Part 2: WIFI TAS Time Varying Validation Report for FCC

(Test Under Dynamic Transmission Condition)

Applicant Name	:	***ASUSTeK COMPUTER INC.***
Applicant Address	:	***1F., No. 15, Lide Rd., Beitou Dist., Taipei City 112, Taiwan***
Product Name	:	***Wi-Fi 6E BT 5.2 M.2 1418 Module***
Brand Name	:	***Qualcomm***
Model Number	:	***QCNFA725***
FCC ID	:	***MSQ-QCNFA725***
Report Number	:	***USSC249349002***
Compliant Standards	:	***FCC 47 CFR §2.1093***
Sample Received Date	:	***Sep. 27, 2024***
Date of Testing	:	***Jan. 18, 2025 ~ Jan. 20, 2025***
Report Issue Date	:	***Feb. 24, 2025***

*The above equipment have been tested by **Eurofins E&E Wireless Taiwan Co., Ltd.**, and found compliance with the requirement of the above standards. The test record, data evaluation & Device Under Test (DUT) configurations represented herein are true and accurate accounts of the measurements of the sample's characteristics under the conditions specified in this report.*

Note:

1. *The test results are valid only for samples provided by customers and under the test conditions described in this report.*
2. *This report shall not be reproduced except in full, without the written approval of Eurofins E&E Wireless Taiwan Co., Ltd.*
3. *The relevant information is provided by customers in this test report. According to the correctness, appropriateness or completeness of the information provided by the customer, if there is any doubt or error in the information which affects the validity of the test results, the laboratory does not take the responsibility.*

Approved By :

Roy Wu / Technical Director

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Revision History

Rev.	Issue Date	Description	Revised by
00	Feb. 24, 2025	Initial release	Rowan Hsieh

1. Information of Testing Laboratory

Test Facilities

Company Name: Eurofins E&E Wireless Taiwan Co., Ltd.
Address No.: 140-1, Changan Street, Bade District, Taoyuan City 334025, Taiwan
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Test Site Location

☐ No. 140-1, Changan Street, Bade District, Taoyuan City 334025, Taiwan
☑ No. 2, Wuquan 5th Rd. Wugu Dist., New Taipei City, Taiwan

Laboratory Accreditation

Location	*TAF*	*FCC*	*ISED*
No. 140-1, Changan Street, Bade District, Taoyuan City 334025, Taiwan	Accreditation No.: 1330	Designation No.: TW0010	Company No.: 7381A CAB ID: TW1330
No. 2, Wuquan 5th Rd. Wugu Dist., New Taipei City, Taiwan	Accreditation No.: 1330	Designation No.: TW0034	Company No.: 28922 CAB ID: TW1330

2. Device Under Test Information

Product Name	Wi-Fi 6E BT 5.2 M.2 1418 Module	
Brand Name	Qualcomm	
Model Name	QCNFA725	
FCC ID	MSQ-QCNFA725	
Host Information	Product Name: Notebook PC Trade Name: ASUS Model Name: UX3407Q, BX3407Q, RX3407Q, UX3407R, BX3407R, RX3407R All models are electrically identical, different model names are for marketing purpose.	
Supported Wireless Technologies	***Tx Frequency (MHz)***	***Operating Mode***
	WLAN 2.4G : 2412 ~ 2472 5G : 5180 ~ 5240, 5260 ~ 5320, 5500 ~ 5720, 5745 ~ 5825, 5845 ~ 5885 6G : 5955 ~ 6415, 6435 ~ 6515, 6535 ~ 6855, 6875 ~ 7115	2.4G : 802.11b/g/n/ax 5G : 802.11a/n/ac/ax 6G : 802.11a/ax
	Bluetooth 2402 ~ 2480	BR, EDR, LE,

Note:

The above DUT information is declared by manufacturer and for more detailed features description please refers to the manufacturer's specifications or User's Manual.

Time-Averaging for SAR/PD

This device is enabled with *Qualcomm FastConnect WIFI Time Averaged SAR (TAS)* for WLAN technologies controls and manages transmit power in real time to always ensure the time averaged RF exposure is in compliance with regulatory requirements.

The *Part 0* report shows *TAS Characterization* of WLAN radios. The characterization is achieved by determining P_{lim} for WLAN bands that corresponds to the exposure design targets after accounting for all device design related uncertainties. The TAS characterization is denoted as TAS Char in this report. The compliance test under the *Static Transmission Scenario* and *Simultaneous Transmission* analysis are reported in the *Part 1* report.

The validation of the *Qualcomm FastConnect WIFI TAS* feature and compliance under the *Dynamic (Time-Varying) Transmission Scenario* for WLAN technologies are reported in this *Part 2* report. This *Part 2* test report provides test results and plots using parameters determined from the static SAR test and configured in *FastConnect WIFI TAS Board Data File (BDF)* for validating the *FastConnect WIFI TAS* feature.

In addition, this device supports WLAN and Bluetooth technology, but the output power of ***Bluetooth*** modem is not controlled by the *FastConnect WIFI TAS* algorithm and has no TAS function.

3. Qualcomm FastConnect WIFI TAS Operation

The regulatory RF exposure limits are defined with respect to Time-Averaged RF exposure. The *Qualcomm FastConnect WIFI TAS* algorithm performs transmit power control to ensures at all times the wireless device is in compliance with the configured limit of RF exposure averaged over a defined time window for SAR and PD.

For FCC, Wi-Fi 6E operates in the 6 GHz to 7 GHz band. The Interim RF Exposure Test Procedures for U-NII 6-7 GHz Portable Devices requires R exposure assessment with SAR and incident PD (total) using mmW near-field probe and total-field / power-density reconstruction method.

The *FastConnect WIFI TAS* supports maximum time-averaging window (denoted as T_{SAR}) as defined by the FCC. For FCC, a 30 second time-averaging window is used by *FastConnect WIFI TAS* for WLAN operation in 2.4 GHz, 5 GHz, and 6 GHz WLAN bands.

3.1. Basic Concept of the Feature

The *FastConnect WIFI TAS* manages the instantaneous transmit power to maintain the time-averaged power and associated RF exposure is below the regulatory compliance limit.

- If the time-averaged transmit power approaches the SAR compliance power, then the instantaneous transmit power is limited to ensure the time-averaged transmit power does not exceed the SAR compliance power in any T_{SAR} time window (i.e., the time-averaged RF exposure complies with the FCC RF exposure limit in any time window).
- The wireless device can instantaneously transmit at high transmit powers for a short time duration before limiting the power to maintain time-averaged SAR compliance.

3.2. Configurable Parameters

This section defines the key parameters required for *FastConnect WIFI TAS* validation. The following inputs are key parameters required for functionality of the *FastConnect WIFI TAS* feature. The OEM must configure these parameters in the *Board Data File (BDF)*.

- ***Time-Averaged Exposure Mode*** or ***Peak Exposure Mode*****:**
  Configurable for a given region / country (FCC or ICNIRP). When enabled in *Peak Exposure Mode*, *FastConnect WIFI TAS* limits instantaneous Tx power not to exceed P_{lim} in both simultaneous and single antenna case.
- ***P_{lim}*****:**
  Per WLAN Band / Antenna / DSI / Regulatory Limit (FCC or ICNIRP limit). Either FCC or ICNIRP limits can be chosen for a given region / country.
- ***Antenna Group (AG) Table*****:**
  Optional feature to group transmit antennas such that the antennas in each group have RF exposure that is mutually exclusive (either have sum of SAR less than regulatory limit or meet SPLSR criteria) with antennas belonging to a different group.
- ***Reserve Margin*****:**
  In dB.

Dynamic Inputs:

- Country of operation (location-based awareness).
- Device State Index (DSI).

Non-Configurable Parameters (fixed entries):

- P_{max} values per each WLAN operating state.

3.2.1. P_{lim}

The P_{lim} (in dBm) is the power corresponding to the $RFexp_{target}$ for *FastConnect* WLAN. In other words, P_{lim} is the maximum time-average transmit power setting for *FastConnect WIFI TAS*, at which this radio configuration (i.e., Antenna, Band and DSI state) reaches the $RFexp_{target}$. The *Fast Connect WIFI TAS* algorithm uses P_{lim} to and the real time transmit power to ensure the real time-averaged SAR is below the $RFexp_{target}$ in real time and thus ensure device RF Exposure compliance.

3.2.2. P_{max}

The P_{max} for *FastConnect* WLAN represents the maximum WLAN transmit power from other power setting in *Board Data File (BDF)*. The P_{max} value could be identified by compare the target power (Rate-to-Power) and compliance transmit (CTL) and other power limit.

$$\boldsymbol{P_{max} = min\{CTL, Regdomain, TPE/TPC, Rate - to - Power\}}$$

3.2.3. Reserve Margin

The *FastConnect WIFI TAS* allows minimum reserve power $P_{reserve}$ (= P_{lim} – *Reserve Margin*) for WLAN radio to transmit, which can be used to maintain the link. The *Reserve Margin* is a global parameter, meaning it applies to all the radio configurations. When the *Reserve Margin* is set to zero dB, the *FastConnect WIFI TAS* effectively allows minimum transmit power $P_{reserve}$ = P_{lim} at all times, in other words, the DUT transmits continuously at P_{lim}.

The value is chosen and stored in the *Board Data File (BDF)*. It is in 0.1 dB increments. A single value is applied to all bands and modes.

4. Compliance Assessment Methodology

This chapter outlines the overall strategy to demonstrate FCC compliance.

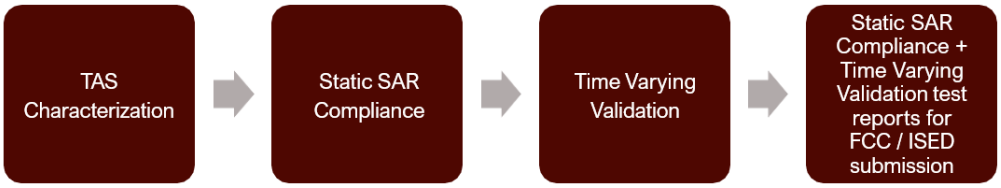
4.1. Overall Strategy

To demonstrate the compliance of *FastConnect WIFI TAS*. Three parts of assessment should be completed, and the *Static SAR Compliance Test Report* and *Time Varying Validation Test Report* should be created for certification approval:

- ***Qualcomm FastConnect WIFI TAS Characterization*:**
  To perform SAR / PD characterization at the device level to determine P_{lim} for RF exposure test.
- ***Qualcomm FastConnect WIFI TAS Static SAR Compliance*:**
  To perform Static SAR testing for all supported WLAN Band / Antenna / DSI. The maximum time average Tx power levels are determined from the TAS characterization and test in static transmission (e.g., FTM mode) to validate and demonstrate RF exposure meets the design target.
- ***Qualcomm FastConnect WIFI TAS Time Varying Validation*:**
  To test with pre-defined test sequence for each validation scenario to demonstrate RF Exposure compliance is achieved by *FastConnect WIFI TAS*. Qualcomm releases a test tool that can be used for the validation scenarios and also provides installation and test guides. The TAS validation should determine the appropriate test mode / channel and complete the *TAS Time Varying Validation Report* and submit it for FCC certification.

The High-level procedure for *FastConnect WIFI TAS* product approval process is shown in *Figure 4-1*.

Figure 4-1: High-Level Process for FastConnect Wi-Fi TAS Approval Process



4.2. Validation Strategy

The following scenarios cover validation tests to prove *FastConnect WIFI TAS* accounts for the history of transmission power accuracy at all times including before, during, and after transition in each scenario.

Since RF exposure is proportional to the Tx power for a SAR wireless device, time-averaging algorithm validation can be effectively performed through conducted power measurements is outlined as specified in *Section 5.3* to all validation scenarios.

Also, to have high confidence in validation, but also be practical, the strategy for the ***Time-Varying Test Sequence*** including both conducted power measurement and RF exposure measurement is outlined as specified in *Section 5.3* and *Section 5.4*.

In addition, since the *FastConnect WIFI TAS* feature operates at the same averaged algorithm to all WLAN bands (2.4 GHz, 5 GHz and 6 GHz), 2.4 GHz and 5.1 GHz are selected to demonstrate the *FastConnect WIFI TAS* functions correctly in this validation test report.

4.2.1. Time-Varying Test Sequence

This test proves the *FastConnect WIFI TAS* accounts for Tx power variations in time accurately.

- Two bands to be selected for this test as possible and one Antenna / DSI from each band should be selected and tested to prove the *FastConnect WIFI TAS* feature accounts for Tx power variations in time accurately using the conducted power measurement approach. This test sequence is also used for *pointSAR* measurement to demonstrate *FastConnect WIFI TAS* feature in radiated test setup.

In addition, this test is performed to capture the maximum time-averaged results in at least two time-averaging window durations.

4.2.2. Change in Antenna (applicable when the software supports SISO diversity operation)

This test is to prove that *FastConnect* functions correctly during transitions in P_{lim} (at different antennas) within the same WLAN Band and same Antenna Group. If device supports SISO and transmission diversity between an Antenna to another Antenna, then this test is applicable. If WLAN MIMO CDD is implemented, then device is always under MIMO transmission, in this case, this test is NOT applicable.

- One Band / DSI and two Antenna ports should be selected for conducted power measurement.

4.2.3. Change in Device State (DSI) (applicable when the device supports multiple DSI)

This is to prove that *FastConnect WIFI TAS* performs power enforcements to maintain compliance during transitions in the device state.

- One Antenna / Band and two DSIs should be selected for conducted measurement.

4.2.4. Change in WLAN Band

This is to prove that the *FastConnect WIFI TAS* functions correctly during transitions in radios and bands.

- One Antenna / DSI and two Bands should be selected for conducted power measurement.

4.2.5. Simultaneous Transmission

This is to prove that the *FastConnect WIFI TAS* functions in transition from 1st standalone WLAN radio to simultaneous WLAN radios and back to 2nd standalone WLAN radio.

- Select two Bands per simultaneous transmissions feature implemented to *FastConnect WIFI TAS* device for this test. One Antenna / DSI and two Bands should be selected for conducted power measurement.

4.3. Conducted Power Measurement

This section provides general procedures to perform conducted power measurement under dynamic transmission scenarios and apply to all test scenarios described in *Section 4.2*.

1. Measure conducted power.
2. Convert it into RF exposure and divide by respective limits to get normalized exposure use equation as described in this section.
3. Perform time-averaging over predefined time window.
4. Demonstrate that the total normalized time-averaged RF exposure is < 1 for all transmission scenarios.

- For frequency below 6 GHz or if regulator requires SAR for WLAN 6 GHz band.

$$\mathbf{1g\_or\_10gSAR}(t) = \frac{\boldsymbol{Conducted\_Tx\_power}(t)}{\boldsymbol{Conducted\_Tx\_power\_Plim}} * \mathbf{1g\_or\_10gSAR\_Plim} \quad (1a)$$

$$\frac{\frac{1}{T_{SAR}}\int_{t-T_{SAR}}^{t} \mathbf{1g\_or\_10gSAR}(t)dt}{\boldsymbol{SAR\ limit}} \leq 1 \quad (1b)$$

- For frequency greater than 6 GHz if regulator requires APD.

$$\mathbf{4cm^2PD}(t) = \frac{\boldsymbol{Conducted\_Tx\_power}(t)}{\boldsymbol{Conducted\_Tx\_power\_Plim}} * \mathbf{4cm^2PD\_Plim} \quad (1c)$$

$$\frac{\frac{1}{T_{SAR}}\int_{t-T_{SAR}}^{t} \mathbf{4cm^2PD}(t)dt}{\boldsymbol{APD\ 4cm^2PD\ limit}} \leq 1 \quad (1d)$$

where, *Conducted_Tx_power(t)*, *Conducted_Tx_power_Plim*, and *1g_or_10gSAR_Plim* and correspond to the measured instantaneous conducted Tx power and conducted Tx power at P_{lim} of DUT, and *1g_or_10gSAR* values at P_{lim} for the worst-case radio configuration within the tested Band / Antenna / DSI. Similarly, *4cm²PD_Plim* correspond to the APD values at P_{lim} for the worst-case radio configuration within the tested Band (greater than 6 GHz) / Antenna / DSI.

The equations (1a) and (1b) are applicable if SAR is required by regulator to address RF exposure for the band greater than 6 GHz.

Note: The ratio circled in red square is obtained from the measurement on the radio configuration is selected for validation test while the *1g_or_10gSAR_Plim* and *4cm²PD_Plim* must be from the SAR value in the worst-case radio configuration within the tested Band / Antenna / DSI in *Static SAR Test Report* and scale to the *Conducted_Tx_power_Plim* level is measured from DUT used in validation test.

4.4. RF Exposure Measurement

This section provides the general procedure to demonstrate the *FastConnect WIFI TAS* comply SAR limit in radiated test setup. Through *pointSAR* measurement for only test scenario ***Time-Varying Test Sequence*** (*Section 4.2.1*) to add confidence in the *FastConnect WIFI TAS* feature validation, while avoiding the complexity in SAR measurement.

1. Choose worst-case DUT orientation of SAR measurement per according to *Static SAR Test Report* and perform *pointSAR* measurement use SPEAG DASY8.
2. Measure instantaneous SAR versus time and demonstrate total normalized time-averaged RF exposure is < 1.0 at all times.

- For frequency below 6 GHz or if regulator requires SAR for WLAN 6 GHz band.

$$\mathbf{1g\_or\_10gSAR}(t) = \frac{\boldsymbol{pointSAR}(t)}{\boldsymbol{pointSAR\_Plim}} * \mathbf{1g\_or\_10gSAR\_Plim} \quad (2a)$$

$$\frac{\frac{1}{T_{SAR}}\int_{t-T_{SAR}}^{t} \mathbf{1g\_or\_10gSAR}(t)dt}{\boldsymbol{SAR\ limit}} \leq 1 \quad (2b)$$

- For frequency greater than 6 GHz if regulator requires APD.

$$4cm^2PD(t) = \frac{pointSAR(t)}{pointSAR\_Plim} * 4cm^2PD\_Plim \quad (2c)$$

$$\frac{\frac{1}{T_{SAR}}\int_{t-T_{SAR}}^{t} 4cm^2PD(t)dt}{APD\ 4cm^2PD\ limit} \leq 1 \quad (2d)$$

where, *pointSAR(t)*, *pointSAR_Plim*, and *1g_or_10gSAR_Plim* correspond to the measured instantaneous point SAR and point SAR at P_{lim} of DUT, and *1g_or_10gSAR* values at P_{lim} for the worst-case radio configuration within the tested Band / Antenna / DSI. Similarly, *4cm²PD_Plim* is the APD values at P_{lim} for the worst-case radio configuration within the tested Band (greater than 6 GHz) / Antenna / DSI.

The equations (2a) and (2b) are applicable if SAR is required by regulator to address RF exposure for the band greater than 6 GHz.

Note: The ratio circled in red square is obtained from the measurement on the radio configuration is selected for validation test while the *1g_or_10gSAR_Plim* and *4cm²PD_Plim* must be from the SAR value in the worst-case radio configuration within the tested Band / Antenna / DSI in *Static SAR Test Report* and scale to the *Conducted_Tx_power_Plim* level is measured from DUT used in validation test.

5. TAS Validation Test Setup Information

5.1. DUT FastConnect WIFI TAS Configured Parameters

The DUT has *FastConnect WIFI TAS* parameters configured in *Board Data File (BDF)* for TAS validation in this test report.

5.2. Validation Test Setup

5.2.1. Conductive Test Setup

This section provides the setup diagram that is performed the *FastConnect WIFI TAS* validation in this test report.

Figure 5-1: Test Setup for Time-Varying Test Sequence and Change in DSI

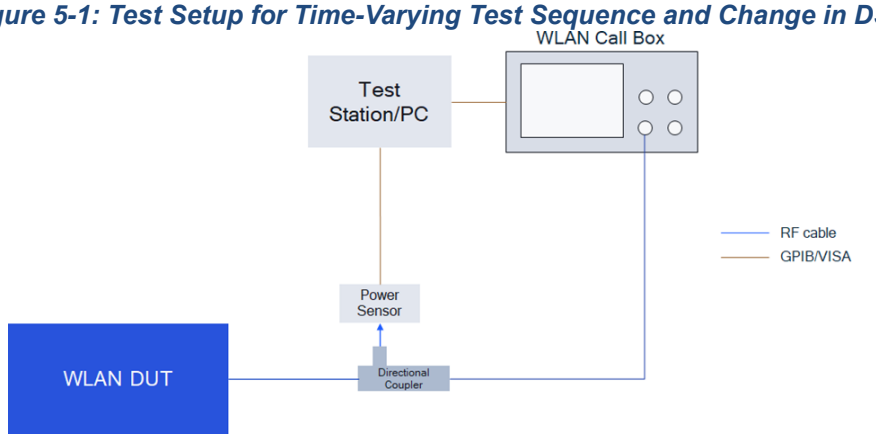


Figure 5-2: Test Setup for Change in Antenna

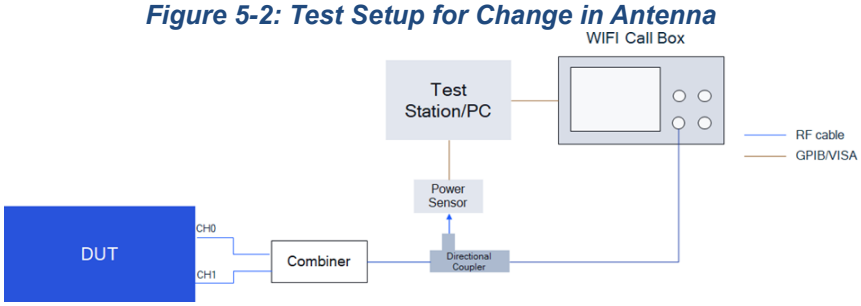


Figure 5-3: Test Setup for Change in WLAN Band

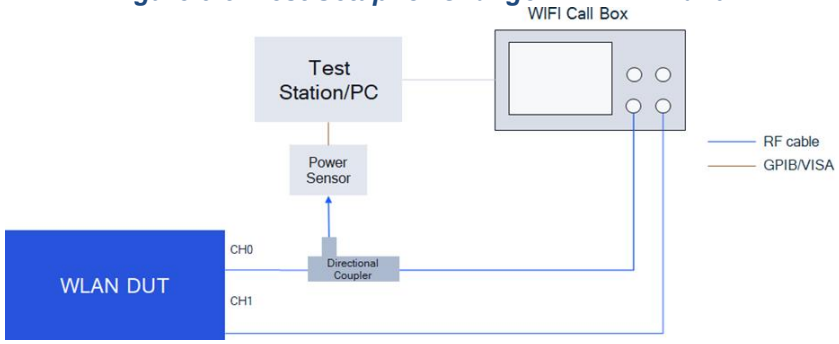
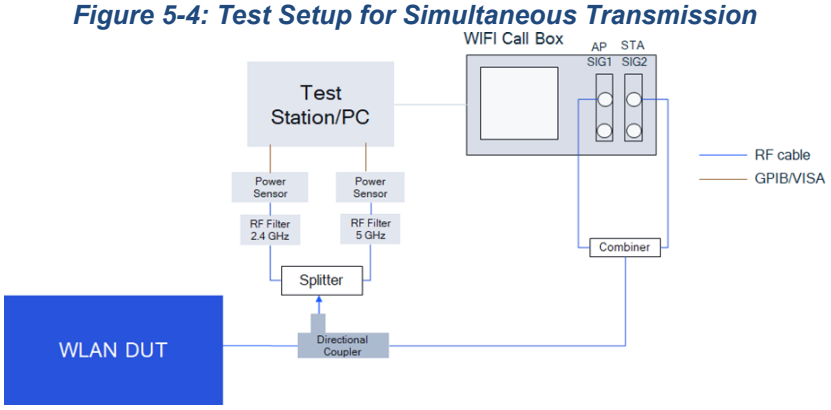


Figure 5-4: Test Setup for Simultaneous Transmission



5.2.2. Point SAR Test Setup

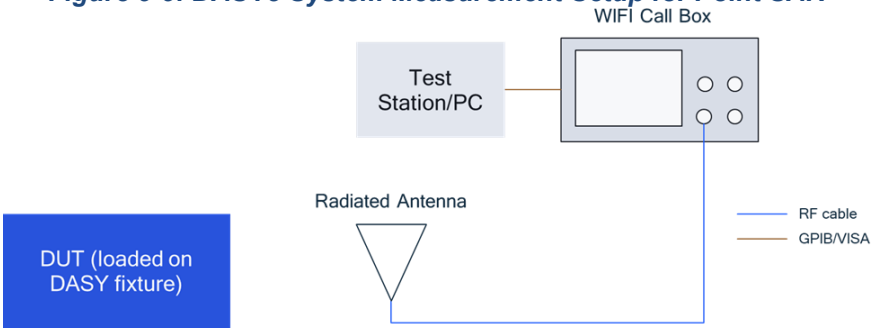
To provide higher confidence in the validation test, the *FastConnect WIFI TAS* Validation test plan includes radiated measurements.

In this test, the measurement setup is similar to the normal SAR measurements:

- The DUT is positioned against the flat section of the SAM Twin phantom and wirelessly connected with the callbox.
- The DUT is placed in worst-case position as determined from the *Static SAR Test Report*.

The same test script from ***Time-Varying Test Sequence*** is also used here for SAR measurements. This section provides the setup diagram that is performed the *FastConnect WIFI TAS* validation in this test report.

Figure 5-5: DASY8 System Measurement Setup for Point SAR



5.3. Conducted Power Measurement

5.3.1. Test Selection Criteria

The conducted power measurement method is used for all validation test scenarios. These tests demonstrate the power enforcement by *FastConnect WIFI TAS* where P_{lim} could vary before and after transition.

5.3.1.1. Test Selection for Time-Varying Test Sequence

Select one representative test channel from all the available radio configurations (Band / Antenna(s) / DSI) that has $P_{max} > P_{lim}$ + Device Uncertainty.

- If $P_{max} < P_{lim}$ + Device Uncertainty for all radio configurations, then select radio configuration with largest (P_{max} dBm – P_{lim} dBm) value.
- If $P_{max} > P_{lim}$ + Device Uncertainty for more than one radio configuration. Then, order of preference is given by:
  - ☐ If multiple radio configurations (Band / Antenna(s) / DSI) meet this criterion, then SISO is preferred over MIMO due to simplified test setup.
  - ☐ After determining SISO vs. MIMO configuration, then select the configuration that has largest (P_{max} dBm – P_{lim} dBm) dB delta.
- Test to be performed at two Bands for Time-Varying Test Sequence test. If only one band within a configuration has $P_{max} > P_{lim}$ and $P_{lim} > P_{max}$ in all other configurations, then only one band needs to be tested.
- Test is not required if $P_{lim} > P_{max}$ for all radio configurations.

Note: The same selection criteria are applicable for both conducted and radiated tests.

5.3.1.2. Test Selection for Change in Antenna

This test scenario does not apply if SISO mode diversity is not supported. (e.g., CDD is enabled and always use MIMO). The criteria to select test configuration for Change in Antenna measurement is:

- The antennas selected for this test should be in the same Antenna Group.
- Whenever possible and supported by the DUT, first select antenna switch configuration within the same Band / DSI (i.e., same Band and DSI combination), and having different P_{lim}, and having both $P_{max} > P_{lim}$ + Device Uncertainty where possible. Otherwise, select at least one antenna having $P_{max} > P_{lim}$ + Device Uncertainty.
  - ☐ If multiple radio configurations (Band / DSI) meet $P_{max} > P_{lim}$ + Device Uncertainty, then select the configuration that has largest (P_{max} dBm – P_{lim} dBm) dB delta.
  - ☐ If $P_{max} < P_{lim}$ + Device Uncertainty for all radio configurations, then select radio configuration with largest (P_{max} dBm – P_{lim} dBm) value.
- If the DUT does not support antenna switch within the same band, but has multiple transmitting antennas to support different frequency bands, then antenna switch test should be performed in combination with Change in WLAN Band test scenario.
- Test for Change in Antenna is not required if all $P_{lim} > P_{max}$ for all radio configurations.

5.3.1.3. Test Selection for Change in Device State Index (DSI)

This test scenario does not apply if multiple DSIs is not supported in the device. The criteria to select test configuration for Change in DSI measurement is:

- Select a Band / Antenna having the $P_{max} > P_{lim}$ + Device Uncertainty within any DSI, and for the same Band / Antenna(s) having a different P_{lim} in any other DSI. Both the selected DSIs should have $P_{max} > P_{lim}$ + Device Uncertainty where possible. Otherwise, select at least one DSI having $P_{max} > P_{lim}$ + Device Uncertainty.
- If $P_{max} < P_{lim}$ + Device Uncertainty for all Band / Antenna(s), then select radio configuration with largest (P_{max} dBm – P_{lim} dBm) value.
- If $P_{max} > P_{lim}$ + Device Uncertainty for more than one radio configuration, then order of preference is given by:
  - ☐ If multiple radio configurations (Band / Antenna(s) / DSI) meet this criteria and if device support SISO. Then SISO is preferred over MIMO due to simplified test setup.
  - ☐ After determining SISO vs. MIMO configuration, then select the configuration that has largest (P_{max} dBm – P_{lim} dBm) dB delta.
- Test for Change in DSI is not required if all $P_{lim} > P_{max}$ for all radio configurations.

5.3.1.4. Test Selection for Change in WLAN Band

The criteria to select test configuration for Change in WLAN Band measurement is:

- First select both bands in a DSI having P_{max} > P_{lim} + Device Uncertainty where possible. Otherwise, select at least one band having P_{max} > P_{lim} + Device Uncertainty.
- If P_{max} < P_{lim} + Device Uncertainty for all radio configurations, then select radio configuration with largest (P_{max} dBm – P_{lim} dBm) value.
- If P_{max} > P_{lim} + Device Uncertainty for more than one radio configuration. Then, order of preference is given by:
  - ☐ If multiple radio configurations (Band / Antenna(s) / DSI) meet this criteria and if device support SISO. Then SISO is preferred over MIMO due to simplified test setup.
  - ☐ After determining SISO vs. MIMO configuration, then select the configuration that has largest (P_{max} dBm – P_{lim} dBm) dB delta.
- The antennas corresponding to the selected bands should be in the same Antenna Group.
- Test for Change in WLAN Band is not required if all P_{lim} > P_{max} for all radio configurations.

5.3.1.5. Test Selection for Simultaneous Transmission

This test scenario does not apply if Simultaneous Transmission within WLAN bands is not supported in the device.
The criteria to select test configuration for Simultaneous Transmission measurement is:

- The bands must be selected from supported Simultaneous Transmission configuration. (e.g., WLAN DBS and/or HBS)
- First select both bands in a DSI having P_{max} > P_{lim} + Device Uncertainty where possible. Otherwise, select at least one band having P_{max} > P_{lim} + Device Uncertainty.
- If P_{max} < P_{lim} + Device Uncertainty for all radio configurations, then select radio configuration with largest (P_{max} dBm – P_{lim} dBm) value.
- If P_{max} > P_{lim} + Device Uncertainty for more than one radio configuration. Then, order of preference is given by:
  - ☐ If multiple radio configurations (Band / Antenna(s) / DSI) meet this criterion and if device support SISO. Then SISO is preferred over MIMO due to simplified test setup.
  - ☐ After determining SISO vs. MIMO configuration, then select the configuration that has largest (P_{max} dBm – P_{lim} dBm) dB delta.
- The antennas corresponding to the selected bands should be in the same antenna group.
- Even if a device has P_{lim} > P_{max} for all radio configurations, then Simultaneous Transmission Test Scenario should still be performed for validation of *FastConnect WIFI TAS* device.

Note: For all above test selection. P_{max} = *min{CTL, Regdomain, TPE/TPC, Rate-to- Power}* of the selected channel / rate / band. Since *FastConnect WIFI TAS* supports the same P_{lim} for all modulations in same Antenna / Band / DSI, the selection of test modulation / channel chooses the highest P_{max} modulation.

5.3.2. Test Procedure

1. Measure P_{lim} for modes at validation Antenna ports, Bands and/or DSIs with ***FastConnect WIFI TAS Peak Exposure Mode*** enabled with callbox to establish the chosen mode for test. Denote this measured power value as *Conducted_Tx_power_Plim*.

   Note: The measurement of ***Peak Exposure Mode*** should be performed with 70 % or higher WLAN duty cycle (for example, using *iPerf* to generate UL traffic).

2. Set DUT to the intended ***FastConnect WIFI TAS mode***.
3. Establish radio link with the callbox in the selected band.

   Note: For the purpose of collecting repeatable time averaged power data, it is recommended to include a section of 30s at the beginning of every test with the device WLAN connection disconnected or turned off or transmitting at a very low duty cycle.

4. Request DUT to transmit in following Transition sequence:
   a. ***Time-Varying Test Sequence:***
   Request DUT to transmit maximum power for at least 30s with 100 % duty cycle and 50 % duty cycle for 60s to determine time- averaged 1gSAR versus time.

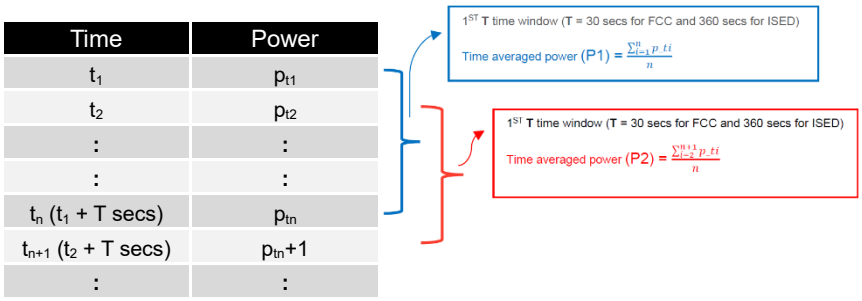
Time Duration (Seconds)	*Duty Cycle (%)*
30	**100%**
60	**50%**

   b. ***Change in Antenna:***
   DUT operates at Antenna 1 (e.g., Main antenna port) and requests to transmit at maximum power for at least 60s. Then switch to operation on Antenna 2 (e.g., Aux antenna port), followed by at least 120s of observation.
   c. ***Change in Device State (DSI):***
   DUT operates at DSI 1 and requests to transmit at maximum power for at least 60s. Then switch to operation on DSI 2, followed by at least 120s of observation (observation period includes transition time).
   d. ***Change in WLAN Band:***
   DUT operates at Band 1 and requests to transmit at maximum power for at least 60s. Then it switches to Band 2 using the same antenna port and observes another 120s (observation period includes transition time).
   e. ***Simultaneous Transmissions:***
   First establish WLAN connection with the callbox in radio2 configuration and request radio2 configuration to transmit at maximum duty cycle for at least 120s to test predominantly radio2 SAR exposure scenario. Then add radio1 configuration to the existing radio2 configuration call, and request both radio1 and radio2 to transmit at maximum duty cycle to test radio1 and radio2 SAR exposure scenario for at least 120s. Then drop (or request low duty cycle) for radio2 configuration to test predominantly radio1 SAR exposure scenario for another at least 120s. Record the conducted Tx powers for both radio1 and radio2 configurations for the entire duration of this test.

   Note: radio1 and radio2 should operate at different band.

5. Measure and record Tx power versus time.
   a. Once the measurement is done, extract instantaneous Tx power versus time, and convert the conducted Tx power into *1g_or_10g SAR* value, see Eq. (1a), using Step 1 result.
   b. Then perform 30s moving average to determine time-averaged *1g_or_10gSAR* versus time as illustrated in *Figure 5-6*.

Figure 5-6: Time Running / Moving Average Illustration



The following normalization is used to convert *1g_or_10gSAR* exposure using Equation (1a) and (1c) in *Section 4.3* to validate the continuity of RF exposure limits during the transition. The procedures from step1 and step 2 in this section should be completed for each configuration under test and use below equations to validate the RF exposure during the transition.

- If tested with both radio configurations below 6 GHz:

$$\mathbf{1g\_or\_10gSAR_1}(t) = \frac{\boldsymbol{Conducted\_Tx\_power\_1}\,(t)}{\boldsymbol{Conducted\_Tx\_power\_Plim\_1}} * \mathbf{1g\_or\_10gSAR\_Plim\_1} \quad (4a)$$

$$\mathbf{1g\_or\_10gSAR_2}(t) = \frac{\boldsymbol{Conducted\_Tx\_power\_2}\,(t)}{\boldsymbol{Conducted\_Tx\_power\_Plim\_2}} * \mathbf{1g\_or\_10gSAR\_Plim\_2} \quad (4b)$$

$$\frac{\frac{\mathbf{1}}{\boldsymbol{T_{SAR}}}\left[\int_{t-T_{SAR}}^{t} \mathbf{1g\_or\_10gSAR1}(t)\,dt + \int_{t-T_{SAR}}^{t} \mathbf{1g\_or\_10gSAR2}(t)\,dt\right]}{\boldsymbol{SAR\ limit}} \leq \mathbf{1} \quad (4c)$$

where, *Conducted_Tx_power_1(t)*, *Conducted_Tx_power_Plim_1*, and *1g_or_10gSAR_Plim_1* correspond to the instantaneous Tx power, conducted Tx power at P_{lim}_1 of DUT, and compliance *1g_or_10gSAR* values of Antenna 1 (or Band 1 or DSI 2) at P_{lim}_1;
Conducted_Tx_power_2(t), *Conducted_Tx_power_Plim_2*, and *1g_or_10gSAR_Plim_2* correspond to the instantaneous Tx power, conducted Tx power at P_{lim}_2 of DUT, and compliance *1g_or_10gSAR* values of Antenna 2 (or Band 2 or DSI 2) at P_{lim}_2.

Transition from the Antenna 1 (or Band 1 or DSI 1) to the Antenna 2 (or Band 2 or DSI 2) happens at time-instant 't_1'.

- If tested with radio configuration: 2.4 / 5 GHz WLAN assessed using SAR + 6 GHz WLAN band assessed using APD (e.g., applicable for ISED):

$$\mathbf{1g\_or\_10gSAR_1}(t) = \frac{\boldsymbol{Conducted\_Tx\_power\_1}\,(t)}{\boldsymbol{Conducted\_Tx\_power\_Plim\_1}} * \mathbf{1g\_or\_10gSAR\_Plim\_1} \quad (5a)$$

$$\mathbf{4cm^2PD_2}(t) = \frac{\boldsymbol{Conducted\_Tx\_power\_2}\,(t)}{\boldsymbol{Conducted\_Tx\_power\_Plim\_2}} * \mathbf{4cm^2PD\_Plim\_2} \quad (5b)$$

$$\frac{\frac{\mathbf{1}}{\boldsymbol{T_{SAR}}}\int_{t-T_{SAR}}^{t1} \mathbf{1g\_or\_10gSAR}(t)\,dt}{\boldsymbol{SAR\ limit}} + \frac{\frac{\mathbf{1}}{\boldsymbol{T_{SAR}}}\int_{t-T_{SAR}}^{t} \mathbf{4cm^2PD}(t)\,dt]}{\boldsymbol{APD\ 4cm^2PD\ limit}} \leq \mathbf{1} \quad (5c)$$

where, *Conducted_Tx_power_1(t)*, *Conducted_Tx_power_Plim_1* and *1g_or_10gSAR_Plim_1* correspond to the measured instantaneous conducted Tx power and conducted Tx power at P_{lim}_1 of DUT, and *1g_or_10gSAR* values at P_{lim}_1 for the worst-case radio configuration within the tested 2.4 / 5 GHz WLAN band;
Conducted_Tx_Power_2(t), *Conducted_Tx_power_Plim_2*, and *4cm²PD_Plim_2* correspond to the instantaneous Tx power, conducted Tx power at P_{lim}_2 of DUT, and *4cm² PD* values (APD) of at P_{lim}_2 for the worst-case radio configuration within the tested 6 GHz WLAN band.

Transition from the Band 1 to the Band 2 happens at time-instant 't_1'.

- If tested with both radio configurations greater than 6 GHz bands that are assessed using APD (e.g., applicable for ISED):

$$\mathbf{4cm^2PD_1}(t) = \frac{\boldsymbol{Conducted\_Tx\_power\_1}\,(t)}{\boldsymbol{Conducted\_Tx\_power\_Plim\_1}} * \mathbf{4cm^2PD\_Plim\_1} \quad (6a)$$

$$\mathbf{4cm^2PD_2}(t) = \frac{\boldsymbol{Conducted\_Tx\_power\_2}\,(t)}{\boldsymbol{Conducted\_Tx\_power\_Plim\_2}} * \mathbf{4cm^2PD\_Plim\_2} \quad (6b)$$

$$\frac{\frac{\mathbf{1}}{\boldsymbol{T_{SAR}}}[\int_{t-T_{SAR}}^{t1} \mathbf{4cm^2PD1}(t)\,dt + \int_{t-T_{SAR}}^{t} \mathbf{4cm^2PD2}(t)\,dt]}{\boldsymbol{APD\ 4cm^2PD\ limit}} \leq \mathbf{1} \quad (6c)$$

where, *Conducted_Tx_power_1(t)*, *Conducted_Tx_power_Plim_1*, and *4cm²PD_Plim_1* correspond to the instantaneous Tx power, conducted Tx power at P_{lim}_1 of DUT, and compliance *4cm² PD* values (APD) of Band 1 (or Antenna 1) at P_{lim}_1;
Conducted_Tx_power_2(t), *Conducted_Tx_power_Plim_2*, and *4cm²PD_Plim_2* correspond to the instantaneous Tx power, conducted Tx power at P_{lim}_2 of DUT, and compliance *4cm² PD* values (APD) of Antenna Band 2 (or Antenna 2) at P_{lim}_2.

Transition from the Band 1 (or Antenna 1) to the Band 2 (or Antenna 2) happens at time- instant 't_1'.

6. Make one plot containing:
   a. Computed time-averaged *1g_or_10gSAR* (and/or *4cm² PD*) versus time from above procedure.
   b. Corresponding regulatory *1g_or_10gSAR* (and/or *4cm² PD*) limit.

The validation criterion is, at all times, the combined time-averaged *1g_or_10gSAR* (and/or *4cm² PD*) versus time shall not exceed the regulatory *1g_or_10gSAR* (and/or *4cm² PD*) limit.

5.4. PointSAR Measurement Test Sequence

5.4.1. Test Selection Criteria

The *pointSAR* test is performed only with ***Time-Varying Test Sequence*** to provide high confidence in the algorithm validation. The radio configuration for this test is selected by following the selection criteria described in *Section 5.3.1.1*.

5.4.2. Test Procedure

1. For a given radio configuration:
   a. Enable WLAN connection with callbox in ***FastConnect WIFI TAS Peak Exposure Mode*** and enable high duty cycle Tx while performing the following steps.
   b. Perform the area scan.
   c. Conduct *pointSAR* measurement at peak location of the area scan for 120s. This *pointSAR* value, *pointSAR_Plim* corresponds to *pointSAR* at the measured P_{lim}.

      Note: The measurement of *Peak Exposure Mode* should be performed with 70 % or higher WLAN duty cycle (for example, using *iPerf* to generate UL traffic).

2. Set DUT to intended ***FastConnect Time-Averaged Exposure Mode*** with callbox to establish the same chosen radio configuration (mode / channel) for test.
   a. Perform Time-averaged point SAR measurements at the same peak location as Peak Exposure Point SAR measurement for 120s. Note this includes initial 30s with WLAN with very low duty cycle (or WLAN is disconnected) and 90s of high duty cycle (WLAN has to be connected with high uplink traffic).
   b. Once the measurement is done, extract instantaneous *pointSAR* versus time data, *pointSAR(t)*.
   c. Convert it into instantaneous 1gSAR versus time by using Equation (2a) and (2c) in *Section 4.4*:

$$\mathbf{1g\_or\_10gSAR}(t) = \frac{\mathbf{pointSAR}(t)}{\mathbf{pointSAR\_Plim}} * \mathbf{1g\_or\_10gSAR\_Plim} \quad \text{(2a)}$$

$$\mathbf{4cm^2PD}(t) = \frac{\mathbf{pointSAR}(t)}{\mathbf{pointSAR\_Plim}} * \mathbf{4cm^2PD\_Plim} \quad \text{(2c)}$$

      where, *pointSAR_Plim* corresponds to the value determined in Step 1, and *pointSAR(t)* corresponds to instantaneous *pointSAR* determined in Step 2 in this section.

   d. Then perform 30s moving average to determine time-averaged 1gSAR versus time.

3. Make one plot containing:
   a. Computed time-averaged *1g_or_10gSAR* (or *4cm² PD*) versus time determined from Step 2.
   b. Regulatory *1g_or_10gSAR* (or *4cm² PD*) limit.

The validation criterion for *pointSAR* measurement is, at all times, the time averaged *1g_or_10gSAR* (or *4cm² PD*) versus time shall not exceed the regulatory *1g_or_10gSAR* (or *4cm² PD*) limit.

5.5. DUT Worst-Case SAR and Test Mode Selection

The P_{lim} is configurated in ***FastConnect WIFI TAS BDF*** per according to the Static SAR test and used for validation in this test report. Base on the *Part 1 Static SAR Test Report,* the worst-case SAR of each radio configuration are extracted and listed in *Table 4-1*.

Table 4-1: P_{lim} and Worst-Case SAR

DSI	Band	Modulation	Channel	Antenna	P_{max}	P_{lim}	Tune-up Limit (dBm)	Reported SAR 1g (W/kg)
0	WLAN 2.4G	802.11b	11	Ant 0	17.50	15.50	17.00	0.49
	WLAN 2.4G	802.11b	11	Ant 1	17.50	15.50	17.00	0.38
	WLAN 2.4G	802.11n HT40	6	Ant 0+1	18.50	18.50	20.00	0.55
	WLAN 5.3G	802.11ac VHT80	58	Ant 0	14.50	13.50	15.00	0.28
	WLAN 5.3G	802.11ac VHT80	58	Ant 1	14.50	13.50	15.00	0.17
	WLAN 5.3G	802.11ac VHT80	58	Ant 0+1	17.50	16.50	18.00	0.34
	WLAN 5.6G	802.11ac VHT80	106	Ant 0	14.00	13.50	15.00	0.56
	WLAN 5.6G	802.11ac VHT80	106	Ant 1	14.00	13.50	15.00	0.42
	WLAN 5.6G	802.11ac VHT80	106	Ant 0+1	17.00	16.50	18.00	0.58
	WLAN 5.8G	802.11ac VHT80	155	Ant 0	15.00	13.50	15.00	0.56
	WLAN 5.8G	802.11ac VHT80	155	Ant 1	16.50	13.50	15.00	0.43
	WLAN 5.8G	802.11ac VHT80	155	Ant 0+1	19.50	16.50	18.00	0.67
	WLAN 6G U-NII 5	802.11ax HE160	15	Ant 0	13.00	11.50	13.00	0.60
	WLAN 6G U-NII 5	802.11ax HE160	47	Ant 1	13.00	11.50	13.00	0.49
	WLAN 6G U-NII 5	802.11ax HE160	79	Ant 0+1	16.00	14.50	16.00	0.80
	WLAN 6G U-NII 6	802.11ax HE160	111	Ant 0+1	11.00	11.00	12.50	0.11
	WLAN 6G U-NII 7	802.11ax HE160	143	Ant 0+1	16.00	14.50	16.00	0.83
	WLAN 6G U-NII 8	802.11ax HE160	207	Ant 0+1	11.00	11.00	12.50	0.12

The radio configurations selection for *FastConnect Time-Varying Validation Measurements* as provided in *Table 4-2*. The conducted power is measured at DUT for this validation test under ***FastConnect WIFI TAS Peak Exposure Mode*** enabled as per procedure required in step 1 in *Section 5.3.2*.

Table 4-2: Radio Configurations Selected for FastConnect Time-Varying Validation Measurements

DSI	WLAN Band	Modulation	Ant	P_{max}	P_{lim}	Conducted Tx Power P_{lim} (dBm)	1g SAR P_{lim} (W/kg)	Time Varying Test Sequence	Change in Antenna	Change in WLAN Band	Simultaneous Transmissions
0	2.4G	802.11b 1Mbps	SISO Ant 0	18.00	15.50	16.20	0.282	Conducted and PointSAR measurement	Conducted measurement	Conducted measurement	Conducted measurement
	2.4G	802.11b 1Mbps	SISO Ant 1	18.00	15.50	15.85	0.324		Conducted measurement		
	5.8G	802.11a 6Mbps	SISO Ant 0	17.50	13.50	13.42	0.437	Conducted and PointSAR measurement		Conducted measurement	Conducted measurement

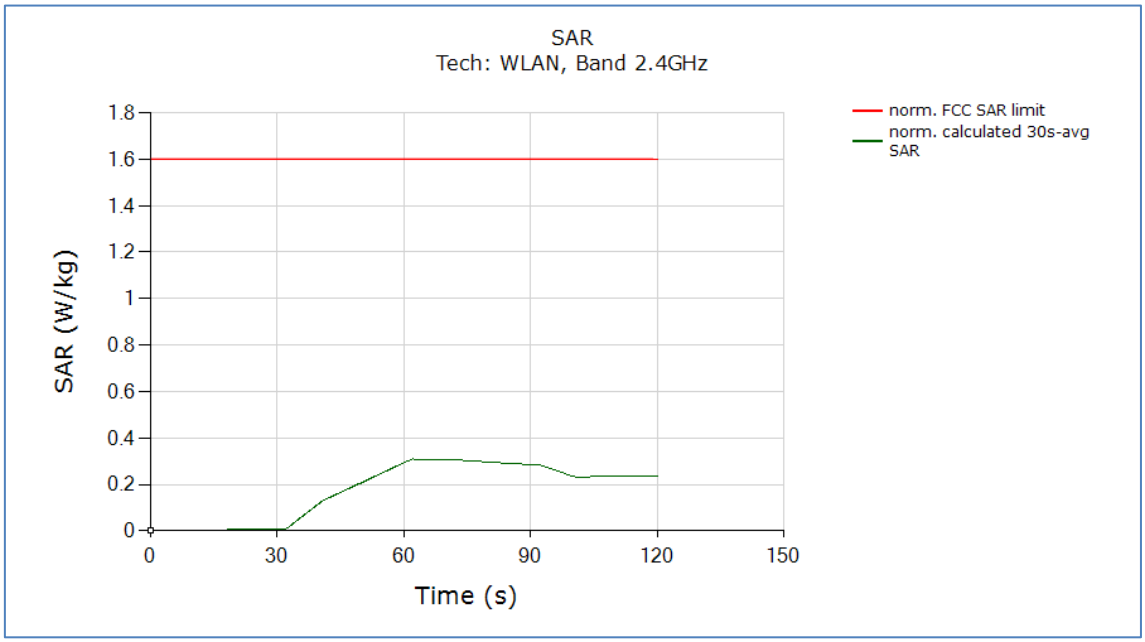
6. TAS Validation Test Result

6.1. Time-Varying Test Sequence

6.1.1. 1st Band – Test Parameters

DSI / Band / Tech / Ant	Parameters	Values
DSI 0, WLAN 2.4G 802.11b / 1Mbps SISO Antenna 0	P_{max}	18.00
	Reserve Margin (dB)	1.0
	Meas. Cond. P_{lim} (dBm)	16.20
	Meas. SAR @P_{lim} (W/kg)	0.282

6.1.2. 1st Band – Test Result

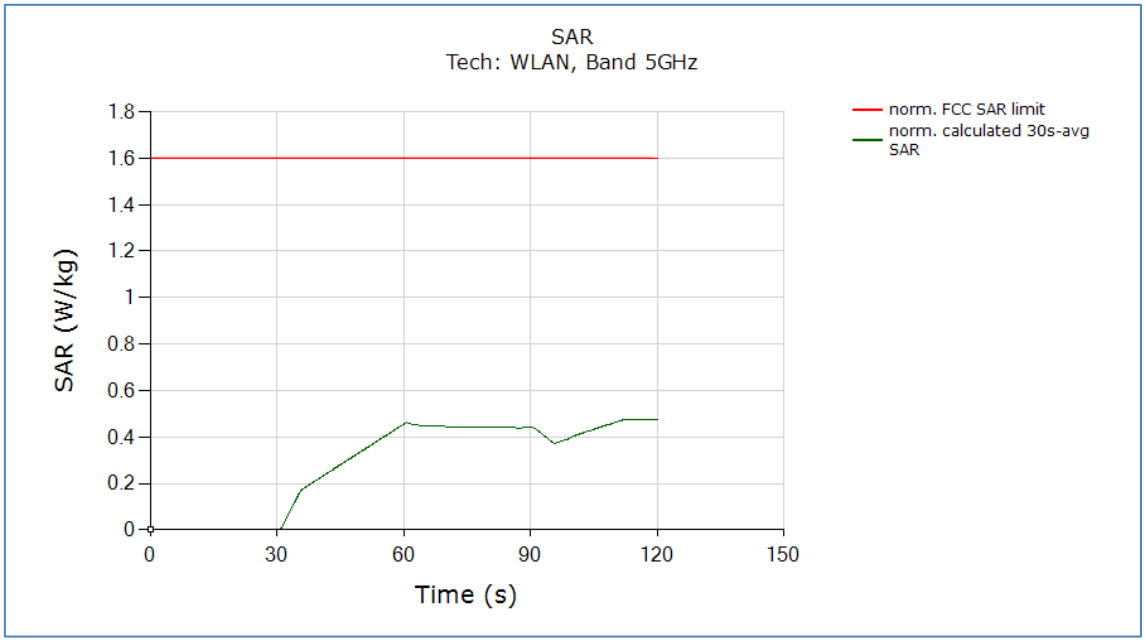


FCC Limit for 1gSAR (W/kg)	1.6
Max. Time-Averaged 1gSAR in Green Curve (W/kg)	0.310
Validated	

6.1.3. 2nd Band – Test Parameters

DSI / Band / Tech / Ant	Parameters	Values
DSI 0, WLAN 5.8G 802.11a / 6Mbps SISO Antenna 0	P_{max}	17.50
	Reserve Margin (dB)	1.0
	Meas. Cond. P_{lim} (dBm)	13.42
	Meas. SAR @P_{lim} (W/kg)	0.437

6.1.4. 2nd Band – Test Result



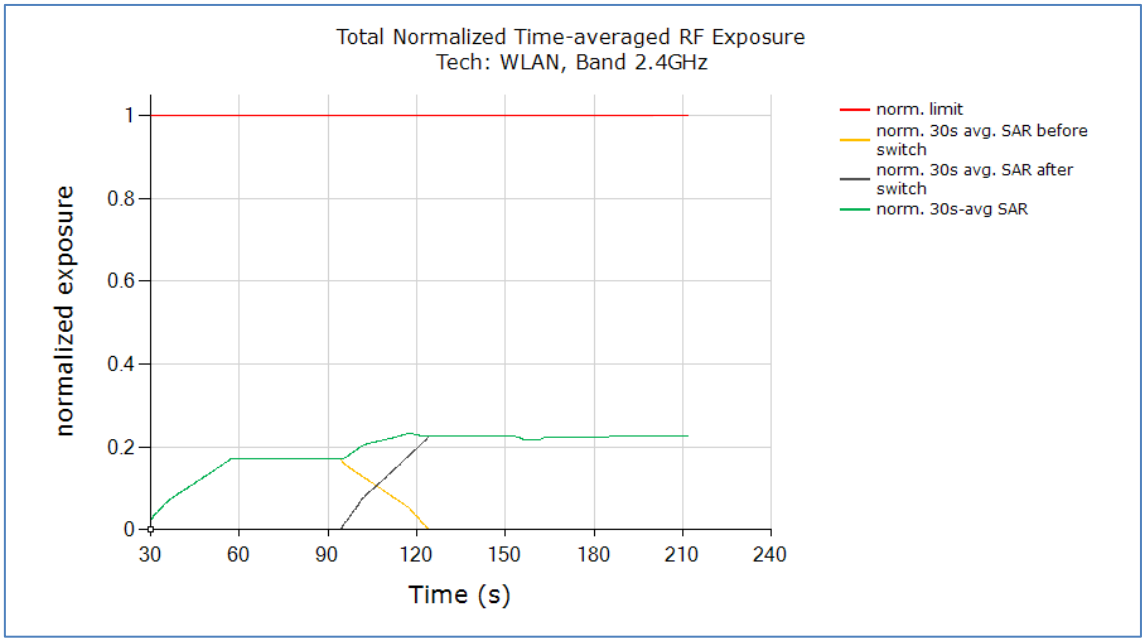
FCC Limit for 1gSAR (W/kg)	1.6
Max. Time-Averaged 1gSAR in Green Curve (W/kg)	0.477
Validated	

6.2. Change in Antenna

6.2.1. Test Parameters

DSI / Band / Tech / Ant	Parameters	Values
DSI 0, WLAN 2.4G 802.11b / 1Mbps SISO Antenna 0	P_{max}	18.00
	Reserve Margin (dB)	1.0
	Meas. Cond. P_{lim} (dBm)	16.20
	Meas. SAR @P_{lim} (W/kg)	0.282
Switch Time (sec)		*94.5*
DSI 0, WLAN 2.4G 802.11b / 1Mbps SISO Antenna 1	P_{max}	18.00
	Reserve Margin (dB)	1.0
	Meas. Cond. P_{lim} (dBm)	15.85
	Meas. SAR @P_{lim} (W/kg)	0.324

6.2.2. Test Result



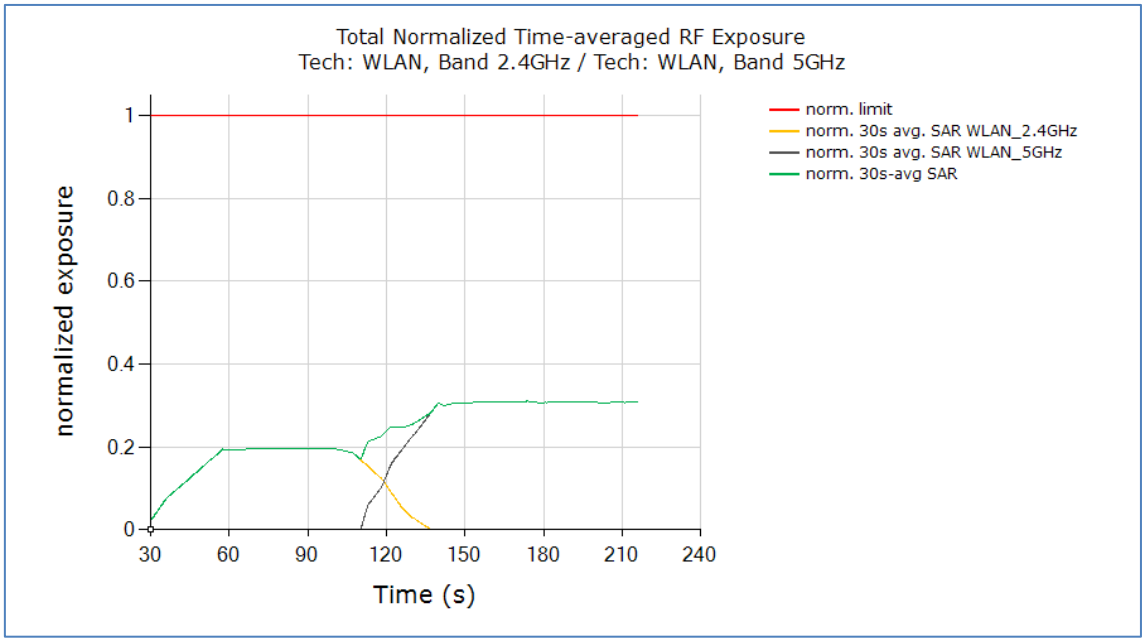
FCC Normalized Total Exposure Limit	1.0
Max. Total Normalized Time-Averaged SAR in Green Curve	0.232
Validated	

6.3. Change in WLAN Band

6.3.1. Test Parameters

DSI / Band / Tech / Ant	Parameters	Values
DSI 0, WLAN 2.4G 802.11b / 1Mbps SISO Antenna 0	P_{max}	18.00
	Reserve Margin (dB)	1.0
	Meas. Cond. P_{lim} (dBm)	16.20
	Meas. SAR @P_{lim} (W/kg)	0.282
Switch Time (sec)		*107.8*
DSI 0, WLAN 5.8G 802.11a / 6Mbps SISO Antenna 0	P_{max}	17.50
	Reserve Margin (dB)	1.0
	Meas. Cond. P_{lim} (dBm)	13.42
	Meas. SAR @P_{lim} (W/kg)	0.437

6.3.2. Test Result



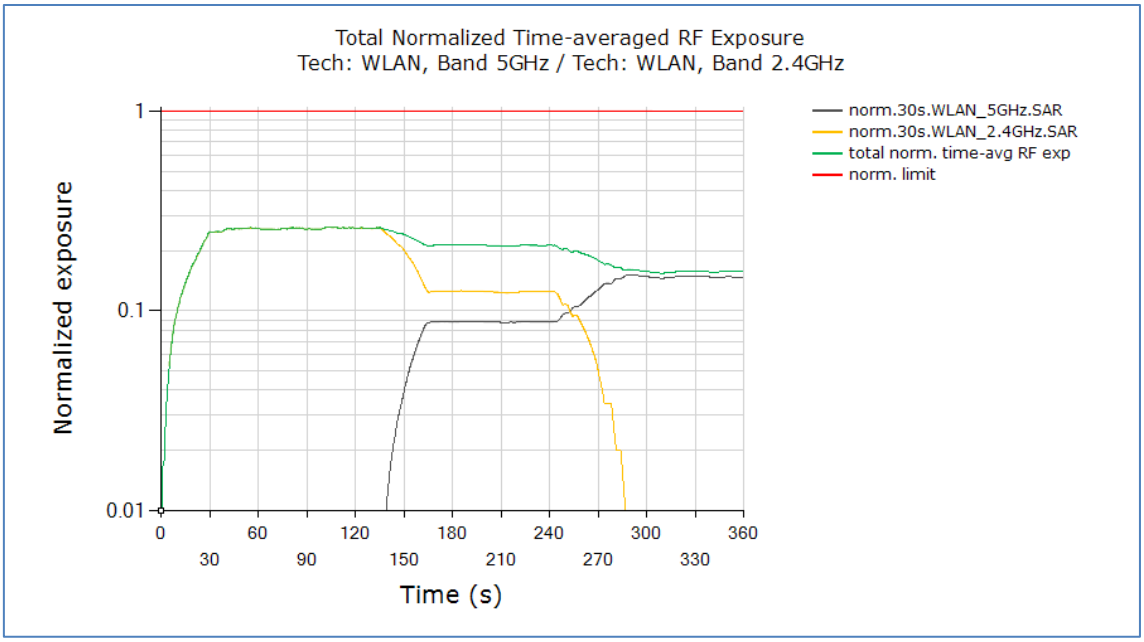
FCC Normalized Total Exposure Limit	1.0
Max. Total Normalized Time-Averaged SAR in Green Curve	0.311
Validated	

6.4. Simultaneous Transmissions

6.4.1. Test Parameters

DSI / Band / Tech / Ant	Parameters	Values
DSI 0, WLAN 2.4G 802.11b / 1Mbps SISO Antenna 0	P_{max}	18.00
	Reserve Margin (dB)	1.0
	Meas. Cond. P_{lim} (dBm)	16.20
	Meas. SAR @P_{lim} (W/kg)	0.282
DSI 0, WLAN 5.8G 802.11a / 6Mbps SISO Antenna 0	P_{max}	17.50
	Reserve Margin (dB)	1.0
	Meas. Cond. P_{lim} (dBm)	13.42
	Meas. SAR @P_{lim} (W/kg)	0.437

6.4.2. Test Result



FCC Normalized Total Exposure Limit	1.0
Max. Total Normalized Time-Averaged SAR in Green Curve	0.263
Validated	

7. pointSAR Test Result

7.1. DASY8 System Verification for SAR Measurement

7.1.1. Tissue Verification

The dielectric properties of the tissue simulating liquid have been measured within 24 hours before the SAR testing and within ±10 % of the target values. Liquid temperature during the SAR testing has kept within ±2 ℃.

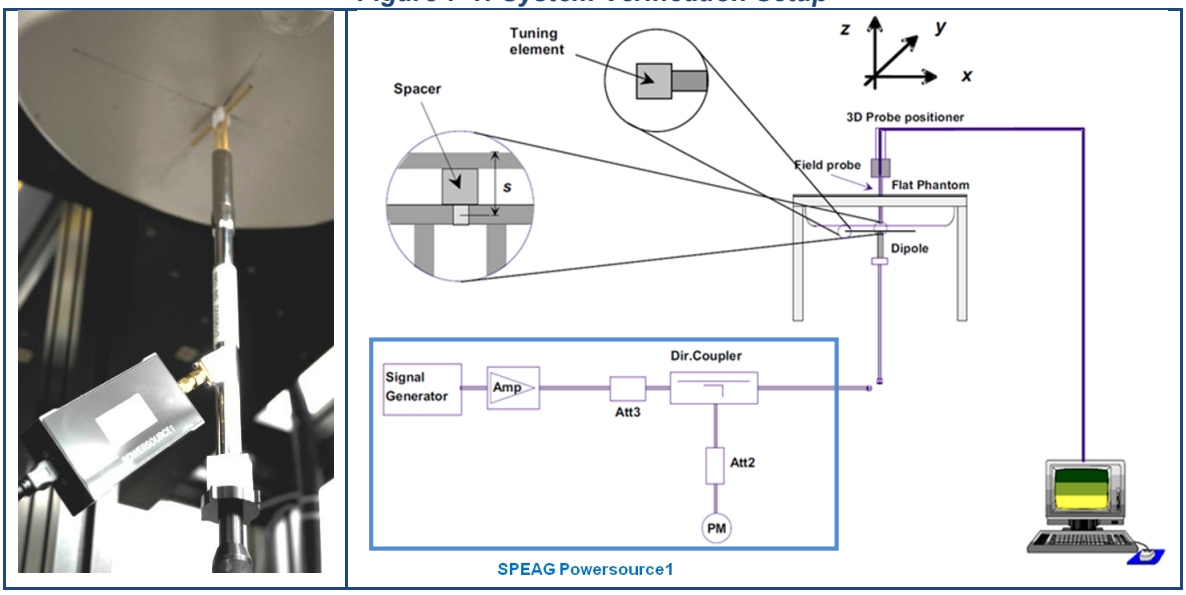
Test Results for Tissue Simulating Liquid

Frequency (MHz)	Liquid Temp. (℃)	Permittivity (εr)	Conductivity (σ)	Permittivity Target (εr)	Conductivity Target (σ)	Permittivity Deviation (%)	Conductivity Deviation (%)	Testing Date
2450	21.5	38.5	1.85	39.2	1.80	-1.79	2.78	Jan. 18, 2025
5800	21.5	36.3	5.23	35.3	5.27	2.83	-0.76	Jan. 18, 2025

7.1.2. Test System Verification

Before time-averaged SAR measurements, DASY8 system has been verified. The result normalized to 1W comparing to the reference SAR value provided by SPEAG in dipole calibration certificate, the deviation of system check results is within its specification of 10 %. The below test results indicate the system check can meet the variation criterion.

Figure 7-1: System Verification Setup



Test Results for SAR System Verification

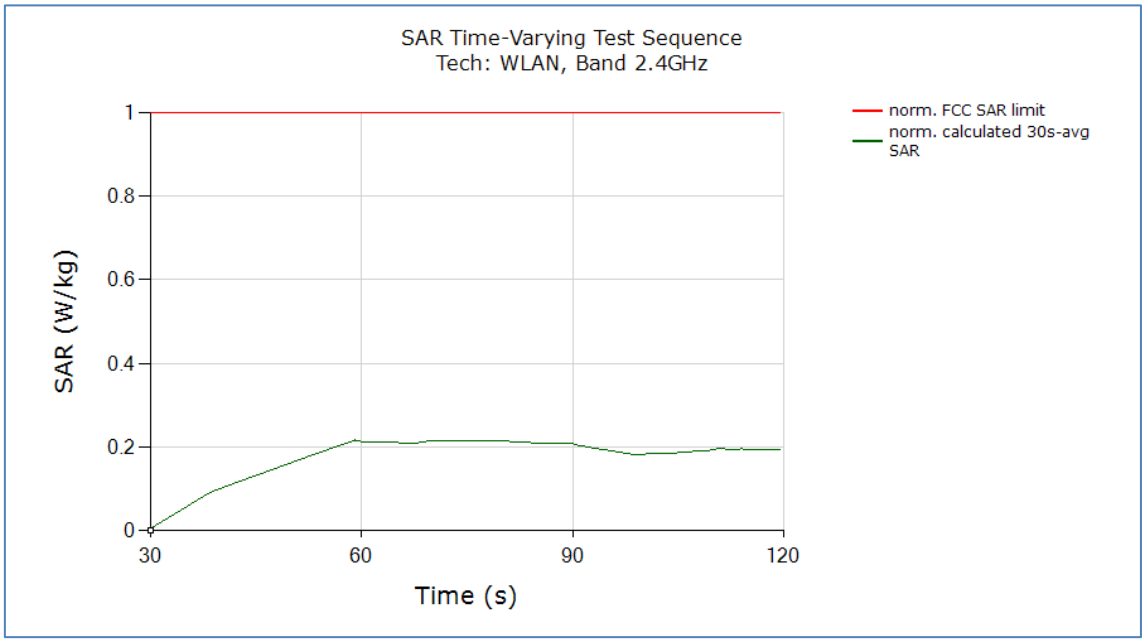
Date	Frequency (MHz)	Targeted 1g SAR (W/kg)	Measured 1g SAR (W/kg)	Normalized 1g SAR (W/kg)	Deviation (%)	Dipole S/N	Probe S/N	DAE S/N
Jan. 18, 2025	2450	53.2	2.77	55.27	3.89	1087	7756	1669
Jan. 18, 2025	5800	79.4	3.99	79.61	0.27	1358	7756	1669

7.2. Time-Varying Test Sequence

7.2.1. 1st Band – Test Parameters

DSI / Band / Tech / Ant	Parameters	Values
DSI 0, WLAN 2.4G 802.11b / 1Mbps SISO Antenna 0	Test Position	Bottom of Laptop
	Meas. SAR @P_{lim} (W/kg)	0.282

7.2.2. 1st Band – Test Result

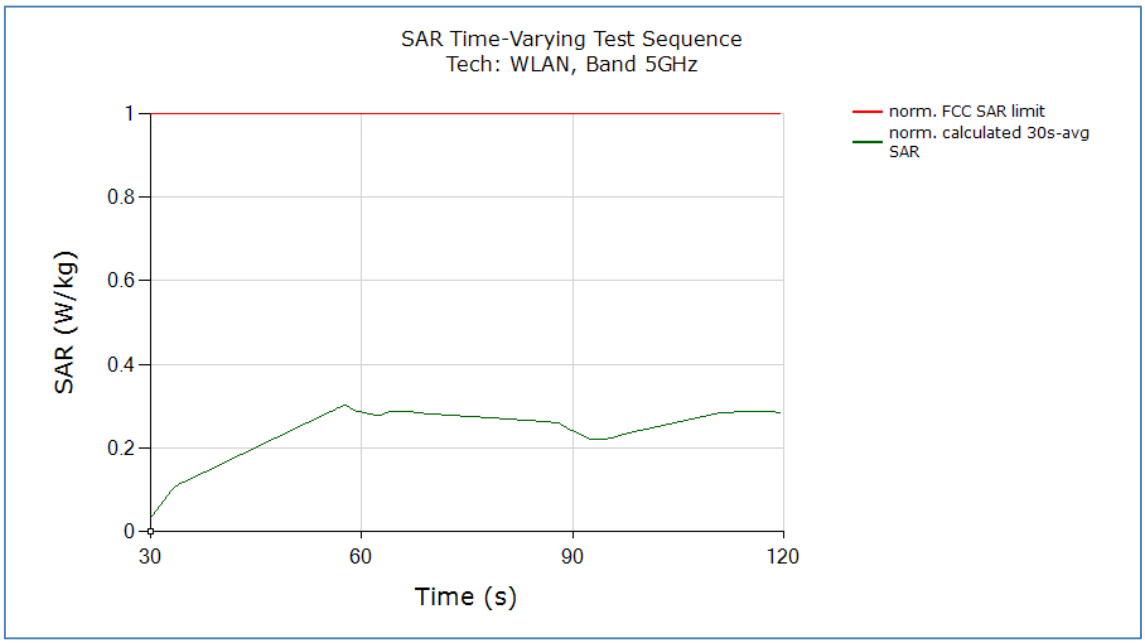


FCC Normalized Exposure Limit	1.0
Max. Normalized Time-Averaged SAR in Green Curve	0.217
Validated	

7.2.3. 2nd Band – Test Parameters

DSI / Band / Tech / Ant	Parameters	Values
DSI 0, WLAN 5.8G 802.11a / 6Mbps SISO Antenna 0	Test Position	Bottom of Laptop
	Meas. SAR @P_{lim} (W/kg)	0.437

7.2.4. 2nd Band – Test Result



FCC Normalized Exposure Limit	1.0
Max. Normalized Time-Averaged SAR in Green Curve	0.303
Validated	

8. Conclusions for Time-Averaging Feature Validation

The ***Qualcomm FastConnect WIFI TAS*** employed in this device has been validated through the conducted power measurement and SAR measurement (as demonstrated in Chapter 6 and Chapter 7).

With the combination of the ***Part 0: WIFI TAS Characterization Evaluation Report*** for determining TAS characterization, ***Part 1: SAR Evaluation Report (Test Under Static Transmission Scenario)*** for demonstrating compliance with design target for RF exposure and FCC equipment authorization, and this ***Part 2: WIFI TAS Time Varying Validation Report (Test Under Dynamic Transmission Condition)*** for time-averaging feature validation, it can be concluded that the time-averaged RF exposure for this device is compliant with the FCC limits in all transmission scenarios for all the supported radios.

9. Equipment List

Manufacturer	Equipment	Model No.	Serial No.	Cal. Date	Cal. Interval
SPEAG	2450 MHz System Validation Kit	D2450V2	1087	Jun. 14, 2024	1 year
SPEAG	5 GHz System Validation Kit	D5GHzV2	1358	Jun. 12, 2024	1 year
SPEAG	Isotropic E-Field Probe	EX3DV4	7756	Sep. 04, 2024	1 year
SPEAG	Data Acquisition Electronics	DAE4	1669	May 16, 2024	1 year
SPEAG	Dielectric Probe Kit	DAK-3.5	1219	Mar. 18, 2024	1 year
SPEAG	Powersource1	SE UMS 160 CA	4283	Aug. 15, 2024	1 year
R&S	Wireless Communication Test Set	CMW500	170768	Nov. 30, 2024	2 years
R&S	Spectrum Analyzer	FSV3013	101679	Jun. 27, 2024	1 year
R&S	Spectrum Analyzer	FSV3013	101701	Oct. 11, 2024	1 year
R&S	Power Sensor	NRP8S	111511	Nov. 28, 2024	1 year
R&S	Power Sensor	NRP8S	111512	Nov. 28, 2024	1 year

Test Engineer：Raymond Wu

10. Measurement Uncertainties

SAR Uncertainty Budget for Frequency Range of 300 MHz to 3 GHz

Symbol	Error Description	Uncertainty (± %)	Probability Distribution	Divisor	C_i (1g)	C_i (10g)	Standard Uncertainty (± %, 1g)	Standard Uncertainty (± %, 10g)
Measurement System Errors								
CF	Probe Calibration	12.0	N	2	1	1	6.0	6.0
CF_{drift}	Probe Calibration Drift	1.7	R	$\sqrt{3}$	1	1	1.0	1.0
LIN	Probe Linearity	4.7	R	$\sqrt{3}$	1	1	2.7	2.7
BBS	Broadband Signal	2.8	R	$\sqrt{3}$	1	1	1.6	1.6
ISO	Probe Isotropy	7.6	R	$\sqrt{3}$	1	1	4.4	4.4
DAE	Other Probe+Electronic	0.8	N	1	1	1	0.8	0.8
AMB	RF Ambient	0.7	N	1	1	1	0.7	0.7
Δ_{sys}	Probe Positioning	0.006	N	1	0.14	0.14	0.0	0.0
DAT	Data Processing	1.2	N	1	1	1	1.2	1.2
Phantom and Device Errors								
LIQ(σ)	Conductivity (meas.)DAK	2.5	N	1	0.78	0.71	2.0	1.8
$LIQ(T_\sigma)$	Conductivity (temp)BB	3.3	R	$\sqrt{3}$	0.78	0.71	1.5	1.4
EPS	Phantom Permittivity	14.0	R	$\sqrt{3}$	0	0	0.0	0.0
DIS	Distance DUT-TSL	2.0	N	1	2	2	4.0	4.0
D_{xyz}	Device Positioning	1.0	N	1	1	1	1.0	1.0
H	Device Holder	2.5	N	1	1	1	2.5	2.5
MOD	DUT Modulation	2.4	R	$\sqrt{3}$	1	1	1.4	1.4
TAS	Time-average SAR	1.7	R	$\sqrt{3}$	1	1	1.0	1.0
RF_{drift}	DUT drift	2.5	N	1	1	1	2.5	2.5
Correction to the SAR Results								
C(ε, σ)	Deviation to Target	1.9	N	1	1	0.84	1.9	1.6
C(R)	SAR Scaling	0.0	R	$\sqrt{3}$	1	1	0.0	0.0
u(ΔSAR)	**Combined Uncertainty**					**RSS**	10.5	10.4
U	**Expanded Uncertainty**					**k=2**	**21.0**	**20.8**

SAR Uncertainty Budget for Frequency Range of 3 GHz to 6 GHz

Symbol	Error Description	Uncertainty (± %)	Probability Distribution	Divisor	C_i (1g)	C_i (10g)	Standard Uncertainty (± %, 1g)	Standard Uncertainty (± %, 10g)
Measurement System Errors								
CF	Probe Calibration	13.1	N	2	1	1	6.55	6.55
CF_{drift}	Probe Calibration Drift	1.7	R	$\sqrt{3}$	1	1	1.0	1.0
LIN	Probe Linearity	4.7	R	$\sqrt{3}$	1	1	2.7	2.7
BBS	Broadband Signal	2.6	R	$\sqrt{3}$	1	1	1.5	1.5
ISO	Probe Isotropy	7.6	R	$\sqrt{3}$	1	1	4.4	4.4
DAE	Other Probe+Electronic	1.2	N	1	1	1	1.2	1.2
AMB	RF Ambient	0.7	N	1	1	1	0.7	0.7
Δ_{sys}	Probe Positioning	0.005	N	1	0.29	0.29	0.0	0.0
DAT	Data Processing	2.3	N	1	1	1	2.3	2.3
Phantom and Device Errors								
LIQ(σ*)*	Conductivity (meas.)DAK	2.5	N	1	0.78	0.71	2.0	1.8
LIQ(T_σ*)*	Conductivity (temp)BB	3.4	R	$\sqrt{3}$	0.78	0.71	1.5	1.4
EPS	Phantom Permittivity	14.0	R	$\sqrt{3}$	0.25	0.25	2.0	2.0
DIS	Distance DUT-TSL	2.0	N	1	2	2	4.0	4.0
D_{xyz}	Device Positioning	1.0	N	1	1	1	1.0	1.0
H	Device Holder	2.5	N	1	1	1	2.5	2.5
MOD	DUT Modulation	2.4	R	$\sqrt{3}$	1	1	1.4	1.4
TAS	Time-average SAR	1.7	R	$\sqrt{3}$	1	1	1.0	1.0
RF_{drift}	DUT drift	2.5	N	1	1	1	2.5	2.5
Correction to the SAR Results								
C(ε *,* σ*)*	Deviation to Target	1.9	N	1	1	0.84	1.9	1.6
C(R)	SAR Scaling	0.0	R	$\sqrt{3}$	1	1	0.0	0.0
u(Δ *SAR)*	**Combined Uncertainty**					**RSS**	11.2	11.1
U	**Expanded Uncertainty**					**k=2**	**22.4**	**22.2**

SAR Uncertainty Budget for Frequency Range of 6 GHz to 10 GHz

Symbol	Error Description	Uncertainty (± %)	Probability Distribution	Divisor	C_i (1g)	C_i (10g)	Standard Uncertainty (± %, 1g)	Standard Uncertainty (± %, 10g)
Measurement System Errors								
CF	Probe Calibration	18.6	N	2	1	1	9.3	9.3
CF_{drift}	Probe Calibration Drift	1.7	R	$\sqrt{3}$	1	1	1.0	1.0
LIN	Probe Linearity	4.7	R	$\sqrt{3}$	1	1	2.7	2.7
BBS	Broadband Signal	2.6	R	$\sqrt{3}$	1	1	1.5	1.5
ISO	Probe Isotropy	7.6	R	$\sqrt{3}$	1	1	4.4	4.4
DAE	Other Probe+Electronic	2.4	N	1	1	1	2.4	2.4
AMB	RF Ambient	0.7	N	1	1	1	0.7	0.7
Δ_{sys}	Probe Positioning	0.005	N	1	0.5	0.5	0.0	0.0
DAT	Data Processing	3.5	N	1	1	1	3.5	3.5
Phantom and Device Errors								
LIQ(σ)	Conductivity (meas.)DAK	2.5	N	1	0.78	0.71	2.0	1.8
LIQ(T_σ)	Conductivity (temp)BB	2.4	R	$\sqrt{3}$	0.78	0.71	1.1	1.0
EPS	Phantom Permittivity	14.0	R	$\sqrt{3}$	0.5	0.5	4.0	4.0
DIS	Distance DUT-TSL	2.0	N	1	2	2	4.0	4.0
D_{xyz}	Device Positioning	1.0	N	1	1	1	1.0	1.0
H	Device Holder	2.5	N	1	1	1	2.5	2.5
MOD	DUT Modulation	2.4	R	$\sqrt{3}$	1	1	1.4	1.4
TAS	Time-average SAR	1.7	R	$\sqrt{3}$	1	1	1.0	1.0
RF_{drift}	DUT drift	2.5	N	1	1	1	2.5	2.5
Correction to the SAR Results								
C(ε, σ)	Deviation to Target	1.9	N	1	1	0.84	1.9	1.6
C(R)	SAR Scaling	0.0	R	$\sqrt{3}$	1	1	0.0	0.0
u(ΔSAR)	**Combined Uncertainty**					**RSS**	13.9	13.8
U	**Expanded Uncertainty**					**k=2**	**27.8**	**27.6**

********** End of Report **********