**[100b-e-NR-5G\_V2X\_NRSL-SYNC-02]**

**Email discussion/approval related to DM-RS and QCL for S-SSB**

[100b-e-NR-5G\_V2X\_NRSL-SYNC-02] Email discussion/approval related to

DM-RS sequence initialization for PSBCH and QCL for S-SSB

(a,k.a. issues 2 and 3) by 4/24, with potential TPs by 4/29 (CATT, Teng)

**Issue 2 DM-RS sequence initialization for PSBCH**

4/20-4/23

From the email responses 4/20-4/23, we can see the most preferences are Alt 2. Since we already have quite lots of discussion on the technical details on two alternatives, I think it is better to follow the majority view by taking Alt 2 as the DM-RS sequence initialization for PSBCH. Please find the FL proposal below for further discussion and check.

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| **Alternatives** | **DM-RS sequence initialization** | **Supporting companies** |
| Alt. 1 | $c\_{init}=2^{11}\left(\overbar{i}\_{S-SSB}+1\right)\left(N\_{ID}^{SL}+1\right)+2^{6}\left(\overbar{i}\_{S-SSB}+1\right)$, where $\overbar{i}\_{S-SSB}$ is 3 LSBs of S-SSB index. | [Futurewei] [vivo] [Samsung] [LGE] [CATT] |
| Alt. 2 | $$c\_{init}=N\_{ID}^{SL}$$ | [Sharp] [ZTE] [OPPO] [Ericsson] [Huawei, HiSilicon] [Spreadtrum] [Qualcomm] [Nokia] [MediaTek] [Intel] [Fujitsu]  |

4/23-4/24

According to the responses on the DM-RS sequence initialization

* Majority companies support the proposal below.
* One company insist to use Alt 1, because it is beneficial of randomization and getting PSBCH timing information.
* Two companies support Alt 1 with replacement that $c\_{init}=N\_{ID}^{SL}+1$**.** The reason is that the Glod sequence would become an m-sequence when $c\_{init}=0 (N\_{ID}^{SL}=0)$. To avoid this issue, it is proposed to add 1 on $N\_{ID}^{SL}$.

FL comment:

Last meeting, all of the companies shared the technical views in detail on which Alt should be taken as the DM-RS sequence initialization. Two Alts were left for down selection by this meeting. There is no technical concerns by taking Alt 1 $c\_{init}=N\_{ID}^{SL}$to do initialization, but for Alt 2, its benefit of randomization is not quite acceptable by other companies. Besides, Alt 2 also raises the complexity of blind decoding. Since there is nothing wrong with Alt 1 (easy and no need of blind decoding), but there are concerns on Alt 2, and majority company support Alt 1. From my perspective, taking Alt 1 as a proposal for potential concensus is a proper way.

***FL proposal:***

* ***The DM-RS sequence initialization for PSBCH can be*** $c\_{init}=N\_{ID}^{SL}$

**Comments 4/24**

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| **Company** | **Views** |
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**Email responses in 4/23-4/24**

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| **Company** | **Views** |
| MediaTek | Agree. |
| Huawei/HiSilicon | Agree. We think there is no significant performance difference between Alt1 and Alt2. And Alt1 will result in addtional blind detection complexity when there are multiple sync sources. |
| Qualcomm | Agree |
| LGE | FL proposal is not supported.Using S-SSB index is beneficial not only for providing interference randomization but also for confirming PSBCH timing information. |
| Sharp | Agree. |
| Spreadtrum | We support FL proposal. |
| OPPO | Agree  |
| Ericsson | Agree with the FL proposal. |
| ZTE, Sanechips | To us, companies' feedback so far focus on comparing alt1 and alt2 and we agree with the majority view that alt2 is preferred. Yet as clarified earlier, this initializer has an issue of reducing a gold sequence to an M sequence and our preference is to correct it as follows. * ***The DM-RS sequence initialization for PSBCH can be*** $c\_{init}=N\_{ID}^{SL}+1$***.***
 |
| Fujitsu | Agree |
| Nokia | Agree. Like pointed by ZTE, the definition could be slightly adjusted e.g. $c\_{init}=2^{9}(N\_{ID}^{SL}+1)$ |
| Samsung | For initial condition of DM-RS sequence of PSBCH, there is **NO NEED** to revise from previous agreement! C\_init is an initial condition of one of the M-sequences constructing the PN-sequence, and setting it as zero doesn’t mean the final PN sequence is an all-zero sequence. The following figure and table show the comparison of using c\_init = SL ID or c\_init = SL ID+1, and there is no obvious difference at all (two CDF curves almost overlap)! Hence, there is no need to revert last meeting’s agreement.

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|   | mean (dB) | max (dB) | 90% (dB) | 10% (dB) |
| c\_init = SL ID | -23.3829 | -12.8531 | -19.3479 | -33.3273 |
| c\_init = SL ID+1 | -23.3847 | -12.8531 | -19.3479 | -33.3273 |

cid:image001.png@01D61A45.FB5055E0 |
| Huawei/HiSilicon (v11) | Agree with the Proposal, i.e., $c\_{init}=N\_{ID}^{SL}$**.**No need to add “+1” as menetioned by ZTE. It is true that Cinit=0 result in a M seq. instead of Gold seq. However, since we only use part of the Gold/M seq. instead of the full $2^{31}$ bits long seq., we think the impact on sequence correlation performance is ignorable. And we think this is the reason that LTE/NR allow for Cinit=0 in many cases, such as LTE/NR PBCH scrambling Cinit. |

**Email responses in 4/20-4/23**

***Proposal 3: The DM-RS sequence initialization for PSBCH can be:***

* $c\_{init}=2^{11}\left(\overbar{i}\_{S-SSB}+1\right)\left(N\_{ID}^{SL}+1\right)+2^{6}\left(\overbar{i}\_{S-SSB}+1\right)$, where $\overbar{i}\_{S-SSB}$ is 3 LSBs of S-SSB index.

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| **Company** | **Views** |
| Futurewei | Support |
| Sharp | It is a little surprising that “Alt2” is removed here, and only “Alt1” is left in the proposal, especially when considering that:* Alt2 has more supporting companies than the currently proposed “Alt1”, according to the FL summary.
* RAN1 explicitly agreed in the last e-meeting to down-select from Alt1 and Alt2.

Please bring back Alt2 for down-selection. Our preference is Alt2. |
| vivo | Support |
| ZTE, Sanechips | We can't agree to the current formula. Introducing S-SSB index would require additional detection efforts and we don't see clear benefits. In R1-2001578, we proposed the following modification to Alt2 from RAN1-100e agreement. The reason is the original alternative would result in potentially c\_{init} = 0 where Gold sequence would reduce to a M sequence.1. Adopt Alt 2 with the following modification
* For PSBCH DM RS, the scrambling sequence generator shall be initialized at the start of every PSBCH subframe with C:\Users\10217598\AppData\Local\Temp\ksohtml\wpsF721.tmp.png.

  |
| OPPO | Agree with Sharp to bring Alt 2 back. We also support Alt 2. |
| Ericsson | Not agree. There is no need to use the index of the slot containing S-SSB. We have from previous meetings the WA that the index of the slot containing the corresponding S-SSB is indicated in the payload of PSBCH, so there is no need to further indicate this information explicitly. We propose to the simpler alternative c\_init = N\_ID^SL. |
| Samsung | We are OK with the proposal if FL insists the benefit of Alt 1.  |
| Huawei/HiSilicon | We share similar view with Sharp that we need to bring back Alt2, especially considering Alt2 has more supporting companies.Our preference is Alt2, i.e. $c\_{init}=N\_{ID}^{SL}$.As analyzed in our Tdoc, considering the sidelink channel conditions are more variable than Uu due to the fast moving UEs, the interference might be already randomized. So overall there is no significant performance difference between Alt1 and Alt2.Considering an NR-V UE may maintain multiple sync sources simultaneously, the blind detection complexity resulting from Alt 1 may be significant. |
| Spreadtrum | We agree with other companies to bring Alt 2 back. We also support Alt 2.For SSB index in Alt.1, it is unknown for the Rx UE when detecting DMRS sequence, and therefore blind detection regarding this information is required. Furthermore in NR V2X, indicating partial S-SSB index by PSBCH DMRS sequence is not necessary, since timing information is indicated by slot index instead of S-SSB index. |
| Qualcomm | We share the majority view that PSBCH DMRS sequence is initialized based on Alt. 2.  |
| LGE | FL proposal is supported.Using S-SSB index is beneficial in two folds. First, it’s helpful for interference randomization in S-SSB detection/decoding. Second, it provides the order of S-SSB at least for FR1 from DM-RS detection, which can be used for confirming the slot index information from PSBCH decoding. |
| CATT | We support this proposal. |
| Nokia | We don’t support this proposal. As the SSB index is only used as sequential index in transmission time determination, and this is not needed by the receiveing UE to determine the timing, it would not seem necessary to introduce hypotheses to DMRS detection due to this. We would support bringing back Alt2 (and it is our preference among the two options).  |
| MediaTek | Disagree. We prefer Alt.2. Alt.1 may lead to more decoding attempts and channel estimations with high complexity. |
| Intel | We do see pros and cons in both alternatives. We are open to accept alternative supported by majority. Anyway, the designed PSBCH will be the most robust channel in the system. |
| Fujitsu | Disagree, since full slot index is included in the payload of PSBCH, there is no need to use DMRS to carry S-SSB index. |

**Issue 3 QCL for S-SSB transmission**

4/20-4/23

From the email responses 4/20-4/23, two directions of this issue are discussed.

* Majority companies think there is not applicable to have QCL for S-SSB transmission in NR SL because of broadcast and SFN transmission type of S-SSB. It is impossible to combine multiple S-SSBs based on QCL in a SFN. At every receiving time, a UE receives different S-SSBs due to moving.
* Three companies propose to apply QCL in NR V2X especially for FR2. In NR Uu, all of the broadcast signal/channel still have QCL assumption, and QCL here is for S-SSB reception but not transmission.

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| **Alternatives** | **QCL for S-SSB transmission** | **Supporting companies** |
| Alt. 1 | Do not support QCL mechanism for S-SSB transmissions in NR SL. | [Futurewei] [Sharp] [ZTE] [OPPO] [Ericsson] [Qualcomm] [LGE] [CATT] [Nokia] [MediaTek] [Intel] [Fujitsu] |
| Alt. 2 | Support a (pre-)configured parameter for determining the QCL assumption of S-SSB. | [vivo] [Samsung] [Huawei, HiSilicon]  |

4/23-4/24

From the proponent perspective, QCL should be defined in NR-V2X with benefitial. For the concerns that QCL cannot be applicable in NR V2X, the proponent has already explained the possibility and technical details. Even the majority companies do not support QCL in NR V2X, I still would like to ask other companies to have a check, because our work is to design SL sync mechanism technically.

FL comment:

I copied the proponent’s explanation as follows, and encourage companies to check and respond if necessary. From my perspective of reading the explanation by the proponent, it is applicable to have QCL in NR V2X.

***FL proposal:***

* ***QCL mechanism is not supported for S-SSB receptions in Rel-16 NR V2X.***

**Comments 4/24**

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| **Company** | **Views** |
| Huawei, HiSilicon | Disagree. We still think QCL relationship should be defined for NR-V2X. The necessities have been stated below. In summary, the benifts for QCL is following: * Multiple S-SSBs QCL within the same S-SSB period can be used to enhance the coverage of S-SSB in order to balance with that of PSSCH. Furthermore, it can further improve the detection performance and reduce the detection time since more than one S-SSB can be combined by the receiver.
* Benift the detection behavior between different S-SSB with the same S-SSB index in adjacent S-SSB periodicities, which has been supported by Uu link.

Some response to the some issues raised by some companies: Concern 1: It is impossible to combine multiple S-SSBs based on QCL in a SFN. Actually, the content will be different in SL-MIB at least the InC bit can be changed from in coverage to out of coverage. And if there is multiple timing from different UEs, from the receiver side, the slot index in the detected S-SSB would be different as well. Then SFN-type transmission cannot be assumed at least in the receiver side.Concern 2: At every receiving time, a UE receives different S-SSBs due to moving. It is possible, when UE distrutes in the whole 160ms periodicity, the speed has great impact on the QCL relationship. Then we have another proposal to reduce the interval such that all the S-SSB locates within 10 or 20 ms duration or smaller one at least in ITS band. Under this assumption, the speed impact will be reduced more. Actually, when multiple S-SSBs are transmitted from one Tx UE, even the Tx UE has high speed, the QCL relationship can still hold, i.e. the doopler shift, the delay spread, etc, should be the same. Similar cases happned when UE has high speed, some QCL assumption should still hold beteen S-SSB and PDSCH since the 20ms periodicity has been used for Pattern 1 SSB and CORESET 0 multiplex awayle there. Concern 3: The detection performance of S-SSB is only based on one-shot detection rather than any combination.Yes, the QCL relationship give the UE chance to do combing. This does not limit the UE has to do the S-SSB combination. It’s up to RAN4 how to define the performance requeriement and how good the performance will be according to different UE implementation. In summary, we proposal RAN1 to agree the following proposal as: ***Proposal 1: The UE may assume that SS/PSBCH blocks transmitted with the same block index and SLSSID on the same center frequency location are quasi co-located with respect to Doppler spread, Doppler shift, average gain, average delay, delay spread, and, when applicable, spatial Rx parameters.******Proposal 2: Support a (pre-)configured parameter for determining the QCL assumption of S-SSB within the S-SSB periodicity.**** ***R equally spaced S-SSB can be (pre-)configured QCLed.***

(v11)Disagree. We still think QCL relationship should be defined for NR-V2X. Since the following concern is mentioned by some companies, we’d like to give our views on it.Concern 4: As S-SSBs are sent in SFN manner, a receiving UE receives the summation of all the S-SSBs transmitted by the transmitting UEs from the different directions.Yes, there would be some scenarios where multiple UEs will transmit S-SSBs with the same content, i.e. S-SSB transmitted by UEs with one two hops from GNSS. Some companies may think this is not QCL.We share similar views with Samsung that we don’t agree the transmission of S-SSB is SFN type means QCL assumption is not needed. In NR Uu, all the broadcast signal/channel still have QCL assumption since it is a multi-beam broadcast. Furthermore, QCL assumption is for S-SSB reception, not transmission. We also think these cases should still be QCLed. The reason is that, for the above cases, the receiver can not distinguish any one of them. They act as different signals like multiple transmsion paths from a single UE. They are transmitted like SFN at least for FR1. This kind of SFN manner is truly a QCL. For example, if this is FR2, then it may not be treated as SFN, since the receiver need change its reception beam in relatively direction. It means if the QCL assumption can not be made by the receiver, the receiver has to distinguish one of them. This will result in some new system design requirement. But this is not true, as pointed, the receiver treats them as SFN transmission. Then definitely, this SFN is QCL. And this QCL can be applied to both within the S-SSB periodicity and between different S-SSB periodicities. |
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**Email responses in 4/23-4/24**

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| **Company** | **Views** |
| MediaTek | Agree. |
| Huawei, HiSilicon | Disagree. We still think QCL relationship should be defined for NR-V2X. The necessities have been stated below. In summary, the benifts for QCL is following: * Multiple S-SSBs QCL within the same S-SSB period can be used to enhance the coverage of S-SSB in order to balance with that of PSSCH. Furthermore, it can further improve the detection performance and reduce the detection time since more than one S-SSB can be combined by the receiver.
* Benift the detection behavior between different S-SSB with the same S-SSB index in adjacent S-SSB periodicities, which has been supported by Uu link.

Some response to the some issues raised by some companies: Concern 1: It is impossible to combine multiple S-SSBs based on QCL in a SFN. Actually, the content will be different in SL-MIB at least the InC bit can be changed from in coverage to out of coverage. And if there is multiple timing from different UEs, from the receiver side, the slot index in the detected S-SSB would be different as well. Then SFN-type transmission cannot be assumed at least in the receiver side.Concern 2: At every receiving time, a UE receives different S-SSBs due to moving. It is possible, when UE distrutes in the whole 160ms periodicity, the speed has great impact on the QCL relationship. Then we have another proposal to reduce the interval such that all the S-SSB locates within 10 or 20 ms duration or smaller one at least in ITS band. Under this assumption, the speed impact will be reduced more. Actually, when multiple S-SSBs are transmitted from one Tx UE, even the Tx UE has high speed, the QCL relationship can still hold, i.e. the doopler shift, the delay spread, etc, should be the same. Similar cases happned when UE has high speed, some QCL assumption should still hold beteen S-SSB and PDSCH since the 20ms periodicity has been used for Pattern 1 SSB and CORESET 0 multiplex awayle there. Concern 3: The detection performance of S-SSB is only based on one-shot detection rather than any combination.Yes, the QCL relationship give the UE chance to do combing. This does not limit the UE has to do the S-SSB combination. It’s up to RAN4 how to define the performance requeriement and how good the performance will be according to different UE implementation. In summary, we proposal RAN1 to agree the following proposal as: ***Proposal 1: The UE may assume that SS/PSBCH blocks transmitted with the same block index and SLSSID on the same center frequency location are quasi co-located with respect to Doppler spread, Doppler shift, average gain, average delay, delay spread, and, when applicable, spatial Rx parameters.******Proposal 2: Support a (pre-)configured parameter for determining the QCL assumption of S-SSB within the S-SSB periodicity.**** ***R equally spaced S-SSB can be (pre-)configured QCLed.***
 |
| LGE | FL proposal is supported. |
| Sharp | Agree. |
| Spreadtrum | We support FL proposal. As S-SSBs are sent in SFN manner, i.e. S-SSBs with the same SL SSID are sent from different Tx UEs, it is difficult for the RX to identify them individualy and perform QCL combinations over multiple transmissions. |
| Ericsson | Agree with the FL proposal. |
| Fujitsu | Agree |
| Nokia | Agree |

**Email responses in 4/20-4/23**

***Proposal 4: QCL mechanism is not used for S-SSB transmissions in NR SL.***

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| **Company** | **Views** |
| Futurewei | Support. Our understanding is that the proposal applies to one SSB period |
| Sharp | Support. We share the view stated already by some other companies that QCL is not applicable here in NR V2X due to the SFN type of transmissions of S-SSB. |
| Vivo | Not support.We prefer to support the QCL assumption between S-SSB within the same 160ms period. In FR2, up to 64 S-SSB are supported as beam-forming is used. By applying beamforming for S-SSB transmission, the synchronization coverage of a single S-SSB is increased. It also enables beam sweeping for S-SSB measurement as well as the reception. However, if the beam direction for S-SSB transmission is all up to UE implementation, the receiving UE can exploit the swept S-SSB neither for combining nor for measurement. If the QCL assumption is allowed, the receiving UE may have decided on a specific receiving beam based on measurement/reception on an S-SSB and it can then assume that the same direction can be also be used for the subsequent S-SSBs, which simplifies the UE implementation. |
| ZTE,Sanechips | Agreed |
| OPPO | Agree |
| Ericsson | Agree. It makes no sense to use the QCL mechanism in S-SSB transmission due to the broadcast nature of the S-SSB where it is not possible to perform QCL without many changes into the S-SSB mechanism. |
| Samsung | Not agree. QCL assumption for S-SSB is the kep feature to support soft combining of S-SSB, and without any QCL assumption, the coverage of S-SSB may not be sufficient especially for FR2. Totally don’t agree with the comment that the transmission of S-SSB is SFN type such that QCL assumption is not needed. In NR Uu, all the broadcast signal/channel still have QCL assumption, since it is a multi-beam broadcast.We also have question on the proposal wording itself. QCL assumption is for S-SSB reception, not transmission.  |
| Huawei/HiSilicon | We think QCL relationship should be defined for NR-V2X. QCL relationship is direct with the logic of LTE-V but not straight forward in NR-V2X since NR-V2X can be applied to both FR1 and FR2. First the S-SSB with same index should be QCL. For NR Uu link, we have the following specification as following in TS38.211:

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| The UE may assume that SS/PBCH blocks transmitted with the same block index on the same center frequency location are quasi co-located with respect to Doppler spread, Doppler shift, average gain, average delay, delay spread, and, when applicable, spatial Rx parameters. |

So the QCL relationship for the same S-SSB index should be QCL too. Furthermore, we also noticed for LTE-V2X, when RAN4 define the SLSS detection performance, multiple SLSS among different periodicity will be used to improve the detection performance. Hence, we have proposal 1 as similar as Uu link:***Proposal 1: The UE may assume that SS/PSBCH blocks transmitted with the same block index on the same center frequency location are quasi co-located with respect to Doppler spread, Doppler shift, average gain, average delay, delay spread, and, when applicable, spatial Rx parameters.***For FR1 and FR2, all the S-SSBs transmitted simultaneously or time to time. If the transmitter does not know which S-SSBs are QCLed, different UE will transmit S-SSB by different way according to UE implementation. And the S-SSB receiver has no knowledge about how or whether to combine S-SSBs. For PSSCH, maximum 32 retransmission can be used to improve the coverage and reliabilities. And then we also define multiple S-SSB transmissions to give the chance to balance the coverage of S-SSB with PSSCH. Furthermore, we noticed the UE type sync source selection/reselection delay would be large to 8.8s in LTE-V2X according to 36.133. Multiple S-SSB combination will reduce the time delay on selection or reselection SyncRef UE, this is very important both to V2X and public safety traffic. ***Proposal 2: Support a (pre-)configured parameter for determining the QCL assumption of S-SSB within the S-SSB periodicity.**** ***R equally spaced S-SSB can be (pre-)configured QCLed.***

During the discussion, some companies pointed the S-SSB is SFN-type transmissions. Actually, the content will be different in SL-MIB at least the InC bit can be changed from in coverage to out of coverage. And if there is multiple timing from different UEs, from the receiver side, the slot index in the detected S-SSB would be different as well. Then SFN-type transmission cannot be assumed at least in the receiver side.  |
| Qualcomm | We support the FL proposal. As also indicated by others, QCL for S-SSB wouldn’t apply here given the broadcast and SFN-type transmission. |
| LGE | FL proposal is supported.In a particular area of interest, a receiving UE receives the summation of all the S-SSBs transmitted by the transmitting UEs from the different directions. In this SFN reception of S-SSBs, combining based on QCL is not possible. Furthermore, even within a S-SSB period, there is no guarantee that the same UEs send S-SSBs for the S-SSB period as the UEs are constantly moving. The received sum of S-SSBs will be different at every receiving time. |
| CATT | Agree the above proposal.In NR SL, QCL is not applicable due to the antenna for S-SSB transmission in V2X are co-located. |
| Nokia | Support the proposal. Like noted during the discussions, UE may assume the given S-SSB is repeated every 160ms, while due to SFN type of transmission the “perceived QCL” may vary. |
| MediaTek | Support the proposal. To be noted, in NR V2X and NR uu, the detection performance of S-SSB is only based on one-shot detection rather than any combination. |
| Intel | Agree with proposal from FL. Reasons were provided in our tdoc - R1-2001995 |
| Fujitsu | Agree |