FCC TA-PD validation – Part 2: Tests under dynamic transmit power scenario

The following samples were submitted and identified on behalf of the client as:

Product Name	SAMSUNG Mobile Tablet
Brand Name	Galaxy Tab S10 PLUS
Model No.	SM-X828U
Applicant	Samsung Electronics. Co., Ltd. 129, Samsung-ro Yeontong-gu, Suwon-si, Gyeonggi-do, Korea
FCC ID	A3LSMX828U
Date of EUT Receipt	Jun. 25, 2024
Date of Test(s)	Jul. 31, 2024 ~ Aug. 01, 2024
Date of Issue	Aug. 07, 2024

In the configuration tested, the EUT complied with the standards specified above.

Remarks:

This report details the results of the testing carried out on one sample, the results contained in this test report do not relate to other samples of the same product. The manufacturer should ensure that all products in series production are in conformity with the product sample detailed in this report.

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Signed on behalf of SGS

Clerk / Cindy Chou	PM / Kiki Lin	Approved By / John Yeh
Cindy Chou	Kiki Lin	John Yeh

Date: Aug. 07, 2024

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Revision History

Report Number	Revision	Description	Issue Date	Revised By	Remark
TESA2406000425ES	00	Initial creation of document	Aug. 07, 2024	Cindy Chou	

Note:

1. The mark " * " is the revised version of the report due to comments submitted by the certification.

Contents

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1 GENERAL INFORMATION

1.1 Test Facility

Laboratory	Test Site Address	Test Site Name	FCC Designation number	IC CAB identifier
SGS Taiwan Ltd. Central RF Lab. (TAF code 3702)	1F, No. 8, Alley 15, Lane 120, Sec. 1, NeiHu Road, Neihu District, Taipei City, 11493, Taiwan.	SAR 2	TW0029	TW3702
		SAR 6		
		SAR 8		
	No. 2, Keji 1st Rd., Guishan Township, Taoyuan County, 33383, Taiwan	SAR 1	TW0028	
		SAR 4		
	No.134, Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan	SAR 3	TW0027	
		SAR 7		

Note: Test site name is remarked on the equipment list in each section of this report as an indication where measurements occurred in specific test site and address.

2 OVERVIEW

FCC regulation allows time averaged RF power to demonstrate compliance to RF exposure safety limits. Because RF exposure is correlated to transmission power (TX power), e.g., lower RF exposure is correlated to lower TX power, the TX power can be controlled to meet FCC RF exposure limits defined specific absorption rate (SAR) limit for transmit frequencies < 6GHz and power density (PD) limit for transmit frequencies > 6 GHz. For SAR limit, the proposed Time-Averaged Specific Absorption Rate (TA-SAR) algorithm manages TX power to ensure that at all times the time-averaged RF exposure is compliant with the FCC SAR requirement. For PD limit, the proposed Time- Averaged Power Density (TA-PD) algorithm controls TX power to ensure that at all times the time- averaged RF exposure is compliant with the FCC PD requirement and total exposure ratio (TER) limit. In the FCC regulation, the averaging window of SAR is 100 seconds for transmit frequencies less than 3GHz, 60 seconds for transmit frequencies between 3GHz and 6GHz, and the averaging window of PD is 4 seconds for transmit frequencies between 24GHz and 42GHz.

This report describes the test plan, test procedures, measurement setup, and measurement results for the verification of the proposed TA-PD algorithm being able to make RF exposure meet FCC requirement.
It is concluded that the proposed TA-PD algorithm can apply dynamic power control to ensure FCC compliance in real-time.

3 OPERATING PARAMETERS FOR ALGORITHMVALIDATION

Mediatek developed the TA-SAR and TA-PD algorithm to control instantaneous TX power for transmit frequencies less and larger than 6GHz respectively, so that the total time-averaged RF exposures (i.e., SAR, PD, and SAR+PD exposure) are less than FCC requirement.

TA-SAR algorithm validation has been performed for 2G, 3G, LTE, NR FR1 according to cases with different combinations of operating parameters listed in Table 3-1.

Table 3-1 TA-SAR operating parameters

Operating parameters	Description
P_{sub6_limit}	The time-averaged maximum power level limit for different band in sub6.
$P_{LowThresh\_offset}$	To calculate $P_{LowThresh}$. ($P_{LowThresh} = P_{sub6\_limit} - P_{LowThresh\_offset}$)
$P_{UE\_backoff\_offset}$	To calculate $P_{UE\_backoff}$. ($P_{UE\_backoff} = P_{sub6\_limit} - P_{UE\_backoff\_offset}$)
$P_{UE\_max\_cust\_offset}$	To calculate $P_{UE\_max\_cust}$. P_{UE_max} is maximum TX power at which a UE can possibly transmit in sub6. $P_{UE\_max\_cust} = \min(P_{UE\_max}, P_{sub6\_limit} + P_{UE\_max\_cust\_offset})$

TA-PD algorithm validation has been performed for millimeter wave (mmW) according to cases with different combinations of operating parameters listed in Table 3-2.

Table 3-2 TA-PD operating parameters

Operating parameters	Description
P_{FR2_limit}[beam]	The time-averaged maximum power level limit for different band/beam in mmW.
$P_{FR2\_LowThresh\_offset}$[beam]	To calculate $P_{FR2\_LowThresh}$[beam]. ($P_{FR2\_LowThresh}$[beam] = P_{FR2_limit}[beam] - $P_{LowThresh\_offset}$)
$P_{FR2\_UE\_backoff\_offset}$[beam]	To calculate $P_{FR2\_UE\_backoff}$[beam]. ($P_{FR2\_UE\_backoff}$[beam] = P_{FR2_limit}[beam] - $P_{FR2\_UE\_backoff\_offset}$[beam])
$P_{FR2\_UE\_max\_cust\_offset}$[beam]	$P_{FR2\_UE\_max}$ is maximum TX power at which a UE can possibly transmit in FR2. $P_{FR2\_UE\_max\_cust}$ = min($P_{FR2\_UE\_max}$, P_{FR2_limit}[beam] + $P_{FR2\_UE\_max\_cust\_offset}$[beam])

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4 OVERVIEW OF TA-PD TEST PROPOSAL

For the completeness of verifying that the proposed TA-PD algorithm can realize FCC compliance regarding RF exposure, several test scenarios are constructed as below:

- **Scenario 1:** test under different TA-PD parameters to verify that the TA-PD algorithm meets compliance requirements with different combinations of operating parameters.
- **Scenario 2:** test under time-varying TX power to verify that the TA-PD algorithm ensures FCC compliance through dynamic TX power.
- **Scenario 3:** test under call drop and re-establishment conditions to ensure the TA-PD algorithm control continuity and FCC compliance.
- **Scenario 4:** test under RAT/band handover to ensure TA-PD algorithm control continuity and correctness.
- **Scenario 5:** test under different transmission beams to ensure TA-PD algorithm control works correctly during beam switching from one beam to another.
- **Scenario 6:** test under SAR-and-PD exposure switching to ensure TA-SAR/TA-PD algorithm control correctness and prove the normalized total RF exposure is less than 1 (FCC requirement).

5 TA-PD TEST CASES AND TEST PROCEDURES

In order to demonstrate that TA-PD algorithm performs as expected under various operating scenarios, Table 5-1 lists the test scenarios and expected test sequences to validate TA-PD algorithm in these scenarios.

Table 5-1 Test scenario list of TA-PD validation

Test scenario		Test sequences #	Description
1	Range of TA-PD parameters	0	Adjust parameters
2	Time-varying TX power	0	Test under time-varying TX power
3	Call disconnection and re-establishment	0	Test call drop and re-establishment
4	Band handover	0	Test band change
5	Beam switching	0	Change beam
6	SAR vs. PD exposure switching	0	Switch RATs of sub6 and mmW when testing(e.g.,LTE→mmW)

5.1 Test Sequences for All Scenarios

In this section, the test sequences for TA-PD validation only use test sequence 0 (i.e., maximum power).

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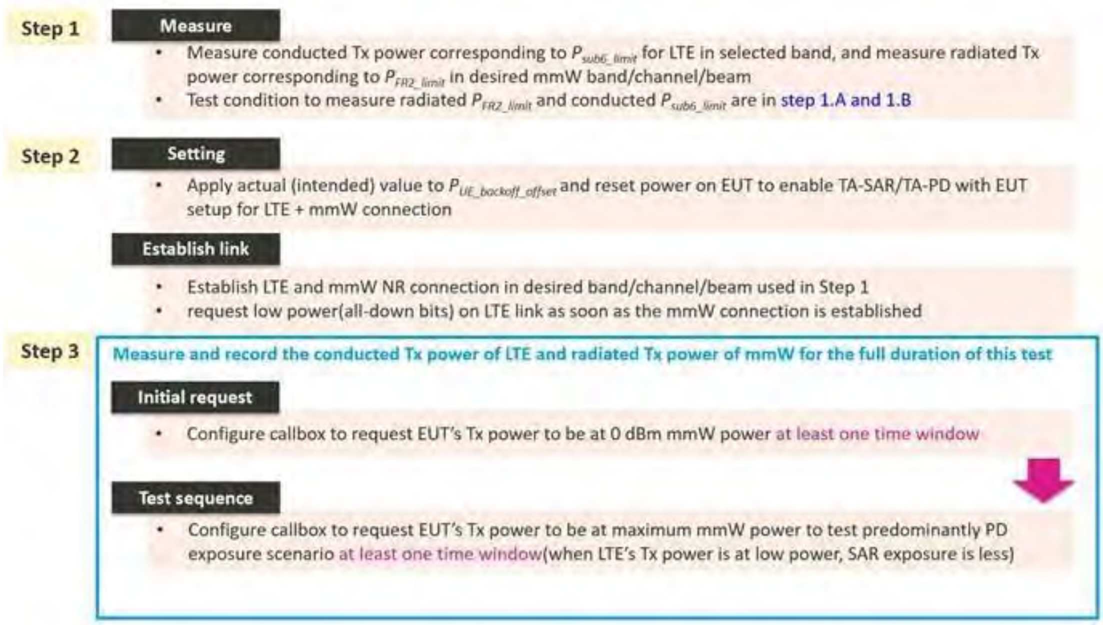
5.2 Test Configuration and Procedure for Scenario 1: Range of TA-PD Parameters via Radiated Power Measurements

5.2.1 Configuration

This test is performed by changing the parameters ($P_{FR2\_LowThresh\_offset}$, $P_{FR2\_UE\_backoff\_offset}$, $P_{FR2\_UE\_max\_cust\_offset}$) for the selected RAT. Since Mediatek's TA algorithm operation is independent of RATs/bands/channels, any one RAT/band can be selected for this test. In principle, two sets of the parameters are determined for this test (if applicable). If the parameters of the EUT are fixed (without a support of dynamic change), only the set of the default parameters needs to be tested.

5.2.2 Procedure

- Step 1~3: measure and record TX power versus time for test scenario 1
  - A. Measure radiated power corresponding to mmW P_{FR2_limit}
    1. Setting up the EUT's TX power in desired band/channel/beam at PFR2_limit in engineering mode
    2. This test is performed in a calibrated anechoic chamber
    3. Rotate the EUT to obtain maximum radiated TX power, keep the EUT in this position and do not disturb the position of the EUT inside the anechoic chamber for the rest of this test
  - B. Measure conducted TX power corresponding to LTE P_{sub6_limit}
    1. Reset EUT to place in online mode and establish radio link in LTE
    2. Measure conducted TX power corresponding to LTE P_{sub6_limit} with TA-SAR enabled and $P_{UE\_backoff\_offset}$ set to 0 dB, and callbox set to request maximum power
    3. When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.



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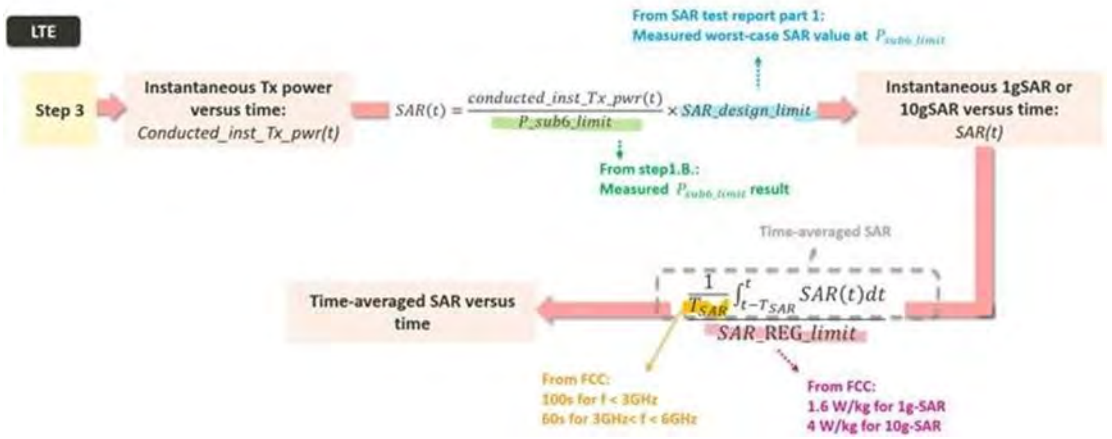
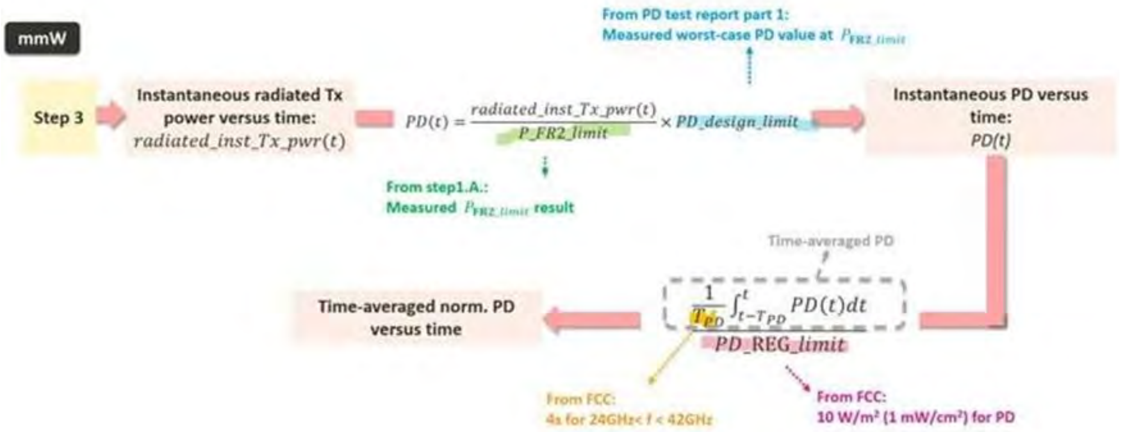
- Step 4: convert the measured conducted TX power and measured radiated TX power into SAR and PD respectively

Convert the measured conducted TX power from step 3 into 1gSAR or 10gSAR value using the following equation. Perform the running time average to power and 1gSAR or 10g SAR to determine time-averaged value versus time as follows,



Convert the measured radiated TX power from step 3 into PD value using the following equation. Perform the running time average to power and PD to determine time-averaged value versus time as follows,



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- Step 5: plot results
  A. Make one power perspective plot containing
    1. Instantaneous conducted TX power (LTE)
    2. Calculated time-averaged conducted TX power (LTE)
    3. Time-averaged conducted power limits (LTE)
    4. Instantaneous radiated TX power (mmW)
    5. Calculated 4s-averaged radiated TX power (mmW)
    6. Time-averaged radiated power limits (mmW)
  B. Make one SAR/PD perspective plot containing
    1. Calculated norm. time-averaged SAR (LTE)
    2. Calculated norm. 4s-averaged PD (mmW)
    3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0 or PD/10
    4. Summation of all normalized time-averaged RF exposures
    5. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR) or 10 W/m^2(PD)

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5.3 Test Configuration and Procedure for Scenario 2: Time- Varying TX Power via Radiated Power Measurements

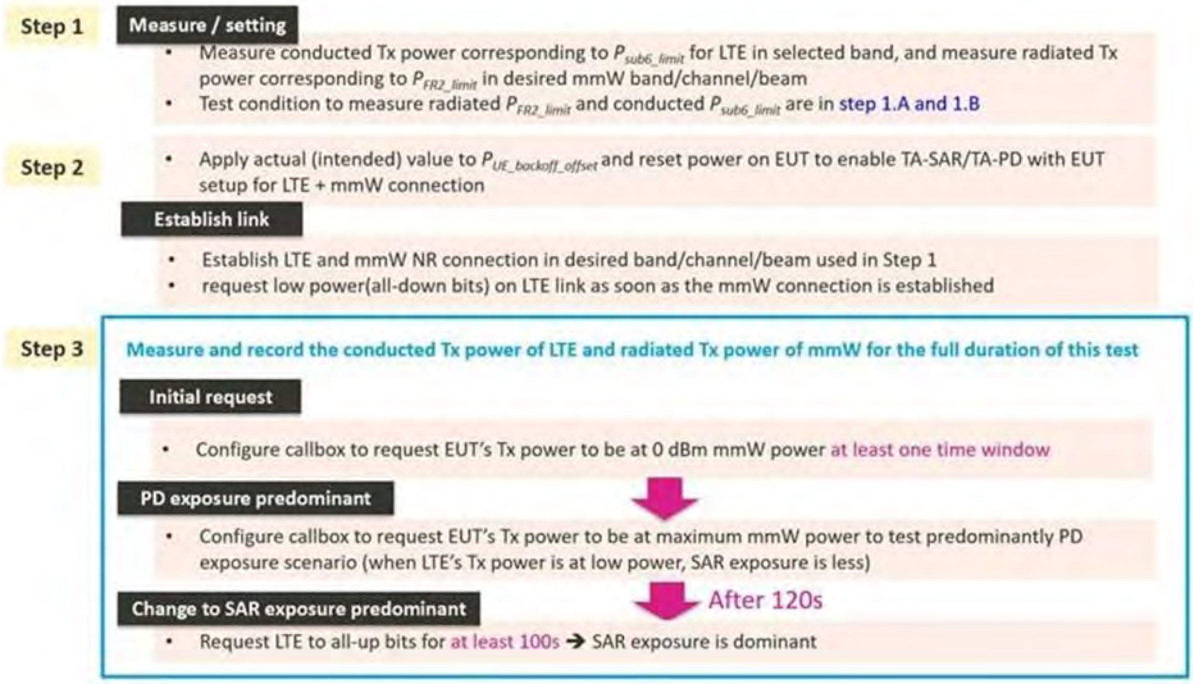
5.3.1 Configuration

Mediatek's TA algorithm operation is independent of bands, channels, and antenna configurations (beams) for a given RAT.

- Any one band/channel per RAT is sufficient to validate the algorithm.

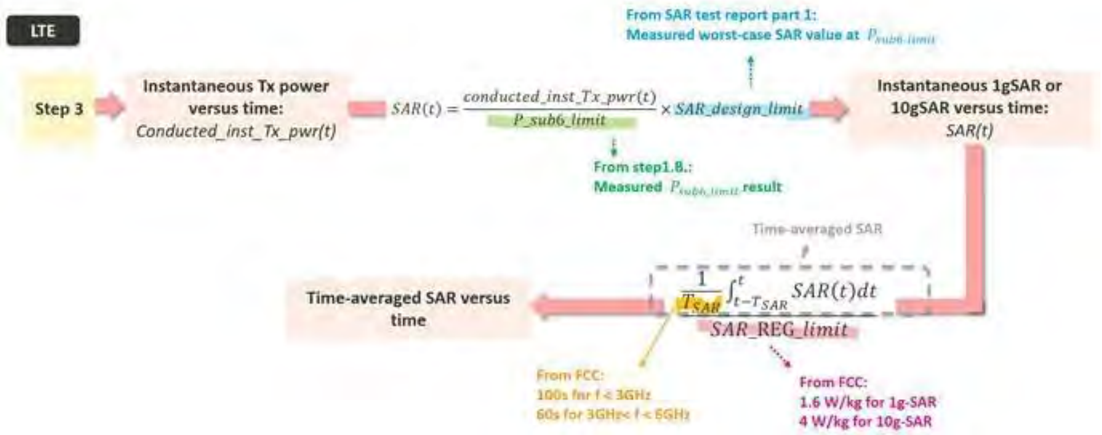
5.3.2 Procedure

- Step 1~3: measure and record TX power versus time for test scenario 2
  - A. Measure radiated power corresponding to mmW P_{FR2_limit}
    1. Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} in engineering mode
    2. This test is performed in a calibrated anechoic chamber
    3. Rotate the EUT to obtain maximum radiated TX power, keep the EUT in this position and do not disturb the position of the EUT inside the anechoic chamber for the rest of this test
  - B. Measure conducted TX power corresponding to LTE P_{sub6_limit}
    4. Reset EUT to place in online mode and establish radio link in LTE
    5. Measure conducted TX power corresponding to LTE Psub6_limit with TA-SAR enabled and $P_{UE\_backoff\_offset}$ set to 0 dB, and callbox set to request maximum power
    6. When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.

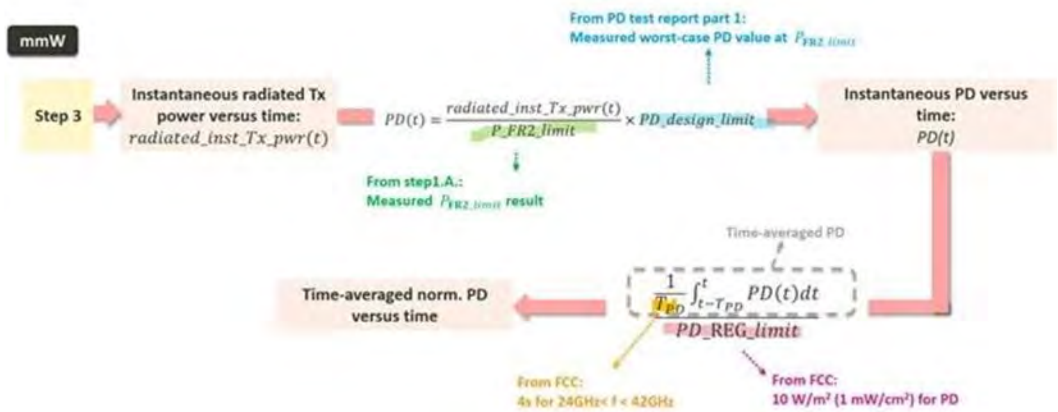


- Step 4: convert the measured conducted TX power and measured radiated TX power into SAR and PD respectively

Convert the measured conducted TX power from step 3 into 1gSAR or 10gSAR value using the following equation. Perform the running time average to power and 1gSAR or 10g SAR to determine time-averaged value versus time as follows,



Convert the measured radiated TX power from step 3 into PD value using the following equation. Perform the running time average to power and PD to determine time-averaged value versus time as follows,



- Step 5: plot results
  - A. Make one power perspective plot containing
    1. Instantaneous conducted TX power (LTE)
    2. Calculated time-averaged conducted TX power (LTE)
    3. Time-averaged conducted power limits (LTE)
    4. Instantaneous radiated TX power (mmW)
    5. Calculated 4s-averaged radiated TX power (mmW)
    6. Time-averaged radiated power limits (mmW)
  - B. Make one SAR/PD perspective plot containing
    1. Calculated norm. time-averaged SAR (LTE)
    2. Calculated norm. 4s-averaged PD (mmW)
    3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0 or PD/10
    4. Summation of all normalized time-averaged RF exposures
    5. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR) or 10 W/m2(PD)

5.4 Test Configuration and Procedure for Scenario 3: Call Disconnection and Re-establishment via Radiated Power Measurements

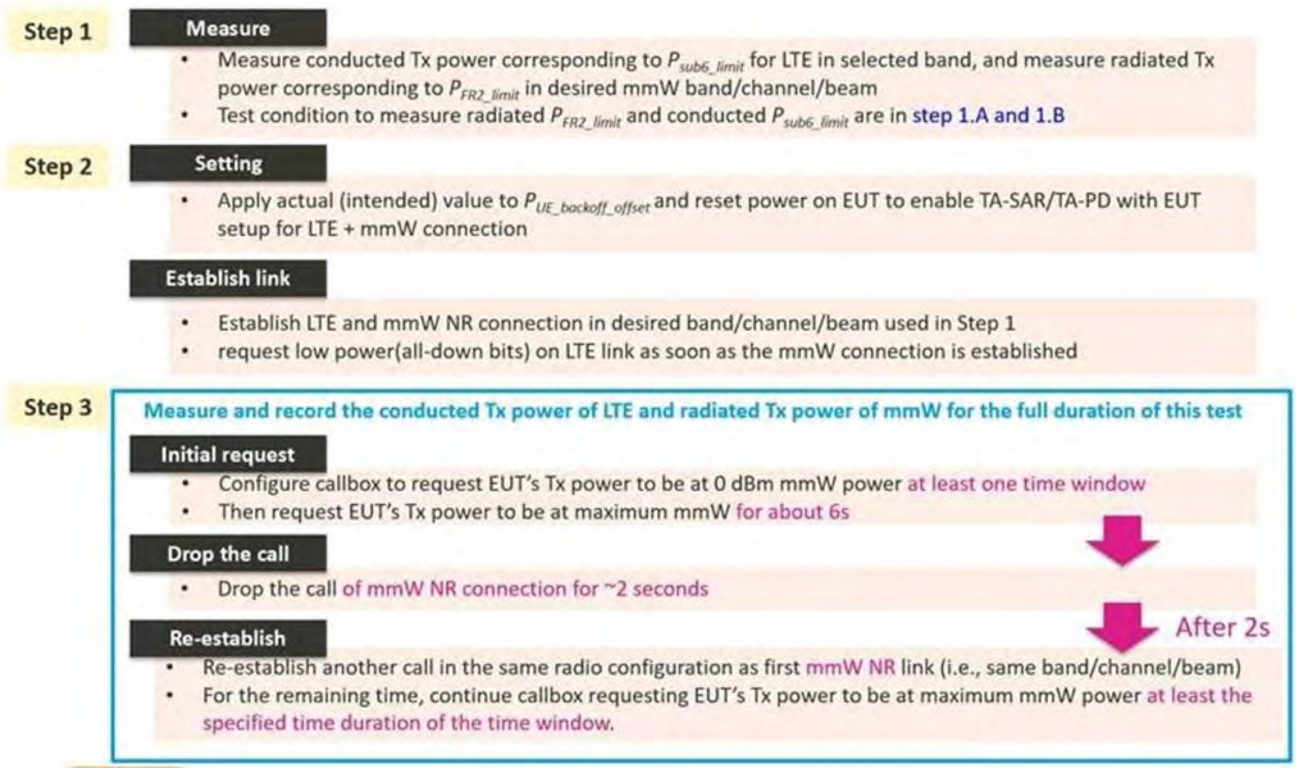
5.4.1 Configuration

Mediatek's TA algorithm operation is independent of bands, channels, ANT configurations (beams) for a given RAT.

- Any one band/channel is sufficient to validate the algorithm.

5.4.2 Procedure

- Step 1~3: measure and record TX power versus time for test scenario 3
  - A. Measure radiated power corresponding to mmW P_{FR2_limit}
    1. Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} in engineering mode
    2. This test is performed in a calibrated anechoic chamber
    3. Rotate the EUT to obtain maximum radiated TX power, keep the EUT in this position and do not disturb the position of the EUT inside the anechoic chamber for the rest of this test
  - B. Measure conducted TX power corresponding to LTE P_{sub6_limit}
    1. Reset EUT to place in online mode and establish radio link in LTE
    2. Measure conducted TX power corresponding to LTE P_{sub6_limit} with TA-SAR enabled and $P_{UE\_backoff\_offset}$ set to 0 dB, and callbox set to request maximum power
    3. When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at Psub6_limit without TA-SAR.



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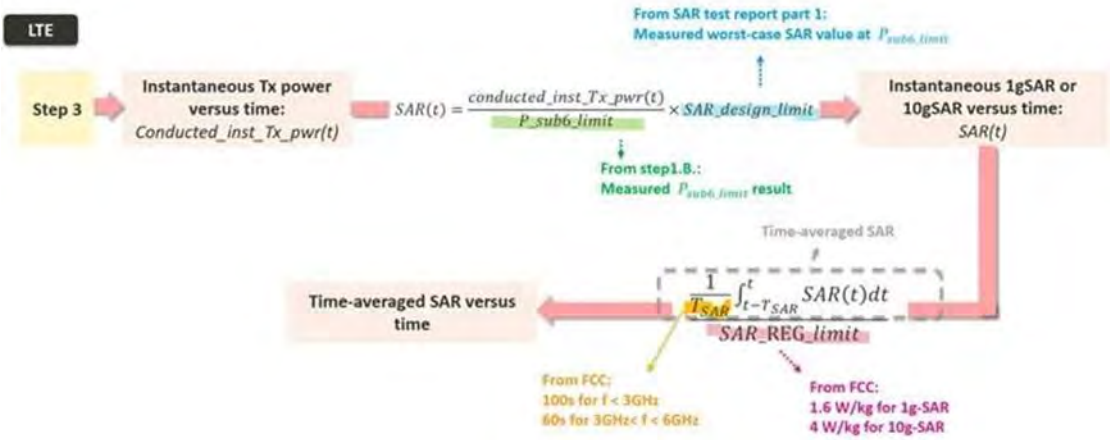
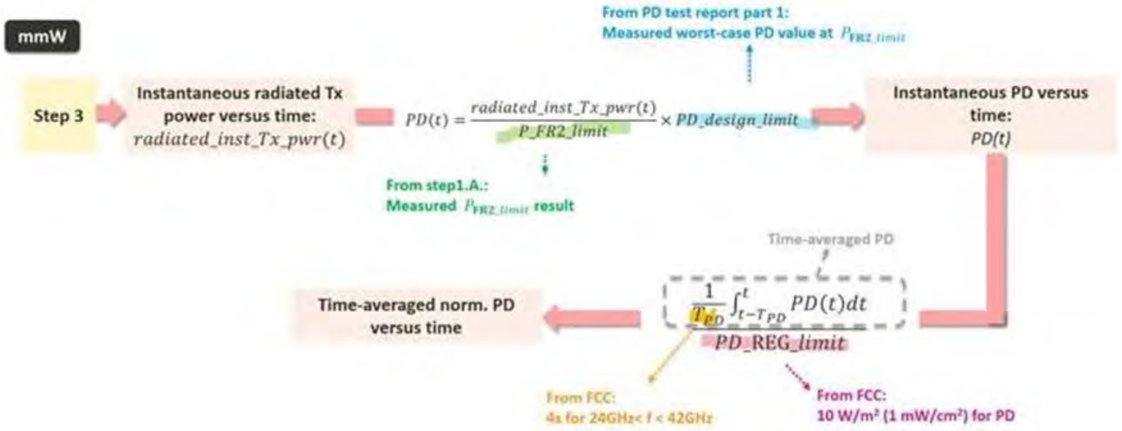
- Step 4: convert the measured conducted TX power and measured radiated TX power into SAR and PD respectively

Convert the measured conducted TX power from step 3 into 1gSAR or 10gSAR value using the following equation. Perform the running time average to power and 1gSAR or 10g SAR to determine time-averaged value versus time as follows,



Convert the measured radiated TX power from step 3 into PD value using the following equation. Perform the running time average to power and PD to determine time-averaged value versus time as follows,



- Step 5: plot results
  A. Make one power perspective plot containing
     1. Instantaneous conducted TX power (LTE)
     2. Calculated time-averaged conducted TX power (LTE)
     3. Time-averaged conducted power limits (LTE)
     4. Instantaneous radiated TX power (mmW)
     5. Calculated 4s-averaged radiated TX power (mmW)
     6. Time-averaged radiated power limits (mmW)
  B. Make one SAR/PD perspective plot containing
     1. Calculated norm. time-averaged SAR (LTE)
     2. Calculated norm. 4s-averaged PD (mmW)
     3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0 or PD/10
     4. Summation of all normalized time-averaged RF exposures
     5. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR) or 10 W/m^2(PD)

5.5 Test Configuration and Procedure for Scenario 4: Band Handover via Radiated Power Measurements

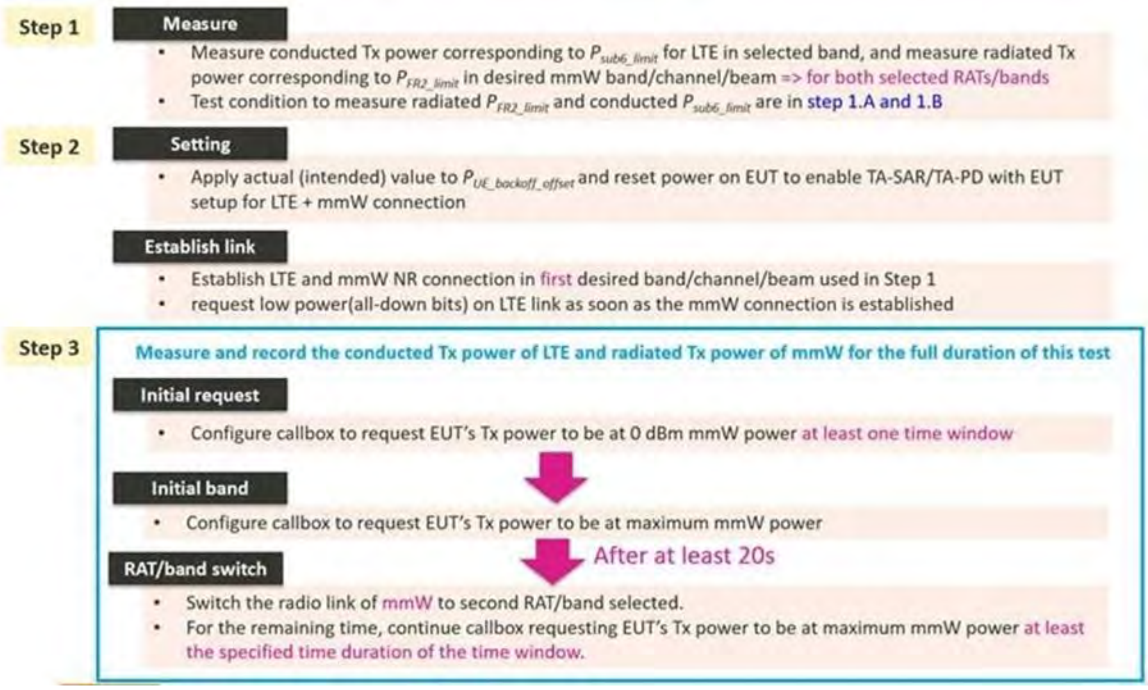
5.5.1 Configuration

Mediatek's TA algorithm operation is independent of bands, channels, antenna configurations (beams) for a given RAT.

- Any two bands are sufficient to validate the algorithm.

5.5.2 Procedure

- Step 1~3: measure and record TX power versus time for test scenario 4
  - A. Measure radiated power corresponding to mmW P_{FR2_limit}
    1. Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} of band1 in engineering mode
    2. This test is performed in a calibrated anechoic chamber
    3. Do not disturb the position of the EUT inside the anechoic chamber for the rest of this test
    4. Repeat the procedure above for band2
  - B. Measure conducted TX power corresponding to LTE P_{sub6_limit}
    1. Reset EUT to place in online mode and establish radio link in LTE
    2. Measure conducted TX power corresponding to LTE P_{sub6_limit} with TA-SAR enabled and $P_{UE\_backoff\_offset}$ set to 0 dB, and callbox set to request maximum power
    3. When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.



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- Step 4: Re-scale the measured instantaneous radiated power in step 2~3 to maximum instantaneous radiated power for both beams

Reason:

- The measured radiated powers for band 1 and band 2 in step1 A. were performed at an arbitrary rotation of EUT in anechoic chamber
- Not the desired measured PFR2_limit (not maximum instantaneous radiated power for the condition)
- Both bands have different position of EUT for maximum power
- Need to rotate the EUT during step 2~3 test to acquire maximum power for both bands
- Might not acquire accurate results for step 2~3 if rotating the EUT during test

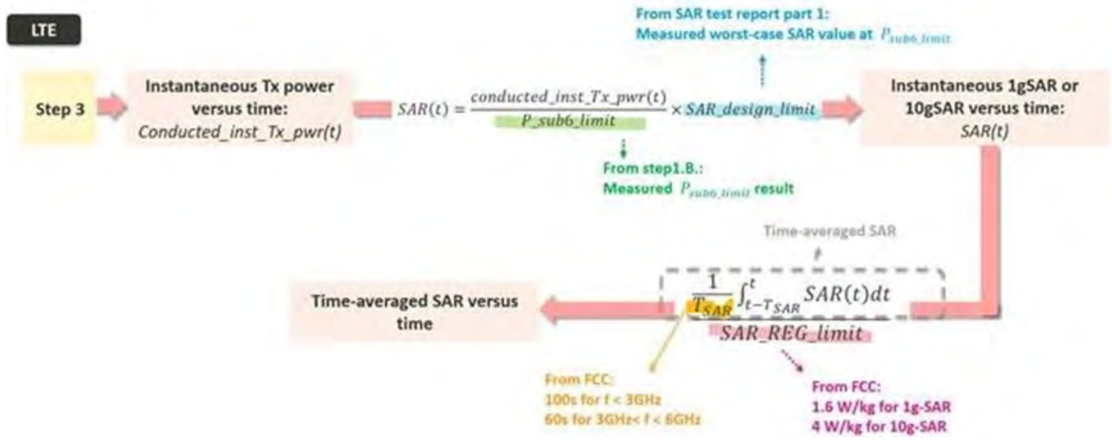
Method:

- Repeat step1 A. of this procedure by rotating the EUT to determine maximum radiated power at P_{FR2_limit} in engineering mode for both bands separately

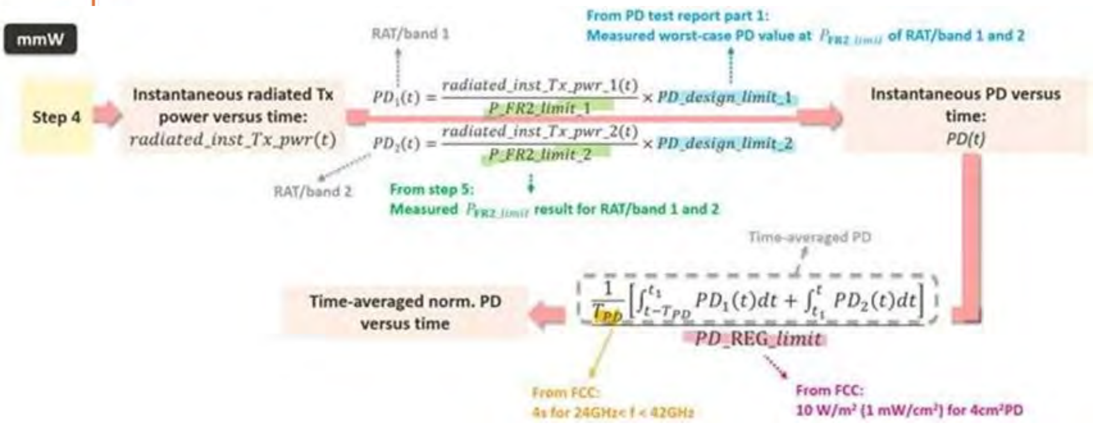
Re-scale the measured instantaneous radiated power in Step 3 by the delta in radiated power measured in Step 4 and the radiated power measured in Step1 A.

- Step 5: convert the measured conducted TX power and measured radiated TX power into SAR and PD respectively

Convert the measured conducted TX power from step 3 into 1gSAR or 10gSAR value using the following equation. Perform the running time average to power and 1gSAR or 10g SAR to determine time-averaged value versus time as follows,



Convert the measured radiated TX power from step 3 into PD value using the following equation. Perform the running time average to power and PD to determine time-averaged value versus time as follows,



- Step 6: plot results
  A. Make one power perspective plot containing
     1. Instantaneous conducted TX power (LTE)
     2. Calculated time-averaged conducted TX power (LTE)
     3. Time-averaged conducted power limits (LTE)
     4. Instantaneous radiated TX power (mmW)
     5. Calculated 4s-averaged radiated TX power (mmW)
     6. Time-averaged radiated power limits (mmW)
  B. Make one SAR/PD perspective plot containing
     1. Calculated norm. time-averaged SAR (LTE)
     2. Calculated norm. 4s-averaged PD (mmW)
     3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0 or PD/10
     4. Summation of all normalized time-averaged RF exposures
     5. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR) or 10 W/m2(PD)

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5.6 Test Configuration and Procedure for Scenario 5: Beam Switching via Radiated Power Measurements

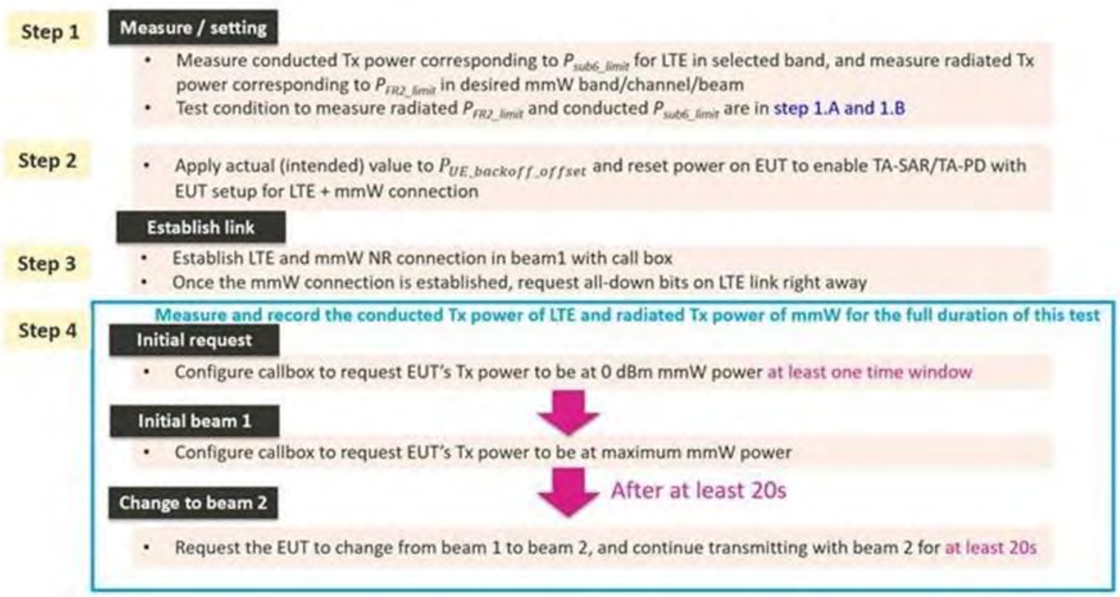
5.6.1 Configuration

Mediatek's TA algorithm operation is independent of bands, channels, ANT configurations (beams) for a given RAT.

- Any two beams are sufficient to validate the algorithm.

5.6.2 Procedure

- Step 1~3: measure and record TX power versus time for test scenario 5
  - A. Measure radiated power corresponding to mmW P_{FR2_limit}
    1. Setting up the EUT's TX power in desired band/channel/beam at PFR2_limit of beam 1 in engineering mode
    2. This test is performed in a calibrated anechoic chamber
    3. Do not disturb the position of the EUT inside the anechoic chamber for the rest of this test
    4. Repeat the procedure above for beam 2
  - B. Measure conducted TX power corresponding to LTE P_{sub6_limit}
    1. Reset EUT to place in online mode and establish radio link in LTE
    2. Measure conducted TX power corresponding to LTE P_{sub6_limit} with TA-SAR enabled and
    3. $P_{UE\_backoff\_offset}$ set to 0 dB, and callbox set to request maximum power
    4. When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.



- Step 5: Re-scale the measured instantaneous radiated power in step 2~4 to maximum instantaneous radiated power for both beams

Reason:

- The measured radiated powers for beam 1 and beam 2 in step1 A. were performed at an arbitrary rotation of EUT in anechoic chamber
- Not the desired measured P_{FR2_limit} (not maximum instantaneous radiated power for the condition)
- Both beams have different position of EUT for maximum power
- Need to rotate the EUT during step 2~4 test to acquire maximum power for both beams
- Might not acquire accurate results for step 2~4 if rotating the EUT during test

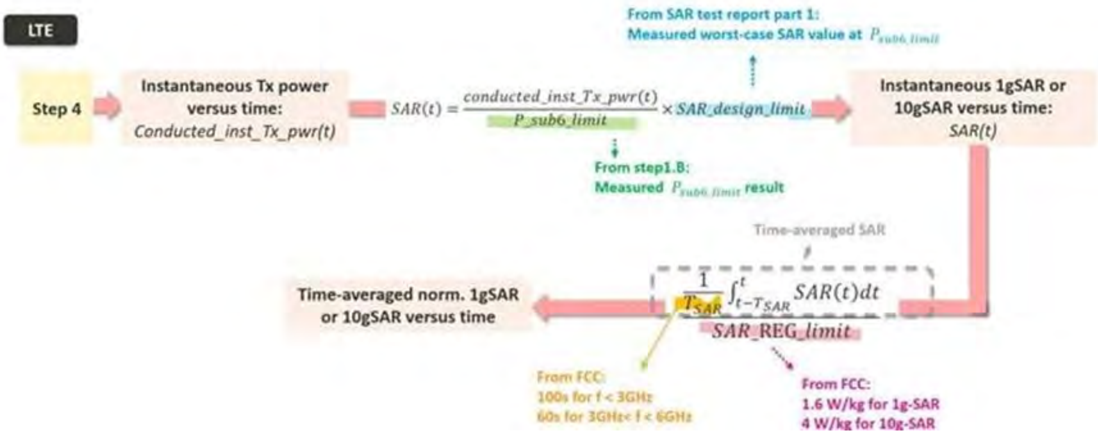
Method:

- Repeat step1 A. of this procedure by rotating the EUT to determine maximum radiated power at P_{FR2_limit} in engineering mode for both beams separately

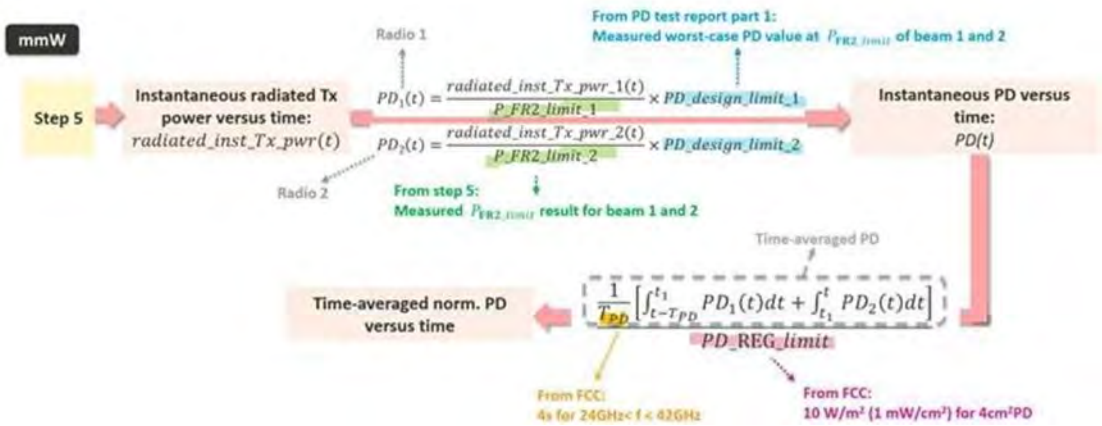
Re-scale the measured instantaneous radiated power in Step 4 by the delta in radiated power measured in Step 5 and the radiated power measured in Step1 A.

- Step 6: convert the measured conducted TX power and measured radiated TX power into SAR and PD respectively

Convert the measured conducted TX power from step 4 into 1gSAR or 10gSAR value using the following equation. Perform the running time average to power and 1gSAR or 10g SAR to determine time-averaged value versus time as follows,



Convert the measured radiated TX power (after rescaling) from step 5 into PD value using the following equation. Perform the running time average to power and PD to determine time-averaged value versus time as follows,



- Step 7: plot results
  - A. Make one power perspective plot containing
    1. Instantaneous conducted TX power (LTE)
    2. Calculated time-averaged conducted TX power (LTE)
    3. Time-averaged conducted power limits (LTE)
    4. Instantaneous radiated TX power (mmW)
    5. Calculated 4s-averaged radiated TX power (mmW)
    6. Time-averaged radiated power limits (mmW)
  - B. Make one SAR/PD perspective plot containing
    1. Calculated norm. time-averaged SAR (LTE)
    2. Calculated norm. 4s-averaged PD (mmW)
    3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0 or PD/10
    4. Summation of all normalized time-averaged RF exposures
    5. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR) or 10 W/m2(PD)

5.7 Test Configuration and Procedure for Scenario 6: SAR vs. PD Exposure Switching via Radiated Power Measurements

5.7.1 Configuration

Mediatek's TA algorithm operation is independent of the RF exposure types (i.e., SAR and PD).

- Any one band/channel/beam/RAT for mmW + LTE (or NR sub6) transmission is sufficient to validate the algorithm.
- The exposure condition during the test varies among PD dominant scenario, SAR+PD scenario, and SAR dominant scenario.

5.7.2 Procedure

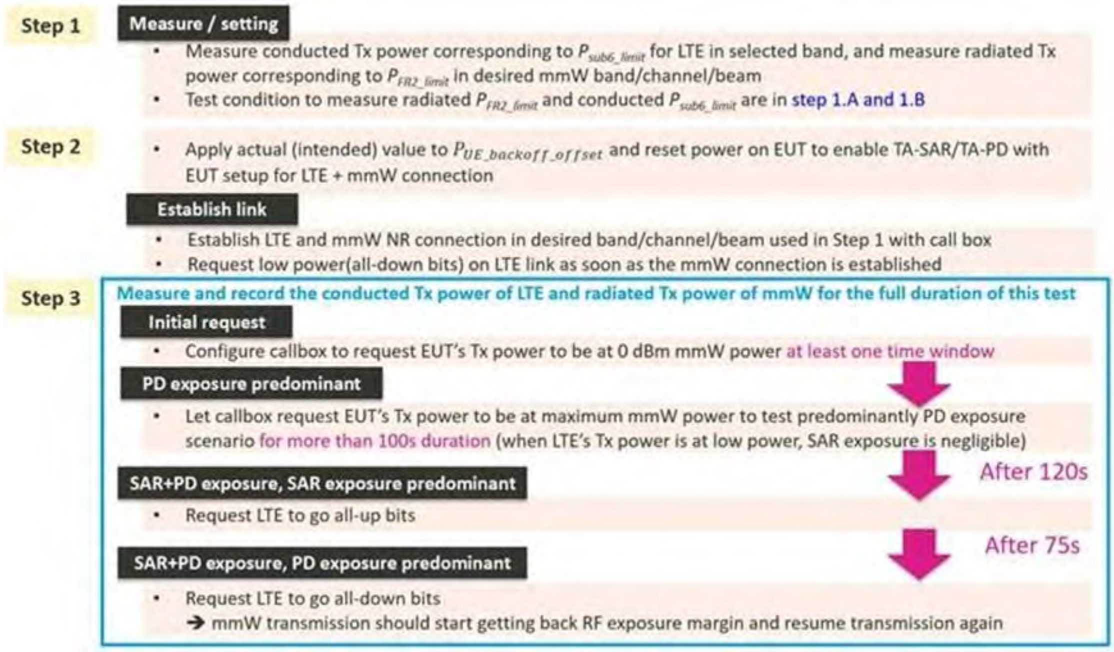
- Step 1~3: measure and record TX power versus time for test scenario 6

A. Measure radiated power corresponding to mmW P_{FR2_limit}

1. Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} in engineering mode
2. This test is performed in a calibrated anechoic chamber
3. Rotate the EUT to obtain maximum radiated TX power, keep the EUT in this position and
4. do not disturb the position of the EUT inside the anechoic chamber for the rest of this test

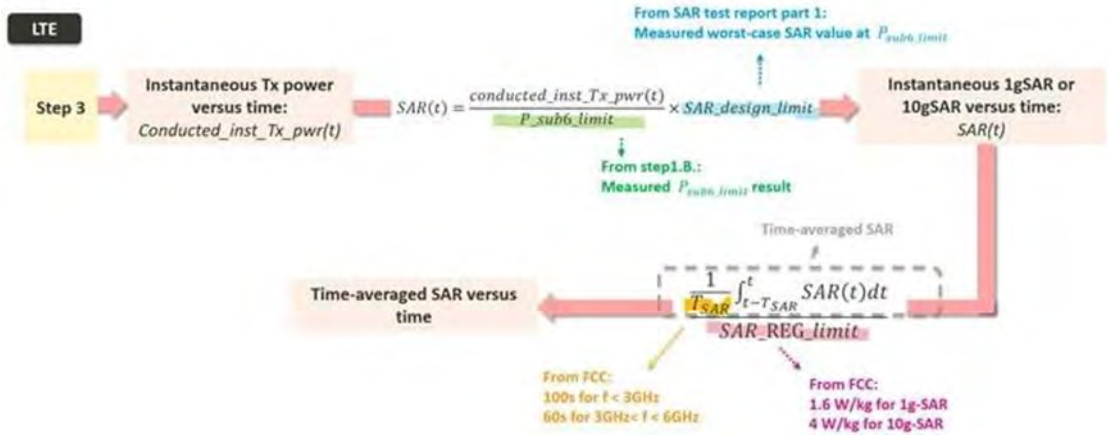
B. Measure conducted TX power corresponding to LTE P_{sub6_limit}

1. Reset EUT to place in online mode and establish radio link in LTE
2. Measure conducted TX power corresponding to LTE P_{sub6_limit} with TA-SAR enabled and $P_{UE\_backoff\_offset}$ set to 0 dB, and callbox set to request maximum power
3. When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.

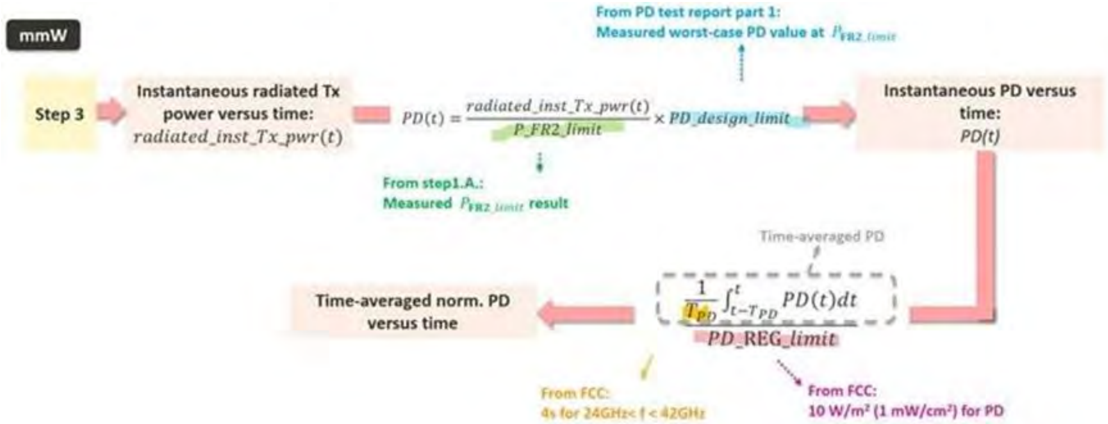


- Step 4: convert the measured conducted TX power and measured radiated TX power into SAR and PD respectively

Convert the measured conducted TX power from step 3 into 1gSAR or 10gSAR value using the following equation. Perform the running time average to power and 1gSAR or 10g SAR to determine time-averaged value versus time as follows,



Convert the measured radiated TX power from step 3 into PD value using the following equation. Perform the running time average to power and PD to determine time-averaged value versus time as follows,



- Step 5: plot results

  A. Make one power perspective plot containing
     1. Instantaneous conducted TX power (LTE)
     2. Calculated time-averaged conducted TX power (LTE)
     3. Time-averaged conducted power limits (LTE)
     4. Instantaneous radiated TX power (mmW)
     5. Calculated 4s-averaged radiated TX power (mmW)
     6. Time-averaged radiated power limits (mmW)

  B. Make one SAR/PD perspective plot containing
     1. Calculated norm. time-averaged SAR (LTE)
     2. Calculated norm. 4s-averaged PD (mmW)
     3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0 or PD/10
     4. Summation of all normalized time-averaged RF exposures
     5. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR) or 10 W/m2(PD)

5.8 Test Configuration and Procedure for Scenario 2: Time- Varying TX Power via PD Measurements

5.8.1 Configuration

Sections 5.2 to 5.7 focus on Mediatek's TA feature compliance validation via radiated TX power measurements. This section further provides a PD measurement procedure for the time-varying TX power scenario described in section 5.3. Hence, this section follows the test configuration of section 5.3.

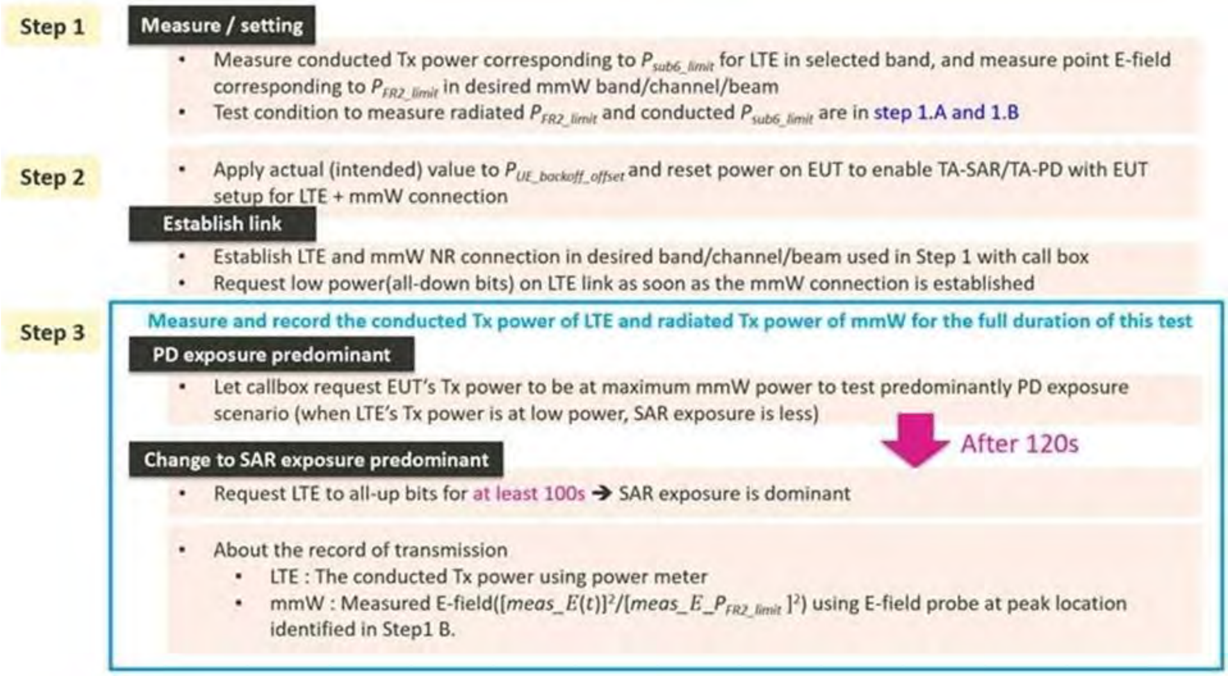
5.8.2 Procedure

PD is measured and recorded by the following steps:

- Step 1~4: measure and record PD versus time

  A. Measure conducted TX power corresponding to LTE P_{sub6_limit}
     1. Measure conducted TX power corresponding to LTE P_{sub6_limit} with TA-SAR enabled and $P_{UE\_backoff\_offset}$ set to 0 dB, and callbox set to request maximum power
     2. When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.

  B. Measure point E-field corresponding to mmW P_{FR2_limit}
     1. Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} in engineering mode
     2. Measure E-field at peak location of fast area scan corresponding to P_{FR2_limit}
     3. Do not disturb the position of EUT and mmW probe



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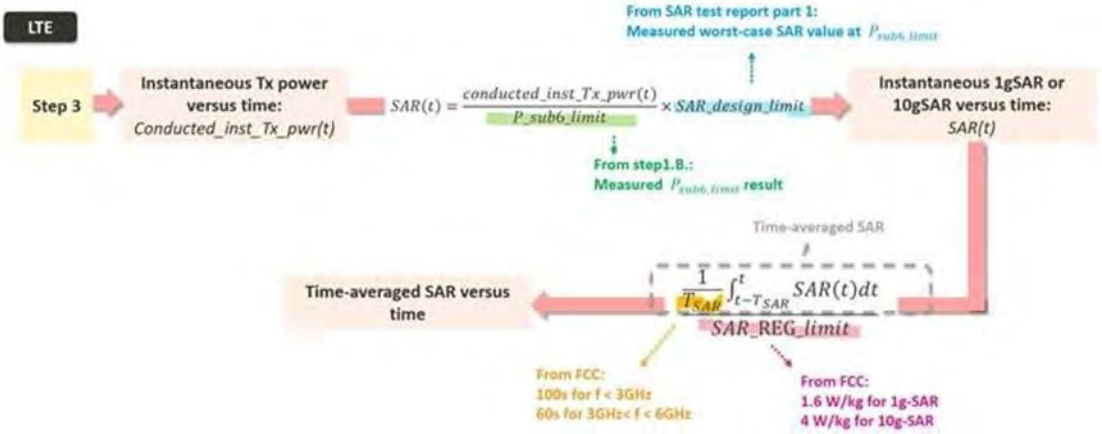
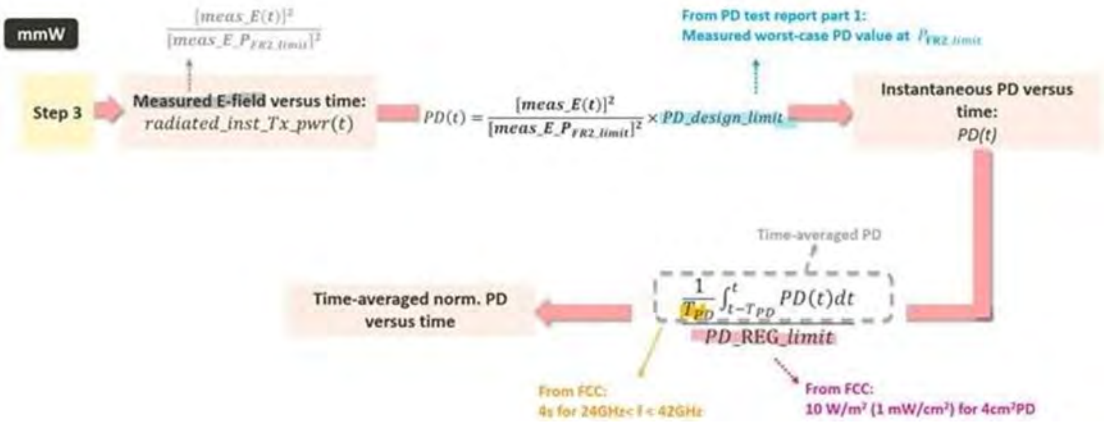
- Step 4: convert the measured conducted TX power and measured E-field into SAR and PD respectively

Convert the measured conducted TX power from step 3 into 1gSAR or 10gSAR value using the following equation. Perform the running time average to power and 1gSAR or 10g SAR to determine time-averaged value versus time as follows,



Convert the measured E-field from step 3 into PD value using the following equation. Perform the running time average to PD to determine time-averaged value versus time as follows,



- Step 5: plot results

  A. Make one SAR/PD perspective plot containing
     1. Calculated norm. time-averaged SAR (LTE)
     2. Calculated norm. 4s-averaged PD (mmW)
     3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0 or PD/10
     4. Summation of all normalized time-averaged RF exposures
     5. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR) or 10 W/m2(PD)

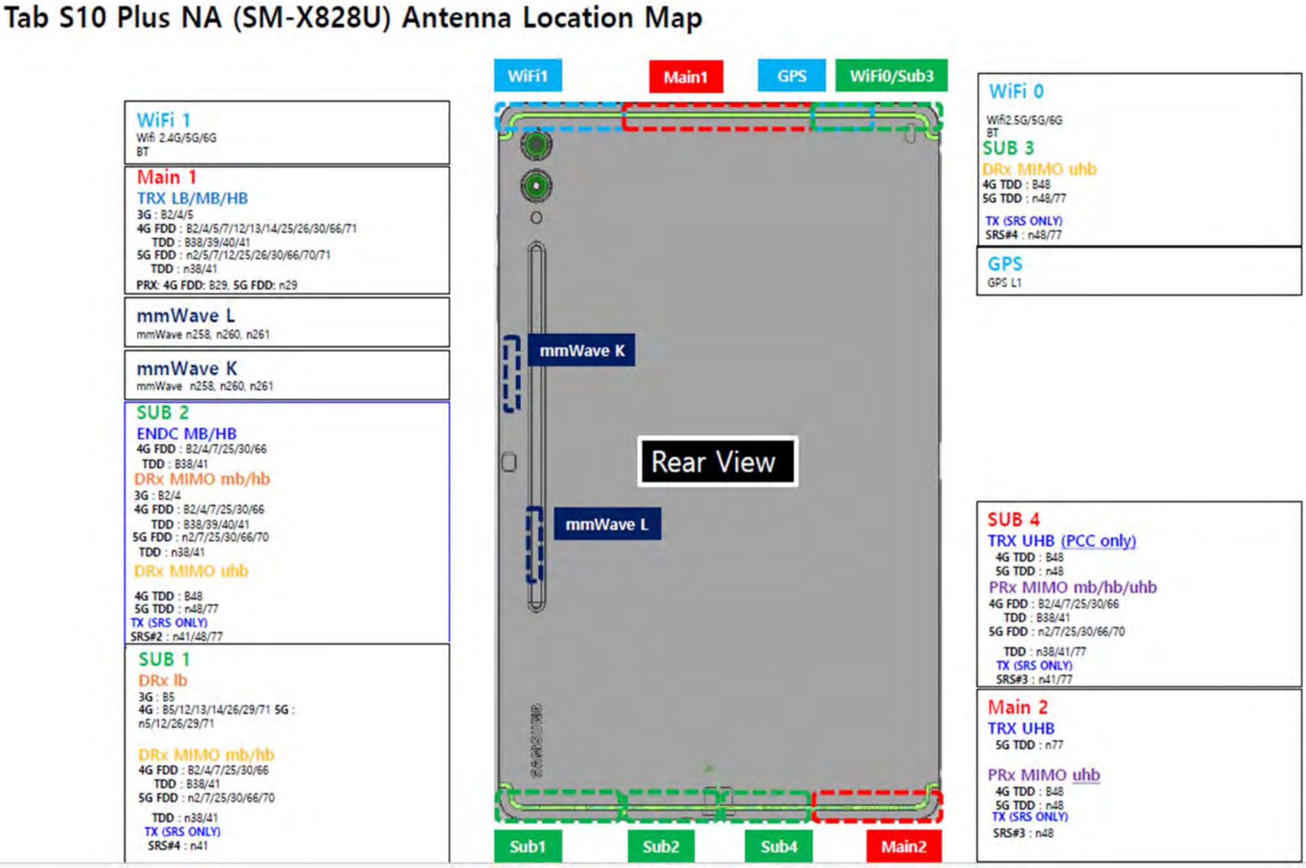
6 TA-SAR/TA-PD JOINT VALIDATION VIA RADIATED POWER MEASUREMENTS

6.1 Measurement Setup

6.1.1 Configuration

The mmWave antenna module placement of the tablet for each technology is illustrated in Figure 6-1.

Figure 6-1 FR2 antenna module placement on the tablet



The schematic of measurement setup is shown in Figure 6-2, where a Keysight UXM is used as signaling callbox to establish mmW and LTE links. For mmW path, the UXM callbox with two RF radio heads can generate mmW signals and in turn connect to two horn antennas for H- and V-polarizations to establish wireless phone call with a device in direct far field chamber. In order to capture and record the mmW time-varying power, a mmW coupler is used to provide a divided path from the radiated power by device to UXM callbox for Rohde & Schwarz NR50S power meter to measure power. The isolation of coupler should be considered for providing sufficient attenuation from the callbox signal to the power meter. For LTE path, the LTE port of callbox are connected to the RF port of device via a coupler to measure the conducted LTE time-varying power by using Rohde & Schwarz NR8S power meter. Furthermore, the ATE tool is installed in PC to control device by USB and control two power meters by GPIB. The path losses from device through direct far field chamber to power meter should be calibrated for power accuracy. Please refer to Figure 8-3 for the actual setup photos.

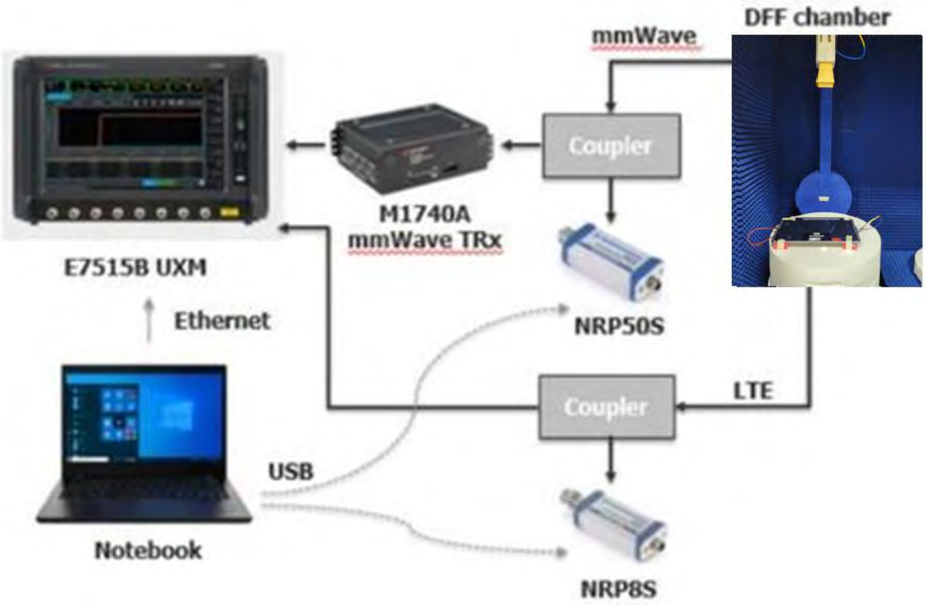


Figure 6-2 TA-PD radiated power measurement setup

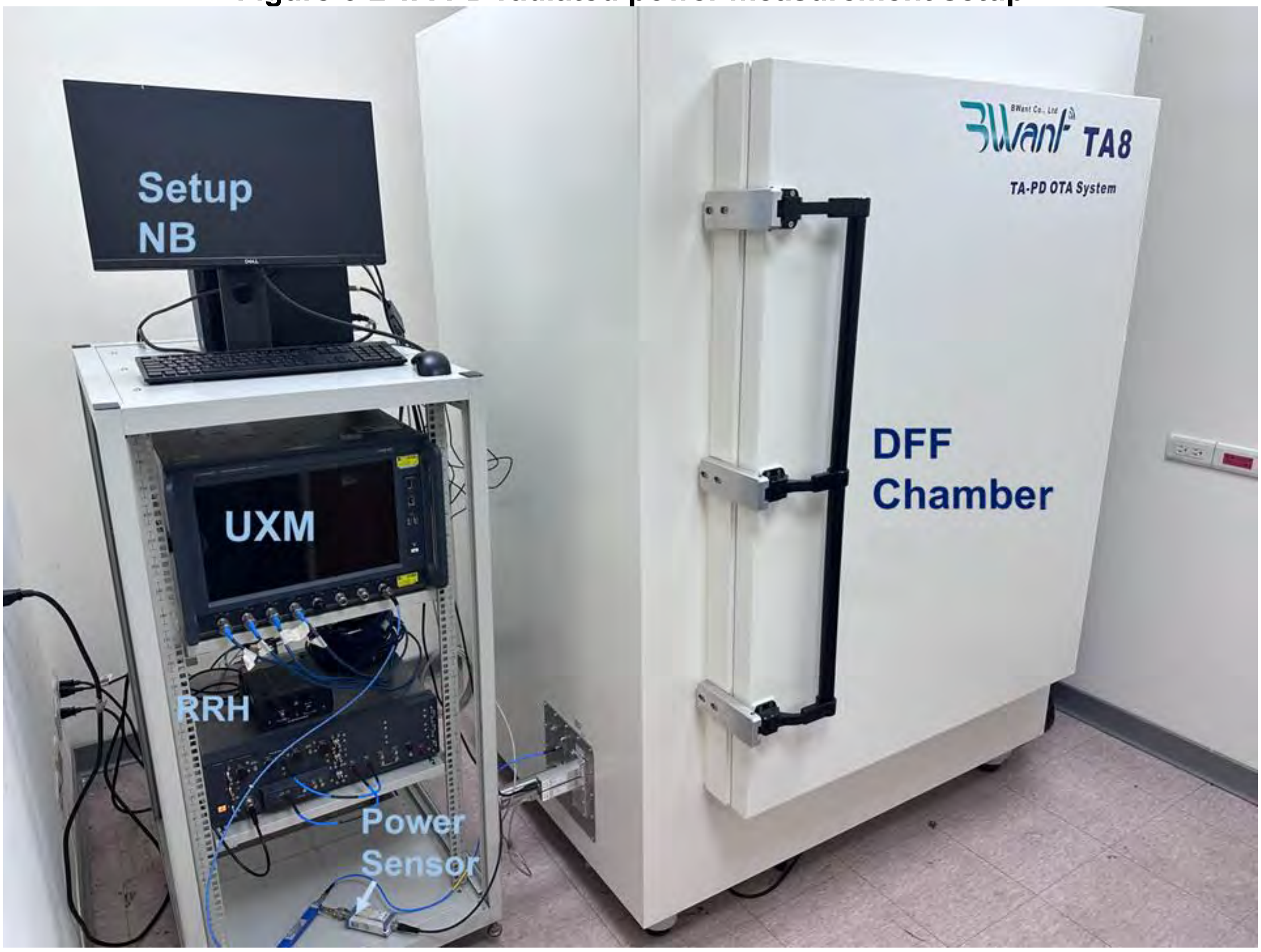


Figure 6-3 Picture of the block diagram shown in Figure 6-2 (FR2 and LTE)

6.1.2 mmWave Radiated Power Measurement

mmWave NR uses beamforming technology to enhance uplink performance, and each beam's EIRP is different. So, the power limit is beam dependent. To quantify PD in the following test scenarios, the scaling method is used, that is, PD of a time instance is calculated from a reference worst-case 4cm^2 PD with a scaling factor based on the measured EIRP. All beams' input power limit values of each mmWave antenna module are relegated to Appendix A. It is noted that TA-PD is independent of the used antenna module and beams. Without loss of generality, module mmW K is selected and its two beams with the largest and smallest PD are selected as well to demonstrate the proposed TA-PD algorithm in the following test scenarios. Below is a summarized table for the two beams' EIRPs and corresponding PDs under their individual input power limit settings.

Table 6-1 Worst-case 1gSAR, 4cm2 avg. PD and EIRP measured at Input.power.limit for the selected configurations

Tech	Band	Antenna	Beam ID	input.power.limit	meas. 4cm2PD at input.power.limit (W/m2)	Configuration	meas. EIRP at input.power.limit (dBm)
mmWave NR	n260	mmW L	42	-3.15	3.81	Back	8.44
			46	-2.45	-	Back	7.67
mmWave NR	n261	mmW L	41	-2.85	1.57	Back	9.67
			46	-4.37	4.77	Back	8.14

Tech	Band	Antenna	ECI	meas. Plimit	meas. 1gSAR at Plimit (W/kg)	Configuration
LTE	B25	M1	2	17.11	0.363	Right

The radio configurations and selections for LTE and mmW NR validation test are listed in Table 6-2.

Table 6-2 Selections for LTE + mmW NR validation measurements

Test Scenario list of TA-PD Validation																
Case	Test scenario	Tech	Band	Ant	Beam	ECI	Precoding	Channel	Frequency (MHz)	Modulation	RB size	RB offset	UL Duty cycle	Position	Worst-case Measured PD at P_FR2_limit W/m2 or 1g SAR W/kg	Result
All test cases	All scenario	LTE	B25	M1	-	2	-	26140	1860	QPSK	50	50	100%	Right	0.363	Pass
1.1	Range of TA-PD parameters	mmWave	N261	mmW L	46	0	2	2071667	27550.08	CP-OFDM, QPSK	66	0	100%	N/A	4.77	Pass
2.1	Time-varying TX power	mmWave	N260	mmW L	42	0	2	2229999	37050	CP-OFDM, QPSK	66	0	100%	Back	3.81	Pass
2.2			N261	mmW L	46	0	2	2071667	27550.08	CP-OFDM, QPSK	66	0	100%	Back	4.77	Pass
3.1	Call disconnection and re-establishment	mmWave	N261	mmW L	46	0	2	2071667	27550.08	CP-OFDM, QPSK	66	0	100%	N/A	4.77	Pass
4.1	Band handover	mmWave	N260	mmW L	42	0	2	2229999	37050	CP-OFDM, QPSK	66	0	100%	N/A	3.81	Pass
			N261	mmW L	46		2	2071667	27550.08	CP-OFDM, QPSK	66	0	100%	N/A	4.77	
5.1	Beam switching	mmWave	N261	mmW L	41	0	2	2071667	27550.08	CP-OFDM, QPSK	66	0	100%	N/A	1.57	Pass
					46		2				66	0	100%	N/A	4.77	
6.1	SAR vs. PD exposure switching	mmWave	N261	mmW L	46	0	2	2071667	27550.08	CP-OFDM, QPSK	66	0	100%	N/A	4.77	Pass

By following the selection criteria in Chapter 5, the selected test configurations for TA-SAR/TA-PD joint validation are descripted as below:

- **Band for scenario 1 - range of TA-PD parameters:** TA-SAR/TA-PD operations are independent of parameter sets, bands, and RAT. By following the sections before, test cases in Table 6-2 are selected to test different combinations of operating parameters in a band (mmW band n261).
  NOTE : if the EUT uses only one parameter set at all times, then one test case is sufficient.
- **Bands for scenario 2 - time-varying TX power:** Based on selection criteria in sections before, test cases in Table 6-2 are selected to test time-vary TX power for both radiated power measurement and PD measurement.
- **Band for scenario 3 - call disconnection and re-establishment:** Based on selection criteria in sections before, test case in Table 6-2 is selected for performing call disconnection and re-establishment.
- **Band for scenario 4 - band handover:** Based on sections before, test case in Table 6-2 is selected to validate the TA-SAR/TA-PD algorithm with a handover from a band (mmW band n260) to another one (mmW band n261).
- **Band for scenario 5 - beam switching:** Based on sections before, test case (mmW band n261) in Table 6-2 is selected to validate the TA-SAR/TA-PD algorithm with beam switching between two beams.
- **Bands for scenario 6 - SAR vs. PD Exposure Switching:** Based on sections before, test case (mmW band n261) in Table 6-2 is selected to validate the TA-SAR/TA-PD algorithm with one of the supported simultaneous transmission, i.e, LTE+mmW.

6.2 Radiated Power Measurement Results for Scenario 1:

Range of TA-PD Parameters

In this scenario, two TA-PD parameters are swept to validate Mediatek's TA-PD algorithm. The parameter settings for mmW NR and anchor LTE are summarized in Tables 6-3 and 6-4, and the test procedure follows section before. The high-level summary of the final validation results is given in the last column of the table, which concludes that Mediatek's TA-PD algorithm can maintain TER below the FCC limit for all test cases. The following context will demonstrate case-by-case to show how Mediatek's TA-PD algorithm behaves.

Table 6-3 TA-PD parameter settings for scenario 1

Test case	Test band	Test seq.	Beam ID	Max power (dBm)	P_{FR2_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)	Pass/Fail PD limit
1.1	N261	0	46	26.45	8.14	7.14	6.64	9.64	Pass

Table 6-4 TA-SAR parameter setting for LTE

Test band	Test seq.	ECI	Max power (dBm)	P_{sub6_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)
LTE B25	0	2	24.00	17.50	16.25	15.75	23.50

In this test scenario, when mmWave link is established, LTE TX power level is set at -17dBm and lasts till the end of test, and PD exposure dominates during the whole test period.

For the figure set of each case, the first figure demonstrates the EUT's instantaneous radiated TX power, the time-averaged radiated TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty, P_reg_FR2_limit = P_{FR2_limit} + 2.5 dB device uncertainty). The second figure illustrates the corresponding normalized time-averaged exposures for LTE (1gSAR), mmWave ($4cm^2$PD), as well as total normalized time-averaged exposure over time converted from the TX time-averaged power by using the equation listed in section before.

As seen in the figures, either TX average power or total normalized exposure ratio is below the compliance limit.

- Case 1.1 in table 6-3

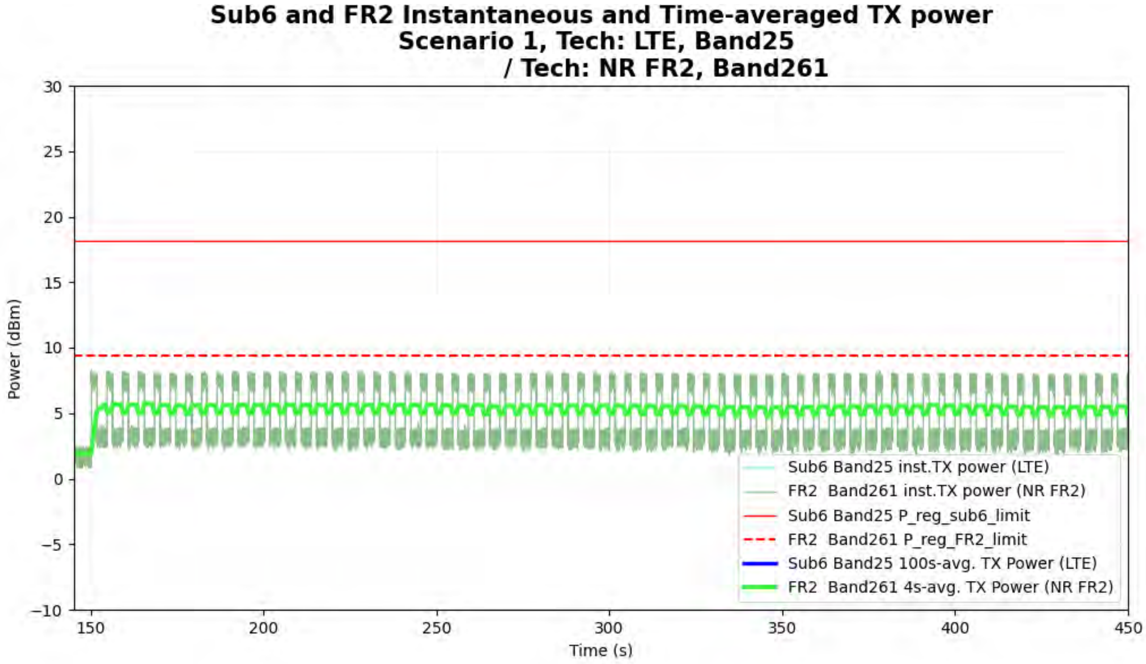


Figure 6-4 LTE, mmW inst. Pwr and Time-averaged Tx Pwr (case 1.1)

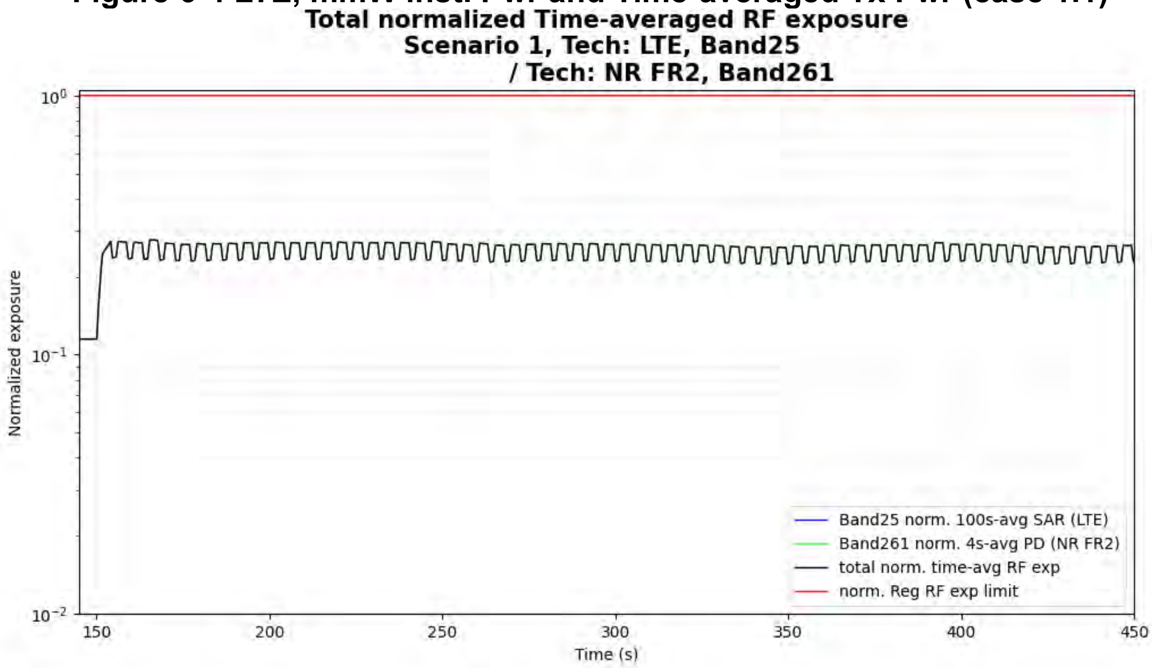


Figure 6-5 Total Normalized Time-averaged RF exposure (case 1.1)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.278
Validation result: pass	

6.3 Radiated Power Measurement Results for Scenario 2: Time-Varying TX Power

In this scenario, Mediatek's TA-SAR/TA-PD algorithm is tested under more dynamic power test sequences. The parameter settings for mmW NR and anchor LTE are summarized in Tables 6-5 and 6-6, and the test procedure follows section before. The high-level summary of the final validation results is given in the last column of the table, which concludes that Mediatek's TA-SAR/TA-PD algorithm can maintain TER below the FCC limit for all test cases. The following context will demonstrate case-by-case to show how Mediatek's TA-SAR/TA-PD algorithm behaves.

Table 6-5 TA-PD parameter settings for scenario 2

Test case	Test band	Test seq.	Beam ID	Max power (dBm)	P_{FR2_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)	Pass/Fail PD limit
2.1	N260	0	42	26.1	8.44	7.44	6.94	9.94	Pass
2.2	N261	0	46	26.45	8.14	7.14	6.64	9.64	Pass

Table 6-6 TA-SAR parameter setting for LTE

Test band	Test seq.	ECI	Max power (dBm)	P_{sub6_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)
LTE B25	0	2	24.00	17.50	16.25	15.75	23.50

In this test scenario, when mmWave link is established, LTE TX power level is set at -17dBm. PD exposure dominates from 0 to 270 seconds. At the time instance of 270 seconds, LTE TX power level is set at 23dBm.

For the figure set of each case, the first figure demonstrates the EUT's instantaneous radiated TX power, the time-averaged radiated TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty, P_reg_FR2_limit = P_{FR2_limit} + 2.5 dB device uncertainty). The second figure illustrates the corresponding normalized time-averaged exposures for LTE (1gSAR), mmWave (4cm^{2}PD), as well as total normalized time-averaged exposure over time converted from the TX time-averaged power by using the equation listed in section before. As seen in the figures, either TX average power or total normalized exposure ratio is below the compliance limit.

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- Case 2.1 in table 6-5

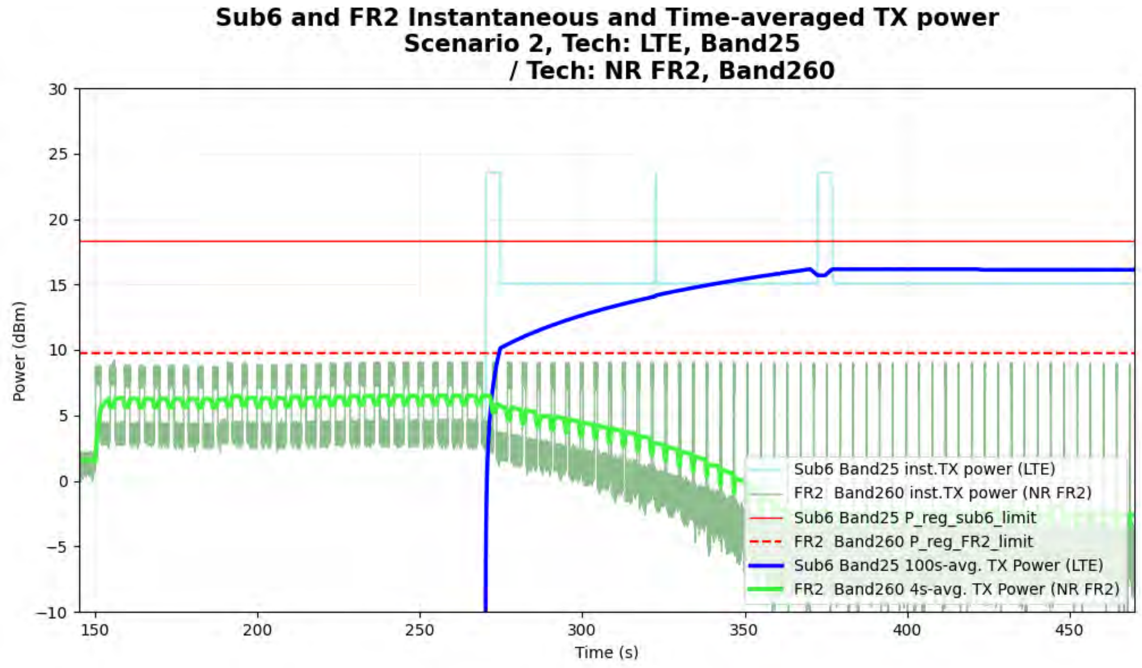

Figure 6-8 LTE, mmW inst. Pwr and Time-averaged Tx Pwr (case 2.1)

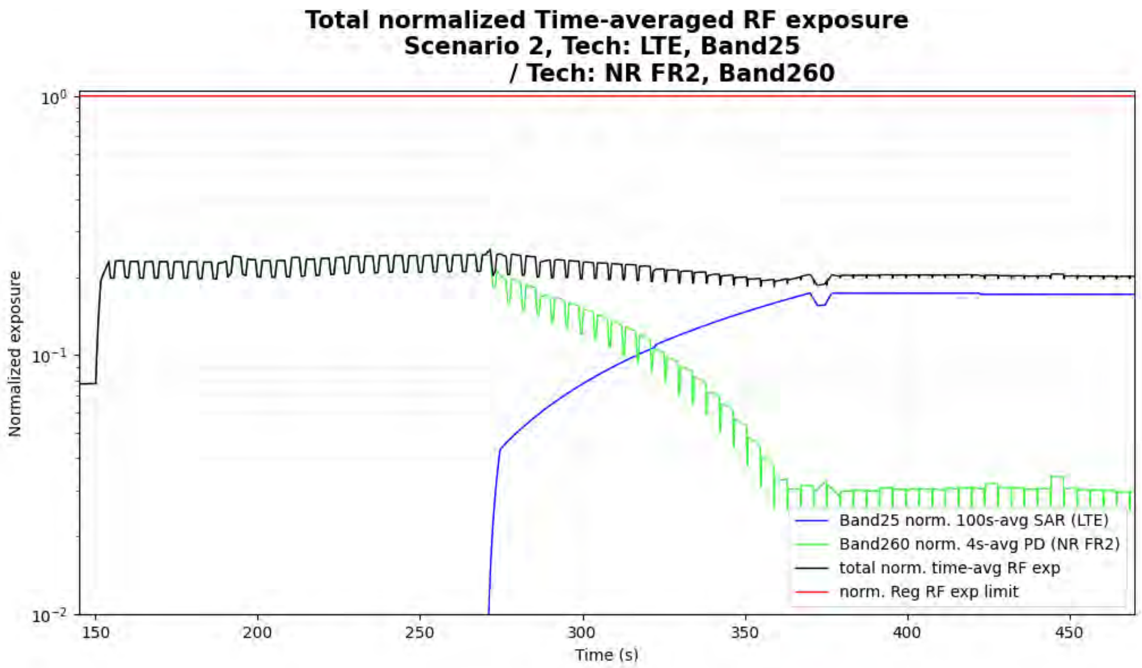

Figure 6-9 Total Normalized Time-averaged RF exposure (case 2.1)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.255
Validation result: pass	

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- Case 2.2 in table 6-5

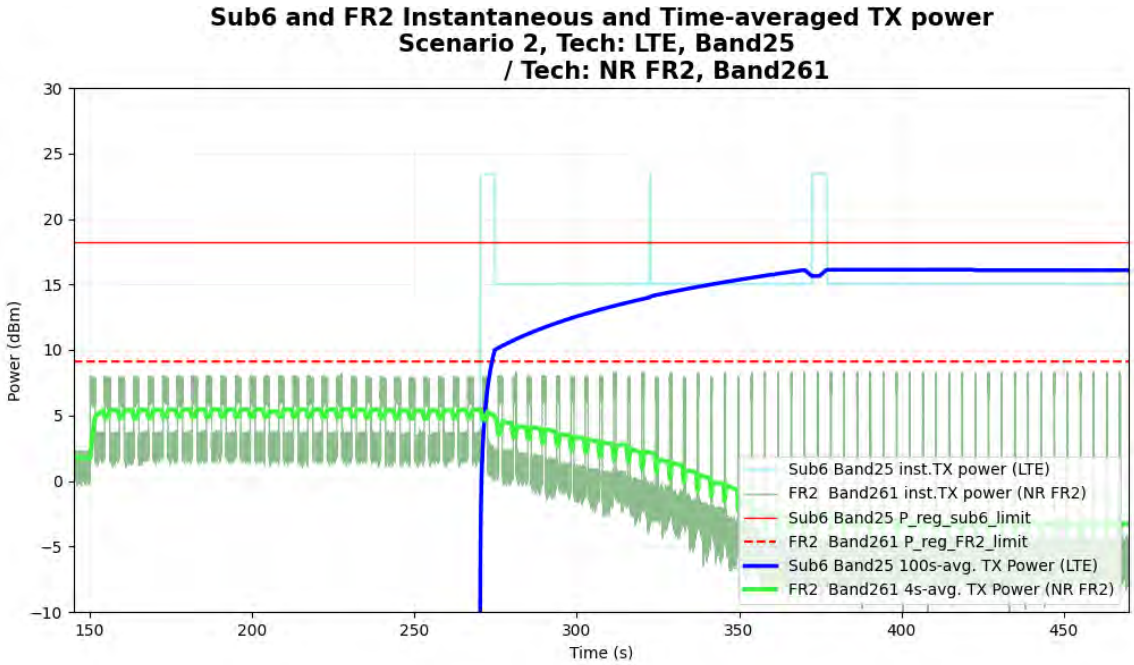

Figure 6-10 LTE, mmW inst. Pwr and Time-averaged Tx Pwr (case 2.2)

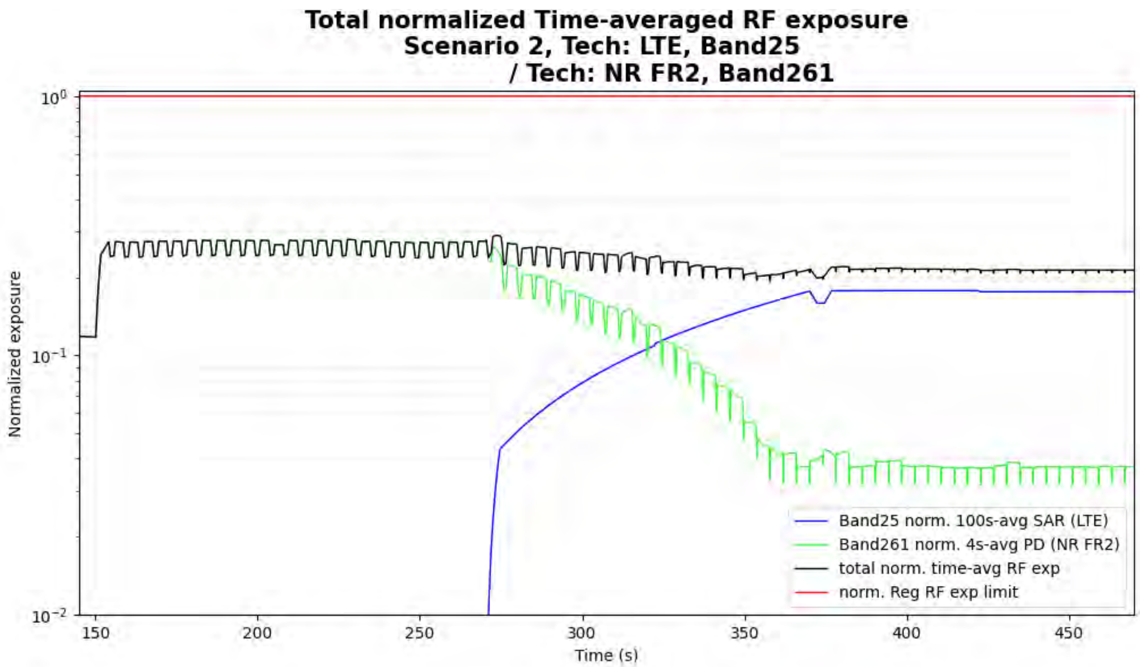

Figure 6-11 Total Normalized Time-averaged RF exposure (case 2.2)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.290
Validation result: pass	

6.4 Radiated Power Measurement Results for Scenario 3: Call Disconnection and Re-establishment

In this scenario, the test power sequence #0 (i.e., maximum TX power is requested by a call box) is used, and the call drop is manually configured for a pre-defined period and then the call is re- established to continue data transmission. The parameter settings for mmW NR and anchor LTE are summarized in Tables 6-7 and 6-8, and the test procedure follows section before. The high-level summary of the final validation results is given in the last column of the table, which concludes that Mediatek's TA-PD algorithm can maintain TER below the FCC limit for all test cases. The following context will demonstrate how Mediatek's TA-PD algorithm behaves.

Table 6-7 TA-PD parameter settings for scenario 3

Test case	Test band	Test seq.	Beam ID	Max power (dBm)	P_{FR2_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)	Pass/Fail PD limit
3.1	N261	0	46	26.45	8.44	7.44	6.94	9.94	Pass

Table 6-8 TA-SAR parameter setting for LTE

Test band	Test seq.	ECI	Max power (dBm)	P_{sub6_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)
LTE B25	0	2	24.00	17.50	16.25	15.75	23.50

In this test scenario, when mmWave link is established, LTE TX power level is set at -17dBm and lasts until the end of test. During the test, the call drop is configured at the time instance of 156 seconds, and the call is re-established at the time instance of 158 seconds.

For the figure set of each case, the first figure demonstrates the EUT's instantaneous radiated TX power, the time-averaged radiated TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty, P_reg_FR2_limit = P_{FR2_limit} + 2.5 dB device uncertainty). The second figure illustrates the corresponding normalized time-averaged exposures for LTE (1gSAR), mmWave (4cm^{2}PD), as well as total normalized time-averaged exposure over time converted from the TX time-averaged power by using the equation listed in section before.

As seen in the figures, either TX average power or total normalized exposure ratio is below the compliance limit.

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- Case 3.1 in table 6-7

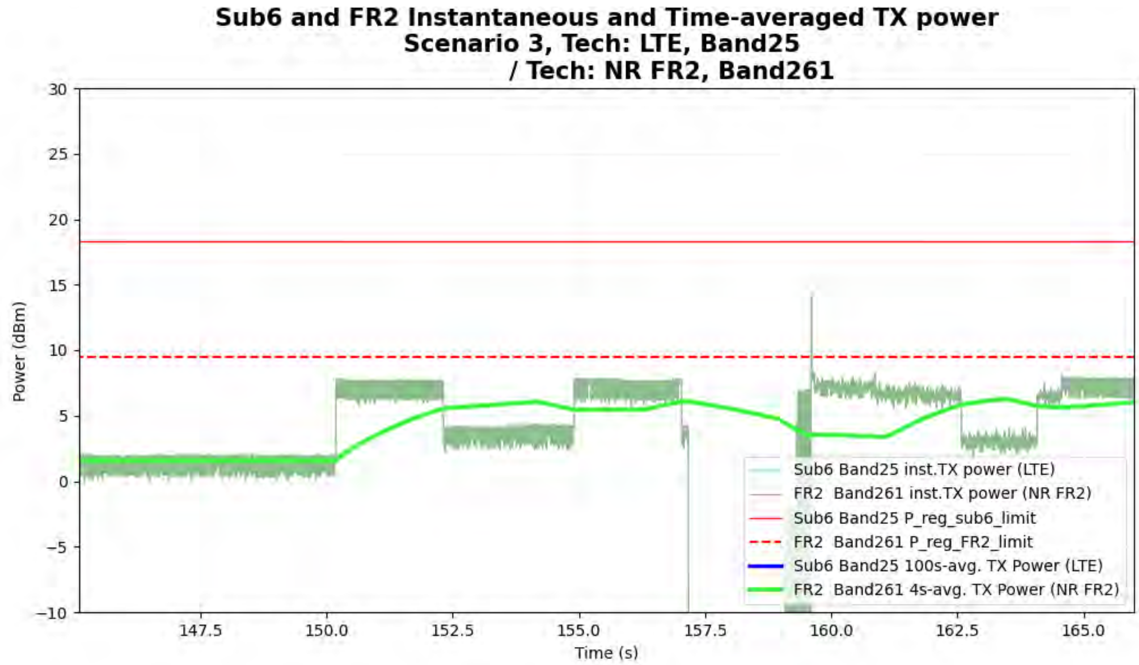

Figure 6-12 LTE, mmW inst. Pwr and Time-averaged Tx Pwr (case 3.1)

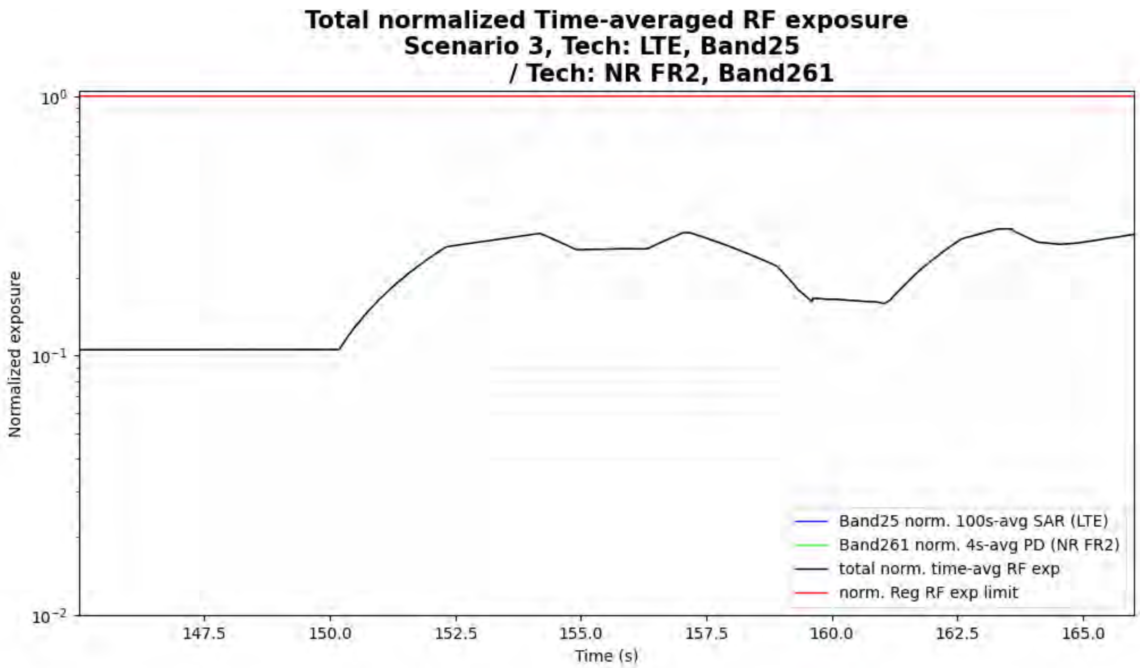

Figure 6-13 Total Normalized Time-averaged RF exposure (case 3.1)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.308
Validation result: pass	

6.5 Radiated Power Measurement Results for Scenario 4: Band Handover

In this scenario, the test power sequence #0 (i.e., maximum TX power is requested by a call box) is used, and the band is manually changed after pre-defined period. The parameter settings for mmW NR and anchor LTE are summarized in Tables 6-9 and 6-10, and the test procedure follows section before. The high-level summary of the final validation results is given in the last column of the table, which concludes that Mediatek's TA-PD algorithm can maintain TER power below the FCC limit for all test cases. The following context will demonstrate how Mediatek's TA-PD algorithm behaves.

Table 6-9 TA-PD parameter settings for scenario 4

Test case	Test band	Test seq.	Beam ID	Max power (dBm)	P_{FR2_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)	Pass/Fail PD limit
4.1	N260	0	42	26.1	8.44	7.44	6.94	9.94	Pass
	N261		46	26.45	8.14	7.14	6.64	9.64	Pass

Table 6-10 TA-SAR parameter setting for LTE

Test band	Test seq.	ECI	Max power (dBm)	P_{sub6_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)
LTE B25	0	2	24.00	17.50	16.25	15.75	23.50

In this test scenario, when mmW link is established, LTE TX power level is set at -17dBm and lasted until the end of test. In this test, band n260 operates from 0 to 170 seconds, and at the time instance of ~170s the band is changed to n261.

For the figure set of each case, the first figure demonstrates the EUT's instantaneous radiated TX power, the time-averaged radiated TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty, P_reg_FR2_limit = P_{FR2_limit} + 2.5 dB device uncertainty). The second figure illustrates the corresponding normalized time-averaged exposures for LTE (1gSAR), mmWave ($4cm^2$PD), as well as total normalized time-averaged exposure over time converted from the TX time-averaged power by using the equation listed in section before.

As seen in the figures, either TX average power or total normalized exposure ratio is below the compliance limit.

- Case 4.1 in table 6-9

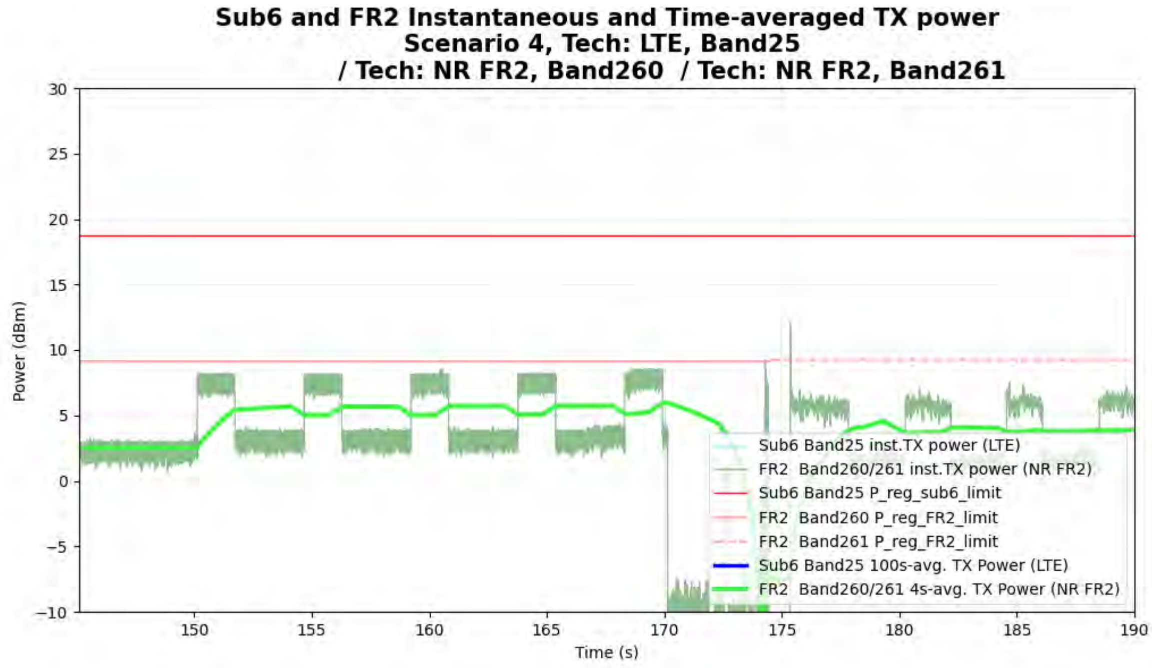

Figure 6-14 LTE, mmW inst. Pwr and Time-averaged Tx Pwr (case 4.1)

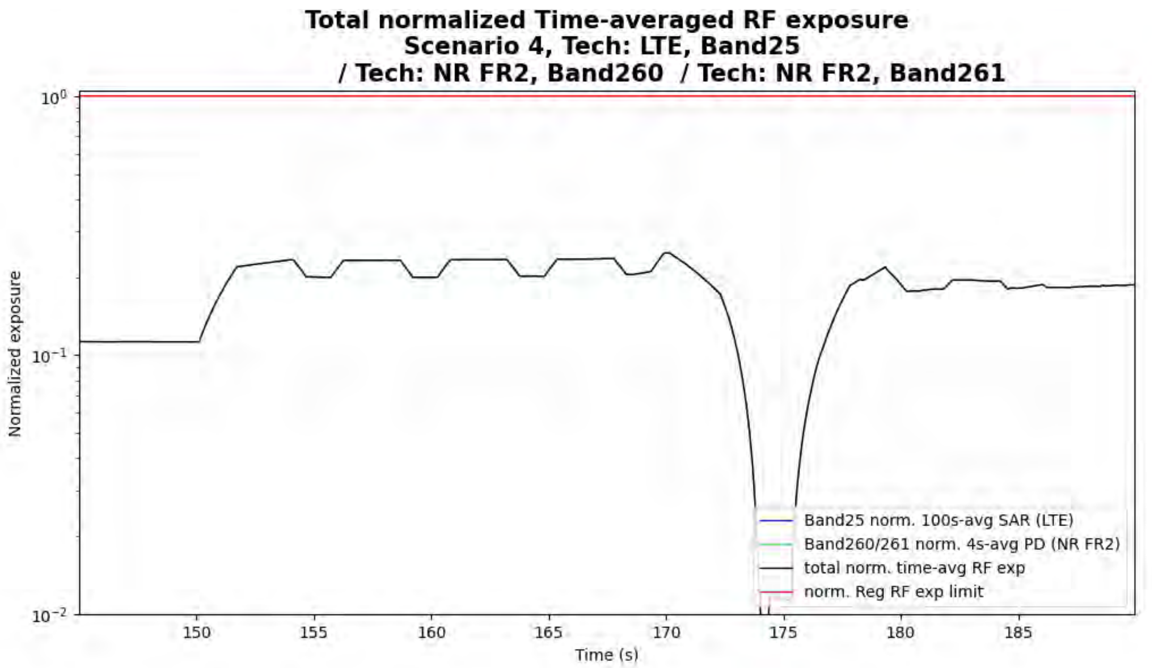

Figure 6-15 Total Normalized Time-averaged RF exposure (case 4.1)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.248
Validation result: pass	

6.6 Radiated Power Measurement Results for Scenario 5: Beam Switching

In this scenario, the test power sequence #0 (i.e., maximum TX power is requested by a call box) is used, and the beam is manually changed after pre-defined period. The parameter settings for mmW NR and anchor LTE are summarized in Tables 6-11 and 6-12, and the test procedure follows section before. The high-level summary of the final validation results is given in the last column of the table, which concludes that Mediatek's TA-PD algorithm can maintain TER power below the FCC limit for all test cases. The following context will demonstrate how Mediatek's TA-PD algorithm behaves.

Table 6-11 TA-PD parameter settings for scenario 5

Test case	Test band	Test seq.	Beam ID	Max power (dBm)	P_{FR2_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)	Pass/Fail PD limit
5.1	N261	0	41	26.45	9.67	8.67	8.17	11.17	Pass
			46		8.14	7.14	6.64	9.64	Pass

Table 6-12 TA-SAR parameter setting for LTE

Test band	Test seq.	ECI	Max power (dBm)	P_{sub6_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)
LTE B25	0	2	24.00	17.50	16.25	15.75	23.50

In this test scenario, when mmW link is established, LTE TX power level is set at -17dBm and lasts until the end of test. The first beam dominates from 0 to 170 seconds, and the second beam dominates after the time instance of 170 seconds.

For the figure set of each case, the first figure demonstrates the EUT's instantaneous radiated TX power, the time-averaged radiated TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty, P_reg_FR2_limit = P_{FR2_limit} + 2.5 dB device uncertainty). The second figure illustrates the corresponding normalized time-averaged exposures for LTE (1gSAR), mmW (($4cm^2$PD), as well as total normalized time-averaged exposure over time converted from the TX time-averaged power by using the equation listed in section before. As seen in the figures, total normalized exposure ratio is below the compliance limit.

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- Case 5.1 in table 6-11

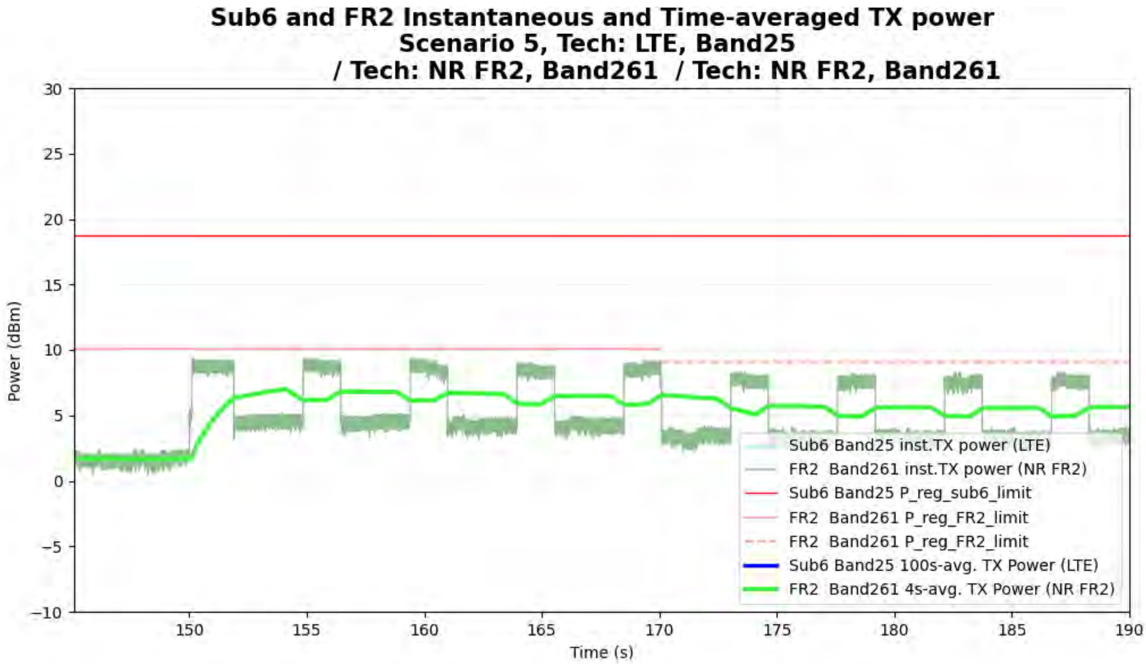

Figure 6-16 LTE, mmW inst. Pwr and Time-averaged Tx Pwr (case 5.1)

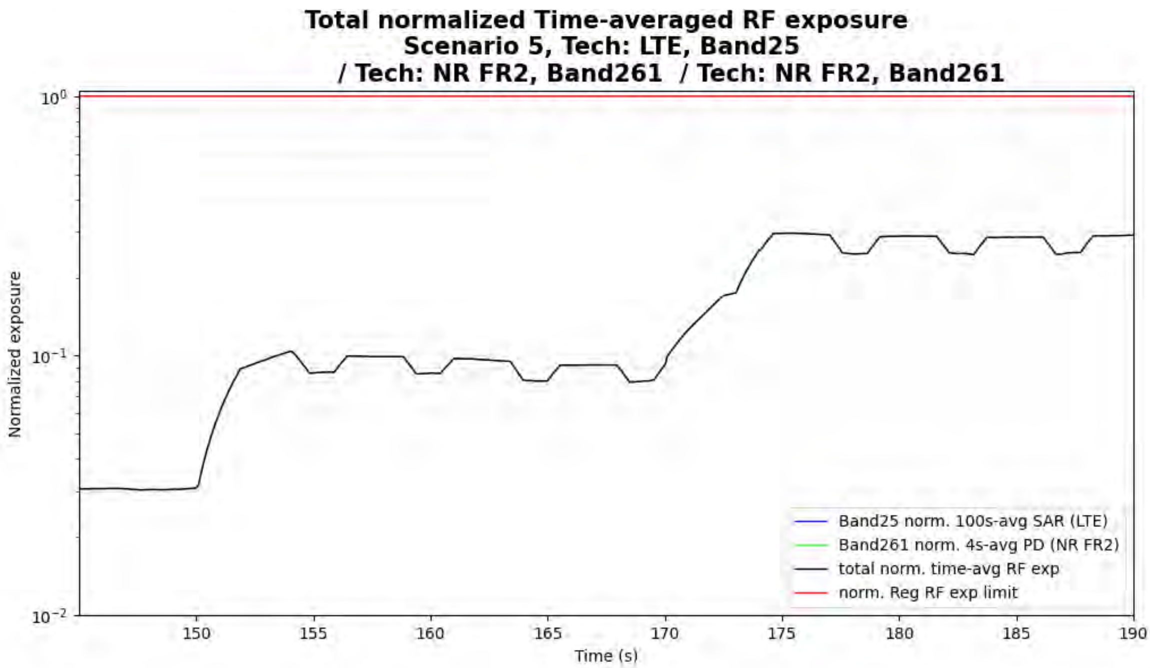

Figure 6-17 Total Normalized Time-averaged RF exposure (case 5.1)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.297
Validation result: pass	

6.7 Radiated Power Measurement Results for Scenario 6: SAR vs. PD Exposure Switching

In this scenario, the test power sequence #0 (i.e., maximum TX power is requested by a call box) is used for mmWave, and during the test the LTE TX power level is alternated to be maximum and minimum at specific time instances. The parameter settings for mmW NR and anchor LTE are summarized in Tables 6-13 and 6-14, and the test procedure follows section before. The high-level summary of the final validation results is given in the last column of the table, which concludes that Mediatek's TA-SAR/TA-PD algorithm can maintain TER below the FCC limit for all test cases. The following context will demonstrate how Mediatek's TA-SAR/TA-PD algorithm behaves.

Table 6-13 TA-PD parameter settings for scenario 6

Test case	Test band	Test seq.	Beam ID	Max power (dBm)	P_{FR2_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)	Pass/Fail PD limit
6.1	N261	0	46	26.45	8.14	7.14	6.64	9.64	Pass

Table 6-14 TA-SAR parameter setting for LTE

Test band	Test seq.	ECI	Max power (dBm)	P_{sub6_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)
LTE B25	0	2	24.00	17.50	16.25	15.75	23.50

In this test scenario, when mmW link is established, LTE TX power level is set at -17dBm, and so PD exposure dominates from 0 to 270 seconds. At the time instance of 270 seconds, LTE TX power level is set at 23dBm. At the time instance of 345 seconds, LTE is set back to -17dBm, PD exposure dominates again.

For the figure set of each case, the first figure demonstrates the EUT's instantaneous radiated TX power, the time-averaged radiated TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty, P_reg_FR2_limit = P_{FR2_limit} + 2.5 dB device uncertainty). The second figure illustrates the corresponding normalized time-averaged exposures for LTE (1gSAR), mmWave (4cm^{2}PD), as well as total normalized time-averaged exposure over time converted from the TX time-averaged power by using the equation listed in section before. As seen in the figures, total normalized exposure ratio is below the compliance limit.

- Case 6.1 in table 6-13

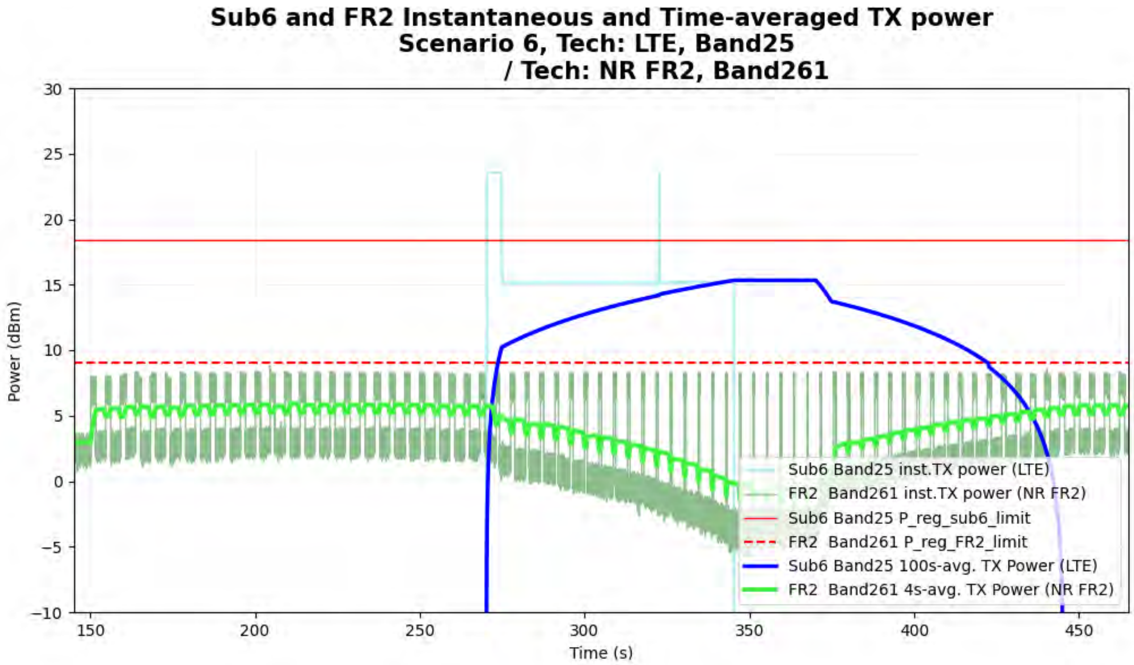

Figure 6-18 LTE, mmW inst. Pwr and Time-averaged Tx Pwr (case 6.1)

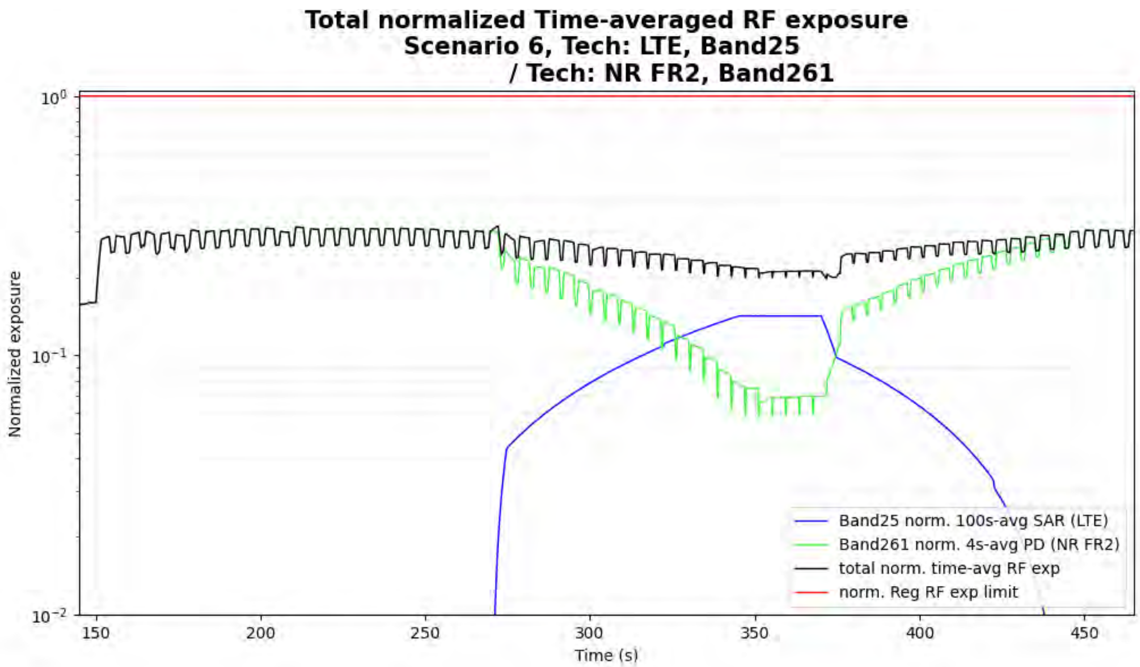

Figure 6-19 Total Normalized Time-averaged RF exposure (case 6.1)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.316
Validation result: pass	

7 TA-SAR/TA-PD JOINT VALIDATION VIA PD MEASUREMENTS

7.1 Measurement Setup

In this section, the near-field measurements are conducted in an FCC certified lab, and the measurement setup is shown in Figure 7-1. The call box Keysight UXM is connected to the PC using Ethernet interface and its LTE connection port is connected to the EUT's LTE antenna port. The power meter is connected to the PC by a USB interface for LTE power measurement. Mediatek's automation tool is used to control the EUT and call box to establish an ENDC link (LTE+mmWave) and at the same time the power meter is triggered to record LTE conducted power. Based on a test sequence defined in section before, once the mmWave link is established, LTE TX power of the EUT is set at -17dBm for a predefined period and then set to be max power level by using "all-up bits" command of the call box. During the whole test period, the mmWave TX power of the EUT is always requested to be maximum all the time.

Time-averaged E-field measurements are performed by using a EUmmWV3 mmWave probe at the peak location of fast area scan. The first step for this test is a reference single-point power density ($PD_{sp,ref}$) measurement by DASY6, in which the EUT transmits at a static power level with the selected beam, whose input power is set at its *input.power.limit*. Once the TA-PD algorithm is enabled, DASY6 records the relative single-point PD over time ($PD_{sp,relative}[t]$) with respect to $PD_{sp,ref}$ during the user specified time interval. As a result, the time-averaging PD is derived based on $PD(t)$= $PD_{sp,relative}[t]$ x *PD_design_target*, where *PD_design_target* is the 4cm^2 PD of the selected beam under its *input.power.limit*. The spec of the EUmmWV3 probe and how DASY6 converts the E-field measurement to PD are detailed in Appendix C.

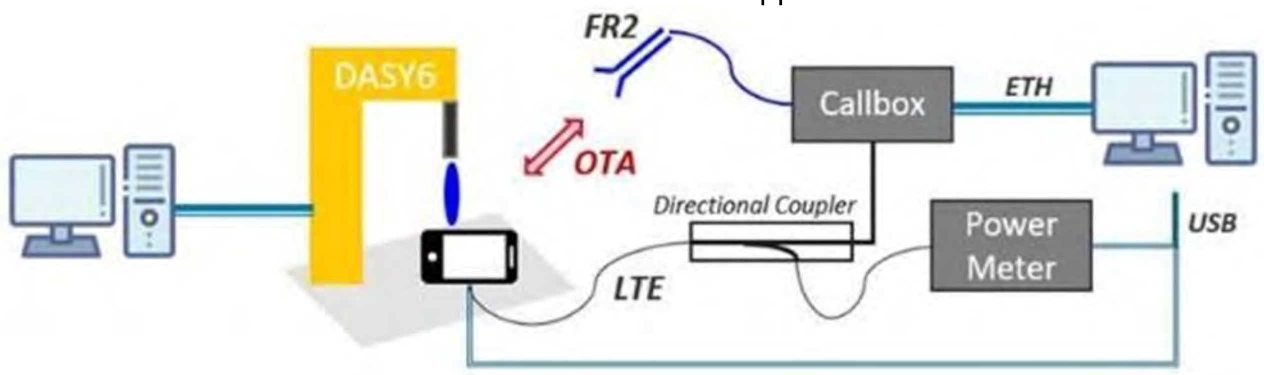

Figure 7-1 TA-PD near-field measurement setup diagram

7.2 PD Measurement Results for Scenario 2: Time-Varying TX Power

In this scenario, Mediatek's TA-SAR/TA-PD algorithm is tested under more dynamic power test sequences. The parameter settings for mmW NR and anchor LTE are summarized in Tables 7-1 and 7-2, and the test procedure follows section before. The measurement setup is shown in Figure 7-2. All of the measurements are conduct by using DASY6. The high-level summary of the final validation results is given in the last column of the table, which concludes that Mediatek's TA-SAR/TA-PD algorithm can maintain TER below the FCC limit for all test cases. The following context will demonstrate case-by-case to show how Mediatek's TA-SAR/TA-PD algorithm behaves.

Table 7-1 TA-PD parameter settings for scenario 2

Test band	Test seq.	Beam ID	Max power (dBm)	P_{FR2_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)	Pass/Fail PD limit
N260	0	42	26.1	8.44	7.44	6.94	9.94	Pass
N261	0	46	26.45	8.14	7.14	6.64	9.64	Pass

Table 7-2 TA-SAR parameter setting for LTE

Test band	Test seq.	ECI	Max power (dBm)	P_{FR2_limit} (dBm)	$P_{LowThresh}$ (dBm)	$P_{UE\_backoff}$ (dBm)	$P_{UE\_max\_cust}$ (dBm)
LTE B25	0	2	24.00	17.50	16.25	15.75	23.50

The following figure illustrates the normalized time-averaged exposures for LTE (1gSAR), mmW (4cm^2 PD), as well as total normalized time-averaged exposure over time converted from the measured conducted TX power and measured E-field by using the equation listed in section before.

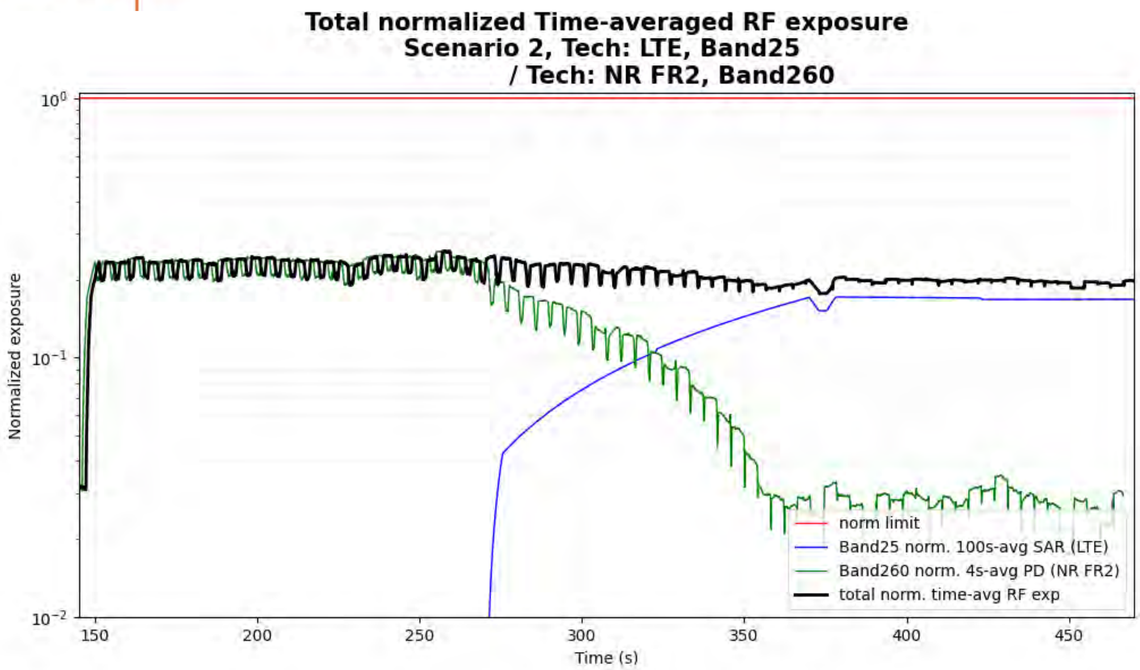

Figure 7-3 The Total Normalized Time-averaged RF exposure (n260)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.256
Validation result: pass	

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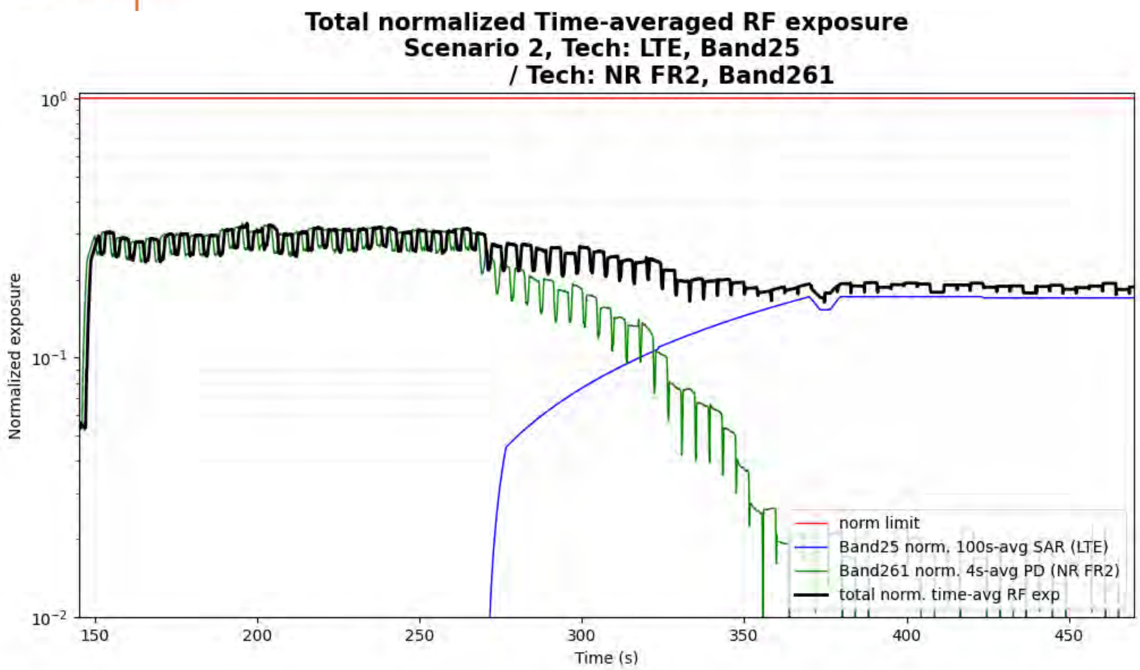

Figure 7-4 The Total Normalized Time-averaged RF exposure (n261)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.329
Validation result: pass	

8 CONCLUSIONS

This report proposes TA-PD test scenarios and procedures, and further proves Mediatek's TA-PD algorithms can meet the FCC PD regulations with the proposed test scenarios and procedures. As shown in these Chapters, Mediatek's TA-PD algorithms are able to maintain PD over time below the FCC regulatory limits (based on the agreed TX-power-to-PD translation). Furthermore, the near-field measurements are also done to further validate the proposed test methodologies, and the results demonstrate that Mediatek's TA-PD algorithms really can maintain PD over time below the FCC regulatory limits under the proposed test procedures. Based on the provided measurement evidences, it is concluded that Mediatek's TA-PD algorithms can be tested by using the proposed test methodology for FCC compliance.

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APPENDIX-A: TA-PD INPUT.POWER.LIMIT TABLE

Table A-1 Summary table of power limit (PFR2_limit) for Band n258

Module	Type	Beam ID	Feed No.	Input_Pwr_limit (dBm)	Module	Type	Beam ID	Feed No.	Input_Pwr_limit (dBm)
mmW L	Patch	0	4	2.55	mmW K	Patch	0	4	2.92
		1	4	2.18			1	4	2.83
		2	4	2.75			2	4	3.20
		3	4	2.77			3	4	3.13
		4	4	2.43			4	4	3.31
		5	4	2.69			5	4	3.86
		6	4	2.64			6	4	2.73
		7	4	3.32			7	4	2.55
		8	4	1.97			8	4	3.34
		9	4	1.64			9	4	3.11
		10	4	2.55			10	4	3.97
		11	4	1.66			11	4	2.84
		12	4	2.48			12	4	2.96
		13	4	3.10			13	4	3.34
		14	4	1.95			14	4	3.79
		15	4	2.11			15	4	3.96
		16	4	2.76			16	4	2.97
		17	4	2.26			17	4	2.99
		18	4	2.73			18	4	3.28
		19	4	2.73			19	4	3.81
		20	4	2.45			20	4	3.42
		21	4	2.99			21	4	2.61
		22	4	2.60			22	4	2.91
		23	4	3.00			23	4	3.50
		24	4	1.93			24	4	2.72
		25	4	1.83			25	4	4.29
		26	4	2.73			26	4	3.48
		27	4	1.61			27	4	2.95
		28	4	2.43			28	4	2.84
		29	4	3.26			29	4	3.88
		30	4	2.05			30	4	2.97
		31	4	2.12			31	4	2.71
		32	8	-0.48			32	8	-0.47

mmW L	Patch	33	8	-0.97	mmW K	Patch	33	8	-0.85
		34	8	-0.40			34	8	-0.44
		35	8	-0.46			35	8	-1.37
		36	8	-0.74			36	8	-1.03
		37	8	-0.83			37	8	-1.40
		38	8	-1.00			38	8	-0.92
		39	8	-0.19			39	8	-1.90
		40	8	-1.26			40	8	-1.17
		41	8	-1.60			41	8	-1.33
		42	8	-1.01			42	8	-0.60
		43	8	-1.82			43	8	-1.05
		44	8	-0.70			44	8	-0.99
		45	8	-0.54			45	8	-1.22
		46	8	-1.44			46	8	-1.09
		47	8	-1.13			47	8	-1.31
		48	2	4.83			48	2	5.48
		49	2	4.67			49	2	5.74
		50	2	4.83			50	2	5.38
		51	2	4.67			51	2	5.65
		52	2	4.67			52	2	5.43
		53	2	4.79			53	2	5.90
		54	2	4.79			54	2	5.38
		55	2	4.79			55	2	5.43
		56	2	4.82			56	2	5.95
		57	2	4.72			57	2	5.65
		58	2	4.77			58	2	5.90
		59	2	4.72			59	2	5.38
		60	2	4.83			60	2	5.95
		61	2	4.77			61	2	5.65
		62	2	4.77			62	2	5.65
		63	2	4.83			63	2	5.65
		64	2	4.83			64	2	5.48
		65	2	4.79			65	2	5.65
		66	2	4.72			66	2	5.71
		67	2	4.72			67	2	5.54
		68	2	4.88			68	2	5.71
		69	2	4.72			69	2	5.66
		70	2	4.72			70	2	5.55
		71	2	4.62			71	2	5.55
		72	2	4.62			72	2	5.71

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mmW L	Patch	73	2	4.62	mmW K	Patch	73	2	5.55
		74	2	4.80			74	2	5.41
		75	2	4.55			75	2	5.66
		76	2	4.73			76	2	5.55
		77	2	4.55			77	2	5.71
		78	2	4.88			78	2	5.41
		79	2	4.73			79	2	5.66
		80	2	4.73			80	2	5.66
		81	2	4.88			81	2	5.66
		82	2	4.88			82	2	5.71
		83	2	4.62			83	2	5.66
		84	4	1.60			84	4	1.70
		85	4	1.43			85	4	1.76
		86	4	1.67			86	4	1.52
		87	4	1.43			87	4	1.42
		88	4	1.43			88	4	1.22
		89	4	1.40			89	4	1.62
		90	4	1.40			90	4	1.52
		91	4	1.40			91	4	1.22
		92	4	1.59			92	4	1.72
		93	4	1.28			93	4	1.42
		94	4	1.45			94	4	1.62
		95	4	1.28			95	4	1.52
		96	4	1.67			96	4	1.72
		97	4	1.45			97	4	1.42
		98	4	1.45			98	4	1.42
		99	4	1.67			99	4	1.42
		100	4	1.67			100	4	2.47
		101	4	1.57			101	4	1.42
		102	1	7.52			102	1	8.24
		103	1	7.84			103	1	8.34
		104	1	7.41			104	1	8.48
		105	1	7.76			105	1	8.24
		106	2	4.16			106	2	4.26
		107	2	4.56			107	2	4.28

Table A-2 Summary table of power limit (P_{FR2_limit}) for Band n260

Module	Type	Beam ID	Feed No.	Input_Pwr_limit (dBm)	Module	Type	Beam ID	Feed No.	Input_Pwr_limit (dBm)
mmW L	Patch	0	4	1.93	mmW K	Patch	0	4	3.52
		1	4	1.75			1	4	3.41
		2	4	1.90			2	4	3.33
		3	4	0.75			3	4	3.51
		4	4	1.10			4	4	3.46
		5	4	0.99			5	4	3.28
		6	4	1.35			6	4	3.11
		7	4	1.15			7	4	3.51
		8	4	1.07			8	4	3.24
		9	4	1.26			9	4	3.12
		10	4	1.08			10	4	3.30
		11	4	1.40			11	4	3.40
		12	4	1.03			12	4	3.36
		13	4	1.04			13	4	3.19
		14	4	1.31			14	4	3.31
		15	4	1.23			15	4	3.13
		16	4	2.06			16	4	3.52
		17	4	1.69			17	4	3.56
		18	4	2.07			18	4	3.53
		19	4	0.65			19	4	3.57
		20	4	0.96			20	4	3.75
		21	4	0.92			21	4	3.21
		22	4	0.91			22	4	3.30
		23	4	1.08			23	4	3.72
		24	4	1.29			24	4	3.22
		25	4	1.09			25	4	3.09
		26	4	0.60			26	4	3.75
		27	4	1.30			27	4	3.45
		28	4	1.29			28	4	3.60
		29	4	0.69			29	4	3.62
		30	4	1.06			30	4	3.38
		31	4	0.85			31	4	3.14
		32	8	-1.81			32	8	0.33

mmW L	Patch	33	8	-1.96	mmW K	Patch	33	8	0.05
		34	8	-1.75			34	8	0.14
		35	8	-2.87			35	8	0.30
		36	8	-2.63			36	8	0.26
		37	8	-2.56			37	8	-0.07
		38	8	-2.53			38	8	-0.10
		39	8	-2.46			39	8	0.24
		40	8	-2.30			40	8	0.01
		41	8	-2.48			41	8	-0.38
		42	8	-3.15			42	8	0.30
		43	8	-2.08			43	8	0.12
		44	8	-2.08			44	8	0.09
		45	8	-3.09			45	8	0.09
		46	8	-2.45			46	8	0.06
		47	8	-2.62			47	8	-0.24
		48	2	3.93			48	2	5.86
		49	2	3.62			49	2	5.86
		50	2	3.93			50	2	5.74
		51	2	2.81			51	2	5.74
		52	2	2.93			52	2	5.09
		53	2	3.22			53	2	5.04
		54	2	2.81			54	2	5.09
		55	2	3.26			55	2	5.36
		56	2	3.22			56	2	5.16
		57	2	2.93			57	2	5.04
		58	2	2.81			58	2	5.36
		59	2	3.26			59	2	5.45
		60	2	3.74			60	2	5.86
		61	2	2.93			61	2	5.09
		62	2	2.89			62	2	5.16
		63	2	2.89			63	2	5.16
		64	2	3.93			64	2	5.86
		65	2	2.81			65	2	5.04
		66	2	3.81			66	2	5.90
		67	2	3.62			67	2	5.75
		68	2	3.81			68	2	6.02
		69	2	2.75			69	2	6.02
		70	2	2.81			70	2	5.15
		71	2	3.25			71	2	5.25
		72	2	2.75			72	2	5.15

mmW L	Patch	73	2	3.20	mmW K	Patch	73	2	5.22
		74	2	3.25			74	2	5.53
		75	2	2.81			75	2	5.25
		76	2	2.75			76	2	5.22
		77	2	3.20			77	2	5.90
		78	2	3.62			78	2	5.75
		79	2	2.81			79	2	5.15
		80	2	2.92			80	2	5.53
		81	2	2.92			81	2	5.53
		82	2	2.75			82	2	5.15
		83	2	3.81			83	2	6.02
		84	4	0.19			84	4	2.62
		85	4	0.17			85	4	2.57
		86	4	0.19			86	4	2.64
		87	4	-0.73			87	4	2.64
		88	4	-0.63			88	4	1.76
		89	4	0.09			89	4	1.73
		90	4	-0.73			90	4	1.76
		91	4	-0.13			91	4	2.04
		92	4	0.09			92	4	1.95
		93	4	-0.63			93	4	1.73
		94	4	-0.73			94	4	2.04
		95	4	-0.13			95	4	2.38
		96	4	0.44			96	4	2.57
		97	4	-0.63			97	4	1.76
		98	4	-0.53			98	4	1.95
		99	4	-0.53			99	4	1.95
		100	4	-0.63			100	4	1.82
		101	4	0.14			101	4	2.40
		102	1	5.90			102	1	8.12
		103	1	6.37			103	1	8.33
		104	1	5.53			104	1	8.01
		105	1	6.72			105	1	8.66
		106	2	2.41			106	2	4.89
		107	2	3.18			107	2	5.22

Table A-3 Summary table of power limit (P_{FR2_limit}) for Band n261

Module	Type	Beam ID	Feed No.	Input_Pwr_limit (dBm)	Module	Type	Beam ID	Feed No.	Input_Pwr_limit (dBm)
mmW L	Patch	0	4	0.04	mmW K	Patch	0	4	4.35
		1	4	0.41			1	4	4.17
		2	4	0.11			2	4	4.64
		3	4	0.49			3	4	4.03
		4	4	0.08			4	4	4.21
		5	4	-0.02			5	4	3.59
		6	4	0.53			6	4	3.96
		7	4	0.10			7	4	4.05
		8	4	0.34			8	4	4.29
		9	4	0.92			9	4	3.71
		10	4	0.60			10	4	4.19
		11	4	-0.08			11	4	3.46
		12	4	0.82			12	4	4.32
		13	4	0.11			13	4	3.78
		14	4	0.39			14	4	3.79
		15	4	0.44			15	4	4.19
		16	4	-0.22			16	4	4.15
		17	4	0.30			17	4	4.28
		18	4	0.04			18	4	4.78
		19	4	0.27			19	4	3.84
		20	4	-0.03			20	4	4.29
		21	4	-0.12			21	4	3.52
		22	4	0.87			22	4	3.72
		23	4	0.40			23	4	4.19
		24	4	0.91			24	4	4.13
		25	4	1.04			25	4	3.36
		26	4	0.28			26	4	4.39
		27	4	0.01			27	4	3.22
		28	4	0.90			28	4	4.06
		29	4	0.48			29	4	3.81
		30	4	0.21			30	4	3.62
		31	4	0.50			31	4	4.39
		32	8	-3.40			32	8	0.82
		33	8	-3.53			33	8	0.85
		34	8	-3.48			34	8	1.02
		35	8	-3.94			35	8	-0.50

mmW L	Patch	36	8	-3.31	mmW K	Patch	36	8	0.54
		37	8	-3.36			37	8	-0.62
		38	8	-3.73			38	8	0.12
		39	8	-3.36			39	8	0.50
		40	8	-3.63			40	8	-0.20
		41	8	-2.85			41	8	-0.79
		42	8	-4.23			42	8	0.71
		43	8	-3.47			43	8	-0.83
		44	8	-3.42			44	8	0.61
		45	8	-3.47			45	8	0.04
		46	8	-4.37			46	8	-0.60
		47	8	-3.21			47	8	0.79
		48	2	2.39			48	2	6.67
		49	2	2.31			49	2	6.85
		50	2	2.39			50	2	6.51
		51	2	2.31			51	2	6.07
		52	2	2.39			52	2	6.07
		53	2	2.39			53	2	6.29
		54	2	2.23			54	2	6.25
		55	2	2.18			55	2	6.51
		56	2	2.18			56	2	6.07
		57	2	2.18			57	2	6.07
		58	2	2.31			58	2	6.51
		59	2	2.23			59	2	6.00
		60	2	2.18			60	2	6.25
		61	2	2.18			61	2	6.75
		62	2	2.31			62	2	6.29
		63	2	2.23			63	2	6.51
		64	2	2.39			64	2	6.85
		65	2	2.18			65	2	6.07
		66	2	2.38			66	2	6.37
		67	2	2.29			67	2	6.82
		68	2	2.31			68	2	6.71
		69	2	2.29			69	2	6.28
		70	2	2.31			70	2	6.28
		71	2	2.38			71	2	6.61
		72	2	2.35			72	2	6.02
		73	2	2.48			73	2	6.71
		74	2	2.42			74	2	6.28
		75	2	2.42			75	2	6.28

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mmW L	Patch	76	2	2.29	mmW K	Patch	76	2	6.71
		77	2	2.49			77	2	6.01
		78	2	2.42			78	2	6.02
		79	2	2.48			79	2	6.82
		80	2	2.29			80	2	6.61
		81	2	2.35			81	2	6.71
		82	2	2.38			82	2	6.82
		83	2	2.42			83	2	6.28
		84	4	-1.02			84	4	2.90
		85	4	-1.78			85	4	3.31
		86	4	-1.34			86	4	2.97
		87	4	-1.78			87	4	2.26
		88	4	-1.34			88	4	2.26
		89	4	-1.02			89	4	2.59
		90	4	-1.96			90	4	2.40
		91	4	-1.46			91	4	2.97
		92	4	-1.77			92	4	2.26
		93	4	-1.77			93	4	2.26
		94	4	-1.78			94	4	2.97
		95	4	-1.26			95	4	2.16
		96	4	-1.77			96	4	2.40
		97	4	-1.46			97	4	3.26
		98	4	-1.78			98	4	2.59
		99	4	-1.96			99	4	2.97
		100	4	-1.24			100	4	3.28
		101	4	-1.80			101	4	2.79
		102	1	4.95			102	1	8.96
		103	1	5.15			103	1	9.34
		104	1	5.12			104	1	9.21
		105	1	5.25			105	1	9.39
		106	2	1.19			106	2	5.48
		107	2	1.38			107	2	5.62

APPENDIX-B: SPECIFICATION OF EUMMWV3 PROBE AND DASY6 PD CALCULATION

B.1 SPEAG EUmmWV3 Probe / E-Field 5G Probe

The EUmmWV3 probe consists of two dipoles optimally arranged to obtain pseudo-vector information.

Frequency Range	750 MHz – 110 GHz
Dynamic Range	< 20 V/m – 10,000 V/m with PRE-10 (min < 50 V/m – 3,000 V/m)
Position Precision	< 0.2 mm (DASY6)
Dimensions	Probe Overall Length: 320 mm Probe Body Diameter: 8 mm Probe Tip Length: 23 mm Probe Tip Diameter: Encapsulation 8 mm Distance from Probe Tip to Sensor X Calibration Point: 1.5 mm Distance from Probe Tip to Sensor Y Calibration Point: 1.5 mm
Applications	E-field measurements of 5G devices and other mm-wave transmitters operating above 10 GHz in < 2 mm distance from device (free-space) Power density, H-field and far-field analysis using total field reconstruction
Compatibility	DASY6 + 5G-Module SW 2.0.2.34

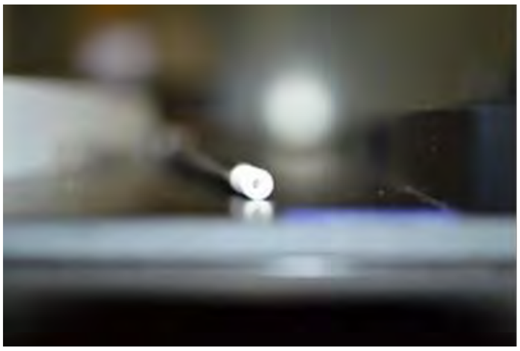
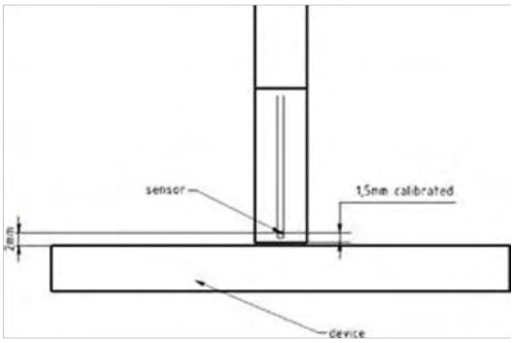

Figure C-1 EUmmWV3 Probe

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B.2 Peak Spatially Averaged Power Density Assessment Based on E- field Measurement

Within a short distance from the transmitting source, power density was determined based on both

electric and magnetic fields. Generally, the magnitude and phase of two components of either the E- field or H-field were needed on a sufficiently large surface to fully characterize the total E-field and H-field distributions. Nevertheless, solutions based on direct measurement of E-field and H-field can be used to compute power density. The general measurement approach used for this device was:

a) The local E field on the measurement surface was measured at a reference location where the field is well above the noise level. This reference level was used at the end of this procedure to assess output power drift of the EUT during the measurement.

b) The electric field on the measurement surface was scanned. Measurements are conducted according to the instructions provided by the measurement system manufacturer. Measurement spatial resolution can depend on the measured field characteristic and measurement methodology used by the system. The planar scan step size was configured at λ/4.

c) For DASY6, H-field was calculated from the measured E-field using a reconstruction algorithm. As the power density calculation requires knowledge of both amplitude and phase, reconstruction algorithms can also be used to obtain field information from the measured E-field data (e.g. the phase from the amplitude if only the amplitude is measured). H-field and phase data was reconstructed from repeated measurements (three per measurement point) on two measurement planes separated by λ/4.

d) The total Peak spatially averaged power density (psPD) distribution on the evaluation surface is determined per the below equation. The spatial averaging area, A, is specified by the applicable exposure limits or regulatory requirements. A circular shape was used.

$$psPD = \frac{1}{2A_{av}} \iint_{A_{av}} \| Re\{E \times H^*\} \| \, dA$$

e) The maximum spatial-average on the evaluation surface is the final quantity to determine compliance against applicable limits.

f) The local E field reference value, at the same location as step b), was re-measured after the scan was complete to calculate the power drift. If the drift deviated by more than 5%, the power density test and drift measurements were repeated.

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B.3 Reconstruction Algorithm

Computation of the power density in general requires measurement information from the both E-field and H-field amplitudes and phases in the plane of incidence. Reconstruction of these quantities

from pseudo-vector E-field measurements is feasible according to the manufacturer, as they are determined via Maxwell's equations. As such, the SPEAG reconstruction approach was based on the Gerchberg-Saxton algorithm, which benefits from the availability of the E-field polarization ellipse information obtained with the EUmmWV3 probe.

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APPENDIX-C: CDASY6 SYSTEM VERIFICATION

EX3DV4 E-Field Probe

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
Calibration	Basic Broad Band Calibration in air Conversion Factors (CF) for HSL 1900 MHz Additional CF for other liquids and frequencies upon request	
Frequency	10 MHz to > 6 GHz	
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)	
Dynamic Range	10 μW/g to > 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 μW/g)	
Dimensions	Tip diameter: 2.5 mm	
Application	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%.	

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Phantom

Model	Twin SAM	
Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points with the robot.	
Shell Thickness	2 ± 0.2 mm	
Filling Volume	Approx. 25 liters	
Dimensions	Height: 850 mm; Length: 1000 mm; Width: 500 mm	

DEVICE HOLDER

Construction	In combination with the Twin SAM Phantom V4.0/V4.0C or Twin SAM, the Mounting Device (made from POM) enables the rotation of the mounted transmitter in spherical coordinates, whereby the rotation point is the ear opening. The devices can be easily and accurately positioned according to IEC, IEEE, CENELEC, FCC or other specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).	 Device Holder

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APPENDIX-D: EQUIPMENT LIST

Equipment List					
Manufacturer	Device	Type	Serial number	Date of last calibration	Date of next calibration
SPEAG	Data acquisition Electronics	DAE4	1719	Jan/17/2024	Jan/16/2025
SPEAG	Dosimetric E-Field Probe	EX3DV4	7754	Nov/22/2023	Nov/21/2024
SPEAG	E-field Probe for Near Field Application	EUmmWV3	9399	Jan/23/2024	Jan/22/2025
SPEAG	System Validation Dipole	D1900V2	5d173	Apr/25/2024	Apr/24/2025
SPEAG	5G Verification Source 30GHz	5G-Veri30	1028	Apr/17/2024	Apr/16/2025
SPEAG	Dielectric Assessment Kit	DAKS-12	1039	Sep/21/2023	Sep/20/2024
Agilent	MXG Analog Signal Generator	N5181A	MY50144143	May/03/2024	May/02/2025
Agilent	Dual-directional coupler	772D	MY52180142	Oct/23/2023	Oct/22/2024
Agilent	Dual-directional coupler	778D	MY52180302	Oct/23/2023	Oct/22/2024
EMCI	Amplifier	ZHL-42	980189	Calibration not required	Calibration not required
EMCI	Amplifier	ZVE-8G	980190	Calibration not required	Calibration not required
R&S	Power Meter	NRX	102034	Dec/13/2023	Dec/12/2024
R&S	Power Sensor	NRP18S	101974	Nov/21/2023	Nov/20/2024
R&S	Power Sensor	NRP18S	109066	Oct/23/2023	Oct/22/2024
SPEAG	Software	DASY 6 mmWave V2.4.2.62	N/A	Calibration not required	Calibration not required
SPEAG	Software	DASY 52 V52.10.4.1527	N/A	Calibration not required	Calibration not required
SPEAG	Phantom	ELI	N/A	Calibration not required	Calibration not required
SPEAG	Phantom	mmWave Phantom	N/A	Calibration not required	Calibration not required
BWANT	FR2 test system	TA8	FIT-04-5500-0258	Calibration not required	Calibration not required
Keysight	UXM 5G Wireless Test Platform	E7515B	MY60101215	Feb/27/2024	Feb/26/2025
TECPEL	Digital thermometer	HTC-1	EC23010603	Jan/16/2024	Jan/15/2025

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APPENDIX-E: TISSUE AND SYSTEM VERIFICATION

Tissue Verification

The following tissue formulations are provided for reference only as some of the parameters have not been thoroughly verified. The composition of ingredients may be modified accordingly to achieve the desired target tissue parameters required for routine SAR evaluation.

The composition of the brain tissue simulating liquid is:

Simulating Liquids for 600 MHz -10 GHz, Manufactured by SPEAG:

Broad-band head tissue simulating liquids	SPEAG Product	Frequency range (MHz)	Main Ingredients
	HBBL600-10000V6	600 - 10000	Water, Oil

Tissue Simulant Fluid for the Frequency Band

The dielectric properties for this Head-simulant fluid were measured by using the SPEAG Dielectric Assessment Kit (DAKS-3.5)

All dielectric parameters of tissue simulates were measured within 24 hours of SAR measurements. The measured conductivity and permittivity are all within ± 5% of the target values.

The depth of the tissue simulant in the flat section of the phantom was ≥ 15 cm ± 5 mm during all tests. (Fig. 2)

Measured Frequency (MHz)	Target Dielectric Constant, εr	Target Conductivity, σ (S/m)	Measured Dielectric Constant, εr	Measured Conductivity, σ (S/m)	% dev εr	% dev σ	Limit	Measurement Date	Liquid Temp. (°C)	Ambient Temp (°C)
1860	40.000	1.400	40.683	1.420	1.71%	1.43%	± 5%	Jul. 31, 2024	22.1	22.4
1900	40.000	1.400	40.611	1.427	1.53%	1.93%	± 5%	Jul. 31, 2024	22.1	22.4

System Verification

The microwave circuit arrangement for system verification is sketched in Fig. b. The daily system accuracy verification occurs within the flat section of the SAM phantom. A SAR measurement was performed to see if the measured SAR was within +/- 10% from the target SAR values. These tests were done at 1900/2600MHz. The tests were conducted on the same days as the measurement of the DUT. The obtained results from the system accuracy verification are displayed in the table 1 (SAR values are normalized to 1W forward power delivered to the dipole). During the tests, the liquid depth above the ear reference points was above 15 cm in all the cases. It is seen that the system is operating within its specification, as the results are within acceptable tolerance of the reference values.

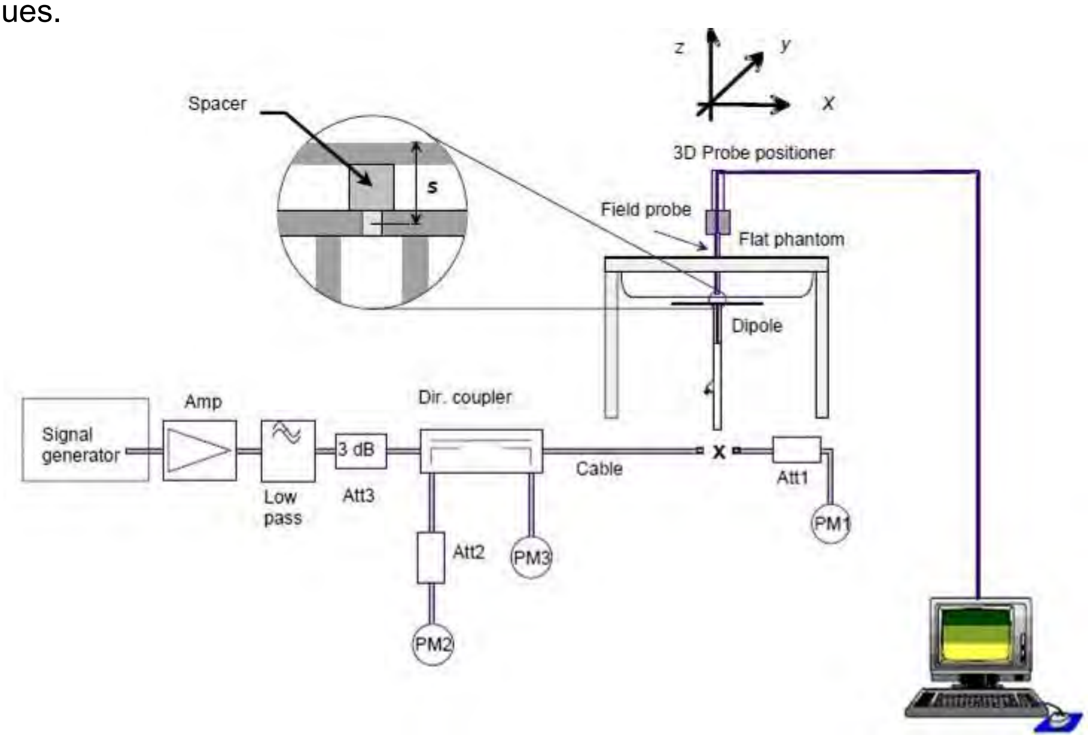


Fig. b The block diagram of system verification

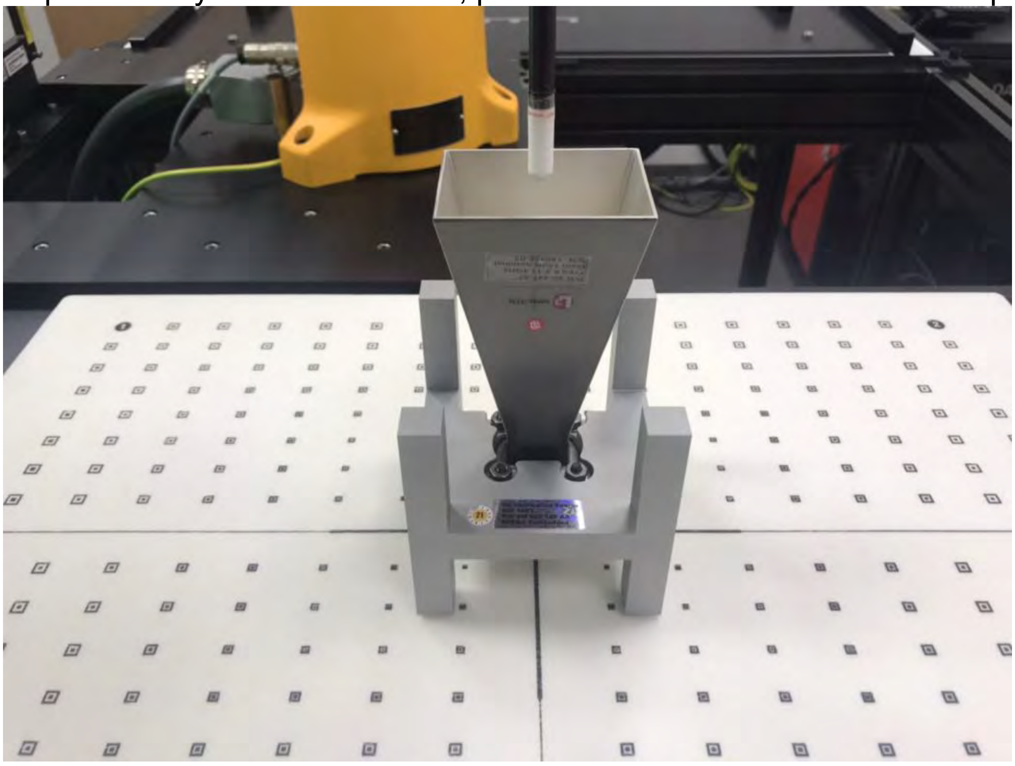
Validation Kit	S/N	Frequency (MHz)	1W Target 1g-SAR (W/kg)	pin=250mW Measured 1g-SAR (W/kg)	Normalized to 1W 1g-SAR (W/kg)	Deviation (%)	Limit	Measurement Date
D1900V2	5d173	1900	39.9	9.83	39.32	-1.45	± 10%	Jul.31,2024

APPENDIX-F: PD SYSTEM VERIFICATION

F.1 System check

The system was verified to be within ±0.66 dB of the power density targets on the calibration certificate according to the test system specification in the user's manual and calibration facility recommendation. The 0.66 dB deviation threshold represents the expanded uncertainty for system performance checks using SPEAG's mmWave verification sources. The same spatial resolution and measurement region used in the source calibration was applied during the system check.

The measured power density distribution of verification source was also confirmed through visual inspection to have no noticeable differences, both spatially (shape) and numerically (level) from the distribution provided by the manufacturer, per November 2017 TCBC Workshop Notes.



System Verification Setup Photo

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F.2 System check result

The system was verified to be within ±0.66 dB of the power density targets on the calibration certificate according to the test system specification in the user's manual and calibration facility recommendation. The 0.66 dB deviation threshold represents the expanded uncertainty for system performance checks using SPEAG's mmWave verification sources. The same spatial resolution and measurement region used in the source calibration was applied during the system check. The measured power density distribution of verification source was also confirmed through visual inspection to have no noticeable differences, both spatially (shape) and numerically (level) from the distribution provided by the manufacturer, per November 2017 TCBC Workshop Notes.

Frequency (MHz)	PD Verification Source (MHz)	Probe S/N	DAE S/N	Distance (mm)	Prad (mW)	Measured 4cm^2 (W/m^2)	Target 4cm^2 (W/m^2)	Deviation (dB)	Date
30000	30000	9399	1719	5.55	30.2	28.7	32	-0.47	Jul.31,2024

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APPENDIX-G: SAR SYSTEM CHECK RESULTS

Report No. :TESA2406000425ES
Measurement Report
Dipole_D1900-SN:5d173
Ambient temperature: 22.4; Liquid temperature: 22.1

Exposure Conditions

Phantom Section, TSL	Position, Test Distance [mm]	Conversion Factor	TSL Conductivity [S/m]	TSL Permittivity
Flat, HSL	FRONT, 10.00	8.1	1.427	40.611

Hardware Setup

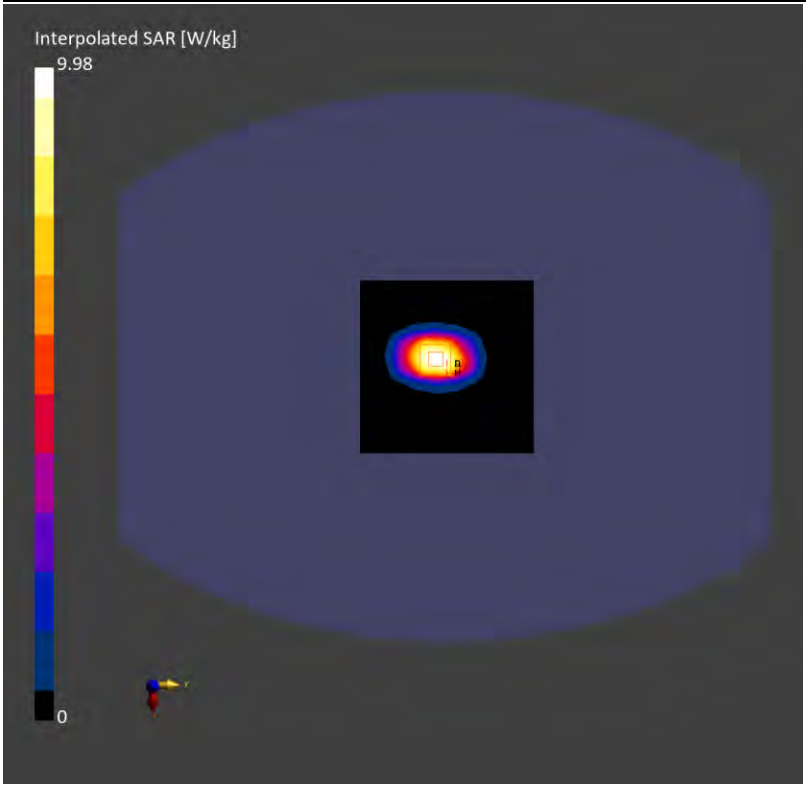
Phantom	Probe, Calibration Date	DAE, Calibration Date
ELI	EX3DV4 - SN7754, 2023-11-22	DAE Sn1719, 2024-01-17

Scans Setup

	Area Scan	Zoom Scan
Grid Extents [mm]	120.0 x 120.0	30.0 x 30.0 x 30.0
Grid Steps [mm]	15.0 x 15.0	5.0 x 5.0 x 5.0
Sensor Surface [mm]	3.0	1.4

Measurement Results

	Area Scan	Zoom Scan
Date	2024-07-31	2024-07-31
psSAR1g [W/kg]	8.46	9.83
psSAR8g [W/kg]	5.13	5.56
psSAR10g [W/kg]	4.75	5.11
Power Drift [dB]	-0.05	-0.02
M2/M1 [%]		53.3
Dist 3dB Peak [mm]		10.1



Report No. :TESA2406000425ES
Measurement Report for Device, FRONT, Validation band, CW, Channel 30000 (30000.0 MHz), SN:1028

Exposure Conditions

Phantom Section	Position, Test Distance [mm]	Conversion Factor
5G	FRONT, 5.55	1.0

Hardware Setup

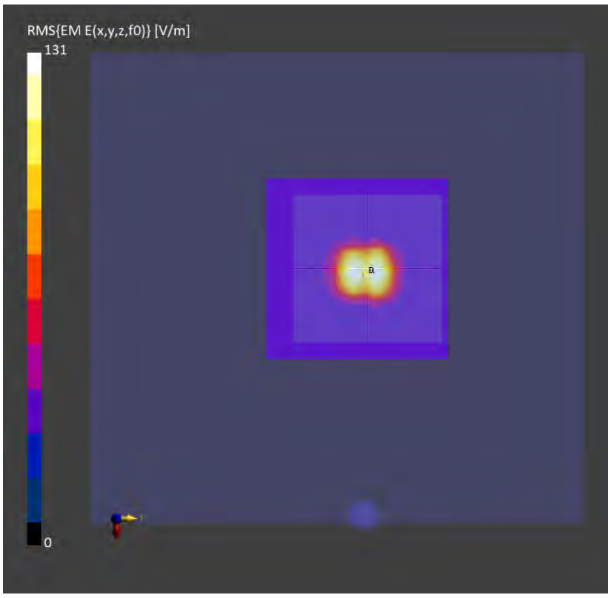
Phantom	Medium	Probe, Calibration Date	DAE, Calibration Date
mmWave	Air -	EUmmWV3 - SN9399_F1-55GHz, 2024-01-23	DAE4 Sn1719, 2024-01-17

Scans Setup

Scan Type	5G Scan
Grid Extents [mm]	120.0 x 120.0
Grid Steps [lambda]	0.25 x 0.25
Sensor Surface [mm]	5.55

Measurement Results

Scan Type	5G Scan
Date	2024-07-31
Avg. Area [cm^2]	4.00
psPDn+ [W/m^2]	28.4
psPDtot+ [W/m^2]	28.7
psPDmod+ [W/m^2]	31.0
E_{max} [V/m]	131
Power Drift [dB]	0.05



16 APPENDIXES

Refer to separated files for the following appendixes.

16.1 SAR_Appendix H Photographs

16.2 SAR_Appendix I DAE & Probe Cal. Certificate

16.3 SAR_Appendix J Phantom Description & Dipole Cal. Certificate

- End of report -

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