



TEST REPORT

Report No...... : **CHTEW19010211**

Report verification:



Project No...... : **SHT1901053901EW**

FCC ID : **2AB4FD2000**

Applicant's name : **Fujian Juston Electronic Equipment Co.,Ltd.**

Address..... : No.66 Changtai Road,Shudou Industrial Park,Jiangnan Licheng District,Quanzhou,China

Manufacturer..... : Fujian Juston Electronic Equipment Co.,Ltd.

Address..... : No.66 Changtai Road,Shudou Industrial Park,Jiangnan Licheng District,Quanzhou,China

Test item description..... : **DMR Digital two way radio**

Trade Mark..... : HYDX

Model/Type reference..... : D2000

Listed Model(s) : D2100,D2200,D2300

Standard : **FCC 47 CFR Part2.1093**
IEEE Std C95.1, 1999 Edition
IEEE 1528: 2013

Date of receipt of test sample..... : Jan. 23, 2019

Date of testing..... : Jan. 24, 2019- Jan. 31, 2019

Date of issue..... : Feb. 01, 2019

Result..... : **PASS**

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The test report merely correspond to the test sample.

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1 . Test Standards and Report version

1.1. Test Standards

The tests were performed according to following standards:

[FCC 47 Part 2.1093](#): Radiofrequency Radiation Exposure Evaluation:Portable Devices

[IEEE Std C95.1, 1999 Edition](#): IEEE Standard for Safety Levels with Respect to Human Exposure to Radio Frequency Electromagnetic Fields, 3 kHz to 300 GHz

[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.

[KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz v01r04](#): SAR Measurement Requirements for 100 MHz to 6 GHz

[KDB 865664 D02 RF Exposure Reporting v01r02](#): RF Exposure Compliance Reporting and Documentation Considerations

[KDB 447498 D01 General RF Exposure Guidance v06](#): Mobile and Portable Device RF Exposure Procedures and Equipment Authorization Policies

[KDB 643646 D01:SAR Test for PTT Radios v01r03](#): SAR Test Reduction Considerations for Occupational PTT Radios

1.2. Report version

Revision No.	Date of issue	Description
N/A	2019-02-01	Original

2. Summary

2.1. Client Information

Applicant:	Fujian Juston Electronic Equipment Co.,Ltd.
Address:	No.66 Changtai Road,Shudou Industrial Park,Jiangnan Licheng District,Quanzhou,China
Manufacturer:	Fujian Juston Electronic Equipment Co.,Ltd.
Address:	No.66 Changtai Road,Shudou Industrial Park,Jiangnan Licheng District,Quanzhou,China

2.2. Product Description

Name of EUT:	DMR Digital two way radio		
Trade mark:	HYDX		
Model/Type reference:	D2000		
Listed model(s):	D2100,D2200,D2300		
Accessories	Belt Clip		
Device Category:	Portable		
RF Exposure Environment:	Occupational/Controlled		
Power supply:	DC 7.4V		
Hardware version:	JST-HD-D2000-V2.2		
Software version:	JST-SW-D2000-V1-3		
Device Dimension:	Overall (Length x Width x Thickness):118 x 57 x 35mm Antenna(Length):158mm		
Maximum SAR Value			
Separation Distance:	Front-of-face:	25mm	
	Body:	0mm	
Maximun SAR Value (1g):	Front-of-face:	1.473 W/kg	
	Body:	2.711 W/kg	
PMR			
Operation Frequency Range:	136~174MHz,400~480MHz		
Rated Output Power:	<input checked="" type="checkbox"/> High Power:	4W(36.02dBm)	<input checked="" type="checkbox"/> Low Power: 1W(30.00dBm)
Modulation Type:	Analog:	FM	
	Digital:	4FSK	
Channel Separation:	Analog:	<input checked="" type="checkbox"/> 12.5kHz	<input type="checkbox"/> 20kHz <input type="checkbox"/> 25kHz
	Digital:	<input type="checkbox"/> 6.25kHz	<input checked="" type="checkbox"/> 12.5kHz
Digital Type:	DMR		
Antenna type:	External		
<i>Remark:</i> The EUT battery must be fully charged and checked periodically during the test to ascertain uniform power.			

2.3. Test frequency list

When the frequency channels required for SAR testing are not specified, the following should be applied to determine the number of required test channels. The test channels should be evenly spread across the transmission frequency band of each wireless mode.

$$N_c = \text{Round}\left\{\left[100\left(f_{\text{high}} - f_{\text{low}}\right) / f_c\right]^{0.5} \times \left(f_c / 100\right)^{0.2}\right\},$$

N_c is the number of test channels, rounded to the nearest integer,
 f_{high} and f_{low} are the highest and lowest channel frequencies within the transmission band,
 f_c is the mid-band channel frequency,
 all frequencies are in MHz.

Operation Frequency		Test Frequency number
Start Frequency	Stop Frequency	
136	174	5
400	480	6

ModulationType	Channel Separation	Test Channel	Test Frequency (MHz)	
			TX	RX
Analog	12.5kHz	CH _{V1}	136.0250	136.0250
		CH _{V2}	145.5000	145.5000
		CH _{V3}	155.0250	155.0250
		CH _{V4}	164.5000	164.5000
		CH _{V5}	173.9750	173.9750
Digital	12.5kHz	CH _{V1}	136.0250	136.0250
		CH _{V2}	145.5000	145.5000
		CH _{V3}	155.0250	155.0250
		CH _{V4}	164.5000	164.5000
		CH _{V5}	173.9750	173.9750

ModulationType	Channel Separation	Test Channel	Test Frequency (MHz)	
			TX	RX
Analog	12.5kHz	CH _{U1}	400.0250	400.0250
		CH _{U2}	416.0250	416.0250
		CH _{U3}	432.0250	432.0250
		CH _{U4}	448.0250	448.0250
		CH _{U5}	464.0250	464.0250
		CH _{U6}	479.9750	479.9750
Digital	12.5kHz	CH _{U1}	400.0250	400.0250
		CH _{U2}	416.0250	416.0250
		CH _{U3}	432.0250	432.0250
		CH _{U4}	448.0250	448.0250
		CH _{U5}	464.0250	464.0250
		CH _{U6}	479.9750	479.9750

3. Test Environment

3.1. Test laboratory

Laboratory: Shenzhen Huatongwei International Inspection Co., Ltd.

Address: 1/F, Bldg 3, Hongfa Hi-tech Industrial Park, Genyu Road, Tianliao, Gongming, Shenzhen, China

3.2. Test Facility

CNAS-Lab Code: L1225

Shenzhen Huatongwei International Inspection Co., Ltd. has been assessed and proved to be in compliance with CNAS-CL01 Accreditation Criteria for Testing and Calibration Laboratories (identical to ISO/IEC17025: 2005 General Requirements) for the Competence of Testing and Calibration Laboratories.

A2LA-Lab Cert. No.: 3902.01

Shenzhen Huatongwei International Inspection Co., Ltd. EMC Laboratory has been accredited by A2LA for technical competence in the field of electrical testing, and proved to be in compliance with ISO/IEC 17025: 2005 General Requirements for the Competence of Testing and Calibration Laboratories and any additional program requirements in the identified field of testing.

FCC-Registration No.: 762235

Shenzhen Huatongwei International Inspection Co., Ltd. EMC Laboratory has been registered and fully described in a report filed with the FCC (Federal Communications Commission). The acceptance letter from the FCC is maintained in our files. Registration 762235.

IC-Registration No.: 5377B-1

Two 3m Alternate Test Site of Shenzhen Huatongwei International Inspection Co., Ltd. has been registered by Certification and Engineering Bureau of Industry Canada for the performance of radiated measurements with Registration No. 5377B-1.

ACA

Shenzhen Huatongwei International Inspection Co., Ltd. EMC Laboratory can also perform testing for the Australian C-Tick mark as a result of our A2LA accreditation.

3.3. Environmental conditions

During the measurement the environmental conditions were within the listed ranges:

Ambient temperature	18 °C to 25 °C
Ambient humidity	30%RH to 70%RH
Air Pressure	950-1050mbar

4. Equipments Used during the Test

Used	Test Equipment	Manufacturer	Model No.	Serial No.	Cal. date (YY-MM-DD)	Due date (YY-MM-DD)
●	Data Acquisition Electronics DAEx	SPEAG	DAE4	1549	2018/04/25	2019/04/24
●	E-field Probe	SPEAG	EX3DV4	7494	2018/02/26	2019/02/25
○	Universal Radio Communication Tester	R&S	CMW500	137681	2018/07/11	2019/07/10
● Tissue-equivalent liquids Validation						
○	Dielectric Assessment Kit	SPEAG	DAK-3.5	1267	2018/03/01	2019/02/28
●	Dielectric Assessment Kit	SPEAG	DAK-12	1130	2018/03/01	2019/02/28
●	Network analyzer	Keysight	E5071C	MY46733048	2018/09/19	2019/09/18
○ System Validation						
●	System Validation Antenna	SPEAG	CLA-150	4024	2018/02/21	2021/02/20
●	System Validation Dipole	SPEAG	D450V3	1102	2018/02/23	2021/02/22
○	System Validation Dipole	SPEAG	D750V3	1180	2018/02/07	2021/02/06
○	System Validation Dipole	SPEAG	D835V2	4d238	2018/02/19	2021/02/18
○	System Validation Dipole	SPEAG	D1750V2	1164	2018/02/06	2021/02/05
○	System Validation Dipole	SPEAG	D1900V2	5d226	2018/02/22	2021/02/21
○	System Validation Dipole	SPEAG	D2450V2	1009	2018/02/05	2021/02/04
○	System Validation Dipole	SPEAG	D2600V2	1150	2018/02/05	2021/02/04
○	System Validation Dipole	SPEAG	D5GHzV2	1273	2018/02/21	2021/02/20
●	Signal Generator	R&S	SMB100A	114360	2018/08/21	2019/08/20
●	Power Viewer for Windows	R&S	N/A	N/A	N/A	N/A
●	Power sensor	R&S	NRP18A	101010	2018/08/21	2019/08/20
●	Power sensor	R&S	NRP18A	101011	2018/08/21	2019/08/20
●	Power Amplifier	BONN	BLWA 0160-2M	1811887	2018/11/15	2019/11/14
●	Dual Directional Coupler	Mini-Circuits	ZHDC-10-62-S+	F975001814	2018/11/15	2019/11/14
●	Attenuator	Mini-Circuits	VAT-3W2+	1819	2018/11/15	2019/11/14
●	Attenuator	Mini-Circuits	VAT-10W2+	1741	2018/11/15	2019/11/14

Note:

1. The Probe, Dipole and DAE calibration reference to the Appendix B and C.
2. Referring to KDB865664 D01, the dipole calibration interval can be extended to 3 years with justification. The dipole are also not physically damaged or repaired during the interval.

5. Measurement Uncertainty

Per KDB 865664 D01 SAR Measurement 100 MHz to 6 GHz, when the highest measured 1-g SAR within a frequency band is < 1.5 W/kg. The equivalent ratio (1.5/1.6) should be applied to extremity and occupational exposure conditions. The expanded SAR measurement uncertainty must be ≤ 30%, for a confidence interval of k = 2. If these conditions are met, extensive SAR measurement uncertainty analysis described in IEEE Std 1528-2013 is not required in SAR reports submitted for equipment approval.

System Check Uncertainty										
No.	Error Description	Type	Uncertainty Value	Probably Distribution	Div.	(Ci) 1g	(Ci) 10g	Std. Unc. (1g)	Std. Unc. (10g)	Degree of freedom
Measurement System										
1	Probe calibration	B	6.0%	N	1	1	1	6.0%	6.0%	∞
2	Axial isotropy	B	4.70%	R	$\sqrt{3}$	0.7	0.7	1.90%	1.90%	∞
3	Hemispherical isotropy	B	9.60%	R	$\sqrt{3}$	0.7	0.7	3.90%	3.90%	∞
4	Boundary Effects	B	1.00%	R	$\sqrt{3}$	1	1	0.60%	0.60%	∞
5	Probe Linearity	B	4.70%	R	$\sqrt{3}$	1	1	2.70%	2.70%	∞
6	Detection limit	B	1.00%	R	$\sqrt{3}$	1	1	0.60%	0.60%	∞
7	RF ambient conditions-noise	B	0.00%	R	$\sqrt{3}$	1	1	0.00%	0.00%	∞
8	RF ambient conditions-reflection	B	0.00%	R	$\sqrt{3}$	1	1	0.00%	0.00%	∞
9	Response time	B	0.80%	R	$\sqrt{3}$	1	1	0.50%	0.50%	∞
10	Integration time	B	5.00%	R	$\sqrt{3}$	1	1	2.90%	2.90%	∞
11	RF ambient	B	3.00%	R	$\sqrt{3}$	1	1	1.70%	1.70%	∞
12	Probe positioned mech. restrictions	B	0.40%	R	$\sqrt{3}$	1	1	0.20%	0.20%	∞
13	Probe positioning with respect to phantom shell	B	2.90%	R	$\sqrt{3}$	1	1	1.70%	1.70%	∞
14	Max.SAR evaluation	B	3.90%	R	$\sqrt{3}$	1	1	2.30%	2.30%	∞
System validation source-dipole										
15	Deviation of experimental dipole from numerical dipole	A	1.58%	N	1	1	1	1.58%	1.58%	∞
16	Dipole axis to liquid distance	A	1.35%	N	1	1	1	1.35%	1.35%	∞
17	Input power and SAR drift	B	4.00%	R	$\sqrt{3}$	1	1	2.30%	2.30%	∞
Phantom and Set-up										
18	Phantom uncertainty	B	4.00%	R	$\sqrt{3}$	1	1	2.30%	2.30%	∞
20	Liquid conductivity (meas.)	A	0.50%	N	1	0.64	0.43	0.32%	0.26%	∞
22	Liquid cpermittivity (meas.)	A	0.16%	N	1	0.64	0.43	0.10%	0.07%	∞
Combined standard uncertainty			$u_c = \sqrt{\sum_{i=1}^{22} c_i^2 u_i^2}$	/	/	/	/	8.80%	8.79%	∞
Expanded uncertainty (confidence interval of 95 %)			$u_e = 2u_c$	R	K=2	/	/	17.59%	17.58%	∞

6. SAR Measurements System Configuration

6.1. SAR Measurement Set-up

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

A standard high precision 6-axis robot (Stäubli RX family) with controller and software. An arm extension for accommodating the data acquisition electronics (DAE).

A dosimetric probe, i.e. an isotropic E-field probe optimized and calibrated for usage in tissue simulating liquid. The probe is equipped with an optical surface detector system.

A data acquisition electronic (DAE) which performs the signal amplification, signal multiplexing, AD-conversion, offset measurements, mechanical surface detection, collision detection, etc. The unit is battery powered with standard or rechargeable batteries. The signal is optically transmitted to the EOC.

A unit to operate the optical surface detector which is connected to the EOC.

The Electro-Optical Coupler (EOC) performs the conversion from the optical into a digital electric signal of the DAE. The EOC is connected to the DASY5 measurement server.

The DASY5 measurement server, which performs all real-time data evaluation for field measurements and surface detection, controls robot movements and handles safety operation. A computer operating Windows 2003.

DASY5 software and SEMCAD data evaluation software.

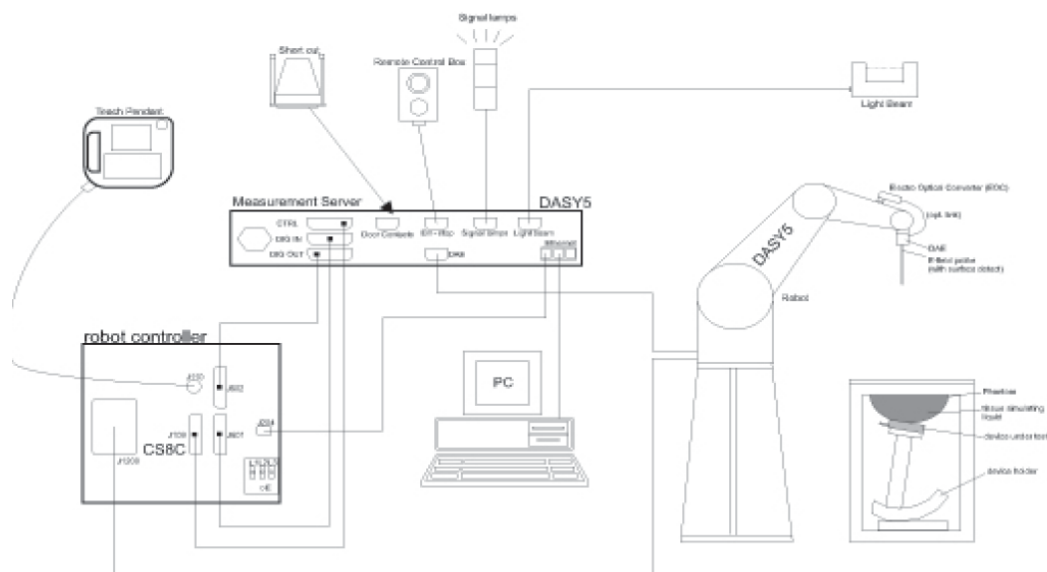
Remote control with teach panel and additional circuitry for robot safety such as warning lamps, etc.

The generic twin phantom enabling the testing of left-hand and right-hand usage.

The device holder for handheld Mobile Phones.

Tissue simulating liquid mixed according to the given recipes.

System validation dipoles allowing to validate the proper functioning of the system.



6.2. DASY5 E-field Probe System

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

● Probe Specification

Construction Symmetrical design with triangular core
 Interleaved sensors
 Built-in shielding against static charges
 PEEK enclosure material (resistant to organic solvents, e.g., DGBE)

Calibration ISO/IEC 17025 calibration service available.

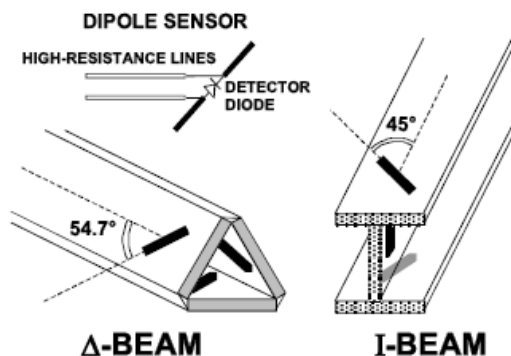
Frequency	10 MHz to 10 GHz; Linearity: ± 0.2 dB (30 MHz to 10 GHz)
Directivity	± 0.1 dB in TSL (rotation around probe axis) ± 0.3 dB in TSL (rotation normal to probe axis)
Dynamic Range	10 μ W/g to > 100 mW/g; Linearity: ± 0.2 dB
Dimensions	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 2.5 mm (Body: 12 mm) Distance from probe tip to dipole centers: 2.0 mm
Application	General dosimetry up to 10 GHz Dosimetry in strong gradient fields Compliance tests of Mobile Phones
Compatibility	DASY3, DASY4, DASY52 SAR and higher, EASY4/MRI



● Isotropic E-Field Probe

The isotropic E-Field probe has been fully calibrated and assessed for isotropicity, and boundary effect within a controlled environment. Depending on the frequency for which the probe is calibrated the method utilized for calibration will change.

The E-Field probe utilizes a triangular sensor arrangement as detailed in the diagram below:



6.3. Phantoms

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 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.



ELI Phantom

6.4. Device Holder

The device was placed in the device holder (illustrated below) that is supplied by SPEAG as an integral part of the DASY system.

The DASY device holder is designed to cope with the different positions given in the standard. It has two scales for device rotation (with respect to the body axis) and device inclination (with respect to the line between the ear reference points). The rotation centers for both scales is the ear reference point (ERP). Thus the device needs no repositioning when changing the angles.



Device holder supplied by SPEAG

7. SAR Test Procedure

7.1. Scanning Procedure

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

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

The “surface check” measurement tests the optical surface detection system of the DASY5 system by repeatedly detecting the surface with the optical and mechanical surface detector and comparing the results. The output gives the detecting heights of both systems, the difference between the two systems and the standard deviation of the detection repeatability. Air bubbles or refraction in the liquid due to separation of the sugar-water mixture gives poor repeatability (above $\pm 0.1\text{mm}$). To prevent wrong results tests are only executed when the liquid is free of air bubbles. The difference between the optical surface detection and the actual surface depends on the probe and is specified with each probe (It does not depend on the surface reflectivity or the probe angle to the surface within $\pm 30^\circ$.)

Area Scan

The Area Scan is used as a fast scan in two dimensions to find the area of high field values before running a detailed measurement around the hot spot. Before starting the area scan a grid spacing of 15 mm x 15 mm is set. During the scan the distance of the probe to the phantom remains unchanged. After finishing area scan, the field maxima within a range of 2 dB will be ascertained.

Zoom Scan

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.

Spatial Peak Detection

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

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

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

Extrapolation routines are used to obtain SAR values between the lowest measurement points and the inner phantom surface. The extrapolation distance is determined by the surface detection distance and the probe sensor offset. Several measurements at different distances are necessary for the extrapolation. Extrapolation routines require at least 10 measurement points in 3-D space.

They are used in the Zoom Scan to obtain SAR values between the lowest measurement points and the inner phantom surface. The routine uses the modified Quadratic Shepard’s method for extrapolation.

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

Table 1: Area and Zoom Scan Resolutions per FCC KDB Publication 865664 D01v04

		≤ 3 GHz	> 3 GHz	
Maximum distance from closest measurement point (geometric center of probe sensors) to phantom surface		5 mm \pm 1 mm	$\frac{1}{2} \cdot \delta \cdot \ln(2)$ mm \pm 0.5 mm	
Maximum probe angle from probe axis to phantom surface normal at the measurement location		$30^\circ \pm 1^\circ$	$20^\circ \pm 1^\circ$	
Maximum area scan spatial resolution: Δx_{Area} , Δy_{Area}		≤ 2 GHz: ≤ 15 mm 2 – 3 GHz: ≤ 12 mm	3 – 4 GHz: ≤ 12 mm 4 – 6 GHz: ≤ 10 mm	
		When the x or y dimension of the test device, in the measurement plane orientation, is smaller than the above, the measurement resolution must be \leq the corresponding x or y dimension of the test device with at least one measurement point on the test device.		
Maximum zoom scan spatial resolution: Δx_{Zoom} , Δy_{Zoom}		≤ 2 GHz: ≤ 8 mm 2 – 3 GHz: ≤ 5 mm*	3 – 4 GHz: ≤ 5 mm* 4 – 6 GHz: ≤ 4 mm*	
Maximum zoom scan spatial resolution, normal to phantom surface	uniform grid: $\Delta z_{Zoom}(n)$	≤ 5 mm	3 – 4 GHz: ≤ 4 mm 4 – 5 GHz: ≤ 3 mm 5 – 6 GHz: ≤ 2 mm	
	graded grid	$\Delta z_{Zoom}(1)$: between 1 st two points closest to phantom surface	≤ 4 mm	3 – 4 GHz: ≤ 3 mm 4 – 5 GHz: ≤ 2.5 mm 5 – 6 GHz: ≤ 2 mm
		$\Delta z_{Zoom}(n>1)$: between subsequent points	$\leq 1.5 \cdot \Delta z_{Zoom}(n-1)$ mm	
Minimum zoom scan volume	x, y, z	≥ 30 mm	3 – 4 GHz: ≥ 28 mm 4 – 5 GHz: ≥ 25 mm 5 – 6 GHz: ≥ 22 mm	
<p>Note: δ is the penetration depth of a plane-wave at normal incidence to the tissue medium; see IEEE Std 1528-2013 for details.</p> <p>* When zoom scan is required and the <i>reported</i> SAR from the <i>area scan based 1-g SAR estimation</i> procedures of KDB Publication 447498 is ≤ 1.4 W/kg, ≤ 8 mm, ≤ 7 mm and ≤ 5 mm zoom scan resolution may be applied, respectively, for 2 GHz to 3 GHz, 3 GHz to 4 GHz and 4 GHz to 6 GHz.</p>				

7.2. Data Storage and Evaluation

Data Storage

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

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

Data Evaluation

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

Probe parameters:	Sensitivity:	Normi, ai0, ai1, ai2
	Conversion factor:	ConvFi
	Diode compression point:	Dcpi
Device parameters:	Frequency:	f
	Crest factor:	cf
Media parameters:	Conductivity:	σ
	Density:	ρ

These parameters must be set correctly in the software. They can be found in the component documents or they can be imported into the software from the configuration files issued for the DASY5 components. In the direct measuring mode of the multimeter option, the parameters of the actual system setup are used. In the scan visualization and export modes, the parameters stored in the corresponding document files are used.

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

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

Vi:	compensated signal of channel (i = x, y, z)
Ui:	input signal of channel (i = x, y, z)
cf:	crest factor of exciting field (DASY parameter)
dcp _i :	diode compression point (DASY parameter)

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

$$E - \text{fieldprobes} : \quad E_i = \sqrt{\frac{V_i}{Norm_i \cdot ConvF}}$$

$$H - \text{fieldprobes} : \quad H_i = \sqrt{V_i} \cdot \frac{a_{i0} + a_{i1}f + a_{i2}f^2}{f}$$

Vi:	compensated signal of channel (i = x, y, z)
Norm _i :	sensor sensitivity of channel (i = x, y, z), [mV/(V/m) ²] for E-field Probes
ConvF:	sensitivity enhancement in solution
aij:	sensor sensitivity factors for H-field probes
f:	carrier frequency [GHz]
E _i :	electric field strength of channel i in V/m
H _i :	magnetic field strength of channel i in A/m

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

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

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

$$SAR = E_{tot}^2 \cdot \frac{\sigma}{\rho \cdot 1'000}$$

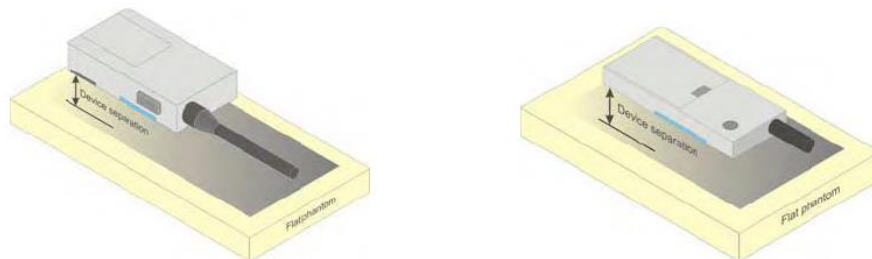
SAR: local specific absorption rate in mW/g
Etot: total field strength in V/m
 σ : conductivity in [mho/m] or [Siemens/m]
 ρ : equivalent tissue density in g/cm³

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

8. Position of the wireless device in relation to the phantom

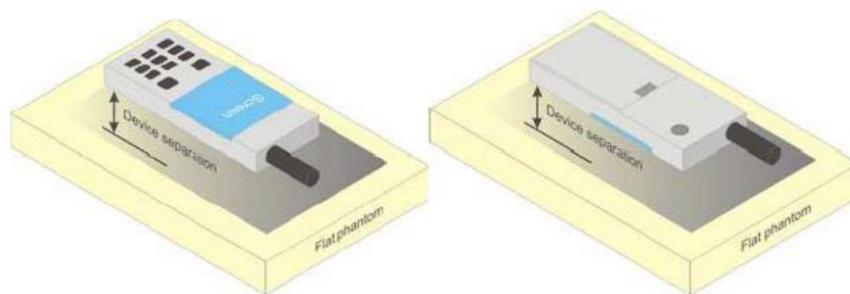
8.1. Front-of-face

A typical example of a front-of-face device is a two-way radio that is held at a distance from the face of the user when transmitting. In these cases the device under test shall be positioned at the distance to the phantom surface that corresponds to the intended use as specified by the manufacturer in the user instructions. If the intended use is not specified, a separation distance of 25 mm between the phantom surface and the device shall be used.



8.2. Body Position

A typical example of a body-worn device is a mobile phone, wireless enabled PDA or other battery operated wireless device with the ability to transmit while mounted on a person's body using a carry accessory approved by the wireless device manufacturer.



9. System Check

9.1. Tissue Dielectric Parameters

It's satisfying the latest tissue dielectric parameters requirements proposed by the KDB865664 D01.

Targets for tissue simulating liquid

Tissue dielectric parameters for head and body				
Target Frequency (MHz)	Head		Body	
	ϵ_r	σ (s/m)	ϵ_r	σ (s/m)
150	52.3	0.76	61.9	0.80
450	43.5	0.87	56.7	0.94

CheckResult:

Dielectric performance of Head tissue simulating liquid									
Frequency (MHz)	ϵ_r		σ (s/m)		Delta (ϵ_r)	Delta (σ)	Limit	Temp (°C)	Date
	Target	Measured	Target	Measured					
150	52.30	53.22	0.76	0.75	1.76%	-0.92%	±5%	22.5	2019-01-31
450	43.50	44.49	0.87	0.86	2.28%	-1.26%	±5%	22.5	2019-01-30

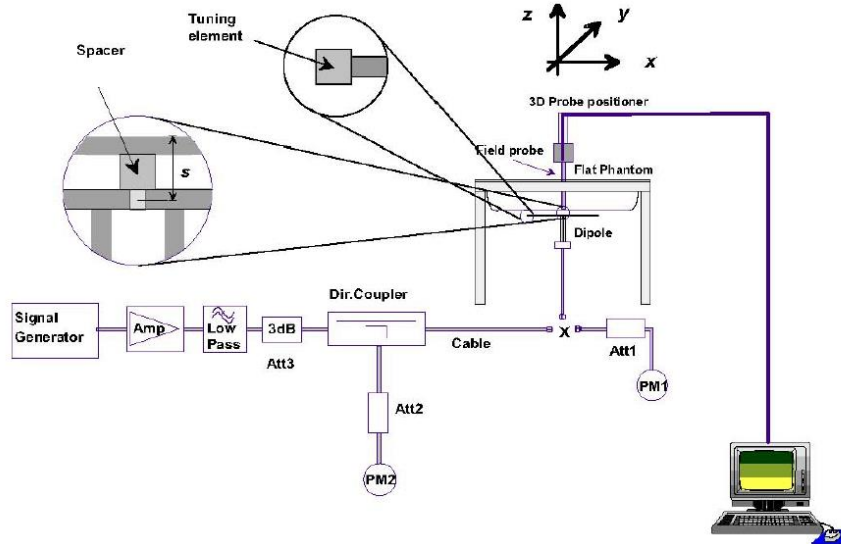
Dielectric performance of Body tissue simulating liquid									
Frequency (MHz)	ϵ_r		σ (s/m)		Delta (ϵ_r)	Delta (σ)	Limit	Temp (°C)	Date
	Target	Measured	Target	Measured					
150	61.90	61.45	0.80	0.81	-0.72%	1.13%	±5%	22.5	2019-01-31
450	56.70	56.11	0.94	0.96	-1.05%	2.23%	±5%	22.5	2019-01-30

9.2. SAR System Check

The purpose of the system check is to verify that the system operates within its specifications at the device test frequency. The system check is simple check of repeatability to make sure that the system works correctly at the time of the compliance test;

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

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



System Performance Check Setup



Photo of Dipole Setup

Check Result:

Head											
Frequency (MHz)	1g SAR			10g SAR			Delta (1g)	Delta (10g)	Limit	Temp (°C)	Date
	Target 1W	Normalize to 1W	Measured 1W	Target 1W	Normalize to 1W	Measured 1W					
150	3.68	3.86	3.86	2.45	2.56	2.56	4.89%	4.49%	±10%	22.5	2019-01-31

Head											
Frequency (MHz)	1g SAR			10g SAR			Delta (1g)	Delta (10g)	Limit	Temp (°C)	Date
	Target 1W	Normalize to 1W	Measured 250mW	Target 1W	Normalize to 1W	Measured 250mW					
450	4.48	4.64	1.16	3.00	3.09	0.77	3.57%	3.07%	±10%	22.5	2019-01-30

Body											
Frequency (MHz)	1g SAR			10g SAR			Delta (1g)	Delta (10g)	Limit	Temp (°C)	Date
	Target 1W	Normalize to 1W	Measured 1W	Target 1W	Normalize to 1W	Measured 1W					
150	3.75	3.98	3.98	2.50	2.59	2.59	6.13%	3.60%	±10%	22.5	2019-01-31

Body											
Frequency (MHz)	1g SAR			10g SAR			Delta (1g)	Delta (10g)	Limit	Temp (°C)	Date
	Target 1W	Normalize to 1W	Measured 250mW	Target 1W	Normalize to 1W	Measured 250mW					
450	4.47	4.88	1.22	3.01	3.30	0.83	9.17%	9.77%	±10%	22.5	2019-01-30

Note:

1. the graph results see follow.

Plots of System Performance Check

SystemPerformanceCheck-Head 150MHz

DUT: Antenna 150 MHz; Type: CLA150; Serial: 4024

Date: 2019-01-31

Communication System: UID 0, A-CW (0); Frequency: 150 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 150 \text{ MHz}$; $\sigma = 0.753 \text{ S/m}$; $\epsilon_r = 53.218$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7494; ConvF(13.63, 13.63, 13.63) @ 150 MHz; Calibrated: 2/26/2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1549; Calibrated: 4/25/2018
- Phantom: ELI V8.0 ; Type: QD OVA 004 AA ; Serial: 2078
- DASY52 52.10.1(1476); SEMCAD X 14.6.12(7450)

Head/d=0mm, Pin=1W/Area Scan (81x81x1): Interpolated grid: $dx=1.500 \text{ mm}$, $dy=1.500 \text{ mm}$

Maximum value of SAR (interpolated) = 5.50 W/kg

Head/d=0mm, Pin=1W/Zoom Scan (5x5x7) (5x5x7)/Cube 0: Measurement grid:

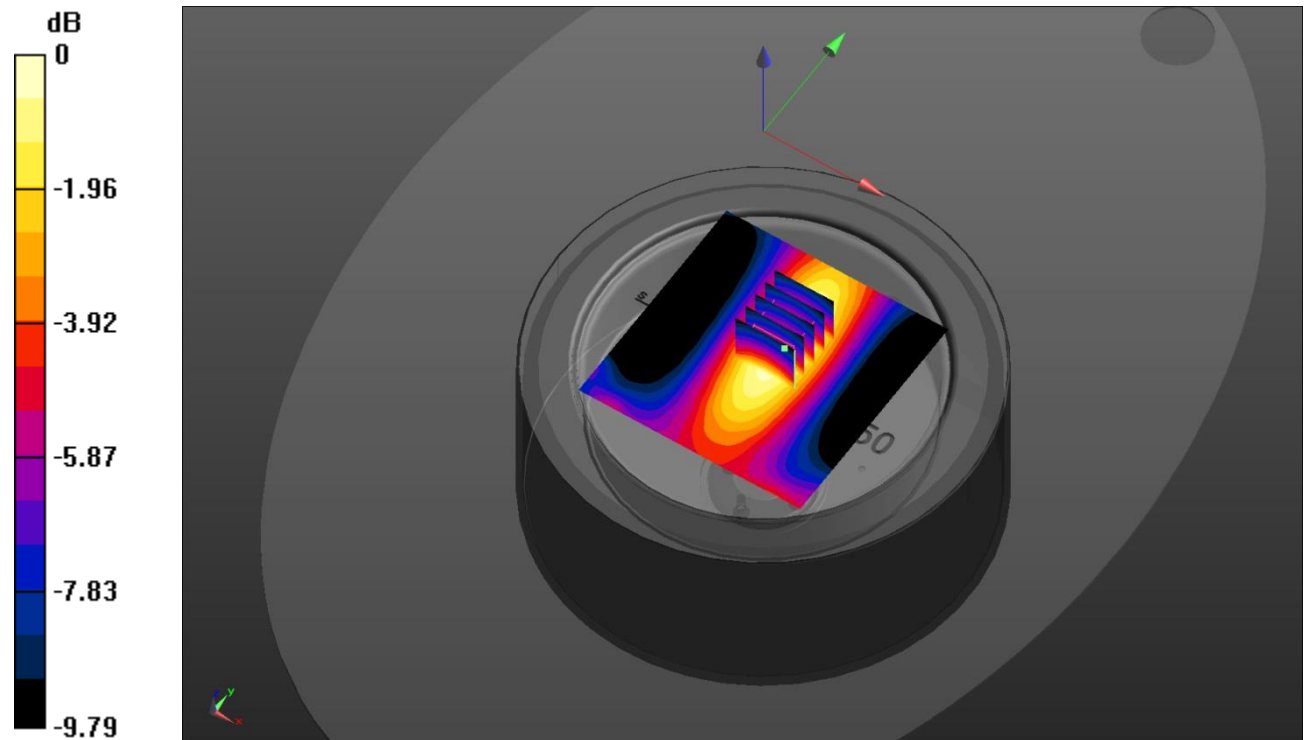
$dx=8\text{mm}$, $dy=8\text{mm}$, $dz=5\text{mm}$

Reference Value = 81.34 V/m; Power Drift = -0.11 dB

Peak SAR (extrapolated) = 6.87 W/kg

SAR(1 g) = 3.86 W/kg; SAR(10 g) = 2.56 W/kg

Maximum value of SAR (measured) = 5.52 W/kg



0 dB = 5.52 W/kg = 7.42 dBW/kg

SystemPerformanceCheck-Body 150MHz

DUT: Antenna 150 MHz; Type: CLA150; Serial: 4024

Date: 2019-01-31

Communication System: UID 0, A-CW (0); Frequency: 150 MHz; Duty Cycle: 1:1

Medium parameters used: $f = 150$ MHz; $\sigma = 0.809$ S/m; $\epsilon_r = 61.453$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7494; ConvF(12.81, 12.81, 12.81) @ 150 MHz; Calibrated: 2/26/2018
- Sensor-Surface: 1.4mm (Mechanical Surface Detection)
- Electronics: DAE4 Sn1549; Calibrated: 4/25/2018
- Phantom: ELI V8.0 ; Type: QD OVA 004 AA ; Serial: 2078
- DASY52 52.10.1(1476); SEMCAD X 14.6.12(7450)

Body/d=0mm, Pin=1W/Area Scan (81x81x1): Interpolated grid: dx=1.500 mm, dy=1.500 mm

Maximum value of SAR (interpolated) = 5.89 W/kg

Body/d=0mm, Pin=1W/Zoom Scan (5x5x7) (5x5x7)/Cube 0: Measurement grid:

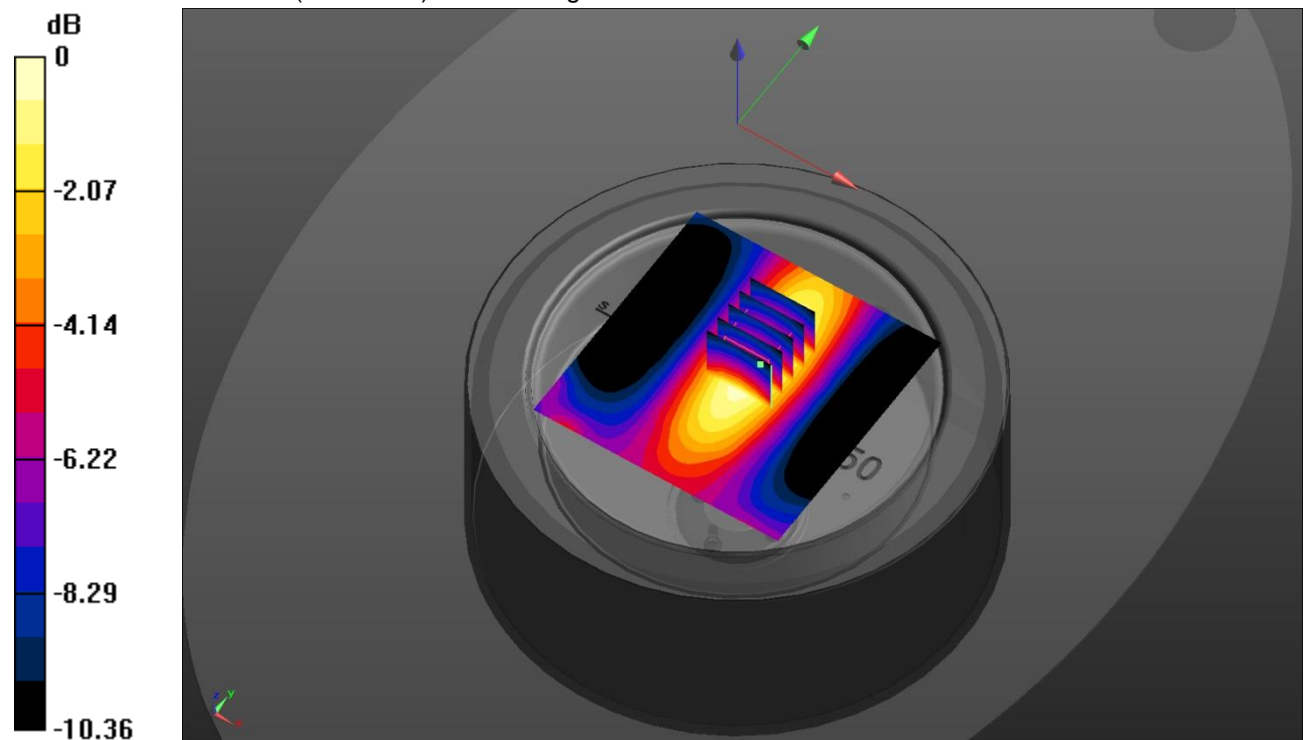
dx=8mm, dy=8mm, dz=5mm

Reference Value = 80.36 V/m; Power Drift = -0.05 dB

Peak SAR (extrapolated) = 7.76 W/kg

SAR(1 g) = 3.98 W/kg; SAR(10 g) = 2.59 W/kg

Maximum value of SAR (measured) = 5.92 W/kg



0 dB = 5.92 W/kg = 7.72 dBW/kg

SystemPerformanceCheck-Head 450MHz

DUT: Dipole 450 MHz; Type: D450V3; Serial: 1102

Date: 2019-01-30

Communication System: UID 0, A-CW (0); Frequency: 450 MHz

Medium parameters used: $f = 450$ MHz; $\sigma = 0.859$ S/m; $\epsilon_r = 44.492$; $\rho = 1000$ kg/m³

Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7494; ConvF(11.7, 11.7, 11.7); Calibrated: 2/26/2018;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE4 Sn1549; Calibrated: 4/25/2018
- Phantom: ELI V8.0 ; Type: QD OVA 004 AA ; Serial: 2078
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Head/d=15mm, Pin=250mW/Area Scan (81x81x1): Interpolated grid: $dx=1.500$ mm, $dy=1.500$ mm

Maximum value of SAR (interpolated) = 1.60 W/kg

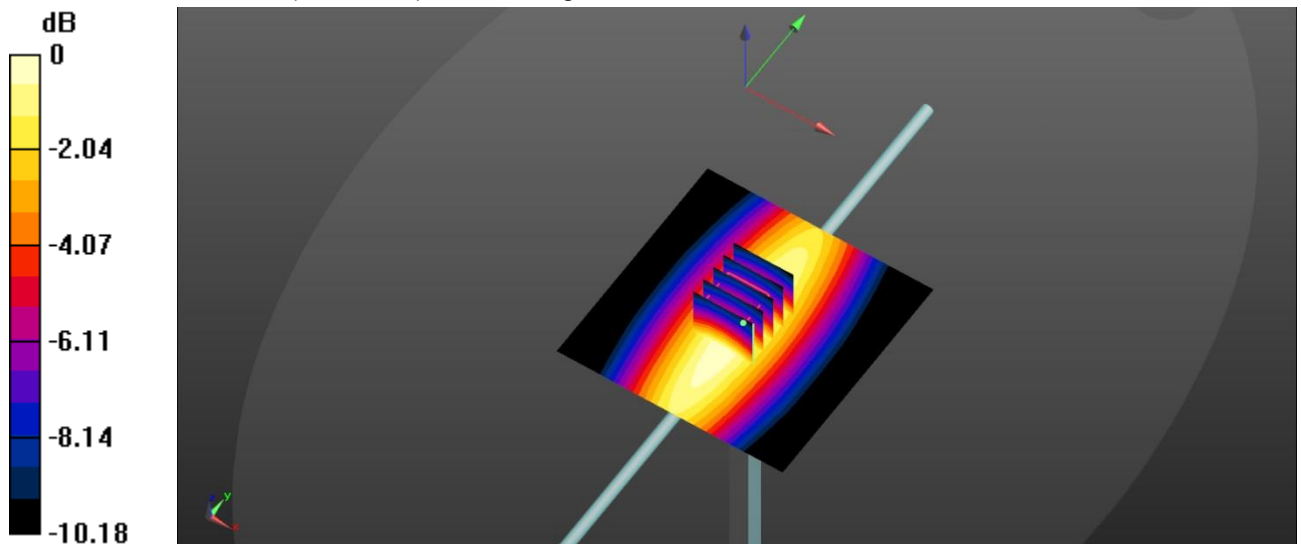
Head/d=15mm, Pin=250mW/Zoom Scan (5x5x7)/Cube 0: Measurement grid: $dx=8$ mm, $dy=8$ mm, $dz=5$ mm

Reference Value = 44.31 V/m; Power Drift = -0.04 dB

Peak SAR (extrapolated) = 1.85 W/kg

SAR(1 g) = 1.16 W/kg; SAR(10 g) = 0.773 W/kg

Maximum value of SAR (measured) = 1.58 W/kg



0 dB = 1.58 W/kg = 1.99 dBW/kg

SystemPerformanceCheck-Body 450MHz

DUT: Dipole 450 MHz; Type: D450V3; Serial: 1102

Date: 2019-01-30

Communication System: UID 0, A-CW (0); Frequency: 450 MHz

Medium parameters used: $f = 450 \text{ MHz}$; $\sigma = 0.961 \text{ S/m}$; $\epsilon_r = 56.106$; $\rho = 1000 \text{ kg/m}^3$

Phantom section: Flat Section

DASY Configuration:

- Probe: EX3DV4 - SN7494; ConvF(11.87, 11.87, 11.87); Calibrated: 2/26/2018;
- Sensor-Surface: 1.4mm (Mechanical Surface Detection), $z = 1.0, 31.0$
- Electronics: DAE4 Sn1549; Calibrated: 4/25/2018
- Phantom: ELI V8.0 ; Type: QD OVA 004 AA ; Serial: 2078
- DASY52 52.10.0(1446); SEMCAD X 14.6.10(7417)

Head/d=15mm, Pin=250mW/Area Scan (51x121x1): Interpolated grid: $dx=1.500 \text{ mm}$, $dy=1.500 \text{ mm}$

Maximum value of SAR (interpolated) = 1.67 W/kg

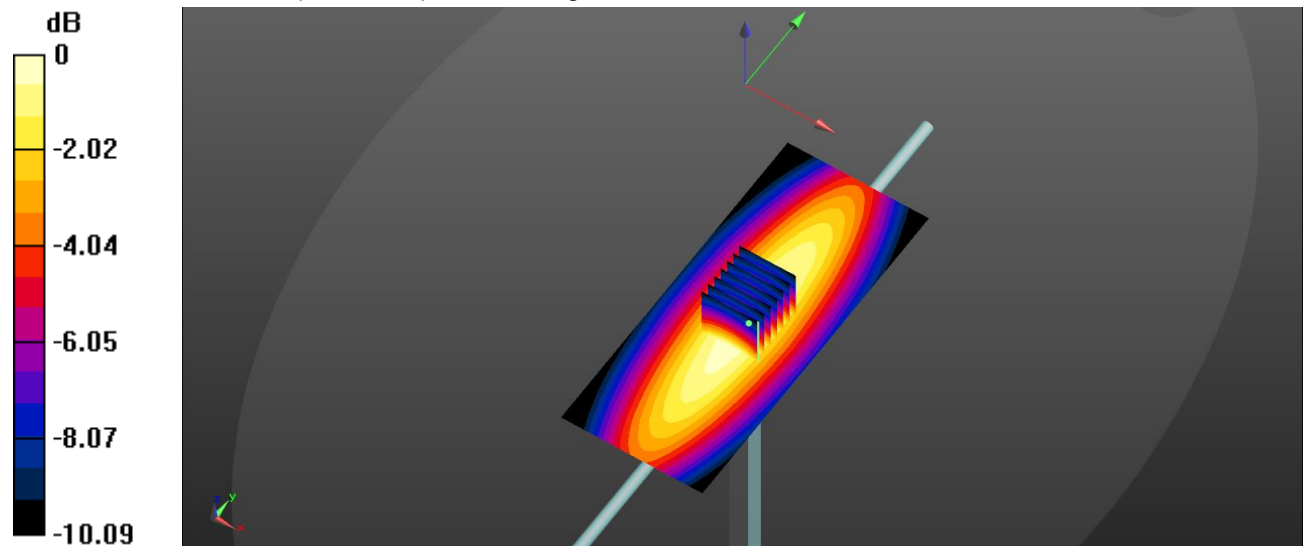
Head/d=15mm, Pin=250mW /Zoom Scan (7x7x7)/Cube 0: Measurement grid: $dx=5\text{mm}$, $dy=5\text{mm}$, $dz=5\text{mm}$

Reference Value = 42.66 V/m; Power Drift = 0.02 dB

Peak SAR (extrapolated) = 2.03 W/kg

SAR(1 g) = 1.22 W/kg; SAR(10 g) = 0.826 W/kg

Maximum value of SAR (measured) = 1.72 W/kg



0 dB = 1.72 W/kg = 2.36 dBW/kg

10. SAR Exposure Limits

SAR assessments have been made in line with the requirements of FCC 47 CFR § 2.1093.

Type Exposure	Limit (W/kg)	
	General Population / Uncontrolled Exposure Environment	Occupational / Controlled Exposure Environment
Spatial Average SAR (whole body)	0.08	0.4
Spatial Peak SAR (1g cube tissue for head and trunk)	1.6	8.0
Spatial Peak SAR (10g for limb)	4.0	20.0

Population/Uncontrolled Environments: are defined as locations where there is the exposure of individual who have no knowledge or control of their exposure.

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

11. Conducted Power Measurement Results

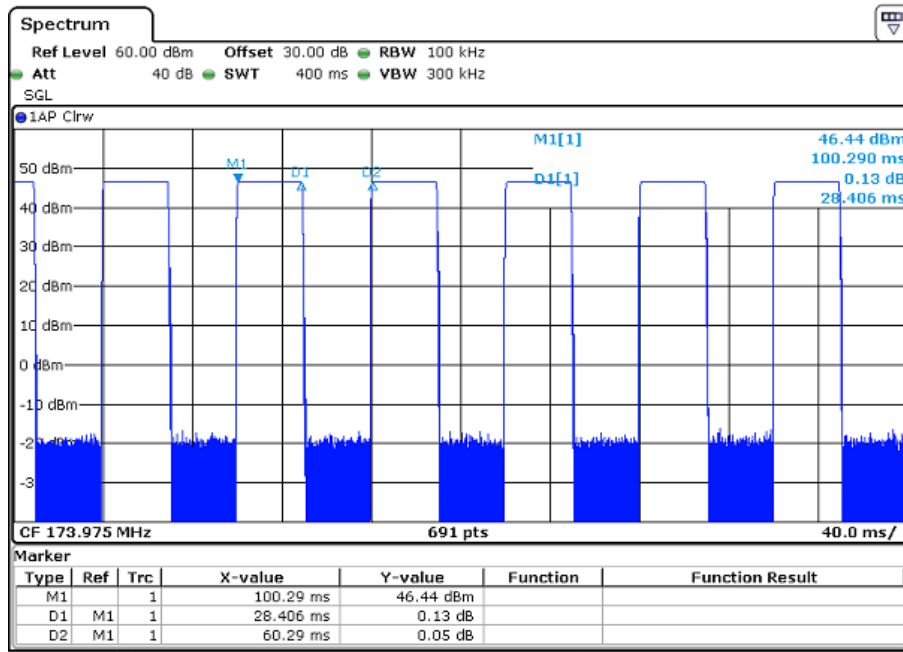
PMR(136~174MHz)				
Mode	Channel Separation	Frequency		Conducted Power (dBm)
		Channel	MHz	
Analog	12.5KHz	CH _{V1}	136.0250	35.52
		CH _{V2}	145.5000	35.36
		CH _{V3}	155.0250	35.48
		CH _{V4}	164.5000	35.42
		CH _{V5}	173.9750	35.55
Digital	12.5KHz	CH _{V1}	136.0250	35.38
		CH _{V2}	145.5000	35.34
		CH _{V3}	155.0250	35.40
		CH _{V4}	164.5000	35.45
		CH _{V5}	173.9750	35.57

PMR(400~480MHz)				
Mode	Channel Separation	Frequency		Conducted Power (dBm)
		Channel	MHz	
Analog	12.5KHz	CH _{U1}	400.0250	34.99
		CH _{U2}	416.0250	34.56
		CH _{U3}	432.0250	34.34
		CH _{U4}	448.0250	34.41
		CH _{U5}	464.0250	34.32
		CH _{U6}	479.9750	34.38
Digital	12.5KHz	CH _{U1}	400.0250	34.97
		CH _{U2}	416.0250	34.85
		CH _{U3}	432.0250	34.56
		CH _{U4}	448.0250	34.47
		CH _{U5}	464.0250	34.32
		CH _{U6}	479.9750	34.40

Duty Factor Measured Results

Mode	Type	T on (ms)	Period (ms)	Duty Cycle	Crest Factor (1/duty cycle)
Digital	4FSK	28.406	60.29	47.12%	2.12243

Duty Cycle plot



12. Maximum Tune-up Limit

This device operates using the following maximum output power specifications. SAR values were scaled to the maximum allowed power to determine compliance per KDB publication 447498 D01.

PMR(136~174MHz)			
Mode	Channel Separation (KHz)	Operation Frequency Range (MHz)	Maximum tune-up power (dBm)
Analog	12.5	136~174	36.02
Digital			36.02
Analog	12.5	400~480	36.02
Digital			36.02

13. SAR Measurement Results

136~174MHz

Front-of-face											
Mode	Channel Separation	Frequency		Conducted Power (dBm)	Tune-up limit (dBm)	Tune-up scaling factor	Power Drift(dB)	Measured SAR(1g)	Report SAR(1g)	50% Duty factor SAR	Test Plot
		CH	MHz					(W/kg)	(W/kg)	(W/kg)	
Analog	12.5KHz	CH _{v1}	136.0250	35.52	36.02	1.12	-	-	-	-	-
		CH _{v2}	145.5000	35.36	36.02	1.16	-	-	-	-	-
		CH _{v3}	155.0250	35.48	36.02	1.13	-	-	-	-	-
		CH _{v4}	164.5000	35.42	36.02	1.15	-	-	-	-	-
		CH _{v5}	173.9750	35.55	36.02	1.11	-0.17	0.276	0.306	0.153	1
Digital	12.5KHz	CH _{v1}	136.0250	35.38	36.02	1.16	-	-	-	-	-
		CH _{v2}	145.5000	35.34	36.02	1.17	-	-	-	-	-
		CH _{v3}	155.0250	35.40	36.02	1.15	-	-	-	-	-
		CH _{v4}	164.5000	35.45	36.02	1.14	-	-	-	-	-
		CH _{v5}	173.9750	35.57	36.02	1.11	-0.02	0.145	0.161	0.080	3

Body-worn (Rear)											
Mode	Channel Separation	Frequency		Conducted Power (dBm)	Tune-up limit (dBm)	Tune-up scaling factor	Power Drift(dB)	Measured SAR(1g)	Report SAR(1g)	50% Duty factor SAR	Test Plot
		CH	MHz					(W/kg)	(W/kg)	(W/kg)	
Analog	12.5KHz	CH _{v1}	136.0250	35.52	36.02	1.12	-	-	-	-	-
		CH _{v2}	145.5000	35.36	36.02	1.16	-	-	-	-	-
		CH _{v3}	155.0250	35.48	36.02	1.13	-	-	-	-	-
		CH _{v4}	164.5000	35.42	36.02	1.15	-	-	-	-	-
		CH _{v5}	173.9750	35.55	36.02	1.11	-0.18	0.378	0.420	0.210	2
Digital	12.5KHz	CH _{v1}	136.0250	35.38	36.02	1.16	-	-	-	-	-
		CH _{v2}	145.5000	35.34	36.02	1.17	-	-	-	-	-
		CH _{v3}	155.0250	35.40	36.02	1.15	-	-	-	-	-
		CH _{v4}	164.5000	35.45	36.02	1.14	-	-	-	-	-
		CH _{v5}	173.9750	35.57	36.02	1.11	-0.15	0.197	0.219	0.109	4

Note:

- The value with blue color is the maximum SAR Value of each test band.
- Batteries are fully charged at the beginning of the SAR measurements.
- The Body-worn SAR evaluation was performed with the Leather Case body-worn accessory attached to the DUT and touching the outer surface of the planar phantom.
- When the SAR for all antennas tested using the default battery is ≤ 3.5 W/kg (50% PTT duty factor), testing of all other required channels is not necessary.
- When the SAR of an antenna tested on the highest output power using the default battery is > 3.5 W/Kg and ≤ 4.0 W/Kg (50% PTT duty factor), testing of the immediately adjacent channel(s) is not necessary, but testing of other required channels may still be required.

400~480MHz

Front-of-face											
Mode	Channel Separation	Frequency		Conducted Power (dBm)	Tune-up limit (dBm)	Tune-up scaling factor	Power Drift(dB)	Measured SAR(1g)	Report SAR(1g)	50% Duty factor SAR	Test Plot
		CH	MHz					(W/kg)	(W/kg)	(W/kg)	
Analog	12.5KHz	CH _{U1}	400.0250	34.99	36.02	1.27	-0.10	2.320	2.946	1.473	5
		CH _{U2}	416.0250	34.56	36.02	1.40	-	-	-	-	-
		CH _{U3}	432.0250	34.34	36.02	1.47	-	-	-	-	-
		CH _{U4}	448.0250	34.41	36.02	1.45	-	-	-	-	-
		CH _{U5}	464.0250	34.32	36.02	1.48	-	-	-	-	-
		CH _{U6}	479.0250	34.38	36.02	1.46	-	-	-	-	-
Digital	12.5KHz	CH _{U1}	400.0250	34.97	36.02	1.27	0.18	1.290	1.638	0.819	7
		CH _{U2}	416.0250	34.85	36.02	1.31	-	-	-	-	-
		CH _{U3}	432.0250	34.56	36.02	1.40	-	-	-	-	-
		CH _{U4}	448.0250	34.47	36.02	1.43	-	-	-	-	-
		CH _{U5}	464.0250	34.32	36.02	1.48	-	-	-	-	-
		CH _{U6}	479.0250	34.40	36.02	1.45	-	-	-	-	-

Note:

1. The value with blue color is the maximum SAR Value of each test band.
2. Batteries are fully charged at the beginning of the SAR measurements.
3. The Body-worn SAR evaluation was performed with the Leather Case body-worn accessory attached to the DUT and touching the outer surface of the planar phantom.
4. When the SAR for all antennas tested using the default battery is ≤ 3.5 W/kg (50% PTT duty factor), testing of all other required channels is not necessary.
5. When the SAR of an antenna tested on the highest output power using the default battery is > 3.5 W/Kg and ≤ 4.0 W/Kg (50% PTT duty factor), testing of the immediately adjacent channel(s) is not necessary, but testing of other required channels may still be required.

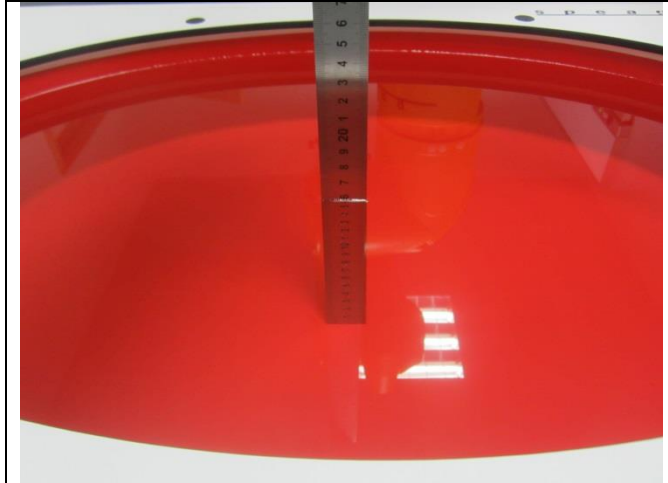
Body-worn (Rear)											
Mode	Channel Separation	Frequency		Conducted Power (dBm)	Tune-up limit (dBm)	Tune-up scaling factor	Power Drift(dB)	Measured SAR(1g)	Report SAR(1g)	50% Duty factor SAR	Test Plot
		CH	MHz					(W/kg)	(W/kg)	(W/kg)	
Analog	12.5KHz	CH _{U1}	400.0250	34.99	36.02	1.27	-0.16	4.270	5.423	2.711	6
		CH _{U2}	416.0250	34.56	36.02	1.40	-	-	-	-	-
		CH _{U3}	432.0250	34.34	36.02	1.47	-	-	-	-	-
		CH _{U4}	448.0250	34.41	36.02	1.45	-	-	-	-	-
		CH _{U5}	464.0250	34.32	36.02	1.48	-	-	-	-	-
		CH _{U6}	479.0250	34.38	36.02	1.46	-	-	-	-	-
Digital	12.5KHz	CH _{U1}	400.0250	34.97	36.02	1.27	0.09	2.110	2.680	1.340	8
		CH _{U2}	416.0250	34.85	36.02	1.31	-	-	-	-	-
		CH _{U3}	432.0250	34.56	36.02	1.40	-	-	-	-	-
		CH _{U4}	448.0250	34.47	36.02	1.43	-	-	-	-	-
		CH _{U5}	464.0250	34.32	36.02	1.48	-	-	-	-	-
		CH _{U6}	479.0250	34.40	36.02	1.45	-	-	-	-	-

Note:

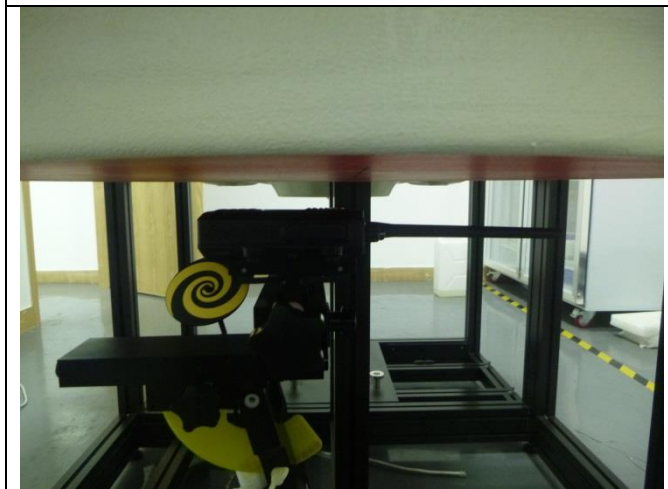
1. The value with blue color is the maximum SAR Value of each test band.
2. Batteries are fully charged at the beginning of the SAR measurements.
3. The Body-worn SAR evaluation was performed with the Leather Case body-worn accessory attached to the DUT and touching the outer surface of the planar phantom.
4. When the SAR for all antennas tested using the default battery is ≤ 3.5 W/kg (50% PTT duty factor), testing of all other required channels is not necessary.
5. When the SAR of an antenna tested on the highest output power using the default battery is > 3.5 W/Kg and ≤ 4.0 W/Kg (50% PTT duty factor), testing of the immediately adjacent channel(s) is not necessary, but testing of other required channels may still be required.

SAR Test Data Plots to the Appendix A.

14. Test Setup Photos



Liquid depth in the Flat Phantom



Front-of-face(25mm)



Body-worn(0mm)

15. External Photos of the EUT



-----End of Report-----