SAR TEST REPORT

for

Texas Instruments Incorporated

TI-Nspire CX Wireless Network Adapter v2

Model No.: TINAVWNA2

FCC ID: V7R-TINAVWNA2

The MAX Report SAR(1g)	
Body SAR	0.298W/Kg

Test distance: 0mm

Prepared for : Texas Instruments Incorporated
12500 TI Boulevard Dallas, TX 75243 4136 USA

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Report No. : ACS-SF24001

Date of Test : Dec.28, 2023

Date of Report : Feb.21, 2024

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Applicant	:	Texas Instruments Incorporated
Product	:	TI-Nspire CX Wireless Network Adapter v2
Model No.	:	TINAVWNA2
FCC ID	:	V7R-TINAVWNA2
Test Voltage	:	DC 3.7V From Battery

Measurement Standard Used:

- FCC 47 CFR Part 2 (2.1093)
- IEEE C95.1-1999
- IEC/IEEE 62209-1528: 2020
- IEC62209-1:2016
- IEC62209-2:2010
- FCC OET Bulletin 65 Supplement C (Edition 01-01)
- RSS-102 ISSUE 5: 2015+A1: 2021
- FCC KDB 447498 D01 v06
- FCC KDB 447498 D04 v01
- FCC KDB 865664 D01/D02
- FCC KDB 248227 D01 v02r02

The device described above is tested by Audix Technology (Shenzhen) Co., Ltd. to determine the maximum emission levels emanating from the device and the severe levels of the device can endure and its performance criterion. The test results are contained in this test report and Audix Technology (Shenzhen) Co., Ltd. is assumed full responsibility for the accuracy and completeness of test. This report contains data that are not covered by the NVLAP accreditation. Also, this report shows that the EUT is technically compliant with the FCC test requirements.

This report applies to single evaluation of one sample of above mentioned product. This report shall not be reproduced in part without written approval of Audix Technology (Shenzhen) Co., Ltd.

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Date of Test : Dec.28, 2023 Date of Report: Feb.21, 2024

Prepared by : Jasmine Ning
Jasmine Ning / Assistant

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Audix Technology (Shenzhen) Co., Ltd.
EMC 部門報告專用章
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Approved & Authorized Signer : Sunny Lu
Sunny Lu / Manager

Modified History

Edition No.	Summary	Date of Rev.	Report No.
0	Original Report.	Jul.07, 2016	ACS-SF16004
Rev.01	1. Antenna Information change 2. Antenna location and components change	Nov.30, 2017	EM-SR170017& EM-SR170018
Rev.02	1. Upgrade Chip version 2. Manufacturer and Manufacturer Address change	Feb.21, 2024	ACS-SF24001

1. GENERAL INFORMATION

1.1.Description of Equipment Under Test

Applicant	Texas Instruments Incorporated
Applicant Address	12500 TI Boulevard Dallas, TX 75243 4136 USA
Manufacturer	Texas Instruments Incorporated
Manufacturer Address	12500 TI Boulevard Dallas, TX 75243 4136 USA
Product	TI-Nspire CX Wireless Network Adapter v2
Model No.	TINAVWNA2
FCC ID	V7R-TINAVWNA2
Radio	2.4GHz Wi-Fi; 5GHz Wi-Fi
Sample Type	Prototype production
Date of Receipt	Dec.25, 2023
Date of Test	Dec.28, 2023

1.2.Feature of Equipment under Test

Product Feature & Specification		
Product	TI-Nspire CX Wireless Network Adapter v2	
Model No.	TINAVWNA2	
Power Source	☐ Commercial Power	AC 100~240 V
	☐ External Power Source	DC V
	☒ Li-ion Battery	DC 3.7V
	☐ UM battery	DC V
2.4GHz Wi-Fi		
Support Modes	802.11b/g/n20	
Frequency Range	2412-2462MHz	
Type of Modulation	802.11b(DSSS): CCK, QPSK, BPSK; 802.11g/n(OFDM): 64QAM,16QAM, QPSK, BPSK	
Data Rate	802.11b: 1/2/5.5/11 Mbps; 802.11g: 6/9/12/18/24/36/48/54 Mbps; 802.11n: up to 150Mbps	
Channel Separation	5MHz	
5GHz Wi-Fi		
Support Modes	802.11a/n20	
Frequency Range	5180-5240MHz, 5745-5825MHz	
Type of Modulation	802.11a/n (OFDM): QPSK, BPSK, 16QAM, 64QAM	
Data Rate	802.11a: 6/9/12/18/24/36/48/54 Mbps; 802.11n: up to 150Mbps;	
Channel Separation	5MHz	
Antenna System		
Type of Antenna & Antenna Peak Gain	(see table below)	

	Manufacturer	Type	Antenna Gain	Different
Original Antenna	MURATA	Chip Dielectric Antenna	1.5dBi at 2.4GHz band 1.5dBi at 5GHz band	**1.Frequency range:** 2403 ~2518MHz 5125 ~5695MHz **2. Size:** 7x2.5x1.2mm **3. Matching circuit:** L5=2.7nH, L6=DNP, C24=1pF
New Antenna	ACON	Coupling Ceramics Chip Antenna	3.79dBi at 2.4GHz band 2.24dBi for 5GHz band I 3.29dBi for 5GHz Band III	**1.Frequency range:** 2400 ~2500MHz 5000 ~6000MHz **2. Size:** 5.2x3.7x0.7mm **3. Matching circuit:** L5=1nH, L6=2.7nH, L7=0ohm, R30=0.3Nf, C31=DNP

2. GENERAL DESCRIPTION

2.1.Product Description For EUT

[None]

2.2.Applied Standards

The Specific Absorption Rate (SAR) testing specification, method and procedure for this device is in accordance with the following standards:

- FCC 47 CFR Part 2 (2.1093)
- IEEE C95.1-1999
- IEC/IEEE 62209-1528: 2020
- IEC62209-1:2016
- IEC62209-2:2010
- FCC OET Bulletin 65 Supplement C (Edition 01-01)
- RSS-102 ISSUE 5: 2015+A1: 2021
- FCC KDB 447498 D01 v06
- FCC KDB 447498 D04 v01
- FCC KDB 865664 D01/D02
- FCC KDB 248227 D01 v02r02

2.3.Device Category and SAR Limits

This device belongs to portable device category because its radiating structure is allowed to be used within 20 centimeters of the body of the user. Limit for General Population/Uncontrolled exposure should be applied for this device, it is 1.6 W/kg as averaged over any 1 gram of tissue.

2.4.Test Conditions

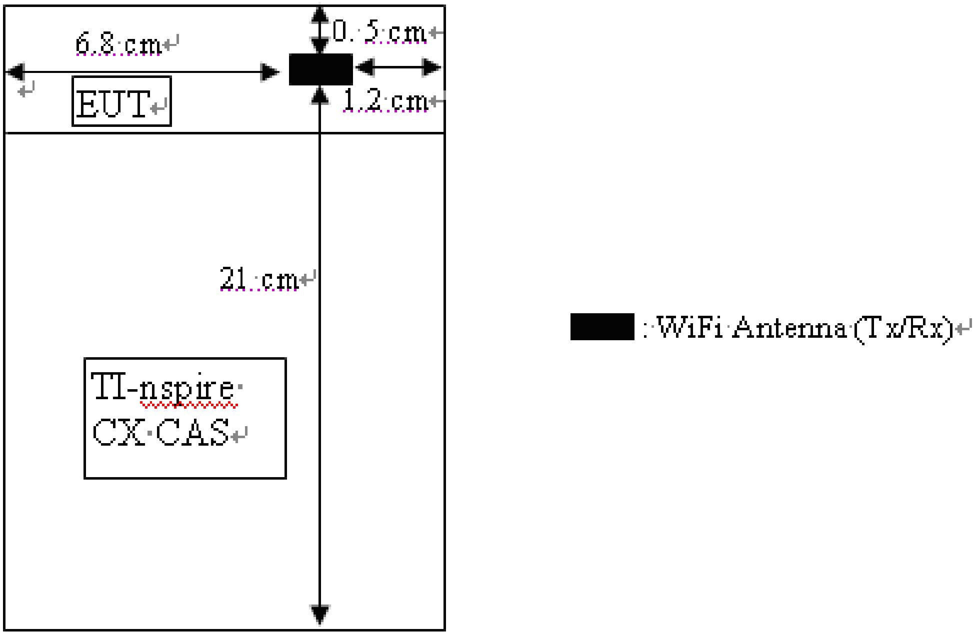
2.4.1. **Ambient Condition**

Ambient Temperature	20 to 24 ℃
Humidity	< 60 %

2.4.2. **Test Configuration**

The distance between the EUT and the antenna of the emulator is larger than 50 cm and the output power radiated from the emulator antenna is at least 30dB smaller than the output power of EUT. The EUT was set from the emulator to radiate maximum output power during all tests.

2.5.Exposure Positions Consideration



Sides for SAR tests Test distance: 0 mm(Body)										
Band	Body						Head Touch		Head (15°)	
	Back	Front	Top	Bottom	Left	Right	Left	Right	Left	Right
WLAN 2.4GHz	✓	X	✓	X	X	X	X	X	X	X
WLAN 5GHz	✓	X	✓	X	X	X	X	X	X	X

Note:

1. **The length of the diagonal dimension of the EUT is less than 20cm.**
2. **The side which has a distance larger than 2.5cm from antenna can be excluded from SAR measurement.**

2.6. Standalone SAR Test Exclusion Considerations

Standalone 1-g head or body SAR evaluation by measurement or numerical simulation is not required when the corresponding SAR Exclusion Threshold condition, listed below, is satisfied. The 1-g SAR test exclusion threshold for 100 MHz to 6 GHz at test separation distances ≤ 50 mm are determined by:
[(max. power of channel, including tune-up tolerance, mW) / (min. test separation distance, mm)] ·[√f(GHz)] ≤ 3.0 for 1-g SAR, where

- f(GHz) is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation
- The result is rounded to one decimal place for comparison

According to the KDB447498 appendix A, the SAR test exclusion threshold for 2450MHz at 5mm test separation distances is 3mW, 5.8GHz is 1mW

Table B.2—Example Power Thresholds (mW)

Frequency (MHz)	Distance (mm)									
	5	10	15	20	25	30	35	40	45	50
300	39	65	88	110	129	148	166	184	201	217
450	22	44	67	89	112	135	158	180	203	226
835	9	25	44	66	90	116	145	175	207	240
1900	3	12	26	44	66	92	122	157	195	236
2450	3	10	22	38	59	83	111	143	179	219
3600	2	8	18	32	49	71	96	125	158	195
5800	1	6	14	25	40	58	80	106	136	169

2.7.EUT Configuration and operation conditions for test.

EUT

(EUT: TI-Nspire CX Wireless Network Adapter v2**)**

2.8.Test Equipments

Item	Equipment	Manufacturer	Model No.	Serial No.	Calibration Date	Calibration Due Date	Calibration Body	Cal Method (Note)
1.	DASY5 SAR Test System	Speag	TX60 L speag	F09/5B1H1/01	NCR	NCR	NCR	N/A
2.	Power meter	Anritsu	ML2487A	6K00003262	2023.06.26	2024.06.25	CCIC	c)
3.	Power sensor	Anritsu	MA2491A	0332516	2023.06.26	2024.06.25	CCIC	c)
4.	Dipole Validation Kits	Speag	D2450V2	862	2023.05.18	2026.05.17	SPEAG	c)
5.	Dipole Validation Kits	Speag	D5GHzV2	1102	2023.05.19	2026.05.18	SPEAG	c)
6.	Attenuator	N/A	1527	001	2023.09.15	2024.09.14	CCIC	d)
7.	ENA SERIES NETWORK ANALYZER	Agilent	E5071C	MY46316760	2023.09.15	2024.09.14	CCIC	c)
8.	Date Acquisition Electronics	Speag	DAE4	899	2023.05.17	2024.05.16	CCTL	c)
9.	E-Field Probe	Speag	EX3DV4	3767	2023.06.12	2024.06.11	CCTL	c)
10.	Signal Generator	Rohde & Schwarz	SMB100A	181375	2023.04.02	2024.04.01	CCIC	c)
11.	Attenuator	N/A	1527	002	2023.09.15	2024.09.14	CCIC	c)
12.	Test Software	Schmid&Partner Englinnering AG	DASY5	52.8.7.1137	NCR	NCR	NCR	N/A
Note: NCR means no calibration required(calibrated with system).								

2.9.Laboratory Environment

Temperature	Min:20℃,Max.25℃
Relative humidity	Min. = 30%, Max. = 70%
Note: Ambient noise is checked and found very low and in compliance with requirement of standards.	

2.10. Measurement Uncertainty

Test Item	Uncertainty
Uncertainty for SAR test	1g: 21.1
	10g: 20.6
Uncertainty for test site temperature	0.6℃

Source	Type	Uncertainly Value (%)	Probability Distribution	K	C1(1g)	C1(10g)	Standard uncertaint y uI(%)1g	Standard uncertaint y uI(%)10g	Degree of freedom Veff or Vi
Measurement system repetivity	A	0.5	N	1		1	0.5	0.5	9
Probe calibration	B	5.9	N	1	1	1	5.9	5.9	∞
Isotropy	B	4.7	R	√3	1	1	2.7	2.7	∞
Linearity	B	4.7	R	√3	1	1	2.7	2.7	∞
Probe modulation response	B	0	R	√3	1	1	0	0	∞
Detection limits	B	1.0	R	√3	1	1	0.6	0.6	∞
Boundary effect	B	1.9	R	√3	1	1	1.1	1.1	∞
Readout electronics	B	1.0	N	1	1	1	1.0	1.0	∞
Response time	B	0	R	√3	1	1	0	0	∞
Integration time	B	4.32	R	√3	1	1	2.5	2.5	∞
RF ambient conditions – noise	B	0	R	√3	1	1	0	0	∞
RF ambient conditions – reflections	B	3	R	√3	1	1	1.73	1.73	∞
Probe positioner mech. Restrictions	B	0.4	R	√3	1	1	0.2	0.2	∞
Probe positioning with respect to phantom shell	B	2.9	R	√3	1	1	1.7	1.7	∞
Post-processing	B	0	R	√3	1	1	0	0	∞
Test sample related									
Device holder uncertainty	A	2.94	N	1	1	1	2.94	2.94	M-1
Test sample positioning	A	4.1	N	1	1	1	4.1	4.1	M-1
Power scaling	B	5.0	R	√3	1	1	2.9	2.9	∞
Drift of output power (measured SAR drift)	B	5.0	R	√3	1	1	2.9	2.9	∞
Phantom and set-up									
Phantom uncertainty (shape and thickness tolerances)	B	4.0	R	√3	1	1	2.3	2.1	∞
Algorithm for correcting SAR for deviations in permittivity and conductivity	B	1.9	N	1	1	0,84	1,9	1,6	∞
Liquid conductivity (meas.)	A	0.55	N	1	0.78	0.71	0.24	0.21	M-1
Liquid permittivity (meas.)	A	0.19	N	1	0.23	0.26	0.09	0.06	M
Liquid permittivity – temperature uncertainty	A	5.0	R	√3	0,78	0,71	1.4	1.1	∞
Liquid conductivity – temperature uncertainty	A	5.0	R	√3	0.23	0,26	1.2	0.8	∞
Combined standard uncertainty	$u_c' = \sqrt{\sum_{i=1}^{23} c_i^2 u_i^2}$						**10.57**	**10.32**	
Expanded uncertainty (95 % conf. interval)	$u_e = 2u_c$		N		K=2		**21.14**	**20.64**	

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

Salt: 99+% Pure Sodium Chloride
Sugar: 98+% Pure Sucrose
Water: De-ionized, 16 MΩ+ resistivity
HEC: Hydroxyethyl 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

3. MEASURE PROCEDURES

3.1.General description of test procedures

For the 802.11b/g SAR body tests, a communication link is set up with the test mode software for WIFI mode test. The Absolute Radiofrequency Channel Number (ARFCN) is allocated to 1,6and 11 respectively in the case of 2450 MHz. During the test, at the each test frequency channel, the EUT is operated at the RF continuous emission mode. Each channel should be tested at the lowest data rate. Testing at higher data rates is not required when the maximum average output power is less than 0.25dB higher than those measured at the lowest data rate.

802.11b/g operating modes are tested independently according to the service requirements in each frequency band.802.11b/g modes are tested on channels1,6,11;however,if output power reduction is necessary for channels 1 and /or 11 to meet restricted band requirements the highest output channels closest to each of these channels must be tested instead.

SAR is not required for 802.11g channels when the maximum average output power is less than 0.25dB higher than that measured on the corresponding 802.11b channels. When the maximum average output channel in each frequency band is not included in the “default test channels”, the maximum channel should be tested instead of an adjacent “default test channels”, these are referred to as the “required test channels” and are illustrated in table 1.

Mode	GHz	Channel	Turbo Channel	“Default Test Channels”	
				15.247	
				802.11b	802.11g
802.11b/g	2.412	1#	1#	√	*
	2.437	6	6	√	*
	2.462	11#	11#	√	*

Table 1

Note: #= when output power is reduced for channel 1 and /or 11 to meet restricted band requirements the highest out put channels closet to each of these channels should be tested.

√= ” default test channels”

* = possible 802.11g channels with maximum average output 0.25dB>=the “default test channels”

Please apply the following guidance for SAR testing:

1. Please use a 0 mm (touching) test separation distance on the flat phantom during SAR testing of this device. This separation distance is based on the guidance found in FCC KDB Publication 447498 D01, Section 5.2.3 3)
2. Please utilize a body tissue simulating liquid (TSL) of the appropriate frequency during SAR testing.
3. Please use the guidance found in FCC KDB Publication 447498 D01 to determine which sides of the device need to be tested for SAR.
4. FCC KDB Publication 248227 D01 should be used for selection of the WiFi channels, data rates, etc.

4. SAR MEASUREMENTS SYSTEM

4.1.SAR Measurement Set-up

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

(1) A standard high precision 6-axis robot (Stäubli RX family) with controller and software. An arm extension for accommodating the data acquisition electronics (DAE).
(2) A dosimetric probe, i.e. an isotropic E-field probe optimized and calibrated for usage It issue simulating liquid. The probe is equipped with an optical surface detector system.
(3) A data acquisition electronic (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.
(4) A unit to operate the optical surface detector which is connected to the EOC.
(5) The Electro-Optical Coupler (EOC) performs the conversion from the optical into a digital electric signal of the DAE. The EOC is connected to the DASY5 measurement server.
(6) The DASY5 measurement server, which performs all real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operation. A computer operating Windows 2003.
(7) DASY5 software and SEMCAD data evaluation software.
(8) Remote control with teach panel and additional circuitry for robot safety such as warning lamps, etc.
(9) The generic twin phantom enabling the testing of left-hand and right-hand usage.
(10) The device holder for handheld mobile phones.
(11) Tissue simulating liquid mixed according to the given recipes.
(12) System validation dipoles allowing to validate the proper functioning of the system.

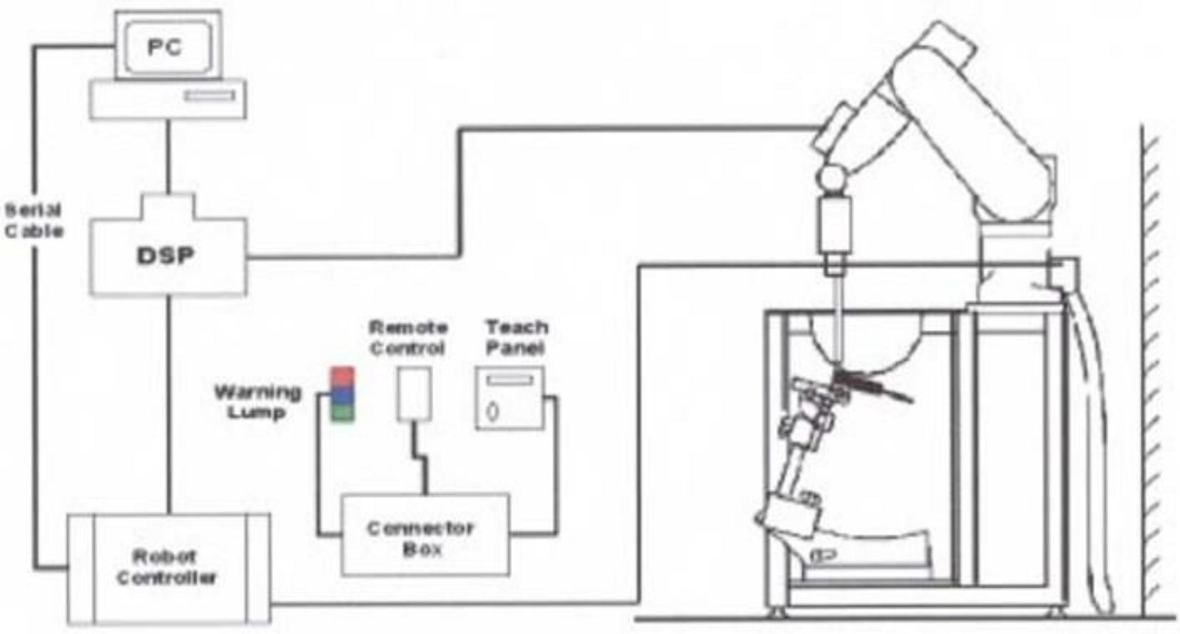
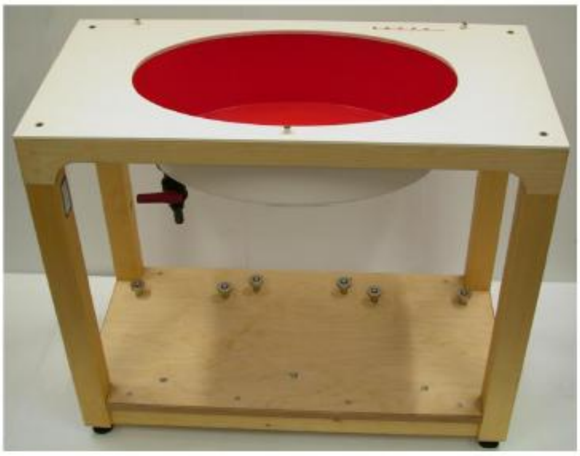


Figure 4.1 SAR Lab Test Measurement Set-up

4.2. ELI Phantom

Phantom for compliance testing of handheld and body-mounted wireless devices in the frequency range of 30 MHz to 6 GHz. ELI is fully compatible with the IEC 62209-2 standard and all known tissue simulating liquids. ELI 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 compatible with all SPEAG dosimetric probes and dipoles.



Material	Vinylester, glass fiber reinforced (VE-GF)
Liquid Compatibility	Compatible with all SPEAG tissue simulating liquids (incl. DGBE type)
Shell Thickness	2.0 ± 0.2 mm (bottom plate)
Dimensions	Major axis: 600 mm Minor axis: 400 mm
Filling Volume	approx. 30 liters
Wooden Support	SPEAG standard phantom table

The bottom plate contains three pair of bolts for locking the device holder. The device holder positions are adjusted to the standard measurement positions in the three sections.

Figure 6.2 Top View of Twin Phantom

A white cover is provided to tap the phantom during off-periods to prevent water evaporation and changes in the liquid parameters.

On the phantom top, three reference markers are provided to identify the phantom position with respect to the robot.

The phantom can be used with the following tissue simulating liquids:

*Water-sugar based liquid
*Glycol based liquids

4.3.Device Holder for SAM Twin Phantom

The SAR in the Phantom is approximately inversely proportional to the square of the distance between the source and the liquid surface. For a source in 5 mm distance, a positioning uncertainty of ±0.5mm would produce a SAR uncertainty of ± 20%. An accurate device position is therefore crucial for accurate and repeatable measurement. The position in which the devices must be measured, are defined by the standards.

The DASY5 device holder is designed to cope with different positions given in the standard. It has two scales for the device rotation (with respect to the body axis) and the device inclination (with respect to the line between the ear reference points). The rotation centers for both scales is the ear reference point (EPR).

Thus the device needs no repositioning when changing the angles.

The DASY5 device holder has been made out of low-loss POM material having the following dielectric parameters: relative permittivity ε_r=3 and loss tangent δ = 0.02. The amount of dielectric material has been reduced in the closest vicinity of the device, since measurements have suggested that the influence of the clamp on the test results could thus be lowered.

Figure 4.3 Device Holder

4.4.DASY5 E-field Probe System

The SAR measurements were conducted with the dosimetric probe EX3DV4 (manufactured by SPEAG), designed in the classical triangul -ar configuration and optimized for dosimetric evaluation.

Figure 4.4 EX3DV4 E-field Probe

4.4.1. EX3DV4 Probe Specification

Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)
Calibration	ISO/IEC 17025 calibration service available
Frequency	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)
Directivity	± 0.3 dB in HSL (rotation around probe axis) ± 0.5 dB in tissue material (rotation normal to probe axis)
Dynamic Range	10 μW/g to > 100 mW/g Linearity: ± 0.2dB (noise: typically < 1 μW/g)
Dimensions	Overall length: PRS-T2 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical 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%.

4.5.E-field Probe Calibration

Each probe is calibrated according to a dosimetric assessment procedure with accuracy better than ±10%. The spherical isotropy was evaluated and found to be better than ± 0.25dB. The sensitivity parameters (NormX, NormY, NormZ), the diode compression parameter (DCP) and the conversion factor (ConvF) of the probe are tested.

The free space E-field from amplified probe outputs is determined in a test chamber. This is performed in a TEM cell for frequencies bellow 1 GHz, and in a wave guide above 1 GHz for free space. For the free space calibration, the probe is placed in the volumetric center of the cavity and at the proper orientation with the field. The probe is then rotated 360 degrees.

E-field temperature correlation calibration is performed in a flat phantom filled with the appropriate simulated brain tissue. The measured free space E-field in the medium correlates to temperature rise in a dielectric medium. For temperature correlation calibration a RF transparent thermistor-based temperature probe is used in conjunction with the E-field probe.

$$SAR = C\frac{\Delta T}{\Delta t}$$

Where: Δt = Exposure time (30 seconds),
C = Heat capacity of tissue (brain or muscle),
ΔT = Temperature increase due to RF exposure.
Or

$$SAR = \frac{|E|^2 \sigma}{\rho}$$

Where:
σ = Simulated tissue conductivity,
ρ = Tissue density (kg/m3).

4.6.Scanning procedure

The DASY5 installation includes predefined files with recommended procedures for measurements and validation. They are read-only document files and destined as fully defined but unmeasured masks. All test positions (head or body-worn) are tested with the same configuration of test steps differing only in the grid definition for the different test positions.

The ”reference“ and ”drift“ measurements are located at the beginning and end of the batch process. They measure the field drift at one single point in the liquid over the complete procedure.The indicated drift is mainly the variation of the EUT’s output power and should vary max. ± 5 %.

The ”surface check“ measurement tests the optical surface detection system of the DASY5 system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above ± 0.1mm). To prevent wrong results tests are only executed when the liquid is free of air bubbles.

The difference between the optical surface detection and the actual surface depends on the Probe and is specified with each probe. (It does not depend on the surface reflectivity or the probe angle to the surface within ± 30°.)

Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values before running a detailed measurement around the hot spot. Before starting the area scan a grid spacing of 15 mm x 15 mm is set. During the scan the distance of the probe to the phantom remains unchanged.

After finishing area scan, the field maxima within a range of 2 dB will be ascertained.

Zoom Scan

Zoom Scans are used to estimate the peak spatial SAR values within a cubic averaging volume containing 1 g and 10 g of simulated tissue. The default Zoom Scan is done by 7x7x7 points within a cube whose base is centered around the maxima found in the preceding area scan.

Spatial Peak Detection

The procedure for spatial peak SAR evaluation has been implemented and can determine values of masses of 1g and 10g, as well as for user-specific masses. The DASY5 system allows evaluations that combine measured data and robot positions, such as:

- · maximum search
- · extrapolation
- · boundary correction
- · peak search for averaged SAR

During a maximum search, global and local maxima searches are automatically performed in 2-D after each Area Scan measurement with at least 6 measurement points. It is based on the evaluation of the local SAR gradient calculated by the Quadratic Shepard's method. The algorithm will find the global maximum and all local maxima within -2 dB of the global maxima for all SAR distributions.

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. Several measurements at different distances are necessary for the extrapolation. Extrapolation routines require at least 10 measurement points in 3-D space.They are used in the Zoom Scan to obtain SAR values between the lowest measurement points and the inner phantom surface. The routine uses the modified Quadratic Shepard's method for extrapolation. For a grid using 7x7x7 measurement points with 5mm resolution amounting to 343 measurement points, the uncertainty of the extrapolation routines is less than 1% for 1g and 10g cubes.

A Z-axis scan measures the total SAR value at the x-and y-position of the maximum SAR value found during the cube 7x7x7 scan. The probe is moved away in z-direction from the bottom of the SAM phantom in 5mm steps.

5. DATA STORAGE AND EVALUATION

5.1.Data Storage

The DASY5 software stores the acquired data from the data acquisition electronics as raw data (in microvolt readings from the probe sensors), together with all necessary software parameters for thedata evaluation (probe calibration data, liquid parameters and device frequency and modulation data) in measurement files with the extension ".DA4". The software evaluates the desired unit and format for output each time the data is visualized or exported. This allows verification of the complete software setup even after the measurement and allows correction of incorrect parameter settings. For example, if a measurement has been performed with a wrong crest factor parameter in the device setup, the parameter can be corrected afterwards and the data can be re-evaluated.

The measured data can be visualized or exported in different units or formats, depending on the selected probe type ([V/m], [A/m], [°C], [mW/g], [mW/cm²], [dBrel], etc.). Some of these units are not available in certain situations or show meaningless results, e.g., a SAR output in a lossless media will always be zero. Raw data can also be exported to perform the evaluation with other software packages.

5.2.Data Evaluation by SEMCAD

The SEMCAD software 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	Normi, ai0, ai1, ai2
	- Conversion factor	ConvFi
	- Diode compression point	Dcpi
Device parameters:	- Frequency	f
	- Crest factor	cf
Media parameters:	- Conductivity	
	- Density	

These parameters must be set correctly in the software. They can be found in the component documents or they can be imported into the software from the configuration files issued for the DASY5 components. In the direct measuring mode of the multimeter 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:

$$V_i = U_i + U_i^2 \cdot cf / dcp_i$$

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: $E_i = (V_i / Norm_i \cdot ConvF)^{1/2}$

H-field probes: $H_i = (V_i)^{1/2} \cdot (a_{i0} + a_{i1} f + a_{i2} f^2) / f$

With **V_i** = compensated signal of channel i (i = x, y, z)

$Norm_i$ = sensor sensitivity of channel i (i = x, y, z)

$ConvF$ = 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):

$$E_{tot} = (E_x^2 + E_Y^2 + E_z^2)^{1/2}$$

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

$$SAR = (E_{tot}^2 \cdot \quad) \quad / (\quad \cdot 1000) \quad \text{with}$$

SAR = local specific absorption rate in mW/g

E_{tot} = total field strength in V/m

= conductivity in [mho/m] or [Siemens/m]

= 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 to be a free space field.

$P_{pwe} = E_{tot}^2 / 3770$ or $P_{pwe} = H_{tot}^2 \cdot 37.7$

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. SYSTEM CHECK

The manufacturer calibrates the probes annually. Dielectric parameters of the tissue simulates were measured every day using the dielectric probe kit and the network analyzer. A system check measurement was made following the determination of the dielectric parameters of the simulates, using the dipole validation kit. A power level of 250 mW was supplied to the dipole antenna, which was placed under the flat section of the twin SAM phantom. The system check results (dielectric parameters and SAR values) are given in the ANNEX A.

System check results have to be equal or near the values determined during dipole calibration with the relevant liquids and test system (±10 %).

System check is performed regularly on all frequency bands where tests are performed with the DASY5 system.

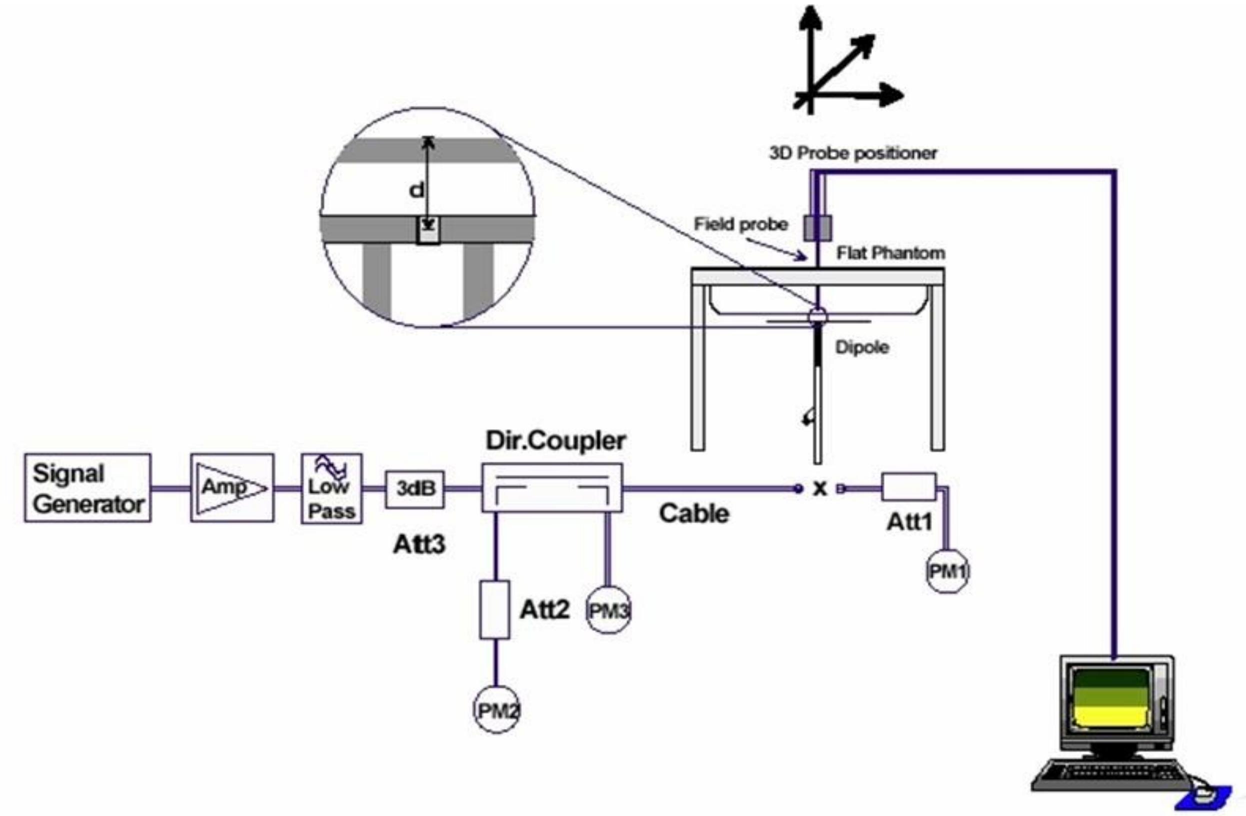


Figure 6.1: System Check Set-up

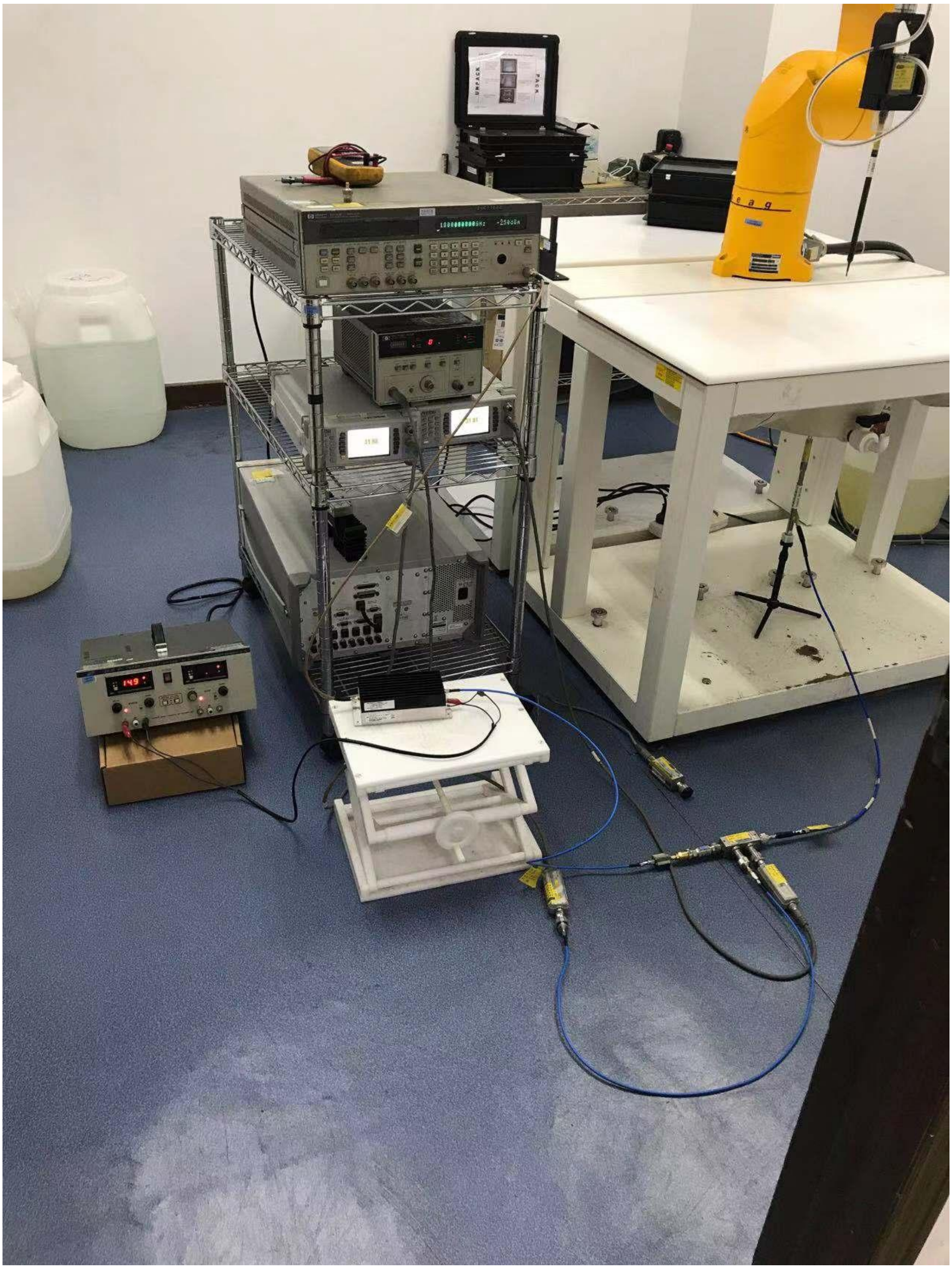


Figure 6.3: photos of system

7. TEST RESULTS

7.1.Output power

(WiFi 2.4GHz)

Mode	Frequency	Duty Cycle Factor	Reading (dBm)	Average Output Power (dBm)	Limit (dBm)
11b	2412	0	11.49	11.49	30
	2437		11.26	11.26	
	2462		11.22	11.22	
11g	2412	0	9.86	9.86	
	2437		10.85	10.85	
	2462		10.01	10.01	
11nHT20	2412	0	8.12	8.12	
	2437		10.52	10.52	
	2462		7.67	7.67	

Note: Use the data rate with the maximum output level for the SAR test.

(U-NII-1 Band)

Mode	UNII Band	Frequency	Duty Cycle Factor	Reading (dBm)	Average Output Power (dBm)	Limit (dBm)
802.11a	I	5180	0	8.26	8.26	24
		5200		8.52	8.52	
		5240		8.99	8.99	
	III	5745	0	11.26	11.26	30
		5785		11.87	11.87	
		5825		11.62	11.62	
802.11nHT20	I	5180	0	8.25	8.25	24
		5200		8.26	8.26	
		5240		8.74	8.74	
	III	5745	0	11.68	11.68	30
		5785		10.71	10.71	
		5825		10.52	10.52	

(U-NII-3 Band)

Mode	UNII Band	Frequency	Average Output power (dBm)	10log (1/X)	Antenna Gain （dBi）	Total Average Output Power		Limit (dBm)
						(dBm)	(W)	
802.11 a	I	5180	8.26	0	2.24	10.50	0.01122	<200mW (23 dBm) (E.I.R.P.)
		5200	8.52			10.76	0.01191	
		5240	8.99			11.23	0.01327	
	III	5745	11.26			11.26	0.01337	<1w (30dBm)
		5785	11.87			11.87	0.01538	
		5825	11.62			11.62	0.01452	
802.11 nHT20	I	5180	8.25	0	2.24	10.49	0.01119	<200mW (23 dBm) (E.I.R.P.)
		5200	8.26			10.50	0.01122	
		5240	8.74			10.98	0.01253	
	III	5745	11.68			11.68	0.01472	<1w (30dBm)
		5785	10.71			10.71	0.01178	
		5825	10.52			10.52	0.01127	

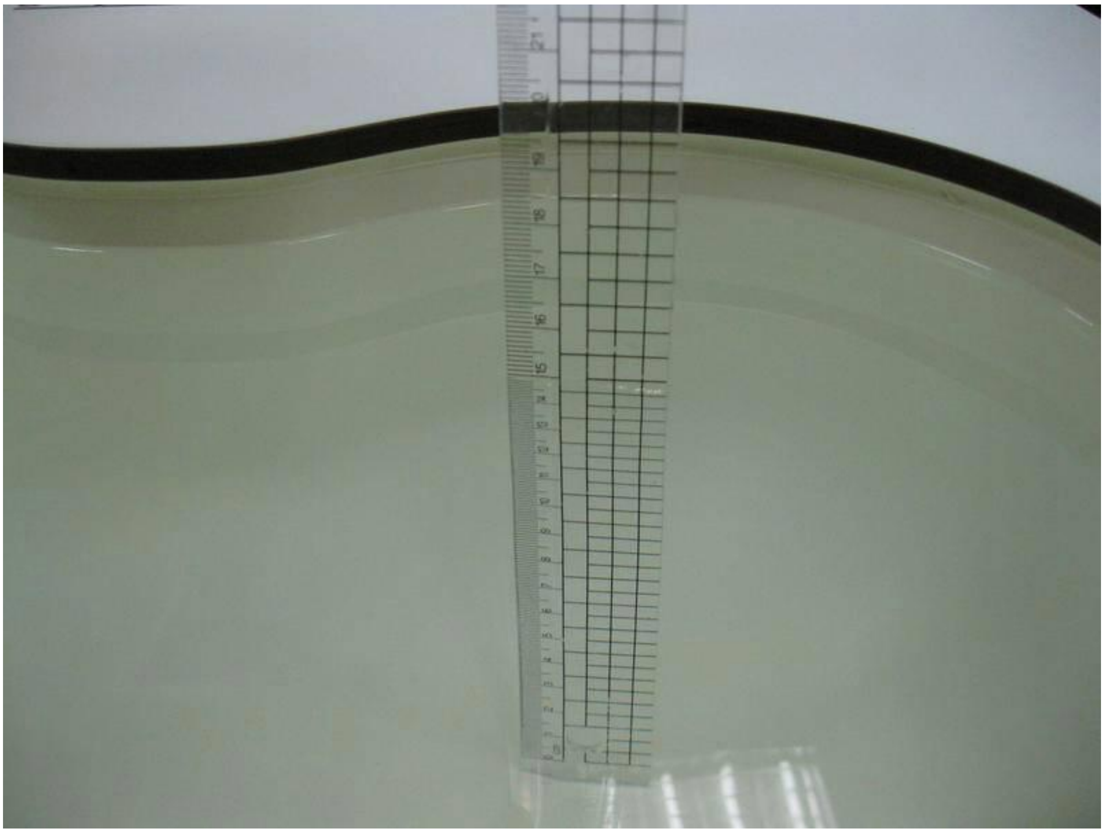
Note: Use the data rate with the maximum output level for the SAR test.

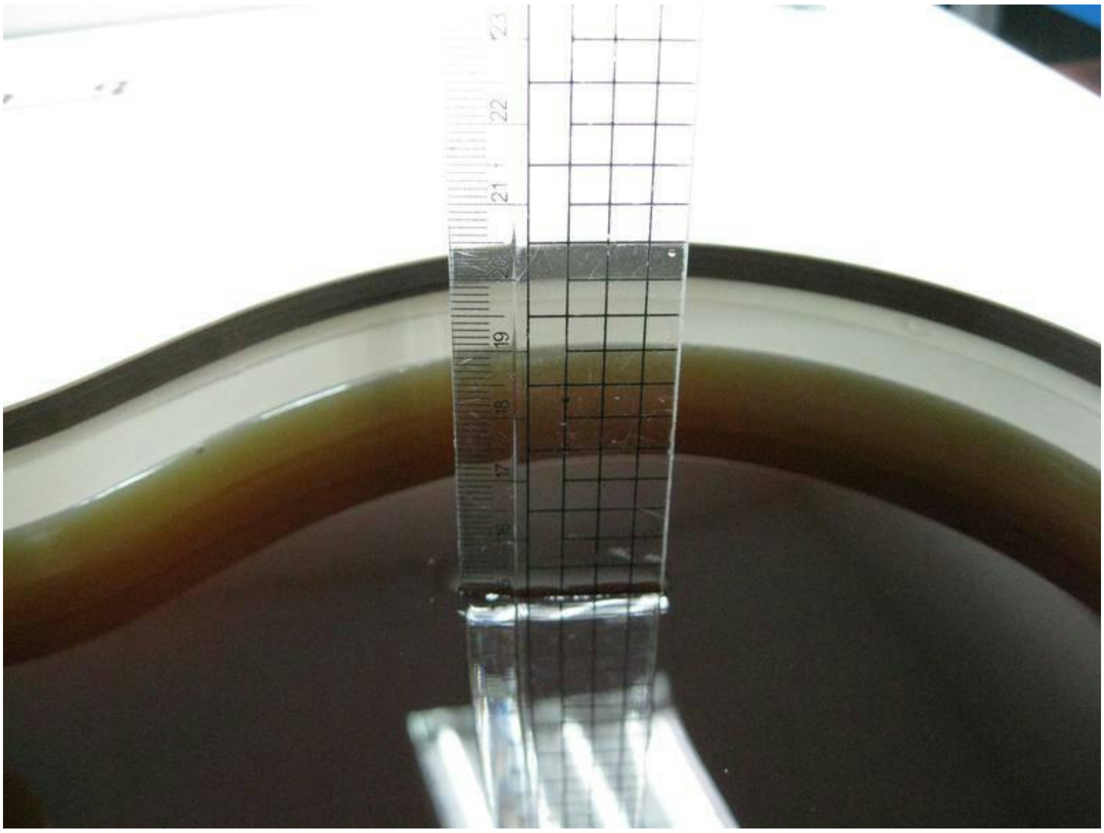
7.2.System Check for Head Tissue simulating liquid

Frequency	Description	SAR(W/kg) (1g±18.8% window; 10g±18.7% window)		Dielectric Parameters (±10% window)		Temp
		1g	10g	εr	σ(s/m)	℃
2450MHz	Recommended value (250mW input power)	13.5 10.962-16.038	6.29 5.11377-7.46623	39.2 35.28-43.12	1.80 1.62-1.98	/
	Normalized to 1W	53.9	25.2			
	Measurement value **2023-12-28**	12.4	5.57	39.440	1.818	**21.05**
5250MHz	Recommended value (100mW input power)	7.88 5.95728-9.80272	2.23 1.69034-2.76966	35.9 32.31-39.49	4.71 4.239-5.181	/
	Normalized to 1W	78.7	22.3			
	Measurement value **2023-12-28**	8.36	2.53	35.49	4.52	**21.04**
5750MHz	Recommended value (100mW input power)	7.75 5.859-9.641	2.17 1.64486-2.69514	35.4 31.86-38.94	5.22 4.698-5.742	/
	Normalized to 1W	77.3	21.6			
	Measurement value **2023-12-28**	7.17	2.36	35.211	5.29	**21.02**

7.3.Dielectric Performance for Tissue simulating liquid

Frequency		Description	Dielectric Parameters (±10% window)		Temp
			εr	σ(s/m)	℃
WiFi 2.4GHz	**2412MHz**	Recommended value	39.20 35.28-43.12	1.80 1.62-1.98	/
		Measurement value **2023-12-28**	38.849	1.841	**21.03**
U-NII-1 Band	**5180MHz**	Recommended value	35.90 32.31- 39.49	4.71 4.284 - 5.236	/
		Measurement value **2023-12-28**	35.53	4.51	**21.07**
U-NII-3 Band	**5825MHz**	Recommended value	35.4 31.77 – 38.83	5.22 4.743 – 5.797	/
		Measurement value **2023-12-28**	34.54	5.12	**21.02**





7.4.Test Results

(WiFi 2.4GHz)

SAR Test Record For WIFI 2.4G										
Test Position	Test CH	Duty Cycle	Measure SAR 1g(W/kg)	Measure SAR 10g(W/kg)	Conducted Power(dBm)	Tune up Power(dBm)	Factor	Scaled Final SAR 1g	Scaled Final SAR 10g	power drift
Back	1	1	0.12	0.056	11.49	14	1.782379	0.214	0.100	-0.16
Conclusion: PASS										
Note: Factor= Max. Scaled AV Power(W)/Measured Power(W) Scaled SAR-1= Measured SAR*Factor Scaled-Final= Scaled SAR-1*(1/Duty Cycle)										

(U-NII-1 Band)

SAR Test Record For WIFI 5G										
Test Position	Test CH	Duty Cycle	Measure SAR 1g(W/kg)	Measure SAR 10g(W/kg)	Conducted Power(dBm)	Tune up Power(dBm)	Factor	Scaled Final SAR 1g	Scaled Final SAR 10g	power drift
Back	36	1	0.1	0.068	8.26	13	2.978516	0.298	0.203	-0.18
Conclusion: PASS										
Note: Factor= Max. Scaled AV Power(W)/Measured Power(W) Scaled SAR-1= Measured SAR*Factor Scaled-Final= Scaled SAR-1*(1/Duty Cycle)										

(U-NII-3 Band)

SAR Test Record For WIFI 5G										
Test Position	Test CH	Duty Cycle	Measure SAR 1g(W/kg)	Measure SAR 10g(W/kg)	Conducted Power(dBm)	Tune up Power(dBm)	Factor	Scaled Final SAR 1g	Scaled Final SAR 10g	power drift
Top	165	1	0.091	0.057	10.52	15.5	3.147748	0.286	0.179	0.11
Conclusion: PASS										
Note: Factor= Max. Scaled AV Power(W)/Measured Power(W) Scaled SAR-1= Measured SAR*Factor Scaled-Final= Scaled SAR-1*(1/Duty Cycle)										

ANNEX A: System Check Results

Test Laboratory: Audix SAR Lab Date: 28/12/2023

CW 2450

DUT: Dipole 2450 MHz D2450V2; Type: D2450V2; Serial: D2450V2 - SN:862

Communication System: UID 0, CW (0); Communication System Band: D2450 (2450.0 MHz); Frequency: 2450 MHz;Communication System PAR: 0 dB

Medium parameters used: f = 2450 MHz; $\sigma = 1.818$ S/m; $\varepsilon_r = 39.440$; $\rho = 1000$ kg/m^3

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3767; ConvF(7.62, 7.62, 7.62); Calibrated: 12/06/2023;
- Modulation Compensation:
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn899; Calibrated: 17/05/2023
- Phantom: ELI v5.0; Type: QDOVA002AA; Serial: 1235
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Configuration/CW 2450MHz/Area Scan (61x71x1): Interpolated grid: dx=2.000 mm, dy=2.000 mm

Maximum value of SAR (interpolated) = 16.7 W/kg

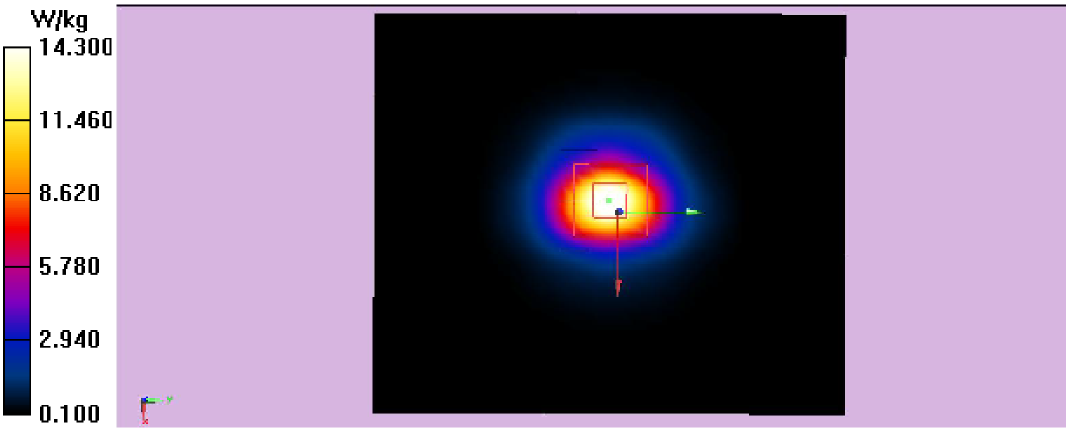
Configuration/CW 2450MHz/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 79.79 V/m; Power Drift = 0.07 dB

Peak SAR (extrapolated) = 25.6 W/kg

SAR(1 g) = 12.4 W/kg; SAR(10 g) = 5.57 W/kg

Maximum value of SAR (measured) = 14.3 W/kg



Test Laboratory: Audix SAR Lab Date: 28/12/2023

CW 5250

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1102

Communication System: UID 0, CW (0); Communication System Band: D5GHz (5000.0 - 6000.0 MHz); Frequency: 5250 MHz;Communication System PAR: 0 dB

Medium parameters used: f = 5250 MHz; $\sigma = 4.52$ S/m; $\varepsilon_r = 35.49$; $\rho = 1000$ kg/m^3

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3767; ConvF(5.55, 5.55, 5.55); Calibrated: 12/06/2023;
- Modulation Compensation:
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn899; Calibrated: 17/05/2023
- Phantom: ELI 4.0; Type: QDOVA001BA; Serial: 1112
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Configuration/CW 5250MHz/Area Scan (61x71x1): Interpolated grid: dx=2.000 mm, dy=2.000 mm

Maximum value of SAR (interpolated) = 9.44 W/kg

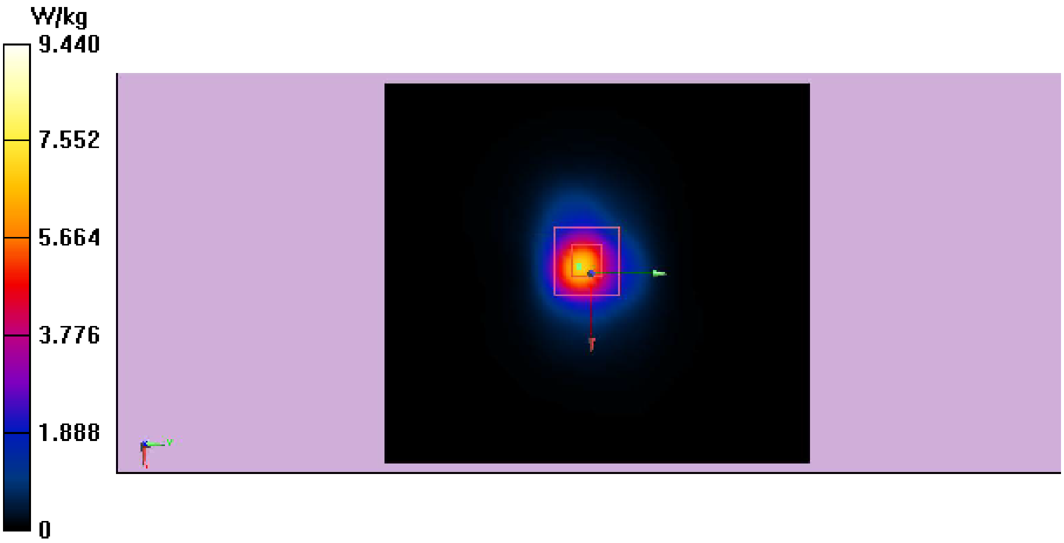
Configuration/CW 5250MHz/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 42.25 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 27.8 W/kg

SAR(1 g) = 8.36 W/kg; SAR(10 g) = 2.53 W/kg

Maximum value of SAR (measured) = 9.44 W/kg



Test Laboratory: Audix SAR Lab Date: 28/12/2023

CW 5750

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1102

Communication System: UID 0, CW (0); Communication System Band: D5GHz (5000.0 - 6000.0 MHz); Frequency: 5750 MHz;Communication System PAR: 0 dB

Medium parameters used: f = 5750 MHz; $\sigma = 5.29$ S/m; $\varepsilon_r = 35.211$; $\rho = 1000$ kg/m^3

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3767; ConvF(4.92, 4.92, 4.92); Calibrated: 12/06/2023;
- Modulation Compensation:
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn899; Calibrated: 17/05/2023
- Phantom: ELI 4.0; Type: QDOVA001BA; Serial: 1112
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Configuration/CW 5750MHz/Area Scan (61x71x1): Interpolated grid: dx=2.000 mm, dy=2.000 mm

Maximum value of SAR (interpolated) = 8.57 W/kg

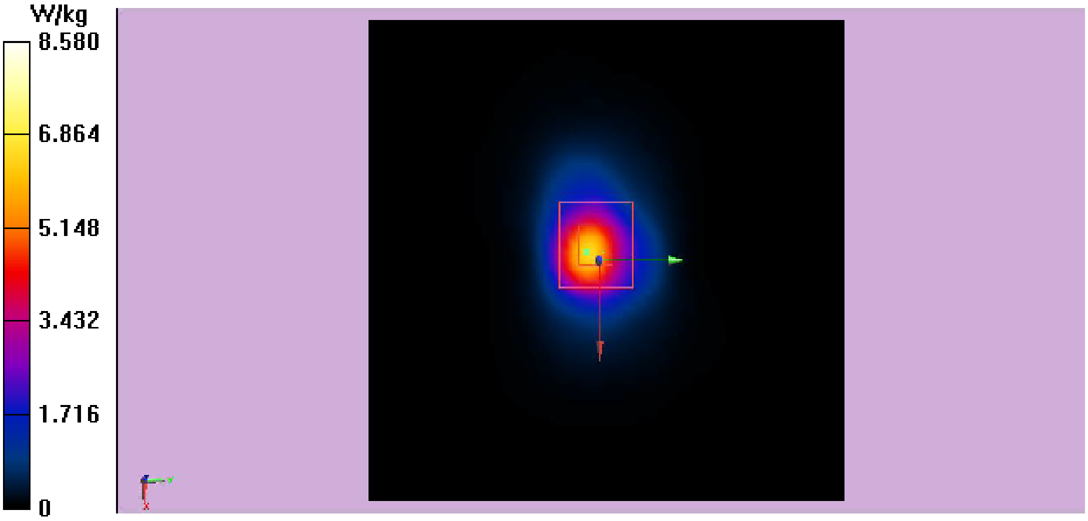
Configuration/CW 5750MHz/Zoom Scan (7x7x7)/Cube 0: Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 33.88 V/m; Power Drift = 0.05 dB

Peak SAR (extrapolated) = 23.6 W/kg

SAR(1 g) = 7.17 W/kg; SAR(10 g) = 2.36 W/kg

Maximum value of SAR (measured) = 8.58 W/kg



ANNEX B: Graph Results

WiFi 2.4GHz:

Test Laboratory: Audix SAR Lab Date: 28/12/2023

11b CH1(2412MHz Back)

DUT: TI-Nspire TM Navigator TM Wireless Network Adapter-v 2; M/N: V7R-TINAVWNA2

Communication System: UID 0, IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps) (0); Communication System Band: ISM 2.4GHz Band (2400.0-2483.5MHz); Frequency: 2412 MHz;Communication System PAR: 0 dB

Medium parameters used: f = 2412 MHz; $\sigma = 1.841$ S/m; $\varepsilon_r = 38.849$; $\rho = 1000$ kg/m^3

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3767; ConvF(7.62, 7.62, 7.62); Calibrated: 12/06/2023;
- Modulation Compensation:
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn899; Calibrated: 17/05/2023
- Phantom: ELI 4.0; Type: QDOVA001BA; Serial: 1112
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Configuration/CH1(2412MHz Back)/Area Scan (51x71x1): Interpolated grid: dx=2.000 mm, dy=2.000 mm

Maximum value of SAR (interpolated) = 0.108 W/kg

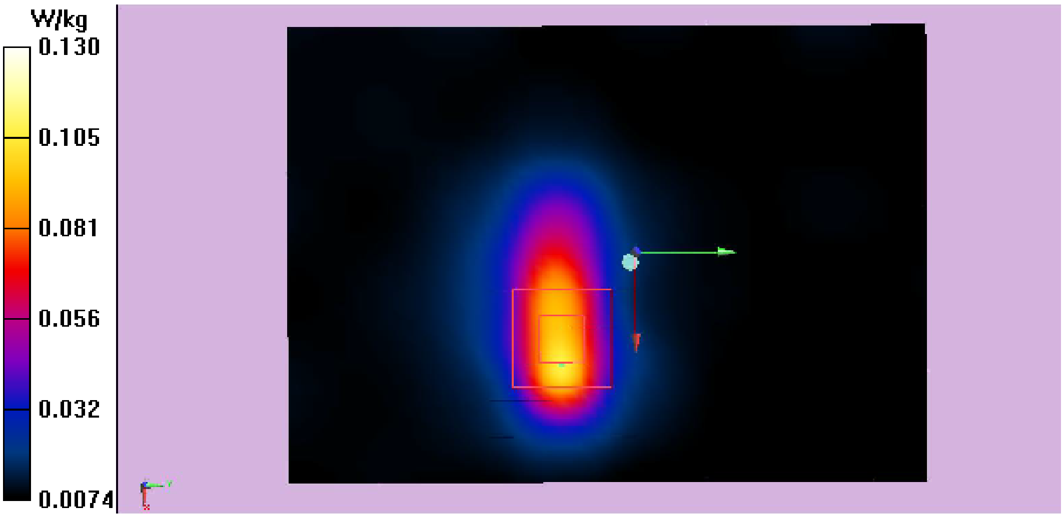
Configuration/CH1(2412MHz Back)/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 3.196 V/m; Power Drift = -0.16 dB

Peak SAR (extrapolated) = 0.270 W/kg

SAR(1 g) = 0.120 W/kg; SAR(10 g) = 0.056 W/kg

Maximum value of SAR (measured) = 0.130 W/kg



U-NII-1 Band:

Test Laboratory: Audix SAR Lab Date: 28/12/2023

11a CH36(5180MHz Back)

DUT: TI-Nspire TM Navigator TM Wireless Network Adapter-v 2; M/N: V7R-TINAVWNA2

Communication System: UID 0, IEEE 802.11a WiFi 5.2GHz (0); Communication System Band: IEEE 802.11a WiFi 5.2GHz; Frequency: 5180 MHz;Communication System PAR: 0 dB

Medium parameters used: f = 5200 MHz; σ = 4.51 S/m; ε_r = 35.53; ρ = 1000 kg/m^3

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3767; ConvF(5.55, 5.55, 5.55); Calibrated: 12/06/2023;
- Modulation Compensation:
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn899; Calibrated: 17/05/2023
- Phantom: ELI 4.0; Type: QDOVA001BA; Serial: 1112
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Configuration/CH36(5180MHz Back)/Area Scan (51x71x1): Interpolated grid: dx=2.000 mm, dy=2.000 mm

Maximum value of SAR (interpolated) = 0.145 W/kg

Configuration/CH36(5180MHz Back)/Zoom Scan (5x5x7)/Cube 0:

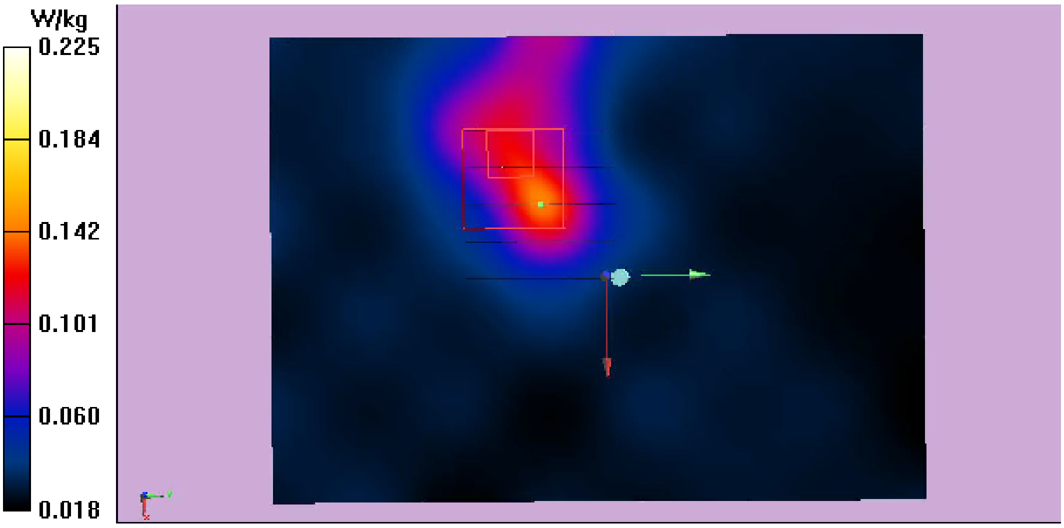
Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 3.496 V/m; Power Drift = -0.18 dB

Peak SAR (extrapolated) = 0.586 W/kg

SAR(1 g) = 0.100 W/kg; SAR(10 g) = 0.068 W/kg

Maximum value of SAR (measured) = 0.225 W/kg



U-NII-3 Band:

Test Laboratory: Audix SAR Lab Date: 28/12/2023

11nHT20 CH165(5825MHz Top)

DUT: TI-Nspire TM Navigator TM Wireless Network Adapter-v 2; M/N: V7R-TINAVWNA2

Communication System: UID 0, IEEE 802.11n20 WiFi 5.8GHz (0); Communication System Band: IEEE 802.11n20 WiFi 5.8GHz ; Frequency: 5825 MHz;Communication System PAR: 0 dB

Medium parameters used: f = 5800 MHz; σ = 5.12 S/m; ε_r = 34.54; ρ = 1000 kg/m^3

Phantom section: Flat Section

DASY5 Configuration:

- Probe: EX3DV4 - SN3767; ConvF(4.92, 4.92, 4.92); Calibrated: 12/06/2023;
- Modulation Compensation:
- Sensor-Surface: 4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn899; Calibrated: 17/05/2023
- Phantom: ELI 4.0; Type: QDOVA001BA; Serial: 1112
- Measurement SW: DASY52, Version 52.8 (8); SEMCAD X Version 14.6.10 (7331)

Configuration/CH165(5825MHz Top)/Area Scan (51x71x1): Interpolated grid: dx=2.000 mm, dy=2.000 mm

Maximum value of SAR (interpolated) = 0.251 W/kg

Configuration/CH165(5825MHz Top)/Zoom Scan (5x5x7)/Cube 0:

Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 3.551 V/m; Power Drift = 0.11 dB

Peak SAR (extrapolated) = 1.36 W/kg

SAR(1 g) = 0.091 W/kg; SAR(10 g) = 0.057 W/kg

Maximum value of SAR (measured) = 0.534 W/kg