RF Exposure report

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

Product Name	Notebook
Brand Name	Dell
Model No.	P190G
Applicant	Dell Inc. One Dell Way, Round Rock, Texas 78682, USA
FCC ID	E2K-QCNCM825
Date of EUT Receipt	Jan. 31, 2024
Date of Test(s)	Mar. 10, 2024 ~ Mar. 28, 2024
Date of Issue	Apr. 29, 2024

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

Remarks:

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

This report may only be reproduced and distributed in full. If the product in this report is used in any configuration other than that detailed in the report, the manufacturer must ensure the new system complies with all relevant standards. Any mention of SGS Taiwan Ltd. Central RF Lab or testing done by SGS Taiwan Ltd. Central RF Lab in connection with distribution or use of the product described in this report must be approved by SGS Taiwan Ltd. Central RF Lab in writing.

Signed on behalf of SGS

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

Date: Apr. 29, 2024

Revision History

Report Number	Revision	Description	Issue Date	Revised By	Remark
TESA2401000059ES	00	Initial creation of document	Apr. 01, 2024	Cindy Chou	
TESA2401000059ES	01	Modify comment	Apr. 29, 2024	Cindy Chou	

Note:

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

Contents

1 GENERAL INFORMATION

1.1 Test Facility

Laboratory	Test Site Address	Test Site Name	FCC Designation number	IC CAB identifier
SGS Taiwan Ltd. Central RF Lab. (TAF code 3702)	**1F, No. 8, Alley 15, Lane 120, Sec. 1, NeiHu Road, Neihu District, Taipei City, 11493, Taiwan.**	SAR 2	TW0029	TW3702
		SAR 6		
		SAR 8		
	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.				

2 INTRODUCTION

Qualcomm® FastConnect™ Time Averaged SAR (TAS) for Qualcomm 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 purpose of this report is to demonstrate the Qualcomm® FastConnect™ time averaged SAR (TAS) feature RF exposure compliance under dynamic transmission scenarios.

This test report provides reference to test results and plots using parameters is determined from for static SAR test and configurate in Qualcomm® FastConnect™ Time Averaged SAR (TAS) BDF for validating the Qualcomm® FastConnect™ Time Averaged SAR (TAS) feature.

2.1 Reference

Table 2-1 References

Document	Report number
Part 1 report	TESA2401000059ES

2.2 Acronyms

Table 2-2 lists the acronyms used in this document.

Table 2-2 Acronyms

Term	Description
AG	Antenna group
PD	Power density
APD	Absorbed power density
IPD	Incident power density
BDF	Board data file
CDD	Cyclic delay diversity
DBS	Dual band simultaneous
DSI	Device state index
EUT	Equipment under test
HBS	High band simultaneous
MIMO	Multiple-input multiple-output
OEM	Original equipment manufacturer
SAR	Specific absorption rate
SISO	Single-input single-output
TAS	Time averaged SAR

3 QUALCOMM® FASTCONNECT™ TIME AVERAGED SAR (TAS) OPERATION

3.1 Background

Regulatory RF exposure limits are defined with respect to time-averaged RF exposure. Qualcomm Qualcomm® FastConnect™ Time Averaged SAR (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 denoted as TSAR for SAR and PD

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

The Qualcomm® FastConnect™ Time Averaged SAR (TAS) supports maximum time-averaging windows (denoted as TSAR) as defined by the FCC:

- For FCC, a 30 second time-averaging window is used by Qualcomm® FastConnect™ Time Averaged SAR (TAS) for WLAN operation in 2.4GHz, 5GHz, and 6GHz WLAN bands.

Table 3-1 Frequencies of operation and time-averaging windows used by Qualcomm® FastConnect™ Time Averaged SAR (TAS)

FCC[1]	
WLAN band	**Time-averaging window length**
2.4GHz, 5GHz, 6GHz	30s

[1]The FCC time-averaging window table is based on FCC interim guidance.

3.2 Basic concept of the feature

Qualcomm® FastConnect™ Time Averaged SAR (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 TSAR 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 durations before limiting the power to maintain time-averaged SAR compliance.

3.3 Configurable parameters

This section defines the key parameters required for Qualcomm® FastConnect™ Time Averaged SAR (TAS) Validation.

The following inputs are key parameters required for functionality of the Qualcomm® FastConnect™ Time Averaged SAR (TAS) feature.

NOTE: The OEM must configure these parameters in the board data file (BDF).

- Time-Averaged Exposure Mode (FCC or ICNIRP) or Peak exposure mode, configurable for a given region/country: When enabled in Peak Exposure mode, Qualcomm® FastConnect™ Time Averaged SAR (TAS) limits instantaneous Tx power not to exceed Plim in both simultaneous and single antenna case.
- P_{lim} per WLAN band/ant/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.

3.4.1 P_{lim}

P_{lim} (in dBm) is the power corresponding to the SAR_{target} for FastConnect WLAN. In other words, P_{lim} is the maximum time-average transmit power setting for Qualcomm® FastConnect™ Time Averaged SAR (TAS), at which this radio configuration (i.e., antenna, band and DSI state) reaches the SAR_{target}. The Fast Connect TAS algorithm uses P_{lim} to and the real time transmit power to ensure the real time-averaged SAR is below the SAR_{target} in real time and thus ensure device RF Exposure compliance.

3.4.2 P_{max}

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

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

3.4.3 Reserve margin

Qualcomm® FastConnect™ Time Averaged SAR (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 Qualcomm® FastConnect™ Time Averaged SAR (TAS) effectively allows minimum transmit power $P_{reserve}$ = P_{lim} at all times, in other words, the EUT transmits continuously at P_{lim}.

The value is chosen by the OEM 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 Qualcomm® FastConnect™ Time Averaged SAR (TAS). Three parts of assessment should be completed, and Static SAR compliance test report and Time Varying Validation test report should be created for certification approval:

Qualcomm_FastConnect_TAS_Characterization – OEM must perform SAR/PD characterization at the device level to determine Plim for RF exposure test.

Qualcomm_FastConnect_TAS_Static_SAR_Compliance – OEM must perform Static SAR testing for all supported WLAN band/antenna/DSI. The maximum time average Tx power levels are determined from the SAR characterization and test in static transmission (e.g., FTM mode) to validate and demonstrate RF exposure meets the design target.

Qualcomm_FastConnect_TAS_Time_Varying_Validation – Test with pre-defined test sequence for each validation scenario to demonstrate RF Exposure compliance is achieved by Qualcomm® FastConnect™ Time Averaged SAR (TAS). Qualcomm releases a test tool that can be used for the validation scenarios and also provides installation and test guides to OEMs manufactures. OEM manufactures should determine the appropriate test mode/channel and complete the TAS Time Varying Validation Report and submit in FCC certification submissions.

High-level procedure for Qualcomm® FastConnect™ Time Averaged SAR (TAS) product approval process is shown in Figure 4-1.

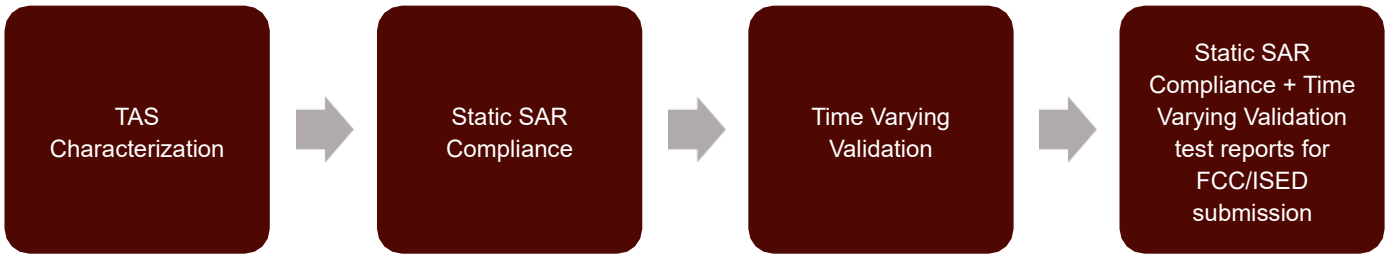


Figure 4-1 High-level process for Qualcomm® FastConnect™ Time Averaged SAR (TAS) approval process

4.2 Validation strategy

The following scenarios cover validation tests to prove Qualcomm® FastConnect™ Time Averaged SAR (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 5.5 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 5.5 Section 5.6.

4.2.1 Time-Varying Test Sequence

This test proves the Qualcomm® FastConnect™ Time Averaged SAR (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 Qualcomm® FastConnect™ Time Averaged SAR (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 Qualcomm® FastConnect™ Time Averaged SAR (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 windows duration.

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 Qualcomm® FastConnect™ Time Averaged SAR (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 Qualcomm® FastConnect™ Time Averaged SAR (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 Qualcomm® FastConnect™ Time Averaged SAR (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 Qualcomm® FastConnect™ Time Averaged SAR (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 windows.
4. Demonstrate that the total normalized time-averaged RF exposure is <1 for all transmission scenarios.

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

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

$$\frac{\frac{1}{TSAR}\int_{t-TSAR}^{t} 1g\_or\_10gSAR(t)\,dt}{FCC\ or\ ICNIRP\ SAR\ limit} \leq 1 \quad (1b)$$

☐ For frequency greater than 6GHz if regulator requires APD. (Applicable for ISED)

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

$$\frac{\frac{1}{TSAR}\int_{t-TSAR}^{t} 4cm2\ PD(t)\,dt}{APD\ 4cm^2\ PD\ limit} \leq 1 \quad (1d)$$

Where, *conducted_Tx_power(t)*, *conducted_Tx_power_Plim* and *1g_or_10gSAR_Plim* correspond to the measured instantaneous conducted Tx power and conducted Tx power at P_{lim} of DUT, and 1*g_or_10gSAR* values at P_{lim} for the worst-case radio configuration within the tested band/Antenna/DSI. Similarly, *4cm² PD_*P_{lim} correspond to the APD values at P_{lim} for the worst-case radio configuration within the tested band (greater than 6GHz)/Antenna/DSI.

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

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 *4cm² PD_Plim* must be from the SAR value in the worst-case radio configuration within the tested band/Antenna/DSI in static SAR 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 Qualcomm® FastConnect™ Time Averaged SAR (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 Qualcomm® FastConnect™ Time Averaged SAR (TAS) feature validation, while avoiding the complexity in SAR measurement.

1. Choose worst case EUT orientation of SAR measurement per according to Static SAR test report and perform pointSAR measurement use cDASY6
2. Measure instantaneous SAR versus time and demonstrate total normalized time-averaged RF exposure is <1.0 at all times.

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

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

$$\frac{\frac{1}{TSAR}\int_{t-TSAR}^{t} 1g\_or\_10gSAR(t)\,dt}{FCC\ or\ ICNIRP\ SAR\ limit} \leq 1 \quad (2b)$$

☐ For frequency greater than 6GHz if regulator requires APD. (Applicable for ISED)

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

$$\frac{\frac{1}{TSAR}\int_{t-TSAR}^{t} 4cm2\ PD(t)\,dt}{APD\ 4cm^2\ PD\ limit} \leq 1 \quad (2d)$$

where, *pointSAR(t), pointSAR_Plim*, and 1*g_or_10gSAR_Plim* correspond to the measured instantaneous point SAR and point SAR at P_{lim} of DUT, and 1*g_or_10gSAR* values at P_{lim} for the worst-case radio configuration within the tested band/Antenna/DSI. Similarly, $4cm^2$ *PD_Plim* is the APD values at P_{lim} for the worst-case radio configuration within the tested band (greater than 6GHz)/Antenna/DSI.

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

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 $4cm^2$ *PD_Plim* must be from the SAR value in the worst-case radio configuration within the tested band/Antenna/DSI in static SAR report and scale to the *conducted_Tx_power_Plim* level is measured from DUT used in validation test.

5 EUT AND TEST SETUP INFORMATION

5.1 DUT information

- DUT: Brand Name: Dell, Model: P190G with Qualcomm WLAN 6GHz module installed (Regulatory Model: QCNCM825, FCC ID: E2K-QCNCM825)
- Qualcomm QCNCM825 module supports WLAN 6GHz and Bluetooth applications includes 2.4/5/6 GHz, 2 streams 802.11a/b/g/n/ac/ax/be + Bluetooth 5.3.

EUT Name	Dell laptop P190G with Qualcomm WLAN 6GHz module installed
EUT FCC ID	Module FCC ID: E2K-QCNCM825
EUT Description	Notebook Computer
Radio Technologies	WLAN 6GHz + Bluetooth
Equipment Categories	Portable
TX Frequencies	WLAN 2.4GHz Band: 2400 MHz ~ 2483.5 MHz WLAN U-NII 1: 5150 MHz ~ 5250 MHz WLAN U-NII 2a: 5250 MHz ~ 5350 MHz WLAN U-NII 2c: 5470 MHz ~ 5725 MHz WLAN U-NII 3: 5725 MHz ~ 5850 MHz WLAN U-NII 4: 5850 MHz ~ 5895 MHz (US only) WLAN U-NII 5: 5925 MHz ~ 6425 MHz WLAN U-NII 6: 6425 MHz ~ 6525 MHz WLAN U-NII 7: 6525 MHz ~ 6875 MHz WLAN U-NII 8: 6875 MHz ~ 7125 MHz Bluetooth: 2400 MHz ~ 2483.5 MHz

QCNCM825 supports 2x2 WLAN with two physical antenna ports:

Radio Tx chain	Antenna port
2GHz (Chain0)	Aux Ant
2GHz (Chain1)	Main Ant
5GHz/6GHz (Chain0)	Aux Ant
5GHz/6GHz (Chain1)	Main Ant

5.2 DUT Qualcomm® FastConnect™ Time Averaged SAR (TAS) Configured Parameters

The DUT has Qualcomm® FastConnect™ Time Averaged SAR (TAS) parameters configured in Board Data File for test in this test report.

5.3 Test equipment list

The test equipment used in this Qualcomm® FastConnect™ Time Averaged SAR (TAS) Time varying test report is listed in Table 5-1.

Table 5-1 Test equipment list

Equipment List					
Manufacturer	**Device**	**Type**	**Serial number**	**Date of last calibration**	**Date of next calibration**
SPEAG	Data acquisition Electronics	DAE4	1824	Aug/08/2023	Aug/07/2024
SPEAG	Dosimetric E-Field Probe	EX3DV4	7823	Aug/11/2023	Aug/10/2024
SPEAG	System Validation Dipole	D2450V2	727	Apr/25/2023	Apr/24/2024
SPEAG	System Validation Dipole	D5GHzV2	1349	Mar/20/2023	Mar/19/2024
SPEAG	Dielectric Assessment Kit	DAKS-3.5	1053	Feb/21/2024	Feb/20/2025
R&S	MXG Analog Signal Generator	SMB100A03	182012	May/23/2023	May/22/2024
Agilent	Dual-directional coupler	772D	MY46151258	Sep/26/2023	Sep/25/2024
Agilent	Dual-directional coupler	778D	MY46151242	Sep/26/2023	Sep/25/2024
EMCI	Amplifier	EMC 2830P	980156	Calibration not required	Calibration not required
R&S	Power Sensor	NRP18S	101974	Nov/21/2023	Nov/20/2024
R&S	Power Sensor	NRP18S	109066	Oct/23/2023	Oct/22/2024
R&S	Power Meter	NRX	105651	Nov/24/2023	Nov/23/2024
SPEAG	Software	DASY 8 V16.0.2.83	N/A	Calibration not required	Calibration not required
R&S	Radio Communication Test	CMW 500	170274	May/25/2023	May/24/2024
SPEAG	Phantom	ELI	N/A	Calibration not required	Calibration not required
TECPEL	Digital thermometer	DTM-303A	TP130074	Apr/28/2023	Apr/27/2024

5.4 Conducted Power Measurement

5.4.1 Test selection criteria

The conducted power measurement method is used for all validation test scenarios. These tests demonstrate the power enforcement by Qualcomm® FastConnect™ Time Averaged SAR (TAS) where ***P**lim* could vary before and after transition.

5.4.1.1 Test selection for Time-Varying Test Sequence

Select one representative test channel from all the available radio configurations (band/ant(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/ant(s)/DSI) meet this criteria, 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 & radiated tests.

5.4.1.2 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 EUT, first select antenna switch configuration within the same band/DSI (i.e., same band and DSI combination), and having different Plim, 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 EUT 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.

5.4.1.3 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 Plim 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 Pmax > Plim + 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/ant(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 – *Plim* dBm) dB delta.
- ○ Test for Change in DSI is not required if all $P_{lim} > P_{max}$ for all radio configurations.

5.4.1.4 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/ant(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.

5.4.1.5 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/ant(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.

○ 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 Qualcomm® FastConnect™ Time Averaged SAR (TAS) device.

NOTE: For all above test selection. Pmax = min (CTL, Regdomain, TPE/TPC, Rate-to- Power) of the selected channel//rate/band. Since Qualcomm® FastConnect™ Time Averaged SAR (TAS) supports the same Plim for all modulations in same antenna/band/DSI, the selection of test modulation/channel chooses the highest Pmax modulation.

5.4.2 Test procedure

1. Measure P_{lim} for modes at validation antenna ports, bands and/or DSIs with **Qualcomm® FastConnect™ Time Averaged SAR (TAS) Peak Exposure Mode** enabled with callbox to establish the chosen mode for test. Denote this measured power value as *Conducted_Tx_power_*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 EUT to the intended **Qualcomm® FastConnect™ Time Averaged SAR (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 EUT to transmit in following **Transition sequence**:

   a. **Time-Varying Test Sequence** – Request EUT 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** – EUT 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)** – EUT 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** – EUT 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.

Time	Power
t1	p_{t1}
t2	p_{t2}
:	:
:	:
$t_n(t_1+T$ secs)	p_{tn}
$t_{n+1}(t_2+T$ secs)	P_{tn+1}
:	:

1ST T time window (T = 30 secs for FCC and 360 secs for ISED)
Time averaged power (P1) = $\frac{\sum_{i=1}^{n} p\_ti}{n}$

1ST T time window (T = 30 secs for FCC and 360 secs for ISED)
Time averaged power (P2) = $\frac{\sum_{i=2}^{n+1} p\_ti}{n}$

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 6GHz:

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

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

$$\frac{\frac{1}{TSAR}\left[\int_{t\text{-}TASR}^{t1} 1g\_or\_10gSAR1(t)\,dt + \int_{t\text{-}TSAR}^{t} 1g\_or\_10gSAR2(t)\,dt\right]}{FCC\ or\ ICNIRP\ SAR\ limit} \leq 1 \quad (4c)$$

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 DSI1) 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 DSI2) at P_{lim}_2.

Transition from the Antenna 1 (or Band 1 or DSI1) to the Antenna 2 (or Band 2 or DSI2) happens at time-instant 't_1'.

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

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

$$4cm^2\ PD_2(t) = \frac{Conducted\_Tx\_Power\_2(t)}{Conducted\_Tx\_Power\_Plim\_2} * 4cm2\ PD\_Plim\_2 \quad (5b)$$

$$\frac{\frac{1}{TSAR}\left[\int_{t\text{-}TASR}^{t1} 1g\_or\_10gSAR(t)\,dt\right]}{ICNIRP\ SAR\ limit} + \frac{\frac{1}{TSAR}\int_{t\text{-}TASR}^{t} 4cm^2\ PD(t)}{APD\ 4cm^2\ PD\ limit} \leq 1 \quad (5c)$$

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 2.4/5GHz WLAN band;

conducted_Tx_power_2(t), conducted_Tx_power_Plim_2, and *4cm² PD_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 6GHz WLAN band.

Transition from the Band1 to the Band2 happens at time-instant 't_1'.

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

$$4cm^2\ PD_1(t) = \frac{Conducted\_Tx\_Power\_1(t)}{Conducted\_Tx\_Power\_Plim\_1} * 4cm2\ PD\_Plim\_1 \quad (6b)$$

$$4cm^2\ PD_2(t) = \frac{Conducted\_Tx\_Power\_2(t)}{Conducted\_Tx\_Power\_Plim\_2} * 4cm2\ PD\_Plim\_2 \quad (6b)$$

$$\frac{\frac{1}{TSAR}\left[\int_{t\text{-}TASR}^{t1} 4cm2\ PD1(t)\,dt + \int_{t\text{-}TASR}^{t} 4cm2\ PD2(t)\,dt\right]}{APD\ 4cm^2\ PD\ limit} \leq 1 \quad (6c)$$

where, *conducted_Tx_power_1(t), conducted_Tx_power_Plim_1*, and *4cm² PD_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 *4cm2 PD_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 4cm^2 PD) versus time from above procedure.
   b. Corresponding regulatory *1g_or_10gSAR* (and/or 4cm^2 PD) limit.

The validation criteria is, at all times, the combined time-averaged *1g_or_10gSAR* (and/or *4cm^2 PD*) versus time shall not exceed the regulatory *1g_or_10gSAR* (and/or *4cm^2 PD*) limit.

5.5 pointSAR measurement test sequence

5.6.1 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 5.5.1.1.

5.6.2 Test procedure

1. For a given radio configuration:
   a. Enable WLAN connection with callbox in **Qualcomm® FastConnect™ Time Averaged SAR (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 EUT 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:

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

$$4cm^2\ PD\ (t) = \frac{pointSAR(t)}{pointSAR\_Plim} * 4cm2\ PD\_Plim \quad (2c)$$

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 criteria 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.

5.6 DUT worst case 1gSAR and test mode selection

The Plim is configurated in Qualcomm® FastConnect™ Time Averaged SAR (TAS) BDF per according to the Static SAR test and used for validation in this test report.

Base on the Static SAR Compliance Test Report. The worst case 1gSAR of each radio configuration are extracted from Static SAR report and listed in Table 5-2.

Table 5-2 Plim and Worst case 1gSAR

		Modulation	Channel	P_{max} (dBm)	P_{lim} (dBm)	Tune up Limit (dBm)	Reported 1g SAR (W/kg)
DSI0	2.4GHz SISO Aux antenna	11b/1Mbps	11	18	17.75	19.25	1.068
	2.4GHz SISO Main antenna	11b/1Mbps	11	18	17.5	19	1.105
	2.4GHz MIMO Aux antenna	11b/1Mbps	6	18	17.25	18.75	1.159
	2.4GHz MIMO Main antenna					18.75	
	5.2GHz MIMO Aux antenna	11ac VHT80/MCS0	42	15	14.5	16	0.856
	5.2GHz MIMO Main antenna					16	
	5.3GHz MIMO Aux antenna	11ac VHT80/MCS0	58	14.25	13.75	15.25	0.898
	5.3GHz MIMO Main antenna					15.25	
	5.6GHz MIMO Aux antenna	11ac VHT160/MCS0	114	12.75	11	12.5	0.811
	5.6GHz MIMO Main antenna					12.5	
	5.8GHz MIMO Aux antenna	11ac VHT80/MCS0	155	16.5	10	11.5	0.554
	5.8GHz MIMO Main antenna					11.5	
	5.9GHz MIMO Aux antenna	11ac VHT80/MCS0	171	16.5	12.5	14	0.912
	5.9GHz MIMO Main antenna					14	
	6.2GHz MIMO Aux antenna	11be EHT320/MCS0	31	14.5	13.25	14.75	0.797
	6.2GHz MIMO Main antenna					14.75	
	6.5GHz MIMO Aux antenna	11be EHT320/MCS0	95	14.5	12.75	14.25	0.662
	6.5GHz MIMO Main antenna					14.25	
	6.7GHz MIMO Aux antenna	11be EHT320/MCS0	127	14.5	12.5	14	0.628
	6.7GHz MIMO Main antenna					14	
	7GHz MIMO Aux antenna	11be EHT320/MCS0	191	14.5	12	13.5	0.662
	7GHz MIMO Main antenna					13.5	

In this test report. The radio configurations selection for FastConnect Time-Varying Validation measurements as provided in Table 5-3. The conducted power is measured at DUT for this validation test under **Qualcomm® FastConnect™ Time Averaged SAR (TAS) Peak Exposure Mode** enabled as per procedure required in step 1 in Section 5.5.2.

Table 5-3 Radio configurations selected for FastConnect Time-Varying Validation measurements in this test report.

	Band	Ant	Modulation	P_{max}	P_{lim}	*conducted_Tx_power_* P_{lim}(dBm)	*1g_or_10gSAR_* P_{lim}(W/kg)	Time Varying Test Sequence	Change in Antenna	Change in WLAN Band	Simultaneous Transmissions
DSI0	2.4GHz SISO	Main	11b / 1Mbps	18	17.5	18.422	0.827		Conducted measurement		
	2.4GHz SISO	Aux	11b / 11Mbps	18	17.75	17.802	0.868		Conducted measurement		
	2.4GHz MIMO	Main	11b / 1Mbps	18	17.25	18.63	0.786	Conducted and pointSAR measurement		Conducted measurement	Conducted measurement
	5.8GHz MIMO	Main	11ac(20) / MCS0	17.5	10	10.8	0.775	Conducted and pointSAR measurement		Conducted measurement	Conducted measurement

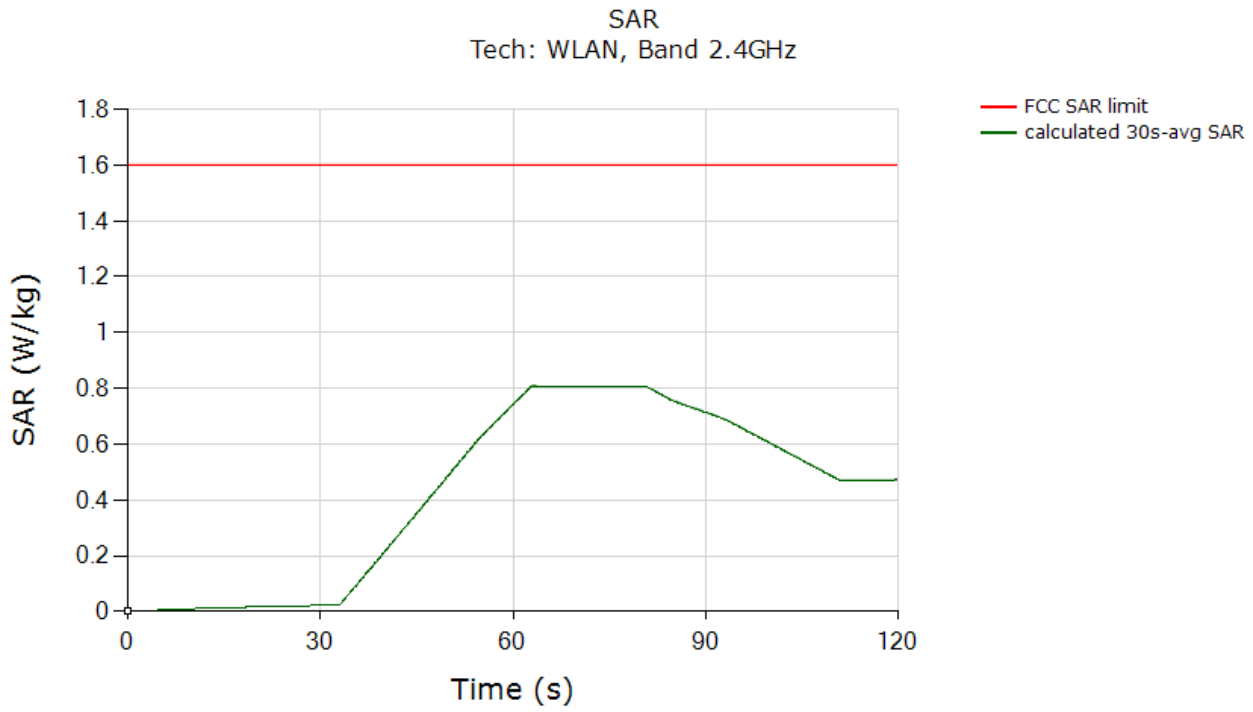
6 FCC VALIDATION TEST RESULT

6.1 Time-Varying Test Sequence

6.1.1 Test parameters – 1st Band

Tech/Band/Ant/DSI	Parameters	Values
11b / 1Mbps; 2.4GHz MIMO Main antenna; DSI0	P_{max}	18
	Reserve margin (dB)	1
	Meas. Cond. P_{lim} (dBm)	18.63
	Meas. SAR @ P_{lim} (W/kg)	0.786

6.1.2 Test plots and result – 1st Band

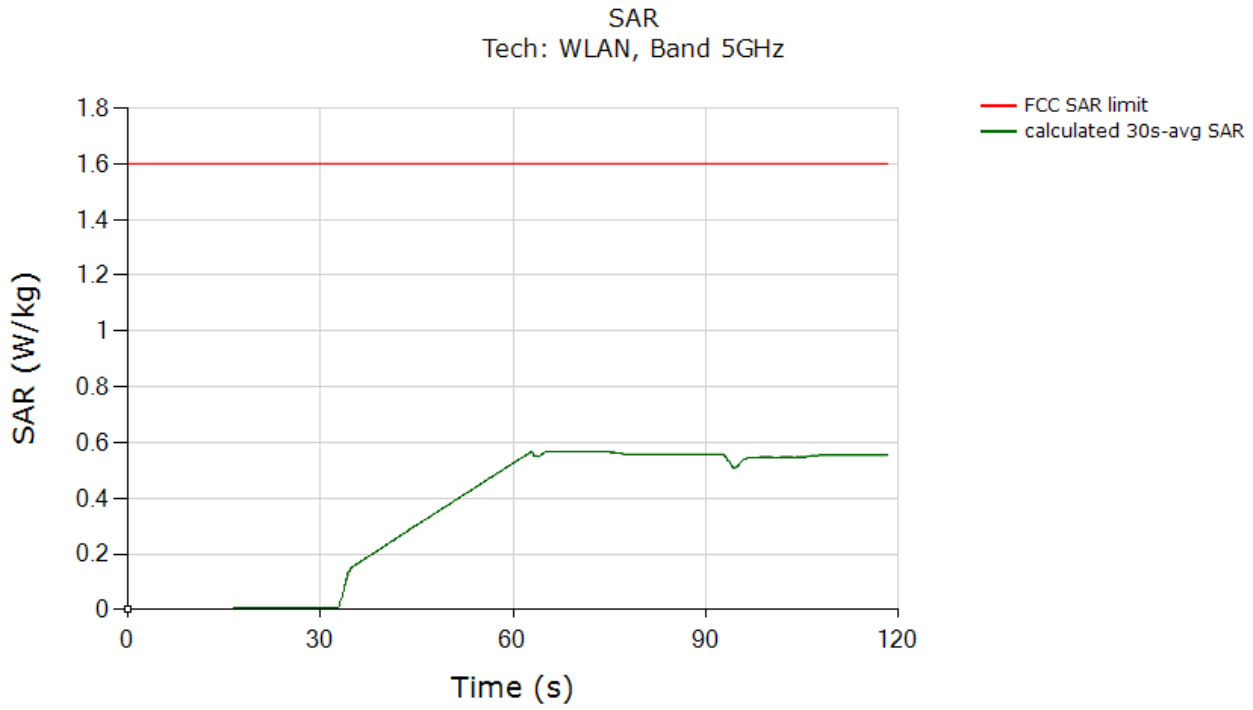


	W/Kg
FCC exposure limit	1.6
Max time-averaged SAR (green curve)	0.809
Validated	

6.1.3 Test parameters – 2nd Band

Tech/Band/Ant/DSI	Parameters	Values
11ac VHT20/ MCS0; 5.8GHz MIMO Main antenna; DSI0	P_{max}	17.5
	Reserve margin (dB)	1
	Meas. Cond. P_{lim} (dBm)	10.8
	Meas. SAR @ P_{lim} (W/kg)	0.775

6.1.4 Test plots and result – 2nd Band



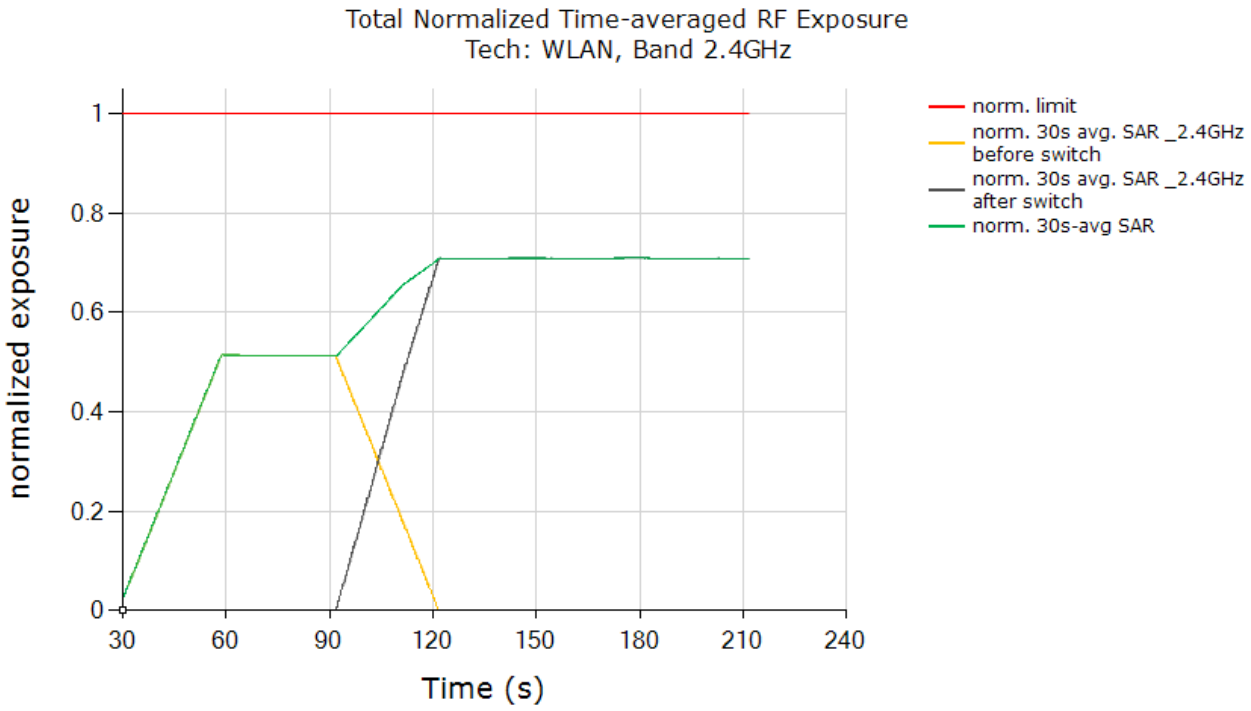
	W/Kg
FCC exposure limit	1.6
Max time-averaged SAR (green curve)	0.567
Validated	

6.2 Change in antenna

6.2.1 Test parameters

Tech/Band/Ant/DSI	Parameters	Values
11b/ 1Mbps; 2.4GHz SISO Main antenna; DSI0	P_{max}	18
	Reserve margin (dB)	1
	Meas. Cond. P_{lim} (dBm)	18.422
	Meas. SAR @ P_{lim} (W/kg)	0.827
Switch time (sec)		92.1
11b/ 11Mbps; 2.4GHz SISO Aux antenna; DSI0	P_{max}	18
	Reserve margin (dB)	1
	Meas. Cond. P_{lim} (dBm)	17.802
	Meas. SAR @ P_{lim} (W/kg)	0.868

6.2.2 Test plots and result



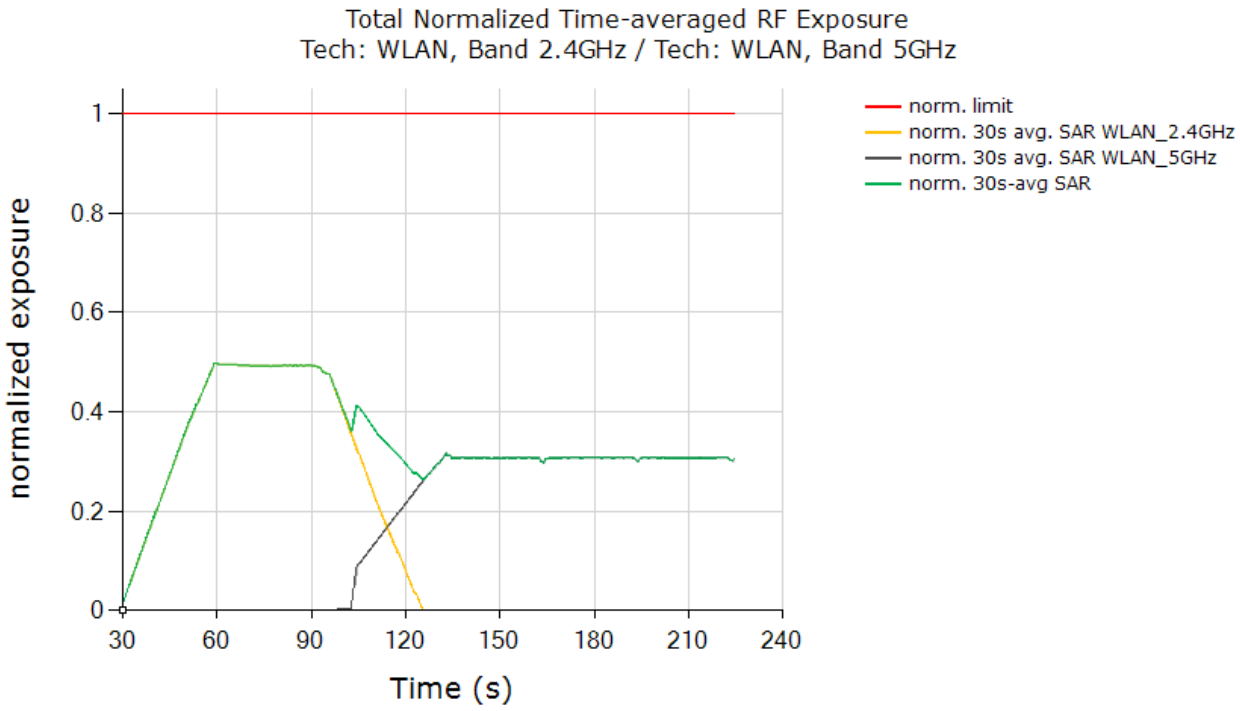
	Norm. exposure value
FCC normalized total exposure limit	1.0
Max total normalized time-averaged SAR (green curve)	0.710
Validated	

6.3 Change in WLAN band

6.4.1 Test parameters

Tech/Band/Ant/DSI	Parameters	Values
11b/ 1Mbps; 2.4GHz MIMO Main Antenna; DSI0	P_{max}	18
	Reserve margin (dB)	1
	Meas. Cond. P_{lim} (dBm)	18.63
	Meas. SAR @ P_{lim} (W/kg)	0.786
Switch time (sec)		96.5
11ac VHT20/ MCS0; 5.8GHz MIMO Main Antenna; DSI0	P_{max}	17.5
	Reserve margin (dB)	1
	Meas. Cond. P_{lim} (dBm)	10.8
	Meas. SAR @ P_{lim} (W/kg)	0.775

6.4.2 Test plots and result



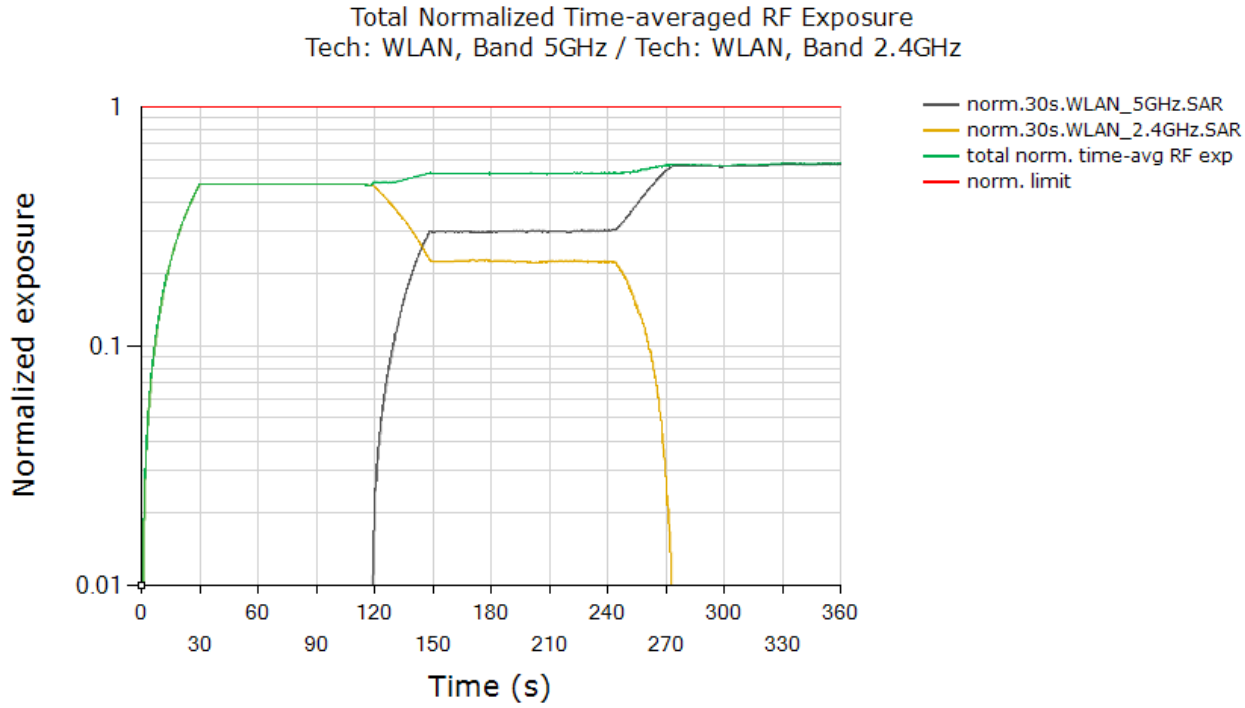
	Norm. exposure value
FCC normalized total exposure limit	1.0
Max total normalized time-averaged SAR (green curve)	0.498
Validated	

6.4 Simultaneous Transmissions

6.5.1 Test parameters

Tech/Band/Ant/DSI	Parameters	Values
11b/ 1Mbps; 2.4GHz MIMO Main antenna; DSI0	P_{max}	18
	Reserve margin (dB)	1
	Meas. Cond. P_{lim} (dBm)	18.63
	Meas. SAR @ P_{lim} (W/kg)	0.786
11ac VHT20/ MCS0; 5.8GHz MIMO Main antenna; DSI0	P_{max}	17.5
	Reserve margin (dB)	1
	Meas. Cond. P_{lim} (dBm)	10.8
	Meas. SAR @ P_{lim} (W/kg)	0.775

6.5.2 Test plots and result



	Norm. exposure value
FCC normalized total exposure limit	1.0
Max total normalized time-averaged SAR (green curve)	0.580
Validated	

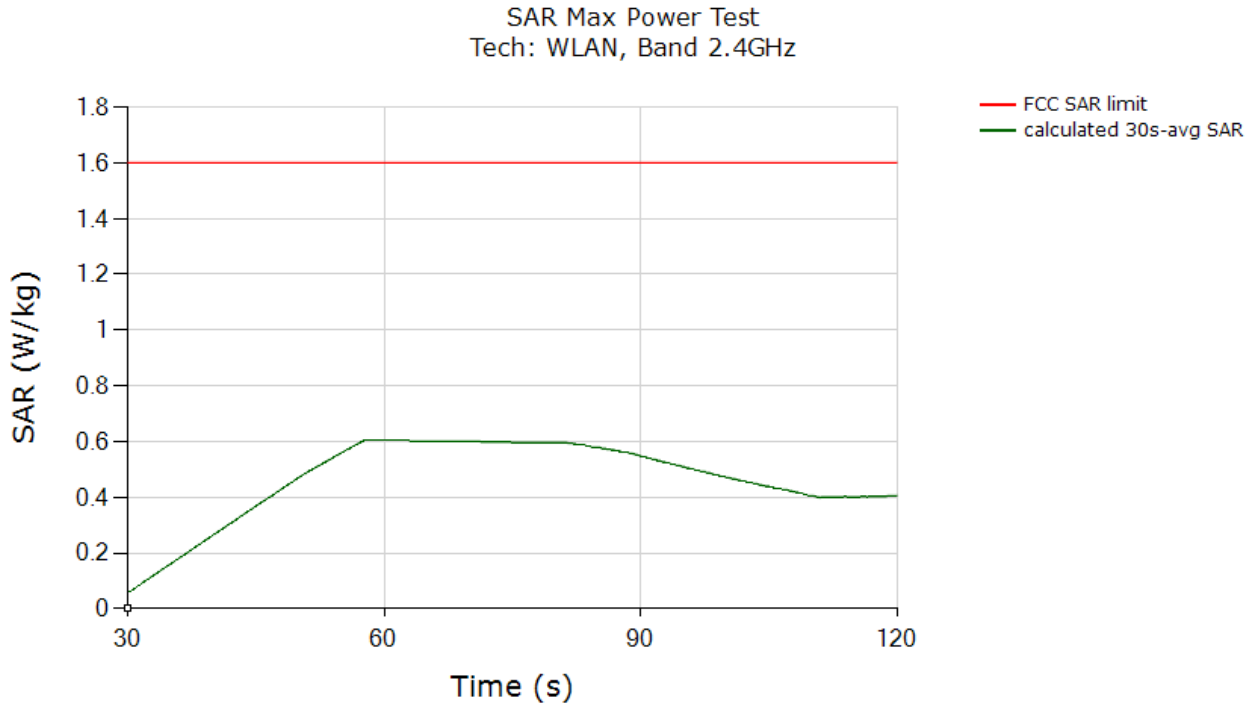
7 POINTSAR TEST

7.1 Time-Varying Test Sequence

7.1.1 Test parameters – 1st Band

Tech/Band/Ant/DSI	Parameters	Values
11b/ 1Mbps; 2.4GHz MIMO Main antenna; DSI0	Test Position	Laptop Mode
	Meas. SAR @ P_{lim} (W/kg)	0.505

7.1.2 Test plots and result – 1st Band

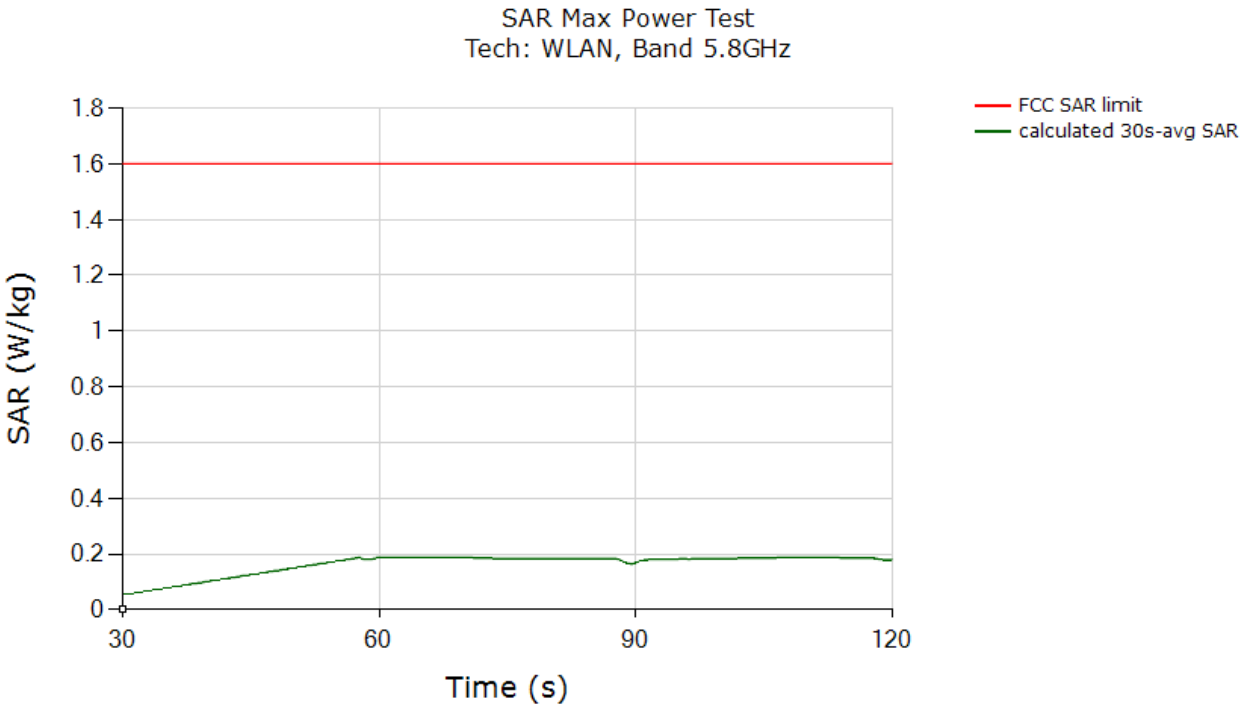


	W/Kg
FCC exposure limit	1.6
Max time-averaged SAR (green curve)	0.606
Validated	

7.1.3 Test parameters – 2nd Band

Tech/Band/Ant/DSI	Parameters	Values
11ac VHT20/ MCS0; 5.8GHz MIMO Main antenna; DSI0	Test Position	Laptop Mode
	Meas. SAR @ P_{lim} (W/kg)	0.153

7.1.4 Test plots and result – 2nd Band



	W/Kg
FCC exposure limit	1.6
Max time-averaged SAR (green curve)	0.187
Validated	

10 APPENDIXES

Refer to separated files for the following appendixes.

10.1 SAR_Appendix A Photographs

10.2 SAR_Appendix B DAE & Probe Cal. Certificate

10.3 SAR_Appendix C Phantom Description & Dipole Cal. Certificate

- End of report -