

ISED 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 A Series
Model No. SM-A156W
Applicant SAMSUNG Electronics Co., Ltd.
129, Samsung-ro, Yeongtong-gu, Suwon-si, Gyeonggi-do,
16677, Rep. of Korea
ISED ID 649E-SMA156W
Date of Receipt Oct. 05, 2023
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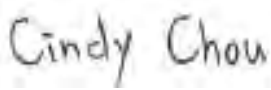
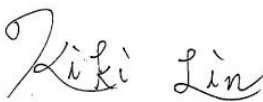
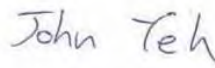
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Remarks:

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Signed on behalf of SGS

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

Date: Nov. 21, 2023

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Note:

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

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1.General Information

1.1 Testing Laboratory

Laboratory	Test Site Address	Test Site Name	ISED 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

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2. Overview

ISED 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 ISED RF exposure limits defined as the specific absorption rate (SAR) limit for transmit frequencies < 6GHz and power density (APD) 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 ISED regulation. For PD limit, the proposed algorithm controls TX power to ensure that at all times the time-averaged RF exposure is compliant with the ISED APD requirement. In the ISED regulation, the averaging time window is 60 seconds for 2.4G/5G/6GHz transmit frequencies.

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

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3. Wi-Fi TA-SAR Algorithm Concept

Mediatek developed the TA-SAR algorithms to control instantaneous TX power for transmit frequencies less and larger than 6GHz respectively, so that the total time-averaged RF exposures are less than ISED requirement.

3.1 Algorithm Description

The proposed algorithms use TX power control to accomplish RF exposure compliance for **Wi-Fi** system. The basic concept is, 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.

- 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 ISED for assessing time-averaged SAR. P_{SAR_limit} is the predefined TX power limit which is mapped from SAR exposure limit.

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

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

where $SAR_{n,limit}$ is the SAR regulatory limit $SAR_REG_limit_n$ that is applicable to the n -th transmitter/test frequency.

In particular, for Wi-Fi SAR,

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$$\frac{1}{T_{SAR}} \int_{t-T_{SAR}}^t SAR(\tau) d\tau = \frac{\frac{1}{T_{SAR}} \int_{t-T_{SAR}}^t inst_SAR_TX_power(\tau) d\tau}{P_{WF_SAR_limit}} \times WF_SAR_design_limit$$

where $inst_SAR_TX_power(\tau)$ denote the instantaneous TX power at time τ for SAR. T_{SAR} is the time averaging window defined by ISED for assessing time-averaged SAR. The meanings of $P_{WF_SAR_limit}$, $WF_SAR_design_limit$, and SAR_REG_limit are described in Table 3-1.

3.2 Operating Parameters for Algorithm Validation

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

Algorithm parameters	Description
$P_{WF_SAR_limit}$ $(P_{WF_SAR_limit})$	<p>The time-averaged maximum power level limit corresponding to $WF_SAR_design_limit$.</p> <ul style="list-style-type: none"> For ISED, 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.
$P_{WF_SAR_MAX_limit}$ $(P_{WF_SAR_MAX_limit})$	<p>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.</p>

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4. Overview of Wi-Fi TA-SAR Test Proposal

For the completeness of verifying that the proposed TA-SAR algorithm can realize ISED 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. The proposed algorithm can ensure TA-SAR control correctness and prove the normalized total RF exposure is less than or equal to 1 (ISED 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.

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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	Test reduction
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	DBDC is not supported for MT6835 module.
3	Antenna switching	Change antenna index	Device only has single antenna.
4	ECI (Exposure Condition Index) change	Test under ECI transition	
5	Simultaneous SAR	TER of 2.4GHz TA-SAR and 6GHz TA-SAR	DBDC is not supported for MT6835 module.

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.

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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.

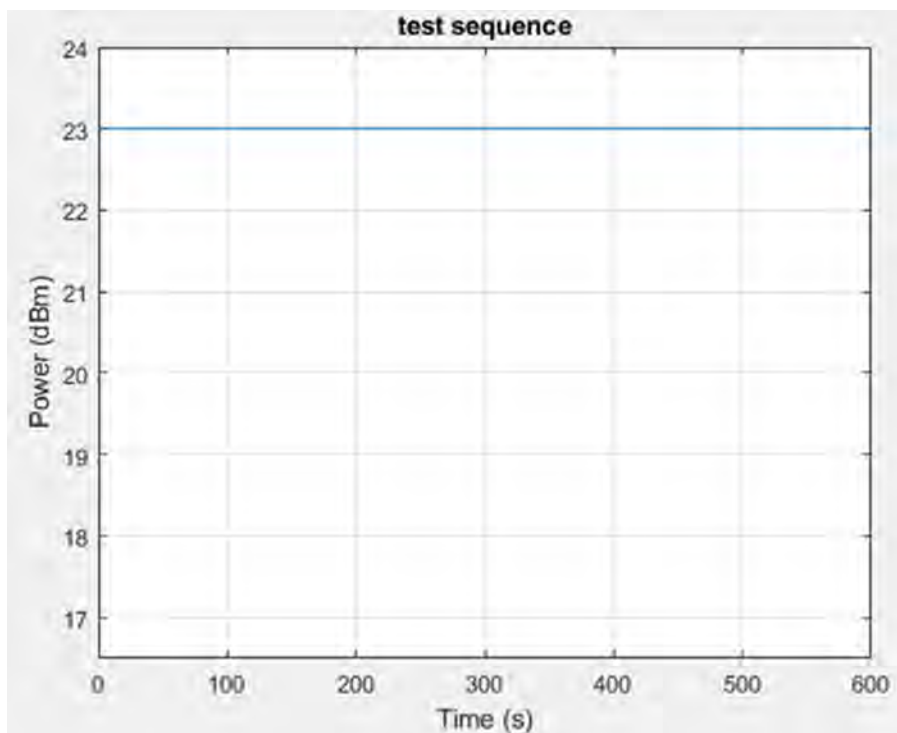


Figure 5-1 Test sequence

Table 5-2 Test sequence

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

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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.
 - Only one band/channel needs to be tested if all the bands have the same P_WF_SAR_limit.
 - Only one band/channel needs to be tested if only one band has P_WF_SAR_limit below P_WF_SAR_MAX.
 - 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.
 - 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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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

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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. ISED limit of 1.6 W/kg (1gSAR) or 4.0 W/kg (10gSAR)

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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.

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

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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 $P_{WF_SAR_limit}$ 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 $P_{WF_SAR_limit}$ 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.

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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. ISED 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 ISED 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 $P_{WF_SAR_limit}$ in one ECI group index: Configure pre-defined TX power sequence to DUT for selected band and then DUT transmits packets for 400s.

Change $P_{WF_SAR_limit}$ value to another ECI group index: Set the command to change $P_{WF_SAR_limit}$ 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

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4. Calculated time-averaged power limits
- B. Make one SAR perspective plot containing
 1. Calculated time-averaged 1gSAR or 10gSAR
 2. ISED 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 ISED limit of 1.6 W/kg for 1gSAR or 4.0 W/kg for 10gSAR.

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

5.6.1 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.

5.6.2 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: $SAR(\tau)$

$$SAR(\tau) = \frac{meas_SAR(\tau)}{meas_SAR_P_{WF_SAR_limit}} \times WF_SAR_design_limit$$

where $meas_SAR_P_{WF_SAR_limit}$ 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 $P_{WF_SAR_limit}$.

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

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

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6.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 6-1. The SAR_design_limit is determined by taking 1-dB device uncertainty into consideration.

Table 6-1 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 2 HOTSPOT		ECI 3 EarJack		ECI 4 Free			
				burst-power	frame-averaged power	burst-power	frame-averaged power	burst-power	frame-averaged power	burst-power	frame-averaged power	burst-power	frame-averaged power
WIFI	2.45 GHz	E	99.57	20.60	20.58	23.80	23.78	23.80	23.78	23.80	23.78	20.00	19.98

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

Table 6-2 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@P _{limit} 1-g SAR (W/kg)	SAR reg.	P _{limit} , frame-averaged	P _{max} , 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	99.57%	Back	10	E(S2)	2	7	2442	0.282	1.6	20.00	20.00	1.00
1	1-2-a. 2G Start-up sequence - a	Wi-Fi	2.45GHz	802.11b	CCK 5.5M	99.57%	N/A	10	E(S2)	2	7	2442	0.282	1.6	20.00	20.00	1.00
2	1-2-b. 2G Start-up sequence - b	Wi-Fi	2.45GHz	802.11b	CCK 5.5M	99.57%	N/A	10	E(S2)	2	7	2442	0.282	1.6	20.00	20.00	1.00
3	4. Exposure Condition Index (ECI) change	Wi-Fi	2.45GHz	802.11b	CCK 5.5M	99.57%	N/A	10	E(S2)	2	7	2442	0.282	1.6	20.00	20.00	1.00 1.00

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

7.1 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 7-1. As seen in this figure, the time-averaged SAR does not exceed the ISED limit.

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

Test band	Max power	$P_{WF_SAR_limit}$
2.4GHz	20 dBm	20 dBm

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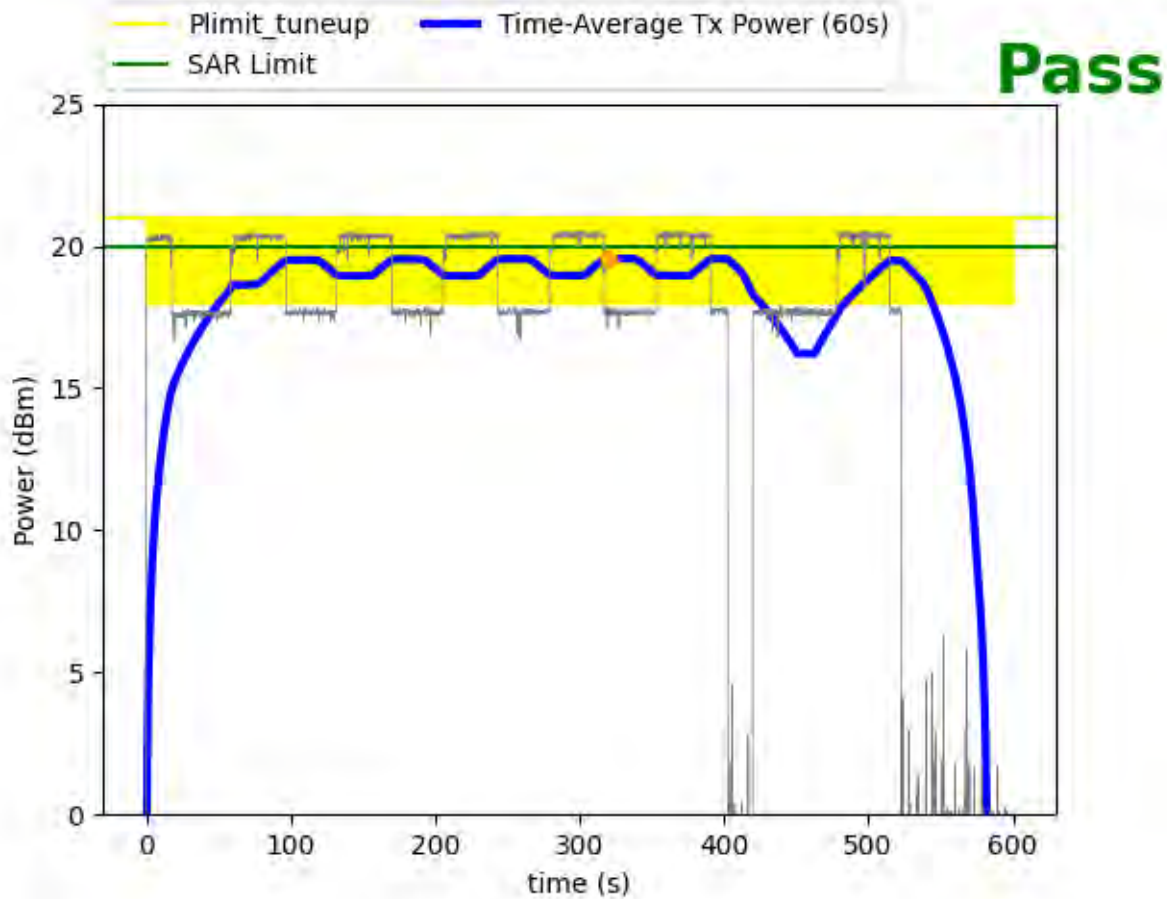


Figure 7-1 Time-averaged conducted TX power over time for test scenario 1-1

Maximum time-averaged conducted power	19.557(dBm)
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7.2 Conducted Power Measurement Results for Scenario 2: Start-up sequence - a

This test is the conducted power measurement for 2.4G CCK 5.5M 400s with CCK 5.5M target power → 2.4G CCK 5.5M 400s with target power set to p_limit

The detailed setting is listed in Table 7-2. As seen in this figure, the time-averaged SAR does not exceed the ISED limit.

Table 7-2 TA-SAR parameters setting for test scenario 1-2

Test band	Max power	$P_{WF_SAR_limit}$
2.4GHz	20 dBm	20 dBm

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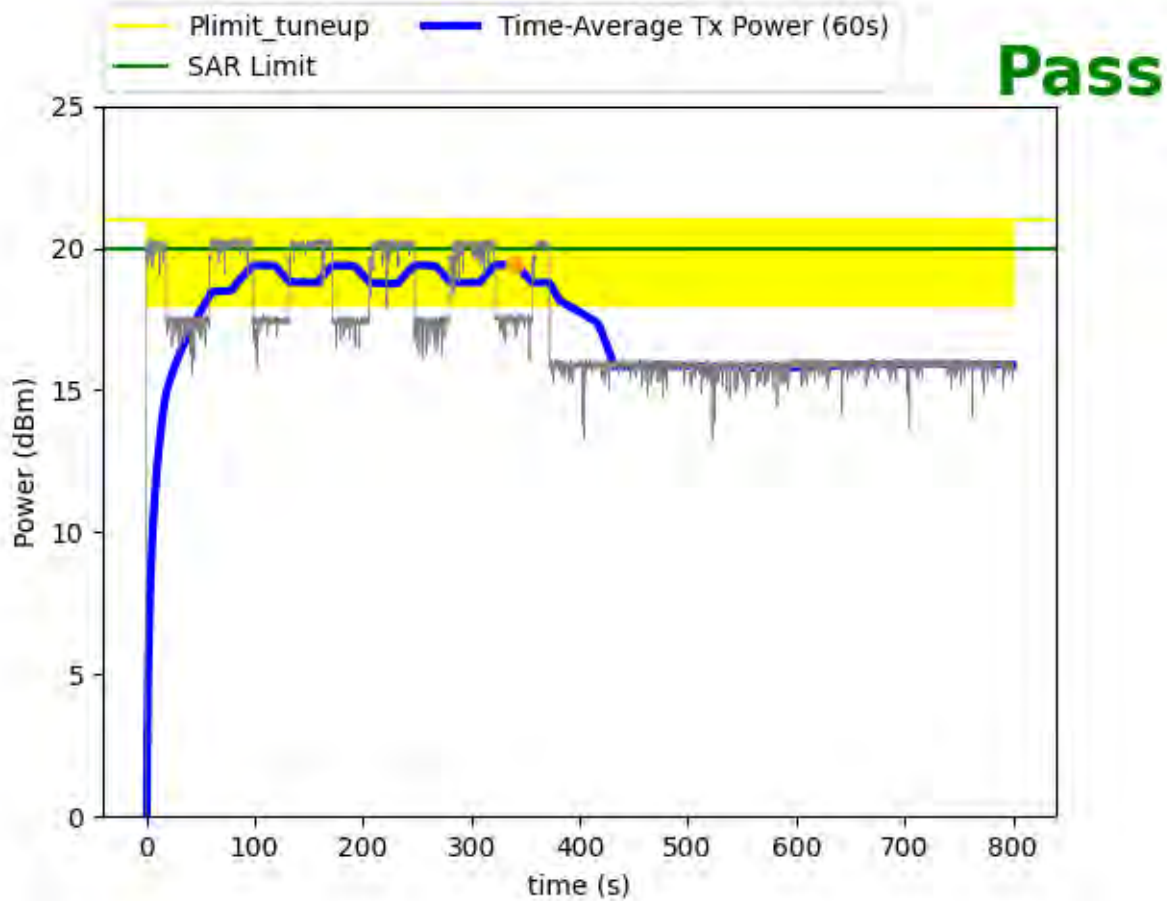


Figure 7-2 Time-averaged conducted TX power over time for test scenario 1-2

Maximum time-averaged conducted power	19.425(dBm)
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7.3 Conducted Power Measurement Results for Scenario 3: Start-up sequence - b

This test is the conducted power measurement for Wi-Fi 2.4G CCK 5.5M 400s with target power set to 1mW (0dBm) → 2.4G CCK 5.5M 400s with CCK 5.5M target power

The detailed setting is listed in Table 7-3. As seen in this figure, the time-averaged SAR does not exceed the ISED limit.

Table 7-3 TA-SAR parameters setting for test scenario 1-3

Test band	Max power	$P_{WF_SAR_limit}$
2.4GHz	20 dBm	20 dBm

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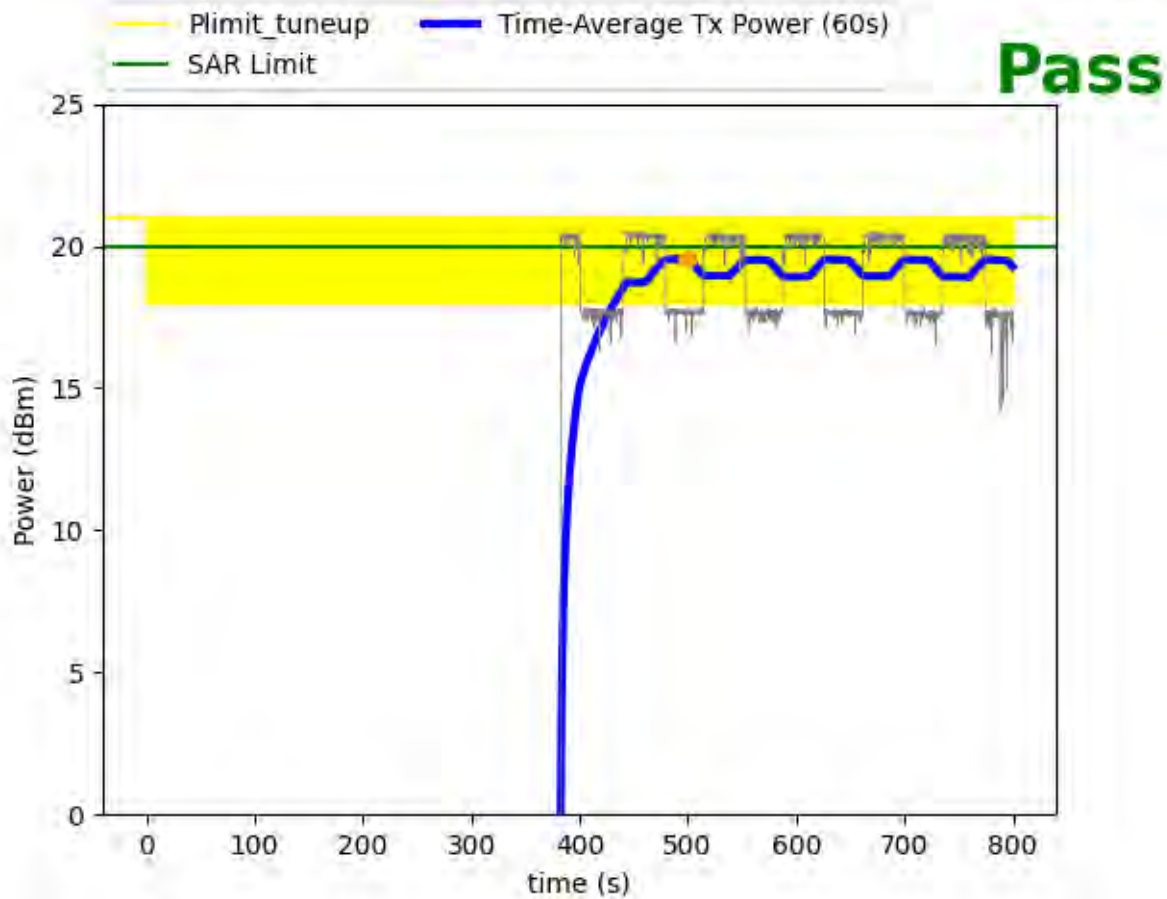


Figure 7-3 Time-averaged conducted TX power over time for test scenario 1-3

Maximum time-averaged conducted power	19.536(dBm)
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7.4 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 7-5. Figure 7-16 demonstrates the DUT's instantaneous conducted TX power, the time-averaged conducted TX power behavior over time, and the power limit. Figure 7-17 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 ISED limit.

Table 7-5 TA-SAR parameters setting for test scenario 4

Test band	Switch time	ECI	Max power	$P_{WF_SAR_limit}$
2.4GHz	0~400s	2	20 dBm	20 dBm
2.4GHz	400s~800s	2	20 dBm	18 dBm

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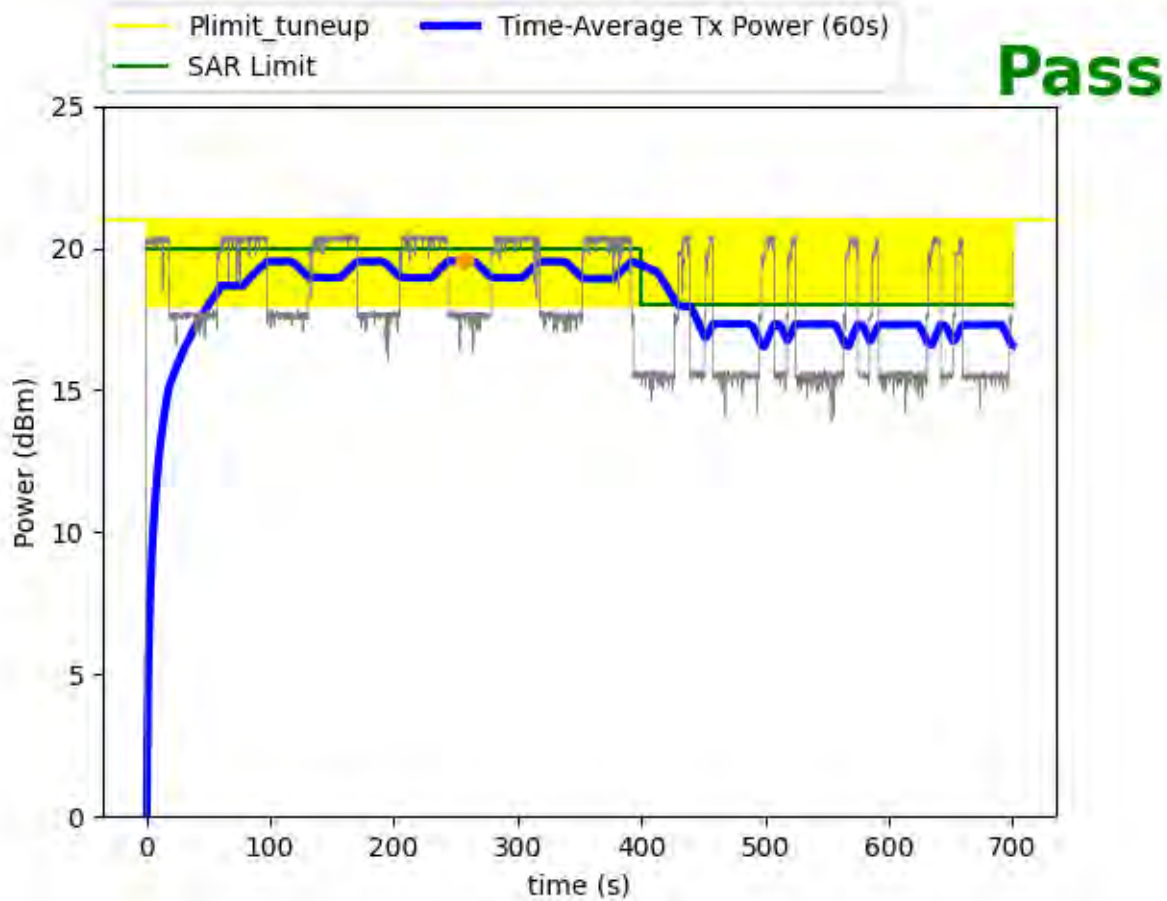


Figure 7-16 Time-averaged conducted TX power over time for test scenario 4

Maximum time-averaged conducted power	19.54(dBm)
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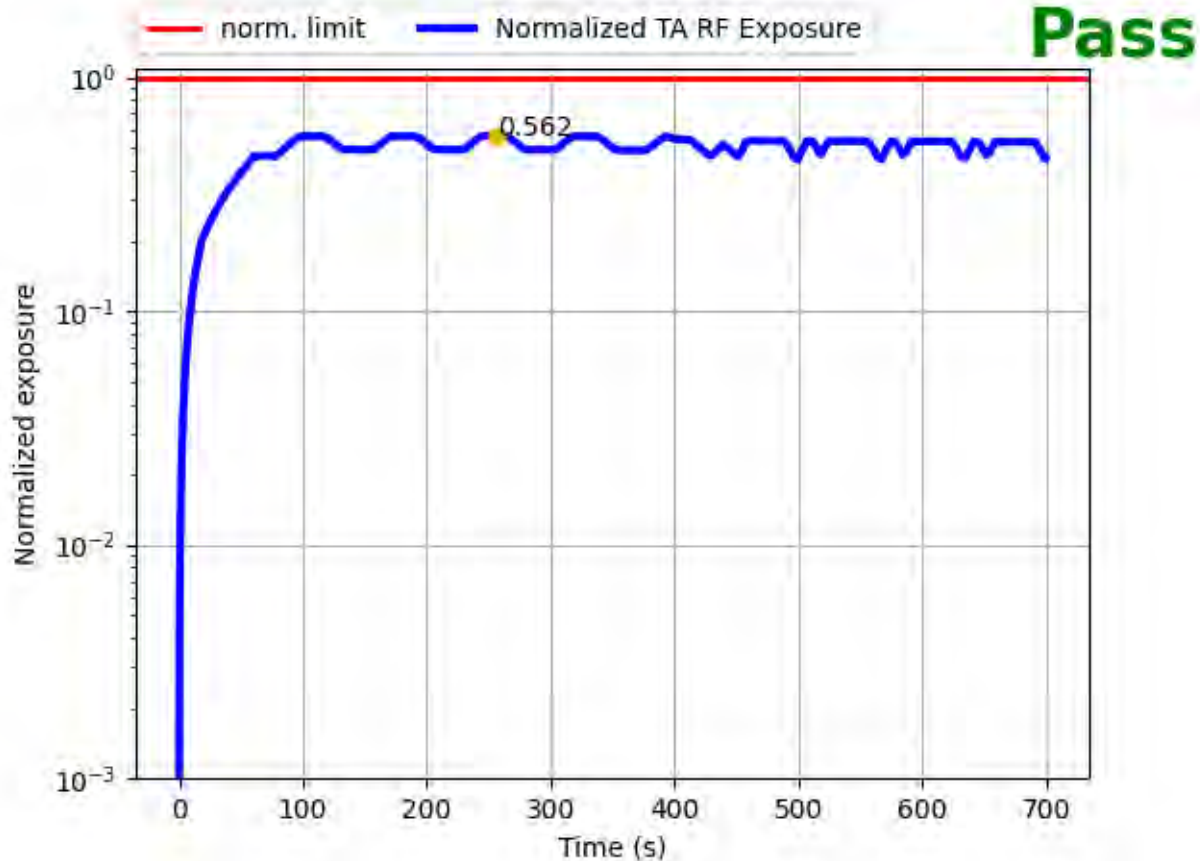


Figure 7-17 Time-averaged SAR over time for test scenario 4

Normalized TA RF Exposure	0.562
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NOTE: The instantaneous TX power should be compared with P_WF_SAR_limit of the corresponding configuration, i.e., 20 dBm for ECI 2 and 18dBm for ECI 2, then transformed and averaged in SAR perspective to check compliance. Therefore, even though the time-averaged TX power seems to exceed P_WF_SAR_limit after ECI changes at 400s, the time-averaged SAR meets regulation as a matter of fact.

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

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

8.1 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 8-1. Figure 8-4 demonstrates scenario 1-1 of 2.4GHz band TA-SAR measurement result.

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

Test band	Max power	$P_{WF_SAR_limit}$
2.4GHz	20 dBm	20 dBm

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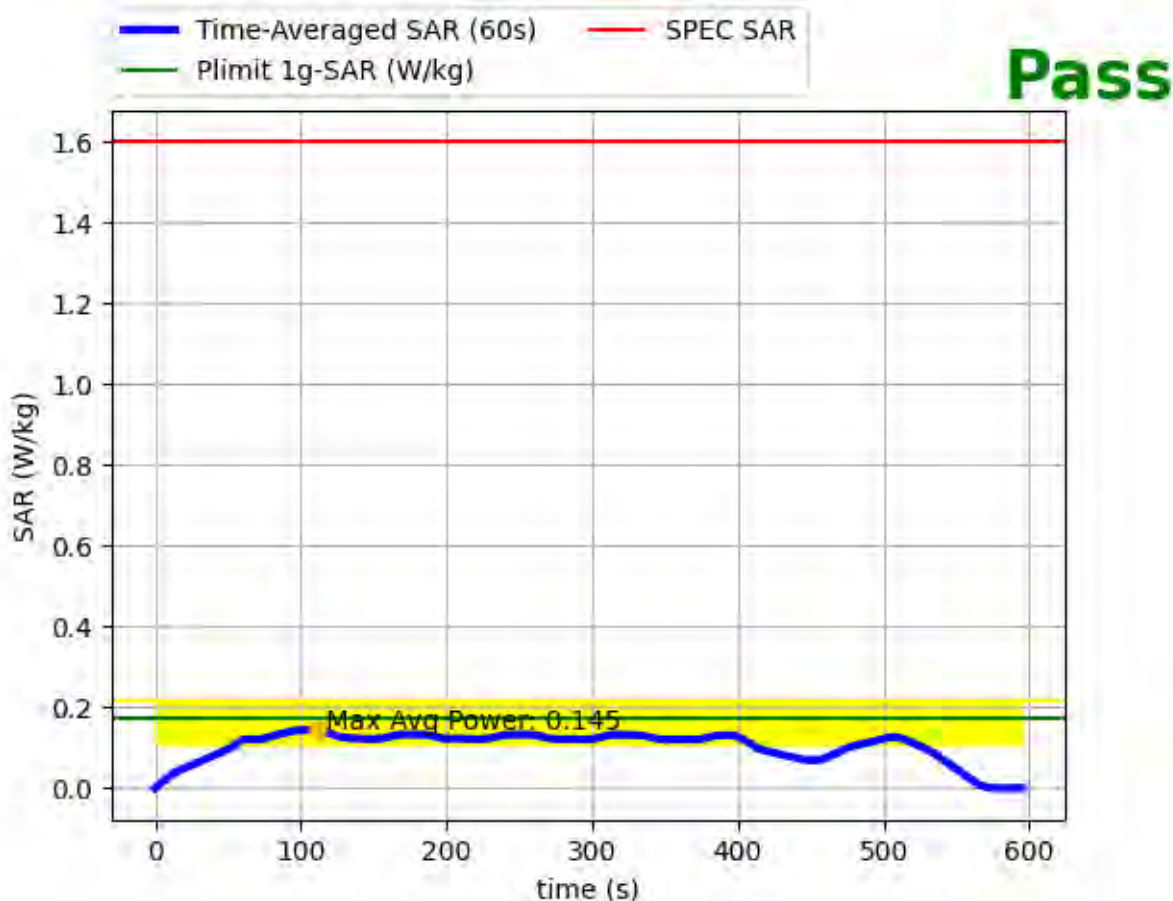


Figure 8-4 Time-averaged SAR measurement for scenario 1-1

ISED 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.145 W/kg
Validation result: pass	

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9. Conclusions

This document proves Mediatek's TA-SAR algorithms can meet the ISED SAR regulations with the proposed test scenarios and procedures. Based on the provided measurement results, it is concluded that Mediatek's TA-SAR algorithms can be tested by using the proposed test methodology for ISED 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	<p>The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209.</p> <p>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.</p>	
Shell Thickness	2 ± 0.2 mm	
Filling Volume	Approx. 25 liters	
Dimensions	Height: 850 mm; Length: 1000 mm; Width: 500 mm	

DEVICE HOLDER

Construction	<p>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, ISED or other specifications. The device holder can be locked at different phantom locations (left head, right head, flat phantom).</p>	 <p>Device Holder</p>
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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	Jan/11/2023	Jan/10/2024
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
R&S	Radio Communication Test	CMW 500	165070	Oct/21/2023	Oct/20/2024
Keysight	EXA Signal Analyzer	N9010A	MY57120290	Apr/11/2023	Apr/10/2023
Keysight	UXM 5G Wireless Test Platform	E7515B	MY60101215	Feb/07/2023	Feb/06/2024
TECPEL	Digital thermometer	DTM-303A	TP130075	Jan/11/2023	Jan/10/2024

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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 $\pm 5\%$ of the target values.

The depth of the tissue simulant in the flat section of the phantom was $\geq 15 \text{ cm} \pm 5 \text{ mm}$ during all tests. (Fig. 2)

Measured Frequency (MHz)	Target Dielectric Constant, ϵ_r	Target Conductivity, σ (S/m)	Measured Dielectric Constant, ϵ_r	Measured Conductivity, σ (S/m)	% dev ϵ_r	% dev σ	Limit	Measurement Date	Liquid Temp. (°C)	Ambient Temp (°C)
2442	39.214	1.793	38.434	1.815	-1.99%	1.23%	$\pm 5\%$	Oct. 31, 2023	21.9	21.5
2450	39.200	1.800	38.449	1.823	-1.92%	1.28%	$\pm 5\%$	Oct. 31, 2023	21.9	21.5

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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 $\pm 10\%$ 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.

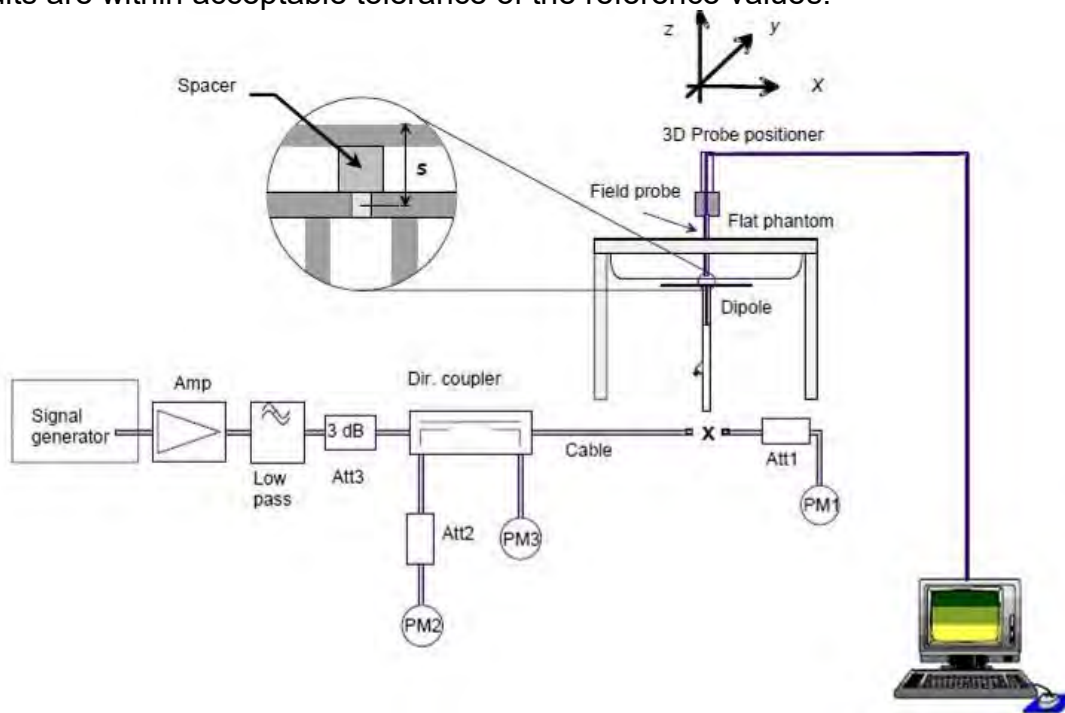


Fig. b The block diagram of system verification

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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	13.3	53.2	0.19	± 10%	Oct.31,2023

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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%	∞
<i>Isotropy , Axial</i>	3.50%	R	√3	1.732	1	1	2.02%	2.02%	∞
<i>Isotropy, Hemispherical</i>	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%	
Expan uncertainty (95% confidence interval), K=2							23.87%	23.62%	

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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	$\sqrt{3}$	1.732	1	1	2.02%	2.02%	∞
Isotropy, Hemispherical	9.60%	R	$\sqrt{3}$	1.732	1	1	5.54%	5.54%	∞
Modulation Response	2.40%	R	$\sqrt{3}$	1.732	1	1	1.40%	1.40%	∞
Boundary Effect	1.00%	R	$\sqrt{3}$	1.732	1	1	0.58%	0.58%	∞
Linearity	4.70%	R	$\sqrt{3}$	1.732	1	1	2.71%	2.71%	∞
Detection Limits	1.00%	R	$\sqrt{3}$	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	$\sqrt{3}$	1.732	1	1	0.46%	0.46%	∞
Integration Time	2.60%	R	$\sqrt{3}$	1.732	1	1	1.50%	1.50%	∞
Measurement drift (class A evaluation)	1.75%	R	$\sqrt{3}$	1.732	1	1	1.01%	1.01%	∞
RF ambient condition - noise	3.00%	R	$\sqrt{3}$	1.732	1	1	1.73%	1.73%	∞
RF ambient conditions - reflections	3.00%	R	$\sqrt{3}$	1.732	1	1	1.73%	1.73%	∞
Probe positioner Mechanical restrictions	0.40%	R	$\sqrt{3}$	1.732	1	1	0.23%	0.23%	∞
Probe Positioning with respect to phantom shell	2.90%	R	$\sqrt{3}$	1.732	1	1	1.67%	1.67%	∞
Post-processing	1.00%	R	$\sqrt{3}$	1.732	1	1	0.58%	0.58%	∞
Max SAR Eval	1.00%	R	$\sqrt{3}$	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	$\sqrt{3}$	1.732	1	1	2.89%	2.89%	∞
Phantom and Setup									
Phantom Uncertainty	4.00%	R	$\sqrt{3}$	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%	
Expan uncertainty (95% confidence interval), K=2							23.05%	22.95%	

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10.SAR SYSTEM CHECK RESULTS

Date: 2023/10/31

Report No. :TESA2310000626ES

Dipole 2450 MHz_SN:727

Communication System: CW; Frequency: 2450 MHz; Duty cycle= 1:1

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.823$ S/m; $\epsilon_r = 38.449$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Ambient temperature: 21.5°C; Liquid temperature: 21.9°C

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 = 107.8 V/m; Power Drift = 0.02 dB

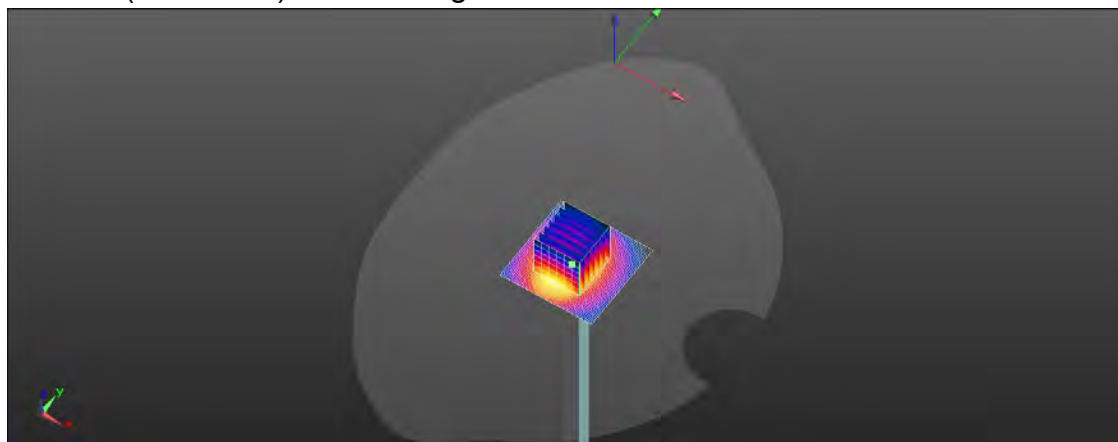
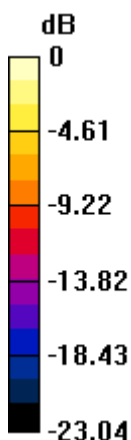
Peak SAR (extrapolated) = 27.5 W/kg

SAR(1 g) = 13.3 W/kg; SAR(10 g) = 6.31 W/kg

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

Ratio of SAR at M2 to SAR at M1 = 47.8%

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



0 dB = 21.0 W/kg = 13.22 dBW/kg

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11.APPENDIXES

Refer to separated files for the following appendixes.

11.1 SAR_Appendix G Photographs

11.2 SAR_Appendix H DAE & Probe Cal. Certificate

11.3 SAR_Appendix I Phantom Description & Dipole Cal. Certificate

- End of report -

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