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Source: **ZTE**
Title: **Maintenance for Reference signals and QCL**
Agenda item: **7.1.2.4**
Document for: **Discussion and Decision**

1 Introduction

In RAN#80 meeting, the updated NR specifications after RAN1#93 meeting were endorsed [1][2][3]. Because there are still some remaining issues to be solved, we provide some TPs on RS related remaining issues in this contribution.

2 Discussion

2.1 CSI-RS

Since it has been agreed that the first CSI-RS symbol can be anyone within one slot, it should be possible to configure one-symbol CSI-RS in symbol 13. Therefore, the correction is made as follows.

TP1 for section 7.4.1.5.3 in 38.211

> **7.4.1.5.3 Mapping to physical resources**
>
> ...
>
> The time-domain locations $l_0 \in \{0,1,\ldots,13\}$ ~~$l_0 \in \{2,3,\ldots,12\}$~~ and $l_1 \in \{2,3,\ldots,12\}$ are provided by the higher-layer parameters *firstOFDMSymbolInTimeDomain* and *firstOFDMSymbolInTimeDomain2*, respectively, in the *CSI-RS-ResourceMapping* IE and defined relative to the start of a slot.

2.2 DM-RS

- For uplink DMRS, as the editor replied in the email discussion, the existence n_{SCID} in DCI is based on the condition of CP-OFDM. So there is a condition 'if present' in the current 38.211 as follows.

  The quantity $n_{SCID} \in \{0,1\}$ is given by the DM-RS sequence initialization field, if present, in the DCI associated with the PDSCH transmission if DCI format 1_1 in [4, TS 38.212] is used, otherwise $n_{SCID} = 0$.

  However, this condition is unnecessary for DL DMRS because of no DFT-s-OFDM in DL. In other words, n_{SCID} field always exists in DCI format 0_1 and 1_1 for CP-OFDM. Therefore, we made the corresponding corrections in the following TPs.

TP1 for section 7.4.1.1.1 in 38.211

7.4.1.1.1 Sequence generation

The UE shall assume the sequence $r(n)$ is defined by

$$r(n) = \frac{1}{\sqrt{2}}(1-2\cdot c(2n)) + j\frac{1}{\sqrt{2}}(1-2\cdot c(2n+1)).$$

where the pseudo-random sequence $c(i)$ is defined in clause 5.2.1. The pseudo-random sequence generator shall be initialized with

$$c_{\text{init}} = \left(2^{17}\left(N_{\text{symb}}^{\text{slot}} n_{\text{s,f}}^{\mu} + l + 1\right)\left(2N_{\text{ID}}^{n_{\text{SCID}}} + 1\right) + 2N_{\text{ID}}^{n_{\text{SCID}}} + n_{\text{SCID}}\right) \bmod 2^{31}$$

where l is the OFDM symbol number within the slot, $n_{\text{s,f}}^{\mu}$ is the slot number within a frame, and

- $N_{\text{ID}}^{0}, N_{\text{ID}}^{1} \in \{0,1,...,65535\}$ are given by the higher-layer parameters *scramblingID0* and *scramblingID1*, respectively, in the *DMRS-DownlinkConfig* IE if provided and the PDSCH is scheduled by PDCCH using DCI format 1_1 with the CRC scrambled by C-RNTI or CS-RNTI
- $N_{\text{ID}}^{0} \in \{0,1,...,65535\}$ is given by the higher-layer parameter *scramblingID0* in the *DMRS-DownlinkConfig* IE if provided and the PDSCH is scheduled by PDCCH using DCI format 1_0 with the CRC scrambled by C-RNTI or CS-RNTI;
- $N_{\text{ID}}^{n_{\text{SCID}}} = N_{\text{ID}}^{\text{cell}}$ otherwise;

The quantity $n_{\text{SCID}} \in \{0, 1\}$ is given by the DM-RS sequence initialization field~~, if present,~~ in the DCI associated with the PDSCH transmission if DCI format 1_1 in [4, TS 38.212] is used, otherwise $n_{\text{SCID}} = 0$.

TP2 for section 7.3.1.1.2 in 38.212

7.3.1.1.2 Format 0_1

...

- DMRS sequence initialization – 0 bit if the higher layer parameter *transformPrecoder=enabled*; 1 bit if the higher layer parameter *transformPrecoder=disabled* ~~and both *scramblingID0* and *scramblingID1* are configured in *DMRS-UplinkConfig*, for n_{SCID} selection defined in Subclause 6.4.1.1.1.1 of [4, TS 38.211]~~.

TP3 for section 7.3.1.2.2 in 38.212

7.3.1.2.2 Format 1_1

...

- DMRS sequence initialization – 1 bit ~~if both *scramblingID0* and *scramblingID1* are configured in *DMRS-DownlinkConfig* for n_{SCID} selection defined in Subclause 7.4.1.1.1 of [4, TS 38.211]; 0 bit otherwise~~.

➢ For PDSCH mapping type B, the DMRS symbol should be shifted after a CORESET. However, since the configuration of CORESET does not include the time domain behavior, we propose to include the associated search space information. In addition, one typo should be corrected as follows.

TP4 for section 7.4.1.1.2 in 38.211

7.4.1.1.2 Mapping to physical resources

The UE shall assume the PDSCH DM-RS being mapped to physical resources according to configuration type 1 or configuration type 2 as given by the higher-layer parameter *dmrs-Type*.

The UE shall assume the sequence $r(m)$ is scaled by a factor $\beta_{\text{PDSCH}}^{\text{DMRS}}$ to conform with the transmission power specified in [6, TS 38.214] and mapped to resource elements $(k,l)_{p,\mu}$ according to

$$a_{k,l}^{(p,\mu)} = \beta_{\text{PDSCH}}^{\text{DMRS}} w_{\text{f}}(k') w_{\text{t}}(l') r(2n+k')$$

$$k = \begin{cases} 4n+2k'+\Delta & \text{Configuration type 1} \\ 6n+k'+\Delta & \text{Configuration type 2} \end{cases}$$

$$k' = 0,1$$

$$l = \bar{l} + l'$$

$$n = 0,1,\ldots$$

where $w_{\text{f}}(k')$, $w_{\text{t}}(l')$, and Δ ~~, and λ~~ are given by Tables 7.4.1.1.2-1 and 7.4.1.1.2-2 and the following conditions are fulfilled:

- the resource elements are within the common resource blocks allocated for PDSCH transmission

...

For PDSCH mapping type B

- if the PDSCH duration is 2, 4, or 7 OFDM symbols for normal cyclic prefix or 2, 4, 6 OFDM symbols for extended cyclic prefix, and the PDSCH allocation collides with resources reserved for a search space set associated with a CORESET, $\bar{l}$ shall be incremented such that the first DM-RS symbol occurs immediately after the CORESET and

2.3 PT-RS

In current 38.214, DL rate matching resources are only used for PDSCH. Since PTRS should not be transmitted on some REs which are not available for PDSCH, so we propose the following TP.

TP1 for section 5.1.4 in 38.214

> **5.1.4 PDSCH resource mapping**
>
> When receiving PDSCH not conveying [RAR, OSI, Paging, Msg4, SIB1], the REs corresponding to the union of configured or dynamically indicated resources in Subclauses 5.1.4.1, 5.1.4.2 and resources corresponding to SS/PBCH are declared as not available for PDSCH in Subclause 7.3.1.5 of [4, TS 38.211]. A UE is not expected to handle the case where PDSCH DM-RS REs are overlapping, even partially, with any RE(s) declared as not available for PDSCH.
>
> **5.1.4.1 PDSCH resource mapping with RB symbol level granularity**
>
> A UE may be configured with any of the higher layer parameters indicating REs declared as not available for PDSCH and PTRS:
>
> ...

2.4 SRS

- In RAN1 #92bis meeting, a working assumption was confirmed that NR supports the case that different ports of one 4-port SRS resource have different comb offsets, and it was captured in TS 38.211 [1]. It means different SRS ports can be mapped on different subcarriers. However, in the section 6.2.1.1 of TS 38.214 [2], there is a description that when frequency hopping within an SRS resource in each slot is not configured (R=Ns), all antenna ports of the SRS resource in each slot are mapped to the same set of subcarriers. Therefore, there is ambiguous description between TS 38.211 and TS 38.214. In our view, the intention of 38.214 is to say each antenna port instead of all ports is mapped in all the N_s symbols to the same set of subcarriers. Therefore, we provide the following TP.

TP1 for section 6.2.1.1in 38.214

6.2.1.1 UE SRS frequency hopping procedure

A UE may be configured to transmit an SRS resource on $N_s \in \{1,2,4\}$ adjacent symbols within the last six symbols of a slot, where all antenna ports of the SRS resource are mapped to each symbol of the resource. For a given SRS resource, the UE is configured with repetition factor R∈{1,2,4} by higher layer parameter *resourceMapping* in *SRS-Resource* where $R \leq N_s$. When frequency hopping within an SRS resource in each slot is not configured ($R=N_s$), each of the~~all~~ antenna ports of the SRS resource in each slot ~~are~~is mapped in ~~each of~~all the N_s symbols to the same set of subcarriers in the same set of PRBs. When frequency hopping within an~~s~~ SRS resource in each slot is configured without repetition ($R=1$), according to the SRS hopping parameters B_{SRS}, C_{SRS} and b_{hop} defined in Subclause 6.4.1.4 of [4, TS 38.211], each of the~~all~~ antenna ports of the SRS resource in each slot ~~are~~is mapped to different sets of subcarriers in each OFDM symbol, where the same transmission comb value is assumed for different sets of subcarriers. When both frequency hopping and repetition within an SRS resource in each slot are configured ($N_s=4$, $R=2$), ~~all~~each of the antenna ports of the SRS resource in each slot ~~are~~is mapped to the same set of subcarriers within each pair of R adjacent OFDM symbols, and frequency hopping across the two pairs is according to the SRS hopping parameters B_{SRS}, C_{SRS} and b_{hop}.

A UE may be configured $N_s = 2 \text{ or } 4$ adjacent symbol aperiodic SRS resource with intra-slot frequency hopping within a bandwidth part, where the full hopping bandwidth is sounded with an equal-size subband across N_s symbols when frequency hopping is configured with $R=1$. A UE may be configured $N_s = 4$ adjacent symbols aperiodic SRS resource with intra-slot frequency hopping within a bandwidth part, where the full hopping bandwidth is sounded with an equal-size subband across two pairs of R adjacent OFDM symbols, when frequency hopping is configured with $R=2$. ~~All~~Each of the antenna ports of the SRS resource is~~are~~ mapped to the same set of subcarriers within each pair of R adjacent OFDM symbols of the resource.

A UE may be configured $N_s = 1$ symbol periodic or semi-persistent SRS resource with inter-slot hopping within a bandwidth part, where the SRS resource occupies the same symbol location in each slot. A UE may be configured $N_s = 2 \text{ or } 4$ symbol periodic or semi-persistent SRS resource with intra-slot and inter-slot hopping within a bandwidth part, where the N-symbol SRS resource occupies the same symbol location(s) in each slot. For $N_s=4$, when frequency hopping is configured with $R=2$, intra-slot and inter-slot hopping is supported with each of the ~~all~~ antenna ports of the SRS resource mapped to different sets of subcarriers across two pairs of R adjacent OFDM symbol(s) of the resource in each slot. Each of the~~All~~ antenna ports of the SRS resource is~~are~~ mapped to the same set of subcarriers within each pair of R adjacent OFDM symbols of the resource in each slot. For $N_s = R$, when frequency hopping is configured, inter-slot frequency hopping is supported with ~~all~~each of the antenna ports of the SRS resource mapped to the same set of subcarriers in R adjacent OFDM symbol(s) of the resource in each slot

- Based on the current 38.214 for the UL beam management as follows, the SRS resources in different SRS resource sets can be transmitted simultaneously. However, this rule seems not correct for some cases.

When the higher layer parameter SRS-SetUse is set to 'BeamManagement', only one SRS resource in each of multiple SRS sets can be transmitted at a given time instant. The SRS resources in different SRS resource sets can be transmitted simultaneously.

Case 1: For those SRS resource sets for BM, SRS resources in one set is configured without *spatialRelationInfo*, and SRS resources in another set is configured with *spatialRelationInfo.* As shown in Figure 2.4-1, SRS resource 0, 1,2,3 in the SRS resource set 0 are configured without *spatialRelationInfo* for initial BM and SRS resource 4, 5 are configured with *spatialRelationInfo* for further beam measurement. RS included in *spatialRelationInfo* of SRS resource 4 is actually SRS resource 0, and RS included in *spatialRelationInfo* of SRS resource 5 is actually SRS resource 2. In other words, the same beam are used for SRS resource 0 and 4, and for resource 2 and 5. Since SRS

resource 0 and 2 cannot be transmitted simultaneously, SRS resource 0 and 5 cannot be transmitted simultaneously either.

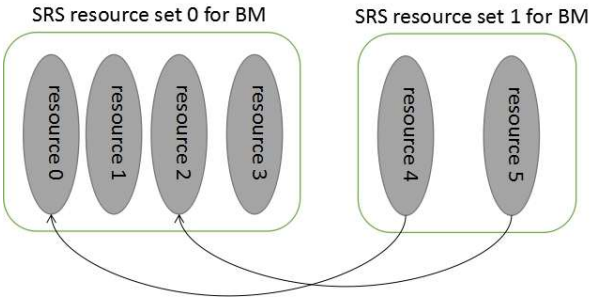

Figure 2.4-1 SRS for BM

Case 2: For those SRS resource sets for BM have different time domain behavior. E.g. two SRS resource sets are configured for initial BM, and SRS resource set 0 and set 1 are periodic and aperiodic respectively. Since some resources in set 1 may have the same beam with some resources in set 0, the rule is also not correct in this case.

In addition, all SRS resource sets we mentioned here should be limited within one CC or BWP since SRS resources across CCs may be the same beam. For SRS resource sets, the rule seems not satisfied either.

Therefore, we propose to clarify the agreed rule should be limited in the specific scenarios, i.e. among SRS resources sets with the same time domain behavior, and all resources in these resource sets should configured either with or without *spatialRelationInfo*.

Proposal 1: *When the higher layer parameter SRS-SetUse is set to 'BeamManagement' for some SRS resource sets within one CC, if all resources in all of these SRS resource sets are configured either with spatialRelationInfo or without spatialRelationInfo, and have the same time domain behavior, the SRS resources in different SRS resource sets among these resource sets can be transmitted simultaneously.*

In addition, it is obvious that all or none of the SRS resources within an SRS resource set should be configured with the higher layer parameter *spatialRelationInfo*. In other words, the case that some resources of an SRS resource set is configured with *spatialRelationInfo* but the other resources is not configured with *spatialRelationInfo* is not allowed.

TP2 for section 6.2.1 in 38.214

6.2.1 UE sounding procedure

The UE can be configured with one or more Sounding Reference Symbol (SRS) resource sets as configured by the higher layer parameter *SRS-ResourceSet*. For each SRS resource set, a UE may be configured with $K \geq 1$ SRS resources (higher later parameter *SRS-Resource*), where the maximum value of K is indicated by [*SRS_capability* [13, 38.306]]. The SRS resource set applicability is configured by the higher layer parameter *SRS-SetUse.* When the higher layer parameter *SRS-SetUse* is set to 'BeamManagement', only one SRS resource in each of multiple SRS sets can be transmitted at a given time instant. When the higher layer parameter *SRS-SetUse* is set to 'BeamManagement', the SRS resources in different SRS resource sets within the same BWP can be transmitted simultaneously if these SRS resources have the same time domain behavior and if all or none of these SRS resources are configured with the higher layer parameter *spatialRelationInfo*~~The SRS resources in different SRS resource sets can be transmitted simultaneously~~.

For aperiodic SRS at least one state of the DCI field is used to select at least one out of the configured SRS resource set.

The following SRS parameters are semi-statically configurable by higher layer parameter *SRS-Resource*.

- *srs-ResourceId* determines SRS resource configuration identify.
- Number of SRS ports as defined by the higher layer parameter *nrofSRS-Ports* and described in Subclause 6.4.1.4 of [4, TS 38.211].
- Time domain behaviour of SRS resource configuration as indicated by the higher layer parameter *SRS-resourceType*, which can be periodic, semi-persistent, aperiodic SRS transmission as defined in Subclause 6.4.1.4 of [4, TS 38.211].
- Slot level periodicity and slot level offset as defined by the higher layer parameters *periodicityAndOffset-p* or *periodicityAndOffset-sp* for an SRS resource of type periodic or semi-persistent. The UE shall not expect to be configured with SRS resources in the same SRS resource set *SRS-ResourceSet* with different slot level periodicities. For an *SRS-ResourceSet* configured with higher layer parameter *resourceType* set to 'aperiodic', a slot level offset is defined by the higher layer parameter *slotOffset*.
- Number of OFDM symbols in the SRS resource, starting OFDM symbol of the SRS resource within a slot including repetition factor R as defined by the higher layer parameter *resourceMapping* and described in Subclause 6.4.1.4 of [4, TS 38.211].
- SRS bandwidth B_{SRS} and C_{SRS}, as defined by the higher layer parameter *freqHopping* and described in Subclause 6.4.1.4 of [4, TS 38.211].
- Frequency hopping bandwidth, b_{hop}, as defined by the higher layer parameter *freqHopping* and described in Subclause 6.4.1.4 of [4, TS 38.211].
- Defining frequency domain position and configurable shift to align SRS allocation to 4 PRB grid, as defined by the higher layer parameters *freqDomainPosition* and *freqDomainShift, respectively,* and described in Subclause 6.4.1.4 of [4, TS 38.211].
- Cyclic shift, as defined by the higher layer parameter *cyclicShift-n2* or *cyclicShift-n4* for transmission comb value 2 and 4, respectively, and described in Subclause 6.4.1.4 of [4, TS 38.211].
- Transmission comb value as defined by the higher layer parameter *transmissionComb* described in Subclause 6.4.1.4 of [4, TS 38.211].

- Transmission comb offset as defined by the higher layer parameter *combOffset-n2* or *combOffset-n4* for transmission comb value 2 or 4, respectively, and described in Subclause 6.4.1.4 of [4, TS 38.211].
- SRS sequence ID as defined by the higher layer parameter *sequenceId* in Subclause 6.4.1.4 of [4].
- The configuration of the spatial relation between a reference RS and the target SRS, where the higher layer parameter *spatialRelationInfo*, if configured, contains the ID of the reference RS. The reference RS can be an SS/PBCH block, CSI-RS or an SRS configured on the same or different component carrier and/or bandwidth part as the target SRS. The higher layer parameter *spatialRelationInfo* is configured for all or none of the SRS resources of an SRS resource set.

- In RAN1#93 meeting, at most two types of time domain behavior of SRS resource sets were agreed in offline discussion for antenna switching including the case T=R, wherein one is aperiodic, the other is either perioidc or semi-persistent. However, it seems not clear enough in the current 38.214. Therefore, we provide the following TP.

TP3 for section 6.2.1.2 in 38.214

6.2.1.2 UE sounding procedure for DL CSI acquisition

When the UE is configured with the higher layer parameter *usage* in *SRS-ResourceSet* set as 'antennaSwitching', the UE may be configured with one of the following configurations depending on the indicated UE capability ('1T2R', '2T4R', '1T4R', '1T4R/2T4R', or 'T=R'):

- For '1T2R', up to two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* set, where each set has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of the second resource in the set is associated with a different UE antenna port than the SRS port of the first resource in the same set, or
- For '2T4R', up to two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* set, where each SRS resource set has two SRS resources transmitted in different symbols, each SRS resource in a given set consisting of two SRS ports, and the SRS port pair of the second resource is associated with a different UE antenna port pair than the SRS port pair of the first resource, or
- For '1T4R', zero or one SRS resource set configured with higher layer parameter *resourceType* in *SRS-ResourceSet* set to 'periodic' or 'semi-persistent' with four SRS resources transmitted in different symbols, each SRS resource in a given set consisting of a single SRS port, and the SRS port of each resource is associated with a different UE antenna port, and
  - zero or two SRS resource sets each configured with higher layer parameter *resourceType* in *SRS-ResourceSet* set to 'aperiodic' and with a total of four SRS resources transmitted in different symbols of two different slots, and where the SRS port of each SRS resource in given two sets is associated with a different UE antenna port. The two sets are each configured with two SRS resources, or one set is configured with one SRS resource and the other set is configured with three SRS resources. The UE shall expect that the two sets are both configured with the same values of the higher layer parameters *alpha*, *p0*, *pathlossReferenceRS*, and *srs-PowerControlAdjustmentStates* in *SRS-ResourceSet*. The UE shall expect that the value(s) of the higher layer parameter *aperiodicSRS-ResourceTrigger* in each *SRS-ResourceSet* are the same, and the value of the higher layer parameter *slottOffset* in each *SRS-ResourceSet* is different. Or,
- For 'T=R',up to two SRS resource sets configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* set, and each with one SRS resource, where the number of SRS ports for each resource is equal to 1, 2, or 4.

If two SRS resource sets are configured with a different value for the higher layer parameter *resourceType* in *SRS-ResourceSet* set, one should be aperiodic and the other should be either perioidc or semi-persistent.

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2.5 TRS

Currently, For a NZP-CSI-RS-ResourceSet configured with the higher layer parameter trs-Info, the UE shall assume the antenna port with the same port index of the configured NZP CSI-RS resources in the NZP-CSI-RS-ResourceSet is the same. So all the resources in the NZP-CSI-RS-ResourceSet should have the same QCL source RS(s). Or else, the tracking result will not be accurate.

In addition, many descriptions for TRS pattern and configuration should be for both periodic TRS and aperiodic TRS, e.g. based on the current specification, we cannot see the aperiodic TRS set should have four NZP CSI-RS resources in two consecutive slots with two NZP CSI-RS resources in each slot for FR1.

TP4 for section 5.1.6.1.1 in 38.214

5.1.6.1.1 CSI-RS for tracking

A UE in RRC connected mode is expected to receive the higher layer UE specific configuration of a periodic *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info*.

For a *NZP-CSI-RS-ResourceSet* configured with the higher layer parameter *trs-Info*, the UE shall assume the antenna port with the same port index of the configured NZP CSI-RS resources in the *NZP-CSI-RS-ResourceSet* is the same and the higher layer parameter *qcl-InfoPeriodicCSI-RS* for the configured NZP CSI-RS resources in the *NZP-CSI-RS-ResourceSet* is the same. For frequency range 1, the UE may be configured with a *NZP-CSI-RS-ResourceSet* of four ~~periodic~~ NZP CSI-RS resources in two consecutive slots with two ~~periodic~~ NZP CSI-RS resources in each slot. For frequency range 2 the UE may be configured with a *NZP-CSI-RS-ResourceSet* of two ~~periodic~~ CSI-RS resources in one slot or with a *NZP-CSI-RS-ResourceSet* of four ~~periodic~~ NZP CSI-RS resources in two consecutive slots with two ~~periodic~~ NZP CSI-RS resources in each slot.

A UE configured with *NZP-CSI-RS-ResourceSet(s)* configured with higher layer parameter *trs-Info* may have the CSI-RS resources configured as:

- Periodic, with the CSI-RS resources in the *NZP-CSI-RS-ResourceSet* configured with same periodicity, bandwidth and subcarrier location
- Periodic CSI-RS resource in one set and aperiodic CSI-RS resources in a second set, with the aperiodic CSI-RS and periodic CSI-RS resource having the same bandwidth (with same RB location) and the aperiodic CSI-RS being 'QCL-Type-A' and 'QCL-TypeD', where applicable, with the periodic CSI-RS resources. The UE does not expect that the scheduling offset between the triggering DCI and the first symbol of the aperiodic CSI-RS resources is smaller than the UE reported *ThresholdSched-Offset*. The UE shall expect that the periodic CSI-RS resource set and aperiodic CSI-RS resource set are configured with the same number of CSI-RS resources. For the aperiodic CSI-RS resource set if triggered, and if the associated periodic CSI-RS resource set is configured with four periodic CSI-RS resources with two consecutive slots with two periodic CSI-RS resources in each slot, the higher layer parameter *aperiodicTriggeringOffset* indicates the triggering offset for the first slot for the first two CSI-RS resources in the set.

A UE does not expect to be configured with a *CSI-ReportConfig* that is linked to a *CSI-ResourceConfig* containing an *NZP-CSI-RS-ResourceSet* configured with *trs-Info* and with the *CSI-ReportConfig* configured with the higher layer parameter *timeRestrictionForChannelMeasurements* set to 'configured'.

A UE does not expect to be configured with a *CSI-ReportConfig* with the higher layer parameter *reportQuantity* set to other than 'none' for aperiodic NZP CSI-RS resource set configured with *trs-Info.*

A UE does not expect to be configured with a *CSI-ReportConfig* for periodic NZP CSI-RS resource set configured with *trs-Info*.

A UE does not expect to be configured with a *NZP-CSI-RS-ResourceSet* configured both with *trs-Info* and *repetition*.

Each CSI-RS resource, defined in Subclause 7.4.1.5.3 of [4, TS 38.211], is configured by the higher layer parameter *NZP-CSI-RS-Resource* with the following restrictions:

- the time-domain locations of the two ~~periodic~~ CSI-RS resources in a slot, or of the four ~~periodic~~ CSI-RS resources in two consecutive slots (which are the same across two consecutive slots), as defined by higher layer parameter *CSI-RS-resourceMapping*, is given by one of
  - $l \in \{4,8\}$, $l \in \{5,9\}$, or $l \in \{6,10\}$ for frequency range 1 and frequency range 2,
  - $l \in \{0,4\}$, $l \in \{1,5\}$, $l \in \{2,6\}$, $l \in \{3,7\}$, $l \in \{7,11\}$, $l \in \{8,12\}$ or $l \in \{9,13\}$ for frequency range 2.

- a single port CSI-RS resource with density $\rho = 3$ given by Table 7.4.1.5.3-1 from [4, TS 38.211] and higher layer parameter *density* configured by *CSI-RS-ResourceMapping*.
- the bandwidth of the CSI-RS resource, as given by the higher layer parameter *freqBand* configured by *CSI-RS-ResourceMapping*, is the minimum of 52 and $N_{\mathrm{RB}}^{\mathrm{BWP}j}$ resource blocks, or is equal to $N_{\mathrm{RB}}^{\mathrm{BWP}j}$ resource blocks
- the UE is not expected to be configured with the periodicity of $2^{\mu} \times 10$ slots if the bandwidth of CSI-RS resource is larger than 52 resource blocks.
- the periodicity and slot offset for periodic NZP CSI-RS resources, as given by the higher layer parameter *periodicityAndOffset* configured by *NZP-CSI-RS-Resource*, is one of $2^{\mu} X_p$ slots where $X_p = 10, 20, 40,$ or 80 ms and where μ is defined in Subclause 4.3 of [4, TS 38.211].
- same *powerControlOffset* and *powerControlOffsetSS* given by *NZP-CSI-RS-Resource* value across all resources.

2.6 QCL

QCL indication considering cross-CC scheduling

In the current 38.214 section 5.1.5, when TCI field is not present in DCI, the QCL of scheduled PDSCH is based on the TCI of PDCCH as shown in the following description marked in red.

----------38.214 section 5.1.5 ----------

> If a UE is configured with the higher layer parameter *tci-PresentInDCI* that is set as 'enabled' for the CORESET scheduling the PDSCH, the UE assumes that the TCI field is present in the DCI format 1_1 of the PDCCH transmitted on the CORESET. If *tci-PresentInDCI* is not configured for the CORESET scheduling the PDSCH or the PDSCH is scheduled by a DCI format 1_0, for determining PDSCH antenna port quasi co-location, the UE assumes that the TCI state for the PDSCH is identical to the TCI state applied for the CORESET used for the PDCCH transmission.

For the same-CC scheduling, PDSCH and its PDCCH can be quasi co-located w.r.t. all QCL parameters. However, for cross-CC scheduling as shown in Figure 2.6-1, PDSCH and CORESET of PDCCH may not be quasi co-located w.r.t. Doppler shift, Doppler spread, average delay, delay spread because different CCs may have different channel properties due to a large frequency gap between CCs. Degradation is expected if multiple CCs share the same QCL parameters. Regarding the spatial Rx parameter, it can be okay since multiple CCs may need to share the same receive beam anyway. In other words, only QCL-TypeD of PDCCH can be used for PDSCH in the case of cross-CC scheduling. Since there may not be CORESET configured in CC1, we propose to use the first one of TCI list configured by RRC in CC1 to indicate QCL assumptions other than QCL-TypeD.

When TCI field is present in DCI for cross-CC scheduling, if there is no CORESET configured in CC1 and the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than a threshold *Threshold-Sched-Offset*, UE can still obtain the QCL assumptions other than QCL-TypeD from the indicated TCI state in *DCI* for the PDSCH. However, there is no any description for the cross-CC scheduling without CORESET configuration in the CC for the PDSCH transmission.

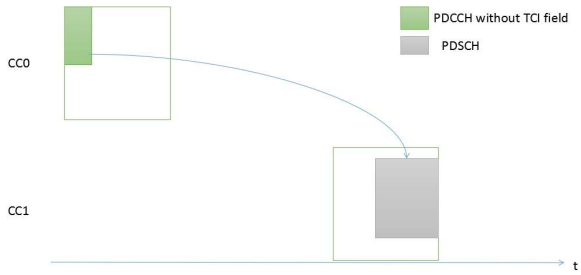

Figure 2.6-1 Cross-CC scheduling, the timing is larger than threshold, DCI without TCI

Hence, we provide the following proposal for cross-CC scheduling

Proposal2 : *When PDSCH and its scheduling PDCCH are in the different CCs,*

- *if TCI field is not present in DCI, UE obtains the QCL assumptions other than QCL-TypeD from the first one of M TCI-States configured for the active BWP in which the PDSCH is scheduled.*
- *if TCI field is present in DCI and the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than a threshold Threshold-Sched-Offset, UE obtains the QCL assumptions other than QCL-TypeD from the indicated TCI state in DCI for the PDSCH.*

In addition, when the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than a threshold *Threshold-Sched-Offset*, the QCL assumption of PDSCH of a serving cell is based on the lowest CORESET of the serving cell as shown in above description marked by blue.

----------38.214 section 5.1.5 ----------

> For both the cases when *tci-PresentInDCI* is set to 'enabled' and *tci-PresentInDCI* is not configured, if the offset between the reception of the DL DCI and the corresponding PDSCH is less than the threshold *Threshold-Sched-Offset*, the UE may assume that the DM-RS ports of PDSCH of a serving cell are quasi co-located with the RS(s) in the TCI state with respect to the QCL parameter(s) used for PDCCH quasi co-location indication of the lowest *CORESET-ID* in the latest slot in which one or more CORESETs within the active BWP of the serving cell are configured for the UE. If none of configured TCI states contains 'QCL-TypeD', the UE shall obtain the other QCL assumptions from the indicated TCI states for its scheduled PDSCH irrespective of the time offset between the reception of the DL DCI and the corresponding PDSCH.

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However, the time domain parameters like start symbol, period and time offset are included in the configuration of search space instead of CORESET. Consequently, the above lowest CORESET-ID should be clarified as a CORESET associated with one search space. In addition, based on the current specification, when the number of search space candidates in one slot is larger than that UE supports, the extra search space sets associated with one CORESET will not be monitored by the UE for keeping the low number of blind detection.

Therefore, the CORESET with the lowest CORESET-ID should be clarified as one CORESET associated with at least one search space set monitored by the UE.

Proposal 3: *When the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than a threshold Threshold-Sched-Offset, UE obtains QCL parameter from the CORESET with the lowest*

CORESET-ID which are associated with at least one search space set monitored by UE in the latest slot in the case that the PDSCH and the CORESET are in the same serving cell.

Configurable QCL Types between CSI-RS for BM and SS/PBCH

In RAN1#90, joint CSI-RS and SS block for beam measurement has been agreed, and in TS 38.214 we have the following. When L1-RSRP computation is determined by both CSI-RS and SS/PBCH, these CSI-RS resources and SS/PBCH block resources should be resource-wise QCLed w.r.t. 'QCL-TypeA' and 'QCL-TypeD'.

TS38.214： 5.2.1.4.3 L1-RSRP Reporting

For L1-RSRP computation

- the UE may be configured with CSI-RS resources, SS/PBCH Block resources or both CSI-RS and SS/PBCH block resources, when resource-wise quasi co-located with 'QCL-Type A' and 'QCL-TypeD'.
- the UE may be configured with CSI-RS resource setting up to 16 CSI-RS resource sets having up to 64 resources within each set. The total number of different CSI-RS resources over all resource sets is no more than 128.

TS38.214： 5.1.5 Antenna ports quasi co-location

- 'QCL-TypeA': {Doppler shift, Doppler spread, average delay, delay spread}
- 'QCL-TypeB': {Doppler shift, Doppler spread}
- 'QCL-TypeC': {Doppler shift, average delay}
- 'QCL-TypeD': {Spatial Rx parameter}

However, according to the following framework of configurable QCL types between CSI-RS for beam management and SS/PBCH in TS 38.214, one CSI-RS resource for BM only can be RRC configured the QCL type of 'QCL-Type C' and 'QCL-TypeD' with one SS/PBCH, rather than 'QCL-Type A' and 'QCL-TypeD'. Therefore, one more QCL-Type candidate pair of 'QCL-Type A' and 'QCL-TypeD' between CSI-RS for beam management and SS/PBCH should be complemented accordingly.

Proposal-4: *One CSI-RS resource for BM and one SS/PBCH resource block can be configured as being quasi co-located with respect to 'QCL-Type A' and 'QCL-TypeD'.*

Consequently, we have the following text proposals.

TP5 for section 5.1.5 in 38.214

For a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition,* the UE shall expect that a *TCI-State* indicates one of the following quasi co-location type(s):

- 'QCL-TypeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'QCL-TypeD' with the same CSI-RS resource, or
- 'QCL-TypeA' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *trs-Info* and, when applicable, 'QCL-TypeD' with a CSI-RS resource in a *NZP-CSI-RS-ResourceSet* configured with higher layer parameter *repetition*, or

- 'QCL-TypeC' with an SS/PBCH block and, when applicable, 'QCL-TypeD' with the same SS/PBCH block.

- 'QCL-TypeA' with an SS/PBCH block and, when applicable, 'QCL-TypeD' with the same SS/PBCH block.

3 Conclusions

In this contribution, we provide our proposal and some TPs on RS and QCL related issues to the current NR specifications.

Proposal 1: *When the higher layer parameter SRS-SetUse is set to 'BeamManagement' for some SRS resource sets within one CC, if all resources in all of these SRS resource sets are configured either with spatialRelationInfo or without spatialRelationInfo, and have the same time domain behavior, the SRS resources in different SRS resource sets among these resource sets can be transmitted simultaneously.*

Proposal2 : *When PDSCH and its scheduling PDCCH are in the different CCs,*

- *if TCI field is not present in DCI, UE obtains the QCL assumptions other than QCL-TypeD from the first one of M TCI-States configured for the active BWP in which the PDSCH is scheduled.*

- *if TCI field is present in DCI and the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than a threshold Threshold-Sched-Offset, UE obtains the QCL assumptions other than QCL-TypeD from the indicated TCI state in DCI for the PDSCH.*

Proposal 3: *When the time offset between the reception of the DL DCI and the corresponding PDSCH is smaller than a threshold Threshold-Sched-Offset, UE obtains QCL parameter from the CORESET with the lowest CORESET-ID which are associated with at least one search space set monitored by UE in the latest slot in the case that the PDSCH and the CORESET are in the same serving cell.*

Proposal-4: *One CSI-RS resource for BM and one SS/PBCH resource block can be configured as being quasi co-located with respect to 'QCL-Type A' and 'QCL-TypeD'.*

4 References

[1] TS 38.211, Physical channels and modulation (Release 15) v15.2.0
[2] TS 38.212, Multiplexing and channel coding (Release 15) v15.2.0
[3] TS 38.214, Physical layer procedures for data (Release 15) v15.2.0