FCC TAS validation – Part 2:

Tests under dynamic transmit power scenarios

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

Equipment Under Test	SAMSUNG Mobile Phone
Brand Name	Galaxy M Series
Model No.	SM-M156B/DSN
Applicant	SAMSUNG Electronics Co., Ltd. 129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Rep. of Korea
FCC ID	A3LSMM156B
Date of Receipt	Dec. 20, 2023
Date of Test(s)	Jan. 12, 2024 ~ Jan. 13, 2024
Date of Issue	Jan. 17, 2024

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

Remarks:

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

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Signed on behalf of SGS

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

Date: Jan. 17, 2024

Revision History

Report Number	Revision	Description	Issue Date	Revised By	Remark
TESA2312000777ES	00	Initial creation of document	Jan. 17, 2024	Cindy Chou	

Note:

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

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
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1.General Information

1.1 Testing Laboratory

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

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

1.2 Details of Applicant

Company Name	SAMSUNG Electronics Co., Ltd.
Company Address	129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do, 16677, Rep. of Korea

2. Overview

FCC regulation allows time-averaged RF exposure to demonstrate compliance to safety limits. Because RF exposure is correlated to transmission power (TX power), the TX power can be controlled to meet FCC RF exposure limits defined as the 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 regulation. 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. For Wi-Fi 6GHz band, the proposed TA-SAR algorithm and the proposed TA-PD algorithm ensure that at all times the time-averaged RF exposure is compliant with the FCC SAR requirement, 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 3 GHz and 60 seconds for transmit frequencies between 3GHz and 6GHz. As a result, for Wi-Fi and BT 2.4GHz band, the time window is 100 seconds and for Wi-Fi 5GHz band, the time window is 60 seconds. For Wi-Fi 6GHz band, the averaging window of PD is 30 seconds.

The measurement results are also provided to show that the requirements defined by FCC can be all met.

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3. Wi-Fi TA-SAR/TA-PD Algorithm Concept

Mediatek developed the TA-SAR and TA-PD algorithms 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.

3.1 Algorithm Description

The proposed TA-SAR and TA-PD algorithms use TX power control to accomplish RF exposure compliance for **Wi-Fi** system**.** The basic concept of both algorithms is the same, if time-averaged TX power approaches a predefined TX power limit which is mapped from SAR or PD limit, the instantaneous TX power will be constrained to ensure that the time-averaged TX power is less than the predefined TX limit at all times. The parameters of the Wi-Fi TA-SAR algorithm are listed in Table 2-1. The parameters of the Wi-Fi TA- PD algorithm are listed in Table 2-2.

- At any time period, TA-SAR algorithm satisfies the following equation:

$$\frac{1}{T_{SAR}} \int_{t-T_{SAR}}^{t} inst\_TX\_power(\tau)d\tau \leq P_{SAR\_limit}$$

where $inst\_TX\_power(\tau)$ denotes the instantaneous TX power at time τ and T_{SAR} is the time averaging window defined by FCC for assessing time-averaged SAR. P_{SAR_limit} is the predefined TX power limit which is mapped from SAR exposure limit.

- At any time period, TA-PD algorithm satisfies the following equation:

$$\frac{1}{T_{PD}} \int_{t-T_{PD}}^{t} inst\_TX\_power(\tau)d\tau \leq P_{PD\_limit}$$

where $inst\_TX\_power(\tau)$ denotes the instantaneous TX power at time τ and T_{PD} is the time averaging window defined by FCC for assessing time-averaged PD. P_{PD_limit} is the predefined TX power limit which is mapped from PD exposure limit.

- To meet total exposure ratio (TER) requirement when 2.4G/5GHz band and 6GHz band or more bands are in simultaneous transmissions, TA-SAR and TA-PD algorithms satisfy the following:

The normalized TA-SAR of each 2.4GHz, 5GHz or 6GHz band is calculated by the following equation,

$$SAR_{n,normalized} = \frac{SAR_{n,avg}}{SAR_{n,limit}} = \frac{\frac{1}{T_{SAR_n}} \int_{t-T_{SAR_n}}^{t} SAR_n(\tau)d\tau}{SAR\_REG\_limit_n}$$

and the normalized TA-PD of each 6GHz band is calculated by the following equation,

$$PD_{m,normalized} = \frac{PD_{m,avg}}{PD_{m,limit}} = \frac{\frac{1}{T_{PD_m}} \int_{t-T_{PD_m}}^{t} PD_m(\tau)d\tau}{PD\_REG\_limit_m}$$

where $SAR_{n,limit}$ is the SAR regulatory limit $SAR\_REG\_limit_n$ that is applicable to the n-th transmitter/test frequency and $PD_{m,limit}$ is the PD regulatory limit $PD\_REG\_limit_m$ that is applicable to the m-th transmitter/test frequency.

In particular, for Wi-Fi SAR,

$$\frac{1}{T_{SAR}} \int_{t-T_{SAR}}^{t} SAR(\tau)d\tau = \frac{\frac{1}{T_{SAR}} \int_{t-T_{SAR}}^{t} inst\_SAR\_TX\_power(\tau)d\tau}{P_{WF\_SAR\_limit}} \times WF\_SAR\_design\_limit$$

for Wi-Fi PD,

$$\frac{1}{T_{PD}} \int_{t-T_{PD}}^{t} PD(\tau)d\tau = \frac{\frac{1}{T_{PD}} \int_{t-T_{PD}}^{t} inst\_PD\_TX\_power(\tau)d\tau}{P_{WF\_PD\_limit}} \times WF\_PD\_design\_limit$$

where $inst\_SAR\_TX\_power(\tau)$ and $inst\_PD\_TX\_power(\tau)$ denote the instantaneous TX power at time τ for SAR and PD respectively. T_{SAR} and T_{PD} are the time averaging windows defined by FCC for assessing time-averaged SAR and PD. The meanings of $P_{WF\_SAR\_limit}$, WF_SAR_design_limit, and SAR_REG_limit are described in Table 3-1, the meanings of $P_{WF\_PD\_limit}$, WF_PD_design_limit, and PD_REG_limit are described in Table 3-2.

3.2 Operating Parameters for Algorithm Validation

Table 3-1 Wi-Fi TA-SAR algorithm parameters

Algorithm parameters	Description
P_WF_SAR_limit ($P_{WF\_SAR\_limit}$)	The time-averaged maximum power level limit corresponding to WF_SAR_design_limit. • For FCC, SAR_REG_limit: 1.6 W/kg (1g-SAR), 4 W/kg (10g-SAR). • WF_SAR_design_limit is SAR_REG_limit with device total uncertainty for more conservative assessment. • P_WF_SAR_limit has the unique value for each Wi-Fi band/antenna/exposure condition index.
P_WF_SAR_MAX_limit ($P_{WF\_SAR\_MAX\_limit}$)	Wi-Fi TA-SAR maximum instantaneous TX power limit, which is less than or equal to maximum TX power P_WF_SAR_MAX that can be possibly transmitted in Wi-Fi. The power limit is dynamically adjusted based on Wi-Fi TA-SAR algorithm.

Table 3-2 Wi-Fi TA-PD algorithm parameters

Algorithm parameters	Description
P_WF_PD_limit ($P_{WF\_PD\_limit}$)	The time-averaged maximum power level limit corresponding to WF_PD_design_limit. • For FCC, PD_REG_limit: 10 W/m^2 ($4cm^2$ PD) • WF_PD_design_limit is PD_REG_limit with device total uncertainty for more conservative assessment. • P_WF_PD_limit has the unique value for each Wi-Fi band/antenna/exposure condition index.
P_WF_PD_MAX_limit ($P_{WF\_PD\_MAX\_limit}$)	Wi-Fi TA-PD maximum instantaneous PD TX power limit, which is less than or equal to maximum TX power P_WF_PD_MAX that can be possibly transmitted in Wi-Fi. The power limit is dynamically adjusted based on Wi-Fi TA-PD algorithm.

4. Overview of Wi-Fi 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 TX mode change between normal mode and sleep mode to verify algorithm and SAR compliance.
- **Scenario 2**: Test band handover to ensure algorithm control continuity and correctness.
- **Scenario 3**: Test different transmission antennas to ensure algorithm control works correctly during antenna switch from one antenna to another.
- **Scenario 4**: Test different ECI (Exposure Condition Index) to ensure algorithm control behaves as expected during ECI switch from one ECI to another. (ex., head→ body- worn)
- **Scenario 5**: Test TER under 2.4GHz band and 6GHz band simultaneous transmission. Since both SAR and PD are required in Wi-Fi 6GHz band, the maximum of normalized TA-SAR and normalized TA-PD in 6GHz band should be used in TER calculation. The proposed algorithm can ensure TA-SAR/TA-PD control correctness and prove the normalized total RF exposure is less than or equal to 1 (FCC requirement).

Note

- The device has one WLAN TX antenna only, and doesn't support DBDC, Wi-Fi 6GHz band, so only 1, 4 is required for testing.

SGS Taiwan Ltd. No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
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5. Wi-Fi TA-SAR Test Scenarios and Test Procedures

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

Table 5-1 Test scenario and test sequence list for Wi-Fi TA-SAR validation

Test scenario		Description	Device requirement
1	TX mode change between normal mode and sleep mode	Test normal mode and sleep mode switch	
2	Band handover	Test 2.4GHz/5GHz band change	Supports DBDC
3	Antenna switching	Change antenna index	
4	ECI (Exposure Condition Index) change	Test under ECI transition	
5	Simultaneous SAR and PD	TER of 2.4GHz TA-SAR and 6GHz TA-SAR/TA-PD	Supports WiFi DBDC or MLO

Note

1. The device has one WLAN TX antenna only, and doesn’t support DBDC, Wi-Fi 6GHz band, so only 1, 4 is required for testing.

5.1 Test Sequences for All Scenarios

The test sequence is predefined for TA-SAR:

- **Test sequence**: Wi-Fi is requested to transmit static and maximum power with high duty.

The test sequence is illustrated in Figure 5-1. The waveform of the test sequence is listed in Table 5-2.

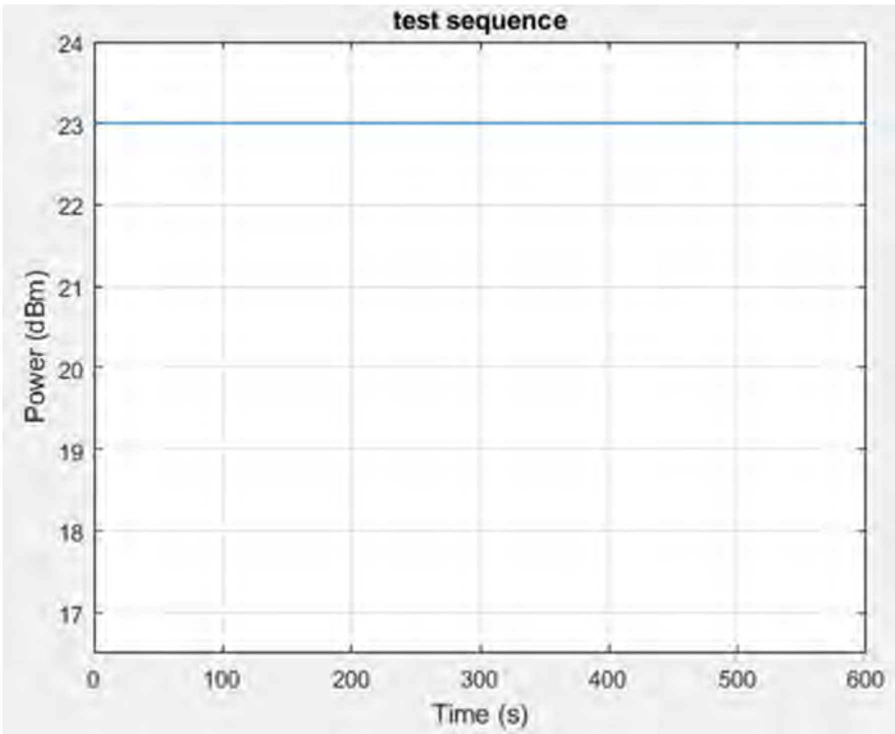

Figure 5-1 Test sequence

Table 5-2 Test sequence

Time (s)	Duration (s)	Power (dBm)	Note
600	600	23	Wi-Fi TX maximum power (P_WF_SAR_MAX)

5.2 Test Configuration and Procedure for Scenario 1: TX Mode Change between Normal Mode and Sleep Mode via Conducted Power Measurements

5.2.1 Configuration

The scenario tests Wi-Fi TX mode switching from normal throughput mode to sleep mode. Since Mediatek's TA-SAR feature operation is independent of bands and channels, selecting one band is sufficient to validate this feature. The criteria for band selection are based on the P_WF_SAR_limit values (corresponding to WF_SAR_design_limit) and are described as below:

- Select one band/channel with least P_WF_SAR_limit among all supported bands and the P_WF_SAR_limit value is below P_WF_SAR_MAX.
  - o Only one band/channel needs to be tested if all the bands have the same P_WF_SAR_limit.
  - o Only one band/channel needs to be tested if only one band has P_WF_SAR_limit below P_WF_SAR_MAX.
  - o If the same least P_WF_SAR_limit applies to multiple bands, select the band with the highest measured 1gSAR at P_WF_SAR_limit.
  - o If P_WF_SAR_limit values of all bands are over P_WF_SAR_MAX, there is no need to test these bands.

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5.2.2 Procedure

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

- Steps 1~4: Measure and record TX power versus time for test scenario 1.
  - Step 1: Start $P_{WF\_SAR\_limit}$ calibration mode and measure $P_{WF\_SAR\_limit}$ for the selected band.
  - Step 2: Establish radio link with AP in the selected band and enable TA-SAR.
  - Step 3: Configure pre-defined TX power sequence to DUT and measure TX power versus time.
  - Step 4: Wi-Fi TX switches modes.

    Initial Wi-Fi normal mode: Configure pre-defined TX power sequence to DUT for selected band and then DUT transmits packets after 400s.

    Switch to Wi-Fi sleep mode: Wi-Fi switches to sleep mode about 10s and no packets are transmitted.

    Wi-Fi wakes up to normal mode: Wi-Fi wakes up from sleep mode and DUT re-transmits packets for at least the specified time duration.

    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.

    Instantaneous 1gSAR or 10gSAR versus time: $SAR(\tau)$

$$SAR(\tau) = \frac{conducted\_inst\_SAR\_TX\_power(\tau)}{P_{WF\_SAR\_limit}} \times WF\_SAR\_design\_limit$$

where $P_{WF\_SAR\_limit}$ is measured from step 1 and $WF\_SAR\_design\_limit$ is measured worst case SAR value at $P_{WF\_SAR\_limit}$.

Time average SAR versus time: $Time\_avg\_SAR(t)$

$$Time\_avg\_SAR(t) = \frac{1}{T_{SAR}} \int_{t-T_{SAR}}^{t} SAR(\tau)d\tau$$

- Step 6: Plot results

  A. Make one power perspective plot containing

    1. Instantaneous TX power

2. Requested power (test sequence)
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)

5.3 Test Configuration and Procedure for Scenario 2: Band Handover via Conducted Power Measurements

5.3.1 Configuration

The scenario tests Wi-Fi 2.4GHz and 5GHz band handover and DBDC mode. The test configuration switches from Wi-Fi 2.4GHz band to Wi-Fi 5GHz band and then switches to 2.4GHz/5GHz DBDC mode.

- For Wi-Fi 2.4GHz band, select the channel with least *P_WF_SAR_limit* value and below *P_WF_SAR_MAX*. If the same least *P_WF_SAR_limit* applies to multiple bands, select the channel with the highest measured 1gSAR at *P_WF_SAR_limit*.
- For Wi-Fi 5GHz band, select the channel with least *P_WF_SAR_limit* value and below *P_WF_SAR_MAX*. If the same least *P_WF_SAR_limit* applies to multiple bands, select the channel with the highest measured 1gSAR at *P_WF_SAR_limit*.

5.3.2 Procedure

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

- Steps 1~4: Measure and record TX power versus time for test scenario 2.
  - Step 1: Start $P_{WF\_SAR\_limit}$ calibration mode and measure $P_{WF\_SAR\_limit}$ for both the selected bands/channels. (2.4GHz and 5GHz)
  - Step 2: Establish radio link with AP in the selected band and enable TA-SAR.
  - Step 3: Configure pre-defined TX power sequence to DUT and measure TX power versus time.
  - Step 4: Wi-Fi TX switches bands.

    Initial 2.4GHz band connection: Configure pre-defined TX power sequence to DUT for 2.4GHz band and then DUT transmits packets for 400s.

    Band switch to 5GHz band connection: Wi-Fi switches to the 5GHz band for 400s**.**

    Dual band mode (DBDC) connection: Wi-Fi connects to 2.4GHz and 5GHz bands simultaneously for 400s.

    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.

Instantaneous 1gSAR or 10gSAR versus time: $SAR\_1(\tau)$ (band1), $SAR\_2(\tau)$ (band2)

$$SAR\_1(\tau) = \frac{conducted\_inst\_SAR\_TX\_power\_1(\tau)}{P_{WF\_SAR\_limit\_1}} \times WF\_SAR\_design\_limit\_1$$

$$SAR\_2(\tau) = \frac{conducted\_inst\_SAR\_TX\_power\_2(\tau)}{P_{WF\_SAR\_limit\_2}} \times WF\_SAR\_design\_limit\_2$$

where $P_{WF\_SAR\_limit\_1}$ and $P_{WF\_SAR\_limit\_2}$ are measured from step 1, $WF\_SAR\_design\_limit\_1$ and $WF\_SAR\_design\_limit\_2$ are measured worst case SAR values at $P_{WF\_SAR\_limit\_1}$ and $P_{WF\_SAR\_limit\_2}$, respectively.

Time average SAR versus time: $Time\_avg\_SAR(t)$

$$Time\_avg\_SAR(t) = \frac{1}{T_{SAR}}\left[\frac{\int_{t-T_{SAR}}^{t} SAR\_1(\tau)d\tau}{WF\_SAR\_REG\_limit\_1} + \frac{\int_{t-T_{SAR}}^{t} SAR\_2(\tau)d\tau}{WF\_SAR\_REG\_limit\_2}\right]$$

- 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

5.4 Test Configuration and Procedure for Scenario 3:Antenna Switching via Conducted Power Measurements

5.4.1 Configuration

Wi-Fi first selects an antenna to transmit packets then switches to another antenna within the same band. Note that *PWF_SAR_limit* may have a unique value for each Wi-Fi "band/antenna/exposure condition index" and time averaging window size also depends on frequencies. For any band supporting multiple TX antennas, select the one with the highest difference in *PWF_SAR_limit* among all supported antennas.

- Select the band having the highest measured 1gSAR at *P_WF_SAR_limit* if multiple bands have the same *P_WF_SAR_limit* among supported antennas.
- Antenna selection order
  - Select the configuration with two antennas having *P_WF_SAR_limit* values less than *P_WF_SAR_MAX.*
  - If the previous configuration does not exist, select the configuration with one antenna having *P_WF_SAR_limit* value less than *P_WF_SAR_MAX*.
  - If the above two cannot be found, select one configuration with the two antennas having the least difference between their *P_WF_SAR_limit* and *P_WF_SAR_MAX*.

5.4.2 Procedure

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

- Steps 1~4: Measure and record TX power versus time for test scenario 3.
  - Step 1: Start $P_{WF\_SAR\_limit}$ calibration mode and measure $P_{WF\_SAR\_limit}$ for both the selected antennas.
  - Step 2: Establish radio link with AP in the selected band and enable TA-SAR.
  - Step 3: Configure pre-defined TX power sequence to DUT and measure TX power versus time.
  - Step 4: Wi-Fi TX switches antennas.

    Connect to one selected antenna: Configure pre-defined TX power sequence to DUT for selected band and selected antenna and then DUT transmits packets for 400s.

Switch to another antenna: Wi-Fi TX switches to another selected antenna and DUT transmits packets for 400s**.**

Step 5: Convert the measured conducted TX power into SAR based on the formulas for scenario 1.

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

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

- The correct power control is realized by TA-SAR algorithm when antenna switches from one 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.

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5.5 Test Configuration and Procedure for Scenario 4: Exposure Condition Index (ECI) Change via Conducted Power Measurements

5.5.1 Configuration

The scenario tests the time-averaged TX power is less than the predefined TX limit at all times when exposure condition index changes which means *P_WF_SAR_limit* changes in the test. This scenario selects any one band having two different *P_WF_SAR_limit* values less than *P_WF_SAR_MAX* in the two ECI groups. One test is sufficient as the feature operation is independent of technology and band.

5.5.2 Procedure

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

- Steps 1~4: Measure and record TX power versus time for test scenario 4.
  - Step 1: Start $P_{WF\_SAR\_limit}$ calibration mode and measure $P_{WF\_SAR\_limit}$ for the selected band/channel.
  - Step 2: Establish radio link with AP in the selected band and enable TA-SAR.
  - Step 3: Configure pre-defined TX power sequence to DUT and measure TX power versus time.
  - Step 4: Wi-Fi TX ECI changes.

    Connect to selected band with initial *PWF_SAR_limit* **in one ECI group index:** Configure pre-defined TX power sequence to DUT for selected band and then DUT transmits packets for 400s.

    Change *PWF_SAR_limit* **value to another ECI group index:** Set the command to change *PWF_SAR_limit* for 400s

    Step 5: Convert the measured conducted TX power into SAR based on the formulas for scenario 1.

    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

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

- The correct power control is controlled by TA_SAR when ECI switches from one 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.

5.6 Test Configuration and Procedure for Scenario 5: Simultaneous SAR and PD via Conducted Power Measurements

5.6.1 Configuration

The scenario is to test TER (total exposure ratio) under 2.4GHz band and 6GHz band simultaneous transmission. Since Wi-Fi 6GHz band needs to obey both SAR and PD exposure limits, the maximum of normalized TA-SAR and normalized TA-PD in 6GHz band should be used in TER calculation. The proposed algorithms can ensure TA-SAR/TA-PD control correctness by demonstrating that TER is less than or equal to 1 (FCC requirement).

- Select one channel of Wi-Fi 2.4GHz band with measured *P_WF_SAR_limit* less than *P_WF_SAR_MAX* and select one channel of Wi-Fi 6GHz band with measured *P_WF_SAR_limit* less than *P_WF_SAR_MAX* and with measured *P_WF_PD_limit* less than *P_WF_PD_MAX.*

5.6.2 Procedure

- Steps 1~4: Measure and record TX power versus time for test scenario 5.
  - Step 1: Start $P_{WF\_SAR\_limit}$ and $P_{WF\_PD\_limit}$ calibration mode, measure $P_{WF\_SAR\_limit}$ for the selected 2.4GHz band, and measure $P_{WF\_SAR\_limit}$ and $P_{WF\_PD\_limit}$ for the selected 6GHz band channel.
  - Step 2: Establish link with AP for the selected band and enable TA-SAR and TA-PD.
  - Step 3: Configure pre-defined TX power sequence to DUT and measure TX power versus time.
  - Step 4: Wi-Fi transmits packets at 2.4GHz band and 6GHz band.
  - Step 5: Convert the measured conducted TX power into SAR, PD and calculate TER

  For TA-SAR of each 2.4GHz, 5GHz, or 6GHz band

$$SAR_{n,normalized} = \frac{SAR_{n,avg}}{SAR_{n,limit}} = \frac{\frac{1}{T_{SAR_n}}\int_{t-T_{SAR_n}}^{t} SAR_n(\tau)d\tau}{SAR\_REG\_limit_n}$$

For TA-PD of each band at 6GHz band

$$PD_{m,normalized} = \frac{PD_{m,avg}}{PD_{m,limit}} = \frac{\frac{1}{T_{APD_m}}\int_{t-T_{APD_m}}^{t} PD_m(\tau)d\tau}{PD\_REG\_limit_m}$$

Instantaneous 1gSAR or 10gSAR versus time: $SAR(\tau)$, $PD(\tau)$

$$SAR(\tau) = \frac{conducted\_inst\_SAR\_TX\_power(\tau)}{P_{WF\_SAR\_limit}} \times WF\_SAR\_design\_limit$$

$$PD(\tau) = \frac{conducted\_inst\_PD\_TX\_power(\tau)}{P_{WF\_PD\_limit}} \times WF\_PD\_design\_limit$$

where $P_{WF\_SAR\_limit}$ is measured from step 1 and $WF\_SAR\_design\_limit$ is measured worst case SAR value at $P_{WF\_SAR\_limit}$, $P_{WF\_PD\_limit}$ is measured from step 1 and $WF\_PD\_design\_limit$ is measured worst case PD value at $P_{WF\_PD\_limit}$.

For simultaneous transmission, the sum of the normalized TA-SAR values in 2.4GHz and 5GHz bands together with the sum of the values of the maximum of normalized TA-SAR and normalized TA-PD in 6GHz band should meet TER requirement, as shown below.

$$TER = \sum_{n=1}^{M} \frac{SAR_{n,avg}}{SAR_{n,limit}} (2GHz/5GHz) + \sum_{m=M+1}^{N} \max\left[\frac{SAR_{m,avg}}{SAR_{m,limit}}, \frac{PD_{m,avg}}{PD_{m,limit}}\right](6GHz) \leq 1$$

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/PD perspective plot containing
   1. Calculated normalized time-averaged 1gSAR or 10gSAR for 2.4GHz band
   2. Calculated maximum of normalized time-averaged SAR (1gSAR or 10gSAR) and normalized time-averaged PD for 6GHz band
   3. Total Exposure Ratio (TER)
   4. FCC TER limit of 1

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5.7 Test Configuration and Procedure for Scenario 1:TX Mode Change between Normal Mode and Sleep Mode via SAR Measurements

5.7.1 Configuration

The test procedures in the previous sections mainly focus on measuring conducted TX power, in this section test via SAR measurement is performed. The validation can be provided by performing one test scenario from the previous section.
In this test via SAR measurement, the test configuration of test scenario 1 is used.

5.7.2 Procedure

SAR is measured and recorded by the following steps:

- Steps 1~3: Measure and record TA-SAR versus time for test scenario 1.
  - Step 1: Start meas_SAR_PWF_SAR_limit calibration mode for the selected band/channel. Measure meas_SAR at peak location of the area scan where meas_SAR_PWF_SAR_limit corresponds to this meas_SAR value at PWF_SAR_limit.
  - Step 2: Establish radio link with AP in the selected band and enable TA-SAR.
  - Step 3: Configure pre-defined TX power sequence to DUT and measure instantaneous SAR versus time.
  - Step 4: Convert the measured SAR into time-averaged SAR. Convert the instantaneous measured SAR from step 3 into 1gSAR or 10gSAR value.

    Perform the running time average to 1gSAR or 10g SAR to determine the time-averaged value versus time by the following equations.

    Instantaneous 1gSAR or 10gSAR versus time: $SAR(\tau)$

$$SAR(\tau) = \frac{meas\_SAR(\tau)}{\mathrm{meas\_SAR\_P_{WF\_SAR\_limit}}} \times WF\_SAR\_design\_limit$$

where $\mathrm{meas\_SAR\_P_{WF\_SAR\_limit}}$ is measured from step 1, *meas_SAR(t)* is the instantaneous SAR measured in step 3, and $WF\_SAR\_design\_limit$ is the measured worse-case SAR value at $P_{WF\_SAR\_limit}$.

$$Time\_avg\_SAR(t) = \frac{1}{T_{SAR}} \int_{t-T_{SAR}}^{t} SAR(\tau)d\tau$$

- Step 5: Plot results
  - A. Calculated time-averaged 1gSAR or 10gSAR
  - B. FCC limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)

6. Wi-Fi TA-PD Test Scenarios and Test Procedures

In order to demonstrate that TA-PD algorithm performs as expected under various operating scenarios, Table 6-1 lists the test scenarios and test sequences to validate TA-PD algorithm. The details of test procedures via conducted power and PD measurements are described in section 6.2 and 6.3

Table 6-1 Test scenario and test sequence list for Wi-Fi TA-PD validation

Test scenario		Description	Device requirement
1	TX mode change between normal mode and sleep mode	Test normal mode and sleep mode switch	Supports 6GHz band

Note

The device has one WLAN TX antenna only, and doesn't support DBDC, Wi-Fi 6GHz band, so only testing not is not required for this section.

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6.1 Test Sequences for All Scenarios

The test sequence is predefined for TA-PD:

- Test sequence: Wi-Fi TX is requested to transmit static and maximum power with high duty.

The test sequence is illustrated in Figure 6-1. The waveform of the test sequence is listed in Table 6-2.

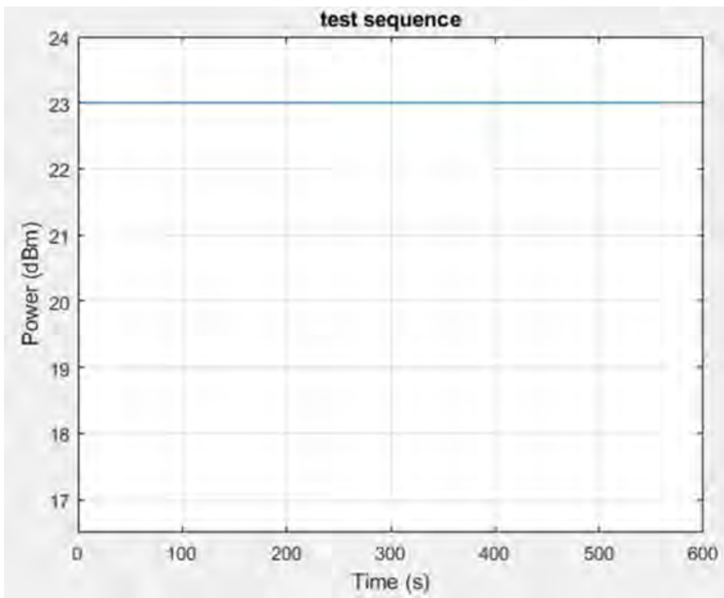

Figure 6-1 Test sequence

Table 6-2 Test sequence

Time (s)	Duration (s)	Power (dBm)	Note
600	600	23	Wi-Fi TX maximum power (P_WF_PD_MAX)

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6.2 Test Configuration and Procedure for Scenario 1: TX Mode Change between Normal Mode and Sleep Mode via Conducted Power Measurements

6.2.1 Configuration

The scenario tests Wi-Fi TX mode switching from normal throughput mode to sleep mode. Since Mediatek's TA-PD feature operation is independent of bands and channels, selecting one band is sufficient to validate this feature. The criteria for band selection are based on the *P_WF_PD_limit* values (corresponding to *WF_PD_design_limit*) and are described as below:

- Select one band with least *P_WF_PD_limit* among the ones whose *P_WF_PD_limit* values are below *P_WF_PD_MAX* .
  - Only one band needs to be tested if all the bands have same *P_WF_PD_limit*.
  - Only one band needs to be tested if only one band has *P_WF_PD_limit* below *P_WF_PD_MAX*.
  - If the same least *P_WF_PD_limit* applies to multiple bands, select the band with the highest measured PD at *P_WF_PD_limit*.
  - If *P_WF_PD_limit* values of all bands are over *P_WF_PD_MAX,* there is no need to test these bands.

6.2.2 Procedure

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

- Steps 1~4: Measure and record TX power versus time for test scenario 1.
  - Step 1: Start $P_{WF\_PD\_limit}$ calibration mode and measure $P_{WF\_PD\_limit}$ for the selected band.
  - Step 2: Establish radio link with AP in the selected band and enable TA-PD.
  - Step 3: Configure pre-defined TX power sequence to DUT and measure TX power versus time.
  - Step 4: Wi-Fi TX switches modes.

    Initial Wi-Fi normal mode: Configure pre-defined TX power sequence to DUT for selected band and then DUT transmits packets for 400s.

    Switch to Wi-Fi sleep mode: Wi-Fi switches to sleep mode about 10s and no packets are transmitted**.**

    Wi-Fi wakes up to normal mode: Wi-Fi wakes up from sleep mode and DUT re-transmits packets for at least the specified time duration.

Step 5: Convert the measured conducted TX power into PD. Convert the measured conducted TX power from Step 4 into spatial-averaged PD value using the following equation. Perform the running time average to power and spatial-averaged PD value to determine time- averaged value versus time as follows.

Instantaneous PD versus time: $PD(\tau)$

$$PD(\tau) = \frac{conducted\_inst\_PD\_TX\_power(\tau)}{P_{WF\_PD\_limit}} \times WF\_PD\_design\_limit$$

where $P_{WF\_PD\_limit}$ is measured from step 1 and $WF\_PD\_design\_limit$ is measured worst case PD value at $P_{WF\_PD\_limit}$.

Time-averaged PD versus time: $Time\_avg\_PD(\tau)$

$$Time\_avg\_PD(t) = \frac{1}{T_{PD}} \int_{t-T_{PD}}^{t} PD(\tau)d\tau$$

- 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 PD
     2. FCC limit of $10W/m^2$ (PD)

6.3 Test Configuration and Procedure for Scenario 1:

TX Mode Change between Normal Mode and Sleep Mode via PD Measurements

6.3.1 Configuration

The test procedure in the previous section mainly focuses on measuring conducted TX power, in this section test via PD measurement is performed. The validation can be provided by performing test scenario 1.

6.3.2 Procedure

PD is measured and recorded by the following steps:

- Steps 1~3: measure and record TA-PD versus time for test scenario 1.
  - Step 1: Start meas_PD_$P_{WF_PD_limit}$ calibration mode for the selected band/channel. Measure meas_PD at peak location of the area scan and the meas_PD_$P_{WF_PD_limit}$ corresponds to this meas_PD value at $P_{WF\_PD\_limit}$.
  - Step 2: Establish radio link with AP in the selected band and enable TA-PD.
  - Step 3: Configure pre-defined TX power sequence to DUT and measure instantaneous PD versus time.
  - Step 4: Convert the measured PD into time-averaged PD. Convert the instantaneous measured PD from step 4 into spatial-averaged PD value. Perform the running time average to spatial-averaged PD value to determine time-averaged value versus time by following equations.

Instantaneous PD versus time: $PD(\tau)$

$$PD(\tau) = \frac{meas\_PD(\tau)}{\text{meas\_PD\_P}_{\text{WF\_PD\_limit}}} \times WF\_PD\_design\_limit$$

where meas_SAR_$P_{WF_PD_limit}$ is measured from step 1, *meas_PD(t)* is the instantaneous measured PD measured in step 3, and $WF\_PD\_design\_limit$ is the measured worse-case PD value at $P_{WF\_PD\_limit}$.

$$Time\_avg\_PD(\tau) = \frac{1}{T_{PD}} \int_{t-T_{PD}}^{t} PD(\tau)d\tau$$

- Step 5: Plot results
  - A. Calculated time-averaged PD
  - B. FCC limit of 10W/m^2 (PD)

7. Wi-Fi TA-SAR Validation via Conducted Power

For the supported bands/antennas of WLAN 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.

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

RAT	Band	ANT	Duty cycle (%)	$P_{limit,nom}$ (dBm) Setting				$P_{max,nom}$ (dBm) Setting	
				ECI 1 RCV		ECI 0 Body-Worn, Hotspot or Phablet			
				burst-power	frame-averaged power	burst-power	frame-averaged power	burst-power	frame-averaged power
WIFI	2.4 GHz	Sub 2	99.50	15.02	15.00	22.12	22.10	18.02	18.00
WIFI	5 GHz	Sub 2	93.50	14.29	14.00	14.29	14.00	17.29	17.00

Table 7-2 summarizes the test configurations of WLAN, and the corresponding worst-case measured SAR for WLAN under the power limit.

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

Test Case	Test Scenario	Test Tech	Test band	Mode	Data Rate	duty cycle	Test Position	Gap (mm)	ANT	ECI	UL Channel	UL Freq (MHz)	Measured SAR@Plimit 1-g SAR (W/kg)	SAR reg.	Plimit, frame-averaged	Pmax, frame-averaged	Tolerance
0	1-1. 2G SAR TX Mode Change between Normal Mode and Sleep Mode	Wi-Fi	2.45GHz	802.11b	CCK 5.5M	99.48%	Right Cheek	0	Sub 2	1	7	2442	0.267	1.6	15.00	18.00	1.00
1	4. Exposure Condition Index (ECI) change	Wi-Fi	2.45GHz	802.11b	CCK 5.5M	99.48%	N/A	0	Sub 2	1	7	2442	0.267	1.6	15.00	18.00	1.00 1.00

8. Wi-Fi TA-SAR Validation via Conducted Power Measurements

8.1 Conducted Power Measurement Results for Scenario 1: TX Mode Change between Normal Mode and Sleep Mode

This test is the conducted power measurement for Wi-Fi 2.4GHz band TX mode change. The detailed setting is listed in Table 8-1. As seen in this figure, the time-averaged SAR does not exceed the FCC limit.

Table 8-1 TA-SAR parameters setting for test scenario 1-1

Test band	Max power	$P_{WF\_SAR\_limit}$
2.4GHz	18 dBm	15 dBm

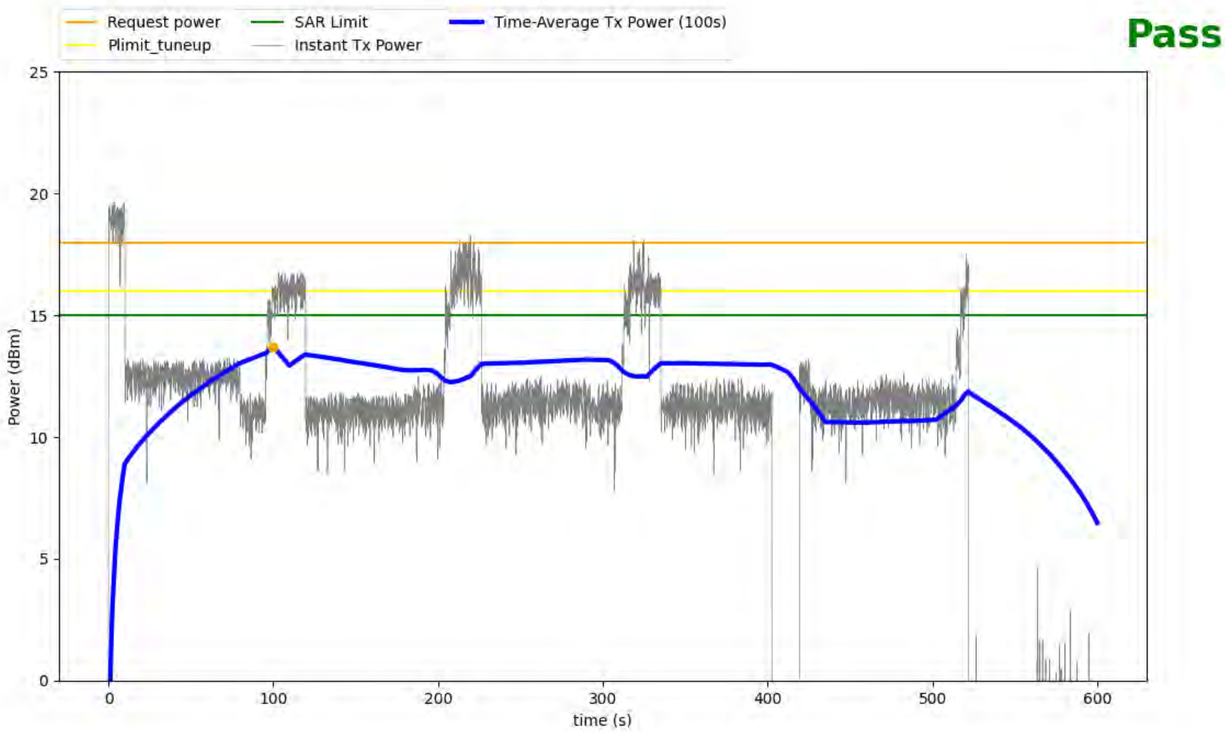

Figure 8-1 Time-averaged conducted TX power over time for test scenario 1-1

Maximum time-averaged conducted power	13.711(dBm)

8.2 Conducted Power Measurement Results for Scenario 4: ECI Change

This test is the conducted power measurement for Wi-Fi ECI change. The detailed setting is listed in Table 8-5. Figure 8-16 demonstrates the DUT's instantaneous conducted TX power, the time-averaged conducted TX power behavior over time, and the power limit. Figure 8-17 illustrates the corresponding time-averaged SAR over time converted from the TX time-averaged power by using the equation. As seen in this figure, the normalized time-averaged SAR does not exceed the FCC limit.

Table 8-5 TA-SAR parameters setting for test scenario 4

Test band	Switch time	ECI	Max power	$P_{WF\_SAR\_limit}$
2.4GHz	0~400s	1	18 dBm	15 dBm
2.4GHz	400s~800s	1*	18 dBm	13 dBm

*Note:

- ECI change for Wi-Fi is p_limit change set by host.
- In TA-SAR LAB testing, the tool doesn't set ECI index to Wi-Fi, instead, it simulates the ECI change by decreasing p_limit with 2 dB. i.e. p_limit' = p_limit – 2.

  Thus, in Table 7-5, when testing scenario 4, the ECI index is not changed by tool, and p_limit is changed from 20 dBm to 18 dBm.

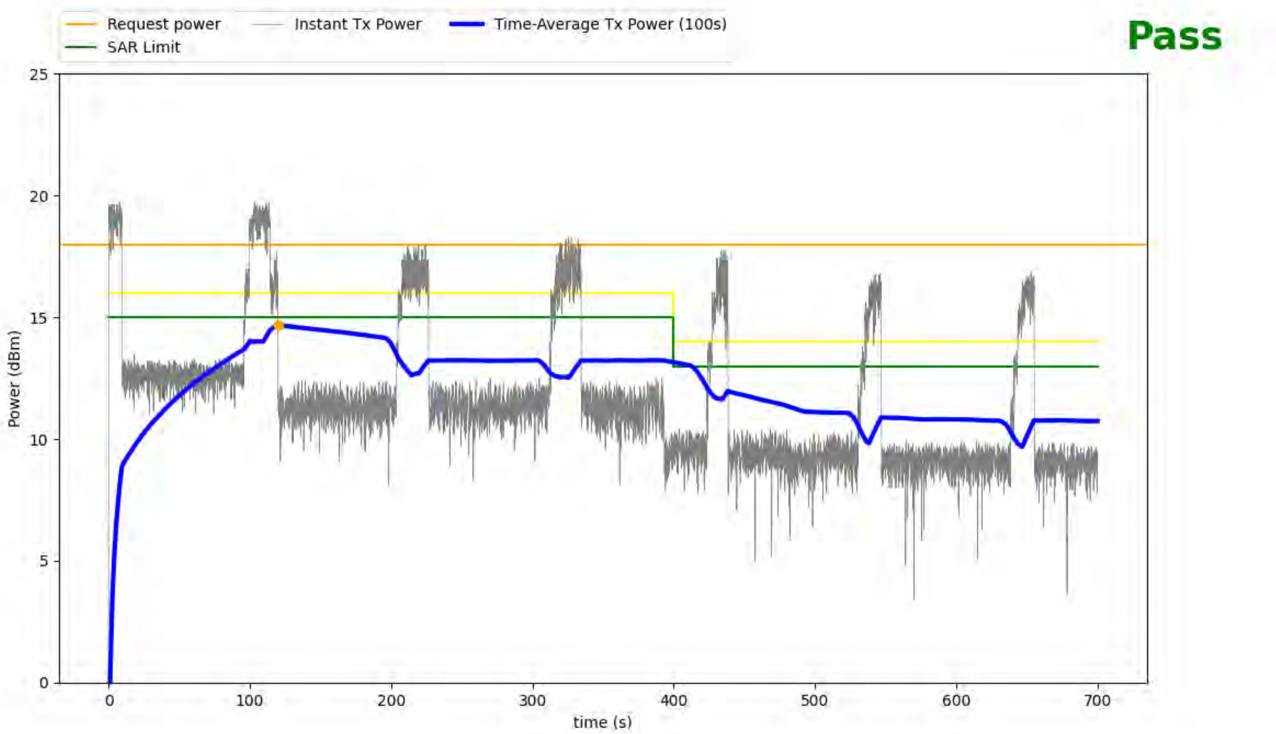

Figure 8-16 Time-averaged conducted TX power over time for test scenario 4

Maximum time-averaged conducted power	14.691(dBm)

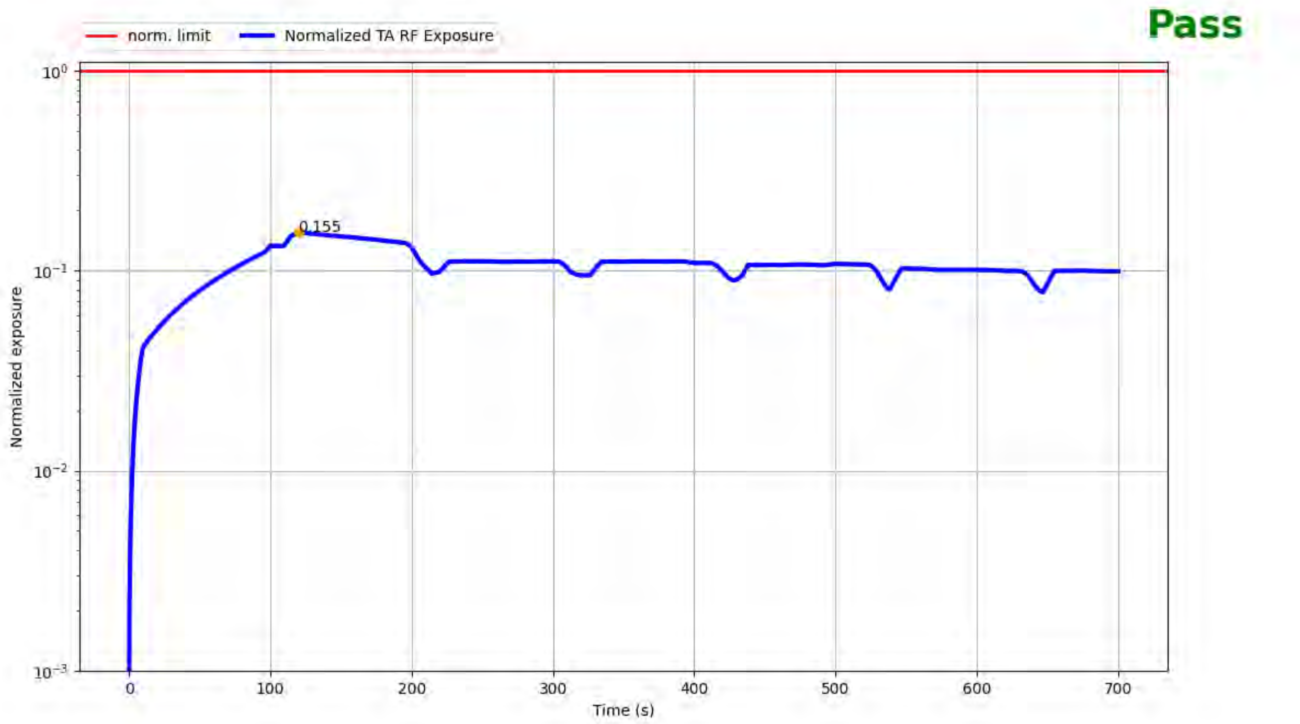

Figure 8-17 Time-averaged SAR over time for test scenario 4

Normalized TA RF Exposure	0.155 (dBm)

NOTE: The instantaneous TX power should be compared with P_WF_SAR_limit of the corresponding configuration, i.e., 15 dBm for ECI 1 and 13dBm for ECI 1, then transformed and averaged in SAR perspective to check compliance. Therefore, even though the time-averaged TX power seems to exceed P_WF_SAR_limit after ECI changes at 400s, the time-averaged SAR meets regulation as a matter of fact.

9.Wi-Fi TA-SAR Validation via SAR Measurements

For SAR measurements, TA-SAR algorithm is implemented in firmware in a phone and a notebook..

9.1 TA-SAR Measurement Results for Scenario 1: TX Mode Change between Normal Mode and Sleep Mode

Mediatek's TA-SAR algorithm is tested by using DASY6. The detailed setting is listed in Table 9-1. Figure 9-4 demonstrates scenario 1-1 of 2.4GHz band TA-SAR measurement result.

Table 9-1 TA-SAR parameters setting for test scenario 1-1

Test band	Max power	$P_{WF\_SAR\_limit}$
2.4GHz	18 dBm	15 dBm

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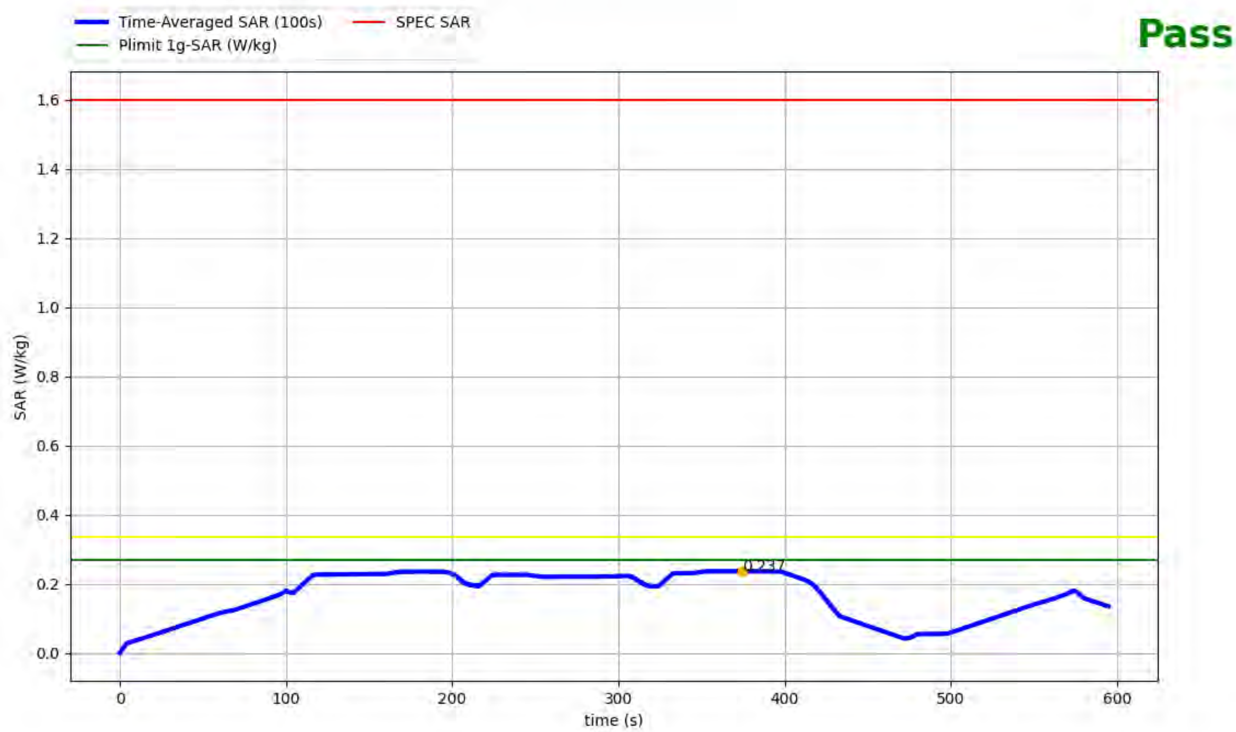

Figure 9-4 Time-averaged SAR measurement for scenario 1-1

FCC 1gSAR limit	1.6 W/kg
Max 100s-time averaged 1gSAR	0.237 W/kg
Validation result: pass	

10. Conclusions

This document proves Mediatek's TA-SAR and TA-PD algorithms can meet the FCC SAR and PD regulations with the proposed test scenarios and procedures. Based on the provided measurement results, it is concluded that Mediatek's TA-SAR and TA-PD algorithms can be tested by using the proposed test methodology for FCC compliance.

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Appendix A. cDASY6 System Verification

EX3DV4 E-Field Probe

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
Calibration	Basic Broad Band Calibration in air Conversion Factors (CF) for HSL 2450 MHz Additional CF for other liquids and frequencies upon request	
Frequency	10 MHz to > 6 GHz	
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)	
Dynamic Range	10 μW/g to > 100 mW/g Linearity: ± 0.2 dB (noise: typically < 1 μW/g)	
Dimensions	Tip diameter: 2.5 mm	
Application	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%.	

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Phantom

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

DEVICE HOLDER

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

Device Holder

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Appendix B. Instruments List

Equipment List					
Manufacturer	**Device**	**Type**	**Serial number**	**Date of last calibration**	**Date of next calibration**
SPEAG	Data acquisition Electronics	DAE4	856	Apr/26/2023	Apr/25/2024
SPEAG	Dosimetric E-Field Probe	EX3DV4	7712	Apr/14/2023	Apr/13/2024
SPEAG	System Validation Dipole	D2450V2	727	Apr/25/2023	Apr/24/2024
SPEAG	Dielectric Assessment Kit	DAKS-3.5	1053	Feb/27/2023	Feb/26/2024
R&S	MXG Analog Signal Generator	SMB100A03	182012	May/23/2023	May/22/2024
Agilent	Dual-directional coupler	772D	MY52180142	Oct/23/2023	Oct/22/2024
Agilent	Dual-directional coupler	778D	MY52180302	Oct/23/2023	Oct/22/2024
EMCI	Amplifier	ZHL-42	980189	Calibration not required	Calibration not required
EMCI	Amplifier	ZVE-8G	980190	Calibration not required	Calibration not required
R&S	Power Sensor	NRP18S	109065	Oct/23/2023	Oct/22/2024
R&S	Power Meter	NRX	102034	Dec/13/2023	Dec/12/2024
R&S	Power Sensor	NRP18S	109066	Oct/23/2023	Oct/22/2024
SPEAG	Software	DASY 6 V16.0.2.136	N/A	Calibration not required	Calibration not required
SPEAG	Phantom	SAM	N/A	Calibration not required	Calibration not required
Keysight	EXA Signal Analyzer	N9010B	MY60242081	Oct/17/2023	Oct/16/2024
TECPEL	Digital thermometer	DTM-303A	TP130075	Jan/11/2023	Jan/10/2024

Appendix C Tissue and System Verification

• Tissue Verification

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

The composition of the brain tissue simulating liquid is:

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

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

• Tissue Simulant Fluid for the Frequency Band

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

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

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

Measured Frequency (MHz)	Target Dielectric Constant, εr	Target Conductivity, σ (S/m)	Measured Dielectric Constant, εr	Measured Conductivity, σ (S/m)	% dev εr	% dev σ	Limit	Measurement Date	Liquid Temp. (°C)	Ambient Temp (°C)
2442	39.214	1.793	38.446	1.825	-1.96%	1.79%	± 5%	Jan. 13, 2024	22.1	22.3
2450	39.200	1.800	38.437	1.834	-1.95%	1.89%	± 5%	Jan. 13, 2024	22.1	22.3

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• System Verification

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

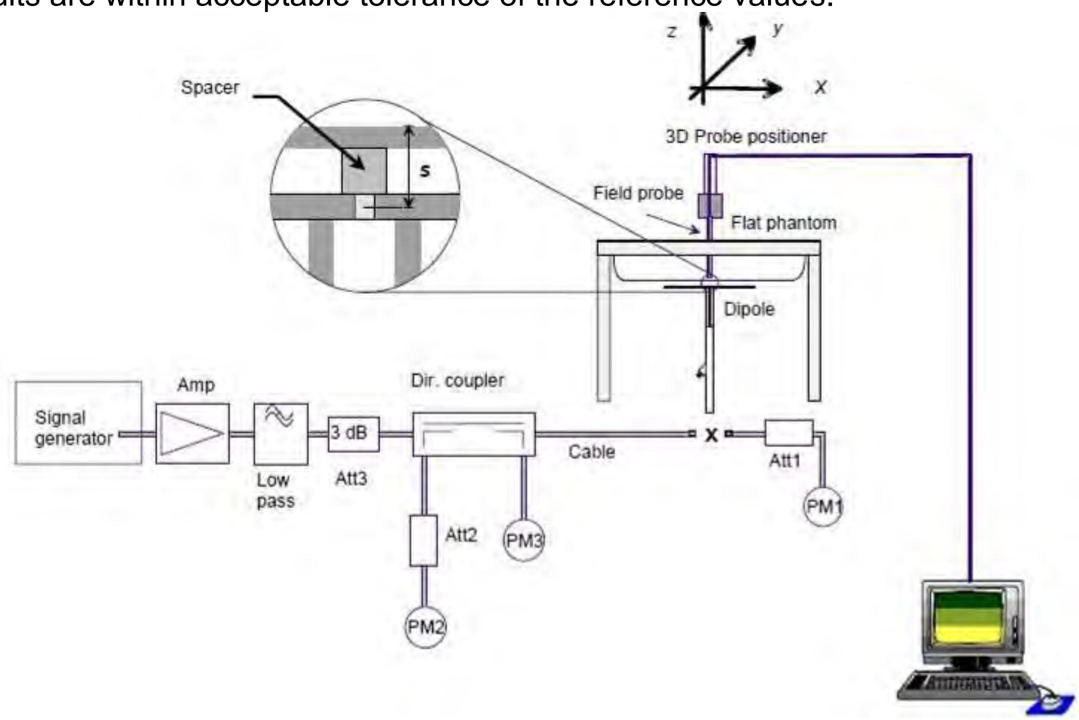

Fig. b The block diagram of system verification

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Validation Kit	S/N	Frequency (MHz)	1W Target 1g-SAR (W/kg)	pin=250mW Measured 1g-SAR (W/kg)	Normalized to 1W 1g-SAR (W/kg)	Deviation (%)	Limit	Measurement Date
D2450V2	727	2450	53.1	13.2	52.8	-0.56	± 10%	Jan.13,2024

Appendix D Measurement uncertainty

Measurement Uncertainty evaluation template for DUT SAR test (3-6G)

A	c	D	e		f	g	h=c * f / e	i=c * g / e	k
Source of Uncertainty	Tolerance/ Uncertainty	Probability Distributio	Div	Div Value	ci (1g)	ci (10g)	Standard uncertainty	Standard uncertainty	vi, or Veff
Measurement system									
Probe calibration	6.55%	N	1	1	1	1	6.55%	6.55%	∞
Isotropy , Axial	3.50%	R	√3	1.732	1	1	2.02%	2.02%	∞
Isotropy, Hemispherical	9.60%	R	√3	1.732	1	1	5.54%	5.54%	∞
Modulation Response	2.40%	R	√3	1.732	1	1	1.40%	1.40%	∞
Boundary Effect	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Linearity	4.70%	R	√3	1.732	1	1	2.71%	2.71%	∞
Detection Limits	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Readout Electronics	0.30%	N	1	1	1	1	0.30%	0.30%	∞
Response time	0.80%	R	√3	1.732	1	1	0.46%	0.46%	∞
Integration Time	2.60%	R	√3	1.732	1	1	1.50%	1.50%	∞
Measurement drift (class A evaluation)	1.75%	R	√3	1.732	1	1	1.01%	1.01%	∞
RF ambient condition - noise	3.00%	R	√3	1.732	1	1	1.73%	1.73%	∞
RF ambient conditions - reflections	3.00%	R	√3	1.732	1	1	1.73%	1.73%	∞
Probe positioner Mechanical restrictions	0.40%	R	√3	1.732	1	1	0.23%	0.23%	∞
Probe Positioning with respect to phantom shell	2.90%	R	√3	1.732	1	1	1.67%	1.67%	∞
Post-processing	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Max SAR Eval	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Test Sample related									
Test sample positioning	2.90%	N	1	1	1	1	2.90%	2.90%	M-1
Device Holder Uncertainty	3.60%	N	1	1	1	1	3.60%	3.60%	M-1
Drift of output power	5.00%	R	√3	1.732	1	1	2.89%	2.89%	∞
Phantom and Setup									
Phantom Uncertainty	4.00%	R	√3	1.732	1	1	2.31%	2.31%	∞
Liquid permittivity (mea.)	3.27%	N	1	1	0.64	0.43	2.09%	1.41%	M
Liquid Conductivity (mea.)	1.44%	N	1	1	0.6	0.49	0.86%	0.71%	M
Combined standard uncertainty		RSS					11.93%	11.81%	
Expant uncertainty (95% confidence interval), K=2							23.87%	23.62%	

SGS Taiwan Ltd. | No.134,Wu Kung Road, New Taipei Industrial Park, Wuku District, New Taipei City, Taiwan/新北市五股區新北產業園區五工路 134 號
台灣檢驗科技股份有限公司 | t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
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Measurement Uncertainty evaluation template for DUT SAR test (0.3-3G)

A	c	D	e		f	g	h=c * f / e	i=c * g / e	k
Source of Uncertainty	Tolerance/ Uncertainty	Probability Distributio	Div	Div Value	ci (1g)	ci (10g)	Standard uncertainty	Standard uncertainty	vi, or Veff
Measurement system									
Probe calibration	6.00%	N	1	1	1	1	6.00%	6.00%	∞
Isotropy , Axial	3.50%	R	√3	1.732	1	1	2.02%	2.02%	∞
Isotropy, Hemispherical	9.60%	R	√3	1.732	1	1	5.54%	5.54%	∞
Modulation Response	2.40%	R	√3	1.732	1	1	1.40%	1.40%	∞
Boundary Effect	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Linearity	4.70%	R	√3	1.732	1	1	2.71%	2.71%	∞
Detection Limits	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Readout Electronics	0.30%	N	1	1	1	1	0.30%	0.30%	∞
Response time	0.80%	R	√3	1.732	1	1	0.46%	0.46%	∞
Integration Time	2.60%	R	√3	1.732	1	1	1.50%	1.50%	∞
Measurement drift (class A evaluation)	1.75%	R	√3	1.732	1	1	1.01%	1.01%	∞
RF ambient condition - noise	3.00%	R	√3	1.732	1	1	1.73%	1.73%	∞
RF ambient conditions - reflections	3.00%	R	√3	1.732	1	1	1.73%	1.73%	∞
Probe positioner Mechanical restrictions	0.40%	R	√3	1.732	1	1	0.23%	0.23%	∞
Probe Positioning with respect to phantom shell	2.90%	R	√3	1.732	1	1	1.67%	1.67%	∞
Post-processing	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Max SAR Eval	1.00%	R	√3	1.732	1	1	0.58%	0.58%	∞
Test Sample related									
Test sample positioning	2.90%	N	1	1	1	1	2.90%	2.90%	M-1
Device Holder Uncertainty	3.60%	N	1	1	1	1	3.60%	3.60%	M-1
Drift of output power	5.00%	R	√3	1.732	1	1	2.89%	2.89%	∞
Phantom and Setup									
Phantom Uncertainty	4.00%	R	√3	1.732	1	1	2.31%	2.31%	∞
Liquid permittivity (mea.)	1.41%	N	1	1	0.64	0.43	0.90%	0.61%	M
Liquid Conductivity (mea.)	2.15%	N	1	1	0.6	0.49	1.29%	1.05%	M
Combined standard uncertainty		RSS					11.53%	11.47%	
Expant uncertainty (95% confidence interval), K=2							23.05%	22.95%	

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台灣檢驗科技股份有限公司 t (886-2) 2299-3279 f (886-2) 2298-0488 www.sgs.com.tw
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11.SAR SYSTEM CHECK RESULTS

Date: 2024/1/13

Report No. :TESA2312000777ES

Dipole 2450 MHz_SN:727

Communication System: CW; Frequency: 2450 MHz; Duty cycle= 1:1
Medium parameters used: f = 2450 MHz; σ = 1.834 S/m; ε_r = 38.437; ρ = 1000 kg/m^3
Phantom section: Flat Section
Ambient temperature: 22.3°C; Liquid temperature: 22.1℃

DASY5 Configuration:

- Probe: EX3DV4 - SN7712; ConvF(7.91, 7.91, 7.91); Calibrated: 2023/4/14
- Sensor-Surface: 2mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn856; Calibrated: 2023/4/26
- Phantom: SAM
- DASY52 52.10.4(1527); SEMCAD X 14.6.14(7483)

Area Scan (51x51x1): Interpolated grid: dx=12 mm, dy=12 mm
Maximum value of SAR (interpolated) = 21.0 W/kg

Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 108.1 V/m; Power Drift = 0.01 dB

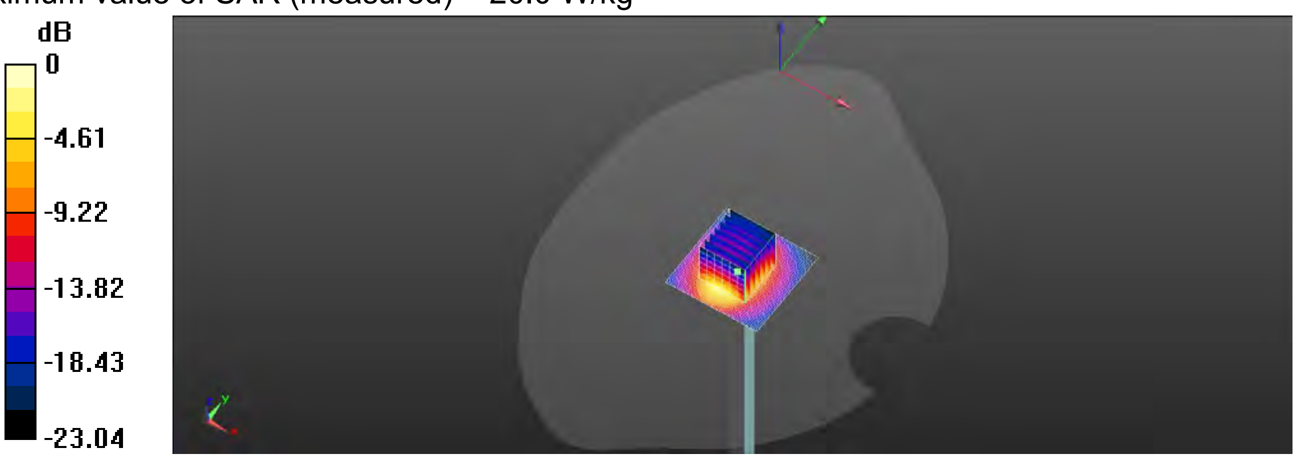
Peak SAR (extrapolated) = 27.5 W/kg

SAR(1 g) = 13.2 W/kg; SAR(10 g) = 6.29 W/kg

Smallest distance from peaks to all points 3 dB below = 10 mm

Ratio of SAR at M2 to SAR at M1 = 48.1%

Maximum value of SAR (measured) = 20.0 W/kg



0 dB = 20.0 W/kg = 13.22 dBW/kg

12.APPENDIXES

Refer to separated files for the following appendixes.

12.1 SAR_Appendix E Photographs

12.2 SAR_Appendix F DAE & Probe Cal. Certificate

12.3 SAR_Appendix G Phantom Description & Dipole Cal. Certificate

- End of report -