FCC TAS validation – Part 2: Tests under dynamic transmit power scenarios

FCC ID	**:**	**IHDT56AE8**
Equipment	**:**	**Mobile Cellular Phone**
Model Name	**:**	**XT2205-3**
Applicant	**:**	**Motorola Mobility LLC 222 W,Merchandise Mart Plaza, Chicago IL 60654 USA**
Standard	**:**	**FCC 47 CFR Part 2 (2.1093)**

The product was received on Jun. 16, 2022 and testing was started from Jun. 17, 2022 and completed on Jun. 25, 2022. We, SPORTON INTERNATIONAL INC., would like to declare that the tested sample provide by manufacturer and the test data has been evaluated in accordance with the test procedures given in 47 CFR Part 2.1093 and FCC KDB and has been pass the FCC requirement.

The test results in this report apply exclusively to the tested model / sample. Without written approval of SPORTON INTERNATIONAL INC. Laboratory, the test report shall not be reproduced except in full.

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History of this test report

Report No.	Version	Description	Issued Date
FA240812-01	01	Initial issue of report	Jun. 24, 2022

1. 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 document describes the test plan, test procedures, measurement setup, and measurement results for the verification of the proposed TA-SAR/TA-PD algorithm being able to make RF exposure meet FCC requirement. The operating parameters for algorithm validation are described in Chapter 2. The overview of test proposal is given in Chapter 3. The test procedures for conducted power measurements and SAR measurements are described in Chapter 4. The test procedures for radiated power measurements and PD measurements are described in Chapter 5. For TA-SAR validation, the measurement setup and results for conducted power are included in Chapter 6, while the measurement setup and results for SAR are included in Chapter 7. For TA-PD validation, the measurement setup and results for radiated power are included in Chapter 8, while the measurement setup and results for PD are included in Chapter 9. It is concluded in Chapter 10 that the proposed TA-SAR/TA-PD algorithm can apply dynamic power control to ensure FCC compliance in real-time.

2. Operating Parameters for Algorithm Validation

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 2-1.

Table 2-1 TA-SAR operating parameters

Operating parameters	Description
P_{sub6_limit}	The time-averaged maximum power level limit for different bands for 2G, 3G, LTE, and NR FR1.
$P_{LowThresh\_offset}$	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. $P_{UE\_max\_cust} = \min(P_{UE\_max}, P_{sub6\_limit} + P_{UE\_max\_cust\_offset})$

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

Table 2-2 TA-PD operating parameters

Operating parameters	Description
$P_{FR2\_limit}[beam]$	The time-averaged maximum power level limit for different bands/beams for FR2.
$P_{FR2\_LowThresh\_offset}[beam]$	To calculate $P_{FR2\_LowThresh}[beam]$. ($P_{FR2\_LowThresh}[beam]$ = $P_{FR2\_limit}[beam]$ - $P_{FR2\_LowThresh\_offset}[beam]$)
$P_{FR2\_UE\_backoff\_offset}[beam]$	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. $P_{FR2\_UE\_max\_cust} = \min(P_{FR2\_UE\_max}, P_{FR2\_limit}[beam] + P_{FR2\_UE\_max\_cust\_offset}[beam])$

3. Overview of TA-SAR/TA-PD Test Proposal

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

- **Scenario 1**: test under different TA-SAR parameters to verify that the TA-SAR algorithm meets compliance requirements with different combinations of operating parameters.
- **Scenario 2**: test under time-varying TX power to verify that the TA-SAR algorithm ensures SAR compliance through dynamic TX power.
- **Scenario 3**: test under call drop and re-establishment conditions to ensure the TA-SAR algorithm control continuity and SAR compliance.
- **Scenario 4**: test under RAT/band handover to ensure the TA-SAR algorithm control continuity and correctness.
- **Scenario 5**: test under different ECIs (Exposure Condition Index) to ensure the TA-SAR algorithm control behaves as expected during ECI switching from one ECI to another. (e.g., head→ body worn)
- **Scenario 6**: test under different transmission antennae to ensure the TA-SAR algorithm control works correctly during antenna switching from one antenna to another.
- **Scenario 7**: test under different time windows to ensure the TA-SAR algorithm control functions correctly during time window switching from one time window setting to another. (e.g., time window 100s→60s)
- **Scenario 8**: test under SAR exposure switching between two active radios (radio#1 only, radio#1+radio#2, and radio#2 only) to ensure the TA-SAR algorithm control continuity and SAR compliance.

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).

For TA-SAR validation, description of the conducted power measurement test procedures is included in section 4.2~4.9, and description of the SAR measurement test procedures is included in section 4.10. In each of the test scenarios, certain test sequence, described in section 4.1, is applied.

For TA-PD validation, description of the radiated power measurement test procedures is included in section 5.2~5.7, and description of the PD measurement test procedures is included in section 5.8.

4. TA-SAR Test Scenarios and Test Procedures

In order to demonstrate that TA-SAR algorithm performs as expected under various operating scenarios, Table 4-1 lists the test scenarios and expected test sequences to validate TA-SAR algorithm in these scenarios. The test sequences 0, 1, 2 are defined in section 4.1. The details of each test procedures via conducted power and SAR measurements are described in section 4.2~4.9 and section 4.10, respectively.

Table 4-1 Test scenario list of TA-SAR validation

Test scenario		Test sequences #	Description
1	Range of TA-SAR parameters	0	Adjust parameters
2	Time-varying TX power	1 and 2	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	ECI (Exposure Condition Index) change	0	Test under ECI transition (e.g., head→ body worn)
6	Antenna switching	0	Change antenna
7	Time window switching	0	Switch frequency bands with larger frequency separation (e.g., time window 100s→60s)
8	SAR exposure switching	0	Switch RATs when testing (e.g., LTE→NR)

4.1 Test Sequences for All Scenarios

Three test sequences having possibly time-varying TX power are predefined for TA-SAR validation:

- **Test sequence 0**: EUT's TX power is requested to be maximum.
- **Test sequence 1**: EUT's TX power is requested to be at power less than $P_{LowThresh}$ for 300s, then at maximum power for 200s, and finally at $P_{LowThresh}$ -2dB for the remaining time.
- **Test sequence 2**: EUT's TX power to vary with time. This sequence is generated relative to measured P_{UE_max}, measured P_{sub6_limit} and calculated $P_{UE\_backoff}$ (= measured P_{sub6_limit} in dBm - $P_{UE\_backoff\_offset}$ in dB) of EUT based on measured P_{sub6_limit}.
- Test sequence is generated based on below parameters of the EUT:
    A. Measured maximum power (P_{UE_max})
    B. Measured Tx_power_at_*SAR_design_limit* (P_{sub6_limit})
    C. Threshold of dynamic power reduction status determination: reserve hysteresis margin for instantaneous power ($P_{LowThresh}$)
    D. *SAR_time_window* (FCC: 100s for f < 3GHz, 60s for 3GHz < f <6GHz)

The test sequence 0, 1, and 2 are illustrated in Figure 4-1, Figure 4-2, and Figure 4-3, respectively. The waveforms of the three test sequences are listed in Table 4-2, Table 4-3, and Table 4-4.

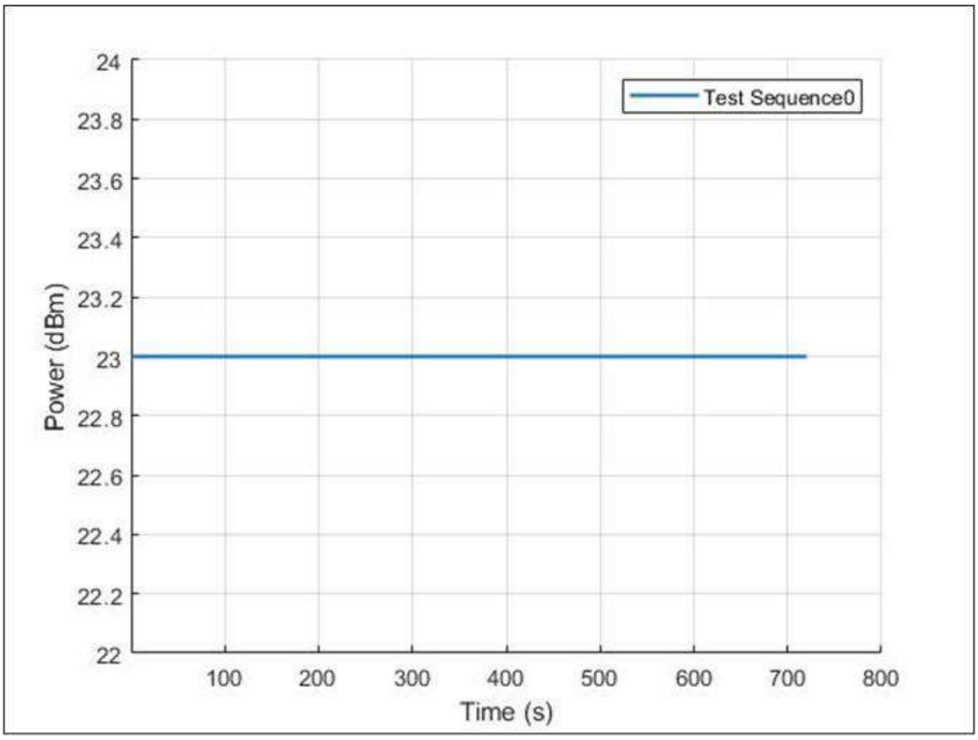


Figure 4-1 Test sequence 0

Table 4-2 Test sequence 0

Time	Duration	Power (dBm)	Note
720	720	23	P_{UE_max}

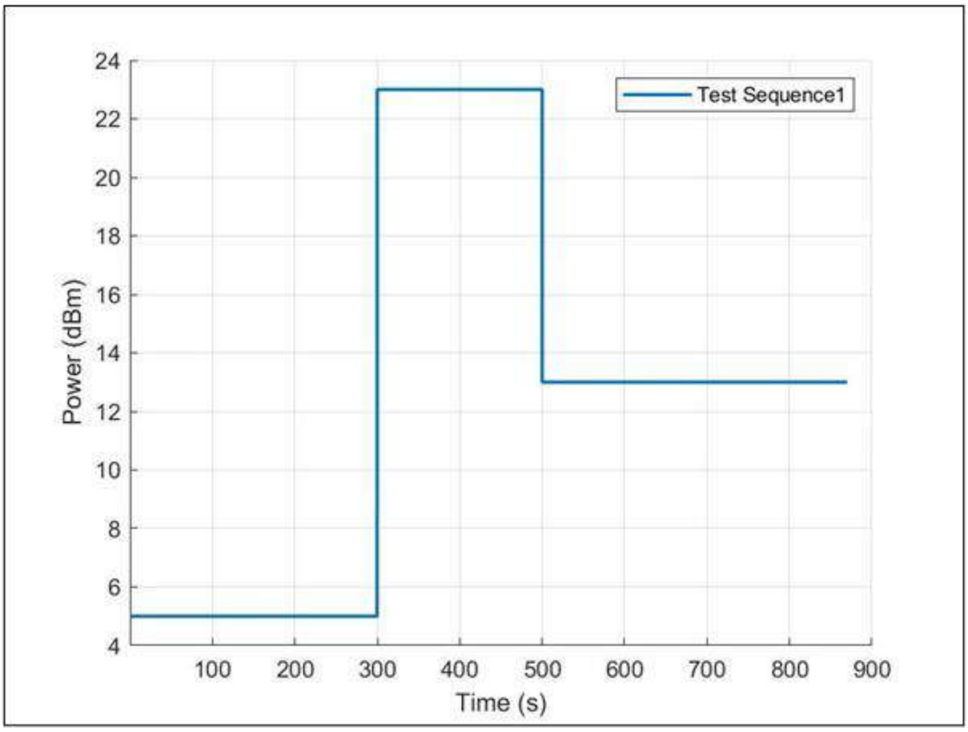


Figure 4-2 Test sequence 1

Table 4-3 Test sequence 1

Time	Duration	Power (dBm)	Note
300	300	5	$< P_{LowThresh}$
500	200	23	P_{UE_max}
870	370	13	$P_{LowThresh}$ - 2dB

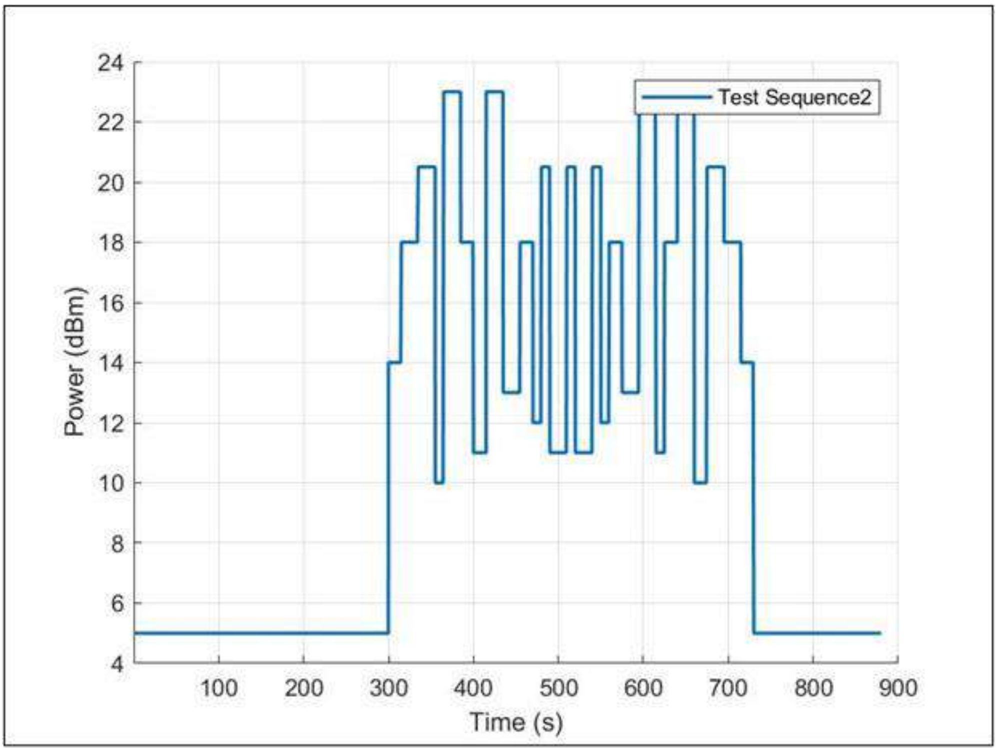


Figure 4-3 Test sequence 2

Table 4-4 Test sequence 2

Time	Duration	Power (dBm)	Note
300	300	5	< $P_{LowThresh}$
315	15	14	P_{sub6_limit} - 4dB
335	20	18	P_{sub6_limit}
355	20	20.5	(P_{sub6_limit}+P_{UE_max})/2
365	10	10	P_{sub6_limit} - 8dB
385	20	23	P_{UE_max}
400	15	18	P_{sub6_limit}
415	15	11	P_{sub6_limit} - 7dB
435	20	23	P_{UE_max}
455	20	13	P_{sub6_limit} - 5dB
470	15	18	P_{sub6_limit}
480	10	12	P_{sub6_limit} - 6dB
490	10	20.5	(P_{sub6_limit} + P_{UE_max})/2
510	20	11	P_{sub6_limit} - 7dB
520	10	20.5	(P_{sub6_limit} + P_{UE_max})/2
540	20	11	P_{sub6_limit} - 7dB
550	10	20.5	(P_{sub6_limit} + P_{UE_max})/2
560	10	12	P_{sub6_limit} - 6dB
575	15	18	P_{sub6_limit}
595	20	13	P_{sub6_limit} - 5dB
615	20	23	P_{UE_max}
625	10	11	P_{sub6_limit} - 7dB
640	15	18	P_{sub6_limit}
660	20	23	P_{UE_max}

675	15	10	P_{sub6_limit} - 8dB
695	20	20.5	(P_{sub6_limit} + P_{UE_max})/2
715	20	18	P_{sub6_limit}
730	15	14	P_{sub6_limit} - 4dB
870	140	5	< $P_{LowThresh}$

4.2 Test Configuration and Procedure for Scenario 1: Range of TA-SAR Parameters via Conducted Power Measurements

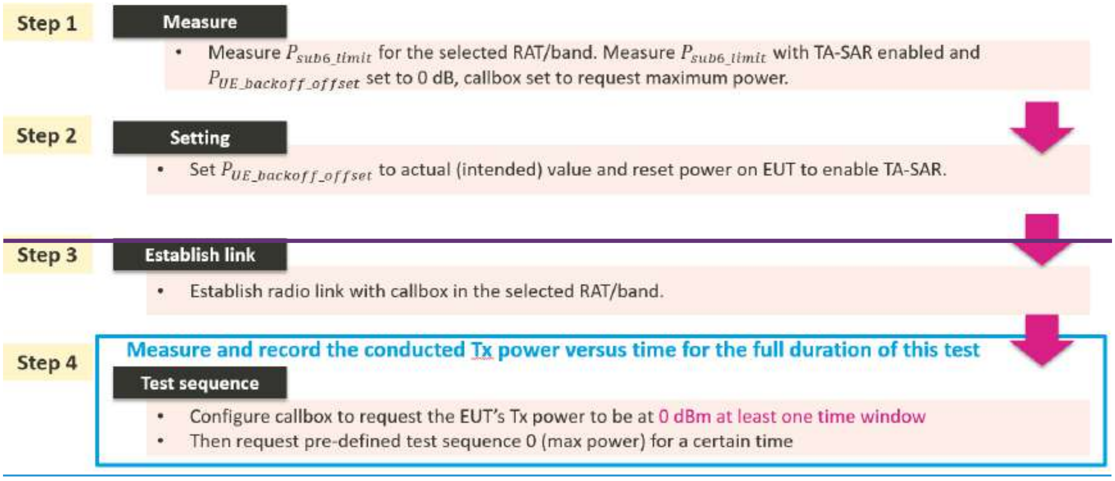
4.2.1 Configuration

This test is performed by changing the parameters ($P_{LowThresh\_offset}$, $P_{UE\_backoff\_offset}$, $P_{UE\_max\_cust\_offset}$) for the selected RAT (Radio Access Technologies) and band. Since Mediatek's TA algorithm operation is independent of RATs/bands/channels, any one RAT can be selected for this test and the selected band of the RAT has the least P_{sub6_limit}. 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.

4.2.2 Procedure

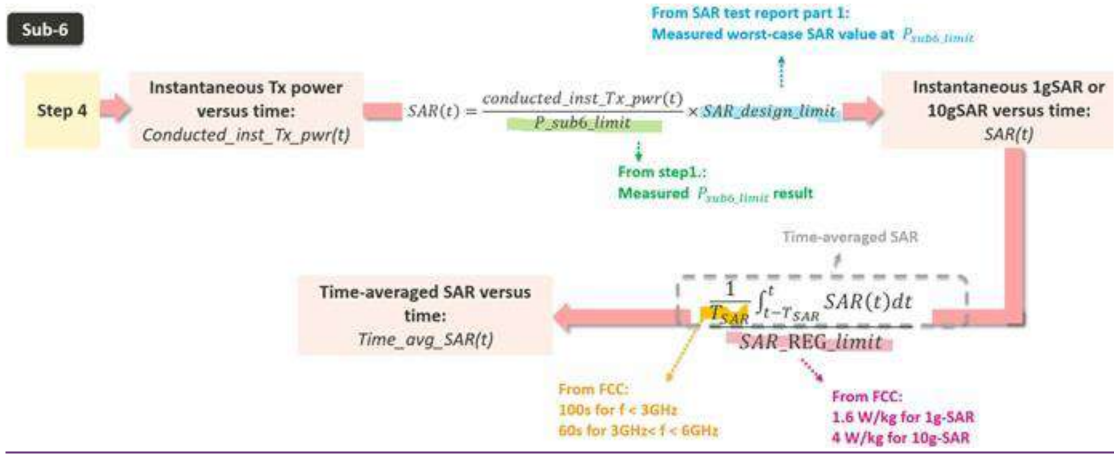
TX power is measured, recorded, and processed by the following steps:

- Step 1~4: measure and record TX power versus time for test scenario 1



- Step 5: convert the measured conducted TX power into SAR

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,



- Step 6: plot results

A. Make one power perspective plot containing

1. Instantaneous TX power
2. Requested power
3. Calculated time-averaged power
4. Calculated time-averaged power limits

B. Make one SAR perspective plot containing

1. Calculated time-averaged 1gSAR or 10gSAR
2. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)

4.3 Test Configuration and Procedure for Scenario 1: Range of TA-SAR Parameters via Conducted Power Measurements

4.3.1 Configuration

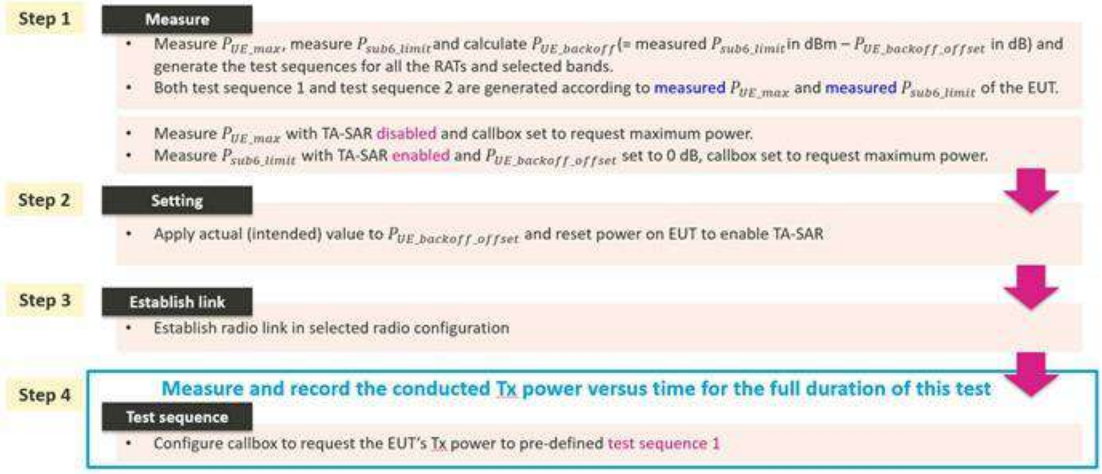
Since Mediatek's TA-SAR feature operation is independent of bands and channels for a given RAT, selecting one band per RAT is sufficient to validate this feature. Two bands per RAT are proposed for this test. The criteria for band selection for each RAT is based on the P_{sub6_limit} values (corresponding to *SAR_design_limit*) and is described as below:

- Select two bands, among the ones whose P_{sub6_limit} values are below P_{UE_max}, which correspond to least and highest P_{sub6_limit} values respectively.
    - Only one band needs to be tested if all the bands have same P_{sub6_limit}.
    - Only one band needs to be tested if only the band has P_{sub6_limit} below P_{UE_max}.
    - If the same least P_{sub6_limit} applies to multiple bands, select the band with the highest measured 1gSAR at P_{sub6_limit}.
    - If P_{sub6_limit} values of all bands are all over P_{UE_max} (i.e., TA-SAR feature is not enabled), there is no need to test this RAT.

4.3.2 Procedure

TX power is measured, recorded, and processed by the following steps:

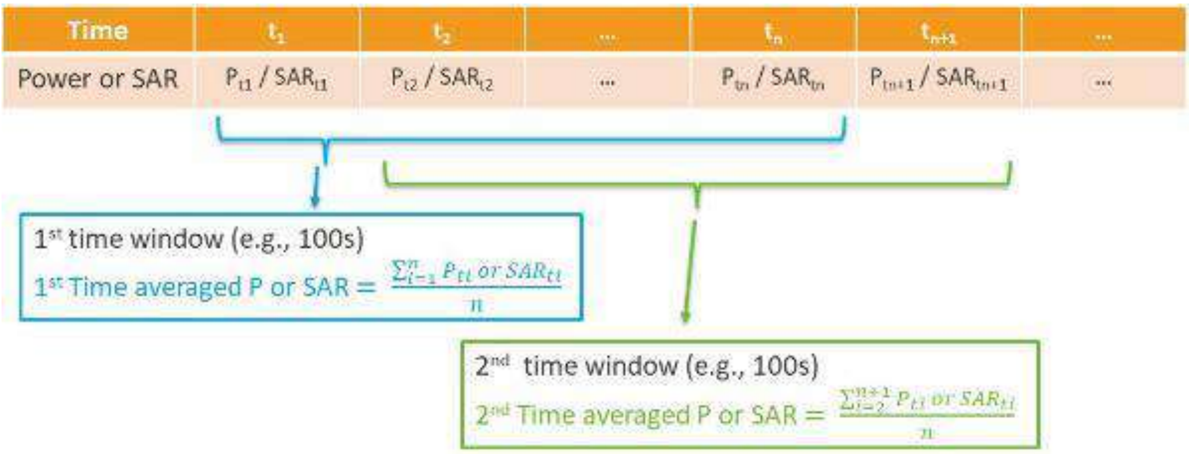
- Step 1~4: measure and record TX power versus time for test scenario 2

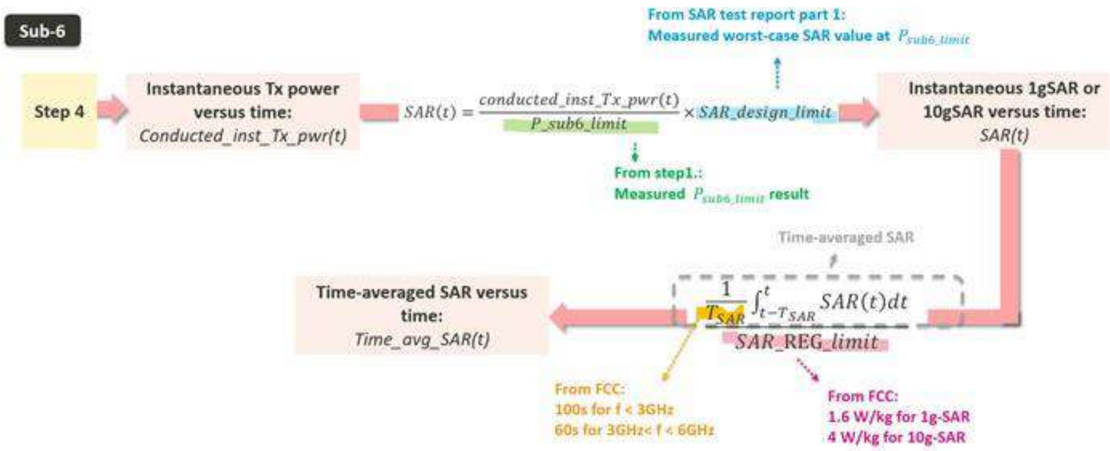


- Step 5: convert the measured conducted TX power into SAR

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 below:





- Step 6: plot results
  - A. Make one power perspective plot containing
    1. Instantaneous TX power
    2. Requested power (test sequence1)
    3. Calculated time-averaged power
    4. Calculated time-averaged power limits
  - B. Make one SAR perspective plot containing
    1. Calculated time-averaged 1gSAR or 10gSAR
    2. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)

- Step 7: repeat steps 2~6 for test sequence 2

Repeat steps 2 ~ 6 for pre-defined test sequence 2 and replace test sequence 1 in step 4 with test sequence 2.

- Step 8: repeat steps 2~7 for different bands

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

4.4.1 Configuration

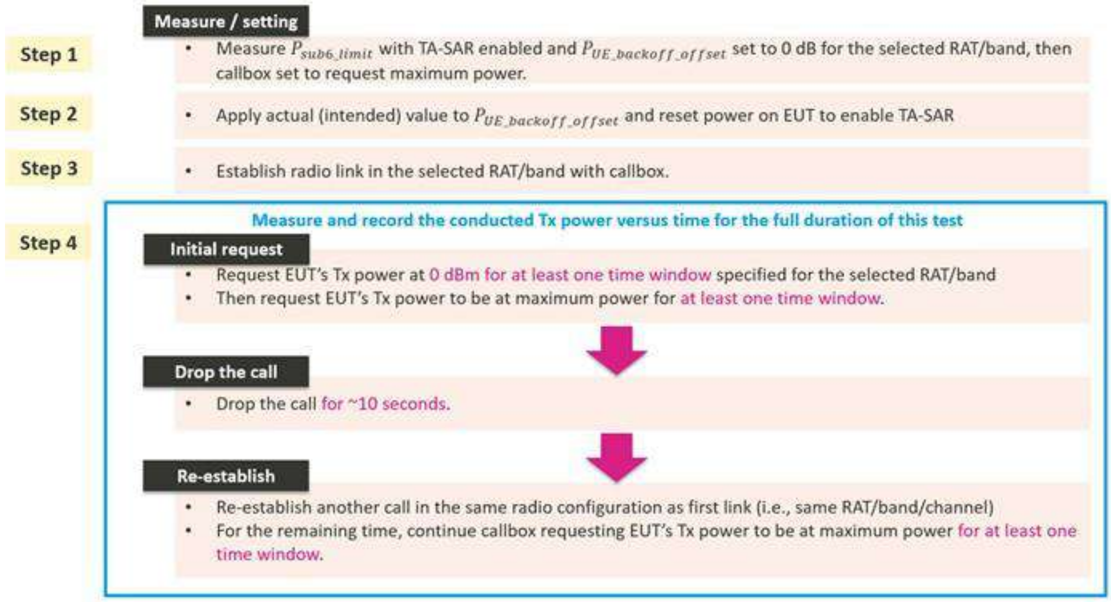
For call disconnection measurement, the criteria of selecting the test configuration is:

- Select the RAT/band with least P_{sub6_limit} among all supported RATs/bands.
- Select the RAT/band having the highest measured 1gSAR at P_{sub6_limit} if multiple RATs/bands having same least P_{sub6_limit}.
- Select the radio configuration in this RAT/band that corresponds to the highest measured 1gSAR at P_{sub6_limit}.

4.4.2 Procedure

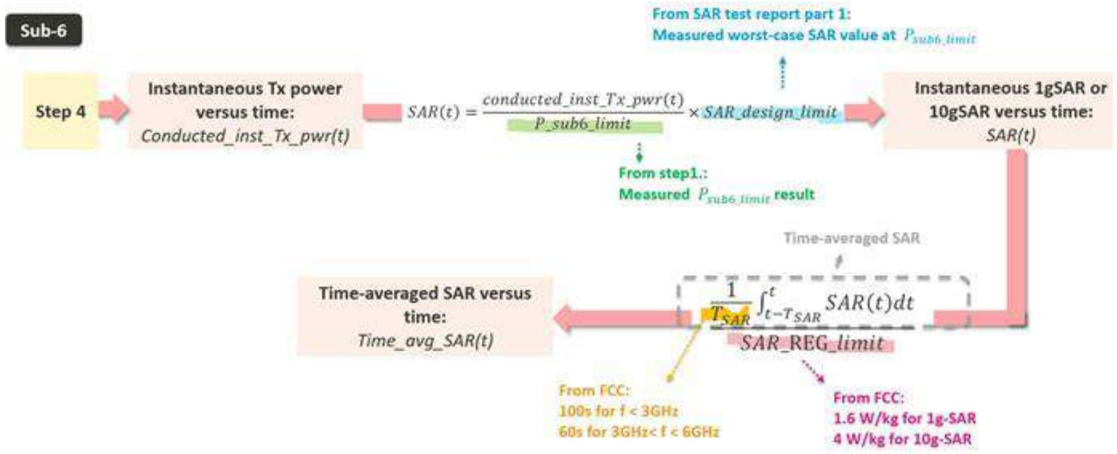
TX power is measured, recorded, and processed by the following steps:

- Step 1~4: measure and record TX power versus time for test scenario 3



- Step 5: convert the measured conducted TX power into SAR

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,



- Step 6: plot results
  - A. Make one power perspective plot containing
    1. Instantaneous TX power
    2. Requested power
    3. Calculated time-averaged power
    4. Calculated time-averaged power limits
  - B. Make one SAR perspective plot containing
    1. Calculated time-averaged 1gSAR or 10gSAR
    2. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)

4.5 Test Configuration and Procedure for Scenario 1: Range of TA-SAR Parameters via Conducted Power Measurements

4.5.1 Configuration

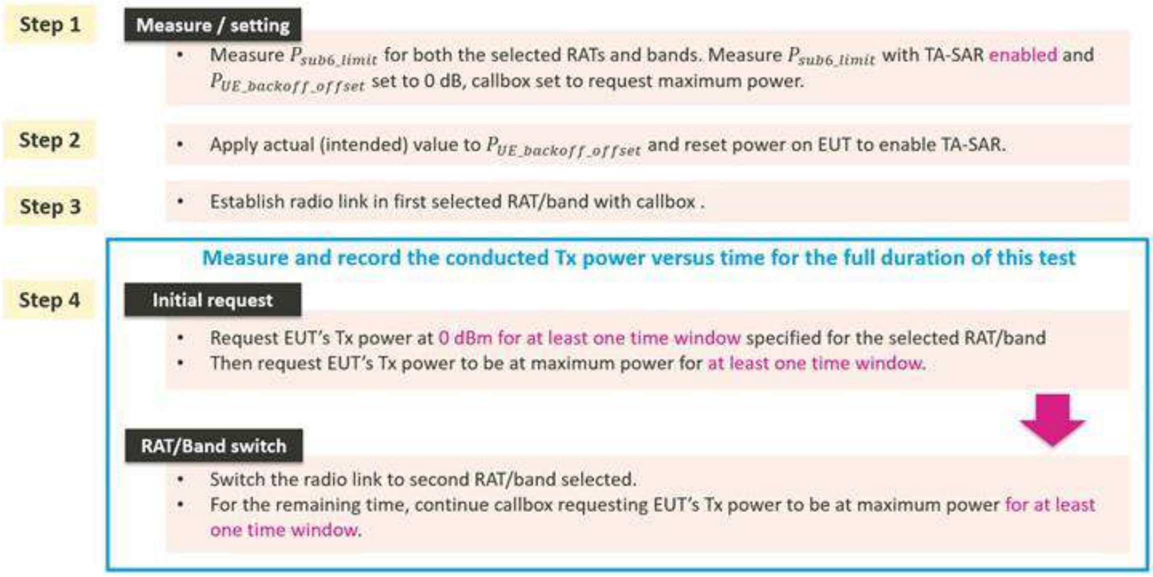
For a given TX antenna, select a RAT/band with the lowest P_{sub6_limit} and the other RAT/band with the highest P_{sub6_limit}. Both of them have P_{sub6_limit} values less than P_{UE_max} if possible.

- Select the RAT/band having the highest measured 1gSAR at P_{sub6_limit} if multiple RATs/bands have the same lowest P_{sub6_limit}.
- Select the RAT/band having the lowest measured 1gSAR at P_{sub6_limit} if multiple RATs/bands have the same highest P_{sub6_limit}.

4.5.2 Procedure

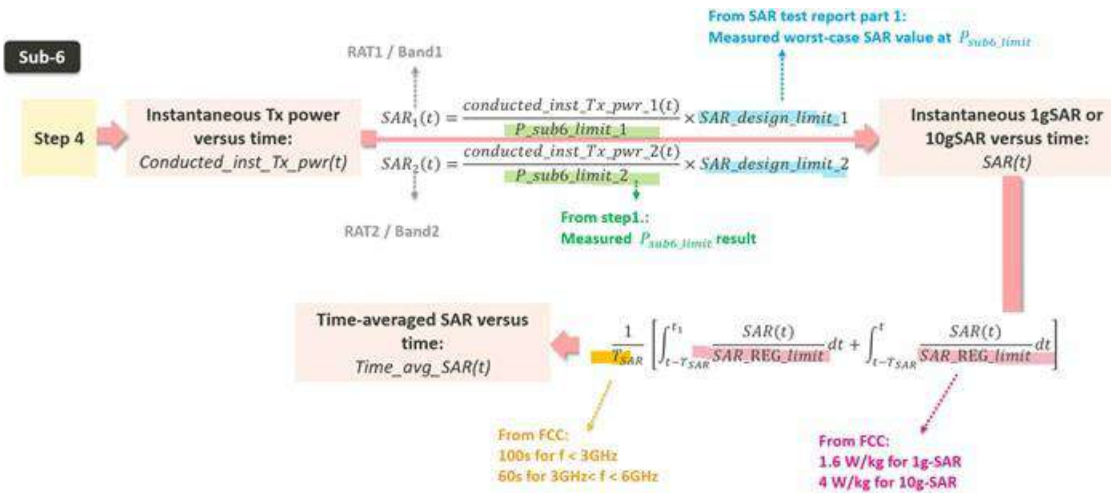
TX power is measured, recorded, and processed by the following steps:

- Step 1~4: measure and record TX power versus time for test scenario 4



- Step 5: convert the measured conducted TX power into SAR

  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,



- Step 6: plot results

A. Make one power perspective plot containing
   1. Instantaneous TX power
   2. Requested power
   3. Calculated time-averaged power
   4. Calculated time-averaged power limits

B. Make one SAR perspective plot containing
   1. Calculated time-averaged 1gSAR or 10gSAR
   2. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)
   3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0

4.6 Test Configuration and Procedure for Scenario 5: Exposure Condition Index (ECI) Change via Conducted Power Measurements

4.6.1 Configuration

Select any one RAT/band, which has at least two ECIs whose Psub6_limit values are different and are below PUE_max.

4.6.2 Procedure

The test procedure is identical to section 4.5.2 except the following 2 changes:

1. Replace band switch operation with ECI switch.
2. In Step 4, the second ECI switching is arranged after the first one lasts for at least one time window, i.e., switch the second ECI back to the first ECI, and then continue with callbox requesting EUT's Tx power to be at maximum power for at least one time window.

It is noted that the following operations are done as well for this scenario:

- The correct power control is controlled by TA_SAR during ECI switches from one ECI to another.
- The validation criteria are, at all times, the time-averaged 1gSAR or 10gSAR versus time shall not exceed FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

4.7 Test Configuration and Procedure for Scenario 6: Antenna Switching via Conducted Power Measurements

4.7.1 Configuration

Among RATs/bands supporting TX antenna switches, select the RAT/band with the highest Psub6_limit difference between a pair of supported TX antennas.

- Select the RAT/band having the highest measured 1gSAR at Psub6_limit if multiple RATs/bands having the same Psub6_limit difference between the supported TX antennas.
- Antenna selection order
  - Select the configuration with two antennas having P_{sub6_limit} values less than P_{UE_max}.
  - If the previous configuration does not exist, select the configuration with one antenna having P_{sub6_limit} value less than P_{UE_max}.
  - If the above two cannot be found, select one configuration with the two antennas having the least difference between their Psub6_limit and PUE_max (i.e., Psub6_limit can be greater than PUE_max).

4.7.2 Procedure

The test procedure is identical to section 4.5.2 except the following 2 changes:

1. Replace band switch operation with antenna switch.
2. In Step 4, the second antenna switching is arranged after the first one lasts for at least one time window, i.e., switch the second antenna back to the first antenna, and then continue with callbox requesting EUT's Tx power to be at maximum power for at least one time window.

It is noted that the following operations are done as well for this scenario:

- The correct power control is controlled by TA_SAR during antenna switches from one antenna to another.
- The validation criteria are, at all times, the time-averaged 1gSAR or 10gSAR versus time shall not exceed FCC limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

4.8 Test Configuration and Procedure for Scenario 7: Time Window Switching via Conducted Power Measurements

4.8.1 Configuration

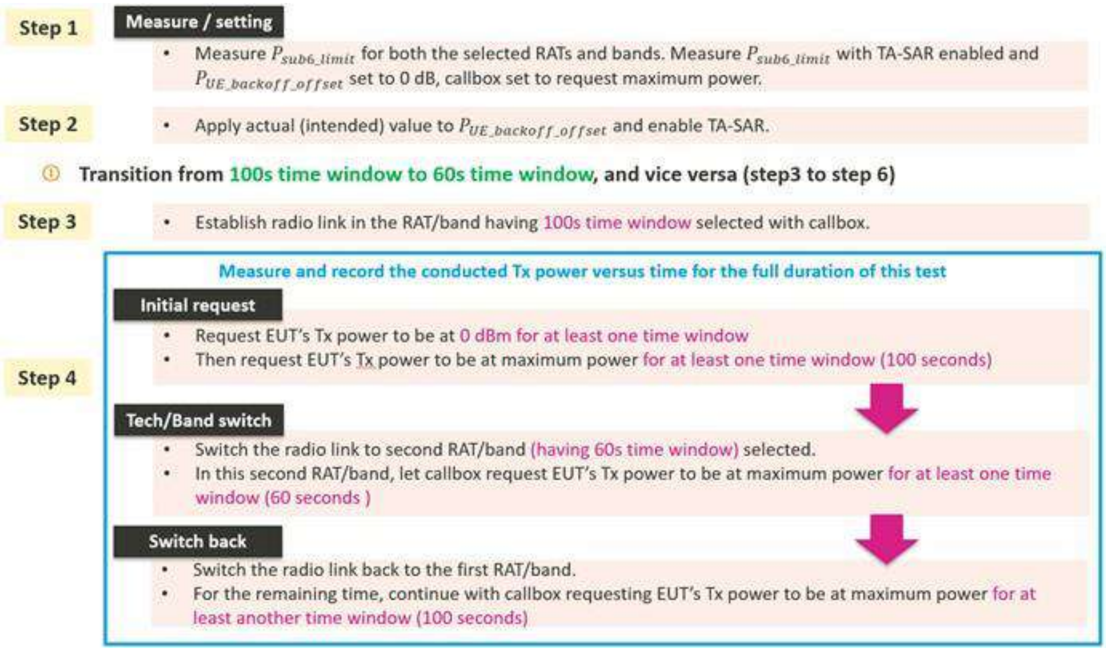
Select one RAT/band with 60-second time averaging window, and the other RAT/band with 100-second time averaging window. Both of them have P_{sub6_limit} values less than P_{UE_max} if possible.

- At least one of the selected RAT/band has its P_{sub6_limit} less than P_{UE_max}.

4.8.2 Procedure

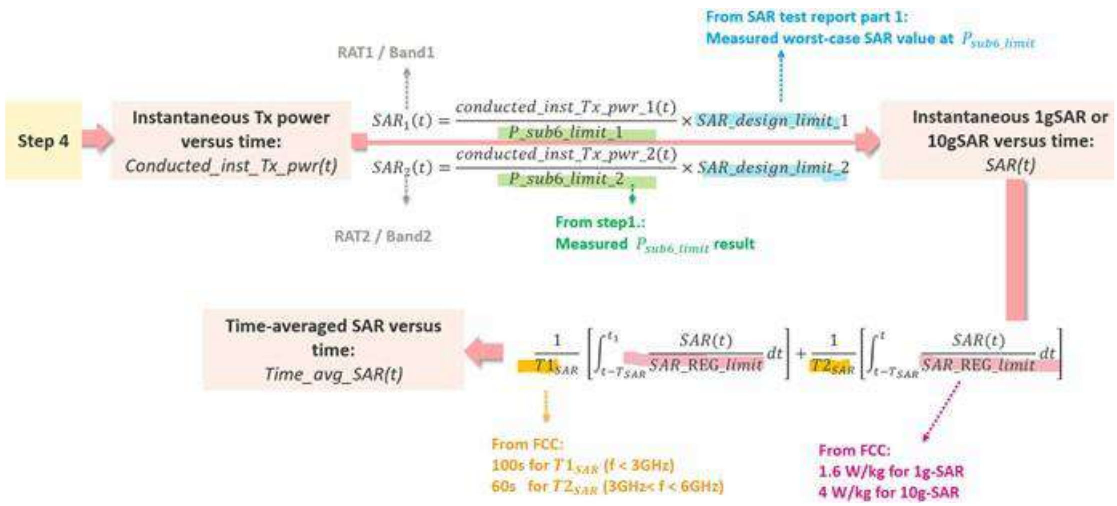
TX power is measured, recorded, and processed by the following steps:

- Step 1~4: measure and record TX power versus time for test scenario 7



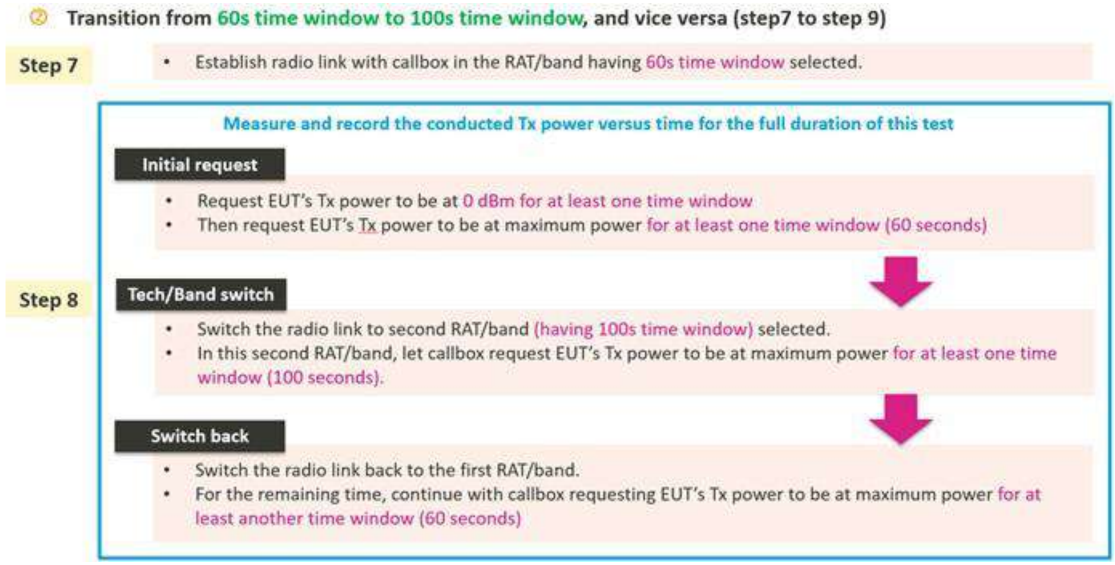
- Step 5: convert the measured conducted TX power into SAR

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,



- Step 6: plot results
  - A. Make one power perspective plot containing
    1. Instantaneous TX power
    2. Requested power
    3. Calculated time-averaged power
    4. Calculated time-averaged power limits
  - B. Make one SAR perspective plot containing
    1. Calculated time-averaged 1gSAR or 10gSAR
    2. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)
    3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0

- Step 7~8: measure and record TX power versus time in another time window change



- Step 9: convert the measurement and plot results

Convert the measured conducted TX power from step 8 into 1gSAR or 10gSAR value using the equation in step 5.

Repeat step 6 to generate the plots.

4.9 Test Configuration and Procedure for Scenario 8: SAR Exposure Switching via Conducted Power Measurements

4.9.1 Configuration

If supported, SAR exposure switch with two active radios having the same and different time averaging windows should be covered in this test. TA algorithm operation is independent of the source of SAR exposure (e.g., LTE vs. NR FR1) and ensures total time-averaged RF exposure compliance for SAR exposure among the scenarios of radio 1 only, radio 1 + radio 2, and radio 2 only.

- Select any two < 6GHz RATs/bands that the EUT supports for simultaneous transmission (e.g., LTE+NR FR1).
- The selection order among all supported simultaneous transmission configurations is
  - Select one configuration with P_{sub6_limit} values of radio1 and radio2 less than their corresponding P_{UE_max}, and their P_{sub6_limit} values are different if possible.
  - If the previous configuration does not exist, at least one radio has its P_{sub6_limit} less than P_{UE_max}.
  - If above two cannot be found, select one configuration that has P_{sub6_limit} of radio1 and radio2 with the least difference between P_{sub6_limit} and P_{UE_max} (i.e., P_{sub6_limit} can be greater than P_{UE_max}).
- One test with two active radios in any two different time windows is sufficient to cover this scenario.
- One SAR switching is sufficient because the TA algorithm operation is the same.

4.9.2 Procedure

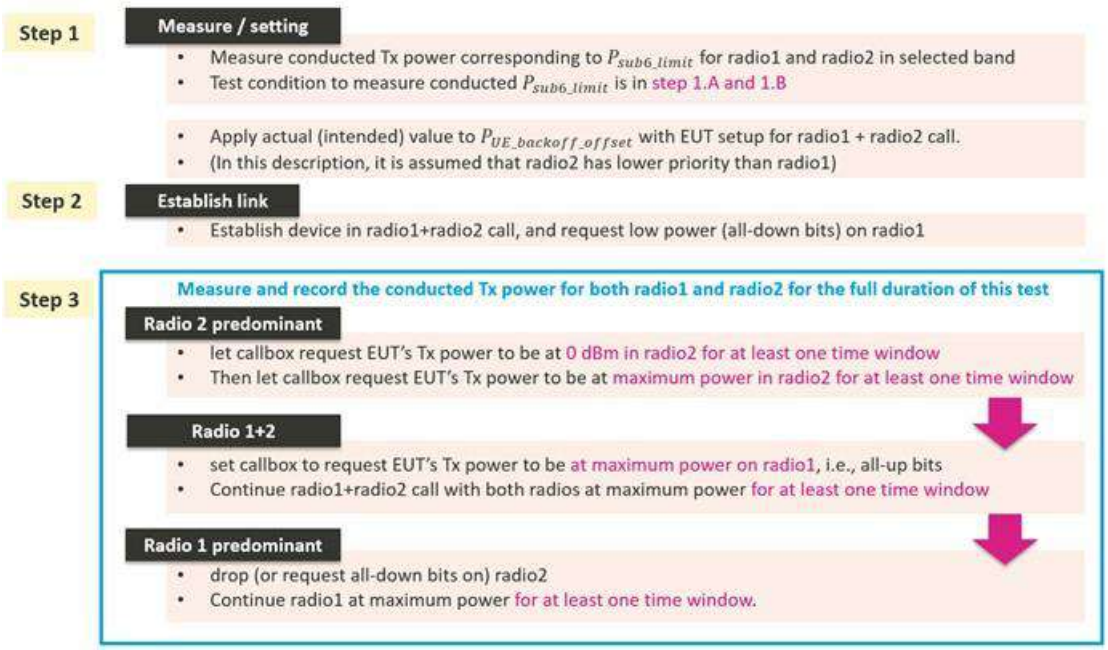
- Step 1~3: measure and record TX power versus time for test scenario 8

  A. Measure conducted TX power corresponding to radio1 P_{sub6_limit}

  - Establish device in call with the callbox for radio1 band.
  - Measure conducted TX power corresponding to radio1 P_{sub6_limit} with TA_SAR enabled and $P_{UE\_backoff\_offset}$ set to 0 dB, callbox set to request maximum power.

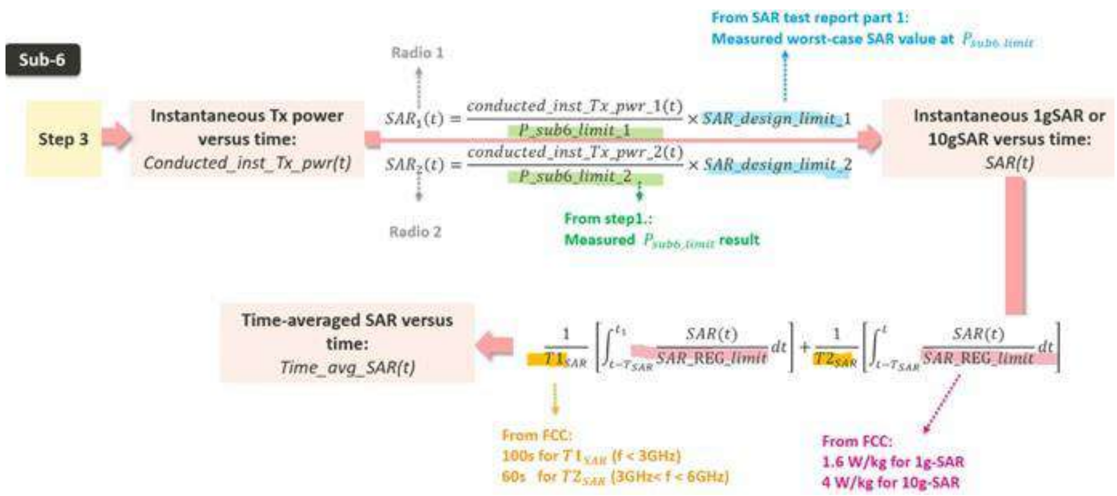
  B. measure conducted TX power corresponding to radio2 P_{sub6_limit}

  - Repeat above step to measure conducted TX power corresponding to radio2 P_{sub6_limit}.
  - If radio2 is dependent on radio1 (for example, non-standalone mode of NR FR1 requiring radio1 LTE as anchor), then establish radio1 + radio2 call with callbox, and request all down bits for radio1 LTE.
  - In this scenario, with callbox requesting maximum power from radio2 NR FR1, measured conducted TX power corresponds to radio2 P_{sub6_limit} (as radio1 LTE is at all-down bits)



- Step 4: convert the measured conducted TX power into SAR

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,



- Step 5: plot results
  - A. Make one power perspective plot containing
    1. Instantaneous TX power
    2. Requested power
    3. Calculated time-averaged power
    4. Calculated time-averaged power limits
  - B. Make one SAR perspective plot containing
    1. Calculated time-averaged 1gSAR or 10gSAR
    2. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)
    3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0

4.10 Test Configuration and Procedure for Scenario 2: Time-Varying TX Power via SAR Measurements

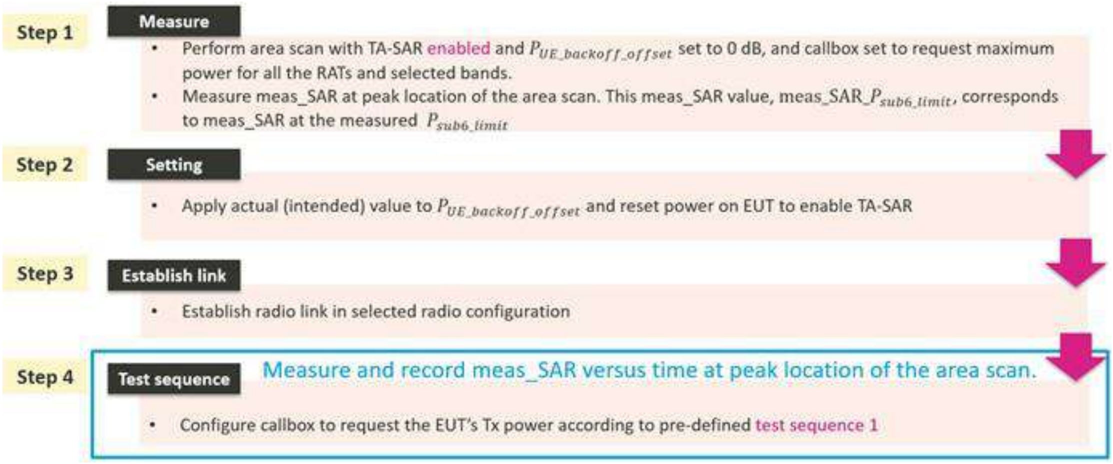
4.10.1 Configuration

Sections 4.2 to 4.9 focus on Mediatek's TA feature compliance validation via conducted TX power measurements. This section further provides a SAR measurement procedure for time-varying TX power scenario described in section 4.3. Hence, this section follows the test configuration of section 4.3, and uses test sequences 1 and 2 defined in section 4.1.

4.10.2 Procedure

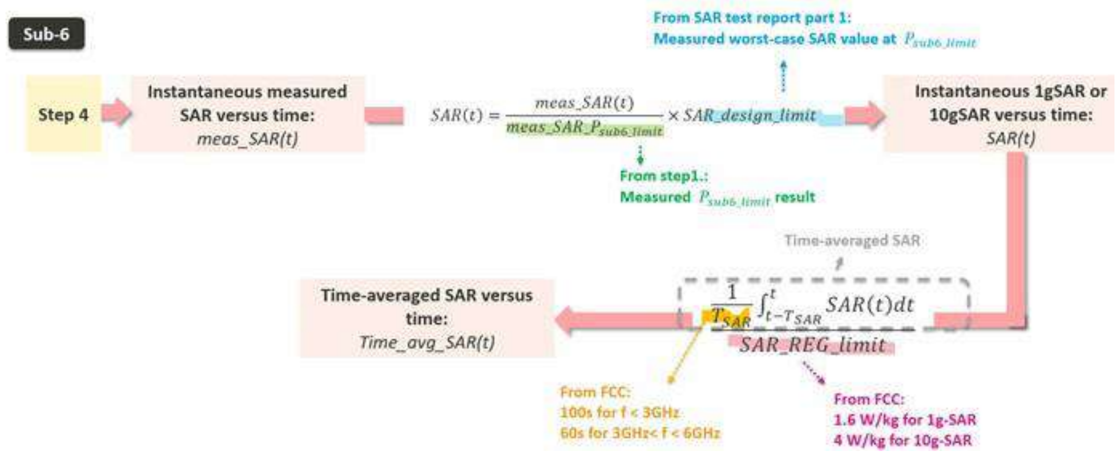
SAR is measured and recorded by the following steps:

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



- Step 5: convert the measured SAR into time-averaged SAR

Convert the instantaneous measured SAR from step 4 into 1gSAR or 10gSAR value. Perform the running time average to 1gSAR or 10g SAR to determine time-averaged value versus time as follows,



where, *meas_SAR_*P_{sub6_limit} is the value determined in step 1, and *meas_SAR(t)* is the instantaneous measured SAR measured in step 4.

- Step 6: plot result
  - A. Calculated time-averaged 1gSAR or 10gSAR
  - B. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)
- Step 7: repeat steps 2 ~ 6 for pre-defined test sequence 2

Repeat steps 2 ~ 6 for pre-defined test sequence 2 and replace test sequence 1 in step 4 with test sequence 2.

- Step 8: repeat steps 2 ~ 7 for all the selected bands

The time-averaged SAR versus time shall not exceed FCC limit at all times.

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. The details of each test procedures via radiated power and PD measurements are described in section 5.2~5.7 and section 5.8, respectively.

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) defined in section 4.1.

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

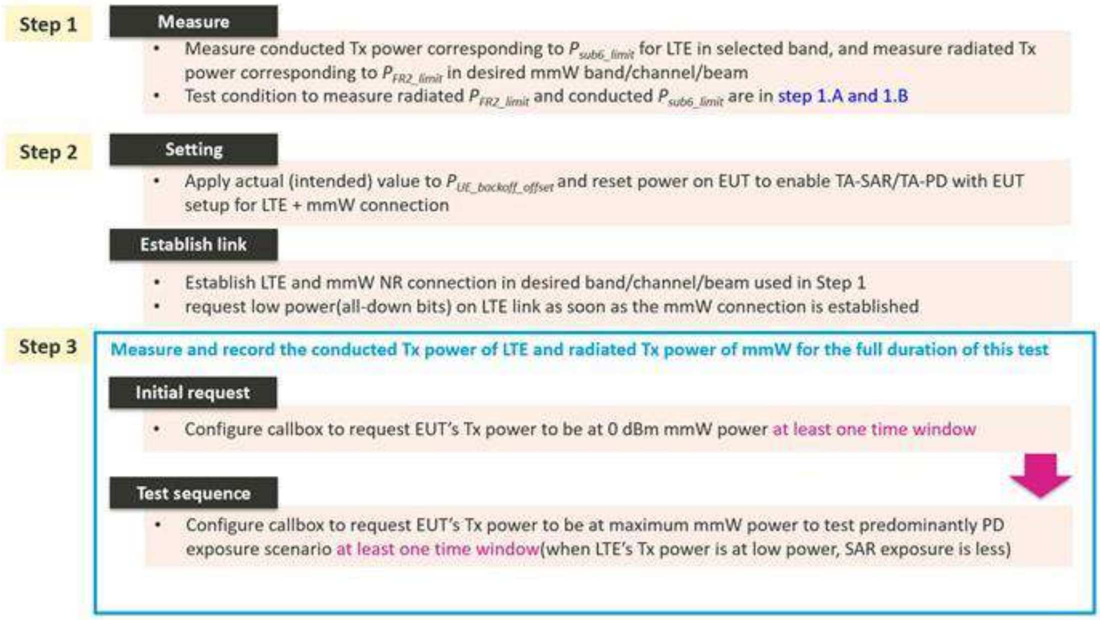
- Step 1~3: measure and record TX power versus time for test scenario 1

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

  - Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} in engineering mode
  - This test is performed in a calibrated anechoic chamber
  - 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

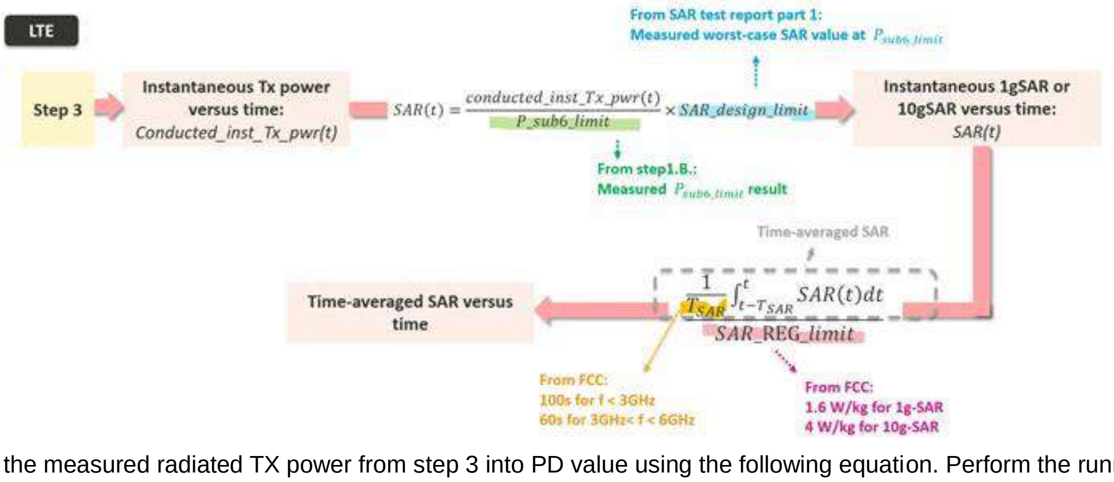
  B. Measure conducted TX power corresponding to LTE P_{sub6_limit}

  - Reset EUT to place in online mode and establish radio link in LTE
  - 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
    - When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.

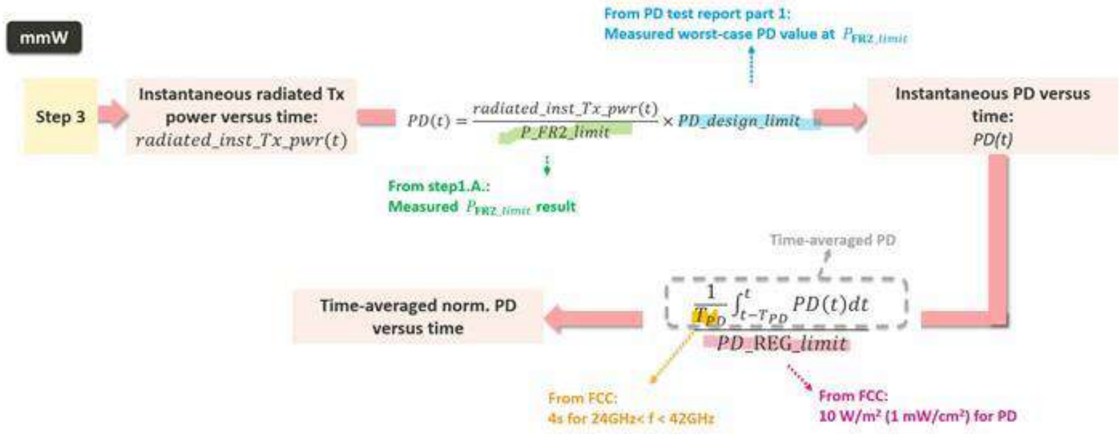


- Step 4: convert the measured conducted TX power and measured radiated TX power into SAR and PD respectively

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/m^2(PD)

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

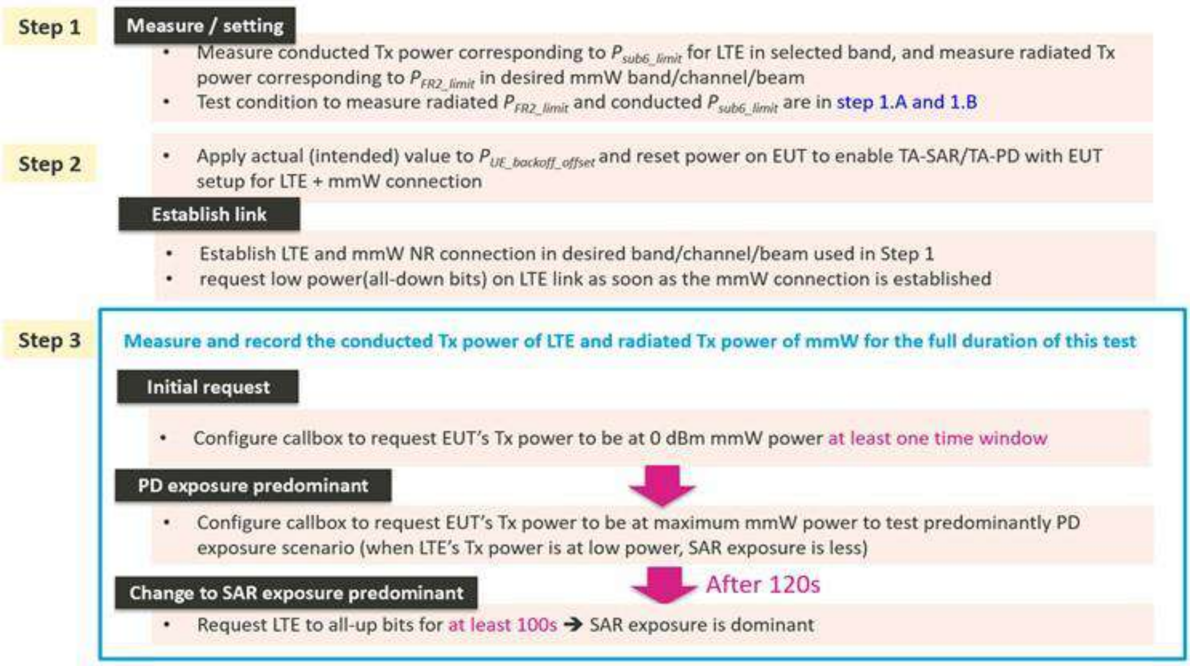
- Step 1~3: measure and record TX power versus time for test scenario 2

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

- Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} in engineering mode
- This test is performed in a calibrated anechoic chamber
- 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

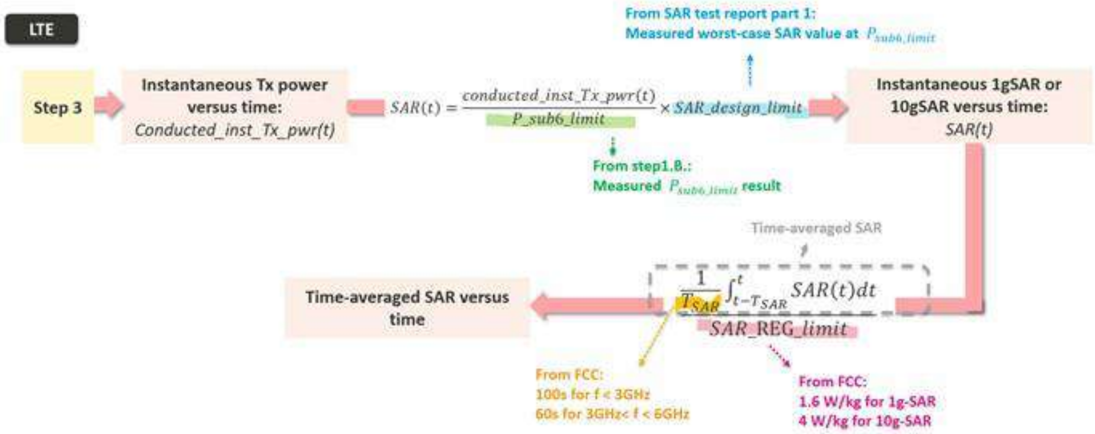
B. Measure conducted TX power corresponding to LTE P_{sub6_limit}

- Reset EUT to place in online mode and establish radio link in LTE
- 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
  - When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.

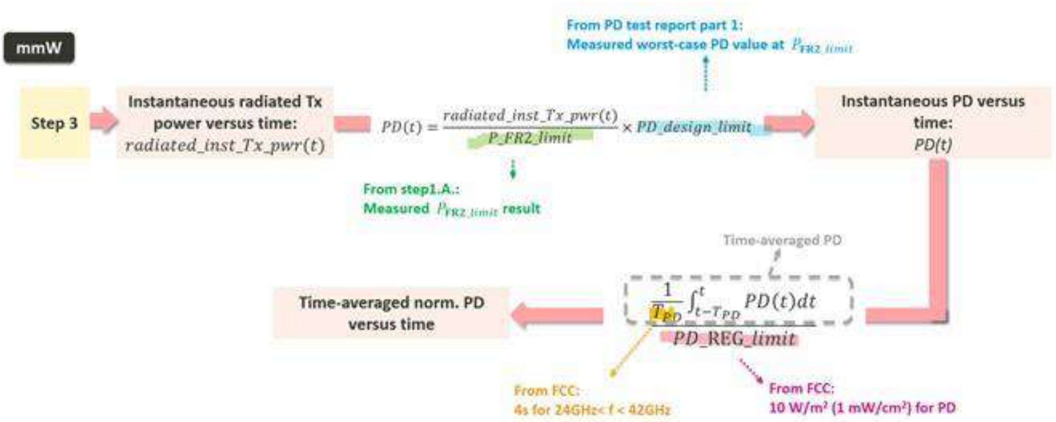


- Step 4: convert the measured conducted TX power and measured radiated TX power into SAR and PD respectively

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/m^2(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

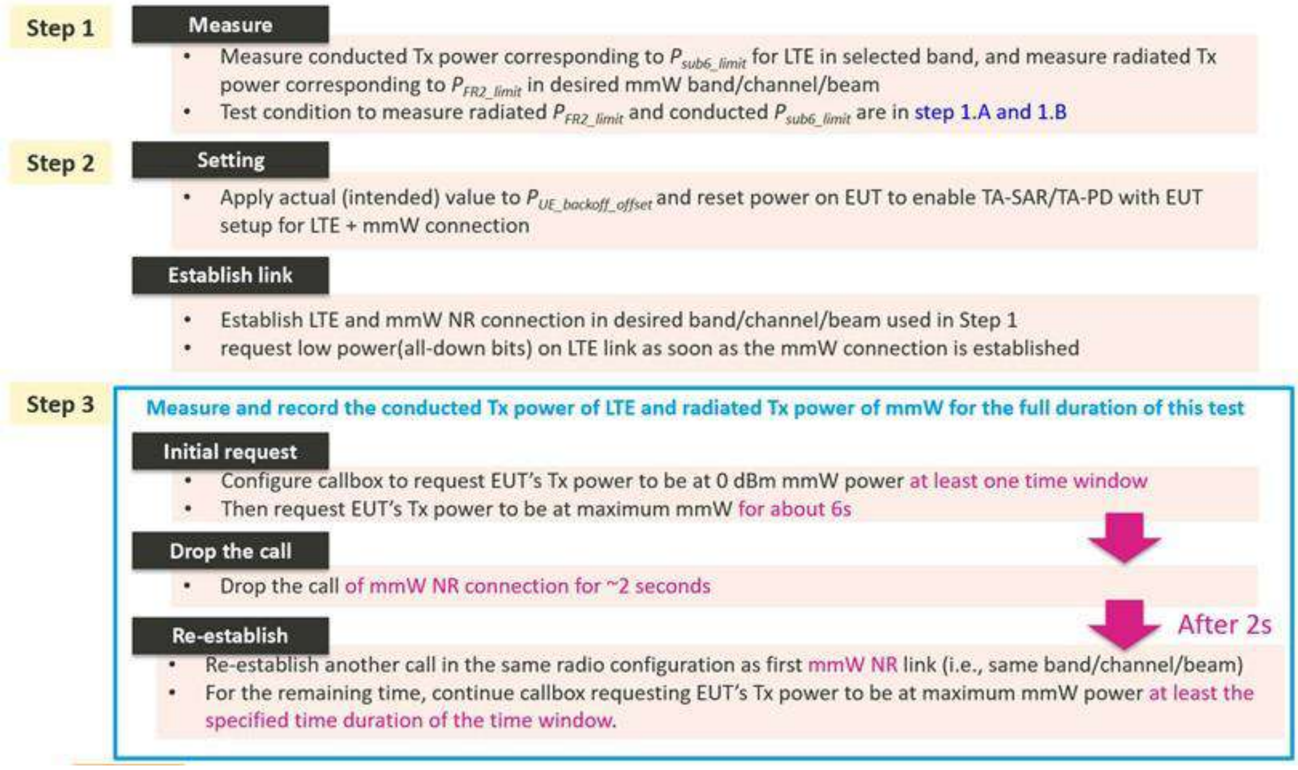
- Step 1~3: measure and record TX power versus time for test scenario 3

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

  - Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} in engineering mode
  - This test is performed in a calibrated anechoic chamber
  - 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

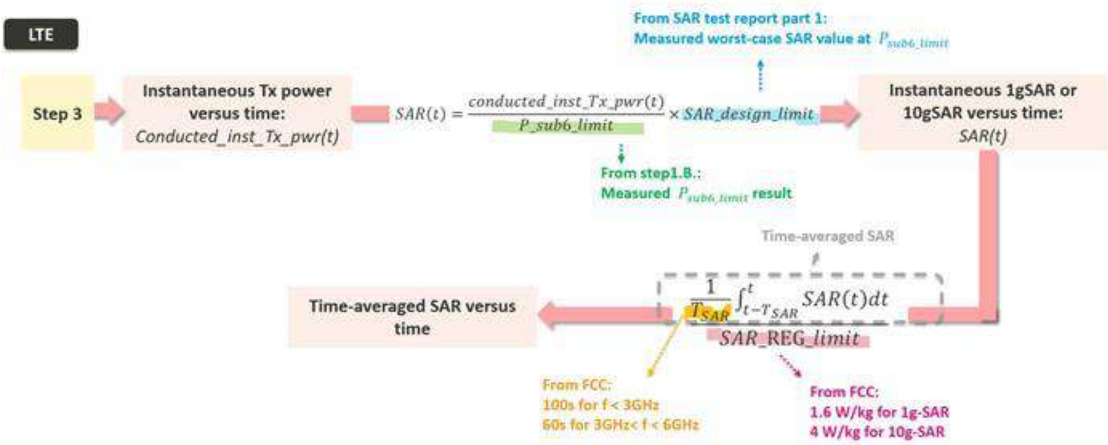
  B. Measure conducted TX power corresponding to LTE P_{sub6_limit}

  - Reset EUT to place in online mode and establish radio link in LTE
  - 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
    - When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.

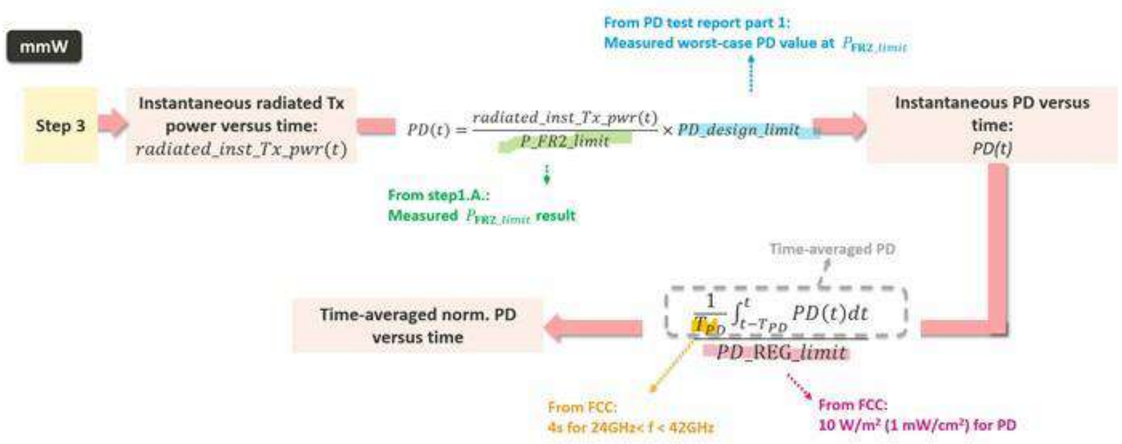


- Step 4: convert the measured conducted TX power and measured radiated TX power into SAR and PD respectively

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/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

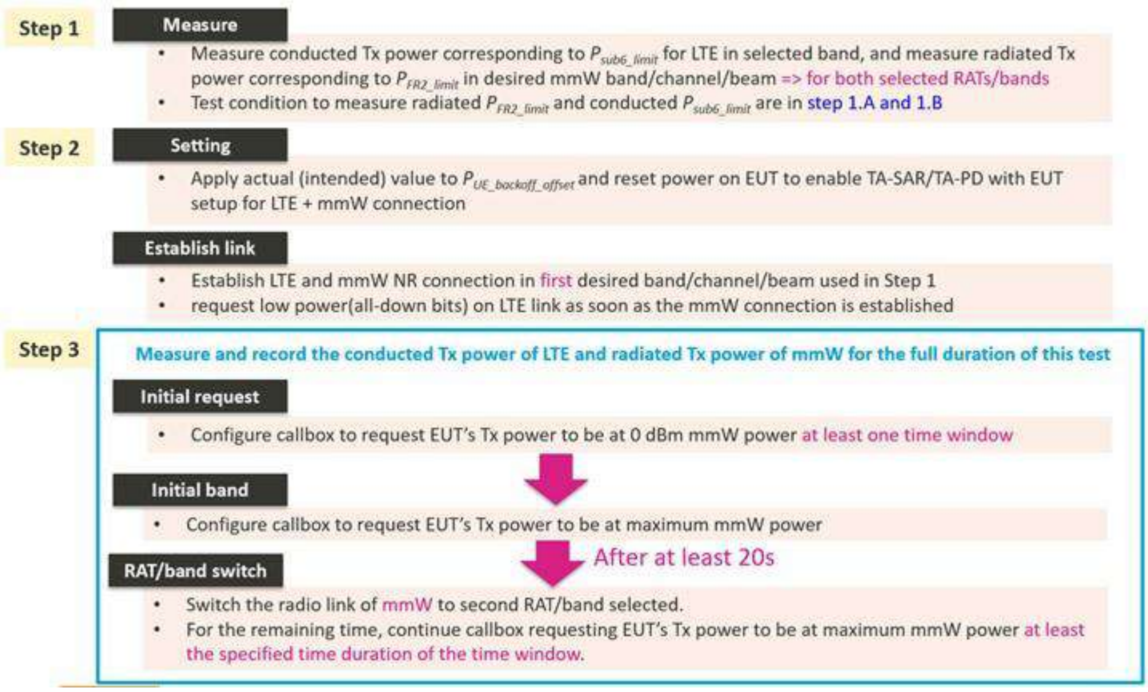
- Step 1~3: measure and record TX power versus time for test scenario 4

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

  - Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} of band1 in engineering mode
  - This test is performed in a calibrated anechoic chamber
  - Do not disturb the position of the EUT inside the anechoic chamber for the rest of this test
  - Repeat the procedure above for band2

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

  - Reset EUT to place in online mode and establish radio link in LTE
  - 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
    - When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.



- 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 P_{FR2_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

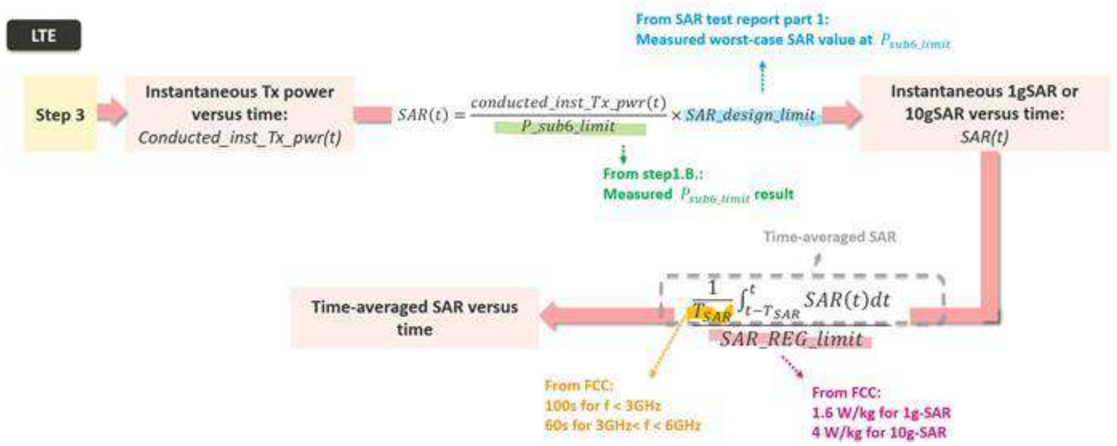
Method:

- 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

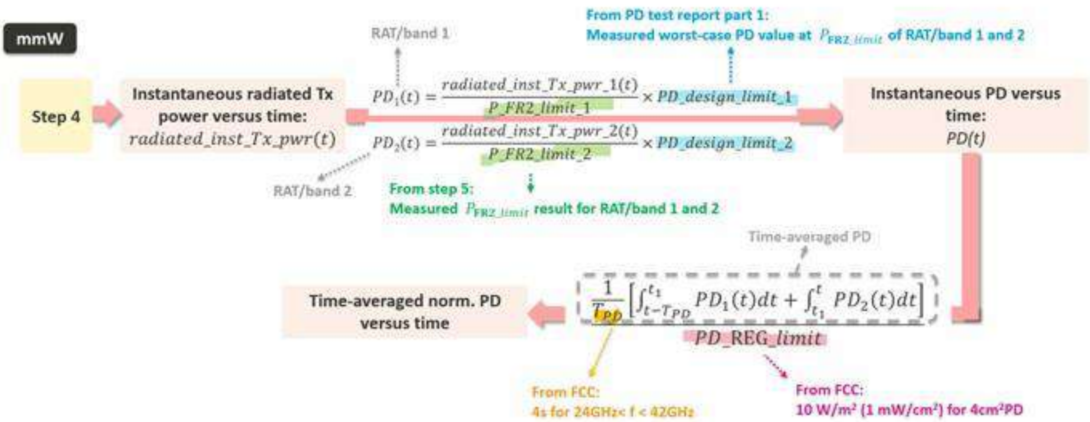
Re-scale the measured instantaneous radiated power in Step 3 by the delta in radiated power measured in Step 4 and the radiated power measured in Step1 A.

- 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 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)

5.6 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

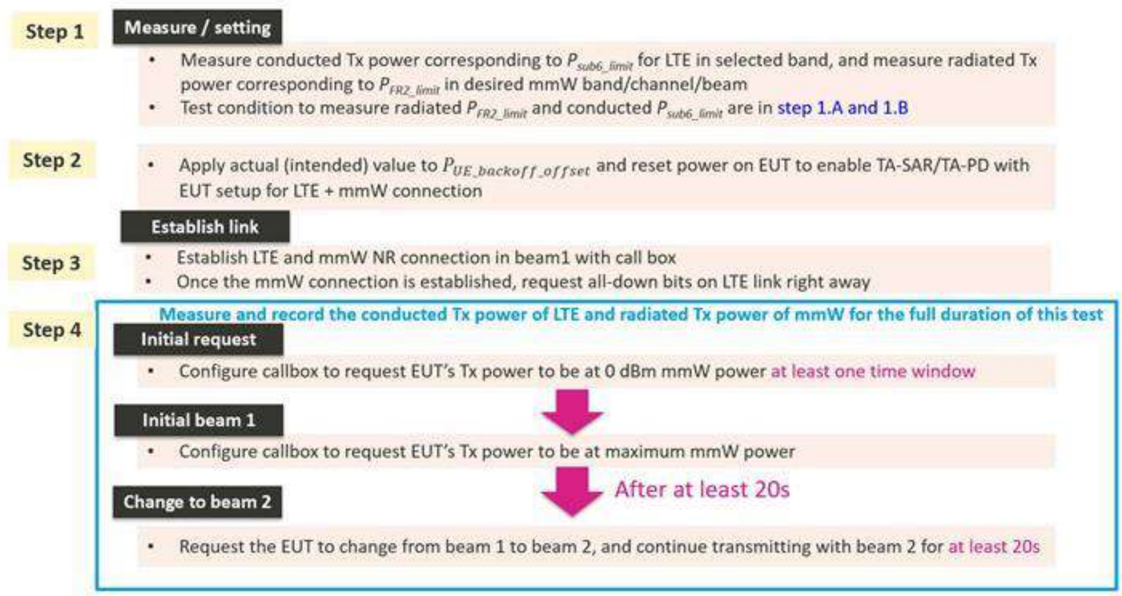
- Step 1~3: measure and record TX power versus time for test scenario 5

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

  - Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} of beam 1 in engineering mode
  - This test is performed in a calibrated anechoic chamber
  - Do not disturb the position of the EUT inside the anechoic chamber for the rest of this test
  - Repeat the procedure above for beam 2

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

  - Reset EUT to place in online mode and establish radio link in LTE
  - 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
    - 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

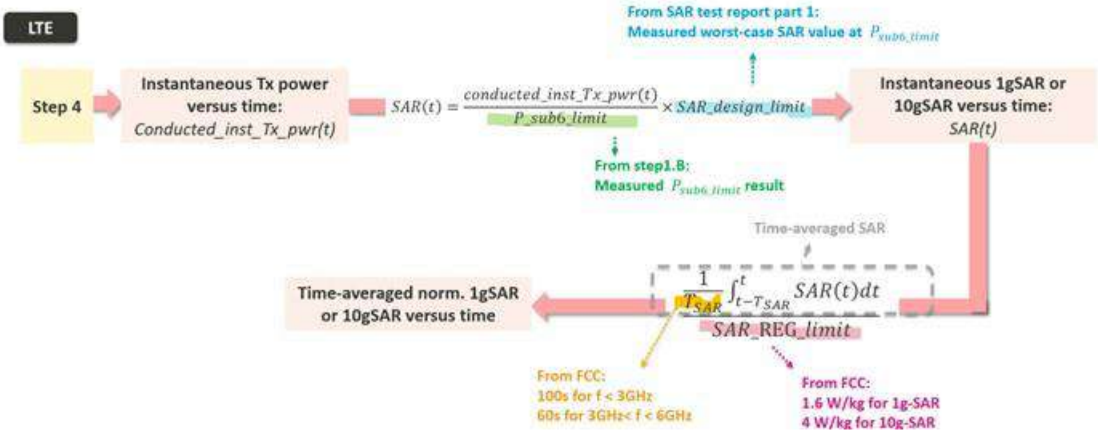
Method:

- 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

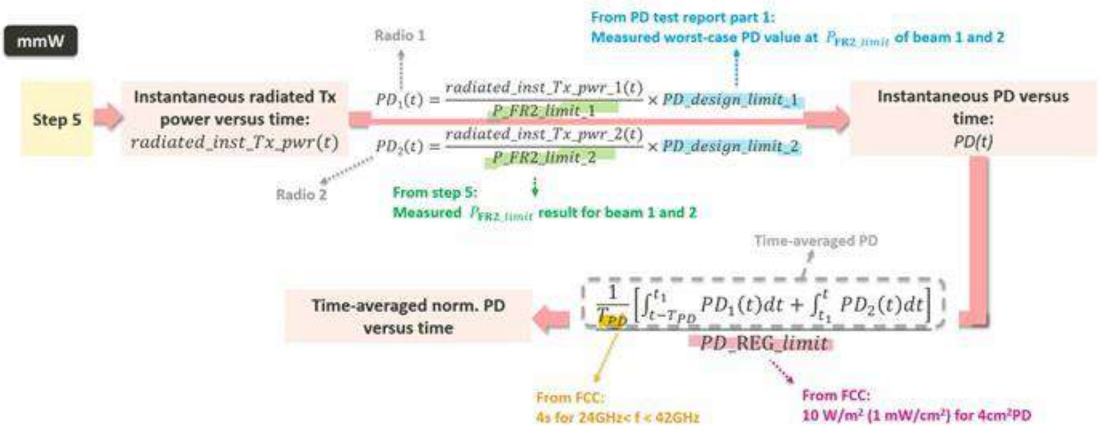
Re-scale the measured instantaneous radiated power in Step 4 by the delta in radiated power measured in Step 5 and the radiated power measured in Step1 A.

- 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/m^2(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 FR1) 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

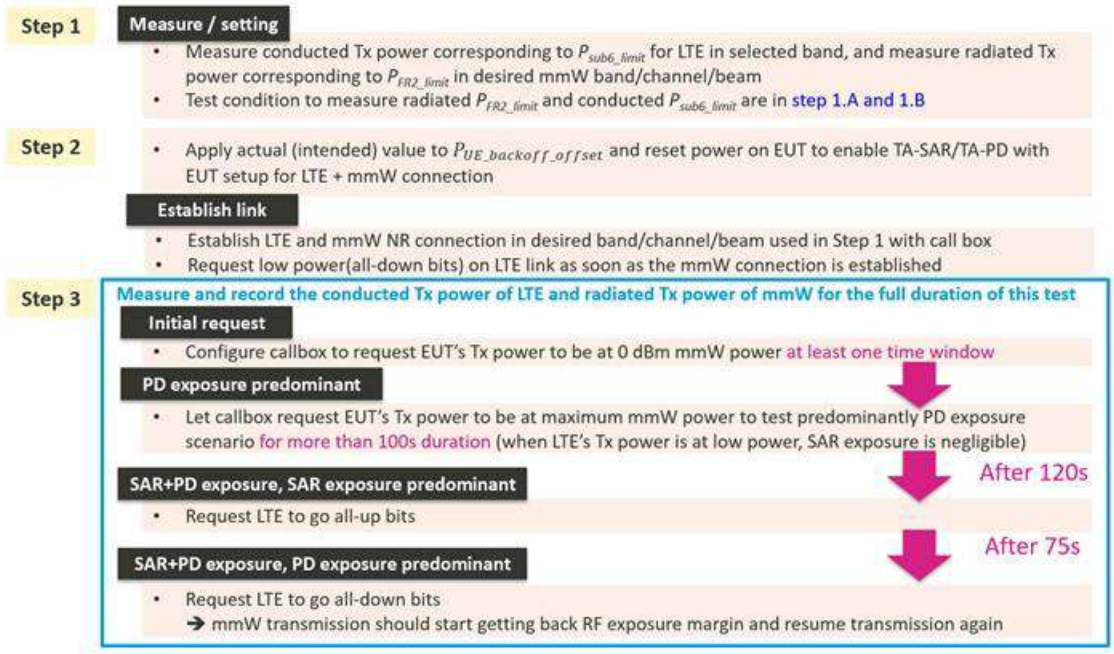
- Step 1~3: measure and record TX power versus time for test scenario 6

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

  - Setting up the EUT's TX power in desired band/channel/beam at P_{FR2_limit} in engineering mode
  - This test is performed in a calibrated anechoic chamber
  - 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

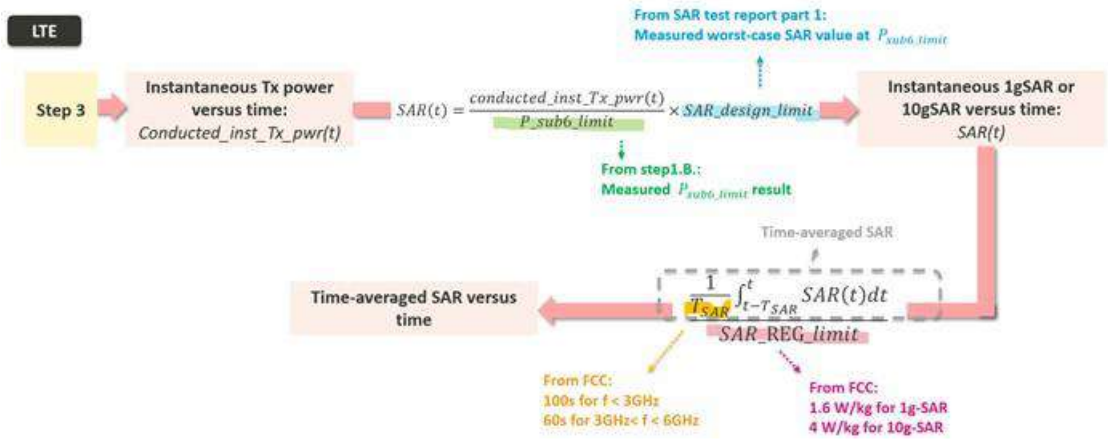
  B. Measure conducted TX power corresponding to LTE P_{sub6_limit}

  - Reset EUT to place in online mode and establish radio link in LTE
  - 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
    - When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.

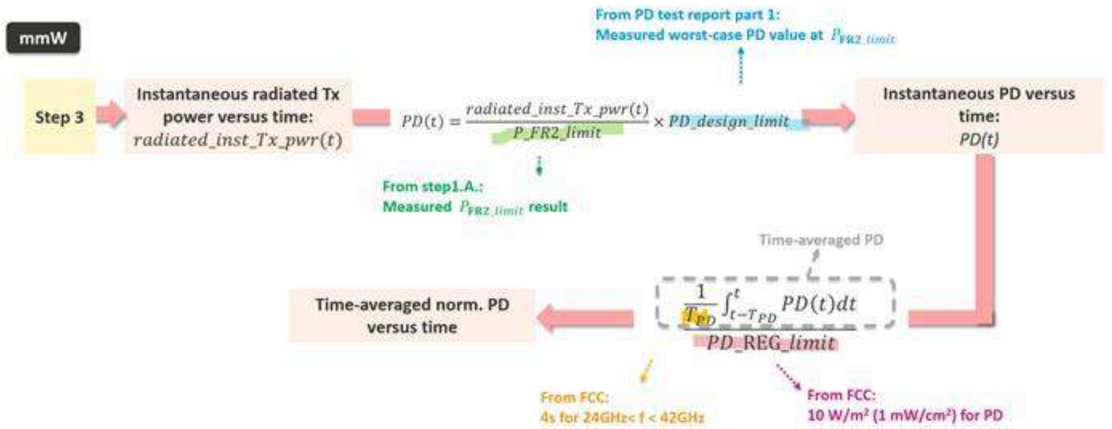


- Step 4: convert the measured conducted TX power and measured radiated TX power into SAR and PD respectively

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/m^2(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:

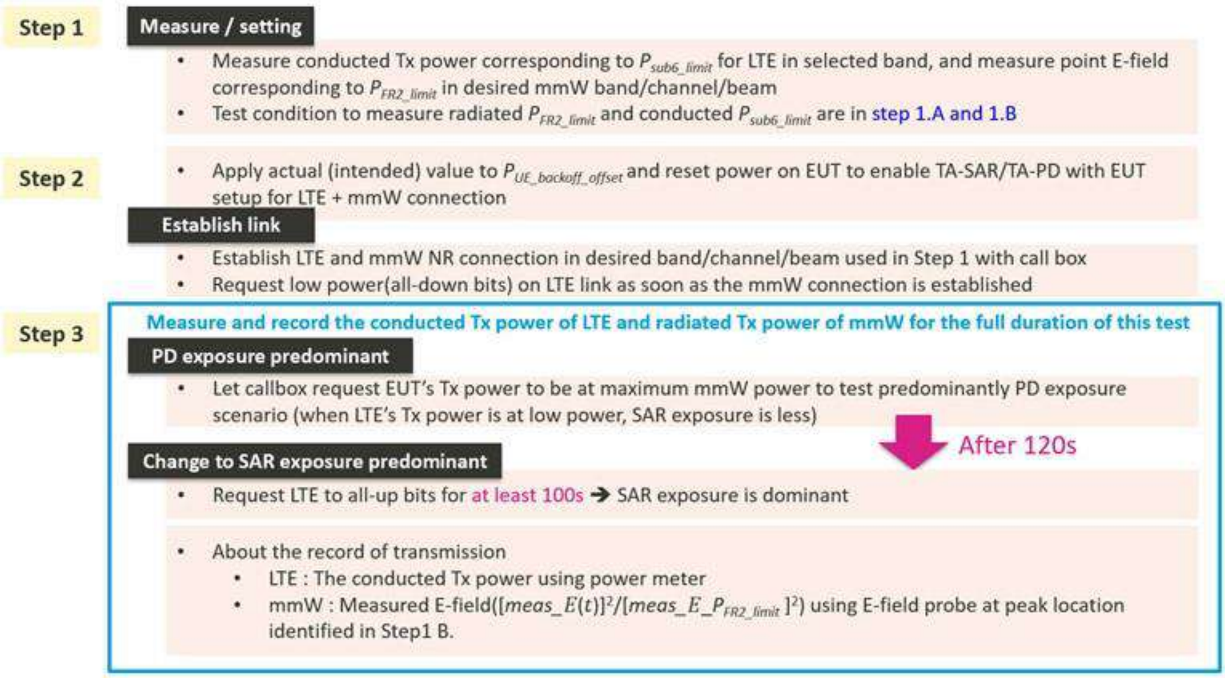
- Step 1~4: measure and record PD versus time

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

- 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
  - When the $P_{UE\_backoff\_offset}$ is set to 0 dB, the EUT transmits continuously at P_{sub6_limit} without TA-SAR.

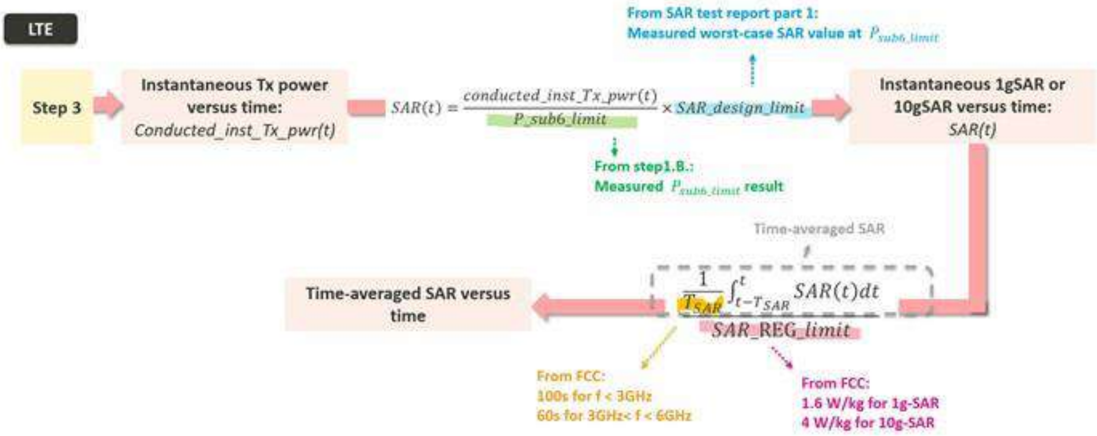
B. Measure point E-field corresponding to mmW P_{FR2_limit}

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

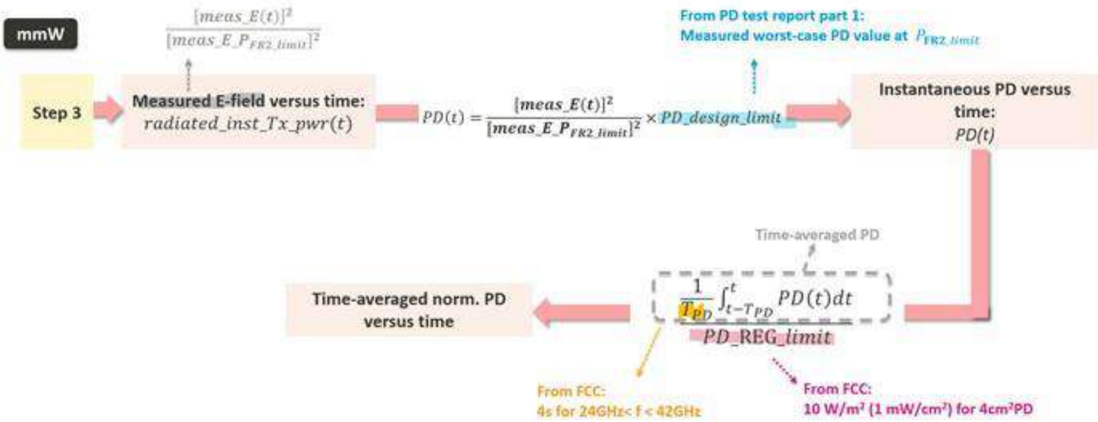


- Step 4: convert the measured conducted TX power and measured E-field into SAR and PD respectively

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/m^2(PD)

6. TA-SAR Validation via Conducted Power Measurements

6.1 Measurement Setup

6.1.1 Test Bench Introduction

The call boxes KeySight UXM (supporting sub6 NR and LTE) and Rohde & Schwarz CMW500 (supporting LTE, WCDMA, C2K and 2G) are used to validate the proposed TA-SAR mechanism. Figure 6-2 shows the block diagram of the measurement bench, which supports the following test scenarios.

- Test scenario 1: range of TA-SAR parameters
- Test scenario 2: time-varying TX power
- Test scenario 3: call disconnection and re-establishment
- Test scenario 5: ECI change

For these measurements, RF port of the call box is connected to the EUT's antenna port, and the call box establishes a connection link through the test script console tool and the power meter measures the conducted output power of the EUT.

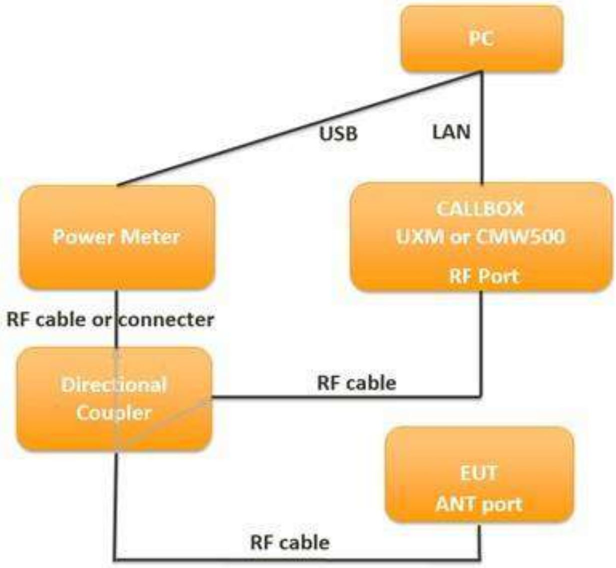


Figure 6- 1 TA-SAR conductive power test setup block diagram for scenarios 1/2/3/5

Figure 6-3 shows the block diagram of the measurement bench, which support test scenario 4 (band handover) and scenario 7 (time window switching). For these measurements, the RF port of the call box is connected with a 1-to-2 power divider, which allows the call box to transmit/receive signals from the two different system configurations set in these two test scenarios. Figure 6-4 shows the setup, which is highly similar to Figure 6-3, to support test scenario 6 (antenna switching); as seen in the figure, two EUT's antenna ports are individually connected with a RF cable.

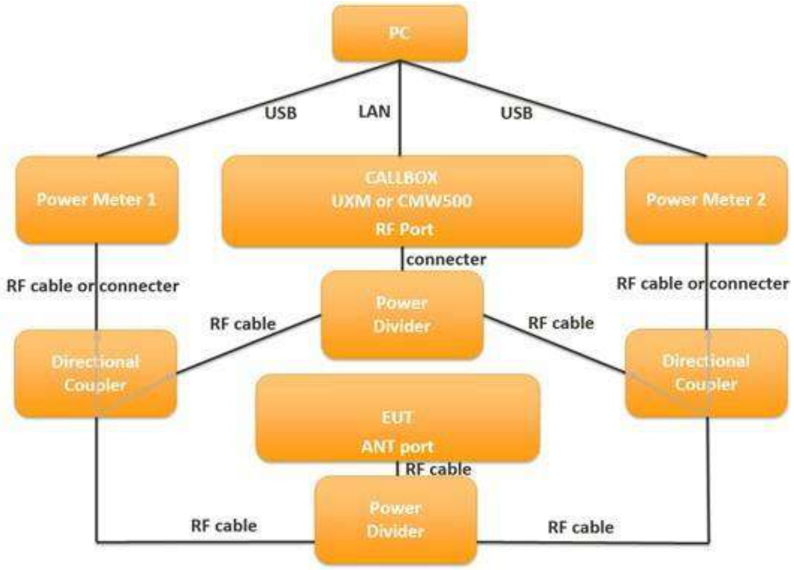


Figure 6- 2 TA-SAR conductive power test setup block diagram for scenarios 4 and 7

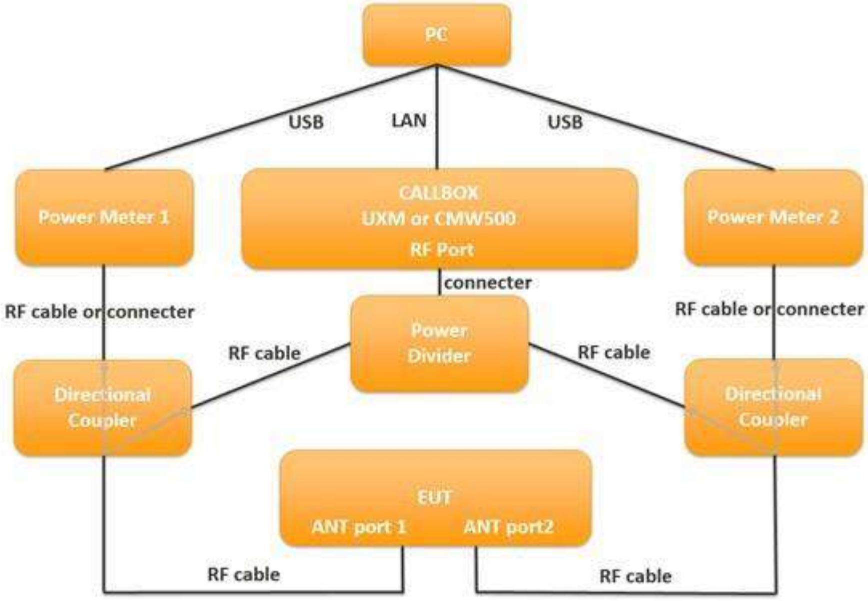


Figure 6- 3 TA-SAR conductive power test setup block diagram for scenario 6

Figure 6-5 shows the setup for test scenario 4 (RAT handover) and scenario 8 (SAR exposure switching). Since two RATs need to be controlled in these two scenarios, RF port of RAT #1 and RF port of RAT #2 of the call box are individually connected to an antenna port of the EUT through a directional coupler. It is noted that each of the two RATs individually transmit signals though one antenna port. The antenna port assignment of each RAT for these two scenarios is described in Figure 6-1.

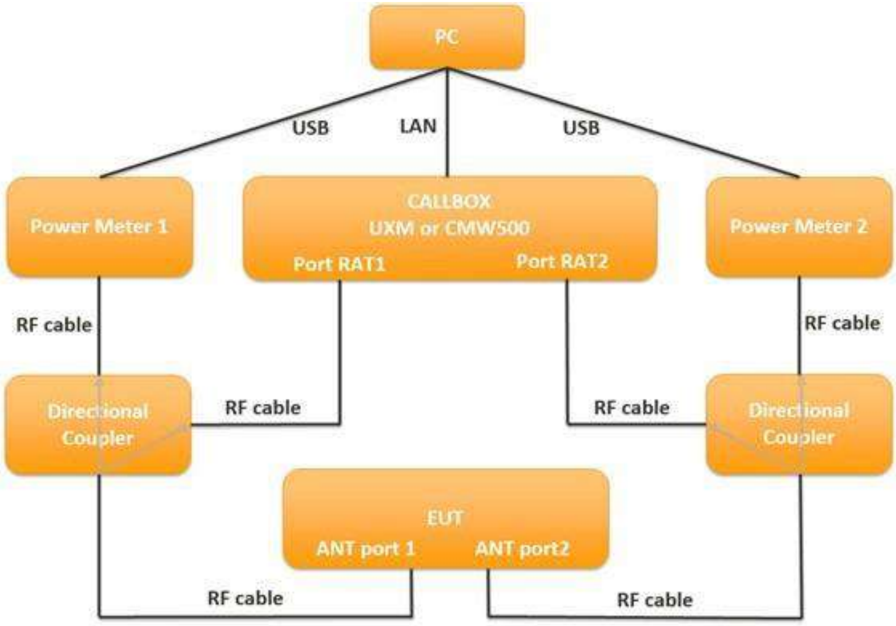


Figure 6- 4 TA-SAR conductive power test setup block diagram for scenarios 4/8

6.1.2 Sub6 NR/LTE/3G/2G Power Limit Table and Test Configurations

For the supported bands/channels/antennas of each technology, the measured power limit (P_{sub6_limit}), corresponding to *SAR_design_limit*, is listed in the table 6-1. The *SAR_design_limit* is determined by taking 1-dB device uncertainty into consideration. Please note that for TDD bands with TX duty cycles less than or equal to 100%, the measured power limit corresponds to the burst averaged power level which does not account for TX duty cycle.

Table 6-1 Summary table of power limit (P_{sub6_limit}) for all supported RAT

Band	Duty Cycle %	Antenna	Head ECI2 Standalone	Body Worn ECI3 Standalone	Body Worn & Hotspot ECI7 Simultaneous	Extremely ECI6 Standalone	Body-worn Extremity Sensor Off ECI4	P Low Thresh offset	P_{UE} Backoff offset	Pmax
GSM850 (4 Tx slots)	50%	Ant 0	31.3	25.3	25.3	29.5	28.2	3	3	26.5
GSM1900 (4 Tx slots)	50%	Ant 0	34.2	16.5	16.5	20.2	24.9	3	3	23.5
WCDMA II	100%	Ant 0	29.1	12.3	12.3	16.4	23	3	3	23
WCDMA V	100%	Ant 0	28.1	21.3	21.3	23.7	24.2	3	3	23
LTE Band 2	100%	Ant 0	34.2	15.4	14.3	19	24.5	3	3	23
LTE Band 2	100%	Ant 1	15.6	16.2	16	18.1	26.2	3	3	23
LTE Band 4	100%	Ant 0	42.1	17.5	16.3	19.5	24.7	3	3	23
LTE Band 4	100%	Ant 1	16.5	16.7	16.7	18.9	25.4	3	3	23
LTE Band 5	100%	Ant 0	29.4	26.5	26.5	23	23	3	3	23
LTE Band 5	100%	Ant 1	20.9	22.6	22.2	23	31.6	3	3	23
LTE Band 7	100%	Ant 0	40.4	20.9	16.7	23.9	24.4	3	3	23
LTE Band 12	100%	Ant 0	29.1	27.3	27.3	23	23	3	3	23
LTE Band 12	100%	Ant 1	22.3	24.5	24.5	23	23	3	3	23
LTE Band 13	100%	Ant 0	30.5	24.9	24.9	23	23	3	3	23
LTE Band 13	100%	Ant 1	23	25.2	25.2	23	23	3	3	23
LTE Band 66	100%	Ant 0	42.1	17.5	16.3	19.5	24.7	3	3	23
LTE Band 66	100%	Ant 1	16.5	16.7	16.7	18.9	25.4	3	3	23
LTE Band 48	63.3%	Ant 3	16.9	15.7	15.7	18	23.5	3	3	21.0
LTE Band 48	63.3%	Ant 4	22.4	15.4	15.4	18	22.2	3	3	21.0
LTE Band 48	63.3%	Ant 5	36.4	18.4	18.4	20.7	22.0	3	3	20.3
LTE Band 48	63.3%	Ant 8	32.3	9.2	9.2	15.2	21.8	3	3	20.1
5G NR n2	100%	Ant 0	33.3	16.5	15.1	20.4	25.2	3	3	23
5G NR n2	100%	Ant 1	16.1	16.9	16.5	19.4	27.2	3	3	23
5G NR n5	100%	Ant 0	30.4	23.9	23.9	23	23	3	3	23
5G NR n5	100%	Ant 1	20.7	22.5	22.5	23	30.6	3	3	23
5G NR n66	100%	Ant 0	33.9	19.3	15.3	19.8	24.7	3	3	23.5
5G NR n66	100%	Ant 1	15.8	17.1	15.7	18.3	25.9	3	3	23
5G NR n48	100%	Ant 3	18.9	17.7	17.7	22.4	26.8	3	3	23
5G NR n48	100%	Ant 4	22.8	16.7	16.7	19.8	23.4	3	3	22.4
5G NR n48	100%	Ant 5	30.2	19.5	19.5	20.9	26.3	3	3	23
5G NR n48	100%	Ant 8	39.4	10.3	10.3	17	23.5	3	3	21.6
5G NR n77 PC3	100%	Ant 3	17.3	17.1	17.1	20	26.7	3	3	23
5G NR n77 PC3	100%	Ant 4	20.2	15.4	15.4	17.8	22.5	3	3	23
5G NR n77 PC3	100%	Ant 5	34.3	18.4	18.4	20.4	27.6	3	3	23
5G NR n77 PC3	100%	Ant 8	32.7	11.4	11.4	16.3	25.8	3	3	21.5
5G NR n77 PC2	100%	Ant 3	17.3	17.1	17.1	20	26.7	3	3	26
5G NR n77 PC2	100%	Ant 4	20.2	15.4	15.4	17.8	22.5	3	3	25.5
5G NR n77 PC2	100%	Ant 5	34.3	18.4	18.4	20.4	27.6	3	3	26
5G NR n77 PC2	100%	Ant 8	32.7	11.4	11.4	16.3	25.8	3	3	22.5
5G NR n78	100%	Ant 3	17.3	17.1	17.1	20	26.7	3	3	23
5G NR n78	100%	Ant 4	20.2	15.4	15.4	17.8	22.5	3	3	22.7
5G NR n78	100%	Ant 5	24	18.4	18.4	20.4	27.6	3	3	23
5G NR n78	100%	Ant 8	22.4	11.4	11.4	16.3	25.8	3	3	21.4

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 2-1.

Table 2-1 TA-SAR operating parameters

Operating parameters	Description
P_{sub6_limit}	The time-averaged maximum power level limit for different bands for 2G, 3G, LTE, and NR FR1.
$P_{LowThresh\_offset}$	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. $P_{UE\_max\_cust} = \min(P_{UE\_max}, P_{sub6\_limit} + P_{UE\_max\_cust\_offset})$

Table for Sub-6GHz TA-SAR validation test case list

Test Case #	Test Scenario	Test Configuration
1	1,Range of TA-SAR-parameters	WCDMA II
2	2.Time-varting TX power	GSM850
3		GSM1900
4		WCDMA II
5		WCDMA V
6		LTE Band 48
7		LTE Band 5
8		FR1 n48
9		FR1 n5
10	3.Call disconnection and re-establishment	LTE Band 48
11	4. Band handover / 6. Antenna Switch	LTE Band 48 Ant8 to WCDMA II Ant 0
12	5. ECI(Exposure Condition Index)	LTE Band 48 ECI 3 to ECI 6
13	7.Time window switching 60s-100s-60s	LTE B2 to LTE B48
14	7.Time window switching 100s-60s-100s	LTE B48 to LTE B2
15	8.SAR exposure switching	LTE B2 to FR1 n66

Table 6-2 summarizes the test configurations of all RATs, and the corresponding worst-case measured SAR for each RAT under the power limit.

Table 6-2 Test configurations of radio technologies and worst-case measured SAR

Test Case #	Test Scenario	Test band	BW (MHz)	Modulation	RB size	RB offset	mode	Test Position	Gap (mm)	Antenna	ECI	Channel	Freq (MHz)	Part 1, SAR@Plimit 1-g SAR (W/kg)	Part 1, SAR@Plimit 10-g SAR (W/kg)
1	1. Range of TA-SAR-parameters	LTE Band 2	20M	QPSK	1	0	-	Back	5mm	Ant 0	3	19100	1900	0.884	
2	2. Time-varting TX power	GSM850	-	-	-	-	GPRS (4 Tx slots)	Back	5mm	Ant 0	3	251	848.8	0.865	
3		GSM1900	-	-	-	-	GPRS (4 Tx slots)	Back	5mm	Ant 0	3	810	1909.8	0.87	
4		WCDMA II	-	-	-	-	RMC 12.2Kbps	Back	5mm	Ant 0	3	9538	1907.6	0.891	
5		WCDMA V	-	-	-	-	RMC 12.2Kbps	Back	5mm	Ant 0	3	4182	836.4	0.987	
6		LTE Band 48	20M	QPSK	1	0	-	Back	5mm	Ant 8	3	55830	3609	0.796	
7		LTE Band 5	10M	QPSK	1	0	-	Back	5mm	Ant 1	3	20525	836.5	0.799	
8		FR1 n48	40M	QPSK,DFT-30	50	28	-	Back	5mm	Ant 8	3	641666	3624.99	0.752	
9		FR1 n5	20M	QPSK,DFT-15	1	1	-	Back	5mm	Ant 1	3	167300	836.5	0.853	
10	3. Call disconnection and re-establishment	FR1 n48	40M	QPSK,DFT-30	50	28	-	Back	5mm	Ant 8	3	641666	3624.99	0.752	
11	4. Band handover / 6. Antenna Switch	LTE Band 48	20M	QPSK	1	0	-	Back	5mm	Ant 8	3	55830	3609	0.796	
		WCDMA II	-	-	-	-	RMC 12.2Kbps	Back	5mm	Ant 0	3	9538	1907.6	0.891	
12	5. ECI(Exposure Condition In dex)	LTE Band 48	20M	QPSK	1	0	-	Back	5mm	Ant 8	3	55830	3609	0.796	
		LTE Band 48	20M	QPSK	1	0	-	Back	0mm	Ant 8	6	55340	3560		1.67
13	7. Time window switching 60s-100s-60s	LTE Band 2	20M	QPSK	1	0	-	Back	5mm	Ant 0	3	19100	1900	0.884	
		LTE Band 48	20M	QPSK	1	0	-	Back	5mm	Ant 8	3	55830	3609	0.796	
14	7. Time window switching 100s-60s-100s	LTE Band 48	20M	QPSK	1	0	-	Back	5mm	Ant 8	3	55830	3609	0.796	
		LTE Band 2	20M	QPSK	1	0	-	Back	5mm	Ant 0	3	19100	1900	0.884	
15	8. SAR exposure switching	LTE Band 2	20M	QPSK	1	0	-	Back	5mm	Ant 0	3	19100	1900	0.884	
		FR1 n66	40M	QPSK,DFT-15	1	1	-	Back	5mm	Ant 1	3	349000	1745	0.993	

Table 6-3 Test configurations of radio technologies and worst-case measured Plimit and Pmax

Test case	RAT	Test band	Test seq.	ECI	Pmax Setting (dBm)	Measurement Pmax (dBm)	Plimit setting (dBm)	Measurement Plimit (dBm)	PEU_backoff (dBm)	PEU_max_cust (dBm)	Pass /Fail SAR limit
1	1. Range of TA-SAR-parameters	LTE Band 2	0	3	23.00	22.12	15.40	15.78	3	3	Pass
2	2. Time-varting TX power	GSM850	1	3	26.49	25.55	25.30	24.80	3	3	Pass
3		GSM1900	2	3	23.49	22.52	16.50	16.18	3	3	Pass
4		WCDMA II	1	3	23.00	23.14	12.30	11.35	3	3	Pass
5		WCDMA V	2	3	23.00	23.60	21.30	20.66	3	3	Pass
6		LTE Band 48	1	3	20.10	20.85	9.20	9.19	3	3	Pass
7		LTE Band 5	2	3	23.00	22.72	22.60	22.20	3	3	Pass
8		FR1 n48	1	3	21.60	21.90	10.30	10.70	3	3	Pass
9		FR1 n5	2	3	23.00	24.00	22.50	22.40	3	3	Pass
10	3. Call disconnection and re-establishment	FR1 n48	1	3	21.60	21.90	10.30	10.70	3	3	Pass
11	4. Band handover / 6. Antenna Switch	LTE Band 48	0	3	20.10	20.85	9.20	9.19	3	3	Pass
		WCDMA II	0	3	23.00	23.14	12.30	11.35	3	3	Pass
12	5. ECI(Exposure Condition In dex)	LTE Band 48	0	3	20.10	20.85	9.20	9.19	3	3	Pass
		LTE Band 48	0	6	20.10	20.85	9.20	9.19	3	3	Pass
13	7. Time window switching 60s-100s-60s	LTE Band 2	0	3	23.00	22.12	15.40	15.78	3	3	Pass
		LTE Band 48	0	3	20.10	20.85	9.20	9.19	3	3	Pass
14	7. Time window switching 100s-60s-100s	LTE Band 48	0	3	20.10	20.85	9.20	9.19	3	3	Pass
		LTE Band 2	0	3	23.00	22.12	15.40	15.78	3	3	Pass
15	8. SAR exposure switching	LTE Band 2	0	3	23.00	22.12	15.40	15.78	3	3	Pass
		FR1 n66	0	3	23.00	23.10	17.10	18.10	3	3	Pass

6.2 Conducted Power Measurement Results for Scenario1: Range of TA-SAR Parameters

In this scenario, two TA-SAR parameters are swept to validate Mediatek's TA-SAR algorithm. The parameter sets are summarized in Table 6-3, and the test procedure follows section 4.2.2. The measurement setup is shown in Figure 6-2. The high-level summary of the final validation results are also listed in the last column of the table, which concludes that Mediatek's TA-SAR algorithm can maintain the time-averaged SAR is always below the FCC requirement for all test cases. The following section will demonstrate case-by-case to show how Mediatek's TA-SAR algorithm behaves for different parameters.

- **Case1: LTE B2 result for Range of TA-SAR**

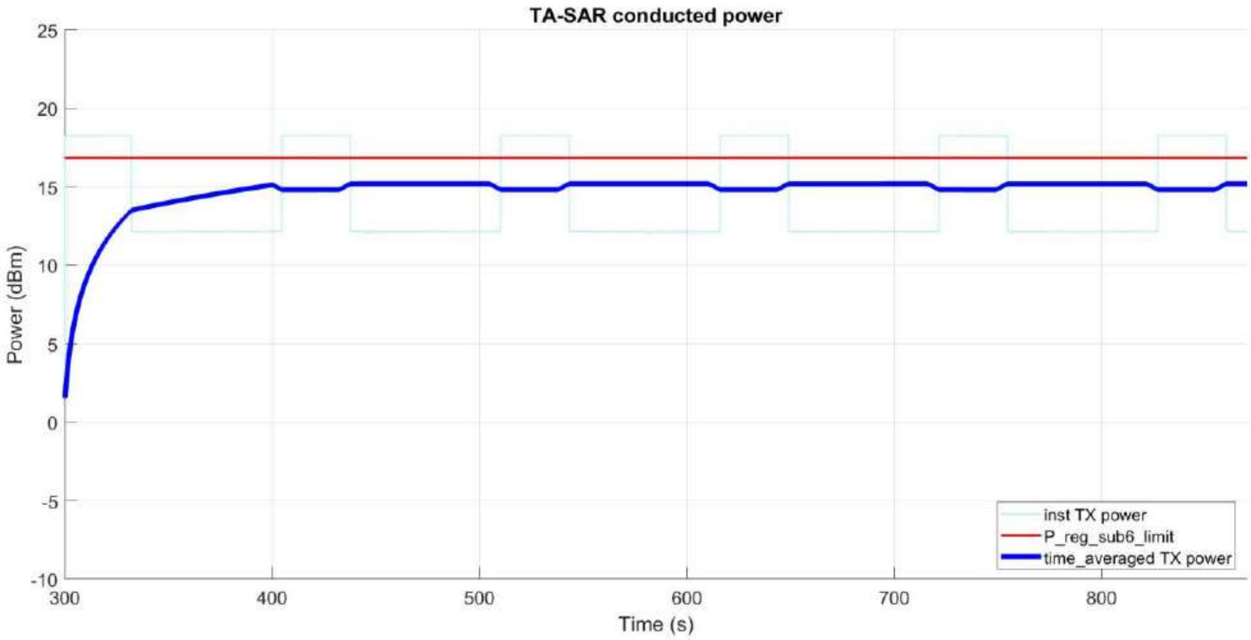


Figure 6- 5 Time-averaged conducted TX power over time

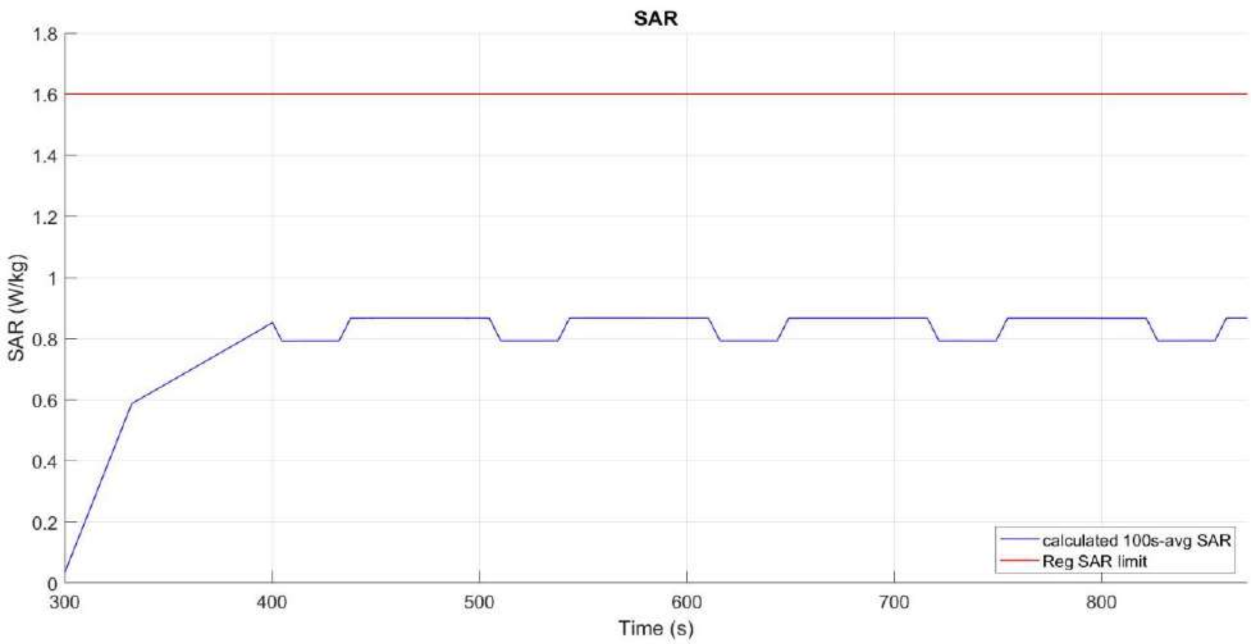


Figure 6- 6 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.866 W/kg
Validation result: pass	

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

In this scenario, Mediatek's TA-SAR algorithm is tested under more dynamic power test sequences. The test sequence #1 is shown in section 4.1 and test sequence #2 is tabulated in table 4.4. All of the test cases for this scenario are relegated in Table 6-3, and the test procedure follows section 4.3.2. The measurement setup is shown in Figure 6-2. The high-level summary of the final validation results are also listed in the last column of the table, which concludes that Mediatek's TA-SAR algorithm can maintain the time-averaged SAR is always below the FCC requirement for all test cases. The following sections will demonstrate case-by-case to show how Mediatek's TA-SAR algorithm behaves for each RAT.

6.3.1 Measurement results for 2G

The corresponding detailed test procedure is described in 4.3.2. For the figure set of each case, the first figure demonstrates the EUT's instantaneous conducted TX power, the time-averaged conducted TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty). The second figure illustrates the corresponding time-averaged SAR over time converted from the TX time-averaged power by using the equation listed in section 4.3.2.

- **Case2-1: GSM850 result for test sequence 1**

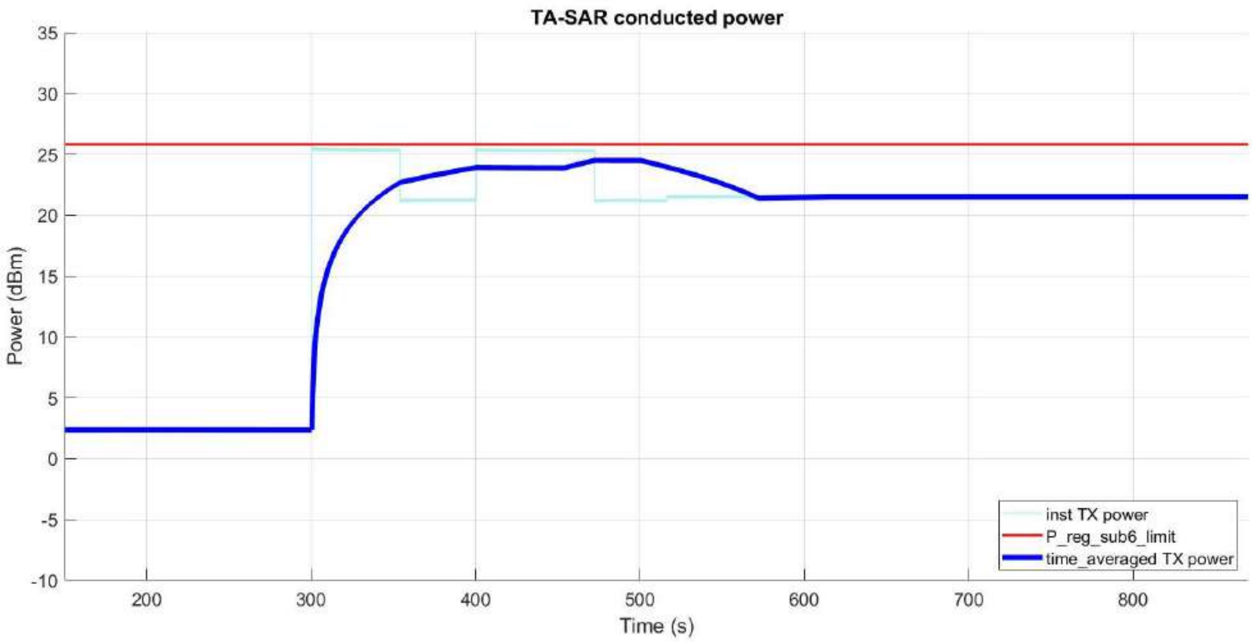


Figure 6- 7 Time-averaged conducted TX power over time

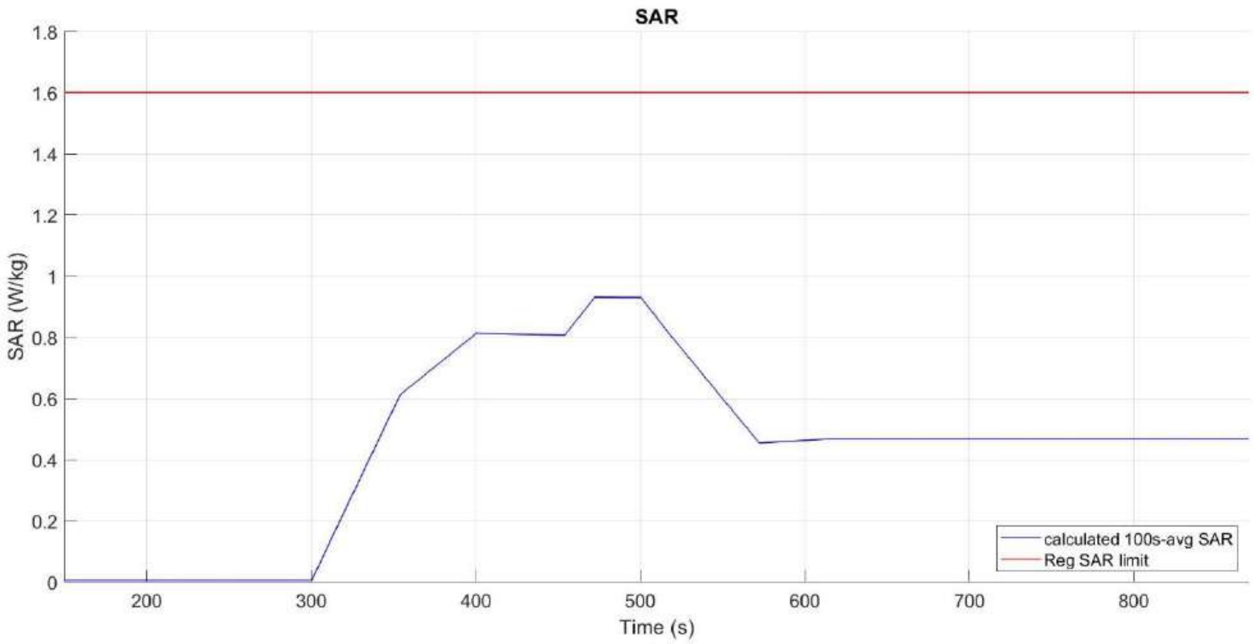


Figure 6- 8 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.931 W/kg
Validation result: pass	

- **Case2-2: GSM850 result for test sequence 2**

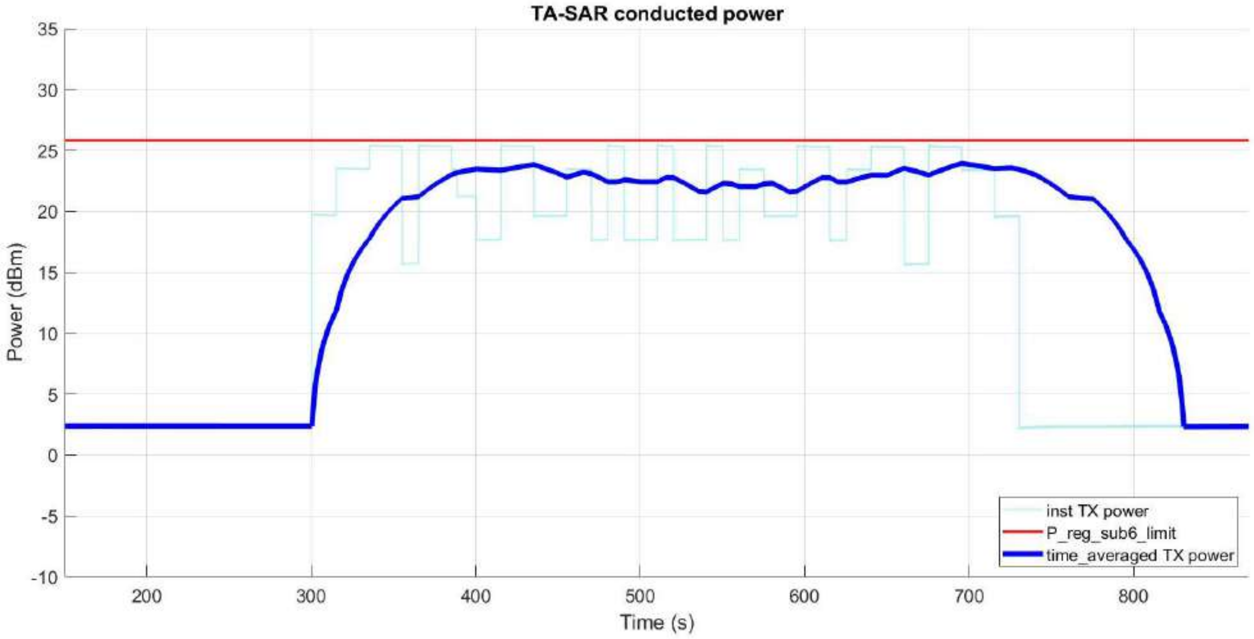


Figure 6- 9 Time-averaged conducted TX power over time

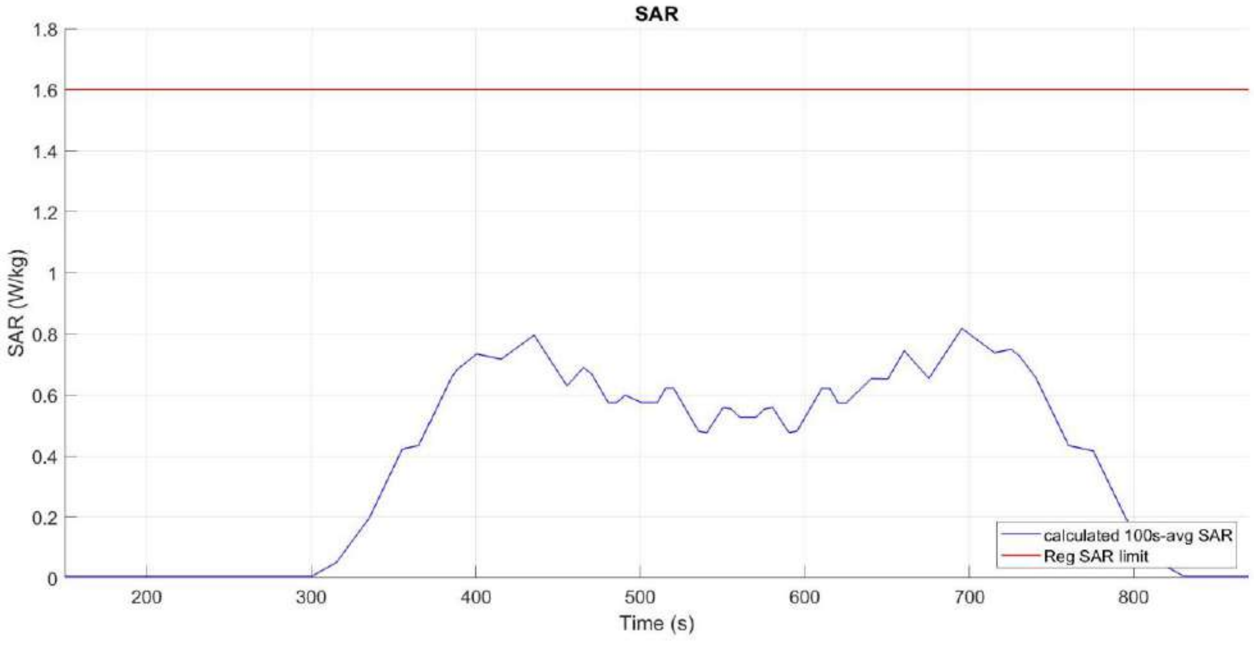


Figure 6- 10 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.818 W/kg
Validation result: pass	

- **Case3-1: GSM1900 result for test sequence 1**

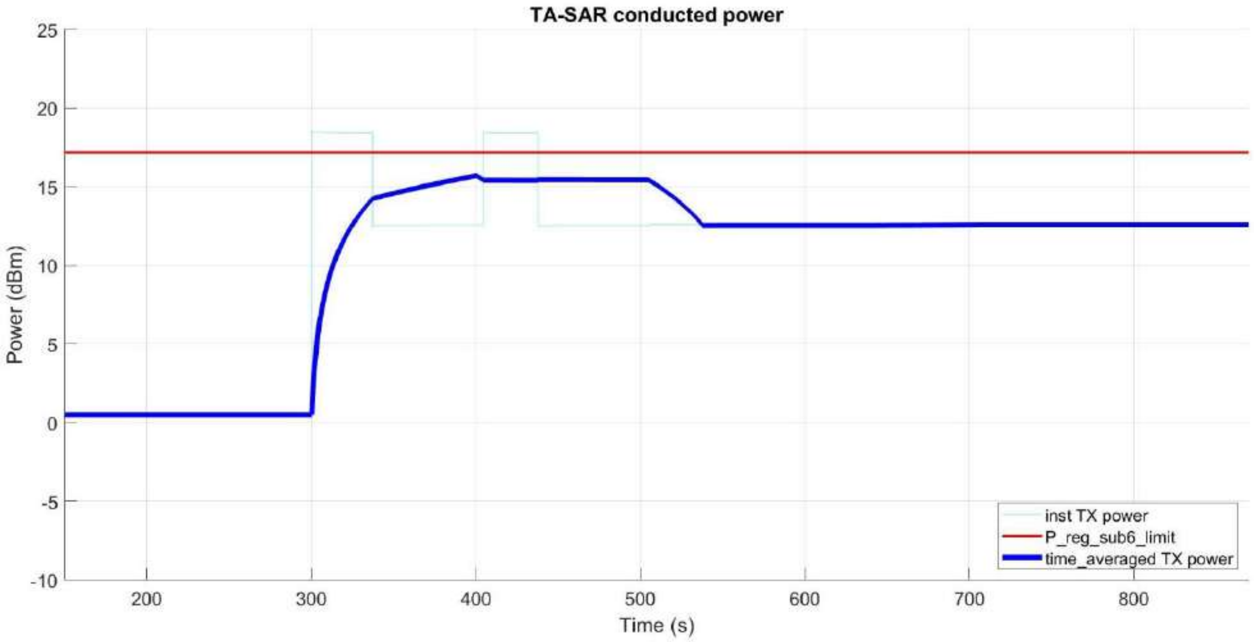


Figure 6- 11 Time-averaged conducted TX power over time

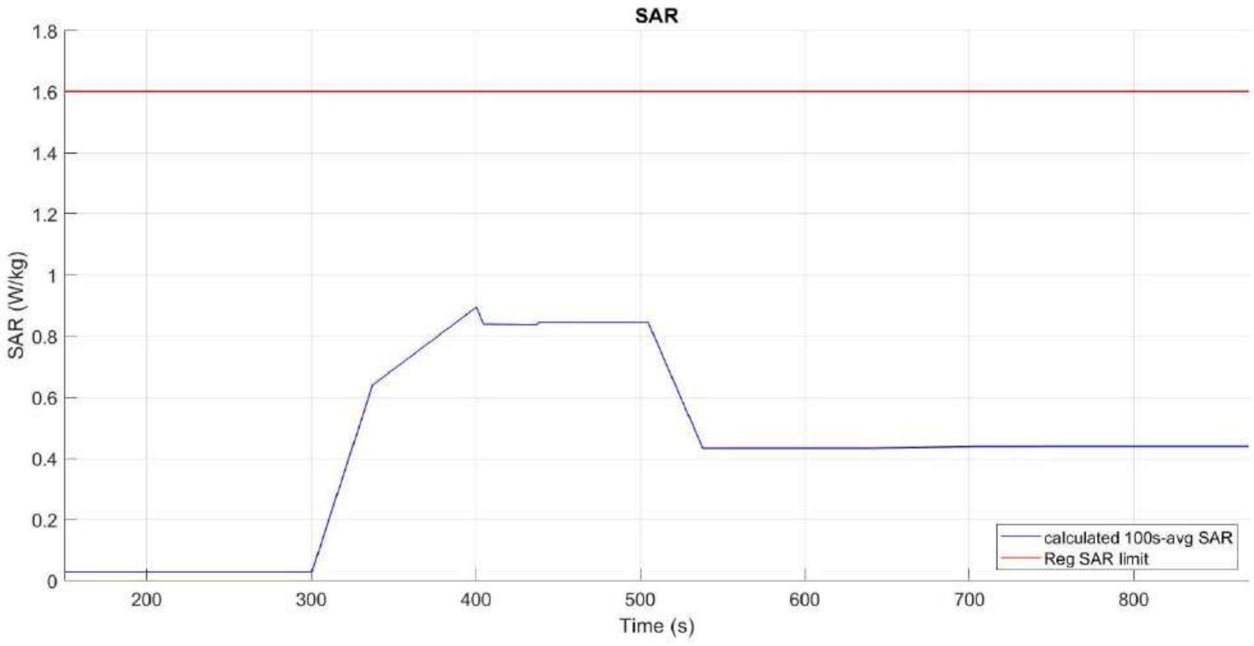


Figure 6- 12 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.894 W/kg
Validation result: pass	

- **Case3-2: GSM1900 result for test sequence 2**

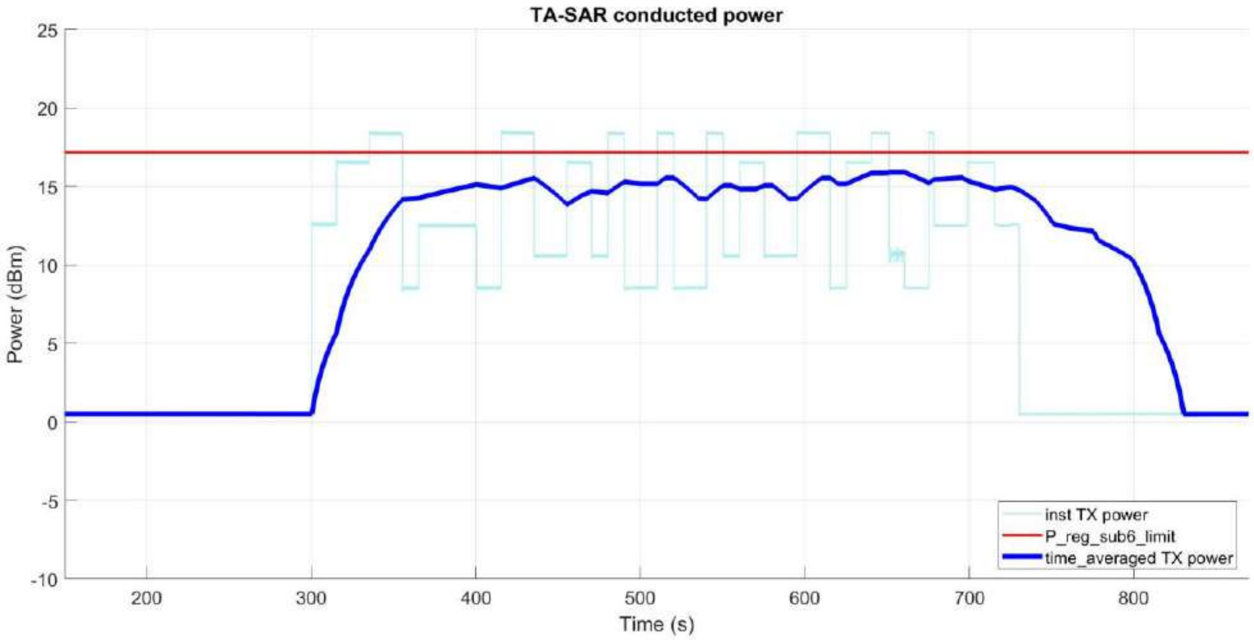


Figure 6- 13 Time-averaged conducted TX power over time

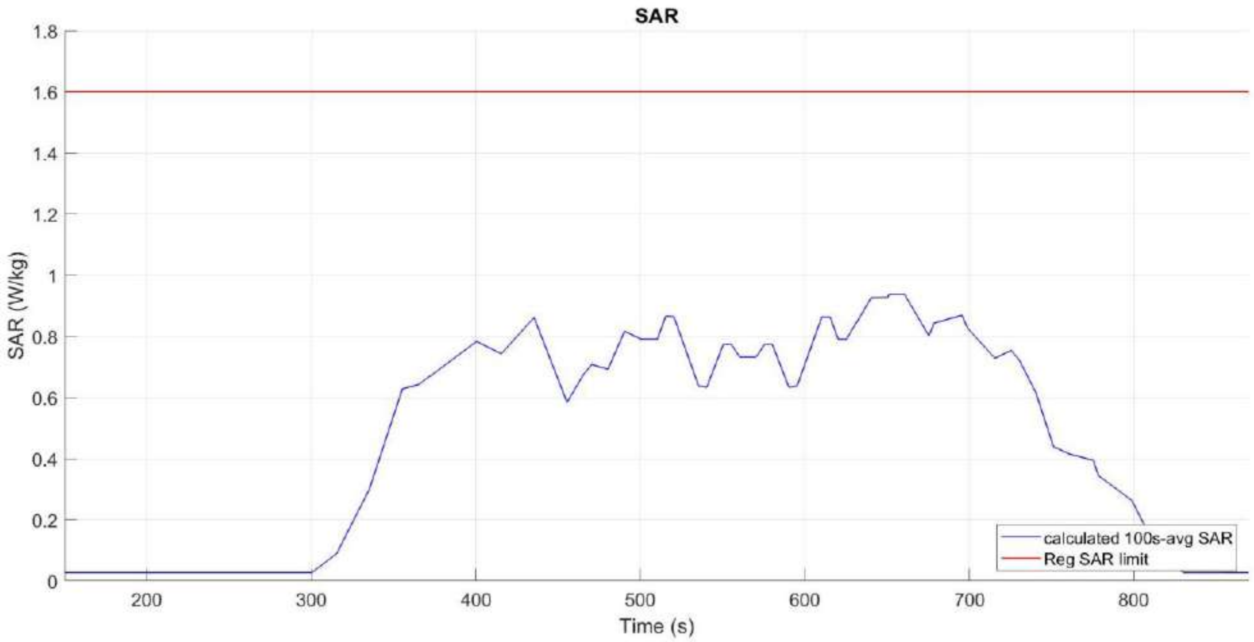


Figure 6- 14 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.938 W/kg
Validation result: pass	

6.3.2 Measurement results for WCDMA

The corresponding detailed test procedure is described in 4.3.2. For the figure set of each case, the first figure demonstrates the EUT's instantaneous conducted TX power, the time-averaged conducted TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty). The second figure illustrates the corresponding time-averaged SAR over time converted from the TX time-averaged power by using the equation listed in section 4.3.2. For all test cases, the time-averaged SAR does not exceed the FCC limit.

- **Case4-1: WCDMA B2 result for test sequence 1**

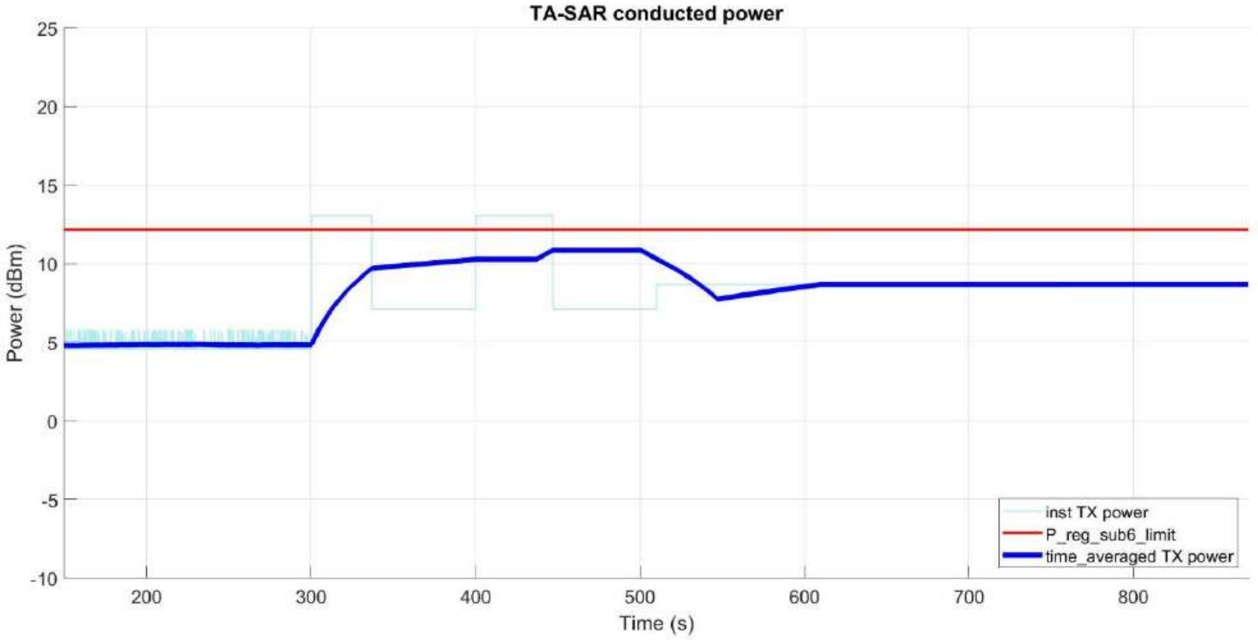
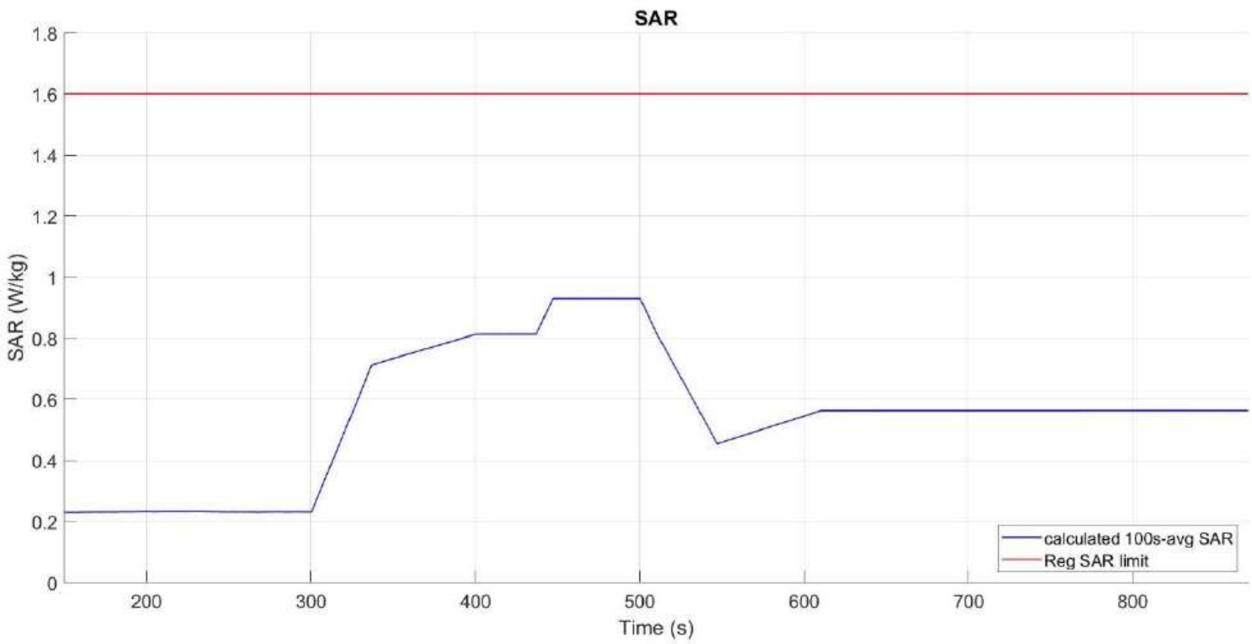


Figure 6- 15 Time-averaged conducted TX power over time



igure 6- 16 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.937 W/kg
Validation result: pass	

- **Case4-2: WCDMA B2 result for test sequence 2**

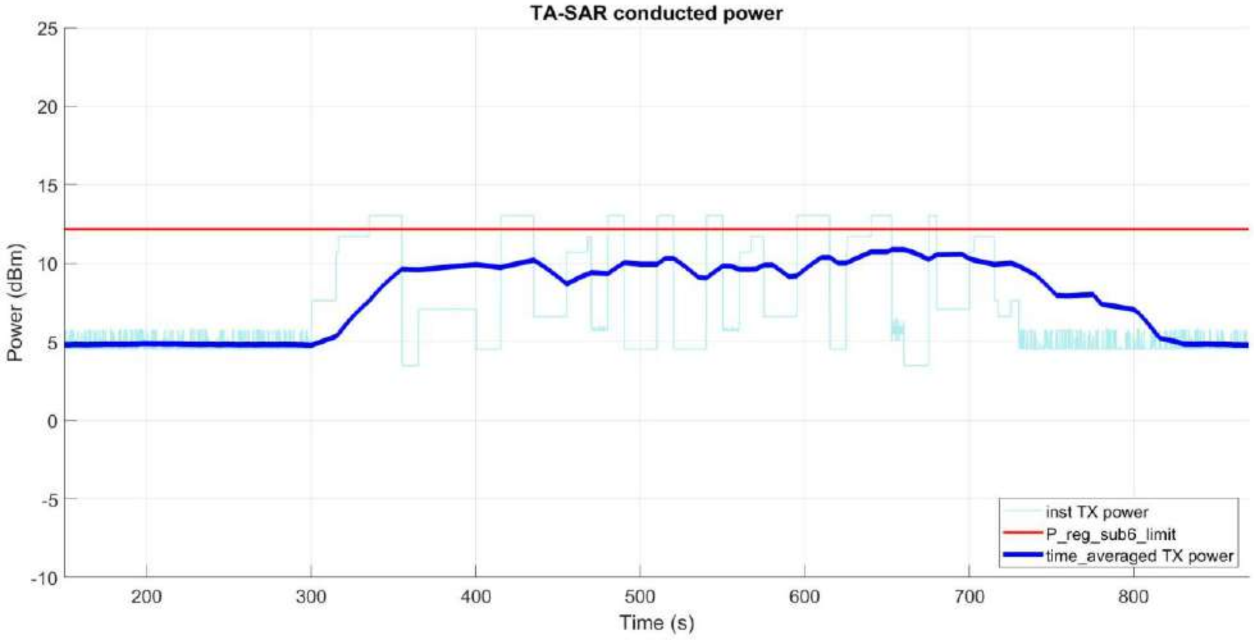


Figure 6- 28 Time-averaged conducted TX power over time

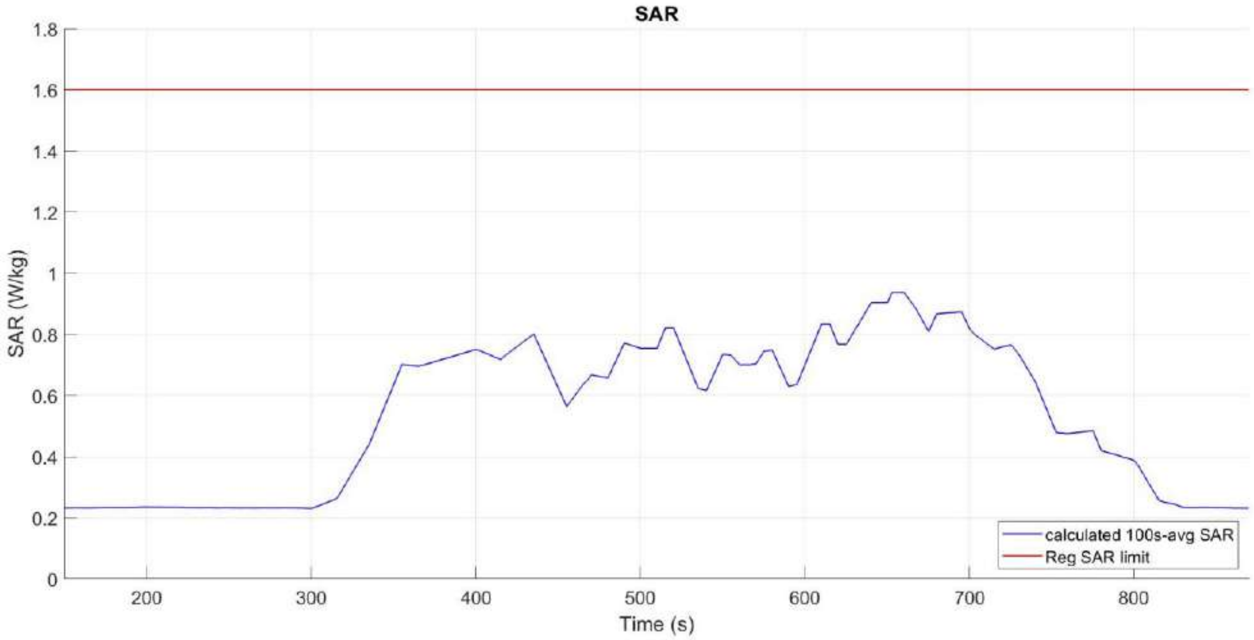


Figure 6- 17 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.930 W/kg
Validation result: pass	

- **Case5-1: WCDMA B5 result for test sequence 1**

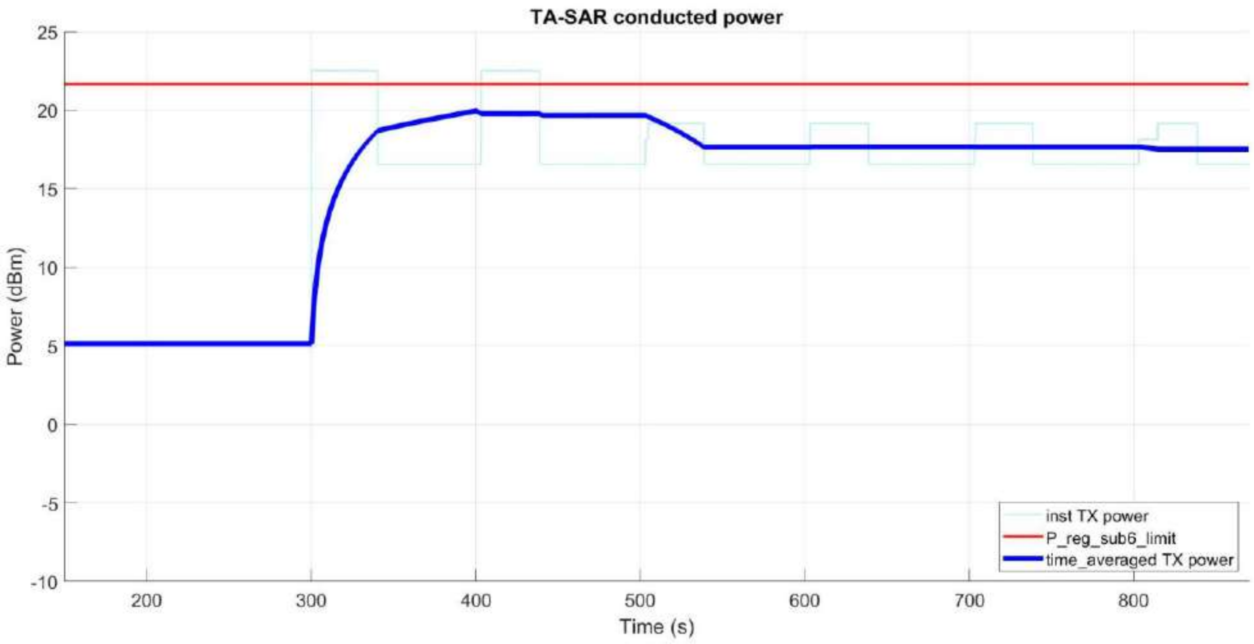


Figure 6- 18 Time-averaged conducted TX power over time

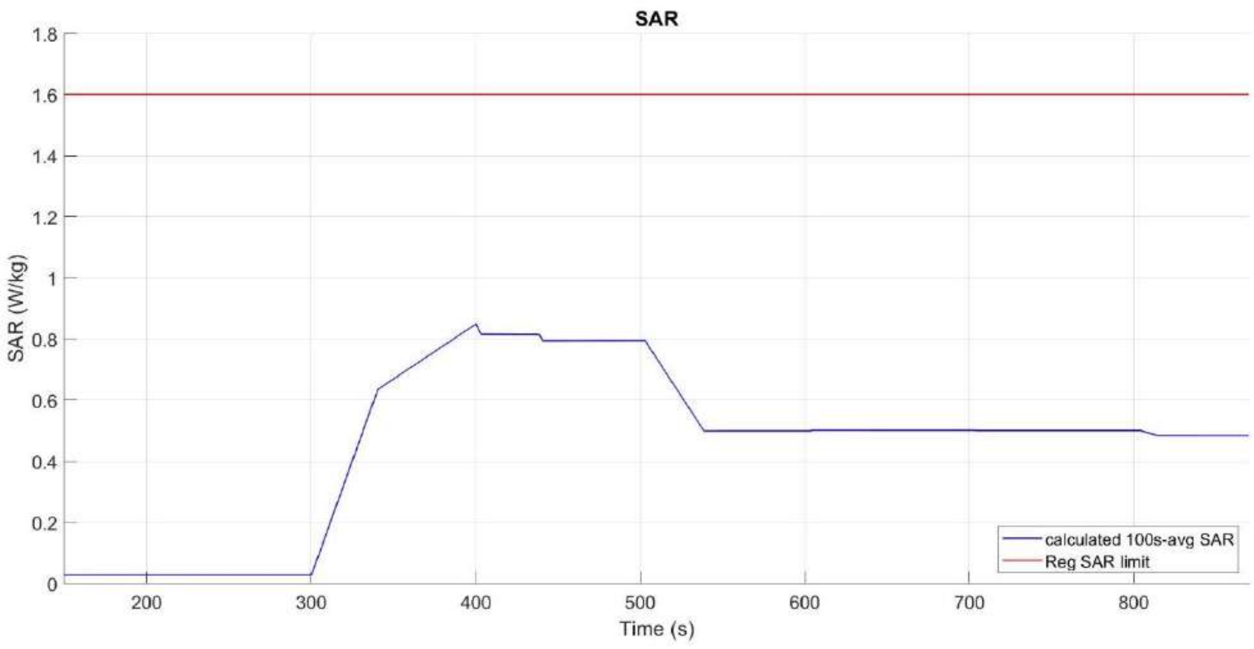


Figure 6- 19 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.849 W/kg
Validation result: pass	

- **Case5-2: WCDMA B5 result for test sequence 2**

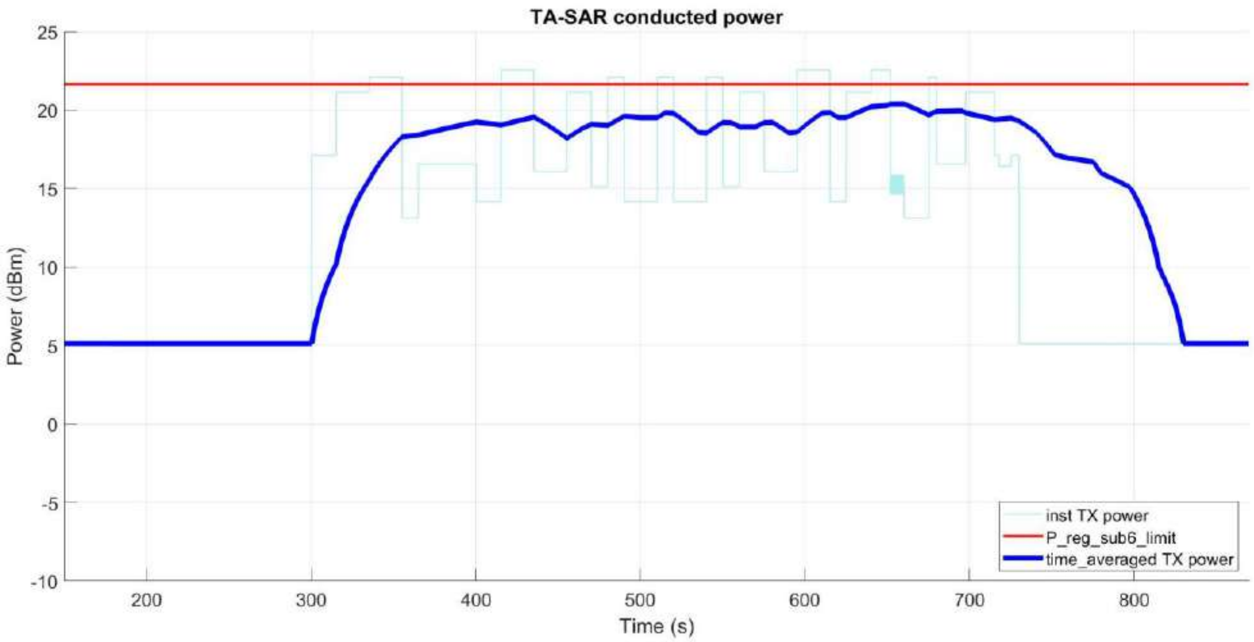


Figure 6- 20 Time-averaged conducted TX power over time

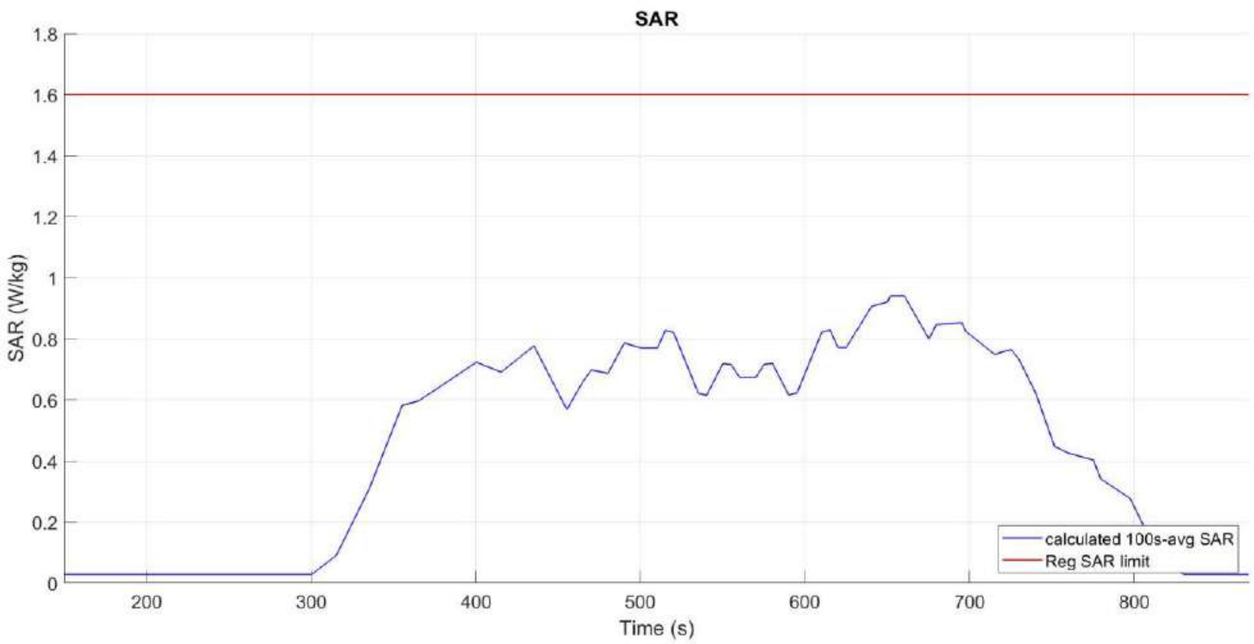


Figure 6- 21 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.941 W/kg
Validation result: pass	

6.3.3 Measurement results for LTE

The corresponding detailed test procedure is described in 4.3.2. For the figure set of each case, the first figure demonstrates the EUT's instantaneous conducted TX power, the time-averaged conducted TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty). The second figure illustrates the corresponding time-averaged SAR over time converted from the TX time-averaged power by using the equation listed in section 4.3.2. For all test cases, the time-averaged SAR does not exceed the FCC limit.

- **Case6-1: LTE B48 result for test sequence 1**

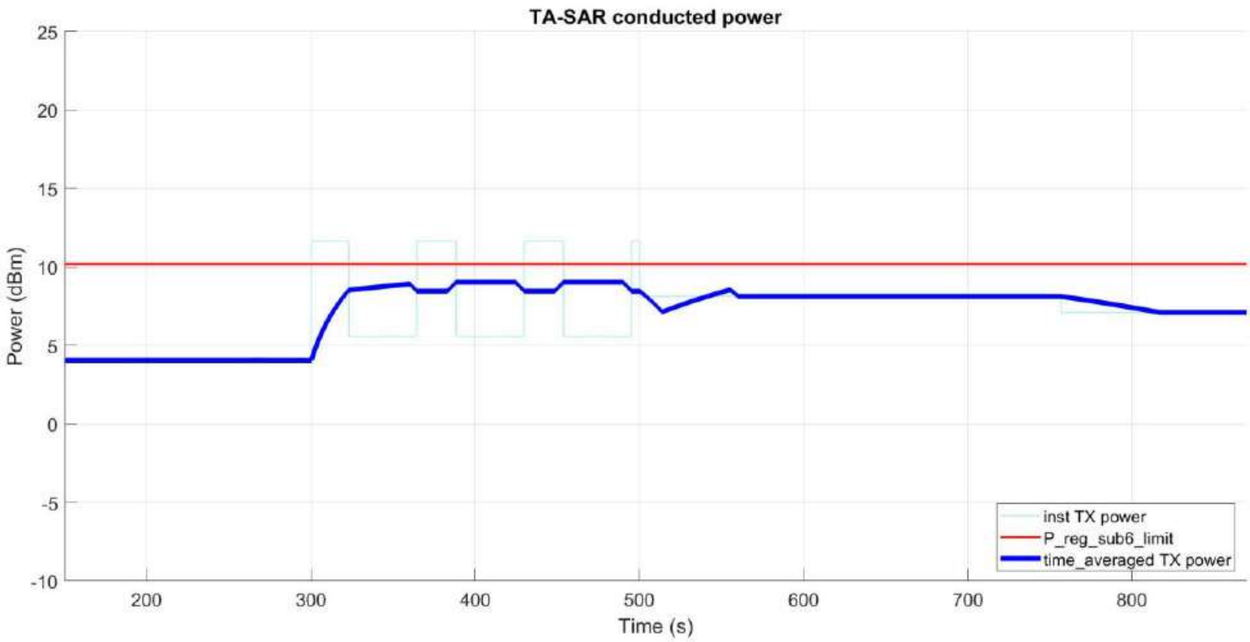


Figure 6- 22 Time-averaged conducted TX power over time

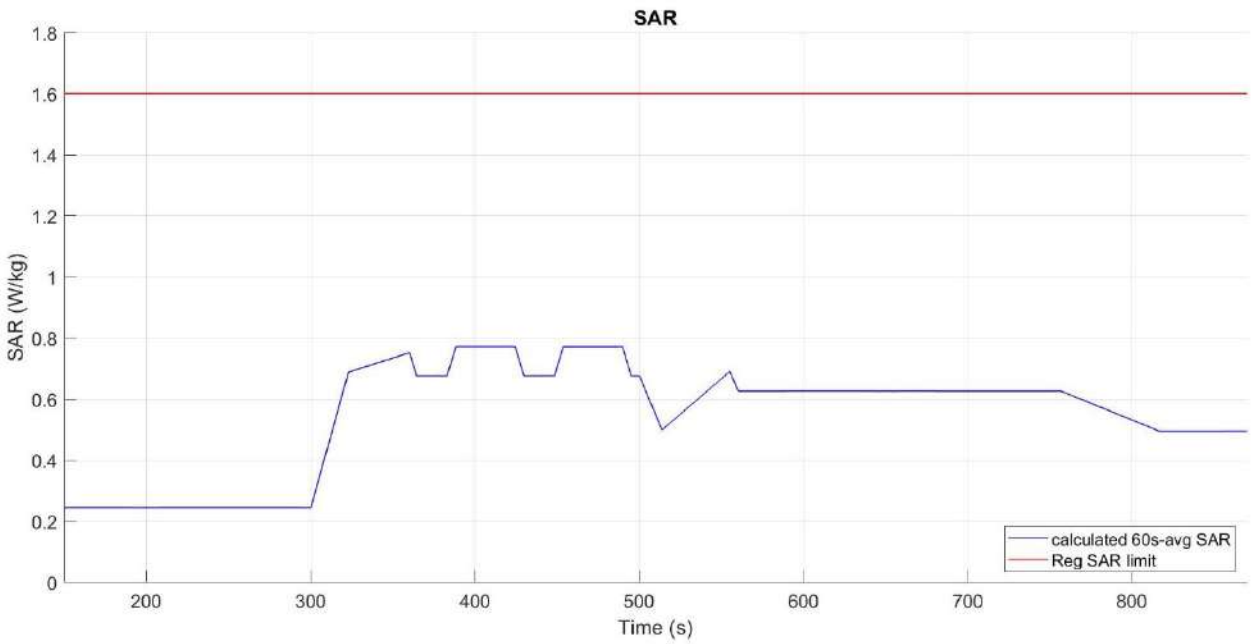


Figure 6- 23 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.772 W/kg
Validation result: pass	

- **Case6-2: LTE B48 result for test sequence 2**

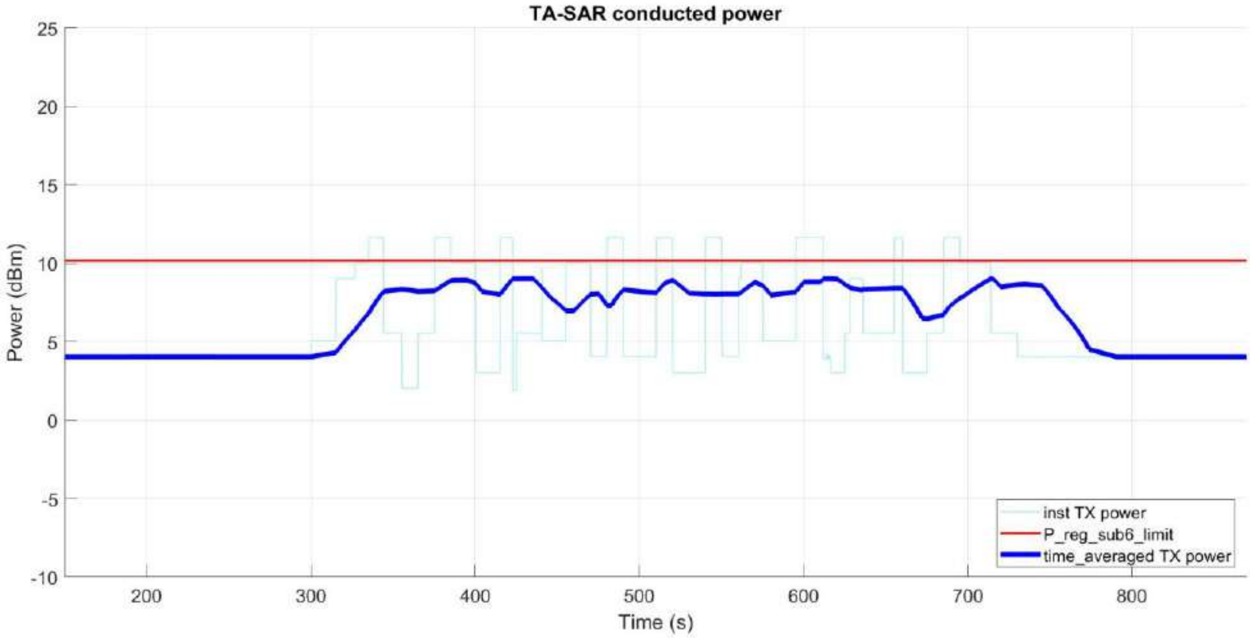


Figure 6- 20 Time-averaged conducted TX power over time

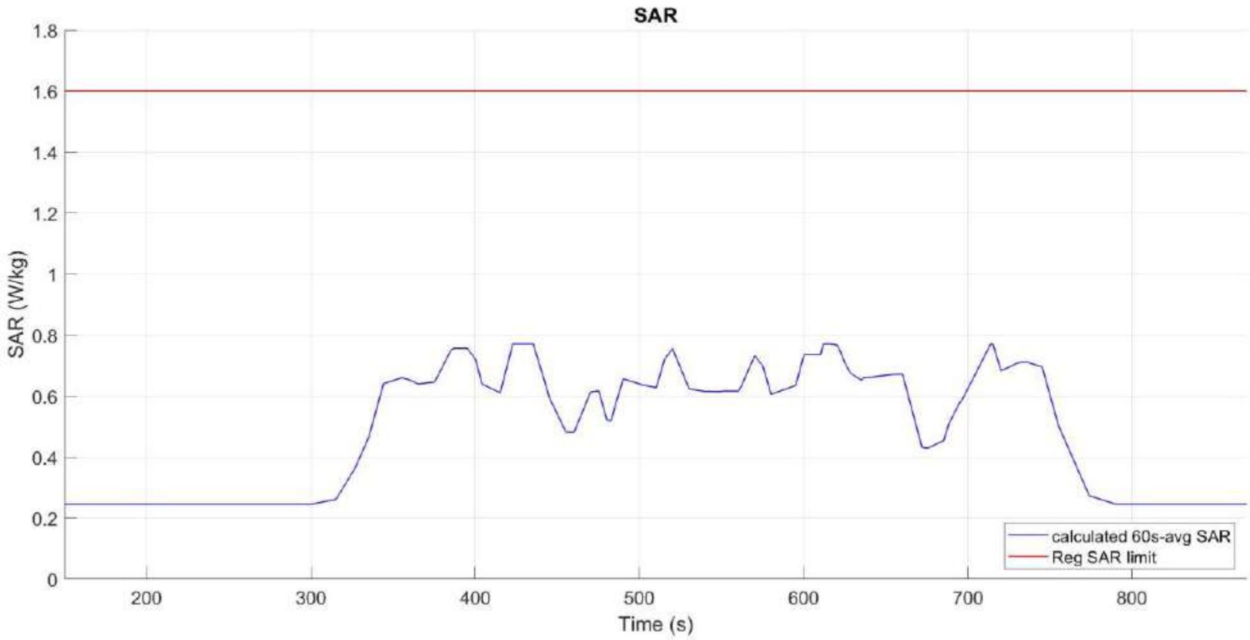


Figure 6- 24 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.771 W/kg
Validation result: pass	

- **Case7-1: LTE B5 result for test sequence 1**

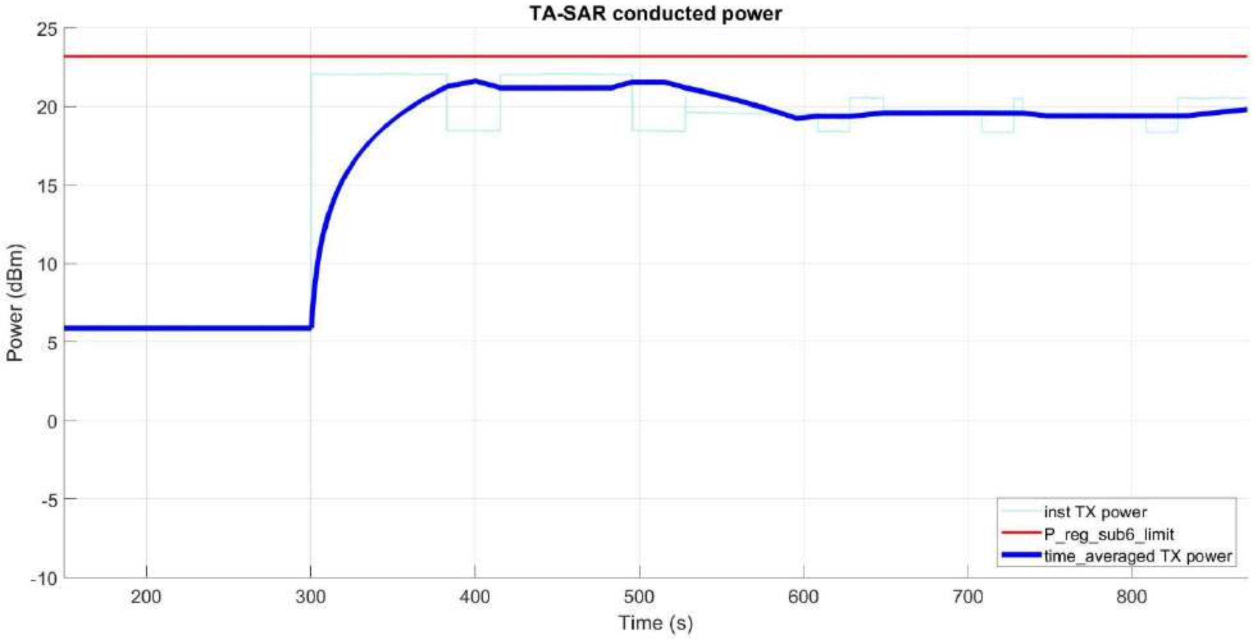


Figure 6- 25 Time-averaged conducted TX power over time

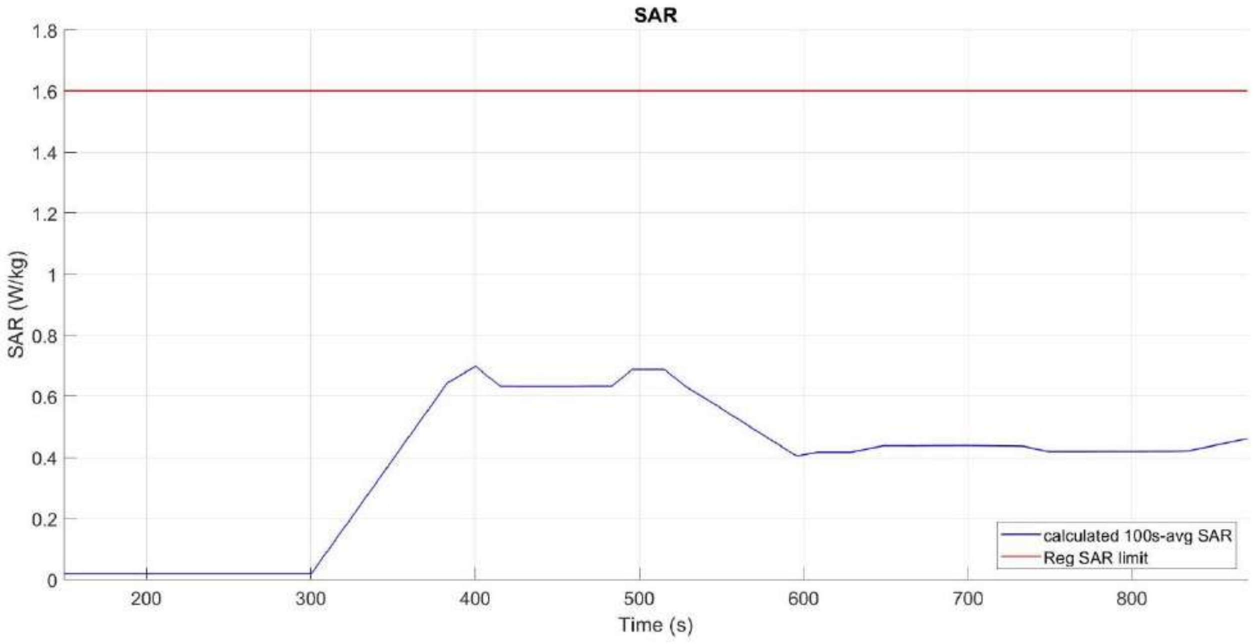


Figure 6- 26 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.698 W/kg
Validation result: pass	

- **Case7-2: LTE B5 result for test sequence 2**

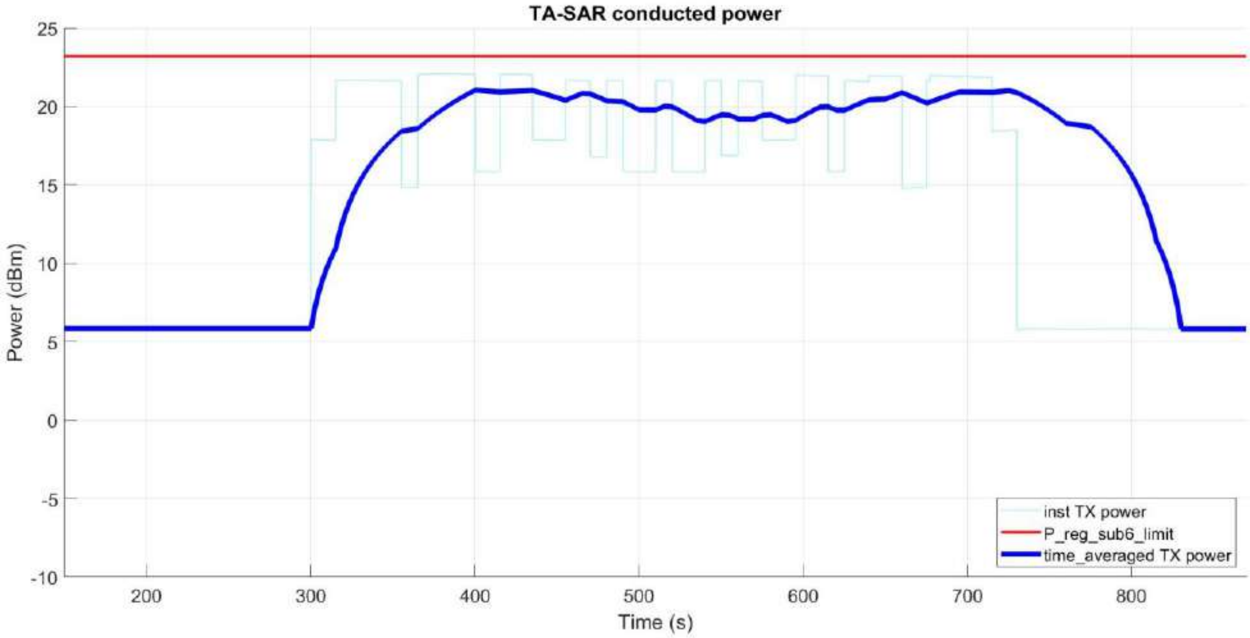


Figure 6- 27 Time-averaged conducted TX power over time

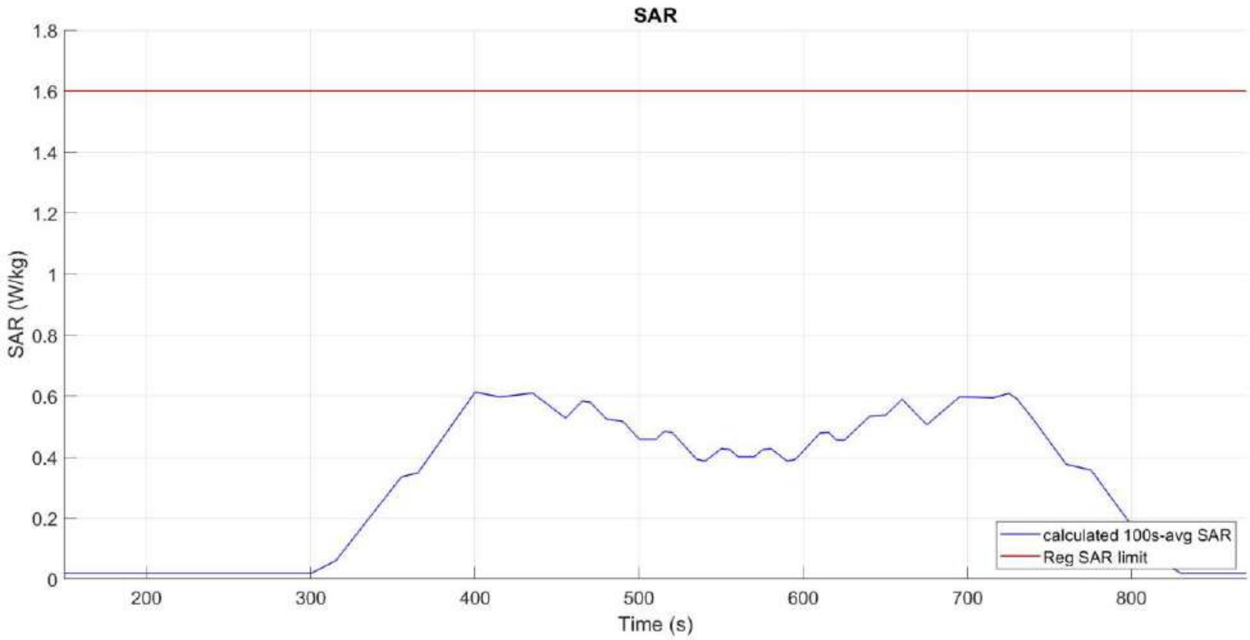


Figure 6- 28 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.613 W/kg
Validation result: pass	

6.3.4 Measurement results for NR

The corresponding detailed test procedure is described in 4.3.2. For the figure set of each case, the first figure demonstrates the EUT's instantaneous conducted TX power, the time-averaged conducted TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty). The second figure illustrates the corresponding time-averaged SAR over time converted from the TX time-averaged power by using the equation listed in section 4.3.2. For all test cases, the time-averaged SAR does not exceed the FCC limit.

- **Case8-1: NR n48 result for test sequence 1**

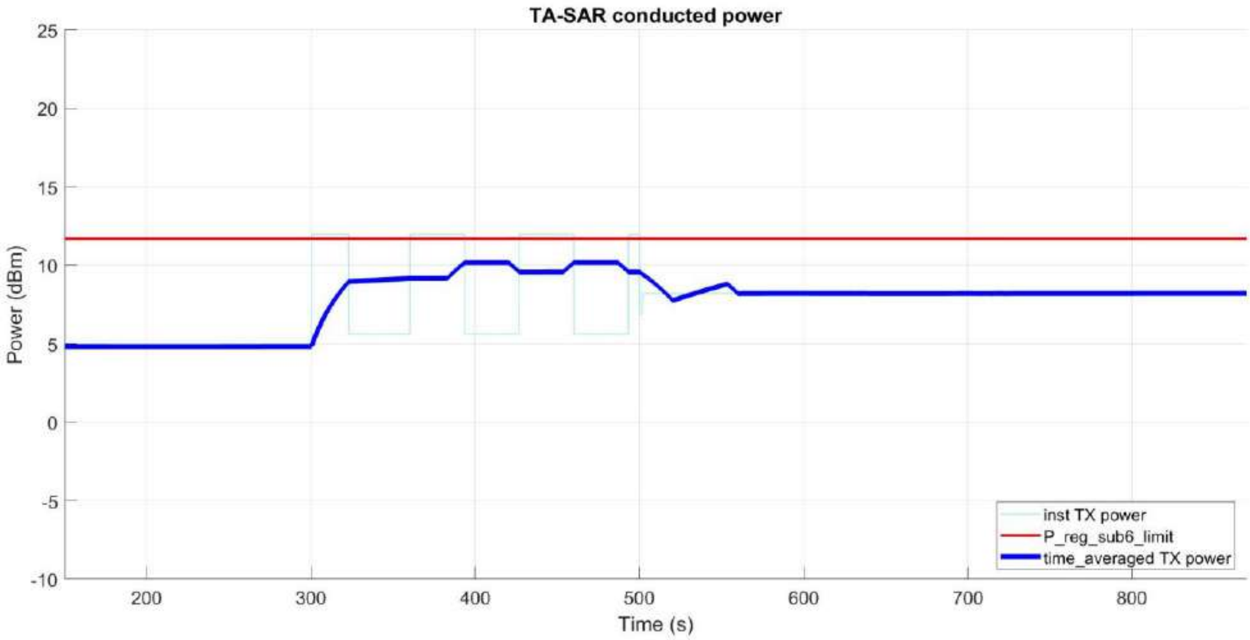


Figure 6- 29 Time-averaged conducted TX power over time

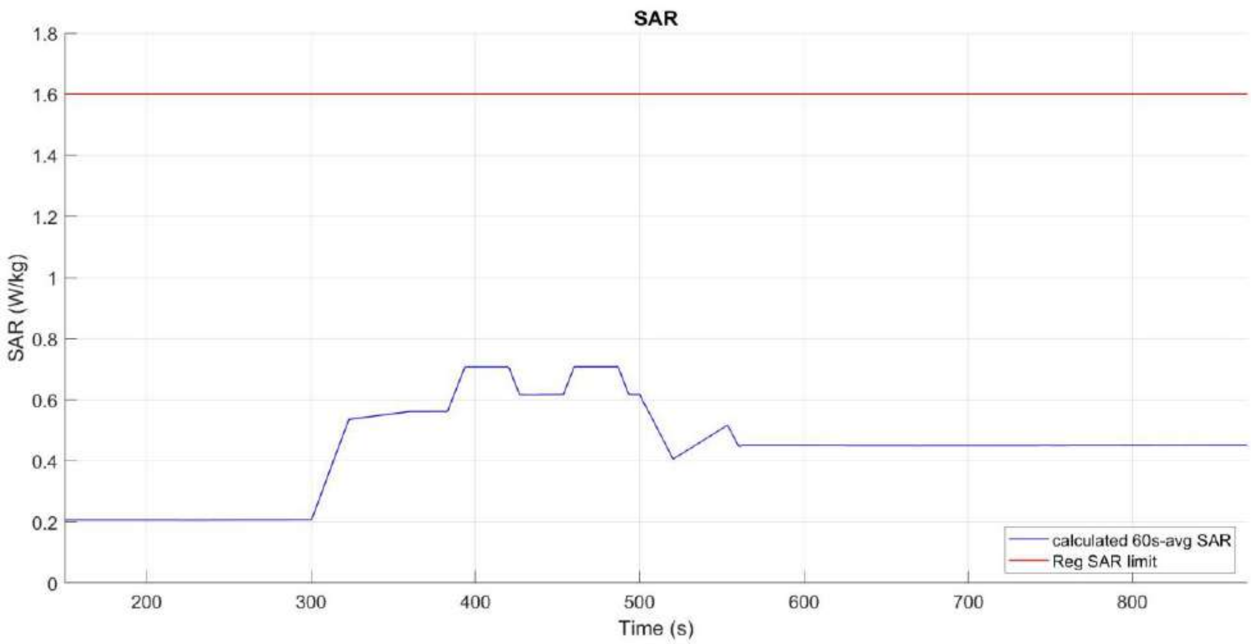


Figure 6- 30 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.707 W/kg
Validation result: pass	

- **Case8-2: NR n48 result for test sequence 2**

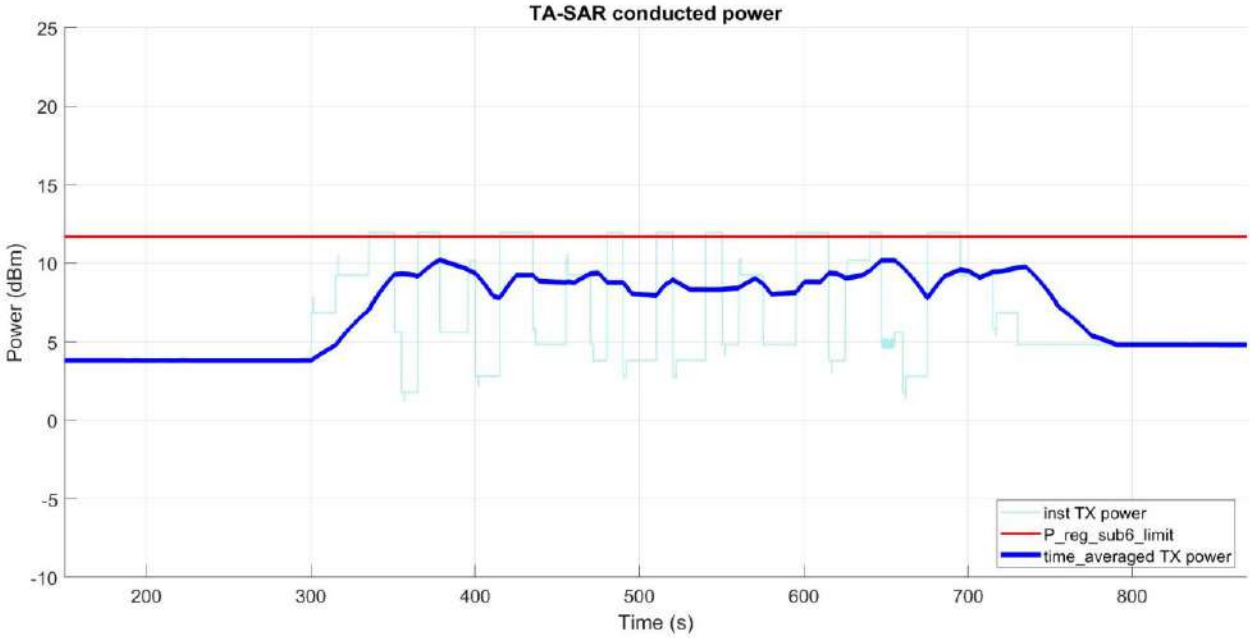


Figure 6- 31 Time-averaged conducted TX power over time

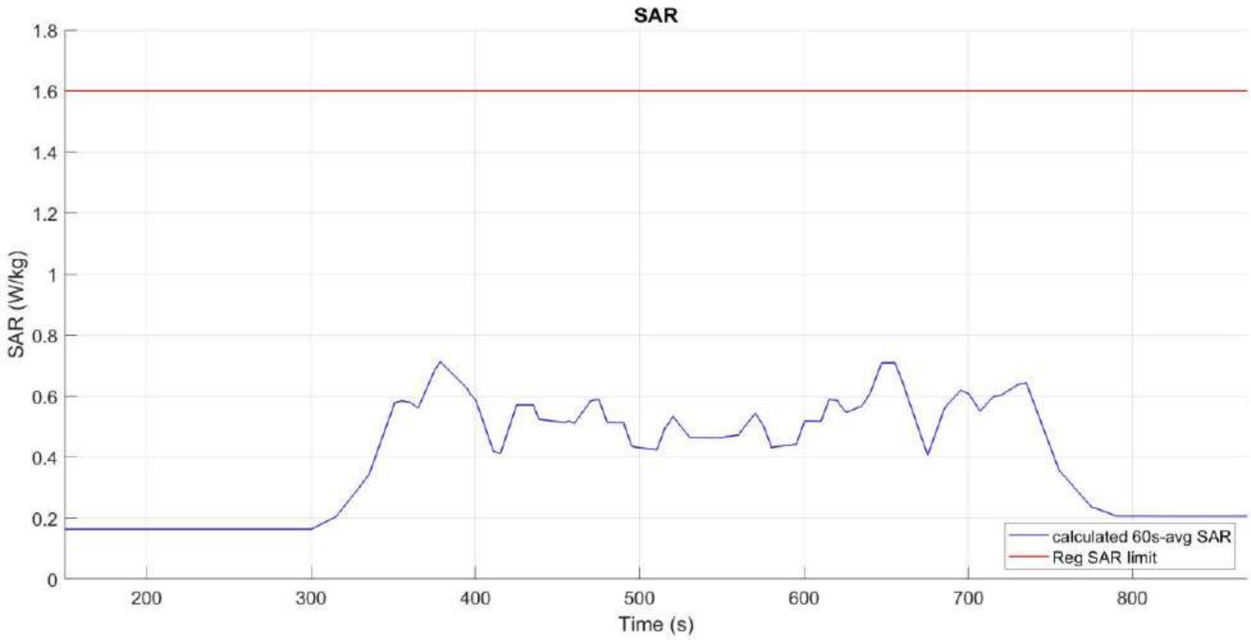


Figure 6- 32 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.712 W/kg
Validation result: pass	

- **Case9-1 in table 6-3: NR n5 result for test sequence 1**

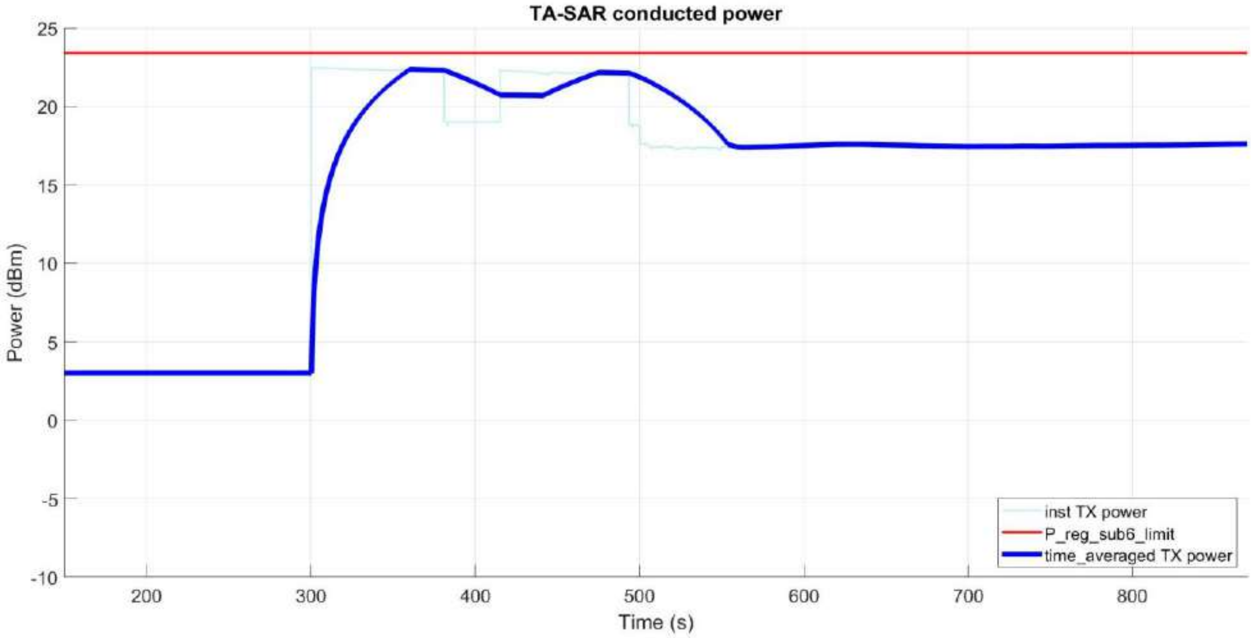


Figure 6- 33 Time-averaged conducted TX power over time

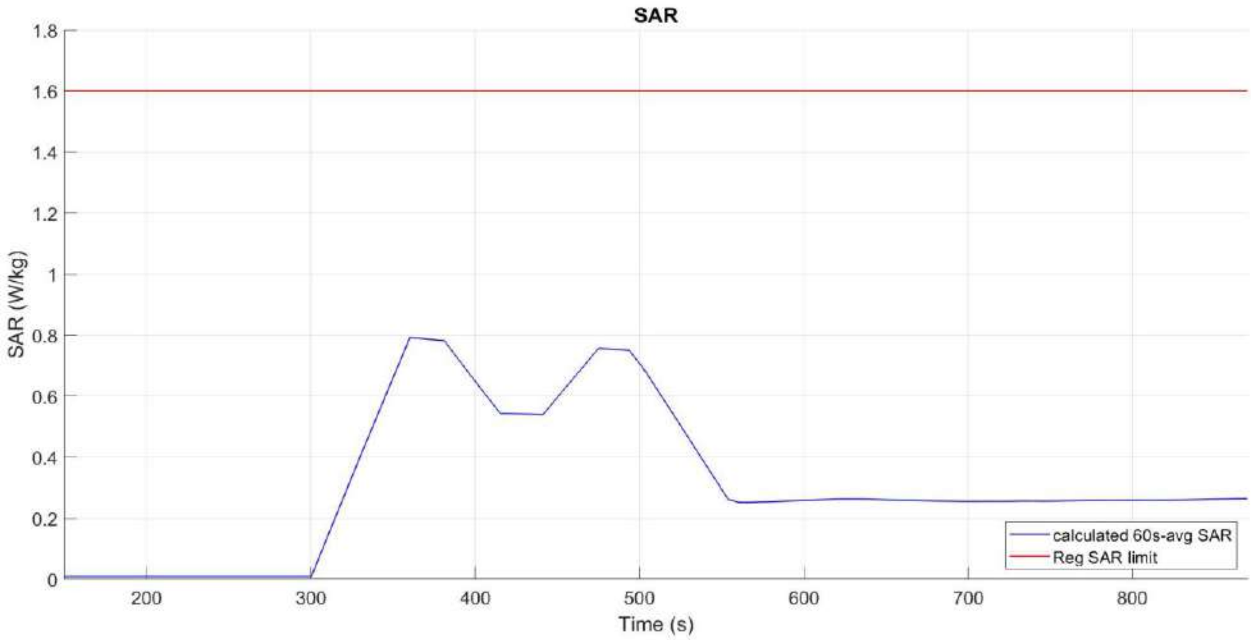


Figure 6- 34 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.793 W/kg
Validation result: pass	

- **Case9-2: NR n5 result for test sequence 2**

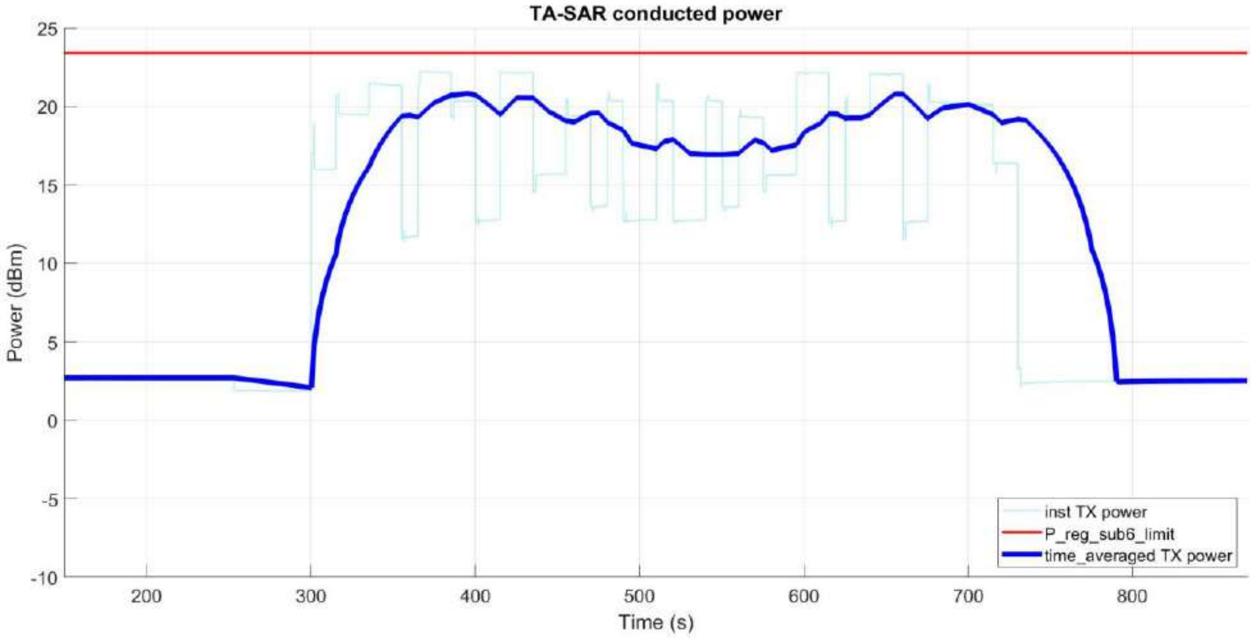


Figure 6- 35 Time-averaged conducted TX power over time

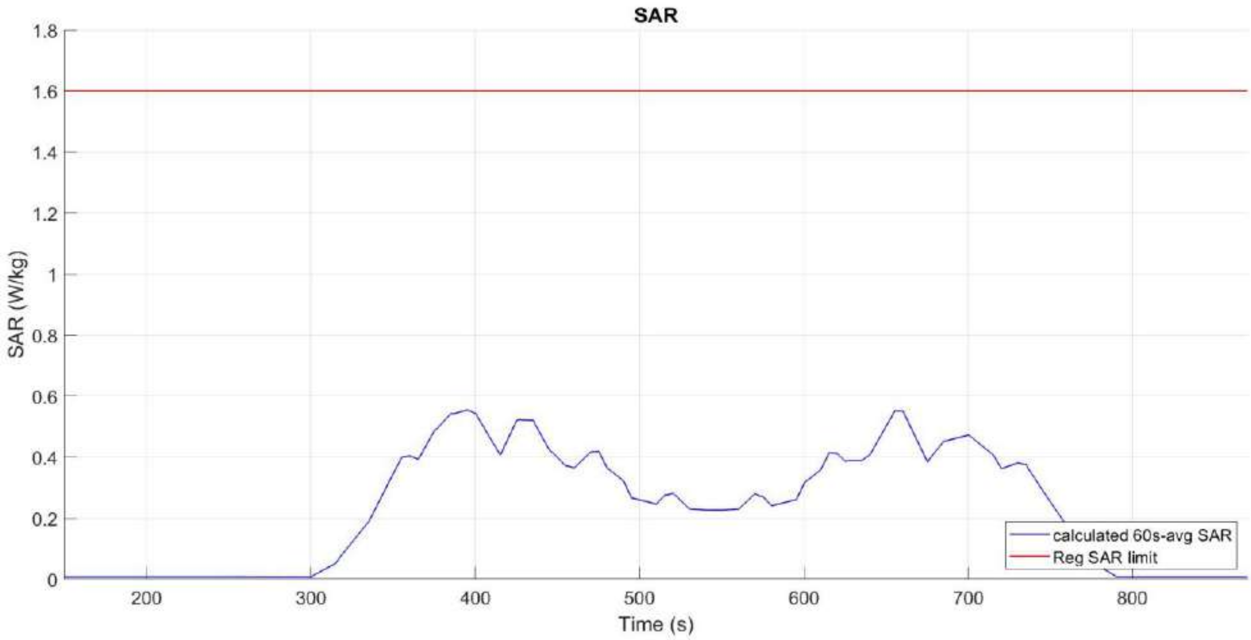


Figure 6- 36 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.555 W/kg
Validation result: pass	

6.4 Conducted 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 for each RAT) 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 test case for this scenario is relegated in Table 6-3, and the test procedure follows section 4.4.2. The measurement setup is shown in Figure 6-2. The high-level summary of the final validation results is also listed in the last column of the table, which concludes that Mediatek's TA-SAR algorithm can maintain the time-averaged SAR is always below the FCC requirement. The following section will demonstrate how Mediatek's TA-SAR algorithm behaves.

The corresponding detailed test procedure is described in 4.4.2. Figure 6-42 demonstrates the EUT's instantaneous conducted TX power, the time-averaged conducted TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty). Figure 6-43 illustrates the corresponding time-averaged SAR over time converted from the TX time-averaged power by using the equation listed in section 4.4.2. As seen in this figure, the time-averaged SAR does not exceed the FCC limit.

- **Case10: FR1 n48 call drop happens at the time instance of 500 seconds.**

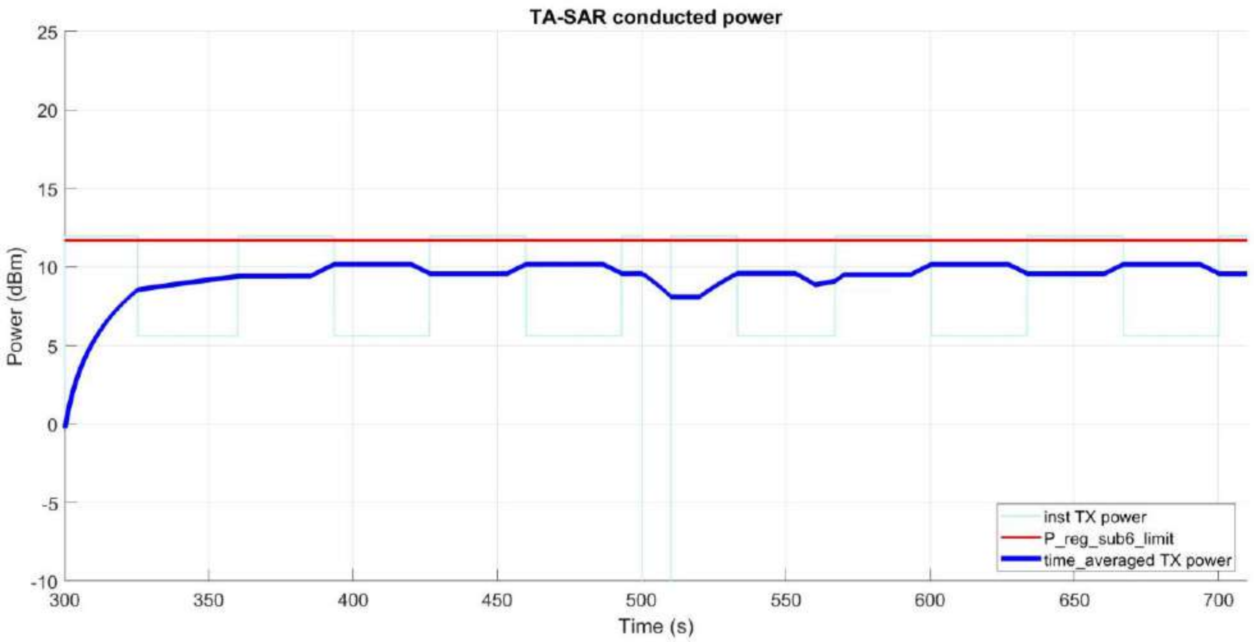


Figure 6- 42 Time-averaged conducted TX power over time

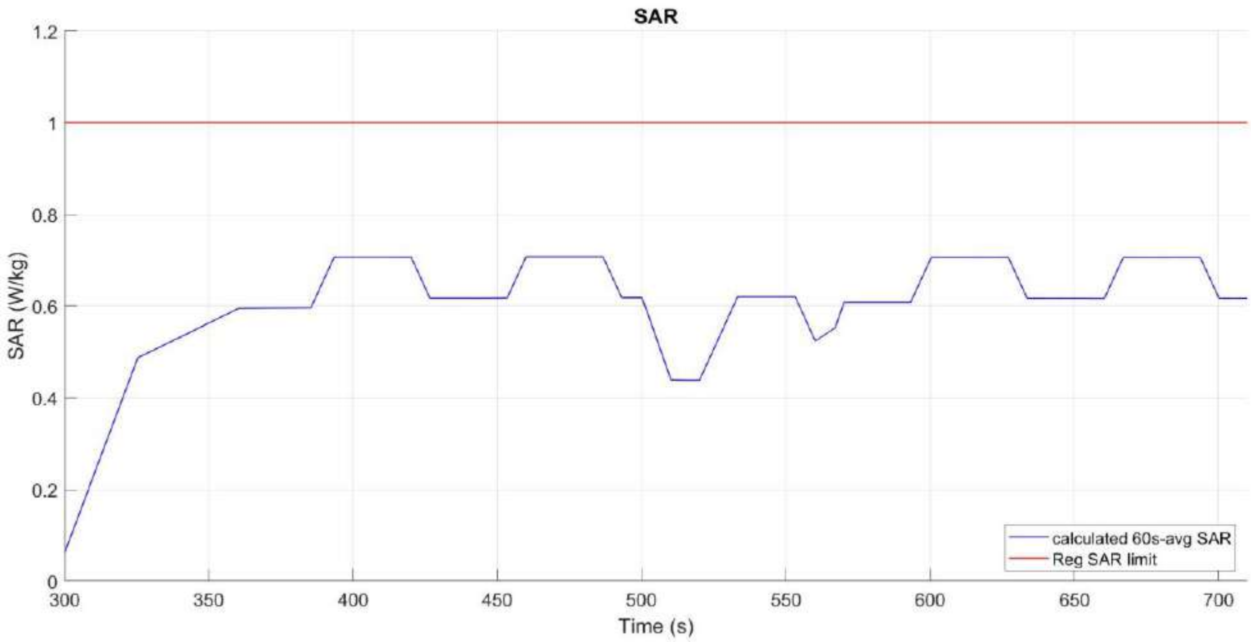


Figure 6- 37 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.706 W/kg
Validation result: pass	

6.5 Conducted Power Measurement Results for Scenario Band Handover

In this scenario, the test power sequence #0 (i.e., maximum TX power is requested by a call box for each RAT) is used, and band (and RAT) handover is manually configured at a specific time instance. The test case widely cover handover scenarios between two RATs. The test case for this scenario is relegated in Table 6-3, and the test procedure follows section 4.5.2. The measurement setup is shown in Figure 6-3 (band handover) and Figure 6-5 (RAT handover). The high-level summary of the final validation results is also listed in the last column of the table, which concludes that Mediatek's TA-SAR algorithm can maintain the time-averaged SAR is always below the FCC requirement. The following section will demonstrate how Mediatek's TA-SAR algorithm behaves.

The corresponding detailed test procedure is described in 4.5.2. The first figure demonstrates the EUT's instantaneous conducted TX power and the time-averaged conducted TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty). The handover is configured at the time instance of 500 seconds. It is observed in the figure that the time-averaged TX power of the individual RAT is below its own P_{sub6_limit}. The second figure illustrates the corresponding time-averaged normalized SAR over time converted from the TX time-averaged power by using the equation listed in section 4.5.2. The figure shows that the time-averaged normalized SAR does not exceed the normalized FCC limit of 1.

- **Case11: band handover happens at the time instance of 500 seconds.**

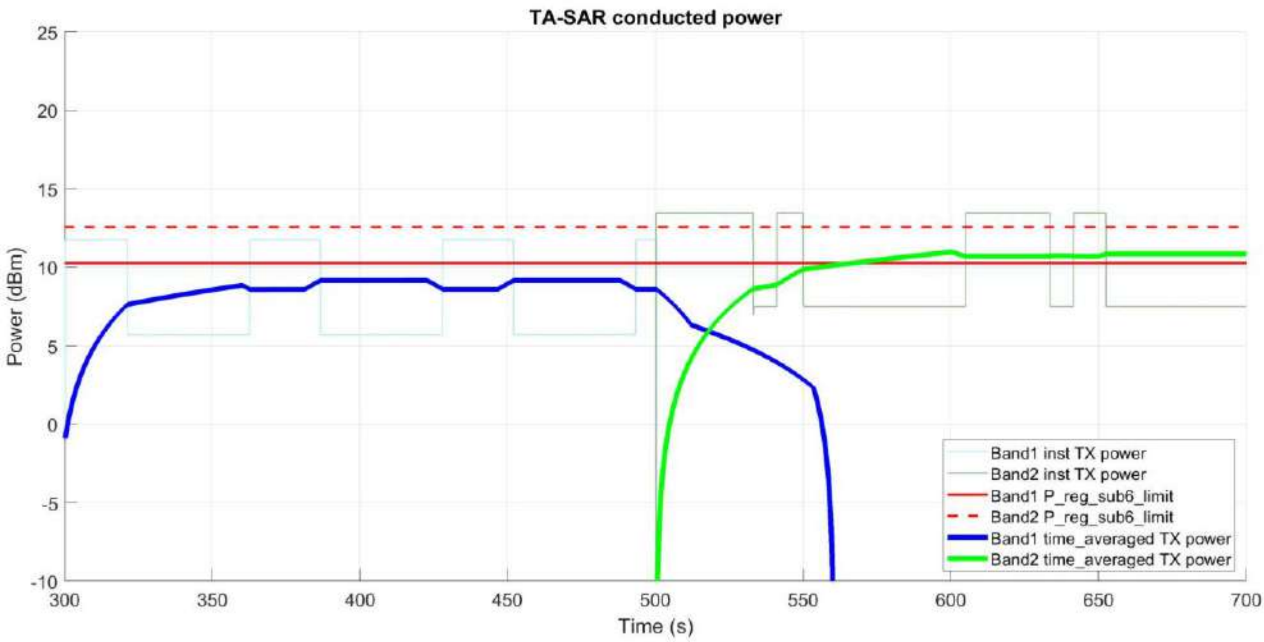


Figure 6- 38 Time-averaged conducted TX power over time

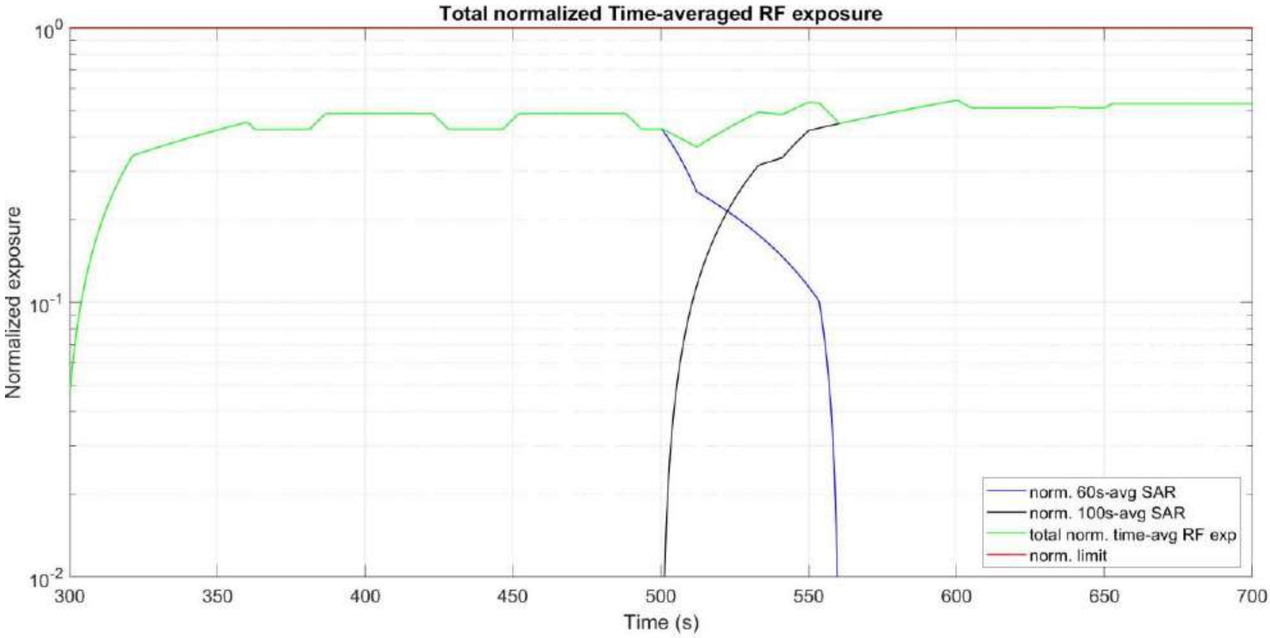


Figure 6- 39 Normalized time-averaged SAR

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.545
Validation result: pass	

6.6 Conducted Power Measurement Results for Scenario 5: ECI Change

In this scenario, the test power sequence #0 (i.e., maximum TX power is requested by a call box for each RAT) is used, and ECI change at the EUT side is manually configured at a specific time instance. The test case cover ECI switching scenario between two ECIs. The test case for this scenario is relegated in Table 6-3, and the test procedure follows section 4.6.2. The measurement setup is shown in Figure 6-2. The high-level summary of the final validation results is also listed in the last column of the table, which concludes that Mediatek's TA-SAR algorithm can maintain the time-averaged SAR is always below the FCC requirement. The following section will demonstrate how Mediatek's TA-SAR algorithm behaves. The corresponding detailed test procedure is described in 4.6.2. The first figure demonstrates the EUT's instantaneous conducted TX power and the time-averaged conducted TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty). During the test period, there are two ECI change events configured individually at the time instances 500 seconds and 700 seconds. The 1st change is from ECI = 3 to ECI = 6 and the 2nd change is from ECI = 6 back to ECI = 3. It is observed in the figure that the time-averaged TX power of the individual RAT is below its own P_{sub6_limit}. The second figure illustrates the corresponding time-averaged normalized SAR over time converted from the TX time-averaged power by using the equation listed in section 4.6.2. The figure shows that the time-averaged normalized SAR does not exceed the normalized FCC limit of 1.

- **Case12: LTE B48 ECI3 changes to ECI6 happen at the time instances of 500 and 700 seconds, respectively**

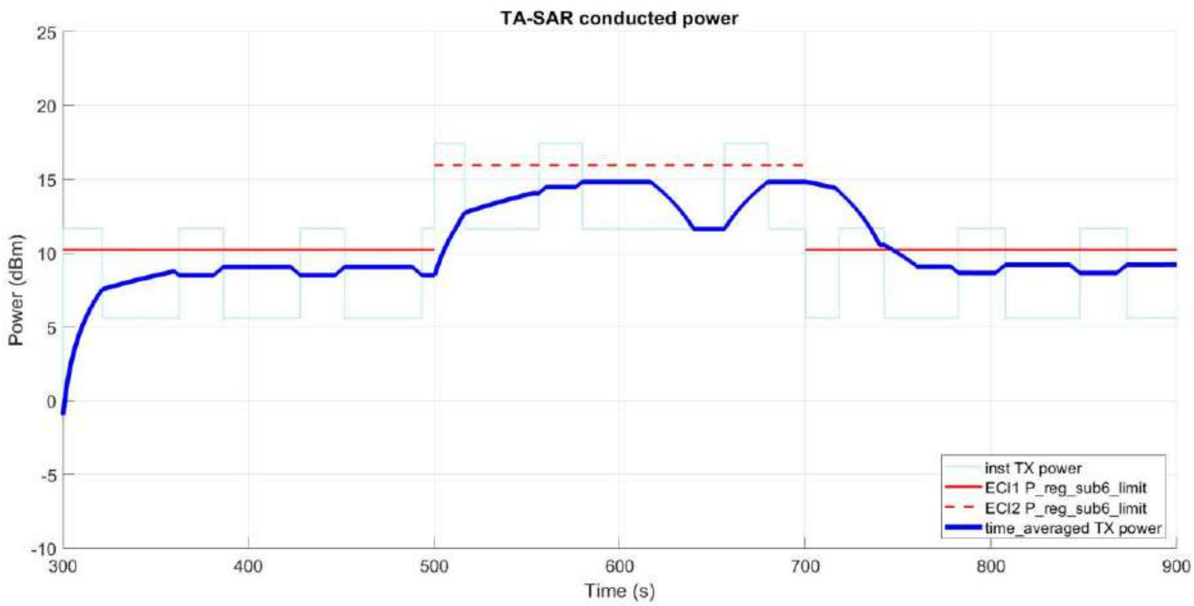


Figure 6- 40 Time-averaged conducted TX power over time

NOTE : The inst. TX power should be compared with P_reg_sub6_limit of the corresponding configuration, i.e. 19.1 dBm for ECI 1 and 18.1 dBm for ECI 2, then transformed and averaged in SAR perspective to check compliance. Therefore, even though the time-averaged TX power seems to exceed P_reg_sub6_limit after configuration changed (from 700s to 730s), the time-averaged SAR pass regulation as a matter of fact.

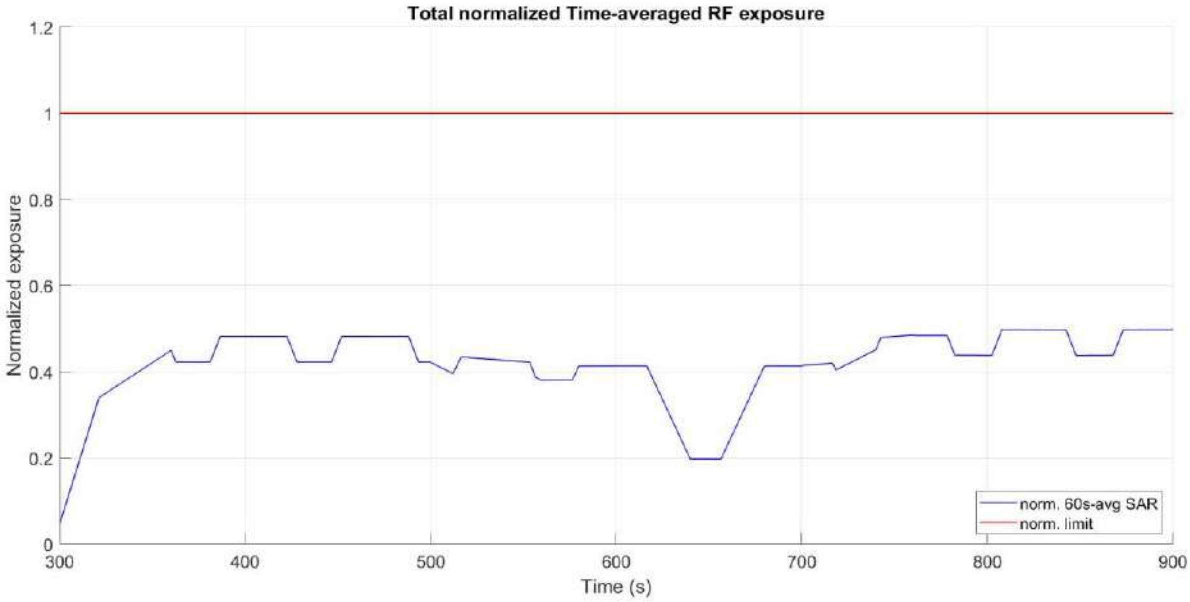


Figure 6- 41 Normalized time-averaged SAR

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.498
Validation result: pass	

6.7 Conducted Power Measurement Results for Scenario 7: Time Window Switching

In this scenario, the test power sequence #0 (i.e., maximum TX power is requested by a call box for each RAT) is used, and band handover events within a RAT are manually configured at specific time instances. This scenario aims to validate the correctness of the TA-SAR algorithm with existence of moving average time window change. The two test cases for this scenario are relegated in Table 6-3, and the test procedure follows section 4.8.2. The measurement setup is shown in Figure 6-3. The high-level summary of the final validation results are also listed in the last column of the table, which concludes that Mediatek's TA-SAR algorithm can maintain the time-averaged SAR is always below the FCC requirement for all the cases. The following sections will demonstrate how Mediatek's TA-SAR algorithm behaves.

6.7.1 Measurement results for Time window switching 60s-100s-60

The corresponding detailed test procedure is described in 4.8.2. During the test period, there are two band handover events configured individually at the time instances 450 seconds and 620 seconds. The 1st handover is from B48 to B2 and the 2nd handover is from B2 back to B48. The first figure demonstrates the EUT's instantaneous conducted TX power and the time-averaged conducted TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty). It is observed in the figure that the time-averaged TX power during the transitions of the band changes is maintained below the power limitation. The second figure illustrates the corresponding time-averaged normalized SAR over time converted from the TX time-averaged power by using the equation listed in section 4.8.2. The figure shows that the time-averaged normalized SAR does not exceed the normalized FCC limit of 1.

- **Case13: LTE B48 handover to LTE B2 happens at the time instances of 450 and 620 seconds.**

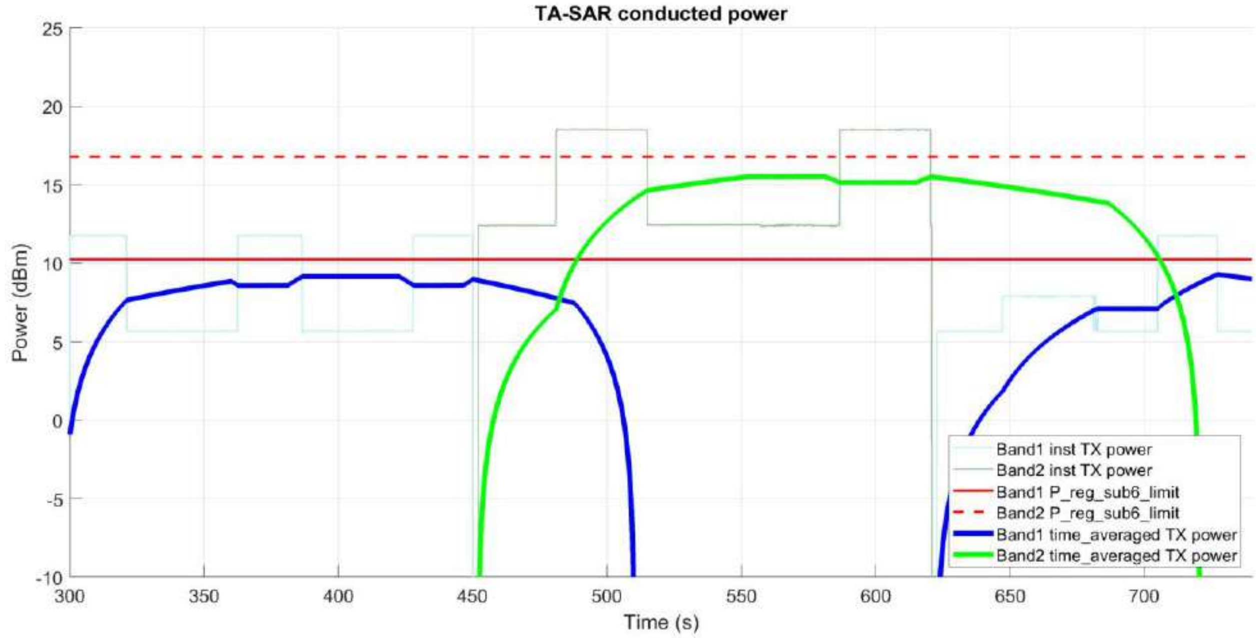


Figure 6- 42 Time-averaged conducted TX power over time

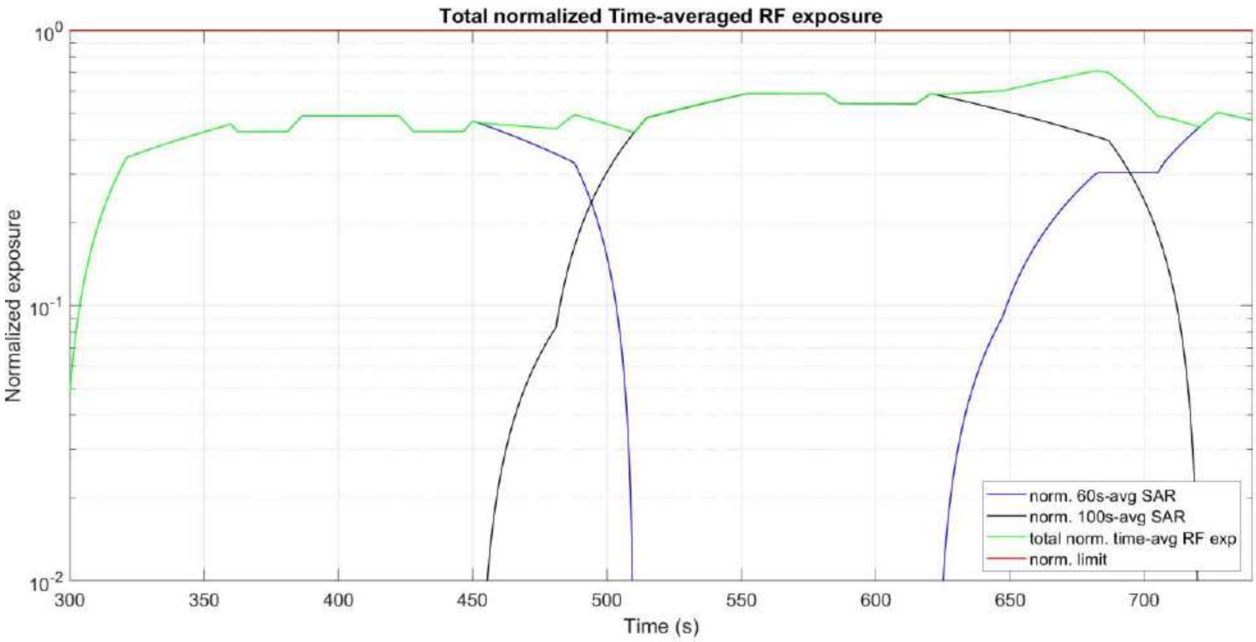


Figure 6- 43 Normalized time-averaged SAR

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.714
Validation result: pass	

6.7.2 Measurement results for Time window switching 100s-60s-100s

The corresponding detailed test procedure is described in 4.8.2. During the test period, there are two band handover events configured individually at the time instances 500 seconds and 620 seconds. The 1st handover is from B2 to B48 and the 2nd handover is from B48 back to B2. The first figure demonstrates the EUT's instantaneous conducted TX power and the time-averaged conducted TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty). It is observed in the figure that the time-averaged TX power during the transitions of the band changes is maintained below the power limitation. The second figure illustrates the corresponding time-averaged normalized SAR over time converted from the TX time-averaged power by using the equation listed in section 4.8.2. The figure shows that the time-averaged normalized SAR does not exceed the normalized FCC limit of 1.

- **Case14: LTE B2 handover to LTE B48 happens at the time instances of 500 and 620 seconds.**

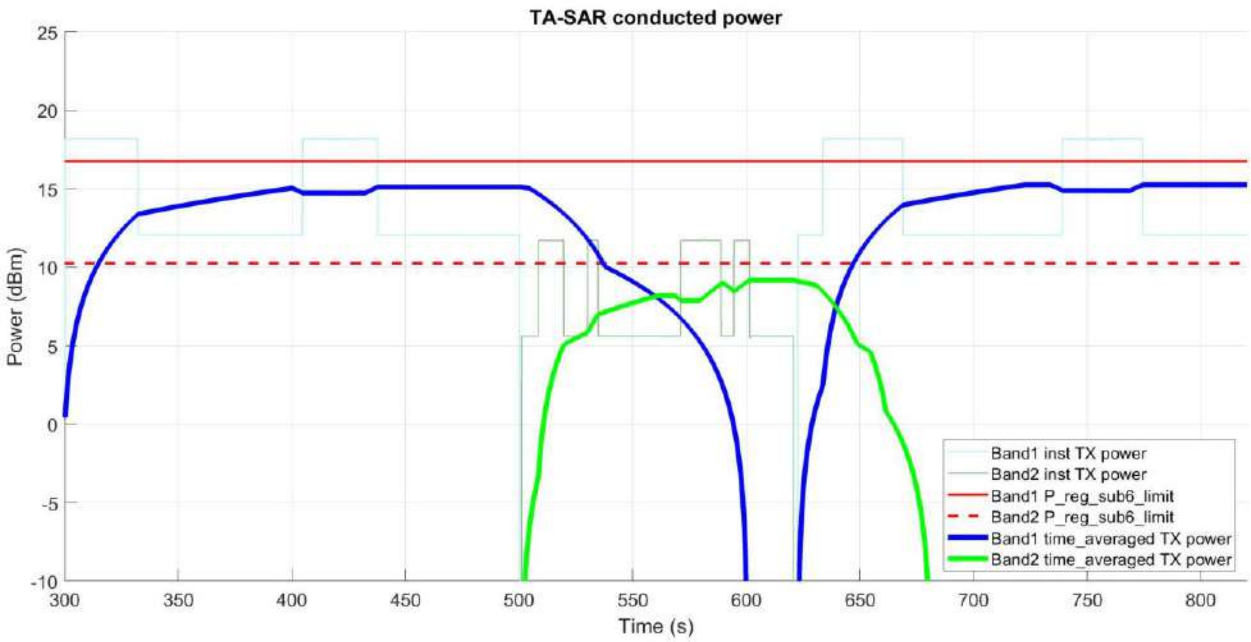


Figure 6- 44 Time-averaged conducted TX power over time

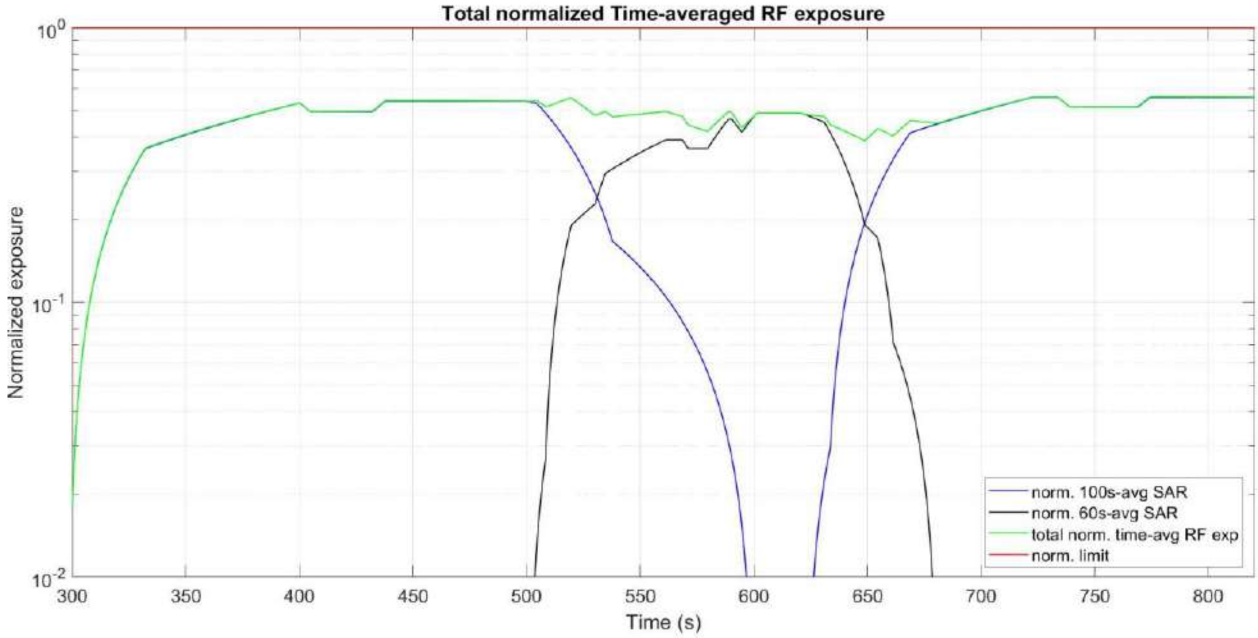


Figure 6- 45 Normalized time-averaged SAR

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.561
Validation result: pass	

6.8 Conducted Power Measurement Results for Scenario 8: SAR Exposure Switching

In this scenario, the test power sequence #0 (i.e., maximum TX power is requested by a call box for each RAT) is used, and LTE and NR FR1 are turned on at the same time for a pre-defined period during the test. This scenario aims to validate whether the TA-SAR algorithm is able to maintain TER below the FCC limit when the two radios change TX power dynamically. The experiment parameters are summarized in Table 6-10, and the test procedure follows section 4.9.2. The measurement setup is shown in Figure 6-5.

During the test period,

- Time = 300s~500s: NR FR1-only scenario.
- Time = 500s~700s: LTE + NR FR1 scenario.
- Time = 700s~900s: LTE-only scenario.

The first figure demonstrates the EUT’s instantaneous conducted TX power and the time-averaged conducted TX power behavior over time, and the power limit (P_reg_sub6_limit = P_{sub6_limit} + 1dB device uncertainty). It is observed in the figure that the time-averaged TX power in all time periods is maintained below the power limitation. The second figure illustrates the corresponding time-averaged normalized SAR over time converted from the TX time-averaged power by using the equation listed in section 4.9.2. The figure shows that the time-averaged normalized SAR does not exceed the normalized FCC limit of 1.

- **Case15: SAR Exposure Switch for LTE B2 to FR1 n66**

Figure 6- 46 Time-averaged conducted TX power over time

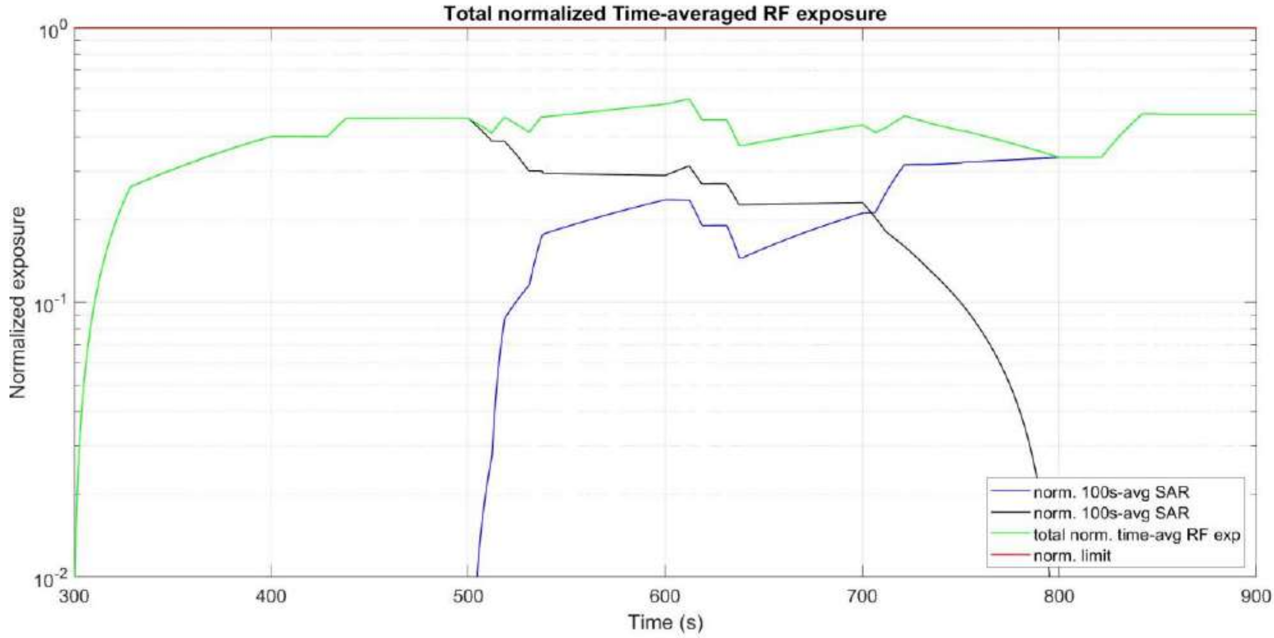


Figure 6- 47 Normalized time-averaged SAR

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.550
Validation result: pass	

7. TA-SAR Validation via SAR Measurements

7.1 Measurement Setup

The measurement setup is similar to normal fixed power SAR measurement. The difference in SAR measurement setup for time averaging feature validation is that the call box operates under the close loop power control mode and is connected to the PC, so that the PC can control the call box based on the test sequence to configure EUT's TX target power. The same test procedure used in conducted power setup for time-varying TX power measurement is also used in this section for time-averaging SAR measurements. Since the SAR chamber is an uncontrolled environment, the path loss between call box antenna and the EUT are well calibrated. The test setup is illustrated in Figure 7-1.

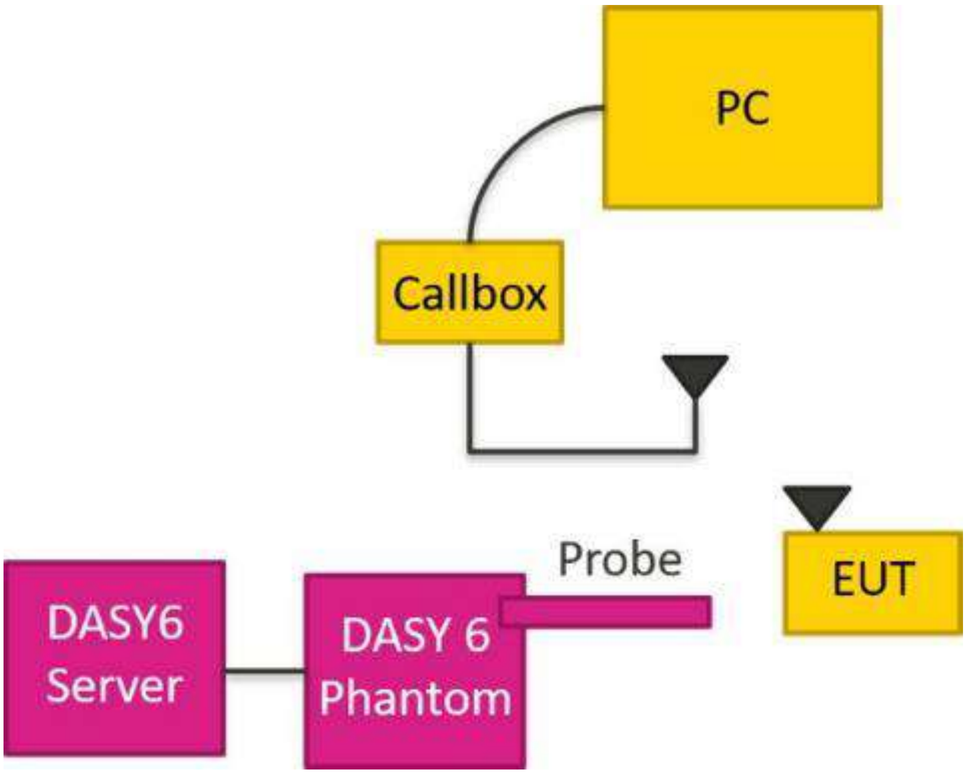


Figure 7-1 TA-SAR wireless test environment

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

In this scenario, Mediatek's TA-SAR algorithm is tested under more dynamic power test sequences. The test sequence #1 is shown in section 4.1 and test sequence #2 is tabulated in table 4.4. All of the test cases for this scenario are relegated in Table 7-1, and the test procedure follows section 4.10.2. The measurement setup is shown in Figure 7-1, 7-2(a) and 7-2(b). All of the measurements are conduct in SPORTON (i.e., an FCC certified lab) 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 algorithm can maintain the time-averaged SAR is always below the FCC requirement for all test cases. The following sections will demonstrate case-by-case to show how Mediatek's TA-SAR algorithm behaves for each RAT.

Table 7-1 Operating parameters for different TA-SAR parameters setting

Test case	RAT	Test band	Test seq.	ECI	Pmax Setting (dBm)	Measurement Pmax (dBm)	Plimit setting (dBm)	Measurement Plimit (dBm)	PEU_backoff (dBm)	PEU_max_cust (dBm)	Pass /Fail SAR limit
1	2.Time-varying TX power	GSM850	1	3	26.49	25.55	25.30	24.80	3	3	Pass
2		GSM1900	2	3	23.49	22.52	16.50	16.18	3	3	Pass
3		WCDMA II	1	3	23.00	23.14	12.30	11.35	3	3	Pass
4		WCDMA V	2	3	23.00	23.60	21.30	20.66	3	3	Pass
5		LTE Band 48	1	3	20.10	20.85	9.20	9.19	3	3	Pass
6		LTE Band 5	2	3	23.00	22.72	22.60	22.20	3	3	Pass
7		FR1 n48	1	3	21.60	21.90	10.30	10.70	3	3	Pass
8		FR1 n5	2	3	23.00	24.00	22.50	22.40	3	3	Pass

7.2.1 SAR Measurement results for 2G

- **Case1-1: 2G GSM850 result for test sequence 1**

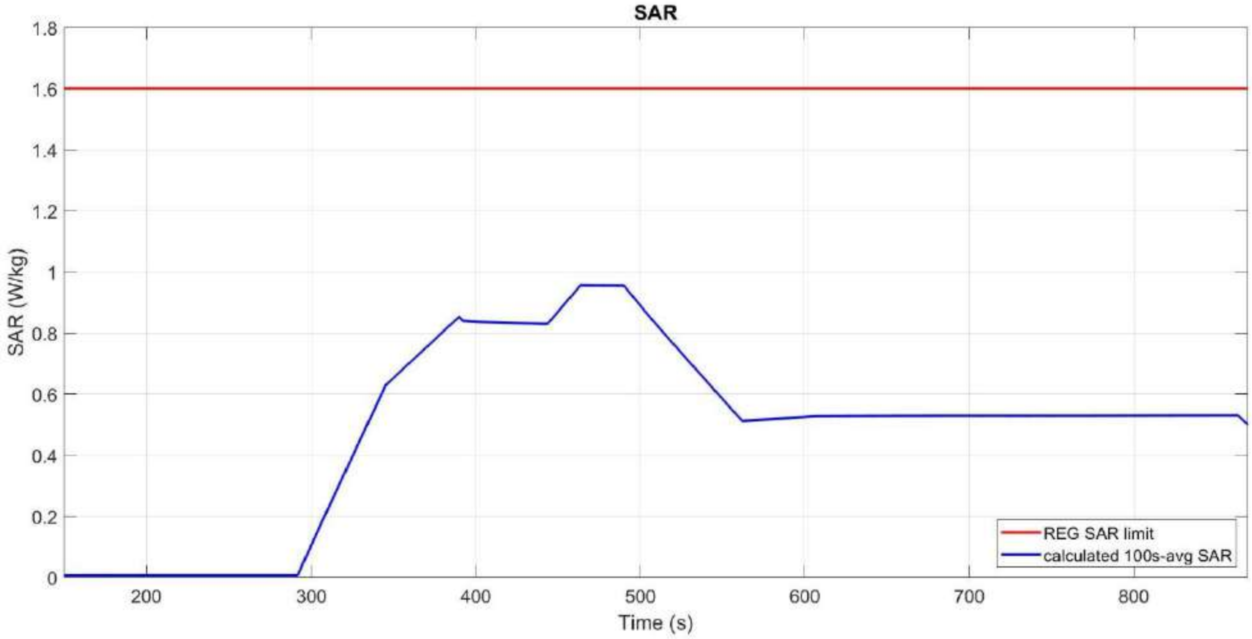


Figure Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.957 W/kg
Validation result: pass	

- **Case1-2: GSM850 result for test sequence 2**

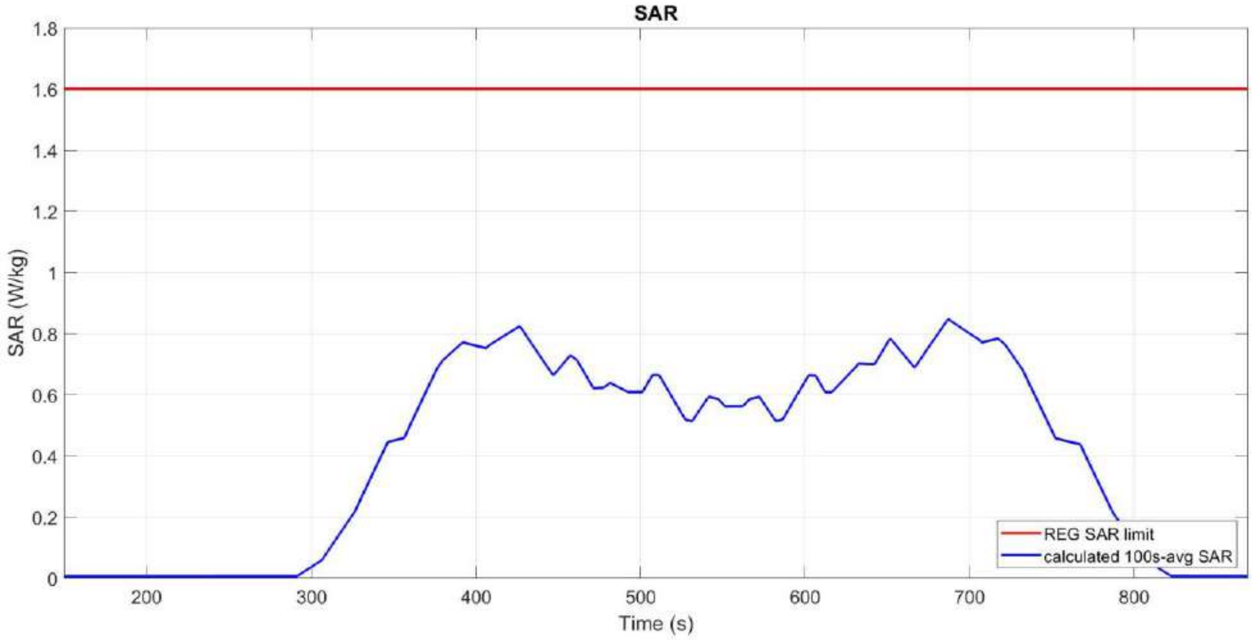


Figure Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.846 W/kg
Validation result: pass	

- **Case2-1: 2G GSM1900 result for test sequence 1**

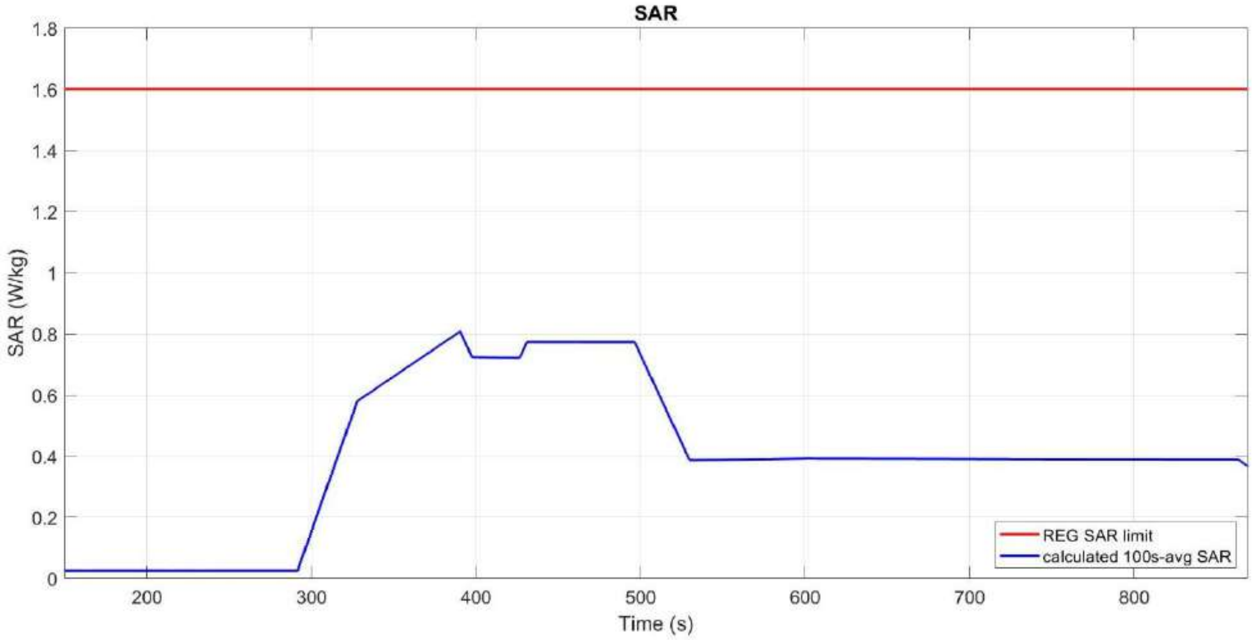


Figure 7-17 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.807 W/kg
Validation result: pass	

- **Case2-2: GSM1900 result for test sequence 2**

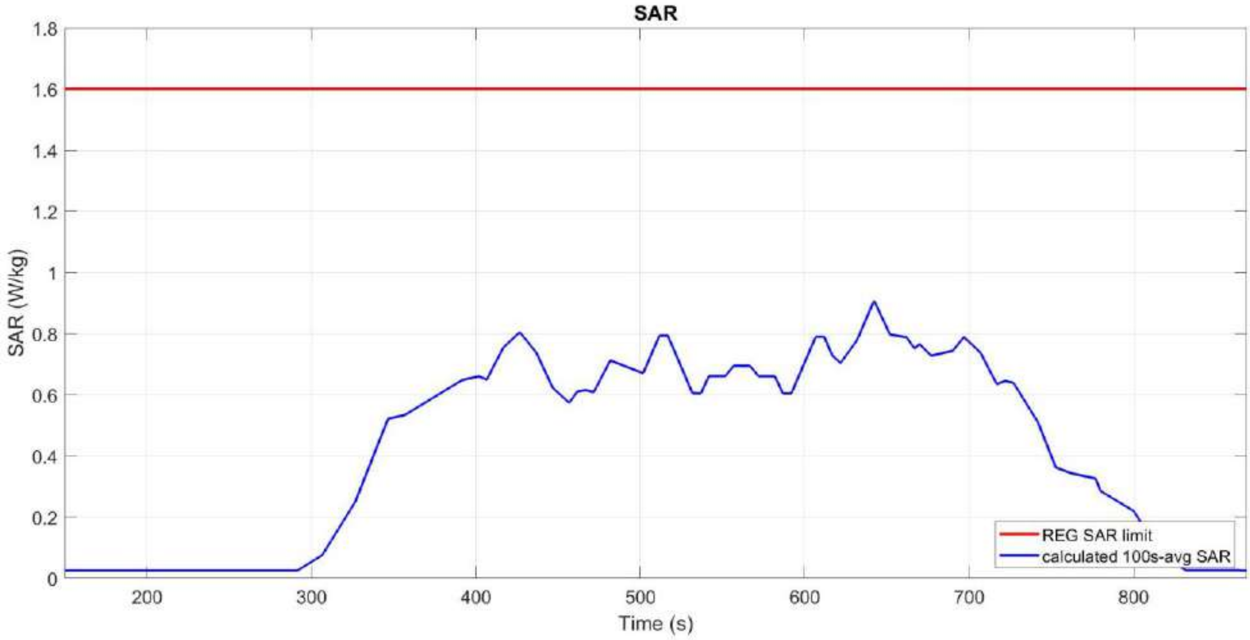


Figure 7-18 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.904 W/kg
Validation result: pass	

7.2.2 SAR Measurement results for 3G WCDMA

- **Case3-1: WCDMA B2 result for test sequence 1**

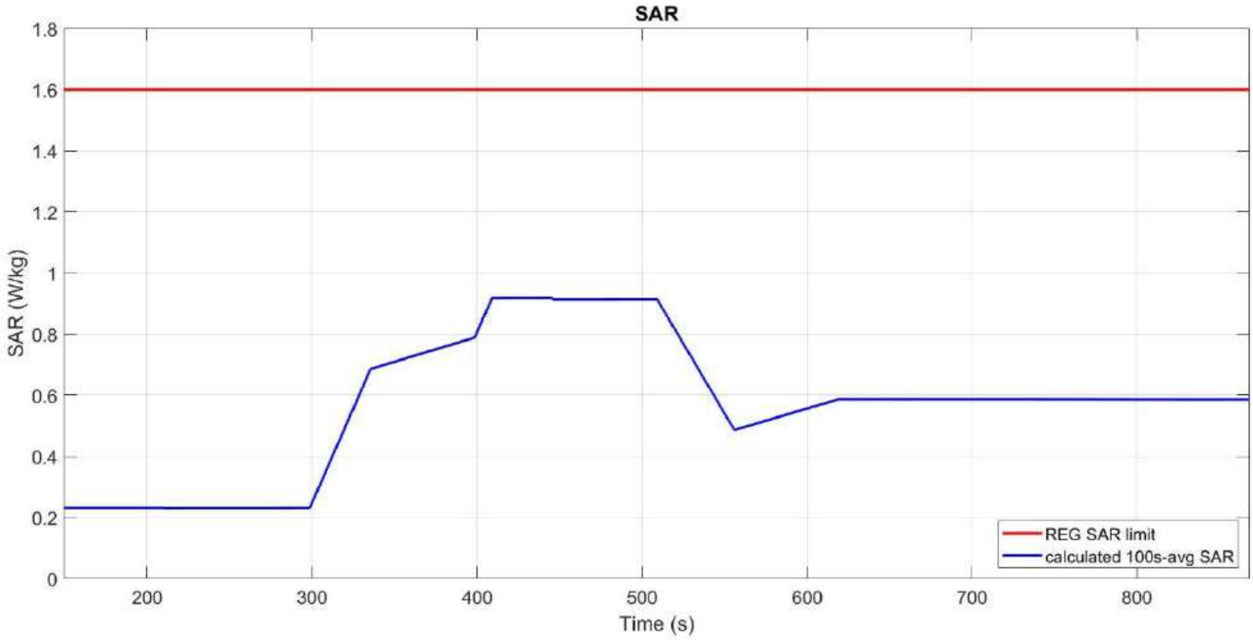


Figure 7-11 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.919 W/kg
Validation result: pass	

- **Case3-2: WCDMA B2 result for test sequence 2**

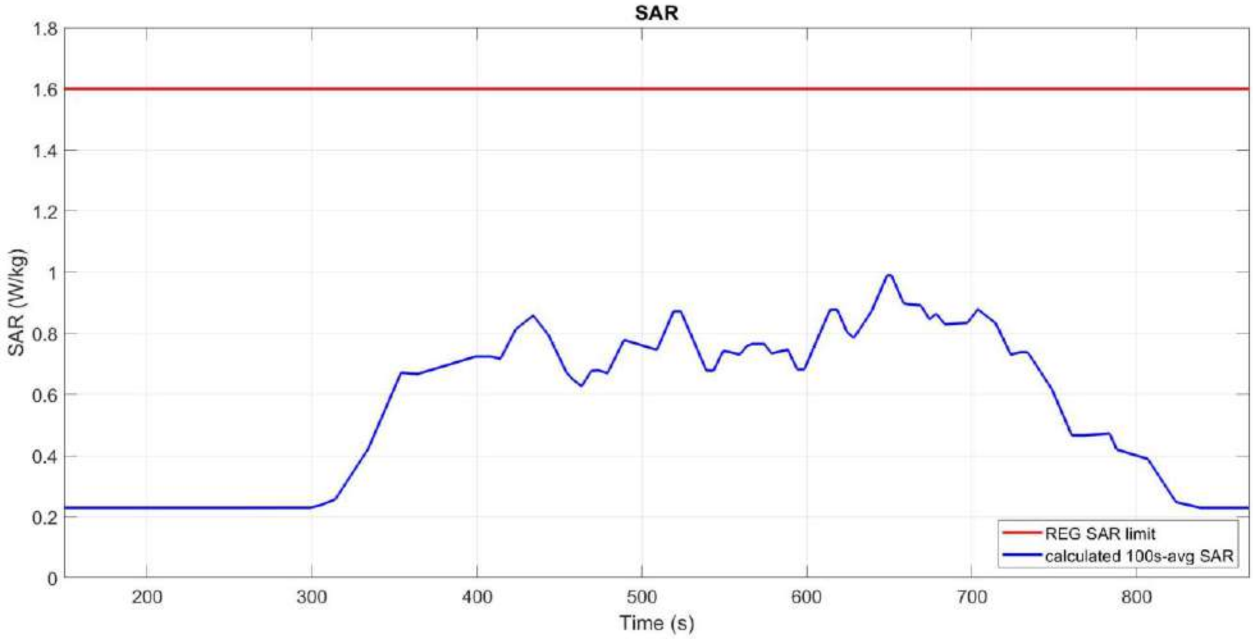


Figure 7-12 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.989 W/kg
Validation result: pass	

- **Case4-1: WCDMA B5 result for test sequence 1**

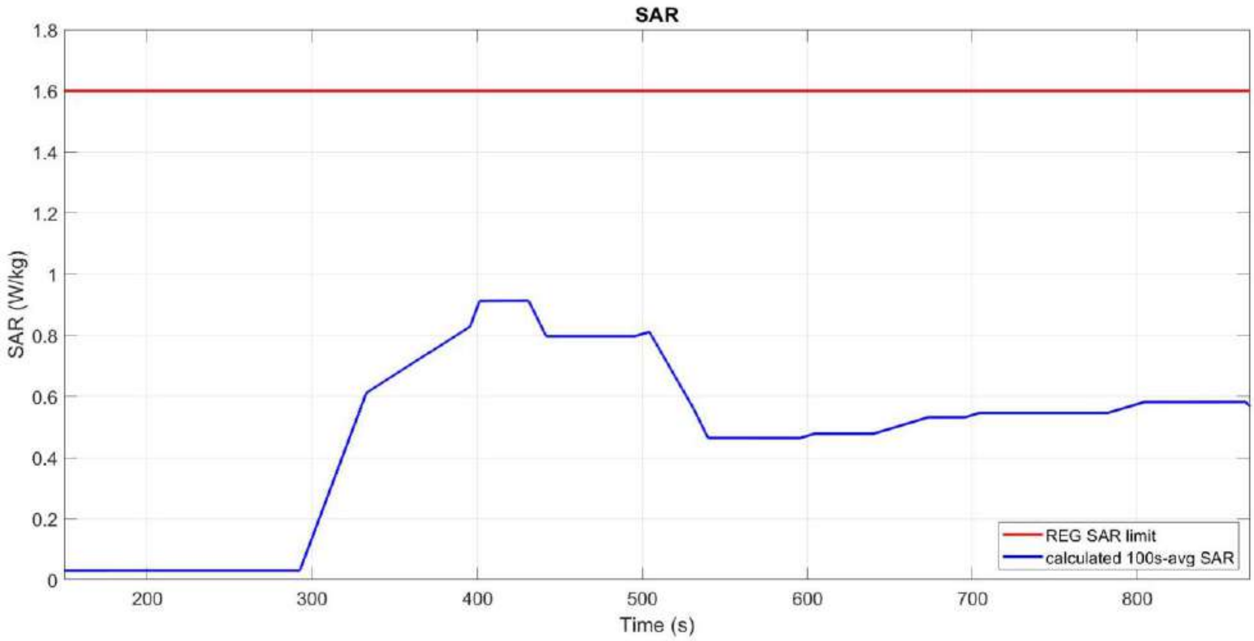


Figure 7-13 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.913 W/kg
Validation result: pass	

- **Case4-2: WCDMA B5 result for test sequence 2**

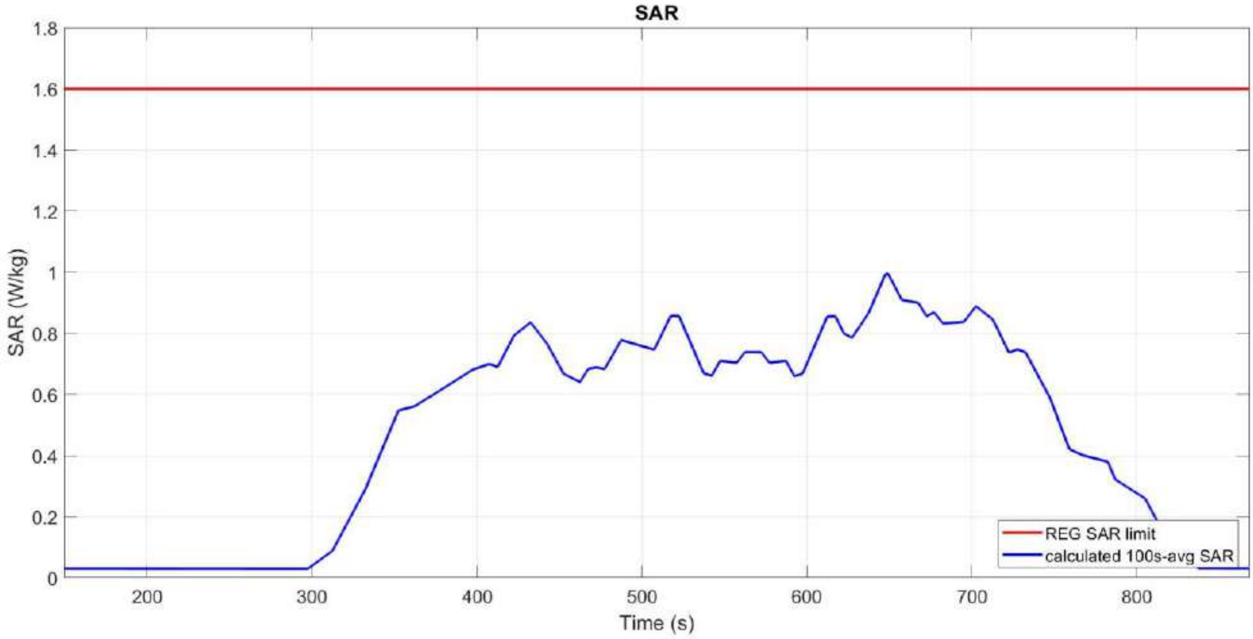


Figure 7-14 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.995 W/kg
Validation result: pass	

7.2.3 SAR Measurement results for LTE

- **Case5-1: LTE B48 result for test sequence 1**

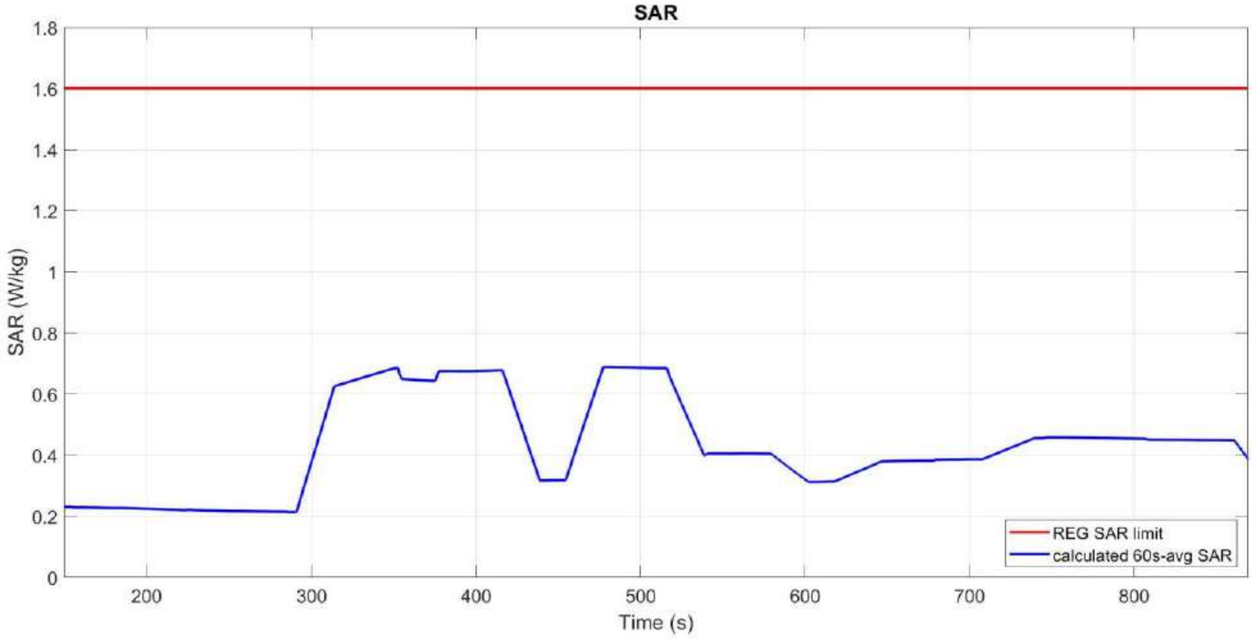


Figure 7-7 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.688 W/kg
Validation result: pass	

- **Case5-2: LTE B48 result for test sequence 2**

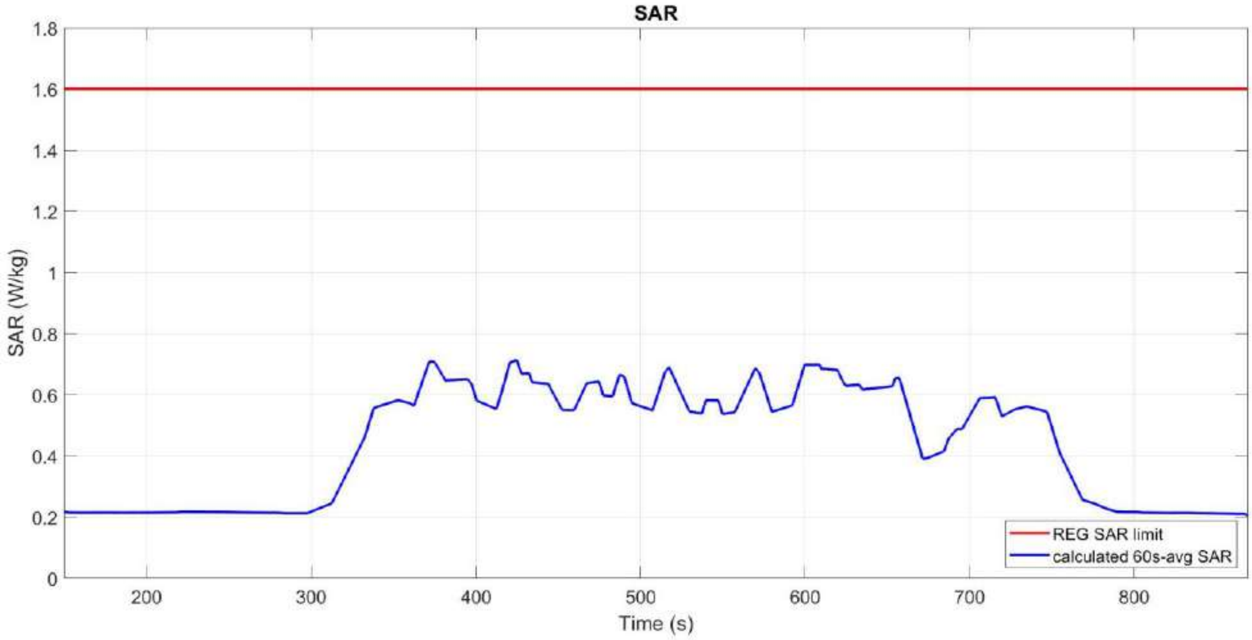


Figure 7-8 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.714 W/kg
Validation result: pass	

- **Case6-1: LTE B5 result for test sequence 1**

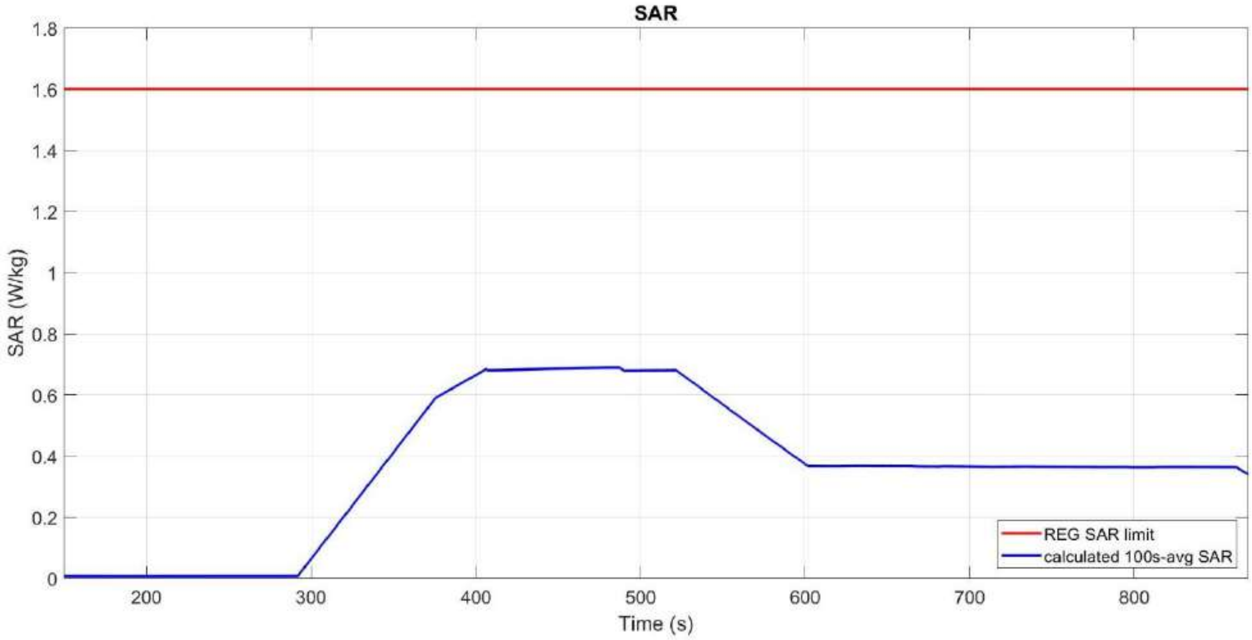


Figure 7-9 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.669 W/kg
Validation result: pass	

- **Case6-2: LTE B5 result for test sequence 2**

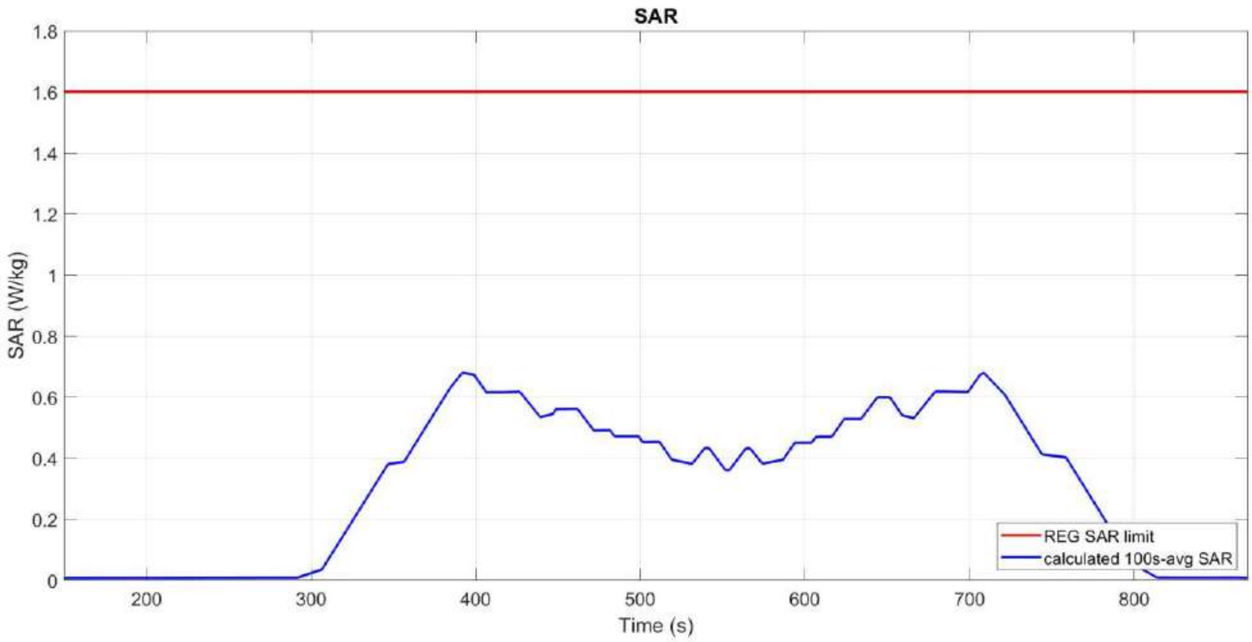


Figure 7-10 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.679 W/kg
Validation result: pass	

7.2.4 SAR Measurement results for NR

- **Case7-1: NR n48 result for test sequence 1**

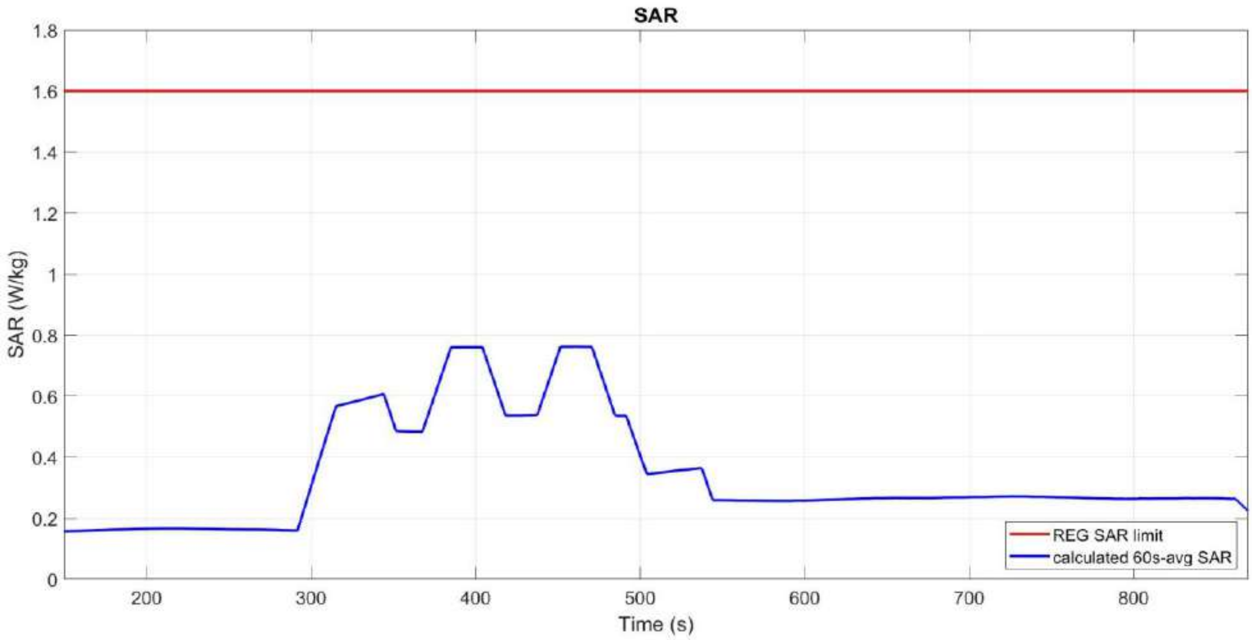


Figure 7-3 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.762 W/kg
Validation result: pass	

- **Case7-2: NR n48 result for test sequence 2**

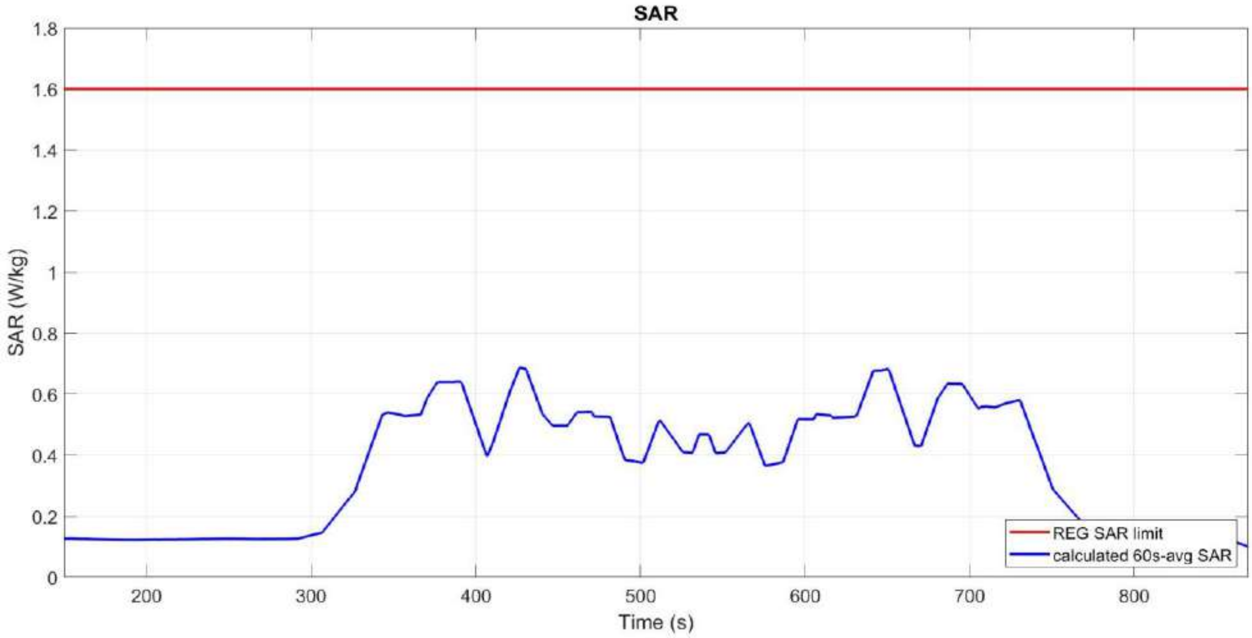


Figure 7-4 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.687 W/kg
Validation result: pass	

- **Case8-1: NR n5 result for test sequence 1**

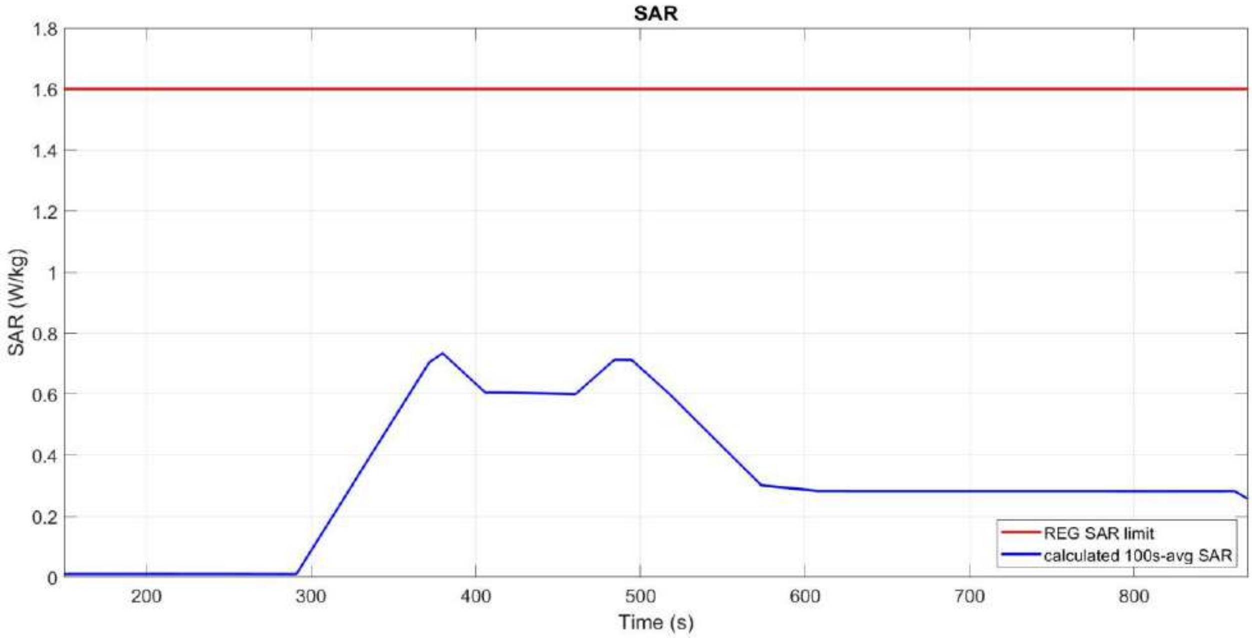


Figure 7-5 Time-averaged SAR

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.733 W/kg
Validation result: pass	

- **Case8-2: NR n5 result for test sequence 2**

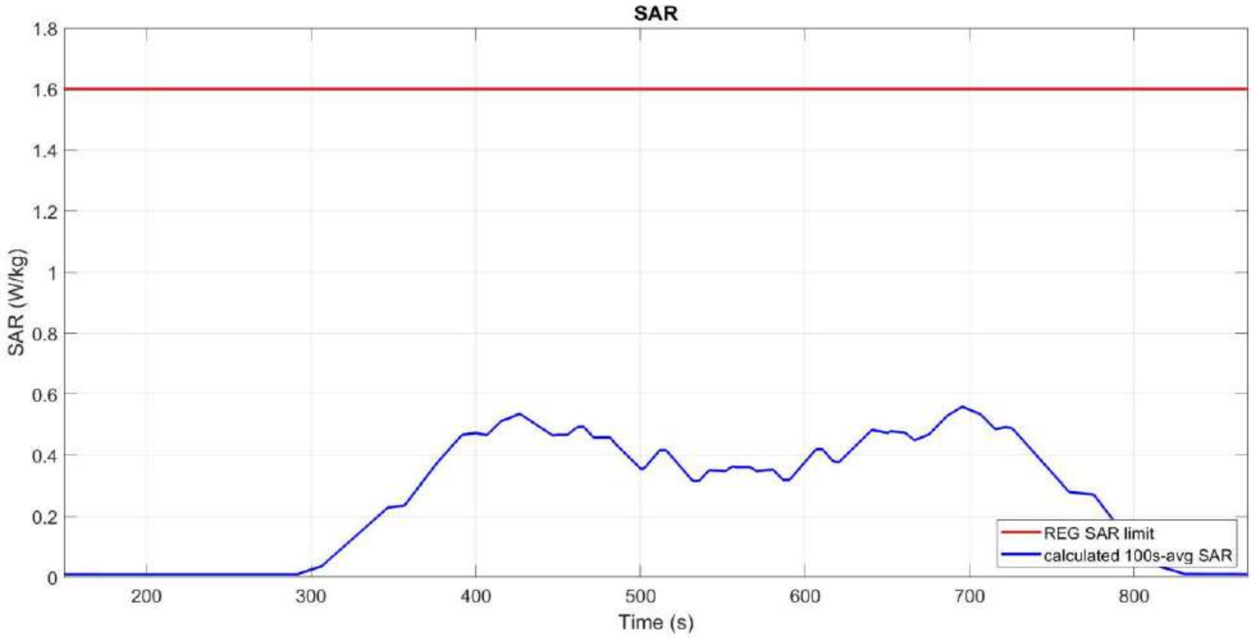


Figure 7-6 Time-averaged SAR for case

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.558 W/kg
Validation result: pass	

8. TA-SAR/TA-PD Joint Validation via Radiated Power Measurements

8.1 Measurement Setup

The schematic of measurement setup is shown in Figure 8-2, 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.

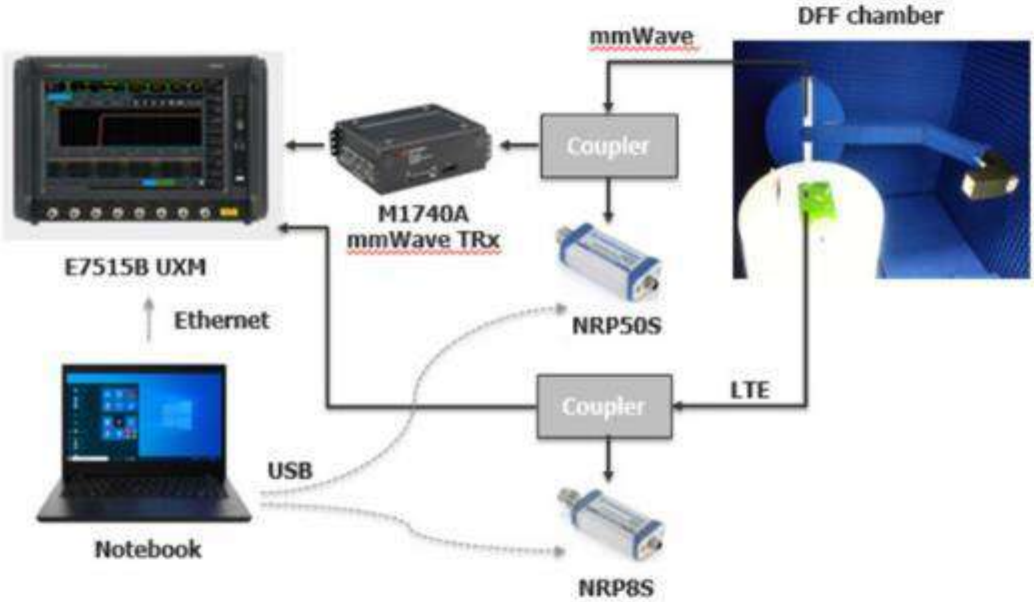


Figure 8-1 TA-PD radiated power measurement setup

8.1.1 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 proposed in Chapter 5 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. It is noted that TA-PD is independent of the used antenna module and beams. Without loss of generality, module head-0 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. It is noted that P_{FR2_limit} = input.power.limit + 10xlog10(N), where N is "Feed No." of each beam ID.

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

Table for FR2 TA-SAR validation test case list

Test Case #	Test Scenario	Test Configuration
1	1.Range of TA-PD Parameter	LTE B2 + n261 Aim0 Beam 0
2	2.Time-varying TX power	LTE B2 + n260 Aim0 Beam 0
3		LTE B2 + n261 Aim0 Beam 0
4	3.Call disconnection	LTE B2 + n261 Aim0 Beam 0
5	4.Band handover	LTE B2 + n261 to LTE B2 + n260
6	5.Beam switching	n261 Aim0 Beam 0 to Beam 14
7	6.SAR vs.PD exposure switching	LTE B2 + n261 Aim0 Beam 0

Table 8-1 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 (dBm)	at Input.power.limit (W/m2)	Configuration	meas.EIRP at input.power.limit (dBm)
mmWave FR2	n260	AiM0	0	0.25	2.74	Top	14.16
	n261	AiM0	0	2.15	3.21	Top	14.71
			14	2.13	2.84	Top	12.24
Tech	Band	Antenna	ECI	mea. Plimit	at Plimit(W/kg)	Configuration	
LTE	Band 2	0	3	15.78	0.88	Back	

The radio configurations and selections for LTE and mmW NR validation test are listed in Table 8-2.

Table 8-2 Selections for LTE + mmW NR validation measurements

Test Case #	Test Scenario	Test band	Ant	Beam ID	ECI	Channel	Freq (MHz)	Modulation	RB size	RB offset	UL Duty cycle	Position	PD result at Input.power.limit (W/m2)
-	Anchor band for FR2	LTE Band 2	Ant 0	-	3	19100	1900	QPSK	1	0	100	Back	-
1	1.Range of TA-PD Parameter	n261	AiM 0	0	-	2077917	27925	DFT-QPSK	1	0	70	Top	3.21
2	2.Time-varying TX power	n260	AiM 0	0	-	2254167	38500	DFT-QPSK	1	0	70	Top	2.74
3		n261	AiM 0	0	-	2077917	27925	DFT-QPSK	1	0	70	Top	3.21
4	3.Call disconnection	n261	AiM 0	0	-	2077917	27925	DFT-QPSK	1	0	70	Top	3.21
5	4.Band handover	n261	AiM 0	0	-	2077917	27925	DFT-QPSK	1	0	70	Top	3.21
		n260	AiM 0	0	-	2077917	27925	DFT-QPSK	1	0	70	Top	3.21
6	5.Beam switching	n261	AiM 0	0	-	2077917	27925	DFT-QPSK	1	0	70	Top	3.21
		n261	AiM 0	14	-	2077917	27925	DFT-QPSK	1	0	70	Top	2.84
7	6.SAR vs.PD exposure switching	n261	AiM 0	0	-	2077917	27925	DFT-QPSK	1	0	70	Top	3.21

Table 8-3 Measured $Plimit$ and $Pmax$ of selected radio configuration

Test case	RAT	Test band	ECI	Pmax Setting (dBm)	Measurement Pmax (dBm)	Plimit setting (dBm)	Measurement Plimit (dBm)	PEU_backoff (dBm)	PEU_max_cust (dBm)	Pass /Fail PD limit
1	Anchor band for FR2	LTE Band 2	3	23.00	22.12	15.40	15.78	3	3	Pass

Test case	RAT	Test band	Test seq.	Beam ID	Plimit setting (dBm)	PEU_backoff (dBm)	PEU_max_cust (dBm)	Pass /Fail PD limit
1	1. Range of TA-PD Parameter	N261	0	0	2.15	1.5	10	Pass
2	2. Time-varying TX power	N260	0	0	0.25	1.5	10	Pass
3		N261	0	0	2.15	1.5	10	Pass
4	3. Call disconnection	N261	0	0	2.15	1.5	10	Pass
5	4. Band handover	N261	0	0	2.15	1.5	10	Pass
		N260	0	0	2.15	1.5	10	Pass
6	5. Beam switching	N261	0	0	2.15	1.5	10	Pass
		N261	0	14	2.13	1.5	10	Pass
7	6. SAR vs.PD exposure switching	N261	0	0	2.15	1.5	10	Pass

8.2 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 8-3, and the test procedure follows section 5.2.2. 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.

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^2PD), as well as total normalized time-averaged exposure over time converted from the TX time-averaged power by using the equation listed in section 5.2.2. As seen in the figures, either TX average power or total normalized exposure ratio is below the compliance limit.

- **Case1 in table 8-3: TA-PS result**

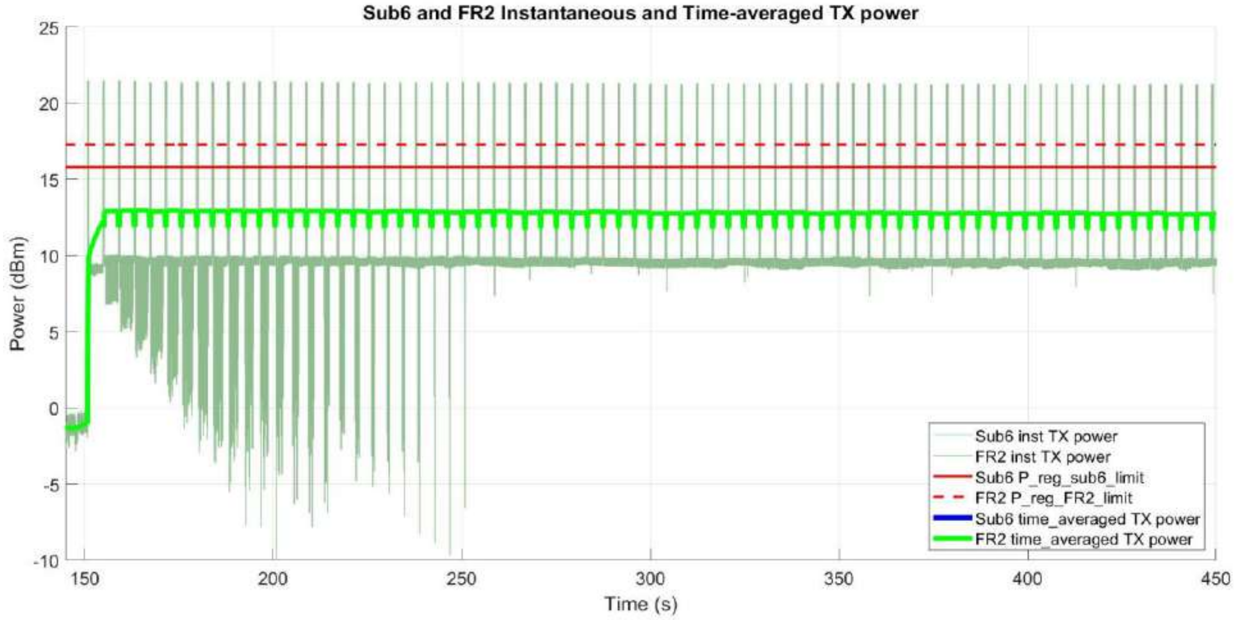


Figure 8-2 LTE, mmW inst. Pwr and Time-averaged Tx Pwr

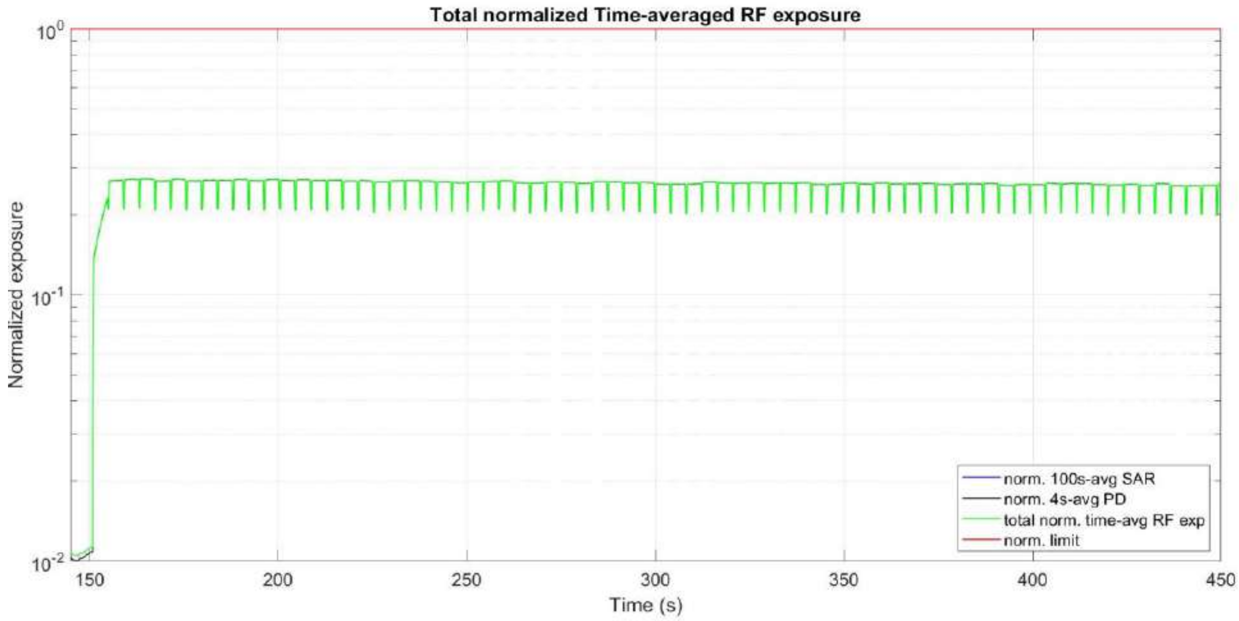


Figure 8-3 Total Normalized Time-averaged RF exposure

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.274
Validation result: pass	

8.3 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 8-3, and the test procedure follows section 5.3.2. 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.

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 ($4\mathrm{cm}^2$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 5.3.2. As seen in the figures, either TX average power or total normalized exposure ratio is below the compliance limit.

- **Case2: Time-varying TX power result for n260**

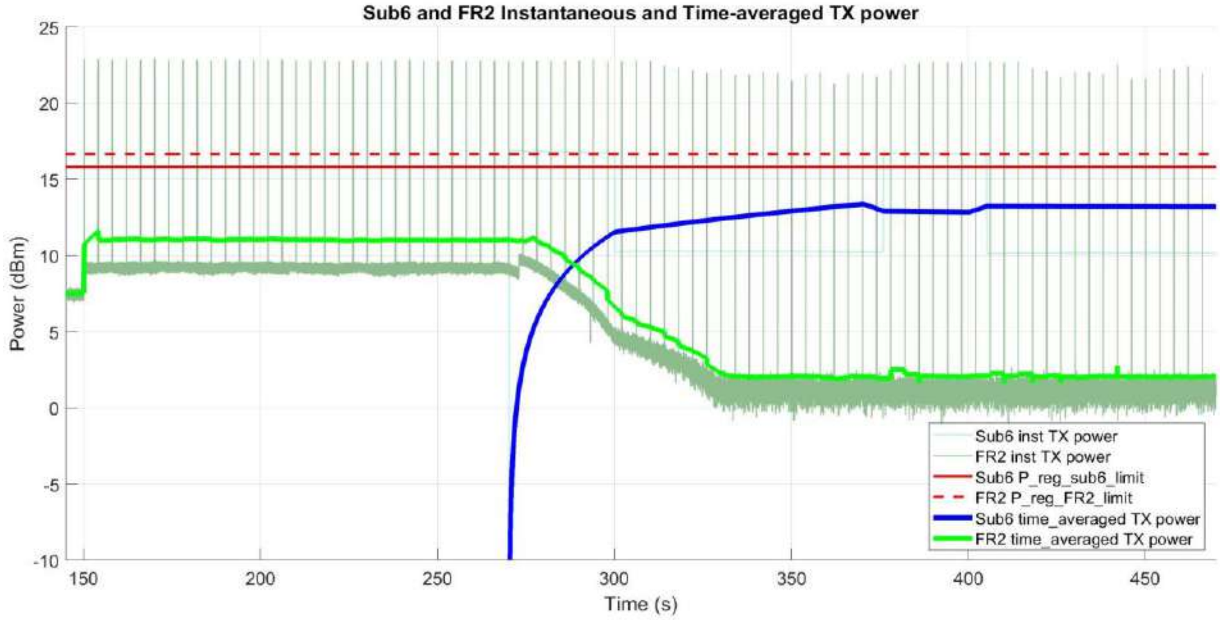


Figure 8-4 LTE, mmW inst. Pwr and Time-averaged Tx Pwr

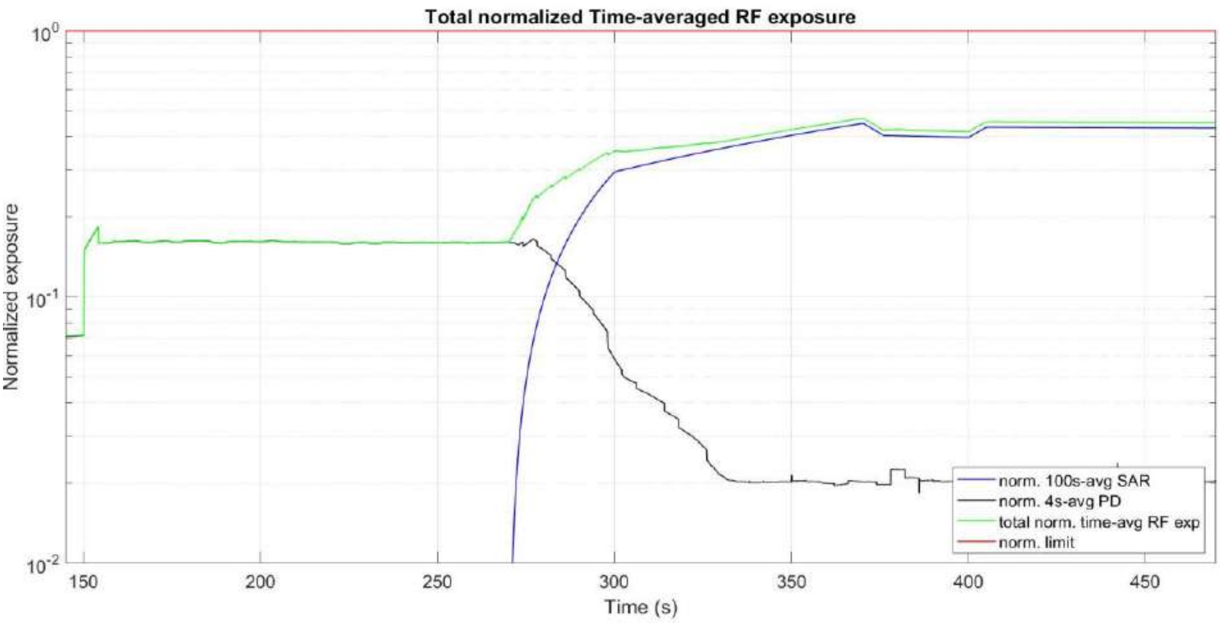


Figure 8-5 Total Normalized Time-averaged RF exposure

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.470
Validation result: pass	

- **Case3: Time-varying TX power result for n261**

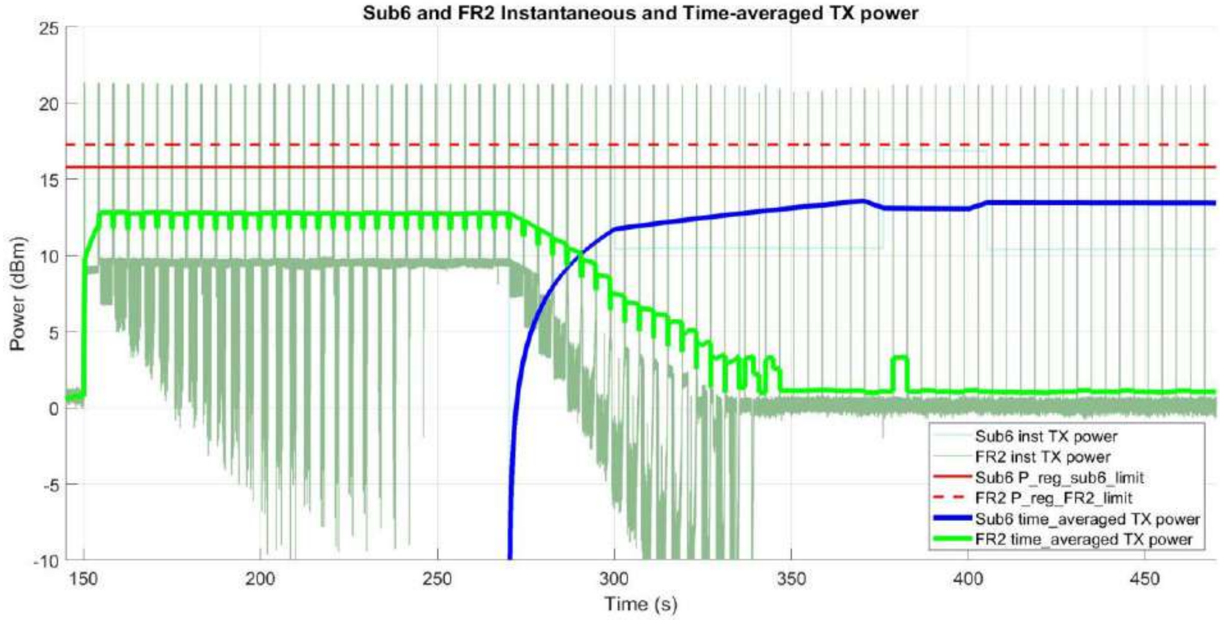


Figure 8-6 LTE, mmW inst. Pwr and Time-averaged Tx Pwr

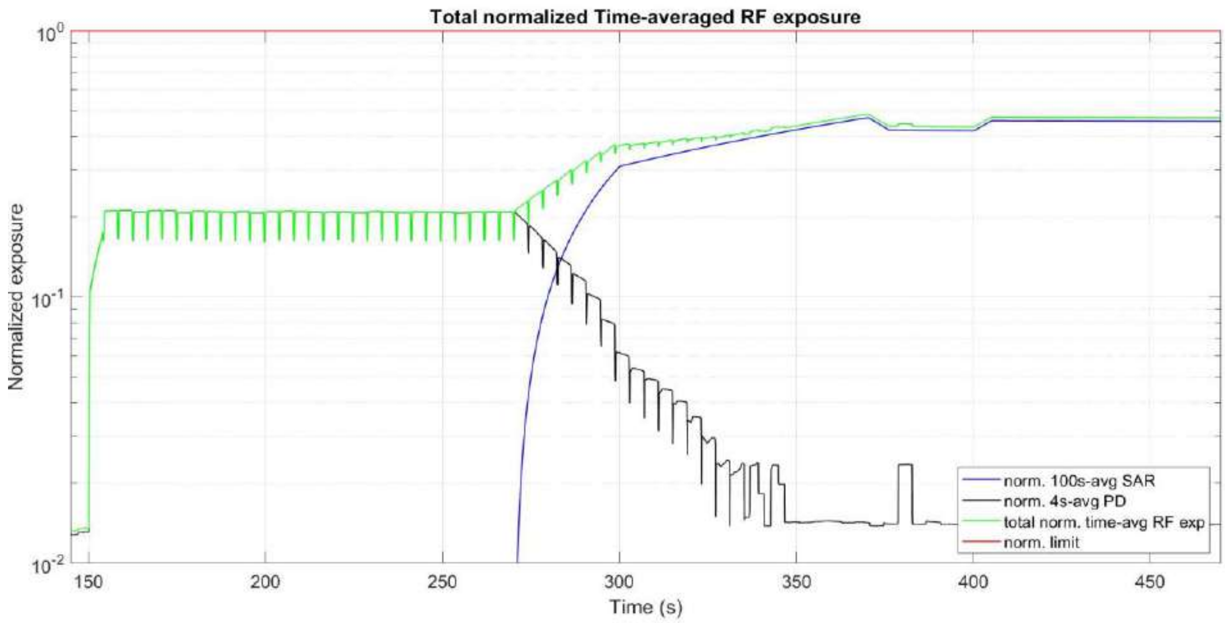


Figure 8-7 Total Normalized Time-averaged RF exposure

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.486
Validation result: pass	

8.4 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 8-3 and the test procedure follows section 5.4.2. 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.

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^2PD), as well as total normalized time-averaged exposure over time converted from the TX time-averaged power by using the equation listed in section 5.4.2. As seen in the figures, either TX average power or total normalized exposure ratio is below the compliance limit.

- **Case4: Call disconnection result for n261**

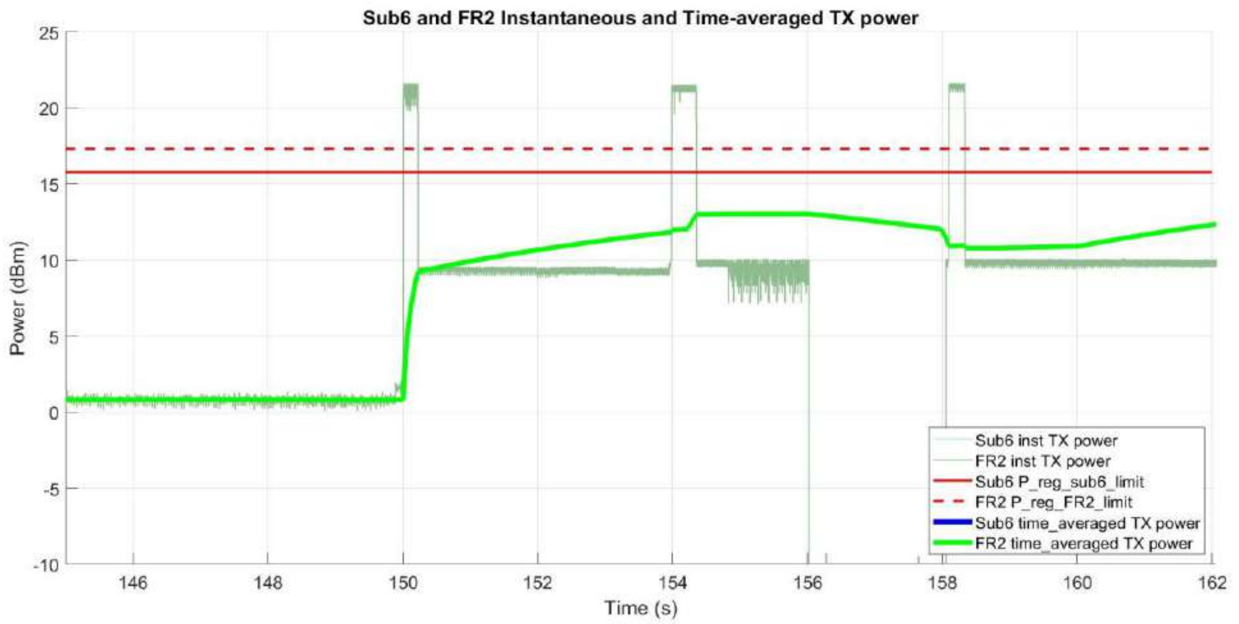


Figure 8-8 LTE, mmW inst. Pwr and Time-averaged Tx Pwr (case #pd3.1)

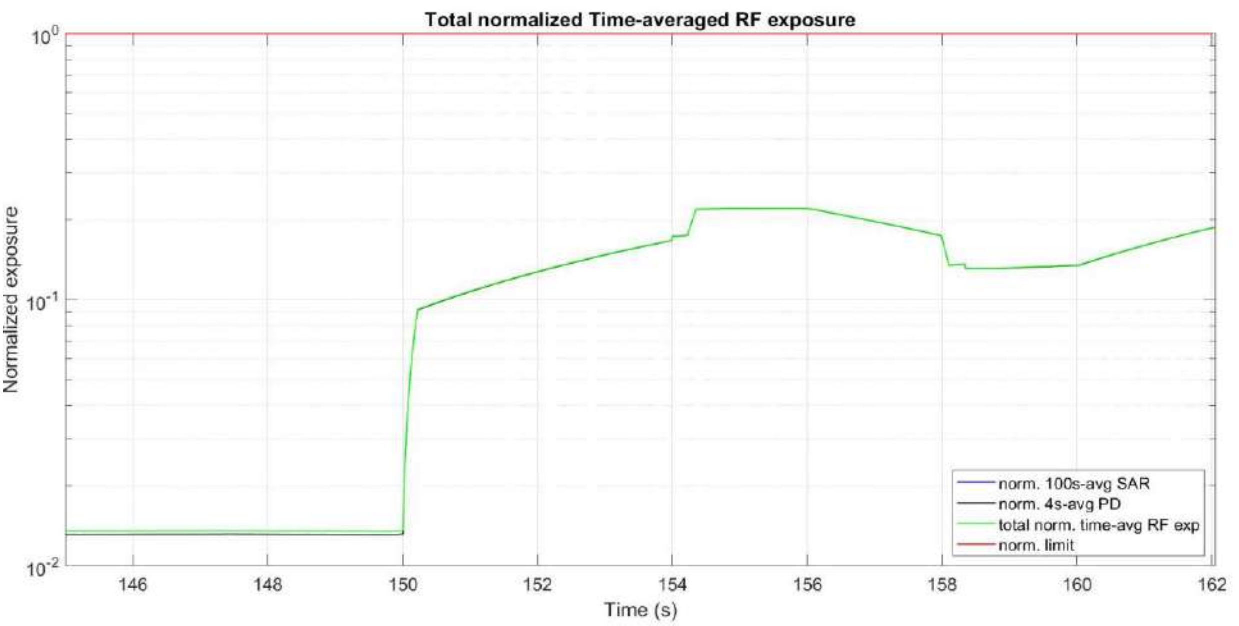


Figure 8-9 Total Normalized Time-averaged RF exposure (case #pd3.1)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.220
Validation result: pass	

8.5 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 8-3, and the test procedure follows section 5.5.2. 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.

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 n261 operates from 0 to 170 seconds, and at the time instance of ~170s the band is changed to n260. 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^2PD), as well as total normalized time-averaged exposure over time converted from the TX time-averaged power by using the equation listed in section 5.5.2. As seen in the figures, either TX average power or total normalized exposure ratio is below the compliance limit.

- **Case5: Band handover for n261 to n260**

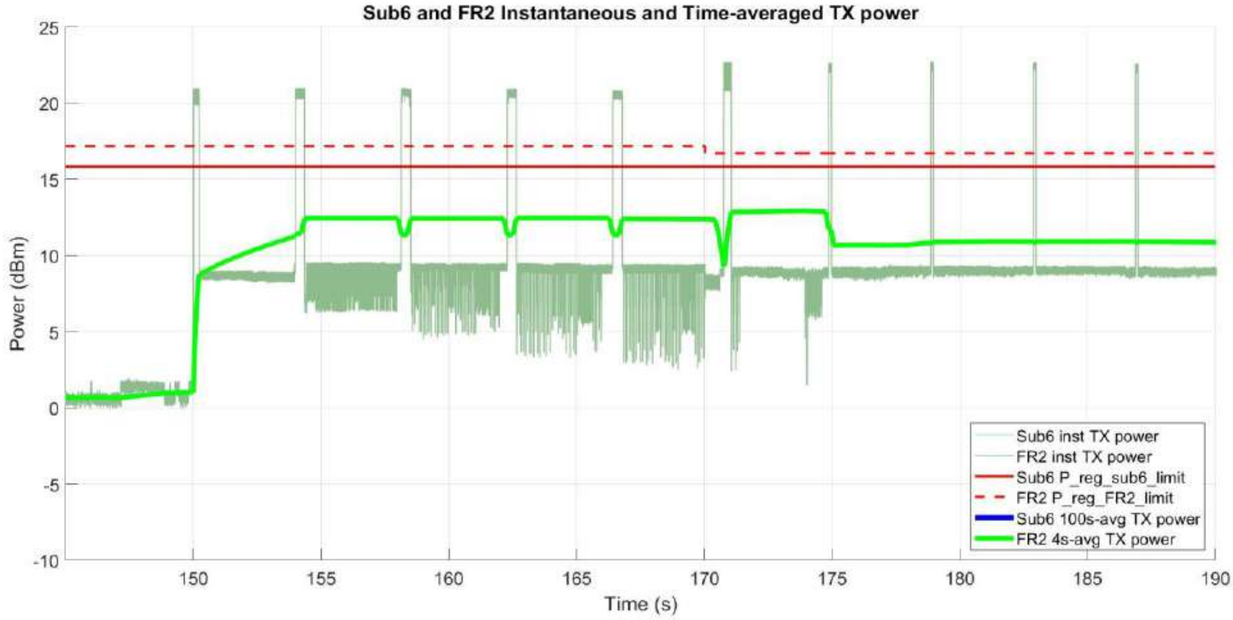


Figure 8-10 LTE, mmW inst. Pwr and Time-averaged Tx Pwr

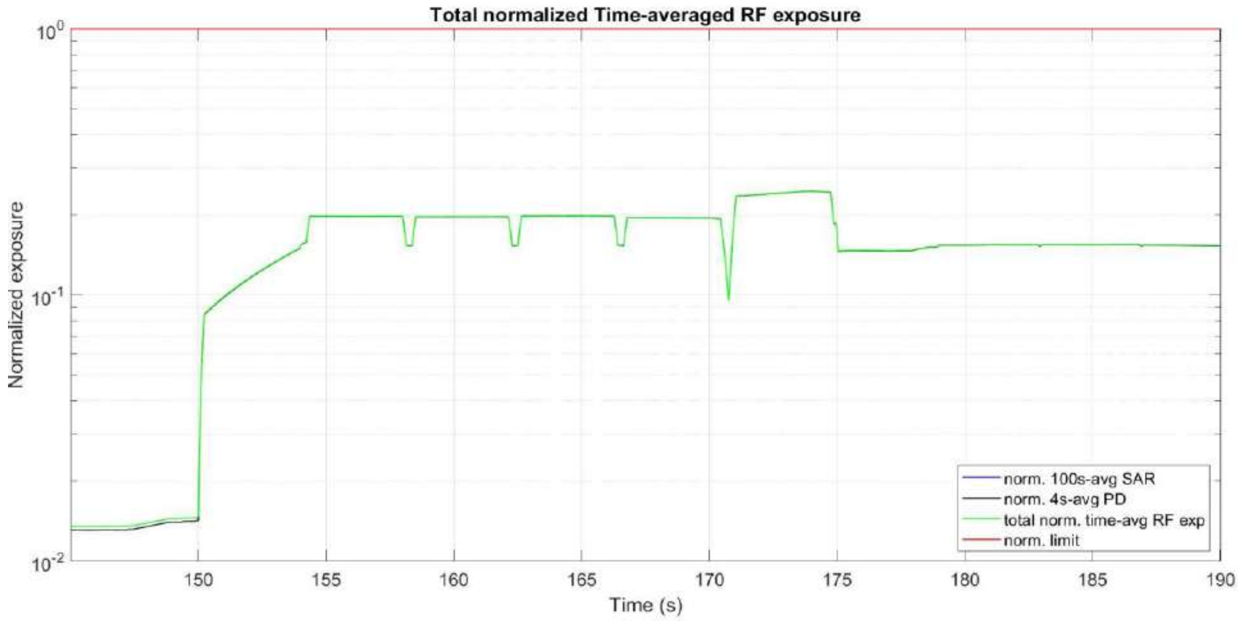


Figure 8-11 Total Normalized Time-averaged RF exposure

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.246
Validation result: pass	

8.6 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 8-3, and the test procedure follows section 5.6.2. 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.

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^2PD), as well as total normalized time-averaged exposure over time converted from the TX time-averaged power by using the equation listed in section 5.6.2. As seen in the figures, total normalized exposure ratio is below the compliance limit.

- **Case 6: Beam Switch result for n261 beam 0 to beam 14**

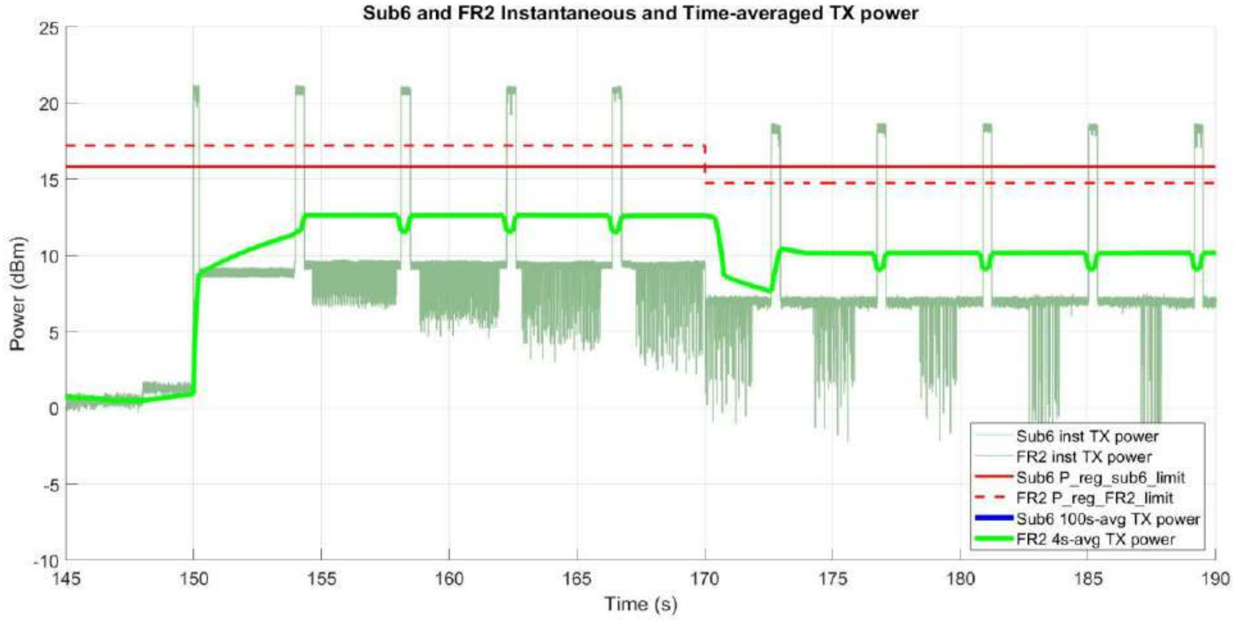


Figure 8-12 LTE, mmW inst. Pwr and Time-averaged Tx Pwr

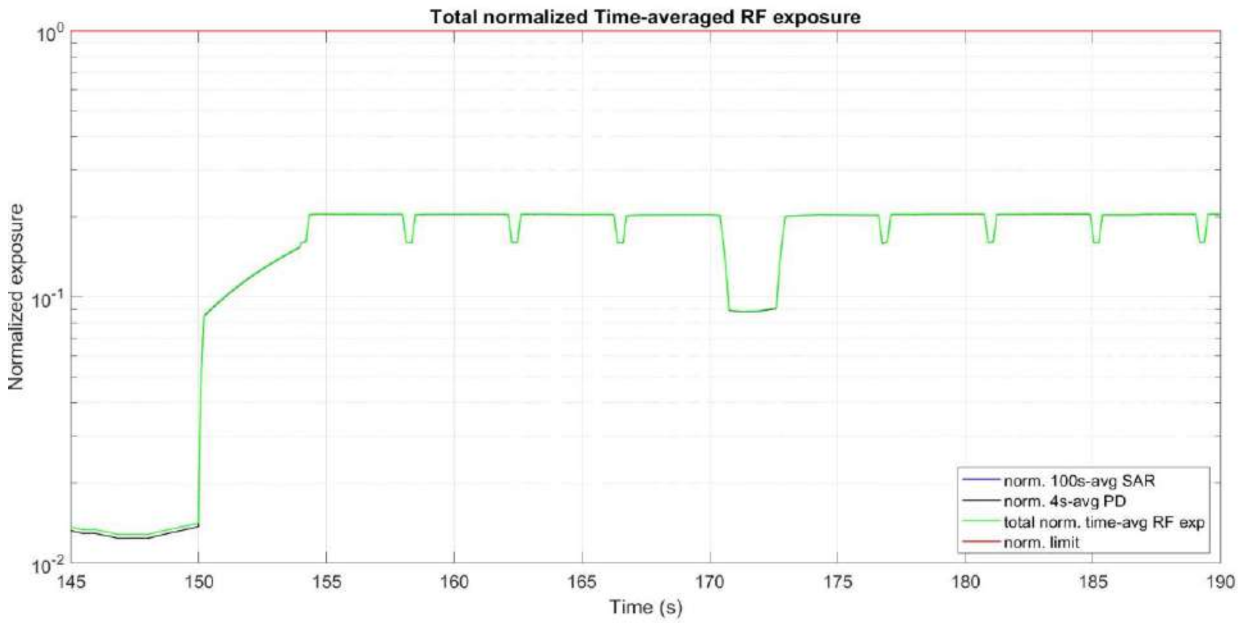


Figure 8-13 Total Normalized Time-averaged RF exposure

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.206
Validation result: pass	

8.7 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 8-3, and the test procedure follows section 5.7.2 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.

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 ($4\mathrm{cm}^2$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 5.7.2. As seen in the figures, total normalized exposure ratio is below the compliance limit.

- **Case 7: SAR vs.PD exposure switching result for n261**

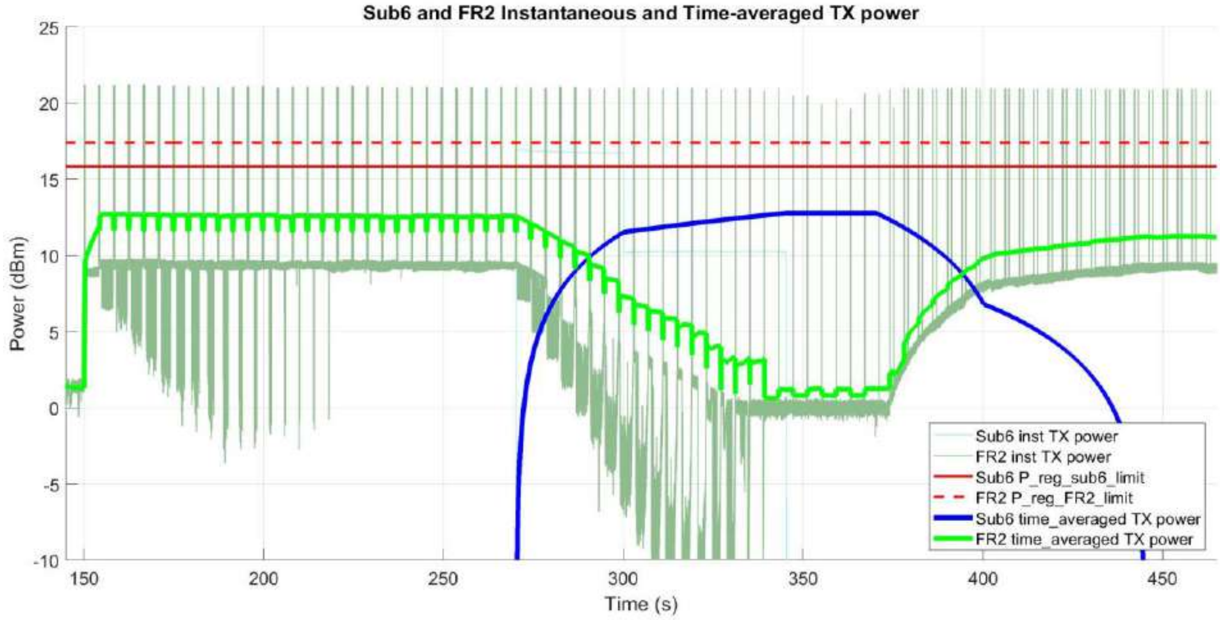


Figure 8-14 LTE, mmW inst. Pwr and Time-averaged Tx Pwr

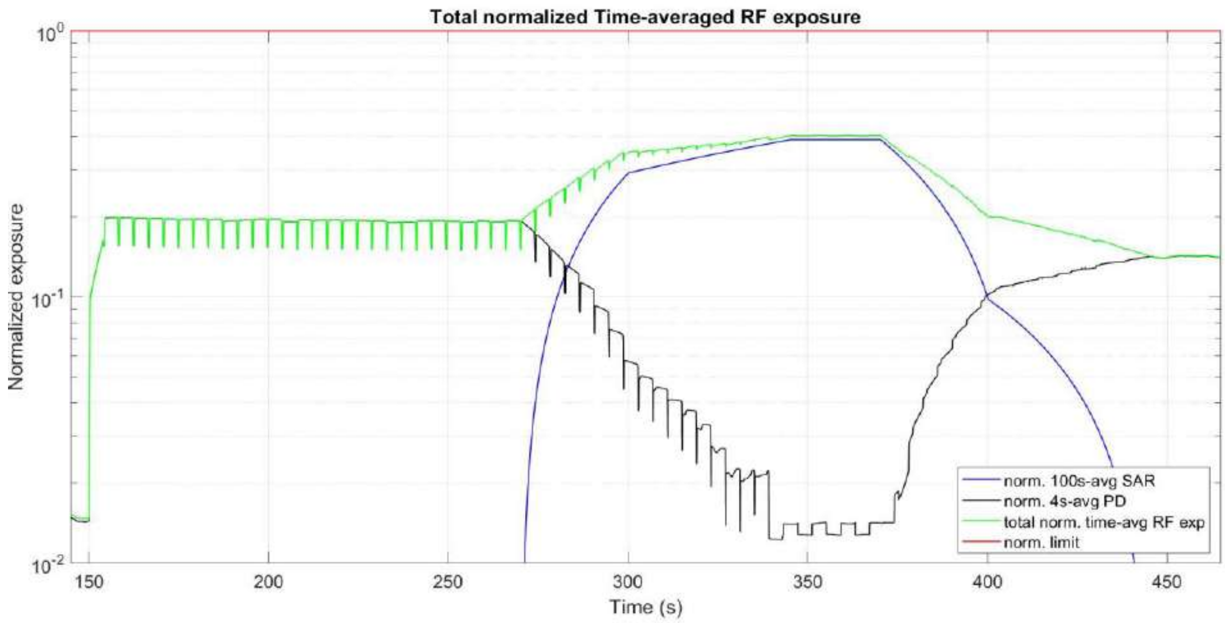


Figure 8-15 Total Normalized Time-averaged RF exposure

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.404
Validation result: pass	

9. TA-SAR/TA-PD Joint Validation via PD Measurements

9.1 Measurement Setup

In this section, the near-field measurements are conducted in an FCC certified lab (i.e., SPORTON), and the measurement setup is shown in Figure 9-1 (and its photo is shown in Figure 9-2). 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 5.1, 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 $PD(t)$=$PD_{sp,relative}(t) \times PD\_design\_target$, 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.

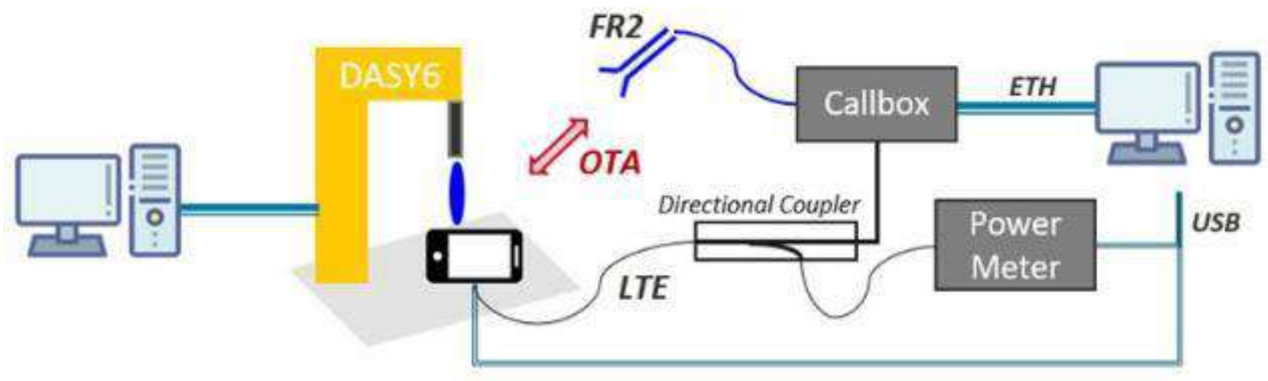


Figure 9-1 TA-PD near-field measurement setup diagram

9.2 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 8-3 and the test procedure follows section 5.8.2. The measurement setup is shown in Figure 9-2. All of the measurements are conduct in SPORTON (i.e., an FCC certified lab) 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.

The following figure illustrates the normalized time-averaged exposures for LTE (1gSAR), mmW ($4\mathrm{cm}^2$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 5.8.2.

- **Case2: Time-varying TX power for n260**

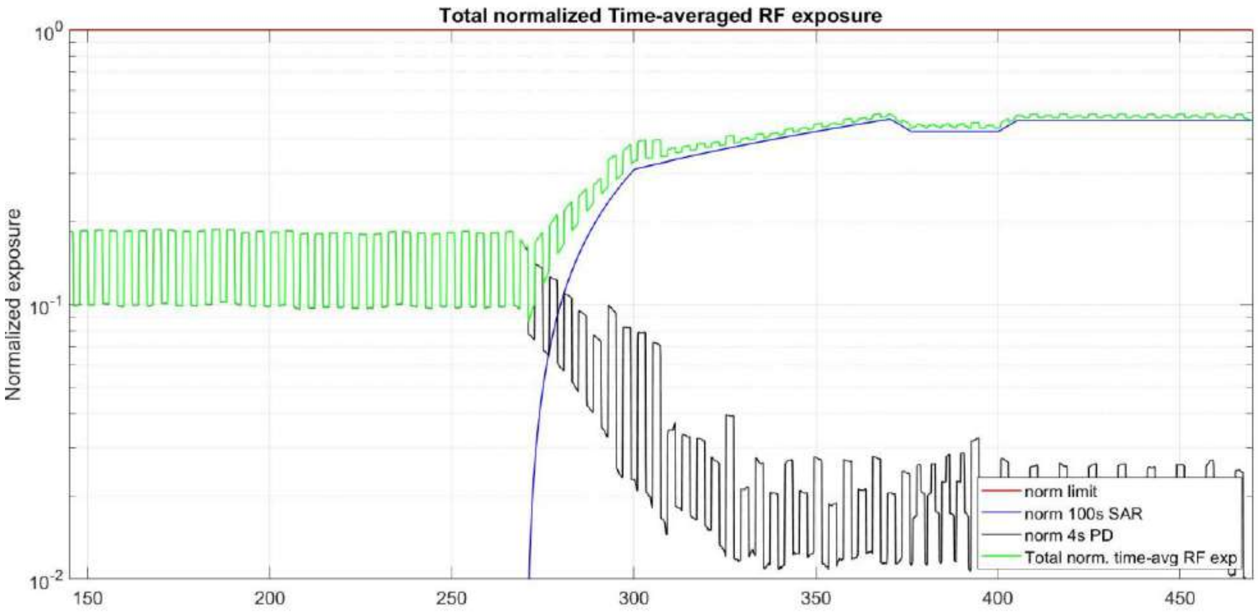


Figure 9-3 The Total Normalized Time-averaged RF exposure (n260)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.494
Validation result: pass	

- **Case3: Time-varying TX power for n261**

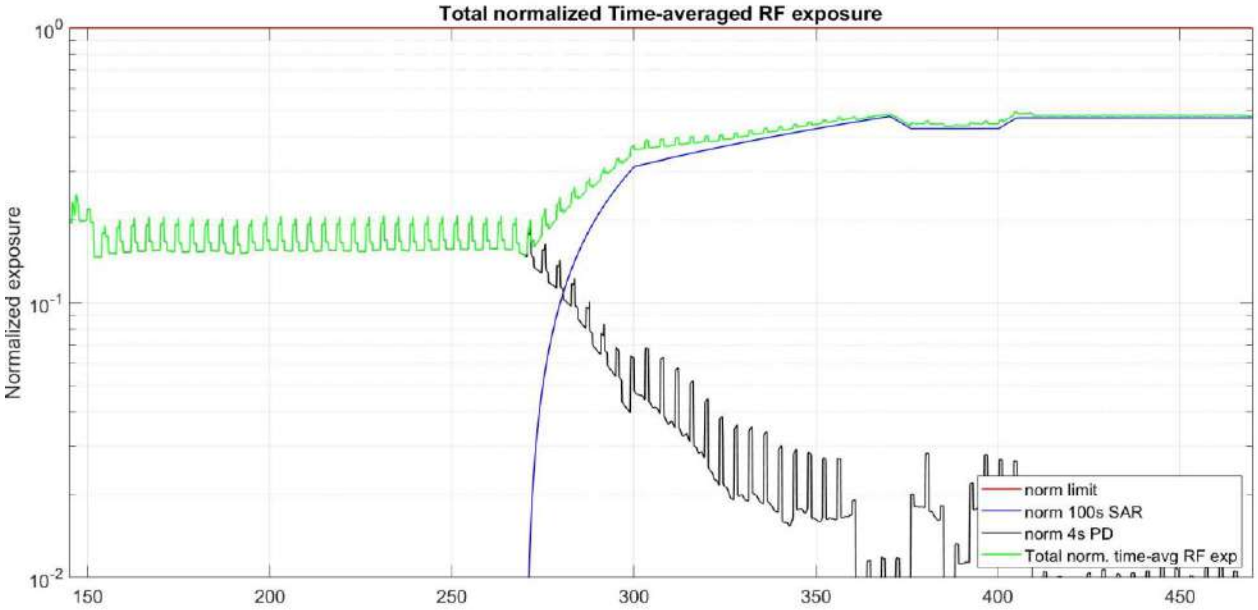


Figure 9-4 The Total Normalized Time-averaged RF exposure (n261)

FCC limit of total RF exposure (normalized)	1.0
Max total normalized time-averaged RF exposure	0.497
Validation result: pass	

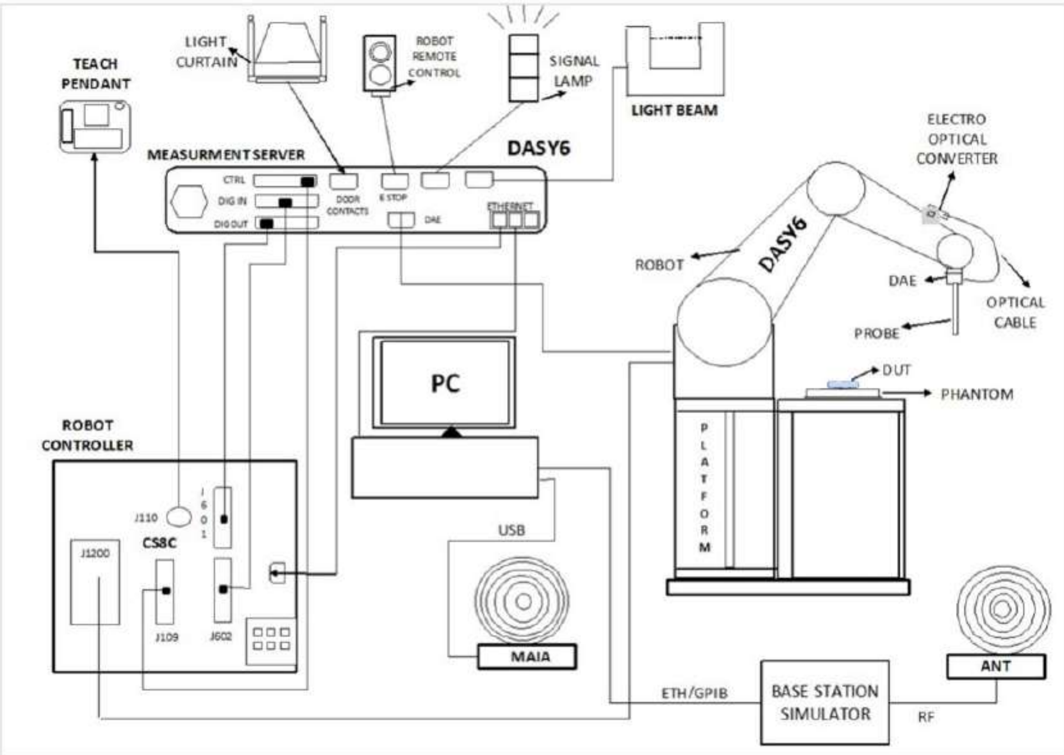
10. Conclusions

This document proposes TA-SAR and TA-PD test scenarios and procedures, and further proves Mediatek's TA-SAR and TA-PD algorithms can meet the FCC SAR and PD regulations with the proposed test scenarios and procedures. As shown in Chapters 6 and 8, Mediatek's TA-SAR and TA-PD algorithms are able to maintain SAR and PD over time below the FCC regulatory limits (based on the agreed TX-power-to-SAR/PD translation). Furthermore, the near-field measurements are also done in an FCC certified lab (i.e., SPORTON) to further validate the proposed test methodologies, and the results shown in Chapters 7 and 9 demonstrate that Mediatek's TA-SAR and TA-PD algorithms really can maintain SAR and 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-SAR and TA-PD algorithms can be tested by using the proposed test methodology for FCC compliance.

11. cDASY6 System Verification

11.1 The system to be used for the near field power density measurement

- SPEAG DASY6 system
- SPEAG cDASY6 5G module software
- EUmmWVx probe
- 5G Phantom cover



11.2 Test Side Location

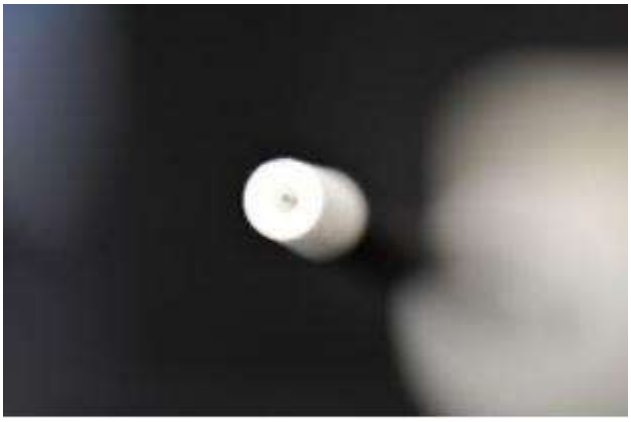
Sporton Lab and below test site location are accredited to ISO 17025 by Taiwan Accreditation Foundation (TAF code: 1190). The ISED Assigned Code is 4086B and 4086H

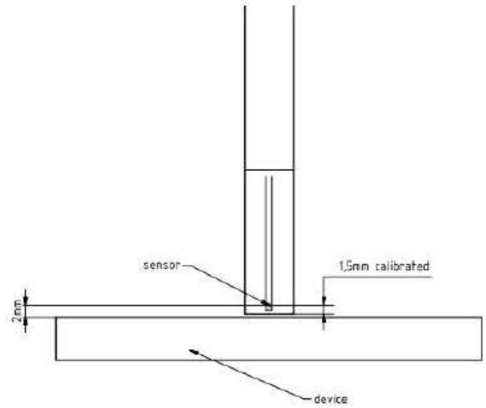
Test Site	SPORTON INTERNATIONAL INC. EMC & Wireless Communications Laboratory
Test Site Location	4086B No. 52, Huaya 1st Rd., Guishan Dist., Taoyuan City 333, CHINESE TAIPEI
Test Site No.	SAR06-HY

11.3 EUmmWave Probe

The probe design allows measurements at distances as small as 2 mm from the sensors to the surface of the device under test (DUT). The typical sensor to probe tip distance is 1.5 mm.

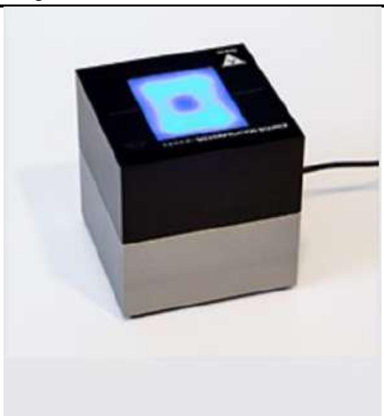
Frequency	750 MHz – 110 GHz
Probe Overall Length	320 mm
Probe Body Diameter	8.0 mm
Tip Length	23.0 mm
Tip Diameter	8.0 mm
Probe's two dipoles length	0.9 mm – Diode loaded
Dynamic Range	< 20 V/m - 10000 V/m with PRE-10 (min < 50 V/m - 3000 V/m)
Position Precision	< 0.2 mm
Distance between diode sensors and probe's tip	1.5 mm
Minimum Mechanical separation between probe tip and a Surface	0.5 mm
Applications	E-field measurements of 5G devices and other mm-wave transmitters operating above 10GHz in < 2 mm distance from device (free-space) Power density, H-field and far-field analysis using total field reconstruction.
Compatibility	cDASY6 + 5G-Module SW1.0 and higher





11.4 EUmmWave Verification source

Model	Ka-band horn antenna
Calibrated frequency:	30 GHz at 10mm from the case surface
Frequency accuracy	± 100 MHz
E-field polarization	linear
Harmonics	-20 dBc
Total radiated power	14 dBm
Power stability	0.05 dB
Power consumption	5 W
Size	100 x 100 x 100 mm
Weight	1 kg



11.5 SAR E-Field Probe

Construction	Symmetric design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Frequency	10 MHz – >6 GHz Linearity: ±0.2 dB (30 MHz – 6 GHz)
Directivity	±0.3 dB in TSL (rotation around probe axis) ±0.5 dB in TSL (rotation normal to probe axis)
Dynamic Range	10 µW/g – >100 mW/g Linearity: ±0.2 dB (noise: typically <1 µW/g)
Dimensions	Overall length: 337 mm (tip: 20 mm) Tip diameter: 2.5 mm (body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm

11.6 Data Acquisition Electronics (DAE)

The data acquisition electronics (DAE) consists of a highly sensitive electrometer-grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD-converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock.
The input impedance of the DAE is 200 MOhm; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

12. Test Equipment List

Manufacturer	Name of Equipment	Type/Model	Serial Number	Calibration	
				Last Cal.	Due Date
SPEAG	835MHz System Validation Kit	D835V2	4d167	Nov. 25, 2019	Nov. 22, 2022
SPEAG	1900MHz System Validation Kit	D1900V2	5d093	Mar. 25, 2022	Mar. 24, 2023
SPEAG	3500MHz System Validation Kit	D3500V2	1014	Jan. 17, 2022	Jan. 16, 2023
SPEAG	3700MHz System Validation Kit	D3700V2	1022	Jul. 14, 2021	Jul. 13, 2022
SPEAG	5G Verification Source	30GHz	1007	Nov. 15, 2021	Nov. 14, 2022
SPEAG	Data Acquisition Electronics	DAE4	316	Jan. 26, 2022	Jan. 25, 2023
SPEAG	EUmmWV Probe Tip Protection	EUmmWV3	9424	Apr. 06, 2022	Apr. 05, 2023
SPEAG	Dosimetric E-Field Probe	EX3DV4	3976	Jan. 27, 2022	Jan. 26, 2023
Keysight	5G Wireless Test Platform	E7515B	MY59321821	Apr. 26, 2022	Apr. 25, 2023
R&S	Base Station	CMW500	115793	Nov. 30, 2021	Nov. 29, 2022
R&S	Power Sensor	NRP8S	109688	Sep. 15, 2021	Sep. 14, 2022
R&S	Power Sensor	NRP50S	100983	Sep. 29, 2021	Sep. 28, 2022
Testo	Hygro meter	608-H1	45196600	Oct. 22, 2021	Oct. 21, 2022
Testo	Hygro meter	608-H1	45207528	Oct. 22, 2021	Oct. 21, 2022
Anritsu	Signal Generator	MG3710A	6201502524	Oct. 24, 2021	Oct. 23, 2022
Anritsu	Power Meter	ML2495A	1419002	Aug. 18, 2021	Aug. 17, 2022
Anritsu	Power Sensor	MA2411B	1911176	Aug. 18, 2021	Aug. 17, 2022
Anritsu	Power Meter	ML2495A	1804003	Oct. 09, 2021	Oct. 08, 2022
Anritsu	Power Sensor	MA2411B	1726150	Oct. 09, 2021	Oct. 08, 2022
Mini-Circuits	Power Amplifier	ZVE-8G+	479102029	Sep. 06, 2021	Sep. 05, 2022
Mini-Circuits	Power Amplifier	ZHL-42W+	321501827	Sep. 06, 2021	Sep. 05, 2022
SCHWARZBECK	18GHz~40GHzSHF-EHF Horn Antenna	BBHA 9170	BBHA9170251	Nov. 30, 2021	Nov. 29, 2022
BWant	mmwave measurement horn antenna	HA2050	110046	Note 1	
Warison	10-50 GHz Directional Coupler	WCOU-10-50S-10	WR889BMC481	Note 1	
ATM	500M-18GHz Dual Directional Coupler	C122H-10	P610410z-02	Note 1	
Woken	Attenuator 1	WK0602-XX	N/A	Note 1	
Woken	Attenuator 2	PE7005-10	N/A	Note 1	
Woken	Attenuator 3	PE7005- 3	N/A	Note 1	

General Note:

1. Prior to system verification and validation, the path loss from the signal generator to the system check source and the power meter, which includes the amplifier, cable, attenuator and directional coupler, was measured by the network analyzer. The reading of the power meter was offset by the path loss difference between the path to the power meter and the path to the system check source to monitor the actual power level fed to the system check source.
2. The dipole calibration interval can be extended to 3 years with justification according to KDB 865664 D01. The dipoles are also not physically damaged, or repaired during the interval. The justification data in appendix C can be found which the return loss is < -20dB, within 20% of prior calibration, the impedance is within 5 ohm of prior calibration for each dipole.

13. System verification and validation

13.1 Tissue Verification

The tissue dielectric parameters of tissue-equivalent media used for SAR measurements must be characterized within a temperature range of 18℃ to 25℃, measured with calibrated instruments and apparatuses, such as network analyzers and temperature probes. The temperature of the tissue-equivalent medium during SAR measurement must also be within 18℃ to 25℃ and within ± 2℃ of the temperature when the tissue parameters are characterized. The tissue dielectric measurement system must be calibrated before use. The dielectric parameters must be measured before the tissue-equivalent medium is used in a series of SAR measurements.

The liquid tissue depth was at least 15cm in the phantom for all SAR testing

<Tissue Check Results>

Frequency (MHz)	Liquid Temp. (℃)	Conductivity (σ)	Permittivity (ε_r)	Conductivity Target (σ)	Permittivity Target (ε_r)	Delta (σ) (%)	Delta (ε_r) (%)	Limit (%)	Date
835	22.3	0.908	42.500	0.90	41.50	0.89	2.41	±5	2022/6/23
1900	22.3	1.430	40.400	1.40	40.00	2.14	1.00	±5	2022/6/23
3500	22.3	3.040	38.900	2.91	37.90	4.47	2.64	±5	2022/6/23
3700	22.3	3.260	38.700	3.12	37.70	4.49	2.65	±5	2022/6/23

13.2 System Verification

Comparing to the original SAR value provided by SPEAG, the verification data should be within its specification of 10 %. Below table shows the target SAR and measured SAR after normalized to 1W input power. The table below indicates the system performance check can meet the variation criterion and the plots can be referred to Appendix D.

<System Verification Results>

Date	Frequency (MHz)	Input Power (mW)	Dipole S/N	Probe S/N	DAE S/N	Measured 1g SAR (W/kg)	Targeted 1g SAR (W/kg)	Normalized 1g SAR (W/kg)	Deviation (%)
2022/6/23	835	50	D835V2-4d167	EX3DV4 - SN3976	DAE4 Sn316	0.477	9.55	9.54	-0.10
2022/6/23	1900	50	D1900V2-5d093	EX3DV4 - SN3976	DAE4 Sn316	1.890	39.90	37.8	-5.26
2022/6/23	3500	50	D3500V2-1014	EX3DV4 - SN3976	DAE4 Sn316	3.270	67.20	65.4	-2.68
2022/6/23	3700	50	D3700V2-1022	EX3DV4 - SN3976	DAE4 Sn316	3.270	68.20	65.4	-4.11

13.3 Power Density system verification and validation

The system performance check verifies that the system operates within its specifications.
The EUT is replaced by a calibrated source, the same spatial resolution, measurement region and the test separation used in the calibration was applied to system check. Through visual inspection into the measured power density distribution, both spatially (shape) and numerically (level) have no noticeable difference. The measured results should be within 0.6dB of the calibrated targets.

Frequency [GHz]	Grid step	Grid extent X/Y [mm]	Measurement points
10	0.25 ($\frac{\lambda}{4}$)	120/120	16 × 16
30	0.25 ($\frac{\lambda}{4}$)	60/60	24 × 24
60	0.25 ($\frac{\lambda}{4}$)	32.5/32.5	26 × 26
90	0.25 ($\frac{\lambda}{4}$)	30/30	36 × 36

Settings for measurement of verification sources

<PD System Verification Results>

Frequency (GHz)	5G Verification Source	Probe S/N	DAE S/N	Distance (mm)	Measured 4 cm^2 (W/m^2)	Targeted 4 cm^2 (W/m^2)	Deviation (dB)	Date
30G	30GHz_1007	9424	316	5.55	40.2	35.9	0.49	2022/6/17

14. Uncertainty Assessment

Declaration of Conformity:

The test results with all measurement uncertainty excluded is presented in accordance with the regulation limits or requirements declared by manufacturers.

Comments and Explanations:

The declared of product specification for EUT presented in the report are provided by the manufacturer, and the ufacturer takes all the responsibilities for the accuracy of product specification.

The component of uncertainly may generally be categorized according to the methods used to evaluate them. The evaluation of uncertainly by the statistical analysis of a series of observations is termed a Type An evaluation of uncertainty. The evaluation of uncertainty by means other than the statistical analysis of a series of observation is termed a Type B evaluation of uncertainty. Each component of uncertainty, however evaluated, is represented by an estimated standard deviation, termed standard uncertainty, which is determined by the positive square root of the estimated variance.

A Type A evaluation of standard uncertainty may be based on any valid statistical method for treating data. This includes calculating the standard deviation of the mean of a series of independent observations; using the method of least squares to fit a curve to the data in order to estimate the parameter of the curve and their standard deviations; or carrying out an analysis of variance in order to identify and quantify random effects in certain kinds of measurement.

A type B evaluation of standard uncertainty is typically based on scientific judgment using all of the relevant information available. These may include previous measurement data, experience, and knowledge of the behavior and properties of relevant materials and instruments, manufacture's specification, data provided in calibration reports and uncertainties assigned to reference data taken from handbooks. Broadly speaking, the uncertainty is either obtained from an outdoor source or obtained from an assumed distribution, such as the normal distribution, rectangular or triangular distributions indicated in table below.

Uncertainty Distributions	Normal	Rectangular	Triangular	U-Shape
Multi-plying Factor[(a)]	1/k[(b)]	$1/\sqrt{3}$	$1/\sqrt{6}$	$1/\sqrt{2}$

(a) standard uncertainty is determined as the product of the multiplying factor and the estimated range of variations in the measured quantity

(b) κ is the coverage factor

Standard Uncertainty for Assumed Distribution

The combined standard uncertainty of the measurement result represents the estimated standard deviation of the result. It is obtained by combining the individual standard uncertainties of both Type A and Type B evaluation using the usual "root-sum-squares" (RSS) methods of combining standard deviations by taking the positive square root of the estimated variances.

Expanded uncertainty is a measure of uncertainty that defines an interval about the measurement result within which the measured value is confidently believed to lie. It is obtained by multiplying the combined standard uncertainty by a coverage factor. Typically, the coverage factor ranges from 2 to 3. Using a coverage factor allows the true value of a measured quantity to be specified with a defined probability within the specified uncertainty range. For purpose of this document, a coverage factor two is used, which corresponds to confidence interval of about 95 %. The DASY uncertainty Budget is shown in the following tables.

The judgment of conformity in the report is based on the measurement results excluding the measurement uncertainty.

Uncertainty Budget for frequency range 30 MHz to 6 GHz							
Error Description	Uncertainty Value (±%)	Probability	Divisor	(Ci) 1g	(Ci) 10g	Standard Uncertainty (1g) (±%)	Standard Uncertainty (10g) (±%)
Measurement System							
Probe Calibration	7.0	N	1	1	1	7.0	7.0
Axial Isotropy	4.7	R	1.732	0.7	0.7	1.9	1.9
Hemispherical Isotropy	9.6	R	1.732	0.7	0.7	3.9	3.9
Linearity	4.7	R	1.732	1	1	2.7	2.7
Modulation Response	3.2	R	1.732	1	1	1.8	1.8
System Detection Limits	1.0	R	1.732	1	1	0.6	0.6
Boundary Effects	2.0	R	1.732	1	1	1.2	1.2
Readout Electronics	0.3	N	1	1	1	0.3	0.3
Response Time	0.0	R	1.732	1	1	0.0	0.0
Integration Time	2.6	R	1.732	1	1	1.5	1.5
RF Ambient Noise	3.0	R	1.732	1	1	1.7	1.7
RF Ambient Reflections	3.0	R	1.732	1	1	1.7	1.7
Probe Positioner	0.4	R	1.732	1	1	0.2	0.2
Probe Positioning	6.7	R	1.732	1	1	3.9	3.9
Post-processing	4.0	R	1.732	1	1	2.3	2.3
Test Sample Related							
Device Holder	3.6	N	1	1	1	3.6	3.6
Test sample Positioning	3.0	N	1	1	1	3.0	3.0
Power Scaling	0.0	R	1.732	1	1	0.0	0.0
Power Drift	5.0	R	1.732	1	1	2.9	2.9
Phantom and Setup							
Phantom Uncertainty	7.6	R	1.732	1	1	4.4	4.4
SAR correction	0.0	R	1.732	1	0.84	0.0	0.0
Liquid Conductivity Repeatability	0.2	N	1	0.78	0.71	0.1	0.1
Liquid Conductivity (target)	5.0	R	1.732	0.78	0.71	2.3	2.0
Liquid Conductivity (mea.)	2.5	R	1.732	0.78	0.71	1.1	1.0
Temp. unc. - Conductivity	3.4	R	1.732	0.78	0.71	1.5	1.4
Liquid Permittivity Repeatability	0.15	N	1	0.23	0.26	0.0	0.0
Liquid Permittivity (target)	5.0	R	1.732	0.23	0.26	0.7	0.8
Liquid Permittivity (mea.)	2.5	R	1.732	0.23	0.26	0.3	0.4
Temp. unc. - Permittivity	0.83	R	1.732	0.23	0.26	0.1	0.1
Combined Std. Uncertainty						**12.9%**	**12.8%**
Coverage Factor for 95 %						**K=2**	**K=2**
Expanded STD Uncertainty						**25.9%**	**25.5%**

The budget is valid for evaluation distances > λ/2π. For specific tests and configurations, the Uncertainty could be considerably smaller.

mmWave Uncertainty Budget Evaluation Distances to the Antennas > λ/2π					
Error Description	Uncertainty Value (±dB)	Probability	Divisor	(Ci)	Standard Uncertainty (±dB)
Uncertainty terms dependent on the measurement system					
Probe Calibration	0.49	N	1	1	0.49
Probe correction	0.00	R	1.732	1	0.00
Frequency response (BW ≤ 1 GHz)	0.20	R	1.732	1	0.12
Sensor cross coupling	0.00	R	1.732	1	0.00
Isotropy	0.50	R	1.732	1	0.29
Linearity	0.20	R	1.732	1	0.12
Probe scattering	0.00	R	1.732	1	0.00
Probe positioning offset	0.30	R	1.732	1	0.17
Probe positioning repeatability	0.04	R	1.732	1	0.02
Sensor mechanical offset	0.00	R	1.732	1	0.00
Probe spatial resolution	0.00	R	1.732	1	0.00
Field impedance dependence	0.00	R	1.732	1	0.00
Amplitude and phase drift	0.00	R	1.732	1	0.00
Amplitude and phase noise	0.04	R	1.732	1	0.02
Measurement area truncation	0.00	R	1.732	1	0.00
Data acquisition	0.03	N	1	1	0.03
Sampling	0.00	R	1.732	1	0.00
Field reconstruction	0.60	R	1.732	1	0.35
Forward transformation	0.00	R	1.732	1	0.00
Power density scaling	0.00	R	1.732	1	0.00
Spatial averaging	0.10	R	1.732	1	0.06
System detection limit	0.04	R	1.732	1	0.02
Uncertainty terms dependent on the DUT and environmental factors					
Probe coupling with DUT	0.00	R	1.732	1	0.0
Modulation response	0.40	R	1.732	1	0.2
Integration time	0.00	R	1.732	1	0.0
Response time	0.00	R	1.732	1	0.0
Device holder influence	0.10	R	1.732	1	0.1
DUT alignment	0.00	R	1.732	1	0.0
RF ambient conditions	0.04	R	1.732	1	0.0
Ambient reflections	0.04	R	1.732	1	0.0
Immunity / secondary reception	0.00	R	1.732	1	0.0
Drift of the DUT		R	1.732	1	
Combined Std. Uncertainty					0.76 dB
Expanded STD Uncertainty (95%)					1.52 dB

Appendix A. Plots of System Performance Check

Appendix B. DASY Calibration Certificate

Appendix C. Test Setup Photos