



FCC ID: AUO-LABQ3
Report No.: T200916W01-SF

Page: 1 / 36
Rev.: 01

FCC TEST REPORT

FCC 47 CFR § 2.1093
IEEE Std 1528-2013

for

LabQuest 3 with 802.11 b/g/n,BT/BLE
Model Name: LABQ3

Issued to:

Vernier Software & Technology LLC
13979 SW Millikan Way
Beaverton, OR 97005-2886, U.S.A

Issued by

Compliance Certification Services Inc.
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Report No.: T200916W01-SF

Page: 2 / 36
Rev.: 01

Revision History

Rev.	Issue Date	Revisions	Effect Page	Revised By
00	09/22/2020	Initial Issue	ALL	Sky
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Table of Contents

1	CERTIFICATE OF COMPLIANCE (SAR EVALUATION)	5
2	DESCRIPTION OF EQUIPMENT UNDER TEST	6
2.1	SUMMARY OF HIGHEST SAR VALUES	7
3	REQUIREMENTS FOR COMPLIANCE TESTING DEFINED	8
3.1	REQUIREMENTS FOR COMPLIANCE TESTING DEFINED BY THE FCC	8
4	DOSIMETRIC ASSESSMENT SYSTEM	9
4.1	MEASUREMENT SYSTEM DIAGRAM	10
4.2	SYSTEM COMPONENTS	11
5	EVALUATION PROCEDURES	14
6	SAR MEASUREMENT PROCEDURES	16
6.1	NORMAL SAR TEST PROCEDURE	16
7	MEASUREMENT UNCERTAINTY	18
8	ANTENNA LOCATION	19
9	RF EXPOSURE CONDITIONS (TEST CONFIGURATIONS)	20
9.1.	STANDALONE SAR TEST EXCLUSION CONSIDERATIONS	20
9.2.	REQUIRED TEST CONFIGURATIONS	20
10	EXPOSURE LIMIT	21
11	TISSUE DIELECTRIC PROPERTIES	22
11.1	TEST LIQUID CONFIRMATION	22
11.2	TYPICAL COMPOSITION OF INGREDIENTS FOR LIQUID TISSUE PHANTOMS	23
11.3	SIMULATING LIQUIDS PARAMETER CHECK RESULTS	24
12	SYSTEM PERFORMANCE CHECK	25
12.1	SYSTEM PERFORMANCE CHECK RESULTS	26
13	RF OUTPUT POWER MEASUREMENT	27
13.1	WI-FI 2.4GHZ (DTS BAND)	28
13.2	BLUETOOTH	29
14	MEASURED AND REPORTED (SCALED) SAR RESULTS	31
14.1.	WI-FI (DTS BAND)	32
14.2.	BLUETOOTH	32
15	SIMULTANEOUS TRANSMISSION SAR ANALYSIS	33
16	EQUIPMENT LIST & CALIBRATION STATUS	34
17	FACILITIES	35



Report No.: T200916W01-SF

Page: 4 / 36
Rev.: 01

18	REFERENCE	35
19	ATTACHMENTS	36

1 Certificate of Compliance (SAR Evaluation)

Applicant Vernier Software & Technology LLC
13979 SW Millikan Way Beaverton, OR 97005-2886, USA

Equipment Under Test: LabQuest 3

Trade Name: Vernier

Model Name: LABQ3

Date of Test: Sep 16, 2020 to Sep 17, 2020

Receive EUT Date: Sep 16, 2020

Device Category: PORTABLE DEVICES

Exposure Category: GENERAL POPULATION/UNCONTROLLED EXPOSURE

Applicable Standards	
FCC	● IEEE 1528 2013 ● KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04 ● KDB 865664 D02 RF Exposure Reporting v01r02 ● KDB 447498 D01 General RF Exposure Guidance v06 ● KDB 248227 D01 SAR Meas for 802.11 v02r02
Limit	
1.6 W/kg	
Test Result	
Pass	

The test results in this report apply only to the tested sample of the stated device/equipment. Other similar device/equipment will not necessarily produce the same results due to production tolerance and measurement uncertainties.

Approved by:



Kevin Tsai
Section Manager
Compliance Certification Services Inc.

Tested by:



Stella Chang
SAR Engineer
Compliance Certification Services Inc.

2 Description of Equipment Under Test

Product	LabQuest 3		
Trade Name	Vernier		
Model Name	LABQ3		
Wireless Technology	Operating Mode	TX Freq Range (MHz)	Peak Antenna Gain(dBi)
Modulation Technique	Bluetooth:GFSK for 1Mbps; π /4-DQPSK for 2Mbps;8DPSK for 3Mbps;LE		
	802.11b: Direct Sequence Spread Spectrum(DSSS)		
	802.11g: Orthogonal Frequency Division Multiplexing (OFDM)		
	802.11n: Orthogonal Frequency Division Multiplexing (OFDM)		
	INPAQ Antenna		
	Operating Mode	TX Freq Range (MHz)	Peak Antenna Gain (dBi)
	WLAN2.4GHz	2412~2472	3
	Bluetooth	2402~2480	3
Antenna Specification	Brand name	INPAQ	
	Type	PCB	
	Parts Number	ACA-5036-A2-CC-S	

Remark:

- 1.The sample selected for test was prototype that representative to production product and was provided by manufacturer

2.1 Summary of Highest SAR Values

Results for highest reported SAR values for each frequency band and mode are as below:

Technology/Band	Test configuration	Mode	Highest Reported 1g-SAR (W/kg)
Wi-Fi 2.4 GHz	Edge3	802.11b	0.244
Bluetooth	Edge3	GFSK	0.168

3 Requirements for Compliance Testing Defined

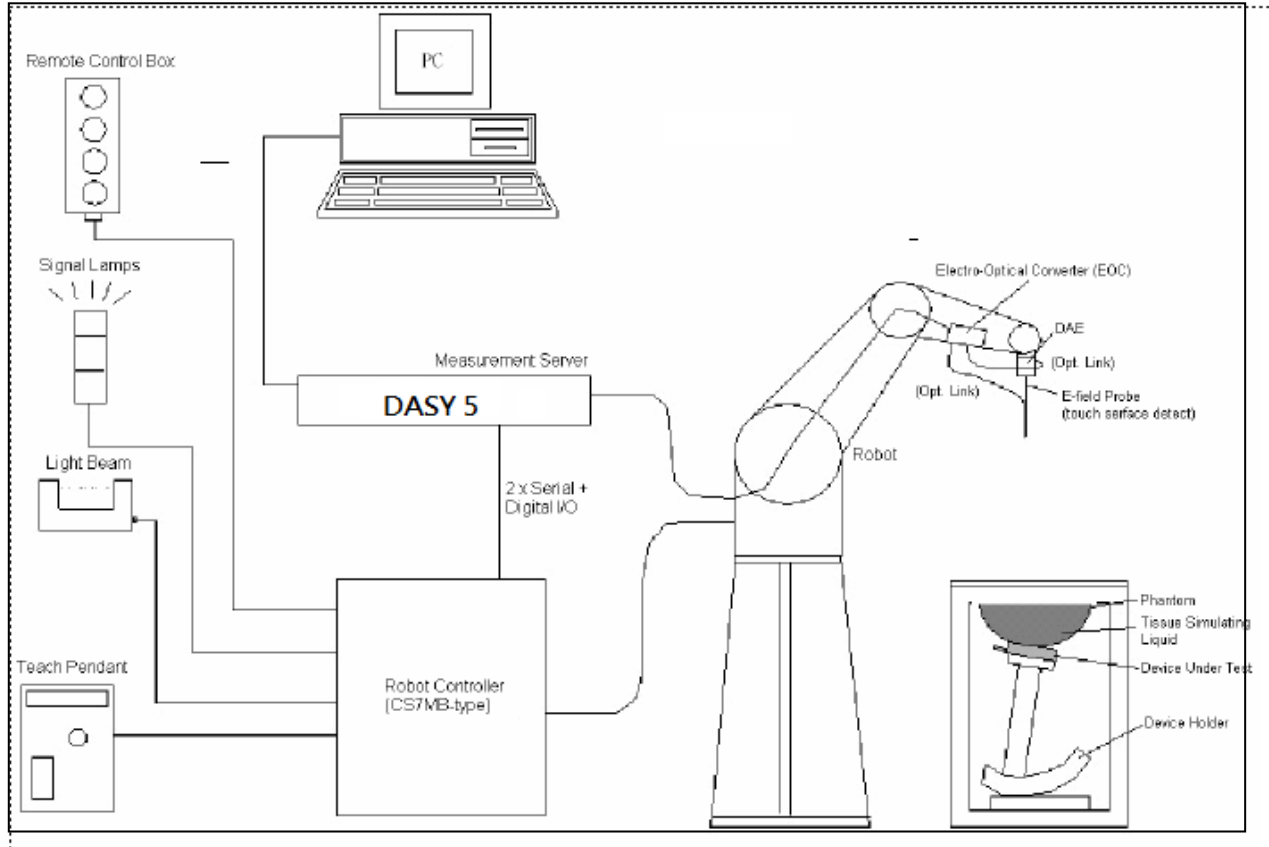
3.1 Requirements for Compliance Testing Defined by the FCC

The US Federal Communications Commission has released the report and order "Guidelines for Evaluating the Environmental Effects of RF Radiation", ET Docket No. 93-62 in August 1996 [1]. The order requires routine SAR evaluation prior to equipment authorization of portable transmitter devices, including portable telephones. For consumer products, the applicable limit is 1.6 W/kg for an uncontrolled environment and 8.0 mW/g for an occupational/controlled environment as recommended by the FCC 47 CFR §2.1093 and IEEE Std 1528-2013.

4 Dosimetric Assessment System

These measurements were performed with the automated near-field scanning system DASY5 from Schmid & Partner Engineering AG (SPEAG). The system is based on a high precision robot (working range greater than 0.9 m) which positions the probes with a positional repeatability of better than ± 0.02 mm. Special E- and H-field probes have been developed for measurements close to material discontinuity, the sensors of which are directly loaded with a Schottky diode and connected via highly resistive lines to the data acquisition unit. The SAR measurements were conducted with the dosimetric probe EX3DV4-SN: 3665 (manufactured by SPEAG), designed in the classical triangular configuration and optimized for dosimetric evaluation. The probe has been calibrated according to the procedure with accuracy of better than $\pm 10\%$. The spherical isotropy was evaluated with the procedure and found to be better than ± 0.25 dB. The phantom used was the ELI Phantom as described in FCC supplement C, IEEE 1528 2013.

4.1 Measurement System Diagram



The DASY5 system for performing compliance tests consists of the following items:

- A standard high precision 6-axis robot (Stäubli RX family) with controller, teach pendant and software. An arm extension for accommodating the data acquisition electronics (DAE).
- A dosimetric probe, i.e., an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.
- A data acquisition electronics (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.
- The Electro-optical converter (EOC) performs the conversion between optical and electrical of the signals for the digital communication to the DAE and for the analog signal from the optical surface detection. The EOC is connected to the measurement server.
- The function of the measurement server is to perform the time critical tasks such as signal filtering, control of the robot operation and fast movement interrupts.
- A probe alignment unit which improves the (absolute) accuracy of the probe positioning.
- A computer operating Windows 7 or Windows XP.
- DASY5 software version: 52.10.3.1513.
- Remote control with teach pendant and additional circuitry for robot safety such as warning lamps, etc.
- The SAM twin phantom enabling testing left-hand and right-hand usage.
- The device holder for handheld mobile phones.
- Tissue simulating liquid mixed according to the given recipes.
- Validation dipole kits allowing validating the proper functioning of the system.

4.2 System Components

DASY5 Measurement Server	
	The DASY5 measurement server is based on a PC/104 CPU board with a 166MHz low-power Pentium, 32MB chip disk and 64MB RAM. The necessary circuits for communication with either the DAE4 electronic box as well as the 16-bit AD-converter system for optical detection and digital I/O interface are contained on the DASY5 I/O-board, which is directly connected to the PC/104 bus of the CPU board. The measurement server performs all real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operation.
	The PC-operating system cannot interfere with these time critical processes. All connections are supervised by a watchdog, and disconnection of any of the cables to the measurement server will automatically disarm the robot and disable all program-controlled robot movements. Furthermore, the measurement server is equipped with two expansion slots which are reserved for future applications. Please note that the expansion slots do not have a standardized pinout and therefore only the expansion cards provided by SPEAG can be inserted. Expansion cards from any other supplier could seriously damage the measurement server. Calibration: No calibration required.
Data Acquisition Electronics (DAE)	
	The data acquisition electronics (DAE4) consists of a highly sensitive electrometer grade preamplifier with auto-zeroing, a channel and gain-switching multiplexer, a fast 16 bit AD converter and a command decoder and control logic unit. Transmission to the measurement server is accomplished through an optical downlink for data and status information as well as an optical uplink for commands and the clock. The mechanical probe mounting device includes two different sensor systems for frontal and sideways probe contacts. They are used for mechanical surface detection and probe collision detection. The input impedance of the DAE4 box is 200MΩ; the inputs are symmetrical and floating. Common mode rejection is above 80 dB.

EX3DV4 Isotropic E-Field Probe for Dosimetric Measurements



Construction:	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration:	Basic Broad Band Calibration in air: 10-3000 MHz. Conversion Factors (CF) for HSL 900 and HSL 1800 CF-Calibration for other liquids and frequencies upon request.
Frequency:	10 MHz to > 6 GHz; Linearity: ± 0.2 dB (30 MHz to 3 GHz)
Directivity:	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in HSL (rotation normal to probe axis)
Dynamic Range:	10 μ W/g to > 100 mW/g; Linearity: ± 0.2 dB (noise: typically < 1 μ W/g)
Dimensions:	Overall length: 330 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Distance from probe tip to dipole centers: 1 mm
Application:	High precision dosimetric measurements in any exposure scenario (e.g., very strong gradient fields). Only probe which enables compliance testing for frequencies up to 6 GHz with precision of better 30%.

SAM Phantom



Construction:	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 2013, CENELEC 50361 and IEC 62209. It enables the dosimetric evaluation of left and right hand phone usage as well as body mounted usage at the flat phantom region. A cover prevents evaporation of the liquid. Reference markings on the phantom allow the complete setup of all predefined phantom positions and measurement grids by manually teaching three points with the robot.
Shell Thickness:	2 $\pm$ 0.2 mm
Filling Volume:	Approx. 25 liters
Dimensions:	Height: 810mm; Length: 1000mm; Width: 500mm

ELI Phantom



Construction:	Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI4 is fully compatible with the latest draft of the standard IEC 62209 Part II and all known tissue simulating liquids. ELI4 has been optimized regarding its performance and can be integrated into our standard phantom tables. A cover prevents evaporation of the liquid. Reference markings on the phantom allow installation of the complete setup, including all predefined phantom positions and measurement grids, by teaching three points. The phantom is supported by software version DASY5 and higher and is compatible with all SPEAG dosimetric probes and dipoles
Shell Thickness:	2.0 $\pm$ 0.2 mm (sagging: <1%)
Filling Volume:	Approx. 25 liters
Dimensions:	Major ellipse axis: 600 mm Minor axis: 400 mm 500mm

Device Holder for SAM Twin Phantom



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

System Validation Kits for SAM Phantom



Construction: Symmetrical dipole with 1/4 balun Enables measurement of feedpoint impedance with NWA Matched for use near flat phantoms filled with brain simulating solutions Includes distance holder and tripod adaptor.

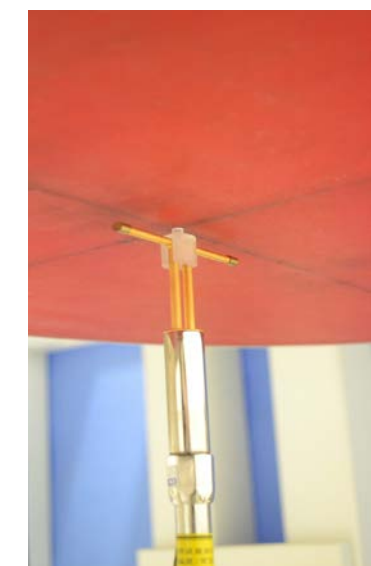
Frequency: 2450, 5300, 5600, 5800 MHz

Return loss: > 20 dB at specified validation position

Power capability: > 100 W ($f < 1\text{GHz}$); > 40 W ($f > 1\text{GHz}$)

Dimensions: D2450V2: dipole length: 51.5 mm; overall height: 290 mm
D5GHzV2: dipole length: 20.6 mm; overall height: 300 mm

System Validation Kits for ELI phantom



Construction: Symmetrical dipole with 1/4 balun Enables measurement of feedpoint impedance with NWA Matched for use near flat phantoms filled with brain simulating solutions Includes distance holder and tripod adaptor.

Frequency: 2450, 5300, 5600, 5800 MHz

Return loss: > 20 dB at specified validation position

Power capability: > 100 W ($f < 1\text{GHz}$); > 40 W ($f > 1\text{GHz}$)

Dimensions: D2450V2: dipole length: 51.5 mm; overall height: 290 mm
D5GHzV2: dipole length: 20.6 mm; overall height: 300 mm

5 Evaluation Procedures

Data Evaluation

The DASY5 post processing software (SEMCAD) automatically executes the following procedures to calculate the field units from the microvolt readings at the probe connector. The parameters used in the evaluation are stored in the configuration modules of the software:

Probe parameters:	- Sensitivity	$Norm_i, a_{i0}, a_{i1}, a_{i2}$
	- Conversion factor	$ConvF_i$
	- Diode compression point	dcp_i
Device parameters:	- Frequency	f
	- Crest factor	cf
Media parameters:	- Conductivity	σ
	- Density	ρ

These parameters must be set correctly in the software. They can be found in the component documents or be imported into the software from the configuration files issued for the DASY components. In the direct measuring mode of the multi-meter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.

The first step of the evaluation is a linearization of the filtered input signal to account for the compression characteristics of the detector diode. The compensation depends on the input signal, the diode type and the DC-transmission factor from the diode to the evaluation electronics. If the exciting field is pulsed, the crest factor of the signal must be known to correctly compensate for peak power. The formula for each channel can be given as:

$$V_i = U_i + U_i^2 \cdot \frac{cf}{dcp_i}$$

with	V_i	= Compensated signal of channel i	(i = x, y, z)
	U_i	= Input signal of channel i	(i = x, y, z)
	cf	= Crest factor of exciting field	(DASY parameter)
	dcp_i	= Diode compression point	(DASY parameter)

From the compensated input signals the primary field data for each channel can be evaluated:

E-field probes:

$$E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

H-field probes:

$$H_i = \sqrt{V_i} \cdot \frac{a_{i10} + a_{i11}f + a_{i12}f^2}{f}$$

with	V_i	= Compensated signal of channel i	(i = x, y, z)
	$Norm_i$	= Sensor sensitivity of channel i	(i = x, y, z)

$\mu V/(V/m)^2$ for E0field Probes

$ConvF$	= Sensitivity enhancement in solution
a_{ij}	= Sensor sensitivity factors for H-field probes
f	= Carrier frequency (GHz)
E_i	= Electric field strength of channel i in V/m
H_i	= Magnetic field strength of channel i in A/m

The RSS value of the field components gives the total field strength (Hermitian magnitude):

$$E_{tot} = \sqrt{E_x^2 + E_y^2 + E_z^2}$$

The primary field data are used to calculate the derived field units.

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1000}$$

with

- SAR = local specific absorption rate in W/kg
- E_{tot} = total field strength in V/m
- σ = conductivity in [mho/m] or [Siemens/m]
- ρ = equivalent tissue density in g/cm³

Note that the density is normally set to 1 (or 1.06), to account for actual brain density rather than the density of the simulation liquid.

The power flow density is calculated assuming the excitation field as a free space field.

$$P_{pwe} = \frac{E_{tot}^2}{377} \quad \text{or} \quad P_{pwe} = H_{tot}^2 \cdot 37.7$$

with

- P_{pwe} = Equivalent power density of a plane wave in mW/cm²
- E_{tot} = total electric field strength in V/m
- H_{tot} = total magnetic field strength in A/m

6 SAR Measurement Procedures

6.1 Normal SAR Test Procedure

- **Power Reference Measurement**

The reference and drift jobs are useful jobs for monitoring the power drift of the device under test in the batch process. Both jobs measure the field at a specified reference position, at a selectable distance from the phantom surface. The reference position can be either the selected section's grid reference point or a user point in this section. The reference job projects the selected point onto the phantom surface, orients the probe perpendicularly to the surface, and approaches the surface using the selected detection method.

- **Area Scan**

The area scan is used as a fast scan in two dimensions to find the area of high field values, before doing a finer measurement around the hot spot. The sophisticated interpolation routines implemented in DASY5 software can find the maximum locations even in relatively coarse grids. The scan area is defined by an editable grid. This grid is anchored at the grid reference point of the selected section in the phantom. When the area scan's property sheet is brought-up, the grid resolution has to less than 15 mm by 15 mm at frequency ≤ 2 GHz; the grid resolution has to less than 12 mm by 12 mm at frequency between 2 GHz to 4 GHz; grid resolution has to less than 10 mm by 10 mm at frequency between 4 GHz to 6 GHz.

Area Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

	≤ 3 GHz	> 3 GHz
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface	5 ± 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2) \pm 0.5$ mm
Maximum probe angle from probe axis to phantom surface normal at the measurement location	$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$
Maximum area scan spatial resolution: $\Delta x_{\text{zoom}}, \Delta y_{\text{zoom}}$	≤ 2 GHz: ≤ 15 mm $2 - 3$ GHz: ≤ 12 mm	$3 - 4$ GHz: ≤ 12 mm $4 - 6$ GHz: ≤ 10 mm
	When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be $\leq$ the corresponding x or y dimension of the test device with at least one measurement point on the test device.	

• Zoom Scan

Zoom scans are used to assess the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. The default zoom scan measures points in accordance with the frequency can be divided into three parts. (1)The zoom scan volume was set to 5x5x7 points at frequency ≤ 2 GHz. (2) The zoom scan volume was set to 7x7x7 points at frequency between 2GHz to 4GHz (3) The zoom scan volume was set to 7x7x12 points at frequency between 4GHz to 6GHz. The measures points within a cube whose base faces are centered around the maximum found in a preceding area scan job within the same procedure. If the preceding Area Scan job indicates more then one maximum, the number of Zoom Scans has to be enlarged accordingly.

Zoom Scan Parameters extracted from KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz

			≤ 3 GHz	> 3 GHz
Maximum zoom scan spatial resolution: $\Delta x_{\text{Zoom}}, \Delta y_{\text{Zoom}}$			≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm	3 – 4 GHz: ≤ 5 mm 4 – 6 GHz: ≤ 4 mm
Maximum zoom scan spatial resolution, normal to phantom surface	Uniform grid: $\Delta z_{\text{Zoom}}(n)$		≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm
	graded grid	$\Delta z_{\text{Zoom}}(1)$:between 1 st two points loiest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{\text{Zoom}}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{\text{Zoom}}(n-1)$	
Maximum zoom scan volume	x, y, z	≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm	

• Power Drift Measurement

The drift job measures the field at the same location as the most recent reference job within the same procedure, and with the same settings. The drift measurement gives the field difference in dB from the reading conducted within the last reference measurement. Several drift measurements are possible for one reference measurement. This allows a user to monitor the power drift of the device under test within a batch process. In the properties of the Drift job, the user can specify a limit for the drift and have DASY5 software stop the measurements if this limit is exceeded.

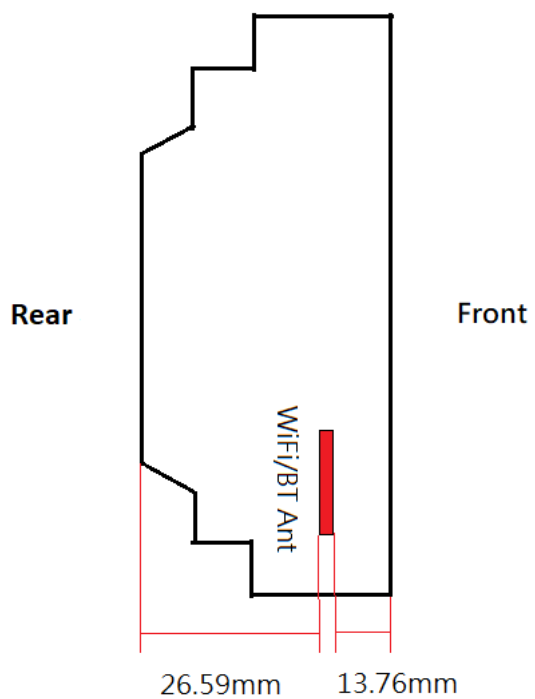
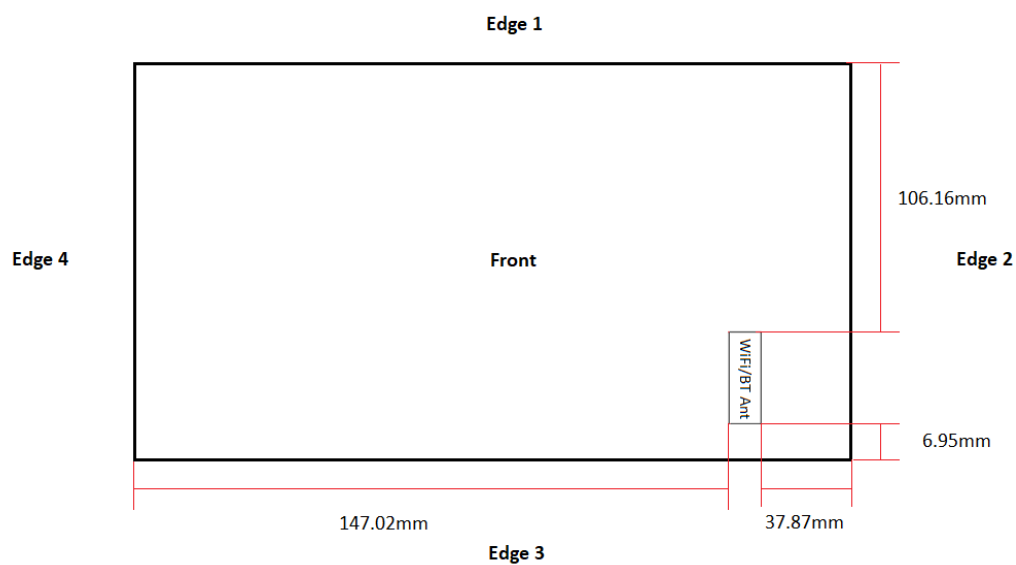
• Z-Scan

The Z Scan job measures points along a vertical straight line. The line runs along the Z-axis of a one-dimensional grid. A user can anchor the grid to the current probe location. As with any other grids, the local Z-axis of the anchor location establishes the Z-axis of the grid.

7 Measurement Uncertainty

According to KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz section 2.8.2, SAR measurement uncertainty analysis is required in SAR reports only when the highest measured SAR in a frequency band is ≥ 1.5 W/kg for 1-g SAR, the extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

8 Antenna Location



9 RF Exposure Conditions (Test Configurations)

Please refer to chapter 8 for detailed information about antenna-to-antenna distance and antenna-to-edge distance.

9.1. STANDALONE SAR TEST EXCLUSION CONSIDERATIONS

Since the *Dedicated Host Approach* is applied, the standalone SAR test exclusion procedure in KDB 447498 § 4.3.1 is applied in conjunction with KDB 616217 § 4.3 to determine the minimum test separation distance:

- o When the separation distance from the antenna to an adjacent edge is ≤ 5 mm, a distance of 5 mm is applied to determine SAR test exclusion.
- o When the separation distance from the antenna to an adjacent edge is > 5 mm, the actual antenna-to-edge separation distance is applied to determine SAR test exclusion.

SAR Test Exclusion Calculations for WWAN

Antennas < 50mm to adjacent edges

Tx Interface	Frequency (MHz)	Output Power		Separation Distances (mm)					Calculated Threshold Value				
		dBm	mW	Rear	Edge 1	Edge 2	Edge 3	Edge 4	Rear	Edge 1	Edge 2	Edge 3	Edge 4
Wi-Fi 2.4 GHz	2462	13.50	22	26.59	106.16	147.02	6.95	37.87	1.3 -EXEMPT-	> 50 mm	> 50 mm	4.9 -MEASURE-	0.9 -EXEMPT-
Bluetooth	2480	12.50	18	26.59	106.16	147.02	6.95	37.87	1 -EXEMPT-	> 50 mm	> 50 mm	4 -MEASURE-	0.7 -EXEMPT-

Note(s):

According to KDB 447498, if the calculated threshold value is >3 then SAR testing is required.

Antennas > 50mm to adjacent edges

Tx Interface	Frequency (MHz)	Output Power		Separation Distances (mm)					Calculated Threshold Value				
		dBm	mW	Rear	Edge 1	Edge 2	Edge 3	Edge 4	Rear	Edge 1	Edge 2	Edge 3	Edge 4
Wi-Fi 2.4 GHz	2462	13.50	22	26.59	106.16	147.02	6.95	37.87	< 50 mm	657.2 mW -EXEMPT-	1065.8 mW -EXEMPT-	< 50 mm	< 50 mm
Bluetooth	2480	12.50	18	26.59	106.16	147.02	6.95	37.87	< 50 mm	656.9 mW -EXEMPT-	1065.5 mW -EXEMPT-	< 50 mm	< 50 mm

Note(s):

According to KDB 447498, if the calculated Power threshold is less than the output power then SAR testing is required.

9.2. REQUIRED TEST CONFIGURATIONS

The table below identifies the standalone test configurations required for this device according to the findings in Section 9.1:

Test Configurations	Rear	Edge 1	Edge 2	Edge 3	Edge 4
Wi-Fi 2.4 GHz	No	No	No	Yes	No
Bluetooth	No	No	No	Yes	No

Note(s):

Yes = Testing is required.

No = Testing is not required.

10 Exposure Limit

(A). Limits for Occupational/Controlled Exposure (W/kg)

<u>Whole-Body</u>	<u>Partial-Body</u>	<u>Hands, Wrists, Feet and Ankles</u>
0.4	8.0	2.0

(B). Limits for General Population/Uncontrolled Exposure (W/kg)

<u>Whole-Body</u>	<u>Partial-Body</u>	<u>Hands, Wrists, Feet and Ankles</u>
0.08	1.6	4.0

NOTE: **Whole-Body SAR** is averaged over the entire body, **partial-body SAR** is averaged over any 1 gram of tissue defined as a tissue volume in the shape of a cube. **SAR for hands, wrists, feet and ankles** is averaged over any 10 grams of tissue defined as a tissue volume in the shape of a cube.

Population/Uncontrolled Environments:

are defined as locations where there is the exposure of individuals who have no knowledge or control of their exposure.

Occupational/Controlled Environments:

are defined as locations where there is exposure that may be incurred by people who are aware of the potential for exposure, (i.e. as a result of employment or occupation).

NOTE

**GENERAL POPULATION/UNCONTROLLED EXPOSURE
PARTIAL BODY LIMIT
1.6 W/kg**

11 Tissue Dielectric Properties

11.1 Test Liquid Confirmation

Simulating Liquids Parameter Check

The simulating liquids should be checked at the beginning of a series of SAR measurements to determine if the dielectric parameters are within the tolerances of the specified target values

The relative permittivity and conductivity of the tissue material should be within $\pm 5\%$ of the values given in the table below. 5% may not be easily achieved at certain frequencies.

The head tissue dielectric parameters recommended by the IEEE SCC-34/SC-2 in IEEE 1528 2013 have been incorporated in the following table. These head parameters are derived from planar layer models simulating the highest expected SAR for the dielectric properties and tissue thickness variations in a human head. Other head tissue parameters that have not been specified in IEEE 1528 2013 are derived from the tissue dielectric parameters computed from the 4-Cole-Cole equations and extrapolated according to the head parameters specified in IEEE 1528 2013

Target Frequency (MHz)	Head	
	ϵ_r	σ (S/m)
150	52.3	0.76
300	45.3	0.87
450	43.5	0.87
835	41.5	0.90
900	41.5	0.97
915	41.5	0.98
1450	40.5	1.20
1610	40.3	1.29
1800 – 2000	40.0	1.40
2450	39.2	1.80
3000	38.5	2.40
5000	36.2	4.45
5100	36.1	4.55
5200	36.0	4.66
5300	35.9	4.76
5400	35.8	4.86
5500	35.6	4.96
5600	35.5	5.07
5700	35.4	5.17
5800	35.3	5.27

IEEE Std 1528-2013

Refer to Table 3 within the IEEE Std 1528-2013

11.2 Typical Composition of Ingredients for Liquid Tissue Phantoms

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

Ingredients (% by weight)	Frequency (MHz)									
	450		835		915		1900		2450	
Tissue Type	Head	Body	Head	Body	Head	Body	Head	Body	Head	Body
Water	38.56	51.16	41.45	52.4	41.05	56.0	54.9	40.4	62.7	73.2
Salt (NaCl)	3.95	1.49	1.45	1.4	1.35	0.76	0.18	0.5	0.5	0.04
Sugar	56.32	46.78	56.0	45.0	56.5	41.76	0.0	58.0	0.0	0.0
HEC	0.98	0.52	1.0	1.0	1.0	1.21	0.0	1.0	0.0	0.0
Bactericide	0.19	0.05	0.1	0.1	0.1	0.27	0.0	0.1	0.0	0.0
Triton X-100	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	36.8	0.0
DGBE	0.0	0.0	0.0	0.0	0.0	0.0	44.92	0.0	0.0	26.7
Dielectric Constant	43.42	58.0	42.54	56.1	42.0	56.8	39.9	54.0	39.8	52.5
Conductivity (S/m)	0.85	0.83	0.91	0.95	1.0	1.07	1.42	1.45	1.88	1.78

alt: 99% Pure Sodium Chloride

Sugar: 98% Pure Sucrose

Water: De-ionized, 16 MΩ⁺ resistivity

HEC: Hydroxy thyl Cellulose

DGBE: 99% Di(ethylene glycol) butyl ether, [2-(2-butoxyethoxy)ethanol]

Triton X-100 (ultra-pure): Polyethylene glycol mono [4-(1, 1, 3, 3-tetramethylbutyl)phenyl]ether

Simulating Liquids for 5 GHz, Manufactured by SPEAG

Ingredients	(% by weight)
Water	78
Mineral oil	11
Emulsifiers	9
Additives and Salt	2

11.3 Simulating Liquids Parameter Check Results

Date	Tissue Type	Frequency (MHz)	Relative Permittivity (ϵ_r)			Conductivity (σ)		
			Measured	Target	Delta (%)	Measured	Target	Delta (%)
2020/9/17	Head	2402	38.36	39.30	-2.39	1.78	1.76	0.97
		2412	38.33	39.28	-2.42	1.79	1.77	1.08
		2437	38.24	39.23	-2.52	1.81	1.79	1.40
		2441	38.22	39.22	-2.55	1.82	1.79	1.40
		2450	38.19	39.20	-2.58	1.83	1.80	1.56
		2462	38.15	39.18	-2.63	1.84	1.81	1.71
		2480	38.09	39.16	-2.73	1.87	1.83	1.80

12 System Performance Check

The system performance check is performed prior to any usage of the system in order to guarantee reproducible results. The system performance check verifies that the system operates within its specifications. The system performance check results are tabulated below. And also the corresponding SAR plot is attached as well in the SAR plots files.

System Performance Check Measurement Conditions

- The measurements were performed in the flat section of the SAM twin phantom filled with Head simulating liquid of the following parameters.
- The DASY5 system with an E-field probe EX3DV4 SN: 3665 was used for the measurements.
- The dipole was mounted on the small tripod so that the dipole feed point was positioned below the center marking of the flat phantom section and the dipole was oriented parallel to the body axis (the long side of the phantom). The standard measuring distance was 15 mm (below 1 GHz) and 10 mm (above 1 GHz) from dipole center to the simulating liquid surface.
- The coarse grid with a grid spacing of 10mm was aligned with the dipole.
- Special 7x7x7 fine cube was chosen for cube integration ($dx=dy=5\text{ mm}$, $dz=5\text{ mm}$).
- Distance between probe sensors and phantom surface was set to 3.0 mm.
- The dipole input power (forward power) was $250\text{ mW} \pm 3\%$ (below 2GHz) and $100\text{ mW} \pm 3\%$
- The results are normalized to 1 W input power.

Reference SAR Values for System Performance Check

The reference SAR values can be obtained from the calibration certificate of system validation dipoles

System Dipole	Serial No.	Cal. Date	Freq. (MHz)	Target SAR Values (W/kg)	
				1g/10g	Head
D2450V2	727	2021/04/22	2450	1g	52.6
				10g	24.7

Report No.: T200916W01-SF

Page: 26 / 36

Rev.: 01

12.1 System Performance Check Results

Date	System Dipole			Parameters	Target[W/kg]	Measured [W/kg]	Deviation[%]	Limited[%]
	Type	Serial No.	Liquid					
2020/9/17	D2450V2	727	Head	1g SAR:	52.6	53.2	1.14	± 10
				10g SAR:	24.7	24.0	-2.67	± 10

13 RF Output Power Measurement

According to KDB248227 D01 802.11 Wi-Fi SAR v02r02 section 4, the default power measurement procedures are:

- 1) Power must be measured at each transmit antenna port according to the DSSS and OFDM transmission configurations in each standalone and aggregated frequency band.
- 2) Power measurement is required for the transmission mode configuration with the highest maximum output power specified for production units.
 - a) When the same highest maximum output power specification applies to multiple transmission modes, the largest channel bandwidth configuration with the lowest order modulation and lowest data rate is measured.
 - b) When the same highest maximum output power is specified for multiple largest channel bandwidth configurations with the same lowest order modulation or lowest order modulation and lowest data rate, power measurement is required for all equivalent 802.11 configurations with the same maximum output power.
- 3) For each transmission mode configuration, power must be measured for the highest and lowest channels; and at the mid-band channel(s) when there are at least 3 channels. For configurations with multiple mid-band channels, due to an even number of channels, both channels should be measured.

13.1 WI-FI 2.4GHZ (DTS BAND)

Band	Mode	Data Rate	Ch #	Freq. (MHz)	Meas. Avg Pwr (dBm)	Max Output Power (dBm)	SAR Test (Yes/No)
2.4GHz (DTS)	802.11b	1 Mbps	1	2412	12.97	13.5	Yes
			6	2437	11.95		
			11	2462	12.06		
	802.11g	6 Mbps	1	2412	Not Required	10.5	No
			6	2437		13.0	
			11	2462		8.5	
	802.11n (HT20)	MCS0	1	2412		9.5	No
			6	2437		12.0	
			11	2462		9.5	
	802.11n (HT40)	MCS0	3	2422		7.5	No
			6	2437		9.5	
			9	2452		6.5	

Note(s):

- Output Power and SAR is not required for 802.11 g/n HT20 channels when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output power and the adjusted SAR is ≤ 1.2 W/kg.

13.2 Bluetooth

Average Power Measured Results

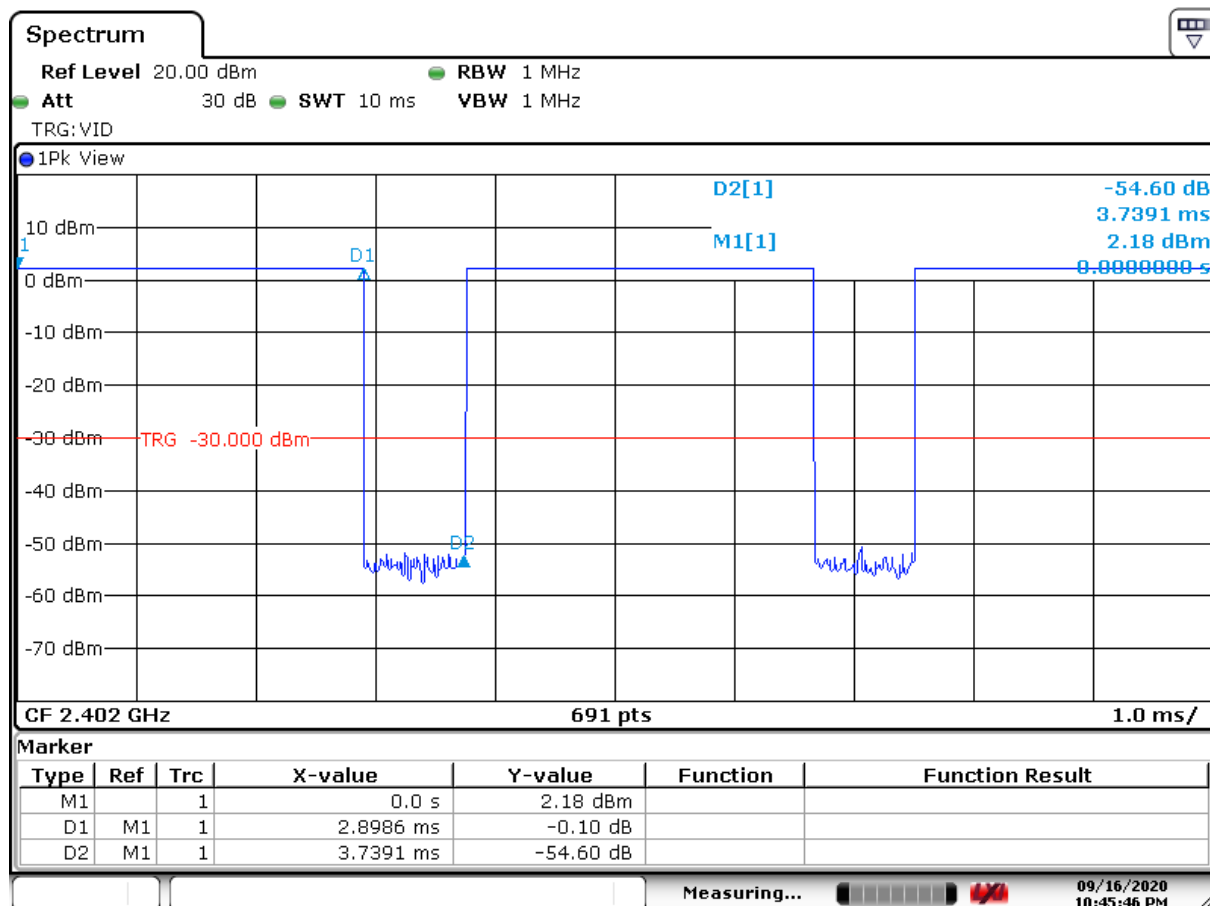
Band (GHz)	Mode	Data Rate	Ch #	Freq. (MHz)	Meas. Avg Pwr (dBm)	Max Output Power (dBm)	SAR Test (Yes/No)
2.4	BR GFSK	1 Mbps	0	2402	12.60	13	Yes
			39	2441	12.53		
			78	2480	12.66		
	EDR, $\pi/4$ DQPSK	2 Mbps	0	2402	Not Required	7	No
			39	2441			
			78	2480			
	EDR, 8-DPSK	3 Mbps	0	2402		7	No
			39	2441			
			78	2480			
	LE, GFSK	1 Mbps	0	2402		10	No
			19	2440			
			39	2480			

Duty Factor Measured Results

Mode	Type	T on (ms)	Period (ms)	Duty Cycle	Crest Factor (1/duty cycle)
GFSK	DH5	2.8986	3.7391	77.5%	1.29

Duty Cycle plots

GFSK



14 Measured and Reported (Scaled) SAR Results

SAR Test Reduction criteria are as follows:

KDB 447498 D01 General RF Exposure Guidance:

Testing of other required channels within the operating mode of a frequency band is not required when the reported 1-g or 10-g SAR for the mid-band or highest output power channel is:

- ≤ 0.8 W/kg or 2.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≤ 100 MHz
- ≤ 0.6 W/kg or 1.5 W/kg, for 1-g or 10-g respectively, when the transmission band is between 100 MHz and 200 MHz
- ≤ 0.4 W/kg or 1.0 W/kg, for 1-g or 10-g respectively, when the transmission band is ≥ 200 MHz

KDB 248227 D01 SAR meas for 802.11:

SAR test reduction for 802.11 Wi-Fi transmission mode configurations are considered separately for DSSS and OFDM. An initial test position is determined to reduce the number of tests required for certain exposure configurations with multiple test positions. An initial test configuration is determined for each frequency band and aggregated band according to maximum output power, channel bandwidth, wireless mode configurations and other operating parameters to streamline the measurement requirements. For 2.4 GHz DSSS, either the initial test position or DSSS procedure is applied to reduce the number of SAR tests; these are mutually exclusive. For OFDM, an initial test position is only applicable to next to the ear, UMPC mini-tablet and hotspot mode configurations, which is tested using the initial test configuration to facilitate test reduction. For other exposure conditions with a fixed test position, SAR test reduction is determined using only the initial test configuration.

The multiple test positions require SAR measurements in head, hotspot mode or UMPC mini-tablet configurations may be reduced according to the highest reported SAR determined using the initial test position(s) by applying the DSSS or OFDM SAR measurement procedures in the required wireless mode test configuration(s). The initial test position(s) is measured using the highest measured maximum output power channel in the required wireless mode test configuration(s). When the reported SAR for the initial test position is:

- ≤ 0.4 W/kg, further SAR measurement is not required for the other test positions in that exposure configuration and wireless mode combination within the frequency band or aggregated band. DSSS and OFDM configurations are considered separately according to the required SAR procedures.
- > 0.4 W/kg, SAR is repeated using the same wireless mode test configuration tested in the initial test position to measure the subsequent next closet/smallest test separation distance and maximum coupling test position, on the highest maximum output power channel, until the reported SAR is ≤ 0.8 W/kg or all required test positions are tested.
 - o For subsequent test positions with equivalent test separation distance or when exposure is dominated by coupling conditions, the position for maximum coupling condition should be tested.
 - o When it is unclear, all equivalent conditions must be tested.
- For all positions/configurations tested using the initial test position and subsequent test positions, when the reported SAR is > 0.8 W/kg, measure the SAR for these positions/configurations on the subsequent next highest measured output power channel(s) until the reported SAR is ≤ 1.2 W/kg or all required test channels are considered.
 - o The additional power measurements required for this step should be limited to those necessary for identifying subsequent highest output power channels to apply the test reduction.
- When the specified maximum output power is the same for both UNII 1 and UNII 2A, begin SAR measurements in UNII 2A with the channel with the highest measured output power. If the reported SAR for UNII 2A is ≤ 1.2 W/kg, SAR is not required for UNII 1; otherwise treat the remaining bands separately and test them independently for SAR.
- When the specified maximum output power is different between UNII 1 and UNII 2A, begin SAR with the band that has the higher specified maximum output. If the highest reported SAR for the band with the highest specified power is ≤ 1.2 W/kg, testing for the band with the lower specified output power is not required; otherwise test the remaining bands independently for SAR.

To determine the initial test position, Area Scans were performed to determine the position with the *Maximum Value of SAR (measured)*. The position that produced the highest *Maximum Value of SAR* is considered the worst case position; thus used as the initial test position.

14.1. Wi-Fi (DTS Band)

Mode	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		1-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
802.11b 1Mbps	0	Edge 3	1	2412	94.8%	13.5	12.97	0.195	0.232	
			6	2437	94.8%	13.5	11.95	0.162	0.244	1
			11	2462	94.8%	13.5	12.06	0.145	0.213	

14.2. Bluetooth

Mode	Dist. (mm)	Test Position	Ch #.	Freq. (MHz)	Duty Cycle	Power (dBm)		1-g SAR (W/kg)		Plot No.
						Tune-up Limit	Meas.	Meas.	Scaled	
GFSK	0	Edge3	0	2402	77.5%	13.0	12.60	0.100	0.141	
			39	2441	77.5%	13.0	12.53	0.117	0.168	2
			78	2480	77.5%	13.0	12.66	0.093	0.130	

15 Simultaneous Transmission SAR Analysis

DTS cannot transmit simultaneously with Bluetooth.

16 Equipment List & Calibration Status

Dielectric Property Measurements

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Network Analyzer	Anritsu	MS46322B	1740002	2021/1/1
Dielectric Assessment Kit	SPEAG	DAK-3.5	1053	2021/1/27
Thermometer	DER EE	DE-3003	P0006880	2020/12/19

System Check

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
MXG Analog Signal Generator	Agilent	N5181A	MY50141235	2021/5/3
Power Meter	Agilent	E4417A	MY51410006	2021/3/8
Power Sensor	Agilent	E9301H	MY51470001	2021/3/8
Power Sensor	Agilent	E9301H	MY51470002	2021/3/8
Dual Directional Coupler	Agilent	772D	MY46151242	2021/8/16
Amplifier	EMCI	ZVE-8G	980190	N/A
Dosimetric E-Field Probe	SPEAG	EX3DV4	3665	2021/8/19
Data Acquisition Electronics	SPEAG	DAE4	856	2021/4/22
System Validation Dipole	SPEAG	D2450V2	727	2021/4/21
Humidity/Temp meter	TECPEL	DTM-303A	TP130074	2021/4/9
Thermometer	DER EE	DE-3003	P0006880	2020/12/19

Software Version

DASY NEO52 10.3.1513

SEMCAD-X-PostPro

17 Facilities

All measurement facilities used to collect the measurement data are located at

☒ No.11, Wugong 6th Rd., Wugu Dist., New Taipei City 24891, Taiwan. (R.O.C.)

18 Reference

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19 Attachments

Exhibit	Content
1	System Performance Check Plots
2	SAR Test Data Plots
3	SAR Equipment calibration report
4	T200916W01-SF PHOTOS

END OF REPORT