3GPP TSG-RAN WG1 Meeting #104-bis-e R1-20xxxxx

e-Meeting, April 12th – 20th, 2020

Agenda Item: 6.1

Source: Moderator (Ericsson)

Title: Moderator Summary [104b-e-LTE-6.1CRs-04]

Document for: Discussion and Decision

# 1 Introduction

In Release-15 the Work Item (WI) on “Even Further Enhanced MTC for LTE (“efeMTC”)” [1], had as one of its objectives to specify “Increased PUSCH spectral efficiency”. As a result, sub-PRB was specified making possible to allocate either 6, 3, or 2-of-3 subcarriers for transmitting over PUSCH.

In [2], it was mentioned that “The current “MPUSCH,c” calculation for the 2-of-3 allocation does not account for the fact that only 1 of the 2 utilized subcarriers is active at a time”. Based on it, [2] presents a Rel-15 CR containing a “Clarification on the UE transmit power for the 2-of-3 subcarrier allocation in sub-PRB”. Moreover, [3] corresponds to the Rel-16 shadow CR and contains the exact change as in [2].

# 2 Background: Clarification on the UE transmit power for the 2-of-3 subcarrier allocation in sub-PRB

In [2] and [3] it was mentioned:

“In the UE’s transmit power equation, the term “” scales-down the power for a full-PRB allocation and sub-PRB allocations respectively as follows:

* When 12 subcarriers are allocated MPUSCH,c = 0 dB, whereas when sub-PRB is used, for 6 allocated subcarriers MPUSCH,c = -3.0103 dB, for 3 allocated subcarriers MPUSCH,c = -6.0206 dB and for 2-of-3 allocated subcarriers MPUSCH,c = -7.7815 dB.

The current “MPUSCH,c” calculation for the 2-of-3 allocation does not account for the fact that only 1 of the 2 utilized subcarriers is active at a time. That is, the two subcarriers are not simultaneously used, since its usage stochastically commutes one at a time among the two usable tones. Thus, the current specification provides a power scaling given by “MPUSCH,c” = (3+1-2)/12 = 2/12 (i.e., -7.7815 dB), instead of “MPUSCH,c” = 1/12 (i.e., -10.7918 dB). This means, that for the 2-of-3 subcarrier allocation currently there is an excess of transmit power of ⁓3dB”.

The CRs in [2] and [3] propose to clarify the issue as follows:

“To avoid an excess of transmit power of ⁓3dB when sub-PRB uses a 2-of-3 subcarrier allocation, and to keep unmodified “”, “*Qm*”, and “”, which are the legacy variables used by ““MPUSCH,c””, in clause 5.1.1.1 the following is appended to the legacy ““MPUSCH,c”” equation as to obtain “MPUSCH,c” = 1/12 for the 2-of-3 subcarrier allocation case:

“if ≠ 1 or if = 1”.”

Below the proposed clarification as in [2] and [3] is shown:

## 2.1 Clarification on the UE transmit power for the 2-of-3 subcarrier allocation in sub-PRB

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#### 5.1.1.1 UE behaviour

The setting of the UE Transmit power for a Physical Uplink Shared Channel (PUSCH) transmission is defined as follows.

If the UE transmits PUSCH without a simultaneous PUCCH for the serving cell , then the UE transmit power  for PUSCH transmission in subframe/slot/subslot *i* for the serving cell is given by

 [dBm]

If the UE transmits PUSCH simultaneous with PUCCH for the serving cell , then the UE transmit power  for the PUSCH transmission in subframe/slot/subslot *i* for the serving cell  is given by

 [dBm]

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- If the UE is a BL/CE UE configured with higher layer parameter *ce-PUSCH-SubPRB-Config-r15*, and the PUSCH resource assignment valid for subframe *i* and serving cell is using uplink resource allocation type 5, is the bandwidth of the PUSCH resource assignment expressed in fraction of a resource block and is given by  if ≠ 1 or if = 1 where  are defined in [3] and is defined in Subclause 8.6.1 for subframe *i,* is the bandwidth of the PUSCH resource assignment expressed in number of resource blocks valid for subframe/slot/subslot *i* and serving cell otherwise.

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| **Company** | **Agree?** | **Comments** |
| Qualcomm | No | The current equation is correct.  The transmission actually uses two subcarriers to transmit data, although a single one is used at a time (the location of the subcarrier encodes one bit of information). In the time domain, there are actually two bits transmitted every symbol.  To put it differently: The proponents argue that the scaling factor for *two out of three tones* is 1/12. What would be the scaling for pure single subcarrier transmission?  In our understanding, the scaling for pure single subcarrier would be 1/12, and it needs to be 2/12 for this case. |
| Ericsson | See comment | To Qualcomm: Thanks for the comment. Maybe we misinterpreted something, but let us explain the way we had seen it. Below we depict the 2-of-3 subcarrier allocation for its two possible variants, in our understanding what we have today is the following:   |  |  |  |  | | --- | --- | --- | --- | | Not used | | | | |  |  |  |  | |  |  |  |  |   Or   |  |  |  |  | | --- | --- | --- | --- | |  |  |  |  | |  |  |  |  | | Not used | | | |   The coloured boxes represent the subcarriers for which power is allocated. But given that at a given point in time only one of the two subcarriers is effectively active, we thought one of the two subcarriers does not have power allocated to it.   |  |  |  |  | | --- | --- | --- | --- | | Not used | | | | |  |  |  |  | |  |  |  |  |   Or   |  |  |  |  | | --- | --- | --- | --- | |  |  |  |  | |  |  |  |  | | Not used | | | |   In Rel-15, there were some PAPR evaluations for the 2-of-3 sub-PRB case, which If I recall correctly resulted to be equivalent to the single-tone NB-IoT case. If for the 2-of-3 sub-PRB case we keep the power scaling as 2/12, would the PAPR be truly similar as single-tone (1/12)? |
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# 5 References

1. [RP-171427](https://www.3gpp.org/ftp/tsg_ran/TSG_RAN/TSGR_76/Docs/RP-171427.zip), “Revised WID on Even further enhanced MTC for LTE”, 3GPP TSG RAN Meeting #76, West Palm Beach, USA, June 5-8, 2017.
2. [R1-2103729](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103729.zip), “Clarification on the UE transmit power for the 2-of-3 subcarrier allocation in sub-PRB,” Ericsson, RAN1 #104-bis-e, Electronic Meeting, April 12th – 20th, 2021.
3. [R1-2103730](https://www.3gpp.org/ftp/TSG_RAN/WG1_RL1/TSGR1_104b-e/Docs/R1-2103730.zip), “Clarification on the UE transmit power for the 2-of-3 subcarrier allocation in sub-PRB,” Ericsson, RAN1 #104-bis-e, Electronic Meeting, April 12th – 20th, 2021.