**3GPP TSG-RAN WG1 Meeting #106b-e *R1-210xxxx***

**Electronic Meeting, October 11th – 19th, 2021**

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| *CR-Form-v12.1* | | | | | | | | |
| **DRAFT CHANGE REQUEST** | | | | | | | | |
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|  | **38.214** | **CR** | **<CR#>** | **rev** | **-** | **Current version:** | **16.7.0** |  |
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| *For* [***HE******LP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network | **X** | Core Network |  |

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| ***Title:*** | Introduction of further enhancements on MIMO for NR | | | | | | | | | |
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| ***Source to WG:*** | Nokia | | | | | | | | | |
| ***Source to TSG:*** |  | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_FeMIMO-Core | | | | |  | ***Date:*** | | | 2021-11-01 |
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| ***Category:*** | **B** |  | | | | | ***Release:*** | | | Rel-17 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-15 (Release 15) Rel-16 (Release 16) Rel-17 (Release 17) Rel-18 (Release 18)* | |
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| ***Reason for change:*** | | Introduction of further enhancements on MIMO for NR | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | **Introduction of Further Enhanced Type II Port Selection codebook and CSI reporting for DL multi-TRP**  In section 5.2.1.1, introduced the mention of Further Enhanced Type II Port Selection as a reporting setting  In section 5.2.1.4, introduced the mention of Further Enhanced Type II Port Selection as a reporting configuration  In section 5.2.1.4, introduced the resource setting configuration for mTRP where “N CMR pairs” and “Two CMR groups” are configured in NZP-CSI-RS-Resource-Set.  In section 5.2.1.4.2, introduced reporting quantity configurations supporting mTRP.  In section 5.2.1.6, defined the CSI processing criteria for mTRP operation.  In secton 5.2.2.2.7, introduced the new Further Enhanced Type II Port Selection Codebook  In section 5.2.2.3.1, defined the NZP CSI-RS configuration for NCJT.  In section 5.2.2.5, defined the UE’s assumption for CQI calculation for an NCJT transmission hypothesis.  In section 5.2.3, added the support for NCJT CSI reporting using PUSCH as well as the support for Further Enhanced Type II Port Selection CSI.  In section 5.2.4, added the support for NCJT CSI reporting using PUCCH, | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | Incomplete support of further enhancements on MIMO for NR | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 5.2.1.1, 5.2.1.4, 5.2.1.4.1, 5.2.1.4.2, 5.2.1.6, 5.2.2.2.7 (new), 5.2.2.3, 5.2.2.3.1, 5.2.2.5, 5.2.3, 5.2.4 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **X** |  | Other core specifications | | | | TS/TR ... CR ... | | |
| ***affected:*** | |  | **X** | Test specifications | | | | TS/TR ... CR ... | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | | TS/TR ... CR ... | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

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#### 5.2.1.1 Reporting settings

Each Reporting Setting *CSI-ReportConfig* is associated with a single downlink BWP (indicated by higher layer parameter *BWP-Id*) given in the associated *CSI-ResourceConfig* for channel measurement and contains the parameter(s) for one CSI reporting band: codebook configuration including codebook subset restriction, time-domain behavior, frequency granularity for CQI and PMI, measurement restriction configurations, and the CSI-related quantities to be reported by the UE such as the layer indicator (LI), L1-RSRP, L1-SINR, CRI, and SSBRI (SSB Resource Indicator).

The time domain behavior of the *CSI-ReportConfig* is indicated by the higher layer parameter *reportConfigType* and can be set to 'aperiodic', 'semiPersistentOnPUCCH', 'semiPersistentOnPUSCH', or 'periodic'. For 'periodic' and 'semiPersistentOnPUCCH'/'semiPersistentOnPUSCH' CSI reporting, the configured periodicity and slot offset applies in the numerology of the UL BWP in which the CSI report is configured to be transmitted on. The higher layer parameter *reportQuantity* indicates the CSI-related, L1-RSRP-related or L1-SINR-related quantities to report. The *reportFreqConfiguration* indicates the reporting granularity in the frequency domain, including the CSI reporting band and if PMI/CQI reporting is wideband or sub-band. The *timeRestrictionForChannelMeasurements* parameter in *CSI-ReportConfig* can be configured to enable time domain restriction for channel measurements and *timeRestrictionForInterferenceMeasurements* can be configured to enable time domain restriction for interference measurements. The *CSI-ReportConfig* can also contain *CodebookConfig*, which contains configuration parameters for Type-I, Type II, Enhanced Type II CSI, or Further Enhanced Type II Port Selection including codebook subset restriction, when applicable, and configurations of group-based reporting.

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#### 5.2.1.4 Reporting configurations

The UE shall calculate CSI parameters (if reported) assuming the following dependencies between CSI parameters (if reported)

- LI shall be calculated conditioned on the reported CQI, PMI, RI and CRI

- CQI shall be calculated conditioned on the reported PMI, RI and CRI

- PMI shall be calculated conditioned on the reported RI and CRI

- RI shall be calculated conditioned on the reported CRI.

The Reporting configuration for CSI can be aperiodic (using PUSCH), periodic (using PUCCH) or semi-persistent (using PUCCH, and DCI activated PUSCH). The CSI-RS Resources can be periodic, semi-persistent, or aperiodic. Table 5.2.1.4-1 shows the supported combinations of CSI Reporting configurations and CSI-RS Resource configurations and how the CSI Reporting is triggered for each CSI-RS Resource configuration. Periodic CSI-RS is configured by higher layers. Semi-persistent CSI-RS is activated and deactivated as described in Clause 5.2.1.5.2. Aperiodic CSI-RS is configured and triggered/activated as described in Clause 5.2.1.5.1.

Table 5.2.1.4-1: Triggering/Activation of CSI Reporting for the possible CSI-RS Configurations.

|  |  |  |  |
| --- | --- | --- | --- |
| CSI-RS Configuration | Periodic CSI Reporting | Semi-Persistent CSI Reporting | Aperiodic CSI Reporting |
| Periodic CSI-RS | No dynamic triggering/activation | For reporting on PUCCH, the UE receives an activation command, as described in clause 6.1.3.16 of [10, TS 38.321]; for reporting on PUSCH, the UE receives triggering on DCI | Triggered by DCI; additionally, subselection indication as described in clause 6.1.3.13 of [10, TS 38.321] possible as defined in Clause 5.2.1.5.1. |
| Semi-Persistent CSI-RS | Not Supported | For reporting on PUCCH, the UE receives an activation command, as described in clause 6.1.3.16 of [10, TS 38.321]; for reporting on PUSCH, the UE receives triggering on DCI | Triggered by DCI; additionally, subselection indication as described in clause 6.1.3.13 of [10, TS 38.321] possible as defined in Clause 5.2.1.5.1. |
| Aperiodic CSI-RS | Not Supported | Not Supported | Triggered by DCI; additionally, subselection indication as described in clause 6.1.3.13 of [10, TS 38.321] possible as defined in Clause 5.2.1.5.1. |

When the UE is configured with higher layer parameter *NZP-CSI-RS-ResourceSet* and when the higher layer parameter *repetition* is set to 'off', the UE shall determine a CRI from the supported set of CRI values as defined in Clause 6.3.1.1.2 of [5, TS 38.212] and report the number in each CRI report. When the higher layer parameter *repetition* is set to 'on', CRI is not reported. CRI reporting is not supported when the higher layer parameter *codebookType* is set to 'typeII', 'typeII-PortSelection', 'typeII-r16', 'typeII-PortSelection-r16', or 'typeII-PortSelection-r17'.

For a periodic or semi-persistent CSI report on PUCCH, the periodicity (measured in slots) and the slot offset are configured by the higher layer parameter *reportSlotConfig*. Unless specified otherwise, the UE shall transmit the CSI report in frames with SFN and slot number within the frame satisfying

where is the SCS configuration of the UL BWP the CSI report is transmitted on.

For a semi-persistent CSI report on PUSCH, the periodicity (measured in slots) is configured by the higher layer parameter *reportSlotConfig.* Unless specified otherwise, the UE shall transmit the CSI report in frames with SFN and slot number within the frame satisfying

where and are the SFN and slot number within the frame respectively of the initial semi-persistent PUSCH transmission according to the activating DCI.

For a semi-persistent or aperiodic CSI report on PUSCH, the allowed slot offsets are configured by the following higher layer parameters:

- if triggered/activated by DCI format 0\_2 and the higher layer parameter reportSlotOffsetListDCI-0-2 is configured, the allowed slot offsets are configured by reportSlotOffsetListDCI-0-2, and

- if triggered/activated by DCI format 0\_1 and the higher layer parameter reportSlotOffsetListDCI-0-1 is configured, the allowed slot offsets are configured by reportSlotOffsetListDCI-0-1*,* and

- otherwise, the allowed slot offsets are configured by the higher layer parameter *reportSlotOffsetList*.

The offset is selected in the activating/triggering DCI.

For CSI reporting, a UE can be configured via higher layer signaling with one out of two possible subband sizes, where a subband is defined as  contiguous PRBs and depends on the total number of PRBs in the bandwidth part according to Table 5.2.1.4-2.

Table 5.2.1.4-2: Configurable subband sizes

|  |  |
| --- | --- |
| **Bandwidth part (PRBs)** | **Subband size (PRBs)** |
| 24 – 72 | 4, 8 |
| 73 – 144 | 8, 16 |
| 145 – 275 | 16, 32 |

The *reportFreqConfiguration* contained in a *CSI-ReportConfig* indicates the frequency granularity of the CSI Report. A CSI Reporting Setting configuration defines a CSI reporting band as a subset of subbands of the bandwidth part, where the *reportFreqConfiguration* indicates:

- the *csi-ReportingBand* as a contiguous or non-contiguous subset of subbands in the bandwidth part for which CSI shall be reported.

- A UE is not expected to be configured with *csi-ReportingBand* which contains a subband where a CSI-RS resource linked to the CSI Report setting has the frequency density of each CSI-RS port per PRB in the subband less than the configured density of the CSI-RS resource.

- If a CSI-IM resource is linked to the CSI Report Setting, a UE is not expected to be configured with *csi-ReportingBand* which contains a subband where not all PRBs in the subband have the CSI-IM REs present.

- wideband CQI or subband CQI reporting, as configured by the higher layer parameter *cqi-FormatIndicator*. When wideband CQI reporting is configured, a wideband CQI is reported for each codeword for the entire CSI reporting band. When subband CQI reporting is configured, one CQI for each codeword is reported for each subband in the CSI reporting band.

- wideband PMI or subband PMI reporting as configured by the higher layer parameter *pmi-FormatIndicator*. When wideband PMI reporting is configured, a wideband PMI is reported for the entire CSI reporting band. When subband PMI reporting is configured, except with 2 antenna ports, a single wideband indication (*i1* in Clause 5.2.2.2) is reported for the entire CSI reporting band and one subband indication (*i2* in clause 5.2.2.2) is reported for each subband in the CSI reporting band. When subband PMIs are configured with 2 antenna ports, a PMI is reported for each subband in the CSI reporting band.

- a UE is not expected to be configured with *pmi-FormatIndicator* if *codebookType* is set to 'typeII-r16' or 'typeII-PortSelection-r16' or 'typeII-PortSelection-r17'.

A CSI Reporting Setting is said to have a wideband frequency-granularity if

- *reportQuantity* is set to 'cri-RI-PMI-CQI', or 'cri-RI-LI-PMI-CQI', *cqi-FormatIndicator* is set to 'widebandCQI' and *pmi-FormatIndicator* is set to 'widebandPMI', or

- *codebookType* is set to 'typeII-PortSelection-r17' with and *cqi-FormatIndicator* is set to 'widebandCQI', or

- *reportQuantity* is set to 'cri-RI-i1' or

- *reportQuantity* is set to 'cri-RI-CQI' or 'cri-RI-i1-CQI' and *cqi-FormatIndicator* is set to 'widebandCQI', or

- *reportQuantity* is set to 'cri-RSRP' or 'ssb-Index-RSRP' or 'cri-SINR', or 'ssb-Index-SINR'

otherwise, the CSI Reporting Setting is said to have a subband frequency-granularity.

If the UE is configured with a CSI Reporting Setting for a bandwidth part with fewer than 24 PRBs, the CSI reporting setting is expected to have a wideband frequency-granularity, and, if applicable, the higher layer parameter *codebookType* is set to 'typeI-SinglePanel'.

The first subband size is given by  and the last subband size given by  if  and if 

If a UE is configured with semi-persistent CSI reporting, the UE shall report CSIwhen both CSI-IM and NZP CSI-RS resources are configured as periodic or semi-persistent. If a UE is configured with aperiodic CSI reporting, the UE shall report CSIwhen both CSI-IM and NZP CSI-RS resources are configured as periodic, semi-persistent or aperiodic.

A UE configured with DCI format 0\_1 or 0\_2 does not expect to be triggered with multiple CSI reports with the same *CSI-ReportConfigId*.

##### 5.2.1.4.1 Resource Setting configuration

For aperiodic CSI, each trigger state configured using the higher layer parameter *CSI-AperiodicTriggerState* is associated with one or multiple *CSI-ReportConfig* where each *CSI-ReportConfig* is linked to periodic, or semi-persistent, or aperiodic resource setting(s):

- When one Resource Setting is configured, the Resource Setting (given by higher layer parameter *resourcesForChannelMeasurement*) is for channel measurement for L1-RSRP or for channel and interference measurement for L1-SINR computation.

- When two Resource Settings are configured, the first one Resource Setting (given by higher layer parameter *resourcesForChannelMeasurement*) is for channel measurement and the second one (given by either higher layer parameter *csi-IM-ResourcesForInterference* or higher layer parameter *nzp-CSI-RS-ResourcesForInterference*) is for interference measurement performed on CSI-IM or on NZP CSI-RS.

- When three Resource Settings are configured, the first Resource Setting (higher layer parameter *resourcesForChannelMeasurement*) is for channel measurement, the second one (given by higher layer parameter *csi-IM-ResourcesForInterference*) is for CSI-IM based interference measurement and the third one (given by higher layer parameter *nzp-CSI-RS-ResourcesForInterference*) is for NZP CSI-RS based interference measurement.

For semi-persistent or periodic CSI, each *CSI-ReportConfig* is linked to periodic or semi-persistent Resource Setting(s):

- When one Resource Setting (given by higher layer parameter *resourcesForChannelMeasurement*) is configured, the Resource Setting is for channel measurement for L1-RSRP or for channel and interference measurement for L1-SINR computation.

- When two Resource Settings are configured, the first Resource Setting (given by higher layer parameter *resourcesForChannelMeasurement*) is for channel measurement and the second Resource Setting (given by higher layer parameter *csi-IM-ResourcesForInterference*) is used for interference measurement performed on CSI-IM. For L1-SINR computation, the second Resource Setting (given by higher layer parameter *csi-IM-ResourcesForInterference* or higher layer parameter *nzp-CSI-RS-ResourceForInterference*) is used for interference measurement performed on CSI-IM or on NZP CSI-RS.

A UE is not expected to be configured with more than one CSI-RS resource in resource set for channel measurement for a *CSI-ReportConfig* with the higher layer parameter *codebookType* set to 'typeII', 'typeII-PortSelection', 'typeII-r16', 'typeII-PortSelection-r16', or 'typeII-PortSelection-r17'.. A UE is not expected to be configured with more than 64 NZP CSI-RS resources and/or SS/PBCH block resources in resource setting for channel measurement for a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'none', 'cri-RI-CQI', 'cri-RSRP', 'ssb-Index-RSRP', 'cri-SINR' or 'ssb-Index-SINR'. If interference measurement is performed on CSI-IM, each CSI-RS resource for channel measurement is resource-wise associated with a CSI-IM resource by the ordering of the CSI-RS resource and CSI-IM resource in the corresponding resource sets. The number of CSI-RS resources for channel measurement equals to the number of CSI-IM resources.

An NZP CSI-RS Resource Set for channel measurement with resources can be configured with two Resource Groups, with resources in Group 1 and resources in Group 2, such that , and with Resource Pairs. Each Resource Pair consists of one resource from Group 1 and one resource from Group 2. The same resource can be associated with two Resource Pairs in frequency range 1 but not in frequency range 2.

Except for L1-SINR, if interference measurement is performed on NZP CSI-RS, a UE does not expect to be configured with more than one NZP CSI-RS resource in the associated resource set within the resource setting for channel measurement. Except for L1-SINR, the UE configured with the higher layer parameter *nzp-CSI-RS-ResourcesForInterference* may expect no more than 18 NZP CSI-RS ports configured in a NZP CSI-RS resource set.

For CSI measurement(s) other than L1-SINR, a UE assumes:

- each NZP CSI-RS port configured for interference measurement corresponds to an interference transmission layer.

- all interference transmission layers on NZP CSI-RS ports for interference measurement take into account the associated EPRE ratios configured in 5.2.2.3.1;

- other interference signal on REs of NZP CSI-RS resource for channel measurement, NZP CSI-RS resource for interference measurement, or CSI-IM resource for interference measurement.

For L1-SINR measurement with dedicated interference measurement resources, a UE assumes:

- the total received power on dedicated NZP CSI-RS resource for interference measurement or dedicated CSI-IM resource for interference measurement corresponds to interference and noise.

##### 5.2.1.4.2 Report Quantity Configurations

A UE may be configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to either 'none', 'cri-RI-PMI-CQI ', 'cri-RI-i1', 'cri-RI-i1-CQI', 'cri-RI-CQI', 'cri-RSRP', 'cri-SINR', 'ssb-Index-RSRP', 'ssb-Index-SINR' or 'cri-RI-LI-PMI-CQI'.

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'none', then the UE shall not report any quantity for the *CSI-ReportConfig*.

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RI-PMI-CQI', or 'cri-RI-LI-PMI-CQI', the UE shall report a preferred precoder matrix for the entire reporting band, or a preferred precoder matrix per subband, according to Clause 5.2.2.2.

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RI-i1',

- the UE expects, for that *CSI-ReportConfig,* to be configured with higher layer parameter *codebookType* set to 'typeI-SinglePanel' and *pmi-FormatIndicator* set to 'widebandPMI'and,

- the UE shall report a PMI consisting of a single wideband indication ( in Clause 5.2.2.2.1) for the entire CSI reporting band.

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RI-i1-CQI',

- the UE expects, for that *CSI-ReportConfig,* to be configured with higher layer parameter *codebookType* set to 'typeI-SinglePanel' and *pmi-FormatIndicator* set to 'widebandPMI'and,

- the UE shall report a PMI consisting of a single wideband indication ( in Clause 5.2.2.2.1) for the entire CSI reporting band. The CQI is calculated conditioned on the reported assuming PDSCH transmission with  precoders (corresponding to the same but different  in Clause 5.2.2.2.1), where the UE assumes that one precoder is randomly selected from the set of  precoders for each PRG on PDSCH, where the PRG size for CQI calculation is configured by the higher layer parameter *pdsch-BundleSizeForCSI*.

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RI-CQI',

- if the UE is configured with higher layer parameter *non-PMI-PortIndication* contained in a *CSI-ReportConfig,* *r* ports are indicated in the order of layer ordering for rank *r* and each CSI-RS resource in the CSI resource setting is linked to the *CSI-ReportConfig* based on the order of the associated *NZP-CSI-RS-ResourceId* in the linked CSI resource setting for channel measurement given by higher layer parameter *resourcesForChannelMeasurement*. The configured higher layer parameter *non-PMI-PortIndication* contains a sequence  of port indices, where  are the CSI-RS port indices associated with rank ν and  where is the number of ports in the CSI-RS resource. The UE shall only report RI corresponding to the configured fields of *PortIndexFor8Ranks*.

- if the UE is not configured with higher layer parameter *non-PMI-PortIndication,* the UE assumes, for each CSI-RS resource in the CSI resource setting linked to the *CSI-ReportConfig*, that the CSI-RS port indices  are associated with ranks  where  is the number of ports in the CSI-RS resource.

- When calculating the CQI for a rank, the UE shall use the ports indicated for that rank for the selected CSI-RS resource. The precoder for the indicated ports shall be assumed to be the identity matrix scaled by .

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RSRP' or 'ssb-Index-RSRP',

- if the UE is configured with the higher layer parameter *groupBasedBeamReporting* set to 'disabled', the UE is not required to update measurements for more than 64 CSI-RS and/or SSB resources, and the UE shall report in a single report *nrofReportedRS* (higher layer configured) different CRI or SSBRI for each report setting.

- if the UE is configured with the higher layer parameter *groupBasedBeamReporting* set to 'enabled', the UE is not required to update measurements for more than 64 CSI-RS and/or SSB resources, and the UE shall report in a single reporting instance two different CRI or SSBRI for each report setting, where CSI-RS and/or SSB resources can be received simultaneously by the UE either with a single spatial domain receive filter, or with multiple simultaneous spatial domain receive filters.

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-SINR' or 'ssb-Index-SINR',

- if the UE is configured with the higher layer parameter *groupBasedBeamReporting* set to 'disabled', the UE shall report in a single report *nrofReportedRS* (higher layer configured) different CRI or SSBRI for each report setting.

- if the UE is configured with the higher layer parameter *groupBasedBeamReporting* set to 'enabled', the UE shall report in a single reporting instance two different CRI or SSBRI for each report setting, where CSI-RS and/or SSB resources can be received simultaneously by the UE.

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RSRP', 'cri-RI-PMI-CQI ', 'cri-RI-i1', 'cri-RI-i1-CQI', 'cri-RI-CQI', 'cri-RI-LI-PMI-CQI', or 'cri-SINR', and resources are configured in the corresponding resource set for channel measurement, then the UE shall derive the CSI parameters other than CRI conditioned on the reported CRI, where CRI *k* (*k* ≥ 0) corresponds to the configured (*k*+1)-th entry of associated *nzp-CSI-RS-Resources* in the corresponding *NZP-CSI-RS-ResourceSet* for channel measurement, and (*k*+1)-th entry of associated *csi-IM-Resource* in the corresponding *csi-IM-ResourceSet* (if configured) or (*k*+1)-th entry of associated *nzp-CSI-RS-Resources* in the corresponding *NZP-CSI-RS-ResourceSet* (if configured for *CSI-ReportConfig* with *reportQuantity* set to 'cri-SINR') for interference measurement. If CSI-RS resources are configured, each resource shall contain at most 16 CSI-RS ports. If CSI-RS resources are configured, each resource shall contain at most 8 CSI-RS ports.

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RI-PMI-CQI', or 'cri-RI-LI-PMI-CQI' and the corresponding *NZP-CSI-RS-ResourceSet* for channel measurement is configured with resources, two Resource Groups with resources in Group 1, resources in Group 2, , and Resource Pairs:

- each of the Resource Pairs is associated to a CRI value.

- The *CSI-ReportConfig* may be configured with higher layer parameter *sharedCMR*. and are the numbers of resources associated to a CRI value in Group 1 and Group 2, respectively, with , such that the total number of CRI values configured for the *CSI-ReportConfig* is .

- If the higher layer parameter *csi-ReportMode* is set to 'Mode1' and the higher layer parameter *numberOfSingleTRP-CSI-Mode1* is set to , ; otherwise,

- if the higher layer parameter *csi-ReportMode* is set to 'Mode1' and the higher layer parameter *numberOfSingleTRP-CSI-Mode1* is set to , or if *csi-ReportMode* is set to 'Mode2',

- if *sharedCMR* is configured: and ; otherwise

- if *sharedCMR* is not configured, only the resources in Group 1 and Group 2 that are not referred to in any Resource Pair are asociated to a CRI value.

- If interference measurement is performed on CSI-IM, resources are configured in the corresponding *csi-IM-ResourceSet*. The resources for channel measurement defined above are resource-wise associated with the first CSI-IM resources by the ordering of the CSI-RS resources and CSI-IM resources in the corresponding Resource Set. The Resource Pairs for channel measurement are associated to the last CSI-IM resources by the ordering of the CSI-RS Resource Pairs and CSI-IM resources in the CSI-IM Resource Set. The UE may assume that the two CSI-RS resources for channel measurement in a Resource Pair and the associated CSI-IM resource for interference measurement are resource-wise QCLed with respect to 'typeD'.

- The UE is not expected to be configured with NZP CSI-RS for interference measurement other than the NZP CSI-RS resources for channel measurement configured in the Resource Pairs.

- The UE expects, for that *CSI-ReportConfig,* to be configured with higher layer parameter *codebookType* set to 'typeI-SinglePanel', and

- The UE shall derive the CSI parameters other than CRI(s) conditioned on the reported CRI(s), as follows:

- If the higher layer parameter *csi-ReportMode* is set to 'Mode1' and the higher layer parameter *numberOfSingleTRP-CSI-Mode1* is set to , CRI(s) are reported:

- one CRI corresponds to the configured -th entry of the associated Resource Pairs in the corresponding CSI-RS Resource Set for channel measurement, and -th entry of the associated resources in the corresponding CSI-IM Resource Set, if configured. The UE shall report two RIs, two PMIs, two LIs (if configured), associated to the resource in Group 1 and the resource in Group 2, respectively, of the -th Resource Pair, and one CQI; and

- if , one CRI () corresponds to the configured -th entry of the associated resources in the corresponding CSI-RS Resource Set for channel measurement, and -th entry of the associated resources in the corresponding CSI-IM Resource Set, if configured. The UE shall report one RI, one PMI, one LI (if configured) and one CQI conditioned on CRI ; or

- if , one CRI corresponds to the configured -th entry of the associated resources in Group 1 of the corresponding CSI-RS Resource Set for channel measurement, and -th entry of the associated resources in the corresponding CSI-IM Resource Set, if configured, and one CRI corresponds to the configured -th entry of the associated resources in Group 2 of the corresponding CSI-RS Resource Set for channel measurement, and -th entry of the associated resources in the corresponding CSI-IM Resource Set, if configured. The UE shall report one RI, one PMI, one LI (if configured) and one CQI conditioned on CRI and one RI, one PMI, one LI (if configured) and one CQI conditioned on CRI .

- If the higher layer parameter *csi-ReportMode* is set to 'Mode2', one CRI is reported, which corresponds to the -th entry of the resources or Resource Pairs in the corresponding CSI-RS Resource Set for channel measurement, and -th entry of the associated resources in the corresponding CSI-IM Resource Set, if configured. The first codepoints of the CRI correspond to resources associated to Group 1 and Group 2. The last codepoints of the CRI correspond to the configured Resource Pairs. The UE shall report one RI, one PMI, one LI, if configured, and one CQI conditioned on CRI if ; or two RIs, two PMIs, two Lis, if configured, associated to the resource in Group 1 and the resource in Group 2, respectively, of the -th Resource Pair, and one CQI, otherwise.

- For a reported CRI corresponding to an entry of the Resource Pairs configured in the corresponding CSI-RS Resource Set for channel measurement:

- the UE shall not report a total number of layers larger than four.

- the two RIs are reported with a joint RI index corresponding to one of the four rank combinations: .

- The *CodebookConfig* in *CSI-ReportConfig* can be configured with two RI restriction parameters. One parameter applies to a reported RI when conditioned on a CRI corresponding to an entry of the CSI-RS resources defined above. Another parameter applies to a reported joint RI index when conditioned on a CRI corresponding to an entry of the Resource Pairs and indicates one [or more] of the four rank combinations that are allowed to correspond to the reported PMIs and RIs.

- The *CodebookConfig* in *CSI-ReportConfig* can be configured with [Alt1: one Codebook Subset Restriction, as defined in clause 5.2.2.2.1, which applies to any reported PMI(s)] [Alt2: two Codebook Subset Restrictions. One restriction applies to a reported PMI associated to a CSI-RS resource in Group 1. Another restriction applies to a reported PMI associated to a CSI-RS resource in Group 2].

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'ssb-Index-RSRP', the UE shall report SSBRI, where SSBRI *k* (*k* ≥ 0) corresponds to the configured (*k*+1)-th entry of the associated *csi-SSB-ResourceList* in the corresponding *CSI-SSB-ResourceSet.*

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'ssb-Index-SINR', the UE shall derive L1-SINR conditioned on the reported SSBRI, where SSBRI *k* (*k* ≥ 0) corresponds to the configured (*k*+1)-th entry of the associated *csi-SSB-ResourceList* in the corresponding *CSI-SSB-ResourceSet* for channel measurement, and (*k*+1)-th entry of associated *csi-IM-Resource* in the corresponding *csi-IM-ResourceSet* (if configured) or (*k*+1)-th entry of associated *nzp-CSI-RS-Resources* in the corresponding *NZP-CSI-RS-ResourceSet* (if configured) for interference measurement.

If the UE is configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to 'cri-RI-PMI-CQI', ' cri-RI-i1', 'cri-RI-i1-CQI', 'cri-RI-CQI' or 'cri-RI-LI-PMI-CQI', then the UE is not expected to be configured with more than 8 CSI-RS resources in a CSI-RS resource set contained within a resource setting that is linked to the *CSI-ReportConfig*.

If the UE is configured with a *CSI-ReportConfig* with higher layer parameter *reportQuantity* set to 'cri-RSRP', 'cri-SINR' or 'none' and the *CSI-ReportConfig* is linked to a resource setting configured with the higher layer parameter *resourceType* set to 'aperiodic', then the UE is not expected to be configured with more than 16 CSI-RS resources in a CSI-RS resource set contained within the resource setting.

The LI indicates which column of the precoder matrix of the reported PMI corresponds to the strongest layer of the codeword corresponding to the largest reported wideband CQI. If two wideband CQIs are reported and have equal value, the LI corresponds to strongest layer of the first codeword.

For operation with shared spectrum channel access, if the UE is configured with a *CSI-ReportConfig* with higher layer parameter *reportQuantity* set to 'cri-RI-PMI-CQI ', 'cri-RI-i1', 'cri-RI-i1-CQI', 'cri-RI-CQI' or 'cri-RI-LI-PMI-CQI', the UE shall derive:

- the CSI parameters without averaging two or more instances of any periodic or semi-persistent *nzp-CSI-RS-Resources* in the corresponding *NZP-CSI-RS-ResourceSet* for channel measurement or for interference measurement located in different DL transmissions,

- the instances of the *nzp-CSI-RS-Resources* are not in the same channel occupancy duration indicated by DCI format 2\_0, if the UE is provided at least one of *SlotFormatIndicator* or co*-DurationList*; or

- the instances of the *nzp-CSI-RS-Resources* occur within a set of consecutive symbols which are not all occupied by PDSCH(s) and/or aperiodic CSI-RS(s) indicated by DCI formats, if any, and the corresponding PDCCH(s), if the UE is neither provided with *CO-DurationPerCell* nor *SlotFormatIndicator*, but is provided with *csi-RS-ValidationWith-DCI*

- the interference measurements for computing CSI value based on periodic/semi-persistent CSI-IM measured only in OFDM symbol(s) that fulfill the same conditions under which the UE is expected to receive periodic/semi-persistent CSI-RS as described in Clause 11.1 and Clause 11.1.1 of [6, TS 38.213].

<omitted text>

#### 5.2.1.6 CSI processing criteria

The UE indicates the number of supported simultaneous CSI calculations with parameter *simultaneousCSI-ReportsPerCC* in a component carrier, and *simultaneousCSI-ReportsAllCC* across all component carriers. If a UE supports simultaneous CSI calculations it is said to have CSI processing units for processing CSI reports. If *L* CPUs are occupied for calculation of CSI reports in a given OFDM symbol, the UE has unoccupied CPUs. If *N* CSI reports start occupying their respective CPUs on the same OFDM symbol on which CPUs are unoccupied, where each CSI report corresponds to , the UE is not required to update the requested CSI reports with lowest priority (according to Clause 5.2.5), where is the largest value such that holds.

A UE is not expected to be configured with an aperiodic CSI trigger state containing more than Reporting Settings. Processing of a CSI report occupies a number of CPUs for a number of symbols as follows:

- for a CSI report with CSI-ReportConfig with higher layer parameter *reportQuantity* set to 'none' and *CSI-RS-ResourceSet* with higher layer parameter *trs-Info* configured

- for a CSI report with *CSI-ReportConfig* with higher layer parameter *reportQuantity* set to 'cri-RSRP', 'ssb-Index-RSRP', 'cri-SINR', 'ssb-Index-SINR' or 'none' (and *CSI-RS-ResourceSet* with higher layer parameter *trs-Info* not configured)

- for a CSI report with *CSI-ReportConfig* with higher layer parameter *reportQuantity* set to 'cri-RI-PMI-CQI', 'cri-RI-i1', 'cri-RI-i1-CQI', 'cri-RI-CQI', or 'cri-RI-LI-PMI-CQI',

- if a CSI report is aperiodically triggered without transmitting a PUSCH with either transport block or HARQ-ACK or both when *L* = 0 CPUs are occupied, where the CSI corresponds to a single CSI with wideband frequency-granularity and to at most 4 CSI-RS ports in a single resource without CRI report and where *codebookType* is set to 'typeI-SinglePanel' or where *reportQuantity* is set to 'cri-RI-CQI', ,

- otherwise, , where is the number of CSI-RS resources in the CSI-RS resource set for channel measurement. For a *CSI-ReportConfig* configured with *codebookType* set to 'typeI-SinglePanel' and the corresponding CSI-RS Resource Set for channel measurement configured with two Resource Groups and Resource Pairs, , where is defined in clause 5.2.1.4.2.

For a CSI report with *CSI-ReportConfig* with higher layer parameter *reportQuantity* not set to 'none', the CPU(s) are occupied for a number of OFDM symbols as follows:

- A periodic or semi-persistent CSI report (excluding an initial semi-persistent CSI report on PUSCH after the PDCCH triggering the report) occupies CPU(s) from the first symbol of the earliest one of each CSI-RS/CSI-IM/SSB resource for channel or interference measurement, respective latest CSI-RS/CSI-IM/SSB occasion no later than the corresponding CSI reference resource, until the last symbol of the configured PUSCH/PUCCH carrying the report.

- An aperiodic CSI report occupies CPU(s) from the first symbol after the PDCCH triggering the CSI report until the last symbol of the scheduled PUSCH carrying the report.

- An initial semi-persistent CSI report on PUSCH after the PDCCH trigger occupies CPU(s) from the first symbol after the PDCCH until the last symbol of the scheduled PUSCH carrying the report.

For a CSI report with *CSI-ReportConfig* with higher layer parameter *reportQuantity* set to 'none' and *CSI-RS-ResourceSet* with higher layer parameter *trs-Info* not configured, the CPU(s) are occupied for a number of OFDM symbols as follows:

- A semi-persistent CSI report (excluding an initial semi-persistent CSI report on PUSCH after the PDCCH triggering the report) occupies CPU(s) from the first symbol of the earliest one of each transmission occasion of periodic or semi-persistent CSI-RS/SSB resource for channel measurement for L1-RSRP computation, until symbols after the last symbol of the latest one of the CSI-RS/SSB resource for channel measurement for L1-RSRP computation in each transmission occasion.

- An aperiodic CSI report occupies CPU(s) from the first symbol after the PDCCH triggering the CSI report until the last symbol between symbols after the first symbol after the PDCCH triggering the CSI report and symbols after the last symbol of the latest one of each CSI-RS/SSB resource for channel measurement for L1-RSRP computation.

where are defined in the table 5.4-2.

In any slot, the UE is not expected to have more active CSI-RS ports or active CSI-RS resources in active BWPs than reported as capability. NZP CSI-RS resource is active in a duration of time defined as follows. For aperiodic CSI-RS, starting from the end of the PDCCH containing the request and ending at the end of the scheduled PUSCH containing the report associated with this aperiodic CSI-RS. For semi-persistent CSI-RS, starting from the end of when the activation command is applied, and ending at the end of when the deactivation command is applied. For periodic CSI-RS, starting when the periodic CSI-RS is configured by higher layer signalling, and ending when the periodic CSI-RS configuration is released. If a CSI-RS resource is referred *N* times by one or more CSI Reporting Settings, the CSI-RS resource and the CSI-RS ports within the CSI-RS resource are counted *N* times. For a CSI-RS Resource Set for channel measurement configured with two Resource Groups and Resource Pairs, if a CSI-RS resource is referred times by one of the CSI-RS resources, where is defined in clause 5.2.1.4.2, and/or one or two Resource Pairs, the CSI-RS resource and the CSI-RS ports within the CSI-RS resource are counted times.

<omitted text>

##### 5.2.2.2.7 Further Enhanced Type II Port Selection Codebook

For 4 antenna ports {3000, 3001, …, 3003}, 8 antenna ports {3000, 3001, …, 3007}, 12 antenna ports {3000, 3001, …, 3011}, 16 antenna ports {3000, 3001, …, 3015}, 24 antenna ports {3000, 3001, …, 3023}, and 32 antenna ports {3000, 3001, …, 3031}, and the UE configured with higher layer parameter *codebookType* set to ' typeII-PortSelection-r17 '

- The number of CSI-RS ports, , is configured as in clause 5.2.2.2.4.

- The values , and are determined by the higher layer parameter *paramCombination-r17*, where the mapping is given in Table 5.2.2.2.7-1.

Table 5.2.2.2.7-1: Codebook parameter configurations for , and

|  |  |  |  |
| --- | --- | --- | --- |
| *paramCombination-r17* |  |  |  |
| 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | ¾ |
| 3 | 1 | 1 | ½ |
| 4 | 1 | ¾ | ½ |
| 5 | 2 | 1 | ¾ |
| 6 | 2 | 1 | ½ |
| 7 | 2 | ¾ | ½ |
| 8 | 2 | ½ | ½ |

- The parameter is configured with the higher-layer parameter *valueOfN*, when .

- The parameter is configured with the higher-layer parameter *numberOfPMI-SubbandsPerCQI-Subband-r17*, when , as in clause 5.2.2.2.5.

- The UE shall report the RI value according to the configured higher layer parameter *typeII-PortSelectionRI-Restriction-r17*. The UE shall not report . The bitmap parameter *typeII-PortSelectionRI-Restriction-r17* forms the bit sequence , where is the LSB and is the MSB. When is zero, , PMI and RI reporting are not allowed to correspond to any precoder associated with layers.

The PMI value corresponds to the codebook indices and where

The precoding matrices indicated by the PMI are determined from vectors, where and .

vectors, , are identified by

which are indicated by the index , where

The elements of are found from using as defined in Tables 5.2.2.2.5-4 and 5.2.2.2.7-2 and the algorithm:

for

Find the largest  in Table 5.2.2.2.5-4, if , or in Table 5.2.2.2.7-2, if , such that

When are known, is found using , where is given in Tables 5.2.2.2.5-4 and 5.2.2.2.7-2, and where the indices are assigned such that increases as increases.

* If , , , and is not reported.

Table 5.2.2.2.7-2: Combinatorial coefficients

|  |  |  |  |
| --- | --- | --- | --- |
|  | **10** | **11** | **12** |
| **0** | 0 | 0 | 0 |
| **1** | 0 | 0 | 0 |
| **2** | 0 | 0 | 0 |
| **3** | 0 | 0 | 0 |
| **4** | 0 | 0 | 0 |
| **5** | 0 | 0 | 0 |
| **6** | 0 | 0 | 0 |
| **7** | 0 | 0 | 0 |
| **8** | 0 | 0 | 0 |
| **9** | 0 | 0 | 0 |
| **10** | 1 | 0 | 0 |
| **11** | 11 | 1 | 0 |
| **12** | 66 | 12 | 1 |
| **13** | 286 | 78 | 13 |
| **14** | 1001 | 364 | 91 |
| **15** | 3003 | 1365 | 455 |

vectors, , , are identified by , where is the number of configured subbands in *csi-ReportingBand*, when , and is defined as in clause 5.2.2.2.5, when , and where

which are indicated by the index , when and , where

- If , or and , is not reported.

- If and , the nonzero offset between and is reported with assuming that (reference for the offset) is 0. The nonzero offset is found from .

The amplitude coefficient indicators and , for , are

The phase coefficient indicator , for , is

Let . The bitmap whose nonzero bits identify which coefficients in and are reported, is indicated by , for

such that is the number of nonzero coefficients for layer and is the total number of nonzero coefficients.

- If and , is not reported, for .

The indices of , and are associated to the codebook indices in .

The mapping from to the amplitude coefficient is given in Table 5.2.2.2.5-2 and the mapping from to the amplitude coefficient is given in Table 5.2.2.2.5-3. The amplitude coefficients are represented by

Let  be the index of and be the index of which identify the strongest coefficient of layer , i.e., the element of , for . The strongest coefficient of layer is identified by the index

which is found from

The amplitude and phase coefficient indicators are reported as follows:

- , , and . The elements , and are not reported for .

- The element is reported for .

- The elements for which , are reported.

- The elements for which , are reported.

- The remaining elements are not reported.

- The remaining elements are not reported.

The codebooks for 1-4 layers are given in Table 5.2.2.2.7-3, where is a -element column vector containing a value of 1 in the element of index and zeros elsewhere (where the first element is the element of index 0), the quantities are given by

where , is the index associated with the precoding matrix and where

for , and the quantities are given by

Table 5.2.2.2.7-3: Codebook for 1-layer. 2-layer, 3-layer and 4-layer CSI reporting using antenna ports 3000 to 2999+*P*CSI‑RS

|  |  |
| --- | --- |
| **Layers** |  |
|
|  |  |
|  |  |
|  |  |
|  |  |
| Where ,  and the mappings from to, , and from to , , , , , , , , , , are as described above, including the ranges of the constituent indices of and . | |

For coefficients with , amplitude and phase are set to zero, i.e., and .

<omitted text>

#### 5.2.2.3 Reference signal (CSI-RS)

##### 5.2.2.3.1 NZP CSI-RS

The UE can be configured with one or more NZP CSI-RS resource set configuration(s) as indicated by the higher layer parameters *CSI-ResourceConfig,* and *NZP-CSI-RS-ResourceSet.* Each NZP CSI-RS resource set consists of *K*≥1 NZP CSI-RS resource(s).

The following parameters for which the UE shall assume non-zero transmission power for CSI-RS resource are configured via the higher layer parameter *NZP-CSI-RS-Resource, CSI-ResourceConfig* and *NZP-CSI-RS-ResourceSet* for each CSI-RS resource configuration:

- *nzp-CSI-RS-ResourceId* determines CSI-RS resource configuration identity.

- *periodicityAndOffset* defines the CSI-RS periodicity and slot offset for periodic/semi-persistent CSI-RS. All the CSI-RS resources within one set are configured with the same periodicity, while the slot offset can be same or different for different CSI-RS resources.

- *resourceMapping* defines the number of ports, CDM-type, and OFDM symbol and subcarrier occupancy of the CSI-RS resource within a slot that are given in Clause 7.4.1.5 of [4, TS 38.211].

- *nrofPorts* in *resourceMapping* defines the number of CSI-RS ports, where the allowable values are given in Clause 7.4.1.5 of [4, TS 38.211].

- *density* in *resourceMapping* defines CSI-RS frequency density of each CSI-RS port per PRB, and CSI-RS PRB offset in case of the density value of 1/2, where the allowable values are given in Clause 7.4.1.5 of [4, TS 38.211]. For density 1/2, the odd/even PRB allocation indicated in *density* is with respect to the common resource block grid.

- *cdm-Type* in *resourceMapping* defines CDM values and pattern, where the allowable values are given in Clause 7.4.1.5 of [4, TS 38.211].

*- powerControlOffset*: which is the assumed ratio of PDSCH EPRE to NZP CSI-RS EPRE when UE derives CSI feedback and takes values in the range of [-8, 15] dB with 1 dB step size.

*- powerControlOffsetSS*: which is the assumed ratio of NZP CSI-RS EPRE to SS/PBCH block EPRE.

- *scramblingID* defines scrambling ID of CSI-RSwith length of 10 bits.

- *BWP-Id* in *CSI-ResourceConfig* defines which bandwidth part the configured CSI-RS is located in.

- *repetition* in *NZP-CSI-RS-ResourceSet* is associated with a CSI-RS resource set and defines whether UE can assume the CSI-RS resources within the NZP CSI-RS Resource Set are transmitted with the same downlink spatial domain transmission filter or not as described in Clause 5.1.6.1.2. and can be configured only when the higher layer parameter *reportQuantity* associated with all the reporting settings linked with the CSI-RS resource set is set to 'cri-RSRP', 'cri-SINR' or 'none'.

- *qcl-InfoPeriodicCSI-RS* contains a reference to a *TCI-State* indicating QCL source RS(s) and QCL type(s). If the *TCI-State* is configured with a reference to an RS configured with *qcl-Type* set to 'typeD' association, that RS may be an SS/PBCH block located in the same or different CC/DL BWP or a CSI-RS resource configured as periodic located in the same or different CC/DL BWP.

- *trs-Info* in *NZP-CSI-RS-ResourceSet* is associated with a CSI-RS resource set and for which the UE can assume that the antenna port with the same port index of the configured NZP CSI-RS resources in the *NZP-CSI-RS-ResourceSet* is the same as described in Clause 5.1.6.1.1 and can be configured when reporting setting is not configured or when the higher layer parameter *reportQuantity* associated with all the reporting settings linked with the CSI-RS resource set is set to 'none'.

All CSI-RS resources within one set are configured with same *density* and same *nrofPorts*, except for the NZP CSI-RS resources used for interference measurement.

The UE expects that all the CSI-RS resources of a resource set are configured with the same starting RB and number of RBs and the same *cdm-type*.

For a CSI-RS Resource Set for channel measurement configured with two Resource Groups and Resource Pairs, the slot offsets of the two resources in a Resource Pair are configured within slots [subject to UE capability], where implies that the two resources are configured in the same slot, and implies that the two resources are configured within two adjacent slots. When DRX is configured, the slot offsets of the two resources in a Resource Pair are configured within the same DRX Active Time.

The bandwidth and initial common resource block (CRB) index of a CSI-RS resource within a BWP, as defined in Clause 7.4.1.5 of [4, TS 38.211], are determined based on the higher layer parameters *nrofRBs* and *startingRB*, respectively, within the CSI-FrequencyOccupation IE configured by the higher layer parameter *freqBand* within the *CSI-RS-ResourceMapping* IE. Both *nrofRBs* and *startingRB* are configured as integer multiples of 4 RBs, and the reference point for *startingRB* is CRB 0 on the common resource block grid. If the UE shall assume that the initial CRB index of the CSI-RS resource is , otherwise . If , the UE shall assume that the bandwidth of the CSI-RS resource is , otherwise . In all cases, the UE shall expect that .

<omitted text>

#### 5.2.2.5 CSI reference resource definition

The CSI reference resource for a serving cell is defined as follows:

- In the frequency domain, the CSI reference resource is defined by the group of downlink physical resource blocks corresponding to the band to which the derived CSI relates.

- In the time domain, the CSI reference resource for a CSI reporting in uplink slot *n'* is defined by a single downlink slot *n*-*nCSI\_ref*,

- where  and and  are the subcarrier spacing configurations for DL and UL, respectively, and and  are determined by higher-layer configured *ca-SlotOffset* for the cells transmitting the uplink and downlink, as defined in clause 4.5 of [4, TS 38.211]

- where for periodic and semi-persistent CSI reporting

- if a single CSI-RS/SSB resource is configured for channel measurement *nCSI\_ref* is the smallest value greater than or equal to , such that it corresponds to a valid downlink slot, or

- if multiple CSI-RS/SSB resources are configured for channel measurement *nCSI\_ref* is the smallest value greater than or equal to , such that it corresponds to a valid downlink slot.

- where for aperiodic CSI reporting, if the UE is indicated by the DCI to report CSI in the same slot as the CSI request, *nCSI\_ref* is such that the reference resource is in the same valid downlink slot as the corresponding CSI request, otherwise *nCSI\_ref* is the smallest value greater than or equal to , such that slot *n*- *nCSI\_ref* corresponds to a valid downlink slot, where *Z'* corresponds to the delay requirement as defined in Clause 5.4.

- when periodic or semi-persistent CSI-RS/CSI-IM or SSB is used for channel/interference measurements, the UE is not expected to measure channel/interference on the CSI-RS/CSI-IM/SSB whose last OFDM symbol is received up to *Z'* symbols before transmission time of the first OFDM symbol of the aperiodic CSI reporting.

A slot in a serving cell shall be considered to be a valid downlink slot if:

- it comprises at least one higher layer configured downlink or flexible symbol, and

- it does not fall within a configured measurement gap for that UE

If there is no valid downlink slot for the CSI reference resource corresponding to a CSI Report Setting in a serving cell, CSI reporting is omitted for the serving cell in uplink slot *n'*.

After the CSI report (re)configuration, serving cell activation, BWP change, or activation of SP-CSI, the UE reports a CSI report only after receiving at least one CSI-RS transmission occasion for channel measurement and CSI-RS and/or CSI-IM occasion for interference measurement no later than CSI reference resource and drops the report otherwise.

When DRX is configured, the UE reports a CSI report only if receiving at least one CSI-RS transmission occasion for channel measurement and CSI-RS and/or CSI-IM occasion for interference measurement in DRX Active Time no later than CSI reference resource and drops the report otherwise. When the UE is configured to monitor DCI format 2\_6 and if the UE configured by higher layer parameter *ps-TransmitOtherPeriodicCSI* to report CSI with the higher layer parameter *reportConfigType* set to 'periodic' and *reportQuantity* set to quantities other than 'cri-RSRP' and 'ssb-Index-RSRP' when *drx-onDurationTimer* is not started, the UE shall report CSI during the time duration indicated by *drx-onDurationTimer* in *DRX-Config* also outside active time according to the procedure described in Clause 5.2.1.4 if receiving at least one CSI-RS transmission occasion for channel measurement and CSI-RS and/or CSI-IM occasion for interference measurement during the time duration indicated by drx-onDurationTimer in *DRX-Config* outside DRX active time or in DRX Active Time no later than CSI reference resource and drops the report otherwise. When the UE is configured to monitor DCI format 2\_6 and if the UE configured by higher layer parameter *ps-TransmitPeriodicL1-RSRP* to report L1-RSRP with the higher layer parameter *reportConfigType* set to 'periodic' and *reportQuantity* set to 'cri-RSRP' or 'ssb-Index-RSRP' when *drx-onDurationTimer* is not started, the UE shall report L1-RSRP during the time duration indicated by *drx-onDurationTimer* in *DRX-Config* also outside active time according to the procedure described in clause 5.2.1.4 and when reportQuantity set to 'cri-RSRP' if receiving at least one CSI-RS transmission occasion for channel measurement during the time duration indicated by drx-onDurationTimer in *DRX-Config* outside DRX active time or in DRX Active Time no later than CSI reference resource and drops the report otherwise.

When deriving CSI feedback, the UE is not expected that a NZP CSI -RS resource for channel measurement overlaps with CSI-IM resource for interference measurement or NZP CSI -RS resource for interference measurement.

If configured to report CQI index, in the CSI reference resource, the UE shall assume the following for the purpose of deriving the CQI index, and if also configured, for deriving PMI and RI:

- The first 2 OFDM symbols are occupied by control signaling.

- The number of PDSCH and DM-RS symbols is equal to 12.

- The same bandwidth part subcarrier spacing configured as for the PDSCH reception

- The bandwidth as configured for the corresponding CQI report.

- The reference resource uses the CP length and subcarrier spacing configured for PDSCH reception

- No resource elements used by primary or secondary synchronization signals or PBCH.

- Redundancy Version 0.

- The ratio of PDSCH EPRE to CSI-RS EPRE is as given in Clause 5.2.2.3.1.

- Assume no REs allocated for NZP CSI-RS and ZP CSI-RS.

- Assume the same number of front-loaded DM-RS symbols as the maximum front-loaded symbols configured by the higher layer parameter *maxLength* in *DMRS-DownlinkConfig.*

- Assume the same number of additional DM-RS symbols as the additional symbols configured by the higher layer parameter *dmrs-AdditionalPosition*.

- Assume the PDSCH symbols are not containing DM-RS.

- Assume PRB bundling size of 2 PRBs.

- The PDSCH transmission scheme where the UE may assume that PDSCH transmission would be performed with up to 8 transmission layers as defined in Clause 7.3.1.4 of [4, TS 38.211]. For CQI calculation, the UE should assume that PDSCH signals on antenna ports in the set [1000,…, 1000+ν-1] for ν layers would result in signals equivalent to corresponding symbols transmitted on antenna ports [3000,…, 3000+*P*-1], as given by

where  is a vector of PDSCH symbols from the layer mapping defined in Clause 7.3.1.4 of [4, TS 38.211],  is the number of CSI-RS ports. If only one CSI-RS port is configured, *W(i)* is 1. If the higher layer parameter *reportQuantity* in *CSI-ReportConfig* for which the CQI is reported is set to either 'cri-RI-PMI-CQI' or 'cri-RI-LI-PMI-CQI', *W(i)* is the precoding matrix corresponding to the reported PMI applicable to *x(i)*. If the higher layer parameter *reportQuantity* in *CSI-ReportConfig* for which the CQI is reported is set to 'cri-RI-CQI', *W(i)* is the precoding matrix corresponding to the procedure described in Clause 5.2.1.4.2. If the higher layer parameter *reportQuantity* in *CSI-ReportConfig* for which the CQI is reported is set to 'cri-RI-i1-CQI', *W(i)* is the precoding matrix corresponding to the reported i1 according to the procedure described in Clause 5.2.1.4.2*.* The corresponding PDSCH signals transmitted on antenna ports [3000,…,3000 + *P* - 1] would have a ratio of EPRE to CSI-RS EPRE equal to the ratio given in Clause 5.2.2.3.1. If the higher layer parameter *reportQuantity* in *CSI-ReportConfig* for which the CQI is reported is set to either 'cri-RI-PMI-CQI' or 'cri-RI-LI-PMI-CQI', the corresponding CSI-RS Resource Set for channel measurement is configured with two Resource Groups and Resource Pairs, as described in clause 5.2.1.4.1, the reported CRI corresponds to an entry of the Resource Pairs, and the reported rank combination is , as described in clause 5.2.1.4.2, the UE should assume that

- PDSCH signals on antenna ports in the set for layers would result in signals equivalent to corresponding symbols transmitted on antenna ports of the Group 1 CSI-RS resource in the Resource Pair indicated by the CRI, and PDSCH signals on antenna ports in the set for layers would result in signals equivalent to corresponding symbols transmitted on antenna ports of the Group 2 CSI-RS resource in the Resource Pair indicated by the CRI, as given by

where , are the two precoding matrices corresponding to the two reported PMIs applicable to , as described in clause 5.2.1.4.2; and that the signals , , fully overlap in time and frequency.

- The UE shall assume that the corresponding PDSCH signals for layers transmitted on the antenna ports of the CSI-RS resource in Group would have a ratio of EPRE to CSI-RS EPRE equal to the *powerControlOffset* of the respective CSI-RS resource, for .

<omitted text>

### 5.2.3 CSI reporting using PUSCH

A UE shall perform aperiodic CSI reporting using PUSCH on serving cell c upon successful decoding of a DCI format 0\_1 or DCI format 0\_2 which triggers an aperiodic CSI trigger state.

When a DCI format 0\_1 schedules two PUSCH allocations, the aperiodic CSI report is carried on the second scheduled PUSCH. When a DCI format 0\_1 schedules more than two PUSCH allocations, the aperiodic CSI report is carried on the penultimate scheduled PUSCH.

An aperiodic CSI report carried on the PUSCH supports wideband, and sub-band frequency granularities. An aperiodic CSI report carried on the PUSCH supports Type I, Type II, Enhanced Type II CSI and Further Enhanced Type II Port Selection.

A UE shall perform semi-persistent CSI reporting on the PUSCH upon successful decoding of a DCI format 0\_1 or DCI format 0\_2 which activates a semi-persistent CSI trigger state. DCI format 0\_1 and DCI format 0\_2 contains a CSI request field which indicates the semi-persistent CSI trigger state to activate or deactivate. Semi-persistent CSI reporting on the PUSCH supports Type I, Type II with wideband, and sub-band frequency granularities Enhanced Type II and Further Enhanced Type II Port Selection CSI. The PUSCH resources and MCS shall be allocated semi-persistently by an uplink DCI.

CSI reporting on PUSCH can be multiplexed with uplink data on PUSCH except that semi-persistent CSI reporting on PUSCH activated by a DCI format is not expected to be multiplexed with uplink data on the PUSCH. CSI reporting on PUSCH can also be performed without any multiplexing with uplink data from the UE.

Type I CSI feedback is supported for CSI Reporting on PUSCH. Type I wideband and sub-band CSI is supported for CSI Reporting on the PUSCH. Type II CSI is supported for CSI Reporting on the PUSCH.

For Type I, Type II, Enhanced Type II and Further Enhanced Type II Port Selection CSI feedback on PUSCH, a CSI report comprises of two parts. Part 1 has a fixed payload size and is used to identify the number of information bits in Part 2. Part 1 shall be transmitted in its entirety before Part 2.

- For Type I CSI feedback, Part 1 contains RI (if reported), CRI (if reported), CQI for the first codeword (if reported). Part 2 contains LI (if reported), PMI (if reported) and contains the CQI for the second codeword (if reported) when RI (if reported) is larger than 4. For a *CSI-ReportConfig* configured with *codebookType* set to 'typeI-SinglePanel' and the corresponding CSI-RS Resource Set for channel measurement configured with two Resource Groups and Resource Pairs, Part 1 contains RI(s), CRI(s), CQI(s) for the first codeword and is zero padded to a fixed payload size (if needed). Part 2 contains the CQI(s) for the second codeword (if reported) when RI is larger than 4, LIs (if reported) and PMI(s).

- For Type II CSI feedback, Part 1 contains RI (if reported), CQI, and an indication of the number of non-zero wideband amplitude coefficients per layer for the Type II CSI (see Clause 5.2.2.2.3). The fields of Part 1 – RI (if reported), CQI, and the indication of the number of non-zero wideband amplitude coefficients for each layer – are separately encoded. Part 2 contains LI (if reported), the PMI of the Type II CSI. The elements of , (if reported) and (if reported) are reported in the increasing order of their indices, , where the element of the lowest index is mapped to the most significant bits and the element of the highest index is mapped to the least significant bits. Part 1 and 2 are separately encoded.

- For Enhanced Type II and Further Enhanced Type II Port Selection CSI feedback, Part 1 contains RI, CQI, and an indication of the overall number of non-zero amplitude coefficients across layers for the Enhanced Type II CSI (see Clause 5.2.2.2.5). The fields of Part 1 – RI, CQI, and the indication of the overall number of non-zero amplitude coefficients across layers – are separately encoded. Part 2 contains the PMI of the Enhanced Type II or Further Enhanced Type II Port Selection CSI. Part 1 and 2 are separately encoded.

A Type II CSI report that is carried on the PUSCH shall be computed independently from any Type II CSI report that is carried on the PUCCH formats 3 or 4 (see Clause 5.2.4 and 5.2.2).

When the higher layer parameter *reportQuantity* is configured with one of the values 'cri-RSRP', 'ssb-Index-RSRP', 'cri-SINR' or 'ssb-Index-SINR', the CSI feedback consists of a single part.

For both Type I and Type II reports configured for PUCCH but transmitted on PUSCH, the determination of the payload for CSI part 1 and CSI part 2 follows that of PUCCH as described in Clause 5.2.4.

When CSI reporting on PUSCH comprises two parts, the UE may omit a portion of the Part 2 CSI. Omission of Part 2 CSI is according to the priority order shown in Table 5.2.3-1, where  is the number of CSI reports configured to be carried on the PUSCH. Priority 0 is the highest priority and priority  is the lowest priority and the CSI report *n* corresponds to the CSI report with the *n*th smallest Prii,CSI(*y,k,c,s*) value among the  CSI reports as defined in Clause 5.2.5. The subbands for a given CSI report *n* indicated by the higher layer parameter *csi-ReportingBand* are numbered continuously in increasing order with the lowest subband of *csi-ReportingBand* as subband 0. When omitting Part 2 CSI information for a particular priority level, the UE shall omit all of the information at that priority level.

- For Enhanced Type II reports, for a given CSI report , each reported element of indices and , indexed by and , is associated with a priority value , with with , , and , and where is defined in Clause 5.2.2.2.5. The element with the highest priority has the lowest associated value . Omission of Part 2 CSI is according to the priority order shown in Table 5.2.3-1, where

- Group 0 includes indices , (if reported) and ().

- Group 1 includes indices (if reported), (if reported), the highest priority elements of , , the highest priority elements of and the highest priority elements of ().

- Group 2 includes the lowest priority elements of , the lowest priority elements of and the lowest priority elements of ().

Table 5.2.3-1: Priority reporting levels for Part 2 CSI

|  |
| --- |
| Priority 0:  For CSI reports 1 to , Group 0 CSI for CSI reports configured as 'typeII-r16' or 'typeII-PortSelection-r16'; Part 2 wideband CSI for CSI reports configured otherwise |
| Priority 1:  Group 1 CSI for CSI report 1, if configured as 'typeII-r16' or 'typeII-PortSelection-r16'; Part 2 subband CSI of even subbands for CSI report 1, if configured otherwise |
| Priority 2:  Group 2 CSI for CSI report 1, if configured as 'typeII-r16' or 'typeII-PortSelection-r16'; Part 2 subband CSI of odd subbands for CSI report 1, if configured otherwise |
| Priority 3:  Group 1 CSI for CSI report 2, if configured as 'typeII-r16' or 'typeII-PortSelection-r16'; Part 2 subband CSI of even subbands for CSI report 2, if configured otherwise |
| Priority 4:  Group 2 CSI for CSI report 2, if configured as 'typeII-r16' or 'typeII-PortSelection-r16'. Part 2 subband CSI of odd subbands for CSI report 2, if configured otherwise |
| ⁞ |
| Priority :  Group 1 CSI for CSI report , if configured as 'typeII-r16' or 'typeII-PortSelection-r16'; Part 2 subband CSI of even subbands for CSI report , if configured otherwise |
| Priority :  Group 2 CSI for CSI report , if configured as 'typeII-r16' or 'typeII-PortSelection-r16'; Part 2 subband CSI of odd subbands for CSI report , if configured otherwise |

When the UE is scheduled to transmit a transport block on PUSCH not using repetition type B multiplexed with a CSI report(s), Part 2 CSI is omitted only when  is larger than , where parameters , , , , , , , , and are defined in Clause 6.3.2.4 of [5, TS 38.212].

Part 2 CSI is omitted level by level, beginning with the lowest priority level until the lowest priority level is reached which causes the  to be less than or equal to .

When the UE is scheduled to transmit a transport block on PUSCH using repetition type B multiplexed with a CSI report(s), Part 2 CSI is omitted only when

is larger than

,

where parameters , , , , , , , , , , , and are defined in Clause 6.3.2.4 of [5, TS 38.212].

Part 2 CSI is omitted level by level, beginning with the lowest priority level until the lowest priority level is reached which causes

to be less than or equal to

.

When part 2 CSI is transmitted on PUSCH with no transport block, lower priority bits are omitted until Part 2 CSI code rate, which is given by where , , are given in clause 6.3.2.4 of [5, 38.212] before HARQ-ACK puncturing part 2 CSI if any, is below a threshold code rate lower than one, where



- is the CSI offset value from Table 9.3-2 of [6, TS 38.213]

- *R* is signaled code rate in DCI

If the UE is in an active semi-persistent CSI reporting configuration on PUSCH, the CSI reporting is deactivated when either the downlink BWP or the uplink BWP is changed. Another activation command is required to enable the semi-persistent CSI reporting.

### 5.2.4 CSI reporting using PUCCH

A UE is semi-statically configured by higher layers to perform periodic CSI Reporting on the PUCCH. A UE can be configured by higher layers for multiple periodic CSI Reports corresponding to multiple higher layer configured CSI Reporting Settings, where the associated CSI Resource Settings are higher layer configured. Periodic CSI reporting on PUCCH formats 2, 3, 4 supports Type I CSI with wideband granularity.

A UE shall perform semi-persistent CSI reporting on the PUCCH applied starting from the first slot that is after slot when the UE would transmit a PUCCH with HARQ-ACK information in slot *n* corresponding to the PDSCH carrying the activation command described in clause 6.1.3.16 of [10, TS 38.321]where ** is the SCS configuration for the PUCCH. The activation command will contain one or more Reporting Settings where the associated CSI Resource Settings are configured. Semi-persistent CSI reporting on the PUCCH supports Type I CSI. Semi-persistent CSI reporting on the PUCCH format 2 supports Type I CSI with wideband frequency granularity. Semi-persistent CSI reporting on PUCCH formats 3 or 4 supports Type I CSI with wideband and sub-band frequency granularities and Type II CSI Part 1.

When the PUCCH carry Type I CSI with wideband frequency granularity, the CSI payload carried by the PUCCH format 2 and PUCCH formats 3, or 4 are identical and the same irrespective of RI (if reported), CRI (if reported). For type I CSI sub-band reporting on PUCCH formats 3, or 4, the payload is split into two parts. The first part contains RI (if reported), CRI (if reported), CQI for the first codeword. The second part contains PMI and contains the CQI for the second codeword when RI > 4. For a *CSI-ReportConfig* configured with subband reporting, *codebookType* set to 'typeI-SinglePanel' and the corresponding CSI-RS Resource Set for channel measurement configured with two Resource Groups and Resource Pairs, Part 1 contains RI(s), CRI(s), CQI(s) for the first codeword and is zero padded to a fixed payload size (if needed). Part 2 contains the CQI(s) for the second codeword (if reported) when RI is larger than 4, LIs (if reported) and PMI(s).

A semi-persistent report carried on the PUCCH formats 3 or 4 supports Type II CSI feedback, but only Part 1 of Type II CSI feedback (See Clause 5.2.2 and 5.2.3). Supporting Type II CSI reporting on the PUCCH formats 3 or 4 is a UE capability *type2-SP-CSI-Feedback-LongPUCCH*. A Type II CSI report (Part 1 only) carried on PUCCH formats 3 or 4 shall be calculated independently of any Type II CSI reports carried on the PUSCH (see Clause 5.2.3).

When the UE is configured with CSI Reporting on PUCCH formats 2, 3 or 4, each PUCCH resource is configured for each candidate UL BWP.

If the UE is in an active semi-persistent CSI reporting configuration on PUCCH and has not received a deactivation command, the CSI reporting takes place when the BWP in which the reporting is configured to take place is the active BWP, otherwise the CSI reporting is suspended.

A UE is not expected to report CSI with a total number of UCI bits and CRC bits larger than 115 bits when configured with PUCCH format 4. For CSI reports transmitted on a PUCCH, if all CSI reports consist of one part, the UE may omit a portion of CSI reports. Omission of CSI is according to the priority order determined from the Prii,CSI(*y,k,c,s*) value as defined in Clause 5.2.5. CSI report is omitted beginning with the lowest priority level until the CSI report code rate is less or equal to the one configured by the higher layer parameter *maxCodeRate*.

If any of the CSI reports consist of two parts, the UE may omit a portion of Part 2 CSI. Omission of Part 2 CSI is according to the priority order shown in Table 5.2.3-1. Part 2 CSI is omitted beginning with the lowest priority level until the Part 2 CSI code rate is less or equal to the one configured by higher layer parameter *maxCodeRate*.

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