



FCC SAR Test Report

Report No. : KES-SR-19T0008
FCC ID : RYK-WUBR508N
Applicant : SparkLAN Communications, Inc.
Manufacturer : SparkLAN Communications, Inc.
Address : 8F., No. 257, sec. 2, Tiding Blvd., Neihu District, Taipei City 11493, Taiwan
DUT Type : Flat Panel Digital X-ray Detector
Model No. : WUBR-508N
FCC Rule Part(s) : CFR §2.1093
Date of Testing : 2019.06.14 ~ 2019.09.19
Issued Date : 2019.09.30

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Revision history

Report No.	Reason for Change	Date Issued
KES-SR-19T0008	Initial release	2019.09.30

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1. General Information

1.1. Host model Information

Applicant Information

Host model No. : EVS 4343W
Derived model (s) : EVS 4343WG, EVS 4343WP, EVS3643WP, EVS 3643W, EVS 3643WG
Applicant : DRTECH Corporation
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1.2. Highest SAR Summary

EUT Type	Flat Panel Digital X-ray Detector				
Brand Name(Applicant)	SparkLAN Communications, Inc.				
Model Name	WUBR-508N				
Antenna Type	PCB Antenna				
EUT Stage	Identical Prototype				
TX Frequency Range	Band	Mode	Bandwidth	Frequency	
					DTS
RX Frequency Range	Band	Mode	Bandwidth	Frequency	
					DTS
Band	Mode	Reported SAR			
		Body 1g SAR (W/Kg)			
		SISO (Ant.1)	SISO (Ant.2)		
DTS	2.4 GHz WLAN	0.015	0.013		
U-NII-1	5.2 GHz WLAN	-	-		
U-NII-2A	5.3 GHz WLAN	0.093	0.083		
U-NII-2C	5.6 GHz WLAN	0.126	0.091		
U-NII-3	5.8 GHz WLAN	0.210	0.073		

This wireless portable device has been shown to be capable of compliance for localized specific absorption rate (SAR) for uncontrolled environment/general population exposure limits specified in ANSI/IEEE C95.1-1992.

1.3. Device Overview

Band	Operating Modes	Tx Frequency
DTS	2.4 GHz WLAN	2412 ~ 2462 MHz
U-NII-1	5.2 GHz WLAN	5180 ~ 5240 MHz
U-NII-2A	5.3 GHz WLAN	5260 ~ 5320 MHz
U-NII-2C	5.6 GHz WLAN	5500 ~ 5700 MHz
U-NII-3	5.8 GHz WLAN	5745 ~ 5825 MHz

1.4. Power Reduction for SAR

This DUT does not support power reduction function.

1.5. Nominal and Maximum Output Power Specifications

This device operates using the following maximum and nominal output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB Publication 447498 D01v06.

Maximum WLAN Output Power

1.5.1 2.4 GHz WLAN

Mode / Band		Antenna	Target Power	Tolerance	Max. Allowed Power	
802.11b	Low	1 (SISO)	19.0 dBm	± 1.0 dB	20.0 dBm	
	Mid		19.0 dBm	± 1.0 dB	20.0 dBm	
	High		19.0 dBm	± 1.0 dB	20.0 dBm	
802.11g	Low		15.0 dBm	± 1.0 dB	16.0 dBm	
	Mid		15.0 dBm	± 1.0 dB	16.0 dBm	
	High		15.0 dBm	± 1.0 dB	16.0 dBm	
802.11b	Low		2 (SISO)	19.0 dBm	± 1.0 dB	20.0 dBm
	Mid			19.0 dBm	± 1.0 dB	20.0 dBm
	High			19.0 dBm	± 1.0 dB	20.0 dBm
802.11g	Low	15.0 dBm		± 1.0 dB	16.0 dBm	
	Mid	15.0 dBm		± 1.0 dB	16.0 dBm	
	High	15.0 dBm		± 1.0 dB	16.0 dBm	
802.11n HT20	Low	1+2 (MIMO)		14.0 dBm	± 1.0 dB	15.0 dBm
	Mid			14.0 dBm	± 1.0 dB	15.0 dBm
	High			14.0 dBm	± 1.0 dB	15.0 dBm
802.11n HT40	Low		12.0 dBm	± 1.0 dB	13.0 dBm	
	Mid		12.0 dBm	± 1.0 dB	13.0 dBm	
	High		12.0 dBm	± 1.0 dB	13.0 dBm	

1.5.2 5.2 GHz WLAN

Mode / Band		Antenna	Target Power	Tolerance	Max. Allowed Power
802.11a	Low	1 (SISO)	15.0 dBm	± 1.0 dB	16.0 dBm
	Mid		15.0 dBm	± 1.0 dB	16.0 dBm
	High		15.0 dBm	± 1.0 dB	16.0 dBm
802.11a	Low	2 (SISO)	15.0 dBm	± 1.0 dB	16.0 dBm
	Mid		15.0 dBm	± 1.0 dB	16.0 dBm
	High		15.0 dBm	± 1.0 dB	16.0 dBm
802.11n HT20	Low	1+2 (MIMO)	15.0 dBm	± 1.0 dB	16.0 dBm
	Mid		15.0 dBm	± 1.0 dB	16.0 dBm
	High		15.0 dBm	± 1.0 dB	16.0 dBm
802.11n HT40	Low		15.0 dBm	± 1.0 dB	16.0 dBm
	High		15.0 dBm	± 1.0 dB	16.0 dBm

1.5.3 5.3 GHz WLAN

Mode / Band		Antenna	Target Power	Tolerance	Max. Allowed Power
802.11a	Low	1 (SISO)	17.0 dBm	± 1.0 dB	18.0 dBm
	Mid		17.0 dBm	± 1.0 dB	18.0 dBm
	High		16.0 dBm	± 1.0 dB	17.0 dBm
802.11a	Low	2 (SISO)	17.0 dBm	± 1.0 dB	18.0 dBm
	Mid		17.0 dBm	± 1.0 dB	18.0 dBm
	High		16.0 dBm	± 1.0 dB	17.0 dBm
802.11n HT20	Low	1+2 (MIMO)	20.0 dBm	± 1.0 dB	21.0 dBm
	Mid		19.0 dBm	± 1.0 dB	20.0 dBm
	High		18.0 dBm	± 1.0 dB	19.0 dBm
802.11n HT40	Low		18.0 dBm	± 1.0 dB	19.0 dBm
	High		17.0 dBm	± 1.0 dB	18.0 dBm

1.5.4 5.5 GHz WLAN

Mode / Band		Antenna	Target Power	Tolerance	Max. Allowed Power
802.11a	Low	1 (SISO)	12.0 dBm	± 1.0 dB	13.0 dBm
	Mid		12.0 dBm	± 1.0 dB	13.0 dBm
	High		10.0 dBm	± 1.0 dB	11.0 dBm
802.11a	Low	2 (SISO)	12.0 dBm	± 1.0 dB	13.0 dBm
	Mid		12.0 dBm	± 1.0 dB	13.0 dBm
	High		10.0 dBm	± 1.0 dB	11.0 dBm
802.11n HT20	Low	1+2 (MIMO)	16.0 dBm	± 1.0 dB	17.0 dBm
	Mid		14.0 dBm	± 1.0 dB	15.0 dBm
	High		15.0 dBm	± 1.0 dB	16.0 dBm
802.11n HT40	Low		15.0 dBm	± 1.0 dB	16.0 dBm
	Mid		14.0 dBm	± 1.0 dB	15.0 dBm
	High		12.0 dBm	± 1.0 dB	13.0 dBm

1.5.5 5.8 GHz WLAN

Mode / Band		Antenna	Target Power	Tolerance	Max. Allowed Power
802.11a	Low	1 (SISO)	8.0 dBm	± 1.0 dB	9.0 dBm
	Mid		10.0 dBm	± 1.0 dB	11.0 dBm
	High		10.0 dBm	± 1.0 dB	11.0 dBm
802.11a	Low	2 (SISO)	8.0 dBm	± 1.0 dB	9.0 dBm
	Mid		10.0 dBm	± 1.0 dB	11.0 dBm
	High		9.0 dBm	± 1.0 dB	10.0 dBm
802.11n HT20	Low	1+2 (MIMO)	18.0 dBm	± 1.0 dB	19.0 dBm
	Mid		17.0 dBm	± 1.0 dB	18.0 dBm
	High		16.0 dBm	± 1.0 dB	17.0 dBm
802.11n HT40	Low		17.0 dBm	± 1.0 dB	18.0 dBm
	High		17.0 dBm	± 1.0 dB	18.0 dBm

Note:

- Per KDB 248227 D01 v02r02, 5.2GHz band WLAN is exempted. Because of adjusted SAR is ≤ 1.2 W/kg and the band is lower maximum output power specified for production units.
- 802.11n HT20 and 802.11n HT40 of WLAN are not supported to SISO mode on this device.

1.6. Simultaneous Transmission Capabilities

2.4GHz and 5GHz of WLAN cannot be used simultaneously from the module.

1.7. DUT Antenna Locations



Back Side view

Note: Exact antenna dimensions and separation distances are shown in the Technical Descriptions in the FCC Filing.

1.8. Near Field Communications (NFC) Antenna

This DUT does not support NFC function.

1.9. SAR Test Configurations and Exclusions

(A) WLAN

Per FCC KDB 447498 D01v06, the 1g SAR exclusion threshold for distances < 50 mm is defined by the following equation:

$$\frac{\text{Max Power of Channel (mW)}}{\text{Test Separation Dist (mm)}} * \sqrt{\text{Frequency(GHz)}} \leq 3.0$$

Band	Mode	Equation	Result	SAR Exclusion Threshold	Required SAR
DTS	2.4 GHz WLAN Ant.1	[(90/5)*√2.412]	27.81	3.0	O
	2.4 GHz WLAN Ant.2	[(93/5)*√2.412]	28.79	3.0	O
U-NII-2A	5.3 GHz WLAN Ant.1	[(57/5)*√5.280]	26.33	3.0	O
	5.3 GHz WLAN Ant.2	[(59/5)*√5.280]	27.01	3.0	O
U-NII-2C	5.6 GHz WLAN Ant.1	[(17/5)*√5.580]	8.19	3.0	O
	5.6 GHz WLAN Ant.2	[(18/5)*√5.580]	8.34	3.0	O
U-NII-3	5.8 GHz WLAN Ant.1	[(12/5)*√5.785]	5.60	3.0	O
	5.8 GHz WLAN Ant.2	[(12/5)*√5.785]	5.89	3.0	O

1.10. Guidance Applied

- IEEE 1528-2013
- FCC KDB Publication 248227 D01v02r02 (802.11 Wi-Fi SAR)
- FCC KDB Publication 447498 D01v06 (General RF Exposure Guidance)
- FCC KDB Publication 690783 D01 SAR Listings on Grants v01r03
- FCC KDB Publication 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04
- FCC KDB Publication 865664 D02 RF Exposure Reporting v01r02

1.11. Device Serial Numbers

Several samples with identical hardware were used to support SAR testing. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units. The serial numbers used for each test are indicated alongside the results in Section 9.

2. Introduction

The FCC and Innovation, Science, and Economic Development Canada have adopted the guidelines for evaluating the environmental effects of radio frequency (RF) radiation in ET Docket 93-62 on Aug. 6, 1996 and Health Canada Safety Code 6 to protect the public and workers from the potential hazards of RF emissions due to FCC-regulated portable devices.

The safety limits used for the environmental evaluation measurements are based on the criteria published by the American National Standards Institute (ANSI) for localized specific absorption rate (SAR) in IEEE/ANSI C95.1-1992 Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3KHz to 300 GHz and Health Canada RF Exposure Guidelines Safety Code 6. The measurement procedure described in IEEE/ANSI C95.3-2002 Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields - RF and Microwave is used for guidance in measuring the Specific Absorption Rate (SAR) due to the RF radiation exposure from the Equipment Under Test (EUT). These criteria for SAR evaluation are similar to those recommended by the International Committee for Non-ionizing Radiation Protection (ICNIRP) in Biological Effects and Exposure Criteria for Radiofrequency Electromagnetic Fields," Report No. Vol 74. SAR is a measure of the rate of energy absorption due to exposure to an RF transmitting source. SAR values have been related to threshold levels for potential biological hazards.

2.1. SAR definition

SAR is related to the rate at which energy is absorbed per unit mass in an object exposed to a radio field. The SAR distribution in a biological body is complicated and is usually carried out by experimental techniques or numerical modeling. The standard recommends limits for two tiers of groups, occupational/controlled and general population/uncontrolled, based on a person's awareness and ability to exercise control over his or her exposure. In general, occupational/controlled exposure limits are higher than the limits for general population/uncontrolled.

The SAR definition is the time derivative (rate) of the incremental energy (dW) absorbed by (dissipated in) an incremental mass (dm) contained in a volume element (dv) of a given density (ρ). The equation description is as below:

$$SAR = \frac{d}{dt} \left(\frac{dW}{dm} \right) = \frac{d}{dt} \left(\frac{dW}{\rho dv} \right)$$

SAR is expressed in units of Watts per kilogram (W/kg)

SAR measurement can be related to the electrical field in the tissue by

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

Where: σ is the conductivity of the tissue, ρ is the mass density of the tissue and E is the RMS electrical field strength.

NOTE: The primary factors that control rate of energy absorption were found to be the wavelength of the incident field in relation to the dimensions and geometry of the irradiated organism, the orientation of the organism in relation to the polarity of field vectors, the presence of reflecting surfaces, and whether conductive contact is made by the organism with a ground plane.

2.4. Probe

The SAR measurement is conducted with the dosimetric probe. The probe is specially designed and calibrated for use in liquid with high permittivity. The dosimetric probe has special calibration in liquid at different frequency.


Model	EX3DV4	
Construction	Symmetrical design with triangular core Built-in shielding against static charges PEEK enclosure material (resistant to organic solvents, e.g., DGBE)	
Frequency	10 MHz to > 6 GHz Linearity: ± 0.2 dB (30 MHz to 6 GHz)	
Directivity	± 0.3 dB in TSL (rotation around probe axis) ± 0.5 dB in TSL (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: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Typical distance from probe tip to dipole centers: 1 mm	

Figure 4. Probe

2.5. Data Acquisition Electronics (DAE)




Model	DAE4	
Construction	Signal amplifier, multiplexer, A/D converter and control logic. Serial optical link for communication with DASY4/5 embedded system (fully remote controlled). Two step probe touch detector for mechanical surface detection and emergency robot stop.	
Measurement Range	-100 to +300 mV (16 bit resolution and two range settings: 4 mV, 40 0mV)	
Input Voltage Offset	± 0.2 dB in HSL (rotation around probe axis) ± 0.3 dB in tissue material (rotation normal to probe axis)	
Input Bias Current	< 50 fA	
Dimensions	60 x 60 x 68 mm	


Figure 5. DAE


2.6. Phantoms

Model	Twin SAM	 Figure 6. Twin SAM
Construction	The shell corresponds to the specifications of the Specific Anthropomorphic Mannequin (SAM) phantom defined in IEEE 1528 and IEC 62209-1. 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 teaching three points with the robot.	
Material	Vinylester, glass fiber reinforced (VE-GF)	
Shell Thickness	2 ± 0.2 mm (6 ± 0.2 mm at ear point)	
Dimensions	Length: 1000 mm Width: 500 mm Height: adjustable feet	
Filling Volume	approx. 25 liters	


Model	ELI	 Figure 7. ELI
Construction	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)	
Shell Thickness	2.0 ± 0.2 mm (bottom plate)	
Dimensions	Major axis: 600 mm Minor axis: 400 mm	
Filling Volume	approx. 30 liters	

2.7. Device holder

Model	Mounting device	 <p>Figure 8. Mounting device</p>
Construction	In combination with the Twin SAM Phantom or ELI4, the Mounting Device enables the rotation of the mounted transmitter device in spherical coordinates. Rotation point is the ear opening point. Transmitter devices can be easily and accurately positioned according to IEC, IEEE, FCC or other specifications. The device holder can be locked for positioning at different phantom sections (left head, right head, flat).	
Material	POM	

Model	Laptop extensions kit	 <p>Figure 9. Laptop extensions kit</p>
Construction	Simple but effective and easy-to-use extension for Mounting Device that facilitates the testing of larger devices according to IEC 62209-2 (e.g., laptops, cameras, etc.). It is lightweight and fits easily on the upper part of the Mounting Device in place of the phone positioner.	
Material	POM, Acrylic glass, Foam	

2.8. System Validation Dipoles

Model	D-Serial	 <p>Figure 10. Dipole Antenna</p>
Construction	Symmetrical dipole with 1/4 balun. Enables measurement of feed point impedance with NWA. Matched for use near flat phantoms filled with tissue simulating solutions.	
Frequency	750 MHz to 5800 MHz	
Return Loss	> 20 dB	
Power Capability	> 100 W (f < 1 GHz), > 40 W (f > 1 GHz)	

3. Dosimetric Assessment

The evaluation was performed using the following procedure compliant to FCC KDB Publication 865664 D01v01r04 and IEEE 1528-2013:

1. The SAR distribution at the exposed side of the head or body was measured at a distance no greater than 5.0 mm from the inner surface of the shell. The area covered the entire dimension of the device-head and body interface and the horizontal grid resolution was determined per FCC KDB Publication 865664 D01v01r04 (See Table 4-1) and IEEE 1528-2013.

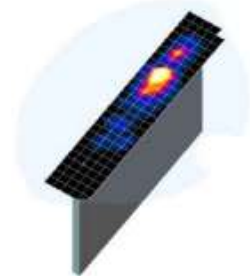


Figure 4-1 Sample SAR Area Scan

2. The point SAR measurement was taken at the maximum SAR region determined from Step 1 to enable the monitoring of SAR fluctuations/drifts during the 1g/10g cube evaluation. SAR at this fixed point was measured and used as a reference value.

3. Based on the area scan data, the peak of the region with maximum SAR was determined by spline interpolation. Around this point, a volume was assessed according to the measurement resolution and volume size requirements of FCC KDB Publication 865664 D01v01r04 (See Table 4-1) and IEEE 1528-2013. On the basis of this data set, the spatial peak SAR value was evaluated with the following procedure (see references or the DASY manual online for more details):

- a. SAR values at the inner surface of the phantom are extrapolated from the measured values along the line away from the surface with spacing no greater than that in Table 4-1. The extrapolation was based on a least-squares algorithm. A polynomial of the fourth order was calculated through the points in the z-axis (normal to the phantom shell).
- b. After the maximum interpolated values were calculated between the points in the cube, the SAR was averaged over the spatial volume (1g or 10g) using a 3D-Spline interpolation algorithm. The 3D-spline is composed of three one-dimensional splines with the “Not a knot” condition (in x, y, and z directions). The volume was then integrated with the trapezoidal algorithm. One thousand points (10 x 10 x 10) were obtained through interpolation, in order to calculate the averaged SAR.
- c. All neighboring volumes were evaluated until no neighboring volume with a higher average value was found.

4. The SAR reference value, at the same location as step 2, was re-measured after the zoom scan was complete to calculate the SAR drift. If the drift deviated by more than 5%, the SAR test and drift measurements were repeated.

Table 4-1 Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01v01r04*

Frequency	Maximum Area Scan Resolution (mm) ($\Delta x_{Area}, \Delta y_{Area}$)	Maximum Zoom Scan Resolution (mm) ($\Delta x_{Zoom}, \Delta y_{Zoom}$)	Maximum Zoom Scan Spatial Resolution (mm)			Minimum Zoom Scan Volume (mm) (x,y,z)
			Uniform Grid		Graded Grid	
			$\Delta z_{Zoom}(n)$	$\Delta z_{Zoom}(1)^*$		
≤ 2 GHz	≤ 15	≤ 8	≤ 5	≤ 4	≤ 1.5* $\Delta z_{Zoom}(n-1)$	≥ 30
2-3 GHz	≤ 12	≤ 5	≤ 5	≤ 4	≤ 1.5* $\Delta z_{Zoom}(n-1)$	≥ 30
3-4 GHz	≤ 12	≤ 5	≤ 4	≤ 3	≤ 1.5* $\Delta z_{Zoom}(n-1)$	≥ 28
4-5 GHz	≤ 10	≤ 4	≤ 3	≤ 2.5	≤ 1.5* $\Delta z_{Zoom}(n-1)$	≥ 25
5-6 GHz	≤ 10	≤ 4	≤ 2	≤ 2	≤ 1.5* $\Delta z_{Zoom}(n-1)$	≥ 22

*Also compliant to IEEE 1528-2013 Table 6

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4. RF Exposure Limits

4.1. Uncontrolled Environment

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

4.2. Controlled Environment

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

Table 7-1 SAR Human Exposure Specified in ANSI/IEEE C95.1-1992 and Health Canada Safety Code 6

Human Exposure Limits		
	Uncontrolled Environment General Population (W/kg) or (mW/g)	Controlled Environment Occupational (W/kg) or (mW/g)
Peak Spatial Average SAR Head	1.6	8.0
Whole Body SAR	0.08	0.4
Peak Spatial Average SAR Hands, Feet, Ankle, Wrists, etc.	4.0	20

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

5. FCC Measurement Procedures

5.1. Measured and Reported SAR

Per FCC KDB Publication 447498 D01v06, when SAR is not measured at the maximum power level allowed for production units, the results must be scaled to the maximum tune-up tolerance limit according to the power applied to the individual channels tested to determine compliance. For simultaneous transmission, the measured aggregate SAR must be scaled according to the sum of the differences between the maximum tune-up tolerance and actual power used to test each transmitter. When SAR is measured at or scaled to the maximum tune-up tolerance limit, the results are referred to as *reported* SAR. The highest *reported* SAR results are identified on the grant of equipment authorization according to procedures in KDB 690783 D01v01r03.

5.2. SAR Testing with 802.11 Transmitters

Normal network operating configurations are not suitable for measuring the SAR of 802.11 b/g/n transmitters. Unpredictable fluctuations in network traffic and antenna diversity conditions can introduce undesirable variations in SAR results. The SAR for these devices should be measured using chipset based test mode software to ensure the results are consistent and reliable. See KDB Publication 248227D01v02r02 for more details.

5.3. General Device Setup

Chipset based test mode software is hardware dependent and generally varies among manufacturers. The device operating parameters established in test mode for SAR measurements must be identical to those programmed in production units, including output power levels, amplifier gain settings and other RF performance tuning parameters. The test frequencies should correspond to actual channel frequencies defined for domestic use. SAR for devices with switched diversity should be measured with only one antenna transmitting at a time during each SAR measurement, according to a fixed modulation and data rate. The same data pattern should be used for all measurements. The reported SAR is scaled to 100% transmission duty factor to determine compliance at the maximum tune-up tolerance limit.

5.4. U-NII-1 and U-NII-2A

For devices that operate in only one of the U-NII-1 and U-NII-2A bands, the normally required SAR procedures for OFDM configurations are applied. For devices that operate in both U-NII bands using the same transmitter and antenna(s), SAR test reduction is determined according to the following, with respect to the highest reported SAR and maximum output power specified for production units. The procedures are applied independently to each exposure configuration; for example, head, body, hotspot mode etc.

- 1) When the same maximum output power is specified for both bands, begin SAR measurement in U-NII-2A band by applying the OFDM SAR requirements. If the highest reported SAR for a test configuration is ≤ 1.2 W/kg, SAR is not required for U-NII-1 band for that configuration (802.11 mode and exposure condition); otherwise, each band is tested independently for SAR.
- 2) When different maximum output power is specified for the bands, begin SAR measurement in the band with higher specified maximum output power. The highest reported SAR for the tested configuration is adjusted by the ratio of lower to higher specified maximum output power for the two bands. When the adjusted SAR is ≤ 1.2 W/kg, SAR is not required for the band with lower maximum output power in that test configuration; otherwise, each band is tested independently for SAR.

5.5. U-NII-2C and U-NII-3

The frequency range covered by U-NII-2C and U-NII-3 is 380 MHz (5.47 – 5.85 GHz), which requires a minimum of at least two SAR probe calibration frequency points to support SAR measurements.

When Terminal Doppler Weather Rader (TDWR) restriction applies, the channels at 5.60 – 5.65 GHz in U-NII-2C band must be disabled with acceptable mechanisms and documented in the equipment certification. Unless band gap channels are permanently disabled, SAR must be considered for these channels. When band gap channels are disabled, each band is tested independently according to the normally required OFDM SAR measurements and probe calibration frequency points requirements.

5.6. Initial Test Position Procedure

For exposure conditions with multiple test positions, such as handset operating next to the ear, devices with hotspot mode or UMPC mini-tablet, procedures for initial test position can be applied. Using the transmission mode determined by the DSSS procedure or initial test configuration, area scans are measured for all position in an exposure condition. The test position with the highest extrapolated (peak) SAR is used as the initial test position.

When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test positions is required. Otherwise, SAR is evaluated at the subsequent highest peak SAR position until the reported SAR result is ≤ 0.8 W/kg or all test position are measured.

5.7. 2.4 GHz SAR Test Requirements

SAR is measured for 2.4 GHz 802.11b DSSS using either a fixed test position or, when applicable, the initial test position procedure. SAR test reduction is determined according to the following:

- 1) When the reported SAR of the highest measured maximum output power channel for the exposure configuration is ≤ 0.8 W/kg, no further SAR testing is required for 802.11b DSSS in that exposure configuration.
- 2) When the reported SAR is > 0.8 W/kg, SAR is required for that exposure configuration using the next highest measured output power channel. When any reported SAR is > 1.2 W/kg, SAR is required for the third channel; i.e., all channels require testing.

2.4 GHz 802.11 g/n OFDM are additionally evaluated for SAR if the highest reported SAR for 802.11b, adjusted by the ratio of the OFDM to DSSS specified maximum output power is > 1.2 W/kg. When SAR is required for OFDM modes in 2.4 GHz band, the Initial Test Configuration Procedures should be followed.

5.8. OFDM Transmission Mode and SAR Test Channel Selection

For the 2.4 GHz and 5 GHz bands, when the same maximum output power was specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration with the largest channel bandwidth, lowest order modulation and lowest data rate. When the maximum output power of a channel is the same for equivalent OFDM configurations; for example, 802.11a, 802.11n and 802.11ac or 802.11g and 802.11n with the same channel bandwidth, modulation and data rate etc., the lower order 802.11 mode i.e., 802.11a, then 802.11n and 802.11ac or 802.11g then 802.11n is used for SAR measurement. When the maximum output power were the same for multiple test channels, either according to the default or additional power measurement requirements, SAR is measured using the channel closest to the middle of the frequency band or aggregated band. When there are multiple channels with the same maximum output power, SAR is measured using the higher number channel.

5.9. Initial Test Configuration Procedure

For OFDM, in both 2.4 and 5 GHz bands, an initial test configuration is determined for each frequency band and aggregated band, according to the transmission mode with the highest maximum output power specified for SAR measurements. When the same maximum output is specified for multiple OFDM transmission mode configurations in a frequency band or aggregated band, SAR is measured using the configuration(s) with the largest channel bandwidth, lowest order modulation, and lowest data rate. The channel of the transmission mode with the highest average RF output conducted power will be the initial test configuration.

When the reported SAR ≤ 0.8 W/kg, no additional measurements on other test channels are required.

Otherwise, SAR is evaluated using the subsequent highest average RF output channel until the reported SAR result is ≤ 1.2 W/kg or all channels are measured.

5.10. Subsequent Test Configuration Procedures

For OFDM configurations, in each frequency band and aggregated band, SAR is evaluated for initial test configuration using the fixed test position or the initial test position procedure, when applicable. When the highest reported SAR for the initial test configuration, adjusted by the ratio of the subsequent test configuration to initial test configuration specified maximum output power is ≤ 1.2 W/kg, no additional SAR testing for the subsequent test configurations is required.

5.11. MIMO SAR considerations

Per KDB Publication 248227 D01v02r02, the simultaneous SAR provision in KDB Publication 447498 D01v06 should be applied to determine simultaneous transmission SAR test exclusion for WIFI MIMO. If the sum of 1g single transmission chain SAR measurements is < 1.6 W/kg, no additional SAR measurements for MIMO are required.

Alternatively, SAR for MIMO can be measured with all antennas transmitting simultaneously at the specified maximum output power of MIMO operation.

6. RF Conducted Powers

6.1. W-LAN Conducted Powers

The measuring conducted power (Unit: dBm) are shown as below.

Mode	Frequency (MHz)	Data rate [Mbps]	Channel	Antenna	Average Power (dBm)
2.4 GHz WLAN 802.11b	2412	1	1	1	19.23
	2437	1	6		18.96
	2462	1	11		18.11
2.4 GHz WLAN 802.11b	2412	1	1	2	19.67
	2437	1	6		19.43
	2462	1	11		18.28
2.4 GHz WLAN 802.11g	2412	6	1	1	15.43
	2437	6	6		15.28
	2462	6	11		14.73
2.4 GHz WLAN 802.11g	2412	6	1	2	15.80
	2437	6	6		15.70
	2462	6	11		14.66
2.4 GHz WLAN 802.11n HT20	2412	MCS8	1	1+2	14.89
	2437	MCS8	6		14.28
	2462	MCS8	11		14.75
2.4 GHz WLAN 802.11n HT40	2422	MCS8	3	1+2	12.30
	2437	MCS8	6		12.28
	2452	MCS8	9		12.96

Table 6.1 2.4 GHz WLAN Average RF Power

Mode	Frequency (MHz)	Data rate [Mbps]	Channel	Antenna Status	Average Power (dBm)
5.2 GHz WLAN 802.11a	5180	6	52	1	14.18
	5220	6	60		15.23
	5240	6	64		15.67
5.2 GHz WLAN 802.11a	5180	6	52	2	14.25
	5220	6	60		15.06
	5240	6	64		16.00
5.2 GHz WLAN 802.11n HT20	5180	MCS8	52	1+2	14.31
	5220	MCS8	60		14.19
	5240	MCS8	64		15.08
5.2 GHz WLAN 802.11n HT40	5190	MCS8	54	1+2	15.13
	5230	MCS8	62		14.60

Table 6.2 5.2 GHz WLAN Average RF Power



Mode	Frequency (MHz)	Data rate [Mbps]	Channel	Antenna Status	Average Power (dBm)
5.3 GHz WLAN 802.11a	5260	6	52	1	17.48
	5280	6	56		17.35
	5320	6	64		16.72
5.3 GHz WLAN 802.11a	5260	6	52	2	17.70
	5280	6	56		17.65
	5320	6	64		16.96
5.3 GHz WLAN 802.11n HT20	5260	MCS8	52	1+2	20.37
	5280	MCS8	56		19.61
	5320	MCS8	64		18.57
5.3 GHz WLAN 802.11n HT40	5270	MCS8	54	1+2	18.72
	5310	MCS8	62		17.59

Table 6.3 5.3 GHz WLAN Average RF Power

Mode	Frequency (MHz)	Data rate [Mbps]	Channel	Antenna Status	Average Power (dBm)
5.6 GHz WLAN 802.11a	5500	6	100	1	12.36
	5580	6	116		12.13
	5700	6	140		10.44
5.6 GHz WLAN 802.11a	5500	6	100	2	12.50
	5580	6	116		12.40
	5700	6	140		10.62
5.6 GHz WLAN 802.11n HT20	5500	MCS8	100	1+2	16.07
	5580	MCS8	116		14.28
	5700	MCS8	140		15.76
5.6 GHz WLAN 802.11n HT40	5510	MCS8	102	1+2	15.48
	5550	MCS8	110		14.55
	5670	MCS8	134		12.93

Table 6.4 5.6 GHz WLAN Average RF Power

Mode	Frequency (MHz)	Data rate [Mbps]	Channel	Antenna Status	Average Power (dBm)
5.8 GHz WLAN 802.11a	5745	6	149	1	8.39
	5785	6	157		10.93
	5825	6	165		10.01
5.8 GHz WLAN 802.11a	5745	6	149	2	8.04
	5785	6	157		10.88
	5825	6	165		9.62
5.8 GHz WLAN 802.11n HT20	5745	MCS8	149	1+2	18.08
	5785	MCS8	157		17.25
	5825	MCS8	165		16.46
5.8 GHz WLAN 802.11n HT40	5755	MCS8	151	1+2	18.00
	5795	MCS8	159		17.48

Table 6.5 5.8 GHz WLAN Average RF Power

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Note:

- 802.11n HT20 and 802.11n HT40 of WLAN are not supported to SISO mode on this device.

Justification for reduced test configurations for WIFI channels per KDB Publication 248227

D01v02r02:

- Power measurements were performed for the transmission mode configuration with the highest maximum output power specified for production units.
- For transmission modes with the same maximum output power specification, powers were measured for the largest channel bandwidth, lowest order modulation and lowest data rate.
- For transmission modes with identical maximum specified output power, channel bandwidth, modulation and data rates, power measurements were required for all identical configurations.
- For each transmission mode configuration, powers were measured for the highest and lowest channels; and at the mid-band channel(s) when there were at least 3 channels supported. For configurations with multiple mid-band channels, duo to an even number of channels, both channels were measured.
- 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 adjust SAR is ≤ 1.2 W/kg.
- The underlined data rate and channel above were tested for SAR.
- DUTY cycle of this device is 100 %.
-DUTY Cycle[%] = (Pulse / Period) X 100 = (1/1)X100 = 100 %



7. System Verification

Tissue Verification

The measuring results for tissue simulating liquid are shown as below.

Table 8-1 Measured Tissue Properties - Body

Tissue Type	Measured Frequency (MHz)	Tissue Temp (°C)	Measured Conductivity (σ)	Measured Permittivity (ϵ_r)	Target Conductivity (σ)	Target Permittivity (ϵ_r)	Conductivity Deviation (%)	Permittivity Deviation (%)	Tests Performed On:
HSL 2450	2450	21.9	1.847	40.165	1.80	39.2	2.61	2.46	2019.06.14
	2412		1.798	40.305	1.80	39.2	-0.11	2.82	
HSL 5GHz	5300	21.9	4.707	34.820	4.76	35.9	-1.06	-2.93	2019.06.18
	5260		4.677	34.940	4.72	35.9	-0.84	-2.72	
HSL 5GHz	5600	21.6	5.148	34.743	4.96	35.6	3.74	-2.52	2019.06.19
	5500		5.504	34.184	5.27	35.3	4.44	-3.16	
HSL 5GHz	5800	21.8	5.438	34.282	5.21	35.4	4.30	-3.06	2019.09.19
	5745		5.481	34.214	5.25	35.3	4.31	-3.12	
	5785		1.847	40.165	1.80	39.2	2.61	2.46	

The above measured tissue parameters were used in the DASY software. The DASY software was used to perform interpolation to determine the dielectric parameters at the SAR test device frequencies (per KDB Publication 865664 D01v01r04 and IEEE 1528-2013 6.6.1.2). The tissue parameters listed in the SAR test plots may slightly differ from the table above due to significant digit rounding in the software.

System Verification

The measuring results for system check are shown as below. Prior to SAR assessment, the system is verified to $\pm 10\%$ of the SAR measurement on the reference dipole at the time of calibration by the calibration facility. Full system validation status and result summary can be found in Appendix A.

Table 8-3 System Verification Results

SAR System #	Test Date	Tissue Frequency (MHz)	Amb. Temp (°C)	Liquid Temp (°C)	Input Power (mW)	Dipole SN	Probe SN	1W Target SAR-1 g (W/kg)	Measured SAR-1 g (W/kg)	Normalized to 1W SAR-1 g (W/kg)	Deviation (%)
#1	2019.06.14	2450	22.8	21.9	250	896	7359	51.40	12.60	50.40	-1.95
#1	2019.06.18	5300	22.7	21.9	100	1170	7359	81.20	7.63	76.30	-6.03
#1	2019.06.19	5600	22.4	21.6	100	1170	7359	83.50	8.64	86.40	3.47
#1	2019.09.19	5800	22.6	21.8	100	1170	7359	79.40	7.86	78.60	-1.01

Note: Per April 2019 TCB Workshop, Effective February 19,2019, FCC has permitted the use of single head-tissue simulating liquid specified in IEC 62209-1 for all SAR tests.

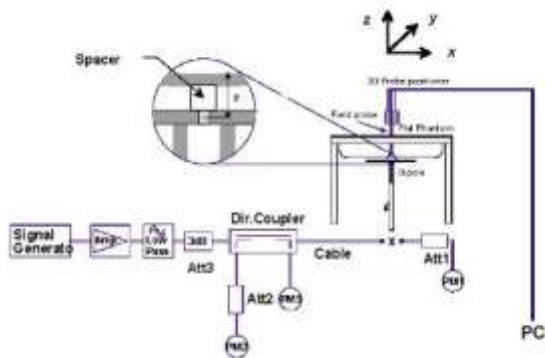


Figure 8-1 System Verification Setup Diagram



Figure 8-2 System Verification Setup Photo



8. SAR Data Summary

8.1. Standalone Body SAR Data

Table 9-1 WLAN Body SAR

Measurement Results														
Frequency		Mode	Antenna Status	Maximum Allowed Power [dBm]	Conducted Power [dBm]	Power Drift [dB]	Spacing [cm]	Test Position	Duty Cycle [%]	SAR (1g) W/kg	Scaling Factor (Duty Cycle)	Scaling Factor (Power)	Reported SAR(1g) W/kg	Plot #
MHz	Ch.													
2412	1	802.11b	Ant.1	20.0	19.52	0.020	0	Front Side	100	0.013	1.000	1.117	0.015	1
2412	1	802.11b	Ant.2	20.0	19.67	-0.170	0	Front Side	100	0.012	1.000	1.079	0.013	2
2412	1	802.11n HT40	Ant.1+2	15.0	14.89	0.160	0	Front Side	100	0.022	1.000	1.026	0.023	3
5260	52	802.11a	Ant.1	18.0	17.59	-0.060	0	Front Side	100	0.085	1.000	1.099	0.093	11
5260	52	802.11a	Ant.2	18.0	17.70	-0.140	0	Front Side	100	0.077	1.000	1.072	0.083	12
5260	52	802.11n HT20	Ant.1+2	21.0	20.37	-0.120	0	Front Side	100	0.087	1.000	1.156	0.101	13
5500	100	802.11a	Ant.1	13.0	12.42	-0.140	0	Front Side	100	0.110	1.000	1.143	0.126	21
5500	100	802.11a	Ant.2	13.0	12.50	0.100	0	Front Side	100	0.081	1.000	1.122	0.091	22
5500	100	802.11n HT20	Ant.1+2	17.0	16.07	0.020	0	Front Side	100	0.100	1.000	1.239	0.124	23
5785	157	802.11a	Ant.1	11.0	10.66	-0.150	0	Front Side	100	0.194	1.000	1.081	0.210	31
5785	157	802.11a	Ant.2	11.0	10.88	-0.010	0	Front Side	100	0.071	1.000	1.028	0.073	32
5745	149	802.11n HT20	Ant.1+2	19.0	18.08	-0.090	0	Front Side	100	0.125	1.000	1.236	0.059	33
ANSI / IEEE C95.1 1992 – SAFETY LIMIT Spatial Peak Uncontrolled Exposure / General Population							Body SARW/kg (mW/g) averaged over 1 gram							

8.2. SAR Test Notes

General Notes:

1. The test data reported are the worst-case SAR values according to test procedures specified in IEEE 1528-2013, and FCC KDB Publication 447498 D01v06.
2. Batteries are fully charged at the beginning of the SAR measurements. A standard battery was used for all SAR measurements.
3. Liquid tissue depth was at least 15.0 cm for all frequencies.
4. The manufacturer has confirmed that the device(s) tested have the same physical, mechanical and thermal characteristics and are within operational tolerances expected for production units
5. SAR results were scaled to the maximum allowed power to demonstrate compliance per FCC KDB Publication 447498 D01v06.
6. The front with touch configuration was only tested since only the front is touched to human body in normal operation condition of this device.
7. FCC has permitted the use of single head-tissue simulating liquid specified February 19, 2019 TCBC Workshop.

WLAN Notes:

1. The initial test position procedures were applied. The test position with the highest extrapolated peak SAR will be used as the initial test position. When reported SAR for the initial test position is ≤ 0.4 W/kg, no additional testing for the remaining test positions was required. Otherwise, SAR is evaluated at the subsequent highest peak SAR positions until the reported SAR result is ≤ 0.8 W/kg or all test positions are measured.
2. Justification for test configurations for W-LAN per KDB Publication 248227 D01v02r02 for 2.4 GHz WIFI single transmission chain operations, the highest measured maximum output power channel for DSSS was selected for SAR measurement. SAR for OFDM modes (2.4 GHz 802.11g/n) was not required due to the maximum allowed powers and the highest reported DSSS SAR when the highest reported SAR for DSSS is adjusted by the ratio of OFDM to DSSS specified maximum output and the adjusted SAR is ≤ 1.2 W/kg.
3. 5.2GHz band WLAN is exempted. Because of adjusted SAR is ≤ 1.2 W/kg and the band is lower maximum output power specified for production units. For WLAN 2.4 GHz, the highest measured maximum output power channel for DSSS was selected Per KDB 248227 D01 v02r02. for SAR measurement. When the reported SAR is ≤ 0.4 W/kg, no further SAR testing is required per KDB Publication 248227 D01v02r02.
4. Justification for test configurations for W-LAN per KDB Publication 248227 D01v02r02 for 5 GHz WIFI single transmission chain operations, the initial test configuration was selected according to the transmission mode with the highest maximum allowed powers. Other transmission modes were not investigated since the highest reported SAR for initial test configuration adjusted by the ratio of maximum output powers is less than 1.2 W/kg.
5. When the maximum reported 1g averaged SAR ≤ 0.8 W/kg, SAR testing on additional channels was not required. Otherwise, SAR for the next highest output power channel was required until the reported SAR result was ≤ 1.20 W/kg or all test channels were measured.
6. The device was configured to transmit continuously at the required data rate, channel bandwidth and signal modulation, using the highest transmission duty factor to determine compliance.



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7. SAR Measurement Uncertainty

The measured SAR was <1.5 W/kg for all frequency bands. Therefore, per KDB Publication 865664 D01v01r04, the extended measurement uncertainty analysis per IEEE 1528-2013 was not required.

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8. Equipment List

Equipment	Manufacturer	Model	Serial No.	Cal. Date	Next Cal. Date	Cal. Interval
SAR Chamber	Dymstec	N/A	N/A	N/A	N/A	N/A
Thermo-Hygrostat	(주)한국문터스	HK-030-AU1	1506231	N/A	N/A	N/A
Staubli Robot Unit	Staubli	TX60L	F15/5Y7QA1/A/0 1	N/A	N/A	N/A
Electro Optical Converter	SPEAG	EOC60	1096	N/A	N/A	N/A
2mm Oval Phantom V4.0C	SPEAG	QD OVA 002 AA	1190	N/A	N/A	N/A
Device Holder	SPEAG	Laptop Holder	SM LH1 001 CD	N/A	N/A	N/A
Data Acquisition Electronics	SPEAG	DAE4	1344	2018-11-15	2019-11-15	1 Year
E-Field Probe	SPEAG	EX3DV4	7359	2019-01-31	2020-01-31	1 Year
Dipole Antenna	SPEAG	D2450V2	896	2018-05-30	2020-05-30	2 Years
Dipole Antenna	SPEAG	D5GHzV2	1170	2018-01-25	2020-01-25	2 Years
Vector Signal Generator	R&S	SMBV100A	256397	2019-06-25	2020-06-25	1 Year
RF POWER AMPLIFIER	NONE	RFSPA24	001	2019-06-24	2020-06-24	1 Year
BROADBAND AMPLIFIER	EMPOWER	1138	1030	2019-06-24	2020-06-24	1 Year
DUAL DIRECTIONAL COUPLER	HP	11692D	1212A03523	2019-06-25	2020-06-25	1 Year
EPM Series Power Meter	HP	E4419B	GB40202055	2019-01-16	2020-01-16	1 Year
E-Series AVG Power Sensor	Agilent	E9300H	MY41495967	2019-01-15	2020-01-15	1 Year
E-Series AVG Power Sensor	Agilent	E9300H	US39215405	2019-01-15	2020-01-15	1 Year
POWER METER	ANRITSU	ML2495A	1438001	2019-01-15	2020-01-15	1 Year
Pulse Power Sensor	ANRITSU	MA2411B	1339205	2019-01-15	2020-01-15	1 Year
Attenuator	HP	8491B	22234	2019-01-15	2020-01-15	1 Year
Attenuator	MINI-CIRCUITS	UNAT-10+	VUU38501715	2019-01-15	2020-01-15	1 Year
Low Pass Filter	FILTRON	F-LPCA-KOO1410	1408004S	2019-01-16	2020-01-16	1 Year
Low Pass Filter	FILTRON	F-LPCA-KOO1420	1408008S	2019-01-16	2020-01-16	1 Year
DIELECTRIC ASSESSMENT KIT	SPEAG	DAK3.5	1092	N/A	N/A	N/A
S-Parameter Network Analyzer	Agilent	8753ES	MY40000210	2019-06-24	2020-06-24	1 Year
HYGRO-THERMOMETER	DAEKWANG	811CE	NONE	2019-06-27	2020-06-27	1 Year
Spectrum Analyzer	Agilent	N9010A	MY51440103	2019-01-16	2020-01-16	1 Year

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

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9. Conclusion

The SAR evaluation indicates that the EUT complies with the RF radiation exposure limits of the FCC and Innovation, Science, and Economic Development Canada, with respect to all parameters subject to this test. These measurements were taken to simulate the RF effects of RF exposure under worst-case conditions. Precise laboratory measures were taken to assure repeatability of the tests. The results and statements relate only to the item(s) tested.

Please note that the absorption and distribution of electromagnetic energy in the body are very complex phenomena that depend on the mass, shape, and size of the body, the orientation of the body with respect to the field vectors, and the electrical properties of both the body and the environment. Other variables that may play a substantial role in possible biological effects are those that characterize the environment (e.g. ambient temperature, air velocity, relative humidity, and body insulation) and those that characterize the individual (e.g. age, gender, activity level, debilitation, or disease). Because various factors may interact with one another to vary the specific biological outcome of an exposure to electromagnetic fields, any protection guide should consider maximal amplification of biological effects as a result of field-body interactions, environmental conditions, and physiological variables.

10. References

- [1] Federal Communications Commission, ET Docket 93-62, Guidelines for Evaluating the Environmental Effects of Radiofrequency Radiation, Aug. 1996.
- [2] ANSI/IEEE C95.1-2005, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, 2006.
- [3] ANSI/IEEE C95.1-1992, American National Standard safety levels with respect to human exposure to radio frequency electromagnetic fields, 3kHz to 300GHz, New York: IEEE, Sept. 1992.
- [4] ANSI/IEEE C95.3-2002, IEEE Recommended Practice for the Measurement of Potentially Hazardous Electromagnetic Fields – RF and Microwave, New York: IEEE, December 2002.
- [5] IEEE Standards Coordinating Committee 39 –Standards Coordinating Committee 34 – IEEE Std. 1528-2013, IEEE Recommended Practice for Determining the Peak Spatial-Average Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques. [6] NCRP, National Council on Radiation Protection and Measurements, Biological Effects and Exposure Criteria for RadioFrequency Electromagnetic Fields, NCRP Report No. 86, 1986. Reprinted Feb. 1995.
- [7] T. Schmid, O. Egger, N. Kuster, Automated E-field scanning system for dosimetric assessments, IEEE Transaction on Microwave Theory and Techniques, vol. 44, Jan. 1996, pp. 105-113.
- [8] K. Pokovic, T. Schmid, N. Kuster, Robust setup for precise calibration of E-field probes in tissue simulating liquids at mobile communications frequencies, ICECOM97, Oct. 1997, pp. 1 -124.
- [9] K. Pokovic, T. Schmid, and N. Kuster, E-field Probe with improved isotropy in brain simulating liquids, Proceedings of the ELMAR, Zadar, Croatia, June 23-25, 1996, pp. 172-175.
- [10] Schmid & Partner Engineering AG, Application Note: Data Storage and Evaluation, June 1998, p2.
- [11] V. Hombach, K. Meier, M. Burkhardt, E. Kuhn, N. Kuster, The Dependence of EM Energy Absorption upon Human Modeling at 900 MHz, IEEE Transaction on Microwave Theory and Techniques, vol. 44 no. 10, Oct. 1996, pp. 1865-1873.
- [12] N. Kuster and Q. Balzano, Energy absorption mechanism by biological bodies in the near field of dipole antennas above 300 MHz, IEEE Transaction on Vehicular Technology, vol. 41, no. 1, Feb. 1992, pp. 17-23.
- [13] G. Hartsgrrove, A. Kraszewski, A. Surowiec, Simulated Biological Materials for Electromagnetic Radiation Absorption Studies, University of Ottawa, Bioelectromagnetics, Canada: 1987, pp. 29-36.
- [14] Q. Balzano, O. Garay, T. Manning Jr., Electromagnetic Energy Exposure of Simulated Users of Portable Cellular Telephones, IEEE Transactions on Vehicular Technology, vol. 44, no.3, Aug. 1995.
- [15] W. Gander, Computermathematick, Birkhaeuser, Basel, 1992.
- [16] W.H. Press, S.A. Teukolsky, W.T. Vetterling, and B.P. Flannery, Numerical Recipes in C, The Art of Scientific Computing, Second edition, Cambridge University Press, 1992.
- [17] N. Kuster, R. Kastle, T. Schmid, Dosimetric evaluation of mobile communications equipment with known precision, IEEE Transaction on Communications, vol. E80-B, no. 5, May 1997, pp. 645-652.

- [18] CENELEC CLC/SC111B, European Prestandard (prENV 50166-2), Human Exposure to Electromagnetic Fields Highfrequency: 10 kHz-300 GHz, Jan. 1995.
- [19] Prof. Dr. Niels Kuster, ETH, Eidgenössische Technische Hochschule Zürich, Dosimetric Evaluation of the Cellular Phone.
- [20] IEC 62209-1, Measurement procedure for the assessment of specific absorption rate of human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Part 1: Devices used next to the ear (Frequency range of 300 MHz to 6 GHz), July 2016.
- [21] Innovation, Science, Economic Development Canada RSS-102 Radio Frequency Exposure Compliance of Radiocommunication Apparatus (All Frequency Bands) Issue 5, March 2015.
- [22] Health Canada Safety Code 6 Limits of Human Exposure to Radio Frequency Electromagnetic Fields in the Frequency Range from 3 kHz – 300 GHz, 2015
- [23] FCC SAR Test Procedures for 2G-3G Devices, Mobile Hotspot and UMPC Devices KDB Publications 941225, D01-D07
- [24] SAR Measurement Guidance for IEEE 802.11 Transmitters, KDB Publication 248227 D01
- [25] FCC SAR Considerations for Handsets with Multiple Transmitters and Antennas, KDB Publications 648474 D03-D04
- [26] FCC SAR Evaluation Considerations for Laptop, Notebook, Netbook and Tablet Computers, FCC KDB Publication 616217 D04
- [27] FCC SAR Measurement and Reporting Requirements for 100MHz – 6 GHz, KDB Publications 865664 D01-D02
- [28] FCC General RF Exposure Guidance and SAR Procedures for Dongles, KDB Publication 447498, D01-D02
- [29] Anexo à Resolução No. 533, de 10 de Setembro de 2009.
- [30] IEC 62209-2, Human exposure to radio frequency fields from hand-held and body-mounted wireless communication devices – Human models, instrumentation, and procedures – Part 2: Procedure to determine the specific absorption rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz), Mar. 2010.

Appendix A. SAR Plots for System Verification

The plots for system verification with largest deviation for each SAR system combination are shown as follows.

Test Laboratory: KES Co., Ltd.

Date: 6/14/2019 Time: 9:51:01 AM

System Verification for 2450 MHz

DUT: Dipole D2450V2-SN: 896

Communication System: CW; Frequency: 2450 MHz; Duty Cycle: 1:1

Medium: HSL2450 Medium parameters used: $f = 2450$ MHz; $\sigma = 1.847$ S/m; $\epsilon_r = 40.165$; $\rho = 1000$ kg/m³

Ambient Temperature : 22.8 °C; Liquid Temperature : 21.9 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(7.13, 7.13, 7.13); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0_Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

Pin=250 mW/Area Scan (61x61x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 20.9 W/kg

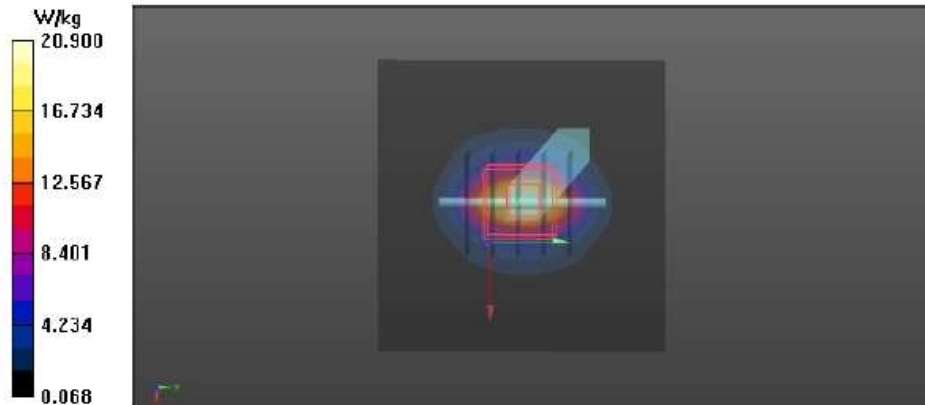
Pin=250 mW/Zoom Scan (5x5x7)/Cube 0: Measurement grid: dx=8mm, dy=8mm, dz=5mm

Reference Value = 111.4 V/m; Power Drift = 0.03 dB

Peak SAR (extrapolated) = 25.6 W/kg

SAR(1 g) = 12.6 W/kg; SAR(10 g) = 5.87 W/kg

Maximum value of SAR (measured) = 20.9 W/kg



Test Laboratory: KES Co., Ltd.

Date: 6/18/2019 Time: 9:45:05 AM

System Verification for 5300 MHz

DUT: Dipole D5GHzV2-SN: 1170

Communication System: CW; Frequency: 5300 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5300$ MHz; $\sigma = 4.707$ S/m; $\epsilon_r = 34.82$; $\rho = 1000$ kg/m³

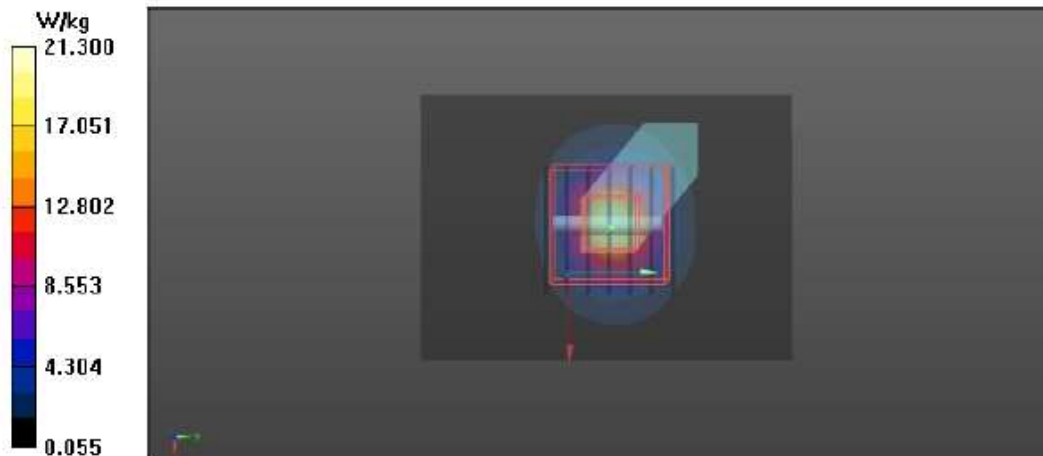
Ambient Temperature : 22.7 °C; Liquid Temperature : 21.9 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.89, 4.89, 4.89); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

Pin=100 mW/Area Scan (51x71x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 21.3 W/kg

Pin=100 mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 70.23 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 30.9 W/kg
SAR(1 g) = 7.63 W/kg; SAR(10 g) = 2.21 W/kg
Maximum value of SAR (measured) = 19.3 W/kg



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Test Laboratory: KES Co., Ltd.

Date: 6/19/2019 Time: 9:52:02 AM

System Verification for 5600 MHz

DUT: Dipole D5GHzV2-SN: 1170

Communication System: CW; Frequency: 5600 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5600$ MHz; $\sigma = 5.267$ S/m; $\epsilon_r = 34.57$; $\rho = 1000$ kg/m³

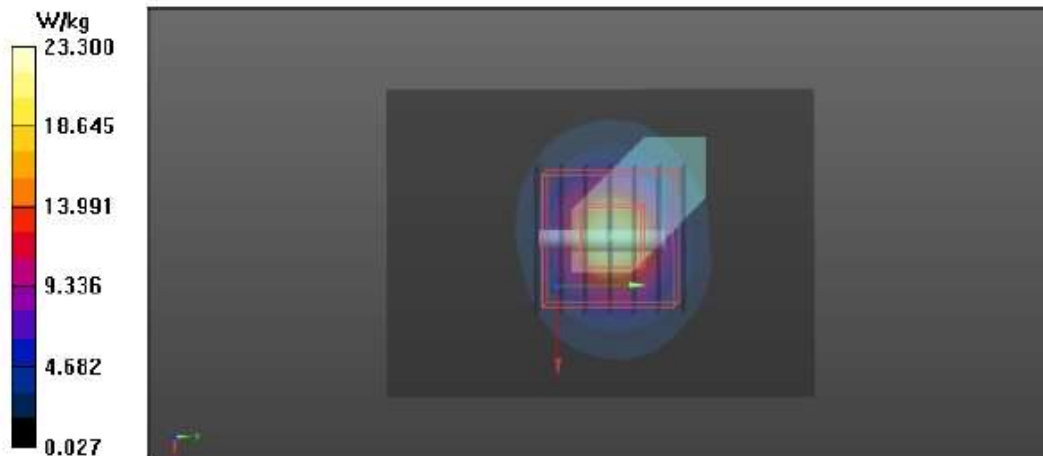
Ambient Temperature : 22.4 °C; Liquid Temperature : 21.6 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.73, 4.73, 4.73); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

Pin=100 mW/Area Scan (51x71x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 23.3 W/kg

Pin=100 mW/Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 69.95 V/m; Power Drift = 0.06 dB
Peak SAR (extrapolated) = 36.9 W/kg
SAR(1 g) = 8.64 W/kg; SAR(10 g) = 2.51 W/kg
Maximum value of SAR (measured) = 22.4 W/kg



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Test Laboratory: KES Co., Ltd.

Date: 9/19/2019 Time: 9:56:32 AM

System Verification for 5800 MHz**DUT: Dipole D5GHzV2-SN: 1170**

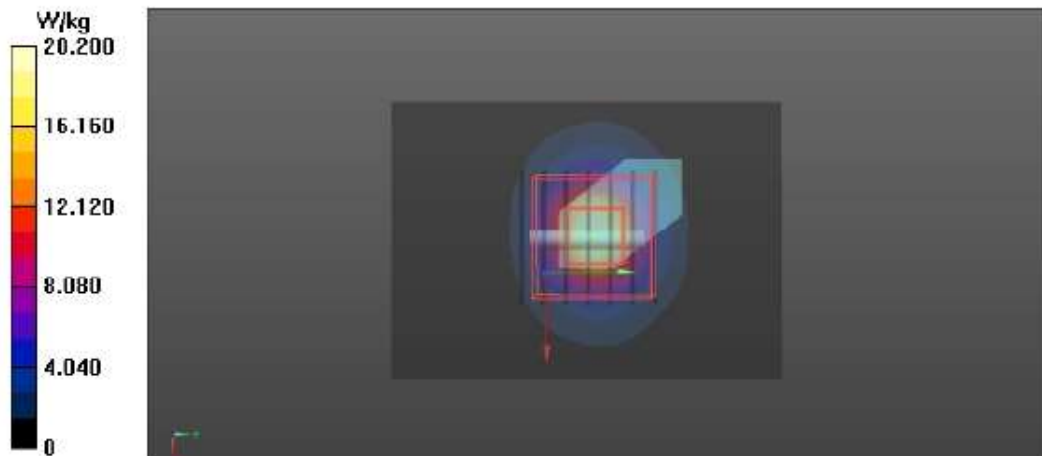
Communication System: CW; Frequency: 5800 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5800$ MHz; $\sigma = 5.504$ S/m; $\epsilon_r = 34.184$; $\rho = 1000$ kg/m³

Ambient Temperature : 22.6 °C; Liquid Temperature : 21.8 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.92, 4.92, 4.92); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

Pin=100 mW/Area Scan (51x71x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 21.4 W/kg**Pin=100 mW/Zoom Scan (7x7x12)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 64.91 V/m; Power Drift = 0.09 dB
Peak SAR (extrapolated) = 33.5 W/kg
SAR(1 g) = 7.86 W/kg; SAR(10 g) = 2.28 W/kg
Maximum value of SAR (measured) = 20.2 W/kg

Appendix B. SAR Plots for SAR Measurement

The plots for SAR measurement are shown as follows.

Test Laboratory: KES Co., Ltd.

Date: 6/14/2019 Time: 5:42:08 PM

P01_2.4 GHz WLAN_802.11b_Front Side_0 cm_Ch.1_Ant.1

DUT: EVS 4343W

Communication System: 2.4 G WLAN; Frequency: 2412 MHz; Duty Cycle: 1:1

Medium: HSL2450 Medium parameters used: $f = 2412$ MHz; $\sigma = 1.798$ S/m; $\epsilon_r = 40.305$; $\rho = 1000$ kg/m³

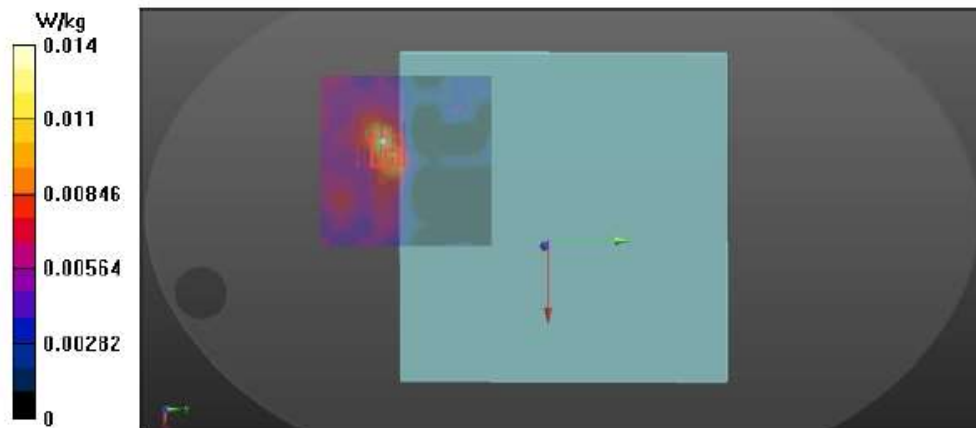
Ambient Temperature : 22.8 °C; Liquid Temperature : 21.9 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(7.13, 7.13, 7.13); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0_Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- **Area Scan (81x81x1)**: Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.0141 W/kg

- **Zoom Scan (5x5x7)/Cube 0**: Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 3.318 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 0.0260 W/kg
SAR(1 g) = 0.013 W/kg; SAR(10 g) = 0.00869 W/kg
Maximum value of SAR (measured) = 0.0193 W/kg



Test Laboratory: KES Co., Ltd.

Date: 6/14/2019 Time: 5:02:53 PM

P02_2.4 GHz WLAN_802.11b_Front Side_0 cm_Ch.1_Ant.2**DUT: EVS 4343W**

Communication System: 2.4 G WLAN; Frequency: 2412 MHz; Duty Cycle: 1:1

Medium: HSL2450 Medium parameters used: $f = 2412$ MHz; $\sigma = 1.798$ S/m; $\epsilon_r = 40.305$; $\rho = 1000$ kg/m³

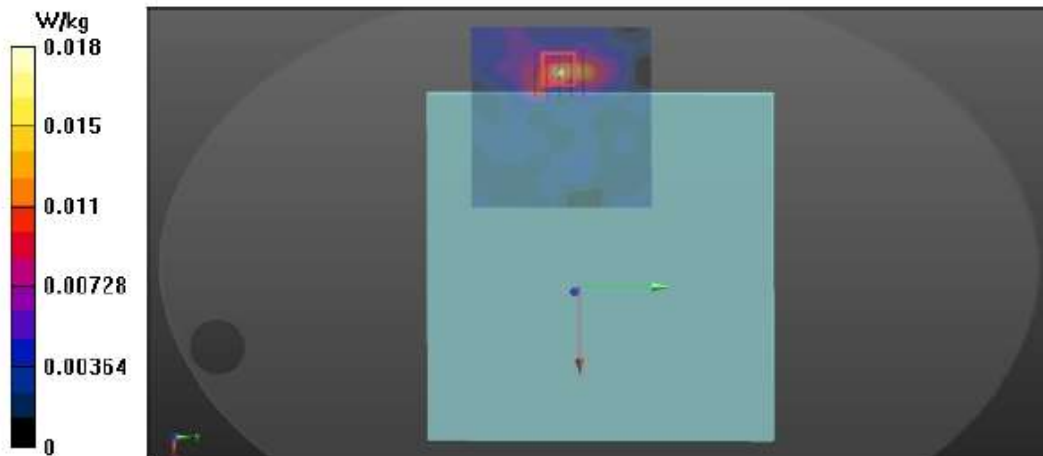
Ambient Temperature : 22.8 °C; Liquid Temperature : 21.9 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(7.13, 7.13, 7.13); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- **Area Scan (81x81x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.0182 W/kg

- **Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 3.415 V/m; Power Drift = -0.17 dB
Peak SAR (extrapolated) = 0.0250 W/kg
SAR(1 g) = 0.012 W/kg; SAR(10 g) = 0.00781 W/kg
Maximum value of SAR (measured) = 0.0166 W/kg



Test Laboratory: KES Co., Ltd.

Date: 6/14/2019 Time: 6:15:24 PM

P03_2.4 GHz WLAN_802.11n HT40_Front Side_0 cm_Ch.1_Ant.1+2

DUT: WUBR-508N

Communication System: 2.4 G WLAN; Frequency: 2412 MHz; Duty Cycle: 1:1

Medium: HSL2450 Medium parameters used: $f = 2412$ MHz; $\sigma = 1.798$ S/m; $\epsilon_r = 40.305$; $\rho = 1000$ kg/m³

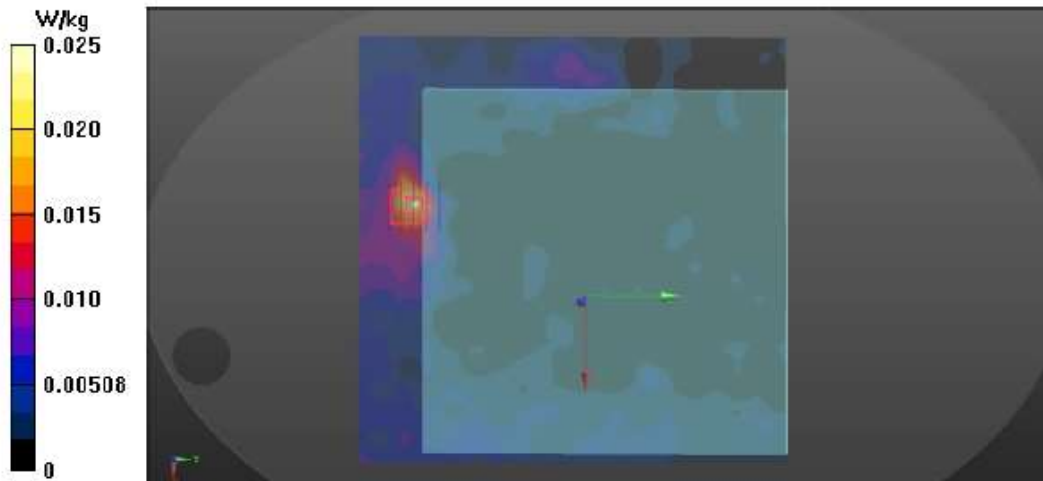
Ambient Temperature : 22.8 °C; Liquid Temperature : 21.9 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(7.13, 7.13, 7.13); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- **Area Scan (181x181x1):** Interpolated grid: dx=1.500 mm, dy=1.500 mm
Maximum value of SAR (interpolated) = 0.0254 W/kg

- **Zoom Scan (5x5x7)/Cube 0:** Measurement grid: dx=8mm, dy=8mm, dz=5mm
Reference Value = 4.327 V/m; Power Drift = 0.16 dB
Peak SAR (extrapolated) = 0.0450 W/kg
SAR(1 g) = 0.022 W/kg; SAR(10 g) = 0.013 W/kg
Maximum value of SAR (measured) = 0.0331 W/kg



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Test Laboratory: KES Co., Ltd.

Date: 6/18/2019 Time: 6:52:52 PM

P11_5.3 GHz WLAN_802.11a_Front Side_0 cm_Ch.52_Ant.1**DUT: EVS 4343W**

Communication System: 5.3 G WLAN; Frequency: 5260 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5260$ MHz; $\sigma = 4.677$ S/m; $\epsilon_r = 34.94$; $\rho = 1000$ kg/m³

Ambient Temperature : 22.7 °C; Liquid Temperature : 21.9 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.89, 4.89, 4.89); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- Area Scan (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.111 W/kg

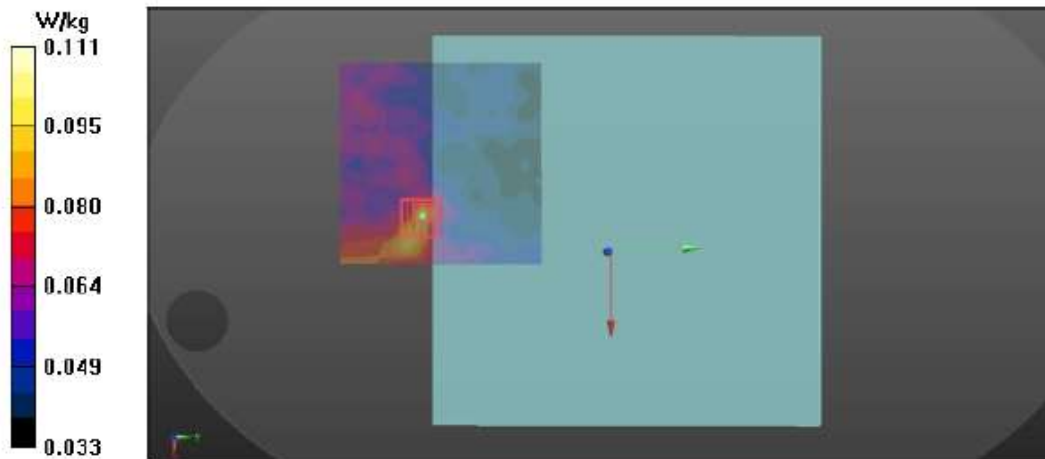
- Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm

Reference Value = 4.222 V/m; Power Drift = -0.06 dB

Peak SAR (extrapolated) = 0.125 W/kg

SAR(1 g) = 0.085 W/kg; SAR(10 g) = 0.076 W/kg

Maximum value of SAR (measured) = 0.109 W/kg



Test Laboratory: KES Co., Ltd.

Date: 6/18/2019 Time: 6:14:25 PM

P12_5.3 GHz WLAN_802.11a_Front Side_0 cm_Ch.52_Ant.2

DUT: EVS 4343W

Communication System: 5.3 G WLAN; Frequency: 5260 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5260$ MHz; $\sigma = 4.677$ S/m; $\epsilon_r = 34.94$; $\rho = 1000$ kg/m³

Ambient Temperature : 22.7 °C; Liquid Temperature : 21.9 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.89, 4.89, 4.89); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- **Area Scan (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

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

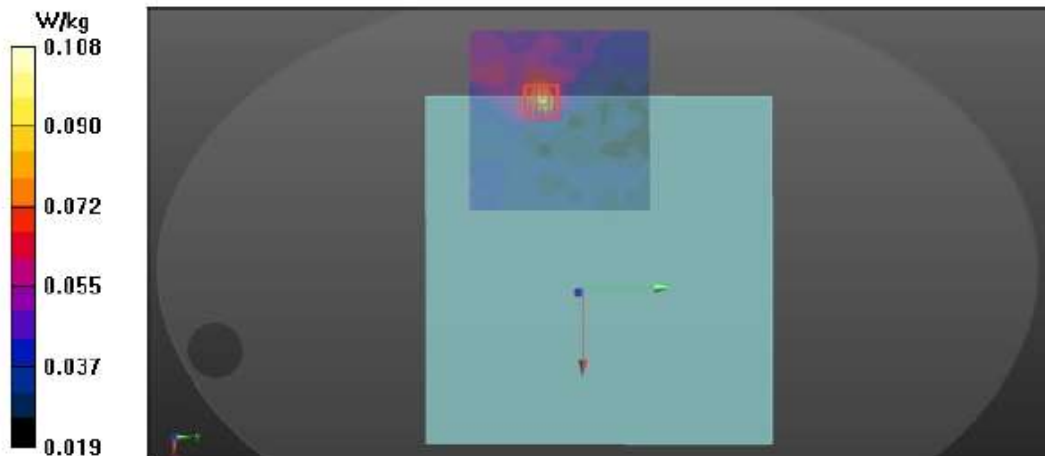
- **Zoom Scan (7x7x12)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=2mm

Reference Value = 4.088 V/m; Power Drift = -0.14 dB

Peak SAR (extrapolated) = 0.148 W/kg

SAR(1 g) = 0.077 W/kg; SAR(10 g) = 0.059 W/kg

Maximum value of SAR (measured) = 0.115 W/kg



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Test Laboratory: KES Co., Ltd.

Date: 6/18/2019 Time: 7:22:34 PM

P13_5.3 GHz WLAN_802.11n HT20_Front Side_0 cm_Ch.52_Ant.1+2

DUT: WUBR-508N

Communication System: 5.3 G WLAN; Frequency: 5260 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5260$ MHz; $\sigma = 4.677$ S/m; $\epsilon_r = 34.94$; $\rho = 1000$ kg/m³

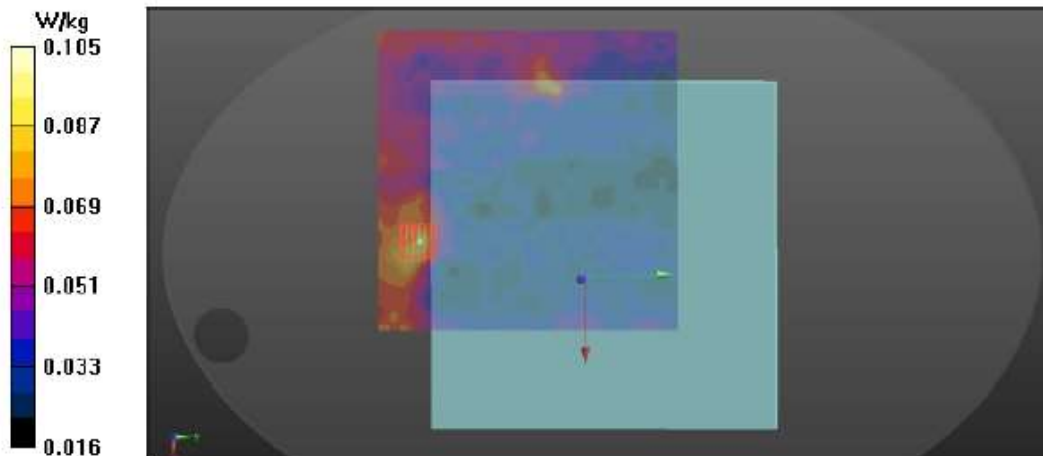
Ambient Temperature : 22.7 °C; Liquid Temperature : 21.9 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.89, 4.89, 4.89); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0_Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- **Area Scan (201x201x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.105 W/kg

- **Zoom Scan (7x7x12)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 4.110 V/m; Power Drift = -0.12 dB
Peak SAR (extrapolated) = 0.109 W/kg
SAR(1 g) = 0.087 W/kg; SAR(10 g) = 0.077 W/kg
Maximum value of SAR (measured) = 0.0981 W/kg



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Test Laboratory: KES Co., Ltd.

Date: 6/19/2019 Time: 7:05:22 PM

P21_5.5 GHz WLAN_802.11a_Front Side_0 cm_Ch.100_Ant.1

DUT: EVS 4343W

Communication System: 5.5 G WLAN; Frequency: 5500 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5500$ MHz; $\sigma = 5.148$ S/m; $\epsilon_r = 34.743$; $\rho = 1000$ kg/m³

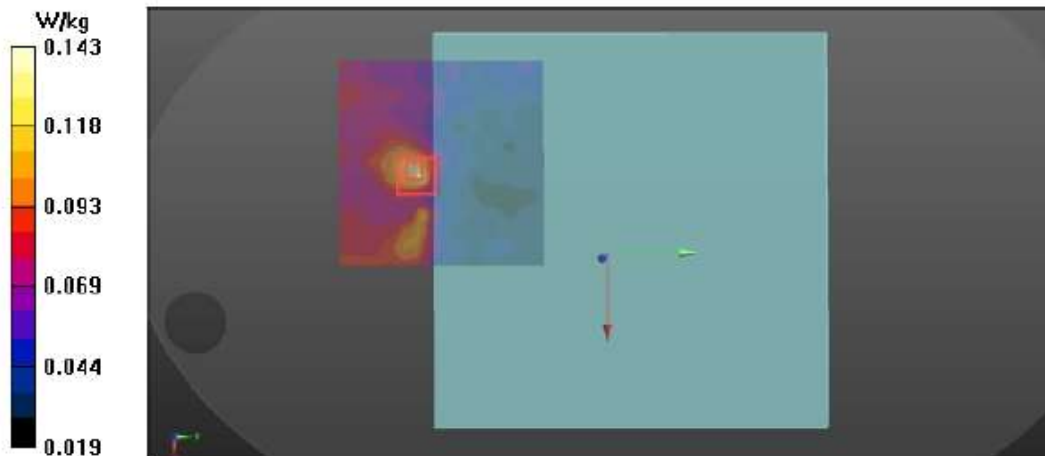
Ambient Temperature : 22.4 °C; Liquid Temperature : 21.6 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.91, 4.91, 4.91); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- **Area Scan (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.143 W/kg

- **Zoom Scan (7x7x12)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 5.016 V/m; Power Drift = -0.14 dB
Peak SAR (extrapolated) = 0.201 W/kg
SAR(1 g) = 0.110 W/kg; SAR(10 g) = 0.091 W/kg
Maximum value of SAR (measured) = 0.150 W/kg



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Test Laboratory: KES Co., Ltd.

Date: 6/19/2019 Time: 6:23:55 PM

P22_5.5 GHz WLAN_802.11a_Front Side_0 cm_Ch.100_Ant.2**DUT: EVS 4343W**

Communication System: 5.5 G WLAN; Frequency: 5500 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5500$ MHz; $\sigma = 5.148$ S/m; $\epsilon_r = 34.743$; $\rho = 1000$ kg/m³

Ambient Temperature : 22.4 °C; Liquid Temperature : 21.6 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.91, 4.91, 4.91); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- Area Scan (121x121x1): Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.0966 W/kg

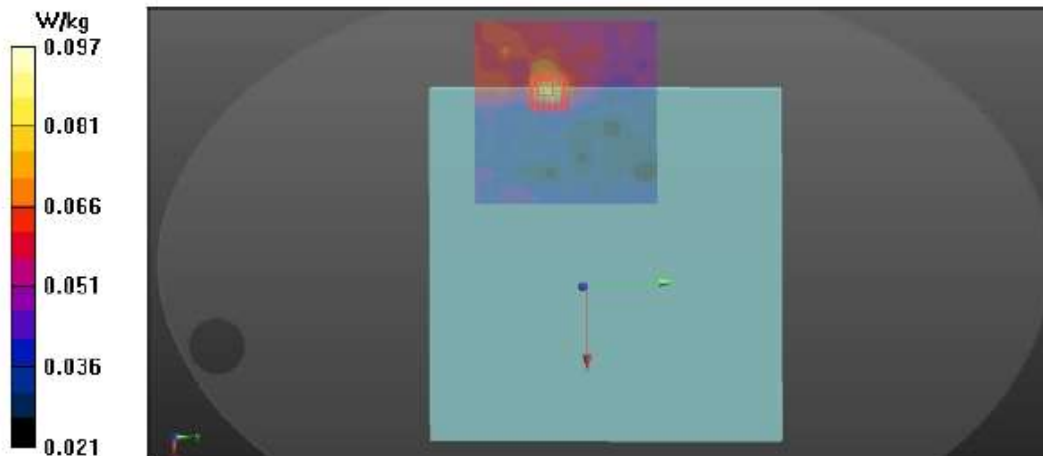
- Zoom Scan (7x7x12)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=2mm

Reference Value = 3.686 V/m; Power Drift = 0.10 dB

Peak SAR (extrapolated) = 0.124 W/kg

SAR(1 g) = 0.081 W/kg; SAR(10 g) = 0.068 W/kg

Maximum value of SAR (measured) = 0.107 W/kg



Test Laboratory: KES Co., Ltd.

Date: 6/19/2019 Time: 7:38:09 PM

P23_5.5 GHz WLAN_802.11n HT20_Front Side_0 cm_Ch.100_Ant.1+2

DUT: WUBR-508N

Communication System: 5.5 G WLAN; Frequency: 5500 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5500$ MHz; $\sigma = 5.148$ S/m; $\epsilon_r = 34.743$; $\rho = 1000$ kg/m³

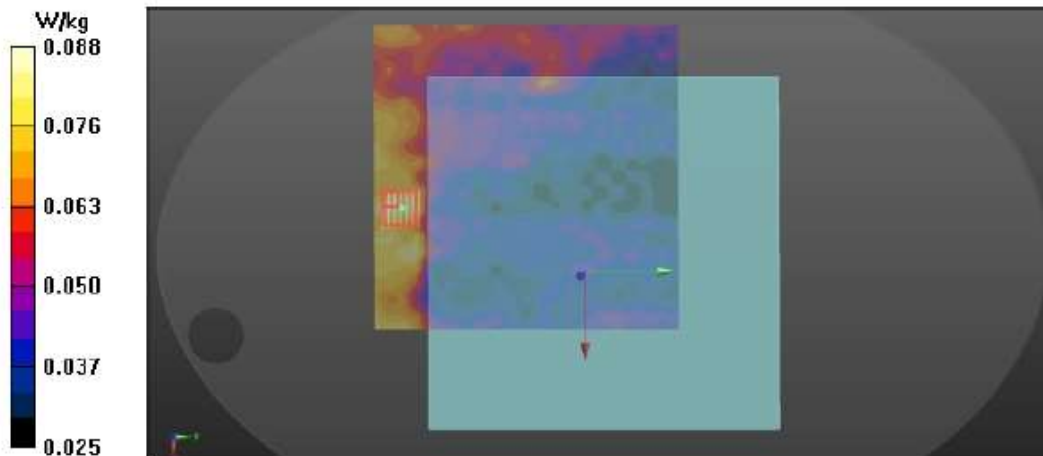
Ambient Temperature : 22.4 °C; Liquid Temperature : 21.6 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.91, 4.91, 4.91); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- **Area Scan (201x201x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.0883 W/kg

- **Zoom Scan (7x7x12)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 4.065 V/m; Power Drift = 0.02 dB
Peak SAR (extrapolated) = 0.114 W/kg
SAR(1 g) = 0.100 W/kg; SAR(10 g) = 0.090 W/kg
Maximum value of SAR (measured) = 0.114 W/kg



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Test Laboratory: KES Co., Ltd.

Date: 9/19/2019 Time: 11:07:27 AM

P31_5.8 GHz WLAN_802.11a_Front Side_0 cm_Ch.157_Ant.1

DUT: EVS 4343W

Communication System: 5.8 G WLAN; Frequency: 5785 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5785 \text{ MHz}$; $\sigma = 5.481 \text{ S/m}$; $\epsilon_r = 34.214$; $\rho = 1000 \text{ kg/m}^3$

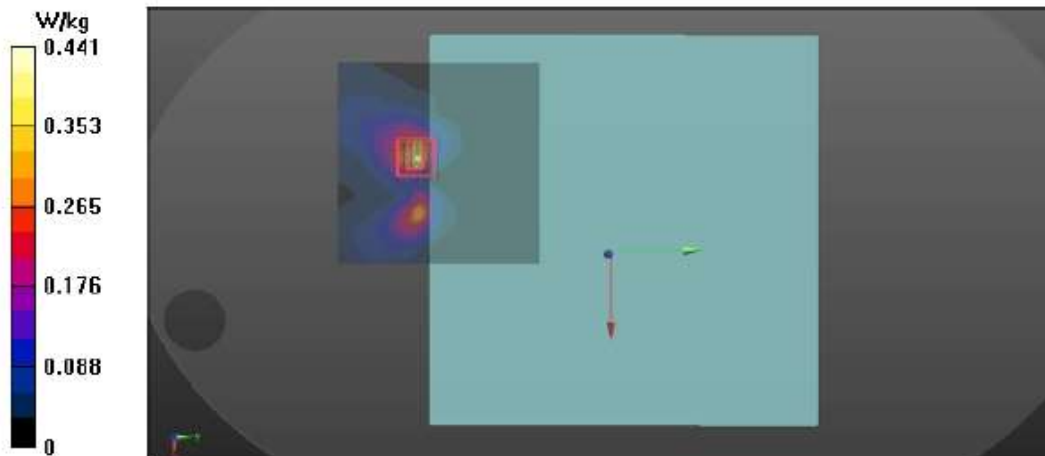
Ambient Temperature : $22.6 \text{ }^\circ\text{C}$; Liquid Temperature : $21.8 \text{ }^\circ\text{C}$

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.92, 4.92, 4.92); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0_Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- **Area Scan (121x121x1):** Interpolated grid: $dx=1.000 \text{ mm}$, $dy=1.000 \text{ mm}$
Maximum value of SAR (interpolated) = 0.441 W/kg

- **Zoom Scan (7x7x12)/Cube 0:** Measurement grid: $dx=4\text{mm}$, $dy=4\text{mm}$, $dz=2\text{mm}$
Reference Value = 9.840 V/m ; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 0.818 W/kg
SAR(1 g) = 0.194 W/kg ; SAR(10 g) = 0.083 W/kg
Maximum value of SAR (measured) = 0.439 W/kg



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Test Laboratory: KES Co., Ltd.

Date: 9/19/2019 Time: 10:10:20 AM

P32_5.8 GHz WLAN_802.11a_Front Side_0 cm_Ch.157_Ant.2

DUT: EVS 4343W

Communication System: 5.8 G WLAN; Frequency: 5785 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5785$ MHz; $\sigma = 5.481$ S/m; $\epsilon_r = 34.214$; $\rho = 1000$ kg/m³

Ambient Temperature : 22.6 °C; Liquid Temperature : 21.8 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.92, 4.92, 4.92); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0_Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- **Area Scan (121x121x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm

Maximum value of SAR (interpolated) = 0.166 W/kg

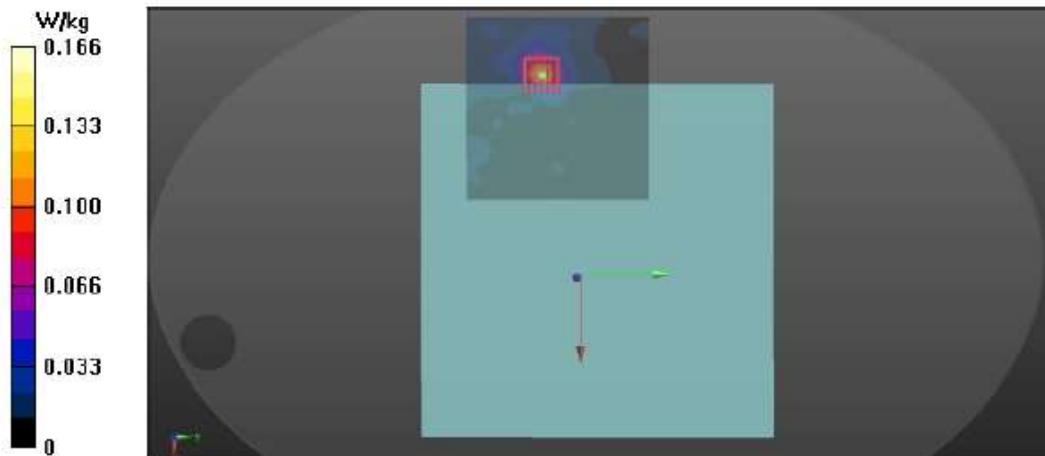
- **Zoom Scan (7x7x12)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=2mm

Reference Value = 6.083 V/m; Power Drift = -0.15 dB

Peak SAR (extrapolated) = 0.307 W/kg

SAR(1 g) = 0.071 W/kg; SAR(10 g) = 0.032 W/kg

Maximum value of SAR (measured) = 0.161 W/kg



Test Laboratory: KES Co., Ltd.

Date: 9/19/2019 Time: 11:53:46 AM

P33_5.8 GHz WLAN_802.11n HT20_Front Side_0 cm_Ch.149_Ant.1+2

DUT: WUBR-508N

Communication System: 5.8 G WLAN; Frequency: 5745 MHz; Duty Cycle: 1:1

Medium: HSL5GHz Medium parameters used: $f = 5745$ MHz; $\sigma = 5.438$ S/m; $\epsilon_r = 34.282$; $\rho = 1000$ kg/m³

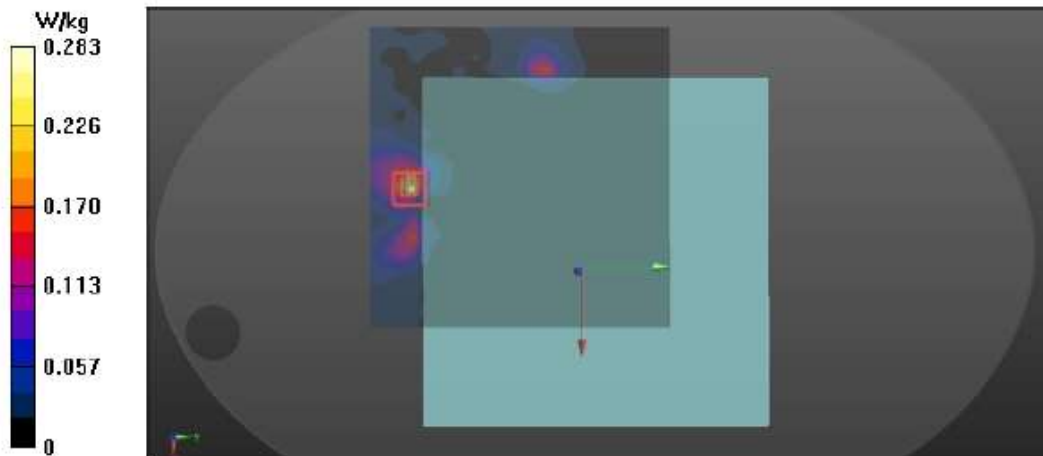
Ambient Temperature : 22.6 °C; Liquid Temperature : 21.8 °C

DASY5 Configuration:

- Probe: EX3DV4 - SN7359; ConvF(4.92, 4.92, 4.92); Calibrated: 1/31/2019;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1344; Calibrated: 11/15/2018
- Phantom: ELI v5.0 Front; Type: QDOVA002AA; Serial: 1190
- Measurement SW: DASY52, Version 52.10 (0); SEMCAD X Version 14.6.10 (7417)

- **Area Scan (201x201x1):** Interpolated grid: dx=1.000 mm, dy=1.000 mm
Maximum value of SAR (interpolated) = 0.283 W/kg

- **Zoom Scan (7x7x12)/Cube 0:** Measurement grid: dx=4mm, dy=4mm, dz=2mm
Reference Value = 7.872 V/m; Power Drift = -0.09 dB
Peak SAR (extrapolated) = 0.458 W/kg
SAR(1 g) = 0.125 W/kg; SAR(10 g) = 0.059 W/kg
Maximum value of SAR (measured) = 0.268 W/kg



Appendix C. Probe & Dipole Antenna Calibration Certificates

The SPEAG calibration certificates are shown as follows.

Calibration Laboratory of Schmid & Partner Engineering AG
 Zeughausstrasse 43, 8004 Zurich, Switzerland




S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
S Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
 The Swiss Accreditation Service is one of the signatories to the EA Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Client **KES (Dymstec)** Certificate No: **EX3-7359_Jan19/2**

CALIBRATION CERTIFICATE (Replacement of No: EX3-7359_Jan19)

Object	EX3DV4 - SN:7359
Calibration procedure(s)	QA CAL-01.v9, QA CAL-12.v9, QA CAL-14.v5, QA CAL-23.v5, QA CAL-25.v7 Calibration procedure for dosimetric E-field probes
Calibration date:	January 31, 2019

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI). The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility; environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: S5277 (20x)	04-Apr-18 (No. 217-02682)	Apr-19
DAE4	SN: 660	19-Dec-18 (No. DAE4-660_Dec18)	Dec-19
Reference Probe ES3DV2	SN: 3013	31-Dec-18 (No. ES3-3013_Dec18)	Dec-19
Secondary Standards	ID	Check Date (in house)	Scheduled Check
Power meter E4419B	SN: GB41293874	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
Power sensor E4412A	SN: MY41498087	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
Power sensor E4412A	SN: 000110210	06-Apr-16 (in house check Jun-18)	In house check: Jun-20
RF generator HP 8848C	SN: US3642U01700	04-Aug-99 (in house check Jun-18)	In house check: Jun-20
Network Analyzer E8358A	SN: US41080477	31-Mar-14 (in house check Oct-18)	In house check: Oct-19

	Name	Function	Signature
Calibrated by:	Jeton Kastrioti	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

Issued: March 12, 2019

This calibration certificate shall not be reproduced except in full without written approval of the laboratory.

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**Calibration Laboratory of
 Schmid & Partner
 Engineering AG**
 Zeughausstrasse 43, 8004 Zurich, Switzerland



S Schweizerischer Kalibrierdienst
C Service suisse d'étalonnage
S Servizio svizzero di taratura
 Swiss Calibration Service

Accredited by the Swiss Accreditation Service (SAS)
 The Swiss Accreditation Service is one of the signatories to the EA
 Multilateral Agreement for the recognition of calibration certificates

Accreditation No.: **SCS 0108**

Glossary:

TSL	tissue simulating liquid
NORM _{x,y,z}	sensitivity in free space
ConvF	sensitivity in TSL / NORM _{x,y,z}
DCP	diode compression point
CF	crest factor (1/duty_cycle) of the RF signal
A, B, C, D	modulation dependent linearization parameters
Polarization φ	φ rotation around probe axis
Polarization θ	θ rotation around an axis that is in the plane normal to probe axis (at measurement center), i.e., $\theta = 0$ is normal to probe axis
Connector Angle	information used in DASY system to align probe sensor X to the robot coordinate system

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865864, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Methods Applied and Interpretation of Parameters:

- **NORM_{x,y,z}**: Assessed for E-field polarization $\theta = 0$ ($f \leq 900$ MHz in TEM-cell; $f > 1800$ MHz: R22 waveguide). NORM_{x,y,z} are only intermediate values, i.e., the uncertainties of NORM_{x,y,z} does not affect the E²-field uncertainty inside TSL (see below ConvF).
- **NORM(f)_{x,y,z}** = NORM_{x,y,z} * frequency_response (see Frequency Response Chart). This linearization is implemented in DASY4 software versions later than 4.2. The uncertainty of the frequency response is included in the stated uncertainty of ConvF.
- **DCP_{x,y,z}**: DCP are numerical linearization parameters assessed based on the data of power sweep with CW signal (no uncertainty required). DCP does not depend on frequency nor media.
- **PAR**: PAR is the Peak to Average Ratio that is not calibrated but determined based on the signal characteristics
- **A_{x,y,z}; B_{x,y,z}; C_{x,y,z}; D_{x,y,z}; VR_{x,y,z}**: A, B, C, D are numerical linearization parameters assessed based on the data of power sweep for specific modulation signal. The parameters do not depend on frequency nor media. VR is the maximum calibration range expressed in RMS voltage across the diode.
- **ConvF and Boundary Effect Parameters**: Assessed in flat phantom using E-field (or Temperature Transfer Standard for $f \leq 800$ MHz) and inside waveguide using analytical field distributions based on power measurements for $f > 800$ MHz. The same setups are used for assessment of the parameters applied for boundary compensation (alpha, depth) of which typical uncertainty values are given. These parameters are used in DASY4 software to improve probe accuracy close to the boundary. The sensitivity in TSL corresponds to NORM_{x,y,z} * ConvF whereby the uncertainty corresponds to that given for ConvF. A frequency dependent ConvF is used in DASY version 4.4 and higher which allows extending the validity from ± 50 MHz to ± 100 MHz.
- **Spherical isotropy (3D deviation from isotropy)**: in a field of low gradients realized using a flat phantom exposed by a patch antenna.
- **Sensor Offset**: The sensor offset corresponds to the offset of virtual measurement center from the probe tip (on probe axis). No tolerance required.
- **Connector Angle**: The angle is assessed using the information gained by determining the NORM_x (no uncertainty required).

EX3DV4 – SN:7359

January 31, 2019

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7359

Basic Calibration Parameters

	Sensor X	Sensor Y	Sensor Z	Unc (k=2)
Norm ($\mu\text{V}/(\text{V}/\text{m})^2$) ^A	0.39	0.38	0.48	± 10.1 %
DCP (mV) ^B	100.2	107.5	97.6	

Calibration Results for Modulation Response

UID	Communication System Name		A dB	B dB· μV	C	D dB	VR mV	Max dev.	Max Unc ^C (k=2)
0	CW	X	0.00	0.00	1.00	0.00	160.1	± 2.7 %	± 4.7 %
		Y	0.00	0.00	1.00		167.9		
		Z	0.00	0.00	1.00		179.6		
10352-AAA	Pulse Waveform (200Hz, 10%)	X	1.88	62.24	9.18	10.00	60.0	± 2.8 %	± 9.6 %
		Y	15.00	85.61	18.28		60.0		
		Z	15.00	87.18	19.70		60.0		
10353-AAA	Pulse Waveform (200Hz, 20%)	X	1.51	63.36	8.34	6.99	80.0	± 2.0 %	± 9.6 %
		Y	15.00	87.76	18.02		80.0		
		Z	15.00	88.44	18.86		80.0		
10354-AAA	Pulse Waveform (200Hz, 40%)	X	0.54	60.00	5.26	3.98	95.0	± 1.1 %	± 9.6 %
		Y	15.00	93.00	19.08		95.0		
		Z	15.00	89.68	17.70		95.0		
10355-AAA	Pulse Waveform (200Hz, 60%)	X	0.31	60.00	3.76	2.22	120.0	± 1.3 %	± 9.6 %
		Y	15.00	122.99	31.33		120.0		
		Z	15.00	85.47	14.10		120.0		
10387-AAA	QPSK Waveform, 1 MHz	X	0.45	60.00	5.83	0.00	150.0	± 3.4 %	± 9.6 %
		Y	0.47	60.06	6.93		150.0		
		Z	0.55	60.37	7.27		150.0		
10368-AAA	QPSK Waveform, 10 MHz	X	2.14	68.87	16.09	0.00	150.0	± 1.1 %	± 9.6 %
		Y	2.39	70.79	17.41		150.0		
		Z	2.29	69.17	16.31		150.0		
10396-AAA	64-QAM Waveform, 100 kHz	X	2.58	68.98	18.03	3.01	150.0	± 0.9 %	± 9.6 %
		Y	2.57	69.91	18.76		150.0		
		Z	2.93	70.48	19.07		150.0		
10399-AAA	64-QAM Waveform, 40 MHz	X	3.43	67.48	15.97	0.00	150.0	± 2.2 %	± 9.6 %
		Y	3.53	68.08	16.43		150.0		
		Z	3.55	67.60	16.13		150.0		
10414-AAA	WLAN CCDF, 64-QAM, 40MHz	X	4.73	65.97	15.76	0.00	150.0	± 4.2 %	± 9.6 %
		Y	4.73	66.14	15.88		150.0		
		Z	4.90	66.02	15.90		150.0		

Note: For details on all calibrated UID parameters see Appendix

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor k=2, which for a normal distribution corresponds to a coverage probability of approximately 95%.

^A The uncertainties of Norm X,Y,Z do not affect the E²-field uncertainty inside TSL (see Pages 5 and 6).

^B Numerical linearization parameter: uncertainty not required.

^C Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.



EX3DV4- SN:7359

January 31, 2019

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7359

Sensor Model Parameters

	C1 fF	C2 fF	α V ⁻¹	T1 ms.V ⁻²	T2 ms.V ⁻¹	T3 ms	T4 V ⁻²	T5 V ⁻¹	T6
X	35.8	270.97	36.43	6.04	0.65	5.00	0.09	0.43	1.01
Y	33.6	243.08	33.90	7.59	0.25	5.03	0.88	0.18	1.00
Z	42.5	330.32	38.20	10.11	0.59	5.09	0.00	0.53	1.01

Other Probe Parameters

Sensor Arrangement	Triangular
Connector Angle (°)	-10.2
Mechanical Surface Detection Mode	enabled
Optical Surface Detection Mode	disabled
Probe Overall Length	337 mm
Probe Body Diameter	10 mm
Tip Length	9 mm
Tip Diameter	2.5 mm
Probe Tip to Sensor X Calibration Point	1 mm
Probe Tip to Sensor Y Calibration Point	1 mm
Probe Tip to Sensor Z Calibration Point	1 mm
Recommended Measurement Distance from Surface	1.4 mm

EX3DV4- SN:7359

January 31, 2019

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7359

Calibration Parameter Determined in Head Tissue Simulating Media

f (MHz) ^c	Relative Permittivity ^f	Conductivity (S/m) ^f	ConvF X	ConvF Y	ConvF Z	Alpha ^g	Depth ^g (mm)	Unc (k=2)
150	52.3	0.76	13.75	13.75	13.75	0.00	1.00	± 13.3 %
300	45.3	0.87	12.20	12.20	12.20	0.09	1.30	± 13.3 %
450	43.5	0.87	10.85	10.85	10.85	0.14	1.40	± 13.3 %
600	42.7	0.88	10.50	10.50	10.50	0.12	1.40	± 13.3 %
750	41.9	0.89	9.57	9.57	9.57	0.52	0.81	± 12.0 %
835	41.5	0.90	9.31	9.31	9.31	0.42	0.86	± 12.0 %
900	41.5	0.97	9.11	9.11	9.11	0.51	0.84	± 12.0 %
1750	40.1	1.37	8.23	8.23	8.23	0.36	0.85	± 12.0 %
1900	40.0	1.40	7.88	7.88	7.88	0.34	0.85	± 12.0 %
1950	40.0	1.40	7.67	7.67	7.67	0.38	0.85	± 12.0 %
2450	39.2	1.80	7.13	7.13	7.13	0.41	0.87	± 12.0 %
2600	39.0	1.96	6.90	6.90	6.90	0.41	0.89	± 12.0 %
5200	36.0	4.66	5.04	5.04	5.04	0.40	1.80	± 13.1 %
5300	35.9	4.76	4.89	4.89	4.89	0.40	1.80	± 13.1 %
5500	35.6	4.96	4.91	4.91	4.91	0.40	1.80	± 13.1 %
5600	35.5	5.07	4.73	4.73	4.73	0.40	1.80	± 13.1 %
5800	35.3	5.27	4.92	4.92	4.92	0.40	1.80	± 13.1 %

^c Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4-9 MHz, and ConvF assessed at 13 MHz is 9-19 MHz. Above 5 GHz frequency validity can be extended to ± 110 MHz.

^f At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^g Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe lip diameter from the boundary.

EX3DV4- SN:7359

January 31, 2019

DASY/EASY - Parameters of Probe: EX3DV4 - SN:7359

Calibration Parameter Determined in Body Tissue Simulating Media

f (MHz) ^C	Relative Permittivity ^F	Conductivity (S/m) ^F	ConvF X	ConvF Y	ConvF Z	Alpha ^G	Depth ^G (mm)	Unc (k=2)
450	56.7	0.94	11.31	11.31	11.31	0.08	1.40	± 13.3 %
2450	52.7	1.95	7.30	7.30	7.30	0.33	0.89	± 12.0 %
5200	49.0	5.30	4.66	4.66	4.66	0.50	1.90	± 13.1 %
5300	48.9	5.42	4.49	4.49	4.49	0.50	1.90	± 13.1 %
5500	48.6	5.65	4.04	4.04	4.04	0.50	1.90	± 13.1 %
5600	48.5	5.77	3.86	3.86	3.86	0.50	1.90	± 13.1 %
5800	48.2	6.00	4.17	4.17	4.17	0.50	1.90	± 13.1 %

^C Frequency validity above 300 MHz of ± 100 MHz only applies for DASY v4.4 and higher (see Page 2), else it is restricted to ± 50 MHz. The uncertainty is the RSS of the ConvF uncertainty at calibration frequency and the uncertainty for the indicated frequency band. Frequency validity below 300 MHz is ± 10, 25, 40, 50 and 70 MHz for ConvF assessments at 30, 64, 128, 150 and 220 MHz respectively. Validity of ConvF assessed at 6 MHz is 4-9 MHz, and ConvF assessed at 13 MHz is 9-19 MHz. Above 5 GHz frequency validity can be extended to ± 110 MHz.

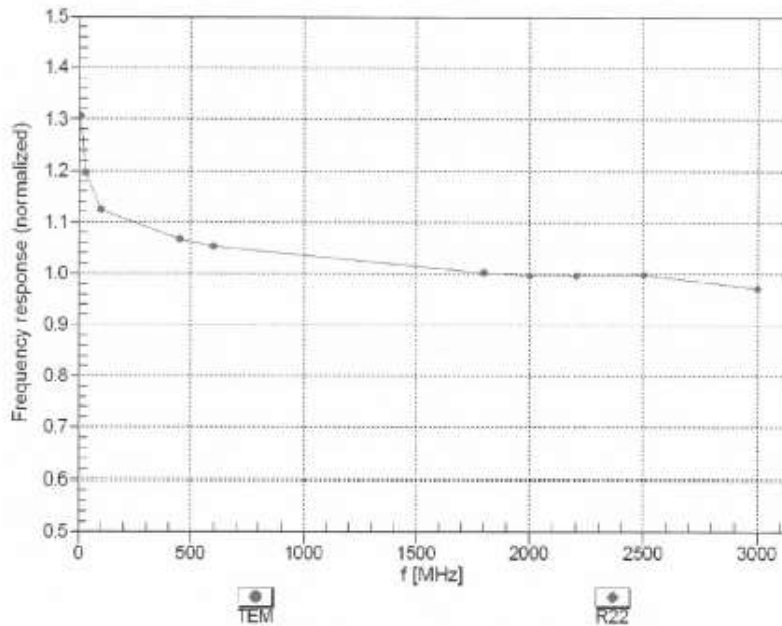
^F At frequencies below 3 GHz, the validity of tissue parameters (ϵ and σ) can be relaxed to ± 10% if liquid compensation formula is applied to measured SAR values. At frequencies above 3 GHz, the validity of tissue parameters (ϵ and σ) is restricted to ± 5%. The uncertainty is the RSS of the ConvF uncertainty for indicated target tissue parameters.

^G Alpha/Depth are determined during calibration. SPEAG warrants that the remaining deviation due to the boundary effect after compensation is always less than ± 1% for frequencies below 3 GHz and below ± 2% for frequencies between 3-6 GHz at any distance larger than half the probe tip diameter from the boundary.

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Frequency Response of E-Field
 (TEM-Cell:ifi110 EXX, Waveguide: R22)

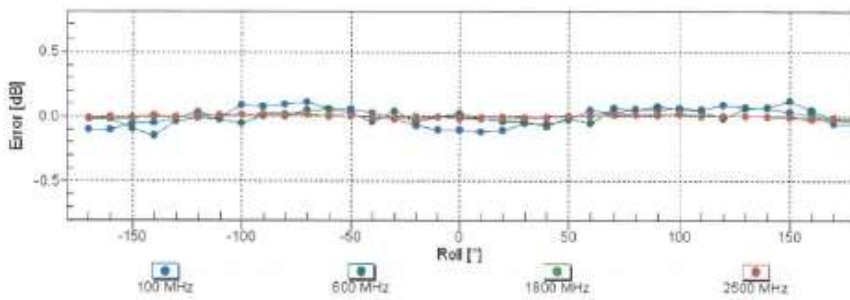
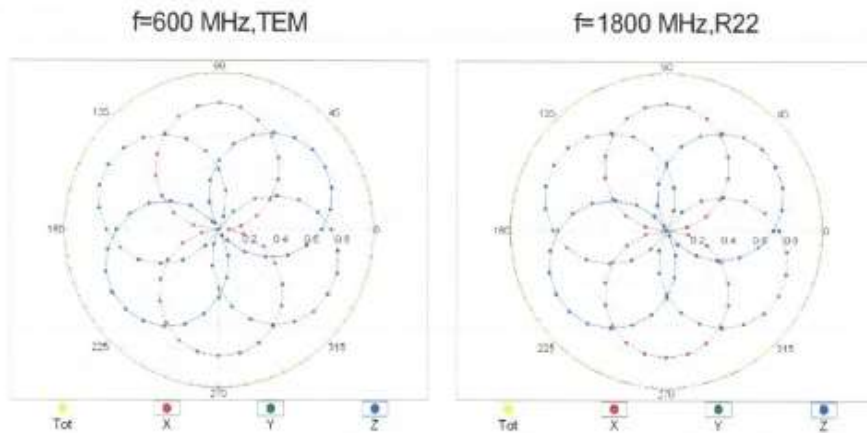


Uncertainty of Frequency Response of E-field: $\pm 6.3\%$ (k=2)

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Receiving Pattern (ϕ), $\theta = 0^\circ$

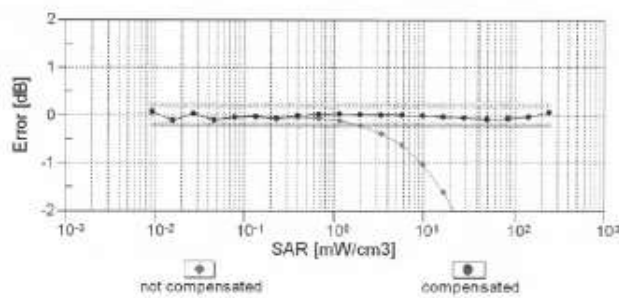
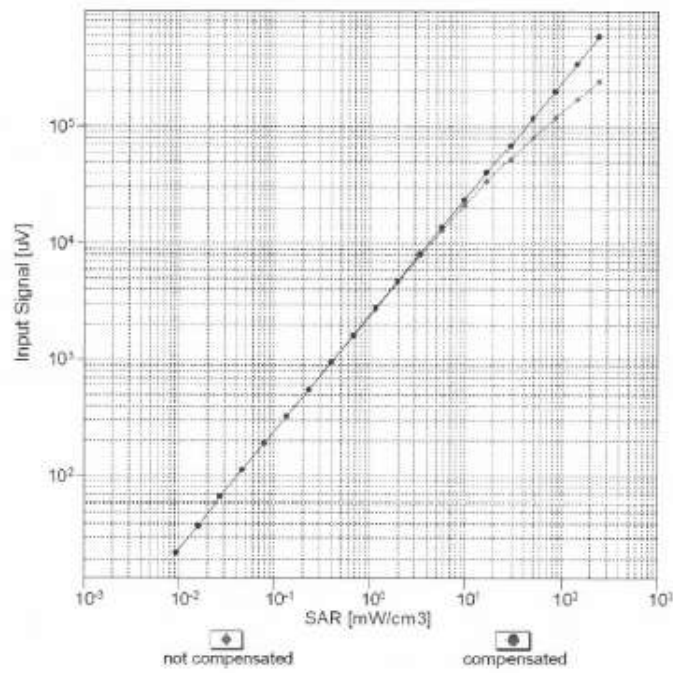


Uncertainty of Axial Isotropy Assessment: $\pm 0.5\%$ (k=2)

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Dynamic Range f(SAR_{head})
 (TEM cell , f_{eval}= 1900 MHz)

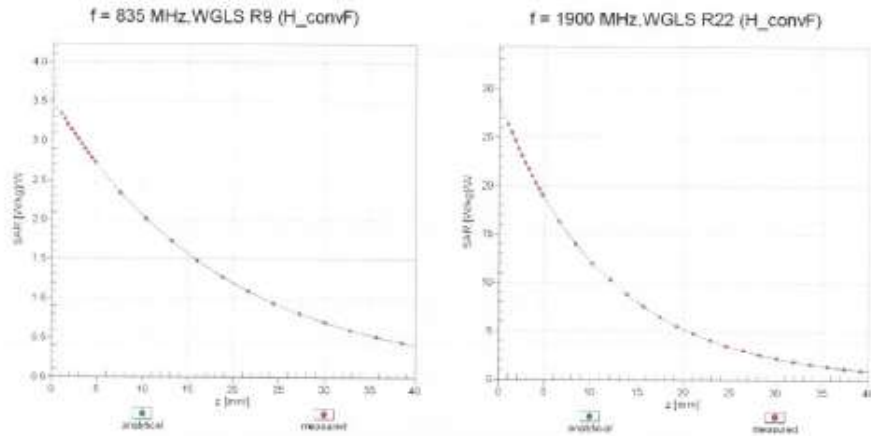


Uncertainty of Linearity Assessment: ± 0.6% (k=2)

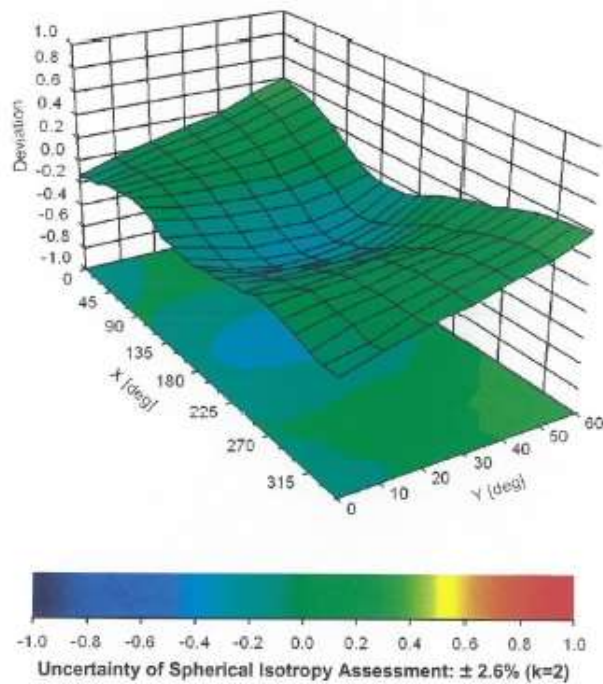
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Conversion Factor Assessment



Deviation from Isotropy in Liquid Error (ϕ , θ), $f = 900 \text{ MHz}$



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Appendix: Modulation Calibration Parameters

UID	Rev	Communication System Name	Group	PAR (dB)	Unc [±] (k=2)
0		CW	CW	0.00	±4.7 %
10010	CAA	SAR Validation (Square, 100ms, 10ms)	Test	10.00	±9.6 %
10011	CAB	UMTS-FDD (WCDMA)	WCDMA	2.91	±9.6 %
10012	CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 1 Mbps)	WLAN	1.87	±9.6 %
10013	CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS-OFDM, 6 Mbps)	WLAN	9.46	±9.6 %
10021	DAC	GSM-FDD (TDMA, GMSK)	GSM	9.39	±9.6 %
10023	DAC	GPRS-FDD (TDMA, GMSK, TN 0)	GSM	9.57	±9.6 %
10024	DAC	GPRS-FDD (TDMA, GMSK, TN 0-1)	GSM	6.56	±9.6 %
10025	DAC	EDGE-FDD (TDMA, 8PSK, TN 0)	GSM	12.62	±9.6 %
10026	DAC	EDGE-FDD (TDMA, 8PSK, TN 0-1)	GSM	9.55	±9.6 %
10027	DAC	GPRS-FDD (TDMA, GMSK, TN 0-1-2)	GSM	4.80	±9.6 %
10028	DAC	GPRS-FDD (TDMA, GMSK, TN 0-1-2-3)	GSM	3.55	±9.6 %
10029	DAC	EDGE-FDD (TDMA, 8PSK, TN 0-1-2)	GSM	7.78	±9.6 %
10030	CAA	IEEE 802.15.1 Bluetooth (GFSK, DH1)	Bluetooth	5.30	±9.6 %
10031	CAA	IEEE 802.15.1 Bluetooth (GFSK, DH3)	Bluetooth	1.87	±9.6 %
10032	CAA	IEEE 802.15.1 Bluetooth (GFSK, DH5)	Bluetooth	1.16	±9.6 %
10033	CAA	IEEE 802.15.1 Bluetooth (PI/4-DQPSK, DH1)	Bluetooth	7.74	±9.6 %
10034	CAA	IEEE 802.15.1 Bluetooth (PI/4-DQPSK, DH3)	Bluetooth	4.53	±9.6 %
10035	CAA	IEEE 802.15.1 Bluetooth (PI/4-DQPSK, DH5)	Bluetooth	3.83	±9.6 %
10036	CAA	IEEE 802.15.1 Bluetooth (8-DPSK, DH1)	Bluetooth	8.01	±9.6 %
10037	CAA	IEEE 802.15.1 Bluetooth (8-DPSK, DH3)	Bluetooth	4.77	±9.6 %
10038	CAA	IEEE 802.15.1 Bluetooth (8-DPSK, DH5)	Bluetooth	4.10	±9.6 %
10039	CAB	CDMA2000 (1xRTT, RC1)	CDMA2000	4.57	±9.6 %
10042	CAB	IS-54 / IS-136 FDD (TDMA/FDM, PI/4-DQPSK, Halfrate)	AMPS	7.78	±9.6 %
10044	CAA	IS-91/EIA/TIA-553 FDD (FDMA, FM)	AMPS	0.00	±9.6 %
10048	CAA	DECT (TDD, TDMA/FDM, GFSK, Full Slot, 24)	DECT	13.80	±9.6 %
10049	CAA	DECT (TDD, TDMA/FDM, GFSK, Double Slot, 12)	DECT	10.79	±9.6 %
10056	CAA	UMTS-TDD (TD-SCDMA, 1.28 Mcps)	TD-SCDMA	11.01	±9.6 %
10058	DAC	EDGE-FDD (TDMA, 8PSK, TN 0-1-2-3)	GSM	6.52	±9.6 %
10059	CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 2 Mbps)	WLAN	2.12	±9.6 %
10060	CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 5.5 Mbps)	WLAN	2.83	±9.6 %
10061	CAB	IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps)	WLAN	3.60	±9.6 %
10062	CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 6 Mbps)	WLAN	8.68	±9.6 %
10063	CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 9 Mbps)	WLAN	8.63	±9.6 %
10064	CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 12 Mbps)	WLAN	9.09	±9.6 %
10065	CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 18 Mbps)	WLAN	9.00	±9.6 %
10066	CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 24 Mbps)	WLAN	9.38	±9.6 %
10067	CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 36 Mbps)	WLAN	10.12	±9.6 %
10068	CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 48 Mbps)	WLAN	10.24	±9.6 %
10069	CAC	IEEE 802.11a/h WiFi 5 GHz (OFDM, 54 Mbps)	WLAN	10.56	±9.6 %
10071	CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 9 Mbps)	WLAN	9.83	±9.6 %
10072	CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 12 Mbps)	WLAN	9.62	±9.6 %
10073	CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 18 Mbps)	WLAN	9.94	±9.6 %
10074	CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 24 Mbps)	WLAN	10.30	±9.6 %
10075	CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 36 Mbps)	WLAN	10.77	±9.6 %
10076	CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 48 Mbps)	WLAN	10.94	±9.6 %
10077	CAB	IEEE 802.11g WiFi 2.4 GHz (DSSS/OFDM, 54 Mbps)	WLAN	11.00	±9.6 %
10081	CAB	CDMA2000 (1xRTT, RC3)	CDMA2000	3.97	±9.6 %
10082	CAB	IS-54 / IS-136 FDD (TDMA/FDM, PI/4-DQPSK, Fullrate)	AMPS	4.77	±9.6 %
10090	DAC	GPRS-FDD (TDMA, GMSK, TN 0-4)	GSM	6.56	±9.6 %
10097	CAB	UMTS-FDD (HSDPA)	WCDMA	3.98	±9.6 %
10098	CAB	UMTS-FDD (HSUPA, Subtest 2)	WCDMA	3.96	±9.6 %
10099	DAC	EDGE-FDD (TDMA, 8PSK, TN 0-4)	GSM	9.55	±9.6 %
10100	CAE	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, QPSK)	LTE-FDD	5.67	±9.6 %
10101	CAE	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM)	LTE-FDD	6.42	±9.6 %
10102	CAE	LTE-FDD (SC-FDMA, 100% RB, 20 MHz, 64-QAM)	LTE-FDD	6.60	±9.6 %
10103	CAG	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK)	LTE-TDD	9.29	±9.6 %
10104	CAG	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM)	LTE-TDD	9.97	±9.6 %
10105	CAG	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, 64-QAM)	LTE-TDD	10.01	±9.6 %
10108	CAG	LTE-FDD (SC-FDMA, 100% RB, 10 MHz, QPSK)	LTE-FDD	5.80	±9.6 %

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Table with columns for ID, Modulation, Bandwidth, and Signal-to-Noise Ratio (SNR) for various test cases (10109-10219).

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Table with 6 columns: ID, Modem, Standard, Modulation, Bandwidth, and Results. It lists various test configurations and their corresponding performance metrics.

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Table with 6 columns: ID, Test Case, Standard/Modem, Modem, Measured Value, and Error. Rows include various wireless standards like LTE-FDD, WiMAX, WiFi, CDMA2000, and WLAN.

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10451	AAA	W-CDMA (BS Test Model 1, 64 DPCH, Clipping 44%)	WCDMA	7.59	± 9.6 %
10456	AAB	IEEE 802.11ac WiFi (160MHz, 64-QAM, 99pc duty cycle)	WLAN	8.63	± 9.6 %
10457	AAA	UMTS-FDD (DC-HSDPA)	WCDMA	6.62	± 9.6 %
10458	AAA	CDMA2000 (1xEV-DO, Rev. B, 2 carriers)	CDMA2000	6.55	± 9.6 %
10459	AAA	CDMA2000 (1xEV-DO, Rev. B, 3 carriers)	CDMA2000	8.25	± 9.6 %
10460	AAA	UMTS-FDD (WCDMA, AMR)	WCDMA	2.39	± 9.6 %
10461	AAA	LTE-TDD (SC-FDMA, 1 RB, 1.4 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.82	± 9.6 %
10462	AAA	LTE-TDD (SC-FDMA, 1 RB, 1.4 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.30	± 9.6 %
10463	AAA	LTE-TDD (SC-FDMA, 1 RB, 1.4 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.56	± 9.6 %
10464	AAB	LTE-TDD (SC-FDMA, 1 RB, 3 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.82	± 9.6 %
10465	AAB	LTE-TDD (SC-FDMA, 1 RB, 3 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.32	± 9.6 %
10466	AAB	LTE-TDD (SC-FDMA, 1 RB, 3 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.57	± 9.6 %
10467	AAE	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.82	± 9.6 %
10468	AAE	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.32	± 9.6 %
10469	AAE	LTE-TDD (SC-FDMA, 1 RB, 5 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.56	± 9.6 %
10470	AAE	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.82	± 9.6 %
10471	AAE	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.32	± 9.6 %
10472	AAE	LTE-TDD (SC-FDMA, 1 RB, 10 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.57	± 9.6 %
10473	AAE	LTE-TDD (SC-FDMA, 1 RB, 15 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.82	± 9.6 %
10474	AAE	LTE-TDD (SC-FDMA, 1 RB, 15 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.32	± 9.6 %
10475	AAE	LTE-TDD (SC-FDMA, 1 RB, 15 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.57	± 9.6 %
10477	AAF	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.32	± 9.6 %
10478	AAF	LTE-TDD (SC-FDMA, 1 RB, 20 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.57	± 9.6 %
10479	AAA	LTE-TDD (SC-FDMA, 50% RB, 1.4 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.74	± 9.6 %
10480	AAA	LTE-TDD (SC-FDMA, 50% RB, 1.4 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.18	± 9.6 %
10481	AAA	LTE-TDD (SC-FDMA, 50% RB, 1.4 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.45	± 9.6 %
10482	AAB	LTE-TDD (SC-FDMA, 50% RB, 3 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.71	± 9.6 %
10483	AAB	LTE-TDD (SC-FDMA, 50% RB, 3 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.39	± 9.6 %
10484	AAB	LTE-TDD (SC-FDMA, 50% RB, 3 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.47	± 9.6 %
10485	AAE	LTE-TDD (SC-FDMA, 50% RB, 5 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.59	± 9.6 %
10486	AAE	LTE-TDD (SC-FDMA, 50% RB, 5 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.38	± 9.6 %
10487	AAE	LTE-TDD (SC-FDMA, 50% RB, 5 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.60	± 9.6 %
10488	AAE	LTE-TDD (SC-FDMA, 50% RB, 10 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.70	± 9.6 %
10489	AAE	LTE-TDD (SC-FDMA, 50% RB, 10 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.31	± 9.6 %
10490	AAE	LTE-TDD (SC-FDMA, 50% RB, 10 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.54	± 9.6 %
10491	AAE	LTE-TDD (SC-FDMA, 50% RB, 15 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.74	± 9.6 %

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10492	AAE	LTE-TDD (SC-FDMA, 50% RB, 15 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.41	± 9.6 %
10493	AAE	LTE-TDD (SC-FDMA, 50% RB, 15 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.55	± 9.6 %
10494	AAF	LTE-TDD (SC-FDMA, 50% RB, 20 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.74	± 9.6 %
10495	AAF	LTE-TDD (SC-FDMA, 50% RB, 20 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.37	± 9.6 %
10496	AAF	LTE-TDD (SC-FDMA, 50% RB, 20 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.54	± 9.6 %
10497	AAA	LTE-TDD (SC-FDMA, 100% RB, 1.4 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.67	± 9.6 %
10498	AAA	LTE-TDD (SC-FDMA, 100% RB, 1.4 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.40	± 9.6 %
10499	AAA	LTE-TDD (SC-FDMA, 100% RB, 1.4 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.68	± 9.6 %
10500	AAB	LTE-TDD (SC-FDMA, 100% RB, 3 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.67	± 9.6 %
10501	AAB	LTE-TDD (SC-FDMA, 100% RB, 3 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.44	± 9.6 %
10502	AAB	LTE-TDD (SC-FDMA, 100% RB, 3 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.52	± 9.6 %
10503	AAE	LTE-TDD (SC-FDMA, 100% RB, 5 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.72	± 9.6 %
10504	AAE	LTE-TDD (SC-FDMA, 100% RB, 5 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.31	± 9.6 %
10505	AAE	LTE-TDD (SC-FDMA, 100% RB, 5 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.54	± 9.6 %
10506	AAE	LTE-TDD (SC-FDMA, 100% RB, 10 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.74	± 9.6 %
10507	AAE	LTE-TDD (SC-FDMA, 100% RB, 10 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.36	± 9.6 %
10508	AAE	LTE-TDD (SC-FDMA, 100% RB, 10 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.55	± 9.6 %
10509	AAE	LTE-TDD (SC-FDMA, 100% RB, 15 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.99	± 9.6 %
10510	AAE	LTE-TDD (SC-FDMA, 100% RB, 15 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.49	± 9.6 %
10511	AAE	LTE-TDD (SC-FDMA, 100% RB, 15 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.51	± 9.6 %
10512	AAF	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, QPSK, UL Subframe=2,3,4,7,8,9)	LTE-TDD	7.74	± 9.6 %
10513	AAF	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, 16-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.42	± 9.6 %
10514	AAF	LTE-TDD (SC-FDMA, 100% RB, 20 MHz, 64-QAM, UL Subframe=2,3,4,7,8,9)	LTE-TDD	8.45	± 9.6 %
10515	AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 2 Mbps, 99pc duty cycle)	WLAN	1.58	± 9.6 %
10516	AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 5.5 Mbps, 99pc duty cycle)	WLAN	1.57	± 9.6 %
10517	AAA	IEEE 802.11b WiFi 2.4 GHz (DSSS, 11 Mbps, 99pc duty cycle)	WLAN	1.58	± 9.6 %
10518	AAB	IEEE 802.11a/h WiFi 5 GHz (OFDM, 9 Mbps, 99pc duty cycle)	WLAN	8.23	± 9.6 %
10519	AAB	IEEE 802.11a/h WiFi 5 GHz (OFDM, 12 Mbps, 99pc duty cycle)	WLAN	8.39	± 9.6 %
10520	AAB	IEEE 802.11a/h WiFi 5 GHz (OFDM, 18 Mbps, 99pc duty cycle)	WLAN	8.12	± 9.6 %
10521	AAB	IEEE 802.11a/h WiFi 5 GHz (OFDM, 24 Mbps, 99pc duty cycle)	WLAN	7.97	± 9.6 %
10522	AAB	IEEE 802.11a/h WiFi 5 GHz (OFDM, 36 Mbps, 99pc duty cycle)	WLAN	8.45	± 9.6 %
10523	AAB	IEEE 802.11a/h WiFi 5 GHz (OFDM, 48 Mbps, 99pc duty cycle)	WLAN	8.08	± 9.6 %
10524	AAB	IEEE 802.11a/h WiFi 5 GHz (OFDM, 54 Mbps, 99pc duty cycle)	WLAN	8.27	± 9.6 %
10525	AAB	IEEE 802.11ac WiFi (20MHz, MCS0, 99pc duty cycle)	WLAN	8.36	± 9.6 %
10526	AAB	IEEE 802.11ac WiFi (20MHz, MCS1, 99pc duty cycle)	WLAN	8.42	± 9.6 %
10527	AAB	IEEE 802.11ac WiFi (20MHz, MCS2, 99pc duty cycle)	WLAN	8.21	± 9.6 %
10528	AAB	IEEE 802.11ac WiFi (20MHz, MCS3, 99pc duty cycle)	WLAN	8.36	± 9.6 %
10529	AAB	IEEE 802.11ac WiFi (20MHz, MCS4, 99pc duty cycle)	WLAN	8.36	± 9.6 %
10531	AAB	IEEE 802.11ac WiFi (20MHz, MCS6, 99pc duty cycle)	WLAN	8.43	± 9.6 %
10532	AAB	IEEE 802.11ac WiFi (20MHz, MCS7, 99pc duty cycle)	WLAN	8.29	± 9.6 %
10533	AAB	IEEE 802.11ac WiFi (20MHz, MCS8, 99pc duty cycle)	WLAN	8.38	± 9.6 %
10534	AAB	IEEE 802.11ac WiFi (40MHz, MCS0, 99pc duty cycle)	WLAN	8.45	± 9.6 %

Certificate No: EX3-7359_Jan19/2

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Test report No.: KES-SR-19T0008 Page (65) of (97)

EX3DV4-SN:7359

January 31, 2019

Table with 6 columns: Test ID, Modulation, Standard, Bandwidth, Modulation, Throughput, and Error Rate. Rows include various IEEE 802.11ac and 802.11g WiFi configurations.

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Test report No.: KES-SR-19T0008 Page (66) of (97)

EX3DV4- SN:7359

January 31, 2019

Table with columns: Test ID, Modulation, Standard, Bandwidth, Modulation, Data Rate, Modulation, SNR, and Error Rate. Rows include IEEE 802.11a/h WiFi 5 GHz (OFDM), IEEE 802.11ac WiFi (20MHz to 160MHz), and LTE-TDD (SC-FDMA, OFDMA).

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Test report No.: KES-SR-19T0008 Page (67) of (97)

EX3DV4- SN.7359

January 31, 2019

Table with columns: ID, Test Type, Test Name, Method, Value, and Error. Rows include LTE-TDD, Pulse Waveform, Bluetooth Low Energy, and various IEEE 802.11ax MCS tests at 20MHz, 40MHz, and 80MHz.

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EX3DV4- SN:7359

January 31, 2019

10728	AAA	IEEE 802.11ax (80MHz, MCS9, 90pc duty cycle)	WLAN	8.65	± 9.6 %
10729	AAA	IEEE 802.11ax (80MHz, MCS10, 90pc duty cycle)	WLAN	8.64	± 9.6 %
10730	AAA	IEEE 802.11ax (80MHz, MCS11, 90pc duty cycle)	WLAN	8.67	± 9.6 %
10731	AAA	IEEE 802.11ax (80MHz, MCS0, 99pc duty cycle)	WLAN	8.42	± 9.6 %
10732	AAA	IEEE 802.11ax (80MHz, MCS1, 99pc duty cycle)	WLAN	8.46	± 9.6 %
10733	AAA	IEEE 802.11ax (80MHz, MCS2, 99pc duty cycle)	WLAN	8.40	± 9.6 %
10734	AAA	IEEE 802.11ax (80MHz, MCS3, 99pc duty cycle)	WLAN	8.25	± 9.6 %
10735	AAA	IEEE 802.11ax (80MHz, MCS4, 99pc duty cycle)	WLAN	8.33	± 9.6 %
10736	AAA	IEEE 802.11ax (80MHz, MCS5, 99pc duty cycle)	WLAN	8.27	± 9.6 %
10737	AAA	IEEE 802.11ax (80MHz, MCS6, 99pc duty cycle)	WLAN	8.36	± 9.6 %
10738	AAA	IEEE 802.11ax (80MHz, MCS7, 99pc duty cycle)	WLAN	8.42	± 9.6 %
10739	AAA	IEEE 802.11ax (80MHz, MCS8, 99pc duty cycle)	WLAN	8.29	± 9.6 %
10740	AAA	IEEE 802.11ax (80MHz, MCS9, 99pc duty cycle)	WLAN	8.48	± 9.6 %
10741	AAA	IEEE 802.11ax (80MHz, MCS10, 99pc duty cycle)	WLAN	8.40	± 9.6 %
10742	AAA	IEEE 802.11ax (80MHz, MCS11, 99pc duty cycle)	WLAN	8.43	± 9.6 %
10743	AAA	IEEE 802.11ax (160MHz, MCS0, 90pc duty cycle)	WLAN	8.94	± 9.6 %
10744	AAA	IEEE 802.11ax (160MHz, MCS1, 90pc duty cycle)	WLAN	9.16	± 9.6 %
10745	AAA	IEEE 802.11ax (160MHz, MCS2, 90pc duty cycle)	WLAN	8.93	± 9.6 %
10746	AAA	IEEE 802.11ax (160MHz, MCS3, 90pc duty cycle)	WLAN	9.11	± 9.6 %
10747	AAA	IEEE 802.11ax (160MHz, MCS4, 90pc duty cycle)	WLAN	9.04	± 9.6 %
10748	AAA	IEEE 802.11ax (160MHz, MCS5, 90pc duty cycle)	WLAN	8.93	± 9.6 %
10749	AAA	IEEE 802.11ax (160MHz, MCS6, 90pc duty cycle)	WLAN	8.90	± 9.6 %
10750	AAA	IEEE 802.11ax (160MHz, MCS7, 90pc duty cycle)	WLAN	8.79	± 9.6 %
10751	AAA	IEEE 802.11ax (160MHz, MCS8, 90pc duty cycle)	WLAN	8.82	± 9.6 %
10752	AAA	IEEE 802.11ax (160MHz, MCS9, 90pc duty cycle)	WLAN	8.81	± 9.6 %
10753	AAA	IEEE 802.11ax (160MHz, MCS10, 90pc duty cycle)	WLAN	9.00	± 9.6 %
10754	AAA	IEEE 802.11ax (160MHz, MCS11, 90pc duty cycle)	WLAN	8.94	± 9.6 %
10755	AAA	IEEE 802.11ax (160MHz, MCS0, 99pc duty cycle)	WLAN	8.64	± 9.6 %
10756	AAA	IEEE 802.11ax (160MHz, MCS1, 99pc duty cycle)	WLAN	8.77	± 9.6 %
10757	AAA	IEEE 802.11ax (160MHz, MCS2, 99pc duty cycle)	WLAN	8.77	± 9.6 %
10758	AAA	IEEE 802.11ax (160MHz, MCS3, 99pc duty cycle)	WLAN	8.69	± 9.6 %
10759	AAA	IEEE 802.11ax (160MHz, MCS4, 99pc duty cycle)	WLAN	8.58	± 9.6 %
10760	AAA	IEEE 802.11ax (160MHz, MCS5, 99pc duty cycle)	WLAN	8.49	± 9.6 %
10761	AAA	IEEE 802.11ax (160MHz, MCS6, 99pc duty cycle)	WLAN	8.58	± 9.6 %
10762	AAA	IEEE 802.11ax (160MHz, MCS7, 99pc duty cycle)	WLAN	8.49	± 9.6 %
10763	AAA	IEEE 802.11ax (160MHz, MCS8, 99pc duty cycle)	WLAN	8.53	± 9.6 %
10764	AAA	IEEE 802.11ax (160MHz, MCS9, 99pc duty cycle)	WLAN	8.54	± 9.6 %
10765	AAA	IEEE 802.11ax (160MHz, MCS10, 99pc duty cycle)	WLAN	8.54	± 9.6 %
10766	AAA	IEEE 802.11ax (160MHz, MCS11, 99pc duty cycle)	WLAN	8.51	± 9.6 %

² Uncertainty is determined using the max. deviation from linear response applying rectangular distribution and is expressed for the square of the field value.



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Accreditation No.: **SCS 0108**

Client **KES (Dymstec)**
Certificate No: **D2450V2-896_May18**

CALIBRATION CERTIFICATE

Object: **D2450V2 - SN:896**

Calibration procedure(s): **QA CAL-05.v10
 Calibration procedure for dipole validation kits above 700 MHz**

Calibration date: **May 30, 2018**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
 The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-18 (No. 217-02672/02673)	Apr-19
Power sensor NRP-Z91	SN: 103244	04-Apr-18 (No. 217-02672)	Apr-19
Power sensor NRP-Z91	SN: 103245	04-Apr-18 (No. 217-02673)	Apr-19
Reference 20 dB Attenuator	SN: 5058 (20k)	04-Apr-18 (No. 217-02682)	Apr-19
Type-N mismatch combination	SN: 5047.2 / 06327	04-Apr-18 (No. 217-02683)	Apr-19
Reference Probe EX3DV4	SN: 7349	30-Dec-17 (No. EX3-7349_Dec17)	Dec-18
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

	Name	Function	Signature
Calibrated by:	Manu Seitz	Laboratory Technician	
Approved by:	Katja Pokovic	Technical Manager	

issued: May 31, 2018

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Certificate No: D2450V2-896_May18
Page 1 of 8

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Accreditation No.: **SCS 0108**

Glossary:

TSL tissue simulating liquid
ConvF sensitivity in TSL / NORM x,y,z
N/A not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.1
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy, dz = 5 mm	
Frequency	2450 MHz ± 1 MHz	

Head TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	39.2	1.80 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	38.2 ± 6 %	1.85 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	250 mW input power	13.1 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	51.4 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	250 mW input power	6.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	24.2 W/kg ± 16.5 % (k=2)

Body TSL parameters

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	52.7	1.95 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	52.3 ± 6 %	1.99 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	250 mW input power	12.4 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	49.0 W/kg ± 17.0 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	250 mW input power	5.79 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	23.0 W/kg ± 16.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL

Impedance, transformed to feed point	55.0 Ω + 2.6 jΩ
Return Loss	- 25.4 dB

Antenna Parameters with Body TSL

Impedance, transformed to feed point	50.2 Ω + 2.9 jΩ
Return Loss	- 30.8 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.157 ns
----------------------------------	----------

After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	June 19, 2012

DASY5 Validation Report for Head TSL

Date: 30.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:896

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.85$ S/m; $\epsilon_r = 38.2$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(7.88, 7.88, 7.88) @ 2450 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole Calibration for Head Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

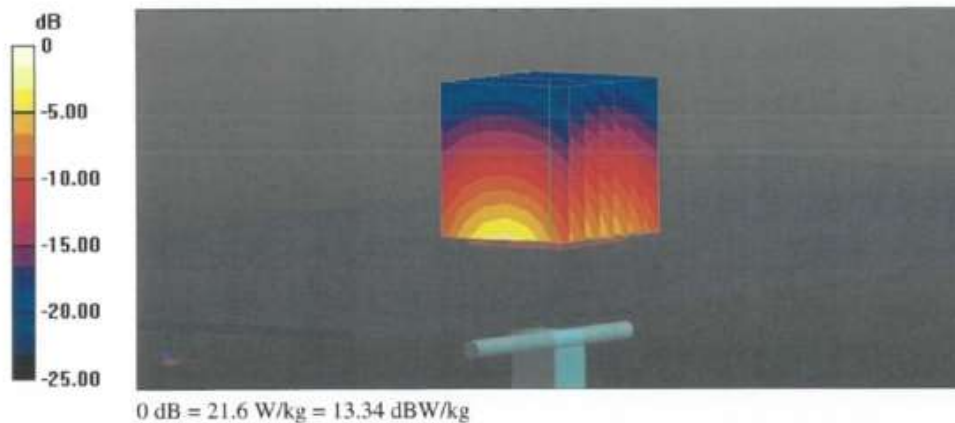
Measurement grid: dx=5mm, dy=5mm, dz=5mm

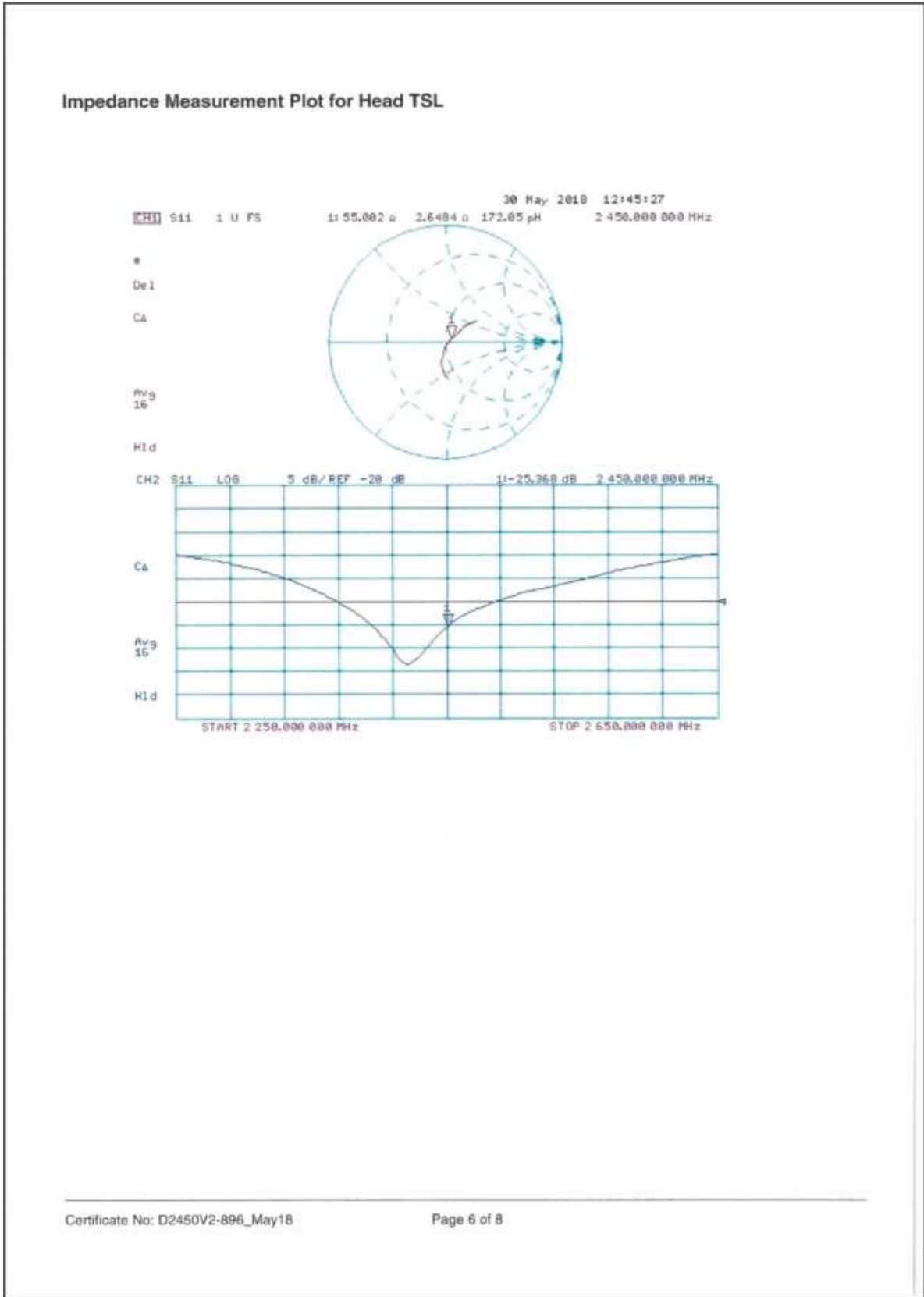
Reference Value = 115.6 V/m; Power Drift = -0.01 dB

Peak SAR (extrapolated) = 26.1 W/kg

SAR(1 g) = 13.1 W/kg; SAR(10 g) = 6.11 W/kg

Maximum value of SAR (measured) = 21.6 W/kg





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DASY5 Validation Report for Body TSL

Date: 29.05.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole 2450 MHz; Type: D2450V2; Serial: D2450V2 - SN:896

Communication System: UID 0 - CW; Frequency: 2450 MHz

Medium parameters used: $f = 2450$ MHz; $\sigma = 1.99$ S/m; $\epsilon_r = 52.3$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN7349; ConvF(8.01, 8.01, 8.01) @ 2450 MHz; Calibrated: 30.12.2017
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.1(1476); SEMCAD X 14.6.11(7439)

Dipole Calibration for Body Tissue/Pin=250 mW, d=10mm/Zoom Scan (7x7x7)/Cube 0:

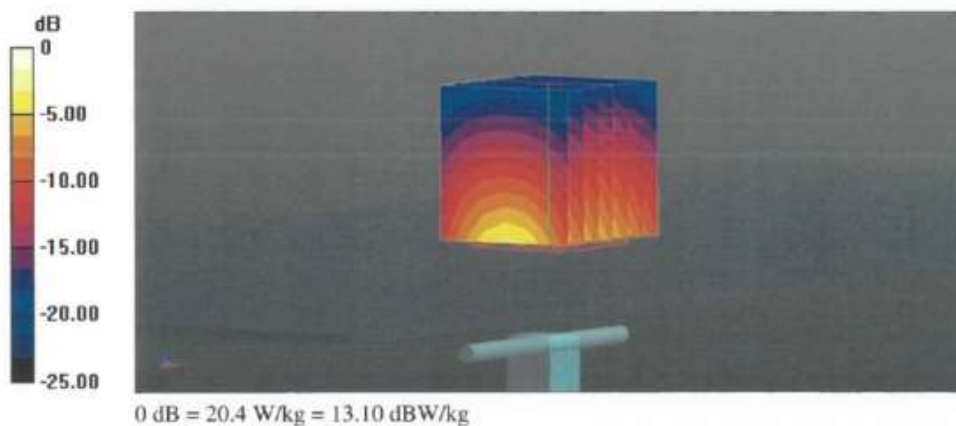
Measurement grid: dx=5mm, dy=5mm, dz=5mm

Reference Value = 107.2 V/m; Power Drift = -0.05 dB

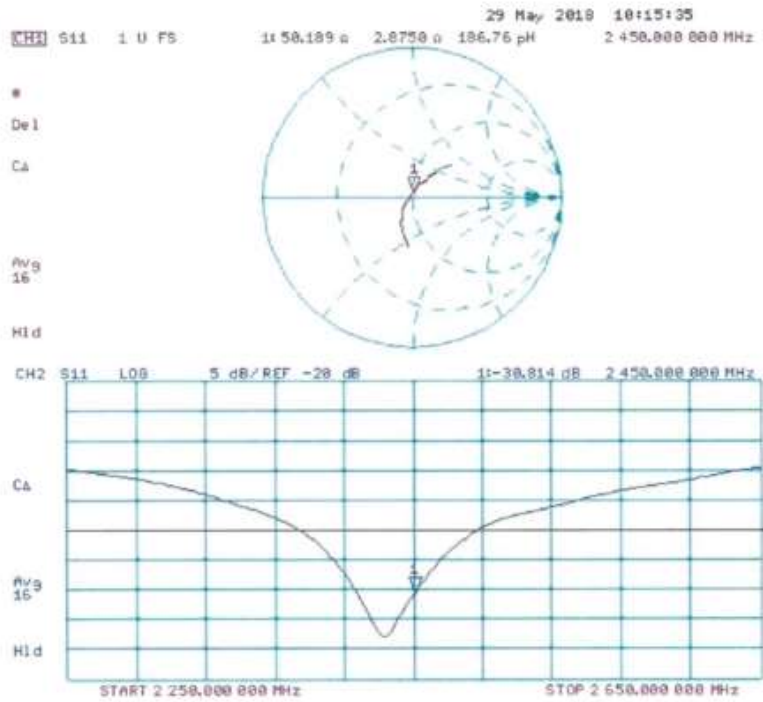
Peak SAR (extrapolated) = 24.5 W/kg

SAR(1 g) = 12.4 W/kg; SAR(10 g) = 5.79 W/kg

Maximum value of SAR (measured) = 20.4 W/kg



Impedance Measurement Plot for Body TSL



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Accreditation No.: **SCS 0108**

Client **KES (Dymstec)**

Certificate No: **D5GHzV2-1170_Jan18**

CALIBRATION CERTIFICATE

Object: **D5GHzV2 - SN:1170**

Calibration procedure(s): **QA CAL-22.v2
 Calibration procedure for dipole validation kits between 3-6 GHz**

Calibration date: **January 25, 2018**

This calibration certificate documents the traceability to national standards, which realize the physical units of measurements (SI).
 The measurements and the uncertainties with confidence probability are given on the following pages and are part of the certificate.

All calibrations have been conducted in the closed laboratory facility: environment temperature (22 ± 3)°C and humidity < 70%.

Calibration Equipment used (M&TE critical for calibration)

Primary Standards	ID #	Cal Date (Certificate No.)	Scheduled Calibration
Power meter NRP	SN: 104778	04-Apr-17 (No. 217-02521,02522)	Apr-18
Power sensor NRP-Z91	SN: 103244	04-Apr-17 (No. 217-02521)	Apr-18
Power sensor NRP-Z91	SN: 103245	04-Apr-17 (No. 217-02522)	Apr-18
Reference 20 dB Attenuator	SN: 5058 (20k)	07-Apr-17 (No. 217-02528)	Apr-18
Type-N mismatch combination	SN: 5047.2 / 06327	07-Apr-17 (No. 217-02529)	Apr-18
Reference Probe EX30V4	SN: 3503	30-Dec-17 (No. EX3-3503_Dec17)	Dec-18
DAE4	SN: 601	26-Oct-17 (No. DAE4-601_Oct17)	Oct-18

Secondary Standards	ID #	Check Date (in house)	Scheduled Check
Power meter EPM-442A	SN: GB37480704	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: US37292783	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
Power sensor HP 8481A	SN: MY41092317	07-Oct-15 (in house check Oct-16)	In house check: Oct-18
RF generator R&S SMT-06	SN: 100972	15-Jun-15 (in house check Oct-16)	In house check: Oct-18
Network Analyzer HP 8753E	SN: US37390585	18-Oct-01 (in house check Oct-17)	In house check: Oct-18

Calibrated by: **Jeton Kastrall** (Name), **Laboratory Technician** (Function), [Signature]

Approved by: **Katja Pokovic** (Name), **Technical Manager** (Function), [Signature]

Issued: January 25, 2018

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Accredited by the Swiss Accreditation Service (SAS)

Accreditation No.: **SCS 0108**

The Swiss Accreditation Service is one of the signatories to the EA
Multilateral Agreement for the recognition of calibration certificates

Glossary:

TSL	tissue simulating liquid
ConvF	sensitivity in TSL / NORM x,y,z
N/A	not applicable or not measured

Calibration is Performed According to the Following Standards:

- a) IEEE Std 1528-2013, "IEEE Recommended Practice for Determining the Peak Spatial-Averaged Specific Absorption Rate (SAR) in the Human Head from Wireless Communications Devices: Measurement Techniques", June 2013
- b) IEC 62209-1, "Measurement procedure for the assessment of Specific Absorption Rate (SAR) from hand-held and body-mounted devices used next to the ear (frequency range of 300 MHz to 6 GHz)", July 2016
- c) IEC 62209-2, "Procedure to determine the Specific Absorption Rate (SAR) for wireless communication devices used in close proximity to the human body (frequency range of 30 MHz to 6 GHz)", March 2010
- d) KDB 865664, "SAR Measurement Requirements for 100 MHz to 6 GHz"

Additional Documentation:

- e) DASY4/5 System Handbook

Methods Applied and Interpretation of Parameters:

- *Measurement Conditions:* Further details are available from the Validation Report at the end of the certificate. All figures stated in the certificate are valid at the frequency indicated.
- *Antenna Parameters with TSL:* The dipole is mounted with the spacer to position its feed point exactly below the center marking of the flat phantom section, with the arms oriented parallel to the body axis.
- *Feed Point Impedance and Return Loss:* These parameters are measured with the dipole positioned under the liquid filled phantom. The impedance stated is transformed from the measurement at the SMA connector to the feed point. The Return Loss ensures low reflected power. No uncertainty required.
- *Electrical Delay:* One-way delay between the SMA connector and the antenna feed point. No uncertainty required.
- *SAR measured:* SAR measured at the stated antenna input power.
- *SAR normalized:* SAR as measured, normalized to an input power of 1 W at the antenna connector.
- *SAR for nominal TSL parameters:* The measured TSL parameters are used to calculate the nominal SAR result.

The reported uncertainty of measurement is stated as the standard uncertainty of measurement multiplied by the coverage factor $k=2$, which for a normal distribution corresponds to a coverage probability of approximately 95%.

Measurement Conditions

DASY system configuration, as far as not given on page 1.

DASY Version	DASY5	V52.10.0
Extrapolation	Advanced Extrapolation	
Phantom	Modular Flat Phantom V5.0	
Distance Dipole Center - TSL	10 mm	with Spacer
Zoom Scan Resolution	dx, dy = 4.0 mm, dz = 1.4 mm	Graded Ratio = 1.4 (Z direction)
Frequency	5200 MHz ± 1 MHz 5300 MHz ± 1 MHz 5500 MHz ± 1 MHz 5600 MHz ± 1 MHz 5800 MHz ± 1 MHz	

Head TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	36.0	4.66 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.3 ± 6 %	4.50 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.72 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	77.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.21 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.1 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.9	4.76 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	36.2 ± 6 %	4.60 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5300 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.11 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	81.2 W / kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.32 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.2 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.6	4.96 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.9 ± 6 %	4.79 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.21 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	82.1 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.33 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.3 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.5	5.07 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.8 ± 6 %	4.90 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	8.35 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	83.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.38 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	23.8 W/kg ± 19.5 % (k=2)

Head TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Head TSL parameters	22.0 °C	35.3	5.27 mho/m
Measured Head TSL parameters	(22.0 ± 0.2) °C	35.5 ± 6 %	5.11 mho/m ± 6 %
Head TSL temperature change during test	< 0.5 °C	----	----

SAR result with Head TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Head TSL	Condition	
SAR measured	100 mW input power	7.94 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	79.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Head TSL	condition	
SAR measured	100 mW input power	2.26 W/kg
SAR for nominal Head TSL parameters	normalized to 1W	22.6 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5200 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	49.0	5.30 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.3 ± 6 %	5.41 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5200 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.23 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	71.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.03 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.1 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5300 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.9	5.42 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	47.1 ± 6 %	5.54 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5300 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.39 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	73.4 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.08 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.6 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5500 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.6	5.65 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.8 ± 6 %	5.80 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5500 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.83 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	77.8 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.17 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.5 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5600 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.5	5.77 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.6 ± 6 %	5.94 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5600 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.88 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	76.3 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.21 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	21.9 W/kg ± 19.5 % (k=2)

Body TSL parameters at 5800 MHz

The following parameters and calculations were applied.

	Temperature	Permittivity	Conductivity
Nominal Body TSL parameters	22.0 °C	48.2	6.00 mho/m
Measured Body TSL parameters	(22.0 ± 0.2) °C	46.2 ± 6 %	6.22 mho/m ± 6 %
Body TSL temperature change during test	< 0.5 °C	----	----

SAR result with Body TSL at 5800 MHz

SAR averaged over 1 cm ³ (1 g) of Body TSL	Condition	
SAR measured	100 mW input power	7.50 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	74.5 W/kg ± 19.9 % (k=2)

SAR averaged over 10 cm ³ (10 g) of Body TSL	condition	
SAR measured	100 mW input power	2.09 W/kg
SAR for nominal Body TSL parameters	normalized to 1W	20.7 W/kg ± 19.5 % (k=2)

Appendix (Additional assessments outside the scope of SCS 0108)

Antenna Parameters with Head TSL at 5200 MHz

Impedance, transformed to feed point	51.3 Ω - 10.4 $j\Omega$
Return Loss	- 19.8 dB

Antenna Parameters with Head TSL at 5300 MHz

Impedance, transformed to feed point	51.0 Ω - 5.7 $j\Omega$
Return Loss	- 24.9 dB

Antenna Parameters with Head TSL at 5500 MHz

Impedance, transformed to feed point	52.9 Ω - 6.0 $j\Omega$
Return Loss	- 23.8 dB

Antenna Parameters with Head TSL at 5600 MHz

Impedance, transformed to feed point	56.9 Ω - 3.2 $j\Omega$
Return Loss	- 22.9 dB

Antenna Parameters with Head TSL at 5800 MHz

Impedance, transformed to feed point	57.6 Ω - 4.5 $j\Omega$
Return Loss	- 21.7 dB

Antenna Parameters with Body TSL at 5200 MHz

Impedance, transformed to feed point	51.2 Ω - 9.1 $j\Omega$
Return Loss	- 20.9 dB

Antenna Parameters with Body TSL at 5300 MHz

Impedance, transformed to feed point	51.3 Ω - 4.7 $j\Omega$
Return Loss	- 26.4 dB

Antenna Parameters with Body TSL at 5500 MHz

Impedance, transformed to feed point	53.5 Ω - 5.3 $j\Omega$
Return Loss	- 24.2 dB

Antenna Parameters with Body TSL at 5600 MHz

Impedance, transformed to feed point	59.2 Ω - 2.5 j Ω
Return Loss	- 21.2 dB

Antenna Parameters with Body TSL at 5800 MHz

Impedance, transformed to feed point	58.1 Ω - 5.1 j Ω
Return Loss	- 21.1 dB

General Antenna Parameters and Design

Electrical Delay (one direction)	1.202 ns
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After long term use with 100W radiated power, only a slight warming of the dipole near the feedpoint can be measured.

The dipole is made of standard semirigid coaxial cable. The center conductor of the feeding line is directly connected to the second arm of the dipole. The antenna is therefore short-circuited for DC-signals. On some of the dipoles, small end caps are added to the dipole arms in order to improve matching when loaded according to the position as explained in the "Measurement Conditions" paragraph. The SAR data are not affected by this change. The overall dipole length is still according to the Standard.

No excessive force must be applied to the dipole arms, because they might bend or the soldered connections near the feedpoint may be damaged.

Additional EUT Data

Manufactured by	SPEAG
Manufactured on	December 09, 2013

DASY5 Validation Report for Head TSL

Date: 25.01.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1170

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz,
Frequency: 5600 MHz, Frequency: 5800 MHz
Medium parameters used: f = 5200 MHz; $\sigma = 4.5$ S/m; $\epsilon_r = 36.3$; $\rho = 1000$ kg/m³,
Medium parameters used: f = 5300 MHz; $\sigma = 4.6$ S/m; $\epsilon_r = 36.2$; $\rho = 1000$ kg/m³,
Medium parameters used: f = 5500 MHz; $\sigma = 4.79$ S/m; $\epsilon_r = 35.9$; $\rho = 1000$ kg/m³,
Medium parameters used: f = 5600 MHz; $\sigma = 4.9$ S/m; $\epsilon_r = 35.8$; $\rho = 1000$ kg/m³,
Medium parameters used: f = 5800 MHz; $\sigma = 5.11$ S/m; $\epsilon_r = 35.5$; $\rho = 1000$ kg/m³
Phantom section: Flat Section
Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.75, 5.75, 5.75); Calibrated: 30.12.2017,
ConvF(5.5, 5.5, 5.5); Calibrated: 30.12.2017, ConvF(5.2, 5.2, 5.2); Calibrated: 30.12.2017,
ConvF(5.05, 5.05, 5.05); Calibrated: 30.12.2017, ConvF(4.96, 4.96, 4.96); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (front); Type: QD 000 P50 AA; Serial: 1001
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

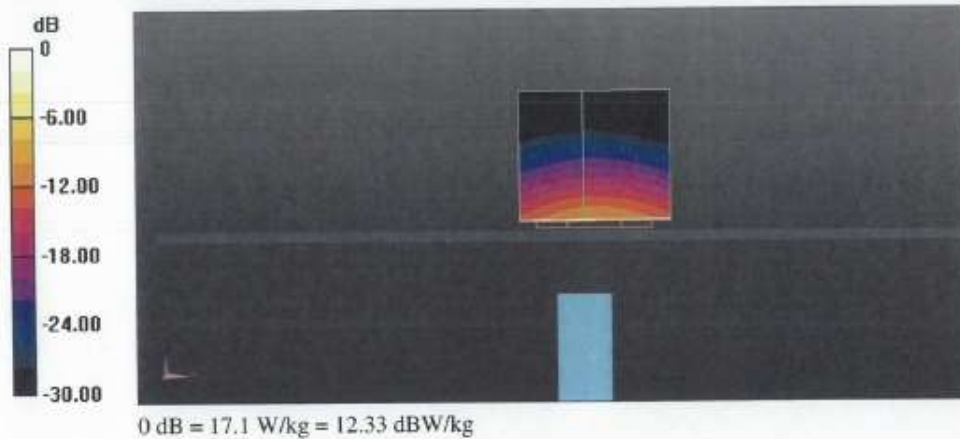
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5200 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 68.22 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 27.4 W/kg
SAR(1 g) = 7.72 W/kg; SAR(10 g) = 2.21 W/kg
Maximum value of SAR (measured) = 17.1 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 68.97 V/m; Power Drift = -0.01 dB
Peak SAR (extrapolated) = 29.6 W/kg
SAR(1 g) = 8.11 W/kg; SAR(10 g) = 2.32 W/kg
Maximum value of SAR (measured) = 18.4 W/kg

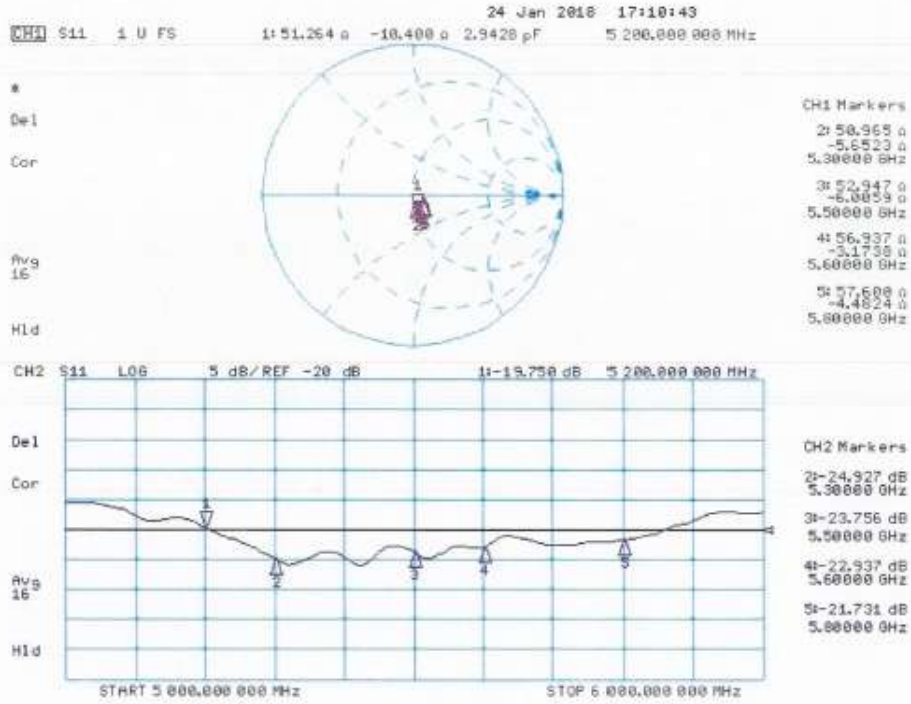
Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 68.78 V/m; Power Drift = -0.06 dB
Peak SAR (extrapolated) = 31.7 W/kg
SAR(1 g) = 8.21 W/kg; SAR(10 g) = 2.33 W/kg
Maximum value of SAR (measured) = 18.9 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm
(8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 69.34 V/m; Power Drift = -0.04 dB
Peak SAR (extrapolated) = 31.8 W/kg
SAR(1 g) = 8.35 W/kg; SAR(10 g) = 2.38 W/kg
Maximum value of SAR (measured) = 19.2 W/kg

Dipole Calibration for Head Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm
(8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
Reference Value = 67.64 V/m; Power Drift = -0.05 dB
Peak SAR (extrapolated) = 31.0 W/kg
SAR(1 g) = 7.94 W/kg; SAR(10 g) = 2.26 W/kg
Maximum value of SAR (measured) = 17.1 W/kg



Impedance Measurement Plot for Head TSL



DASY5 Validation Report for Body TSL

Date: 23.01.2018

Test Laboratory: SPEAG, Zurich, Switzerland

DUT: Dipole D5GHzV2; Type: D5GHzV2; Serial: D5GHzV2 - SN:1170

Communication System: UID 0 - CW; Frequency: 5200 MHz, Frequency: 5300 MHz, Frequency: 5500 MHz,
 Frequency: 5600 MHz, Frequency: 5800 MHz
 Medium parameters used: f = 5200 MHz; $\sigma = 5.41$ S/m; $\epsilon_r = 47.3$; $\rho = 1000$ kg/m³ ,
 Medium parameters used: f = 5300 MHz; $\sigma = 5.54$ S/m; $\epsilon_r = 47.1$; $\rho = 1000$ kg/m³ ,
 Medium parameters used: f = 5500 MHz; $\sigma = 5.8$ S/m; $\epsilon_r = 46.8$; $\rho = 1000$ kg/m³ ,
 Medium parameters used: f = 5600 MHz; $\sigma = 5.94$ S/m; $\epsilon_r = 46.6$; $\rho = 1000$ kg/m³ ,
 Medium parameters used: f = 5800 MHz; $\sigma = 6.22$ S/m; $\epsilon_r = 46.2$; $\rho = 1000$ kg/m³ ,
 Phantom section: Flat Section
 Measurement Standard: DASY5 (IEEE/IEC/ANSI C63.19-2011)

DASY52 Configuration:

- Probe: EX3DV4 - SN3503; ConvF(5.35, 5.35, 5.35); Calibrated: 30.12.2017,
 ConvF(5.15, 5.15, 5.15); Calibrated: 30.12.2017, ConvF(4.7, 4.7, 4.7); Calibrated: 30.12.2017,
 ConvF(4.65, 4.65, 4.65); Calibrated: 30.12.2017, ConvF(4.53, 4.53, 4.53); Calibrated: 30.12.2017;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn601; Calibrated: 26.10.2017
- Phantom: Flat Phantom 5.0 (back); Type: QD 000 P50 AA; Serial: 1002
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

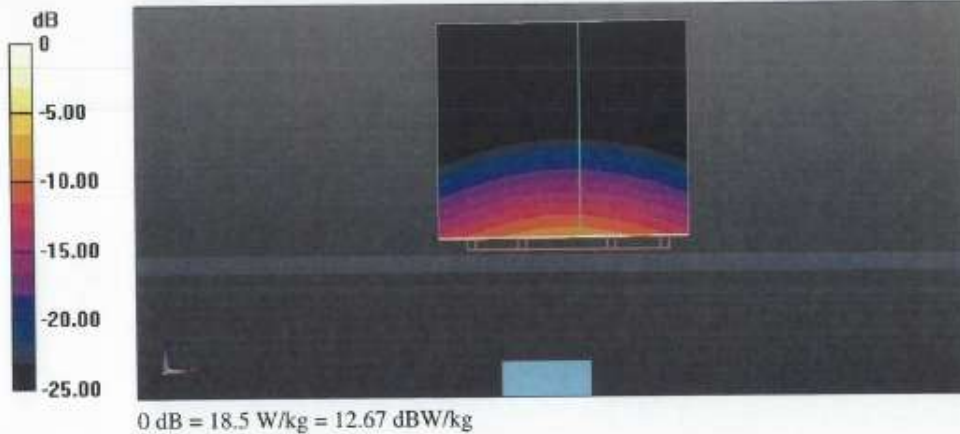
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 Reference Value = 64.32 V/m; Power Drift = -0.06 dB
 Peak SAR (extrapolated) = 27.0 W/kg
SAR(1 g) = 7.23 W/kg; SAR(10 g) = 2.03 W/kg
 Maximum value of SAR (measured) = 17.1 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5300 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 64.53 V/m; Power Drift = -0.05 dB
 Peak SAR (extrapolated) = 28.6 W/kg
SAR(1 g) = 7.39 W/kg; SAR(10 g) = 2.08 W/kg
 Maximum value of SAR (measured) = 17.5 W/kg

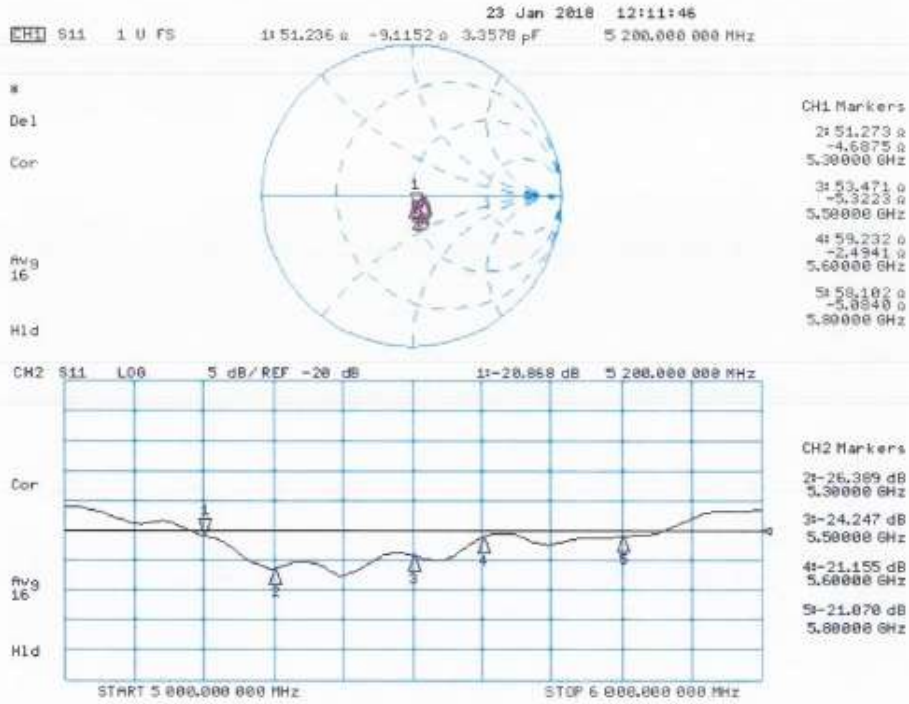
Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5500 MHz/Zoom Scan, dist=1.4mm (8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 65.26 V/m; Power Drift = -0.08 dB
 Peak SAR (extrapolated) = 32.1 W/kg
SAR(1 g) = 7.83 W/kg; SAR(10 g) = 2.17 W/kg
 Maximum value of SAR (measured) = 19.0 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5600 MHz/Zoom Scan, dist=1.4mm
(8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 65.40 V/m; Power Drift = -0.04 dB
 Peak SAR (extrapolated) = 32.9 W/kg
SAR(1 g) = 7.88 W/kg; SAR(10 g) = 2.21 W/kg
 Maximum value of SAR (measured) = 19.3 W/kg

Dipole Calibration for Body Tissue/Pin=100mW, dist=10mm, f=5800 MHz/Zoom Scan, dist=1.4mm
(8x8x7)/Cube 0: Measurement grid: dx=4mm, dy=4mm, dz=1.4mm
 Reference Value = 63.12 V/m; Power Drift = -0.04 dB
 Peak SAR (extrapolated) = 32.4 W/kg
SAR(1 g) = 7.5 W/kg; SAR(10 g) = 2.09 W/kg
 Maximum value of SAR (measured) = 18.5 W/kg



Impedance Measurement Plot for Body TSL



Appendix D. SAR Tissue Specifications

Measurement Procedure for Tissue verification:

- 1) The network analyzer and probe system was configured and calibrated.
- 2) The probe was immersed in the tissue. The tissue was placed in a nonmetallic container. Trapped air bubbles beneath the flange were minimized by placing the probe at a slight angle.
- 3) The complex admittance with respect to the probe aperture was measured.
- 4) The complex relative permittivity ϵ' can be calculated from the below equation (Pournaropoulos and Misra):

$$Y = \frac{j2\omega\epsilon_r\epsilon_0}{[\ln(b/a)]^2} \int_a^b \int_a^b \int_0^\pi \cos\phi' \frac{\exp[-j\omega r'(\mu_0\epsilon_r'\epsilon_0)^{1/2}]}{r'} d\phi' d\rho' d\rho$$

where Y is the admittance of the probe in contact with the sample, the primed and unprimed coordinates refer to source and observation points, respectively, $r^2 = \rho^2 + \rho'^2 - 2\rho\rho'\cos\phi'$, ω is the angular frequency, and $j = \sqrt{-1}$.

Table D-1 Composition of the Tissue Equivalent Matter - Head

Tissue Type	Water	SUGAR	Salt	DGBE	BACTERIA CIDE	HEC	Mineral Oil	Emulsifiers
HSL2450	54.9	-	0.1	45.0	-	-	-	-
HSL5GHz	78.0	-	2.0	-	-	-	11.0	9.0

Appendix E. SAR System Validation

Per FCC KDB Publication 865664 D02v01r02, SAR system validation status should be documented to confirm measurement accuracy. The SAR systems (including SAR probes, system components and software versions) used for this device were validated against its performance specifications prior to the SAR measurements. Reference dipoles were used with the required tissue- equivalent media for system validation, according to the procedures outlined in FCC KDB Publication 865664 D01v01r04 and IEEE 1528-2013. Since SAR probe calibrations are frequency dependent, each probe calibration point was validated at a frequency within the valid frequency range of the probe calibration point, using the system that normally operates with the probe for routine SAR measurements and according to the required tissue-equivalent media.

A tabulated summary of the system validation status including the validation date(s), measurement frequencies, SAR probes and tissue dielectric parameters has been included.

Justification for Extended SAR Dipole Calibrations

Usage of SAR dipoles calibrated less than 3 years ago but more than 1 year ago were confirmed in maintaining return loss(<-20 dB, within 20% of prior calibration) and impedance (within 5 ohm from prior calibration) requirements per extended calibrations in KDB 864664 D01v01r04.

Table E-1 SAR System Validation Summary

SAR System #	Freq. [MHz]	Date	Probe SN	Probe Type	Return loss (dB)	Impedance (Ω)	CW Validation			Mod. Validation		
							Sensitivity	Probe Linearity	Probe Isotropy	Mod. Type	Duty Factor	PAR
1	2450	2019-06-14	7359	EX3DV4	-25.7	54.8+0.9j	PASS	PASS	PASS	DSSS/OFDM	PASS	PASS
2	5300	2019-02-23	7359	EX3DV4	-24.5	51.5-5.9j	PASS	PASS	PASS	OFDM	PASS	PASS
3	5600	2019-02-23	7359	EX3DV4	-22.3	56.5-4.9j	PASS	PASS	PASS	OFDM	PASS	PASS
4	5800	2019-02-23	7359	EX3DV4	-22.0	56.8-3.3j	PASS	PASS	PASS	OFDM	PASS	PASS

NOTE: While the probes have been calibrated for both CW and modulated signals, all measurements were performed using communication systems calibrated for CW signals only. Modulations in the table above represent test configurations for which the measurement system has been validated per FCC KDB Publication 865664 D01v01r04 for scenarios when CW probe calibrations are used with other signal types. SAR systems were validated for modulated signals with a periodic duty cycle, such as GMSK, or with a high peak to average ratio (> 5 dB), such as OFDM according to FCC KDB Publication 865664 D01v01r04.

Appendix F. DUT Antenna Diagram & SAR Test Setup Photographs

DUT Antenna Diagram



Note: Exact antenna dimensions and separation distances are shown in the Technical Descriptions in the FCC Filing.

EUT Photo



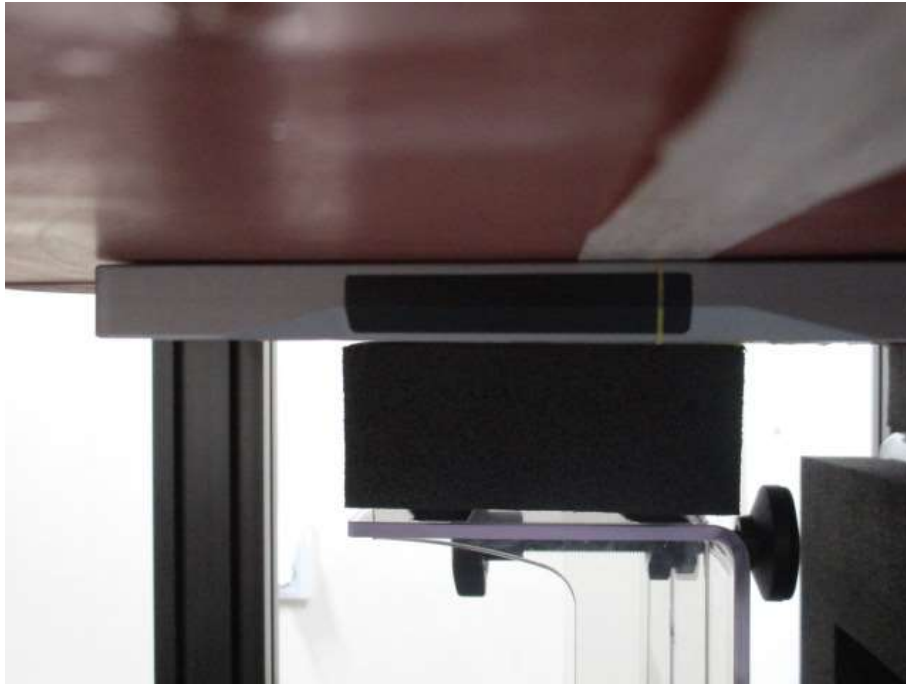
Front Side of EUT



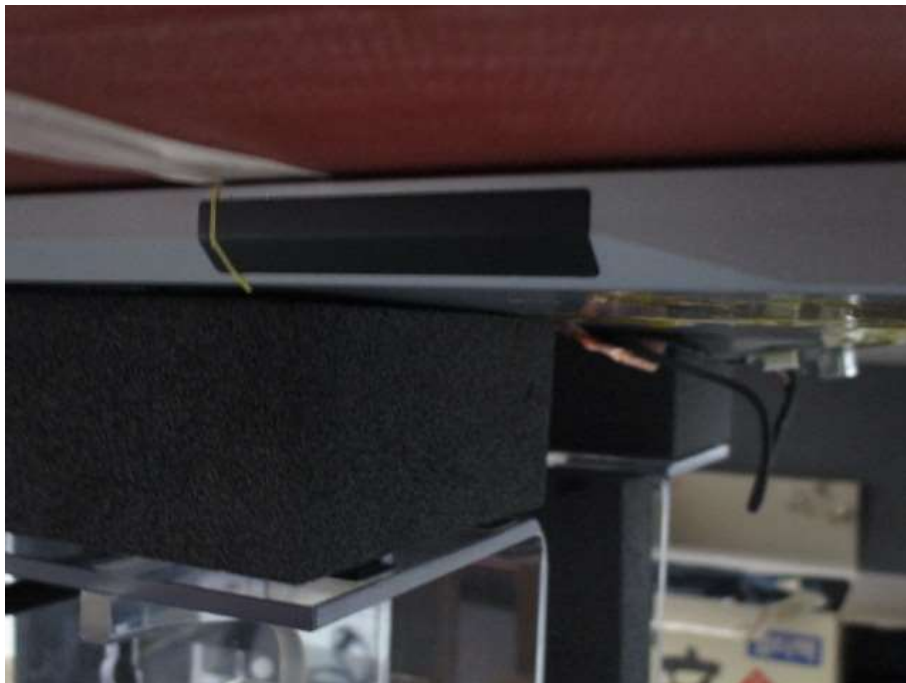
Rear Side of EUT

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Body SAR Setup Photo



Antenna 1



Antenna 2

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