PART 2 RF EXPOSURE REPORT

Test File No: F690501-RF-SAR000520-A2

Equipment Under Test	SAMSUNG Mobile Phone
Model No.	SM-A253D
Variant Model	SC-53F, SCG33
Test Device Serial No	R3CX90B4X4F, R3CX90B52PM
Applicant	SAMSUNG ELECTRONICS Co., Ltd.
Address of Applicant	129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Rep. of Korea
Date of Test(s)	2024-11-27 ~ 2024-12-03
Date of Issue	2024-12-16
Test Result	Pass

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

This test report does not assure KOLAS accreditation.

Remarks:

1) The results of this test report are effective only to the items tested.
2) The SGS Korea is not responsible for the sampling, the results of this test report apply to the sample as received.

Report prepared by /
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Approved by /
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Revision history

Revision	Date of issue	Revisions	Revised By
-	2024-12-09	Initial issue	
A1	2024-12-12	Revision Update - Correct typo and Update Table 7-1, 7-2 and 7-3	Jane Lee
A2	2024-12-16	Revision Update - Update Figure 7-1	Jane Lee

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1. General Information

1.1 Testing Laboratory

Company Name	SGS Korea Co., Ltd.
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All SGS services are rendered in accordance with the applicable SGS conditions of service available on request and accessible at http://www.sgs.com/en/Terms-and-Conditions.aspx	

1.2 Details of Manufacturer

Applicant	SAMSUNG ELECTRONICS Co., Ltd.
Address	129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Rep. of Korea
Email	jaiheon.cho@samsung.com
Tel No	+82 +10 - 4109 - 1645

1.3 Description of EUT(s)

Product Name	SAMSUNG Mobile Phone
Model Name	SM-A253D
Variant Model	SC-53F, SCG33
Software Version	A253D.001
Hardware Version	REV1.0
Serial Number	R3CX90B4X4F, R3CX90B52PM
Mode of Operation	GSM850/1900, WCDMA5, LTE2/5/12/26/41/66, 5G NR n5
Tx Frequency Range	GSM850(824.2 MHz ~ 848.8 MHz) GSM1900(1850.2 MHz ~ 1909.8 MHz) WCDMA5(826.4 MHz ~ 846.6 MHz) LTE2(1850.7 MHz ~ 1909.3 MHz) LTE5(824.7 MHz ~ 848.3 MHz) LTE12(699.7 MHz ~ 715.3 MHz) LTE26(814.7 MHz ~ 848.3 MHz) LTE41(2498.5 MHz ~ 2687.5 MHz) LTE66(1710.7 MHz ~ 1779.3 MHz) 5G NR n5(826.5 MHz ~ 846.5 MHz)

2. Test Standards and Limits

According to FCC 47CFR §2.1093(d) The limits to be used for evaluation are based generally on criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (‘‘SAR’’) in Section 4.2 of ‘‘IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 ㎑ to 300 ㎓,’’ ANSI/IEEE C95.3–2003, Copyright 2003 by the Institute of Electrical and Electronics Engineers, Inc., New York, New York 10017. These criteria for SAR evaluation are similar to those recommended by the National Council on Radiation Protection and Measurements (NCRP) in ‘‘Biological Effects and Exposure Criteria for Radio frequency Electromagnetic Fields,’’ NCRP Report No. 86, Section 17.4.5. Copyright NCRP, 1986, Bethesda, Maryland 20814. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards. The criteria to be used are specified in paragraphs (d)(1) and (d)(2) of this section and shall apply for portable devices transmitting in the frequency range from 100 ㎑ to 6 ㎓. Portable devices that transmit at frequencies above 6 ㎓ are to be evaluated in terms of the MPE limits specified in § 1.1310 of this chapter. Measurements and calculations to demonstrate compliance with MPE field strength or power density limits for devices operating above 6 ㎓ should be made at a minimum distance of 5 cm from the radiating source.

(1) Limits for Occupational/Controlled exposure: 0.4 W/kg as averaged over the whole-body and spatial peak SAR not exceeding 8 W/kg as averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the hands, wrists, feet and ankles where the spatial peak SAR shall not exceed 20 W/kg, as averaged over an 10 grams of tissue (defined as a tissue volume in the shape of a cube). Occupational/Controlled limits apply when persons are exposed as a consequence of their employment provided these persons are fully aware of and exercise control over their exposure. Awareness of exposure can be accomplished by use of warning labels or by specific training or education through appropriate means, such as an RF safety program in a work environment.

(2) Limits for General Population/Uncontrolled exposure: 0.08 W/kg as averaged over the whole-body and spatial peak SAR not exceeding 1.6 W/kg as averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the hands, wrists, feet and ankles where the spatial peak SAR shall not exceed 4 W/kg, as averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube). General Population/Uncontrolled limits apply when the general public may be exposed, or when persons that are exposed as a consequence of their employment may not be fully aware of the potential for exposure or do not exercise control over their exposure. Warning labels placed on consumer devices such as cellular telephones will not be sufficient reason to allow these devices to be evaluated subject to limits for occupational/controlled exposure in paragraph (d)(1) of this section.

Human Exposure	Uncontrolled Environment General Population	Controlled Environment Occupational
Partial Peak SAR (Partial)	1.60 mW/g	8.00 mW/g
Partial Average SAR (Whole Body)	0.08 mW/g	0.40 mW/g
Partial Peak SAR (Hands/Feet/Ankle/Wrist)	4.00 mW/g	20.00 mW/g

1. The spatial Peak value of the SAR averaged over any 1g gram of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.
2. The spatial Average value of the SAR averaged over the whole body.
3. The Spatial Peak value of the SAR averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube) and over the appropriate averaging time.

※ The tests using the DUT had been conducted according to the Mediatek “TA-SAR/TA-PD Test Proposal Version 2.0” Document test methods, and the results met the Regulatory SAR limit. The test results in this report were only evaluated by measured value, not apply the measurement uncertainty.

3. 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.

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. 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.

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 equipment under test (EUT) is a mobile phone, it contains supports 2G/3G/4G/5G bands. These modems are enabled with MediaTek TAS feature to control and manage transmitting power in real time and to ensure at all times the time-averaged RF exposure is in compliance with the FCC requirement.

This purpose of the Part 2 report is to demonstrate the EUT complies with FCC RF exposure requirement under Tx varying transmission scenarios, thereby validity of MediaTek TAS feature for FCC equipment authorization.

4. 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 10 GHz, 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, 5G NR according to cases with different combinations of operating parameters listed in Table 4-1.

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 $PLowThresh$. ($P_{LowThresh} = P_{sub6\ limit}$ - $P_{LowThresh\ offset}$)
$P_{UE\_backoff\_offset}$	To calculate $PUE\_backoff$. ($P_{UE\ backoff} = P_{sub6\ limit} - P_{UE\ backoff\ offset}$)
$PU_{E\_max\_cust\_offset}$	To calculate PUE_max_cust. P_{UE_max} is maximum TX power at which a UE can possibly transmit. $P_{UE\ max\ cust}$=min ($P_{UE\ max,Psub6\ limit}$+$P_{UE\ max\ cust\ offset}$)

Table 4-1 TA-SAR operating parameters

5. 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 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 TA-SAR validation, description of the conducted power measurement test procedures is included in section 6.2~6.8. In each of the test scenarios, certain test sequence, described in section 6.1, is applied.

6. TA-SAR Test Scenarios and Test Procedures

In order to demonstrate that TA-SAR algorithm performs as expected under various operating scenarios, Table 6-1 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 6.1. The details of each test procedures via conducted power and SAR measurements are described in section 6.2~6.7 and section 6.8, respectively.

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)
8	SAR exposure switching	0	Switch RATs when testing (e.g., LTE→NR)

Table 6-1 Test scenario list of TA-SAR validation

6.1 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 6-1, Figure 6-2, and Figure 6-3, respectively. The waveforms of the three test sequences are listed in Table 6-2, Table 6-3, and Table 6-4.

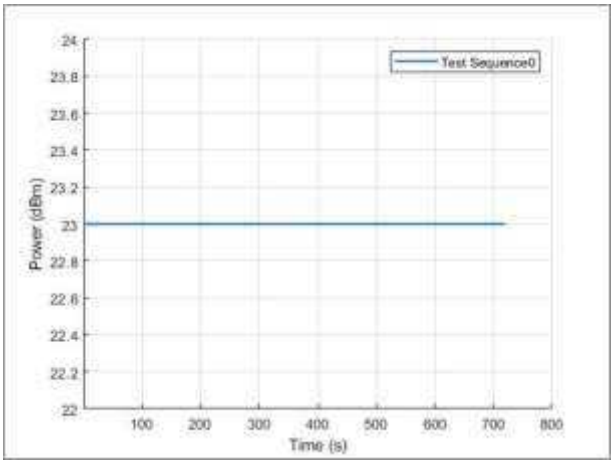


Figure 6-1 Test sequence 0

Time	Duration	Power (dBm)	Note
720	720	23	$P_{UE\ max}$

Table 6-2 Test sequence 0

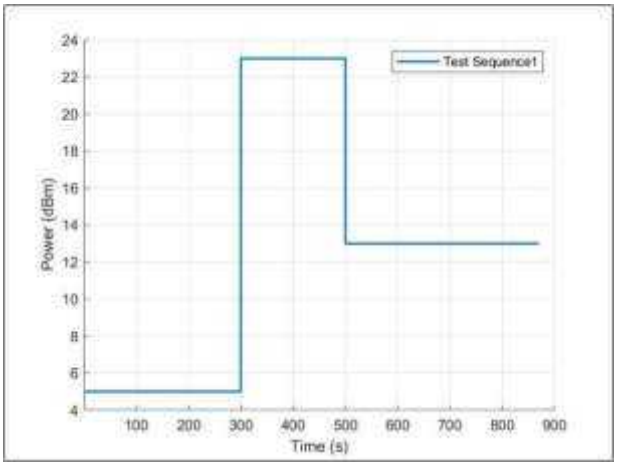


Figure 6-2 Test sequence 1

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

Table 6-3 Test sequence 1

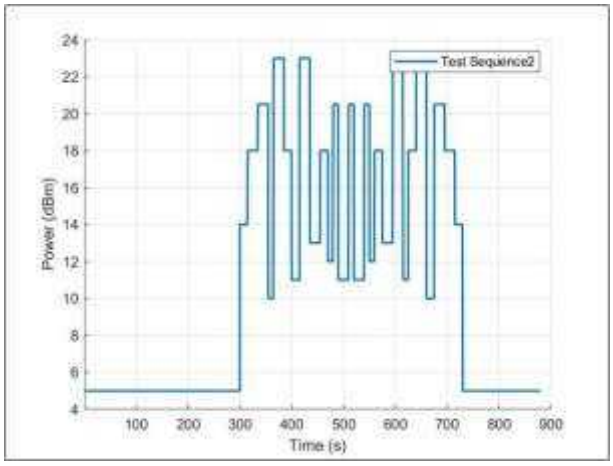


Figure 6-3 Test sequence 2

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	$< P_{LowThresh}$

Table 6-4 Test sequence 2

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

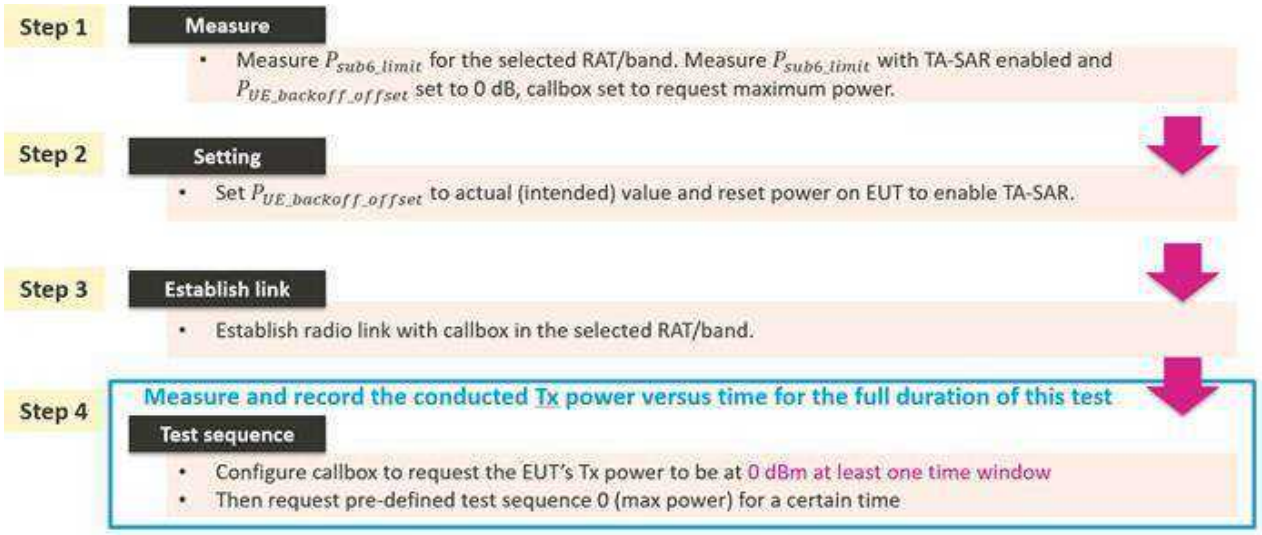
6.2.1 Configuration

This test is performed by changing the parameters ($P_{LowThresh\_offset}$, $P_{UE\_backoff\_offset}$, $PU_{E\_max\_cust\_offset}$) 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.

6.2.2 Procedure

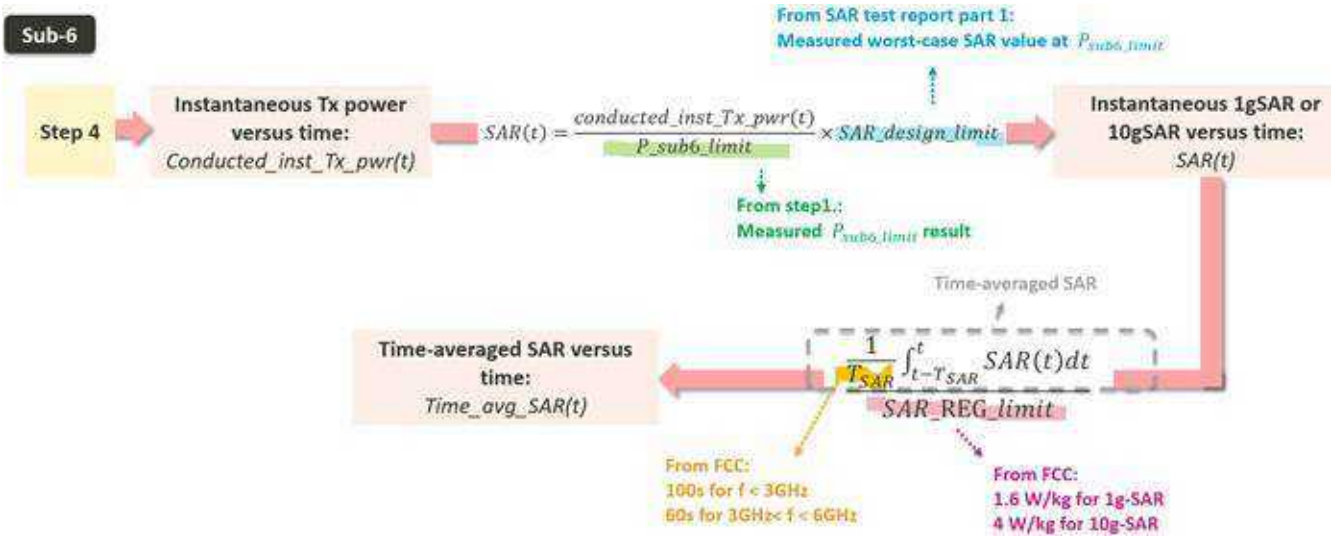
TX power is measured, recorded, and processed by the following steps:

- 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 (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)

6.3 Test Configuration and Procedure for Scenario 2: Time-Varying TX Power via Conducted Power Measurements

6.3.1 Configuration

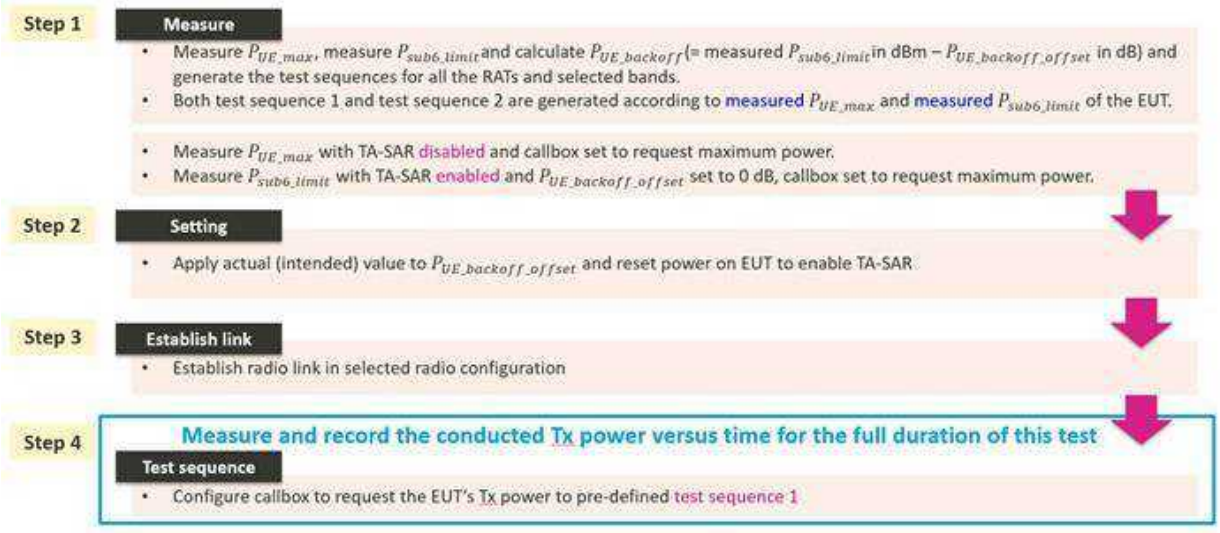
Since Mediatek's TA-SAR feature operation is independent of bands and channels for a given RAT, selecting one band per RAT is sufficient to validate this feature. Two bands per RAT are proposed for this test. The criteria for band selection for each RAT is based on the P_{sub6_limit} values (corresponding 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 Psub6_limit below P_{UE_max}.
  - If the same least Psub6_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.

6.3.2 Procedure

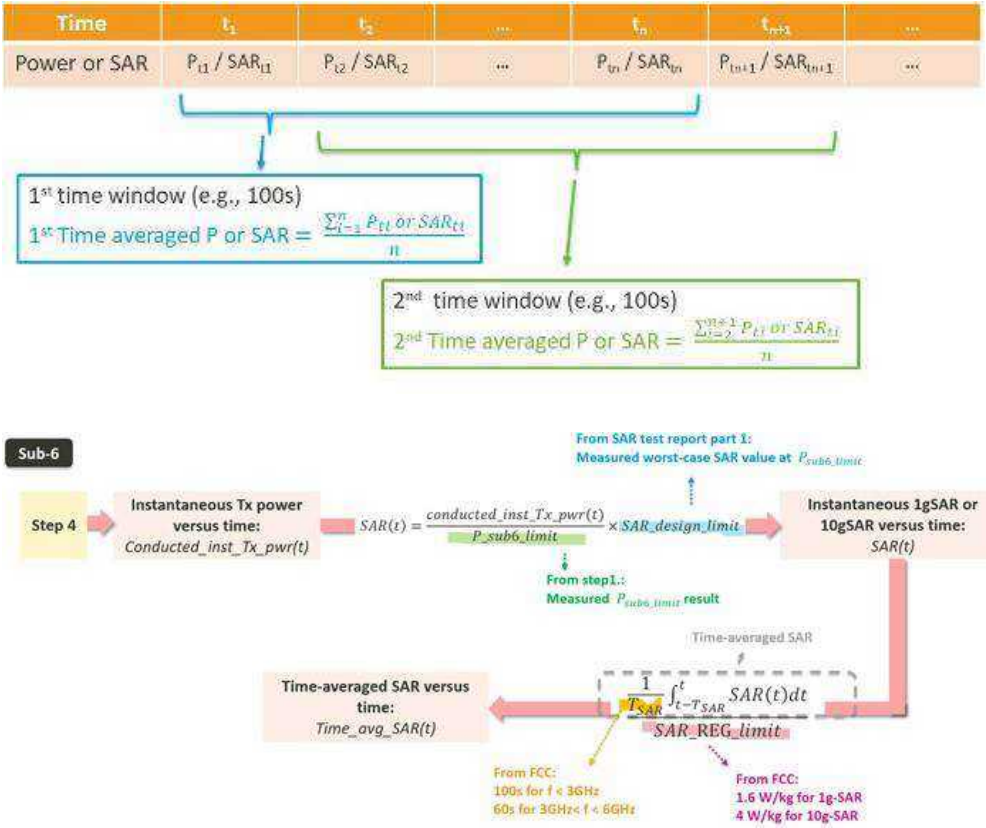
TX power is measured, recorded, and processed by the following steps:

- 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

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

6.4.1 Configuration

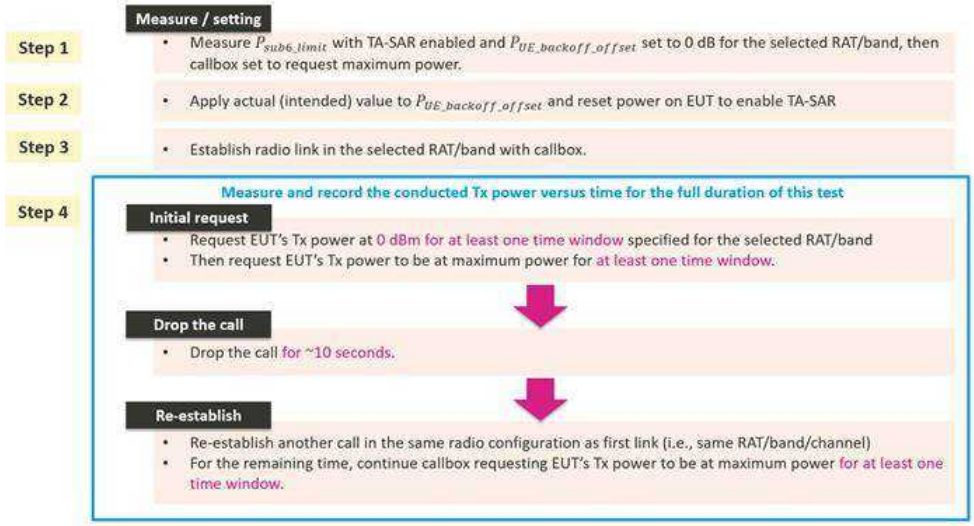
For call disconnection measurement, the criteria of selecting the test configuration is:

- 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}.

6.4.2 Procedure

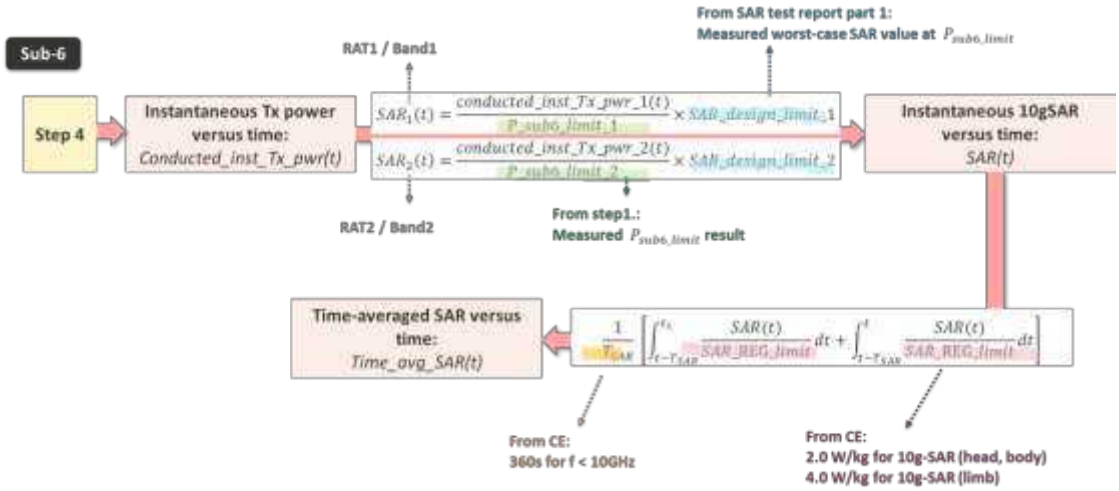
TX power is measured, recorded, and processed by the following steps:

- 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)

6.5 Test Configuration and Procedure for Scenario 4: Band Handover via Conducted Power Measurements

6.5.1 Configuration

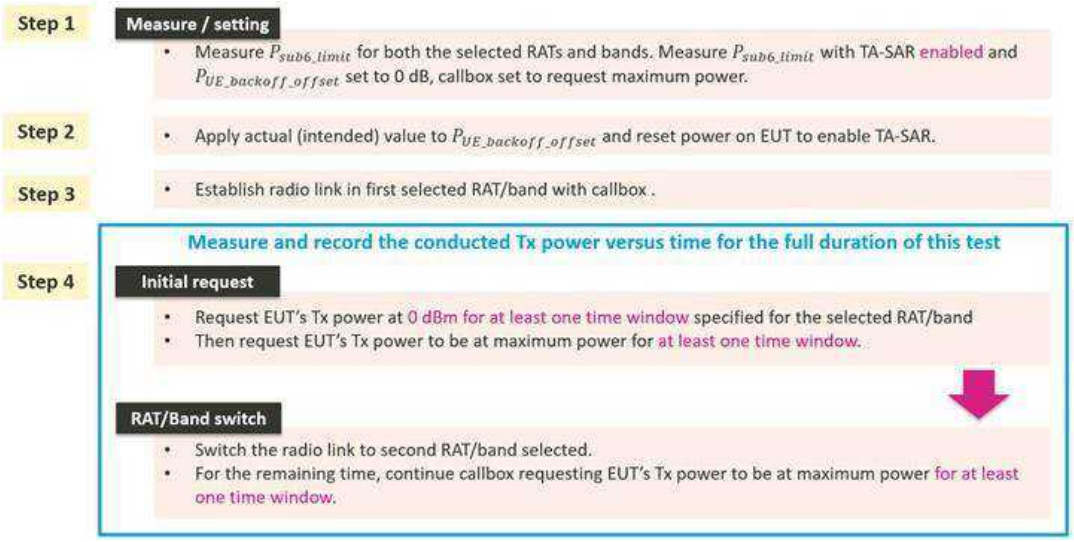
For a given TX antenna, select a RAT/band with the lowest P_{sub6_limit} and the other RAT/band with the highest P_{sub6_limit}. Both of them have Psub6_limit values less than P_{UE_max} if possible.

- Select the RAT/band having the highest measured 1gSAR at Psub6_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}.

6.5.2 Procedure

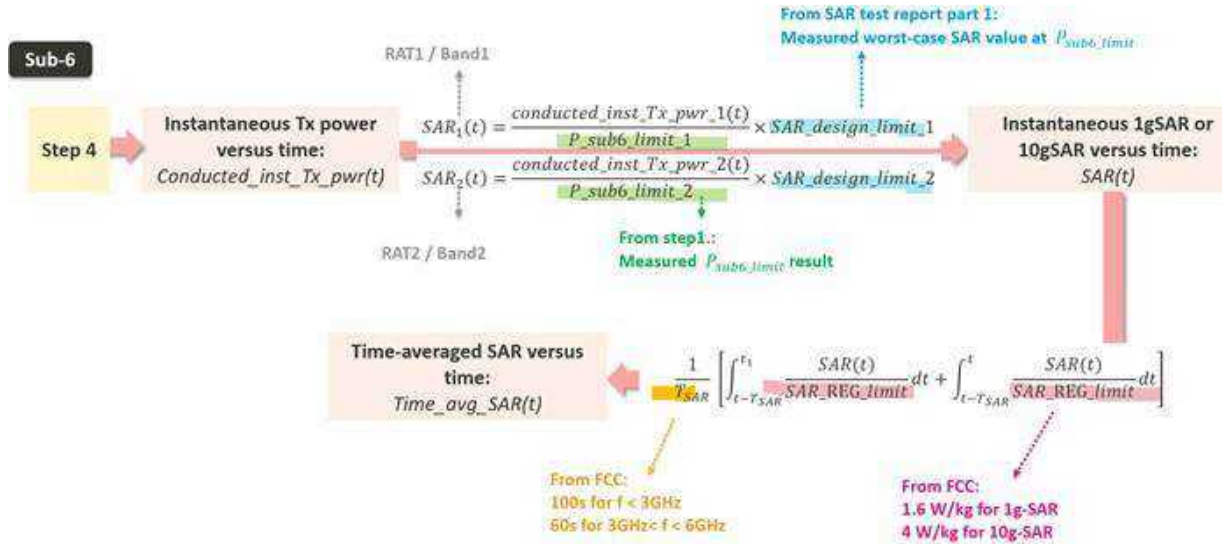
TX power is measured, recorded, and processed by the following steps:

- 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

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

6.6.1 Configuration

Select any one RAT/band, which has at least two ECIs whose P_{sub6_limit} values are different and are below P_{UE_max}.

6.6.2 Procedure

The test procedure is identical to section 6.5.2 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.

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

6.7.1 Configuration

If supported, SAR exposure switch with two active radios having the same and different time averaging windows should be covered in this test. Mediatek's 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 Psub6_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.

6.7.2 Procedure

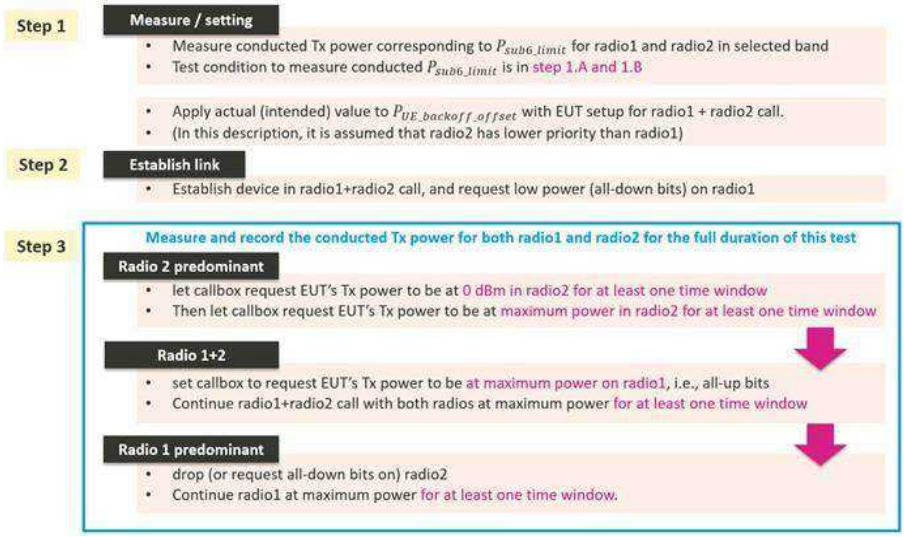
- Step 1~3: measure and record TX power versus time for test scenario 8

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.

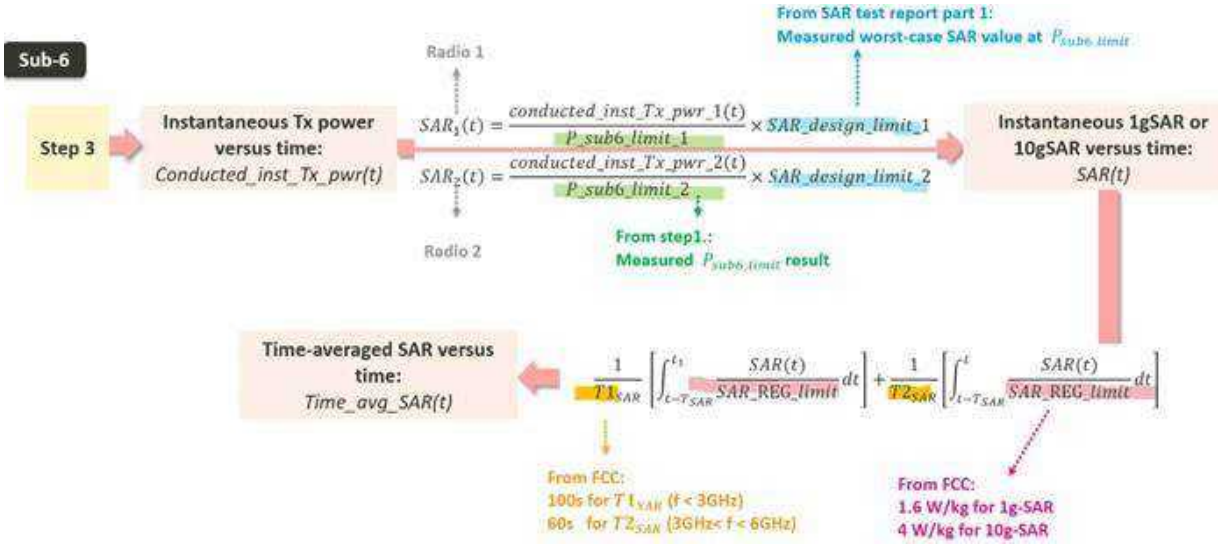
B. measure conducted TX power corresponding to radio2 P_{sub6_limit}

- 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

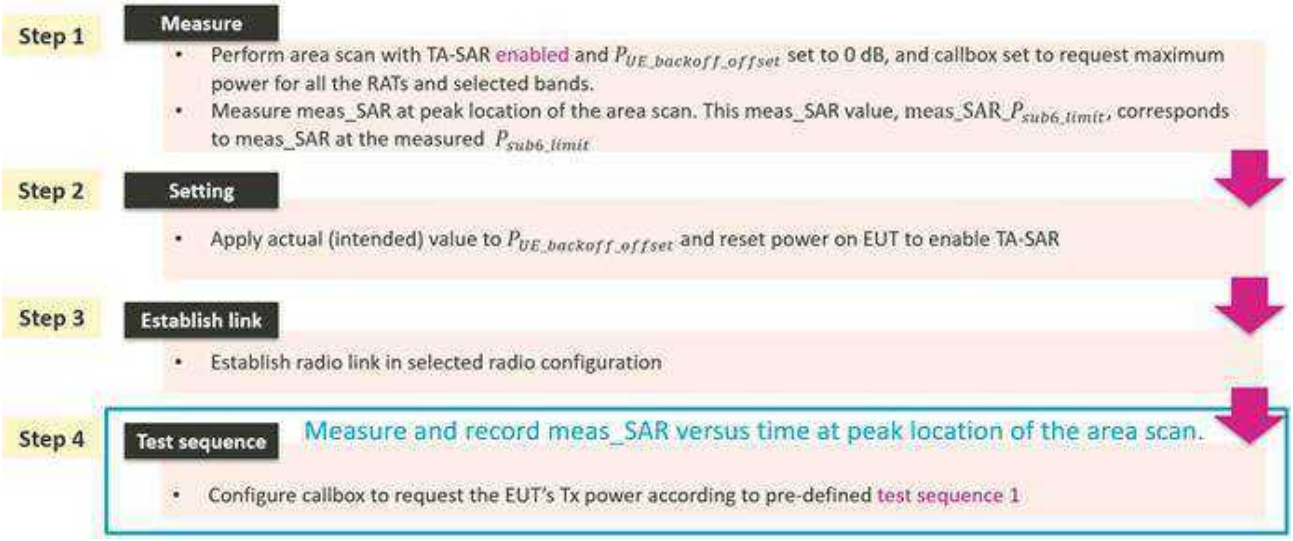
  1. Calculated time-averaged 1gSAR or 10gSAR
  2. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)
  3. Normalized time-averaged 1gSAR/1.6 or 10gSAR/4.0

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

6.8.1 Procedure

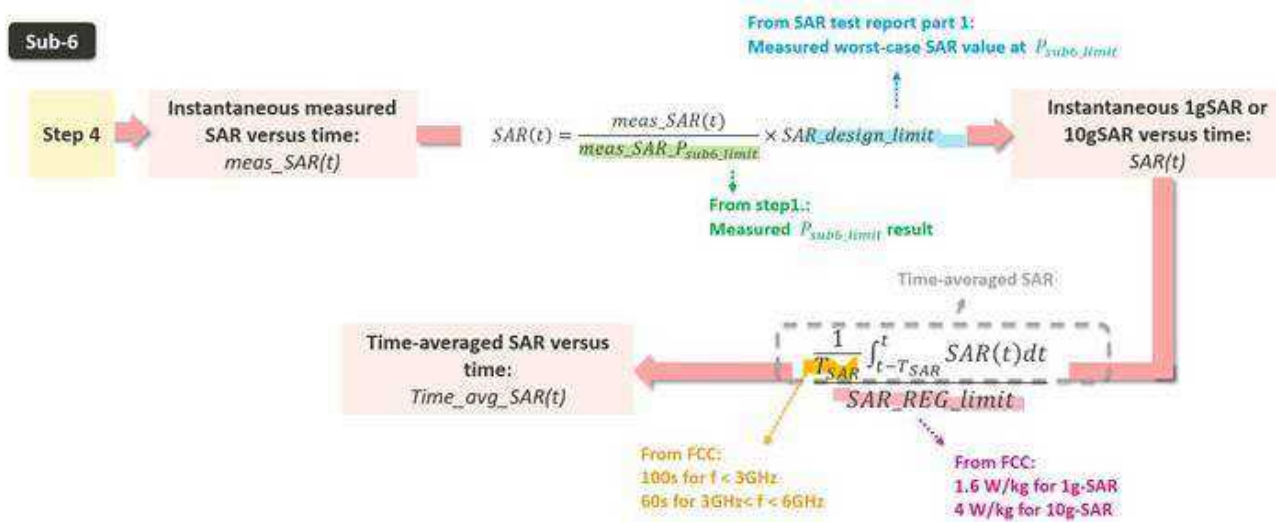
SAR is measured and recorded by the following steps:

- 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_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.

7. TA-SAR Validation via Conducted Power Measurement

7.1 Measurement Setup

7.1.1 Test Bench Introduction

All of the test cases defined in this chapter are conducted by using EUT, whose antenna placement for each RAT is illustrated in Figure 7-1.

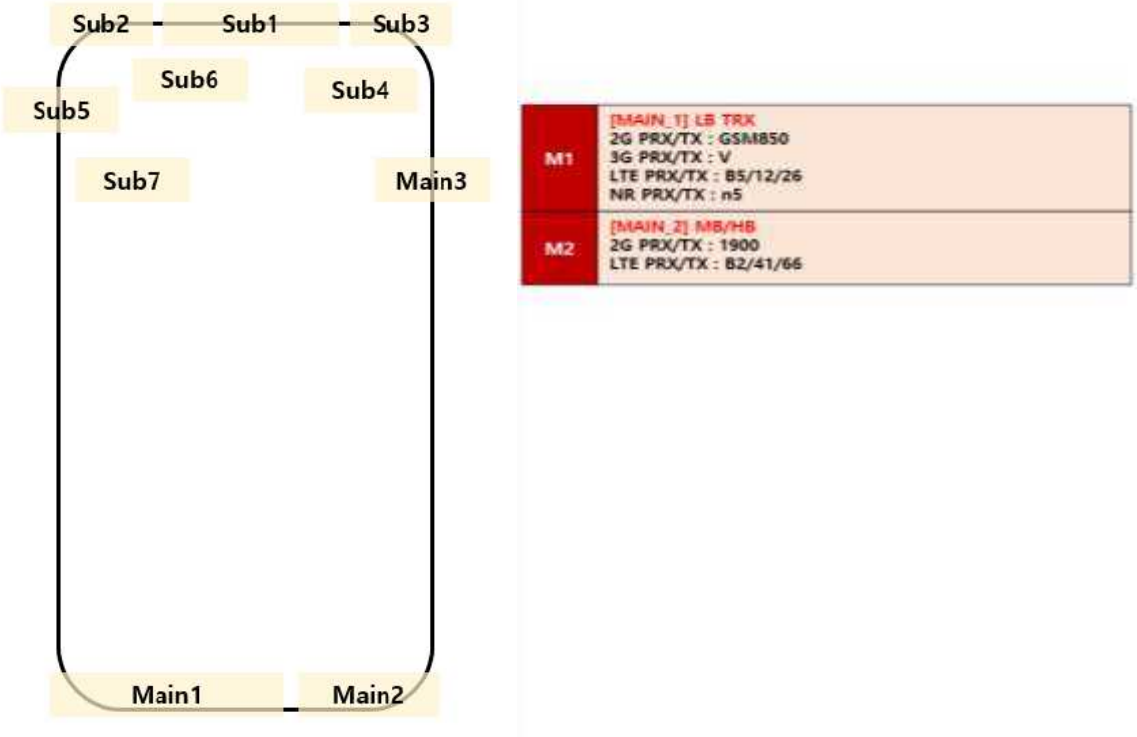


Figure 7-1 Antenna placement of the EUT

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 7-2 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.

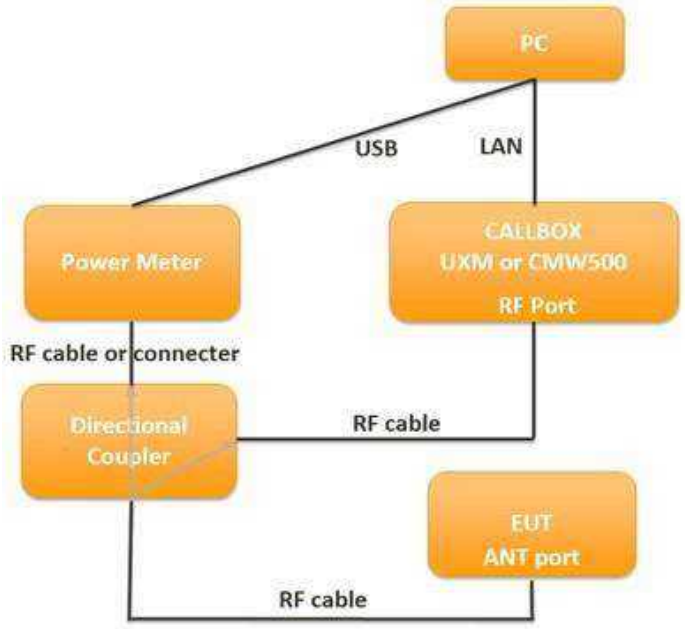


Figure 7-2 TA-SAR conductive power test setup block diagram for scenarios 1/2/3/5

Figure 7-3 shows the block diagram of the measurement bench, which support test scenario 4 (band handover). 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.

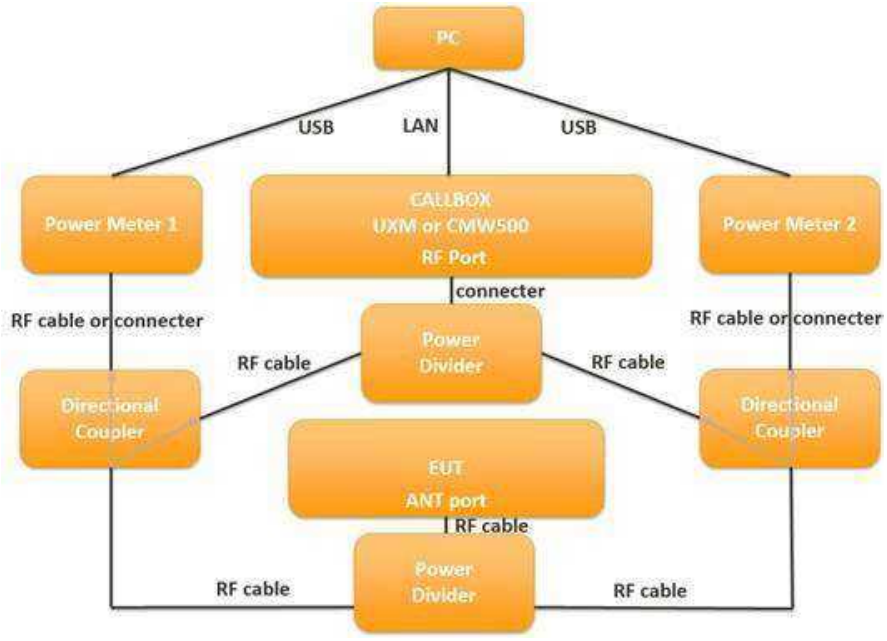


Figure 7-3 TA-SAR conductive power test setup block diagram for scenarios 4

Figure 7-4 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 7-1.

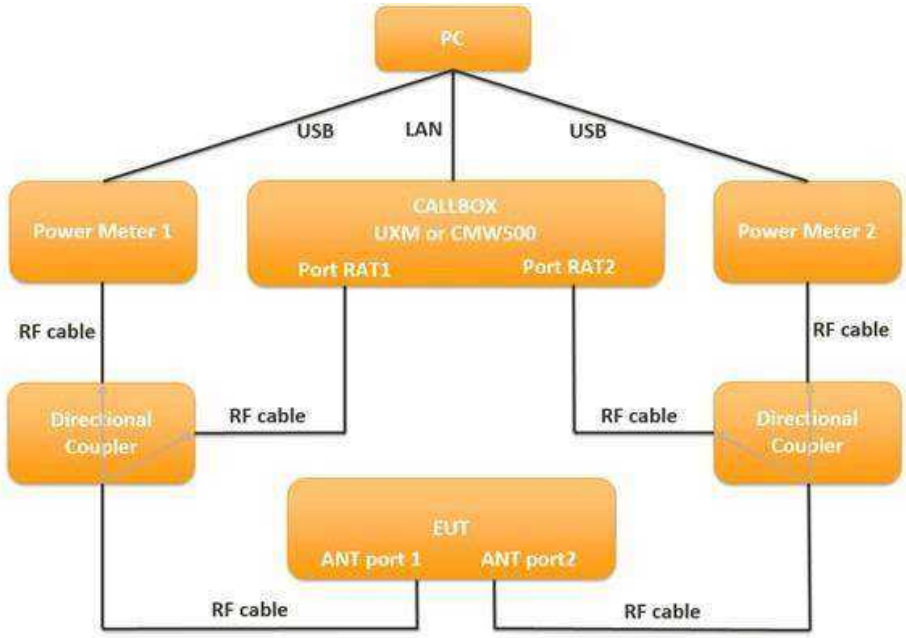


Figure 7-4 TA-SAR conductive power test setup block diagram for scenarios 4/8

7.1.2 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 7-1. 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 power level which does not account for TX duty cycle. In contrast, frame-averaged power level does account for TX duty cycle. The power of ECI0 and ECI2 are the same. For LTE Band 41 Pmax measurement, it was measured considering MPR-1 dB according to 50 RB 50 Offset condition.

RAT	Band	ANT	Duty cycle (%)	$P_{limit,nom}$ (dBm) Setting						$P_{max,nom}$ (dBm) Setting	
				ECI 0 Normal		ECI 1 RCV		ECI 2 Hotspot			
				burst-power	frame-averaged power	burst-power	frame-averaged power	burst-power	frame-averaged power	burst-power	frame-averaged power
2G GSM	850	M1	12.5	29.00	19.97	33.50	24.47	29.00	19.97	33.50	24.47
2G GPRS	850 1Tx	M1	12.5	29.00	19.97	33.50	24.47	29.00	19.97	33.50	24.47
2G GPRS	850 2Tx	M1	25	26.00	19.98	31.50	25.48	26.00	19.98	31.50	25.48
2G GPRS	850 3Tx	M1	37.5	24.00	19.74	29.00	24.74	24.00	19.74	29.00	24.74
2G GPRS	850 4Tx	M1	50	22.50	19.49	27.50	24.49	22.50	19.49	27.50	24.49
2G GSM	1900	M2	12.5	26.00	16.97	30.00	20.97	26.00	16.97	30.00	20.97
2G GPRS	1900 1Tx	M2	12.5	26.00	16.97	30.00	20.97	26.00	16.97	30.00	20.97
2G GPRS	1900 2Tx	M2	25	23.00	16.98	28.00	21.98	23.00	16.98	28.00	21.98
2G GPRS	1900 3Tx	M2	37.5	21.00	16.74	26.00	21.74	21.00	16.74	26.00	21.74
2G GPRS	1900 4Tx	M2	50	19.50	16.49	25.00	21.99	19.50	16.49	25.00	21.99
3G WCDMA	V	M1	100	22.00	22.00	24.00	24.00	22.00	22.00	24.00	24.00
4G LTE	B2	M2	100	19.00	19.00	23.00	23.00	19.00	19.00	23.00	23.00
	B5	M1	100	22.00	22.00	24.50	24.50	22.00	22.00	24.50	24.50
	B12	M1	100	22.00	22.00	24.50	24.50	22.00	22.00	24.50	24.50
	B26	M1	100	21.00	21.00	24.50	24.50	21.00	21.00	24.50	24.50
	B66	M2	100	19.00	19.00	23.00	23.00	19.00	19.00	23.00	23.00
	B41	M2	63.34	19.00	17.02	24.50	22.52	19.00	17.02	24.50	22.52
5G NR	n5	M1	100	22.00	22.00	24.00	24.00	22.00	22.00	24.00	24.00

Table 7-1 Summary table of power limit (P_{sub6_limit}) for all supported RAT

Table 7-2 summarizes the test configurations of all RATs, and the corresponding part 1 SAR of P_{limit}.

Table 7-3 summarizes the conducted test configurations of all RATs and shows the measured power limit, maximum and operating parameters for algorithm validation.

Test Case	Test Scenario	Test band	Test Sequence	BW (MHz)	Modulation	duty cycle	RB size	RB offset	Test Position	Gap (mm)	ANT	ANT Index	ANT state (TX/RX)	ECI	UL Channel	UL Freq (MHz)	DL Channel	DL Freq (MHz)	Part 1. SAR@Plimit 1-g SAR (W/kg)	SAR req.	Plimit, frame-averaged	Pmax, frame-averaged	min power duration	duration1	drop call	duration2	duration3
0	1. Range of TA-SAR parameters	LTE Band 41	0	20	QPSK	63.34%	50	50	Rear	5	M2	1	0/0	0(=2)	41490	2680.0	41490	2680.0	0.773	1.6	17.02	22.52	300	570			
1	2. Time-varying TX power	GSM850	1	-	4TX	50.00%	-	-	Rear	5	M1	0	0/0	0(=2)	251	848.8	251	893.8	1.050	1.6	19.49	24.49	150	720			
2		GSM1900	1	-	4TX	50.00%	-	-	Rear	5	M2	1	0/0	0(=2)	512	1850.2	512	1930.2	1.050	1.6	16.49	21.99	150	720			
3		WCDMA Band 5	1	-	RMC	100.00%	-	-	Rear	5	M1	0	0/0	0(=2)	4233	846.6	4458	891.6	0.739	1.6	22.00	24.00	150	720			
4		LTE Band 5	1	10	QPSK	100.00%	1	25	Rear	5	M1	0	0/0	0(=2)	20525	836.5	2525	881.5	0.611	1.6	22.00	24.50	150	720			
5		LTE Band 41	1	20	QPSK	63.34%	50	50	Rear	5	M2	1	0/0	0(=2)	41490	2680.0	41490	2680.0	0.773	1.6	17.02	22.52	150	720			
7		GSM850	2	-	4TX	50.00%	-	-	Rear	5	M1	0	0/0	0(=2)	251	848.8	251	893.8	1.050	1.6	19.49	24.49	150	720			
8		GSM1900	2	-	4TX	50.00%	-	-	Rear	5	M2	1	0/0	0(=2)	512	1850.2	512	1930.2	1.050	1.6	16.49	21.99	150	720			
9		WCDMA Band 5	2		RMC	100.00%	-	-	Rear	5	M1	0	0/0	0(=2)	4233	846.6	4458	891.6	0.739	1.6	22.00	24.00	150	720			
10		LTE Band 5	2	10	QPSK	100.00%	1	25	Rear	5	M1	0	0/0	0(=2)	20525	836.5	2525	881.5	0.611	1.6	22.00	24.50	150	720			
11		LTE Band 41	2	20	QPSK	63.34%	50	50	Rear	5	M2	1	0/0	0(=2)	41490	2680.0	41490	2680.0	0.773	1.6	17.02	22.52	150	720			
12	3. Call disconnection and re-establishment	LTE Band 41	0	20	QPSK	63.34%	50	50	Rear	5	M2	1	0/0	0(=2)	41490	2680.0	41490	2680.0	0.773	1.6	17.02	22.52	300	200	10	200	
13	4. band handover	WCDMA Band 5	0	-	RMC	100.00%	-	-	Rear	5	M1	0	0/0	0(=2)	4233	846.6	4458	891.6	0.739	1.6	22.00	24.00	300	200		200	200
		LTE Band 41		20	QPSK	63.34%	50	50			M2	1	0/0		41490	2680.0	41490	2680.0	0.773		17.02	22.52					
14	5. Change in operating state	LTE Band 41	0	20	QPSK	63.34%	50	50	Rear	5	M2	1	0/0	0(=2)	41490	2680.0	41490	2680.0	0.773	1.6	17.02	22.52	300	200		200	200
									Left Touch	0				1							22.52						
15	8. SAR exposure switching (ENDC)	LTE Band 2	0	20	QPSK	100.00%	1	49	Rear	5	M2	1	0/0	0(=2)	19100	1900.0	1100	1980.0	0.666	1.6	19.00	23.00	300	200		200	200
		FR1 n5		20	DFT-s QPSK	100.00%	50	28			M1	0	0/0		167300	836.5	176300	881.5			22.00	24.00					

Table 7-2 Test configurations of radio technologies and worst-case measured SAR

Test Scenario	Test Tech	Test band	Test Sequence	ECI	Pmax Setting (dBm)	Meas. Pmax (dBm)	Plimit Setting (dBm)	Meas. Plimit (dBm)	PLowThresh Offset (dBm)	PUE_backoff Offset (dBm)	PUE_max_cust Offset (dBm)	Pass / Fail SAR limit
1. Range of TA-SAR parameters	LTE	Band 41	0	0(=2)	22.52	20.18	17.02	16.63	1.25	1.75	4.00	Pass
2. Time-varying TX power	GSM	850	1	0(=2)	24.49	24.63	19.49	19.86	1.25	1.75	9.00	Pass
	GSM	1900	1	0(=2)	21.99	21.52	16.49	17.06	1.25	1.75	9.00	Pass
	WCDMA	Band 5	1	0(=2)	24.00	23.78	22.00	21.79	1.25	1.75	3.50	Pass
	LTE	Band 5	1	0(=2)	24.50	24.39	22.00	20.95	1.25	1.75	3.50	Pass
	LTE	Band 41	1	0(=2)	22.52	20.18	17.02	16.63	1.25	1.75	4.00	Pass
	GSM	850	2	0(=2)	24.49	24.63	19.49	19.86	1.25	1.75	9.00	Pass
	GSM	1900	2	0(=2)	21.99	21.52	16.49	17.06	1.25	1.75	9.00	Pass
	WCDMA	Band 5	2	0(=2)	24.00	23.78	22.00	21.79	1.25	1.75	3.50	Pass
	LTE	Band 5	2	0(=2)	24.50	24.39	22.00	20.95	1.25	1.75	3.50	Pass
	LTE	Band 41	2	0(=2)	22.52	20.18	17.02	16.63	1.25	1.75	4.00	Pass
3. Call disconnection and re-establishment	LTE	Band 41	0	0(=2)	22.52	20.18	17.02	16.63	1.25	1.75	4.00	Pass
4. band handover	WCDMA	Band 5	0	0(=2)	24.00	23.78	22.00	21.79	1.25	1.75	3.50	Pass
	LTE	Band 41			22.52	20.18	17.02	16.63	1.25	1.75	4.00	Pass
5. Change in operating state	LTE	Band 41	0	0(=2)	22.52	20.18	17.02	16.63	1.25	1.75	4.00	Pass
				1		20.18	22.52	20.18	1.25	1.75		Pass
8. SAR exposure switching (ENDC)	LTE	Band 2	0	0(=2)	23.00	23.40	19.00	19.38	1.25	1.75	4.00	Pass
	FR1	n5			24.00	24.41	22.00	22.45	1.25	1.75	3.00	Pass

Table 7-3 Test configurations of radio technologies and worst-case measured P_{limit} and P_{max}

7.2 Conducted Power Measurement Results for Scenario 1: Time-Varying TX Power

In this scenario, two TA-SAR parameters are swept to validate Mediatek's TA-SAR algorithm. The parameter sets are summarized in Table 7-4, and the test procedure follows section 6.2.2. The measurement setup is shown in Figure 7-2. 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.

Test case	RAT	Test band	Test seq.	ECI	Max power (dBm)	$Psub6\_limit$ (dBm)	$PLowThresh$ (dBm)	$PUE\_backoff$ (dBm)	PUE_max_cust (dBm)	Pass /Fail SAR limit
0	LTE	Band 41	0	0	22.52	17.02	15.77	15.27	21.02	Pass

Table 7-4 TA-SAR parameters setting for scenario 1

The corresponding detailed test procedure is described in 6.2.2. 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 6.2.2. For all test cases, the time-averaged SAR does not exceed the FCC limit.

- **Case 0: result for test sequence 1**

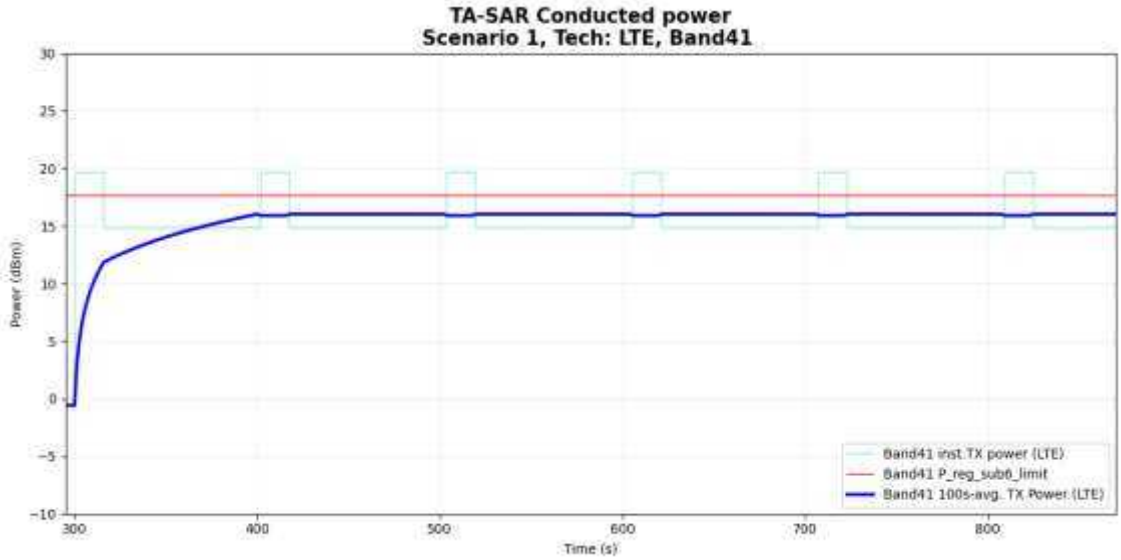


Figure 7- 5 Time-averaged conducted TX power over time for case 0(LTE B41)

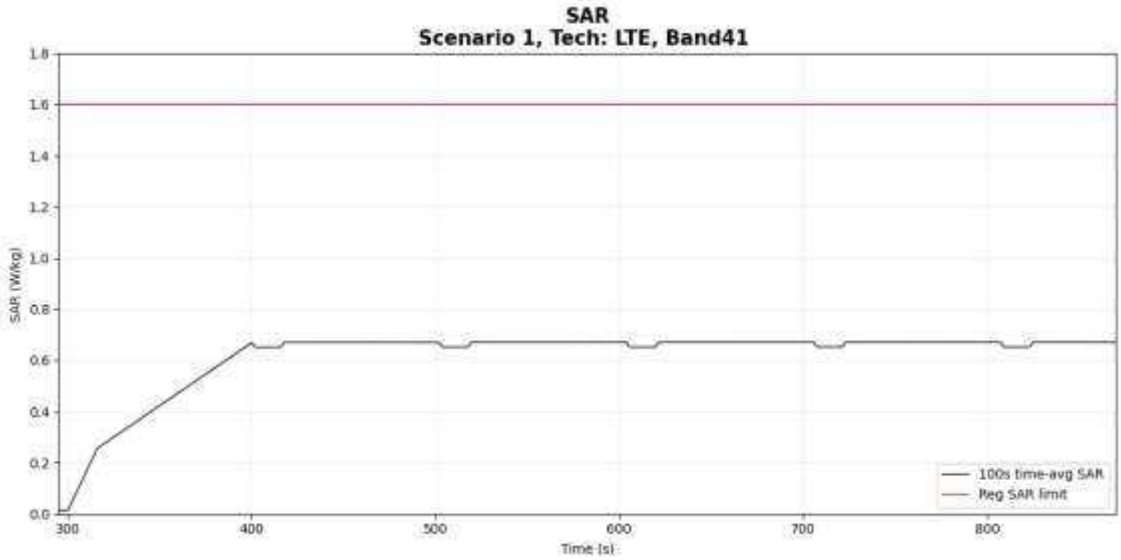


Figure 7- 6 Time-averaged SAR for case 0(LTE B41)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.671 W/kg
Validation result: Pass	

7.3 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. All of the test cases for this scenario are relegated in Table 7-5, and the test procedure follows section 6.3.2. The measurement setup is shown in Figure 7-2. 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.

Test case	RAT	Test band	Test seq.	ECI	Max power (dBm)	$Psub6\_limit$ (dBm)	$PLowThresh$ (dBm)	$PUE\_backoff$ (dBm)	PUE_max_cust (dBm)	Pass /Fail SAR limit
1	GSM	850	1	0	24.47	19.49	18.24	17.74	24.49	Pass
2	GSM	1900	1	0	21.99	16.49	15.24	14.74	21.99	Pass
3	WCDMA	Band 5	1	0	24.00	22.00	20.75	20.25	24.00	Pass
4	LTE	Band 5	1	0	24.50	22.00	20.75	20.25	24.50	Pass
5	LTE	Band 41	1	0	22.52	17.02	15.77	15.27	21.02	Pass
7	GSM	850	2	0	24.47	19.49	18.24	17.74	24.49	Pass
8	GSM	1900	2	0	21.99	16.49	15.24	14.74	21.99	Pass
9	WCDMA	Band 5	2	0	24.00	22.00	20.75	20.25	24.00	Pass
10	LTE	Band 5	2	0	24.50	22.00	20.75	20.25	24.50	Pass
11	LTE	Band 41	2	0	22.52	17.02	15.77	15.27	21.02	Pass

Table 7-5 TA-SAR parameters setting for scenario 2

7.3.1 Measurement results for 2G GSM

The corresponding detailed test procedure is described in 6.3.2. 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 = $Psub6\_limit$ + 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 6.3.2. For all test cases, the time-averaged SAR does not exceed the FCC limit.

- **Case 1: result for test sequence 1**

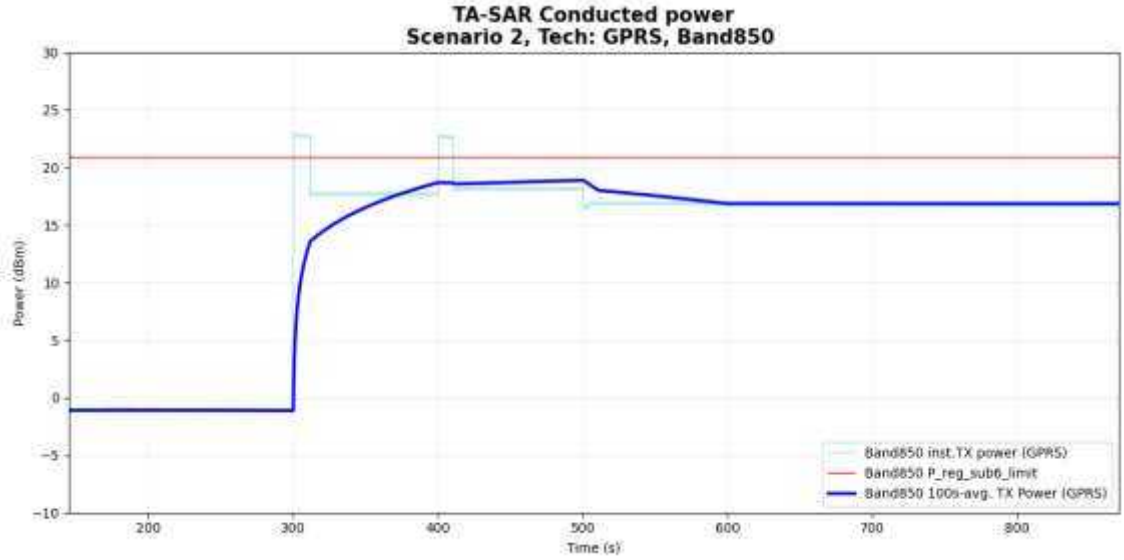


Figure 7-7 Time-averaged conducted TX power over time for case 1(GSM850)

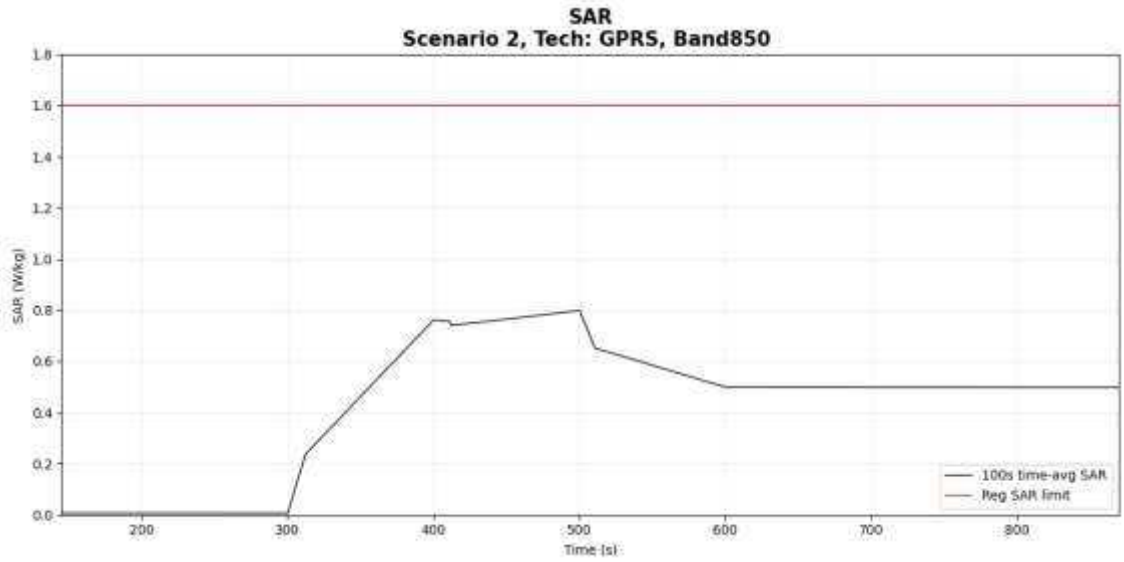


Figure 2-8 Time-averaged SAR for case 1(GSM850)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.798 W/kg
Validation result: Pass	

- **Case 2: result for test sequence 1**

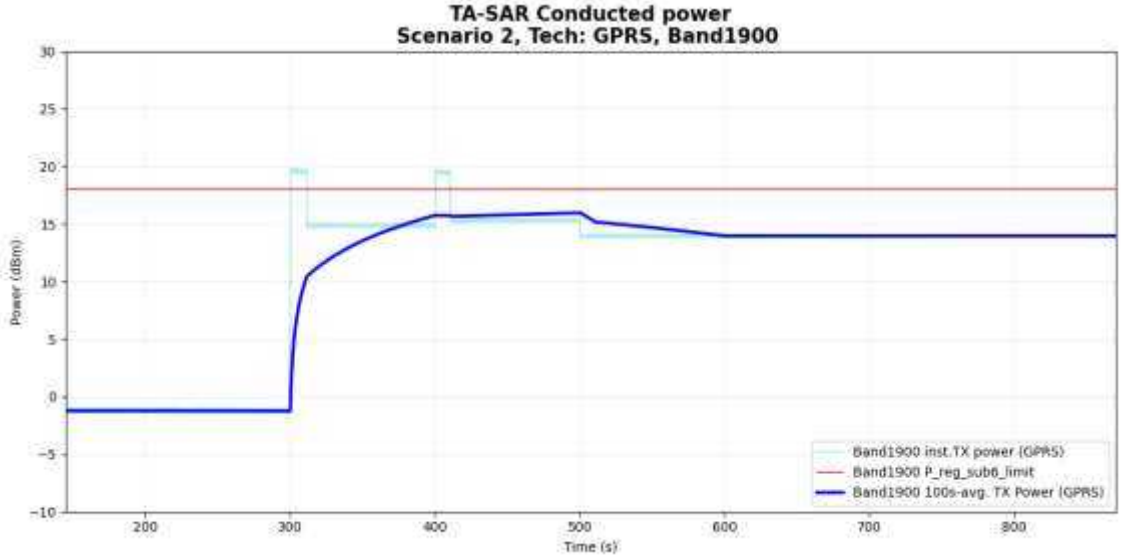


Figure 7-9 Time-averaged conducted TX power over time for case 2(GSM1900)

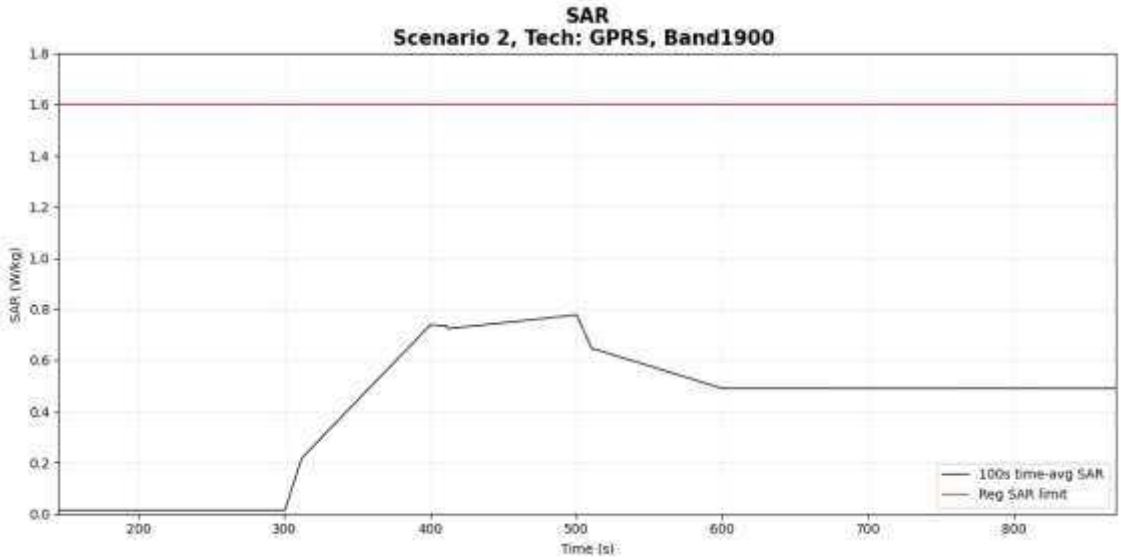


Figure 3-10 Time-averaged SAR for case 2(GSM1900)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.778 W/kg
Validation result: Pass	

- **Case 7: result for test sequence 2**

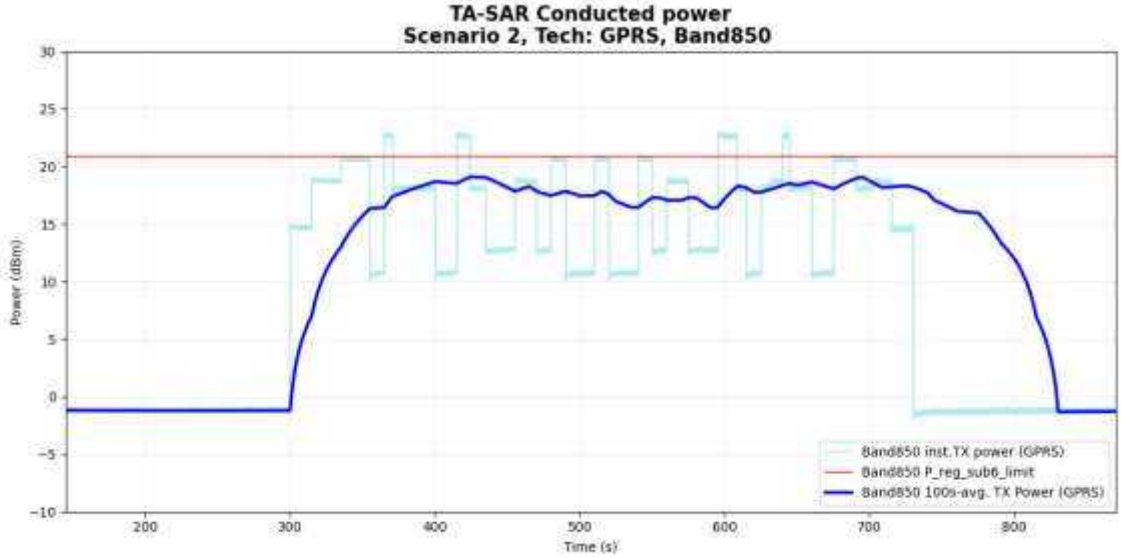


Figure 7-11 Time-averaged conducted TX power over time for case 7(GSM850)

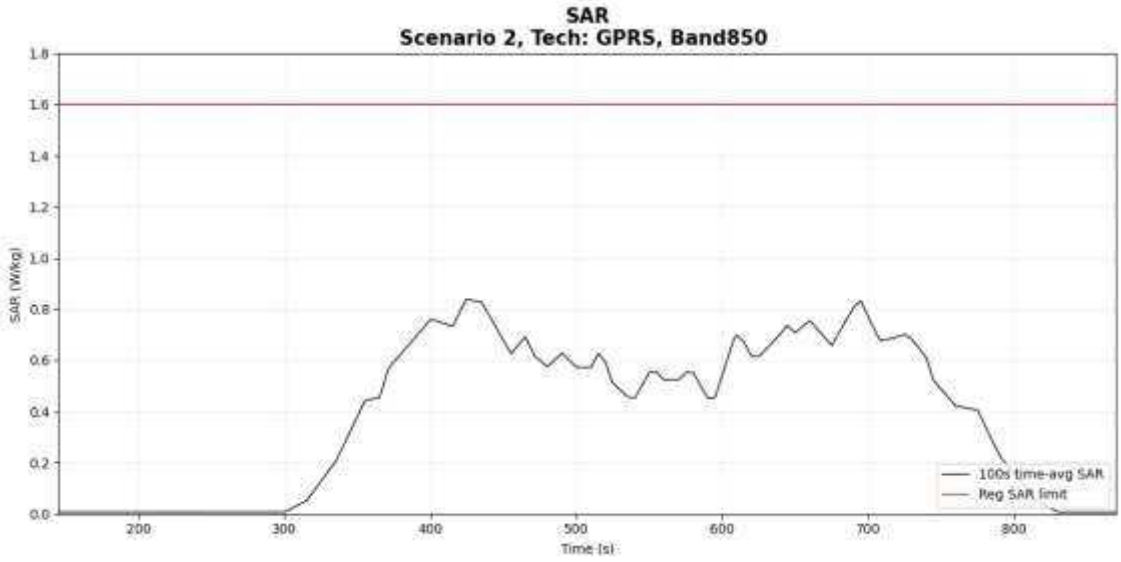


Figure 4-12 Time-averaged SAR for case 7(GSM850)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.838 W/kg
Validation result: Pass	

- **Case 8: result for test sequence 2**

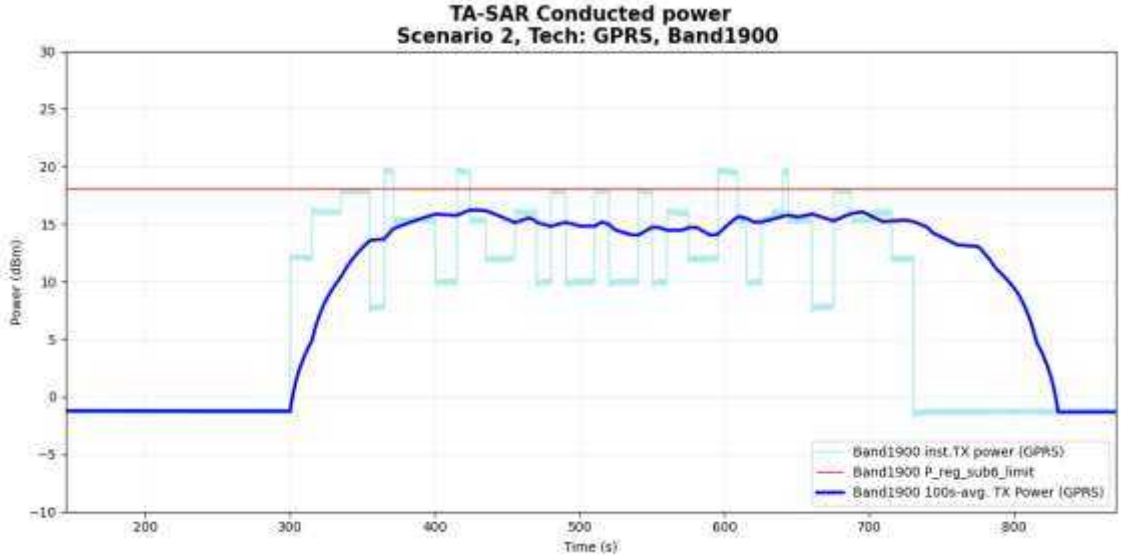


Figure 7-13 Time-averaged conducted TX power over time for case 8(GSM1900)

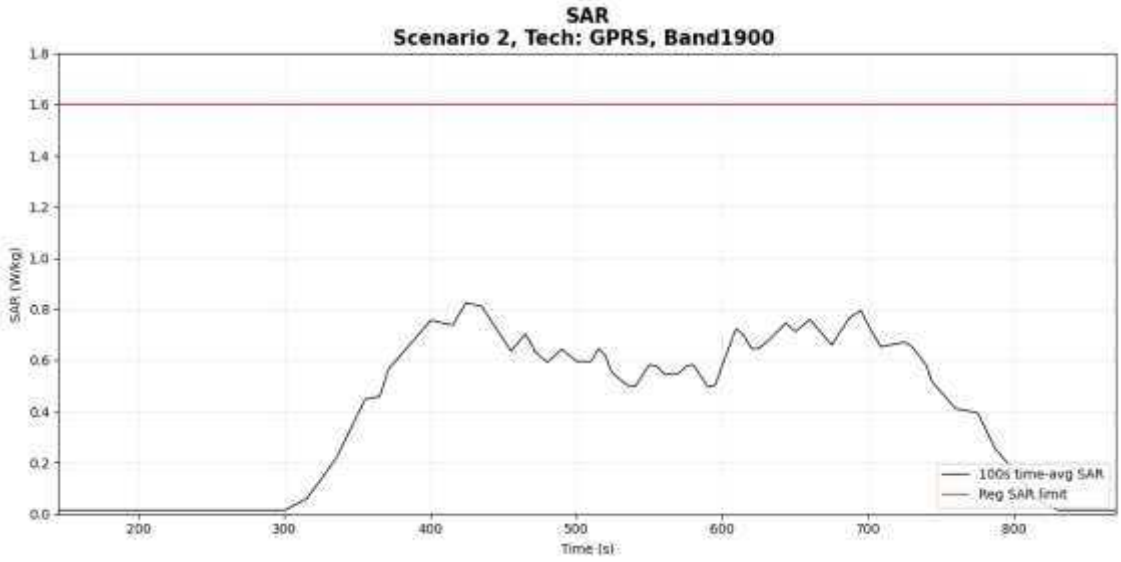


Figure 5-14 Time-averaged SAR for case 8(GSM1900)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.825 W/kg
Validation result: Pass	

7.3.2 Measurement results for 3G WCDMA

The corresponding detailed test procedure is described in 6.3.2. 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 = $Psub6\_limit$ + 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 6.3.2. For all test cases, the time-averaged SAR does not exceed the FCC limit.

- **Case 3: result for test sequence 1**

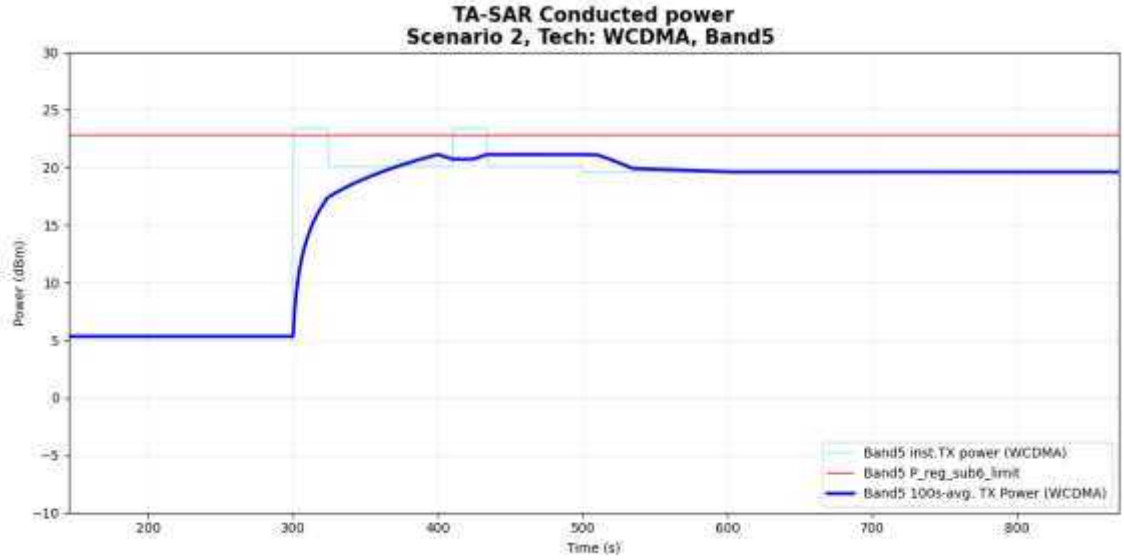


Figure 7-15 Time-averaged conducted TX power over time for case 3(WCDMA B5)

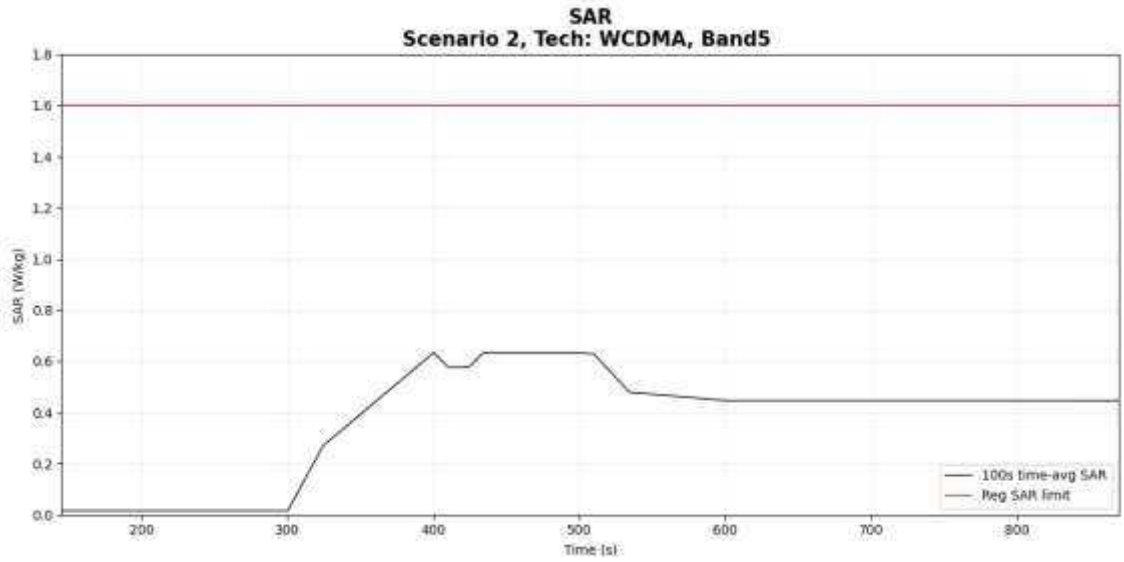


Figure 6-16 Time-averaged SAR for case 3(WCDMA B5)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.634 W/kg
Validation result: Pass	

- **Case 9: result for test sequence 2**

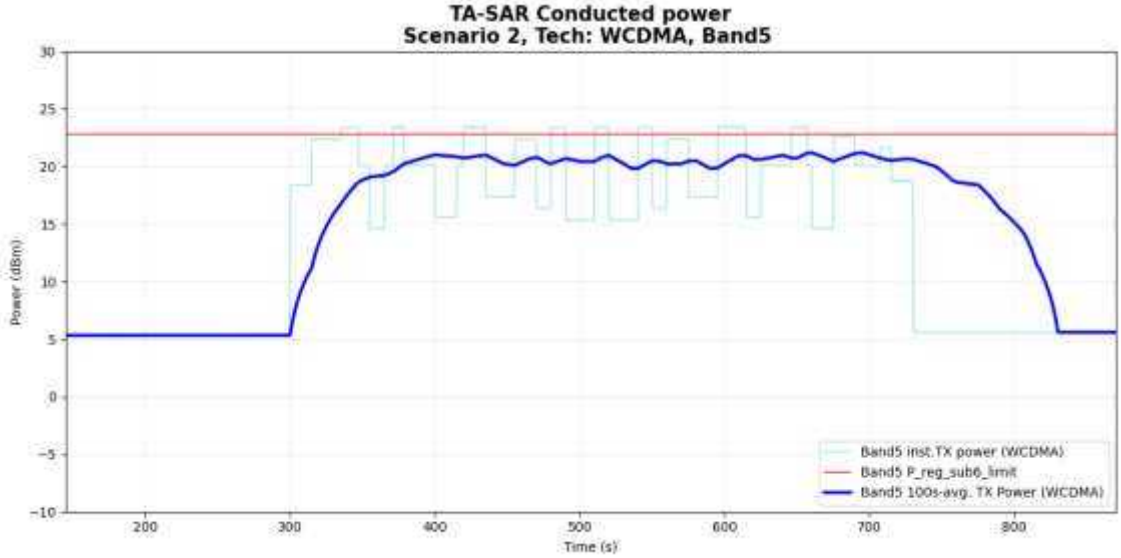


Figure 7-17 Time-averaged conducted TX power over time for case 9(WCDMA B5)

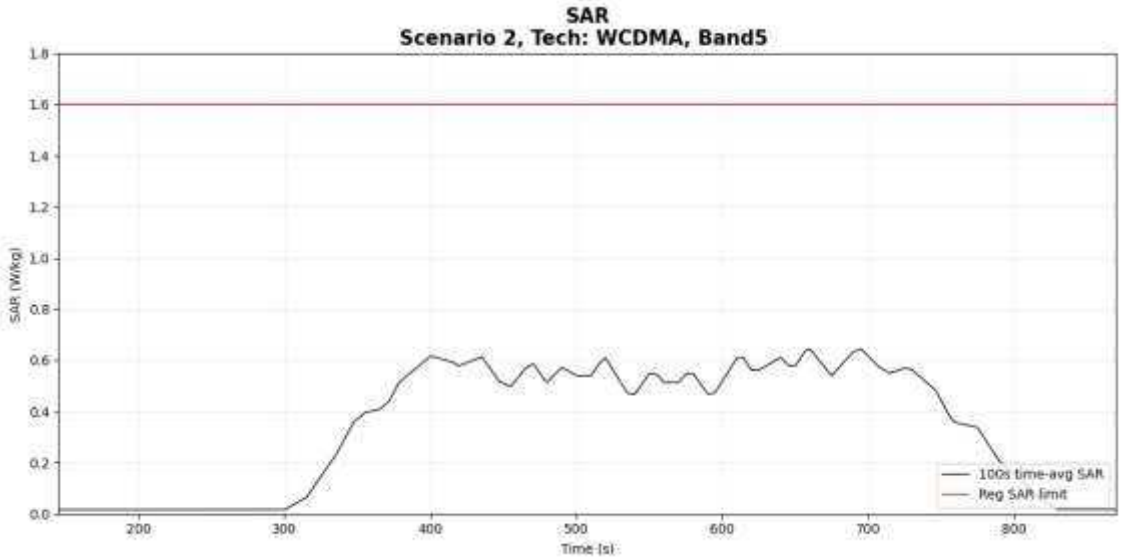


Figure 7-18 Time-averaged SAR for case 9(WCDMA B5)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.645 W/kg
Validation result: Pass	

7.3.3 Measurement results for 4G LTE

The corresponding detailed test procedure is described in 6.3.2. 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 = $Psub6\_limit$ + 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 6.3.2. For all test cases, the time-averaged SAR does not exceed the FCC limit.

- **Case 4: result for test sequence 1**

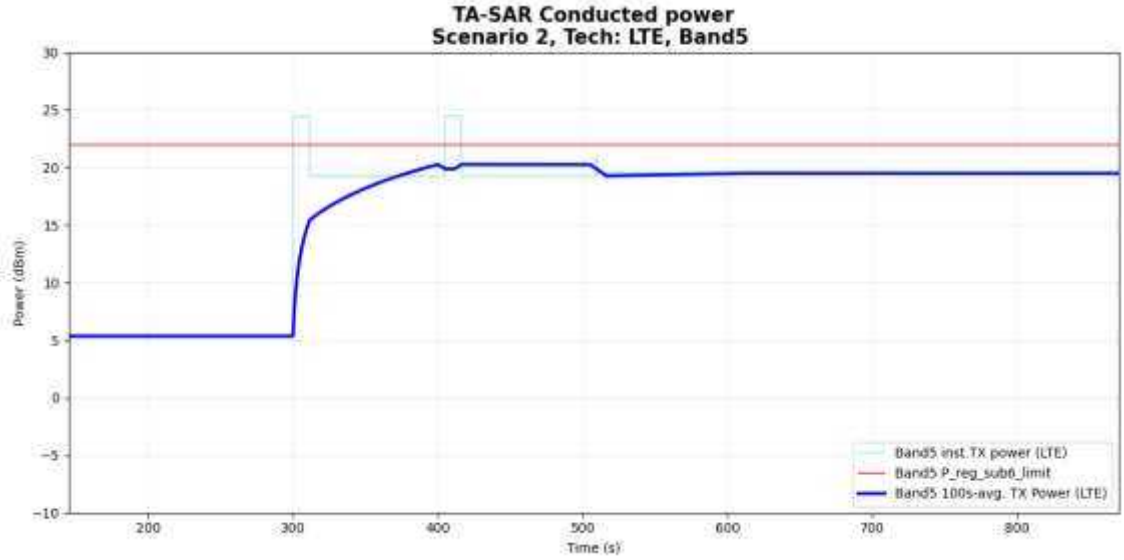


Figure 7-19 Time-averaged conducted TX power over time for case 4(LTE B5)

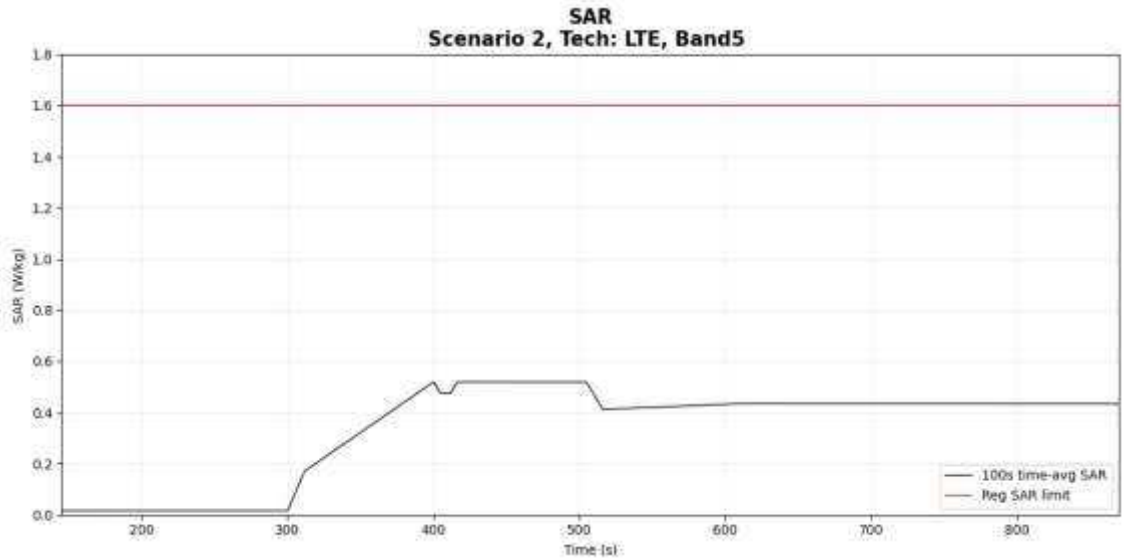


Figure 8-20 Time-averaged SAR for case 4(LTE B5)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.519 W/kg
Validation result: Pass	

- **Case 5: result for test sequence 1**

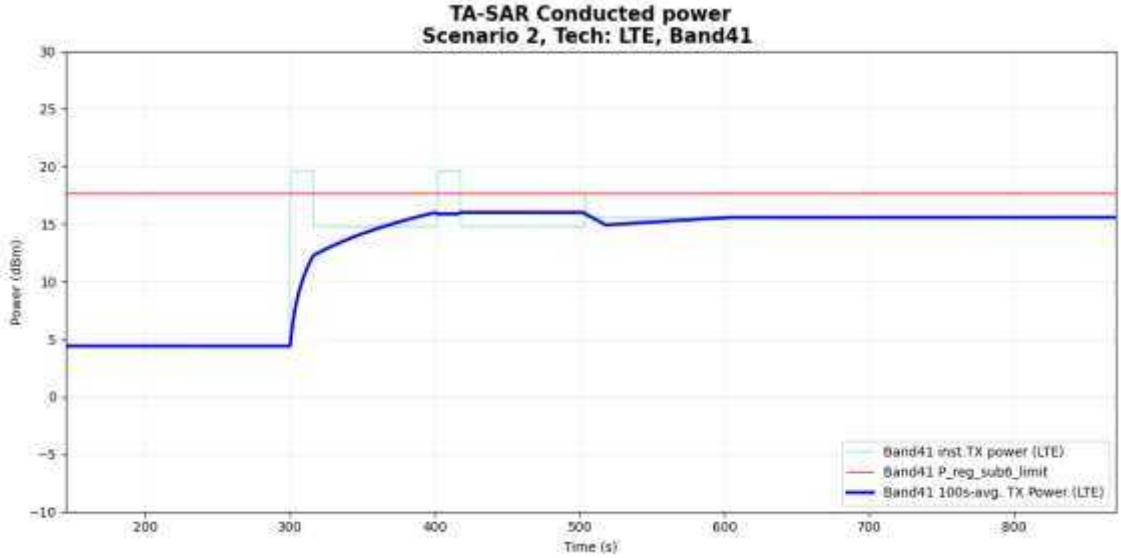


Figure 7-21 Time-averaged conducted TX power over time for case 5(LTE B41)

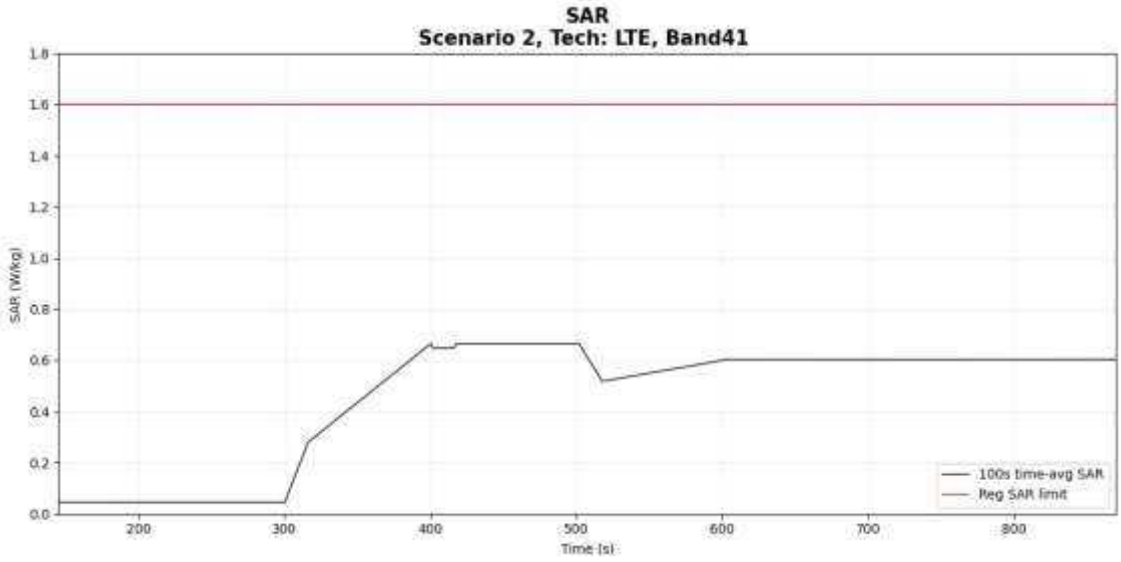


Figure 9-22 Time-averaged SAR for case 5(LTE B41)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.665 W/kg
Validation result: Pass	

- **Case 10: result for test sequence 2**

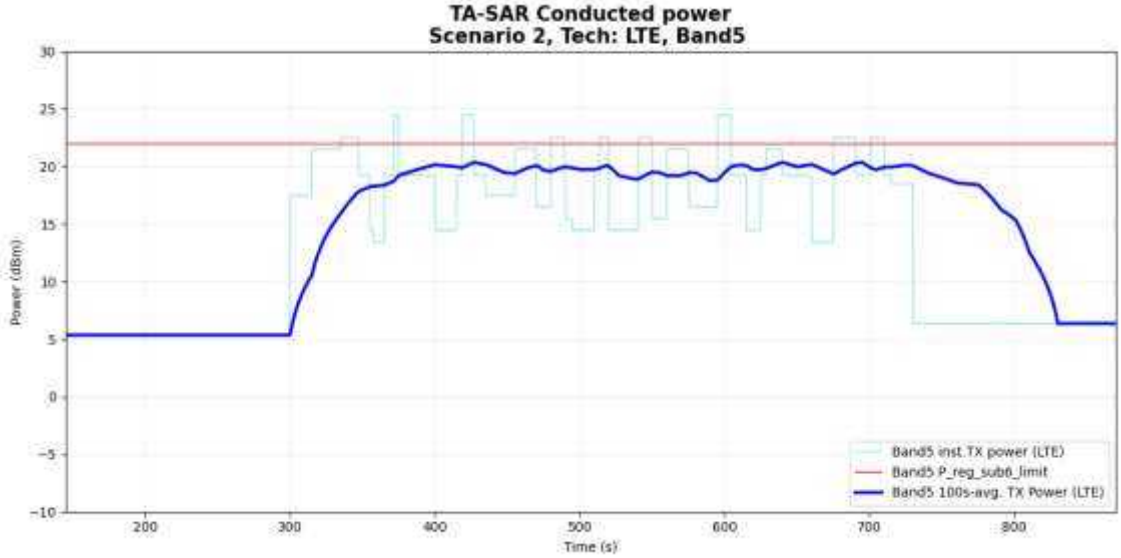


Figure 7-23 Time-averaged conducted TX power over time for case 10(LTE B5)

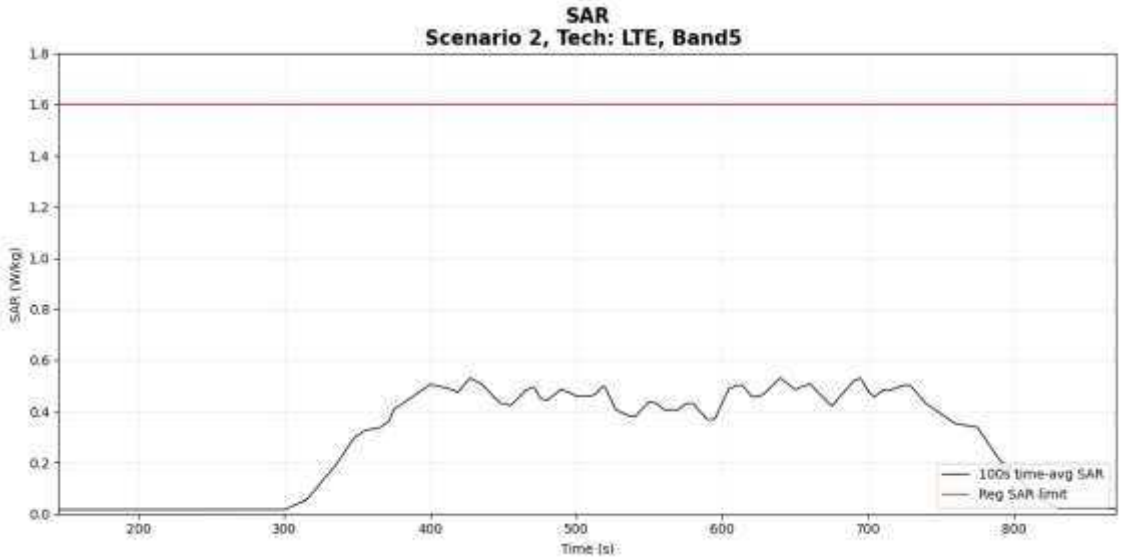


Figure 10-24 Time-averaged SAR for case 10(LTE B5)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.531 W/kg
Validation result: Pass	

- **Case 11: result for test sequence 2**

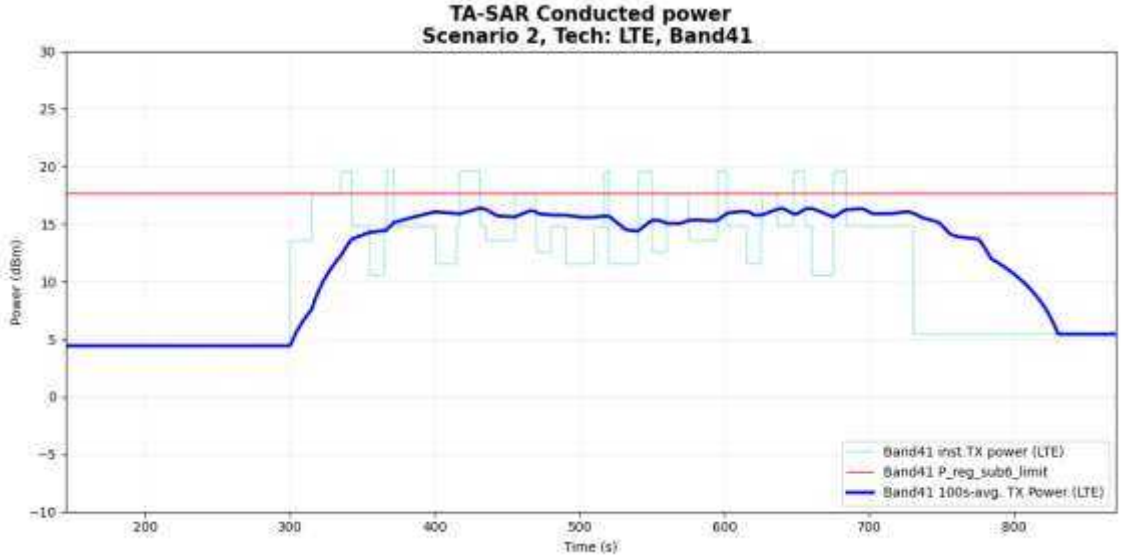


Figure 7-25 Time-averaged conducted TX power over time for case 11(LTE B41)

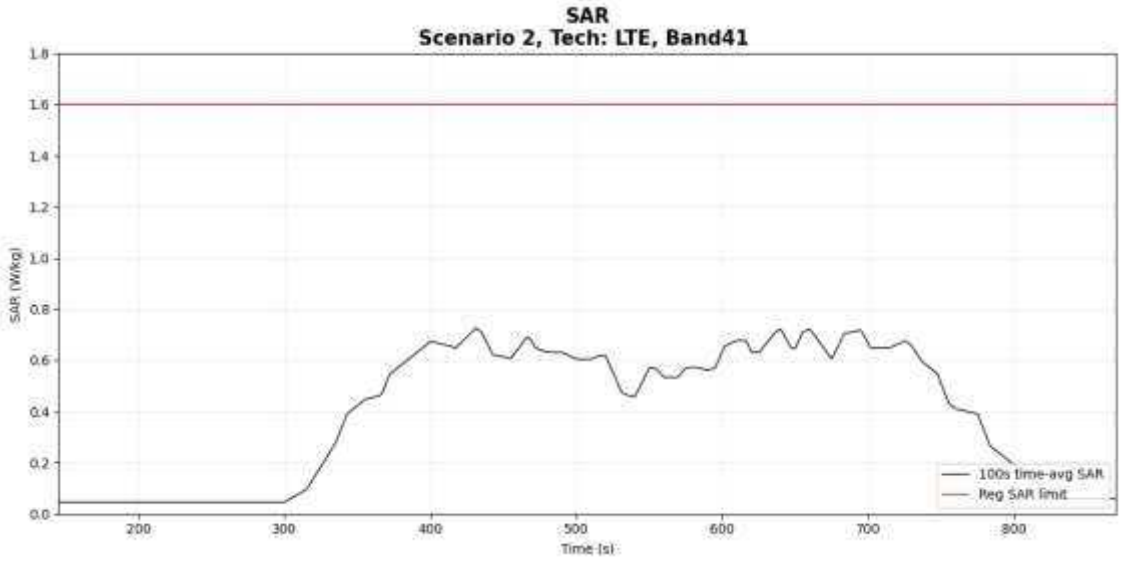


Figure 11-26 Time-averaged SAR for case 11(LTE B41)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.727 W/kg
Validation result: Pass	

7.4 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 7-6, and the test procedure follows section 6.4.2. The measurement setup is shown in Figure 7-2. 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.

Test case	RAT	Test band	Test seq.	ECI	Max power (dBm)	$Psub6\_limit$ (dBm)	$PLowThresh$ (dBm)	$PUE\_backoff$ (dBm)	PUE_max_cust (dBm)	Pass /Fail SAR limit
12	LTE	Band 41	0	0	22.52	17.02	15.77	15.27	21.02	Pass

Table 7-6 TA-SAR parameters setting for scenario 3

The corresponding detailed test procedure is described in 6.4.2. Figure 7-27 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 = $Psub6\_limit$ + 1dB device uncertainty). Figure 7-28 illustrates the corresponding time-averaged SAR over time converted from the TX time-averaged power by using the equation listed in section 6.4.2. As seen in this figure, the time-averaged SAR does not exceed the FCC limit.

- **Case 12: call drop happens at the time instance of 500 seconds**

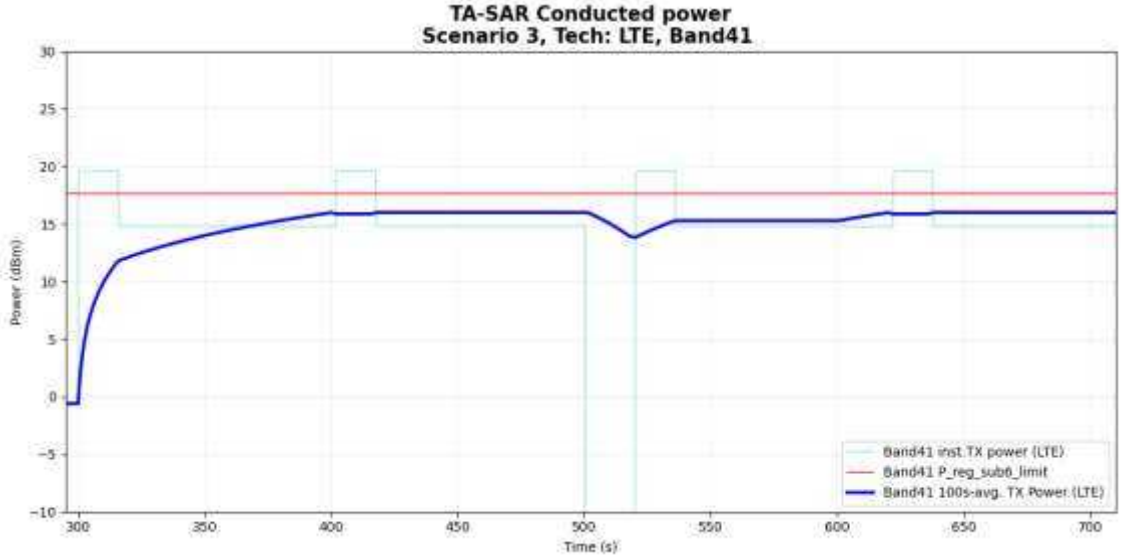


Figure 7-27 Time-averaged conducted TX power over time for case 12(LTE B41)

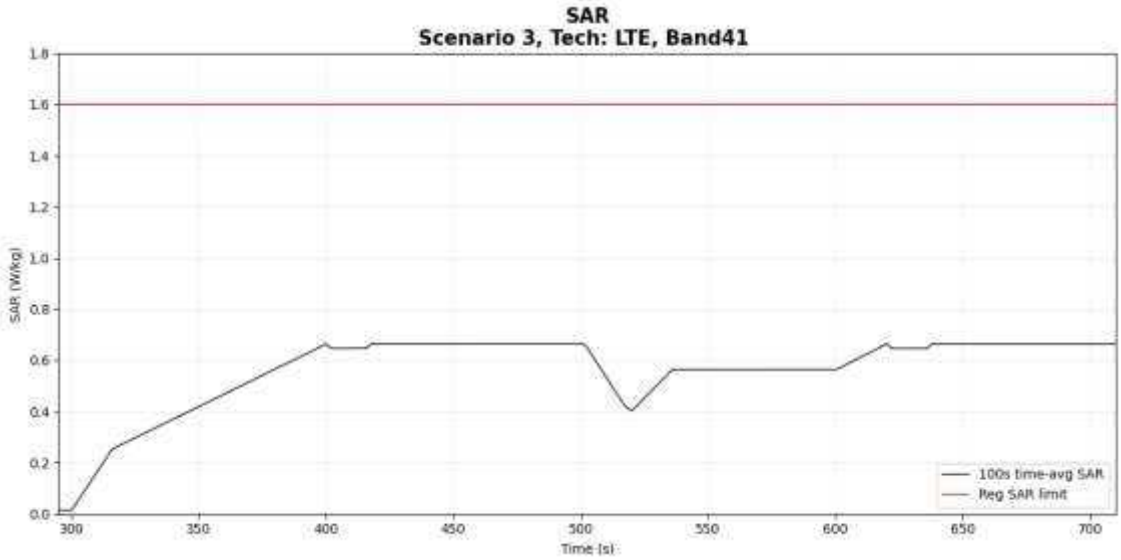


Figure 12-28 Time-averaged SAR for case 12(LTE B41)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.666 W/kg
Validation result: Pass	

7.5 Conducted 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 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 7-7, and the test procedure follows section 6.5.2. The measurement setup is shown in Figure 7-3 (band handover) and Figure 7-4 (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.

Test case	RAT	Test band	Test seq.	ECI	Max power (dBm)	$Psub6\_limit$ (dBm)	$PLowThresh$ (dBm)	$PUE\_backoff$ (dBm)	PUE_max_cust (dBm)	Pass /Fail SAR limit
13	WCDMA	Band 5	0	0	24.00	22.00	20.75	20.25	24.00	Pass
	LTE	Band 41	0	0	22.52	17.02	15.77	15.27	21.02	Pass

Table 7-7 TA-SAR parameters setting for scenario 4

The corresponding detailed test procedure is described in 6.5.2. 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 = $Psub6\_limit$ + 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 Psub6_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 6.5.2. The figure shows that the time-averaged normalized SAR does not exceed the normalized FCC limit of 1.

- **Case 13: Band handover happens at the time instance of 500 seconds**

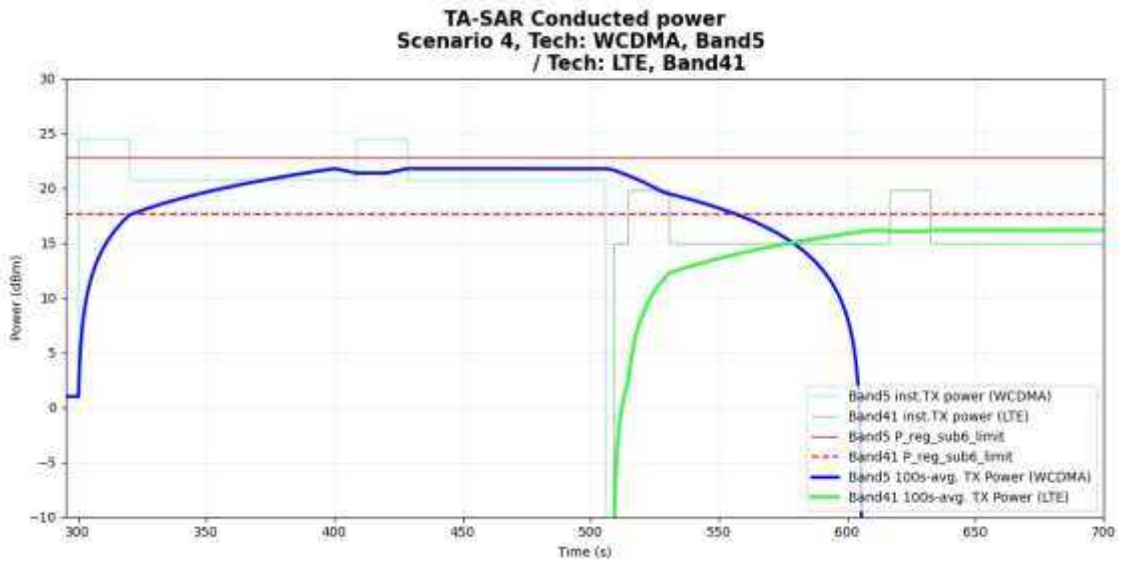


Figure 7-29 Time-averaged conducted TX power over time for case 13 (WCDMA B5, LTE B41)

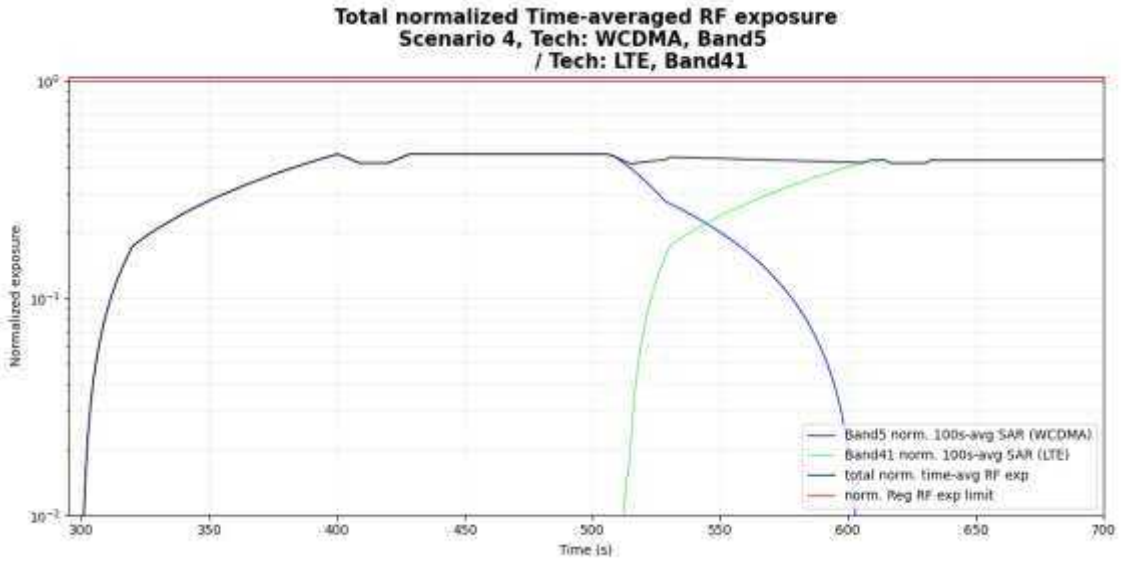


Figure 13-30 Normalized time-averaged SAR for case 13 (WCDMA B5, LTE B41)

FCC limit of total RF exposure (normalized)	1.0
Max 60s-time averaged 1gSAR	0.461
Validation result: Pass	

7.6 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 7-8, and the test procedure follows section 6.6.2. The measurement setup is shown in Figure 7-2. 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.

Test case	RAT	Test band	Test seq.	ECI	Max power (dBm)	$Psub6\_limit$ (dBm)	$PLowThresh$ (dBm)	$PUE\_backoff$ (dBm)	PUE_max_cust (dBm)	Pass /Fail SAR limit
14	LTE	Band 41	0	0	22.52	17.02	15.77	15.27	21.02	Pass
				1		22.52	21.27	20.77		

Table 7-8 TA-SAR parameters setting for scenario 5

The corresponding detailed test procedure is described in 6.6.2. 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 = $Psub6\_limit$ + 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 = 0 to ECI = 1 and the 2nd change is from ECI = 1 back to ECI = 0. It is observed in the figure that the time-averaged TX power of the individual RAT is below its own Psub6_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 6.6.2. The figure shows that the time-averaged normalized SAR does not exceed the normalized FCC limit of 1.

- **Case 14: two ECI changes happen at the time instances of 500 and 700 seconds, respectively**

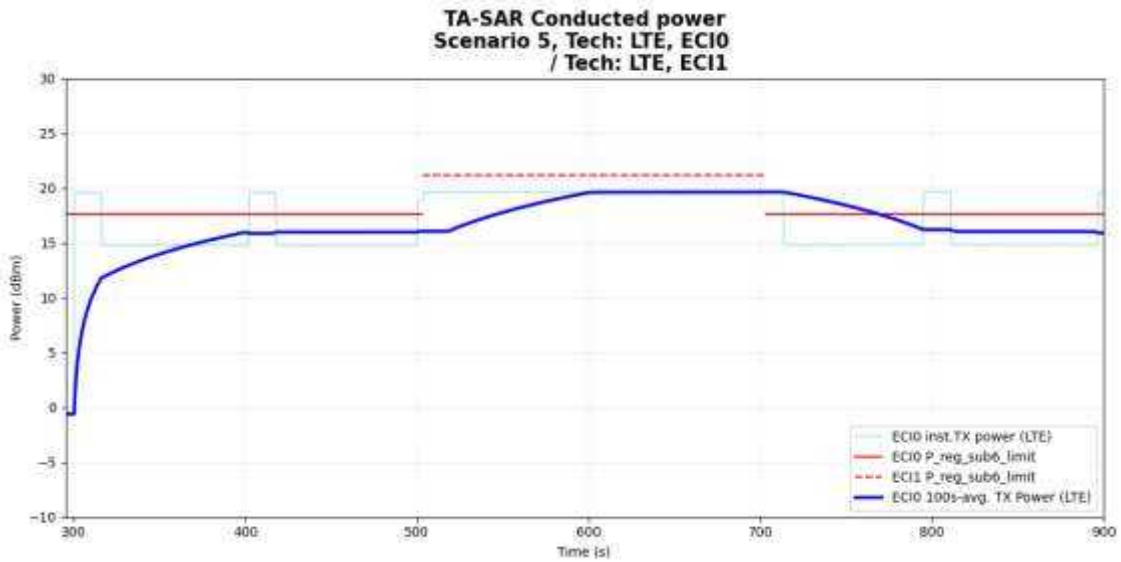


Figure 7-31 Time-averaged conducted TX power over time for case 14 (LTE B41)

* Note: The inst. TX power should be compared with P_reg_sub6_limit of the corresponding configuration, 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.

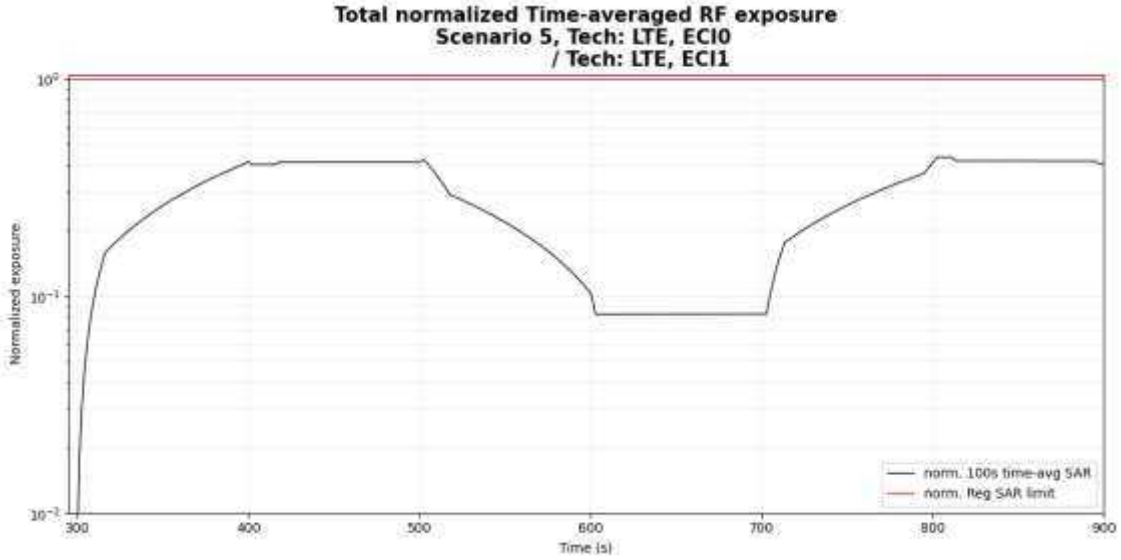


Figure 14-32 Normalized time-averaged SAR for case 16 (LTE B41)

FCC limit of total RF exposure (normalized)	1.0
Max 60s-time averaged 1gSAR	0.437
Validation result: Pass	

7.7 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 sub6 NR 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 7-9, and the test procedure follows section 6.7.2. The measurement setup is shown in Figure 7-4.

Test case	RAT	Test band	Test seq.	ECI	Max power (dBm)	$Psub6\_limit$ (dBm)	$PLowThresh$ (dBm)	$PUE\_backoff$ (dBm)	PUE_max_cust (dBm)	Pass /Fail SAR limit
15	LTE	Band 2	0	0	23.00	19.00	17.75	17.25	23.00	Pass
	FR1	n5	0	0	24.00	22.00	20.75	20.25	24.00	

Table 7-9 TA-SAR parameters setting for scenario 8

During the test period,

- Time = 300s~500s: NR sub5-only scenario.
- Time = 500s~700s: LTE+ NR sub6 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 $Psub6\_limit$ + 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 6.7.2. The figure shows that the time-averaged normalized SAR does not exceed the normalized FCC limit of 1.

- **Case 15**

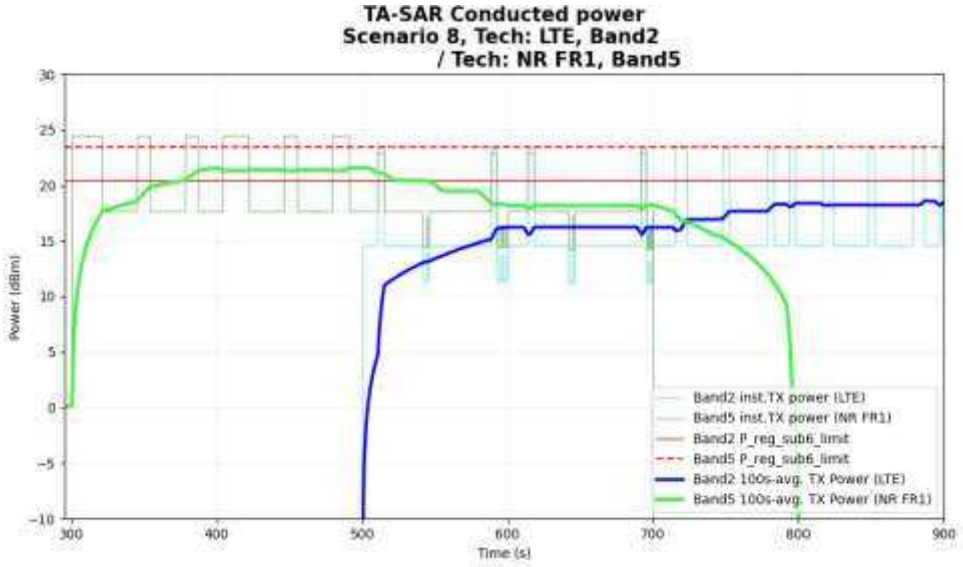


Figure 7-33 Time-averaged conducted TX power over time for case 15 (LTE B2, sub6 NR n5)

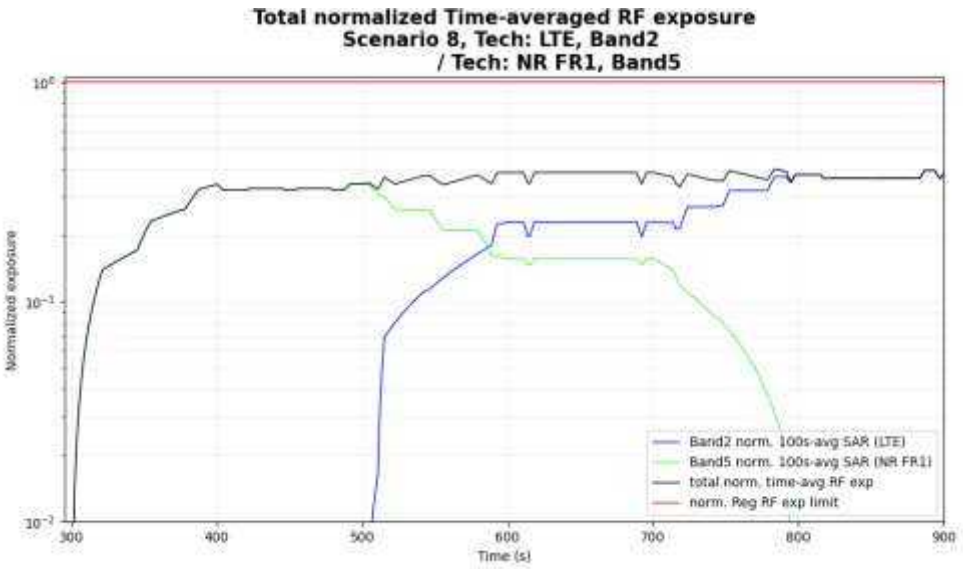


Figure 15-34 Normalized time-averaged SAR for case 15 (LTE B2, sub6 NR n5)

FCC limit of total RF exposure (normalized)	1.0
Max 60s-time averaged 1gSAR	0.401
Validation result: Pass	

8. TA-SAR Validation via SAR Measurements

8.1 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 9-1.

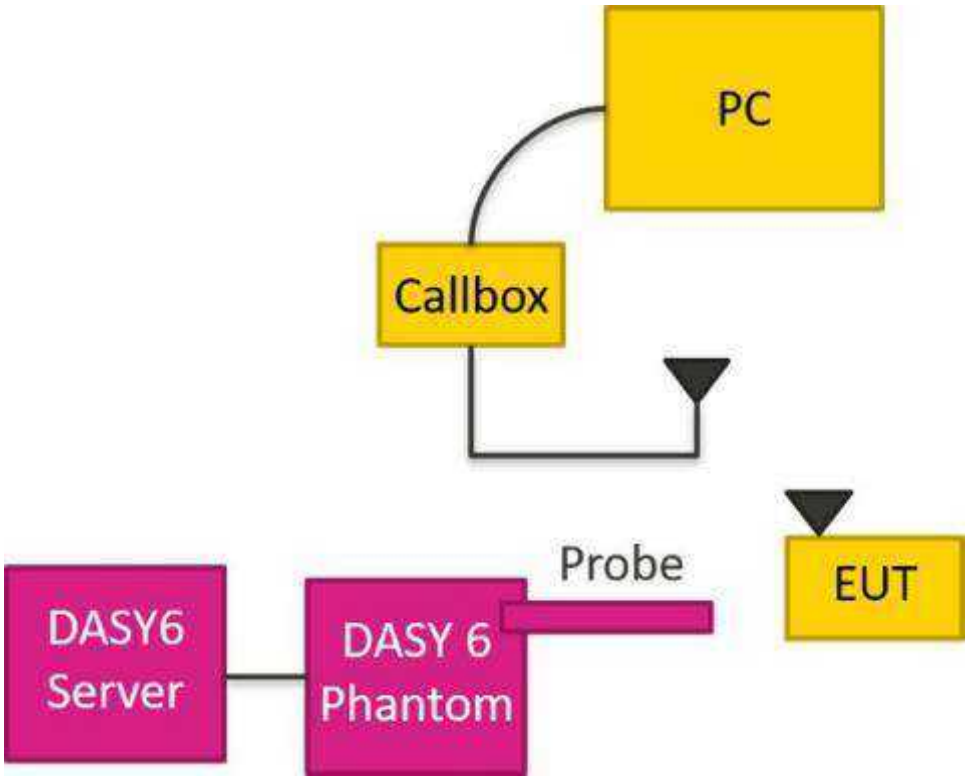


Figure 9-1 TA-SAR wireless test environment

8.2 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 6.1 and test sequence #2 is tabulated in table 6.4. All of the test cases for this scenario are relegated in Table 9-1, and the test procedure follows section 6.8.2. The measurement setup is shown in Figure 9-1. All of the measurements are conduct by using DASY6. The high-level summary of the final validation results is given in the last column of the table, which concludes that Mediatek's TA-SAR 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.

Test case	RAT	Test band	Test seq.	ECI	Max power (dBm)	*Psub6_limit* (dBm)	*PLowThresh* (dBm)	*PUE_backoff* (dBm)	*PUE_max_cust* (dBm)	Pass /Fail SAR limit
1	GSM	850	1	0	24.47	19.49	18.24	17.74	24.49	Pass
2	GSM	1900	1	0	21.99	16.49	15.24	14.74	21.99	Pass
3	WCDMA	Band 5	1	0	24.00	22.00	20.75	20.25	24.00	Pass
4	LTE	Band 5	1	0	24.50	22.00	20.75	20.25	24.50	Pass
5	LTE	Band 41	1	0	22.52	17.02	15.77	15.27	21.02	Pass
7	GSM	850	2	0	24.47	19.49	18.24	17.74	24.49	Pass
8	GSM	1900	2	0	21.99	16.49	15.24	14.74	21.99	Pass
9	WCDMA	Band 5	2	0	24.00	22.00	20.75	20.25	24.00	Pass
10	LTE	Band 5	2	0	24.50	22.00	20.75	20.25	24.50	Pass
11	LTE	Band 41	2	0	22.52	17.02	15.77	15.27	21.02	Pass

Table 9-1 Operating parameters for different TA-SAR parameters setting

8.2.1 SAR Measurement results for 2G GSM

- **Case 1: result for test sequence 1**

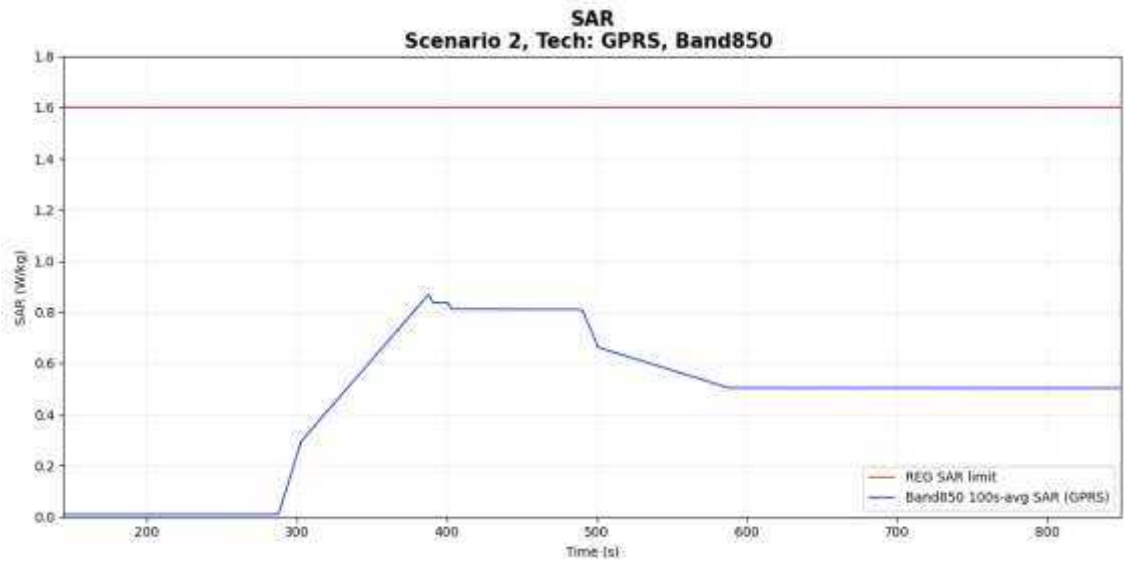


Figure 9-2 Time-averaged SAR for case 1(GSM850)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.868 W/kg
Validation result: Pass	

- **Case 2: result for test sequence 1**

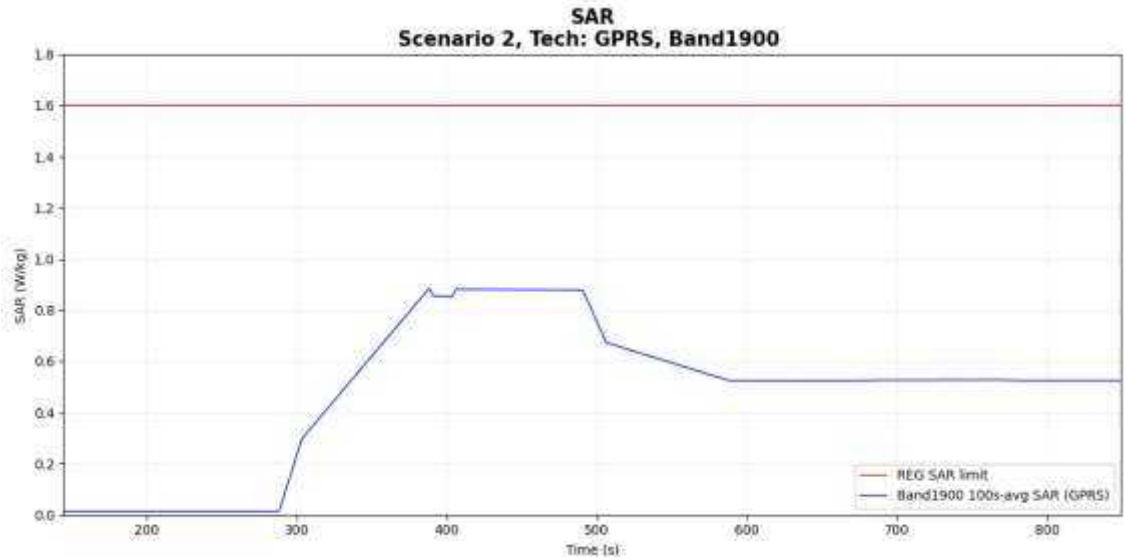


Figure 9-3 Time-averaged SAR for case 2(GSM1900)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.885 W/kg
Validation result: Pass	

- **Case 7: result for test sequence 2**

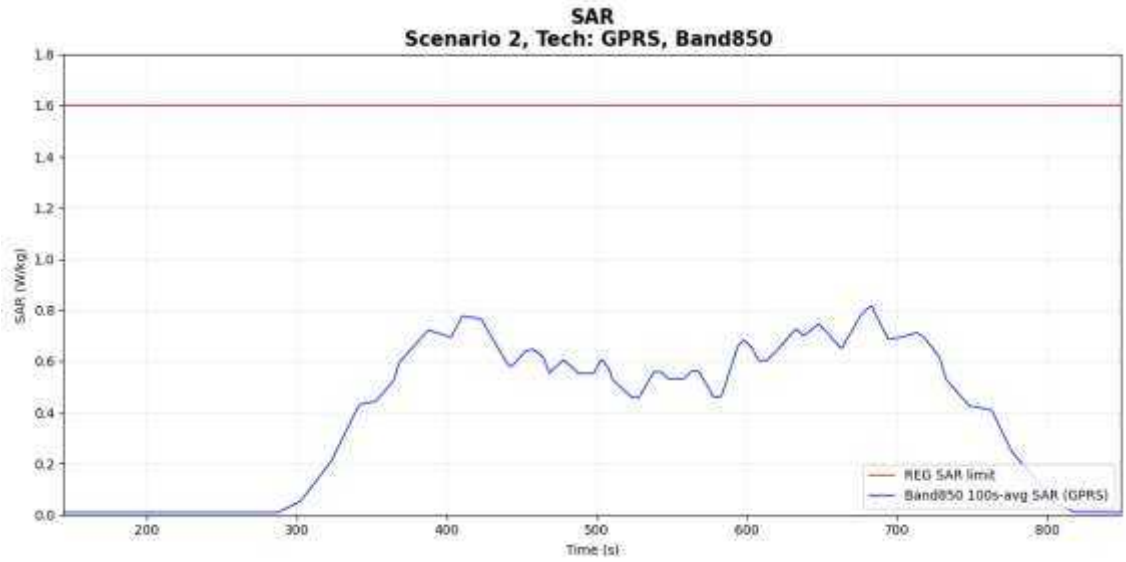


Figure 9-4 Time-averaged SAR for case 7(GSM850)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.817 W/kg
Validation result: Pass	

- **Case 8: result for test sequence 2**

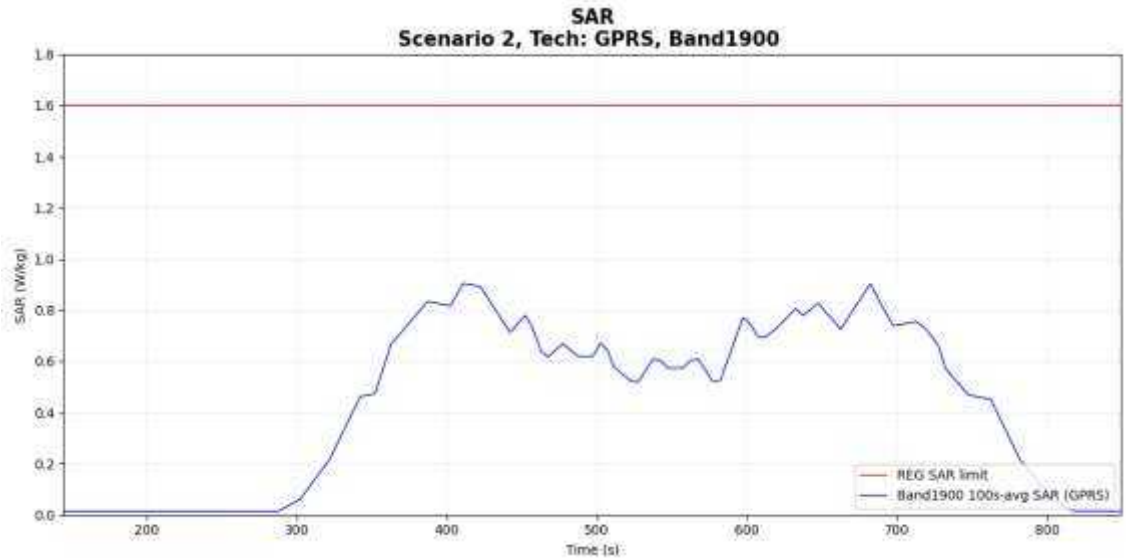


Figure 9-5 Time-averaged SAR for case 8(GSM1900)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.904 W/kg
Validation result: Pass	

8.2.2 SAR Measurement results for 3G WCDMA

- **Case 3: result for test sequence 1**

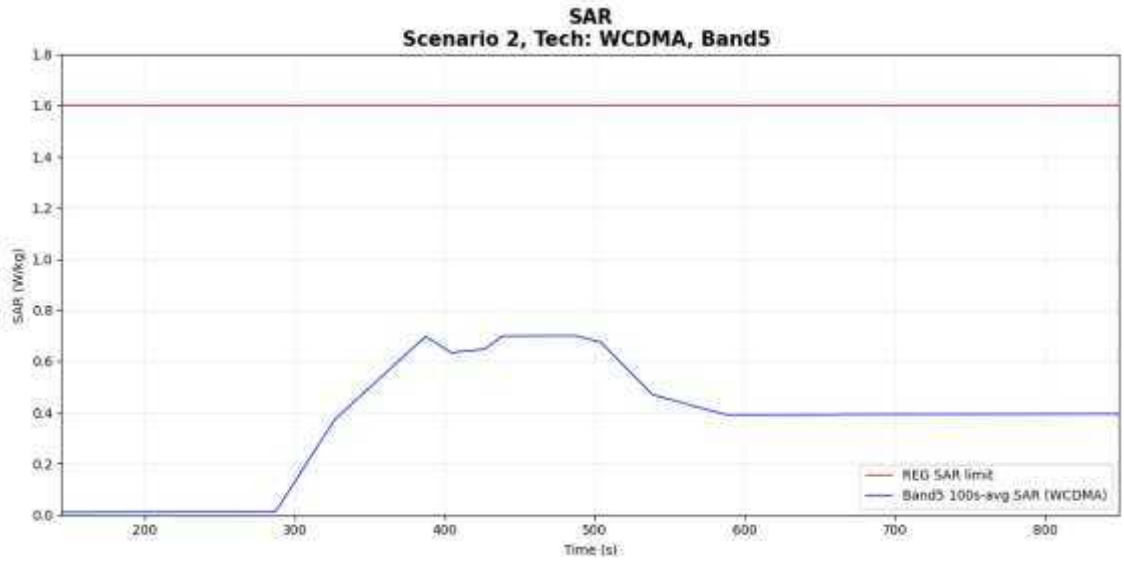


Figure 9-6 Time-averaged SAR for case 3(WCDMA B5)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.700 W/kg
Validation result: Pass	

- **Case 9: result for test sequence 2**

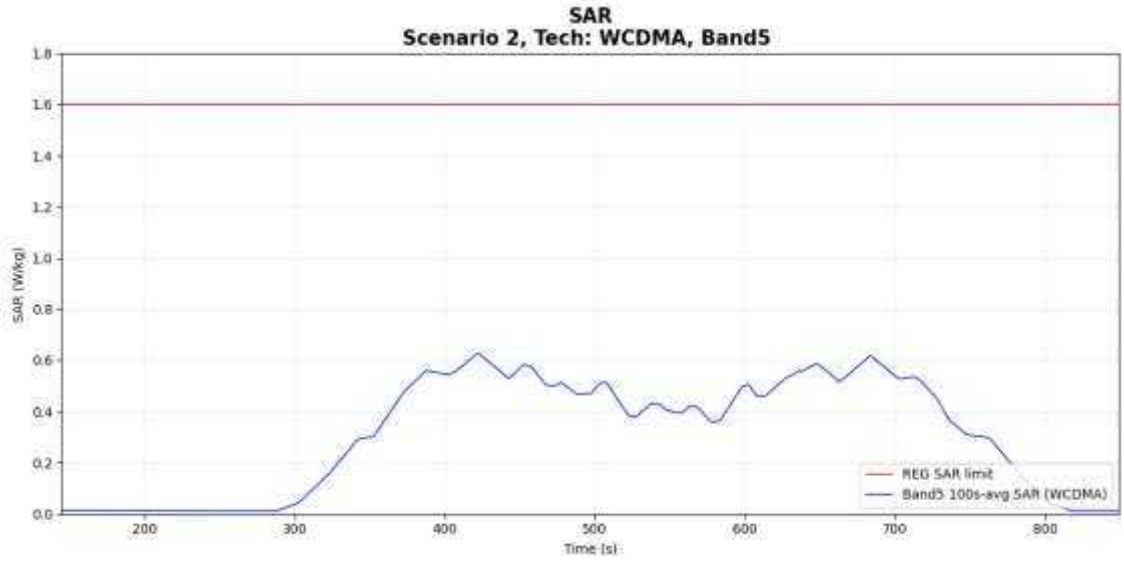


Figure 9-7 Time-averaged SAR for case 9(WCDMA B5)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.627 W/kg
Validation result: Pass	

8.2.3 SAR Measurement results for 4G LTE

- **Case 4: result for test sequence 1**

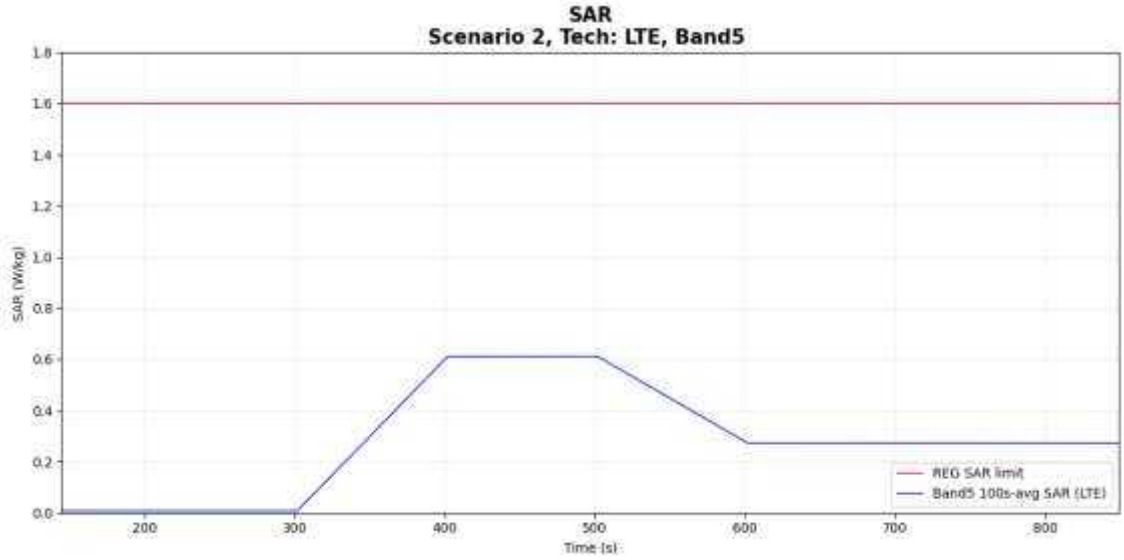


Figure 9-8 Time-averaged SAR for case 4(LTE B5)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.612 W/kg
Validation result: Pass	

- **Case 5: result for test sequence 1**

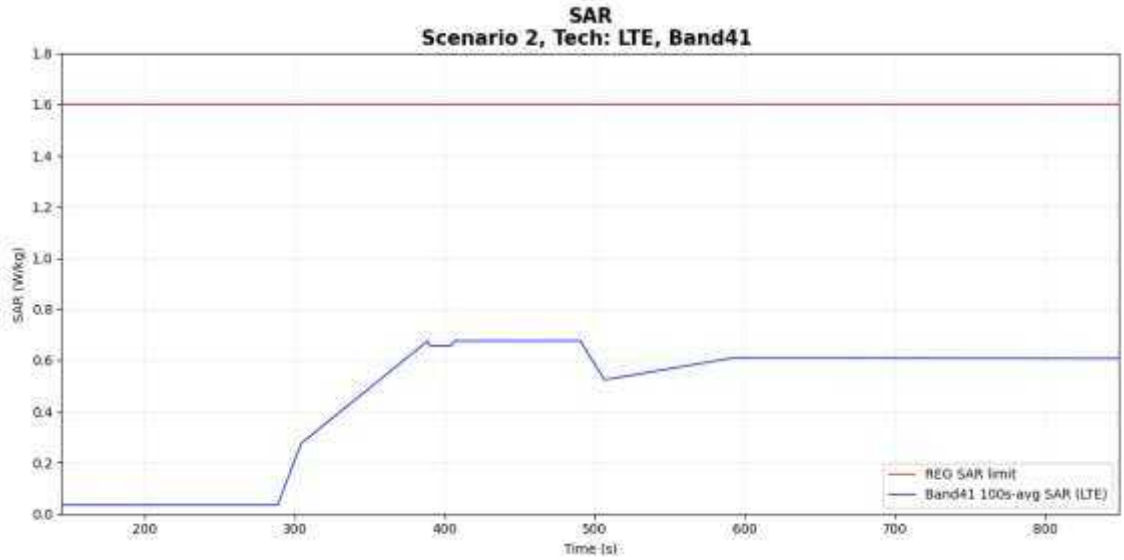


Figure 9-9 Time-averaged SAR for case 5(LTE B41)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.677 W/kg
Validation result: Pass	

- **Case 10: result for test sequence 2**

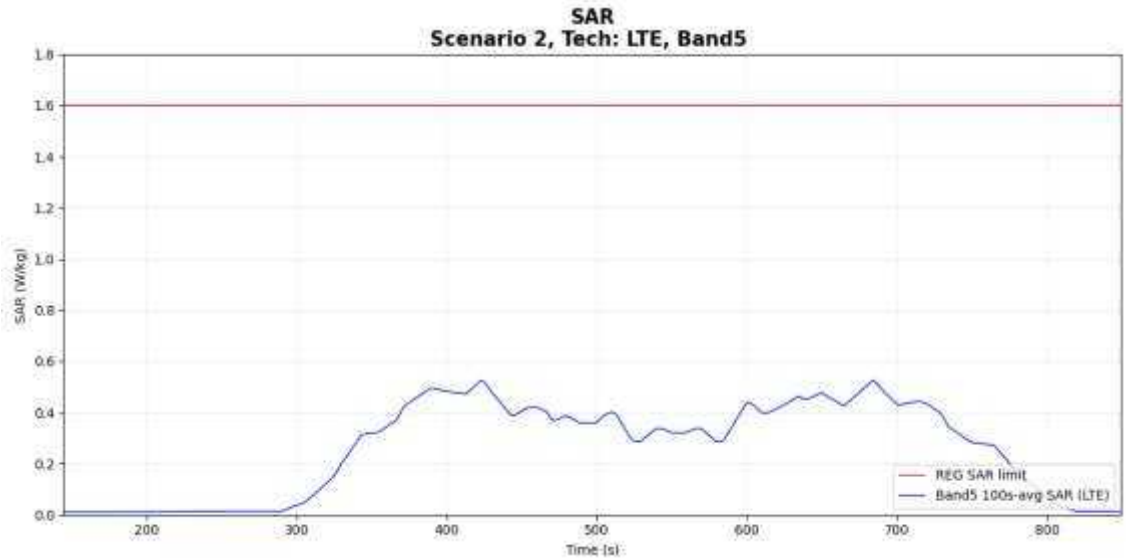


Figure 9-10 Time-averaged SAR for case 10(LTE B5)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.526 W/kg
Validation result: Pass	

- **Case 11: result for test sequence 2**

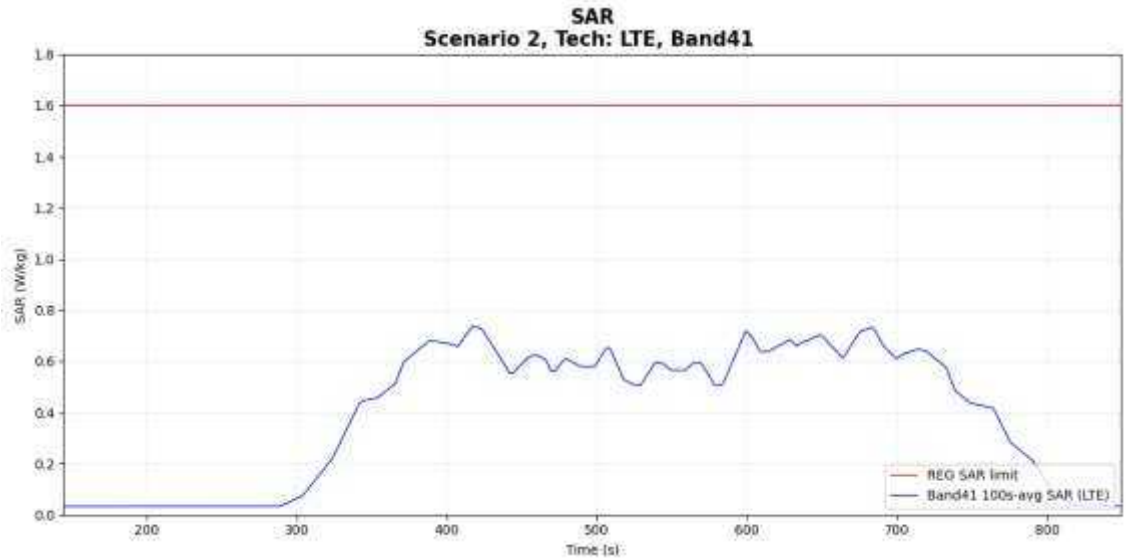


Figure 9-11 Time-averaged SAR for case 11(LTE B41)

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.738 W/kg
Validation result: Pass	

9. Conclusions

This report TA-SAR test scenarios further proves TA-SAR algorithms can meet the FCC SAR regulations with the proposed test scenarios and procedures by Mediatek's. As shown in Chapters 7, Mediatek's TA-SAR algorithms are able to maintain SAR over time below the FCC regulatory limits (based on the agreed TX-power-to-SAR translation). Based on the provided measurement evidence, it is concluded that Mediatek's TA-SAR algorithms can be tested by using the proposed test methodology for FCC compliance.

10. Equipment Used During Test

10.1 DASY System

Test Platform	SPEAG DASY System				
Manufacture	SPEAG				
Description	SAR Test System				
Software Reference	DASY6 Module SAR V16.4.0.5005				
Equipment	**Type**	**Serial Number**	**Cal Date**	**Cal Interval**	**Cal Due**
Phantom	SAM Phantom	1997	N/A	N/A	N/A
Phantom	SAM Phantom	1998	N/A	N/A	N/A
Verification Dipole	D835V2	490	2024-06-07	Biennial	2026-06-07
Verification Dipole	D1900V2	5d033	2024-06-13	Biennial	2026-06-13
Verification Dipole	D2600V2	1124	2024-07-22	Biennial	2026-07-22
Dielectric Assessment Kit	DAK-3.5	1107	2024-05-21	Annual	2025-05-21
DAE	DAE4	1504	2024-01-17	Annual	2025-01-17
E-Field Probe	EX3DV4	7574	2024-05-23	Annual	2025-05-23
Network Analyzer	E5063A	MY54706220	2024-01-10	Annual	2025-01-10
Vector Signal Generator	E4438C	MY44270498	2024-02-08	Annual	2025-02-08
RF Amplifier	AMP2027ADB	10001	2024-08-29	Annual	2025-08-29
Power Meter	N1914A	MY56120017	2024-06-03	Annual	2025-06-03
Power Sensor	E9300H	MY41495307	2024-04-17	Annual	2025-04-17
Power Sensor	NRP8S	110814	2024-07-05	Annual	2025-07-05
Power Sensor	NRP8S	110815	2024-07-05	Annual	2025-07-05
Dual Directional Coupler	777D	50128	2024-05-29	Annual	2025-05-29
Dual Directional Coupler	778D	MY52180497	2024-03-07	Annual	2025-03-07
Directional Coupler	100312420	222969	2024-05-21	Annual	2025-05-21
Directional Coupler	100312420	222970	2024-05-21	Annual	2025-05-21
LP Filter	LA-15N	LF02	2024-03-05	Annual	2025-03-05
LP Filter	WLJ4-3000-5850-8000-60EF	1	2024-05-29	Annual	2025-05-29
Attenuator	2	CB6049	2024-05-28	Annual	2025-05-28
Hygro-Thermometer	303	210700048	2024-01-30	Annual	2025-01-30
Digital Thermometer	SDT25	19041500179	2024-08-29	Annual	2025-08-29
UXM 5G Wireless Test Platform	E7515B	MY61349610	2024-02-26	Annual	2025-02-26
Radio Communication	CMW500	144030	2024-08-29	Annual	2025-08-29

10.2 The SAR Measurement System

A block diagram of the SAR measurement System is given in Fig. 1. This SAR Measurement System uses a Computer-controlled 3-D stepper motor system (SPEAG DASY professional system). The model EX3DV4 field probe is used to determine the internal electric fields. The SAR can be obtained from the equation SAR= σ (|Ei| ^{2})/ ρ where σ and ρ are the conductivity and mass density of the tissue-simulant.

The DASY system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Staubli TX family) with controller, teach pendant and software. An arm extension is for accommodating the data acquisition electronics (DAE).
- A dosimeter probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
- Data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.

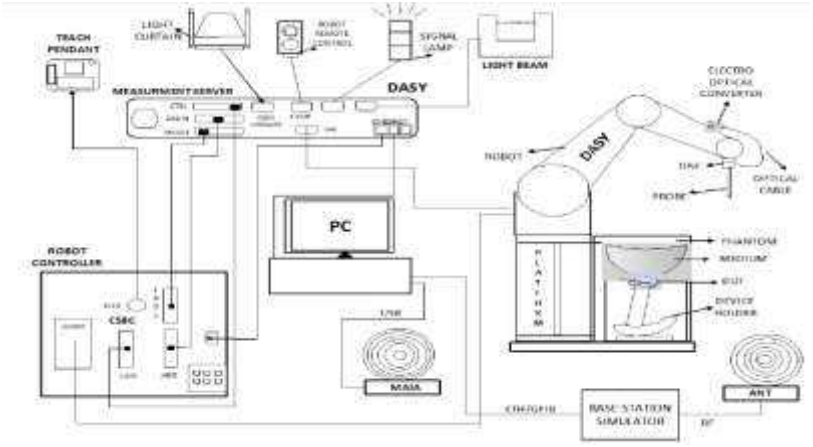


Fig 1. The microwave circuit arrangement used for SAR system verification

- The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows.
- DASY software.
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom enabling testing left-hand and right-hand usage.
- The device holder for handheld mobile phones.
- Tissue simulating liquid mixed according to the given recipes.

- Verification dipole kits allowing to validate the proper functioning of the system.

10.3 System Components

10.3.1 Probe

10.3.1.1 Construction : Symmetrical design with triangular core.
Built-in shielding against static charges.
PEEK enclosure material (resistant to organic solvents, e.g., DGBE)

Calibration : Basic Broad Band Calibration in air Conversion Factors (CF) for HSL 835 and HSL1900.
Additional CF-Calibration for other liquids and frequencies upon request.

Frequency : 10 ㎒ to 6 ㎓; Linearity: ± 0.2 ㏈ (30 ㎒ to 6 ㎓)

Directivity : ± 0.3 ㏈ in HSL (rotation around probe axis)
± 0.5 ㏈ in tissue material (rotation normal to probe axis)

Dynamic Range : 10μW/g to > 100 m W/g;
Linearity: ± 0.2 ㏈(noise: typically < 1 μW/g)

Dimensions : Overall length: 337 ㎜ (Tip length: 20 ㎜)
Tip diameter: 2.5 ㎜ (Body diameter: 12 ㎜)
Distance from probe tip to dipole centers: 1 ㎜

Application : High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 ㎓ with precision of better 30%


EX3DV4 E-Field Probe

NOTE:

1. The Probe parameters have been calibrated by the SPEAG. Please reference “APPENDIX C” for the Calibration Certification Report.

10.3.2 SAM Phantom

Construction : The SAM Phantom is constructed of a fiberglass shell integrated in a wooden table. The shape of the shell is based on data from an anatomical study designed to determine the maximum exposure in at least 90 % of all users. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents the evaporation of the liquid. Reference markings on the Phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points in the robot

Shell Thickness : 2.0 ㎜ ± 0.1 ㎜

Filling Volume : Approx. 25 liters


SAM Phantom

10.3.3 Device Holder

Construction: : In combination with the Twin SAM PhantomV4.0/V4.0C or Twin SAM, the Mounting Device (made from POM) enables the rotation of the mounted transmitter in spherical coordinates, whereby the rotation point is the ear opening. The devices can be easily and accurately positioned according to IEC, IEEE, CENELEC, FCC or other specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).


Device Holder

11. SAR System Verification Procedure

11.1 Tissue Simulant Fluid for the Frequency Band

The dielectric properties for this simulant fluid were measured by using the Speag Model DAK-3.5 Dielectric Probe in conjunction with Agilent E5063A Network Analyze by using a procedure.

Freq. (MHz)	Target Value		Measure Value		Deviation (%)		Date	Liquid Temperature (°C)
	Permitivity	Conductivity (S/m)	Permittivity	Conductivity (S/m)	Permittivity	Conductivity (S/m)		
835*	41.50	0.90	40.505	0.862	-2.40	-4.22	2024-11-27	21.6
836.50	41.50	0.90	40.494	0.864	-2.42	-4.00		
846.60	41.50	0.90	40.468	0.869	-2.49	-3.44		
835*	41.50	0.90	40.212	0.863	-3.10	-4.11	2024-12-03	21.6
848.80	41.50	0.90	40.166	0.870	-3.21	-3.33		
1900*	40.00	1.40	39.177	1.426	-2.06	1.86	2024-11-28	21.6
1850.20	40.00	1.40	39.290	1.399	-1.78	-0.07		
2600*	39.00	1.96	40.491	1.960	3.82	0.00	2024-12-03	21.8
2680.00	39.00	1.96	40.223	2.051	3.14	4.64		

Note: The data marked (*) in this table was Permittivity/Conductivity results of Verification

Table 1 Tissue results

12. SAR System Verification

The microwave circuit arrangement for system verification is sketched in Fig. 2. The daily system accuracy verification occurs within the flat section of the SAM phantom. A SAR measurement was performed to see if the measured SAR was within +/- 10% from the target SAR values. These tests were done at 835 / 1900 / 2600 MHz. The tests were conducted on the same days as the measurement of the DUT. The obtained results from the system accuracy verification are displayed in the table 2 (SAR values are normalized to 1W forward power delivered to the dipole). During the tests, the liquid depth above the ear reference points was ≥ 15 cm ± 5 mm (frequency ≤ 3 GHz) or ≥ 10 cm ± 5 mm (frequency > 3 G Hz)in all the cases. It is seen that the system is operating within its specification, as the results are within acceptable tolerance of the reference values.

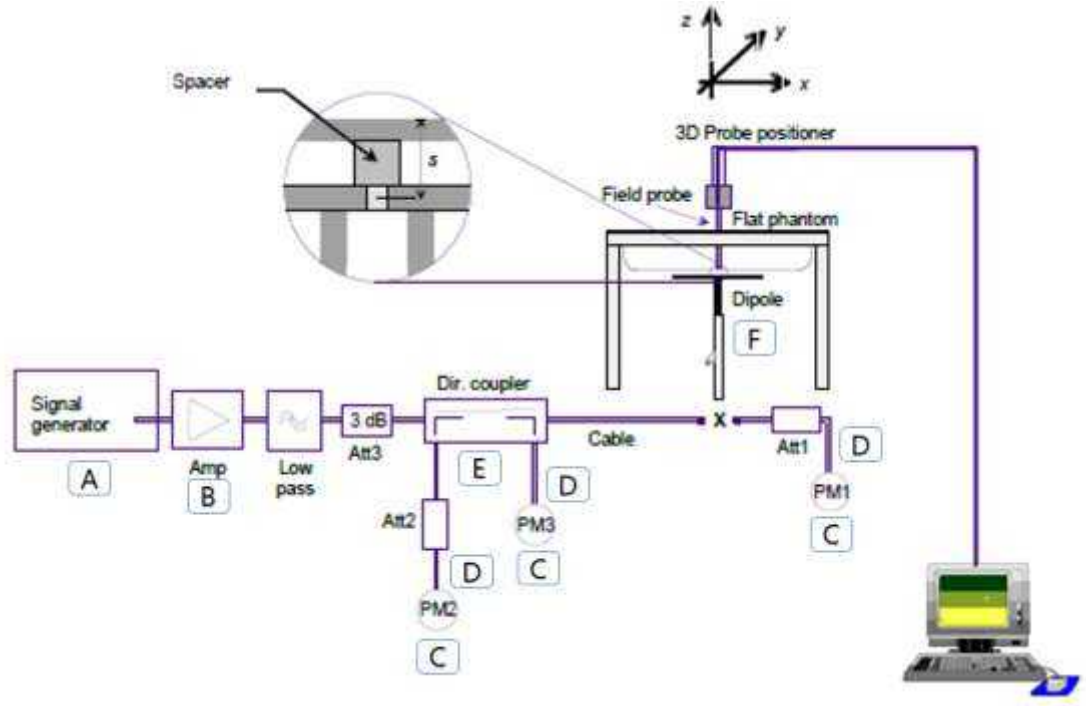


Fig 2 The microwave circuit arrangement used for SAR system verification

A. Signal Generator
B. Power Amplifier
C. Power Meter
D. Power Sensor
E. Dual Directional Coupler
F. Reference dipole Antenna

Fig 3 Photo of the dipole Antenna

Dipole Validation Kits		Probe S/N	Freq. (MHz)	Input Power (W)	Target SAR values (W/Kg)		1 W normalized Measured SAR (W/Kg)		Deviation (%)		Date	Temperature (°C)	
Model	S/N				1g SAR	10g SAR	1g SAR	10g SAR	1g SAR	10g SAR		Ambient	Liquid
D835V2	490	7574	835	0.10	9.64	6.28	9.33	6.25	-3.22	-0.48	2024-11-27	22.9	21.6
D835V2	490	7574	835	0.10	9.64	6.28	10.10	6.56	4.77	4.46	2024-12-03	22.6	21.6
D1900V2	5d033	7574	1900	0.10	40.60	21.30	39.70	21.30	-2.22	0.00	2024-11-28	23.3	21.6
D2600V2	1124	7574	2600	0.10	54.50	24.50	53.10	23.80	-2.57	-2.86	2024-12-03	22.6	21.8

Table 2 Results system Verification

Appendixes List

Appendix A	Appendix A Verification Plots
Appendix B	Appendix B Photographs
Appendix C	Appendix C Probe, DAE and Dipole Calibration Certificates

-THE END-