**3GPP TSG-RAN WG4 Meeting #101-e R4-2119970**

**Nov 2021**

**Title: WF on PC2 TxD implementations with 26+23 and 26+26 PA’s**

**Source: Qualcomm Incorporated**

**Agenda item: 8.7.1**

**Release: Rel-17**

**Work Item: NR\_RF\_TxD**

**Responsible WG: RAN4**

**Document for: Approval**

# 1. Introduction

This paper is Way Forward on Tx Diversity implementations with 26 dBm PA, namely 26+23 and 26+26 dBm PA’s for RAN4#101e email thread [123]. It should be noted that this discussion is for single CC TxD and the mentioned PA architectures may be motivated by other features such as UL MIMO support of UL CA but for this WF, the context shall be limited to single CC and TxD.

# 2. Discussion

## 2.1 Agreements in GTW Nov 5th

### 2.1.1 Issue 2-4-1 Declaration of TxD for UE’s with at least one full power PA

Agreement:

* Leave TxD as implementation aspect and assume that UE that does not declare TxD meets 1Tx requirements and has at least one full power PA
  + Only UE supporting 23+23 for PC2 and UE supporting 26+26 for PC1.5 are allowed to report TxD
    - FFS whether 1Tx PC2 MPR requirement or 23+23 TxD MPR requirement needs be applied to 23+26 UE
  + If PC2 UE does not report TxD, then 1Tx PC2 MPR requirement will be applied at least in one Tx operation mode

### 2.1.2 Issue 2-3-1: PC2 26+23 dBm MPR

* Agreement: encourage companies to provide more evaluation and measurement data in future.

## 2.2 Way forward after GTW

### 2.2.1 Interpretation of agreements

Agreement in GTW is that in two places it is spelled that specification does not recognise 23+26 dBm PA implementation.

First

* + Only UE supporting 23+23 for PC2 and UE supporting 26+26 for PC1.5 are allowed to report TxD

Second

* + If PC2 UE does not report TxD, then 1Tx PC2 MPR requirement will be applied at least in one Tx operation mode

So depending on TxD indication, UE has to meet either MPR for TxD or then MPR for 1Tx.

Agreement also provides possibility to discuss such 23+26 dBm UE in future and in relation to other features.

### 2.2.2 Proposed Way Forward

For background, this kind of implementation exists because of other features, for example 1Tx PC2 UE needs secondary 23 dBm PA for UL MIMO.

In this WF we can check if we can recognise single CC TxD UE with 23+26 dBm PAs in requirements when that same UE supports other features such as UL MIMO or CA.

**Issue 1-1: Can 23+26 dBm UE indicate TxD for single CC if same UE also supports UL CA or UL MIMO?**

Option 1: Yes

Option 2: No

**Issue 1-2: If answer is yes to the issue 1-1, are requirements for 23+26 dBm UE with TxD indication:**

Option 1: New MPR based on future proposals

Option 2: Same as 1Tx MPR

Option 3: Same as agreed TxD MPRs (note, they are subject to change in this meeting)

Option 1 means discussion is needed under what assumptions new proposals are made.

It should also be noted that unless issued 1-1 is yes, then agreement in GTW holds i.e. new data can be provided in future.

### 2.2.3 Company comments

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| --- | --- |
| Company | Comments |
| LGE | LGE) 23+26 PA UE using TxD indication signaling shall follow the MPR of 23+23 PA. This is the same situation of PC2 intra-band UL CA with 23+26 PA UE. When the UE transmits using a single Tx without TxD indication, then can follow the MPR of 1Tx PC2 UE. The capability signaling is FFS to reuse existing TxD signaling or new capability signaling.  For the issue 1-1) it can be possible to support with UE implementation. Even though the answer is Yes for issue 1-1, the TxD (2x23) MPR is reused in issue 1-2. One example is n79 UL CA+MIMO UE can support TxD also. |
| Skyworks | Skyworks: we do not see that this is the same case than ULCA which was done only for the sake of reducing the number of MPR tables for 4 different architectures. In this case the 1Tx and 2Tx requirements can be different to 23+23 for both 26+23 and 26+26 and between tham. Like for the CA and SRS antenna switching cases we think specific architecture signaling (full power PA = 0, 1, all) is needed if TxD can be signaled for all architectures. |
| Qualcomm | Can LGE give some more information? It seems you are saying that there is UE with TxD that follows TxD MPR and UE without TxD and it follows 1Tx MPR. So no new proposals are needed. Both are in specification already. |
| Skyworks | We do not understand why 26+26dBm is ignored since with a similar reasoning than for 26+23dBm can apply: a UE can implement two PC2 PAs to support NC UL CA to support any separation class and gaps without the need for swapping the PA to the two 2 antennas, and yet only declare PC2 and support 1CC UL MIMO with two PC2 PAs. So If we are OK with a statement that TxD only applies to 23+23 we still think that there is value for UL MIMO to support 26+23 and 26+26dBm architectures with improved MPR: for the 26+23dBm in 1Tx mode it can use 1Tx MPR and for 2x26dBm it can use the PC1.5 MPR with just changing the Pmax reference thus use max(0,PC1.5 MPR -3dB). this has also implications on how many cases should be handled for SRS antenna switching.  The GTW only agreed that TxD can be signalled by 23+23 PC2 and 26+26 PC1.5. yet it does not prevent us to define properly the behaviour and MPR applying to other architectures supporting UL MIMO (which should be done by default wo TxD which is not an fully aggred or standardized feature) |
| OPPO | Agree that there is confusions on whether 23+26 can support TxD. According to the GTW in TxD it was understood as TxD is excluded from 23+26 single CC, then in contiguous UL CA+UL MIMO discussion it seems TxD is allowed there for the 23+26 case with signalling to indicate which MPR requirement apply.  To keep consistent, we are ok to align TxD in single CC and intra-band contiguous UL CA that it can be supported by 23+26 UE and use signalling to differentiate the requirements it apply. |
| vivo | Issue 1-1: Yes. This should be rather a quite typical implementation for 26+23 as proponents raised, and there is no reason to do further restriction. Actually, the sub-bullet in GTW agreements “Only UE supporting 23+23 for PC2 and UE supporting 26+26 for PC1.5 are allowed to report TxD” may over restrictive.  Issue 1-2: Option 3. Align the requirements of 26+23 and 23+23 is still preferred. For UL-MIMO requirements to be aligned with TxD, is also results of previous discussion , and not likely to be over turned. |
| Huawei | Theoretically, a 23+26 UE can still report TxD capability and use the MPR applicable for TxD indication, but in practical, we don't think that is necessary. TxD is a method to reach the max output power for certain PA implementation, e.g. for PC1.5, that is the only possible implementation. 23+26 would be beneficial for ULFPTx. But for this kind of implementation to support 2Tx, it does not have to indicate TxD.  We prefer to use TxD as indication to distinguish the applicable requirements. If needed, we are ok to have a note in the specification to reflect the agreement in the GTW or the interpretation of the GTW agreements. |
| Ericsson | Issue 1-1: the RAN4 specification cannot ‘prohibit’ a UE from indicating TxD and virtualization is not clearly specified in the RAN1 specification thus leaving room for implementations. However, the RAN4 requirements can be specified such that the UE not indicating TxD must meet the MOP per connector and the associated 1 TX MPR. A UE supporting full-power Mode 2 supporting PC2 with full-power TPMI would be implemented with 23 + 26 (Mode 0 always with 26 + 26) and should therefore meet the 1 TX requirements for at least one connector for single-port transmissions no matter any TxD indication. Hence a modified Option 1: yes, but it must meet the MOP requirement for at least one connector.  In our view PA architectures are of limited interest for capability signalling, the power capability and the feature supported more important. However, using such a PA capability for indicating that the input power for sounding the SRS connectors is varying between these could be useful as Skyworks suggests.  Issue 1-2: Option 2 for single-port/single-layer transmissions.  We recognise that different MPR are relevant for different PA arrangements. But equally important is the SRS mapping and virtualization used. Inconsistent mapping would not facilitate channel estimation. In our understanding, there are limited possibilities for 2 TX to this end and power requirements should be specified such as to ‘discourage’ inconsistent virtualization (Mode 2 with full-power TPMI should meet the requirement per connector in single-antenna fallback). |

### 2.2.4 Summary of discussions

Opinions are very divided and coming up with consensus on the presented issues and options is difficult. The discussion is about the requirements, MPR applicability since capabilities do not clearly indicate what is the implementation. There is also a strong connection to the [119] and there is a discussion on the new capability to indicate which MPRs apply. this discussion should be merged with that discussion. It should be also noted that TxD in ran2 is currently per band and not per band combination so if UE indicates TxD for single CC operation in a band, it also means UE is TxD UE for CA and UL MIMO where applicable.

Moderators proposals for WF is:

Using capability to indicate if 1Tx or 2Tx MPR applies (reuse of existing signalling is prioritized, introduction of additional signalling is not precluded). Details and which case to mandate which capability are left for next meeting.

# References

[1] R4-2117200, 1CC 2Tx MPR for different PAs implementations and signaling for 1CC and 2CC cases Skyworks Solutions Inc.

[2] R4-2118474, MPR of Tx Diversity (TxD) PC2 for two PC3 PA architecture, LG Electronics Inc.

[3] R4-2118550, Draft CR TS 38.101-1: Move PC1.5 MPR to Clause 6.2G, Huawei, HiSilicon, Qualcomm

[3] R4-2118874, R17 FR1 UL MIMO fallback to TxD and draft LS, OPPO

[4] R4-2118875, Draft R17 CR on UL MIMO falllback to TxD, OPPO

[5] R4-2119593, On Using the Pseudo-Inverse to Define EVM for Transmit Diversity, Lenovo, Motorola Mobility

[6] R4-2119723, Email discussion summary for [101-e][123] NR\_TxD, Moderator (Qualcomm)