**3GPP TSG RAN WG1 #110 R1-22xxxxx**

**Toulouse, France, August 22nd – 26th, 2022**

**Source: Moderator(vivo)**

**Title: Summary of SL power control P0 issue in R1-2206715**

**Agenda item: 7.2.4**

**Document for:** **Discussion and Decision**

Introduction

In RAN1#110 meeting, one contribution [1, vivo] is submitted to clarify the SL power control. According to the chairman’s guidance, this document is to collect companies’ views on the issue of SL power control raised in R1-2206715.

[de-actived]Discussion before Wednesday online

## Round 1

In [1], the following issue was identified:

In the power control formula in Uu, the transmission power of PUCCH or PUSCH is related to **two components**: P0 and P0nominal, whereas the value range of P0 for PUCCH or PUSCH is **[-16,15]**, and the value range of P0nominal for PUCCH or PUSCH is **[-202..24]**. While the value range for P0 used for power control of PSCCH/PSSCH/PSFCH/S-SSB is [-16,15], the same as that for Uu, but the **P0nominal is missing and the corresponding RRC parameter has even not been defined in R16 SL**. This results in inappropriate transmission power for SL, e.g., the controllable Tx power range of SL is much smaller than UL, and consequently, the minimum SL power would be much larger than that of UL, which causes strong interference to UL in the same frequency. This defeats the purpose of DL pathloss-based SL power control, which is to mitigate interference to the UL reception of the gNB. The relevant NR spec text is copied in appendix A for convenience.

Moreover, it was agreed that the baseline for R16 SL open-loop power control is R14 LTE V2X open-loop power control, in which case only P0 is considered. But it should be noted that the lower limit for *P0-SL* for LTE V2X is the same as the lower limit for *p0-NominalPUSCH* for LTE UL(i.e., -126).

* LTE UL

UplinkPowerControlCommon ::= SEQUENCE {

p0-NominalPUSCH INTEGER (-126..24),

alpha Alpha-r12,

p0-NominalPUCCH INTEGER (-127..-96),

deltaFList-PUCCH DeltaFList-PUCCH,

deltaPreambleMsg3 INTEGER (-1..6)

}

UplinkPowerControlDedicated ::= SEQUENCE {

p0-UE-PUSCH INTEGER (-8..7),

deltaMCS-Enabled ENUMERATED {en0, en1},

accumulationEnabled BOOLEAN,

p0-UE-PUCCH INTEGER (-8..7),

pSRS-Offset INTEGER (0..15),

filterCoefficient FilterCoefficient DEFAULT fc4

}

* LTE V2X

SL-TxParameters-r12 ::= SEQUENCE {

alpha-r12 Alpha-r12,

p0-r12 P0-SL-r12

}

P0-SL-r12 ::= INTEGER (-126..31)

-- ASN1STOP

| *SL-TxParameters* field descriptions |
| --- |
| ***alpha***  Parameter(s): ,,,,,,, See TS 36.213 [23], clauses 14.1.1.5, 14.2.1.3, 14.3.1 and 14.4, where al0 corresponds to 0, al04 corresponds to value 0.4, al05 to 0.5, al06 to 0.6, al07 to 0.7, al08 to 0.8, al09 to 0.9 and al1 corresponds to 1. This field applies for sidelink power control. |
| ***p0***  Parameter: ,,,,,,, see TS 36.213 [23], clauses 14.1.1.5, 14.2.1.3, 14.3.1 and 14.4, unit dBm. |

|  |
| --- |
| Agreements:   * SL open-loop power control is supported.   + For unicast, groupcast, broadcast, it is supported that the open-loop power control is based on the pathloss between TX UE and gNB (if TX UE is in-coverage).     - This is at least to mitigate interference to UL reception at gNB.     - Rel-14 LTE sidelink open-loop power control is the baseline.     - gNB should be able to enable/disable this power control.   + At least for unicast, it is supported that the open-loop power control is also based on the pathloss between TX UE and RX UE.     - (Pre-)configuration should be able to enable/disable this power control.     - FFS whether this is applicable to groupcast     - FFS whether this requires information signaling in the sidelink.   + Further study its potential impact, e.g., on resource allocation. * FFS whether closed-loop power control is additionally needed |

Observation 1: NR PUCCH or PUSCH transmission power is determined based on two components: P0 and P0nominal. However, in NR SL, P0nominal is not defined, which results in inappropriate or incorrect TX power for SL transmission and also defeats the purpose of mitigating interference to UL reception at gNB.

To address this issue, the following options are proposed:

* Option 1. Introduce new RRC parameters (e.g., *dl-P0-nominal-PSSCH-PSCCH, sl-P0-nominal-PSSCH-PSCCH, dl-P0-nominal-PSBCH, dl-P0-nominal-PSFCH*) indicating the nominal power for PSSCH/PSCCH/S-SSB/PSFCH, and modify the power formula by adding the value of the nominal power for sidelink transmission.
* Option 2. Reuse the nominal power of UL transmission (e.g., the value indicated by p0-NominalWithGrant) for SL power control.
* Option 3. Change the value range of the existing RRC parameter P0, e.g., to [-218, 39], or other value ranges.

Option 1 and option 3 are much more flexible and aligned with the Uu, however, both of them require RRC specification changes. Option 2 requires PHY spec change only. However, it is only applicable to in-coverage UE (e.g., connected UE or idle UE), but not applicable to OoC UE (e.g., OoC UE performing SL pathloss-based power control).

**Q1: Do you agree that the issue of SL power control as discussed in** [1] **should be addressed?**

|  |  |  |
| --- | --- | --- |
| **Company** | **agree or not** | **Comment** |
| vivo | yes | If this issue is not addressed, the SL TX power would be forced to be Pcmax or Pmax,CBR even if DL PL or SL PL is used for SL power control, which would lead to large interference to UL reception at gNB side or to SL reception of other SL UEs. |
| Intel | Comments | We acknowledge that the resulting power control is different due to the different parameter ranges, but at this stage to us it is unclear what the parameter range of UL would be and whether the range for SL needs to be the same, considering that the UL has closed loop power control, but the SL only has open loop power control.  [vivo 2022/8/22]  Firstly, in LTE, as shown in the discussion section, the minimum value of P0 of V2X is the same as the minimum value of P0nominal of UL, i.e., -126, so that the value range of LTE V2X power can be similar as that of Uu and strong interference from V2X to Uu can be avoided by proper configuration. Moreover, it was agreed to use LTE V2X PC as baseline for NR SL PC, thus it is reasonable and essential to keep at least the same or similar value limit between NR SL power and LTE SL power.  Second, a typical case of NR SL is that SL BWP bandwidth = Uu BWP bandwidth and under this assumption it can be seen that when the P0nominal of UL is small (e.g. -100dBm, a typical value of P0nominal is <=-100dBm), the UL power can be much lower than the SL power according to the current formula. Furthermore, the P0nominal of UL and the P0 of NR SL can be cell-specific provided, which means all UEs within the cell coverage are suffering the SL-UL power gap due to (P0 of UL + P0nominal of UL) *minus* (P0 of SL). It is difficult to compensate this gap by configuration solely. SL UEs, especially those in cell-centre, are forced to transmit SL with a SL transmit power much higher than their UL transmit power, thus causing strong interference to the gNB.  The proposed changes are just to reuse the LTE V2X design principle and reflect the previous agreement. |
| ZTE,Sanechips | No | It's not clear why this would lead to interference over UL.  [vivo 2022/08/22] please check my comments to intel. The SL UEs in coverage, especially those in cell-centre, are forced to transmit SL with a SL transmit power that can be much higher than their UL transmit power, thus causing strong interference to the gNB. |
| Qualcomm | No | At this stage, Rel-16 changes should be avoided to the extent possible, especially since the solutions are NBC |
| OPPO | Comment | We prefer to not change the power control mechanism for SL at this stage. One more question for clarification: if SL power control (PC) maintain the current mechanism without change based on the new updated power control in Uu, does the current SL PC mechanism broken?  [vivo 2022/8/22] please check my comments to intel and ZTE. |
| Nokia, Nokia Shanghai Bell | Yes |  |
| Huawei, HiSilicon | Comments | It seems P0\_nomial refers to a cell specific parameter, but there is no concept on cell in SL. So not sure whether this change is needed or not. |
| Samsung | Comments | We also not prefer to change the power control mechanism for SL at this stage. |

**Q2: If the answer to Q1 is yes, which option do you prefer? If you have concerns about the options, please further elaborate on your concerns or a different option to address this issue.**

|  |  |  |
| --- | --- | --- |
| **Company** | **Option** | **Comment** |
| vivo | Option2 or option1 | Option2 avoids changes to ASN.1, thus it is our first preference. However, option 2 has a disadvantage that it does not solve the problem of power control of the OoC UE, in other words, SL TX power control based on SL PL for unicast transmission of OoC UE is still broken. Option1 is also supported to fix this issue for both IC UE and OoC UE. If option1 is agreed, we need to send a LS to RAN2 for ASN.1 change. |
| Nokia, Nokia Shanghai Bell | Option 3 | The range of the parameter should be be changed. It can be the same as the range specified for PUSCH. |
|  |  |  |

## Round 2

[updated by vivo 2022/08/22]

@all, thank you all for the valuable inputs. It seems all companies acknowledged that the resulting power control could be quite different: 2 companies think the issue should be fixed. 1 company have concerns on Rel-16 spec change because the change will be NBC. 2 companies are not sure if there would be strong interference or anything broken. One company is not sure if the value range between SL and Uu need to be the same.

Please check my responses marked in red in the table of Q1 and hopefully they can address your concerns. I also copied my responses below for convenience.

“*Firstly, in LTE, as shown in the discussion section, the minimum value of P0 of V2X is the same as the minimum value of P0nominal of UL, i.e., -126, so that the value range of LTE V2X power can be similar as that of Uu and strong interference from V2X to Uu can be avoided by proper configuration. Moreover, it was agreed to use LTE V2X PC as baseline for NR SL PC, thus it is reasonable and essential to keep at least the same or similar value limit between NR SL power and LTE SL power.*

*Second, a typical case of NR SL is that SL BWP bandwidth = Uu BWP bandwidth and under this assumption it can be seen that when the P0nominal of UL is small (e.g. -100dBm, a typical value of P0nominal is <=-100dBm), the UL power can be much lower than the SL power according to the current formula. Furthermore, the P0nominal of UL and the P0 of NR SL can be cell-specific provided, which means all UEs within the cell coverage are suffering the SL-UL power gap due to (P0 of UL + P0nominal of UL) minus (P0 of SL). It is difficult to compensate this gap by configuration solely. SL UEs, especially those in cell-centre, are forced to transmit SL with a SL transmit power much higher than their UL transmit power, thus causing strong interference to the gNB.*

*The proposed changes are just to reuse the LTE V2X design* *principle and reflect the previous agreement.”*

Regarding the concerns on NBC, one way is to introduce these changes to spec of later releases instead of Rel-16.

In my understanding, this issue should be fixed and the proposed changes are to reuse the LTE V2X design principle and reflect the previous agreement. So, I would like to try another round. Please provide your views if you are ok to address the issue in [1], and if it is acceptable to introduce changes for Rel-16 spec or for Rel-17 spec only.

**Q3: Do you agree with introducing spec changes to address the issue in [1]? If yes, which alt of the following alternatives is preferred? and which option (i.e., option1/2/3) do you prefer for spec change?**

**Alt1. Introduce changes to Rel-16 spec to fix this issue**

**Alt2. Introduce changes to Rel-17 spec only to fix this issue and to avoid NBC**

|  |  |  |  |
| --- | --- | --- | --- |
| **Company** | **Yes or no** | **Alt1 or alt2** | **Comment** |
| vivo | Yes | Either way is fine | We prefer to fix it in Rel-16, but if there is strong concern on NBC issue, we are ok with alt2 to fix it in Rel-17.  [2022/08/23] regarding which option is used for spec change, we replied before, we prefer option2 and option1. But option3 is also fine. |
| Ericsson | Yes | Alt1 is preferable, would be fine with Alt 2 too. | At this stage, we are fine with Option 3. |
| Intel | Yes | Alt2 | While we acknowledge the criticality of this issue, we believe that fixing it in Rel-16 is not possible at this point in time. However, if the group believes this issue should be solved, we are open to discuss/address it further in Rel-17 during this maintenance phase. |
| OPPO | Comment | comment | We prefer not to change the power control mechanism at this stage unless there has essential issue. However, if such issue has to be resolved, Option 3 can be considered to change the value range in R17. |
| Sharp | Yes | Alt2 | We prefer Option 3. |

[de-activated]Proposal for online session (Wednesday)

Based on the feedback in the first and second rounds, and further offline with some of the companies, I think the group has acknowledged the issue, but has diverge views on how to fix it.

There are three options to address this issue:

* Option 1. Introduce new RRC parameters (e.g., *dl-P0-nominal-PSSCH-PSCCH, sl-P0-nominal-PSSCH-PSCCH, dl-P0-nominal-PSBCH, dl-P0-nominal-PSFCH*) indicating a nominal power for PSSCH/PSCCH/S-SSB/PSFCH, and modify the power formula by adding the value of the nominal power for sidelink transmission.
  + Spec impact: changes to 331, changes to 213
  + Supported by: vivo
* Option 2. Reuse the nominal power of UL transmission (e.g., the value indicated by p0-NominalWithGrant) for SL power control.
  + Spec impact: changes to 213
  + Supported by: vivo
* Option 3. Change the value range of the existing RRC parameter P0, e.g., to [-218, 39], or other value ranges.
  + Spec impact: changes to 331
  + Supported by: Ericsson, Nokia, Nokia Shanghai Bell, Sharp, [OPPO]
  + Nokia also commented that the range of the parameter can be the same as the range specified for PUSCH, i.e. [-202,24].

Furthermore, considering that this is a very late stage for R16 and changes to R16 could be NBC, in round1, 4 companies (Qualcomm, OPPO, Samsung, intel) commented that they do not prefer to change the power control mechanism in Rel-16, while in round2, Ericsson and intel are ok to fix this in Rel-17, OPPO is ok to consider option3 in Rel-17 if the issue need to be solved.

* Alt1. Introduce changes to Rel-16 spec to fix this issue in Rel-16
  + Ericsson, vivo
* Alt2. Introduce changes to Rel-17 spec to fix this issue and to avoid NBC
  + Intel, Ericsson, vivo, Sharp, [OPPO]

Therefore, we would like to have the following proposal:

**Proposal1: Down select one of the following options to fix the SL power issue identified in R1-2206715**

* **Option1 for Rel-16.** Introduce RRC parameters (e.g., *dl-P0-nominal-PSSCH-PSCCH- r16, sl-P0-nominal-PSSCH-PSCCH-r16, dl-P0-nominal-PSBCH-r16, dl-P0-nominal-PSFCH-r16*) indicating nominal power for PSSCH/PSCCH/S-SSB/PSFCH to Rel-16 SL power control
* **Option2 for Rel-16.** Use the P0\_nominal power of UL transmission (e.g., the value indicated by p0-NominalWithGrant) for Rel-16 SL power control.
* **Option 3 for Rel-16.** Modify the value range of P0 (i.e., *dl-P0-PSSCH-PSCCH-r16, sl-P0-PSSCH-PSCCH-r16, dl-P0- PSBCH-r16, dl-P0-PSFCH-r16*) in Rel-16 SL power control
* **Option1 for Rel-17.** Introduce RRC parameters (e.g., *dl-P0-nominal-PSSCH-PSCCH-r17, sl-P0-nominal-PSSCH-PSCCH-r17, dl-P0-nominal-PSBCH-r17, dl-P0-nominal-PSFCH-r17*) indicating nominal power for PSSCH/PSCCH/S-SSB/PSFCH to Rel-17 SL power control
* **Option3 for Rel-17.** Introduce RRC parameters (i.e., *dl-P0-PSSCH-PSCCH-r17, sl-P0-PSSCH-PSCCH-r17, dl-P0- PSBCH-r17, dl-P0-PSFCH-r17*) with a value range (e.g., [-202, 24]) different from the corresponding Rel-16 SL P0 parameters to Rel-17 SL power control

[active]Discussion after Wednesday online

During the online discussion, moderator proposed to fix this issue in Rel-17. Some companies commented that it is too late to add new RRC parameters, one company commented that the proposed range of values should be the same as for LTE V2X *P0-SL*, and one company commented that this issue is very crucial for NW and should be addressed.

As option3 has the most supportive companies, moderator suggest the group consider option3 to address this issue in Rel-17. Moreover, based on the received comments so far, there can be three options for the value range. Moderator also would like to check companies’ preferences on these options.

* Option3 Introduce new parameters Rel-17 SL P0 (i.e., *dl-P0-PSSCH-PSCCH-r17, sl-P0-PSSCH-PSCCH-r17, dl-P0-PSBCH-r17, dl-P0-PSFCH-r17*) with a value range different from the corresponding Rel-16 SL P0 parameters for SL power control, where the value range of the new parameters is
  + Option 3-a: [-202, 24] (note: this value range is the same as P0\_nominal of PUSCH)
  + Option 3-b: [-126, 31] (note: this value range is the same as LTE V2X *P0-SL*)
  + Option 3-c: [-218, 39] (note: [-218, 39] is the value range of the sum of P0\_nominal of PUSCH and P0)

From the moderator's point of view, Option 3-a is preferred as it is consistent with UL and mostly covers the range of LTE V2X *P0-SL*. Additionally, due to different open loop power control parameters would be used between R16 and R17 UEs, a new UE capability should be introduced to indicate the support of Rel-17 SL P0. Therefore, we have the following proposal:

**Proposal2**

* Introduce parameter Rel-17 SL P0 (i.e., *dl-P0-PSSCH-PSCCH-r17, sl-P0-PSSCH-PSCCH-r17, dl-P0- PSBCH-r17, dl-P0-PSFCH-r17*) for SL open loop power control, where the value range of the new parameters is [-202, 24]
  + Introduce a new capability for UE supporting SL open loop power control based on these new Rel-17 SL P0 parameters, SL open loop power control based on the new Rel-17 SL P0 parameters should be subject to this UE capability.

A draft LS to RAN2 based on the above proposal can be found in the appendix for reference.

**Q4: Do you agree with proposal2?**

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| --- | --- | --- |
| **Company** | **Agree or not** | **Comment** |
| vivo | Yes | Also fine with the other value range (i.e., option 3-b/c) if the majority support option 3-b or option 3-c. |
| Nokia, Nokia Shanghai Bell | Yes | The proposed value range is fine. If SL UEs with higher Tx power class are introduced the highest value in the range may need to be increased. |
| Qualcomm | Yes with comment | We agree with the proposal itself and would also like for it to also include the UE capability details to provide the information as soon as possible:   * Features:   + 32. NR\_SL\_enh * Index:   + 32-8 * Feature group   + Use of new P0 parameters for open loop power control * Components   + 1. UE uses *dl-P0-PSSCH-PSCCH-r17, sl-P0-PSSCH-PSCCH-r17, dl-P0- PSBCH-r17, dl-P0-PSFCH-r17* for SL open loop power control * Prerequisite feature groups   + None * Need for the gNB to know if the feature is supported   + Yes * Applicable to the capability signalling exchange between UEs (Sidelink WI only)”.   + No * Consequence if the feature is not supported by the UE   + UE uses *dl-P0-PSSCH-PSCCH-r16, sl-P0-PSSCH-PSCCH-r16, dl-P0- PSBCH-r16, dl-P0-PSFCH-r16* for SL open loop power control * Type   + Per band * Need of FDD/TDD differentiation   + N.A. * Need of FR1/FR2 differentiation   + N.A. * Capability interpretation for mixture of FDD/TDD and/or FR1/FR2   + N.A. * Note   + None |
|  |  |  |

**Q5: Any comments on the draft LS in the appendix? Please provide your comments in the table.**

|  |  |
| --- | --- |
| **Company** | **Comment** |
|  |  |

Summary

TBD

Reference

1. R1-2206715,‘Correction on P0 of SL power control’, vivo

Appendix: draft LS

**Title: LS on SL P0 parameter**

**Response to: -**

**Release: Release 17**

**Work Item: NR\_SL\_enh-Core**

**Source: RAN1**

**To: RAN2**

**Cc: -**

**Contact person: Siqi Liu**

**liusiqi@vivo.com**

**Send any reply LS to: 3GPP Liaisons Coordinator,** [**mailto:3GPPLiaison@etsi.org**](mailto:3GPPLiaison@etsi.org)

**Attachments:** **-**

**Overall description**

The value range of the RRC parameters for sidelink open loop power control were defined in a way different from that in Uu.

To address this issue, RAN1 made the following agreement to introduce new P0 parameters for PSCCH/PSSCH/PSFCH/S-SSB in Rel-17.

**Proposal2[to be updated as agreement once it is confirmed]**

* Introduce parameter Rel-17 SL P0 (i.e., *dl-P0-PSSCH-PSCCH-r17, sl-P0-PSSCH-PSCCH-r17, dl-P0- PSBCH-r17, dl-P0-PSFCH-r17*) for SL open loop power control, where the value range of the new parameters is [-202, 24]
  + Introduce a new capability for UE supporting SL open loop power control based on these new Rel-17 SL P0 parameters, SL open loop power control based on the new Rel-17 SL P0 parameters should be subject to this UE capability.

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| **WI code** | **Parameter name in the spec** | **New or existing?** | **Description** | **Value range** | **Specification** |
| NR\_SL\_enh-Core | *dl-P0-PSSCH-PSCCH-r17* | New | Indicates P0 value for downlink pathloss based power control for PSCCH/PSSCH. | *[-202..24]* | 38.331 |
| NR\_SL\_enh-Core | *sl-P0-PSSCH-PSCCH-r17* | New | Indicates P0 value for sidelink pathloss based power control for PSCCH/PSSCH. | *[-202..24]* | 38.331 |
| NR\_SL\_enh-Core | *dl-P0-PSBCH-r17* | New | Indicates P0 value for DL pathloss based power control for PSBCH. | *[-202..24]* | 38.331 |
| NR\_SL\_enh-Core | *dl-P0-PSFCH-r17* | New | Indicates P0 value for downlink pathloss based power control for PSFCH. | *[-202..24]* | 38.331 |

**Actions**

**To RAN1**

**ACTION:** RAN1 respectfully requests RAN2 to take the above response into account.

**Dates of next TSG RAN WG1 meetings**

RAN1#110bis-e 10th -19th Oct 2022 E-Meeting

RAN1#111 14th -18th Nov 2022 Canada , CA

Appendix A: copy of NR spec

* **PUCCH**

|  |
| --- |
| If a UE transmits a PUCCH on active UL BWP  of carrier  in the primary cell  using PUCCH power control adjustment state with index , the UE determines the PUCCH transmission power  in PUCCH transmission occasion  as  [dBm]  where  -  is the UE configured maximum output power defined in [8-1, TS 38.101-1], [8-2, TS 38.101-2] and [8-3, TS 38.101-3] for carrier  of primary cell  in PUCCH transmission occasion  -  is a parameter composed of the sum of a component , provided by *p0-nominal*, or  dBm if *p0-nominal* is not provided, for carrier  of primary cell  and, if provided, a component  provided by *p0-PUCCH-Value* in *P0-PUCCH* for active UL BWP  of carrier  of primary cell , where .  is a size for a set of  values provided by *maxNrofPUCCH-P0-PerSet*. The set of  values is provided by *p0-Set*. If *p0-Set* is not provided to the UE, , |

PUCCH related P0 and P0nominal

PUCCH-PowerControl ::= SEQUENCE {

p0-Set SEQUENCE (SIZE (1..maxNrofPUCCH-P0-PerSet)) OF P0-PUCCH OPTIONAL, -- Need M

pathlossReferenceRSs SEQUENCE (SIZE (1..maxNrofPUCCH-PathlossReferenceRSs)) OF PUCCH-PathlossReferenceRS

OPTIONAL, -- Need M

twoPUCCH-PC-AdjustmentStates ENUMERATED {twoStates} OPTIONAL, -- Need S

...,

[[

pathlossReferenceRSs-v1610 SetupRelease { PathlossReferenceRSs-v1610 } OPTIONAL -- Need M

]]

}

P0-PUCCH ::= SEQUENCE {

p0-PUCCH-Id P0-PUCCH-Id,

p0-PUCCH-Value INTEGER (-16..15)

}

PUCCH-ConfigCommon ::= SEQUENCE {

pucch-ResourceCommon INTEGER (0..15) OPTIONAL, -- Cond InitialBWP-Only

pucch-GroupHopping ENUMERATED { neither, enable, disable },

hoppingId INTEGER (0..1023) OPTIONAL, -- Need R

p0-nominal INTEGER (-202..24) OPTIONAL, -- Need R

...

}

* **PUSCH**

|  |
| --- |
| If a UE transmits a PUSCH on active UL BWP  of carrier  of serving cell  using parameter set configuration with index  and PUSCH power control adjustment state with index , the UE determines the PUSCH transmission power  in PUSCH transmission occasion  as  [dBm]  where,  - is the UE configured maximum output power defined in [8-1, TS 38.101-1], [8-2, TS 38.101-2] and [8-3, TS 38.101-3] for carrier  of serving cell  in PUSCH transmission occasion .  -  is a parameter composed of the sum of a component  and a component  where .  If a UE established dedicated RRC connection using a Type-1 random access procedure, as described in clause 8, and is not provided *P0-PUSCH-AlphaSet* or for a PUSCH (re)transmission corresponding to a RAR UL grant as described in clause 8.3,  , , and ,  where is provided by *preambleReceivedTargetPower* [11, TS 38.321] and is provided by *msg3-DeltaPreamble*, or  dB if *msg3-DeltaPreamble* is not provided, for carrier  of serving cell  - If a UE established dedicated RRC connection using a Type-2 random access procedure, as described in clause 8, and is not provided *P0-PUSCH-AlphaSet*,or for a PUSCH transmission for Type-2 random access procedure as described in clause 8.1A,  , , and ,  where is provided by *msgA-preambleReceivedTargetPower*, or by *preambleReceivedTargetPower* if *msgA-preambleReceivedTargetPower* isnot provided and is provided by *msgA-DeltaPreamble*, or dB if *msgA-DeltaPreamble* is not provided, for carrier of serving cell  - For a PUSCH (re)transmission configured by *ConfiguredGrantConfig*, ,  is provided by *p0-NominalWithoutGrant*, or  if *p0-NominalWithoutGrant* is not provided, and  is provided by *p0* obtained from *p0-PUSCH-Alpha* in *ConfiguredGrantConfig* that provides an index *P0-PUSCH-AlphaSetId* to a set of *P0-PUSCH-AlphaSet* for active UL BWP  of carrier  of serving cell  - For , a  value, applicable for all , is provided by *p0-NominalWithGrant,* or  if *p0-NominalWithGrant* is not provided, for each carrier  of serving cell  and a set of values are provided by a set of *p0* in *P0-PUSCH-AlphaSet* indicated by a respective set of *p0-PUSCH-AlphaSetId* for active UL BWP  of carrier  of serving cell  - If the UE is provided by *SRI-PUSCH-PowerControl* more than one values of *p0-PUSCH-AlphaSetId* and if a DCI format scheduling the PUSCH transmission includes an SRI field, the UE obtains a mapping from *sri-PUSCH-PowerControlId* in *SRI-PUSCH-PowerControl* between a set of values for the SRI field in the DCI format [5, TS 38.212] and a set of indexes provided by *p0-PUSCH-AlphaSetId* that map to a set of *P0-PUSCH-AlphaSet* values and determines the value of  from the *p0-PUSCH-AlphaSetId* value that is mapped to the SRI field value. If the DCI format also includes an open-loop power control parameter set indication field and a value of the open-loop power control parameter set indication field is '1', the UE determines a value of  from a first value in *P0-PUSCH-Set* with a *p0-PUSCH-SetId* value mapped to the SRI field value.  - If the PUSCH transmission except for the PUSCH retransmission corresponding to a RAR UL grant is scheduled by a DCI format that does not include an SRI field, or if *SRI-PUSCH-PowerControl* is not provided to the UE, ,  - If *P0-PUSCH-Set* is provided to the UE and the DCI format includes an open-loop power control parameter set indication field, the UE determines a value of  from  - a first *P0-PUSCH-AlphaSet* in *p0-AlphaSets* if a value of the open-loop power control parameter set indication field is '0' or '00'  - a first value in *P0-PUSCH-Set* with the lowest *p0-PUSCH-SetID* value if a value of the open-loop power control parameter set indication field is '1' or '01'  - a second value in *P0-PUSCH-Set* with the lowest *p0-PUSCH-SetID* value if a value of the open-loop power control parameter set indication field is '10'  - else, the UE determines  from the value of the first *P0-PUSCH-AlphaSet* in *p0-AlphaSets* |

PUSCH related P0 and P0nominal

PUSCH-ConfigCommon ::= SEQUENCE {

groupHoppingEnabledTransformPrecoding ENUMERATED {enabled} OPTIONAL, -- Need R

pusch-TimeDomainAllocationList PUSCH-TimeDomainResourceAllocationList OPTIONAL, -- Need R

msg3-DeltaPreamble INTEGER (-1..6) OPTIONAL, -- Need R

p0-NominalWithGrant INTEGER (-202..24) OPTIONAL, -- Need R

...

}

***p0-NominalWithGrant***

P0 value for PUSCH with grant (except msg3). Value in dBm. Only even values (step size 2) allowed (see TS 38.213 [13], clause 7.1) This field is cell specific

PUSCH-PowerControl ::= SEQUENCE {

tpc-Accumulation ENUMERATED { disabled } OPTIONAL, -- Need S

msg3-Alpha Alpha OPTIONAL, -- Need S

p0-NominalWithoutGrant INTEGER (-202..24) OPTIONAL, -- Need M

p0-AlphaSets SEQUENCE (SIZE (1..maxNrofP0-PUSCH-AlphaSets)) OF P0-PUSCH-AlphaSet OPTIONAL, -- Need M

pathlossReferenceRSToAddModList SEQUENCE (SIZE (1..maxNrofPUSCH-PathlossReferenceRSs)) OF PUSCH-PathlossReferenceRS

OPTIONAL, -- Need N

pathlossReferenceRSToReleaseList SEQUENCE (SIZE (1..maxNrofPUSCH-PathlossReferenceRSs)) OF PUSCH-PathlossReferenceRS-Id

OPTIONAL, -- Need N

twoPUSCH-PC-AdjustmentStates ENUMERATED {twoStates} OPTIONAL, -- Need S

deltaMCS ENUMERATED {enabled} OPTIONAL, -- Need S

sri-PUSCH-MappingToAddModList SEQUENCE (SIZE (1..maxNrofSRI-PUSCH-Mappings)) OF SRI-PUSCH-PowerControl

OPTIONAL, -- Need N

sri-PUSCH-MappingToReleaseList SEQUENCE (SIZE (1..maxNrofSRI-PUSCH-Mappings)) OF SRI-PUSCH-PowerControlId

OPTIONAL -- Need N

}

P0-PUSCH-AlphaSet ::= SEQUENCE {

p0-PUSCH-AlphaSetId P0-PUSCH-AlphaSetId,

p0 INTEGER (-16..15) OPTIONAL, -- Need S

alpha Alpha OPTIONAL -- Need S

}

P0-PUSCH-AlphaSetId ::= INTEGER (0..maxNrofP0-PUSCH-AlphaSets-1)

***p0-NominalWithoutGrant***

P0 value for UL grant-free/SPS based PUSCH. Value in dBm. Only even values (step size 2) allowed (see TS 38.213 [13], clause 7.1).

* **SL**

|  |
| --- |
| A UE determines a power for an S-SS/PSBCH block transmission occasion in slot on active SL BWP of carrier as  [dBm]  where  - is defined in [8-1, TS 38.101-1]  - is a value of *dl-P0-PSBCH* if provided; else,  - is a value of *dl-Alpha-PSBCH*, if provided; else,  - when the active SL BWP is on a serving cell , as described in clause 7.1.1 except that  - the RS resource is the one the UE uses for determining a power of a PUSCH transmission scheduled by a DCI format 0\_0 in serving cell when the UE is configured to monitor PDCCH for detection of DCI format 0\_0 in serving cell  - the RS resource is the one corresponding to the SS/PBCH block the UE uses to obtain MIB when the UE is not configured to monitor PDCCH for detection of DCI format 0\_0 in serving cell  - is a number of resource blocks for a S-SS/PSBCH block transmission with SCS configuration |
| A UE determines a power for a PSSCH transmission on a resource pool in symbols where a corresponding PSCCH is not transmitted in PSCCH-PSSCH transmission occasion on active SL BWP of carrier as:  [dBm]  where  - is defined in [8-1, TS 38.101-1]  - is determined by a value of *sl-MaxTxPower* based on a priority level of the PSSCH transmission and a CBR range that includes a CBR measured in slot [6, TS 38.214]; if *sl-MaxTxPower* is not provided, then ;  - if *dl-P0-PSSCH-PSCCH* is provided  - [dBm]  - else  - [dBm]  where  - is a value of *dl-P0-PSSCH-PSCCH* if provided  - is a value of *dl-Alpha-PSSCH-PSCCH*, if provided; else,  - when the active SL BWP is on a serving cell , as described in clause 7.1.1 except that  - the RS resource is the one the UE uses for determining a power of a PUSCH transmission scheduled by a DCI format 0\_0 in serving cell when the UE is configured to monitor PDCCH for detection of DCI format 0\_0 in serving cell  - the RS resource is the one corresponding to the SS/PBCH block the UE uses to obtain MIB when the UE is not configured to monitor PDCCH for detection of DCI format 0\_0 in serving cell  - is a number of resource blocks for the PSSCH transmission occasion and is a SCS configuration  - if *sl-P0-PSSCH-PSCCH* is provided and if a SCI format scheduling the PSSCH transmission includes a cast type indicator field indicating unicast  - [dBm]  - else  - [dBm]  where  - is a value of *sl-P0-PSSCH-PSCCH*, if provided  - is a value of *sl-Alpha-PSSCH-PSCCH*, if provided; else,  - , where  - is obtained from a PSSCH transmit power per RE summed over the antenna ports of the UE, higher layer filtered across PSSCH transmission occasions using a filter configuration provided by *sl-FilterCoefficient*, and  - is a RSRP, as defined in [7, TS 38.215], that is reported to the UE from a UE receiving the PSCCH-PSSCH transmission and is obtained from a PSSCH DM-RS using a filter configuration provided by *sl-FilterCoefficient*  - is a number of resource blocks for PSCCH-PSSCH transmission occasion and is a SCS configuration  ===omitted=== |
| A UE with scheduled PSFCH transmissions, and capable of transmitting a maximum of PSFCHs, determines a number of simultaneous PSFCH transmissions and a power for a PSFCH transmission , , on a resource pool in PSFCH transmission occasion on active SL BWP of carrier as  - if *dl-P0-PSFCH* is provided,  [dBm]  where  - is a value of *dl-P0-PSFCH*  - is a value of *dl-Alpha-PSFCH*, if provided; else,  ===omitted===  - else  [dBm]  where the UE autonomously determines PSFCH transmissions with ascending order of corresponding priority field values as described in clause 16.2.4.2 such that and where is determined for the PSFCH transmissions according to [8-1, TS 38.101-1]. |

SL related P0 and P0nominal

SL-PSBCH-Config-r16 ::= SEQUENCE {

dl-P0-PSBCH-r16 INTEGER (-16..15) OPTIONAL, -- Need M

dl-Alpha-PSBCH-r16 ENUMERATED {alpha0, alpha04, alpha05, alpha06, alpha07, alpha08, alpha09, alpha1} OPTIONAL, -- Need M

...

}

SL-PowerControl-r16 ::= SEQUENCE {

sl-MaxTransPower-r16 INTEGER (-30..33),

sl-Alpha-PSSCH-PSCCH-r16 ENUMERATED {alpha0, alpha04, alpha05, alpha06, alpha07, alpha08, alpha09, alpha1} OPTIONAL, -- Need M

dl-Alpha-PSSCH-PSCCH-r16 ENUMERATED {alpha0, alpha04, alpha05, alpha06, alpha07, alpha08, alpha09, alpha1} OPTIONAL, -- Need S

sl-P0-PSSCH-PSCCH-r16 INTEGER (-16..15) OPTIONAL, -- Need S

dl-P0-PSSCH-PSCCH-r16 INTEGER (-16..15) OPTIONAL, -- Need M

dl-Alpha-PSFCH-r16 ENUMERATED {alpha0, alpha04, alpha05, alpha06, alpha07, alpha08, alpha09, alpha1} OPTIONAL, -- Need S

dl-P0-PSFCH-r16 INTEGER (-16..15) OPTIONAL, -- Need M

...

}

Appendix B: TP based on option2

### 16.2.0 S-SS/PSBCH blocks

A UE determines a power for an S-SS/PSBCH block transmission occasion in slot on active SL BWP of carrier as

[dBm]

where

- is defined in [8-1, TS 38.101-1]

- is a value of *dl-P0-PSBCH* if provided; else,

- is a value of *p0-NominalWithGrant* if provided for a serving cell when the active SL BWP is on the serving cell ; else,

- is a value of *dl-Alpha-PSBCH*, if provided; else,

- when the active SL BWP is on a serving cell , as described in clause 7.1.1 except that

- the RS resource is the one the UE uses for determining a power of a PUSCH transmission scheduled by a DCI format 0\_0 in serving cell when the UE is configured to monitor PDCCH for detection of DCI format 0\_0 in serving cell

- the RS resource is the one corresponding to the SS/PBCH block the UE uses to obtain MIB when the UE is not configured to monitor PDCCH for detection of DCI format 0\_0 in serving cell

- is a number of resource blocks for a S-SS/PSBCH block transmission with SCS configuration

### 16.2.1 PSSCH

A UE determines a power for a PSSCH transmission on a resource pool in symbols where a corresponding PSCCH is not transmitted in PSCCH-PSSCH transmission occasion on active SL BWP of carrier as:

[dBm]

where

- is defined in [8-1, TS 38.101-1]

- is determined by a value of *sl-MaxTxPower* based on a priority level of the PSSCH transmission and a CBR range that includes a CBR measured in slot [6, TS 38.214]; if *sl-MaxTxPower* is not provided, then ;

- if *dl-P0-PSSCH-PSCCH* is provided

- [dBm]

- else

- [dBm]

where

- is a value of *dl-P0-PSSCH-PSCCH* if provided

- is a value of *p0-NominalWithGrant* if provided for a serving cell when the active SL BWP is on the serving cell ; else,

- is a value of *dl-Alpha-PSSCH-PSCCH*, if provided; else,

- when the active SL BWP is on a serving cell , as described in clause 7.1.1 except that

- the RS resource is the one the UE uses for determining a power of a PUSCH transmission scheduled by a DCI format 0\_0 in serving cell when the UE is configured to monitor PDCCH for detection of DCI format 0\_0 in serving cell

- the RS resource is the one corresponding to the SS/PBCH block the UE uses to obtain MIB when the UE is not configured to monitor PDCCH for detection of DCI format 0\_0 in serving cell

- is a number of resource blocks for the PSSCH transmission occasion and is a SCS configuration

- if *sl-P0-PSSCH-PSCCH* is provided and if a SCI format scheduling the PSSCH transmission includes a cast type indicator field indicating unicast

- [dBm]

- else

- [dBm]

where

- is a value of *sl-P0-PSSCH-PSCCH*, if provided

- is a value of *p0-NominalWithGrant* if provided for a serving cell when the active SL BWP is on the serving cell ; else,

- is a value of *sl-Alpha-PSSCH-PSCCH*, if provided; else,

- , where

- is obtained from a PSSCH transmit power per RE summed over the antenna ports of the UE, higher layer filtered across PSSCH transmission occasions using a filter configuration provided by *sl-FilterCoefficient*, and

- is a RSRP, as defined in [7, TS 38.215], that is reported to the UE from a UE receiving the PSCCH-PSSCH transmission and is obtained from a PSSCH DM-RS using a filter configuration provided by *sl-FilterCoefficient*

- is a number of resource blocks for PSCCH-PSSCH transmission occasion and is a SCS configuration

The UE splits the power equally across the antenna ports on which the UE transmits the PSSCH with non-zero power.

A UE determines a power for a PSSCH transmission on a resource pool in the symbols where a corresponding PSCCH is transmitted in PSCCH-PSSCH transmission occasion on active SL BWP of carrier as

[dBm]

where is a number of resource blocks for the corresponding PSCCH transmission in PSCCH-PSSCH transmission occasion .

The UE splits the power equally across the antenna ports on which the UE transmits the PSSCH with non-zero power.

### 16.2.3 PSFCH

A UE with scheduled PSFCH transmissions, and capable of transmitting a maximum of PSFCHs, determines a number of simultaneous PSFCH transmissions and a power for a PSFCH transmission , , on a resource pool in PSFCH transmission occasion on active SL BWP of carrier as

- if *dl-P0-PSFCH* is provided,

[dBm]

where

- is a value of *dl-P0-PSFCH*

- a value of *p0-NominalWithGrant* if provided for a serving cell when the active SL BWP is on the serving cell ; else,

- is a value of *dl-Alpha-PSFCH*, if provided; else,

- when the active SL BWP is on a serving cell , as described in clause 7.1.1 except that

- the RS resource is the one the UE uses for determining a power of a PUSCH transmission scheduled by a DCI format 0\_0 in serving cell when the UE is configured to monitor PDCCH for detection of DCI format 0\_0 in serving cell

- the RS resource is the one corresponding to the SS/PBCH block the UE uses to obtain MIB when the UE is not configured to monitor PDCCH for detection of DCI format 0\_0 in serving cell

- if

- if , where is determined for PSFCH transmissions according to [8-1, TS 38.101-1]

- and [dBm]

- else

- UE autonomously determines PSFCH transmissions with ascending order of corresponding priority field values as described in clause 16.2.4.2 such that where is a number of PSFCHs with priority value and is defined as

- the largest value satisfying where is determined according to [8-1, TS 38.101-1] for transmission of all PSFCHs assigned with priority values 1, 2, …, , if any

- zero, otherwise

and

[dBm]

where is defined in [8-1, TS 38.101-1] and is determined for the PSFCH transmissions

- else

- the UE autonomously selects PSFCH transmissions with ascending order of corresponding priority field values as described in clause 16.2.4.2

- if , where is determined for the PSFCH transmissions according to [8-1, TS 38.101-1]

- and [dBm]

- else

- the UE autonomously selects PSFCH transmissions in ascending order of corresponding priority field values as described in clause 16.2.4.2 such that where is a number of PSFCHs with priority value and is defined as

- the largest value satisfying where is determined according to [8-1, TS 38.101-1] for transmission of all PSFCHs assigned with priority values 1, 2, …, , if any

- zero, otherwise

and

[dBm]

where is determined for the simultaneous PSFCH transmissions according to [8-1, TS 38.101-1]

- else

[dBm]

where the UE autonomously determines PSFCH transmissions with ascending order of corresponding priority field values as described in clause 16.2.4.2 such that and where is determined for the PSFCH transmissions according to [8-1, TS 38.101-1].