**3GPP TSG-RAN4 Meeting #111 *R4-2409902***

**Fukuoka, Japan, May 20 – 24, 2024**

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| *CR-Form-v12.3* | | | | | | | | |
| **CHANGE REQUEST** | | | | | | | | |
|  | | | | | | | | |
|  | **38.870** | **CR** | **0005** | **rev** | **1** | **Current version:** | **18.1.0** |  |
|  | | | | | | | | |
| *For* [***HELP***](http://www.3gpp.org/3G_Specs/CRs.htm#_blank)*on using this form: comprehensive instructions can be found at* [*http://www.3gpp.org/Change-Requests*](http://www.3gpp.org/Change-Requests)*.* | | | | | | | | |
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| ***Proposed change affects:*** | UICC apps |  | ME | **X** | Radio Access Network |  | Core Network |  |

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|  | | | | | | | | | | |
| ***Title:*** | CR to TR38.870 on UL MIMO radiated output power metric | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Source to WG:*** | Apple | | | | | | | | | |
| ***Source to TSG:*** | R4 | | | | | | | | | |
|  |  | | | | | | | | | |
| ***Work item code:*** | NR\_FR1\_TRP\_TRS\_enh-Core | | | | |  | ***Date:*** | | | 2024-05-20 |
|  |  | | | |  | |  | | |  |
| ***Category:*** | **F** |  | | | | | ***Release:*** | | | Rel-18 |
|  | *Use one of the following categories:* ***F*** *(correction)* ***A*** *(mirror corresponding to a change in an earlier release)* ***B*** *(addition of feature),* ***C*** *(functional modification of feature)* ***D*** *(editorial modification)*  Detailed explanations of the above categories can be found in 3GPP [TR 21.900](http://www.3gpp.org/ftp/Specs/html-info/21900.htm). | | | | | | | | *Use one of the following releases: Rel-8 (Release 8) Rel-9 (Release 9) Rel-10 (Release 10) Rel-11 (Release 11) … Rel-17 (Release 17) Rel-18 (Release 18) Rel-19 (Release 19)  Rel-20 (Release 20)* | |
|  |  | | | | | | | | | |
| ***Reason for change:*** | | RAN4 has discussed the radiated output power test methodology for UL MIMO capable devices and has reached conclusions in R4-2313891 and R4-2406081. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Summary of change:*** | | Introduces the following sub-clauses to Clause 5:  5.1.1.1 Applicability of TRP metrics  5.1.1.2 TRP for UEs supporting single-port transmission  5.1.1.3 TRP for UEs supporting non-coherent UL MIMO  5.1.1.4 TRP for UEs supporting coherent UL MIMO  Correct the Min. number of grid points in Table 5.1.1-1 for sin(theta) for Dq=Df=15° to 264 and for Dq=Df=30° to 60 (as the pole points can be skipped); similarly for Table 5.2.1-1  Correct the minimum number of grid points in Table 5.2.1-1 | | | | | | | | |
|  | |  | | | | | | | | |
| ***Consequences if not approved:*** | | The metric to quantify the radiated output power for devices utilizing 2Tx is not specified. | | | | | | | | |
|  | |  | | | | | | | | |
| ***Clauses affected:*** | | 5.1.1, 5.1.1.1 (new), 5.1.1.2 (new), 5.1.1.3 (new), 5.1.1.4 (new), 5.2.1 | | | | | | | | |
|  | |  | | | | | | | | |
|  | | **Y** | **N** |  | | | |  | | |
| ***Other specs*** | | **X** |  | Other core specifications | | | | TS38.161 | | |
| ***affected:*** | | **X** |  | Test specifications | | | | TS38.521-1 | | |
| ***(show related CRs)*** | |  | **X** | O&M Specifications | | | |  | | |
|  | |  | | | | | | | | |
| ***Other comments:*** | |  | | | | | | | | |
|  | |  | | | | | | | | |
| ***This CR's revision history:*** | |  | | | | | | | | |

<< start of change >>

# 5 Performance metrics

## 5.1 Definition of the Total Radiated Power (TRP)

### 5.1.1 Definition of the Total Radiated Power (TRP) for AC

#### 5.1.1.1 Applicability of TRP metrics

The TRP metrics are defined in Clauses 5.1.1.2 through 5.1.1.3, with the applicability provided in Table 5.1.1.1-1 below.

Table 5.1.1.1-1: Applicability of TRP metrics

|  |  |  |
| --- | --- | --- |
| Clause | TRP definition | Applicability |
| 5.1.1.2 |  | General TRP for UEs supporting single-port transmission, including single Tx, TxD and other cases |
| 5.1.1.3 |  | TRP for UEs supporting non-coherent UL MIMO |
| 5.1.1.4 |  | Both TRPenv and TRPavg are applicable for UEs supporting coherent UL MIMO |
|  |

#### 5.1.1.2 TRP for UEs supporting single-port transmission

Transmitter power measurements shall be performed using the Total Radiated Power (TRP) as the measurement metric. This clause defines the definition of TRP value of NR FR1 DUT for Anechoic Chamber (AC) method.

The TRP with Anechoic Chamber method is defined as:

(5.1)

Where the effective isotropic radiated power (EIRP) is defined as

(5.2)

Where is the product of the power delivered to the antenna and the antenna’s power gain.

Where EIRPθ and EIRPϕ are the EIRP in the corresponding θ and ϕ polarizations.

The summation form based on the sin⋅ weights of TRP with Anechoic Chamber method is defined as:

(5.3)

Where N and M are the number of sampling intervals for θ and ϕ. θn and ϕm are the measurement angles.

The summation form based on the Clenshaw-Curtis quadrature integral approximation of TRP with Anechoic Chamber method is defined as:

(5.4)

Where the value of can be calculated as follows:

(5.5)

with

and

The applicability of TRP quadratures, frequency ranges, and measurement grids is tabulated in Table 5.1.1-1.

Table 5.1.1-1: Applicability for TRP measurement grids

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Frequency Range | Quadrature | [°] | *N* | *M* | Min. Number of Grid Points |
| < 3GHz | sin() | 15 | 12 | 24 | 264 |
| 30 | 6 | 12 | 60 |
| Clenshaw-Curtis | 15 | 12 | 24 | 266 |
| 30 | 6 | 12 | 62 |
| > 3GHz | sin() | 15 | 12 | 24 | 264 |
| 30 | 6 | 12 | 60 |
| Clenshaw-Curtis | 15 | 12 | 24 | 266 |
| 30 | 6 | 12 | 62 |

#### 5.1.1.3 TRP for UEs supporting non-coherent UL MIMO

For devices capable of non-coherent UL MIMO and intended to be verified under the fixed TPMI test condition, the TRP metric defined in 5.1.1.2 is enhanced as follows:

(5.6)

Where the effective isotropic radiated power (EIRP) is measured by configuring the UE with the transmit precoding matrix index (TPMI) set to 2:

(5.7)

By substituting equation 5.1 in Clause 5.1.1.2 for 5.8 in this Clause, all of the remaining definitions in Clause 5.1.1.2 apply for TRP for non-coherent UL MIMO.

#### 5.1.1.4 TRP for UEs supporting coherent UL MIMO

For devices capable of coherent UL MIMO, the TRP metric defined in 5.1.1.2 is enhanced as follows:

(5.8)

(5.9)

Where both TRPenv and TRPavg are applicable for UEs supporting coherent UL MIMO.

In Equation 5.8, the effective isotropic radiated power (EIRP) is defined as the outcome of selecting the best EIRP from a sweep of all EIRP per grid point measured by configuring the UE with the transmit precoding matrix indices (TPMI) which are applicable according to the UE reported UL MIMO capability:

(5.10)

(5.11)

In Equation 5.9, the effective isotropic radiated power (EIRP) of the n-th TPMI is measured by configuring the UE with the corresponding transmit precoding matrix index set to n, where n is selected out of the set of TPMI indices according to the UE reported UL MIMO capability:

(5.12)

By substituting equation 5.1 in Clause 5.1.1.2 for 5.8 and 5.9 in this Clause, all of the remaining definitions in Clause 5.1.1.2 apply for TRP for coherent UL MIMO.

### 5.1.2 Definition of the Total Radiated Power (TRP) for RC method

TRP in the reverberation chamber is a measurement of transmitter performance in an isotropic Rayleigh fading environment that is based on sampling the radiated power of the UE/MS for a discrete number of field combinations. The average value of these statistically distributed samples is proportional to the TRP and by calibrating the average power transfer function, an absolute value of the TRP can be obtained. The TRP with Reverberation Chamber method is defined as:

Where is the reference power transfer function for the fixed measurement antenna, is the reflection coefficient for the fixed measurement antenna and is the path loss in the cables connecting the measurement receiver to fixed measurement antenna. These parameters are calculated from the calibration measurement and are further discussed in calibration section. is the average power measured by the fixed measurement antenna and can be calculated using the following expression:

Where is sample number of the complex transfer function measured with the fixed measurement antenna and is the total number of samples measured.

## 5.2 Definition of Total Radiated Sensitivity (TRS)

### 5.2.1 Definition of the Total Radiated Sensitivity (TRS) for AC

Receiver sensitivity measurements shall be performed using data throughput as the measurement metric. The DUT’s receiver sensitivity corresponds to the minimum downlink signal power required to provide a data throughput rate greater than or equal to 95% of the maximum throughput of the reference measurement channel (RMC).

This definition will be used to calculate the Total Radiated Sensitivity (TRS) value of NR FR1 DUT.

The TRS with Anechoic Chamber method is defined as:

(5.13)

Where the effective isotropic sensitivity (EIS) is defined as the minimum power level at which the throughput exceeds or equal to 95% of the maximum throughput of the specified RMC, at each sampling point.

Where EISθ and EISϕ are the EIS in the corresponding θ and ϕ polarizations.

The summation form based on the sin⋅ weights of TRS with Anechoic Chamber method defined as:

(5.14)

Where N and M are the number of sampling intervals for θ and ϕ. θn and ϕm are the measurement angles.

The summation form based on the Clenshaw-Curtis quadrature integral approximation of TRS with Anechoic Chamber method is defined as:

(5.15)

Where the value of follows Equation 5.5.

The applicability of TRP quadratures, frequency ranges, and measurement grids is tabulated in Table 5.2.1-1.

Table 5.2.1-1: Applicability for TRS measurement grids

|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
| Frequency Range | Quadrature | [°] | *N* | *M* | Min. Number of Grid Points |
| < 3GHz | sin() | 30 | 6 | 12 | 60 |
| Clenshaw-Curtis | 30 | 6 | 12 | 62 |
| 45 | 4 | 8 | 26 |
| > 3GHz | sin() | 30 | 6 | 12 | 60 |
| Clenshaw-Curtis | 30 | 6 | 12 | 62 |
| 45 | 4 | 8 | 26 (Note 1) |
| Note 1: When the back pole at = 180° cannot be measured due to obstruction and/or blocking, extrapolation is used to estimate EIS at = 180° for measurement grids with =45° by either a) using at least two points within 15° of the pole or b) averaging the last cut (i.e. = 135°) | | | | | |

### 5.2.2 Definition of the Total Radiated Sensitivity (TRS) for RC method

The calculation of TRS is based on searching for the lowest power received by the UE for a discrete number of field combinations in the chamber. The downlink power received by the UE at each discrete field combination that provides a BER (or BLER) which is better than the specified target BER/BLER level shall be averaged with other such measurements using different field combinations. By calibrating the average power transfer function, an absolute value of the TRS can be obtained when the linear values of all downlink power levels have been averaged.

The TRS with Reverberation Chamber method is defined as:

Where is the reference power transfer function for the fixed measurement antenna, is the reflection coefficient for the fixed measurement antenna and is the path loss in the cables connecting the measurement receiver to fixed measurement antenna. The parameters are calculated from the calibration measurement and are further discussed in calibration section. is the output power from the base station emulator when it is adjusted to give the specified digital error rate or throughput from the DUT for mode-stirring sample

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## 7.4 TRP Test procedure

<Editor’s note: includes test procedure for both SA and EN-DC. Consider NR 1Tx, 2Tx, RedCap, and CA,>

### 7.4.1 General

For TRP and TRS testing in SA or EN-DC mode, measurements should be only performed at NR carrier. The LTE link antenna in EN-DC mode is used to provide a stable LTE link to the DUT without precise path loss or polarization control.

The TRP of the DUT is measured by sampling the radiated transmit power of the DUT with three-dimensional scan at various locations surrounding the device. The measurement is performed with the sampling step for theta () and phi () axes defined in Table B.2.12-1, Annex B.2.12. For some test system can not measure 180º EIRP, then the extrapolation approach can be adopted when generating the 3D antenna pattern. All of the measured power values will be integrated to TRP, as defined in Clause 5.1.1.2.

For TRP measurement, the evaluations shall be performed at maximum transmit power.

### 7.4.2 TRP test procedure for NR 1Tx configuration

#### 7.4.2.1 UE configuration

For devices containing multiple Tx antennas, the Tx Antenna Switching (TAS) function should be OFF, and the TRP should be measured for each Tx antenna individually. The antenna with better TRP is identified as the primary antenna, and the corresponding TRP result will be used to determine the pass/fail compliance. Otherwise, the primary antenna should be selected based on manufacturer declaration. To ensure the TAS OFF testing, the manufacture should provide either software/guidance to lab to control which Tx antenna is used, or the pre-configured DUT locked at primary antenna.

For Standalone, the NR System Simulator (SS) and DUT shall be configured per TS 38.521-1 [5], section 6.2.1 (UE maximum output power) using the default settings specified in TS 38.521-1 [5] and TS 38.508-1 [7] as applicable. The measurement should be carried out based on the detailed test parameters for each band, as defined in Clause 4.3.

For EN-DC, the SS and DUT shall be configured per TS 38.521-3 [6], Section 6.2B.1 (UE Maximum Output Power for EN-DC) using the default settings specified in TS 38.521-3 [6] and TS 38.508-1 [7] as applicable. The measurement should be carried out based on the detailed test parameters for each band, as defined in Clause 4.3. The UL output power of LTE carrier should be set as a constant power of 10dBm, while measuring NR at maximum output power, i.e., with fixed p-MaxEUTRA-r15=10 dBm, and p-NR-FR1 not configured.

#### 7.4.2.2 Test procedure

<Editor’s note: in general, RedCap test procedure is the same except for forearm positioning.>

For UE configured with 1Tx for NR carrier, SA or EN-DC mode, the measurement procedure includes the following steps:

1) Place the DUT inside the QZ following the positioning guideline defined in Clause 6.

2) Connect the SS with the DUT through the link antenna following steps 1 and 2 in section 6.2.1.4.2 of TS 38.521-1 [5] and ensure the DUT transmits with its maximum power.

3) Measure the power at each measurement point, and calculate by adding the composite loss of the entire transmission path.

The TRP value is calculated using the TRP integration approaches outlined in Clause 5.1.1.2.

### 7.4.3 TRP test procedure for NR 2Tx configuration

<Editor’s note: this clause defines test procedure for single-layer UL MIMO, TxD >

#### 7.4.3.1 UE configuration

In general, the UE 2Tx configuration can be categorized into two test cases, i.e., TxD and UL-MIMO.

For TxD test case, the TRP should be measured with all the Tx antenna ON. For SA, the NR System Simulator (SS) and DUT shall be configured per TS 38.521-1 [5], section 6.2G.1 (UE maximum output power for Tx Diversity) using the default settings specified in TS 38.521-1 [5] and TS 38.508-1 [7] as applicable. The measurement should be carried out based on the detailed test parameters for each band, as defined in Clause 4.3 of this TR.

FFS phase issue between 2Tx antennas under TxD configuration, e.g., with additional UE-specific configuration based on UE declaration.

For single-layer UL-MIMO, the baseline TRP measurement should be performed with all the Tx antenna ON. The detailed TPMI configuration for each UE type is as following:

- For non-coherent UE support fullpowerMode1, fixed TPMI index =2 as baseline configuration

- For non-coherent UE does not support fullpowerMode1, single-layer UL-MIMO TRP testing is not required.

- For coherent UE, two or four TPMI index from TPMI index =2~5 based on UE declaration.

#### 7.4.3.2 TxD TRP Test procedure

<Editor’s note: the study to mitigate or consider the phase between antennas unresolved issues is FFS >

For UE configured with 2Tx for TxD mode, the measurement procedure of TRP includes the following steps:

1) Place the DUT inside the QZ following the positioning guideline defined in Clause 6.

2) Connect the SS with the DUT through the link antenna following steps 1 and 2 in section 6.2G.1.4.2 of TS 38.521-1 [5] and ensure the DUT transmits with its maximum power.

3) Measure the power at each measurement point, and calculate by adding the composite loss of the entire transmission path.

The TRP value is calculated using the TRP integration approaches outlined in Clause 5.1.1.2.

#### 7.4.3.3 Single-layer UL-MIMO TRP Test procedure

For non-coherent UE support fullpowerMode1, the test procedure for single-layer UL-MIMO TRP Testing is as following:

1) Place the DUT inside the QZ following the positioning guideline defined in Clause 6.

2) Connect the SS with the DUT through the link antenna following step 4 for ULFPTx in section 6.2D.1.4.2 of TS 38.521-1 [5] with the exception of UE configuration defined in clause 7.4.3.1 and ensure the DUT transmits with its maximum power.

3) Measure the power at each measurement point, and calculate by adding the composite loss of the entire transmission path.

The TRP value is calculated using the TRP integration approaches outlined in Clause 5.1.1.3.

For coherent UE UL-MIMO TRP testing, the common test procedure is as following:

1) Place the DUT inside the QZ following the positioning guideline defined in Clause 6.

2) Connect the SS with the DUT through the link antenna following steps for ULFPTx in section 6.2D.1.4 of TS 38.521-1 [5] with the exception of UE configuration defined in clause 7.4.3.1 and ensure the DUT transmits with its maximum power.

3) Set the SS to transmit with [*i=2*].

4) Measure the power and calculate by adding the composite loss of the entire transmission path.

5) Repeat steps 3) and 4) for the remaining or subset of with [*i={3,4,5}*].

6) Repeat steps 3) to 5) for each measurement grid point.

Note: Based on different test system implementation, step 5 and step 6 may be switched.

The TRP value is calculated using the TRP integration approaches outlined in Clause 5.1.1.4.

### 7.4.4 TRP test procedure for NR DL CA configuration

#### 7.4.4.1 UE configuration

For UE radiated conformance testing P-MPRc shall be 0 dB.

FR1 TRP and TRS radiated conformance testing shall be performed with the UE consistently operating at maximum power level, e.g., Time-Averaged Algorithm (TAA) and other power back-off functions should be disabled. The above functions OFF should be based on manufacturer declaration, if declared, then the manufacturer is required to provide a mechanism for the test lab to enable/disable the function.

The NR SS should send continuous uplink power control “up” commands to the DUT to ensure the DUT’s transmitter is at maximum output power during the CA TRP and TRS test.

For devices containing multiple Tx antennas, the Tx Antenna Switching (TAS), the guidelines specified in Clause 7.4.2 of TR 38.870 shall be used. However, devices supporting dual Tx in CA mode, without TAS, it can be tested as normal, namely no special handling of the Tx antennas is needed.

For CA, the SS and DUT shall be configured per TS 38.521-1 [5], Section 6.2A.1 (UE Maximum Output Power for CA) using the default settings specified in TS 38.521-1 [5] and TS 38.508-1 [7] as applicable. The measurement should be carried out based on the detailed test parameters for each band, as defined in Table 4.3.3-1 in TR 38.870.

#### 7.4.4.2 Test procedure

For UE configured with inter-band DL CA (two bands) with only single uplink CC, the measurement procedure includes the following steps:

1) Place the DUT inside the QZ following the positioning guideline defined in Clause 6.

2) Connect the SS with the DUT through the link antenna following steps 1 and 2 in section 6.2A.1.1.4.2 of TS 38.521-1 [5] and ensure the DUT transmits with its maximum power.

3) Measure the power for the UL CC at each measurement point, and calculate EIRP(θ,ϕ) by adding the composite loss of the entire transmission path.

The TRP value is calculated using the TRP integration approaches outlined in Clause 5.1.1.2.

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