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RF EXPOSURE PART 2 TEST REPORT

Applicant Name:
Apple, Inc.
One Apple Park Way
Cupertino, CA, 95014

Date of Testing:
1/07/2025 – 1/21/2025
Test Site/Location:
Element, Morgan Hill, CA, USA
Document Serial No.:
1C2410210076-12.BCG (Rev1)

FCC ID:	**BCGA3354**
APPLICANT:	**APPLE INC.**

DUT Type:	Tablet Device
Application Type:	Certification
FCC Rule Part(s):	CFR §2.1093
Model(s):	A3354
Device Serial Numbers:	Pre-Production Samples [6XR3K, TQCW5, YCM2W]

Note: This revised test report supersedes and replaces the previously issued test report on the same subject device for the same type of testing as indicated. Please discard or destroy the previously issued test report(s) and dispose of it accordingly.

I attest to the accuracy of data. All measurements reported herein were performed by me or were made under my supervision and are correct to the best of my knowledge and belief. I assume full responsibility for the completeness of these measurements and vouch for the qualifications of all persons taking them. Test results reported herein relate only to the item(s) tested.

RJ Ortanez
Executive Vice President

ACCREDITED
CERT #2041.02

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1. DEVICE UNDER TEST

1.1 Device Overview

Band & Mode	Operating Modes	Tx Frequency
2.4 GHz WIFI	Voice/Data	2412 - 2472 MHz
5 GHz WIFI	Voice/Data	U-NII-1: 5180 - 5240 MHz U-NII-2A: 5260 - 5320 MHz U-NII-2C: 5500 - 5720 MHz U-NII-3: 5745 - 5825 MHz
2.4 GHz Bluetooth	Data	2402 - 2480 MHz

*BT TA-SAR algorithm is not supported for this device.

1.2 Key Parameter Description

Table 2-1 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.

1.3 Time-Averaging Algorithm for RF Exposure Compliance

This device is enabled with Mediatek TA-SAR Algorithm feature. This feature performs time-averaging algorithm in real time to control and manage transmitting power and ensure the time-averaged RF exposure is in compliance with FCC requirements all the time.

The basic concept of the algorithm is, if time-averaged TX power approaches a predefined TX power limit which is mapped from SAR 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.

For TA-SAR only, below are the itemized descriptions to detail the algorithm operations.

- The current time-averaged TX power is guaranteed to be lower than the predefined nominal TX power limit ($P_{SAR\_limit,nom}$) which corresponds to the nominal psSAR target ($SAR_{target,nom}$).
- If the predicted time-averaged TX power tends to be larger than PSAR_limit, TA-SAR algorithm enables TX constraint to limit instantaneous TX power. The constraint power is dynamically adjusted based on predicted power and duty of the next time period.
- At any time period, the TA-SAR algorithm satisfies the following equation:

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

where $inst\_TX\_power(\tau)$ denotes the instantaneous TX power at time τ, where T_{SAR} is the time averaging window defined by FCC for assessing time-averaged SAR.

The purpose of the Time-averaged SAR report is to demonstrate the DUT complies with FCC RF exposure requirement under Tx varying transmission scenarios, thereby validity of Mediatek TA-SAR Algorithm feature implementation in this device. It serves to complement the SAR Test Reports to justify compliance per FCC.

Mediatek WIFI TAS Algorithm feature can operate in one set of time-averaging windows: FCC defined windows 100s for 2.4GHz and 60s for 5GHz. This operation can be selected based on Mobile Country Codes (MCC) used by wireless networks.

1.4 Bibliography

Report Type	Report Serial Number
RF Exposure Part 1 Test Report	1C2410210076-01.BCG

2. RF EXPOSURE LIMITS

2.1 Uncontrolled Environment

UNCONTROLLED ENVIRONMENTS are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure. The general population/uncontrolled exposure limits are applicable to situations in which the general public may be exposed or in which persons who are exposed as a consequence of their employment may not be made fully aware of the potential for exposure or cannot exercise control over their exposure. Members of the general public would come under this category when exposure is not employment-related; for example, in the case of a wireless transmitter that exposes persons in its vicinity.

2.2 Controlled Environment

CONTROLLED ENVIRONMENTS are defined as locations where there is exposure that may be incurred by persons who are aware of the potential for exposure, (i.e. as a result of employment or occupation). In general, occupational/controlled exposure limits are applicable to situations in which persons are exposed as a consequence of their employment, who have been made fully aware of the potential for exposure and can exercise control over their exposure. This exposure category is also applicable when the exposure is of a transient nature due to incidental passage through a location where the exposure levels may be higher than the general population/uncontrolled limits, but the exposed person is fully aware of the potential for exposure and can exercise control over his or her exposure by leaving the area or by some other appropriate means.

2.3 RF Exposure Limits for Frequencies Below 6 GHz

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SAR Human Exposure Specified in ANSI/IEEE C95.1-1992 and Health Canada Safety Code 6

HUMAN EXPOSURE LIMITS		
	UNCONTROLLED ENVIRONMENT *General Population* (W/kg) or (mW/g)	CONTROLLED ENVIRONMENT *Occupational* (W/kg) or (mW/g)
Peak Spatial Average SAR Head	1.6	8.0
Whole Body SAR	0.08	0.4
Peak Spatial Average SAR Hands, Feet, Ankle, Wrists, etc.	4.0	20

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

2.4 Time Averaging Windows for FCC Compliance

Per October 2018 TCB Workshop Notes, the below time-averaging windows can be used for assessing time-averaged exposures for devices that are capable of actively monitoring and adjusting power output over time to comply with exposure limits.

Interim Guidance	Frequency (GHz)	Maximum Averaging Time (sec)
SAR	< 3	100
	3 – 6	60
MPE	6 - 10	30
	10 - 16	14
	16 – 24	8
	24 – 42	4
	42 – 95	2

3. TIME VARYING TRANSMISSION TEST CASES

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

• **Wi-Fi test scenario 1:** test TX mode change among various TX power levels to verify algorithm for SAR compliance.
• **Wi-Fi test scenario 2**: test band handover to ensure algorithm control continuity and correctness.
• **Wi-Fi test scenario 3:** test different transmission antennas to ensure algorithm control works correctly during antenna switch from one antenna to another.

The strategy for testing in Tx varying transmission condition is outlined as follows:

- Demonstrate the total RF exposure averaged over FCC defined time windows does not exceed FCC's SAR limits, through time-averaged power measurements
  - Measure conducted Tx power versus time,
  - Convert it into RF exposure and divide by respective FCC limits to get normalized exposure versus time.
  - Perform running time-averaging over FCC defined time windows.
  - Demonstrate that the total normalized time-averaged RF exposure is less than 1 for all transmission scenarios at all times.

Considerations for single point SAR measurements outlined as follows:

- Demonstrate that the time-averaged SAR*[t]* remains less than 1.6 W/kg (1g SAR) or 4.0 W/kg (10g SAR)*,* for every time step associated with the test.

▪ Determine the location of maximum SAR by an area scan in accordance with IEC/IEEE 62209-1528 with the DUT output power set to $P_{WF\_SAR\_limit}$.

▪ Perform a single point SAR measurement, *meas_SAR*, with the DUT output power set to $P_{WF\_SAR\_limit}$

  - Perform a single point SAR measurement, *meas_SAR[t],* with TAS algorithm enabled.

▪ Convert the instantaneous measured SAR into 1g SAR or 10g SAR value.

▪ Demonstrate that the calculated time-averaged 1g SAR or 10g SAR versus time shall not exceed 1.6 W/kg (1g SAR) or 4.0 W/kg (10g SAR).

Mathematical expression:

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

Where instantaneous 1g SAR or 10g SAR versus time: $SAR(t)$. And $\text{meas\_SAR\_P}_{\text{WF\_SAR\_limit}}$ is measured from single point SAR measurement at *meas_SAR*, $\text{meas\_}SAR(t)$ is the instantaneous SAR measured with pre-defined TX power sequence, and $WF\_SAR\_design\_limit$ is the measured worse-case SAR value at $P_{WF\_SAR\_limit}$.

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

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

Where $SARn,limit$ is the basic restriction limit that is applicable to the n-th transmitter/test frequency.

4. FCC MEASUREMENT PROCEDURES

This chapter provides the test plan and test procedure for validating Mediatek WIFI TAS feature for WIFI transmission.

4.1 Test Configuration and Procedure for Wi-Fi Test: Tx Mode Change

Two distinct sequences shall be applied to validate the start-up behavior of the TAS algorithm:

Test sequence 1: Wi-Fi is requested to transmit static and maximum power with high duty.

4.1.1 Configuration

The criteria for band selection are based on the $P_{SAR\_limit,nom}$ for 2.4GHz/5GHz bands is 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.

4.1.2 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 $P_{\mathrm{WF}\_SAR\_limit}$ calibration mode and measure $P_{\mathrm{WF}\_SAR\_limit}$ 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 1g SAR value using the following equation. Perform the running time average to power and 1g 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
    2. FCC limit of 1.6 W/kg (1gSAR)

4.2 Test Configuration and Procedure for Wi-Fi Test: Band Handover

4.2.1 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 1g SAR 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 1g SAR at *P_WF_SAR_limit*.

4.2.2 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 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.
    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 1g SAR value using the following equation. Perform the running time average to power and 1g SAR to determine time-averaged value versus time as follows.

Instantaneous 1g SAR versus time: $SAR\_1(t)$ (band1), $SAR\_2(t)$ (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 (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
2. FCC limit of 1.6 W/kg (1gSAR)
3. Normalized time-averaged 1gSAR/1.6

The validation criteria are, at all times, the normalized time-averaged 1g SAR or 10g SAR versus time shall not exceed FCC limit of 1.6 W/kg (1g SAR) or 4.0 W/kg (10g SAR).

4.3 Test Configuration and Procedure for Wi-Fi Test: Antenna Switching

4.3.1 Configuration

Wi-Fi first selects an antenna to transmit packets then switches to another antenna within the same band. For any band supporting multiple TX antennas, select the one with the highest difference in $P_{WF\_SAR\_limit}$ among all supported antennas for 2.4GHz/5GHz bands.

- Select the band having the highest measured 1g SAR at *P_WF_SAR_limit* if multiple bands having 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*.

4.3.2 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 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 test scenario 1 in Section 4.1.2
- 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 on SAR perspective plot containing
     1. Calculated time-averaged 1gSAR
     2. FCC limit of 1.6 W/kg (1gSAR)
     3. Normalized time-averaged 1gSAR/1.6

Note: 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 1g SAR or 10g SAR versus time shall not exceed FCC limit of 1.6 W/kg for 1g SAR or 4.0 W/kg for 10g SAR.

4.4 Test Configuration and Procedure for Wi-Fi Test: TX Mode Change via Single Point SAR

4.4.1 Configuration

This section provides general time-varying SAR measurement procedures to perform compliance tests under dynamic transmission scenarios described in Section 3.

- Single point SAR measurements shall be performed only for configurations involving a single transmitter, i.e., not for simultaneous transmission.

The test procedures in the previous sections (sections 4.1 ~ 4.3) 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 in section 4.1.1 is used.

4.4.2 Procedure

The following steps are for time averaging feature validation through SAR measurement:

- Steps 1~3: Measure and record TA-SAR versus time for test scenario 1.

- Step 1: Start $\mathrm{meas\_SAR\_P}_{WF\_SAR\_limit}$ calibration mode for the selected band/channel. Measure $meas\_SAR$ at peak location of the area scan where meas_SAR_P$_{\mathrm{WF_SAR_limit}}$ corresponds to this meas_SAR value at $P_{WF\_SAR\_limit}$.
- 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 1g SAR or 10g SAR value. Perform the running time average to 1g SAR or 10g SAR to determine the time-averaged value versus time by the following equations.
Instantaneous 1g SAR or 10g SAR 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, $meas\_SAR(\tau)$ is the instantaneous SAR measured in step 3, and $WF\_SAR\_design\_limit$ is the measured worse-case SAR value at $\mathrm{P}_{WF\_SAR\_limit}$.

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 5: Plot results
  1. Calculated time-averaged 1g SAR or 10g SAR
  2. FCC limit of 1.6 W/kg (1g SAR) or 4.0 W/kg (10g SAR)

The validation criteria are, at all times, the calculated time-averaged 1g SAR or 10g SAR versus time shall not exceed 1.6 W/kg (1g SAR) or 4.0 W/kg (10g SAR)

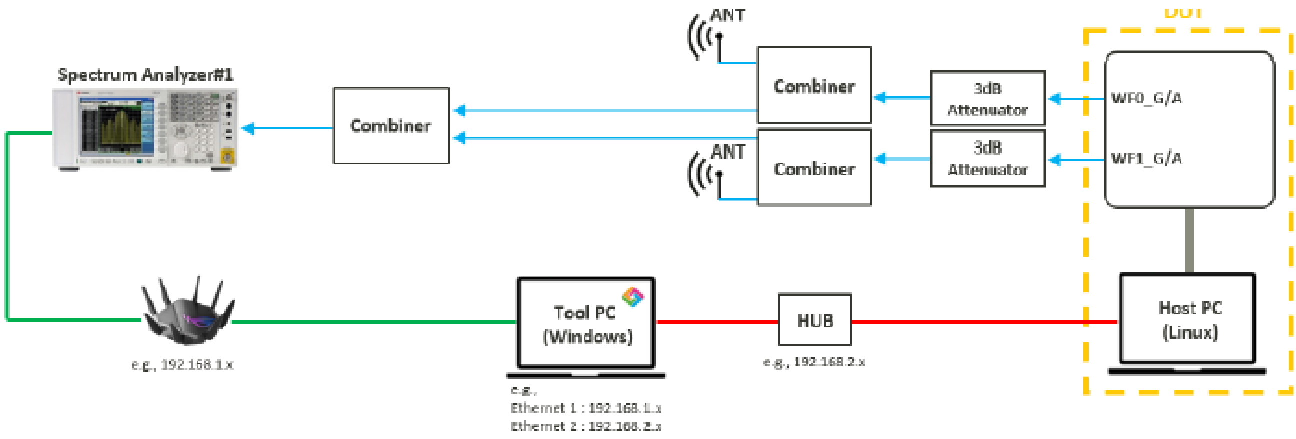
5. MEASUREMENT TEST SETUP

5.1 Measurement Setup

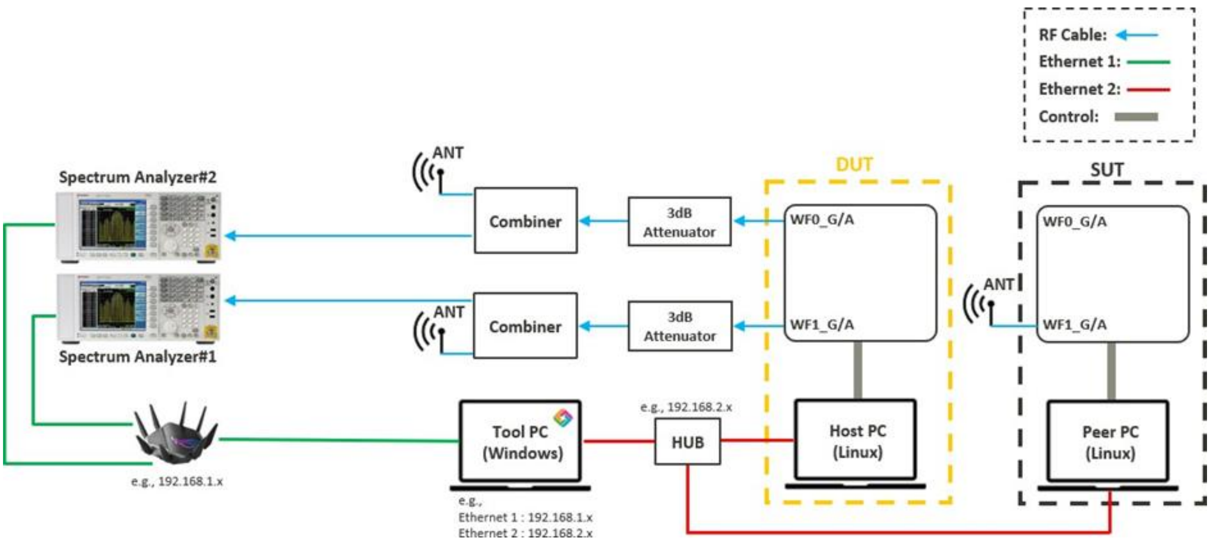
The general measurement setup for the DUT is shown in Figure 5-1. There is a control PC which controls DUT and peer devices that act as soft-AP or STA. The WLAN traffic is established between peer devices and DUT. The traffic from DUT TX is UDP and controlled by the control PC.

The test sequence and scenarios are controlled by PC command. The transmitter power is measured with MXA Keysight spectrum analyzers. There are two peer devices and two spectrum analyzers to support test scenarios with multiple operation frequencies. Furthermore, the moving average of each measured power is calculated to ensure the conductive time-averaging power is always below the power limit threshold.

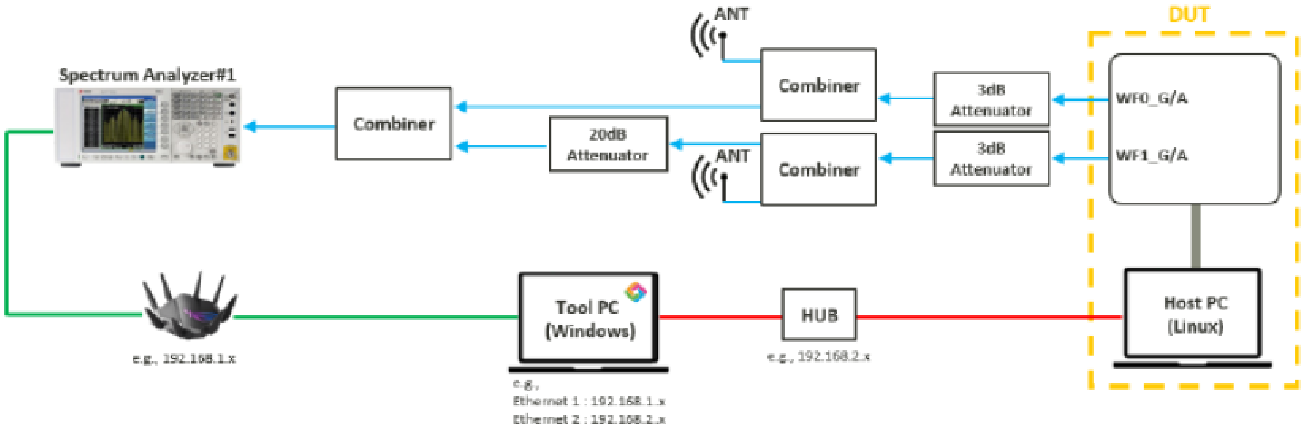
Spectrum analyzer utilizing zero-span mode is used for monitoring the time-domain conductive power of the DUT.



(a) Appendix D – Test Setup Photo 1



(b) Appendix D – Test Setup Photo 2



(c) Appendix D – Test Setup Photo 3

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Conducted power measurement setup

5.2 SAR Measurement Setup

The measurement setup is similar to normal SAR measurements as described in the Part 1 Test Report. The difference in SAR measurement setup for time averaging feature validation is that the DUT is connected to the PC via AP so that the test script executed on PC can send commands to control the DUT's signaling power over time (test sequence). The same test script used in conducted setup for time-varying Tx power measurements is also used in this section for running the test sequences during SAR measurements.

The DUT is placed in worst-case position according to Table 6-1, Table 6-2, and Table 6-3.

6. CONDUCTED TEST CASES

6.1 TX Mode Change Conducted Power Measurements

This test is the conducted power measurement for Wi-Fi 5GHz band and mode change. The detailed setting is listed in Table 6-1. Figure 6-1 demonstrate the DUT's instantaneous conducted TX power, the time-averaged conducted TX power behavior over time, and the power limit for scenario 1-1. As seen in these figures, the time-averaged TX power does not exceed the FCC limit.

Note: Per MTK, due to a tool limitation, TA-SAR was evaluated with the DUT transmitting to the lowest Tx rate for maximum power at BW 20 MHz

Note: Per MTK, Tx power of wf0 (Core 0 antennas) and wf1 (Core 1 antennas) will always have the delta "abs(p_limit_wf0 – p_limit_wf1) in the TA-SAR design for single band scenario. Therefore, the maximum power for 5GHz wf0 will be limited due to 5GHz wf1 having a higher p_limit.

Table 6-1 TA-SAR parameters setting for test scenario 1-1

Test Band	P_WF_SAR_limit [dBm]	Max Power [dBm]
5GHz	13.5	20.0

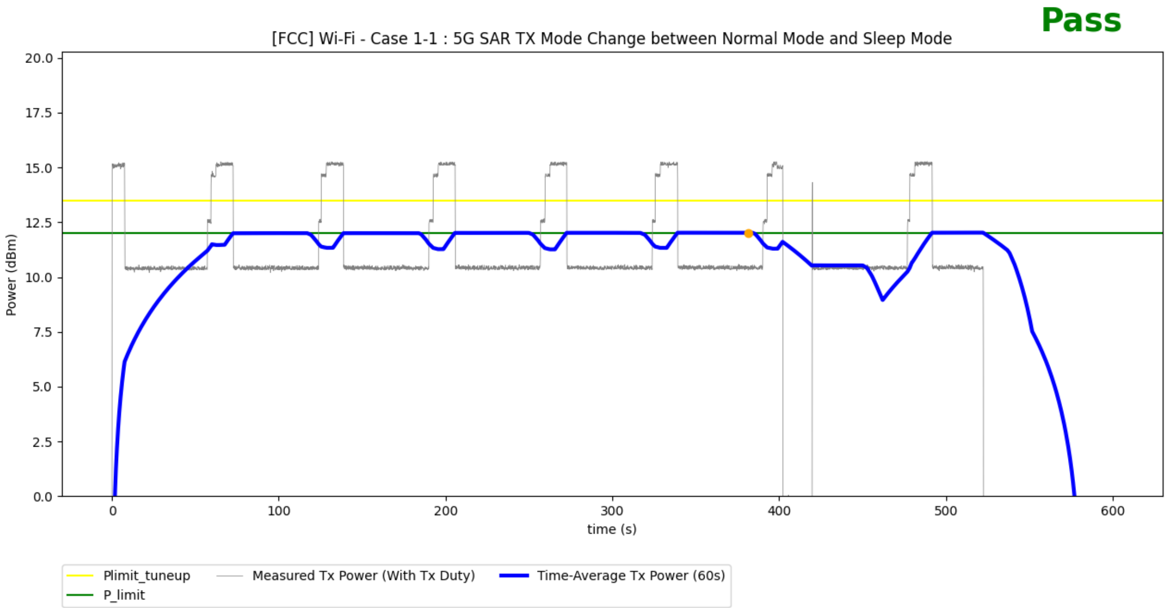

Figure 6-1 Time-averaged conducted TX power over time for test scenario 1-1

6.2 Band Handover Conducted Power Measurements

This test is the conducted power measurement for Wi-Fi 2.4GHz/5GHz band handover. The detailed setting is listed in Table 6-2. Figure 6-2 demonstrates the DUT's instantaneous conducted TX power, the time-averaged conducted TX power behavior over time, and the power limit. Figure 6-3 illustrates the corresponding time-averaged SAR over time converted from the TX time-averaged power by using the equation listed in section 4.2.2. As seen in this figure, the normalized time-averaged SAR does not exceed the FCC limit.

Table 6-2 TA-SAR parameters setting for scenario 2

Test Band	Switch Time	P_WF_SAR_limit [dBm]	Max Power [dBm]
2.4 GHz	0~400s	19.5	20.0
5GHz	400s~800s	13.5	20.0
2.4GHz + 5GHz	800s~1200s	19.5/13.5	20.0/20.0

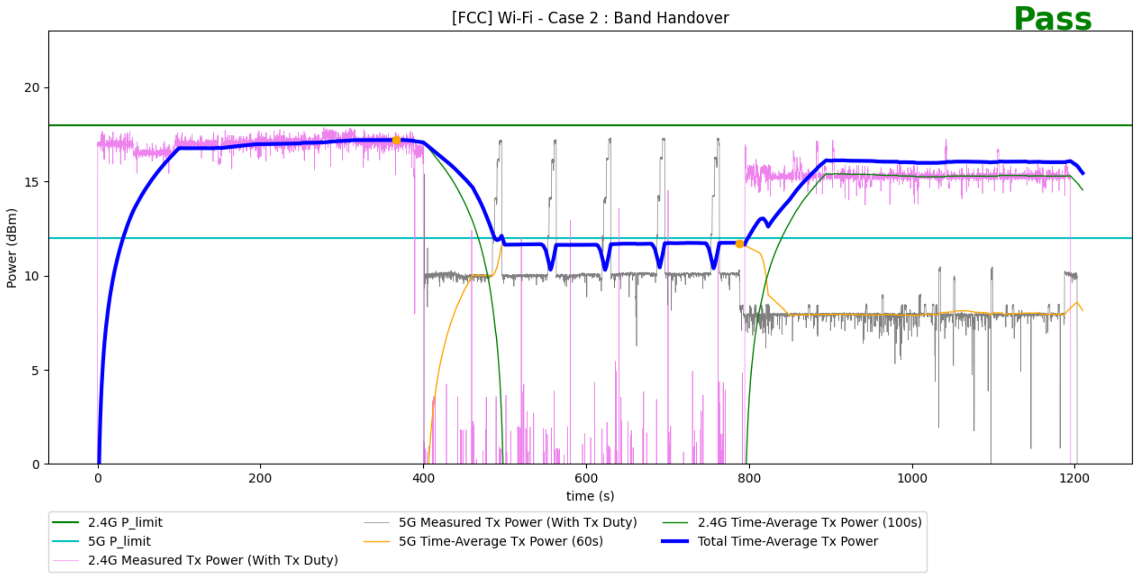

Figure 6-2 Time-averaged conducted TX power over time for test scenario 2

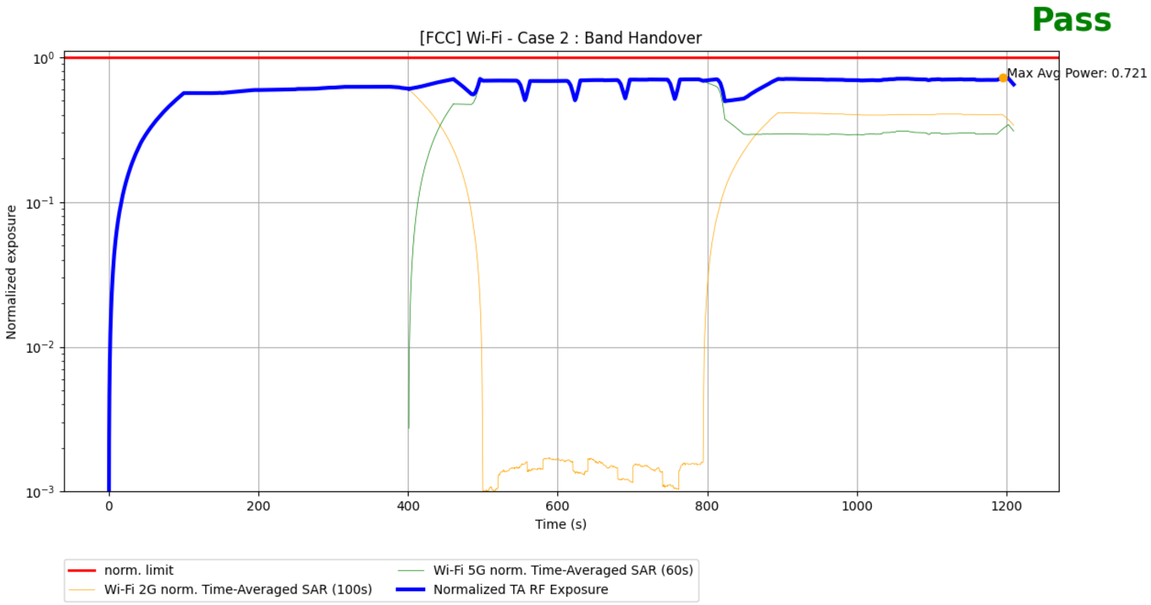

Figure 6-3 Normalized time-averaged SAR over time for test scenario 2

6.3 Antenna Switch Conducted Power Measurements

This test is the conducted power measurement for Wi-Fi antenna switching. The detailed setting is listed in Table 6-3. Figure 6-4 demonstrates the DUT's instantaneous conducted TX power, the time-averaged conducted TX power behavior over time, and the power limit. Figure 6-5 illustrates the corresponding time-averaged SAR over time converted from the TX time-averaged power by using the equation listed in section 4.3.2. As seen in this figure, the normalized time-averaged SAR does not exceed the FCC limit.

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

Test Band	Antenna	Switch Time	P_WF_SAR_limit [dBm]	Max Power [dBm]
5GHz	WF7a (wf0)	0~400s	13.5	20.0
	WF8 (wf1)	400s~800s	17.0	20.0

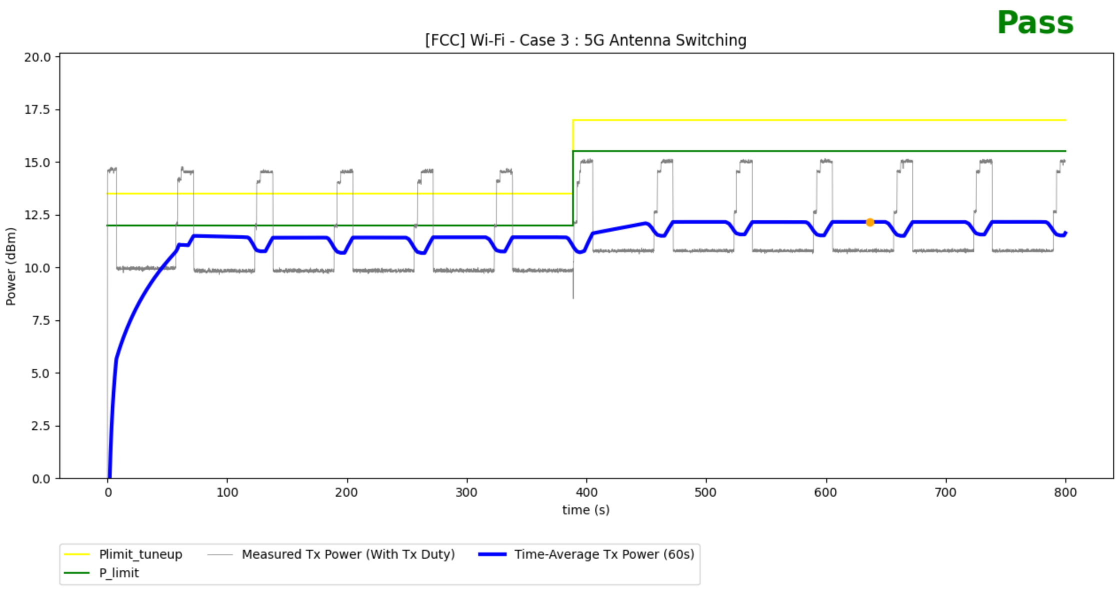

Figure 6-4 Time-averaged conducted TX power over time for test scenario 3

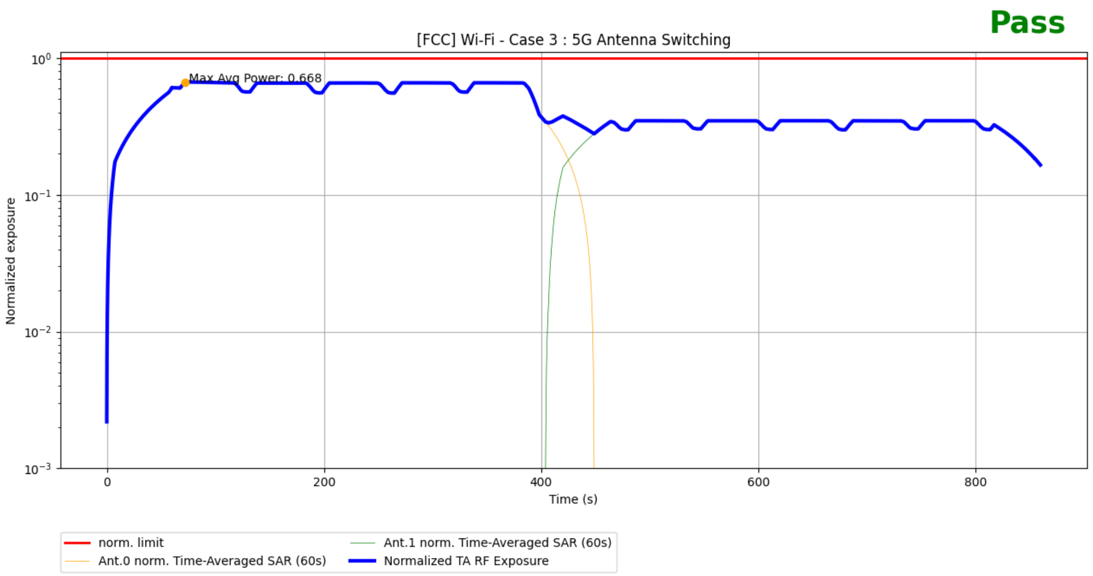

Figure 6-5 Normalized time-averaged SAR over time for test scenario 3

7 SYSTEM VERIFICATION

7.1 Tissue Verification

Table 7-1
Measured Tissue Properties

Calibrated for Tests Performed on:	Tissue Type	Tissue Temp During Calibration (˚C)	Measured Frequency (MHz)	Measured Conductivity, σ (S/m)	Measured Dielectric Constant, ε	TARGET Conductivity, σ (S/m)	TARGET Dielectric Constant, ε	% dev σ	% dev ε
01/13/2025	5 GHz Head	19	5500	4.883	34.205	4.963	35.643	-1.61%	-4.03%
			5510	4.896	34.198	4.973	35.632	-1.55%	-4.02%
			5520	4.906	34.178	4.983	35.620	-1.55%	-4.05%
			5530	4.916	34.154	4.994	35.609	-1.56%	-4.09%
			5540	4.930	34.124	5.004	35.597	-1.48%	-4.14%
			5550	4.943	34.094	5.014	35.586	-1.42%	-4.19%
			5560	4.954	34.092	5.024	35.574	-1.39%	-4.17%
			5580	4.963	34.089	5.045	35.551	-1.63%	-4.11%
			5600	4.995	34.039	5.065	35.529	-1.38%	-4.19%
			5610	5.006	34.025	5.076	35.518	-1.38%	-4.20%
			5620	5.018	34.020	5.086	35.506	-1.34%	-4.19%
			5640	5.043	33.967	5.106	35.483	-1.23%	-4.27%
			5660	5.068	33.922	5.127	35.460	-1.15%	-4.34%
			5670	5.080	33.922	5.137	35.449	-1.11%	-4.31%
			5680	5.087	33.920	5.147	35.437	-1.17%	-4.28%
			5690	5.093	33.905	5.158	35.426	-1.26%	-4.29%
			5700	5.101	33.875	5.168	35.414	-1.30%	-4.35%

The above measured tissue parameters were used in the DASY software. The DASY software was used to perform interpolation to determine the dielectric parameters at the SAR test device frequencies (IEEE 1528-2013 6.6.1.2). The tissue parameters listed in the SAR test plots may slightly differ from the table above due to significant digit rounding in the software.

Note: All frequencies were measured to be within 5% of targets listed in IEC/IEEE 62209-1528:2020 (Head) and RSS 102, Annex D (Body). Per IEC/IEEE 62209-1528:2020, since the dielectric properties of the tissue simulating are all equal or less than 5% of the target values, SAR was not scaled. The measurement uncertainty of 5% for deviation of conductivity and liquid permittivity from the target was added to the uncertainty budget .

7.2 Test System Verification

Prior to SAR assessment, the system is verified to ±10% of the SAR measurement on the reference dipole at the time of calibration by the calibration facility.

Table 7-2
System Verification Results – 1g

System Verification TARGET & MEASURED													
SAR System #	Tissue Frequency (MHz)	Tissue Type	Date	Amb. Temp (°C)	Liquid Temp (°C)	Input Power (W)	Source SN	Probe SN	DAE	Measured SAR_{1g} (W/kg)	1 W Target SAR_{1g} (W/kg)	1 W Normalized SAR_{1g}(W/kg)	$Deviation_{1g}$ (%)
AM8	5600	Head	1/13/2025	21.6	20.0	0.050	1123	7427	467	4.120	82.500	82.400	-0.12%

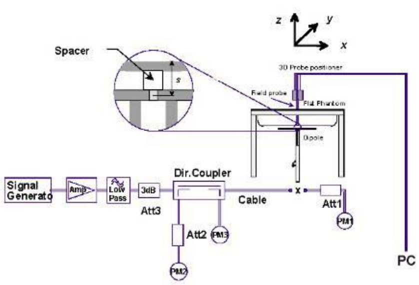

Figure 7-1
System Verification Setup Diagram

Figure 7-2
System Verification Setup Photo

8. SAR TEST RESULTS

8.1 TX Mode Change TA-SAR Measurement Results

Following Section 4.4.2 procedure, time-averaged SAR measurements are conducted using a SAR probe at peak location of area scan over 600 seconds. cDASY6 system verification for SAR measurement is provided in Section 7.2, and the associated SPEAG certificates are attached in Appendix E.

Following Section 4.4, for TX Mode Change test:

With device configured to $\mathrm{meas\_SAR\_P}_{WF\_SAR\_limit}$ calibration mode, area scan is performed at $\mathrm{meas\_SAR\_P}_{\mathrm{WF\_SAR\_limit}}$, and time-averaged meas_SAR measurements are conducted to determine the meas_SAR at $P_{WF\_SAR\_limit}$ at peak location.

With radio link with AP established and TA-SAR enabled, one more time-averaged meas_SAR measurement is performed at the same peak location for TX Mode Change test case.

To demonstrate compliance, all the meas_SAR measurement results were converted into $Time\_avg\_SAR(t)$ values by using Equation rewritten below:

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

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

where $\mathrm{meas\_SAR\_P}_{WF\_SAR\_limit}$ is measured from step 1, $meas\_SAR(\tau)$ is the instantaneous SAR measured in step 3, and $WF\_SAR\_design\_limit$ is the measured worse-case SAR value at $\mathrm{P}_{WF\_SAR\_limit}$.

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

Test Band	P_WF_SAR_limit [dBm]	Max Power [dBm]
5GHz	13.5	20.0

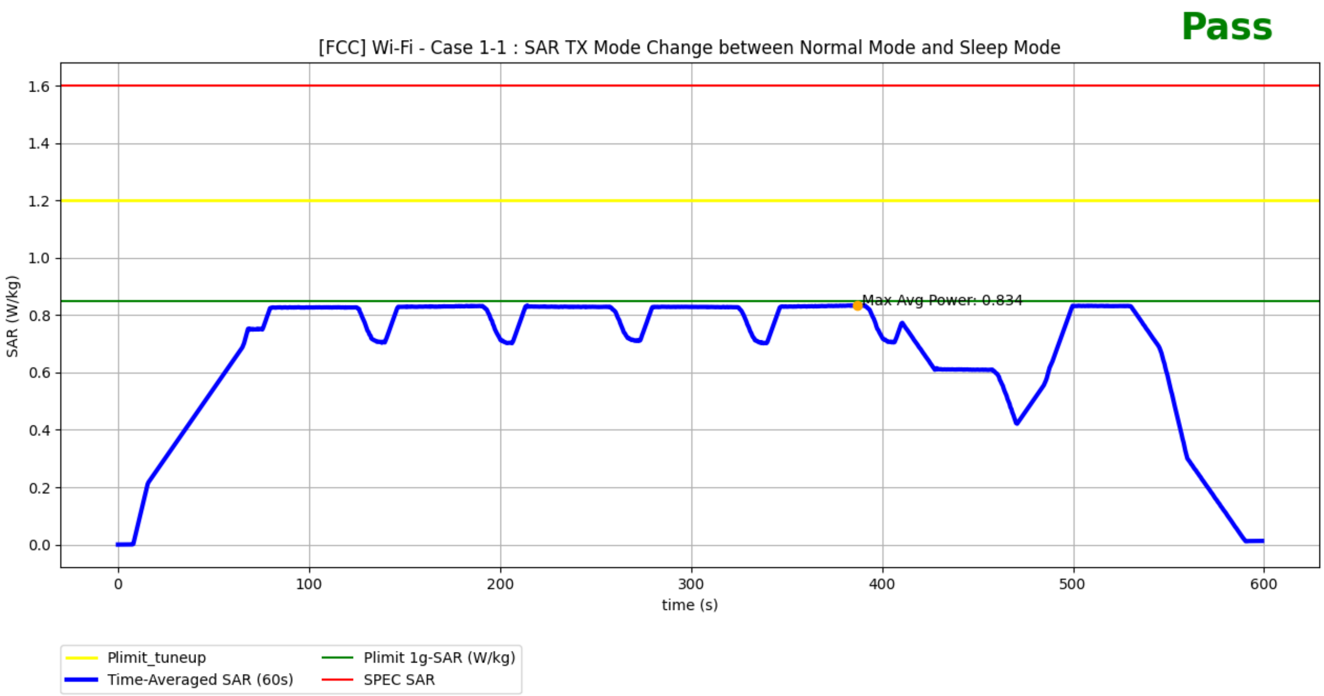

Figure 8-1 Time-averaged SAR measurement for scenario 1-1

FCC 1gSAR limit	1.6 W/kg
Max 60s-time averaged 1gSAR	0.834 W/kg
Validation result: pass	

9. EQUIPMENT LIST

Manufacturer	Model	Description	Cal Date	Cal Interval	Cal Due	Serial Number
Agilent	N5182A	MXG Vector Signal Generator	3/15/2024	Annual	3/15/2025	MY47420651
Agilent	N9020A	MXA Signal Analyzer	10/27/2024	Annual	10/27/2025	MY51240479
Agilent	N9020A	MXA Signal Analyzer	9/27/2024	Annual	9/27/2025	MY53280290
Amplifier Research	15S1G6	Amplifier	CBT	N/A	CBT	433973
Anritsu	MA24106A	USB Power Sensor	6/7/2024	Annual	6/7/2025	1827529
Anritsu	8753ES	S-Parameter Vector Network Analyzer	9/25/2024	Annual	9/25/2025	US39170118
Control Company	4052	Long Stem Thermometer	10/16/2023	Biennial	10/16/2025	230703247
Control Company	14-650-286	Therm./ Clock/ Humidity Monitor	1/24/2023	Biennial	1/24/2025	230053919
Mini-Circuits	ZN4PD1-63W-S+	250-6000 MHz Power Splitter	CBT	N/A	CBT	F121101139
Mini-Circuits	ZN2PD2-63-S+	350-6000 MHz Power Splitter	CBT	N/A	CBT	UU1R602047
Mini-Circuits	ZN2PD-9G-S	1700-9000 MHz Power Splitter	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-2950+	Low Pass Filter DC to 2700 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	NLP-1200+	Low Pass Filter DC to 1000 MHz	CBT	N/A	CBT	N/A
Mini-Circuits	BW-N20W5	Power Attenuator	CBT	N/A	CBT	1226
Mini-Circuits	ZUDC10-83-S+	Directional Coupler	CBT	N/A	CBT	2050
SPEAG	MAIA	Modulation and Audio Interference Analyzer	N/A	N/A	N/A	1237
SPEAG	D5GHzV2	5 GHz SAR Dipole	3/12/2024	Annual	3/12/2025	1123
SPEAG	DAE4	Dasy Data Acquisition Electronics	2/9/2024	Annual	2/9/2025	467
SPEAG	EX3DV4	SAR Probe	2/9/2024	Annual	2/9/2025	7427

Notes:

1. CBT (Calibrated Before Testing). Prior to testing, the measurement paths containing a cable, amplifier, attenuator, coupler or filter were connected to a calibrated source (i.e. a signal generator) to determine the losses of the measurement path. The power meter offset was then adjusted to compensate for the measurement system losses. This level offset is stored within the power meter before measurements are made. This calibration verification procedure applies to the system verification and output power measurements. The calibrated reading is then taken directly from the power meter after compensation of the losses for all final power measurements.
2. Each equipment item is used solely within its respective calibration period.

10. MEASUREMENT UNCERTAINTIES

For Conducted Power Measurements

List of Contributing Factors	Value [dB]	Distribution Function	Probability Distr. Divisor	Component Uncertainty [dB]
RF Power Sensor Accuracy	0.168	Normal (k=2)	2	0.084
Mismatch antenna port to receiver	0.643	U-Shaped	1.4142	0.455
Expanded Uncertainty				
95% Confidence Level			k=2	0.925

For SAR Measurements

a			c	d	e= f(d,k)	f	g	h = c x f/e	i = c x g/e	k
Symbol	**Uncertainty Component**	IEC/IEEE 62209-1528 ref.	Tol. (± %)*	Prob. Dist.	Div.	c_i 1gm	c_i 10 gms	1gm u_i (± %)	10gms u_i (± %)	v_i
Measurement System Errors										
CF	Probe Calibration	8.4.1.1	14.0	N	2	1.0	1.0	7.0	7.0	∞
CFdrift	Probe CalibrationDrift	8.4.1.2	1.7	R	1.73	1.0	1.0	1.0	1.0	∞
LIN	Probe Linearity	8.4.1.3	4.7	R	1.73	1.0	1.0	2.7	2.7	∞
BBS	Broadband Signal	8.4.1.4	3.0	R	1.73	1.0	1.0	1.7	1.7	∞
ISO	Probe Isotropy	8.4.1.5	7.6	R	1.73	1.0	1.0	4.4	4.4	∞
DAE	Other Probe and data acquisition errors	8.4.1.6	0.3	N	1	1.0	1.0	0.3	0.3	∞
AMB	RF ambient and noise	8.4.1.7	1.8	N	1	1.0	1.0	1.8	1.8	∞
Δxyz	Probe Positioning errors	8.4.1.8	±0.005 mm	N	1	0.29	0.29	0.15	0.15	∞
DAT	Data processing errors	8.4.1.9	2.3	N	1	1.0	1.0	2.3	2.3	∞
Phantom and Device Errors										
LIQ(σ)	Conductivity (Meas.)	8.4.2.1	2.5	N	1	0.78	0.71	2.0	1.8	∞
LIIQ(T_{σ})	Conductivity (temp.)	8.4.2.2	3.4	R	1.73	0.78	0.71	1.5	1.4	∞
EPS	Phantom Permitivity	8.4.2.3	14.0	R	1.73	0.25	0.25	2.0	2.0	∞
DIS	Distance DUT - TSL	8.4.2.4	2.0	N	1	2.00	2.00	4.0	4.0	∞
Dxyz	Test Sample Positioning	8.4.2.5	3.1	N	1	1.0	1.0	3.1	3.1	35
H	Device Holder Uncertainty	8.4.2.6	1.7	N	1	1.0	2.0	1.7	3.4	5
MOD	Modulation Response	8.4.2.7	4.8	R	1.73	1.0	1.0	2.8	2.8	∞
TAS	Time-average SAR	8.4.2.8	0.0	R	1.73	1.0	1.0	0.0	0.0	∞
RFdrift	Output Power Variation - SAR drift measurement	8.4.2.9	2.5	N	1	1.0	1.0	2.5	2.5	∞
Corrections to the SAR result										
C(ε', σ)	Deviations to TSL targets	8.4.3.1	5.0	R	1.73	0.64	0.43	1.8	1.2	∞
C(R)	SAR Scaling	8.4.3.2	0.0	R	1.73	1.0	1.0	0.0	0.0	∞
	Combined Standard Uncertainty (k=1)			RSS				12.0	12.3	40
	Expanded Uncertainty (95% CONFIDENCE LEVEL)			k=2				24.0	24.5	

The above measurement uncertainties are according to IEC/IEEE Std.62209-1528:2020
* Unit for Probe Positioning Errors is as indicated per IEC/IEEE Std.62209-1528:2020

11. CONCLUSION

This document proposes Wi-Fi TA-SAR test scenarios and procedures and proves Mediatek's TA-SAR algorithm can meet the FCC SAR regulation with the proposed test scenarios and procedures. The conducted power measurements in Chapter 6 show that Mediatek's TA-SAR algorithm can maintain SAR over time below the FCC regulatory limits. Furthermore, the near-field measurements are also done in a certified lab to further validate the proposed test methodologies, and the SAR measurement results in Chapter 8 demonstrate that Mediatek's TA-SAR algorithm can maintain SAR over time below the FCC regulatory limits with the proposed test procedures. Based on the provided measurement results, it is concluded that Mediatek's TA-SAR algorithm can be validated for FCC compliance by the proposed test methodology.

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