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)? |
| Qualcomm |  | We agree with the figures from Ericsson, that is indeed what is happenning if you take a snapshot in the frequency domain per symbol. But it still does not justify the change.  In our understanding, the PAPR does not change regardless of the power control equation. The power control just gives a common scaling to the signal, so both the average and peak values are scaled by the same factor. |
| ZTE | No | We think this CR is not necessary.  Current equation is aligned with RAN1’s agreement. Since power scaling has impact on both average and peak values, the PAPR does not change. |
| Ericsson v005 | See comment | If the corresponding component in power control equation is scaled for two subcarriers but actually only 1 subcarrier is transmitted, the PSD of the received signal will be 3 dB higher and thus may generate interference to other simultaneous sub-PRB UE(s) at BS receiver. |

# 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.