO(s) in a PF. To be clearer, “a PF” can be removed, but it is not so necessary because PO(s) is definitely included in a PF.* One bit in the DCI payload indicating one UE subgroup of a PO or one UE group/PO (if UE paging subgrouping is not configured)
* One PEI provides paging indications to UE group(s)/subgroups of Ns PO(s) ~~in a PF~~

For the maximum number of bits for the UE group/subgroup indication, 32 is fine for us.For the RNTI, we are fine for the new RNTI. |
| Ericsson | We do not see any UE power consumption issue with 1-PEI to multiple PO mapping, and it would be good if other companies can explain what the expected UE impact is for supporting it. One PEI to multiple PO should be supported, both within a single PF and across multiple PFs. It is necessary tool to reduce NW resource overhead. So, the 2nd main bullet should be updated as follows:* *One PEI provides paging indications to UE group(s)/subgroups of Ns PO(s) in a PF or up to M=4 PO(s) across one or multiple PFs.*

The PEI DCI size and RNTI should be configurable, and allowing up to 32 bits for paging indication, fields for TRS availability indication and additional margin for future use. Again, it would be good if other companies can explain what the expected UE impact is if configurable PEI DCI and RNTI are supported.  |
| Xiaomi | Generally fine with the proposal. but still open to discuss whether a PEI can corresponds to N PO, and N can be different from Ns. for example N=2\*Ns. This is beneficial in a paging configuration where number of PF in a DRX cycle is oneT, since the number of PEI-DCI can be reduced by half. |
| CATT | Since we are designing new DCI formats, we should define the target range of the new DCI format for PEI first. The contents of new DCI format for PEI should range from12 bits to 144 bits. However, we might reduce the range from 12 bits to the paging DCI size (around 41 bits). In order not to pad the DCI contents to satisfy 12 bits payload size, it would be more efficient to support one PEI indicating more than one PO since one PO would be configured up to 8 paging subgroups. The maximum size of PEI payload to match with that of paging DCI is to have same level of detection performance for PEI and paging DCI. One PEI indicating more than one PO would also increase the power saving gain by PDCCH-based PEI. We support one bit in the DCI format to indicate the one paging group or subgroup if configured. We don’t agree to link the number of POs indicating by the PEI to the number of paging occasions (Ns) within a paging frame. In most deployment scenarios, the number of paging occasions in a paging frame is one. This will lead to large amount of padding bits in the new DCI format. The number of paging occasions indicating by one PEI should be configurable by the network with number N1, which is the subset of N paging occasions within a DRX.We support a new RNTI to avoid any confusion by legacy UEs when PEI for one UE and paging DCI for another UE could be in the same slot.  |
| Sharp | We support mapping of one PEI to multiple POs that can reduce the PDCCH blocking probability, and the number should be flexible and can be configured. And one PEI should be allowed to map multiple POs in consecutives PFs when the PEI DCI size is not exceed the maximum value |
| vivo | We have concerns on the sub-bullet 1 and 2. In our view, the maximum number of total payload size for PEI DCI should be much shorter than 32bits given the reasons below.* In RAN1#104e, as quoted below, we have agreed that the miss detection rate of PEI is no worse than 0.5% (assuming MDR\_PEI = MDR\_pagingPDCCH = 0.5%, so MDR\_joint\_A will be no worse than 1%) for Alt1 and no larger than 0.1% for Alt2. Due to the MDR of paging PDCCH is 1% which is one order higher than the MDR of PEI, the total DCI payload of PEI ought to be much lower than that of paging DCI (i.e., 39bits for 20MHz). Besides, as observed by the MDR results below (given in our contribution [R1-2106606]), there will be around **2dB performance degradation** by adopting PDCCH-PEI with 12bits, compared to PDCCH-PEI with 40bits (Note: the performance of PDCCH-PEI with 40bits is approximately equal to that of paging PDCCH). And the MDR of 0.1% is about 1-2dB worse than 1% in link-level performance. **Hence, around 12bit seems to be a better choice.**
* Secondly, for some cases, the network could transmit PEI in the first PEI occasion by using a broad Tx beam for the sake of the wide coverage, the network resource saving and UE power saving (i.e., the UE can skip the detection of the remaining PEI occasions). However, this may require better PEI detection performance compared to Paging DCI which may be received from a narrow beam by UE implementation. To give the network enough implementation flexibility, the performance of PEI should be as good as possible.

**Given the above reasons, the maximum payload of PEI DCI should be limited to around 12bits.** Considering the maximum number of sub-grouping is 8, we prefer to have a value multiple times of 8, such as the maximum payload of PEI DCI should be limited to around 16bits. Accordingly, bitmap method for 4 POs which will give rise to heavy PEI DCI payload and the degradation of performance is not suitable. **As such, codepoint mapping method should be applied for subgroup-based paging early indication.**Besides, in accordance with the agreement endorsed in RAN plenary #93, **one PEI indicates multiple POs is not an essential function for PEI**. And, **one to one mapping for PEI and PO should at least be the baseline scheme.**And we support the last sub-bullet for designing a new PEI-RNTI. (a) Alt-1 Behaviour -A (b) Alt-2 Behaviour -A

|  |
| --- |
| Agreement:* Take Alt 1 as mandatory, and Alt 2 as optional

**Alt 1** For the performance evaluations of PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, 1. The following are assumed, at the SNR where the Miss-Detection Rate (MDR) of paging PDSCH is 1%,
	* When Behv-A is assumed:
		+ The joint miss-detection rate (MDR) of PEI and paging PDCCH defined below should be no worse than 1%:

MDR\_Joint\_A = MDR\_PEI + (1 – MDR\_PEI) MDR\_PagingPDCCH* + - The False-Alarm Rate (FAR) of PEI should be no larger than [1%]
	+ When Behv-B is assumed:
		- The joint miss-detection rate (MDR) of PEI and paging PDCCH defined below should be no worse than 1%:

MDR\_Joint\_B = FAR\_PEI + (1 – FAR\_PEI) MDR\_PagingPDCCH* + - The MDR of PEI should be no larger than [1%]
	+ Note: The CFO is modeled at the input of PEI detection and based on LLS assumptions agreed in RAN1 #102-e. Companies should justify the applied random range for the CFO.
* Companies to provide:
	+ Information on the utilized detection method for each PEI candidate design (e.g., non-coherent detection or coherent detection)
	+ The required #REs to comply with the performance assumptions
	+ The maximum number of subgroups that can be carried in PEI, subject to the performance assumptions

**Alt 2** For the performance evaluations of PEI candidate designs based on PDCCH, TRS/CSI-RS and SSS, 1. The following are assumed, at the SNR where the Miss-Detection Rate (MDR) of paging DCI is 1%,
	* When Behv-A is assumed:
		+ The MDR of PEI should be no larger than 0.1%
		+ The False-Alarm Rate (FAR) of PEI should be no larger than 1%
	* When Behv-B is assumed:
		+ The FAR of PEI should be no larger than 0.1%
		+ The MDR of PEI should be no larger than 1%
	* Note: The CFO is modeled at the input of PEI detection and based on LLS assumptions agreed in RAN1 #102-e. Companies should justify the applied random range for the CFO.
* Companies to provide:
	+ Information on the utilized detection method for each PEI candidate design (e.g., non-coherent detection or coherent detection)
	+ The required #REs to comply with the performance assumptions
	+ The maximum number of subgroups that can be carried in PEI, subject to the performance assumptions
 |

 |
| Nokia | In general we are OK with the proposal, with few comments.We think that from system operation point of view enabling to PEI to be able to address multiple POs is an essential function for the PEI deployment e.g. for FR2. For number of POs, we think that the upper limit should not be Ns, nor that we should restrict to single “PF”. The configuration could be limited by the size of the DCI format. UE will be provided the DCI format configuration (format size, field location and size) as well the monitoring occasion, thus the number of POs is transparent to the UE.For RNTI, we don’t really have a strong view, but as pointed out by Nordic, assuming that possible DCI size is kept smaller than the minimum of DCI 1\_0, we could also use the P-RNTI. |
| Apple | We support bitmap-based subgroup indication.On 1-to-1 vs 1-to-multiple mapping, we think 1-to-1 mapping should at least be supported. We are open to consider 1-to-multiple mapping, but we don’t think the multiple POs should go across different PFs because it can cause non-negligible paging latency.For RNTI, it depends on the DCI size. If the size is always different from paging DCI, P-RNTI can be reused. |
| Huawei, HiSilicon | 1. We think one PEI mapping to multiple PO is essential. We need to consider the PDCCH blocking issues if only one PEI mapping to one PO is supported. It is an essential functionality for PEI deployment.
2. Regarding the number of POs associated with one PEI, we are OK with Ns POs considering it would save standard work. But we are also OK to make the number of POs associated with one PEI configurable.
3. For the DCI format size, we would like to keep it more flexible considering PEI may be also deployed in a cell with good coverage. For RNTI, we support a new RNTI to avoid any impact on legacy UE PDCCH detection.
 |
| CMCC | 1）support the bitmap indication2) support 1-to-multiple mapping between PEI and POs to reduce the NW overhead, since the PEI should also have the full beam sweeping pattern, if only support 1-to-1 mapping and the PO density is high, the PEI overhead is huge, especially in FR1 which only pattern 1 is supported for SSB and CORESET multiplexing.3) support using a new RNTI |
| ZTE,Sanechips |  (1) We support only bitmap based indication.(2) We think one-to-many PEI VS PO mapping is important to reduce the overhead of PEI transmission. We agree with LG that putting Ns PO into one paging frame is already too crowded and it is difficult for NW to allocate more resource for PEI transmission without collision. Hence, we agree that carrying paging information for Ns PO within a PF is a feasible way to reduce resource overhead. And it does not impact UE power saving as these UEs monitor POs in the same PF would process the same/similar SSB.(3)For the max payload size, we think it is an upper bound for implementation flexibility, it does not imply that NW will configure the PEI DCI as 32 regardless of the coverage. |
| TCL | We generally support the proposal Regarding One bit in the DCI payload indicating one UE subgroup of a PO,A PDCCH based PEI may have used for subgroup’s paging indication, TRS availability indication and SI update/ETWS indication, which may increase the PEI payload size. Therefore, it is recommended to consider codepoint based indication for subgroup’s indication in case one PEI is used for multiple PO. The codepoint based subgroup’s indication also support Behv-A, i.e. whether a UE shall monitor paging PDCCH or not is based on the presence or absence of PEI. In other words, whether a UE shall monitor paging PDCCH or not is based on the presence or absence of codepoints in PEI. Regarding one PEI mapping to Ns PO(s) in a PF, in our view, mapping of PDCCH based PEI to multiple PO is beneficial in both power saving gain and network overhead reduction. However, we support the CATT statement of not linking the number of POs to the number of paging occasion (Ns) within a paging frame.We support new RNTI to avoid conflict with paging PDCCH and other legacy channels. |
| Panasonic | We are basically okay except the second bullet, which is regarding to how many POs/PFs that a PEI may cover. In our preference, this can be configurable by SIB on supporting one or more POs. But we are okay to discuss further after the basic structure is settled. |
| DOCOMO | Generally fine with the proposal, but open to discuss whether a new PEI-RNTI is utilized for CRC scrambling.For one or multiple POs, we think it is essential functionality to reduce Overhead. Also, we are OK to make the number of POs associated with one PEI configurable although we prefer to link the number of POs indicating by the PEI to the number of paging occasions (Ns) within a paging frame. |
| OPPO | 1. We support one PEI mapping to multiple POs, it can help to reduce the network overhead and to avoid the collision with other PDCCH transmissions. As for the number of POs associated with one PEI, we can accept the Ns PO(s) in a PF, i.e. all the POs in a PF. We can also accept the number of POs associated with one PEI is configured independently from Ns, such as N, in this way, one PEI can map to multiple POs in a PF or across multiple PFs. The configurable number of POs independently from Ns and configurable number of subgroups in a PO, can have more flexibility in the mapping between PEI and POs.
2. We support bitmap-based subgroup indication.
3. Regarding the DCI format size, it needs to check whether 32bits is appropriate.

We think P-RNTI can be reused. |
| Transsion Holdings | 1. We support bitmap DCI mapping that one bit indicating one UE subgroup of a PO
2. The number of POs associated with a PEI should be configurable or fixed. This is because if the number of POs is Ns and the size of PEI payload is fixed, it would cause a waste of bits.

Whether to use a new RNTI or reuse P-RNTI depends on the size of PEI payload. If PEI and paging DCI are the same size, use new RNTI, otherwise use P-RNTI. |
| IDCC | We support the bitmap-based approach and indicating multiple POs within one PF; supporting POs across different PFs seems unnecessary.We are ok with a new RNTI. |
|  |  |
|  |  |

1 PEI for

* **1 PO** (5): QC (essential), Samsung (1st priority), Intel (essential), vivo (essential and performance benefit with small payload (<= 16 bits)), Apple (essential)
* **Ns POs in one PF** (7): Nordic, LG, Apple, HW (to confine specification work), ZTE, DoCoMo (essential), IDCC
* **M POs** (13): Samsung (2nd priority), Spreadtrum, Ericsson (up to 4 POs), Xiaomi (beneficial for PF interval = oneT), CATT (up to N1), Sharp, Nokia (essential for FR2; allow M POs for a DCI size limit), HW (essential to avoid PDCCH blockage), CMCC, TCL, Panasonic, OPPO, Transsion
* **[Moderator]** Given UE subgrouping enhancement, false paging probability is reduced, and most of the time UE is only required to detect PEI. In this regard, the power saving impact due to one PEI to multiple POs is limited by reduced false paging probability. Regarding performance consideration raised by vivo, it is reasonable to keep a compact for robust PEI detection under CFO. To achieve a balance, we can confine total bit numbers for UE subgroups indication field while allowing gNB to exploit the available indication capacity of PEI.
* **[Suggested revision to 2nd bullet]** The maximum number of total bits for paging indication field in PEI DCI format is [16]:
	+ It is up to gNB configuration how many POs can be indicated by one PEI

RNTI:

* P-RNTI (6):
	+ If DCI size < 36: QC, Nordic, Intel, Nokia, Apple, OPPO, Transsion
	+ Others: Samsung (No need of additional configuration),
* PEI-RNTI (6):
	+ If DCI size >= 36: Nordic
	+ Other reasons: LG (fine with it), Spreadtrum (fine with it), CATT, vivo, HW (avoid impact to legacy UE PDCCH detection), CMCC, TCL, IDCC
* **[Moderator]** Given the DCI size is guaranteed to be different from paging DCI, it is reasonable to reuse P-RNTI.
* **[Suggested revision to 3rd bullet]** P-RNTI is utilized for CRC scrambling

By the above, the following revised proposal is suggested, and companies are encouraged to provide views/suggested revisions to Table 3

Possible Proposal 2-1a:

For PEI, a new DCI format is supported to include at least paging indications to UE group(s)/subgroups of the associated PO(s)

* One bit in the DCI payload indicating one UE subgroup of a PO or one UE group/PO (if UE paging subgrouping is not configured)
* The maximum number of total bits for paging indication field in PEI DCI format is [16]:
	+ It is up to gNB configuration how many POs can be indicated by one PEI
* P-RNTI is utilized for CRC scrambling

Table 3: Companies’ views and/or suggested revisions on Proposal 2-1a

|  |  |
| --- | --- |
| Company | Company’s view(s) and/or suggested revision(s) |
| Samsung | We are fine with the proposal. |
| Qualcomm | One PEI mapping to many POs is not essential design. UE paging procedure is a per PO activity only occurring around its own PO. The one PEI to many PO mapping fundamental has changed this in the way that some UEs need to wake up for PEI detection way before its PO and different UEs have different timelines. This flexible timeline makes UE implementation efforts unnecessarily large. Network overhead is not much increased because typically most UEs are not paged and according to Behv-A, network does not send PEI and hence there is very small amount of overhead. So we do not agree with “It is up to gNB configuration how many POs can be indicated by one PEI” and suggest to remove this sentence. Regarding PEI collision with other signals, it is hard to say one to many mapping has a benefit because once the collision happens, all UEs of associated POs are impacted. One to one mapping instead has less impact.Regarding DCI size, it should be as small as possible to minimize impact to the entire paging performance. For NR, the minimize DCI size is 12. We think 12 should be the maximum DCI size if only sub-group indication is carried by PEI and 14 should be maximum DCI size if TRS availability indication can be carried PEI. We support to use P-RNTI for CRC scrambling the PEI PDCCH. |
| CATT | We are OK with 1st sub-bullet. We don’t agree to have PEI payload size up to 16, which would reduce most UE power saving gain and increase the network overhead. We don’t agree to reuse P-RNTI for PEI since the CORESET used for PEI of group(s) of UEs could share with paging DCI with the other group UEs.  |
| Lenovo/Motorola Mobility | We are fine with making PEI-to-PO mapping configurable. We think that defining a new RNTI for PEI PDCCH is more future-proof design, e.g. with potential increase of max. DCI size in a later release.  |
| LG | We are fine with the 1st and 2nd bullet. **Regarding issue on the one PEI mapping to multiple PO**, as pointed out by several companies, congestion due to the dense PO deployment will cause the PDCCH blocking issues and heavy DL traffic. Also, in case of the dense PO deployment, false alarm due to the paging for other UE that shares the same PO will be decrease. Hence the UE sub-grouping efficiency will be decrease; the number of UE sub-groups smaller than 8 would be enough. **Regarding issues on the maximum number of total bits**, we tend to agree the intention and 16 can be a compromise solution. We do not prefer smaller than 16. Regarding the RNTI, we share the view with Lenovo. Using the New RNTI is preferable. Actually, we do prefer to consider the DCI size alignment, as we commented in our document, which would be very useful for maintaining number of BD while can guarantee effective code rate by take advantage of the known padding bits. Also we believe that applying DCI size alignment is beneficial from forward compatibility point of view. If time is allowed, it would be worth to consider this topic. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Carrying paging subgroup indications:

* Only in PEI (4): ZTE, OPPO, MTK, LG
* Both PEI and paging PDCCH (2): Panasonic (hierarchical), Apple
* FL suggestion: Given there is limited gain by carrying UE subgroup in a PO as shown in RAN1 LS to RAN2 [3], it is suggested RAN1 to focus on carrying subgroups indication only in PEI for Rel-17.

Below please check a proposal for physical layer design carrying paging indications to UE subgroups, and companies are encouraged to provide views and/or suggested revisions in Table 3.

Possible Proposal 2-2

For NR Rel-17, paging indications to UE subgroups are carried only in PEI.

Table 4: Companies’ views and/or suggested revisions on Proposal 2-2

|  |  |
| --- | --- |
| Company | Company’s view(s) and/or suggested revision(s) |
| Qualcomm | We are fine with this proposal for the simplicity of Rel-17 PEI design given there is limited meeting time for Rel-17.(We added us in the following for “TRS availability indication in PEI” and “SI and ETWS”) |
| Nordic  | Agree |
| Samsung | support |
| Intel | Agree |
| LG | We support the proposal.  |
| Spreadtrum | Fine |
| Ericsson | OK. Ericsson view is updated below this table for SI and ETWS.  |
| Xiaomi  | Agree |
| CATT | We support this proposal |
| Sharp | Support the proposal |
| vivo | We are fine with the proposal. |
| Nokia | Agree |
| Apple | We have slight preference to also support it in paging DCI. We understand the power saving gain can only be seen for high group paging rate, but the additional work needed is quite small. |
| Huawei, HiSilicon | Agree |
| CMCC | Agree |
| ZTE,Sanechips | Agree |
| TCL  | Agree  |
| Panasonic | We do not see huge specification effort to support also subgroup information in paging PDCCH. On the other hand, due to the possible DCI bits limitation of PEI, which possibly contains subgroup information for multiple POs and TRS availability indication, the PEI capacity could be an issue. Thus it can be useful to support subgroup information in paging DCI.  |
| DOCOMO | Agree  |
| OPPO | Agree |
| Transsion Holdings | Agree |
| IDCC | Agree. |
| Lenovo/Motorola Mobility | Fine with the proposal  |
|  |  |

Given the significant support, we suggest to make decision on this proposal in GTW2 on 10/12

Possible Proposal 2-2 (ease of reference; no change)

For NR Rel-17, paging indications to UE subgroups are carried only in PEI.

For the other potential indications in PEI, the following are collected for information:

TRS availability indication in PEI:

* Support: HW (configurable via SIB), TCL, ZTE, LG, Apple, Ericsson, Nokia, DoCoMo (configurable via SIB), Spreadtrum, Apple
* No: Samsung, Intel, Qualcomm

SI and ETWS:

* Support: HW (configurable via SIB), ZTE, Xiaomi, LG, Nokia, DENSO, DoCoMo (configurable via SIB), Spreadtrum, Apple
* No: vivo, CATT (no short messages), Samsung, Intel, Qualcomm, Ericsson

# Higher Layer Configuration for PEI, Including Search Space

## Phase-1 Discussion

For the PDCCH related higher layer configurations, including CORESET, search space set, AL etc., Table 2 collects companies’ related views:

Table 5: Companies’ views related to higher layer configuration, including Search Space setting

|  |  |
| --- | --- |
| Company | Company views |
| Huawei, HiSilicon | ***Proposal 8: Existing CORESET0 can be used for PDCCH-based PEI, and the PEI can transmitted in a new CSS.******Proposal 10: PEI is transmitted in the MIB-configured initial DL BWP where SSB is transmitted.*** |
| TCL  |  |
| ZTE, Sanechips | Proposal 9: The aggregation levels of PDCCH-based PEI can be configured Proposal 12: The paging search space can be reused for PEI. |
| Transsion Holdings | ***Proposal 5: CORESET 0 or dedicated CORESET can be used for PDCCH-based PEI and PDCCH-based PEI can reuse the common search space set.*** |
| Spreadtrum  | ***Proposal 3: The actual monitoring occasions of PEI can be overlapping between windows and monitoring occasions configured by search space set. The windows are implicitly defined by higher layer parameters or rules, and each window is a time window before 1 PO or N POs.*** |
| vivo | **Proposal 4: Reuse the legacy paging CSS (i.e., Type 2 CSS set) for PDCCH-based PEI.** |
| OPPO | ***Observation 1: The beam sweeping of PEI transmission requires large resource overhead.*** ***Observation 2: Reusing legacy PDCCH CSS set for PEI delivery has no backward compatibility issue.*** ***Proposal 7: Legacy PDCCH CSS set can be reused for paging early indication delivery to reduce resource overhead.*** |
| CATT | ***Proposal 11: For IDLE/Inactive mode, multiple beams of PEI should be supported.******Proposal 12: For IDLE/Inactive mode, the spatial channel property of PEI is QCLed with the SSB corresponding to paging PDCCH/PDSCH.*** |
| CMCC |  |
| Xiaomi | ***Proposal 1: Paging search space should be reused to transmit PEI.*** |
| Samsung | **Proposal 7: Support SIB based configuration for a search space set for PDCCH based PEI.** |
| MediaTek  | Proposal 3: A dedicated search space configuration for PEI, i.e., *pagingEarlyIndSearchSpace*, is supportedProposal 4: When *SearchSpaceId* = 0 is configured for *pagingEarlyIndSearchSpace*, the candidate PEI monitoring occasions are same as for RMSI as defined in clause 13 in TS 38.213Proposal 5: The following restrictions apply to *pagingEarlyIndSearchSpace*:* **Association with only PEI DCI format**
* **Up to two ALs**
* **Dedicated DMRS scrambling ID**
 |
| Intel  | **Proposal 4: CORESET 0 and paging search space can be used for PDCCH PEI monitoring.** |
| NTT DOCOMO |  |
| Sony | ***Proposal 2 – Support SIB based configuration of PEI, including**** ***a time offset relative to start of an associated PO, to indicate start of PEI monitoring,***
* ***time and frequency resources since multiple PEI opportunities are configured within a time window (i.e., multiplexed in time domain) and/or within a frequency allocation (i.e., multiplex in frequency domain),***
* ***number of PEI occasions for multi beam operation and the association between PEI occasions and SSB,***
* ***minimum time-gap between last PEI occasion and associated PO.***
 |
| Panasonic | **Proposal 6: A new CSS, e.g. Type 2A is configured for PEI monitoring. The time occasions of this CSS should be flexible to allow the network choice between close to SSB or close to the additional TRS occasions.** |
| Lenovo, Motorola Mobility | **Proposal 1: A PEI PDCCH search space configuration can be signaled in SIB1 or in an RRC release message.**  |
| InterDigital,  |  |
| LG Electronics | **Proposal 9: CORESET0 is used for the PEI.** |
| Apple | **Proposal 3: The search space set for PDCCH carrying PEI can be either the paging SSS (default) or separately configured by the gNB.** |
| Ericsson | Proposal 10: If PEI is supported/used by the cell, its configuration is provided via broadcast system information. The configuration is applicable to all POs of the cell and may be updated through existing SI update mechanisms.Proposal 11: Search space for PEI PDCCH monitoring can be configured separately from or can be same as one of the existing search spaces configured for PDCCH monitoring in Idle/inactive.  |
| Qualcomm  | **Proposal 2: For PDCCH-based PEI, the PDCCH configuration is based on the CORESET #0, *pagingSearchSpace* and the P-RNTI**. **DCI size of PEI PDCCH is smaller than that of the paging PDCCH.** |
| Nordic  | ***Proposal-3:**** *For PEI monitoring a gNB may configure*
	+ *monitoring window by minimum and maximum offset relative to PF*
	+ *pei-SearchSpace which can be full SearchSpace or MIB-configured SS#0*
	+ *…*
 |
| Nokia | **Proposal:** **Network flexibility to choose in which cells/beams paging is sent, should be maintained and applied also to PEI.** **Proposal:** **Network should be able to configure the PEI to only sub-set of SSB/‘broadcast’ beams.****Proposal: The monitoring occasions defined for PDCCH-PEI are defined by search space configuration. The paging search space (‘*pagingSearchSpace*’) configuration could be re-used for PEI.** |
| DENSO  | **Proposal 9: A common search space specific to PDCCH-based PEI can be configured by the higher layer.** |

Search space set

* Configuration based on broadcast system information (18): Samsung, Sony, Lenovo (or RRC release message), Ericsson and the following companies
	+ Legacy CSS (9): OPPO, ZTE (paging SS), vivo (Type 2 CSS), Xiaomi (paging SS), MTK (SearchSpaceId = 0), Intel (paging SS), Apple (paging SS), QC (paging SS), Nokia
	+ Dedicated (5): MTK (pagingEarlyIndSearchSpace), Panasonic (New Type 2A CSS), Apple, Nordic, DENSO
	+ FL suggestion: Search space setting should be based on broadcast system information. To reuse legacy CSS, a search space set can have *SearchSpaceId* = 0 or copy PDCCH monitoring occasion setting from *pageSearchSpace*. To also accommodate dedicated SS for PEI, having a ‘*peiSearchSpace*’ broadcasted by SIB is one possible way forward to satisfy all companies’ demands.

CORESET

* CORESET0: HW, Transsion, Intel, LG, QC
* Dedicated CORESET: Transsion,
* FL suggestion: CORESET is based on a CORESET setting in broadcast system information

AL: ZTE (configurable), MTK (up to 2)

* FL suggestion: Consider limited configuration for AL

By the above, the following proposal for PEI search space setting is suggested, and companies are encouraged to provide views and/or suggested revisions in Table 5.

Possible Proposal 3-1:

* CORSET and search space set settings for PEI are based on broadcast system information.
* ‘*peiSearchSpace*’ for PEI is broadcasted if PEI is configured
	+ Only PEI DCI format is configured
	+ Up to [2] ALs can be configured

Table 6: Companies’ views and/or suggested revisions on Proposal 3-1

|  |  |
| --- | --- |
| Company | Company’s view(s) and/or suggested revision(s) |
| Qualcomm | CORESET #0 should be used for PEI. *pagSearchspace* should be also used with a separate *firstPDCCH-MonitoringOccasionOfPEI* configuration*.* In general, the PDCCH configuration for paging PDCCH and PEI PDCCH should be shared as much as possible. This is because these two are the two steps of the same procedure. Then it is not proper to have different BW and basic PDCCH configurations for UE to monitor the two PDCCHs. As mentioned in our reply to proposals in 2.1, UE should distinguish the two DCIs based different DCI sizes. Then there is no issue with heavily reusing *pagingSearchspace* for PEI PDCCH. |
| Nordic | * CORESET and search space set settings for PEI are configured in pdcch-ConfigCommon in SIB1
* ‘*peiSearchSpace*’ for PEI is broadcasted if PEI is configured
	+ Only PEI DCI format is configured
	+ # PDCCH candidates is the same as in SS#0, i.e. 4xAL4, 2xAL8 and 1x16
 |
| Samsung  | For the CORESET, we think existing CORESET can be reused to reduce configuration overhead. CORESET for paging PDCCH can be reused For search space set, we also prefer to reuse existing SS set if possible. For ALs, we think configuration overhead is not a concern. It’s more important to provide flexibility for gNB to ensure the reliability.  |
| Intel | CORESET # 0 (can be specified) and paging search space can be used.ALs and number of candidates per AL can be specified and need not be separately configured. An example is as follows, which provides reasonable flexibility.

|  |  |
| --- | --- |
| **CCE Aggregation Level**  | **Number of Candidates** |
| 4  | 4 |
| 8  | 2 |
| 16  | 1 |

 |
| LG | We are generally fine with the proposal.  |
| Spreadtrum | We are basically fine with the proposal. |
| Ericsson | CORESET and search space set for PEI should be configured via SI signaling. SI signaling details should be left to RAN2.Both configuring a new CORESET/SS for PEI and using an existing CORESET/SS for PEI should be supported. Number of PDCCH candidates/configured ALs should be left up to gNB configuration. So, [2] should be updated to 4. |
| Xiaomi | For the first bullet, we can agree.But we don’t support the second bullet. In this meeting’s contribution, many companies includes Xiaomi propose to reuse paging search space for transmission of PEI, and in this case, no additional searchspace will be needed for PEI. What we need to do is just to say that, PEI search space reuse paging search space. And reusing paging search space is very high efficient since no additional resource overhead, and no additional specification work load. If we specify a dedicated resource for PEI transmitted in a beam sweeping way, that would cost a lot of air interface resource unnecessary. And as to the AL for PEI, we can agree that, limited number of AL will reduce blind decoding power.So we propose,**Paging search space is reused for transmission of PEI** |
| CATT | We are OK that PEI could be configured with its own search Space *PEISearchSpace* similar to *pagingSearchSpace* for paging. PEI could also use CORSET0/SearchSpaceZero as that of paging DCI or shared the search space *pagingSearchSpace* with paging. We can not agree PEISearchSpace is required with “PEISearchSpace for PEI is broadcasted if PEI is configured”We don’t see the justification and the need of limiting the aggregation level for the new DCI format to up to 2 before we agree on the new DCI format for PEI.  |
| Sharp | We are fine with the proposal, and the AL number can be further discussed |
| vivo | we are fine with the first main-bullet. However, it is confused for us on the second main-bullet since the clear majority views are to reuse the legacy CSS e.g., paging CSS as the PEI SS. As analyzed in our contribution [R1-2108985], there is no need to define a new dedicated CSS set for it given the reason that no monitoring configuration are specifically required by PEI monitoring. Additionally, sharing with the legacy CSS set for PDCCH-based PEI monitoring can completely work well without occupying another SS set ID, which can also avoid additional resource overhead and unnecessary specification work. Blocking issue for sharing the Search space with paging search space is not a big issue considering the PEI is not frequently delivered and hence it is expected the congestion is seldom occurred.Besides, for the last sub-bullet, considering that there is no such limitation for legacy SS such as paging SS, we think limiting up to [2] kinds of ALs is not needed for PEI SS. |
| Nokia | We agree that the required configuration for PEI SS and CORESET would need to be provided part of broadcast information, and detailed SI design can be left for RAN2.For aggregation levels, like pointed out by other companies, we support 3 ALs for (scheduling of) other broadcast channels. Thereby it would seem natural to align the PEI assumption for AL’s and number of candidates with Table 10.1-1 in 38.213 at least for the case when Type0-PDCCH CSS. |
| Apple | We think CORESET#0 should be reused. We are also fine with reusing pagingSearchSpace if that is the majority view. |
| Huawei, HiSilicon | 1. We think we need to support to configure deicated PEI search space set. Behv.B is decided not to support in RAN#93. Therefore, we need to consider the case when gNB cannot transmit the PEI PDCCH, especially in case when the bandwidth of CORESERT0 is small. In this case, the network needs the flexibility to configure the PEI search space not overlapped with other common search space set in time domain.
2. We are also fine to configure this dedicated search space the same as paging search space set. However, we don't think SearchSpaceZero can be used. In some cases, the search space set 0’s monitoring occasion may be before the corresponding SSB. This makes the UE to receiver an earlier SS burst to achieve synchronization before the reception of PEI DCI. This makes there is no power saving gain for PEI in this case.
3. For aggregation level, we think it should be at least have the same number of ALs as other common search space.
 |
| CMCC | We support to configure separate CORESET and search space for PEI similar to paging, but CORESET#0 and SS#0 can also be used if no separate CORESET/SS are configured. |
| ZTE, Sanechips | (1)We are okay with the two main bullets.(2)For the configuration of DCI format for peiSearchspace, the following sub-bullet precludes the possibility for NW to share different DCI formats into one SSS configuration, we don’t think this restriction is needed. * + Only PEI DCI format is configured

(3) “up to [2] AL” is too restrictive, we need to provide NW sufficient flexibility to adapt to coverage/channel condition. |
| TCL  | We are ok with the other bullets of the proposal, except the AL. AL [2] may not fulfil the requirements of PEI’s payload and we shall discuss it further.  |
| Panasonic | We can be fine with this proposal considering the 2 AL is in the bracket. For better coverage and flexibility on supporting different DCI bit numbers. We think 2 is too restrictive. |
| DOCOMO | We are generally fine with the proposal. |
| OPPO | We are basically fine with the proposal.  |
| Transsion Holdings | 1. We are OK to the first bullet.

For the second bullet, we think ALs should not be restricted. |
| IDCC | We can reuse the existing CORESET and search space configurations. |
|  |  |
|  |  |

* CORESET in SIB:
	+ CORESET#0 (3): QC, Intel, Apple
	+ CORESET in SIB1 (3): Samsung, Nordic, IDCC
	+ CORESET in SIB (11): LG, Spreadtrum, Nokia, HW, CMCC, ZTE, TCL, Panasonic, DoCoMo, OPPO, Transsion
	+ [Moderator] Since companies that support 3rd sub-bullet should be fine with reusing CORESET#0 or CORESET in SIB1, it is suggested we can agree reusing legacy CORESETs first.
* Search space set in SIB:
	+ Reuse pageSearchSpace (including SS#0) (6): QC, Xiaomi, vivo, Samsung, Apple, IDCC
	+ ‘peiSearchSpace’ (12): Nordic, LG, Spreadtrum, Nokia, HW (SS#0 may not work), CMCC (can refer to legacy SS), ZTE, TCL, Panasonic, DoCoMo, OPPO, Transsion
	+ [Moderator] Since companies that support 2nd sub-bullet should be fine with reusing pagingSearchSpace, it is suggested we can agree reusing at least pagingSearchSpace first.
* AL:
	+ Same as SS#0, i.e. 4xAL4, 2xAL8 and 1xAL16 (9): Nordic, Intel, CATT, vivo, Nokia, HW, ZTE, TCL, Panasonic
	+ Configurable (5): Samsung, LG, Spreadtrum, Xiaomi, Transsion,
	+ Up to 2 ALs (2): DoCoMo, OPPO

By the above, the following revised proposal is suggested, and companies are encouraged to provide views/suggested revisions in Table 7.

Possible Proposal 3-1a:

* Support referencing legacy CORESET#0 or CORESET configuration in SIB1 for PEI
	+ FFS whether to support additional CORESET configuration in SIB for PEI
* Support referencing *pagingSearchSpace* for PEI
	+ FFS whether and how to exclude *SearchSpaceID* = 0 for some SS/PBCH block and CORESET multiplexing pattern(s)
	+ FFS specification change to include or limit to monitoring PEI DCI format
	+ FFS whether to support additional search space set configuration in SIB for PEI
* Support monitoring up to 4 AL4, 2 AL8 and 1 AL16 candidates
	+ FFS whether additional restriction can be included

Table 7: Companies’ views and/or suggested revisions on Proposal 3-1a

|  |  |
| --- | --- |
| Company | Company’s view(s) and/or suggested revision(s) |
| Samsung  |  “referencing” is not clear to us. Does it indicate explicit configuration parameter in SIB1 is still needed? We think *pagingSearchSpace* and associated CORESET can be reused directly for PEI. No explicit configuration or reference is needed. |
| Qualcomm | The proposal is a little confusing. Is “reference” CORESET and search space set the default CORESET and SS set when network does not provide an explicit configuration? If so, before we decide which CORESET or SS set can be used for PEI, there is no need to discuss the default setup.For PEI PDCCH monitoring, the high-level principle per our understanding is to reuse the same CORESET and search space set as for the paging PDCCH monitoring. This ties both paging related behaviours (PEI monitoring, paging PDCCH monitoring) together. I.e., PEI can be monitored in a way close to that for the paging PDCCH. Rel-17 should only define essential functions for paging enhancements. Sharing COERSET/SS set between PEI and paging PDCCH is the way to design essential function with minimum standard efforts. The benefit is this design will automatically work for RedCap UE without further efforts.We are fine with the third because it is a natural result of reusing pagingSearchSpace for PEI PDCCH. |
| CATT | In general, We don’t agree with Proposal 3-1aFirst, CATT does not comment our support of AL for PEI being same as that of SS#0. We don’t see the need to restrict ALs for new DCI format for PEI. We could discuss whether we need further restriction after new DCI format for PEI is finalized. We also confuse about “referencing *pagingSearchSpace”.* Current PDCCH-ConfigCommon includes all search space as follows,PDCCH-ConfigCommon ::= SEQUENCE { controlResourceSetZero ControlResourceSetZero OPTIONAL, -- Cond InitialBWP-Only commonControlResourceSet ControlResourceSet OPTIONAL, -- Need R searchSpaceZero SearchSpaceZero OPTIONAL, -- Cond InitialBWP-Only commonSearchSpaceList SEQUENCE (SIZE(1..4)) OF SearchSpace OPTIONAL, -- Need R searchSpaceSIB1 SearchSpaceId OPTIONAL, -- Need S searchSpaceOtherSystemInformation SearchSpaceId OPTIONAL, -- Need S pagingSearchSpace SearchSpaceId OPTIONAL, -- Need S ra-SearchSpace SearchSpaceId We could decide if we would have new PEISearchSpace in addition to the current search space for PEI.   |
| Lenovo/Motorola Mobility | We prefer to gNB explicitly configuring ‘peiSearchSpace’ for PEI in ‘PDCCH-ConfigCommon’, if PEI is configured. |
| LG | **For the first main bullet,** We are fine with this bullet in general. However, it would be better to remove ‘referencing’ since the intention of this wording is not clear for us. **For the second main bullet,** We are fine with using some parameters from pagingSearchSpace when gNB configures it. If the intention of the ‘referencing’ is to borrow some parameters for paging, we are fine with this bullet in principle. However we would like to point out that at least ‘peiSearchSpace’ shall be introduced. |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

# Identification of PEI Occasion before PO

## Phase-1 Discussion

Relating to identification of PEI MOs before PO, including whether and how to support one PEI indicates multiple POs (in a PF), companies’ views are collected in Table 3.

Table 8: Companies views related to identification of PEI MOs before PO

|  |  |
| --- | --- |
| Company | Company views |
| Huawei, HiSilicon | ***Proposal 1: For PDCCH-based PEI,*** * ***Determination of PEI monitoring occasion(s) is based on,***
	+ ***A search space configuration specifying periodic durations of the candidate monitoring occasions***
		- ***The search space configuration can be dedicated for PEI***
	+ ***A minimum time offset before the start of UE’s PO***
	+ ***A maximum time offset between PEI monitoring occasion(s) and the start of the earlier and Kth SS burst***
		- ***FFS range and unit of the maximum time offset***
		- ***The Kth SS burst is configurable***
* ***UE monitors all candidate monitoring occasion(s) in the earlier and first duration to the start of UE’s PO and subject to the minimum time offset w.r.t. the start of UEs’ PO and the maximum time offset w.r.t. the start of the earlier and Kth SS burst***

***Observation 3: One PEI associating with multiple POs can save the resource overhead for PEI and does not introduce additional paging delay or power saving consumption.******Proposal 5: Support one PEI associating with multiple POs.******Proposal 11: The value of minimum time offset between PEI and PO should consider the conclusion in RedCap regarding whether paging reception can be configured in the separate initial DL BWPs or not.*** |
| TCL  | ***Observation 2: PEI Monitoring location referred to the incoming PO will let PEI to be used only for paging indication and cannot be used for TRS indication.******Observation 3: PEI Monitoring location referred to the previous PO for the incoming PO will let PEI to be used for both paging indication and TRS availability indication.*****Proposal 3: Consider PEI Monitoring occasion referred to the previous paging occasion for the incoming paging occasion to utilize PEI efficiently for paging indication and TRS availability indication.**  |
| ZTE, Sanechips | Proposal 2: A PEI associated with multiple POs should be supported.Proposal 3: The number of POs associated with one PEI should be configurable.Proposal 4: Some legacy parameters can be reused to indicate the number of POs associated with one PEI.Observation 2: Multi-beam based transmission should be supported for PEI, and the QCL information of PEI in each occasion should be associated with an SSB.Proposal 8: The PEI reception window is used to determine the PEI occasion, wherein PEI reception window can be configured by an offset between the start of PEI window and the associated PO, or a reference point and an offset between the start of PEI window and the reference point. |
| Transsion Holdings | ***Proposal 7: PEI supporting for multiple beams*** ***Proposal 8: Specify the setting of PEI detection time window and time offset, both of them can be flexibility*** [***configured***](https://dict.youdao.com/w/configured/#keyfrom=E2Ctranslation) |
| Spreadtrum  | ***Proposal 1: Both 1 PEI to 1 PO mapping and 1 PEI to N POs mapping are supported in R17.******Proposal 3: The actual monitoring occasions of PEI can be overlapping between windows and monitoring occasions configured by search space set. The windows are implicitly defined by higher layer parameters or rules, and each window is a time window before 1 PO or N POs.*** |
| vivo | **Proposal 5: Define a restriction for PEI monitoring i.e., a UE can only monitor the PEI occasion(s) within the PEI window (formed by the maximum and/or minimum offsets between PEI and the associated PO).**Proposal 6: The configuration of PEI occasion should satisfy that the minimum gap between the end of PEI monitoring and the start of PO reception contains M SSB bursts, where the value of M can be 1, 2, 3 etc.**Proposal 7: The maximum offset between the starts of PEI monitoring and PO also needs to be defined.**Proposal 8: Support N>=1 PEI monitoring occasions for one PEI transmission/reception, and PEI have the same multiple beam operations as the associated paging PDCCH.Proposal 9: In multiple beam operations, a UE does not expect to receiver different PEI content in different transmitted beams.**Proposal 10: One-to-one mapping between PEI and PO is supported, and one-to-multiple mapping between PEI and PO should be precluded.****Proposal 11: UE will detect the PEI occasion(s) corresponding to the monitored paging PDCCH occasion(s) for the associated PO.*** **Note for Behavior A: UE is not required to detect all the configured PEI occasion(s) and it can detect the PEI occasion(s) corresponding to the monitored paging PDCCH occasion(s) for the associated PO i.e., the same UE implementation can be assumed for PEI and the associated PO receptions.**
 |
| OPPO | Proposal 1: One-to-one and one-to-many mapping between PEI and PO should be supported.***Proposal 2: Support N>=1 PEI monitoring occasions per PEI transmission, where each monitoring occasion is associated with a PDCCH monitoring occasion of the target PO.******Proposal 3: Time offset parameters are configured for UE to determine a time duration before target PO where the UE starts and stop monitoring PEI.******Proposal 4: Time offsets between PEI and reference point of PO groups can be used to determine the PEI monitoring occasion when one PEI is associated with multi-POs. FFS: the determination of reference point and the number of PO group.******Proposal 5: Use periodic PEI to associated with POs after it and before the next PEI.*** |
| CATT | ***Proposal 3: PDCCH-based PEI can support to indicate multiple POs.******Proposal 6: The maximum offset between PDCCH-based PEI and target PO is the SSB periodicity.******Proposal 7: PEI\_offset is the number of radio frames between PDCCH-based PEI and its PO with the possible values of PEI\_offset being 0 and 1.******Proposal 8: The PEI monitoring occasion in time domain could be determined by one of the following methods:**** ***Method 1: Target PO and offset are used to determine the PDCCH-based PEI resource in time domain.***
	+ ***Target PO is the PO with PO\_Index=0.***
	+ ***Offset is the gap between PDCCH-based PEI and target PO.***
* ***Method 2: The SFN of PDCCH-based PEI monitoring occasion in time domain could be derived by reference of existing procedure and configuration parameters for paging occasion in 38.304.***
	+ ***PO\_Index is derived independently of the SFN of PEI monitoring occasion.***
 |
| CMCC | **Proposal 1. Support 1-to-1 and 1-to-N mapping between PEI and PO(s).****Proposal 2. PDCCH monitoring occasions for PEI are determined by PEI frame and PEI monitoring occasion:*** **SFN for the PF is determined by:**

**(SFNPEI + PEI\_offset) mod T= (T div NPEI)\*[floor(UE\_ID\*NPEI/N) mod NPEI],****where T is DRX cycle of the UE, N is number of total paging frames in T, NPEI is number of total PEI frames in T and PEI\_offset is used for PEI frame determination.*** **PEI monitoring occasion is determined by PEI search space configuration, when *firstPDCCH-MonitoringOccasionOfPEI* is present, the starting PEI monitoring occasion is according to *firstPDCCH-MonitoringOccasionOfPEI* parameter, otherwise, the starting PEI monitoring occasion of all POs are the same.**
 |
| Xiaomi | ***Proposal 2: If a PEI can corresponds to M POs, then 8\*M bits subgrouping information, each 8 bits corresponding to one PO should be contained in PEI.*** |
| Samsung | **Proposal 5: Support SIB based configuration for a time offset between the start of PDCCH MOs for PEI and start of the associated PO(s).****Proposal 6: Support multi-beam operation for PDCCH based PEI, such that*** **A PEI occasion is a set of 'S' consecutive PDCCH monitoring occasions where 'S' is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in SIB1, and**
* **The Kth PDCCH monitoring occasion for PEI in the PEI occasion corresponds to the Kth transmitted SSB.**
 |
| MediaTek  | Proposal 6: For an associated PO, the burst of PEI MOs is a set of PDCCH monitoring occasions associated with the transmitted SSBs. The burst of PEI MOs starts no early from the PF of *PEI\_offset* radio frame(s) before the PF of the PO* ***PEI\_offset*** $\geq 0$ **with unit of T/N radio frame(s), where T and N are defined in clause 7 in TS 38.304**

Proposal 7: When *SearchSpaceId* = 0 is configured for *pagingEarlyIndSearchSpace*, Ns should be either 1 or 2**Proposal 8: When *SearchSpaceId* other than 0 is configured for *pagingEarlyIndSearchSpace,* a burst of PEI MOs is a set of S consecutive PDCCH monitoring occasions where S is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in *SIB1*. The Kth PDCCH monitoring occasion for the burst of PEI MOs corresponds to the Kth transmitted SSB, where K=1,2,…,S. The PDCCH monitoring occasions for PEI which do not overlap with UL symbols (determined according to *tdd-UL-DL-ConfigurationCommon*) are sequentially numbered from zero starting from the first PDCCH monitoring occasion in the PF of *PEI\_offset* radio frame(s) before the PF of the PO.** Proposal 9: New RRC parameter *firstPDCCH-MonitoringOccasionOfPEI*, analogous to *firstPDCCH-MonitoringOccasionOfPO*, is defined as below:

|  |
| --- |
| firstPDCCH-MonitoringOccasionOfPEI CHOICE {sCS15KHZoneT SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..139),sCS30KHZoneT-SCS15KHZhalfT SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..279),sCS60KHZoneT-SCS30KHZhalfT-SCS15KHZquarterT SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..559),sCS120KHZoneT-SCS60KHZhalfT-SCS30KHZquarterT-SCS15KHZoneEighthT SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..1119),sCS120KHZhalfT-SCS60KHZquarterT-SCS30KHZoneEighthT-SCS15KHZoneSixteenthT SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..2239),sCS120KHZquarterT-SCS60KHZoneEighthT-SCS30KHZoneSixteenthT SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..4479),sCS120KHZoneEighthT-SCS60KHZoneSixteenthT SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..8959),sCS120KHZoneSixteenthT SEQUENCE (SIZE (1..maxPO-perPF)) OF INTEGER (0..17919)} OPTIONAL, -- Need R |

Proposal 10: The starting PDCCH monitoring occasion number for the burst of PEI MOs associated with (i\_s + 1)th PO is the (i\_s + 1)th value of the *firstPDCCH-MonitoringOccasionOfPEI* parameter* Note: Value of the *firstPDCCH-MonitoringOccasionOfPEI* parameter is in the range [0, (total number of OFDM symbols in T/N radio frames) – 1]

Observation 1: Larger UE power saving gain can be realized with PEI if UE can detect PEI with only coarse synchronization, assuming fine synchronization with sufficient SSBs between PEI and PO can be guaranteed when UE is pagedProposal 11: UE does not expect the time gap between the burst of PEI MOs and PO is smaller than a minimum time gap. The minimum time gap should be at least 50 ms* **This ensures at least 2 SS bursts can be utilized for fine synchronization before PO, allowing only coarse synchronization is performed before PEI detection**
 |
| Intel  | **Proposal 6: An offset is configured to derive MOs for PEI monitoring with respect to the MOs of PO addressed by the PEI.****Proposal 7: PEI monitoring window includes same total number of MOs per PO, such as S\*X consecutive MOs in total, where 'S' is the number of actual transmitted SSBs and X is the number of PDCCH MOs per SSB.****Proposal 8. First MO for PEI monitoring is identified at an offset before the first MO of the PO addressed by the PEI.** **Proposal 9. Do not support configuration of a minimum time gap between last MO of PEI monitoring and start of PO.** |
| NTT DOCOMO,  | **Proposed 1: Single PEI associated with Multi POs should be supported.** |
| Sony | ***Proposal 1 – Support PEI monitoring/transmission occasion(s) to be based on*** * ***a small time-gap between SSB (***prior to PEI occasion***) and first PEI occasion, his to reduce unnecessary state transition and synchronization cost,***
* ***an offset with respect to the start of PO, this to determine the first PEI occasion,***
* ***inclusion of a window or time duration, following the first PEI occasion, to accommodate multiple opportunities for PEI monitoring/transmission, this to support both flexible scheduling and co-existence with other UE traffic as well as multi-beam operation,***
* ***inclusion of a minimum time-gap between the last PEI occasion and the earliest PO, this to allow the UE to prepare for reception of paging DCI and paging message.***
 |
| Panasonic | **Proposal 1: In the DCI format for PEI, the early indication of one and multiple POs are both supported. The number of POs are configurable by SIB.** |
| Lenovo, Motorola Mobility | **Proposal 2: Support repetition of PEI with multiple beams, where each PEI occasion is QCLed with one SSB of transmitted SSBs.****Proposal 3: A PEI PDCCH is intended to a group of UEs associated with a set of paging frames. A size of the set of paging frames may be dependent on selected paging configuration parameter values.** **Proposal 4: A PEI PDCCH monitoring occasion(s) for a given PO is configured based on a reference PF of the given PO (e.g. the earliest PF of a particular set of consecutive PFs associated with the given PO), e.g., before a start of a reference PF in a given paging cycle.** |
| InterDigital,  | **Proposal 5: One-to-one mapping between PEI and PO is supported.****Proposal 6: One-to-many mapping between PEI and corresponding POs should be configurable.****Proposal 7: UE monitors the PEI PDCCH in K consecutive PDCCH monitoring occasions (where K is the number of actual transmitted SSBs) in a window according to the configured search spaces. The starting and ending points of the window are determined with reference to the *firstPDCCH-MonitoringOccasionOfPO* of the associated PO.** |
| LG Electronics | **Observation 3: UE group indication over PEI can reduce the network overhead due to the PEI transmission.** Figure 2**Proposal 10: Define PEI Occasion, which is a set of PDCCH monitoring occasions.** * **The PDCCH monitoring occasions for PEI are determined according to [*PEISearchSpace*] and [*firstPDCCH-MonitoringOccasionOfPEI*]**
* **When *SearchSpaceId* = 0 is configured for [*PEISearchSpace*], the PDCCH monitoring occasions for PEI are same as for RMSI**
* **When *SearchSpaceId* other than 0 is configured for [*PEISearchSpace*], the UE monitors the PEI occasion where is configured via higher layer**

**Proposal 11: Define PEI Frame, which is one Radio Frame and contains one PEI Occasion or starting point of a PEI Occasion.*** **PEI Frame is determined by offset from the PF**
 |
| Apple | **Proposal 4: An offset relative to the start of the paging frame for the PO is configured for PEI monitoring.****Proposal 5: Mapping of PEI monitoring occasions to SSB/beam is implicitly derived, reusing the mechanism for paging PDCCH.** |
| Ericsson | Observation 5: From the UE power consumption perspective, at average 10% paging rate, the UE can at 90% of the time in idle mode immediately go back to deep sleep after PEI decoding regardless of PEI location with respect to PO.Observation 6: PEI transmissions should not be restricted to be in conjunction/adjacent to other transmission.Proposal 12: PO-specific configuration of the PEI search window includes an offset from the paging frame (PF) associated with the PO ranging at least up to 3 SSBs prior to PF and includes a window of PEI monitoring occasions during which the UE searches for PEI. |
| Qualcomm  | **Observation 1: Aligning SSB and PEI location allows UE to wake up only once to receive both the SSB and the PEI and can save UE power.****Proposal 3: To determine the PEI location, reference time of the PEI is based on SSB and the UE monitors PEI within a window after the associated SSB of the first SSB burst before the PO. Network configures the time offset between the associated SSB and start of the PEI monitoring window and duration for the window.** **Proposal 4: Network separately configures aggregation level and repetition number of PEI occasions for the PDCCH-based PEI. Beam sweeping pattern of PEI follows the same rule as that for the paging PDCCH.** |
| Nordic  | ***Proposal-3:**** *For PEI monitoring a gNB may configure*
	+ *monitoring window by minimum and maximum offset relative to PF*
	+ *pei-SearchSpace which can be full SearchSpace or MIB-configured SS#0*
	+ *PEI-RNTI*
	+ *payload size of DCI format*
	+ *position of DCI field*
* *UE monitors PEI in all MOs of the monitoring window*

***Proposal-4:*** *How many SSBs are between minimum monitoring offset and PF is left up to gNB configuration.* |
| Nokia | **Proposal: A single PEI should be able to address multiple POs to reduce PEI (PDCCH) indication overhead.****Proposal: Define the reference location for PEI monitoring, PEI frame (PEI-F), based on offset to PF. Offset could be defined in radio frames, and be separate for each PF.****Proposal: Define a PO specific offset, PEI-O, (e.g. ‘*firstPDCCH-MonitoringOccasionOfPEI’*) in relation to PEI monitoring reference location PEI-F. Offset could be defined in symbols and be separate for each PO.****Proposal: Determine the valid PDCCH-PEI monitoring occasions from the search space configuration (e.g. ‘*pagingSearchSpace*’ or ‘*peiSearchSpace*’) based on monitoring occasion timing indicated by PEI-F and PEI-O (e.g. ‘*firstPDCCH-MonitoringOccasionOfPEI’*), slot configuration and number of actually transmitted SSBs.****Observation:** *If Type0-PDCCH CSS is re-used for PEI monitoring, PEI-PF offset can be used to indicate the PEI monitoring occasion corresponding to the PF/PO.***Proposal: To enable/disable broadcast beam specific PEI, bit map could be used to indicate the SSBs to which the PEI is active.****Observation:** *Minimum time gap between PO and PEI should enable UE to acquire synchronisation for paging message reception.***Observation:** *It may not be beneficial to consider different UE capabilities for the minimum gap, but that a single minimum gap value that applies to all UEs should be identified.* **Proposal:** **RAN1 discusses and agrees single minimum time gap value between PEI and PO.** |
| DENSO  | **Proposal 10: The time offset between PEI occasion(s) and the start of UE’s PF is at least needed.** |

Identification of PEI MOs before PO:

* Configurable PEI detection window and time offsets (w.r.t. PO and/or SSB) (18): HW, ZTE, Transsion, Spreadtrum, vivo, OPPO, Sony, InterDigital, Ericsson and the following companies
	+ Extend the design for PO (clause 7 of TS 38.304) (9): CATT, CMCC, Samsung, MTK, Intel, LG, Apple, QC, Nokia
* PDCCH MO of previous PO (1): TCL, Xiaomi
* FL suggestion: Majority companies agree to have flexible setting. Given there is specified association between PO and SSB and a framework for determination of POs, extending existing design for PO (clause 7 of TS 38.304) looks a possible way forward to achieve flexible configuration and consistent design with PO determination.

By the above, the following proposal for identification of PEI occasion is suggested, and companies are encouraged to provide views and/or suggestion revisions in Table 7.

Possible proposal 4-1 (based on companies’ extension on legacy PO identification):

* For a target PO, a PEI Occasion (PEI-O) a set of PDCCH monitoring occasions associated with the transmitted SSBs. Reference PEI frame (PEI-F) start is subject to PEI\_offset (in unit of T/N radio frame(s)) before PF of the PO
	+ T and N are defined in clause 7 in TS 38.304
* Determination of PEI-O before PO is in analogous to determination of PO as specified in clause 7 of TS 38.304 expect for the following difference:
	+ Reference frame is offset from PF to PEI-F
	+ ‘*pagingSearchSpace*’ is changed to ‘*peiSearchSpace*’
	+ ‘*firstPDCCH-MonitoringOccasionOfPO*’ is changed to ‘*firstPDCCH-MonitoringOccasionOfPEI*’ while reusing the same definition of ‘*firstPDCCH-MonitoringOccasionOfPO*’
	+ Assume X = 1
	+ FFS: Additional update for one set of PEI MOs to provide paging indication for Ns POs in a PF

Table 9: Companies’ views and/or suggested revisions on Proposal 4-1

|  |  |
| --- | --- |
| Company | Company’s view(s) and/or suggested revision(s) |
| Qualcomm | As mentioned in our replies to previous questions, PEI\_offset is not needed when only one PEI mapping to one PO is supported. Determination of PEI occasion should be based on SSB burst as the reference time. In particular, the PEI-O and SSB can be close enough or overlap in time domain. This has the benefit that UE saves power by waking up once to receive both of SSB and PEI PDCCH. There is no need to change *pagingSearchSpace* to *peiSearchSpace*. Only *firstPDCCH-MonitoringOccasionOfPEI* needs to be defined for the location of the first monitoring occasion of the PEI PDCCH. X=1 should be sufficient for PEI PDCCH with up to 12 or 14 bits. |
| Nordic | IF X is number of consecutive MO for one QCL, then we do not think there should be any restriction |
| Samsung  | We think a time offset configured by higher layer is necessary to determine the start of multiple PEI MOs. But we don’t think we can reuse the mechanism of paging for it. The time offset should be defined as time gap between PEI MO and corresponding N>=1 POs. We can reuse the principle for paging regarding number of MOs and QCL assumptions.  |
| Intel | Assuming one PEI to one PO association, PEI offset can be used to derive MOs of PEI with respect to the MOs of PO. Introducing a new list *firstPDCCH-MonitoringOccasionOfPEI* is possible but seems not necessary. Reference point is the PO. We do not see strong need to restrict X to 1. If for PO monitoring X > 1, same can be assumed for PEI monitoring.  |
| LG | We are fine with the proposal. We already have well-designed definition for determining the PDCCH monitoring occasions for paging, and the purpose and characteristic for the PEI and the paging PDCCH are same in principle. Moreover it is obvious that mimicking existing feature can save the standard effort. Regarding the concern on the offset to the SSB, gNB can handle the gap between the PEI and the SSB even with the method in the proposal. Meanwhile, it seems like simple modification and/or clarification is required. First, the “T” is define as a “DRX cycle of the UE”, and T is determined by the shortest of the UE specific DRX value(s) and default DRX value. So if the “T” is used for determining the PEI\_offset, offset value will be different between the UEs that have different UE specific DRX value. So, it should be “default paging cycle” rather than the “DRX cycle of the UE”Second, we would like to discuss whether the “T/N” is an appropriate unit for determining the offset value, even if T is replaced by the default paging cycle. By the definition of the “N” in the TS38.331, one of the following value can be configured via gNB; {*oneT, halfT, quarterT, oneEighthT, oneSixteenthT*}. Hence the maximum value of T/N is 16. In our view, it is very challenging to use 16 radio frames (i.e. 160 ms) as the unit for determining the offset value. In summary, we prefer to change the unit of PEI\_offset to “(in unit of ~~T/N~~ radio frame(s)). |
| Spreadtrum | We read the proposal as a complicated or large-standard-effort proposal.In R16 DCI format 2-6 or WUS for NB/eMTC, WUS is generally associated to paging or DRX. Maybe we can follow this rule largely.If we associate PEI to paging (default I-DRX) or NW-configured I-DRX, the new high layer parameters can be saved. Moreover, for NW-configured I-DRX (NAS configured), the parameters, such as T, N and Ns, may not applicable, how to handle this issue? However, if PEI is associated to I-DRX, it is easy for standardization. We suggest emulating R16 DCI format 2-6 or WUS for NB/eMTC to define a window before PO(s). The density and offset of PEI is up to gNB implementation. The window can be defined like R16 DCI format 2-6, just including offset to PO(s). |
| Ericsson | The design should enable both 1-to-multiple POs within same PF or across PFs. For this, the time offset must be defined/configured according to a gap (e.g. from the first PF of the M consecutive POs/PFs for which PEI is intended). We are OK to reuse aspects related to MO identification from the paging design (including configurable value of X for PEI). |
| Xiaomi | For the first bullet, we can agreeBut we don’t support the second bullet. The current second bullet excludes a very high potential solution that PEI transmits in paging search space. And we have detailed explained in comments of Proposal 3-1.And from previous meeting discussion, I remember that the main power saving gain of PEI comes from the fact that, UE only needs to do synchronization on 1 SSB to decode PEI-DCI, but needs to do synchronization on 3 SSB to decode paging DCI and paging PDSCH, so PEI-DCI can save power by indicate the UE not to wake up. We admit that by transmitting PEI-DCI close to SSB can save more power, but the gain is limited since only the power of transition period can be saved. But dedicated designing a PEI search space close to SSB will needs lots of specification work and cost massive air interface resource.We can compromise to:**If ‘*peisearchspace*’ is not configured, PEI will be transmitted in paging search space.**And we add our company name after TCL(above Proposal 4-1), we support to transmit PEI PDCCH MO in previous PO. |
| CATT | We are OK to reuse the principle of deriving the paging occasion(s) in Clause 7 of TS38.304 for deriving the PEI monitoring occasions. PEI monitoring occasion(s) should be defined similar to that of PDCCH monitoring occasions in PO. However, we don’t think that we would assume X=1. X > 1 was introduced in Rel-16 for NR-U. When X=1 is assumed, it implies that UE does not have additional PDCCH monitoring capability when one PDCCH monitoring occasion is out due to LBE when operation in unlicensed band.  |
| Sharp | Regarding the first bullet, if one PEI mapping to POs in consecutive PF is , the PEI\_offset should be distance between the first PF and the PEI frameRegarding the second bullet, X can be configured bigger than 1 indicating PEI repetition to increase the reliability. |
| vivo | We generally support to reuse the structure of PF/PO determination defined in TS 38.304 for PEI design. But, as far as it goes, the SS for PEI is not decided yet, so we cannot agree that “*‘pagingSearchSpace’* is changed to *‘peiSearchSpace’*”. Besides, X=1 is enough for PEI DCI with 16 bits. And it might be clearer if we give the detail explanation for what X represents to avoid the potential ambiguity.  |
| Nokia | We are in OK, with the proposal in general (apart X=1), but it would be good to clarify that these parameters are PO specific. For Xiaomi’s comment Idon’t think that the use of paging search space (*peiSearchSpace* ID= *pagingSearchSpace* ID, with zero or non-zero ID) is prevented, we would just need to ensure that the range of the ‘offset’ (between PO/PF and PE) parameters is proper. Like pointed out by CATT, X>1 was intended for NR-U, thus we would prefer not to restrict it. In addition to NR-u case, if ‘*peiSearchSpace*’=0, i.e. we use Type0-PDCCH CSS, the monitoring occasions corresponding to a given SSB index are in two slots. Thus for these cases we should not restrict the value of X. |
| Apple | We are generally fine with the proposal, but it is not clear to us why PEI\_offset is in unit of T/N radio frame(s).We do not see the need to support X>1 for licensed spectrum. |
| Huawei, HiSilicon | We have the similar view with Qualcomm that PEI occasion should be refer to SS burst. We think we need to make sure the PEI occasion is after but close to SS burst transmission. As we commented online, the benefit of paging early indication comes from PEI is early and close to SS burst. Some companies argues that the power saving gain comes from one SS burst is needed for PEI compared with 3 SS bursts for PDSCH. However this is only for the low SINR case to use 3 SS bursts for PDSCH.We agree with Qualcomm that in most cases in a cell, UE has not bad SINR, and eMBB UE would just need one SS burst for the reception of PDSCH. Therefore, to obtain attractive power saving gain, the PEI needs to be transmitted close enough to the SS burst even when only one SS burst is needed for synchronization to receive PDSCH transmission. According to our observation, in most cases, UE has not bad coverage. Therefore, we should care more about the 1 SS burst case. The following table is our evaluation results to show that PEI occasion should be put close to SS burst. Table 10 Power saving gain for PEI in different location

|  |
| --- |
| Power saving gain for 14ms gap between SSB and PO |
|  |  | 1ms gap between the first SSB and PEI | 12.5ms gap between nearest SSB and PEI (PEI 1ms before PO) |
| 1SS burst for PDSCH T/F tracking | w/o RRM | 17.40% | 6.95% |
| 2SS bursts for PDSCH T/F tracking | w/o RRM | 30.15% | 5.72% |
| 3SS bursts for PDSCH T/F tracking | w/o RRM | 39.07% | 4.86% |

Also, we think only the mechanism how the SSB maps to PO occasions need to be reused. For other parameters of paging frame, we don’t think we need to reuse all of them to make the design complicated. |
| CMCC | We are generally fine with the proposal to reuse the PO determination method, especially to determine the PEI occasion in 1-to-muitiple mapping case. One comment is about the PEI\_offset, does it means an absolute frame offset similar to current PF offset design or is a relative offset corresponding to PF?  |
| ZTE,Sanechips | We don’t see the reason why PEI\_offset is in unit of T/N radio frame(s). T/N is the interval between two PFs in a paging cycle, whose range is 1~16. If the ratio is configured as too small, for example, T/N=1, the distance between PEI and PO is too close, which may not provide attractive power saving gain. When the T/N is large, for example, 16, the distance between the PEI and the PO is too large, which is also not beneficial to UE power saving. Hence, we think a flexible configuration of the offset is better, instead of coupling it with other parameters.In addition, we tend to agree with QC that the determination of PEI occasion is relevant to the mapping relationship between PEI and number of POs. It would be clearer if the mapping relationship between PEI and number of POs is settled down. |
| TCL  | We share similar views with Xiaomi  |
| Panasonic | In our understanding, the search space configuration can effectively support the functionality in this proposal by configuration of proper periodic and offset. If it can be proved that UE has some issue by only relying on the search space for PEI, we are open to discuss.  |
| DOCOMO | We are generally fine with the proposal. Regarding X value, we do not see the need to support X>1. |
| OPPO | In our understanding, this proposal is assumed that **proposal 2-1“One PEI provides paging indications to UE group(s)/subgroups of Ns PO(s) in a PF”**, thus the reference point is the PF of the PO. But now we have no consensus on proposal 2-1, it is early to determine the PF of the PO as the reference point. If one PEI can just be associated with one PO, we can determine the PO as reference point. Also, if one PEI can be associated with multiple POs across multiple PFs, which PF should be determined as the referenced point need to be considered.We should first determine the mapping between PEI and PO(s). |
| Transsion Holdings | 1. We support the unit of PEI\_offset should be more precise like slot.

 The meaning of X needs further clarification to avoid confusion. |
| IDCC | We think the offset should be defined with respect to the PO not the PF. We also think that there is no reason not to support X > 1. |
|  |  |
|  |  |

Restricted value on X for PEI:

* Yes (5).
	+ X = 1: QC (PEI DCI payload <= 14), vivo (PEI DCI payload <= 16), Apple (if licensed band), DoCoMo
	+ Configurable: Ericsson (fine with it)
* No (5): Nordic, Intel, CATT (X > 1 for NR-U), Nokia (NR-U and Type-0 PDCCH CSS considerations), IDCC
* [Moderator] PEI performance can be different from paging PDCCH (depending on PEI DCI setting). In this regard, having X configurable for PEI is one reasonable way forward to accommodate NR-U application while taking into account the performance difference

Since association between PEI-O and PO will depend on whether one PEI maps to one or multiple POs, it is suggested to update proposal 4-1 and focus on determination of PEI-O first. In this regard, PEI\_offset is no longer a “relative offset” to PO; instead, it will be a counterpart as PF\_offset for PO.

By the above the following update to proposal 4-1 is suggested, and companies are encouraged to provide views/suggested revisions to Table 11

Possible proposal 4-1a (analogous to PO determination in clause 7 of TS 38.304 with PEI specific parameters):

* A PEI occasion (PEI-O) is a set of PDCCH monitoring occasions and can consist of multiple time slots (e.g. subframe or OFDM symbol) where PEI can be sent. One PEI Frame (PEI-F) is one Radio Frame and may contain one or multiple PEI-O(s) or starting point of a PEI-O.
* SFN for the PEI-F is determined by: (SFN + PF\_offset) mod T = 0
	+ PF\_offset is configured as ‘*nAndPagingEarlyIndFrameOffset*’ with analogous definition as ‘*nAndPagingEarlyIndFrameOffset*’ in TS 38.331
	+ T: default paging cycle broadcast in system information
	+ N: number of total PEI frames in T. N is a factor of the number of total paging frames in T.
	+ Ns: number of PEI occasions for a PEI-F. Ns is a factor of the number of paging occasions for a PF.
* When *searchSpaceZero* is referenced for PEI, the PDCCH monitoring occasions for PEI are same as for RMSI as defined in clause 13 in TS 38.213, and Ns is either 1 or 2. For Ns = 1, there is only one PEI-O which starts from the first PDCCH monitoring occasion for PEI in the PEI-F. For Ns = 2, PEI-O is either in the first half frame or the second half frame of the PEI-F.
* If other search space set is referenced for PEI, a PEI-O is a set of 'S\*X ' consecutive PDCCH monitoring occasions where 'S' is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in *SIB1* and X is the *nrofPDCCH-MonitoringOccasionPerSSB-InPEI-O* if configured or is equal to 1 otherwise. The [x\*S+K]th PDCCH monitoring occasion for PEI in the PEI-O corresponds to the Kth transmitted SSB, where x=0,1,…,X-1, K=1,2,…,S. The PDCCH monitoring occasions for PEI which do not overlap with UL symbols (determined according to *tdd-UL-DL-ConfigurationCommon*) are sequentially numbered from zero starting from the first PDCCH monitoring occasion for PEI in the PEI-F. When *firstPDCCH-MonitoringOccasionOfPEI-O* is present, the starting PDCCH monitoring occasion number of (i + 1)th PEI-O is the (i + 1)th value of the *firstPDCCH-MonitoringOccasionOfPEI-O* parameter; otherwise, it is equal to i \* S\*X.
	+ *‘nrofPDCCH-MonitoringOccasionPerSSB-InPEI-O*’ has analogous definition as *‘nrofPDCCH-MonitoringOccasionPerSSB-InPO*’ is TS 38.331
	+ *‘firstPDCCH-MonitoringOccasionOfPEI-O’* has analogous definition as *‘firstPDCCH-MonitoringOccasionOfPO’* is TS 38.331
* FFS association between PEI-O and PO(s)

Table 11: Companies’ views and/or suggested revisions on Proposal 4-1a

|  |  |
| --- | --- |
| Company | Company’s view(s) and/or suggested revision(s) |
| Samsung | Current proposal repeats almost the entire configuration for paging at a cost of high configuration overhead. And it still didn’t resolve the key problem, i.e. the association between PEI occasions and PO(s). We don’t really see the need to repeat everything defined for paging in 38.304 for PEI. Why we need to introduce a PEI frame? We are fine to define a PEI occasion, similar as PO for multiple beam operation. But the number of PDCCH MOs and corresponding QCL assumption within a PEI-O can be derived from PO implicitly without additional configuration overhead. In our view, the only new issue is to determine the start of PEI-O relative to associated POs. A configurable time offset between PEI-O and associated POs is sufficient, which is also what we used for simulations.  |
| Qualcomm | We think the configuration of paging search space can be heavily reused. Basically:* UE uses its paging PDCCH configuration to identify the location of the PO
* Before the PO, UE identify the first SSB
* Use this SSB as a reference to determine the first location of the PEI occasions
* Starting from the first PEI occasion, the UE follow paging PDCCH beam sweeping patter to identify the subsequently PEI occasions.
* For each PEI occasion, the slot and symbols where the PEI is transmitted is determined by pagingSearchSpace

The proposal has too much redundant information that can be significantly simplied. |
| CATT | Proposal 4-1a is not technical correct. PF\_Offset is the Paging frame offset related to SFN 0. CATT’s contribution R1-2109235 has the complete formula in method 2 based on the derivation of paging occasion in TS38.304. SFN + PF\_offset + PEI\_offset) mod T = (T div N) \* floor((UE\_ID mod N) /A) \* AWhere: * + SFN is the SFN number of the resource allocation of PEI in time domain
	+ PF\_offset is the offset used for PF determination
	+ PEI\_offset is the offset used for the PEI resource determination
	+ T is a DRX cycle
	+ N is the number of paging frames in a DRX cycle
	+ Ns is the number of paging occasions in a Paging Frame
	+ N1 is the number of PO associated with one PEI
	+ A = Ceil(N1/Ns)
	+ UE\_ID is the 5G-S-TMSI mod 1024

All parameters are signaled to UE through NAS and system broadcast (SIB) similar to those of paging occasion. The parameters for PEI resource in time domain could link to existing PO parameters.* **Step 2:** Calculate the index of the PEI within SFN for PEI

PEI\_i\_s = (floor(UE\_ID/N)mod Ns) mod Ceil(Ns/N1)Where: * + PEI\_i\_s is the index of the PEI within SFN of PEI
	+ N is the number of total paging frames in T
	+ Ns is the number of paging occasions for a PF
	+ N1 is the number of PO associated with one PEI
	+ UE\_ID is the 5G-S-TMSI mod 1024

The PDCCH monitoring occasions for PDCCH-based PEI are determined according to PDCCH-based PEI search space and *firstPDCCH-MonitoringOccasionOfPEI* and *nrofPDCCH-MonitoringOccasionPerSSB-InPEI*. All of these parameters are configured by SIB. When *SearchSpaceId* = 0 is configured for PDCCH-based PEI search space, the PDCCH monitoring occasions for PDCCH-based PEI are same as for RMSI.When *SearchSpaceId* = 0 is configured for PDCCH-based PEI search space, the UE monitors the (PEI\_i\_s + 1)th PEI. A PEI is a set of 'S\*X ' consecutive PDCCH monitoring occasions where 'S' is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in *SIB1* and X is the *nrofPDCCH-MonitoringOccasionPerSSB-InPEI* if configured or is equal to 1 otherwise. When *firstPDCCH-MonitoringOccasionOfPEI* is present, the starting PDCCH monitoring occasion number of (PEI\_i\_s + 1)th PEI is the (PEI\_i\_s + 1)th value of the *firstPDCCH-MonitoringOccasionOfPEI* parameter; otherwise, it is equal to PEI\_i\_s \* S\*X. |
| Lenovo/Motorola Mobility | In our view, each UE can determine its starting PEI monitoring occasion based on its Paging Frame (PF), Paging Occasion (PO), PEI-to-PO/PF mapping information, and an offset with respect to a reference PO (i.e. the earliest PO among POs mapped to a PEI). Based on the starting PEI monitoring occasion, the UE can identify subsequent PEI monitoring occasions associated with all transmitted SSB, similar to paging PDCCH beam sweeping.  |
| LG | We support to introduce analogous definition as paging, but have preference with the original version (with some updates). At least, following ideas shall be considered: * PEI-F and frame level offset: Defining PEI frame would be useful when one PEI mapping to multiple PO is used. If we introduce PEI-O to PO offset, each PO will have different offset values. At least from the standard effort point of view, defining PEI-F and frame level offset would be useful.
* One PEI mapping to multiple PO: Our preference is to use Ns for paging directly for PO grouping; it does not increase the signaling overhead and can save the standard work. However, if it is not a majority view, we also fine with ‘up to Ns POs’ with gNB configuration for the progress.
 |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |
|  |  |

Define minimum time offset between PEI and PO:

* Yes (9): HW (configurable), ZTE (configurable), Transsion (configurable), vivo (1/2/3 SS burst period(s)), MTK (specified: [50] ms), Sony, Ericsson (Up to 3 SSBs), Nordic (gNB configuration), Nokia (single value specified), DENSO
* No (1): Intel
* FL suggestion: Given different CFO sensitivity for PDCCH-based PEI and paging PDSCH, it is reasonable to provide additional synchronization resource SSB or TRS for UE fine synchronization before PO. The minimum assume can be adjusted if there is significant issue identified.

Define maximum time offset between SSB and PEI:

* Yes (3): HW (configurable), Sony, QC
* No (1): Ericsson
* FL suggestion: FFS whether and how to define a maximum time offset between SS burst and PEI-O

By the above, the following proposal related to the timing constraint between PEI-O and PO and that between SS burst and PEI-O is suggested, and companies are encouraged to provide views and/or suggested revisions in Table 8.

Possible agreement 4-2:

After detecting paging indication from PEI, UE can expect at least [1] SS burst between PEI-O and PO.

* FFS whether and how to define a maximum time offset between SS burst and PEI-O

Table 12: Companies’ views and/or suggested revisions on Proposal 4-2

|  |  |
| --- | --- |
| Company | Company’s view(s) and/or suggested revision(s) |
| Qualcomm | In typical channel condition for typical deployment, single SSBS reception per idle/inactive DRX cycle should be sufficient to maintain performance of tracking loops. Zero SSB between PEI occasion and PO should be the typical design. Given this, we do not agree that 1 SSB in the proposal.  |
| Nordic | Seems reasonable to us. Having at least one SSB to fine synch for Paging PDSCH reception after PEI could be sufficient. |
| Samsung | We don’t think a restriction of 1 SSB burst is needed. Whether and how to use additional RS resources after PEI for synchronization/AGC is up to UE implementation/capability. There is no consensus for that. A cell-specific value of maximum time offset won’t work for all UEs and all channel conditions. Also, this issue is related to time offset discussed in proposal 4-1. We can consider multiple applicable values for the time offset, and some applicable values can be large to allow gNB to configure large time gap between PEI and PO if needed. |
| Intel | We do not think mandating a certain number of SSB detection between PEI and PO is necessary. We think configuration should allow for zero SSB between PEI and MO. For a given deployment, gNB is expected to have an idea of cell edge condition and could configure offset between PEI and PO accordingly. Also, note that there is no consensus on required number of SSB processing before PEI as well. |
| LG | We are fine with the proposal in principle. The intention of this proposal can be considered when we design offset values for the PEI\_frame or PEI\_Occasion. However, we would like to point out that we do not need to define ‘minimum gap value’ if the minimum offset value that can be configured by gNB is larger than the required gap value. Regarding the ‘maximum time offset between SS burst and PEI-O’, we do not see strong needs for it.  |
| Ericsson | We do not see need for this proposal – it is sufficient to allow offset value such that above condition can be achieved by configuration, and the rest can be left up to gNB implementation.  |
| Xiaomi | We are fine with the proposal in principle. But we think it is guaranteed by gNB configuration. and if TRS for idle UE can be inserted between PEI and PO, maybe no SSB is needed. |
| CATT | WE don’t agree with the proposal since we believe the front end processing for the decoding of PEI and paging DCI would be the same. Thus, no need to have additional SSB between PEI and paging DCI.  |
| Sharp | It is implemented by gNB and does not require explicit restrictions for maximum time offset between SS burst and PEI-O |
| vivo | We support the motivation for this proposal. In our view, “After detecting paging indication from PEI” will make no sense for UE due to the uncertain position for PEI detection among the multiple PEI occasions, so it should be deleted. Additionally, for the sake of equality, the “PEI MOs” need to be modified as “PEI”, which will correspond to the associated PO. Hence, we give some modifications for the proposal as shown below.Possible agreement:~~After detecting paging indication from PEI,~~ UE can expect at least [1] SS burst between PEI ~~MOs~~ and the associated PO.* FFS whether and how to ensure PEI MOs are close to a SS burst
 |
| Nokia | In the end need to agree the range to the parameters that determine the offset between PEI and PO monitoring. Thus having lower limit for ‘PEI\_offset’ would address this to and extent, while this evidently would be dependent on the SSB periodicity. Using the maximum SSB periodicity of 20ms UE assumes for initial cell selection for guidance could be used for companies determining the minimum offset value.  |
| Apple | It should be further discussed whether such a restriction is absolutely necessary. Especially if there is TRS available between PEI and PO, such restriction may not be needed. |
| Huawei, HiSilicon | We think we should discuss how to put PEI occasion close to the SS burst. |
| CMCC | Fine to support, but we wonder if there is spec impact on this agreement since both PEI offset and PF offset can be configured by gNB to guarantee the minimum time offset between PEI and PO. |
| ZTE, Sanechips | Whether the UE processes the SSB before/after the PEI depends on the UE implementation, and whether there is an SSB opportunity between the PEI and the PO depends on the appropriate PEI offset configuration. Separate discussion is not needed. |
| Panasonic | This proposal basically puts restriction on the PEI configuration at gNB side. From the performance requirement perspective, we understand the motivation. But this can be addressed by gNB implementation. If this needs to be specified, it should not be in the scope of RAN1. From the UE side, “UE can expect” is not mandating anything. If necessary, this should be addressed by RAN4. |
| OPPO | Regarding the ‘maximum time offset between SS burst and PEI-O’, if we determine the offset between PEI-O and PO, we don’t see the necessary for it. |
| Transsion Holdings | 1. One SSB between PEI-O and PO is not needed.

We can first discuss which SSB PEI is closest to. |
| Lenovo/Motorola Mobility | Since gNB may provide TRS, the proposed restriction is not necessary.  |
|  |  |

At least [1] SS burst between PEI-O and PO:

* Yes: Nordic, LG, vivo (with revised proposal), Nokia (use [20] ms), CMCC,
* No: QC, Samsung, Intel, Ericsson (gNB configuration), Xiaomi (gNB configuration), CATT, Sharp (gNB configuration), Apple (No need of SSB if TRS available), Transsion

[Moderator] Majority view is to have flexible configuration for the offset between PEI-O and PO. Since this is part of the design on association between PEI-O and PO, we suggest to revisit this part after decision on whether one PEI to multiple POs can be supported.

# Other Remaining Issues

|  |  |
| --- | --- |
| Company | Company views |
| Huawei, HiSilicon | ***Proposal 9: The agreements and progress in RedCap need to be carefully considered in PEI discussion to ensure PEI utilization on RedCap UE, as required by RedCap WID.*** |
| TCL  |  |
| ZTE, Sanechips |  |
| Transsion Holdings |  |
| Spreadtrum  |  |
| vivo |  |
| OPPO |  |
| CATT |  |
| CMCC |  |
| Xiaomi | ***Proposal 4: Not to support cross-slot scheduling with extended k0.*** |
| Samsung |  |
| MediaTek  |  |
| Intel  |  |
| NTT DOCOMO,  |  |
| Sony |  |
| Panasonic |  |
| Lenovo, Motorola Mobility |  |
| InterDigital,  |  |
| LG Electronics |  |
| Apple | **Proposal 8: Support separate PO configurations for legacy UEs and new UEs.** |
| Ericsson | Proposal 13: RAN1 to discuss UE behavior w.r.t. PO PDCCH monitoring (e.g. to acquire ETWS/CMAS/SI updates) even when UE determines that PEI indicates no paging in corresponding PO. Potentially, this behavior could be configurable by the NW.Proposal 14: In case of collision with other activity, rendering the UE unable to perform PEI decoding (for example when entering the cell in-between the PEI and PO occasion), the UE shall for that PO fall back to regular PO monitoring as per legacy procedures. Proposal 15: RAN1 to discuss other scenarios (e.g., fluctuating channel conditions) for which the UE falls back to regular PO reception as per legacy procedures.  |
| Qualcomm  | **Proposal 5: Transmit power of the PEI is configured based on a power offset to the SSS in the PEI configuration.****Observation 2: Allowing PEI and paging PDCCH to carry different availability information forces the UE that supports PEI to always decode the paging PDCCH.****Proposal 6: PEI and paging PDCCH carry the same availability information before the TRS availability indication in both signaling take effect and both take effect at the same time.** |
| Nordic  | ***Proposal-5****: Consider introducing wide-band PDCCH DMRS transmitted in an entire CORESET configured by SIB1 or MIB during PEI monitoring occasions to facilitate sequence-based detection of PEI presence and/or to facilitate PDCCH DMRS for consequent finer-synchronization.**narrow-band precoding can be assumed in CORESET#0, i.e. no change from R15/R16.* |
| Nokia |  |
| DENSO  |  |

# Summary

From the above inputs from companies’ contributions, the following proposals are suggested for further discussion and decision, and companies are encouraged to provide views and suggested revisions in the corresponding sections and tables for consensus proposals:

**New DCI format (Section 2.1)**

Possible Proposal 2-1a (please provide your views to Table 3):

For PEI, a new DCI format is supported to include at least paging indications to UE group(s)/subgroups of the associated PO(s)

* One bit in the DCI payload indicating one UE subgroup of a PO or one UE group/PO (if UE paging subgrouping is not configured)
* The maximum number of total bits for paging indication field in PEI DCI format is [16]:
	+ It is up to gNB configuration how many POs can be indicated by one PEI
* P-RNTI is utilized for CRC scrambling

Possible Proposal 2-2 (no change)

For NR Rel-17, paging indications to UE subgroups are carried only in PEI.

**Higher-layer configuration, including SS (Section 3.1)**

Possible Proposal 3-1a (please provide your views to Table 7):

* Support referencing legacy CORESET#0 or CORESET configuration in SIB1 for PEI
	+ FFS whether to support additional CORESET configuration in SIB for PEI
* Support referencing *pagingSearchSpace* for PEI
	+ FFS whether and how to exclude *SearchSpaceID* = 0 for some SS/PBCH block and CORESET multiplexing pattern(s)
	+ FFS specification change for monitoring PEI DCI format only
	+ FFS whether to support additional search space set configuration in SIB for PEI
* Support monitoring up to 4 AL4, 2 AL8 and 1 AL16 candidates
	+ FFS whether additional restriction can be included

**Identification of PEI MOs before PO (Section 4.1)**

Possible proposal 4-1a (analogous to PO determination in clause 7 of TS 38.304 with PEI specific parameters; please provide your views to Table 11):

* A PEI occasion (PEI-O) is a set of PDCCH monitoring occasions and can consist of multiple time slots (e.g. subframe or OFDM symbol) where PEI can be sent. One PEI Frame (PEI-F) is one Radio Frame and may contain one or multiple PEI-O(s) or starting point of a PEI-O.
* SFN for the PEI-F is determined by: (SFN + PF\_offset) mod T = 0
	+ PF\_offset is configured as ‘*nAndPagingEarlyIndFrameOffset*’ with analogous definition as ‘*nAndPagingEarlyIndFrameOffset*’ in TS 38.331
	+ T: default paging cycle broadcast in system information
	+ N: number of total PEI frames in T. N is a factor of the number of total paging frames in T.
	+ Ns: number of PEI occasions for a PEI-F. Ns is a factor of the number of paging occasions for a PF.
* When *searchSpaceZero* is referenced for PEI, the PDCCH monitoring occasions for PEI are same as for RMSI as defined in clause 13 in TS 38.213, and Ns is either 1 or 2. For Ns = 1, there is only one PEI-O which starts from the first PDCCH monitoring occasion for PEI in the PEI-F. For Ns = 2, PEI-O is either in the first half frame or the second half frame of the PEI-F.
* If other search space set is referenced for PEI, a PEI-O is a set of 'S\*X ' consecutive PDCCH monitoring occasions where 'S' is the number of actual transmitted SSBs determined according to *ssb-PositionsInBurst* in *SIB1* and X is the *nrofPDCCH-MonitoringOccasionPerSSB-InPEI-O* if configured or is equal to 1 otherwise. The [x\*S+K]th PDCCH monitoring occasion for PEI in the PEI-O corresponds to the Kth transmitted SSB, where x=0,1,…,X-1, K=1,2,…,S. The PDCCH monitoring occasions for PEI which do not overlap with UL symbols (determined according to *tdd-UL-DL-ConfigurationCommon*) are sequentially numbered from zero starting from the first PDCCH monitoring occasion for PEI in the PEI-F. When *firstPDCCH-MonitoringOccasionOfPEI-O* is present, the starting PDCCH monitoring occasion number of (i + 1)th PEI-O is the (i + 1)th value of the *firstPDCCH-MonitoringOccasionOfPEI-O* parameter; otherwise, it is equal to i \* S\*X.
	+ *‘nrofPDCCH-MonitoringOccasionPerSSB-InPEI-O*’ has analogous definition as *‘nrofPDCCH-MonitoringOccasionPerSSB-InPO*’ is TS 38.331
	+ *‘firstPDCCH-MonitoringOccasionOfPEI-O’* has analogous definition as *‘firstPDCCH-MonitoringOccasionOfPO’* is TS 38.331
* FFS association between PEI-O and PO(s)

# Reference

1. RP-212611, “Moderator’s summary for discussion [93e-18-PowSav-WI]: Final Round”, Moderator (CMCC), RAN#93-e
2. RP-211452, “Status report for WI UE Power Saving Enhancements for NR”, Rapporteur (MediaTek), RAN#92-e
3. R1-2009801, “LS on Paging Enhancement”, MediaTek, RAN1 to RAN2, RAN1#103-e
4. R1-2108744 Paging enhancements for UE power saving in IDLE/inactive mode Huawei, HiSilicon
5. R1-2108836 Paging enhancements for idle/inactive UE power saving TCL Communication Ltd.
6. R1-2108864 Discussion on power saving enhancements for paging ZTE, Sanechips
7. R1-2108866 Additional simulation results of UE power consumption in RRC idle and inactive state ZTE, Sanechips
8. R1-2108888 Discussion on PEI Design Transsion Holdings
9. R1-2108916 Discussion on potential paging enhancements for UE power saving Spreadtrum Communications
10. R1-2108985 Paging enhancements for idle/inactive mode UE power saving vivo
11. R1-2108987 Discussion on paging grouping vivo
12. R1-2109085 Further discussion on Paging enhancements for power saving OPPO
13. R1-2109235 Paging enhancement for UE power saving CATT
14. R1-2109237 Multiple POs associated with one PEI CATT
15. R1-2109292 Discussion on paging early indication design CMCC
16. R1-2109422 Paging enhancement for power saving Xiaomi
17. R1-2109500 Discussion on paging enhancements Samsung
18. R1-2109581 On PDCCH-based PEI for paging enhancements MediaTek Inc.
19. R1-2109621 On remaining details of paging early indication design Intel Corporation
20. R1-2109689 Discussion on paging enhancement NTT DOCOMO, INC.
21. R1-2109747 Analysis on power consumption for IDLE mode UE Huawei, HiSilicon
22. R1-2109748 Other considerations on power saving in Rel-17 Huawei, HiSilicon
23. R1-2109797 Paging enhancements for idle/inactive UE power saving Sony
24. R1-2109855 On paging enhancement Panasonic
25. R1-2109944 Paging enhancement for UE power saving Lenovo, Motorola Mobility
26. R1-2109952 Discussion on paging enhancements for UE power saving InterDigital, Inc.
27. R1-2109954 Wake-up signal for low power wake-up radio InterDigital, Inc.
28. R1-2109980 Discussion on potential paging enhancements LG Electronics
29. R1-2110043 Paging enhancements for idle/inactive-mode UE Apple
30. R1-2110136 Design of Paging Enhancements Ericsson
31. R1-2110197 Paging enhancements for idle/inactive UE power saving Qualcomm Incorporated
32. R1-2110199 Aligning Paging Occasions to SSB for UE idle and inactive mode power saving Qualcomm Incorporated
33. R1-2110283 On paging early indication Nordic Semiconductor ASA
34. R1-2110311 On paging enhancements for UE power saving Nokia, Nokia Shanghai Bell
35. R1-2110315 Design of PDCCH-based Paging Early Indication DENSO CORPORATION