**3GPP TSG RAN WG1#104e R1-2nnnnnn**

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

**Agenda Item: 7.2.2**

**Source: Moderator (Lenovo)**

**Title: Email discussion/approval [104-e-NR-NRU-01] on DL signals and channels**

**Document for: Discussion, Decision**

This document summarises the discussion on the following topics:

[104-e-NR-NRU-01] Email discussion/approval on DL signals and channels **until Jan-29** – Alex (Lenovo)

High priority on

* DL-C1: Front-loaded DMRS collision with CORESET
* DL-C2: PDSCH mapping type B with durations larger than 7 symbols
* DL-C3: Processing time

Low priority on DL-A2: Search space set group switching

# Topic DL-C: DMRS for PDSCH mapping type B

## Issue DL-C1 (R1-2100240): Front-loaded DMRS collision with CORESET

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| Background:When front-loaded DMRS collides with a CORESET, it is shifted onto the first available symbol after the CORESET. For this case, the current specification prescribes different handlings of additionally configured DMRS depending on if the PDSCH duration is $l\_{d}=5$ or if it is$ l\_{d}=7$:* For $l\_{d}=5$, the UE will always receive the additional DMRS on the 5th symbol, no matter if the front-loaded DMRS is shifted or not. Thus, the gap between the two configured DMRS is varying.
* For $l\_{d}=7$, if the front-loaded DMRS is shifted with a certain number of symbols, then the additional DMRS is also shifted with the same number of symbols. In case the additional DMRS would appear on the last PDSCH position or even outside the PDSCH, the additional DMRS is dropped.

This different DMRS handling is illustrated in Figure 1 below:

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Figure 1 – Additional DMRS handling in case of shifted front-loaded DMRSIn our view there are multiple important reasons to harmonize the DMRS handling for different PDSCH durations:From the implementation perspective:* The UE implementation for $l\_{d}=5$ is complex. The gap between the two DMRS is varying which impacts the processing pipeline in the UE and the UE needs to prepare at most 4 interpolation filters depending on how many symbols the front-loaded DMRS is shifted.

From the performance perspective:* The purpose of the additional DMRS is to obtain better channel estimation in the presence of Doppler shifts, i.e. to estimate the channel rotation through interpolation. To make this operation meaningful, a certain minimum distance between the two DMRS should be preserved. Otherwise, there is no benefit coming from an interpolation and it would make more sense to drop the additional DMRS in order to send data instead.

From the specification:The specification can be simplified if the DMRS handling is made consistent. |
| **Proposal DL-C1-1:*****For PDSCH mapping type B with duration of 5 symbols, additional DMRS symbol is not transmitted if front loaded DMRS is shifted more than X symbols due to collision with CORESET. X can be FFS. Corresponding text proposal are provide in TP#3 in the appendix [R1-2100240].*** |

**Can the proposal DL-C1-1 be accepted?**

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| Company  | Comments |
| Qualcomm | We support the proposal. This aligns better with the design of other duration type B PDSCH. We would suggest X=0 in the FFS above. In other words, additional DMRS not transmitted when front load DMRS is shifted. |
| Ericsson | Support the proposal with X = 0 with the understanding that the allowed patterns are thus 10001, 01000, 00100, and 00010.We think that the TP in R1-2100240 could be improved such that it aligns more closely with the l\_d = 7 case. For example, the following text could be adopted:* if the PDSCH duration $l\_{d}$ is 5 symbols and if one additional single-symbol DMRS is configured, the UE expects the additional DM-RS to be transmitted on the ~~fifth~~ 5th symbol when the front-loaded DM-RS symbol is in the 1st symbol of the PDSCH duration, otherwise the UE should expect that the additional DM-RS is not transmitted;
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| LG Electronics | We are supportive of the proposal and X=0 is preferred to keep the gap between two DM-RS symbols same as in 7-symbol case. OK with Ericsson’s TP. |
| ZTE, Sanechips | We agree the proposal and support X=0. Besides, the updated TP from Ericsson seems better. |
| vivo | Agree the proposal and support X=0. Besides, another alternative simple solution is not to allow additional DM-RS if the PDSCH duration $l\_{d}$ is 5 symbols since the additional DM-RS located in the last symbol may impact the processing time. |
| Nokia, NSB | Strictly speaking this is not an essential correction, but a functional and non-backwards compatible modification of functionality. The spec is not broken, the proposal just wants to change how it works to something “nicer”. Still, we don’t object if there is a strong desire to do this and see Ericsson TP better than the original proposal.  |
| Samsung | Fine with Ericsson TP |
| Huawei, HiSilicon | We support the proposal (X=0). The additional DMRS location of l\_d=5 when the front loaded DMRS is shifted due to collision with COREST was not discussed during the WI and previous maintenance. The consistent design between l\_d=5 and l\_d=7 will simplify UE implementation. Additionally, the additional overhead paid for l\_d=5 do not provide obvious benefit if the front loaded DMRS is shifted close to the additional DMRS. |
| Spreadtrum | We are fine with Ericsson’s updated TP. |
| Sharp | We share the views from Nokia that this is a kind of optimization. Having said that, we can accept the proposal with X=0 if the majority prefers to support it. We also think Ericsson’s TP is better. |

FL Summary:

A majority supports or is fine with Proposal DL-C1-1 with X=0. It is therefore suggested to agree to Proposal DL-FL1, and continue with TP discussion in secton 3 (merged with Issue DL-C2, and based on Ericsson's modification).

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| Proposal DL-FL1:For PDSCH mapping type B with duration of 5 symbols, an additional DMRS symbol is not transmitted if front loaded DMRS is shifted due to a collision with a CORESET.Continue TP drafting discussion. |

## Issue DL-C2 (R1-2100240, R1-2100818): PDSCH mapping type B with durations larger than 7 symbols

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| Background [R1-2100240]:According to Table 7.4.1.1.2-4 in TS38.211, for PDSCH mapping type B with durations larger than 7 symbols, the UE may be configured with double-symbol additional DMRS. When the front-loaded DMRS collides with a CORESET, then the additional DMRS symbols will be shifted together with the front-loaded DMRS. According to the current specification text in TS 38.211 as copied below,It is possible that a part of the double-symbol additional DMRS symbols are shifted outside of valid range and cannot be transmitted. An example is plotted for the case of $l\_{d}=8$ in Figure 2 below. In order to perform channel estimation on DMRS ports differentiated by OCC in the time domain, both of the double-symbol DMRS are required in their entirety. Thus, if only a part of the additional DMRS is transmitted, there is no benefit. A simple solution with minimum standard impact would be to drop the whole double-symbol additional DMRS symbols in this case.- for all values of the PDSCH duration $l\_{d}$ other than 2, 5, and 7 symbols, the UE is not expected to receive a DM-RS symbol beyond the $(l\_{d}-1)$:th symbol;Figure 2 DMRS shifting due to collision with CORESET ($l\_{d}=8$) |
| **Proposal DL-C2-1:*****For PDSCH mapping type B with duration larger than 7 symbols, double-symbol additional DMRS symbols will be dropped if any of the symbols is located beyond the*** $(l\_{d}-1)$***:th symbol. The corresponding text proposal is in TP#3 in the appendix [R1-2100240].*** |

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| Background [R1-2100818]:The DMRS position for PDCSH mapping Type B durations {3,5,6,8,9,10,11,12,13} have been captured in 38.211 v16.4.0 section 7.4.1.1.2 [2] according to the agreements. For all values of the PDSCH duration $l\_{d}$ other than 2, 5, and 7 symbols, it is specified that UE is not expect to receive a DM-RS symbol beyond the $\left(l\_{d}-1\right):$th symbol. Here for double-symbol DMRS, if the front-loaded DMRS of PDSCH allocation collides with resources reserved for a CORESET, the additional DMRS may shift to the last two symbols of the PDSCH allocation. According to the current specification, the last DMRS symbol will be dropped. However, in case of double-symbol DMRS, only one DMRS symbol cannot be used for channel estimation. Since the remaining DMRS symbol of the additional DMRS is useless, it can be discarded and the occupied REs can be used for PDSCH transmission to improve PDSCH performance. Figure 1 shows an example of double-symbol DMRS drop issue.Figure 1If the PDSCH duration $l\_{d}$ is 12 or 13 symbols, it is also specified that the UE is not expected to receive a DM-RS symbol mapped to symbol 12 or later in the slot. Here for double-symbol DMRS, if the front-loaded DMRS of PDSCH allocation collides with resources reserved for a CORESET, the later DMRS symbol of the additional DMRS may shift to symbol 12 of the PDSCH. According to the current specification, this DMRS symbol will be dropped. Then the same issue for channel estimation occurs. Figure 2 shows another example of double-symbol DMRS drop issue.Figure 2 |
| **Proposal DL-C2-2:**- if the PDSCH duration $l\_{d}$ is 12 or 13 symbols, the UE is not expected to receive additional DM-RS mapped to symbol 12 or later in the slot;- for all values of the PDSCH duration $l\_{d}$ other than 2, 5, and 7 symbols, the UE is not expected to receive a DM-RS symbol beyond the $(l\_{d}-1)$:th symbol if single-symbol DMRS is used;- for all values of the PDSCH duration $l\_{d}$ larger than 7 symbols, the UE is not expected to receive additional DM-RS beyond the $(l\_{d}-1)$:th symbol if double-symbol DMRS is used; |

**Can the above proposals DL-C2-1 and DL-C2-2 be accepted?**

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| Company  | Comments |
| Qualcomm | Support DL-C2-1For DL-C2-2, agree in principle that when two symbol DMRS is used, we should drop both DMRS symbol if one is dropped. We may need to clarify that in a TP.Additionally, even for front loading DMRS, we have some problem. Currently, the front loading DMRS will keep shifting if there is a collision with CORESET. For a UE configured with mini-slot PDCCH monitoring, it is possible that the UE will keep shifting the front load DMRS to the end of type B PDSCH. For length 7, there is Rel.15 restriction on front loaded DMRS will not be shifted beyond the fourth symbol. We should introduce similar restriction with proposed TP below==========beginning of TP for 38.211 7.4.1.1.2============ - if the PDSCH duration $l\_{d}$ is 7 symbols for normal cyclic prefix or 6 symbols for extended cyclic prefix: - - if one additional single-symbol DM-RS is configured, the UE only expects the additional DM-RS to be transmitted on the 5th or 6th symbol when the front-loaded DM-RS symbol is in the 1st or 2nd symbol, respectively, of the PDSCH duration, otherwise the UE should expect that the additional DM-RS is not transmitted;- if the PDSCH duration $l\_{d}$ is 5, 6, 7, 8, 9, 10, 11, 12, or 13 symbols, the UE is not expected to receive the front-loaded DM-RS beyond the fourth symbol: =======end of TP===================  |
| Ericsson | Support DL-C2-1 and DL-C2-2For DL-C2-2, it seems some harmonization with the TP for DL-C2-1 could be achieved.  |
| LG Electronics | Agree with Qualcomm. That is, we are OK to drop both of double-symbol DM-RS if at least one of them is not valid. Furthermore, we support to restrict the location of the front-loaded DM-RS up to the fourth symbol, same as 7-symbol case in Rel-15. |
| ZTE, Sanechips | Agree with Qualcomm. |
| vivo | Agree with Qualcomm |
| Nokia, NSB | DL-C2-1&2: Agree in principle, the full DMRS should be dropped if half of it is out of the allocation. The TP for the two issues need to be developed jointly with DC-C2-2 if both are agreed.  |
| Samsung | Agree with Qualcomm |
| Huawei, HiSilicon | Proposal DL-C2-1 and DL-C2-2 discuss the same issue. We agree with Qualcomm that the issue may happen to front loaded DMRS as well. We support to clarify in the spec that the full double-symbol DMRS should be dropped even if it is partially outside of the valid range. The exact TP could be discussed if the proposal(s) were agreed. |
| Spreadtrum | We support proposal DL-C2-1 and DL-C2-2.And the exact TP could be developed if the proposal(s) were agreed. |
| Sharp | Support DL-C2-1 and DL-C2-2 with the restriction proposed by Qualcomm. |

FL Summary:

A majority supports or is fine with Proposals DL-C2-1 and DL-C2-2, with the modification by Qualcomm that not be shifted beyond the fourth symbol for front-loaded DM-RS if the PDSCH duration is 5-13 symbols.

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| Proposal DL-FL2:Continue discussion in TP drafting (section 3) to cover Proposals DL-C2-1 and DL-C2-2 including the following additional modification:if the PDSCH duration $l\_{d}$ is 5, 6, 7, 8, 9, 10, 11, 12, or 13 symbols, the UE is not expected to receive the front-loaded DM-RS beyond the fourth symbol. |

## Issue DL-C3 (R1-2100240): Processing time

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| Background:According to table 5.3-1 in TS 38.214, when additional DMRS is configured, the maximum allowed PDSCH decoding time N1 is relaxed by 3 symbols. The reason is that in this situation, DMRS will appear late in the PDSCH and the UE will start later with channel estimation and sub-sequent operations as shown in the upper part of figure 3.However, when only front-loaded DMRS is configured, no relaxation of the PDSCH decoding time N1 is allowed according to the specification as illustrated in the lower part of figure 3. This poses a problem for the UE implementation in case the DMRS collides with a CORESET. Then, the DMRS can be shifted and it will appear late in the PDSCH. Similar to the situation described above, also here the channel estimation operation and the subsequent demodulation/decoding will be delayed. The UE may not be able to finish the PDSCH decoding and HARQ-ACK preparation. A detailed description and analysis of this issue can be found in section 2.3 of [2].Figure 3– Timing requirements on N1 for additional DMRS being configured vs shifted DMRSIn order to overcome the above mentioned problems, which will be especially severe for processing time capability #2, the timing requirement should also be relaxed when PDSCH DMRS overlaps with a search space set that is associated with a CORESET. One possibility could be to extend Tproc,1 with an additional “delta”-value. However, this option needs modifications of the current specification, which may not be the preferred approach at this current late stage. If RAN1 could not agree to relax the UE processing time requirements, another possibility is to introduce a new UE capability for handling the DMRS shift due to a collision with search space sets. |
| **Proposal DL-C3-1:*****In order to address the issue of a reduced UE processing time budget in case of DMRS shift, RAN1 should consider one of the following options:**** ***Option 1: Relaxation of the UE processing time requirement in case of DMRS shift.***
* ***Option 2: Introduce a Rel-16 UE capability for UEs not supporting DMRS shift due to collisions with search space sets that are associated with a CORESET.***
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**Can proposal DL-C3-1 be accepted?**

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| Company  | Comments |
| Qualcomm | Agree with the issue. Some of the problem can be addressed by our proposal in issue DL-C2 to restrict how far the front-loaded DMRS can shift. More fundamentally, we may want to capture the front-loaded DMRS shift in the processing time (Option 1). A simple solution might be adding the shift in symbols to the processing time budget. |
| LG Electronics | Agree with Qualcomm. If we can restrict the location of the front-loaded DM-RS up to the fourth symbol, UE processing time relaxation may not be needed. |
| ZTE, Sanechips | Agree with Qualcomm. |
| vivo | Agree with Qualcomm |
| Nokia, NSB | This proposal seems to be altering a Rel-15 processing timeline and as such is out of the question. New Rel-16 incapability for DMRS shift of a basic Rel-15 is also out of the question, these new UEs would not work in old networks. This proposal belongs to 7.1, and cannot be discussed in this agenda item. |
| Samsung | Agree with Qualcomm. |
| Huawei, HiSilicon | We support the proposal. Compared with the case of additional DMRS, we find UE may require even tighter UE processing delay when the front loaded DMRS may be shifted to a late position due to collision with CORESET for the newly introduce PDSCH length, such as l\_d=5. Although restricting the shifting range can alleviate the issue, we think a more straightforward method is to relax UE processing capability taking into account of DMRS shifting. |
| Spreadtrum | Agree with Qualcomm |
| Sharp | Agree with Qualcomm. |

FL Summary:

Many companies think the issue could be at least partially resolved by the solution to DL-C2. One company expressed strong concerns if a solution is adopted that changes the Rel-15 processing timeline.

# Topic DL-A: PDCCH Monitoring

## Issue DL-A2 (R1-2101304): Search space set group switching

FL NOTE: This issue has been identified as low priority.

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| Background:In 38.213 Section 10.4 on search space set group switching, the UE procedure associated with the expiration of the timer is described. In the current version of the specification it states that the UE switches back to group 0… after a slot where the timer expires or after a last symbol of a remaining channel occupancy duration for the serving cell that is indicated by DCI format 2\_0This sentence implies that the field in DCI Format 2\_0 that indicates the remaining channel occupancy duration is always present. However, as can be seen from 38.212 Section 7.3.1.3.1 the presence of this field depends on the RRC parameter *co-DurationsPerCellToAddModList* which is optionally is configured:- If the higher layer parameter *co-DurationsPerCellToAddModList* is configured- COT duration indicator 1, COT duration indicator 2, …, COT duration indicator *N2.*To cover the optional presence of the remaining COT duration indicators in DCI 2\_0, the wording "that is" should be changed to "if." A correction for this is contained in TP#1. |
| **Proposal DL-A2-1:****Adopt Text Proposal TP#1 for TS 38.213 Section 10.4.:**Reason for changesUE behavior associated with search space set switching to group 0 does not cover the case when the remaining channel occupancy duration field in DCI 2\_0 is not present.Summary of changes* Change wording "that is" to "if" to cover the case when the remaining channel occupancy duration field in DCI 2\_0 is not present

Specs/Sections impacted38.213 Section 10.4Consequences if not approvedUE behavior on search space set switching to group 0 is undefined when the remaining channel occupancy duration field in DCI 2\_0 is not present.------------------------------- Text Proposal (TP#1) for 38.213, Section 10.4 -------------------------------\*\*\* Unchanged text omitted \*\*\*If a UE is provided by *SearchSpaceSwitchTrigger* a location of a search space set group switching flag field for a serving cell in a DCI format 2\_0, as described in Clause 11.1.1; - […]- if the UE monitors PDCCH for a serving cell according to search space sets with group index 1, the UE starts monitoring PDCCH for the serving cell according to search space sets with group index 0, and stops monitoring PDCCH according to search space sets with group index 1, for the serving cell at the beginning of the first slot that is at least $P\_{switch}$ symbols after a slot where the timer expires or after a last symbol of a remaining channel occupancy duration for the serving cell if indicated by DCI format 2\_0If a UE is not provided *SearchSpaceSwitchTrigger* for a serving cell,- […]- if the UE monitors PDCCH for a serving cell according to search space sets with group index 1, the UE starts monitoring PDCCH for the serving cell according to search space sets with group index 0, and stops monitoring PDCCH according to search space sets with group index 1, for the serving cell at the beginning of the first slot that is at least $P\_{switch}$ symbols after a slot where the timer expires or, if the UE is provided a search space set to monitor PDCCH for detecting a DCI format 2\_0, after a last symbol of a remaining channel occupancy duration for the serving cell if indicated by DCI format 2\_0\*\*\* Unchanged text omitted \*\*\*------------------------------------------------ End Text Proposal -------------------------------------------------- |

**Can proposal DL-A2-1 be accepted?**

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| Company  | Comments |
| Qualcomm | Fine with the TP |
| Ericsson | Support the TP (as proponent) |
| LG Electronics | Support the TP |
| ZTE, Sanechips | Agree the TP. |
| vivo | Agree the TP |
| Nokia, NSB | Support the TP |
| Samsung | Support the TP |
| Huawei, HiSilicon | Support the TP |
| Spreadtrum | Support the TP |
| Sharp | Fine with the TP |

FL Summary:

All companies replying to this issue are fine with the TP.

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| Proposal DL-FL3:Adopt TP#1 for TS 38.213 Section 10.4 from R1-2101304. |

# TP Discussion (Issues DL-C1 and DL-C2)

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| =====================TP for 38.211 Section 7.4.1.1.2 =============================< Unchanged parts are omitted >For PDSCH mapping type B- if the PDSCH duration $l\_{d}$ $\in \left\{2,3,4,5,6,7,8,9,10,11,12,13\right\}$ OFDM symbols for normal cyclic prefix or $l\_{d}\in \left\{2,4,6\right\}$ OFDM symbols for extended cyclic prefix, and the front-loaded DM-RS of the PDSCH allocation collides with resources reserved for a search space set associated with a CORESET,  shall be incremented such that the first DM-RS symbol occurs immediately after the CORESET and until no collision with any CORESET occurs, and- if the PDSCH duration $l\_{d}$ is 2 symbols, the UE is not expected to receive a DM-RS symbol beyond the second symbol;- if the PDSCH duration $l\_{d}$ is 5 symbols and if one additional single-symbol DMRS is configured, the UE only expects the additional DM-RS to be transmitted on the 5th symbol when the front-loaded DM-RS symbol is in the 1st symbol of the PDSCH duration, otherwise the UE should expect that the additional DM-RS is not transmitted;- if the PDSCH duration $l\_{d}$ is 7 symbols for normal cyclic prefix or 6 symbols for extended cyclic prefix: - if one additional single-symbol DM-RS is configured, the UE only expects the additional DM-RS to be transmitted on the 5th or 6th symbol when the front-loaded DM-RS symbol is in the 1st or 2nd symbol, respectively, of the PDSCH duration, otherwise the UE should expect that the additional DM-RS is not transmitted;- if the PDSCH duration $l\_{d}$ $\in \left\{5,6,7,8,9,10,11,12,13\right\}$ OFDM symbols, the UE is not expected to receive the front-loaded DM-RS beyond the 4th symbol; - if the PDSCH duration $l\_{d}$ is 12 or 13 symbols, the UE is not expected to receive additional DM-RS mapped to symbol 12 or later in the slot;- for all values of the PDSCH duration $l\_{d}$ other than 2, 5, and 7 symbols, the UE is not expected to receive a DM-RS symbol beyond the $(l\_{d}-1)$:th symbol if single-symbol DMRS is used;- for all values of the PDSCH duration $l\_{d}$ larger than 7 symbols, the UE is not expected to receive additional DM-RS beyond the $(l\_{d}-1)$:th symbol if double-symbol DMRS is used;- if the PDSCH duration $l\_{d}$ is less than or equal to 4 OFDM symbols, only single-symbol DM-RS is supported. - if the higher-layer parameter *lte-CRS-ToMatchAround*, *lte-CRS-PatternList1*, or *lte-CRS-PatternList2* is configured, the PDSCH duration $l\_{d}=10$ symbols for normal cyclic prefix, the subcarrier spacing configuration $μ=0$, single-symbol DM-RS is configured, and at least one PDSCH DM-RS symbol in the PDSCH allocation collides with a symbol containing resource elements as indicated by the higher-layer parameter *lte-CRS-ToMatchAround*, *lte-CRS-PatternList1*, or *lte-CRS-PatternList2*, then $\overbar{l}$ shall be incremented by one in all slots.The time-domain index $l'$ and the supported antenna ports $p$ are given by Table 7.4.1.1.2-5 where - single-symbol DM-RS is used if the higher-layer parameter *maxLength* in the *DMRS-DownlinkConfig* IE is not configured- single-symbol or double-symbol DM-RS is determined by the associated DCI if the higher-layer parameter *maxLength* in the *DMRS-DownlinkConfig* IE is equal to 'len2'.< Unchanged parts are omitted >=============================end of the TP ================================== |

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| Company  | Comments |
| LG Electronics | One question for the last change: Wouldn’t it be correct not to receive additional DM-RS symbols beyond the $(l\_{d}-2)$:th symbol?- for all values of the PDSCH duration $l\_{d}$ larger than 7 symbols, the UE is not expected to receive additional DM-RS beyond the $(l\_{d}-1)$:th symbol if double-symbol DMRS is used; |
| Huawei, HiSilicon | The TP is fine. As for the last two modifications, we had another more compact TP in our tdoc R1-2100240- for all values of the PDSCH duration $l\_{d}$ other than 2, 5, and 7 symbols, the UE is not expected to receive DM-RS beyond the $(l\_{d}-1)$:th symbol;It can cover both single-symbol DMRS and double-symbol DMRS case.  |
| Spreadtrum | The TP is fine.To LG:In case of double-symbol DM-RS, the DMRS positions with l\_d equals 8 are (l0, 5) for. This means that the additional DMRS positions are located in the 6th and 7th symbol. Therefore, if UE is not expected to receive the additional DM-RS symbols beyond the $(l\_{d}-2)$:th symbol, that will contradict the current spec. The same happens when l\_d equals 10 or 12.To Huawei:Our motivation for distinguishing between single-symbol DMRS case and double-symbol DMRS case is to make the specification legible. As we all know, for double-symbol DMRS, only when l\_d is larger than 7, the additional DMRS is applicable. Therefore, the wording “for all values of PDSCH duration $l\_{d}$ other than 2, 5, and 7 symbols” may not be accurate enough. However, if other companies think that Huawei’s TP is sufficient, then we can also go with Huawei’s TP. |